STUDY REPORT

for

Ravensway Subdivision Drainage Improvements - 2018

Prepared For:
HARRIS COUNTY
PRECINCT 3
UPIN: 19103MF14601

June 2022

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06/28/2022

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EXECUTIVE SUMMARY

LJA Engineering was selected to by Harris County Engineering Department (HCED) to prepare a study and design for drainage improvements in the Ravensway Subdivision. HCED issues a notice to proceed on **June 30, 2021**. A drainage assessment was originally conducted by Costello on **June 23, 2019** and LJA was tasked to further investigate the recommendations made on the assessment and verify the results. This project is in Precinct 3, Cypress, Texas. The Ravensway subdivision is a residential neighborhood located south of Jarvis Road, west of HCFCD Unit No. K163-00-00, north of Ravensway Drive and East of Tall Forest Drive.

LJA Engineering has prepared this study report to present the multiple studies conducted for the subdivision and present the recommendations to reduce excessive ponding in the ATLAS-14 2 and 10-year rainfall and reduce the number of impassable zones within the project area. The Ravensway subdivision has been reported to experience frequent flooding, which can be supported from previous flooded structure records as well as impassable roads from high inundation. Flooded structures were reported for Hurricane Harvey (August 2017), Tax Day Flood (April 2016) and Memorial Day Flood (2015).

The Ravensway Subdivision was built in the 1970s. The subdivision streets and storm sewer system constructed originally did not incorporate extreme event rainfall conveyance. The existing underground storm sewer lacks conveyance capacity to route the ATLAS-14 2-year and 10-year rain events which leads to excessive ponding at low points on the streets leading to impassable areas. Structural flooding occurs in the ATLAS-14 100-year rainfall. The subdivision is in the Cypress Creek watershed and near the confluence of HCFCD Unit No. K100-00-00 (Cypress Creek) and K163-00-00. The subdivision is in the Cypress Creek 100-year floodplain which indicates there is a strong likelihood of out-of-bank channel flooding during an extreme event rainfall. Due to the drainage deficiencies, this subdivision would benefit from the proposed improvements.

The studies performed and their approval dates are as follows: The Threatened and Endangered Species Habitat Evaluation was accepted on **November 19th, 2021.** The Archaeological Investigations assessment desktop study was accepted on **January 13th, 2022**. The Archaeological Investigations for the Proposed Ravensway Subdivision Drainage Improvement Report was submitted to THC on **June 3,2022.** USACE accepted the Waters of the United States (WOUS) on **January 31st, 2022**. right-of-way and topographic survey maps for subdivision streets was accepted on **December 17, 2021** and for the detention basin it was accepted on **January 11, 2022.** The geotechnical detention basin report was accepted on **April 6th, 2022** and the geotechnical pavement investigation was accepted on **May 10th, 2022.** The Drainage Impact Analysis (DIA), provided in **Appendix C,** was approved by Harris County Flood Control District (HCFCD) on **March 23rd, 2022**.

Proposed storm sewer improvements will improve the conveyance capacity to reduce impassable zones and excessive ponding in the ATLAS-14 2-year and 10-year rainfall event. A proposed detention basin located northwest of the project area will provide mitigation to cause no adverse impacts upstream and downstream of Cypress Creek due to the improved conveyance in the storm sewer system and fill in the floodway (a floodway analysis is included in the DIA), refer to **Appendix C**.

The preliminary construction cost estimate for this project is **$14,692,000.00.**

1.0 INTRODUCTION

1.2 Authorization

LJA Engineering, Inc. (LJA) was authorized to proceed with the engineering study and design services for Harris County for the improvements of the existing drainage system to Ravensway Subdivision on **June 30, 2021** to provide drainage improvements along the neighborhood including a proposed detention basin.

1.2 Location

This project is in the Ravensway Subdivision in Harris County Precinct 3 and the Cypress Creek watershed. It is generally bounded by Jarvis Road to the North, HCFCD Unit No. K163-00-00 to the east, Ravensway Drive to the south and Tall Forest Drive to the west. Refer to **Exhibit 1** for Project Location. A portion of the subdivision is in the Cypress Creek 100 and 500-year floodplain as shown in FIRM Panel 48201C0410M and 48201C0430M (see **Exhibit 2**).

1.3 Purpose and Scope

The purpose of this Study Report is to present the findings from the engineering and environmental investigations conducted which provided recommendations for drainage improvements to alleviate the existing flooding that occurs in the Ravensway subdivision. These improvements included replacing storm sewer trunklines, replacing two existing outfalls, adding one outfall, and constructing a detention basin. The implementation of the drainage improvements will reduce the number of impassable zones for the ATLAS-14 2-,10-, and 100-year rainfall event. The drainage improvements will tentatively reduce structural flooding in the ATLAS-14 100-year rainfall event.

The scope of the Study Report consists of the following and will summarize the findings for each assessment, analysis or investigation:

- Review and analysis of the existing conditions
- Environmental Investigation
- Drainage Impact Analysis
- Geotechnical Investigation
- Utility Conflict coordination list
- Right-of-way alignment and topographic survey
- Preliminary cost estimate.

1.4 Existing Conditions

The project is in Harris County, Precinct 3. The existing conditions are as follows:

1. The Ravensway Section 1,2, and 3 Subdivision is comprised of neighborhood streets typically with two-lane concrete pavement 28-feet curb and gutter back-to-back wide, existing inlets, and storm sewer. Streets with this configuration include Campsite Trail, Lakecrest Road, New Kentucky Road, Wiley Martin Drive, Scouts Lane, Tall Forest Drive, Retreat Trail, and Rifleman Trail. Jarvis Road contains a four-lane concrete pavement with a raised median. The eastbound and westbound lanes on Jarvis Road are 25-foot wide from back of curb to back of curb.

2. The apparent right-of-way (ROW) is 60-feet wide on Campsite Trail, Lakecrest Road, New Kentucky Road, Wiley Martin Drive, Scouts Lane, Tall Forest Drive, Retreat Trail, and Rifleman Trail. The apparent right-of-way on Jarvis Road is 100-feet wide.

3. There is an existing 48-inch reinforced concrete pipe (RCP) storm sewer that outfalls to HCFCD Unit No. K100-00-00 and one existing 42-inch corrugated metal pipe (CMP) and an existing 36-inch RCP storm sewer that outfall to HCFCD Unit NO. K163-00-00.

4. The Ravensway Subdivision is near the confluence of two channels, HCFCD Unit No. K100-00-00 (Cypress Creek) and HCFCD Unit No. K163-00-00. Refer to **Exhibit 4** for storm sewer location and existing drainage system within the subdivision. **Exhibit 6** shows the existing typical sections of Campsite Trail, Lakecrest Road, New Kentucky Road, Wiley Martin Drive, Scouts Lane, Tall Forest Drive, Jarvis Road, Retreat Trail, and Rifleman Trail.

5. The expansive K100-00-00 and K163-00-00 floodplains within the study area indicate a strong likelihood of out of bank channel flooding and potential overflow during extreme events. Flood records from Hurricane Harvey indicate a significant number of structures within the regulatory floodplain. This area is vulnerable to overbank flowing from Cypress Creek. Reports on the Tax Day flood showed that flooding located inside the channel floodplain. No structures were reported during the Memorial Day floods.

2.0 STUDIES AND DESIGN INFORMATION

2.1 Survey

The right-of-way, survey controls, topographic survey were performed by Costello, Inc and consisted of vertical and horizontal control, existing right-of-way (ROW) maps and topographic survey. The survey was accepted by HCED for subdivision streets on **December 17, 2022** and for the detention basin on **January 11, 2022.** See **Exhibit 7** for the right-of-way, topographic survey, and survey control map.

2.1.1 Topographic Survey

A topographic survey was conducted in accordance with Texas Society of Professional Surveyors (TSPS) Category 6, Condition II standards and to Harris County Standards. All public and private utilities were found using subsurface Utility Engineering Quality levels “B”, “C” and “D”. Additional survey was conducted for the proposed detention basin site located in two properties owned by Harris County Flood Control District: HCAD Parcel No. 0410650000088 and 0410650000097.

The specific limits are as follows:

1. Ravensway Drive – approximately 3,500 feet
2. Old Hickory Court – approximately 200 feet
3. Lazdins Court – approximately 200 feet
4. Tall Forest Drive – approximately 2,550 feet
5. Texas Army Trail – approximately 550 feet
6. Rifleman Trail – approximately 740 feet
7. Wiley Martin Drive – approximately 805 feet
8. Retreat Trail – approximately 1,394 feet
9. Campsite Trail – approximately 1,200 feet
10. New Kentucky Road – approximately 506 feet
11. Scouts Lane – approximately 815 feet
12. Lakecrest Circle – approximately 200 feet
13. Saracen Drive – approximately 450 feet
14. Twin Sisters Road – approximately 350 feet
15. Jarvis Road – approximately 2,700 feet

Additional survey was conducted for the proposed detention basin site located in two properties owned by Harris County Flood Control District: HCAD Parcel No. 0410650000088 and 0410650000097. Survey of two cross sections of Cypress Creek at proposed outfall location was performed, which included the delineated ordinary high-water mark, bottom of channel, and high bank elevations. See **Exhibit 7** for Survey and ROW Plan Sheets.

Survey deliverables included

- Survey control map (See **Exhibit 6**)
- ROW and topography shown together on a set of standard sized project sheets (See **Exhibit 7**)
- Parcel map for proposed detention pond

2.1.2 Existing ROW

The existing ROW of the subdivision includes of 60-foot ROW on Campsite Trail, Lakecrest Road, New Kentucky Road, Wiley Martin Drive, Scouts Lane, Tall Forest Drive, Retreat Trail, and Rifleman Trial. The apparent ROW on Jarvis Road is 100-foot. Existing ROW was conducted in accordance with Texas Society of Professional Surveyors (TSPS) Category 1B, Condition II Standards and to Harris County Standards.

2.1.3 Level B,C,D SUE

Texas 811 services were done in order to mark utilities within existing ROW and easements within the project area. CenterPoint Energy and AT&T utility maps were requested. Subsurface Utility Engineering (SUE) was performed in accordance with American Society of Civil Engineers (ASCE) 38-02.

2.2 Utilities and Conflict

2.2.1 Water

Ravensway Subdivision are served by Timberlake Utility District. Existing 12-inch, 8-inch, 6-inch waterlines found within the ROW of on Campsite Trail, Lakecrest Road, New Kentucky Road, Wiley Martin Drive, Tall Forest Drive, Jarvis Road, Retreat Trail, and Rifleman Trail. Waterlines that conflict with the proposed improvements will be adjusted accordingly by Timberlake Utility District.

2.2.2 Sanitary Sewer

The Ravensway subdivision is served by Timberlake Utility District. Existing 8-inch sanitary sewers located on Jarvis Road conflict with the proposed improvements. There must be at least a 1-foot cover between sanitary sewer utility and the proposed storm sewer system.

2.2.3 Electric

Ravensway Subdivision are served by CenterPoint Energy. There are both underground and overhead electric utilities within the project area. Power poles along Tall Forest Drive, Rifleman Trail, Wiley Martin Drive, and Scouts Lane may be in conflict. Further coordination with CenterPoint Energy will need to be conducted on utilities that need to be replaced and relocated during construction.

2.2.4 Gas

Ravensway Subdivision are served by CenterPoint Energy. Gas lines within the project area are located inside utility easements. A buried Gas Line will conflict with the proposed improvements on the west side of Ravensway Drive. Gas lamp posts may be impacted during construction of the proposed improvements so further coordination with CenterPoint Energy will need to be conducted these utilities.

2.2.5 Telecommunications

Ravensway Subdivision are served by AT&T telecommunications. Existing buried AT&T fiber optic cables, telephone lines, and cable lines may be affected by the proposed improvements on Campsite Trail, Lakecrest

Road, Tall Forest Drive, Jarvis Road, Retreat Trail, and Rifleman Trail. Coordination with AT&T will be necessary.

2.2.6 Utilities & Conflict Table

The utility contact information and approximate locations within the project area can be found on **Exhibit 10.**

2.3 Environmental Studies

2.3.1 Threatened and Endangered Species Habitat Evaluation

The Threatened and Endangered species field work was performed by Raba Kistner, Inc. (RKI) on October 28th, 2021 and submitted on November 12, 2021, see **Appendix A**. The Threatened and Endangered Species Habitat Evaluation was accepted **November 19, 2021**. The Threatened and Endangered Species Habitat Report complies with both state and federal endangered species requirements that are regulated by the Texas Park and Wildlife Department (TPWD). Based on the their desktop analysis and field observations, RKI concluded the following:

- No designated critical habitat occurs in the Review Area.
- No effect on federally listed species is anticipated.
- Potential habitat exists for the following state-threatened species:
    - Rafinesque's Big-Eared Bat (Corynorhinus rafinesquii)
    - Louisiana Pig Toe (Pleurobema riddellii)
    - Sandback Pocketbook (Lampsilis satura)
    - Alligator Snapping Turtle (Macrochelys temminckii)
- Best Management Practices (BMPs) may be considered to void impacting these species.
- There is the potential to encounter migratory birds.

2.3.2 Cultural Resources (Desktop)

The archaeological site assessment desktop study was performed on November 29, 2021, see **Appendix A**. THC accepted on **January 13, 2022**. This report complies with Texas Historical Commission (THC) standards. Based on the information reviewed, RKI found the following:

- Review of Atlas indicates that there are no archaeological sites within the boundaries of the APE
- Nearest recorded archaeological site is located approximately 422 feet northeast of the APE, site 41HR366 was recorded as a late prehistoric campsite and is eligible for listing on the National Register of Historic Places (NRHP).
- There are 18 other previously recorded archaeological sites within one mile of the Area of Potential Effects (APE) boundaries. Many of these were recorded along the banks of Cypress Creek.
- Dowdell Cemetery has been recorded within the boundaries of the APE, this site dates from the late 19th to early 20th centuries.
- Additional intensive cultural resources survey is recommended that for the northwest region of the project area, within the detention basin property, which includes both shovel testing and backhoe trenching.

2.3.3 Intensive Cultural Resources Survey Report

The archaeological investigations for the proposed Ravensway Subdivision Drainage Improvements study were performed on May 2, 2022, see **Appendix A**. This report was submitted to THC on **June 3, 2022** and complies with THC standards. Based on the information reviewed, RKI found the following:

- No significant deposits or features were encountered during shovel testing, hand auger testing, windshield survey, and mechanical backhoe trenching. RKI recommends no need for further investigations within the project area unless should there be changes made in the future, further work may be required.

2.3.4 Waters of the US Delineation

The Waters of the US delineation field work was performed in October 2021 by RKI and submitted on November 2021, see **Appendix A**. This report supports applications for regulatory permits that are required from the United States Army Corps of Engineers (USACE). Non-wetland waters were delineated based on USACE Regulatory Guidance Letter (RGL) 05-05 Ordinary High Water Mark (OHWM) Identification for non-tidal waters. USACE accepted the WOUS report on **January 31, 2021**. Based on the information reviewed and their field observations, RKI found the following:

- 412 feet of potentially jurisdictional non-wetland water (Cypress Creek, PS-1) was identified within the review area, which is regulated under section 404 of the CWA.

- 496 feet (drainage feathers) and 0.14 acre (waterbodies) of potentially non-jurisdictional non-wetland waters within the review area that are not regulated under section 404 the CWA.

2.3.5 Regional General Permit – Drainage Outfall

A drainage outfall structure into Cypress Creek (HCFCD Unit No. K100-00-00) will be constructed which will require rip-rap under the ordinary high water mark (OHWM). A request was submitted to USACE to perform work under RGP 2011-00629 since a jurisdictional stream was going to be impacted. USACE approved the request on June 6, 2022. A copy of the approval is shown in **Exhibit 11.**

2.4 Geotechnical Investigation

The geotechnical investigation pertaining to the design and construction of the detention basin was performed in October 2021 and a report was finalized on March 2nd, 2022 by HTS, Inc., and is provided in **Appendix B**. The report was performed in accordance with the requirements of the 2020 Harris County Flood Control District (HCFCD) Standard Specifications Book and the HCFCD "Geotechnical Investigation Guidelines" 2019. The geotechnical detention basin report was accepted on **April 6th, 2022,** the ePermit application number associated is **2112090019**. Seven geotechnical borings were drilled to a depth of 50 feet beneath the surface within the area of the proposed detention basin. HTS, Inc. made the following findings and recommendations:

- Data retrieved from the seven borings showed that the upper 50 feet of overburden soils are composed of 8 separate soil layers (Layers I through VIII). Groundwater was encountered at 3 of the 7 borings.

Results of the stability analyses suggest that the proposed basin with a slope no steeper than 4H:1V will be stable with clay liners in the short term and long term conditions

- Analyses verified that a firm and stable base is present, and no evidence of seepage or raveling is present within the side slopes or bottom before erosion control is implemented.
- Laboratory testing performed on subsurface soils verified that most of the soils encountered within the limits of the proposed detention basin depth do not meet the requirements for imported select fill material except Layer VI-A and Layer II.
- Groundwater will not be anticipated during excavation. However, care and control of groundwater and surface water during construction should be performed in accordance with Section 02241 titled “Care and Control of Water” from the 2020 HCFCD Standard Specifications Book.
- Backfill placement operations should be monitored and be in accordance with 2020 HCFCD Standard Specifications Book.

An addition, the geotechnical pavement investigation was conducted on March 2022 by HTS, Inc. The geotechnical roadway report was accepted on **May 10,2022**. This report was prepared in accordance to the latest HCED geotechnical investigation guidelines. Fifteen geotechnical borings were drilled and tested. Boring Nos. 1-6,8, and 10 were drilled at a depth of 30 feet below existing surface. Boring Nos. 7,9 and 11 were drilled to depth of 15 feet below existing ground surface. HTS, Inc. made the following findings and recommendations:

- Groundwater was not encountered at all boring locations except Boring No. 13.
- All excavation and trenching operations for storm sewer and outfalls should be in accordance with OSHA and HCED standards.
- Recommended pavement strength is 3,000 psi 28-day compressive strength
- Bedding and backfill practices for the storm sewer should be in accordance with HCED 430 specification for the storm sewer construction
- Installing of box culvert should be in accordance with 2020 HCFCD standards sections 02612, 02631, and 02321.

2.5 Drainage Study

The Ravensway Section 1,2 and 3 Subdivision resides along Cypress Creek just upstream of its junction with Little Cypress Creek. The watershed does experience out-of-bank flooding during less frequent, more intense rain events due to lack of conveyance in Cypress Creek (HCFCD Unit No. K100-00-00). The subdivision has experience flooding with 22 structures reporting flooding during the Tax Day Floods of 2016 and 242 structures reporting flooding during Hurricane Harvey in 2017. In addition, FEMA records indicate 25 Repetitive Loss (RL) properties in the study area, five of them are classified as Severe Repetitive Loss (SRL). The subdivision streets were constructed in the 1970’s and typically extreme event rainfall conveyance was not incorporated during this era. The existing stormwater drainage system is designed to convey more frequent, less intense storm events based on the 3-year Fugate curves used in 1970s. The current design is undersized to meet Atlas 14, 2-year rainfall.

A 2D InfoWorks ICM model and study was performed by Gauge Engineering, LLC. to determine the extreme flow paths results from a rainfall on grid. An unsteady-state HEC-RAS analysis of Cypress Creek was conducted to evaluate potential impacts due to both changes in floodplain conveyance, and from changes in discharge. 2018 LiDAR was used as the surface for the model. The most current Region 1 Atlas 14 rainfall was used for this study to ensure consistency with HCFCD Policy Criteria & Procedure Manual, 2004, Updated October 2018 & Interim Guidelines, July 2019. The DIA is provided in **Appendix C**, and was approved by HCFCD on March 23rd, 2022. The ePermits application number for the DIA, **2201180135**, is provided in the Letter of No Objection in **Appendix D.**

The proposed improvements included upgrading storm sewer to 6'X5' RCB's along southwest portion of Ravensway Drive, Tall Forest Drive, and bisecting streets to capture overland sheet flow. Upgrading storm sewer to 60" RCP along the eastern portion of Jarvis Road, and upgrading storm sewer to 48" RCP along the northeastern segment of Ravensway Drive to capture overland sheet flow. The proposed detention basin on the west side of project (HCFCD property) is designed to provide 101 ac-ft of storage up to a water surface elevation of 125.30 HCFCD Unit No. K100-00-00. The proposed improvement will have 3.2-ft of freeboard in the ATLAS-14 100-year storm event which will leave 28 ac-ft of volume available for use by Cypress Creek in the ATLAS-14 100-year event. These improvements create no adverse impacts to flood hazard conditions on the receiving waterways, including downstream properties, for storm events up to and including the ATLAS-14 100-year storm event.

3.0 PROPOSED DRAINAGE RECOMMENDATIONS

3.1 Ravensway Subdivision Recommendations

The primary areas that were identified for proposed improvements that provides substantial benefit are summarized as follows:

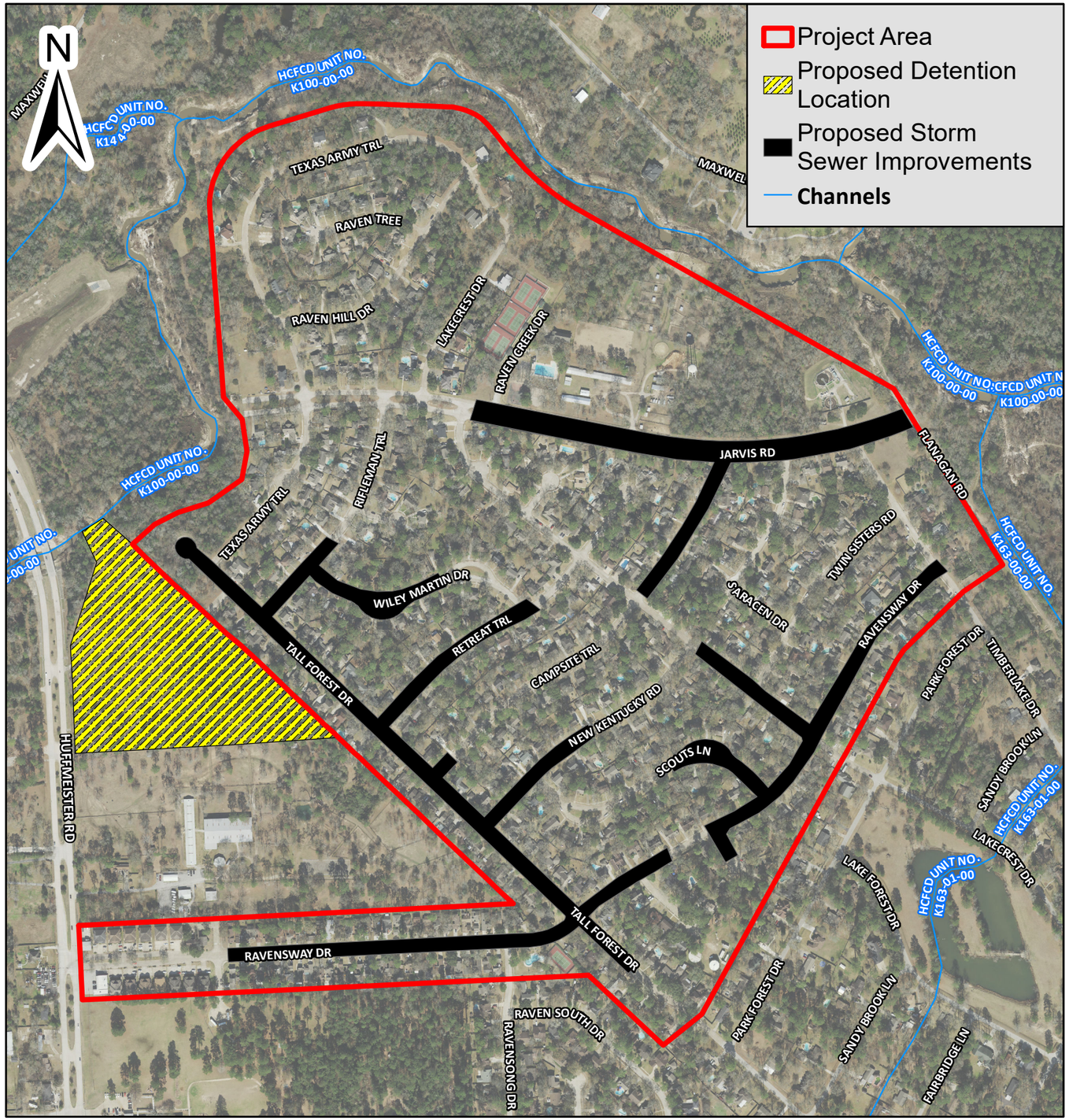
- Replace the existing 36-inch outfall RCP at HCFCD Unit No. K163-00-00 to a 48-inch RCP.
- Proposed 60-inch RCP outfall at HCFCD Unit No. K163-00-00.
- Proposed 10-foot by 5 foot RCB outfall into proposed detention basin which outfalls via 42-inch RCP into HCFCD Unit No. K100-00-00.
- Replace B-B inlets to type C-1 inlets along Jarvis Drive, Campsite Trail, Lakecrest Drive, Scouts Lane, Tall Forest Drive, New Kentucky Road, Retreat Trail, Wiley Martin Drive, Rifleman Trail and Ravensway Drive where necessary.
- Proposed drainage improvements entails the construction of 6678 linear feet of 6'X5' reinforced concrete box culvert storm sewer (RCB), 2363 linear feet of 24" reinforced concrete pipe (RCP),44 linear feet of 36" RCP, 2561 feet of 48" RCP, and 2466 linear feet of 60" RCP.
- Proposed stormwater detention basin that is located west of Tall Forest Drive and north of Ravensway Drive and will occupy HCAD Parcels 041065000097 and 04165000088. It is recommended to hold 101 Ac-ft of volume to mitigate the 100-year storm event.
- Proposed top of bank elevation is to be raised to 128.5 feet and 3.2- feet of freeboard.
- Sidewalks, driveways, and roadways replacements will be necessary as shown on plans. The underground systems will be reconstructed to provide positive flow collection of drainage using curb inlets with extensions

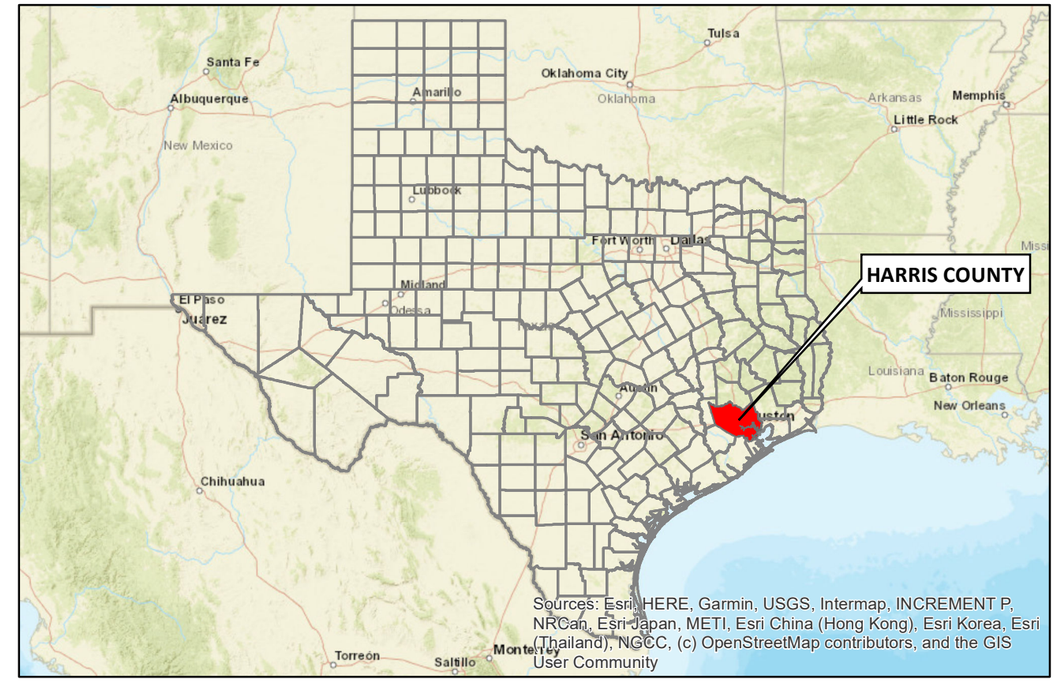
4.0 PRELIMINARY CONSTRUCTION COST ESTIMATE

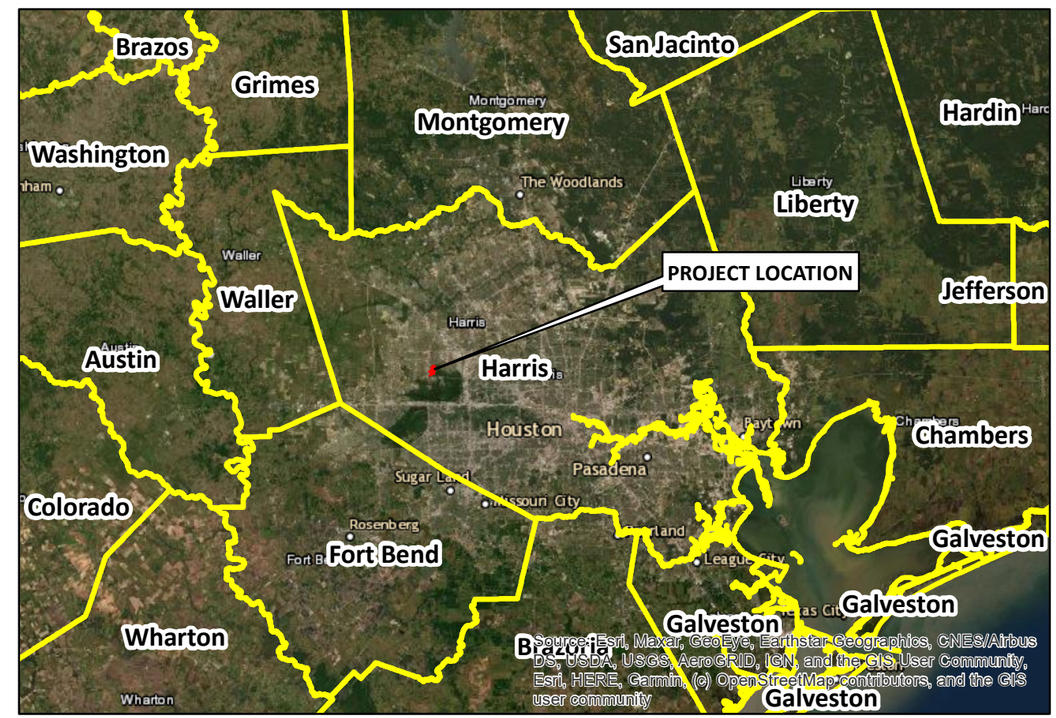
The preliminary construction cost estimate for this project is **$14,692,000.00**. Refer to **Exhibit 9** for a preliminary cost estimate

Exhibits

Exhibit 1
Project Area Map/Location Map







J:\1904\2102\GIS\02 - EXHIBITS\Exhibit 1 - Vicinity Map.mxd

0 250 500 1,000 Feet

1 inch = 500 feet

HARRIS COUNTY ENGINEERING DEPARTMENT

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RAVENSWAY SUBDIVISION
DRAINAGE IMPROVEMENTS

UPIN 19103MF14601
EXHIBIT 1 - LOCATION MAP

Exhibit 2
Project Location FIRM Map

NOTES TO USERS

This map is for use in administering the National Flood Insurance Program. It does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The **community map repository** should be consulted for possible updated or additional flood hazard information.

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

Coastal Base Flood Elevations shown on this map apply only landward of 0.0' North American Vertical Datum of 1988 (NAVD 88). Users of this FIRM should be aware that coastal flood elevations are also provided in the Summary of Stillwater Elevations table in the Flood Insurance Study Report for this jurisdiction. Elevations shown in the Summary of Stillwater Elevations table should be used for construction, and/or floodplain management purposes when they are higher than the elevations shown on this FIRM.

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

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

The **projection** used in the preparation of this map was Universal Transverse Mercator, Zone 15. The **horizontal datum** was NAD83, GRS80 spheroid. Differences in datum, spheroid, projection or UTM zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of this FIRM.

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

NGS Information Services
NOAA, N/NGS12
National Geodetic Survey, SSMC-3, #9202
1315 East-West Highway
Silver Spring, Maryland 20910-3282
(301) 713-3242

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

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

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

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

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

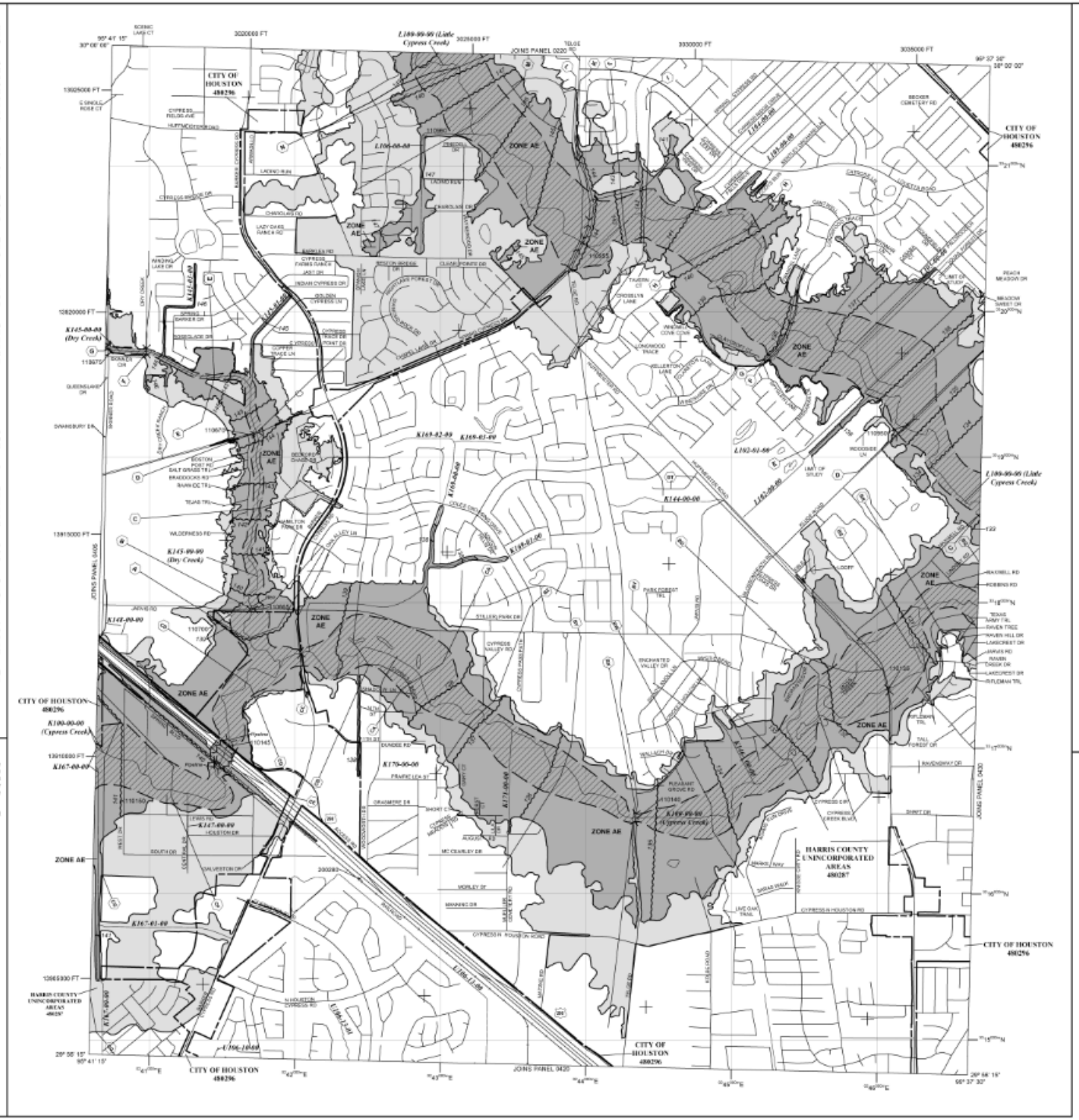
Contact the **FEMA Map Information eXchange** at 1-877-FEMA MAP (1-877-336-2627) for information on available products associated with this FIRM. Available products may include previously issued Letters of Map Change, a Flood Insurance Study report, and/or digital versions of this map. The FEMA Map Information eXchange may also be reached by Fax at 1-800-358-9620 and their website at http://www.msc.fema.gov.

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

Vertical Datum Adjustment due to subsidence is the 2001 adjustment.

Benchmarks shown on this map were provided by either Harris County or the National Geodetic Survey. To obtain elevation, description, and location information for benchmarks provided by Harris County, please contact the Permits Office of the Public Infrastructure Department at (713) 868-3000 or visit their website at http://www.eng.hctx.net/permits. For information regarding the benchmarks provided by the National Geodetic Survey, please see note above.

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



NOTES TO USERS

This map is for use in administering the National Flood Insurance Program. It does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The **community map repository** should be consulted for possible updated or additional flood hazard information.

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

Coastal Base Flood Elevations shown on this map apply only landward of 0.0' North American Vertical Datum of 1988 (NAVD 88). Users of this FIRM should be aware that coastal flood elevations are also provided in the Summary of Stillwater Elevations table in the Flood Insurance Study Report for this jurisdiction. Elevations shown in the Summary of Stillwater Elevations table should be used for construction, and/or floodplain management purposes when they are higher than the elevations shown on this FIRM.

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

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

The **projection** used in the preparation of this map was Universal Transverse Mercator, Zone 15. The **horizontal datum** was NAD83, GRS80 spheroid. Differences in datum, spheroid, projection or UTM zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of this FIRM.

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

NGS Information Services
NOAA, N/NGS12
National Geodetic Survey, SSMC-3, #9202
1315 East-West Highway
Silver Spring, Maryland 20910-3282
(301) 713-3242

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

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

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

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

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

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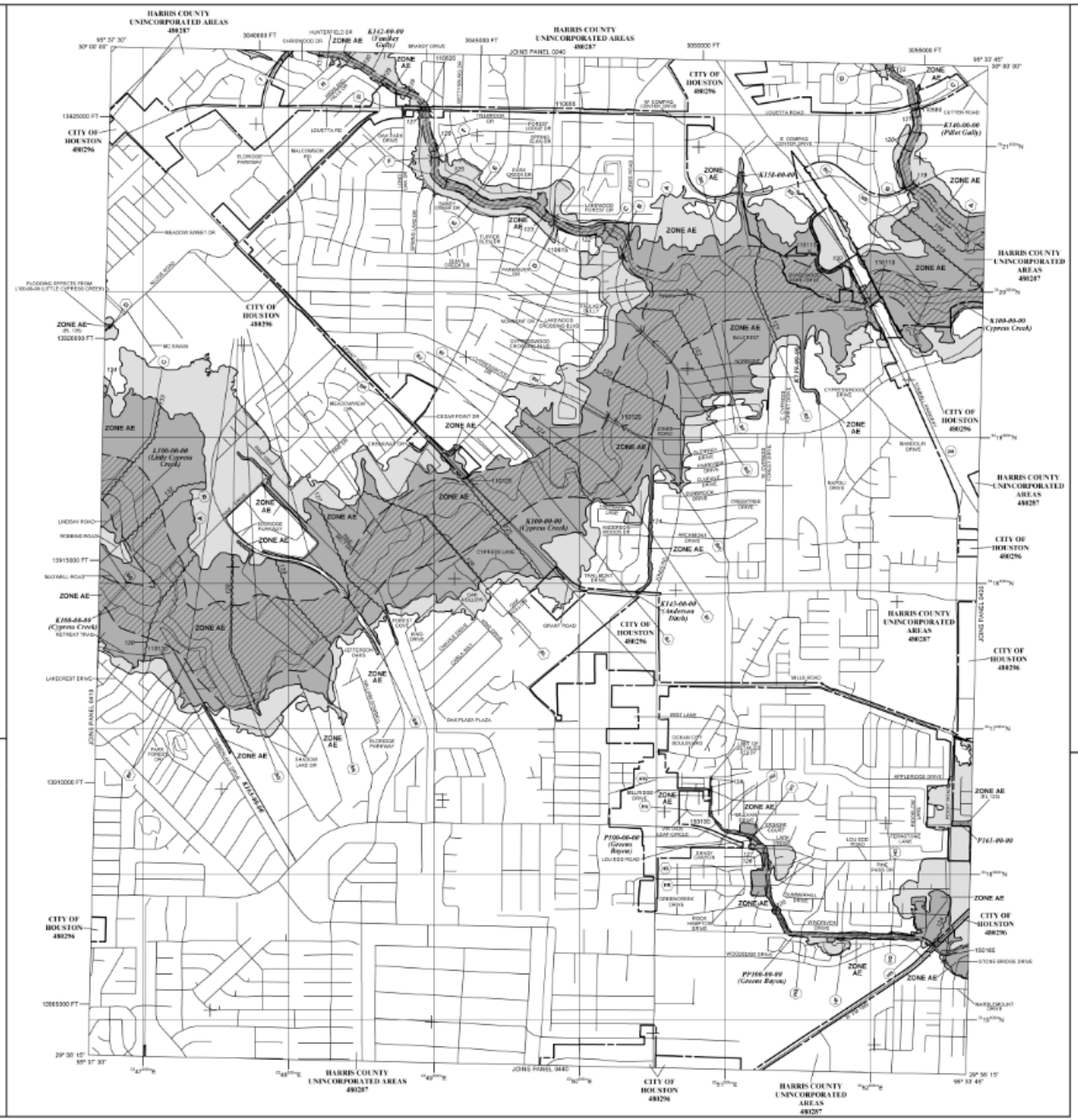


LEGEND

SPECIAL FLOOD HAZARD AREAS (SFHAs) SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual chance flood (100-year flood, also known as the base flood) is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V, and VE. The Base Flood Elevation is the water surface elevation of the 1% annual chance flood.

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

FLOODWAY AREAS IN ZONE AE

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

OTHER FLOOD AREAS

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

OTHER AREAS

ZONE D — Areas determined to be outside the 0.2% annual chance floodplain.
ZONE D — Areas in which flood hazards are undetermined, but possible.

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

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

Floodplain boundary
Floodway boundary
Zone D boundary
CBRS and OPA boundary
Boundary dividing Special Flood Hazard Area Zones and boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths or flood velocities.
513 (EL 147) — Base Flood Elevation line and value; elevation in feet*
Base Flood Elevation value where uniform within zone; elevation in feet*

*Referenced to the North American Vertical Datum of 1988

A — A Cross section line
23 - - - - - 23 Transect line
Culvert, Flume, Pondout or Aqueduct
Road or Railroad Bridge
Footbridge
93° 37' 30", 32° 12' 30" — Geographic coordinates referenced to the North American Datum of 1983 (NAD 83), Western Hemisphere
42/2/2 — 1000-meter Universal Transverse Mercator grid values, zone 15
6000000 FT — 5000-foot grid ticks: Texas State Plane coordinate system, zone South Central (FIPSZONE 4204), Lambert Conformal Conic Projection
DX5513 — Bench mark (see explanation in Notes to Users section of this FIRM panel)
• FB.5 — River Mile

MAP REPOSITORIES
Refer to Map Repositories list on Map Index.

EFFECTIVE DATE OF COUNTYWIDE FLOOD INSURANCE RATE MAP PANEL
SEPTEMBER 28, 2007

EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL
SEPTEMBER 30, 1992
NOVEMBER 5, 1996
APRIL 16, 2003
JUNE 20, 2007
OCTOBER 16, 2013

For accompanying Reasons for Revision, refer to the Notice to Flood Insurance Study Users page in the Flood Insurance Study report.

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

To determine if flood insurance is available in this community, contact your insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

MAP SCALE 1" = 1000'

500 0 1000 2000 FEET

250 0 250 500 METERS

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0430M

FIRM

FLOOD INSURANCE RATE MAP

HARRIS COUNTY, TEXAS AND INCORPORATED AREAS

PANEL 430 OF 1150

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
HARRIS COUNTY UNINCORPORATED AREAS	480287	0430	M
HOUSTON, CITY OF	480296	0430	M

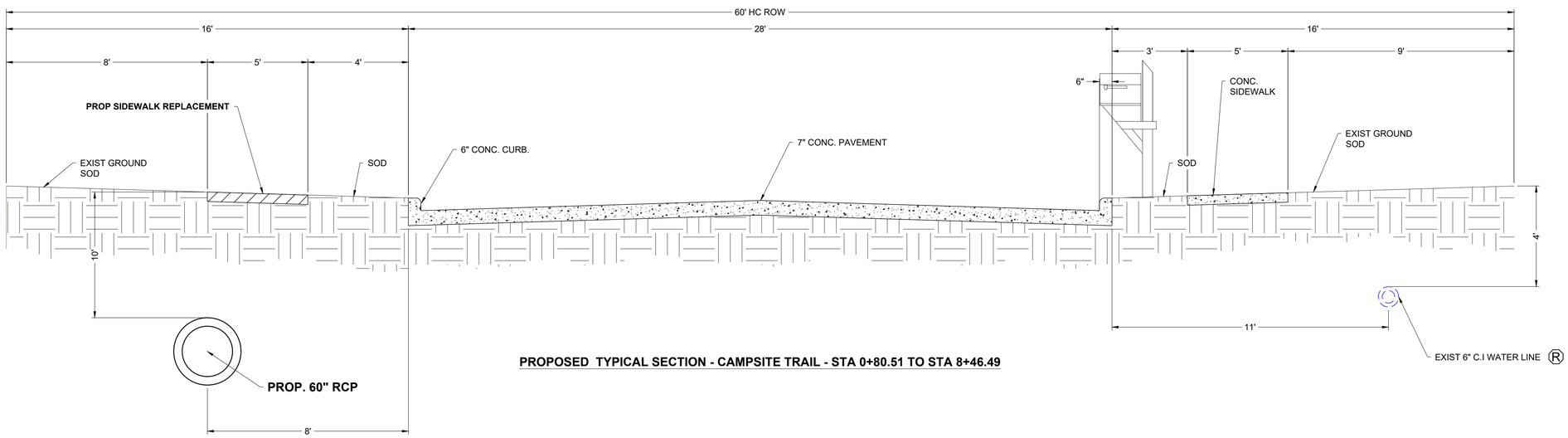
Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER 48201C0430M

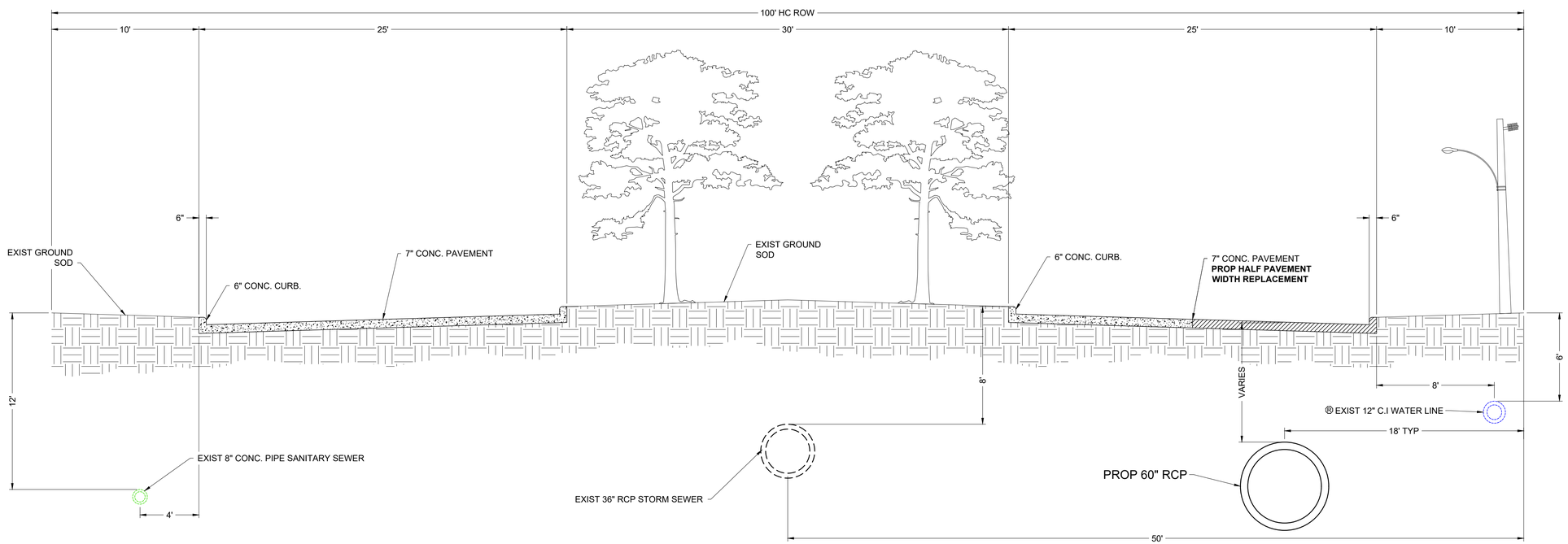
MAP REVISED OCTOBER 16, 2013

Federal Emergency Management Agency

Exhibit 3
Existing and Proposed Cross Sections



PROPOSED TYPICAL SECTION - CAMPSITE TRAIL - STA 0+80.51 TO STA 8+46.49



PROPOSED TYPICAL SECT ION - JARVIS RD - STA 3+10.66 TO STA 20+34.68

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY
ENGINEERING DEPARTMENT

HARRIS COUNTY 1836 TEXAS

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Phone: 713.953.5200 Fax: 713.953.5026
FIRM REGISTRATION No. F-1386
www.LJAengineering.com

STATE OF TEXAS
ISAAC MUÑIZ
125839
LICENSED
PROFESSIONAL ENGINEER
3/2/2022

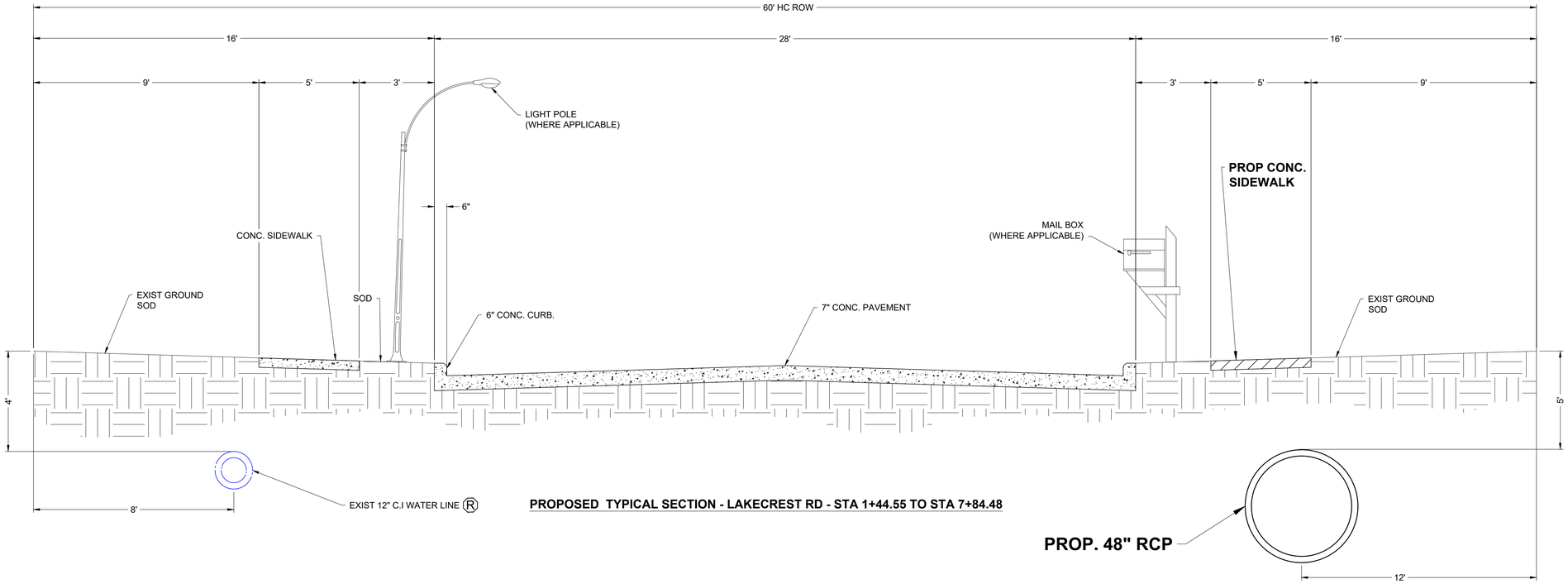
PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **TYPICAL PROPOSED SECTIONS - SHEET 1**

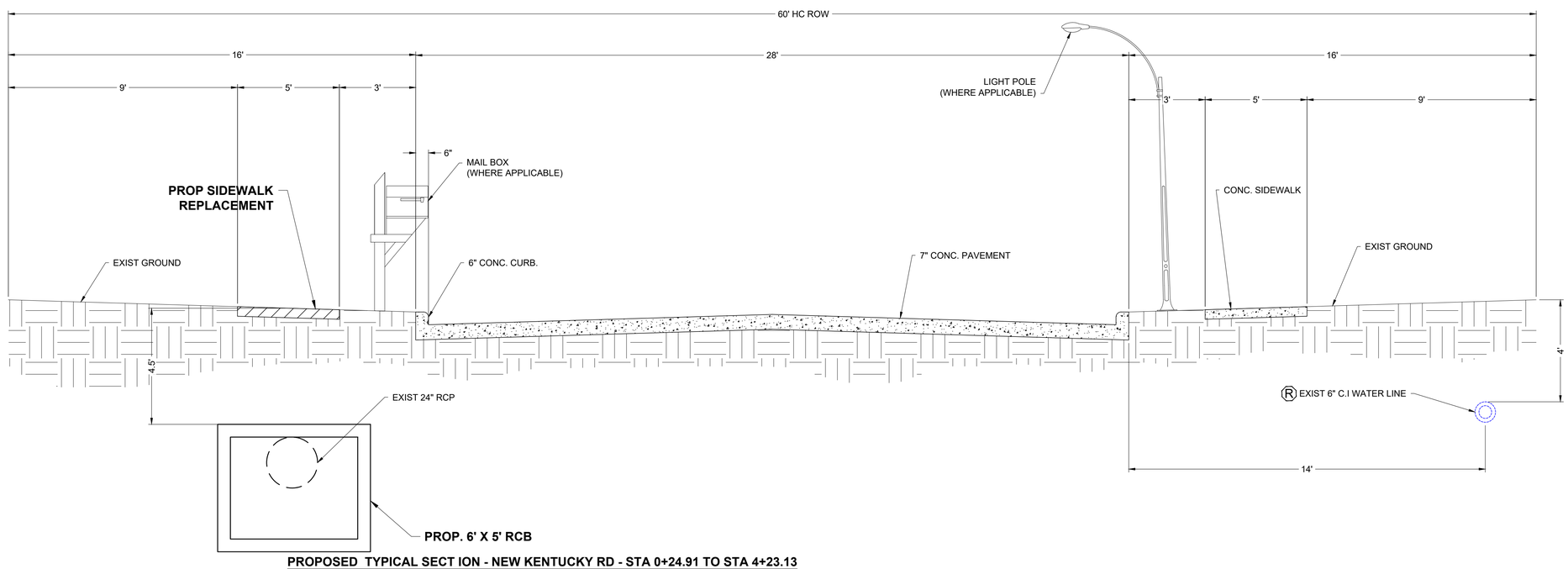
DRAWN BY: | DATE: **3/2/2022**

DESIGN BY: | SCALE: | SHEET NO: **6 OF 200**

J:\1894\210ZA\ACAD\SHEET FILES\605X\6 TYPICAL PROPOSED SECTIONS - SHEET 1.dwg



PROPOSED TYPICAL SECTION - LAKECREST RD - STA 1+44.55 TO STA 7+84.48



PROPOSED TYPICAL SECT ION - NEW KENTUCKY RD - STA 0+24.91 TO STA 4+23.13

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PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **TYPICAL PROPOSED SECTIONS - SHEET 2**

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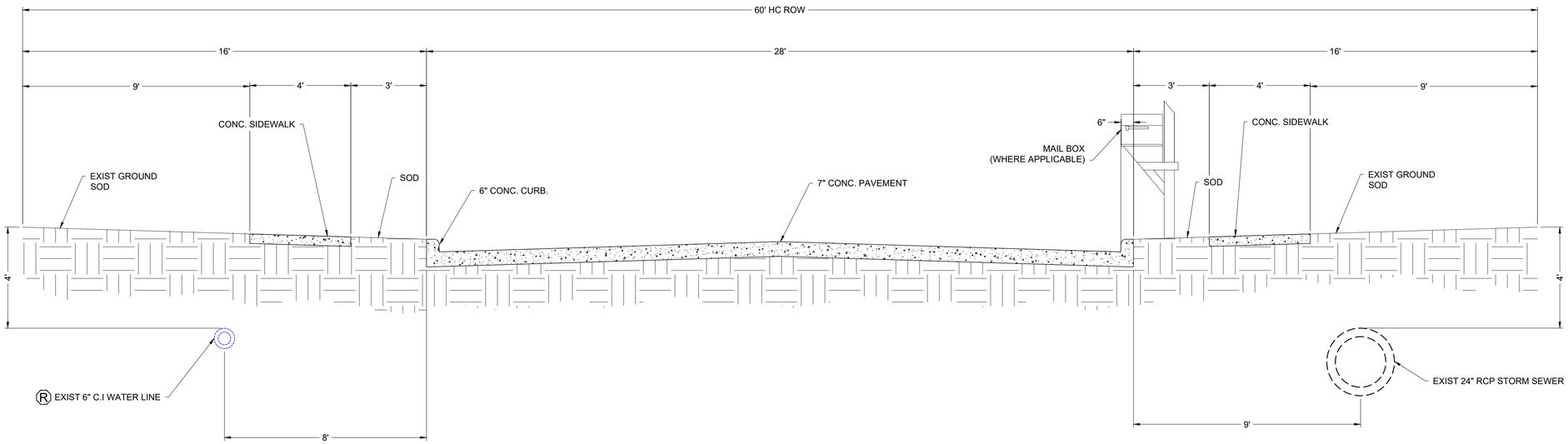
DATE: **3/2/2022**

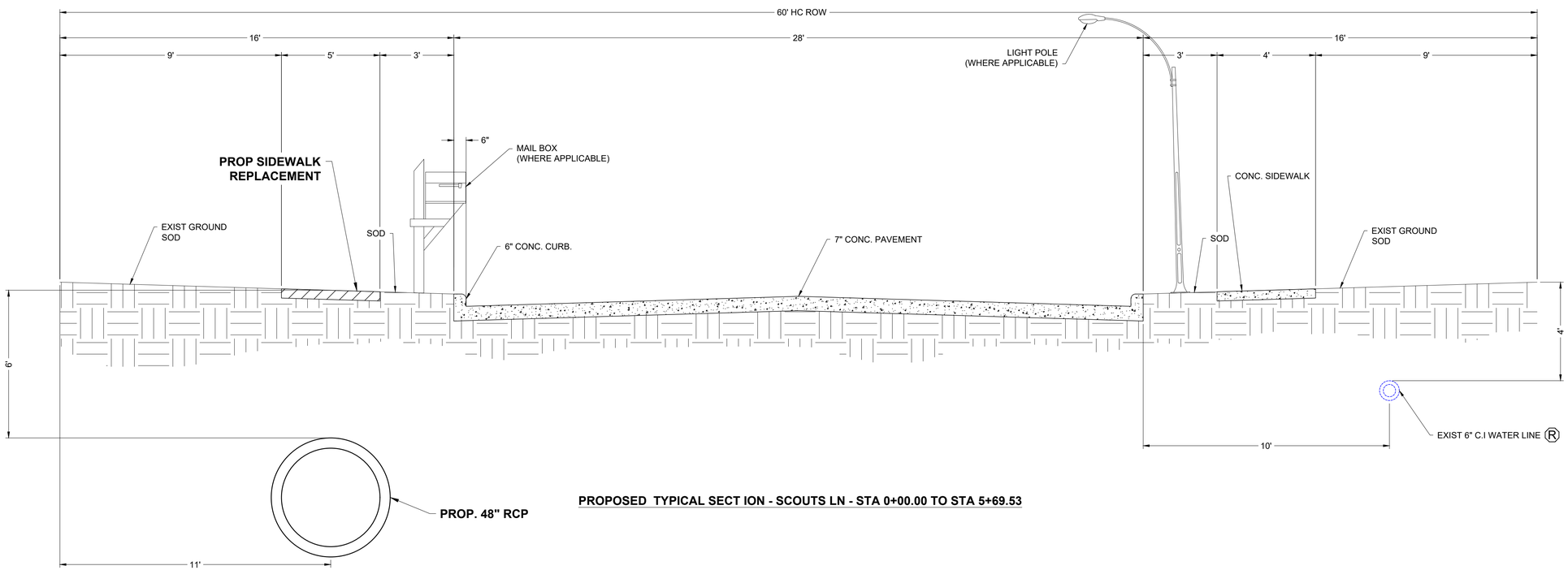
DESIGN BY:

SCALE:

SHEET NO: **7 OF 200**



PROPOSED TYPICAL SECT ION - WILEY MARTIN DR - STA 0+12.41 TO STA 5+91.40



PROPOSED TYPICAL SECT ION - SCOUTS LN - STA 0+00.00 TO STA 5+69.53

J:\190A\2102\ACAD\SHEET FILES\605X.8 TYPICAL PROPOSED SECTIONS - SHEET 3.dwg

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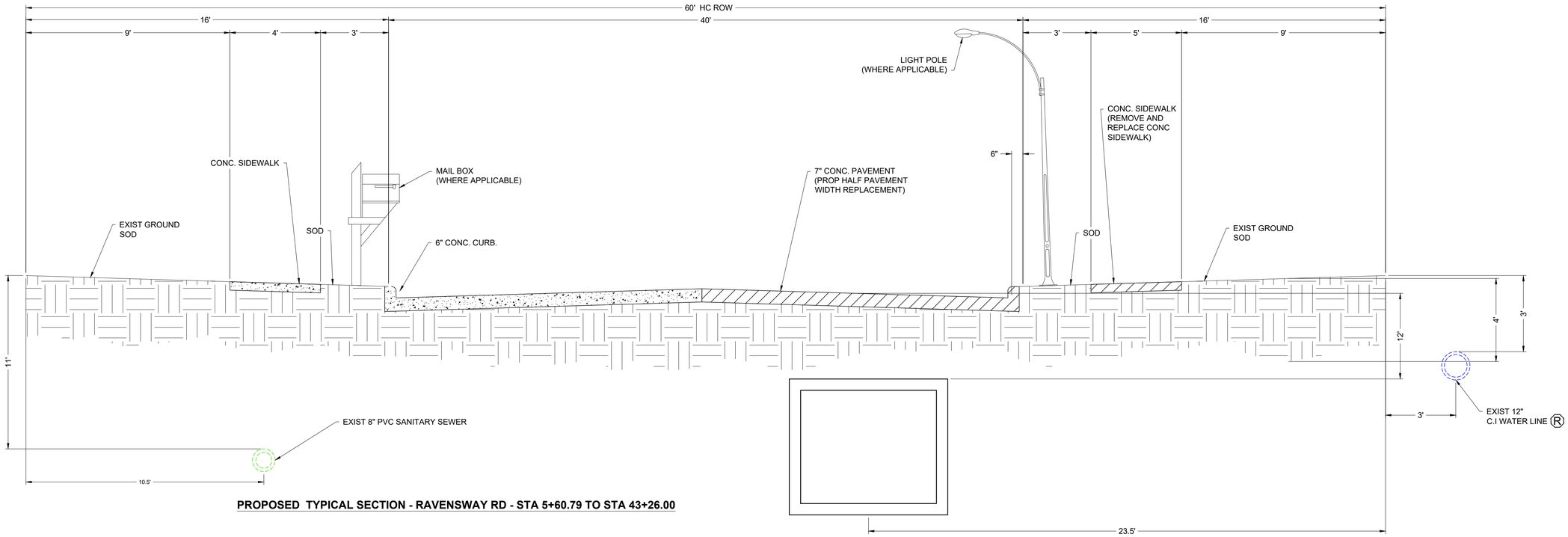
DESIGN BY:

SCALE:

SHEET NO: **8 OF 200**



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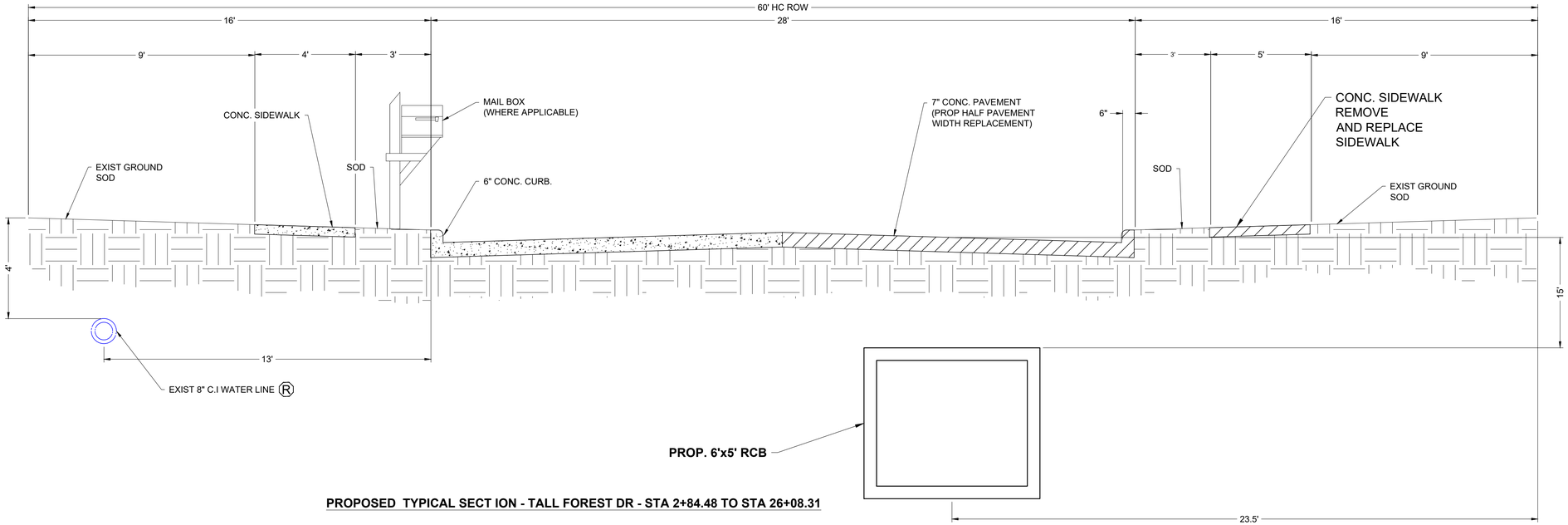

PROPOSED TYPICAL SECT ION - TALL FOREST DR - STA 2+84.48 TO STA 26+08.31

NO.	REVISIONS	DATE	NAME

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PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **TYPICAL PROPOSED SECTIONS - SHEET 4**

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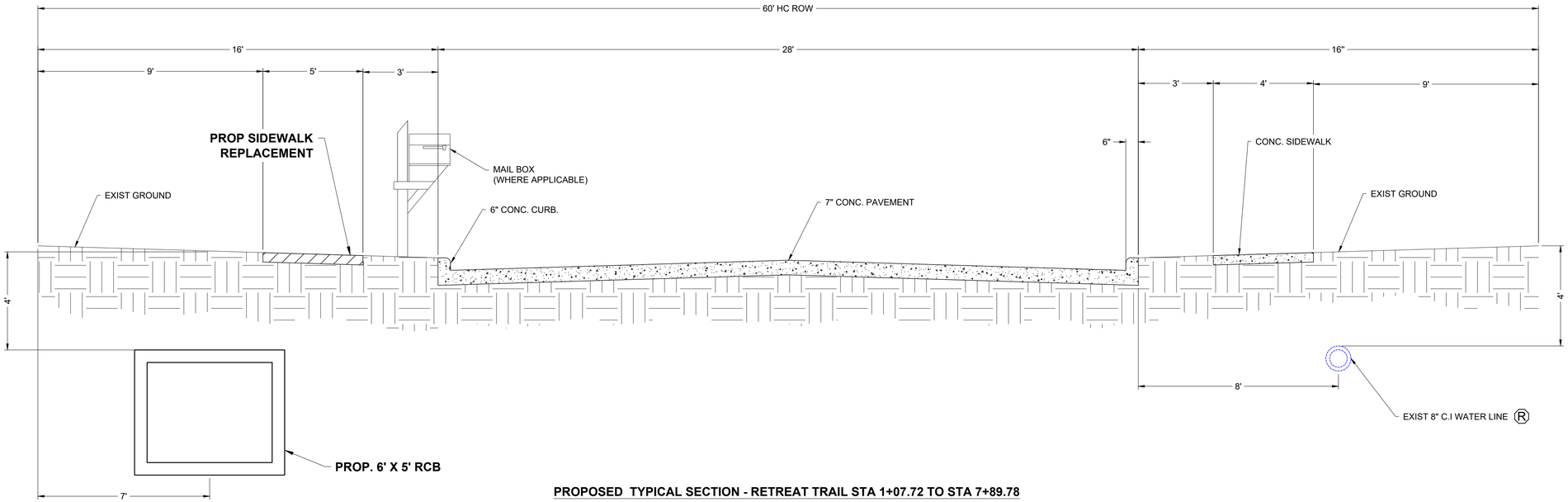

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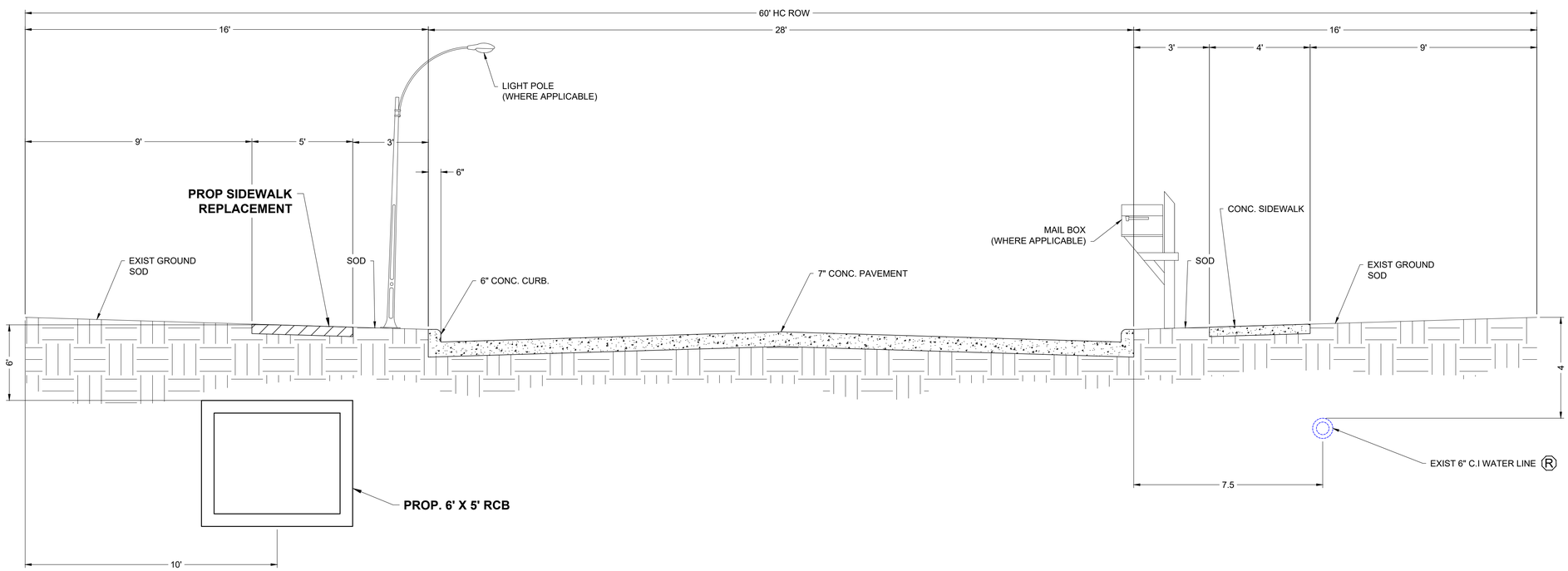

PROPOSED TYPICAL SECTION - RIFLEMAN TRAIL STA 0+23.16 TO STA 6+34.85

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SHEET DESCRIPTION: **TYPICAL PROPOSED SECTIONS - SHEET 5**

DRAWN BY: | DATE: **3/2/2022**

DESIGN BY: | SCALE: | SHEET NO: **10 OF 200**

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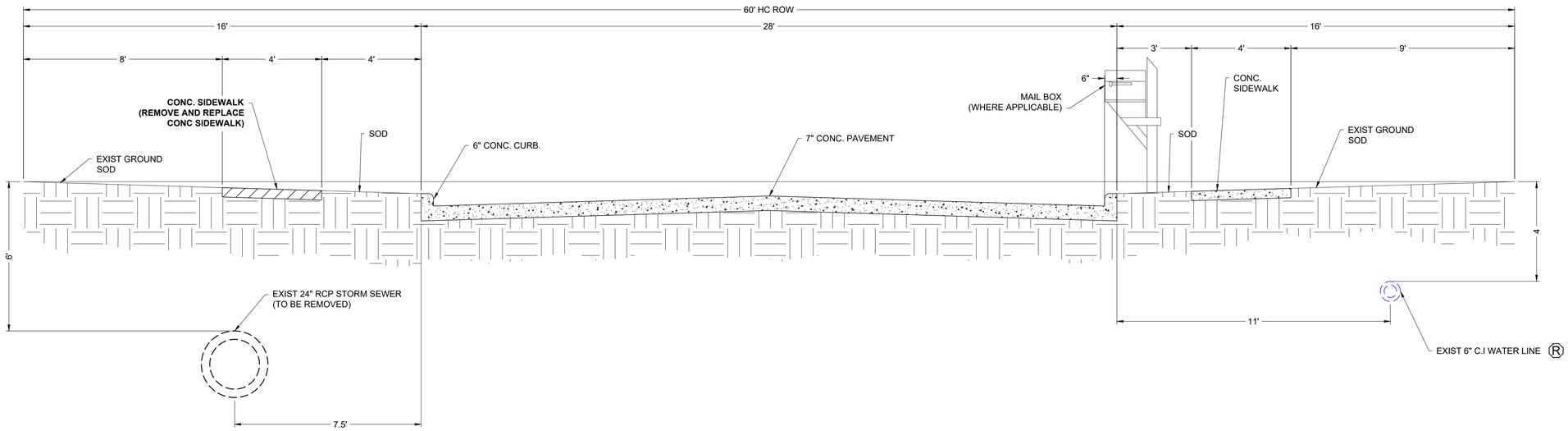
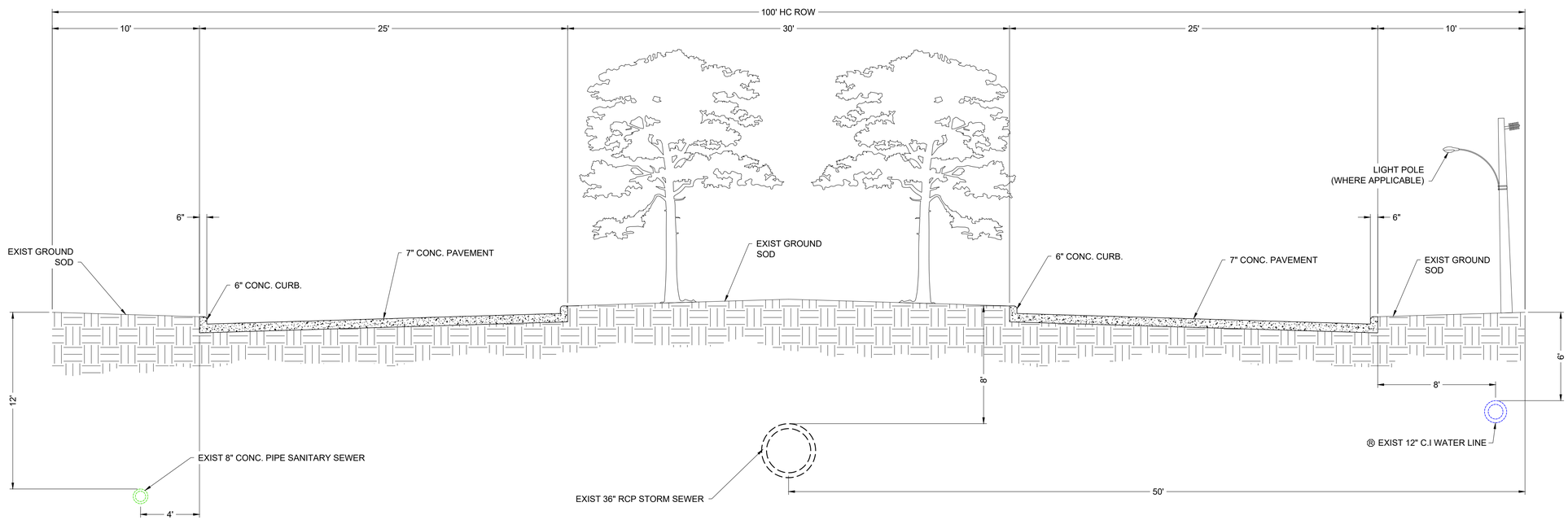


EXISTING TYPICAL SECTION - CAMPSITE TRAIL - STA 0+80.51 TO STA 8+46.49



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SHEET DESCRIPTION: **TYPICAL EXISTING SECTIONS - SHEET 1**

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SCALE:

SHEET NO: **11 OF 200**

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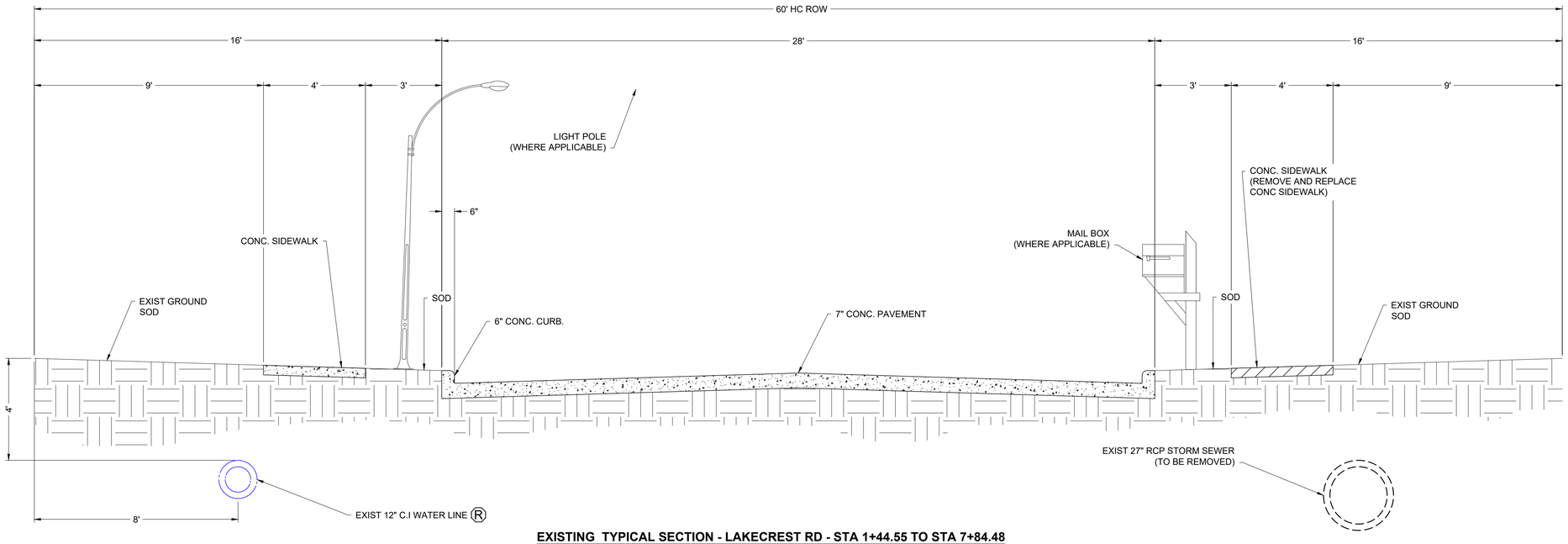
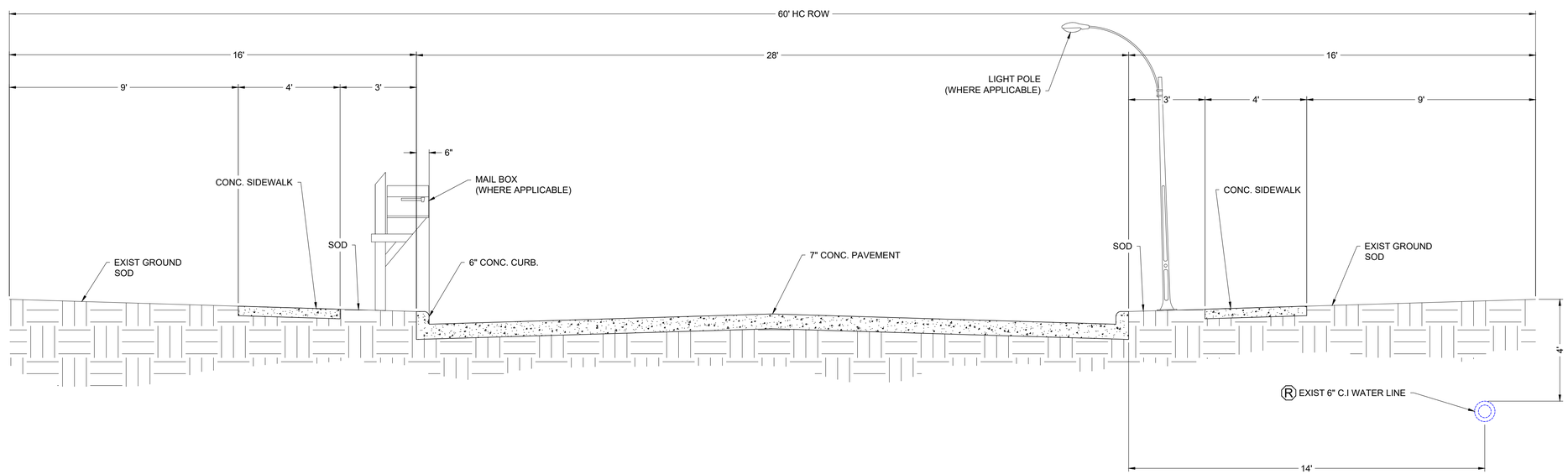


EXISTING TYPICAL SECTION - LAKECREST RD - STA 1+44.55 TO STA 7+84.48



EXISTING TYPICAL SECT ION - NEW KENTUCKY RD - STA 0+24.91 TO STA 4+23.13

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SHEET DESCRIPTION: **TYPICAL EXISTING SECTIONS - SHEET 2**

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SCALE:

SHEET NO: **12 OF 200**

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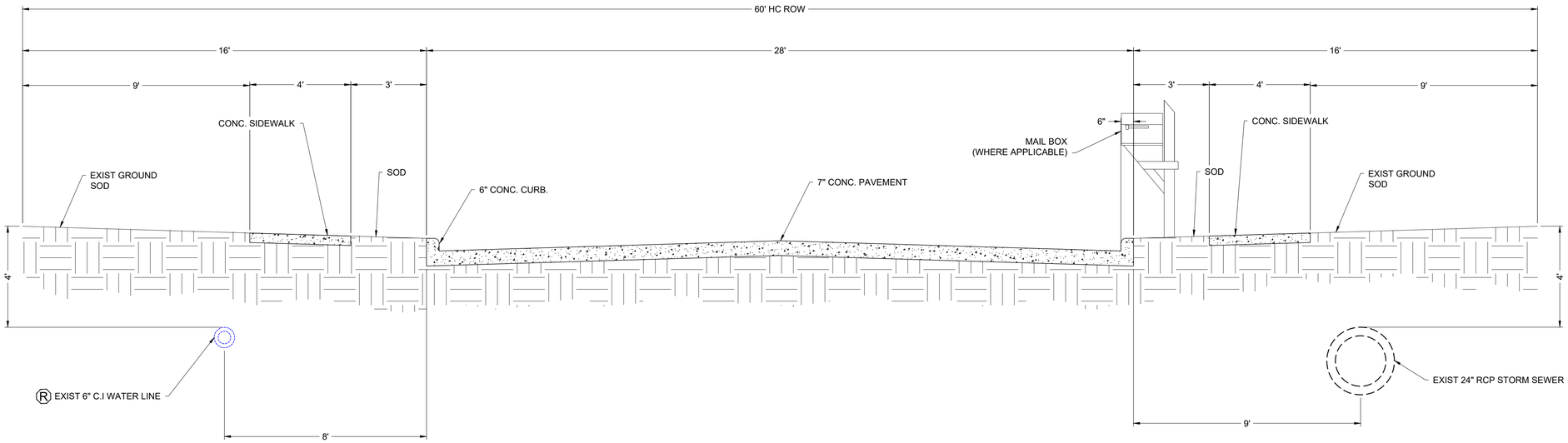
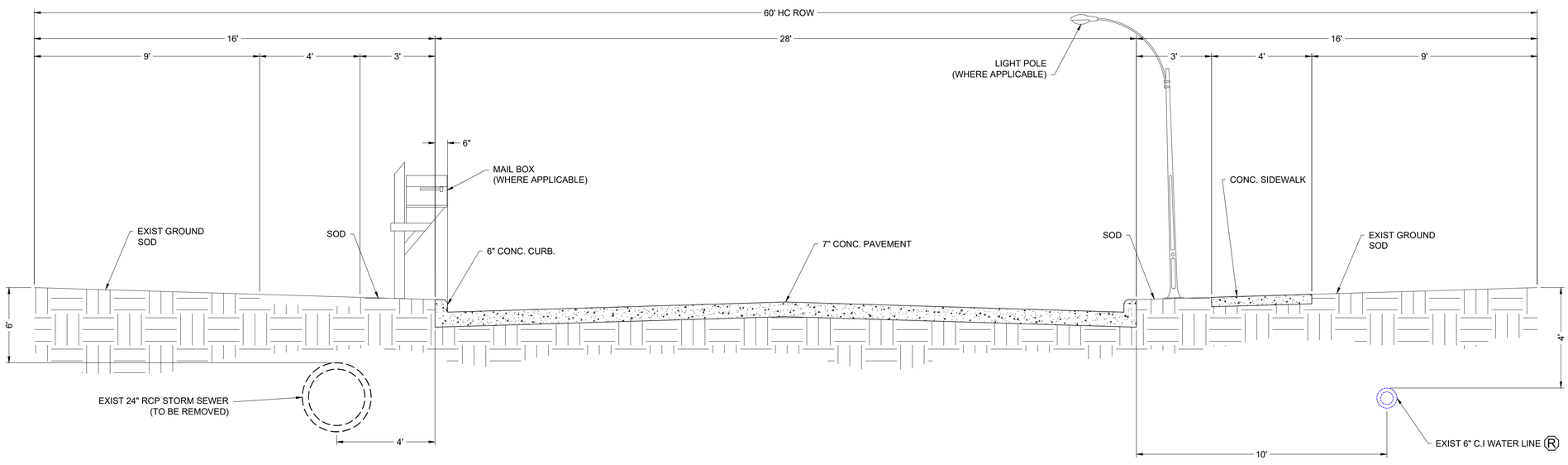


EXISTING TYPICAL SECT ION - WILEY MARTIN DR - STA 0+12.41 TO STA 5+91.40



EXISTING TYPICAL SECT ION - SCOUTS LN - STA 0+00.00 TO STA 5+69.53

NO.	REVISIONS	DATE	NAME

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PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **TYPICAL EXISTING SECTIONS - SHEET 3**

DRAWN BY:

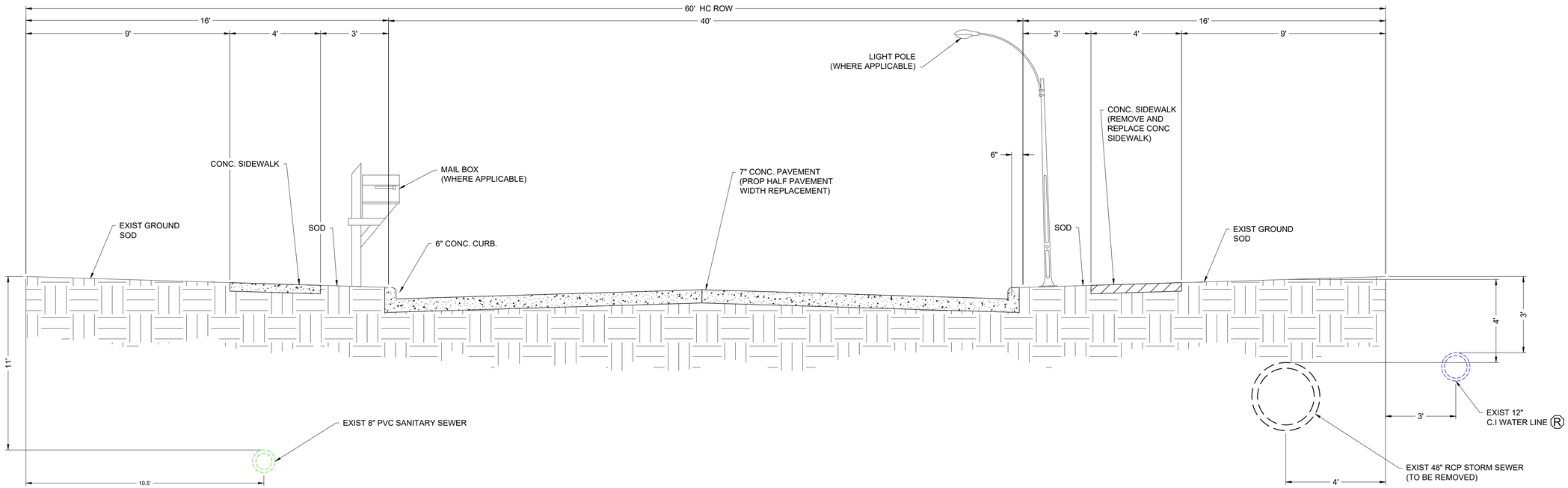
DATE: **3/2/2022**

DESIGN BY:

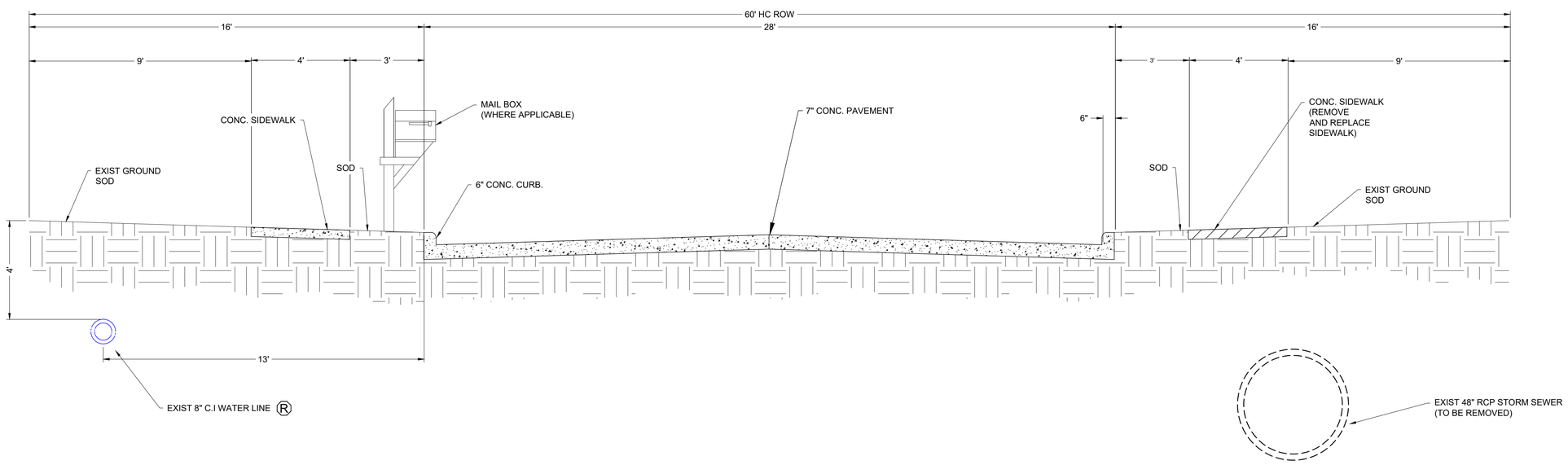
SCALE:

SHEET NO: **13 OF 200**

J:\190A\2102\ACAD\SHEET FILES\605\13 TYPICAL EXISTING SECTIONS – SHEET 3.dwg



EXISTING TYPICAL SECTION - RAVENSWAY RD - STA 5+60.79 TO STA 43+26.00



EXISTING TYPICAL SECT ION - TALL FOREST DR - STA 2+84.48 TO STA 26+08.31

NO.	REVISIONS	DATE	NAME

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FIRM REGISTRATION No. F-1386
www.LJAengineering.com

STATE OF TEXAS
ISAAC MUÑIZ
125839
LICENSED
PROFESSIONAL ENGINEER
3/2/2022

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **TYPICAL EXISTING SECTIONS - SHEET 4**

DRAWN BY: | DATE: **3/2/2022**

DESIGN BY: | SCALE: | SHEET NO: **14 OF 200**

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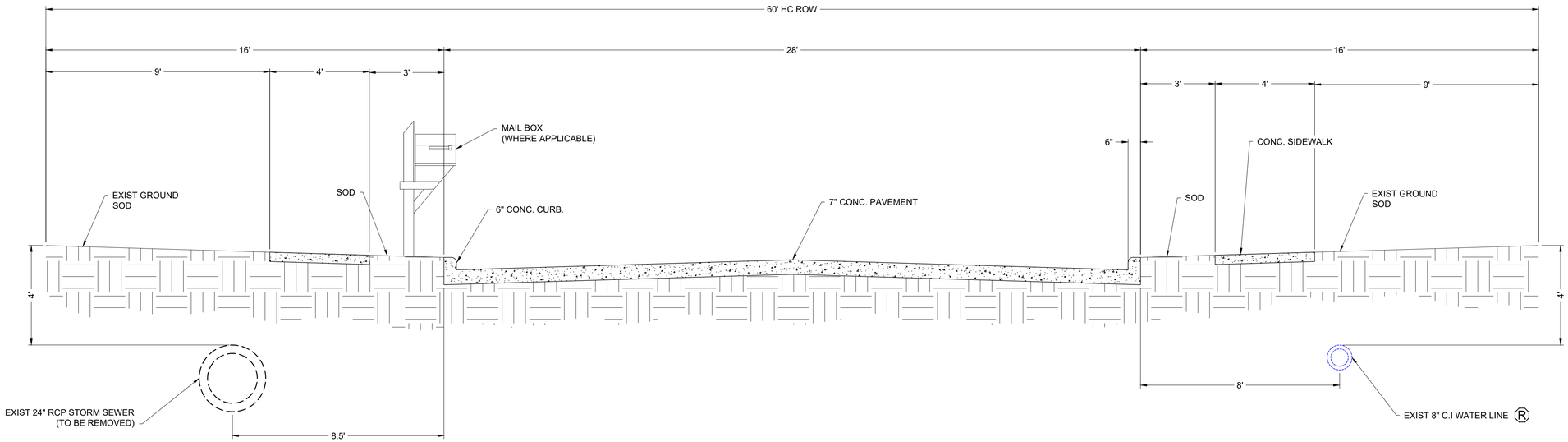
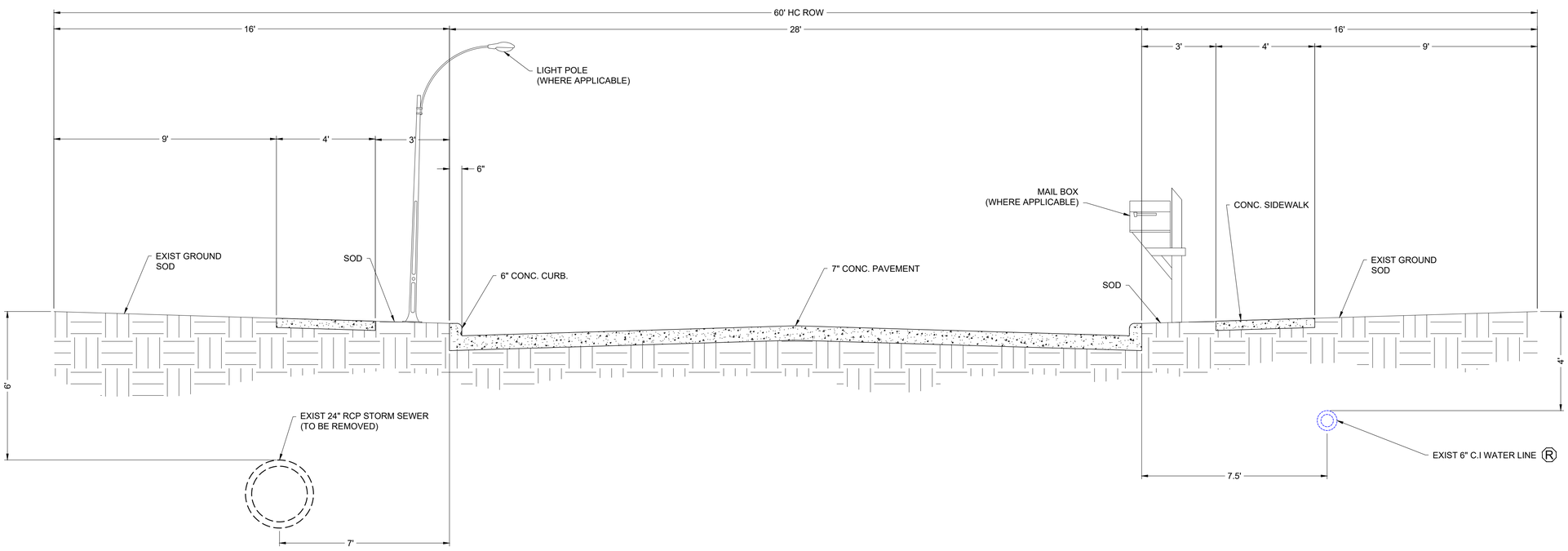


EXISTING TYPICAL SECTION - RETREAT TRAIL STA 1+07.72 TO STA 7+89.78



EXISTING TYPICAL SECTION - RIFLEMAN TRAIL STA 0+23.16 TO STA 6+34.85

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3/2/2022

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **TYPICAL EXISTING SECTIONS - SHEET 5**

DRAWN BY:

DATE: **3/2/2022**

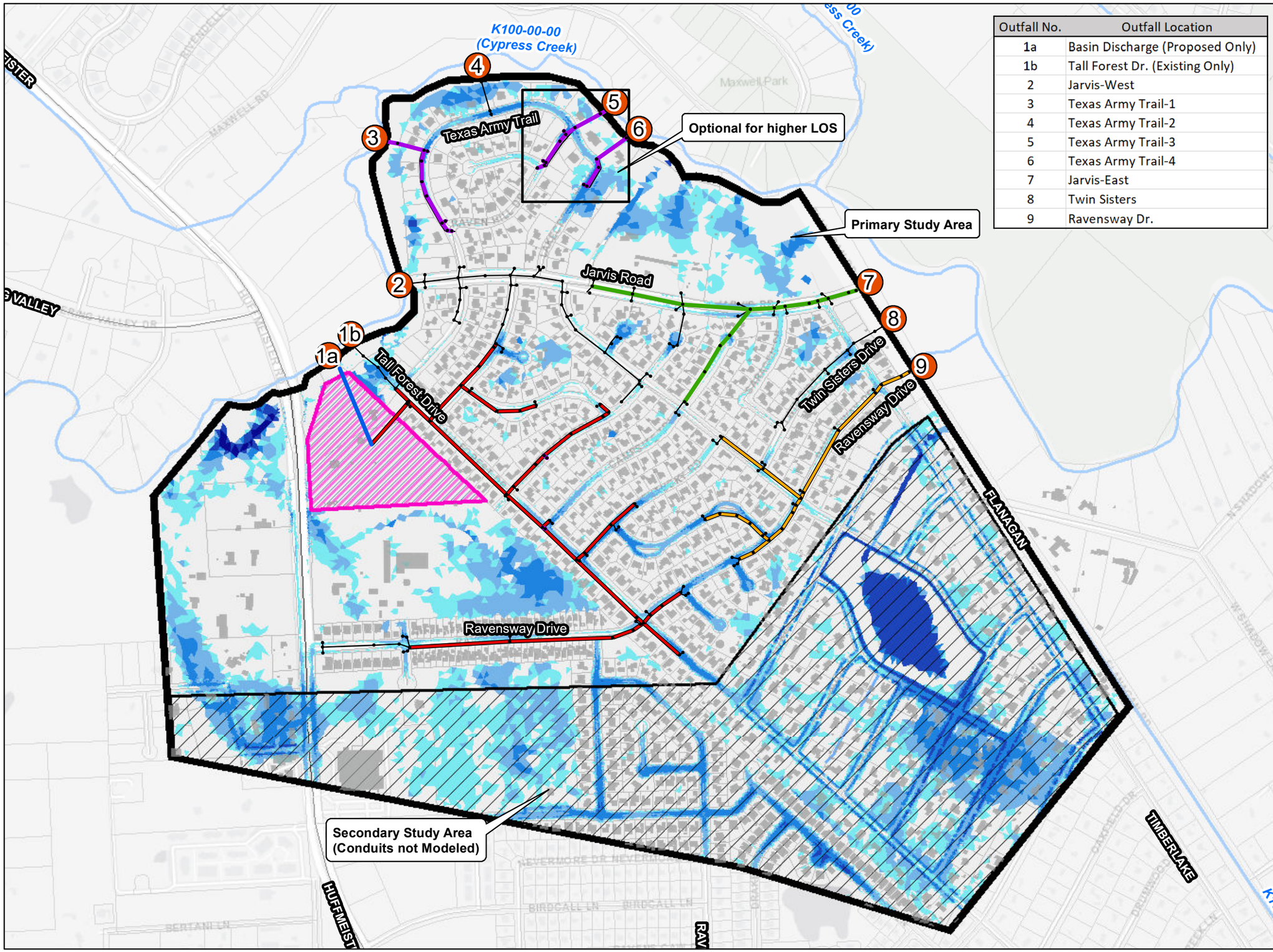
DESIGN BY:

SCALE:

SHEET NO: **15 OF 200**

J:\190A\2102\ACAD\SHEET FILES\605\15 TYPICAL EXISTING SECTIONS – SHEET 5.dwg

Exhibit 4
Proposed Drainage Improvements



Outfall No.	Outfall Location
1a	Basin Discharge (Proposed Only)
1b	Tall Forest Dr. (Existing Only)
2	Jarvis-West
3	Texas Army Trail-1
4	Texas Army Trail-2
5	Texas Army Trail-3
6	Texas Army Trail-4
7	Jarvis-East
8	Twin Sisters
9	Ravensway Dr.

HARRIS COUNTY ENGINEERING DEPARTMENT

RAVENSWAY SUBDIVISIONS DRAINAGE IMPROVEMENTS

EXHIBIT 14
Proposed Drainage Infrastructure

Legend

- Proposed Node

Proposed Conduits

condheight

- 36" RCP
- 42" RCP
- 48" RCP
- 60" RCP
- 6'X5'
- Existing Conduits
- Building Footprints
- Detention Site
- 2D Model Boundary

100-Yr Proposed Inundation Depths (w/o tailwater) (ft)

- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- 2.00 - 5.00
- > 5.00
- Channels
- Parcels

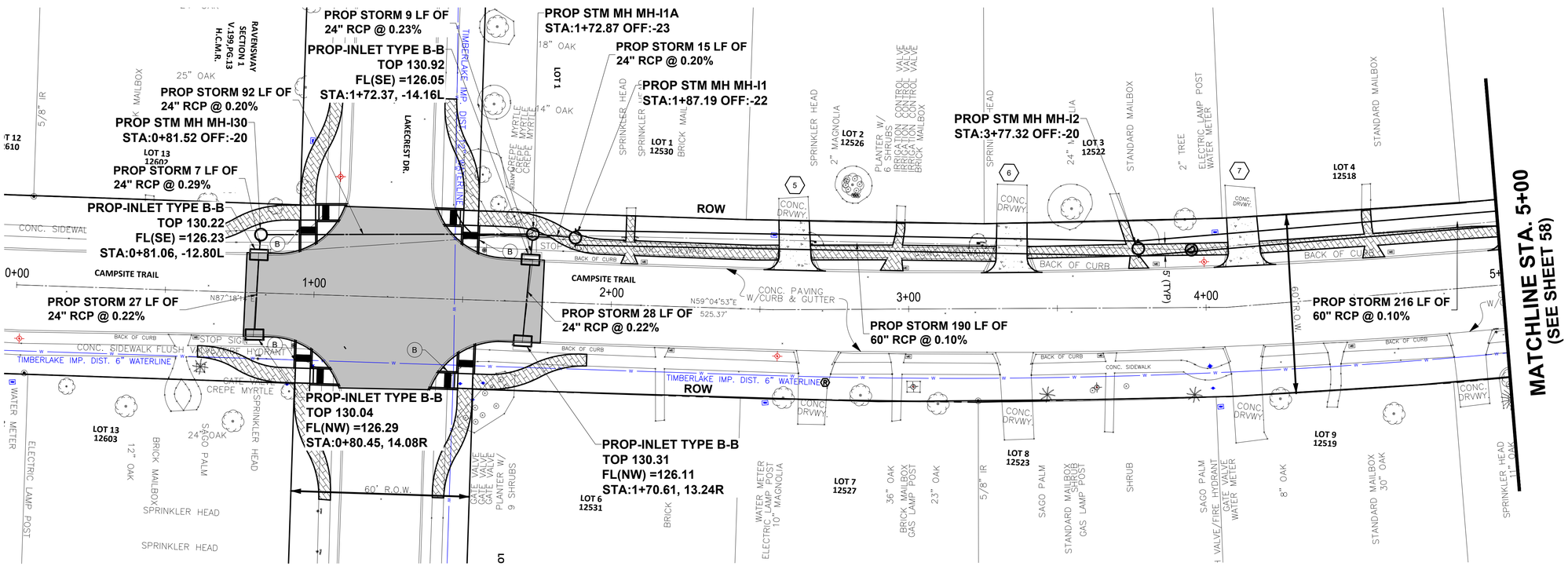
N

0 300 600

1 inch = 600 feet

Gauge ENGINEERING

Exhibit 5
Proposed Road Plan & Profiles



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0 20 40
SCALE IN FEET

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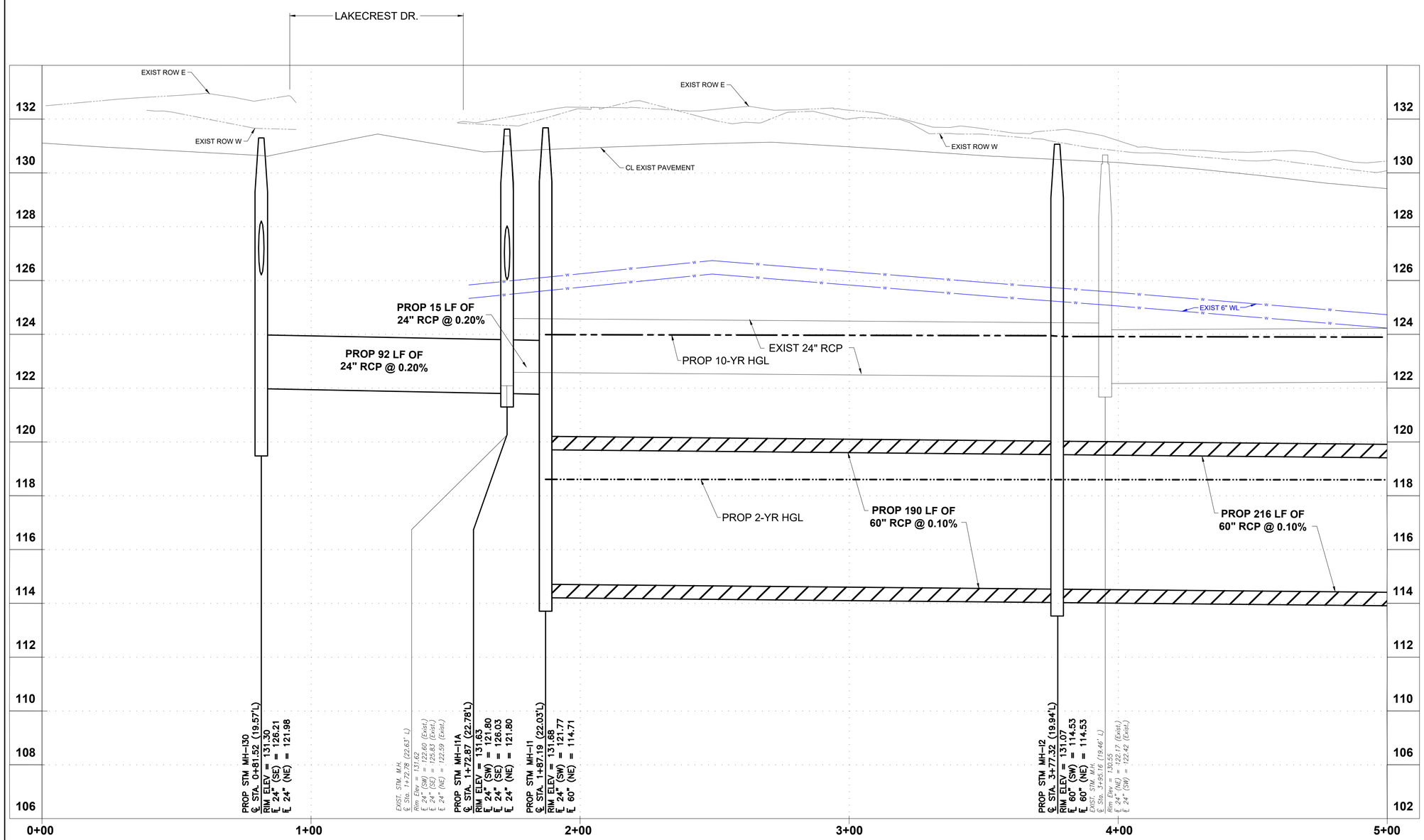
3/2/2022

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: PLAN AND PROFILE - CAMPSITE TRAIL SHEET 1

DRAWN BY:
DATE: 3/2/2022
DESIGN BY:
SCALE:
SHEET NO: 56 OF 200

J:\1904\2102\ACAD\SHEET FILES\60%\56 PLAN AND PROFILE - CAMPSITE TRAIL SHEET 1.dwg



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PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **PLAN AND PROFILE - CAMPSITE TRAIL SHEET 2**

DRAWN BY:
DATE: 3/2/2022
DESIGN BY:
SCALE:
SHEET NO: 57 OF 200

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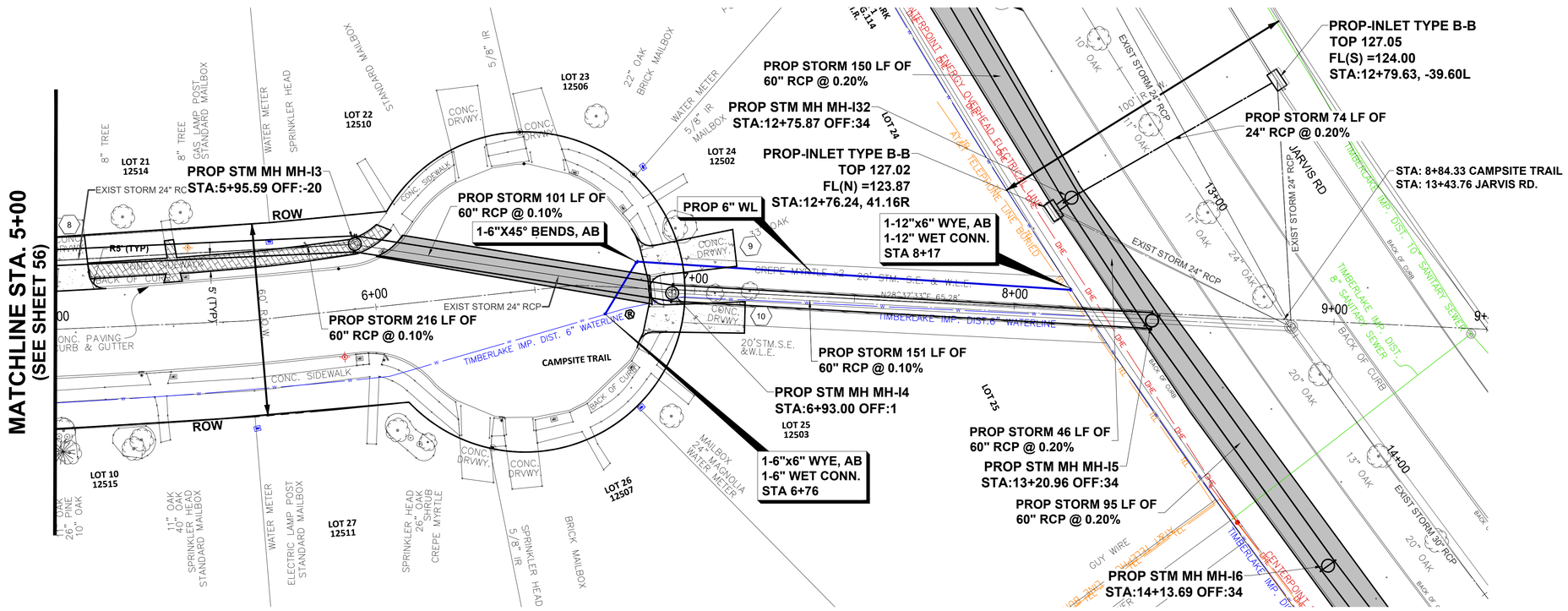

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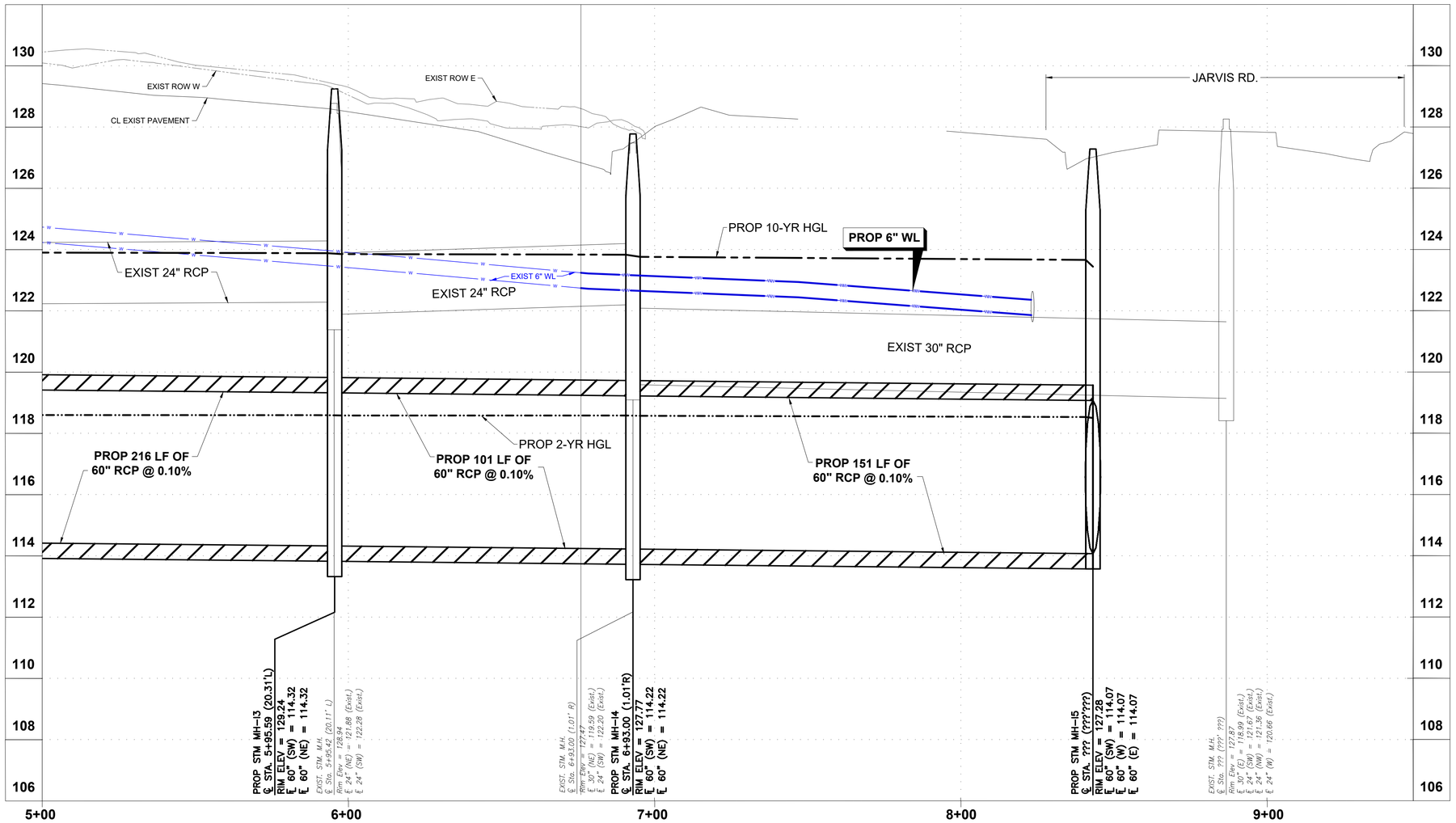
PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **PLAN AND PROFILE - CAMPSITE TRAIL SHEET 3**

DRAWN BY: | DATE: 3/2/2022

DESIGN BY: | SCALE: | SHEET NO: 58 OF 200

J:\1904\2102\ACAD\SHEET FILES\60%\53 PLAN AND PROFILE – CAMPSITE TRAIL SHEET 3.dwg



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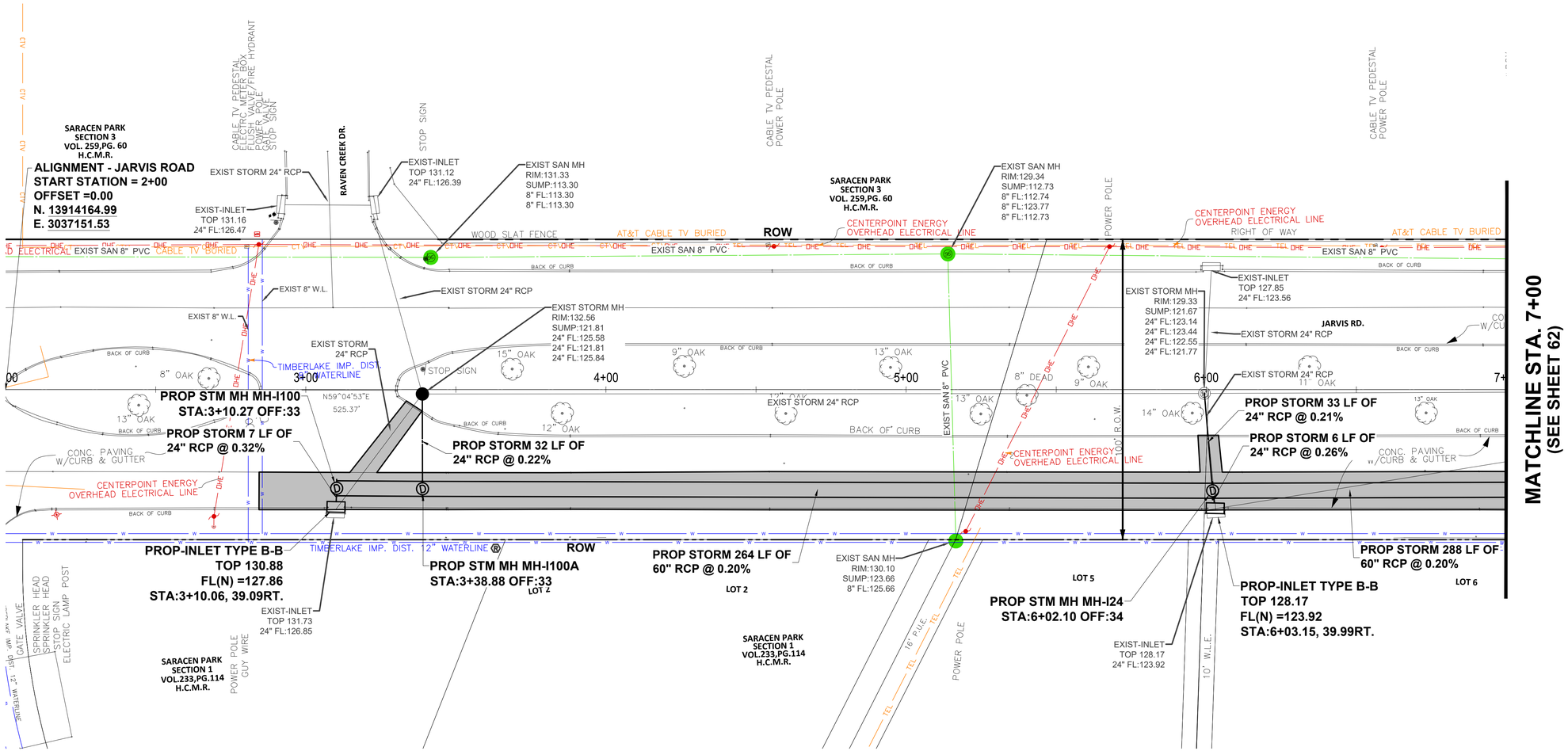
PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **PLAN AND PROFILE - CAMPSITE TRAIL SHEET 4**

DRAWN BY:
DATE: 3/2/2022
DESIGN BY:
SCALE:
SHEET NO: 59 OF 200

J:\1904\2102\ACAD\SHEET FILES\60%\59 PLAN AND PROFILE - CAMPSITE TRAIL SHEET 4.dwg



PROPOSED PAVEMENT AND CURBS

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SHEET DESCRIPTION: **PLAN AND PROFILE - JARVIS RD SHEET 1**

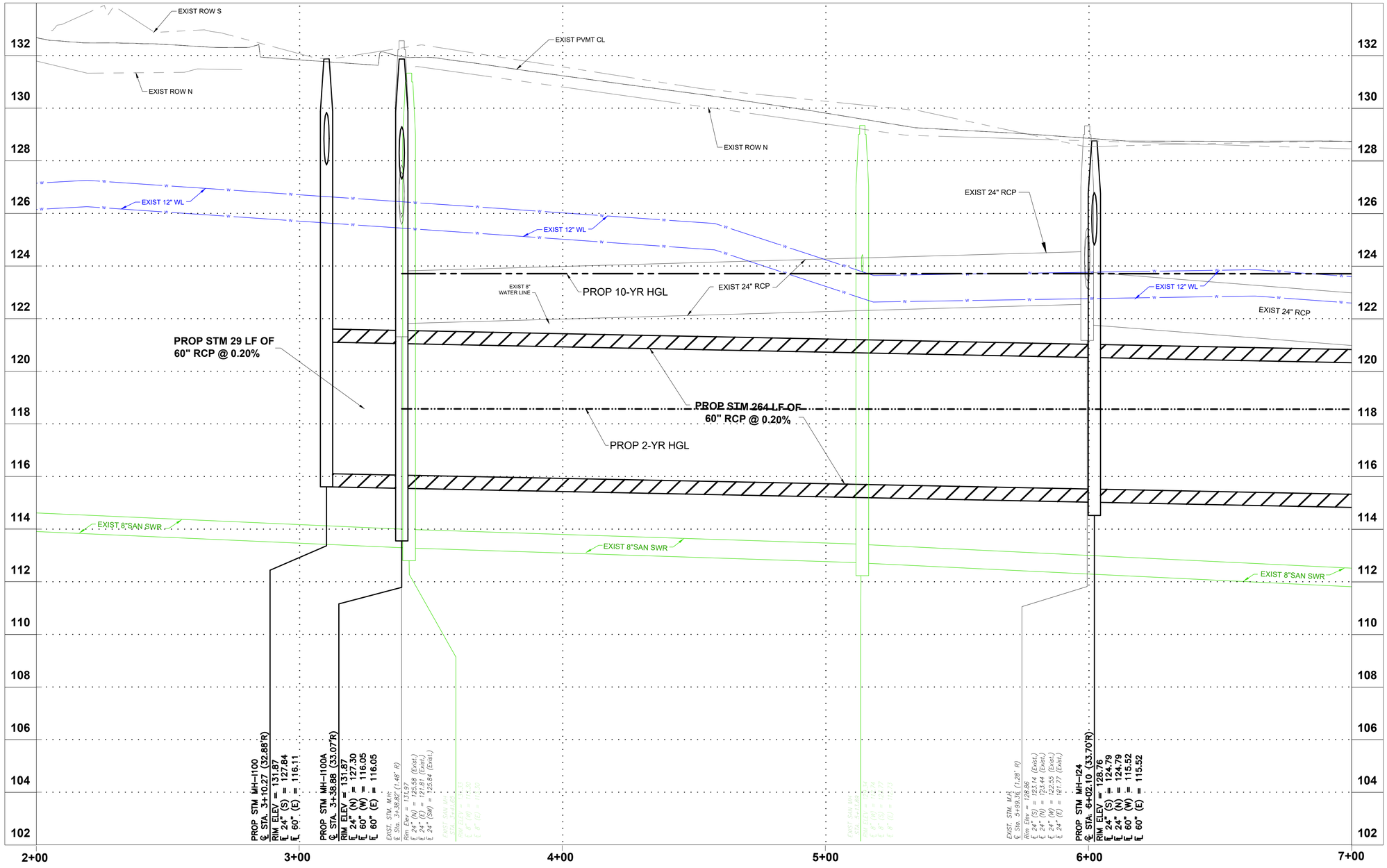
DRAWN BY:

DATE: 3/2/2022

DESIGN BY:

SCALE:

SHEET NO: 60 OF 200



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SCALE IN FEET

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SCALE IN FEET

J:\1904\2102\ACAD\SHEET FILES\60%\61 PLAN AND PROFILE - JARVIS RD SHEET 2.dwg

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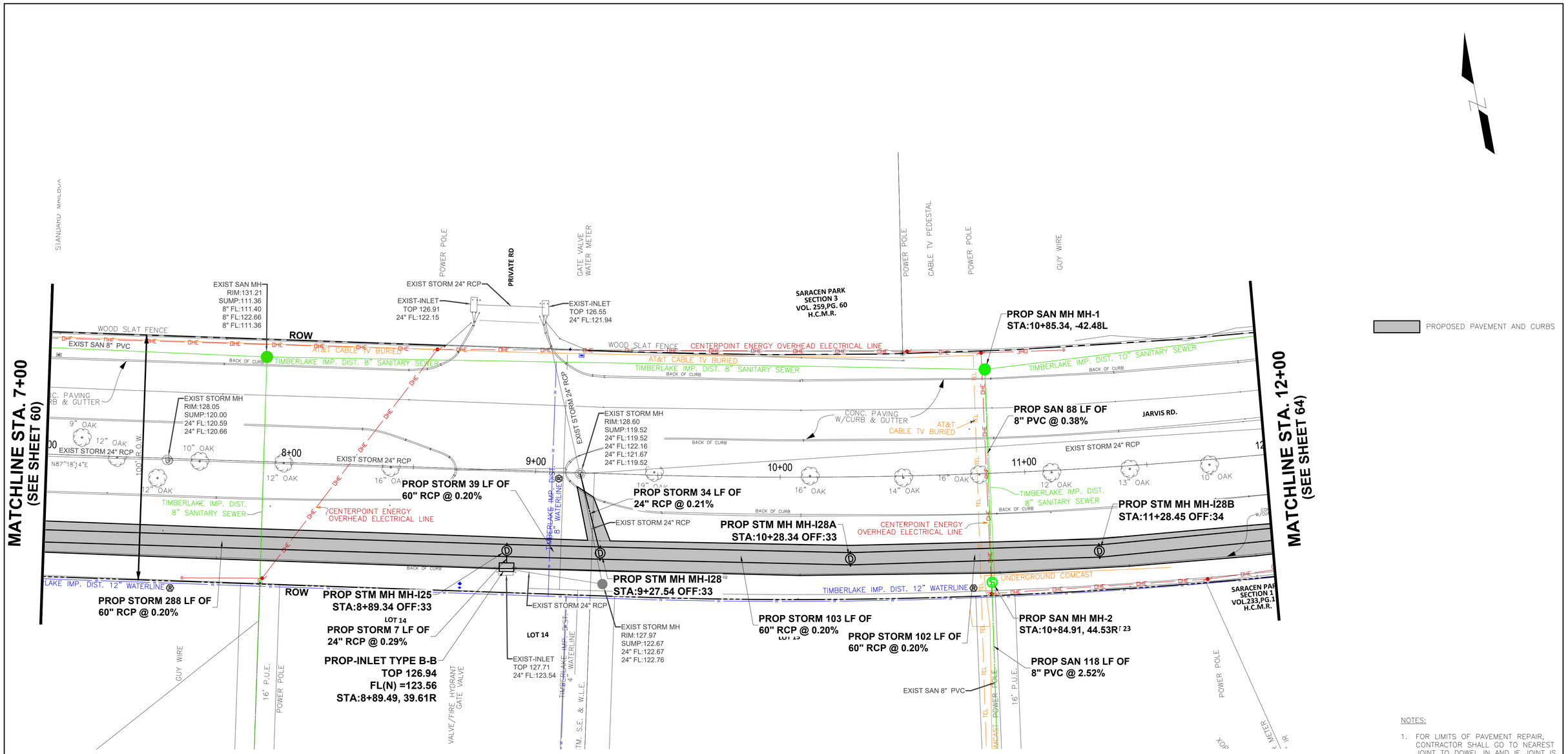
3/2/2022

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **PLAN AND PROFILE - JARVIS RD SHEET 2**

DRAWN BY: | DATE: **3/2/2022**

DESIGN BY: | SCALE: | SHEET NO: **61 OF 200**



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PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **PLAN AND PROFILE - JARVIS RD SHEET 3**

DRAWN BY:

DATE: **3/2/2022**

DESIGN BY:

SCALE:

SHEET NO: **62 OF 200**

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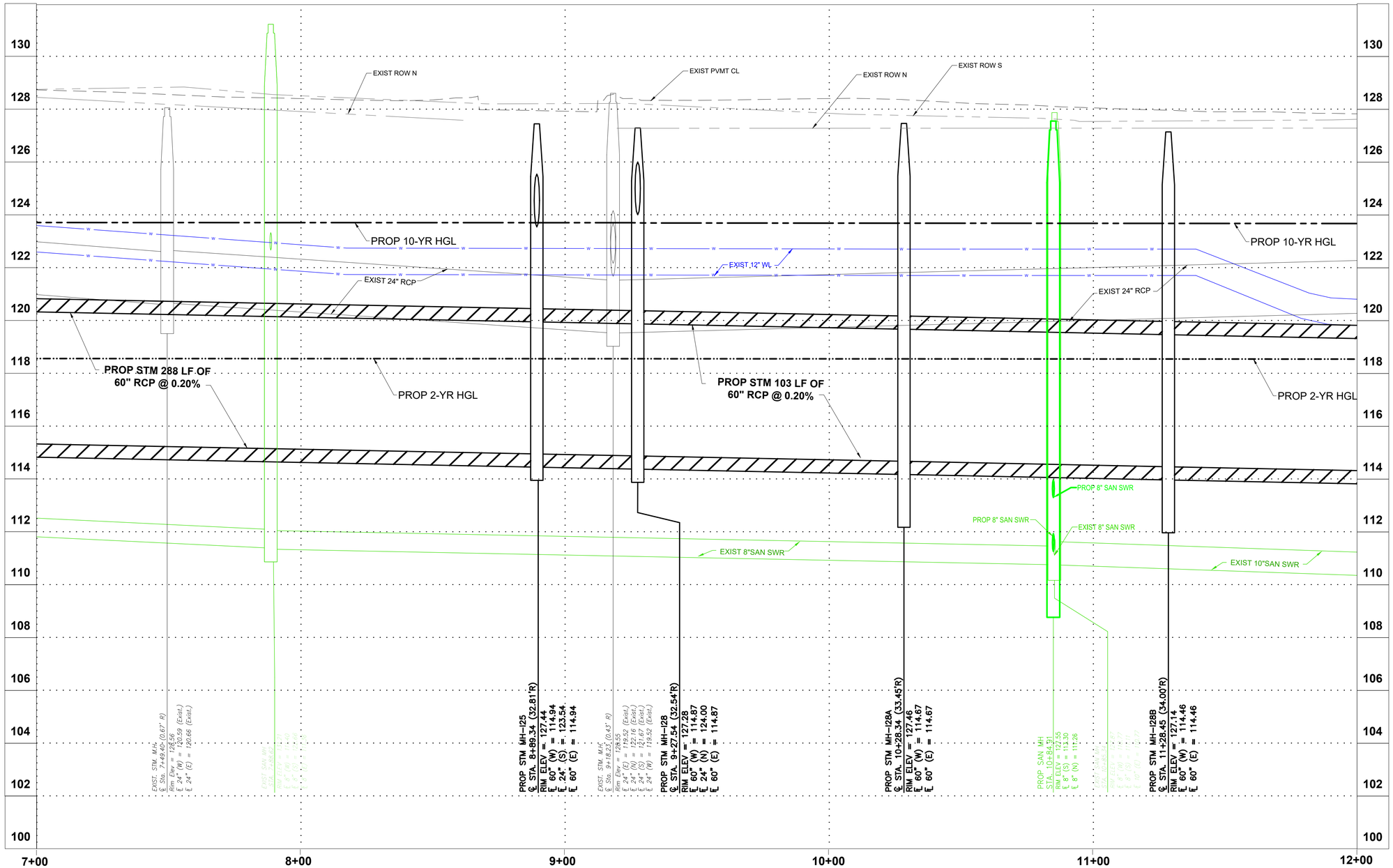

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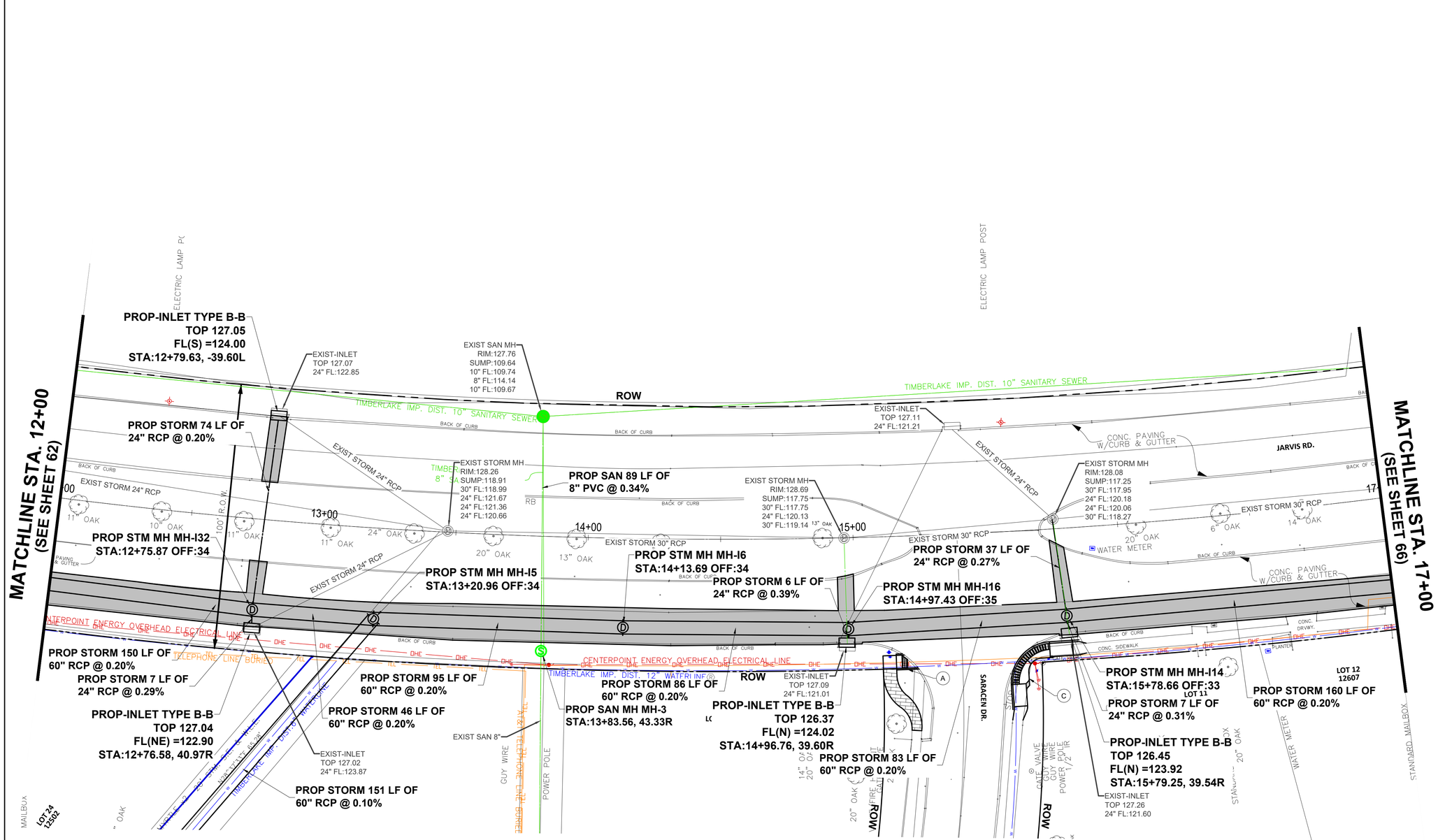
SHEET DESCRIPTION: **PLAN AND PROFILE - JARVIS RD SHEET 4**

DRAWN BY: | DATE: 3/2/2022

DESIGN BY: | SCALE: | SHEET NO: 63 OF 200

J:\1904\2102\ACAD\SHEET FILES\60%\63 PLAN AND PROFILE – JARVIS RD SHEET 4.dwg



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3/2/2022

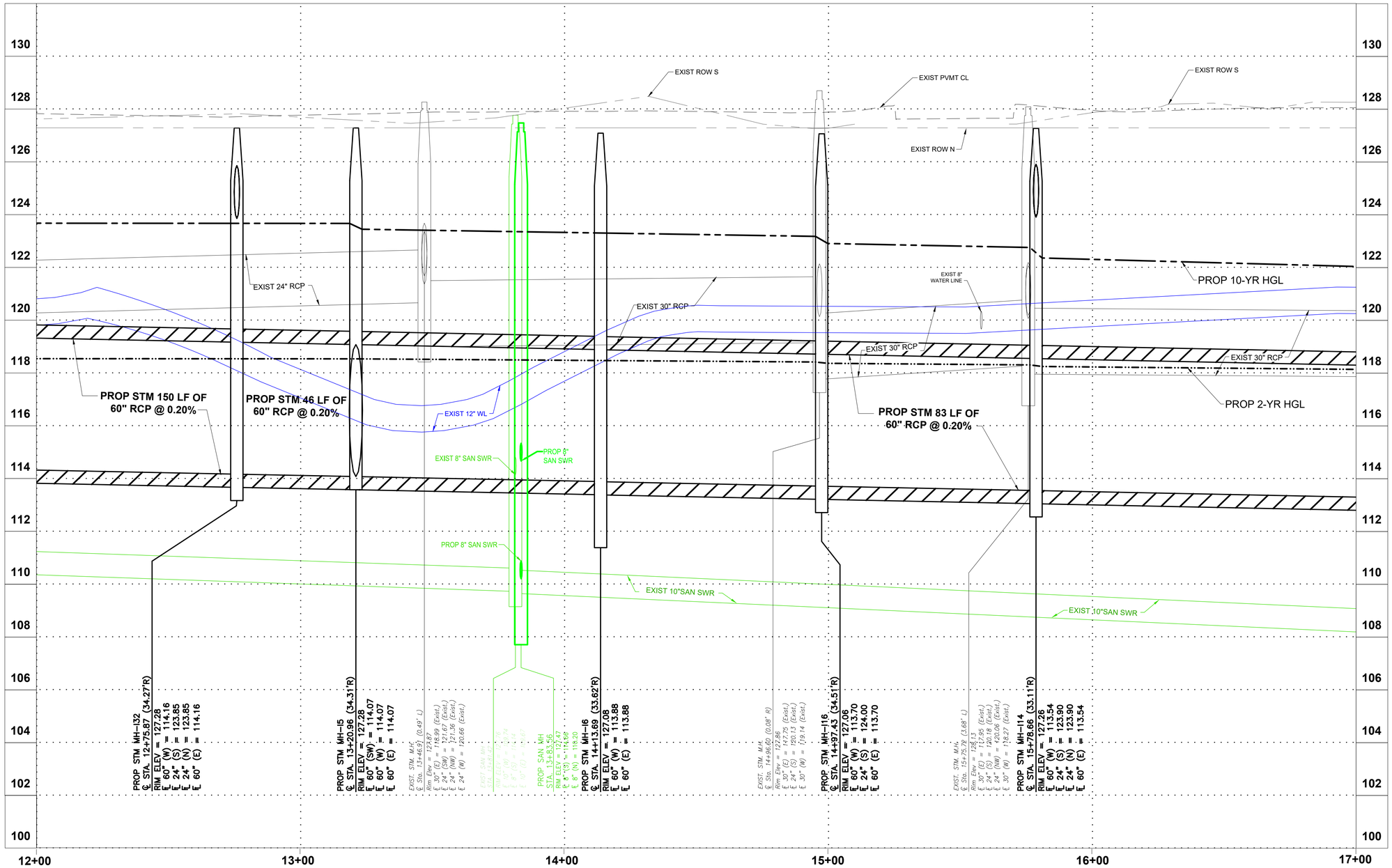
PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **PLAN AND PROFILE - JARVIS RD SHEET 5**

DRAWN BY: | DATE: 3/2/2022

DESIGN BY: | SCALE: | SHEET NO: 64 OF 200

J:\1904\2102\ACAD\SHEET FILES\60%\64 PLAN AND PROFILE – JARVIS RD SHEET 5.dwg



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PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **PLAN AND PROFILE - JARVIS RD SHEET 6**

DRAWN BY:
DATE: 3/2/2022
DESIGN BY:
SCALE:
SHEET NO: 65 OF 200

J:\1904\2102\ACAD\SHEET FILES\60%\65 PLAN AND PROFILE – JARVIS RD SHEET 6.dwg

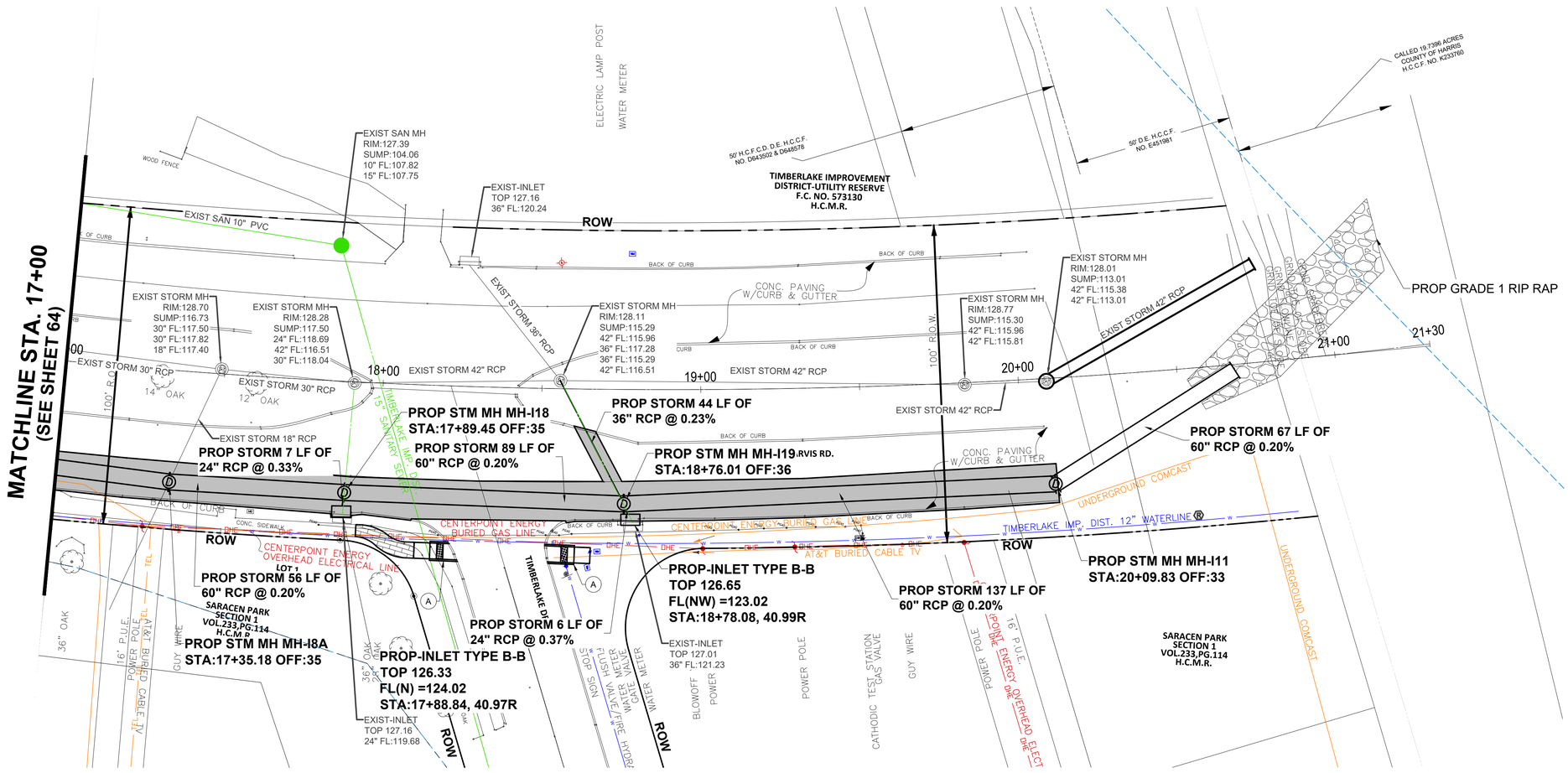
***CONSTRUCTION IN HARRIS COUNTY FLOOD CONTROL DISTRICT RIGHT-OF-WAY REQUIRES:**

1.) HCFCD RIGHT-OF-WAY NOTIFICATION (PERMIT)
2.) HCFCD 48-HR PRE-CONSTRUCTION NOTIFICATION

BOTH ARE REQUIRED PRIOR TO ENTERING OR WORKING WITHIN HARRIS COUNTY FLOOD CONTROL DISTRICT RIGHT-OF-WAY. BOTH THE HCFCD RIGHT-OF-WAY NOTIFICATION AND 48-HOUR NOTIFICATION MUST BE PROVIDED TO HCFCD AT dcid@hcfcd.org. SITE PLANS MUST BE APPROVED PRIOR TO OBTAINING THE REQUIRED HCFCD RIGHT-OF-WAY NOTIFICATION. BE ADVISED THAT THE HCFCD RIGHT-OF-WAY NOTIFICATION IS SEPARATE FROM THE SITE DEVELOPMENT PERMIT PACKAGE.

TO APPLY FOR THE HCFCD RIGHT-OF-WAY NOTIFICATION PLEASE GO TO http://apps.harriscountytx.gov/EPermits AND APPLY FOR THE HCFCD ROW UNDER ROW NOTIFICATION.

FAILURE TO PROVIDE BOTH ITEMS COULD RESULT IN DELAYS AND ADDITIONAL CONSTRUCTION COSTS.



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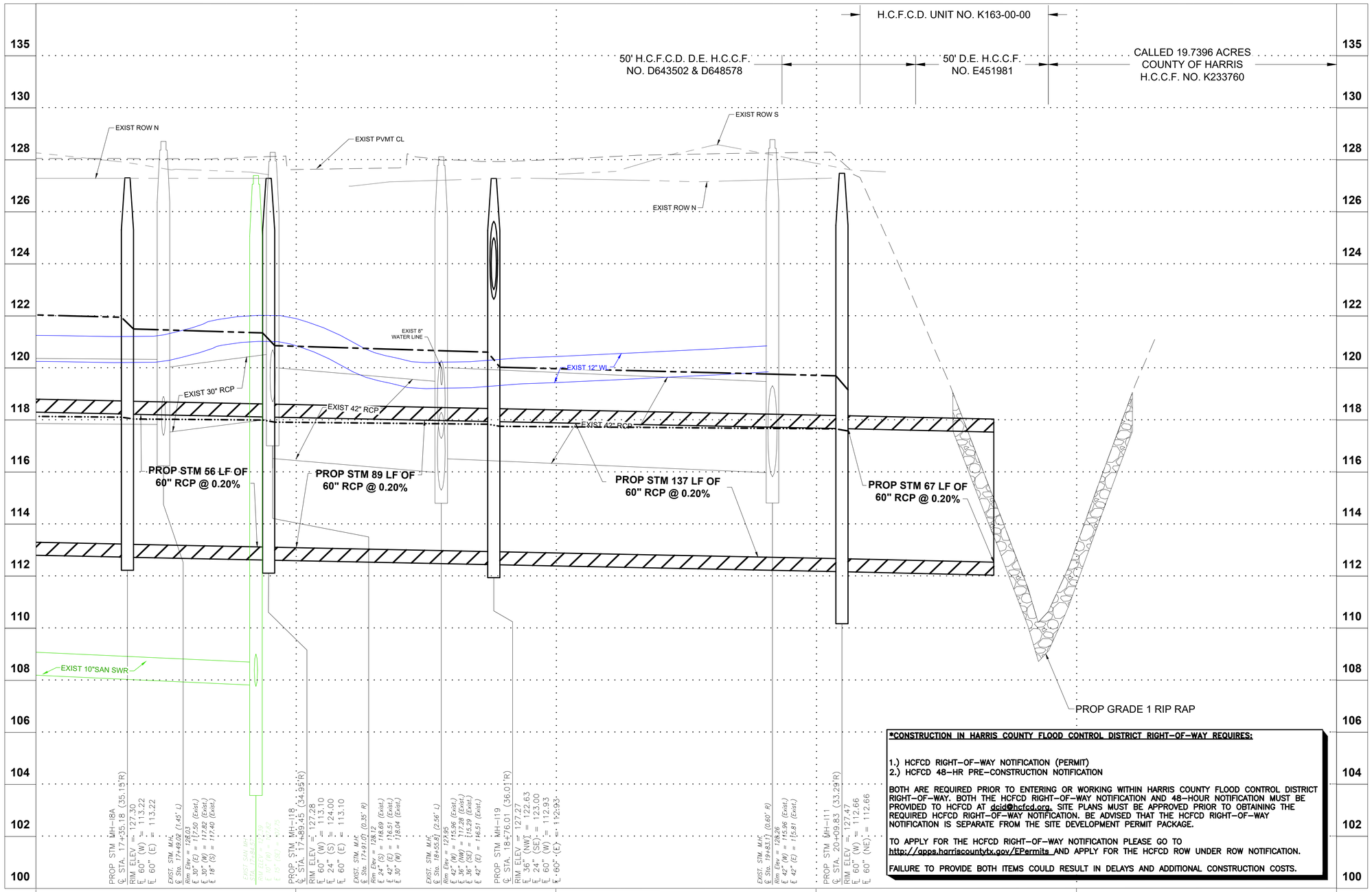
ISAAC MUÑIZ
125839
LICENSED PROFESSIONAL ENGINEER
3/2/2022

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **PLAN AND PROFILE - JARVIS RD SHEET 7**

DRAWN BY:
DATE: 3/2/2022
DESIGN BY:
SCALE:
SHEET NO: 66 OF 200

J:\1904\2102\ACAD\SHEET FILES\60%\66 PLAN AND PROFILE – JARVIS RD SHEET 7.dwg



***CONSTRUCTION IN HARRIS COUNTY FLOOD CONTROL DISTRICT RIGHT-OF-WAY REQUIRES:**

1.) HCFCD RIGHT-OF-WAY NOTIFICATION (PERMIT)
2.) HCFCD 48-HR PRE-CONSTRUCTION NOTIFICATION

BOTH ARE REQUIRED PRIOR TO ENTERING OR WORKING WITHIN HARRIS COUNTY FLOOD CONTROL DISTRICT RIGHT-OF-WAY. BOTH THE HCFCD RIGHT-OF-WAY NOTIFICATION AND 48-HOUR NOTIFICATION MUST BE PROVIDED TO HCFCD AT dcid@hcfcd.org. SITE PLANS MUST BE APPROVED PRIOR TO OBTAINING THE REQUIRED HCFCD RIGHT-OF-WAY NOTIFICATION. BE ADVISED THAT THE HCFCD RIGHT-OF-WAY NOTIFICATION IS SEPARATE FROM THE SITE DEVELOPMENT PERMIT PACKAGE.

TO APPLY FOR THE HCFCD RIGHT-OF-WAY NOTIFICATION PLEASE GO TO http://apps.harriscountytx.gov/EPermits AND APPLY FOR THE HCFCD ROW UNDER ROW NOTIFICATION.

FAILURE TO PROVIDE BOTH ITEMS COULD RESULT IN DELAYS AND ADDITIONAL CONSTRUCTION COSTS.

NOTES:

1. FOR LIMITS OF PAVEMENT REPAIR, CONTRACTOR SHALL GO TO NEAREST JOINT TO DOWEL IN AND IF JOINT IS BEYOND 10', CONTRACTOR SHALL SET NEW JOINT AS LIMITS SHOWN ON PLANS.
2. THE LOCATION OF EXISTING WATER LINE WAS BASED ON RECORD DRAWINGS PROVIDED BY TIMBERLAKE MUNICIPAL UTILITY DISTRICT.

0 20 40
SCALE IN FEET

VERTICAL SCALE
0 2 4
SCALE IN FEET

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY
ENGINEERING DEPARTMENT

HARRIS COUNTY 1836 TEXAS

LJA Engineering, Inc.
3600 W Sam Houston Pkwy S, Suite 600
Houston, TX 77042
Phone: 713.953.5200 Fax: 713.953.5026
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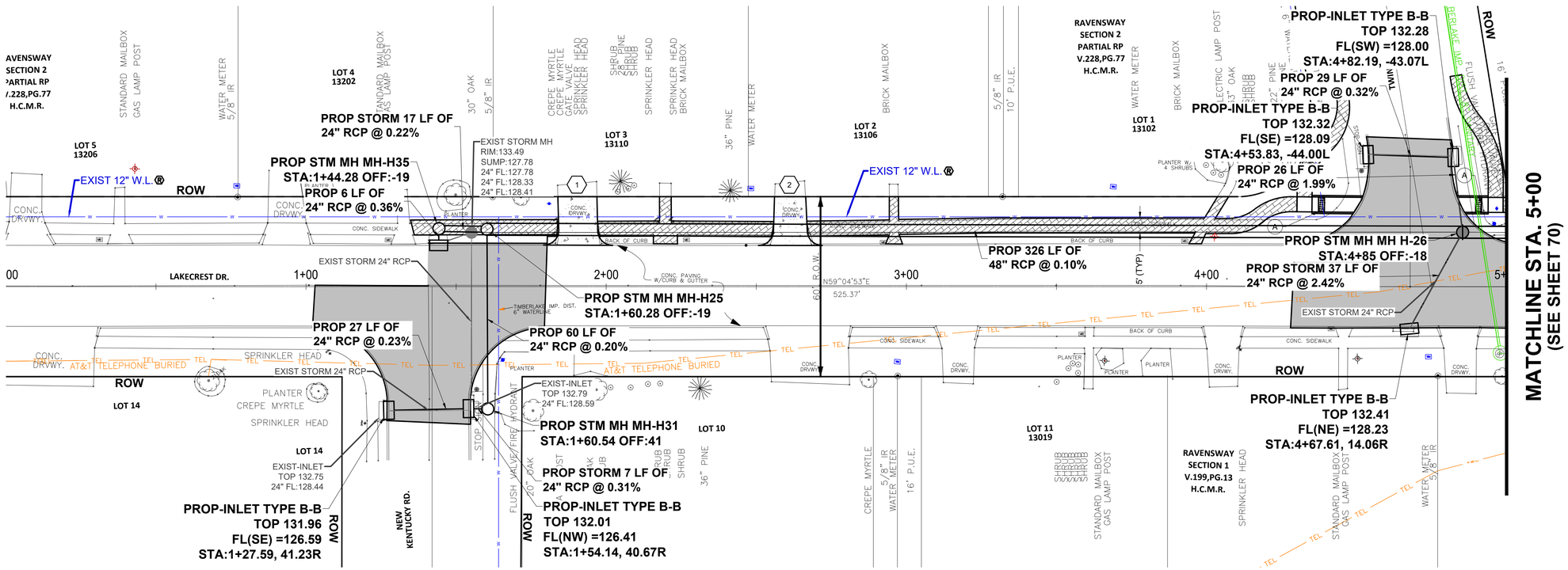
STATE OF TEXAS
ISAAC MUÑIZ
125839
LICENSED
PROFESSIONAL ENGINEER
3/2/2022

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **PLAN AND PROFILE - JARVIS RD SHEET 8**

DRAWN BY:
DATE: 3/2/2022
DESIGN BY:
SCALE:
SHEET NO: 67 OF 200

J:\1904\2102\ACAD\SHEET FILES\60%\67 PLAN AND PROFILE - JARVIS RD SHEET 8.dwg



PROPOSED 4.5" CONCRETE S/W TYPICAL

PROPOSED DRIVEWAY

PROPOSED NEW PAVEMENT

(A) ADA TYPE 7

NOTES:

1. FOR LIMITS OF PAVEMENT REPAIR, CONTRACTOR SHALL GO TO NEAREST JOINT TO DOWEL IN AND IF JOINT IS BEYOND 10', CONTRACTOR SHALL SET NEW JOINT AS LIMITS SHOWN ON PLANS.
2. THE LOCATION OF EXISTING WATER LINE WAS BASED ON RECORD DRAWINGS PROVIDED BY TIMBERLAKE MUNICIPAL UTILITY DISTRICT.
3. CONTRACTOR SHALL REPLACE CURB DRAINS DAMAGED DURING CONSTRUCTION OF PROPOSED STORM SEWER LINE AND PAVEMENT REPLACEMENT, INCIDENTAL TO STORM SEWER PAY ITEM

0 20 40
SCALE IN FEET

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY
ENGINEERING DEPARTMENT

HARRIS COUNTY 1836 TEXAS

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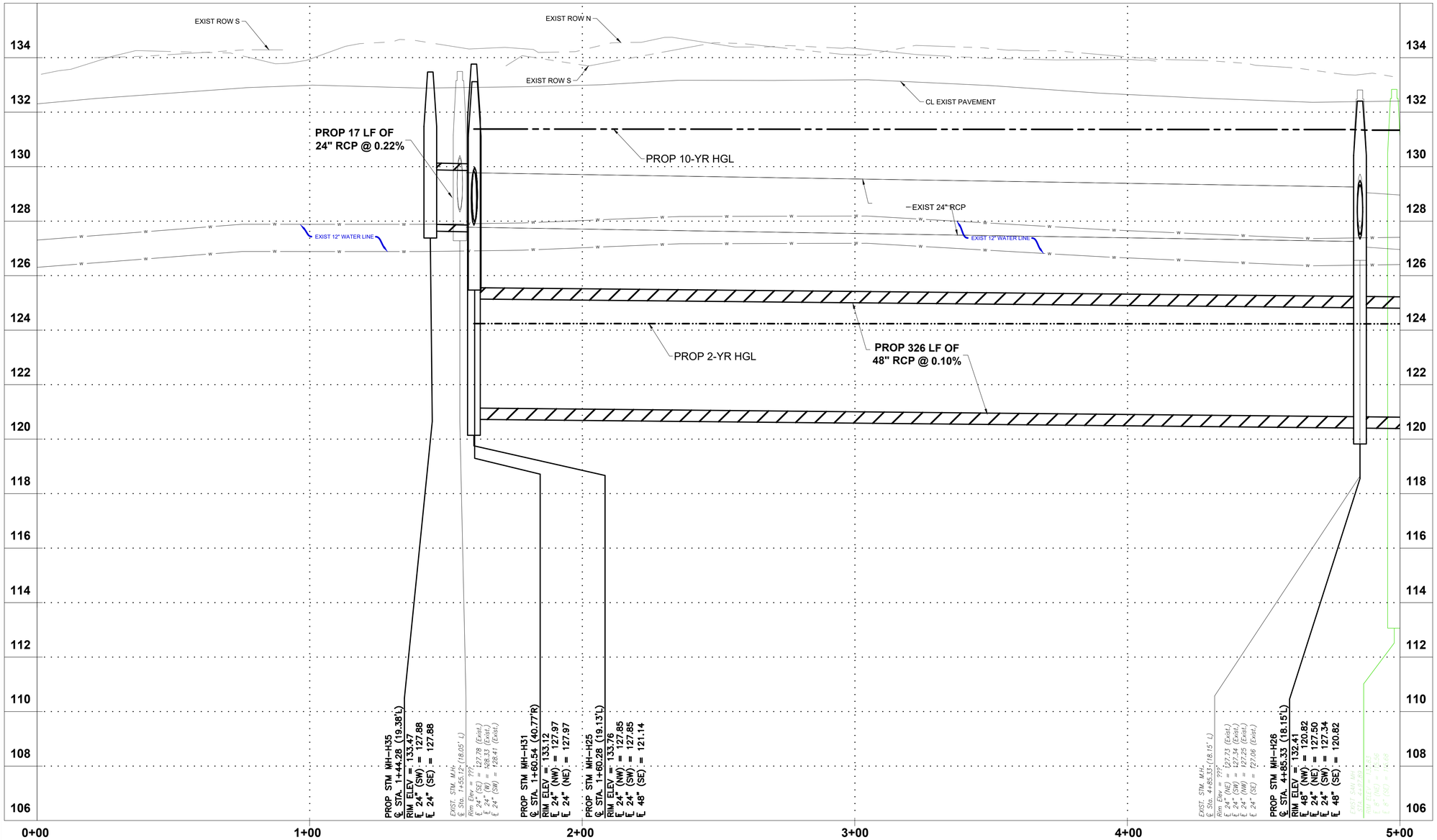
STATE OF TEXAS
ISAAC MUÑIZ
125839
LICENSED
PROFESSIONAL ENGINEER
3/2/2022

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: PLAN AND PROFILE - LAKECREST DR SHEET 1

DRAWN BY:
DATE: 3/2/2022
DESIGN BY:
SCALE:
SHEET NO: 68 OF 200

J:\1904\2102\ACAD\SHEET FILES\60%\68 PLAN AND PROFILE - LAKECREST DR SHEET 1.dwg



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0 20 40
SCALE IN FEET

VERTICAL SCALE
0 2 4
SCALE IN FEET

J:\1904\2102\ACAD\SHEET FILES\60%\69 PLAN AND PROFILE - LAKECREST DR SHEET 2.dwg

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY
ENGINEERING DEPARTMENT

HARRIS COUNTY 1836 TEXAS

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STATE OF TEXAS
ISAAC MUÑIZ
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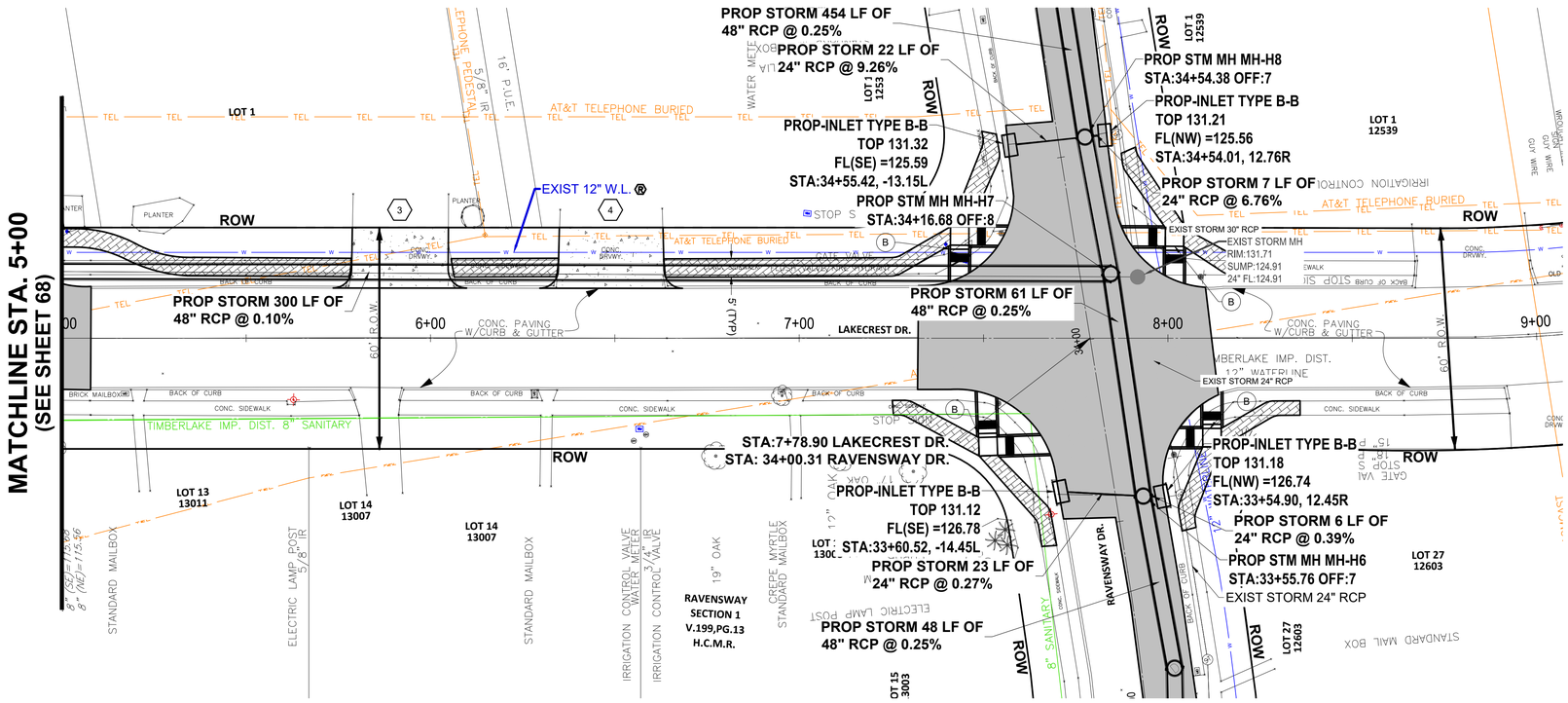
PROFESSIONAL ENGINEER
3/2/2022

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **PLAN AND PROFILE - LAKECREST DR SHEET 2**

DRAWN BY: | DATE: **3/2/2022**

DESIGN BY: | SCALE: | SHEET NO: **69 OF 200**



PROPOSED 4.5" CONCRETE S/W TYPICAL

PROPOSED DRIVEWAY

PROPOSED NEW PAVEMENT

(B) ADA TYPE 12

NOTES:

1. FOR LIMITS OF PAVEMENT REPAIR, CONTRACTOR SHALL GO TO NEAREST JOINT TO DOWEL IN AND IF JOINT IS BEYOND 10', CONTRACTOR SHALL SET NEW JOINT AS LIMITS SHOWN ON PLANS.
2. THE LOCATION OF EXISTING WATER LINE WAS BASED ON RECORD DRAWINGS PROVIDED BY TIMBERLAKE MUNICIPAL UTILITY DISTRICT.
3. CONTRACTOR SHALL REPLACE CURB DRAINS DAMAGED DURING CONSTRUCTION OF PROPOSED STORM SEWER LINE AND PAVEMENT REPLACEMENT, INCIDENTAL TO STORM SEWER PAY ITEM

0 20 40
SCALE IN FEET

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY
ENGINEERING DEPARTMENT

HARRIS COUNTY 1836 TEXAS

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STATE OF TEXAS
ISAAC MUÑIZ
125839
LICENSED
PROFESSIONAL ENGINEER
3/2/2022

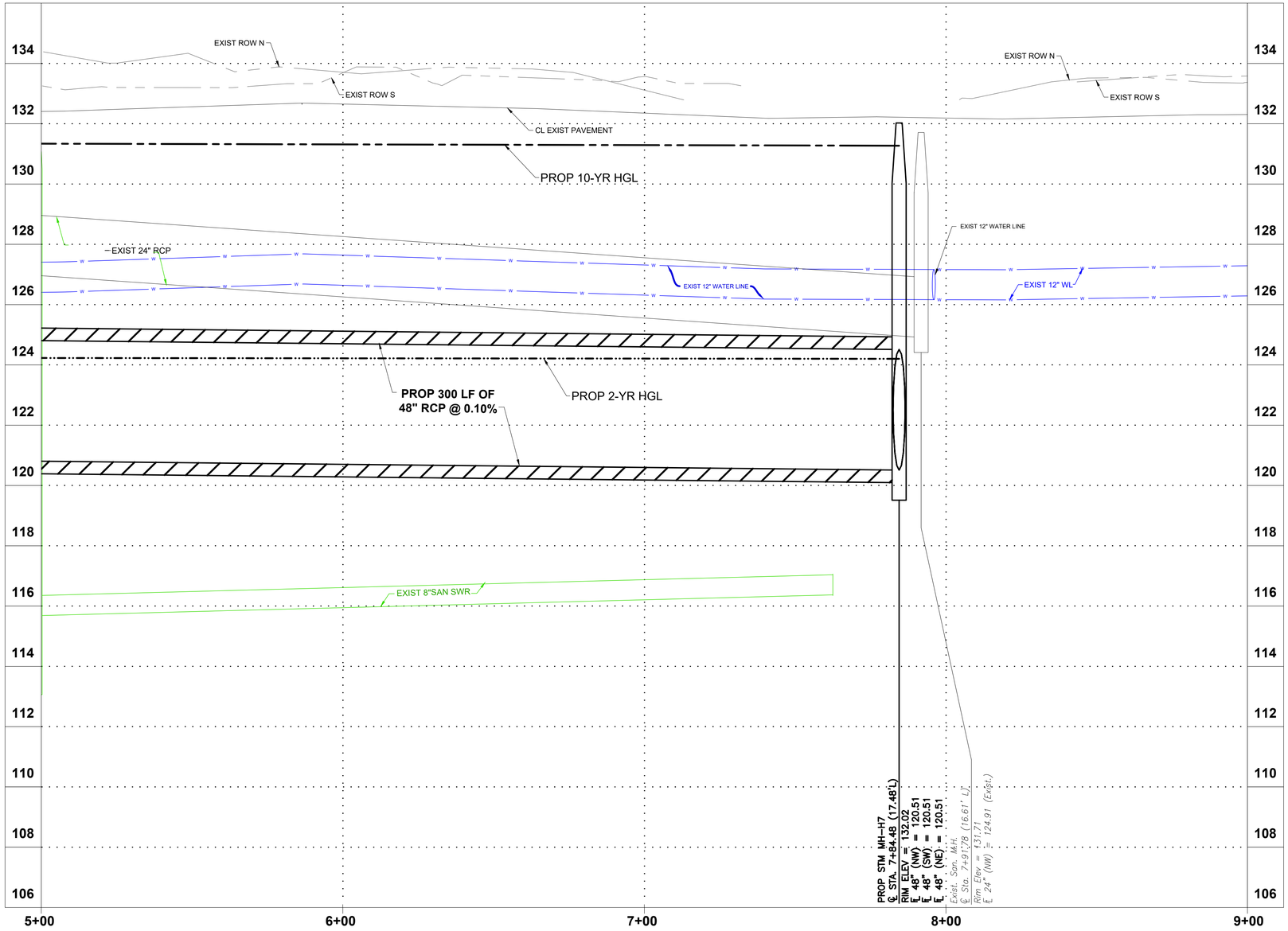
PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **PLAN AND PROFILE - LAKECREST DR SHEET 3**

DRAWN BY: | DATE: 3/2/2022

DESIGN BY: | SCALE: | SHEET NO: 70 OF 200

J:\1904\2102\ACAD\SHEET FILES\60%\70 PLAN AND PROFILE – LAKECREST DR SHEET 3.dwg



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0 20 40
SCALE IN FEET

VERTICAL SCALE
0 2 4
SCALE IN FEET

NO.	REVISIONS	DATE	NAME

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STATE OF TEXAS
ISAAC MUÑIZ
125839
LICENSED
PROFESSIONAL ENGINEER
3/2/2022

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **PLAN AND PROFILE - LAKECREST DR SHEET 4**

DRAWN BY:
DATE: **3/2/2022**
DESIGN BY:
SCALE:
SHEET NO: **71 OF 200**

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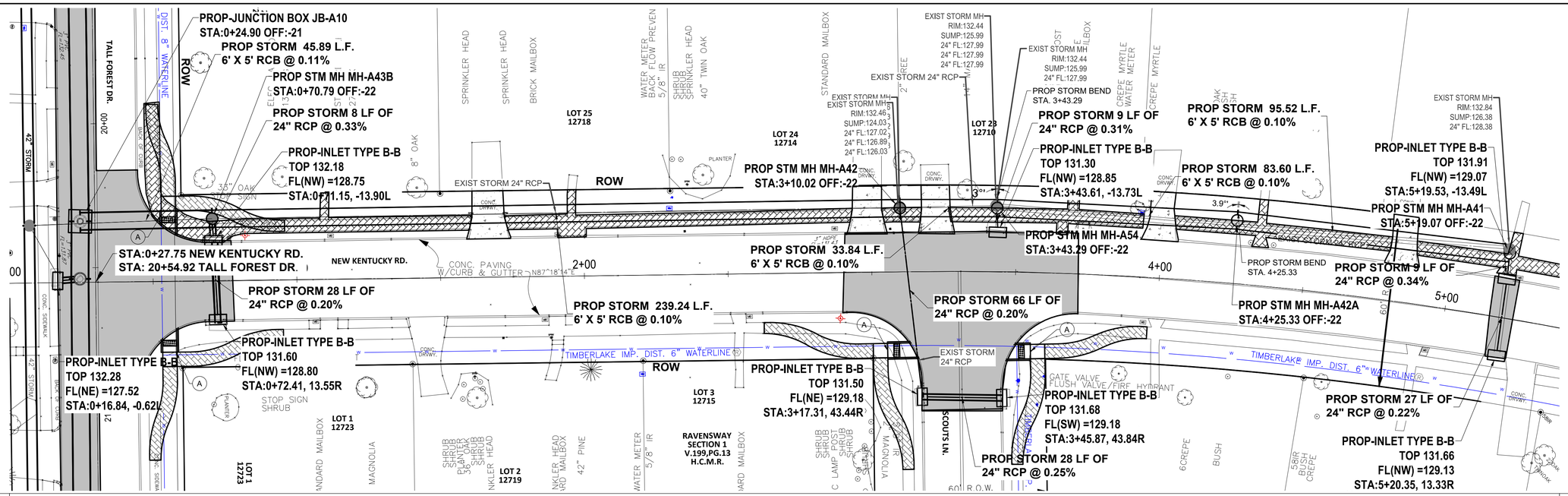

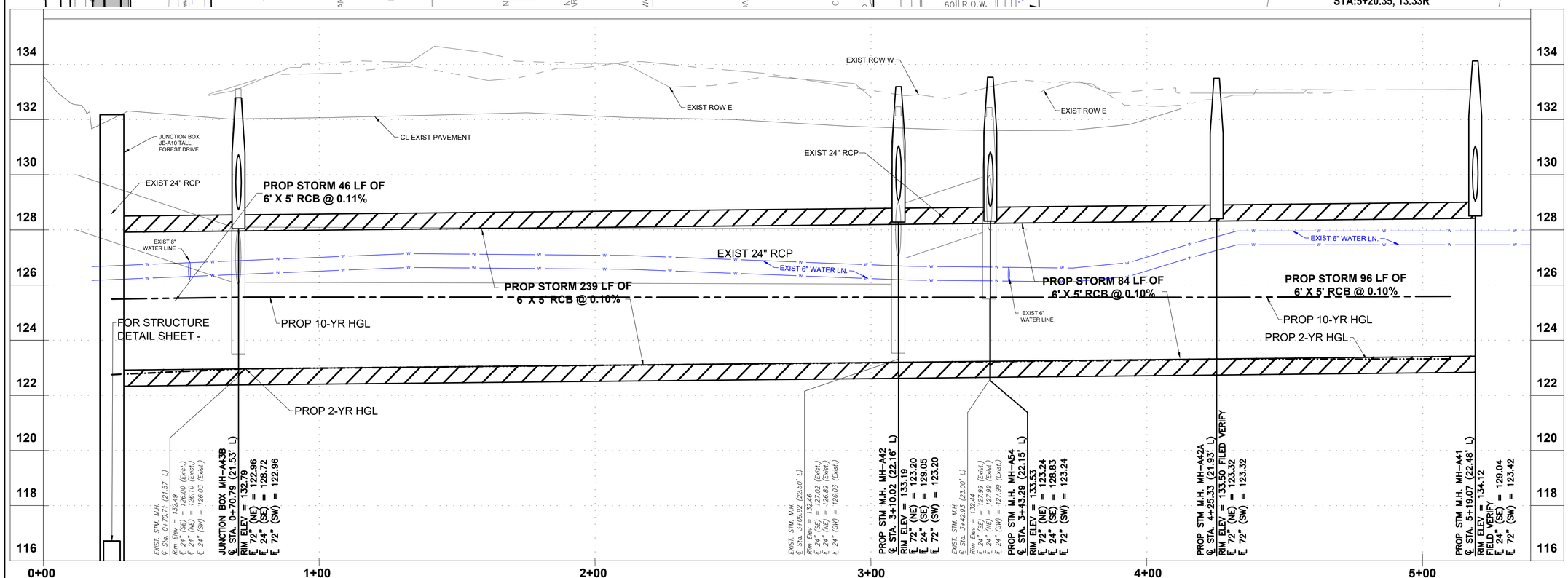

NOTES:

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3. CONTRACTOR SHALL REPLACE CURB DRAINS DAMAGED DURING CONSTRUCTION OF PROPOSED STORM SEWER LINE AND PAVEMENT REPLACEMENT, INCIDENTAL TO STORM SEWER PAY ITEM

SCALE IN FEET: 0 20 40

VERTICAL SCALE: 0 2 4 SCALE IN FEET

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY ENGINEERING DEPARTMENT

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STATE OF TEXAS — ISAAC MUÑIZ — 125839 — LICENSED PROFESSIONAL ENGINEER — 3/3/2022

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: PLAN AND PROFILE - NEW KENTUCKY RD

DRAWN BY:

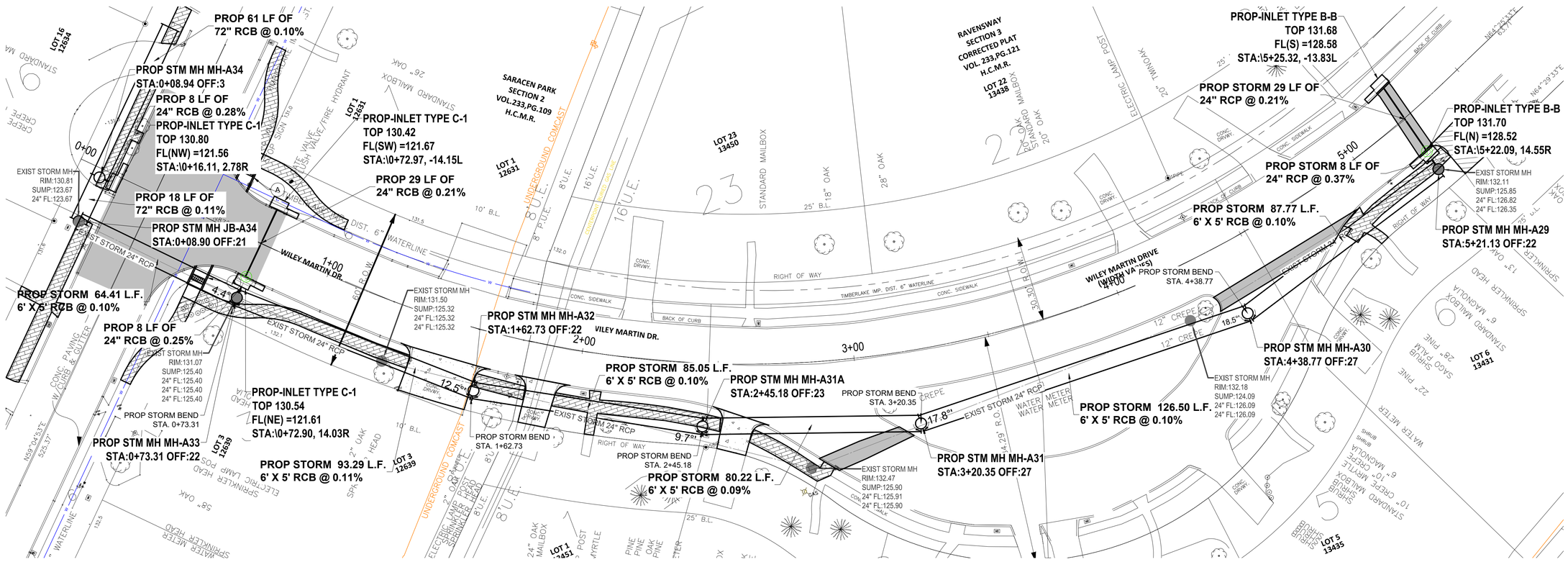
DATE: 3/3/2022

DESIGN BY:

SCALE:

SHEET NO: 72 OF 200

J:\1904\2102\ACAD\SHEET FILES\60%\72 PLAN AND PROFILE – NEW KENTUCKY RD.dwg



PROPOSED 4.5" CONCRETE S/W TYPICAL

PROPOSED DRIVEWAY

PROPOSED NEW PAVEMENT

(A) ADA TYPE 7

NOTES:

1. FOR LIMITS OF PAVEMENT REPAIR, CONTRACTOR SHALL GO TO NEAREST JOINT TO DOWEL IN AND IF JOINT IS BEYOND 10', CONTRACTOR SHALL SET NEW JOINT AS LIMITS SHOWN ON PLANS.
2. THE LOCATION OF EXISTING WATER LINE WAS BASED ON RECORD DRAWINGS PROVIDED BY TIMBERLAKE MUNICIPAL UTILITY DISTRICT.
3. CONTRACTOR SHALL REPLACE CURB DRAINS DAMAGED DURING CONSTRUCTION OF PROPOSED STORM SEWER LINE AND PAVEMENT REPLACEMENT, INCIDENTAL TO STORM SEWER PAY ITEM

0 20 40
SCALE IN FEET

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY
ENGINEERING DEPARTMENT

HARRIS COUNTY 1836 TEXAS

LJA Engineering, Inc.
3600 W Sam Houston Pkwy S, Suite 600
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Phone: 713.953.5200 Fax: 713.953.5026
FIRM REGISTRATION No. F-13166
www.LJAengineering.com

STATE OF TEXAS
ISAAC MUÑIZ
125839
LICENSED
PROFESSIONAL ENGINEER
3/2/2022

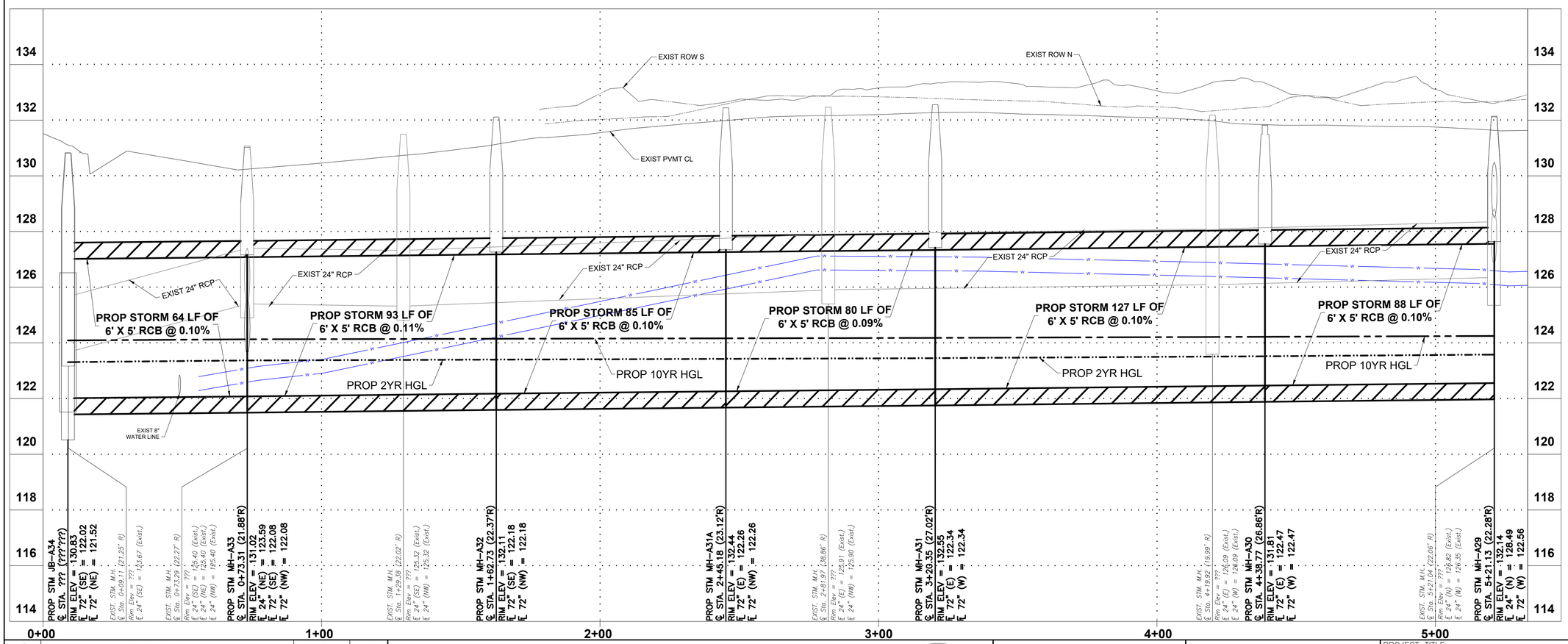
PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **PLAN AND PROFILE - WILEY MARTIN DR SHEET 1**

DRAWN BY: | DATE: 3/2/2022

DESIGN BY: | SCALE: | SHEET NO: 73 OF 200

J:\1904\2102\ACAD\SHEET FILES\60%\73 PLAN AND PROFILE – WILEY MARTIN DR SHEET 1.dwg



0 20 40
SCALE IN FEET

VERTICAL SCALE
0 2 4
SCALE IN FEET

J:\1904\2102\ACAD\SHEET FILES\60%\74 PLAN AND PROFILE - WILEY MARTIN DR SHEET 2.dwg

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY
ENGINEERING DEPARTMENT

HARRIS COUNTY 1836 TEXAS

LJA Engineering, Inc.
3600 W Sam Houston Pkwy S, Suite 600
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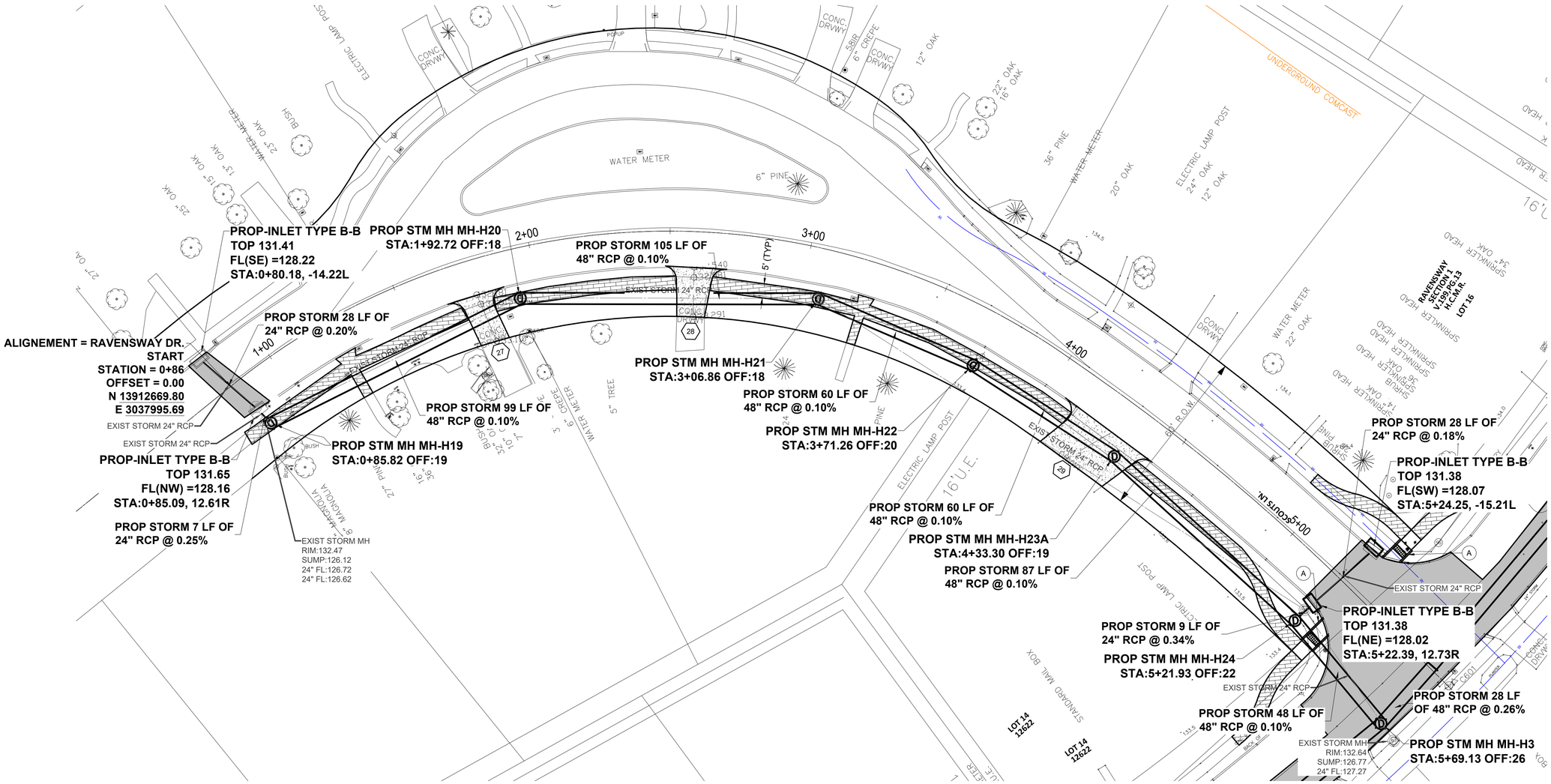
STATE OF TEXAS
ISAAC MUÑIZ
125839
LICENSED
PROFESSIONAL ENGINEER
3/2/2022

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **PLAN AND PROFILE - WILEY MARTIN DR SHEET 2**

DRAWN BY:
DATE: 3/2/2022
DESIGN BY:
SCALE:
SHEET NO: 74 OF 200



NOTES:

1. FOR LIMITS OF PAVEMENT REPAIR, CONTRACTOR SHALL GO TO NEAREST JOINT TO DOWEL IN AND IF JOINT IS BEYOND 10', CONTRACTOR SHALL SET NEW JOINT AS LIMITS SHOWN ON PLANS.
2. THE LOCATION OF EXISTING WATER LINE WAS BASED ON RECORD DRAWINGS PROVIDED BY TIMBERLAKE MUNICIPAL UTILITY DISTRICT.
3. CONTRACTOR SHALL REPLACE CURB DRAINS DAMAGED DURING CONSTRUCTION OF PROPOSED STORM SEWER LINE AND PAVEMENT REPLACEMENT, INCIDENTAL TO STORM SEWER PAY ITEM

0 20 40
SCALE IN FEET

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY
ENGINEERING DEPARTMENT

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STATE OF TEXAS
ISAAC MUÑIZ
125839
LICENSED
PROFESSIONAL ENGINEER
3/2/2022

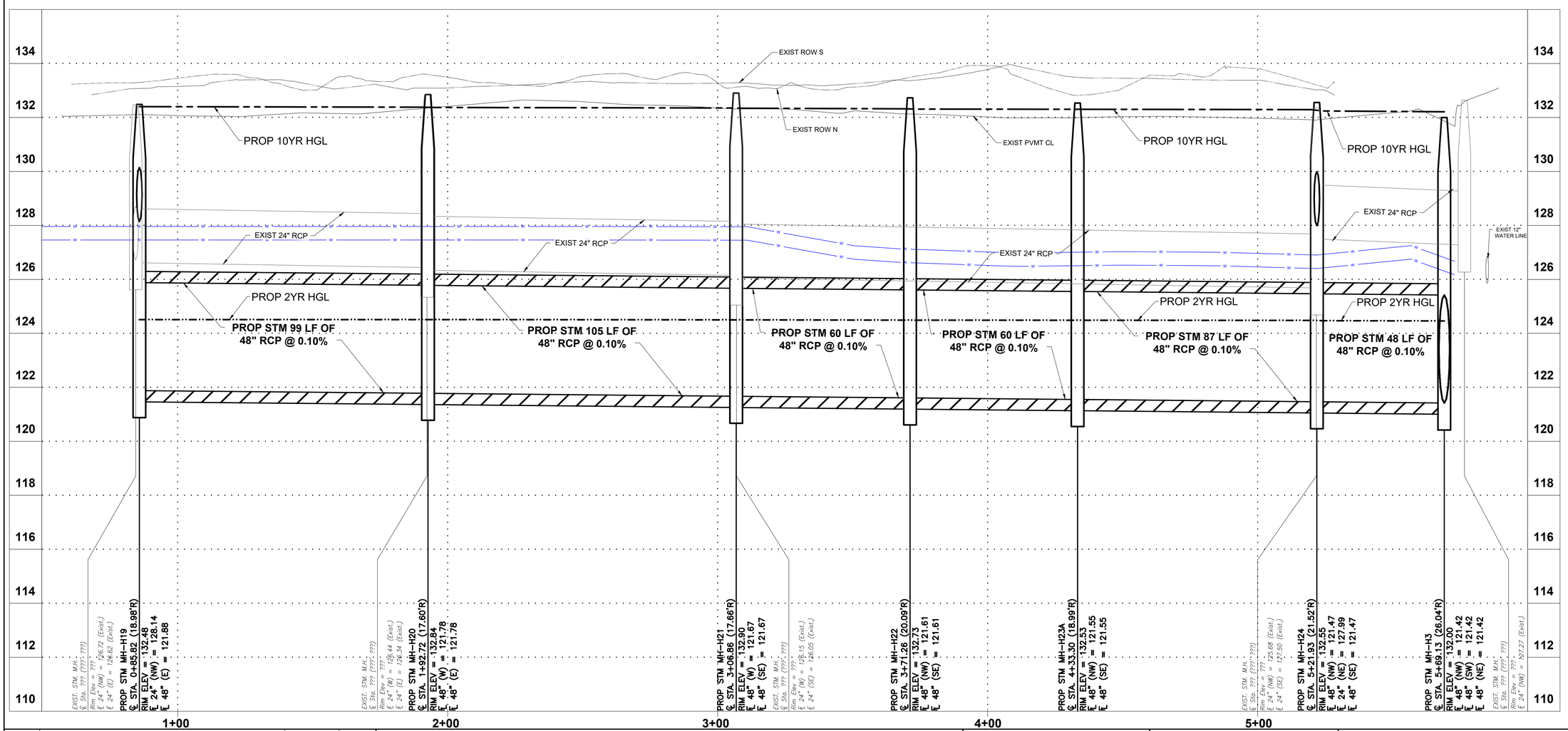
PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **PLAN AND PROFILE - SCOUTS LANE SHEET 1**

DRAWN BY: | DATE: 3/2/2022

DESIGN BY: | SCALE: | SHEET NO: 75 OF 200

J:\1904\2102\ACAD\SHEET FILES\60%\75 PLAN AND PROFILE – SCOUTS LANE SHEET 1.dwg



J:\1904\2102\ACAD\SHEET FILES\60%\76 PLAN AND PROFILE - SCOUTS LANE SHEET 2.dwg

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY
ENGINEERING DEPARTMENT

HARRIS COUNTY TEXAS 1836

LJA Engineering, Inc.
3600 W Sam Houston Pkwy S, Suite 600
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STATE OF TEXAS
ISAAC MUÑIZ
125839
LICENSED
PROFESSIONAL ENGINEER
3/2/2022

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **PLAN AND PROFILE - SCOUTS LANE SHEET 2**

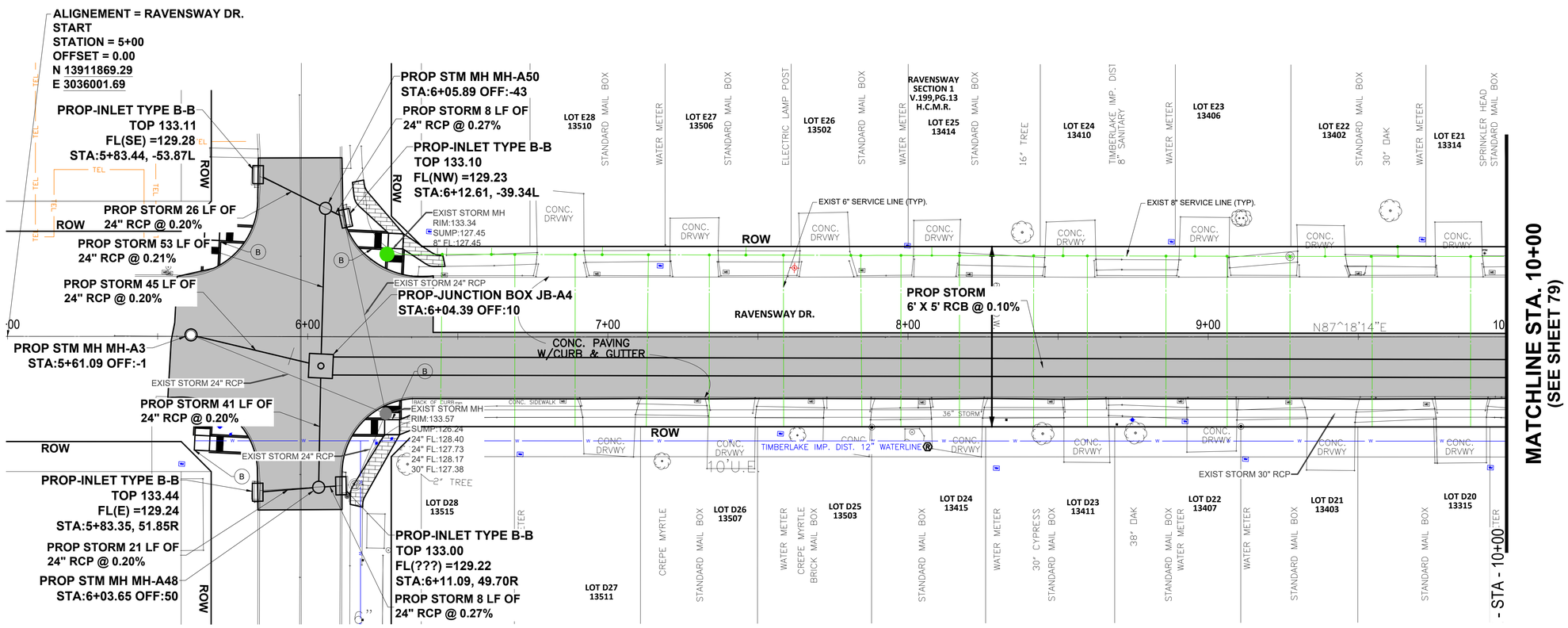
DRAWN BY:

DATE: 3/2/2022

DESIGN BY:

SCALE:

SHEET NO: 76 OF 200



PROPOSED PAVEMENT AND CURBS

PROPOSED 4.5" CONCRETE S/W TYPICAL

(B) ADA TYPE 12

NOTES:

1. FOR LIMITS OF PAVEMENT REPAIR, CONTRACTOR SHALL GO TO NEAREST JOINT TO DOWEL IN AND IF JOINT IS BEYOND 10', CONTRACTOR SHALL SET NEW JOINT AS LIMITS SHOWN ON PLANS.
2. THE LOCATION OF EXISTING WATER LINE WAS BASED ON RECORD DRAWINGS PROVIDED BY TIMBERLAKE MUNICIPAL UTILITY DISTRICT.
3. CONTRACTOR SHALL REPLACE CURB DRAINS DAMAGED DURING CONSTRUCTION OF PROPOSED STORM SEWER LINE AND PAVEMENT REPLACEMENT, INCIDENTAL TO STORM SEWER PAY ITEM

0 20 40
SCALE IN FEET

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY
ENGINEERING DEPARTMENT

HARRIS COUNTY TEXAS 1836

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STATE OF TEXAS
ISAAC MUÑIZ
125839
LICENSED PROFESSIONAL ENGINEER
3/2/2022

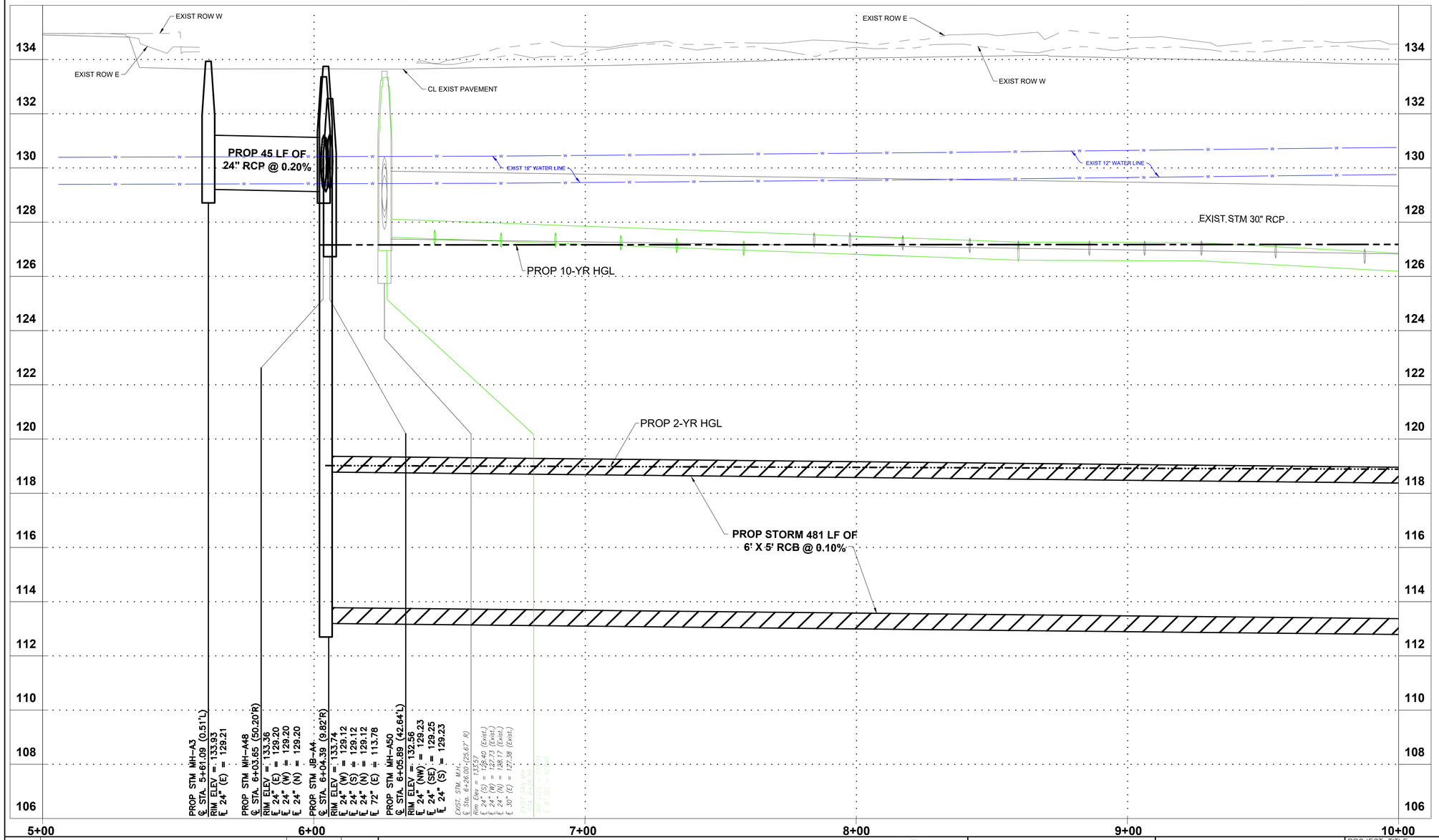
PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **PLAN AND PROFILE - RAVENSWAY DR SHEET 1**

DRAWN BY: | DATE: 3/2/2022

DESIGN BY: | SCALE: | SHEET NO: 77 OF 200

J:\1904\2102\ACAD\SHEET FILES\60%\77 PLAN AND PROFILE - RAVENSWAY DR SHEET 1.dwg



NOTES:

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0 20 40
SCALE IN FEET

VERTICAL SCALE
0 2 4
SCALE IN FEET

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY
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STATE OF TEXAS
ISAAC MUÑIZ
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LICENSED PROFESSIONAL ENGINEER
3/2/2022

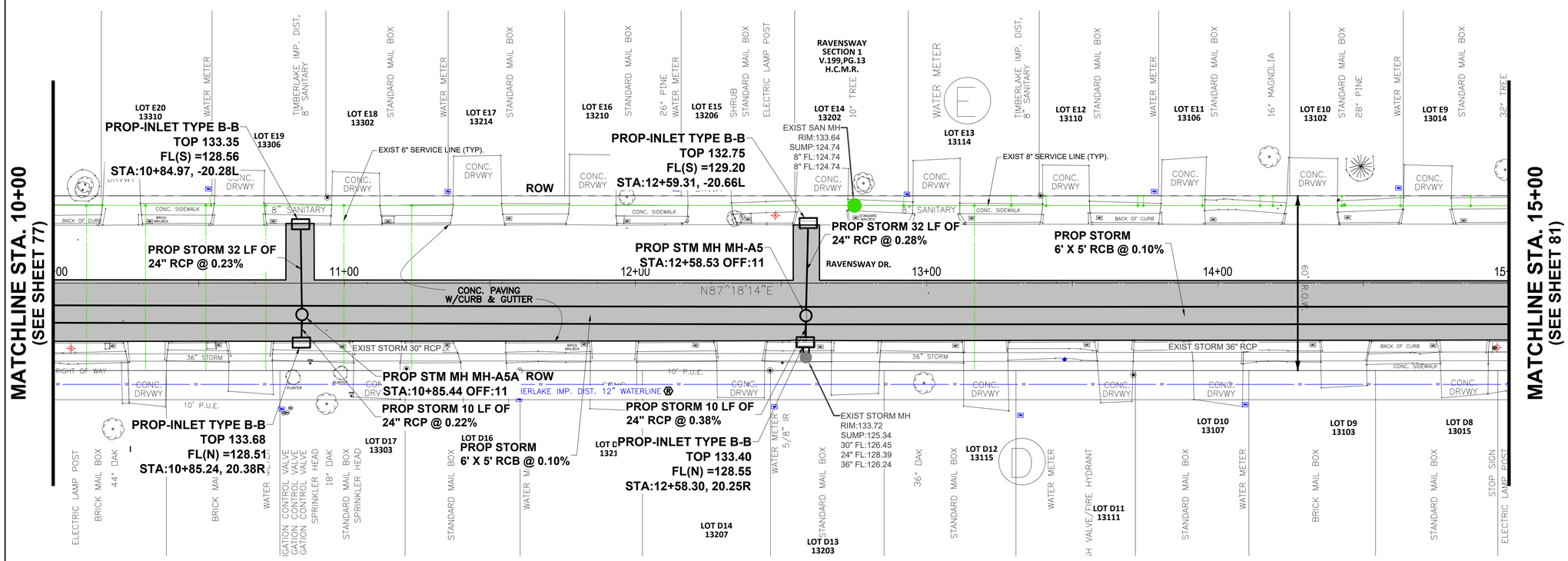
PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **PLAN AND PROFILE - RAVENSWAY DR SHEET 2**

DRAWN BY: | DATE: 3/2/2022

DESIGN BY: | SCALE: | SHEET NO: 78 OF 200

J:\1904\2102\ACAD\SHEET FILES\60%\78 PLAN AND PROFILE – RAVENSWAY DR SHEET 2.dwg



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0 20 40
SCALE IN FEET

NO.	REVISIONS	DATE	NAME

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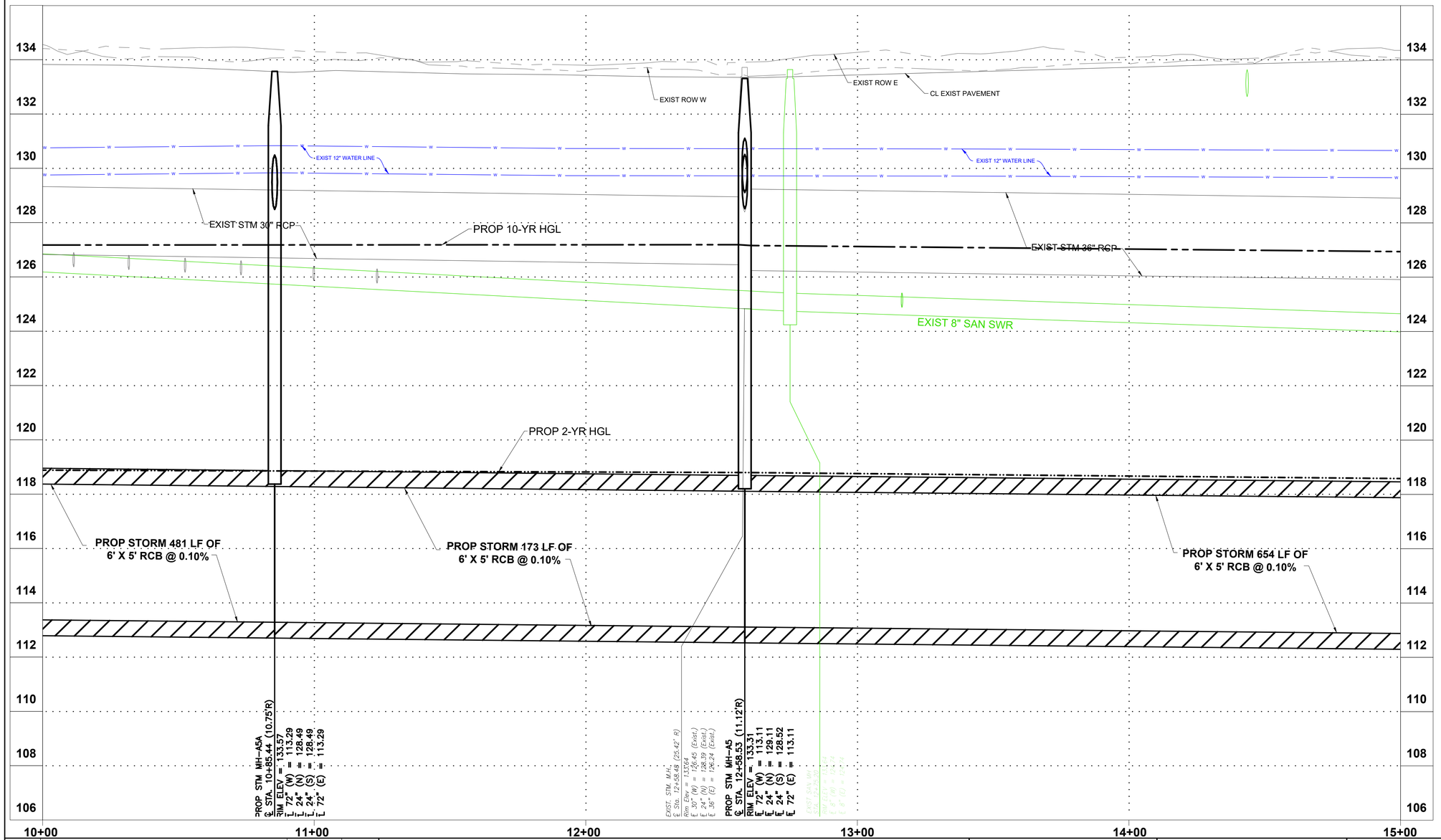
PROFESSIONAL ENGINEER
3/2/2022

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **PLAN AND PROFILE - RAVENSWAY DR SHEET 3**

DRAWN BY:
DATE: 3/2/2022
DESIGN BY:
SCALE:
SHEET NO: 79 OF 200

J:\1904\2102\ACAD\SHEET FILES\60%\79 PLAN AND PROFILE – RAVENSWAY DR SHEET 3.dwg



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0 20 40
SCALE IN FEET

VERTICAL SCALE
0 2 4
SCALE IN FEET

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HARRIS COUNTY 1836 TEXAS

LJA Engineering, Inc.
3600 W Sam Houston Pkwy S, Suite 600
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Phone: 713.953.5200 Fax: 713.953.5026
FIRM REGISTRATION No. F-1386
www.LJAengineering.com

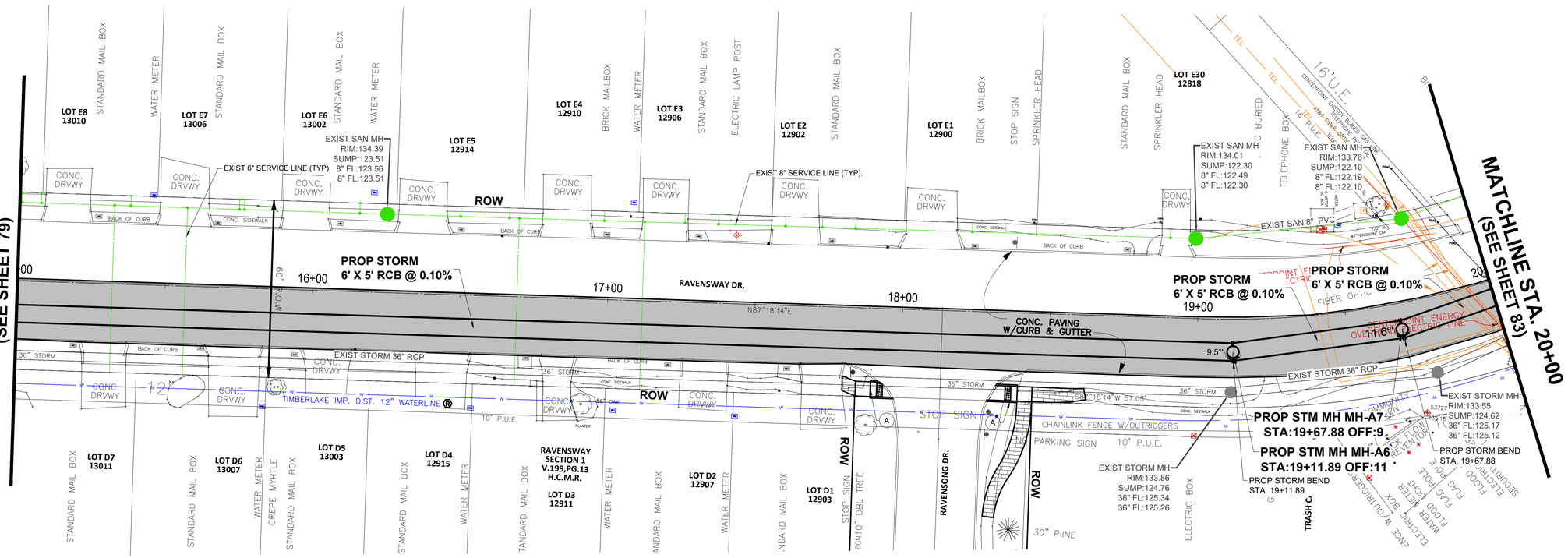
STATE OF TEXAS
ISAAC MUÑIZ
125839
LICENSED PROFESSIONAL ENGINEER
3/2/2022

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **PLAN AND PROFILE - RAVENSWAY DR SHEET 4**

DRAWN BY:
DATE: **3/2/2022**
DESIGN BY:
SCALE:
SHEET NO: **80 OF 200**

J:\1904\2102\ACAD\SHEET FILES\60%\80 PLAN AND PROFILE – RAVENSWAY DR SHEET 4.dwg



NOTES:

1. FOR LIMITS OF PAVEMENT REPAIR, CONTRACTOR SHALL GO TO NEAREST JOINT TO DOWEL IN AND IF JOINT IS BEYOND 10', CONTRACTOR SHALL SET NEW JOINT AS LIMITS SHOWN ON PLANS.
2. THE LOCATION OF EXISTING WATER LINE WAS BASED ON RECORD DRAWINGS PROVIDED BY TIMBERLAKE MUNICIPAL UTILITY DISTRICT.
3. CONTRACTOR SHALL REPLACE CURB DRAINS DAMAGED DURING CONSTRUCTION OF PROPOSED STORM SEWER LINE AND PAVEMENT REPLACEMENT, INCIDENTAL TO STORM SEWER PAY ITEM

0 20 40
SCALE IN FEET

NO.	REVISIONS	DATE	NAME

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3/2/2022

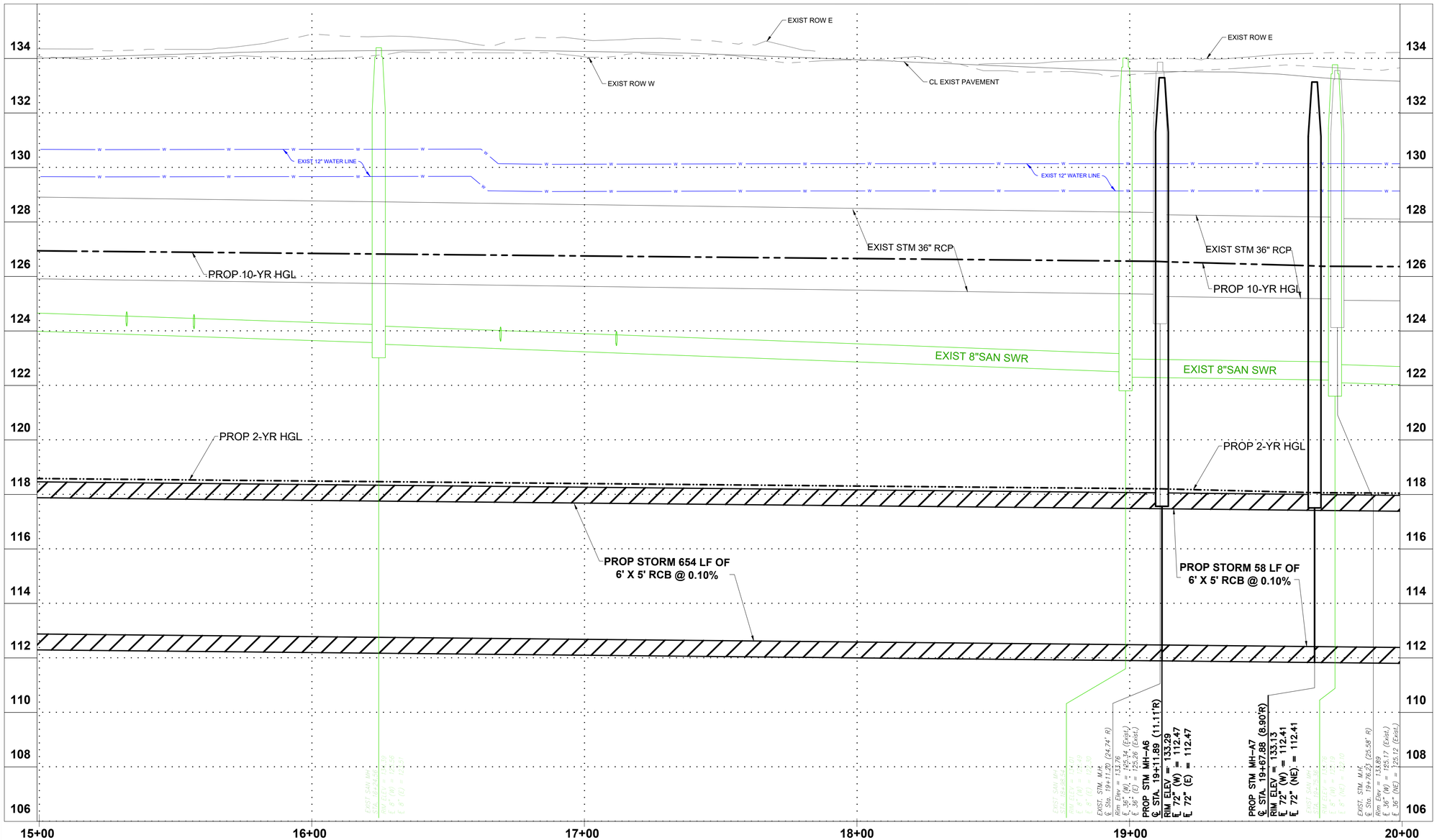
PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: PLAN AND PROFILE - RAVENSWAY DR SHEET 5

DRAWN BY: | DATE: 3/2/2022

DESIGN BY: | SCALE: | SHEET NO: 81 OF 200

J:\1904\2102\ACAD\SHEET FILES\60%\81 PLAN AND PROFILE – RAVENSWAY DR SHEET 5.dwg



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0 20 40
SCALE IN FEET

VERTICAL SCALE
0 2 4
SCALE IN FEET

J:\1904\2102\ACAD\SHEET FILES\60%\82 PLAN AND PROFILE - RAVENSWAY DR SHEET 6.dwg

NO.	REVISIONS	DATE	NAME

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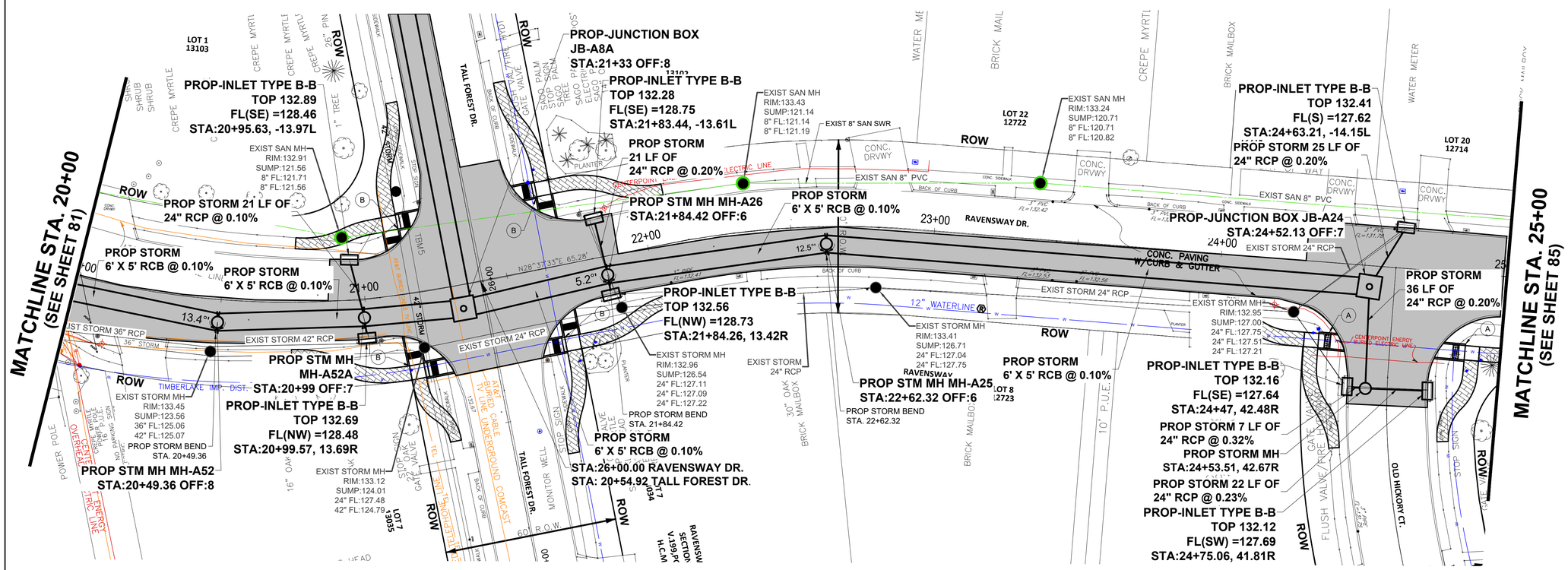
3/2/2022

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **PLAN AND PROFILE - RAVENSWAY DR SHEET 6**

DRAWN BY: | DATE: 3/2/2022

DESIGN BY: | SCALE: | SHEET NO: 82 OF 200



PROPOSED PAVEMENT AND CURBS

PROPOSED 4.5" CONCRETE S/W TYPICAL

(A) ADA TYPE 7

(B) ADA TYPE 12

NOTES:

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SCALE IN FEET

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3/2/2022

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **PLAN AND PROFILE - RAVENSWAY DR SHEET 7**

DRAWN BY:

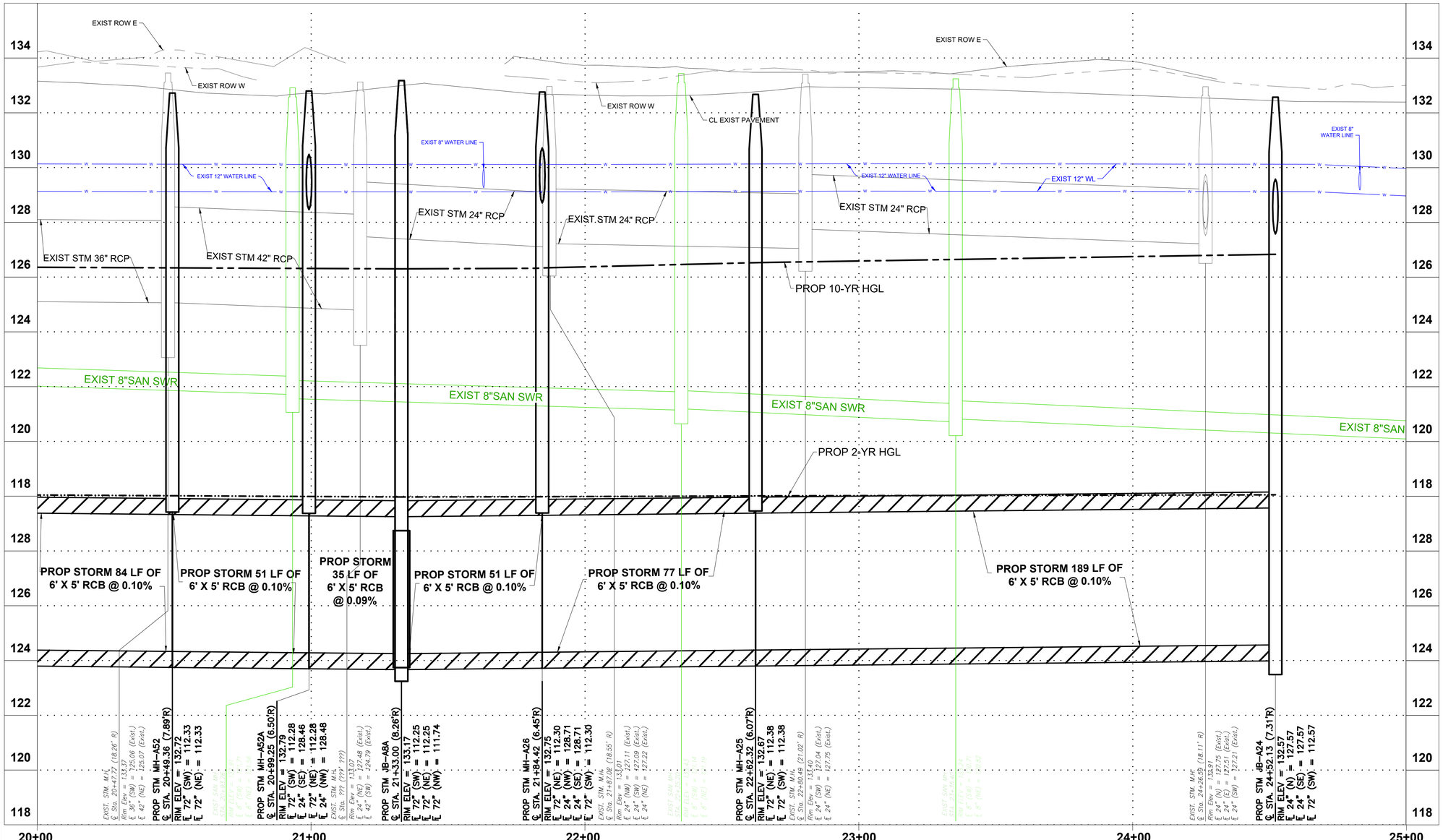
DATE: **3/2/2022**

DESIGN BY:

SCALE:

SHEET NO: **83 OF 200**

J:\1904\2102\ACAD\SHEET FILES\60%\83 PLAN AND PROFILE - RAVENSWAY DR SHEET 7.dwg



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SCALE IN FEET

VERTICAL SCALE
0 2 4
SCALE IN FEET

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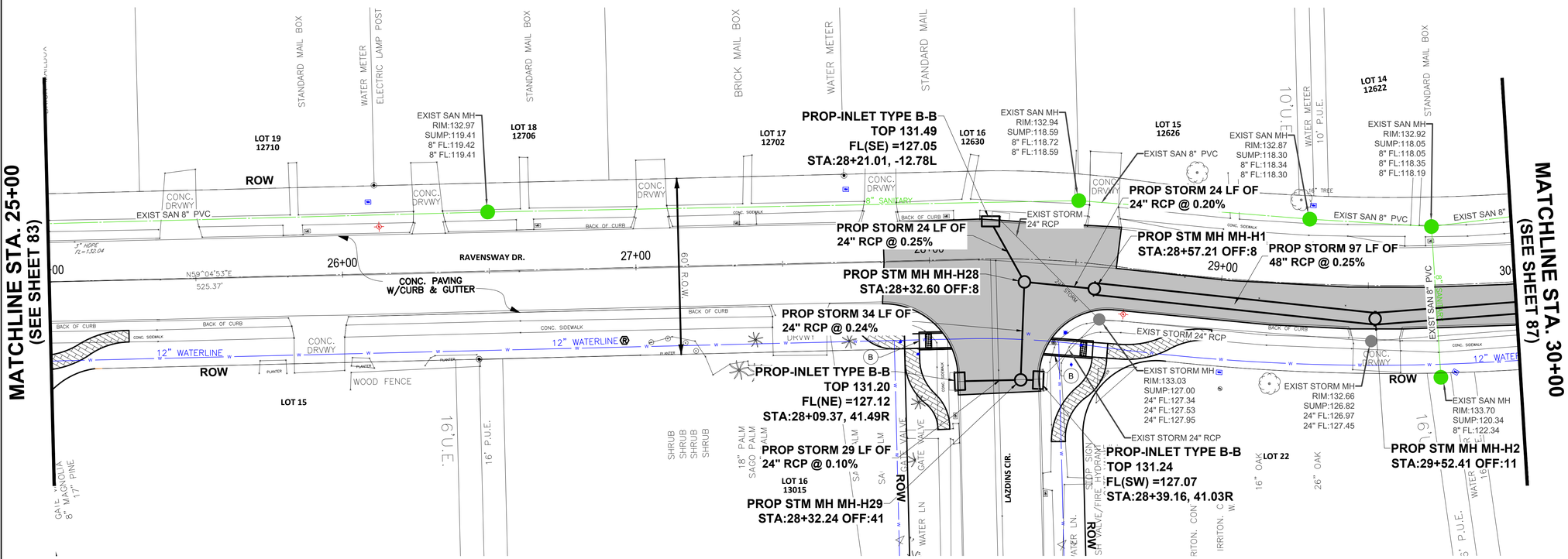
3/2/2022

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **PLAN AND PROFILE - RAVENSWAY DR SHEET 8**

DRAWN BY:
DATE: 3/2/2022
DESIGN BY:
SCALE:
SHEET NO: 84 OF 200

J:\1904\2102\ACAD\SHEET FILES\60%\84 PLAN AND PROFILE – RAVENSWAY DR SHEET 8.dwg



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SCALE IN FEET

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PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **PLAN AND PROFILE - RAVENSWAY DR SHEET 9**

DRAWN BY: | DATE: 3/2/2022

DESIGN BY: | SCALE: | SHEET NO: 85 OF 200

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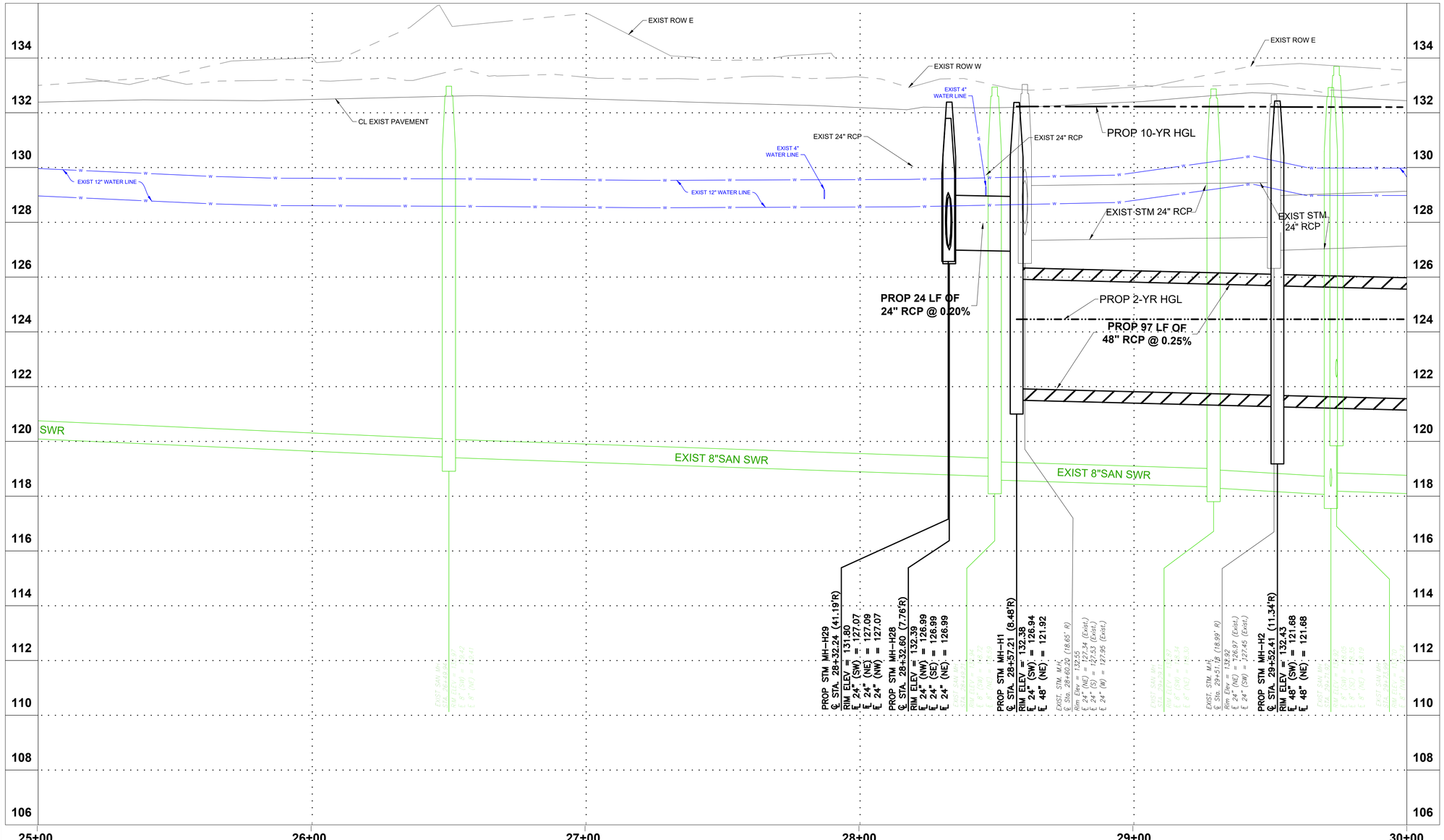

0 20 40
SCALE IN FEET

VERTICAL SCALE
0 2 4
SCALE IN FEET

J:\1904\2102\ACAD\SHEET FILES\60%\86 PLAN AND PROFILE - RAVENSWAY DR SHEET 10.dwg

NO.	REVISIONS	DATE	NAME

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PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **PLAN AND PROFILE - RAVENSWAY DR SHEET 10**

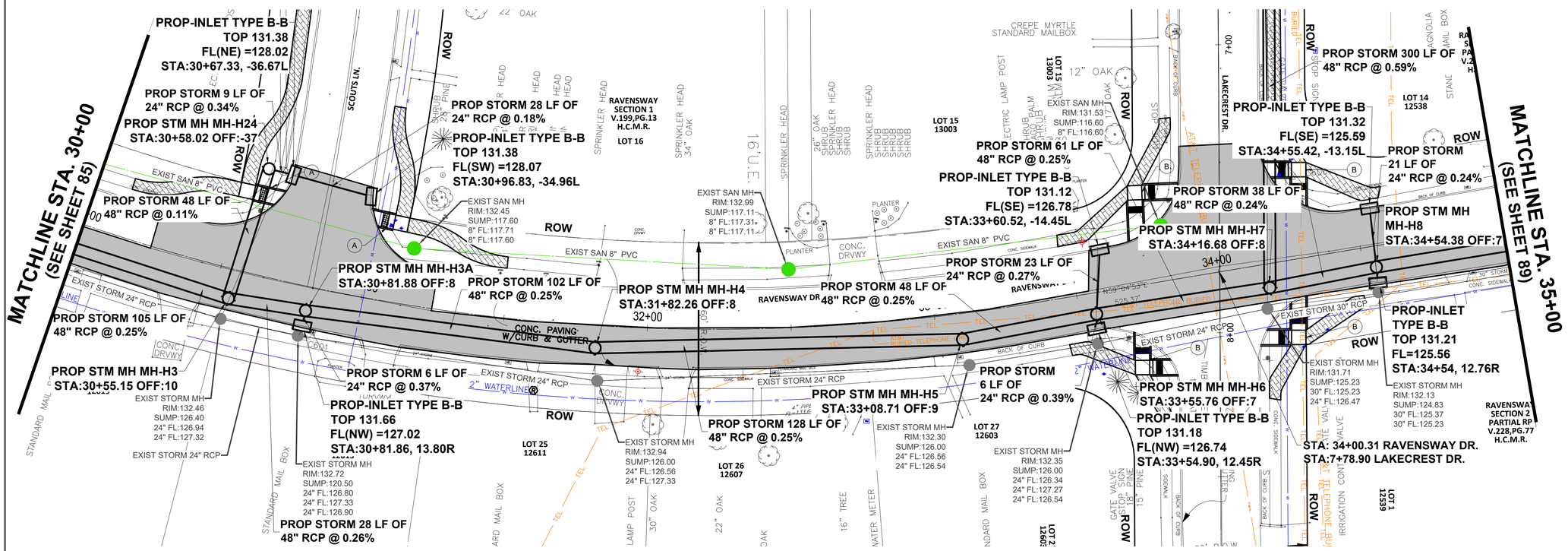
DRAWN BY:

DATE: 3/2/2022

DESIGN BY:

SCALE:

SHEET NO: 86 OF 200



PROPOSED PAVEMENT AND CURBS

PROPOSED 4.5" CONCRETE S/W TYPICAL

(A) ADA TYPE 7

(B) ADA TYPE 12

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0 20 40
SCALE IN FEET

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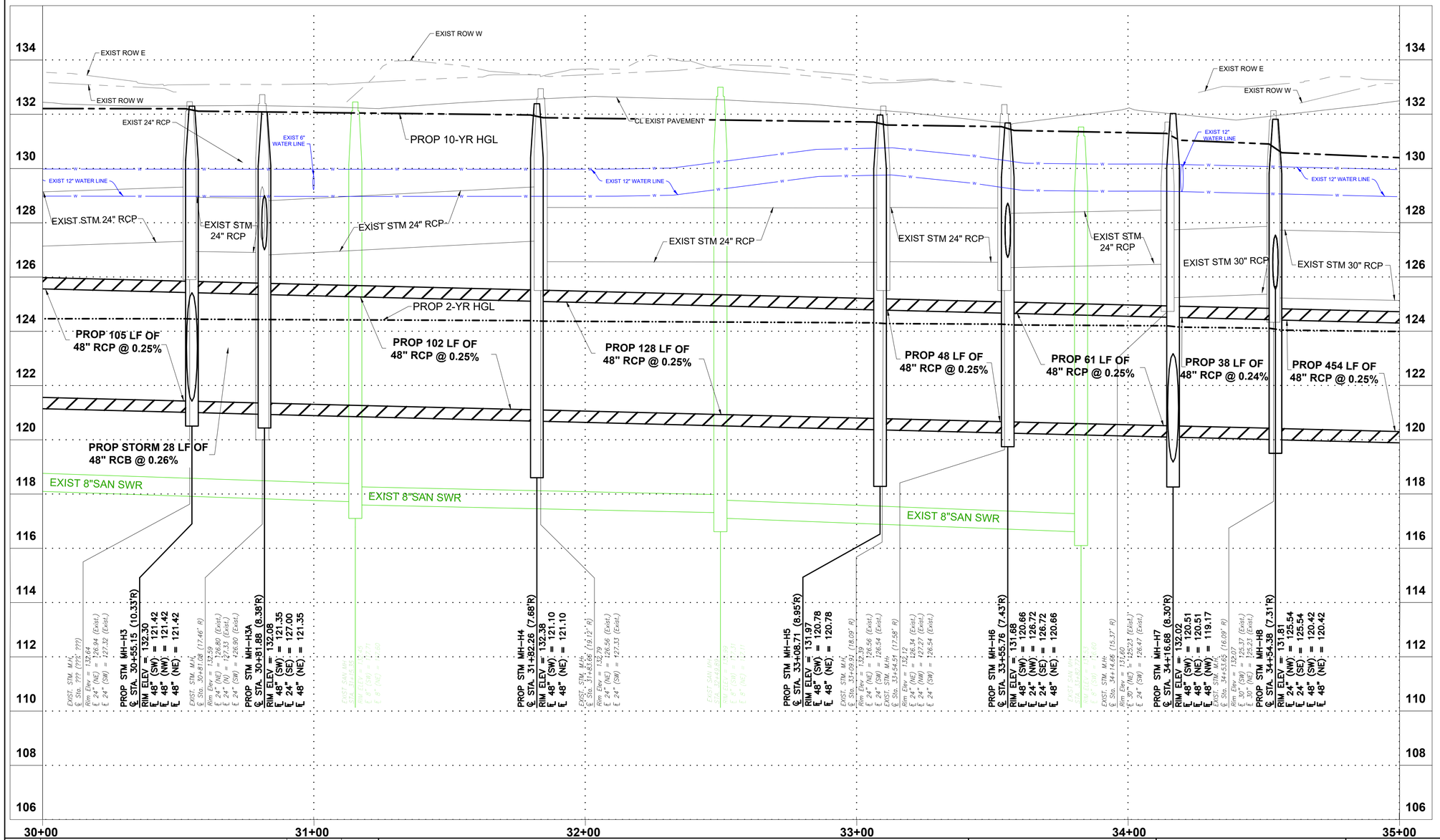
PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: PLAN AND PROFILE - RAVENSWAY DR SHEET 11

DRAWN BY: | DATE: 3/2/2022

DESIGN BY: | SCALE: | SHEET NO: 87 OF 200

J:\1904\2102\ACAD\SHEET FILES\60%\82 PLAN AND PROFILE - RAVENSWAY DR SHEET 11.dwg



0 20 40
SCALE IN FEET

VERTICAL SCALE
0 2 4
SCALE IN FEET

J:\1904\2102\ACAD\SHEET FILES\60%\88 PLAN AND PROFILE - RAVENSWAY DR SHEET 12.dwg

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY
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3/2/2022

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **PLAN AND PROFILE - RAVENSWAY DR SHEET 12**

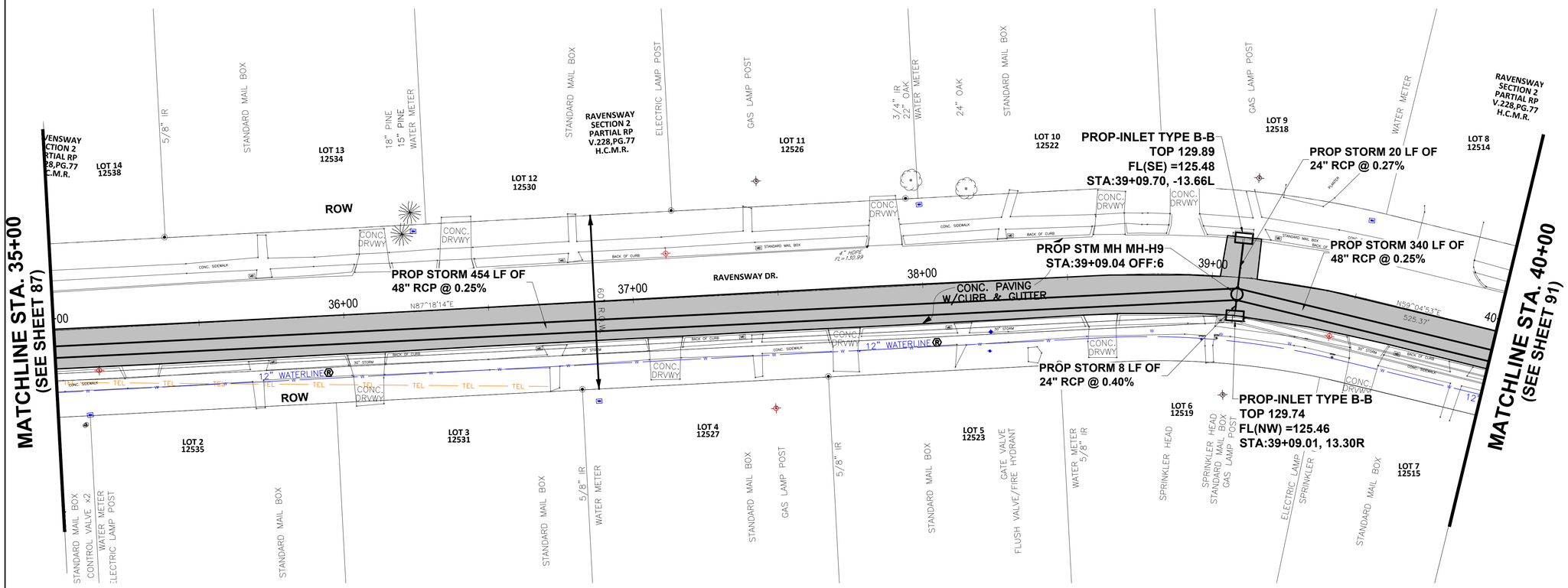
DRAWN BY:

DATE: **3/2/2022**

DESIGN BY:

SCALE:

SHEET NO: **88 OF 200**



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0 20 40
SCALE IN FEET

NO.	REVISIONS	DATE	NAME

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PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **PLAN AND PROFILE - RAVENSWAY DR SHEET 13**

DRAWN BY: | DATE: **3/2/2022**

DESIGN BY: | SCALE: | SHEET NO: **89 OF 200**

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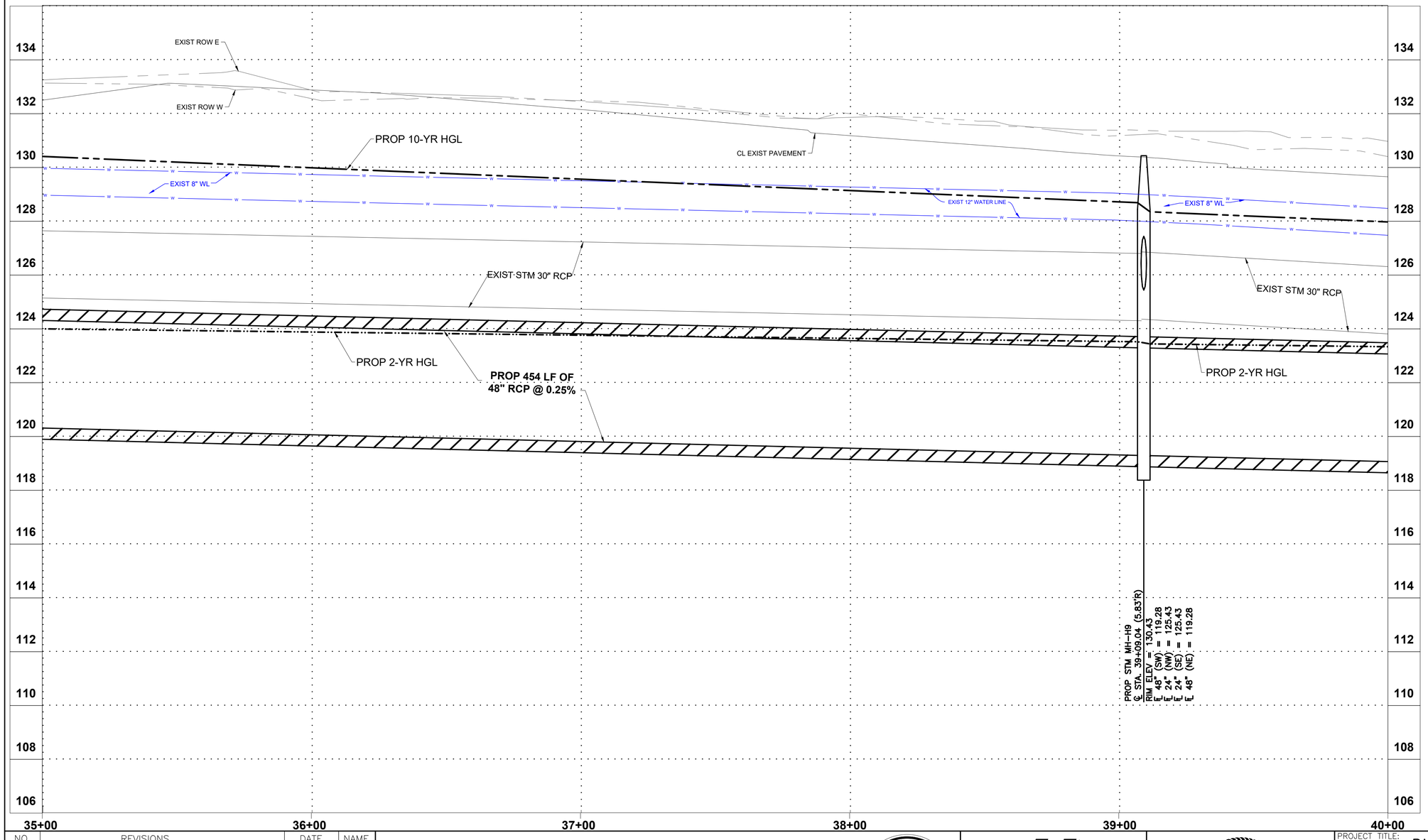

0 20 40
SCALE IN FEET

VERTICAL SCALE
0 2 4
SCALE IN FEET

NO.	REVISIONS	DATE	NAME

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3/2/2022

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **PLAN AND PROFILE - RAVENSWAY DR SHEET 14**

DRAWN BY:
DATE: 3/2/2022
DESIGN BY:
SCALE:
SHEET NO: 90 OF 200

J:\1904\2102\ACAD\SHEET FILES\60%\90 PLAN AND PROFILE - RAVENSWAY DR SHEET 14.dwg

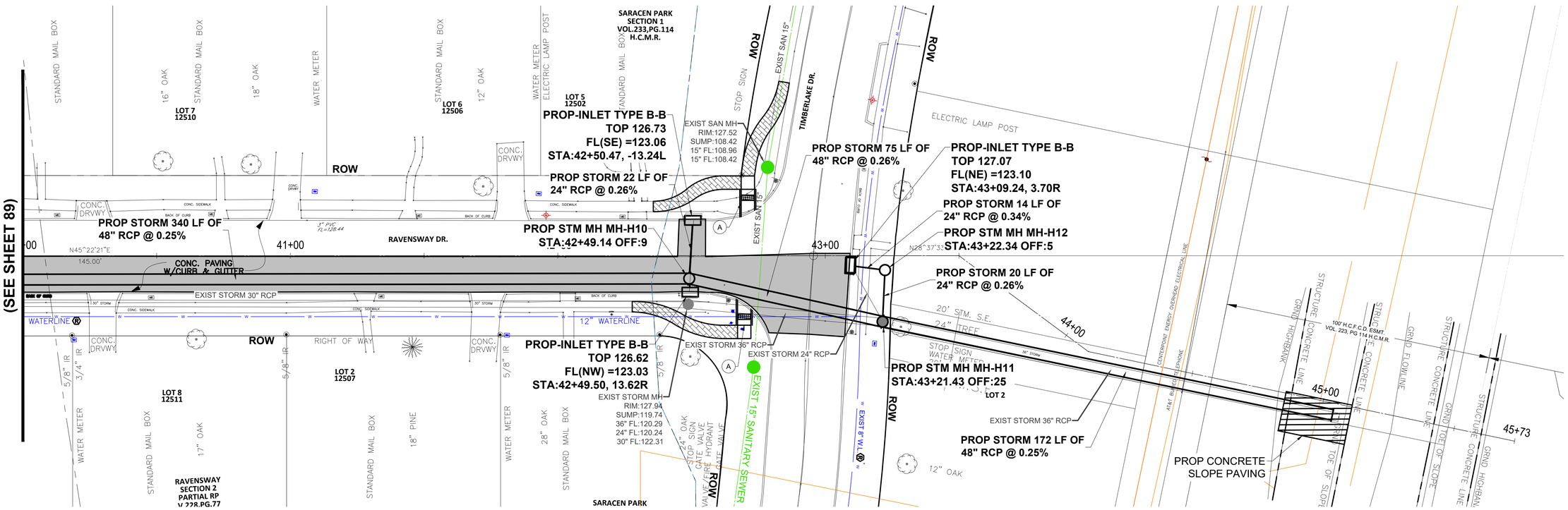
***CONSTRUCTION IN HARRIS COUNTY FLOOD CONTROL DISTRICT RIGHT-OF-WAY REQUIRES:**

1.) HCFCD RIGHT-OF-WAY NOTIFICATION (PERMIT)
2.) HCFCD 48-HR PRE-CONSTRUCTION NOTIFICATION

BOTH ARE REQUIRED PRIOR TO ENTERING OR WORKING WITHIN HARRIS COUNTY FLOOD CONTROL DISTRICT RIGHT-OF-WAY. BOTH THE HCFCD RIGHT-OF-WAY NOTIFICATION AND 48-HOUR NOTIFICATION MUST BE PROVIDED TO HCFCD AT dcid@hcfcd.org. SITE PLANS MUST BE APPROVED PRIOR TO OBTAINING THE REQUIRED HCFCD RIGHT-OF-WAY NOTIFICATION. BE ADVISED THAT THE HCFCD RIGHT-OF-WAY NOTIFICATION IS SEPARATE FROM THE SITE DEVELOPMENT PERMIT PACKAGE.

TO APPLY FOR THE HCFCD RIGHT-OF-WAY NOTIFICATION PLEASE GO TO http://apps.harriscountytx.gov/EPermits AND APPLY FOR THE HCFCD ROW UNDER ROW NOTIFICATION.

FAILURE TO PROVIDE BOTH ITEMS COULD RESULT IN DELAYS AND ADDITIONAL CONSTRUCTION COSTS.



PROPOSED PAVEMENT AND CURBS

PROPOSED 4.5" CONCRETE S/W TYPICAL

(A) ADA TYPE 7

NOTES:

1. FOR LIMITS OF PAVEMENT REPAIR, CONTRACTOR SHALL GO TO NEAREST JOINT TO DOWEL IN AND IF JOINT IS BEYOND 10', CONTRACTOR SHALL SET NEW JOINT AS LIMITS SHOWN ON PLANS.
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SCALE IN FEET

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3/2/2022

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **PLAN AND PROFILE - RAVENSWAY DR SHEET 15**

DRAWN BY: | DATE: 3/2/2022

DESIGN BY: | SCALE: | SHEET NO: 91 OF 200

J:\1904\2102\ACAD\SHEET FILES\60%\91 PLAN AND PROFILE – RAVENSWAY DR SHEET 15.dwg

***CONSTRUCTION IN HARRIS COUNTY FLOOD CONTROL DISTRICT RIGHT-OF-WAY REQUIRES:**

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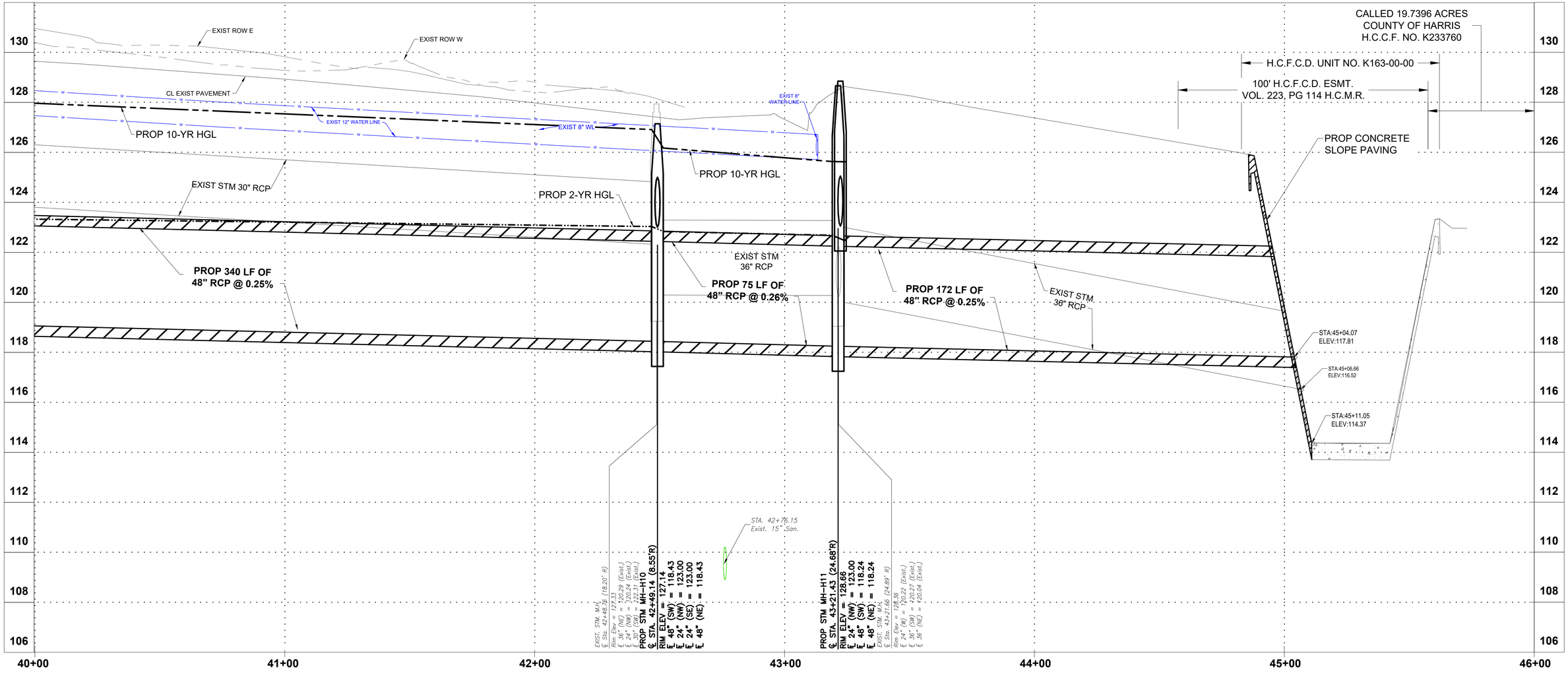

J:\1904\2102\ACAD\SHEET FILES\60%\92 PLAN AND PROFILE - RAVENSWAY DR SHEET 16.dwg

NO.	REVISIONS	DATE	NAME

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3/2/2022

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **PLAN AND PROFILE - RAVENSWAY DR SHEET 16**

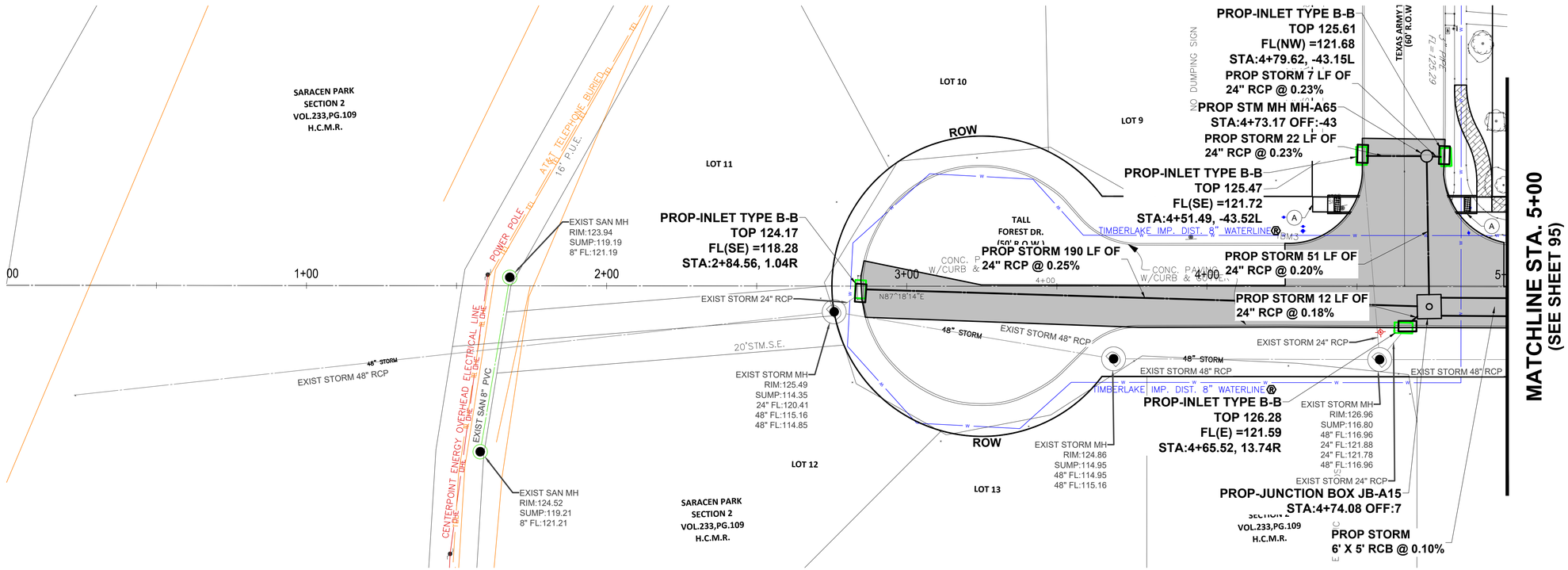
DRAWN BY:

DATE: **3/2/2022**

DESIGN BY:

SCALE:

SHEET NO: **92 OF 200**



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SCALE IN FEET

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3/2/2022

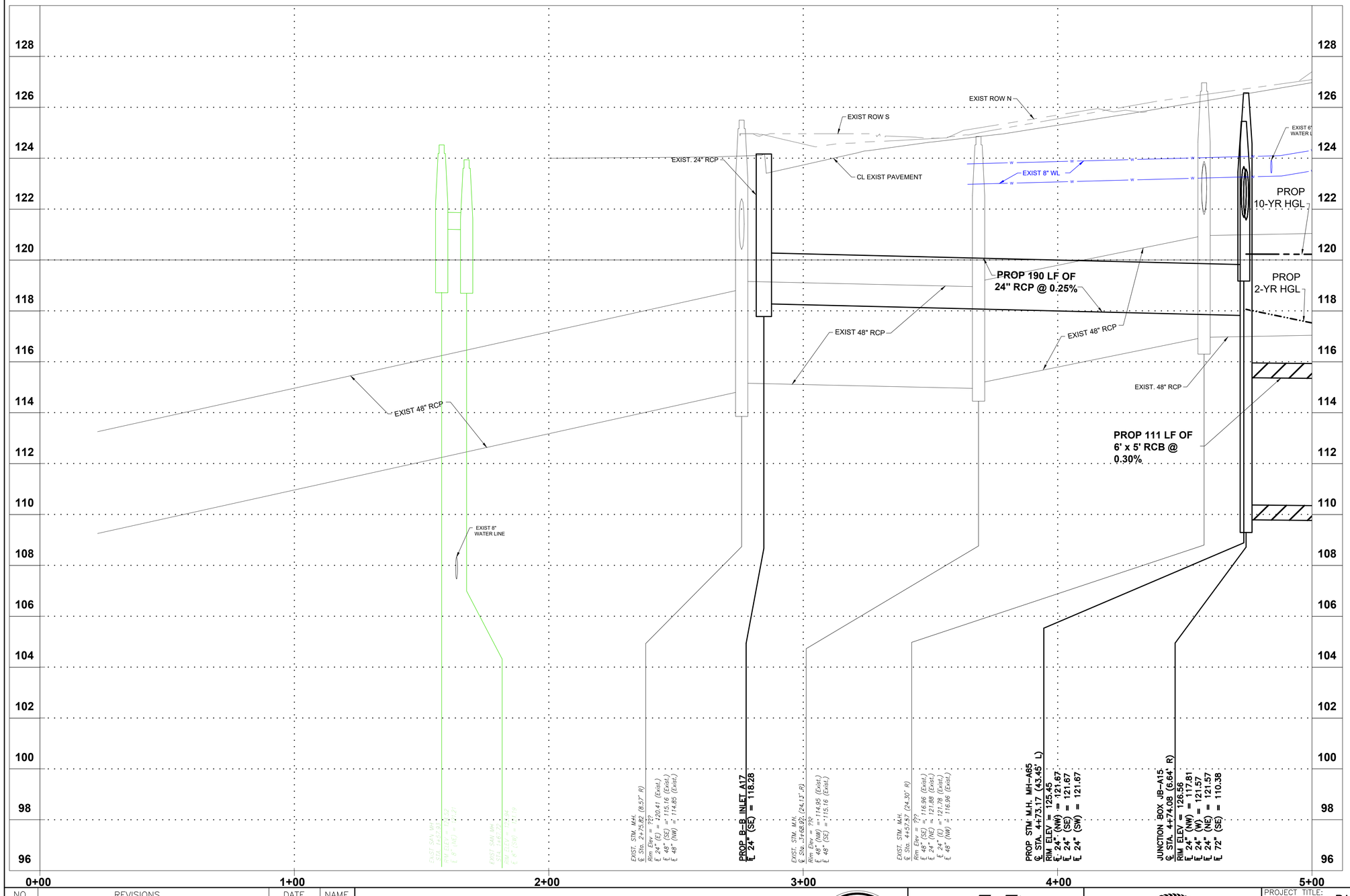
PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: PLAN AND PROFILE - TALL FOREST DR SHEET 1

DRAWN BY: | DATE: 3/2/2022

DESIGN BY: | SCALE: | SHEET NO: 93 OF 200

J:\1904\2102\ACAD\SHEET FILES\60%\93 PLAN AND PROFILE – TALL FOREST DR SHEET 1.dwg



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SCALE IN FEET

VERTICAL SCALE
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SCALE IN FEET

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY
ENGINEERING DEPARTMENT

HARRIS COUNTY 1836 TEXAS

LJA Engineering, Inc.
3600 W Sam Houston Pkwy S, Suite 600
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Phone: 713.953.5200 Fax: 713.953.5026
FIRM REGISTRATION No. F-1386
www.LJAengineering.com

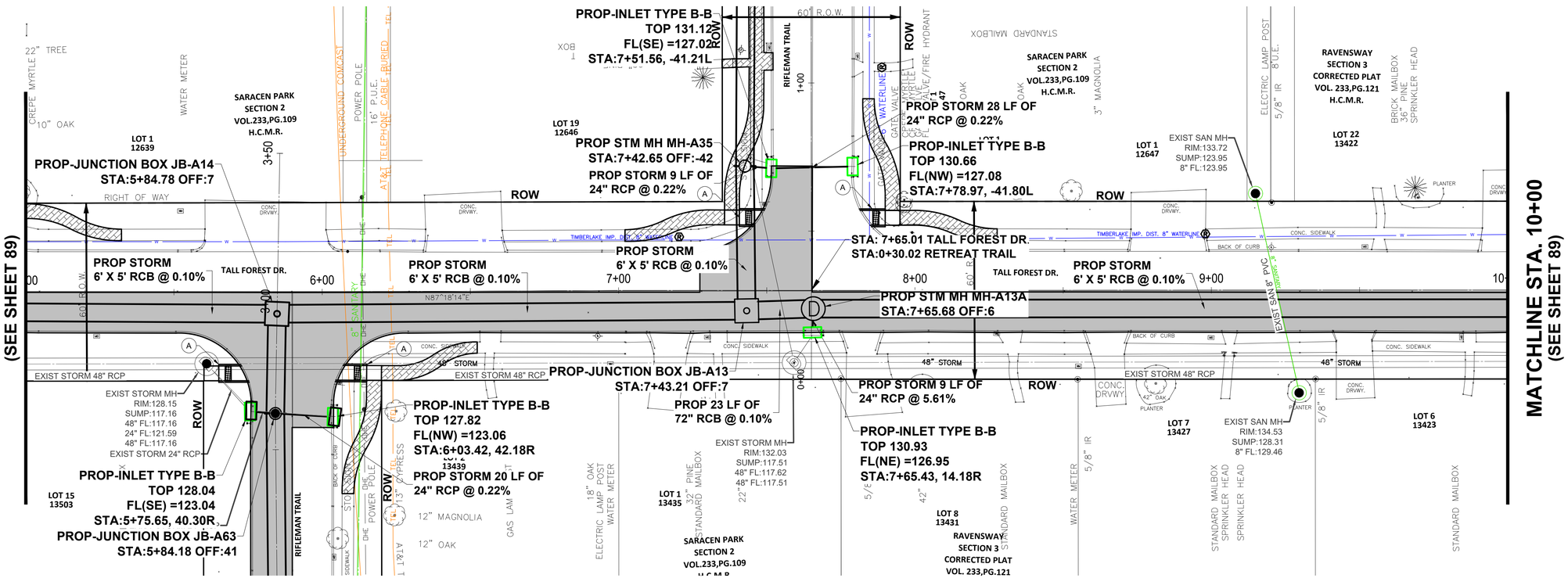
STATE OF TEXAS
ISAAC MUÑIZ
125839
LICENSED PROFESSIONAL ENGINEER
3/3/2022

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **PLAN AND PROFILE - TALL FOREST DR SHEET 2**

DRAWN BY:
DATE: 3/3/2022
DESIGN BY:
SCALE:
SHEET NO: 94 OF 200

J:\1904\2102\ACAD\SHEET FILES\60%\94 PLAN AND PROFILE - TALL FOREST DR SHEET 2.dwg



NOTES:

1. FOR LIMITS OF PAVEMENT REPAIR, CONTRACTOR SHALL GO TO NEAREST JOINT TO DOWEL IN AND IF JOINT IS BEYOND 10', CONTRACTOR SHALL SET NEW JOINT AS LIMITS SHOWN ON PLANS.
2. THE LOCATION OF EXISTING WATER LINE WAS BASED ON RECORD DRAWINGS PROVIDED BY TIMBERLAKE MUNICIPAL UTILITY DISTRICT.
3. CONTRACTOR SHALL REPLACE CURB DRAINS DAMAGED DURING CONSTRUCTION OF PROPOSED STORM SEWER LINE AND PAVEMENT REPLACEMENT, INCIDENTAL TO STORM SEWER PAY ITEM

0 20 40
SCALE IN FEET

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STATE OF TEXAS
ISAAC MUÑIZ
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PROFESSIONAL ENGINEER
3/2/2022

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: PLAN AND PROFILE - TALL FOREST DR SHEET 3

DRAWN BY:
DATE: 3/2/2022
DESIGN BY:
SCALE:
SHEET NO: 95 OF 200

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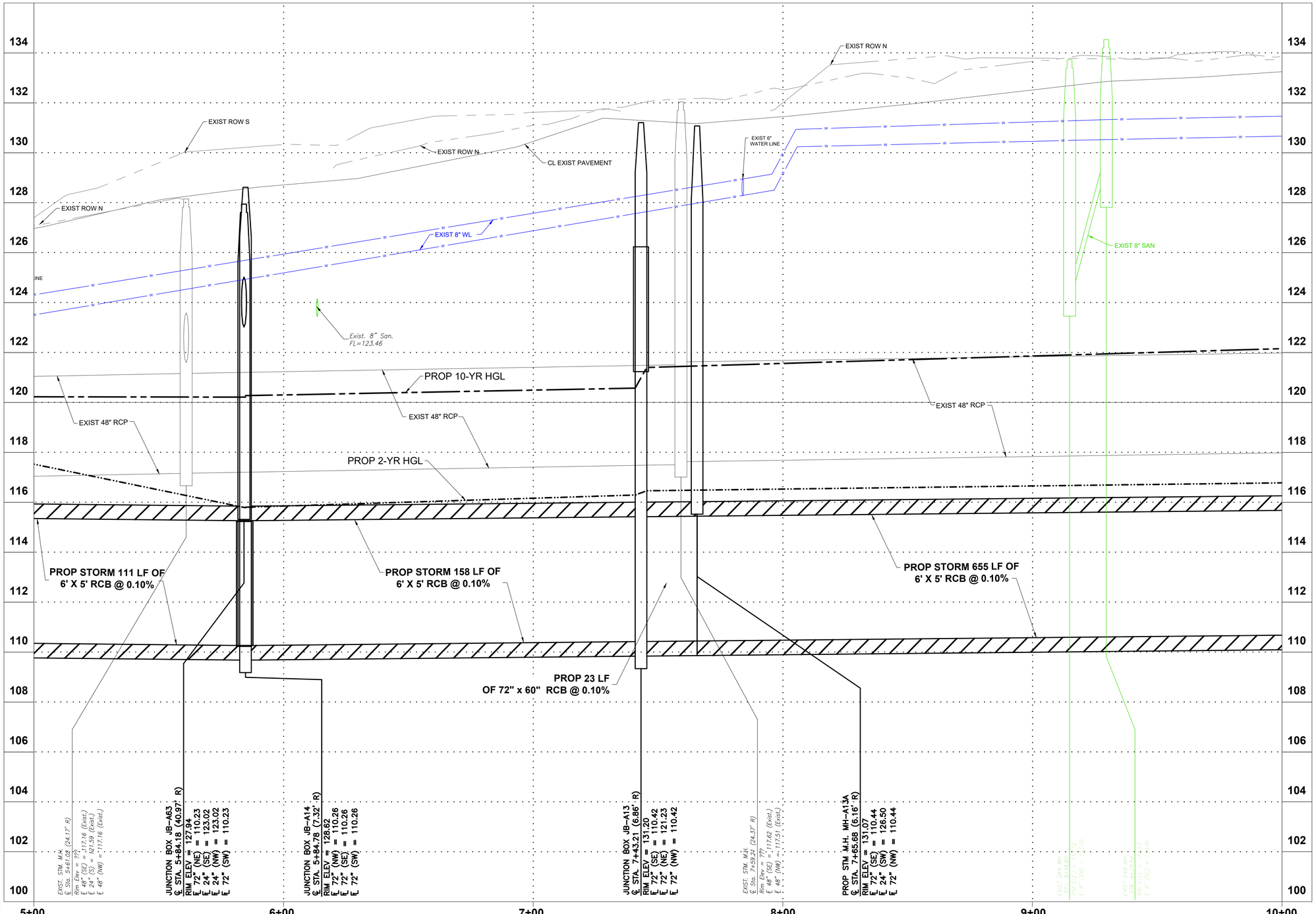

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0 20 40
SCALE IN FEET

VERTICAL SCALE
0 2 4
SCALE IN FEET

J:\1904\2102\ACAD\SHEET FILES\60%\96 PLAN AND PROFILE - TALL FOREST DR SHEET 4.dwg

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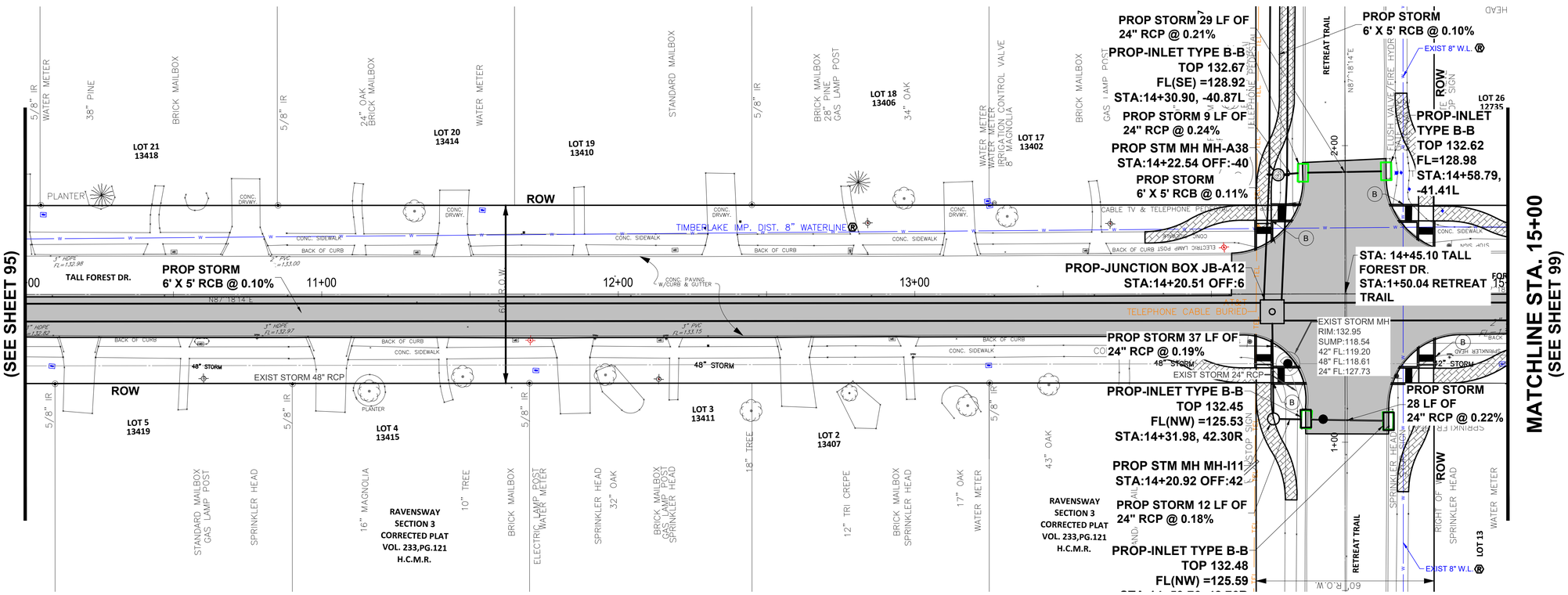
3/3/2022

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **PLAN AND PROFILE - TALL FOREST DR SHEET 4**

DRAWN BY:
DATE: **3/3/2022**
DESIGN BY:
SCALE:
SHEET NO: **96 OF 200**



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SCALE IN FEET

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3/2/2022

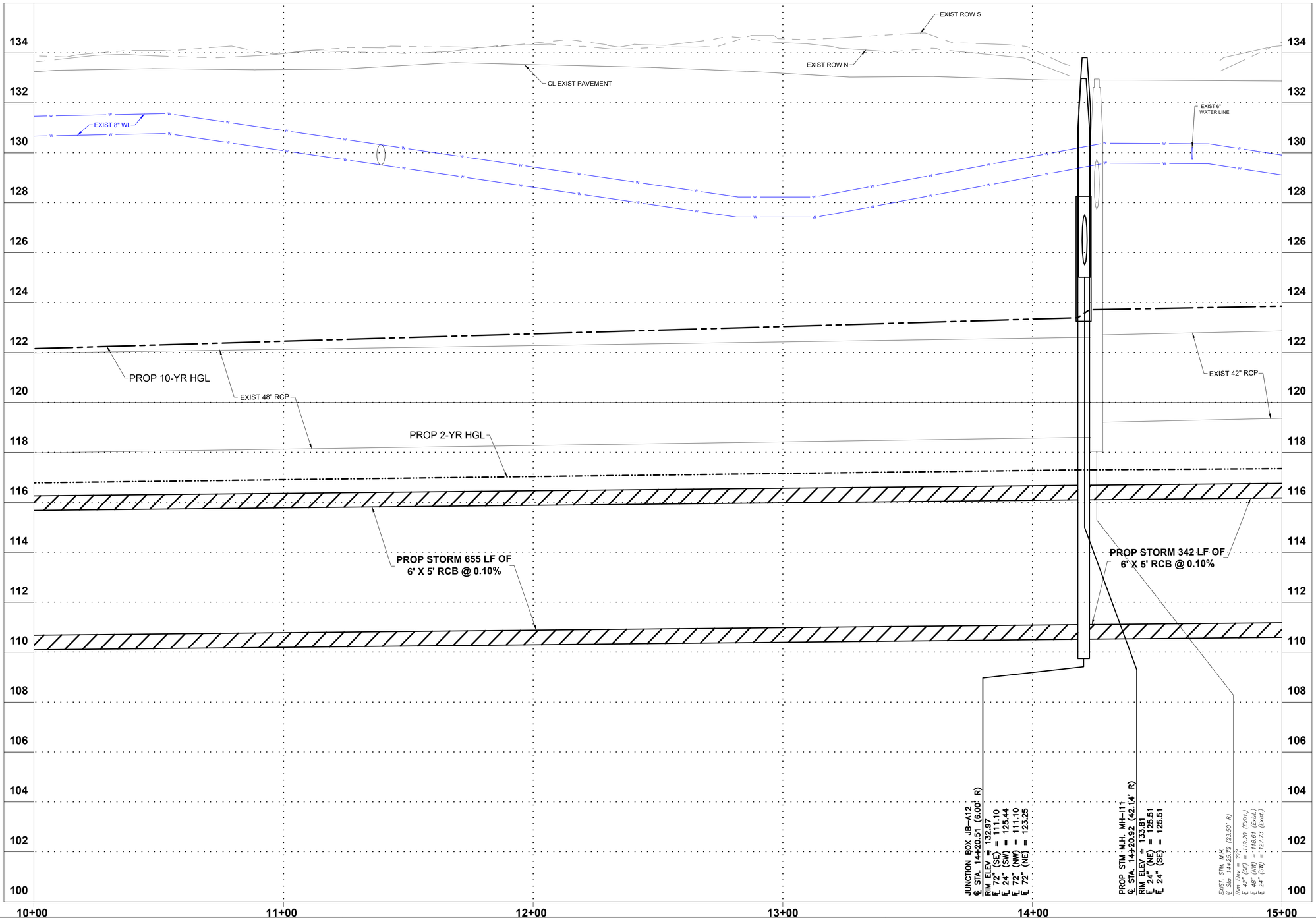
PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **PLAN AND PROFILE - TALL FOREST DR SHEET 5**

DRAWN BY: | DATE: 3/2/2022

DESIGN BY: | SCALE: | SHEET NO: 97 OF 200

J:\1904\2102\ACAD\SHEET FILES\60%\97 PLAN AND PROFILE – TALL FOREST DR SHEET 5.dwg



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0 20 40
SCALE IN FEET

VERTICAL SCALE
0 2 4
SCALE IN FEET

NO.	REVISIONS	DATE	NAME

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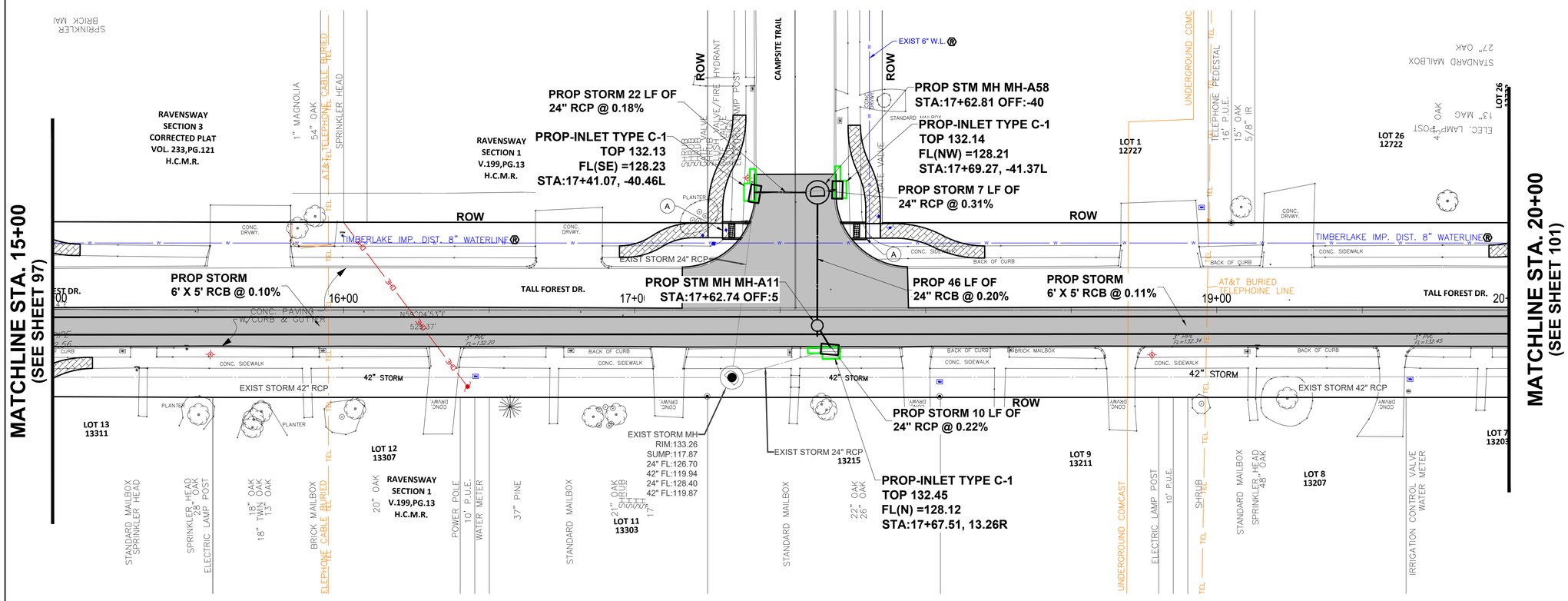
3/3/2022

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **PLAN AND PROFILE - TALL FOREST DR SHEET 6**

DRAWN BY:
DATE: 3/3/2022
DESIGN BY:
SCALE:
SHEET NO: 98 OF 200

J:\1904\2102\ACAD\SHEET FILES\60%\98 PLAN AND PROFILE – TALL FOREST DR SHEET 6.dwg



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0 20 40
SCALE IN FEET

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3/2/2022

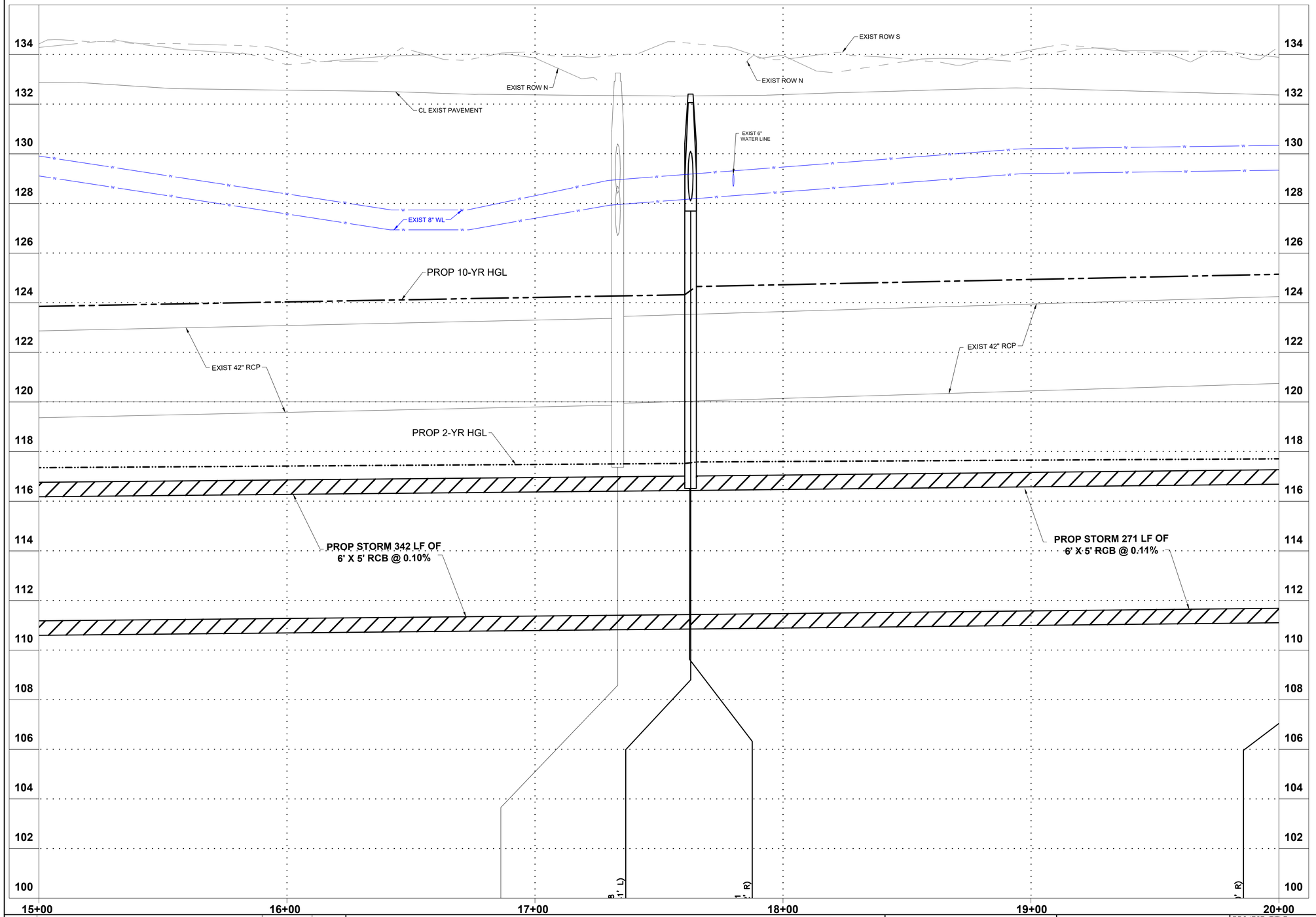
PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: PLAN AND PROFILE - TALL FOREST DR SHEET 7

DRAWN BY: | DATE: 3/2/2022

DESIGN BY: | SCALE: | SHEET NO: 99 OF 200

J:\1904\2102\ACAD\SHEET FILES\60%\99 PLAN AND PROFILE – TALL FOREST DR SHEET 7.dwg



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0 20 40
SCALE IN FEET

VERTICAL SCALE
0 2 4
SCALE IN FEET

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3/3/2022

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **PLAN AND PROFILE - TALL FOREST DR SHEET 8**

DRAWN BY: | DATE: 3/3/2022

DESIGN BY: | SCALE: | SHEET NO: 100OF 200

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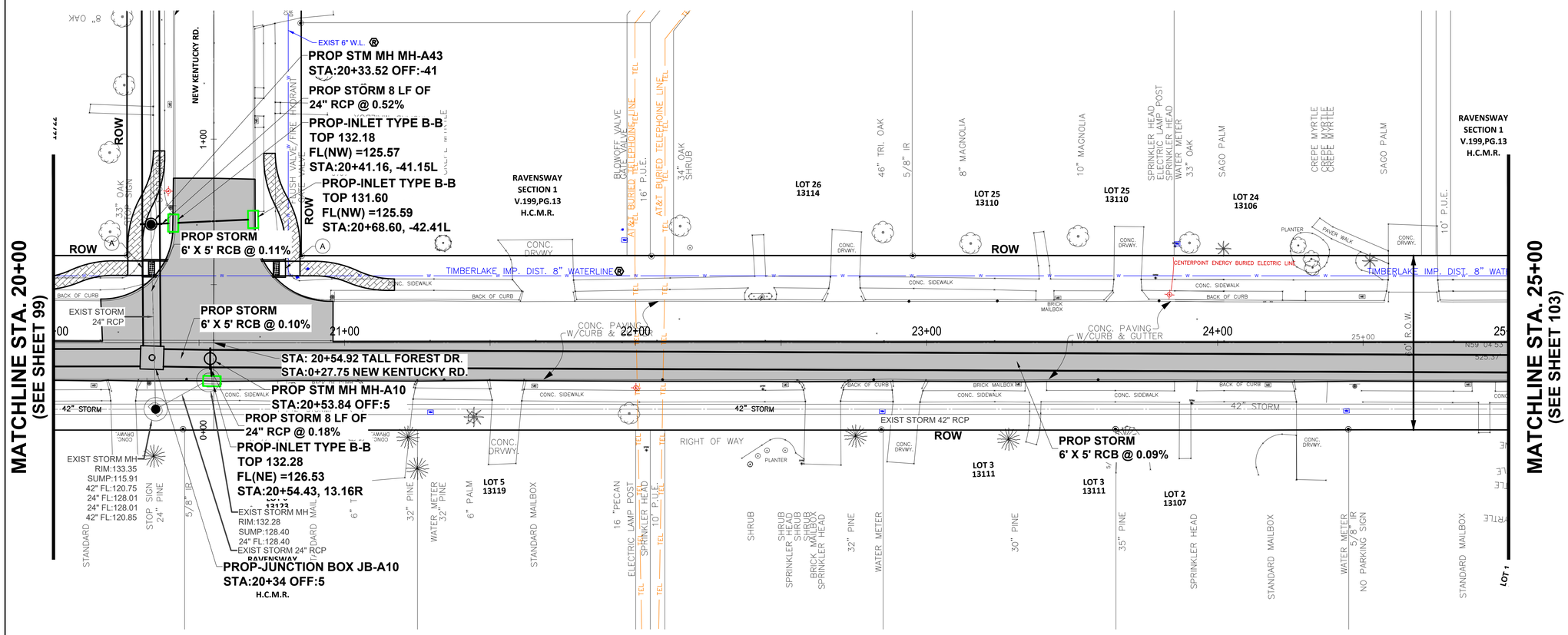

PROPOSED PAVEMENT AND CURBS

PROPOSED 4.5" CONCRETE S/W TYPICAL

(A) ADA TYPE 7

NOTES:

1. FOR LIMITS OF PAVEMENT REPAIR, CONTRACTOR SHALL GO TO NEAREST JOINT TO DOWEL IN AND IF JOINT IS BEYOND 10', CONTRACTOR SHALL SET NEW JOINT AS LIMITS SHOWN ON PLANS.
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0 20 40
SCALE IN FEET

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY
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3/2/2022

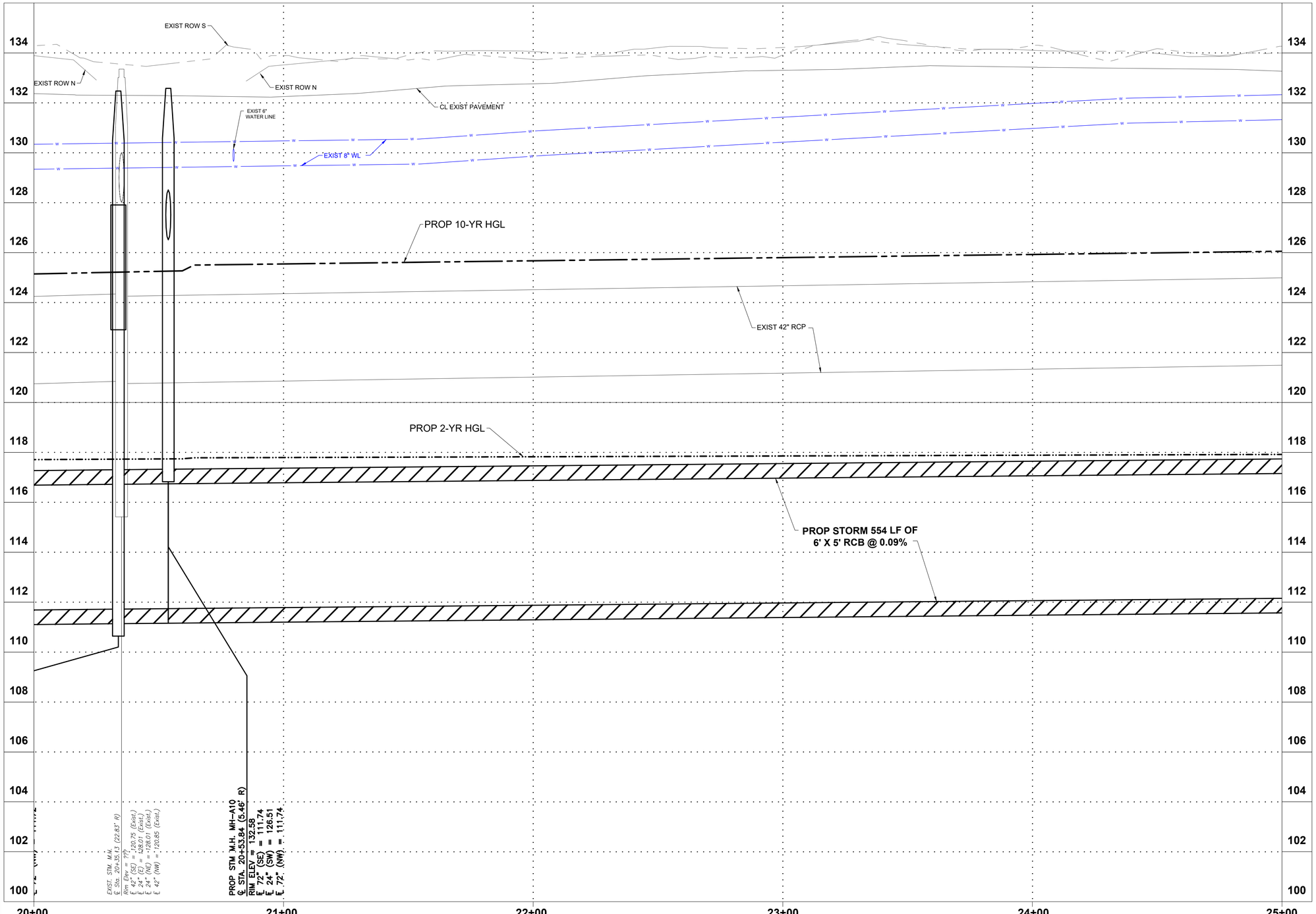
PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **PLAN AND PROFILE - TALL FOREST DR SHEET 9**

DRAWN BY: | DATE: 3/2/2022

DESIGN BY: | SCALE: | SHEET NO: 101OF 200

J:\1904\2102\ACAD\SHEET FILES\60%\101 PLAN AND PROFILE – TALL FOREST DR SHEET 9.dwg



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0 20 40
SCALE IN FEET

VERTICAL SCALE
0 2 4
SCALE IN FEET

J:\1904\2102\ACAD\SHEET FILES\60%\102 PLAN AND PROFILE - TALL FOREST DR SHEET 10.dwg

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY
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HARRIS COUNTY 1836 TEXAS

LJA Engineering, Inc.
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STATE OF TEXAS
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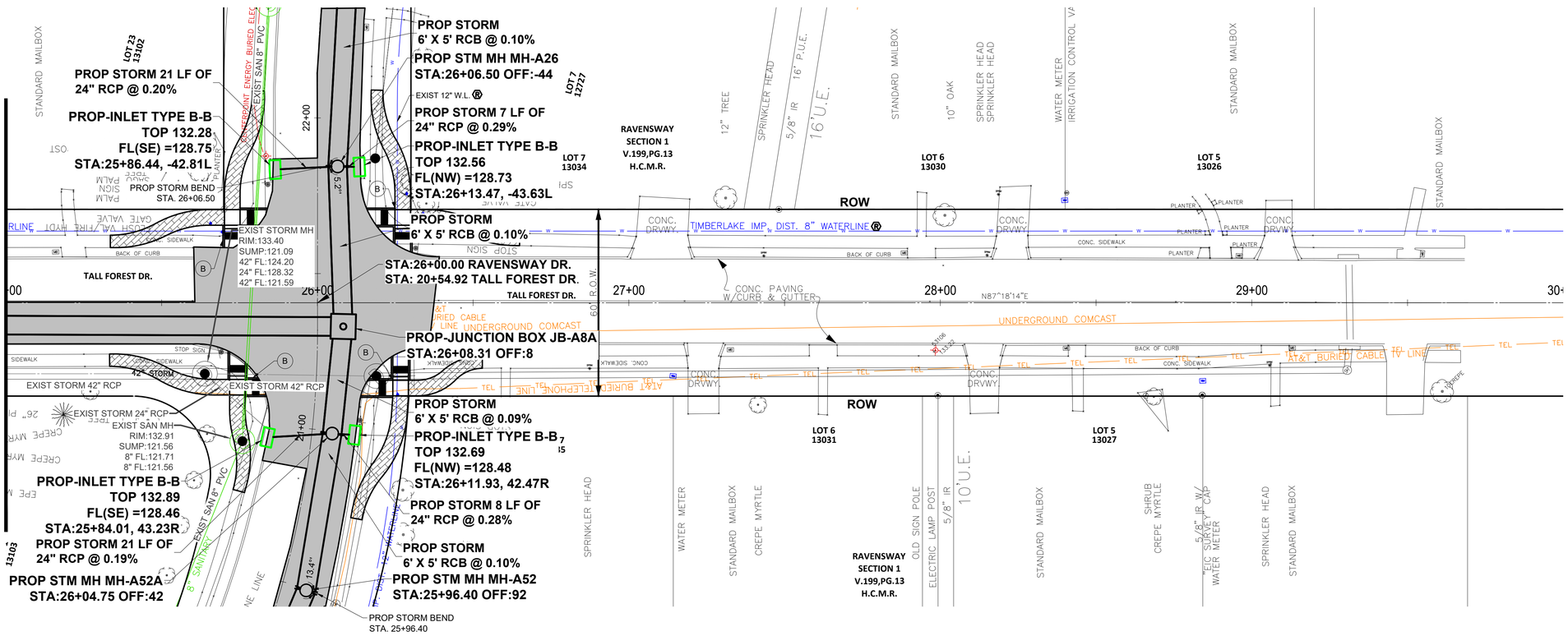
3/3/2022

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **PLAN AND PROFILE - TALL FOREST DR SHEET 10**

DRAWN BY:
DATE: 3/3/2022
DESIGN BY:
SCALE:
SHEET NO: 102OF 200



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0 20 40
SCALE IN FEET

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3/2/2022

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **PLAN AND PROFILE - TALL FOREST DR SHEET 11**

DRAWN BY: | DATE: 3/2/2022

DESIGN BY: | SCALE: | SHEET NO: 103OF 200

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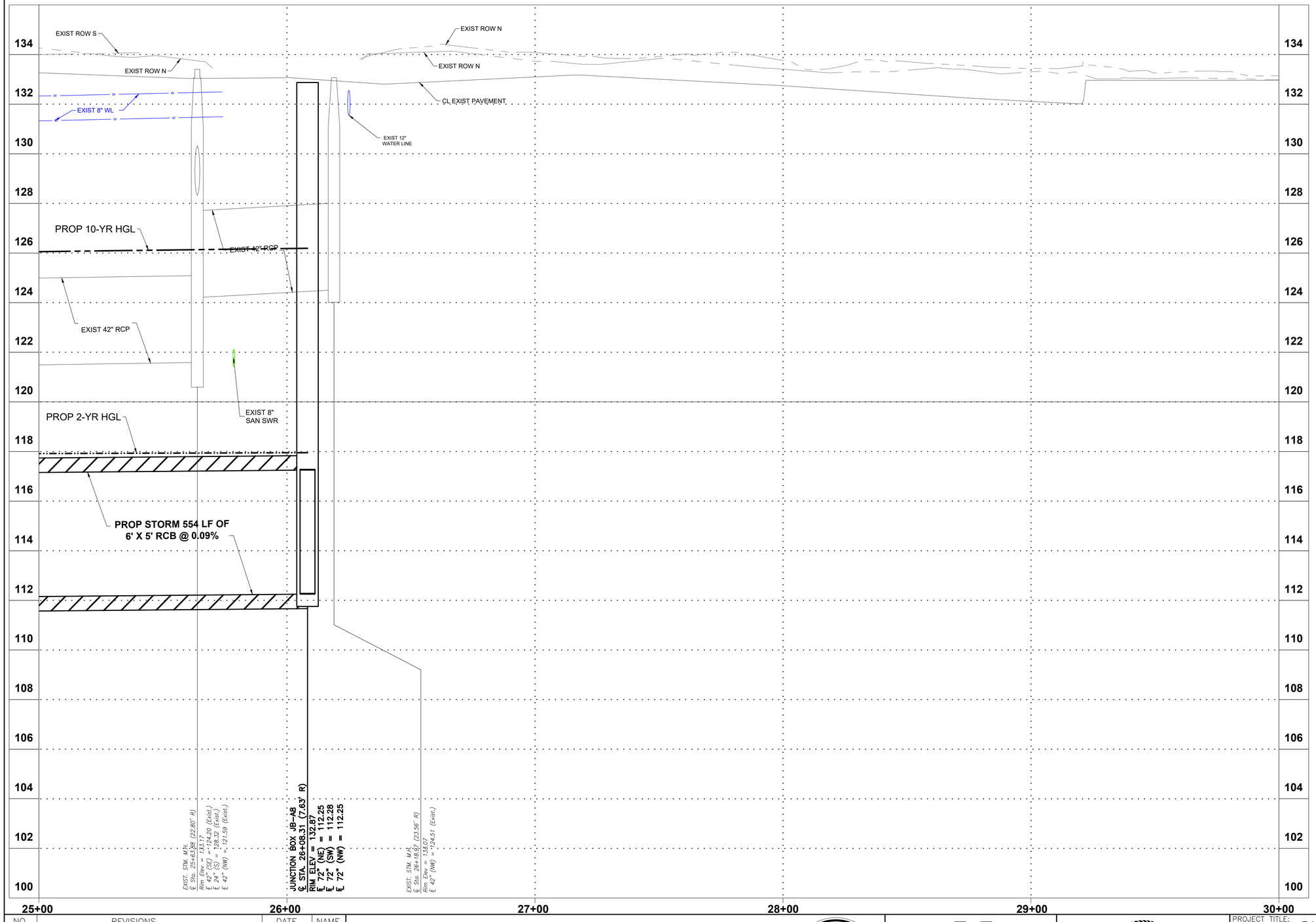

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0 20 40
SCALE IN FEET

VERTICAL SCALE
0 2 4
SCALE IN FEET

J:\1904\2102\ACAD\SHEET FILES\60%\104 PLAN AND PROFILE - TALL FOREST DR SHEET 12.dwg

NO.	REVISIONS	DATE	NAME

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STATE OF TEXAS
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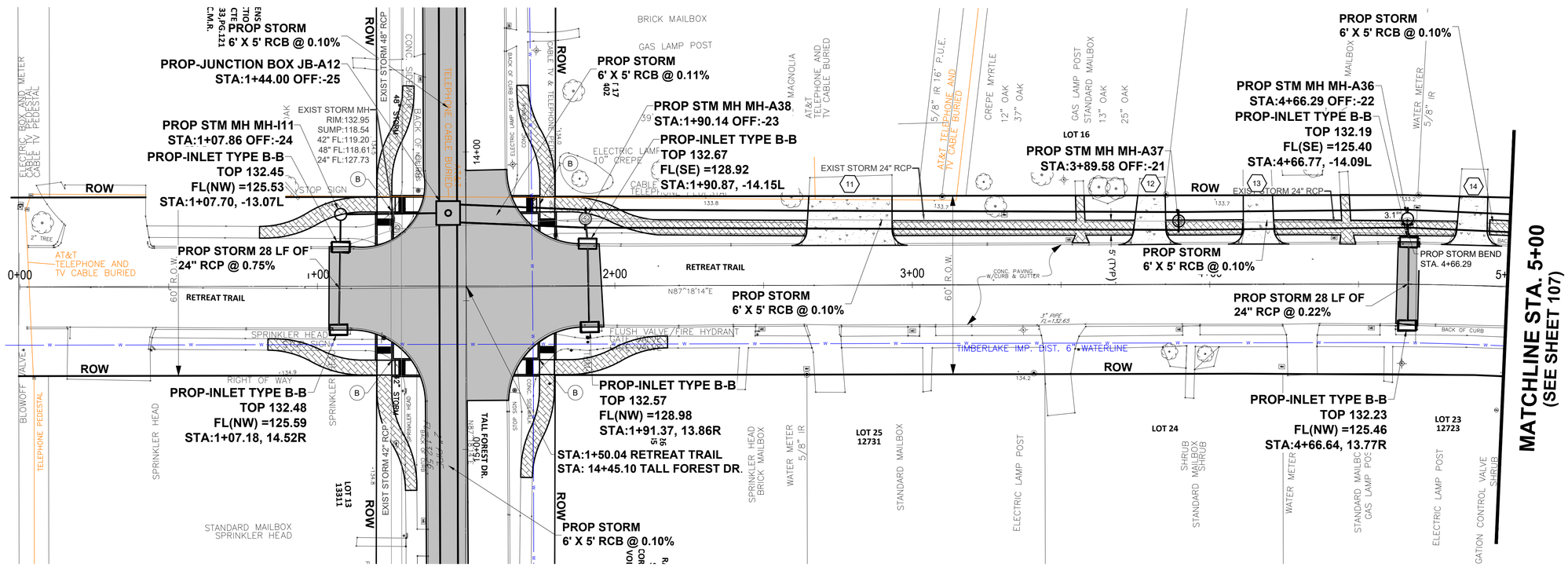
3/3/2022

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **PLAN AND PROFILE - TALL FOREST DR SHEET 12**

DRAWN BY: | DATE: **3/3/2022**

DESIGN BY: | SCALE: | SHEET NO: **104OF 200**



PROPOSED 4.5" CONCRETE S/W TYPICAL

PROPOSED DRIVEWAY

PROPOSED NEW PAVEMENT

(B) ADA TYPE 12

NOTES:

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0 20 40
SCALE IN FEET

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STATE OF TEXAS
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PROFESSIONAL ENGINEER
3/2/2022

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **PLAN AND PROFILE - RETREAT TRAIL SHEET 1**

DRAWN BY:

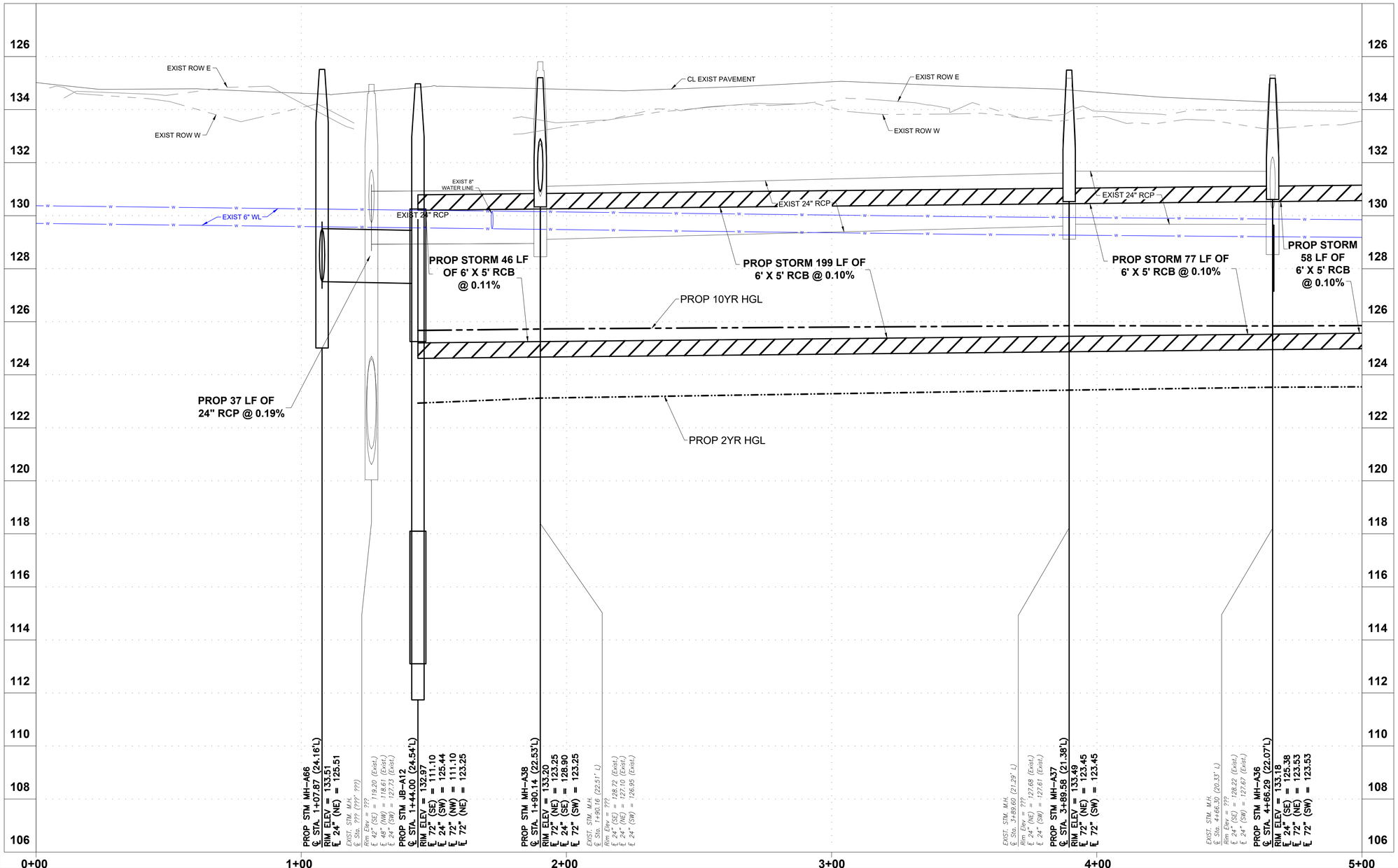
DATE: 3/2/2022

DESIGN BY:

SCALE:

SHEET NO: 105OF 200

J:\1904\2102\ACAD\SHEET FILES\60%\105 PLAN AND PROFILE - RETREAT TRAIL SHEET 1.dwg



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0 20 40
SCALE IN FEET

VERTICAL SCALE
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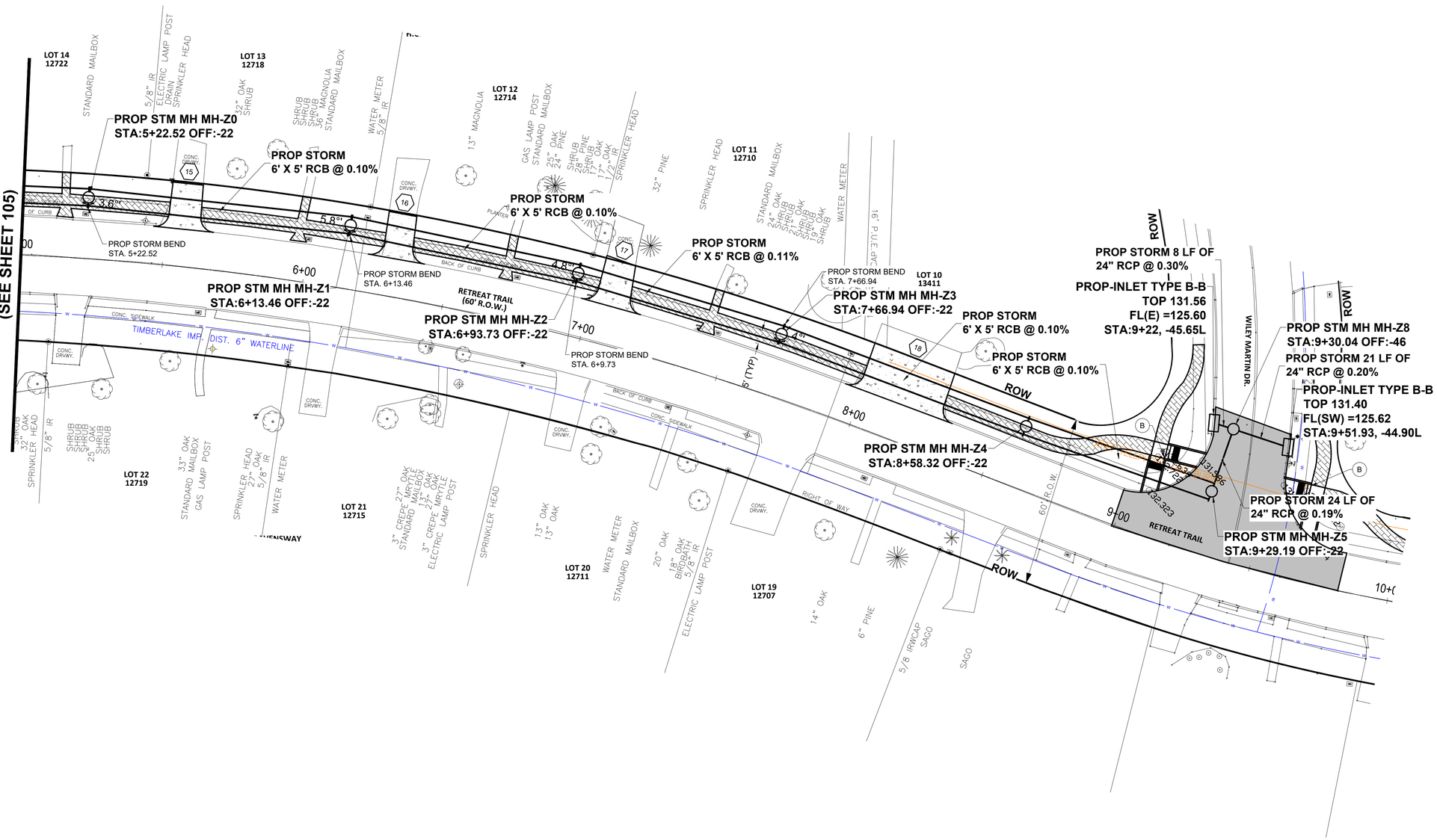
3/2/2022

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **PLAN AND PROFILE - RETREAT TRAIL SHEET 2**

DRAWN BY:
DATE: 3/2/2022
DESIGN BY:
SCALE:
SHEET NO: 106OF 200

J:\1904\2102\ACAD\SHEET FILES\60%\106 PLAN AND PROFILE - RETREAT TRAIL SHEET 2.dwg



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3/2/2022

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: PLAN AND PROFILE - RETREAT TRAIL SHEET 3

DRAWN BY:

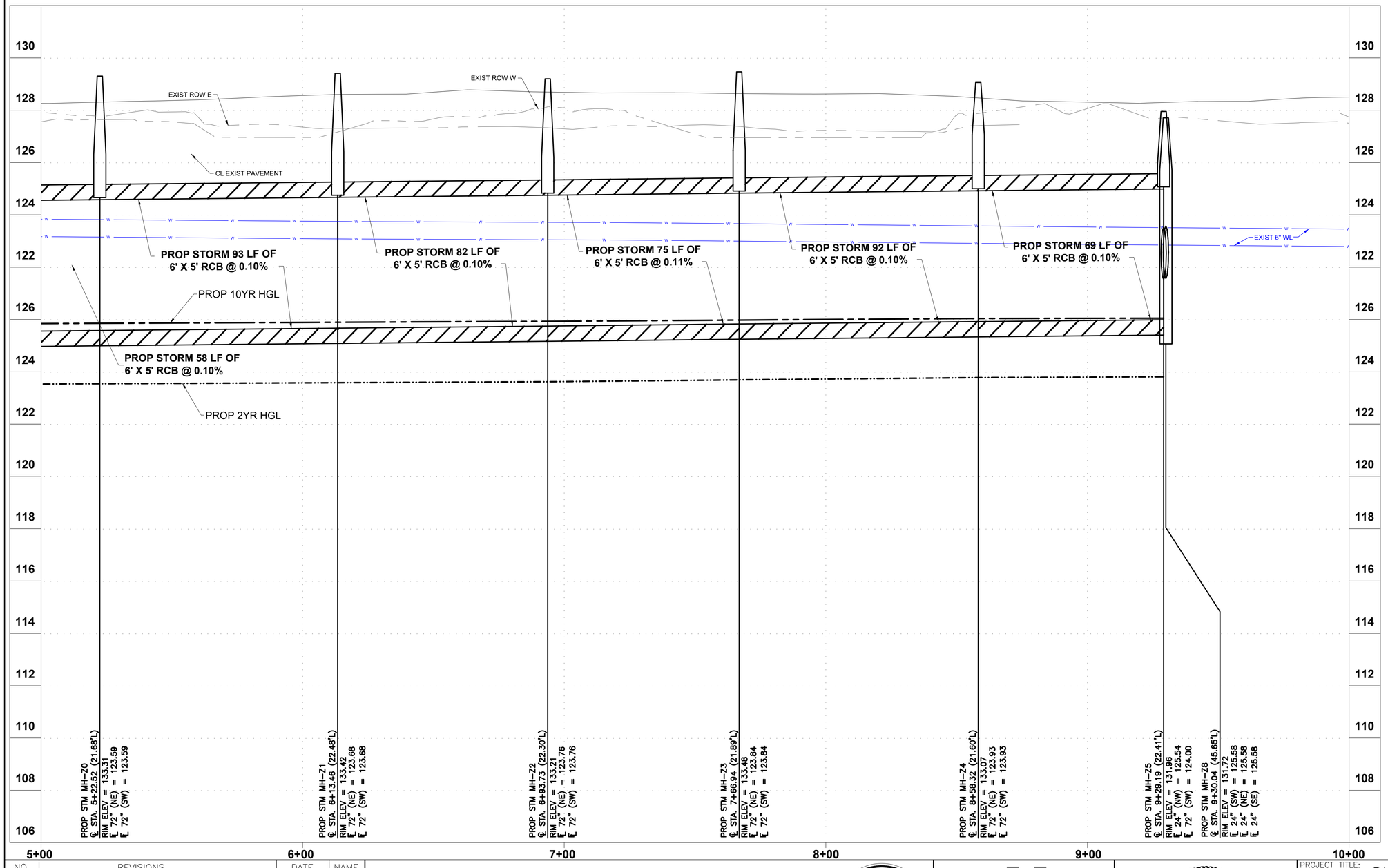
DATE: 3/2/2022

DESIGN BY:

SCALE:

SHEET NO: 107OF 200

J:\1904\2102\ACAD\SHEET FILES\60%\107 PLAN AND PROFILE – RETREAT TRAIL SHEET 3.dwg



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0 20 40
SCALE IN FEET

VERTICAL SCALE
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SCALE IN FEET

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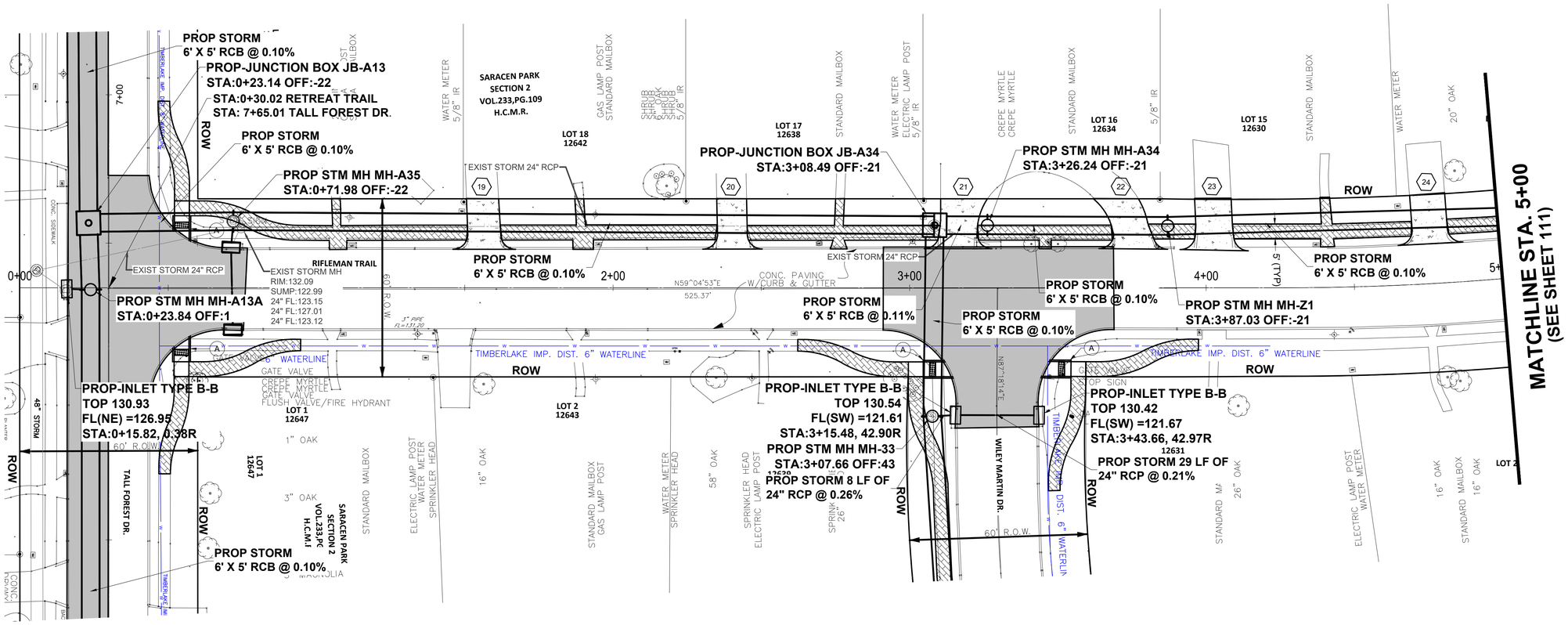
3/2/2022

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **PLAN AND PROFILE - RETREAT TRAIL SHEET 4**

DRAWN BY:
DATE: 3/2/2022
DESIGN BY:
SCALE:
SHEET NO: 108OF 200

J:\1904\2102\ACAD\SHEET FILES\60%\108 PLAN AND PROFILE - RETREAT TRAIL SHEET 4.dwg



NOTES:

1. FOR LIMITS OF PAVEMENT REPAIR, CONTRACTOR SHALL GO TO NEAREST JOINT TO DOWEL IN AND IF JOINT IS BEYOND 10', CONTRACTOR SHALL SET NEW JOINT AS LIMITS SHOWN ON PLANS.
2. THE LOCATION OF EXISTING WATER LINE WAS BASED ON RECORD DRAWINGS PROVIDED BY TIMBERLAKE MUNICIPAL UTILITY DISTRICT.
3. CONTRACTOR SHALL REPLACE CURB DRAINS DAMAGED DURING CONSTRUCTION OF PROPOSED STORM SEWER LINE AND PAVEMENT REPLACEMENT, INCIDENTAL TO STORM SEWER PAY ITEM

0 20 40
SCALE IN FEET

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY
ENGINEERING DEPARTMENT

HARRIS COUNTY 1836 TEXAS

LJA Engineering, Inc.
3600 W Sam Houston Pkwy S, Suite 600
Houston, TX 77042
Phone: 713.953.5200 Fax: 713.953.5026
FIRM REGISTRATION No. F-1386
www.LJAengineering.com

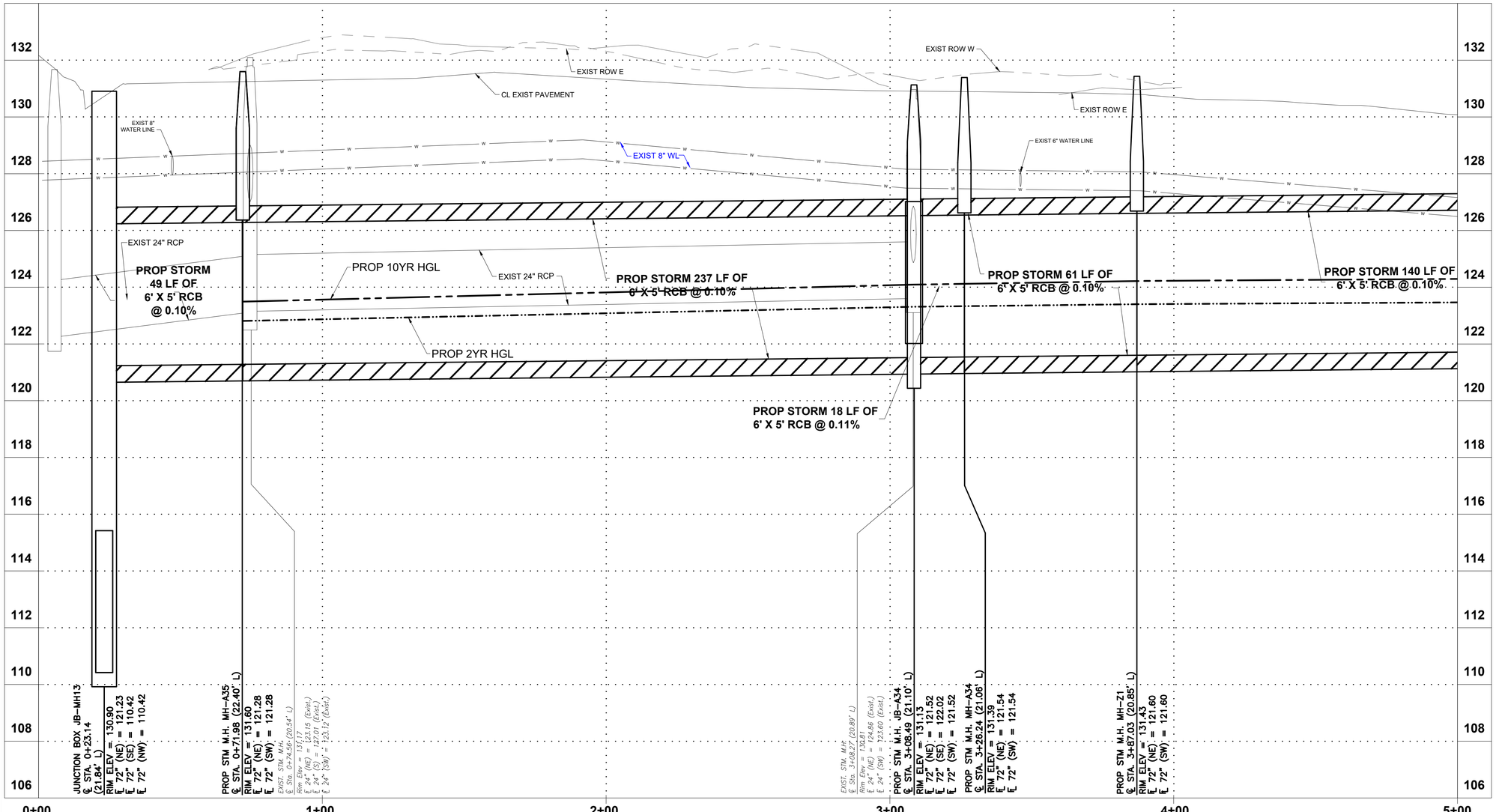
STATE OF TEXAS
ISAAC MUNIZ
125839
LICENSED
PROFESSIONAL ENGINEER
3/2/2022

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **PLAN AND PROFILE - RIFLEMAN TRAIL SHEET 1**

DRAWN BY: | DATE: 3/2/2022

DESIGN BY: | SCALE: | SHEET NO: 109OF 200



0 20 40
SCALE IN FEET

VERTICAL SCALE
0 2 4
SCALE IN FEET

J:\1904\2102\ACAD\SHEET FILES\60%\110 PLAN AND PROFILE - RIFLEMAN TRAIL SHEET 2.dwg

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY
ENGINEERING DEPARTMENT

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PROFESSIONAL ENGINEER
3/2/2022

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **PLAN AND PROFILE - RIFLEMAN TRAIL SHEET 2**

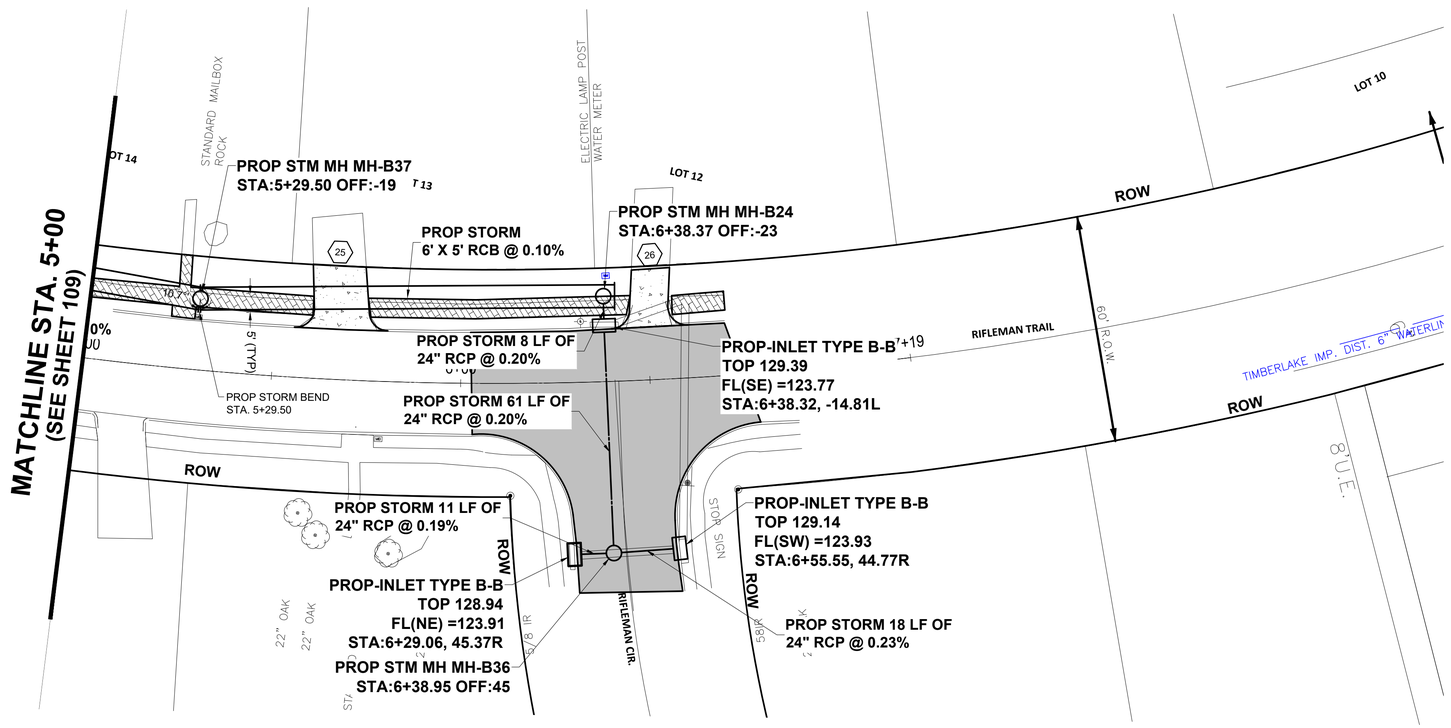
DRAWN BY:

DATE: 3/2/2022

DESIGN BY:

SCALE:

SHEET NO: 110OF 200



PROPOSED 4.5" CONCRETE S/W TYPICAL

PROPOSED DRIVEWAY

PROPOSED PAVEMENT AND CURBS

NOTES:

1. FOR LIMITS OF PAVEMENT REPAIR, CONTRACTOR SHALL GO TO NEAREST JOINT TO DOWEL IN AND IF JOINT IS BEYOND 10', CONTRACTOR SHALL SET NEW JOINT AS LIMITS SHOWN ON PLANS.
2. THE LOCATION OF EXISTING WATER LINE WAS BASED ON RECORD DRAWINGS PROVIDED BY TIMBERLAKE MUNICIPAL UTILITY DISTRICT.
3. CONTRACTOR SHALL REPLACE CURB DRAINS DAMAGED DURING CONSTRUCTION OF PROPOSED STORM SEWER LINE AND PAVEMENT REPLACEMENT, INCIDENTAL TO STORM SEWER PAY ITEM

0 20 40
SCALE IN FEET

NO.	REVISIONS	DATE	NAME

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125839
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PROFESSIONAL ENGINEER
3/2/2022

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **PLAN AND PROFILE - RIFLEMAN TRAIL SHEET 3**

DRAWN BY:

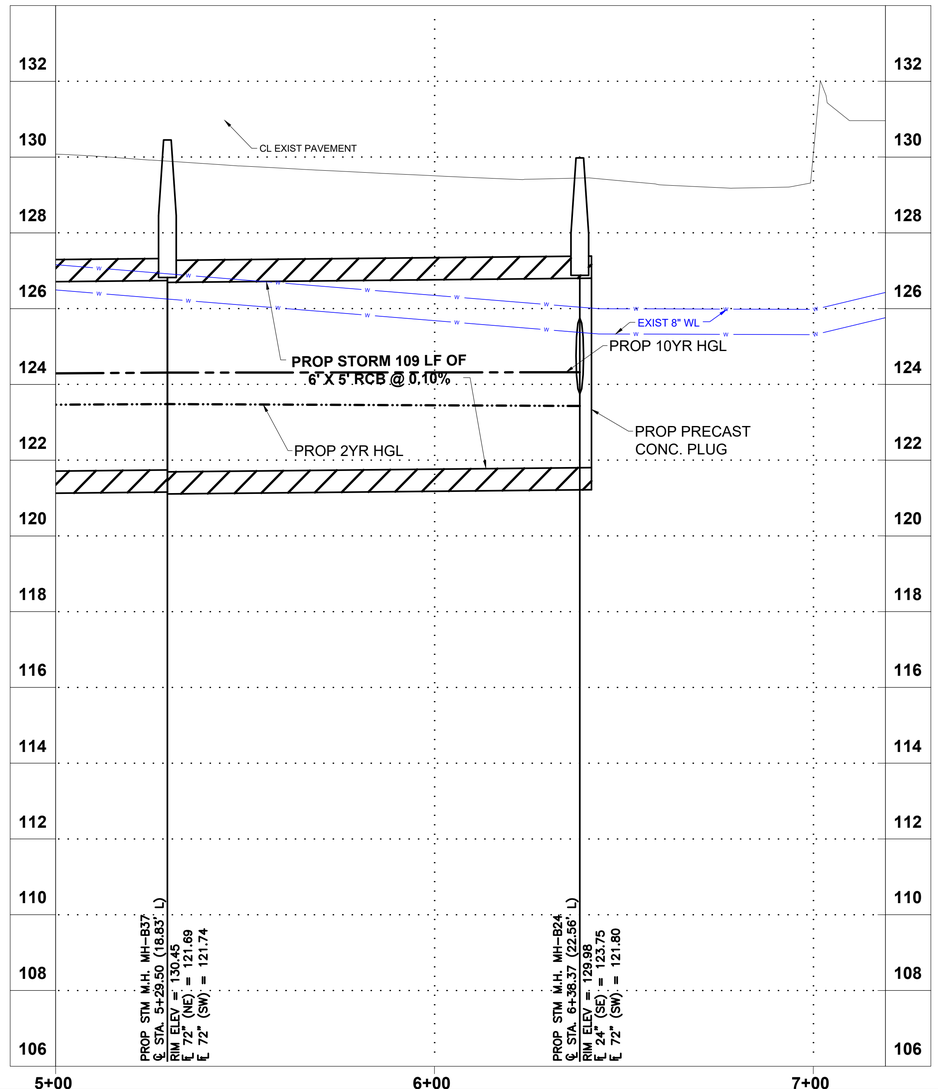
DATE: **3/2/2022**

DESIGN BY:

SCALE:

SHEET NO: **111OF 200**

J:\1904\2102\ACAD\SHEET FILES\60%\111 PLAN AND PROFILE – RIFLEMAN TRAIL SHEET 3.dwg



NOTES:

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2. THE LOCATION OF EXISTING WATER LINE WAS BASED ON RECORD DRAWINGS PROVIDED BY TIMBERLAKE MUNICIPAL UTILITY DISTRICT.

0 20 40
SCALE IN FEET

VERTICAL SCALE
0 2 4
SCALE IN FEET

NO.	REVISIONS	DATE	NAME

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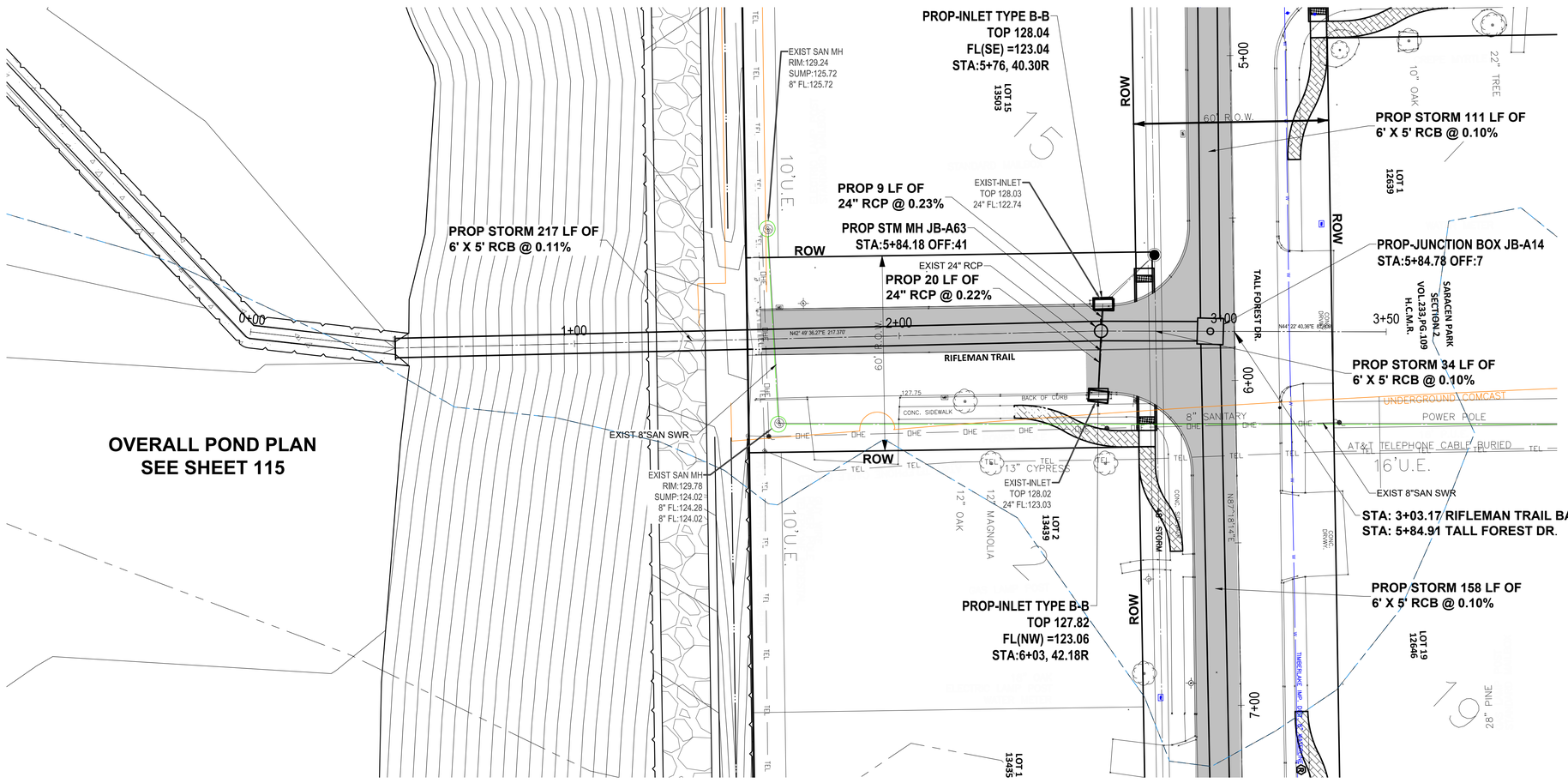
3/2/2022

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **PLAN AND PROFILE - RIFLEMAN TRAIL SHEET 4**

DRAWN BY:
DATE: 3/2/2022
DESIGN BY:
SCALE:
SHEET NO: 112OF 200

J:\1904\2102\ACAD\SHEET FILES\60%\112 PLAN AND PROFILE - RIFLEMAN TRAIL SHEET 4.dwg



PROPOSED PAVEMENT AND CURBS

NOTES:

1. FOR LIMITS OF PAVEMENT REPAIR, CONTRACTOR SHALL GO TO NEAREST JOINT TO DOWEL IN AND IF JOINT IS BEYOND 10', CONTRACTOR SHALL SET NEW JOINT AS LIMITS SHOWN ON PLANS.
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0 20 40
SCALE IN FEET

NO.	REVISIONS	DATE	NAME

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3/2/2022

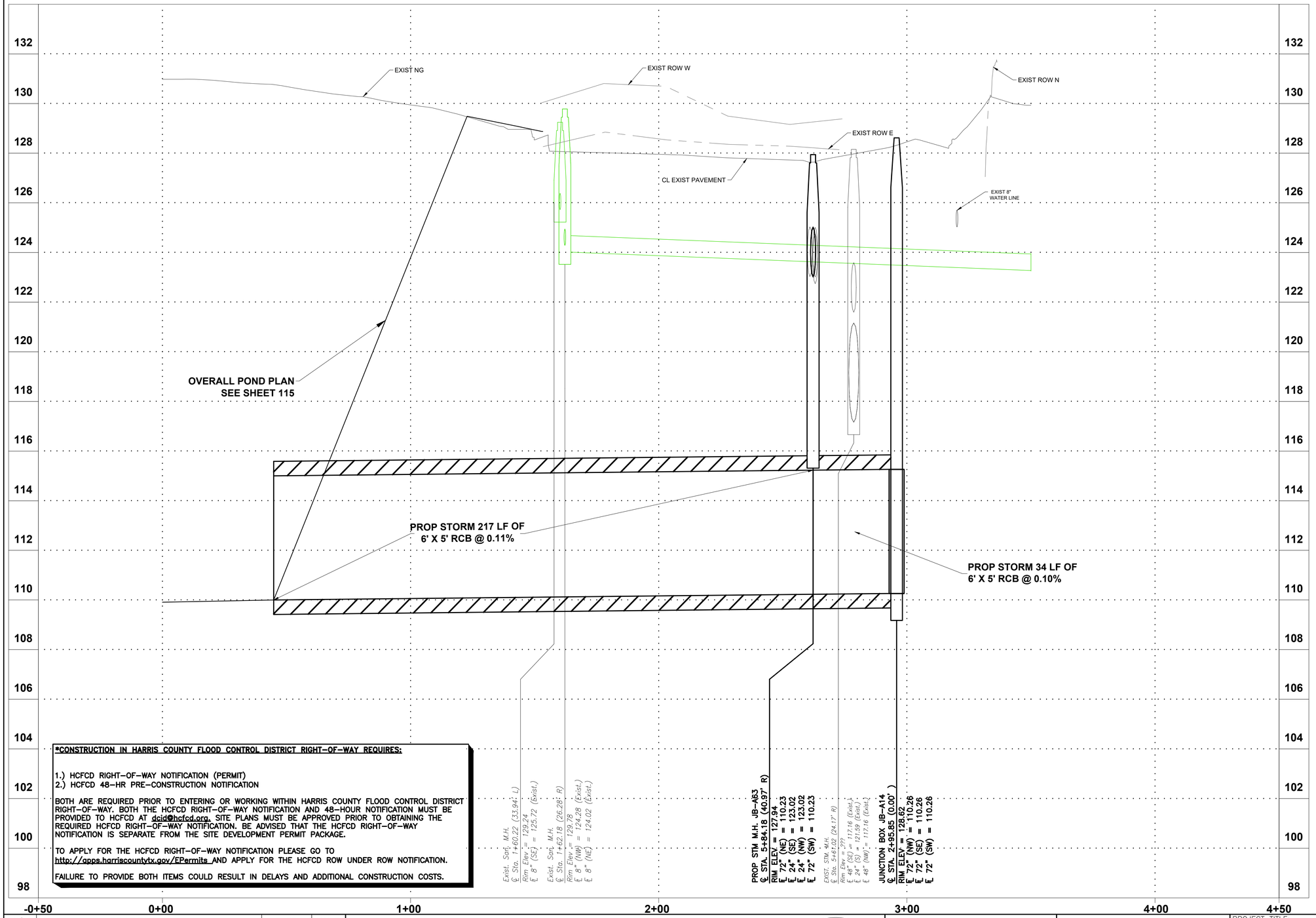
PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **PLAN AND PROFILE - RIFLEMAN TRAIL BASIN OUTFALL SHEET 1**

DRAWN BY: | DATE: 3/2/2022

DESIGN BY: | SCALE: | SHEET NO: 113OF 200

J:\1904\2102\ACAD\SHEET FILES\60%\113 PLAN AND PROFILE – RIFLEMAN TRAIL BASIN OUTFALL SHEET 1.dwg



***CONSTRUCTION IN HARRIS COUNTY FLOOD CONTROL DISTRICT RIGHT-OF-WAY REQUIRES:**

1.) HCFCD RIGHT-OF-WAY NOTIFICATION (PERMIT)
2.) HCFCD 48-HR PRE-CONSTRUCTION NOTIFICATION

BOTH ARE REQUIRED PRIOR TO ENTERING OR WORKING WITHIN HARRIS COUNTY FLOOD CONTROL DISTRICT RIGHT-OF-WAY. BOTH THE HCFCD RIGHT-OF-WAY NOTIFICATION AND 48-HOUR NOTIFICATION MUST BE PROVIDED TO HCFCD AT dcid@hcfcd.org. SITE PLANS MUST BE APPROVED PRIOR TO OBTAINING THE REQUIRED HCFCD RIGHT-OF-WAY NOTIFICATION. BE ADVISED THAT THE HCFCD RIGHT-OF-WAY NOTIFICATION IS SEPARATE FROM THE SITE DEVELOPMENT PERMIT PACKAGE.

TO APPLY FOR THE HCFCD RIGHT-OF-WAY NOTIFICATION PLEASE GO TO http://apps.harriscountytx.gov/EPermits AND APPLY FOR THE HCFCD ROW UNDER ROW NOTIFICATION.

FAILURE TO PROVIDE BOTH ITEMS COULD RESULT IN DELAYS AND ADDITIONAL CONSTRUCTION COSTS.

0 20 40
SCALE IN FEET

VERTICAL SCALE
0 2 4
SCALE IN FEET

J:\1904\2102\ACAD\SHEET FILES\60%\114 PLAN AND PROFILE - RIFLEMAN TRAIL BASIN OUTFALL SHEET 2.dwg

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY
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HARRIS COUNTY 1836 TEXAS

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STATE OF TEXAS
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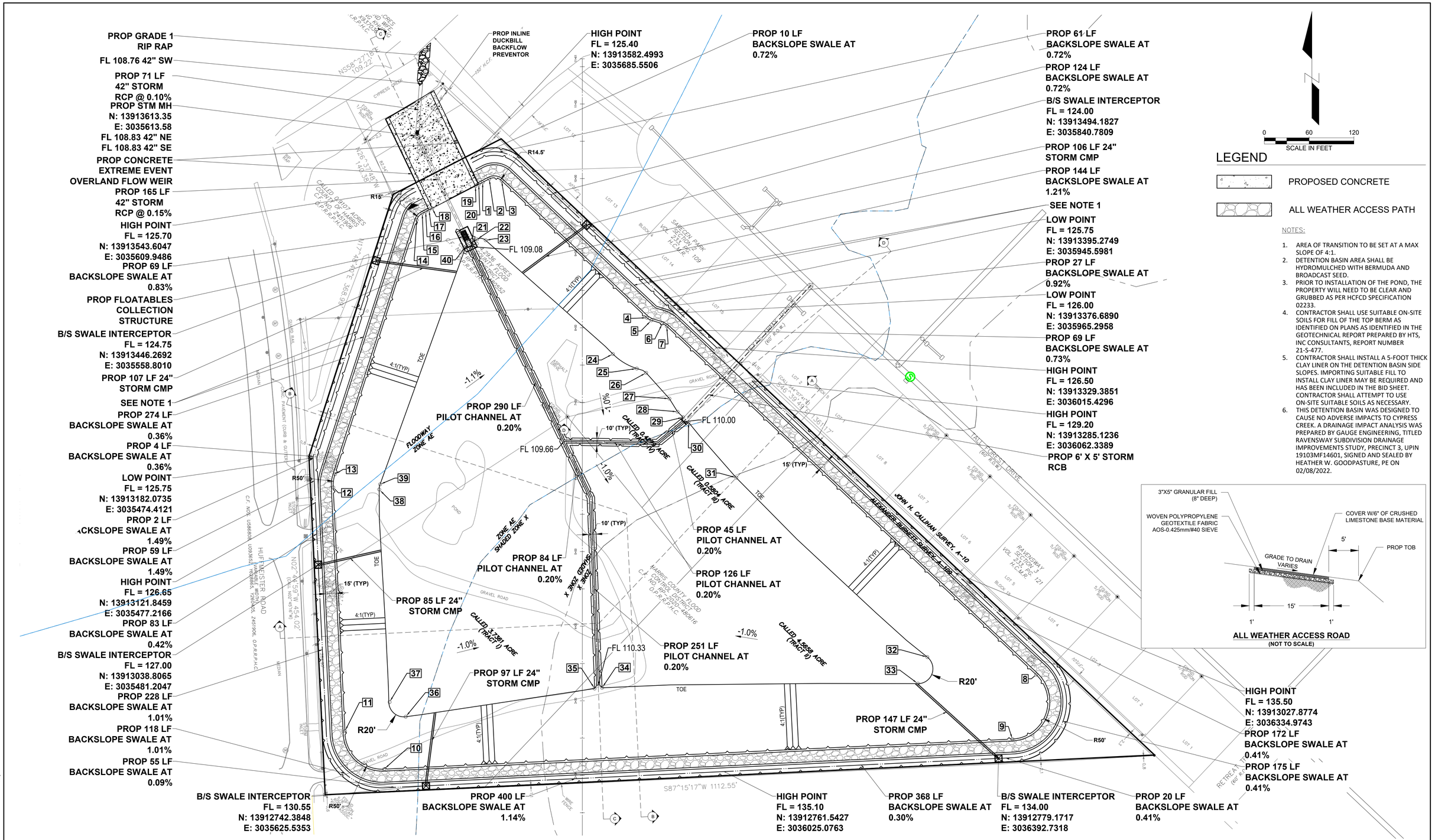
125839
LICENSED
PROFESSIONAL ENGINEER
3/2/2022

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **PLAN AND PROFILE - RIFLEMAN TRAIL BASIN OUTFALL SHEET 2**

DRAWN BY: | DATE: 3/2/2022

DESIGN BY: | SCALE: | SHEET NO: 114OF 200



NOTES:

1. AREA OF TRANSITION TO BE SET AT A MAX SLOPE OF 4:1.
2. DETENTION BASIN AREA SHALL BE HYDROMULCHED WITH BERMUDA AND BROADCAST SEED.
3. PRIOR TO INSTALLATION OF THE POND, THE PROPERTY WILL NEED TO BE CLEAR AND GRUBBED AS PER HCFCD SPECIFICATION 02233.
4. CONTRACTOR SHALL USE SUITABLE ON-SITE SOILS FOR FILL OF THE TOP BERM AS IDENTIFIED ON PLANS AS IDENTIFIED IN THE GEOTECHNICAL REPORT PREPARED BY HTS, INC CONSULTANTS, REPORT NUMBER 21-S-477.
5. CONTRACTOR SHALL INSTALL A 5-FOOT THICK CLAY LINER ON THE DETENTION BASIN SIDE SLOPES. IMPORTING SUITABLE FILL TO INSTALL CLAY LINER MAY BE REQUIRED AND HAS BEEN INCLUDED IN THE BID SHEET. CONTRACTOR SHALL ATTEMPT TO USE ON-SITE SUITABLE SOILS AS NECESSARY.
6. THIS DETENTION BASIN WAS DESIGNED TO CAUSE NO ADVERSE IMPACTS TO CYPRESS CREEK. A DRAINAGE IMPACT ANALYSIS WAS PREPARED BY GAUGE ENGINEERING, TITLED RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS STUDY, PRECINCT 3, UPIN 19103MF14601, SIGNED AND SEALED BY HEATHER W. GOODPASTURE, PE ON 02/08/2022.

NO.	REVISIONS	DATE	NAME

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STATE OF TEXAS
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LICENSED
PROFESSIONAL ENGINEER
3/2/2022

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **OVERALL POND PLAN**

DRAWN BY:

DATE: 3/2/2022

DESIGN BY:

SCALE:

SHEET NO: 115OF 200

J:\1904\2102\ACAD\SHEET FILES\60PA\115 OVERALL POND PLAN.dwg

Point Table

Point #	Raw Description	Northing	Easting	Elevation
1	TOP OF BANK	13913551.3765	3035701.5622	128.50
2	TOP OF BANK	13913555.8713	3035710.2989	128.50
3	TOP OF BANK	13913553.5237	3035726.8829	128.50
4	TOP OF BANK	13913369.8181	3035921.5782	128.50
5	TOP OF BANK	13913366.3662	3035927.5441	128.50
6	TOP OF BANK	13913361.9575	3035942.1729	128.50
7	TOP OF BANK	13913358.5056	3035948.1388	128.50
8	TOP OF BANK	13912891.3988	3036443.1892	135.59
9	TOP OF BANK	13912805.0893	3036411.2699	135.31
10	TOP OF BANK	13912764.7242	3035569.4506	130.71
11	TOP OF BANK	13912815.6442	3035516.9513	129.04
12	TOP OF BANK	13913142.3371	3035501.2612	128.50
13	TOP OF BANK	13913160.0297	3035503.6002	128.50
14	TOP OF BANK	13913500.9480	3035613.1301	128.50
15	TOP OF BANK	13913509.6769	3035620.5080	128.50
16	TOP OF BANK	13913512.0464	3035625.1137	128.50
17	TOP OF BANK	13913514.3346	3035629.5614	127.30
18	TOP OF BANK	13913516.6213	3035634.0061	126.30
19	TOP OF BANK	13913546.3639	3035691.8188	126.30
20	TOP OF BANK	13913548.6521	3035696.2666	127.30

Point Table

Point #	Raw Description	Northing	Easting	Elevation
21	TOE OF SLOPE	13913471.1688	3035687.4321	110.10
22	TOE OF SLOPE	13913474.8931	3035693.8832	110.18
23	TOE OF SLOPE	13913473.6709	3035705.4419	110.28
24	TOE OF SLOPE	13913321.2543	3035875.9490	111.84
25	TOE OF SLOPE	13913301.7621	3035908.0490	111.63
26	TOE OF SLOPE	13913296.0161	3035920.5616	111.58
27	TOE OF SLOPE	13913261.3719	3035951.6989	111.27
28	TOE OF SLOPE	13913243.8074	3035962.6707	111.11
29	TOE OF SLOPE	13913236.4533	3035970.0673	111.05
30	TOE OF SLOPE	13913229.5400	3035977.4065	111.06
31	TOE OF SLOPE	13913155.4188	3036041.2762	112.13
32	TOE OF SLOPE	13912914.9468	3036297.2841	115.52
33	TOE OF SLOPE	13912879.3706	3036284.7038	115.46
34	TOE OF SLOPE	13912873.8161	3035861.4871	111.34
35	TOE OF SLOPE	13912872.8127	3035851.5187	111.35
36	TOE OF SLOPE	13912835.0270	3035598.3603	113.85
37	TOE OF SLOPE	13912854.6602	3035576.7424	114.01
38	TOE OF SLOPE	13913139.6436	3035562.8590	113.14
39	TOE OF SLOPE	13913146.5406	3035564.0453	113.08
40	TOE OF SLOPE	13913465.5354	3035679.0444	110.10

J:\190A\2102\ACAD\SHEET FILES\602\116 POND POINTS.dwg

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY
ENGINEERING DEPARTMENT

HARRIS COUNTY 1836 TEXAS

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STATE OF TEXAS
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125839
LICENSED
PROFESSIONAL ENGINEER
3/2/2022

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **POND POINTS**

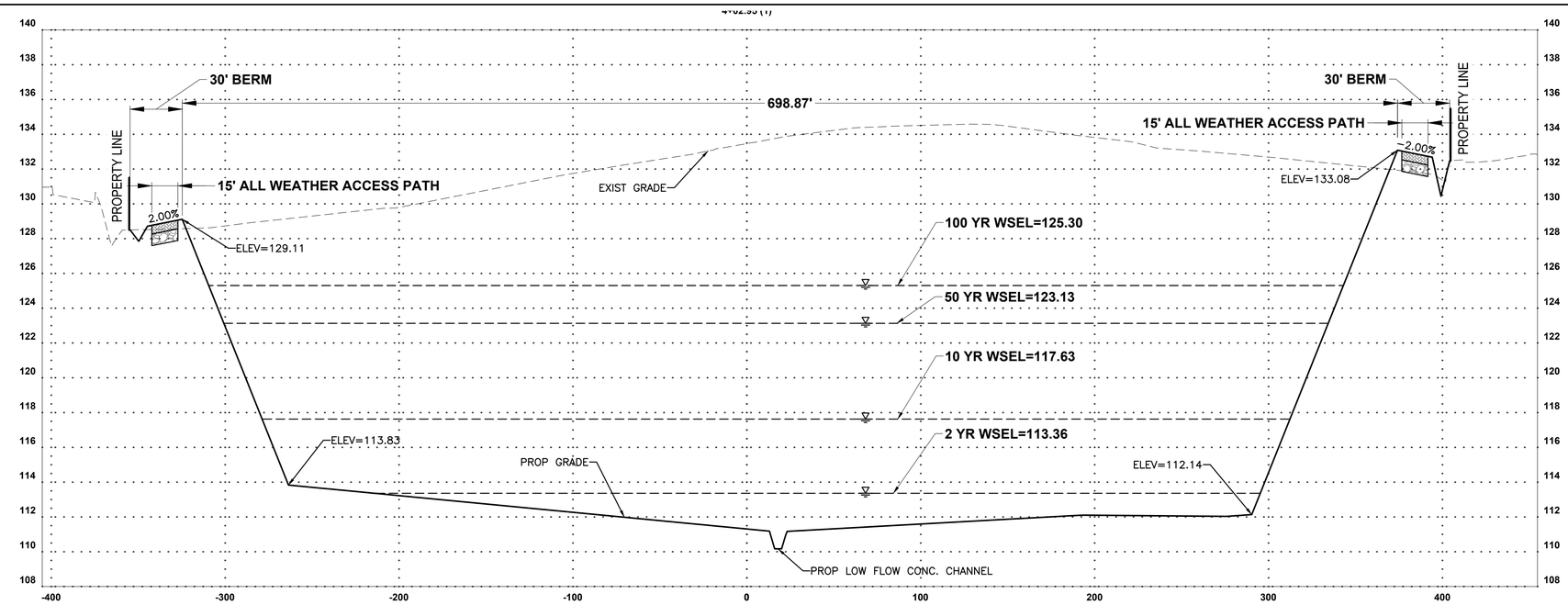
DRAWN BY:

DATE: **3/2/2022**

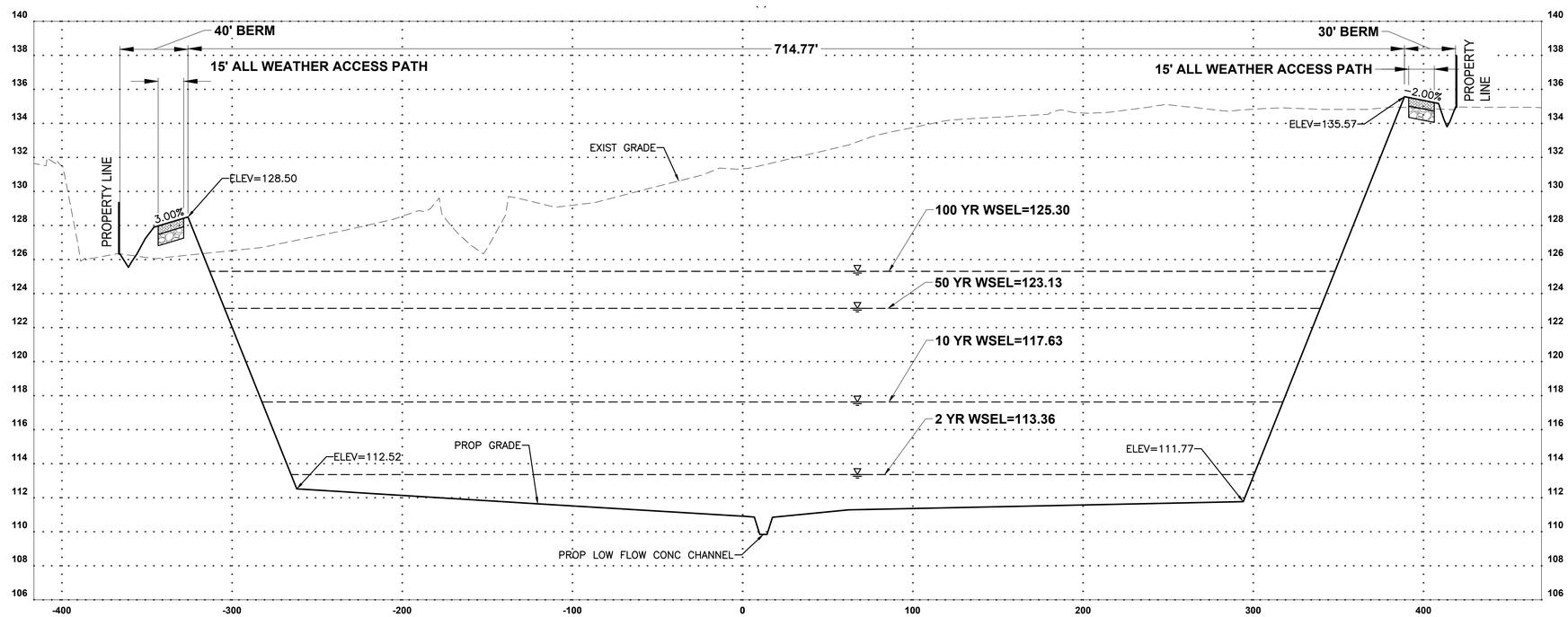
DESIGN BY:

SCALE:

SHEET NO: **116OF 200**



SECTION A–A
1"=40'



SECTION B–B
1"=40'

NOTES:

1. AREA OF TRANSITION TO BE SET AT A MAX SLOPE OF 4:1.
2. DETENTION BASIN AREA SHALL BE HYDROMULCHED WITH BERMUDA AND BROADCAST SEED.
3. PRIOR TO INSTALLATION OF THE POND, THE PROPERTY WILL NEED TO BE CLEAR AND GRUBBED AS PER HCFCD SPECIFICATION 02233.
4. CONTRACTOR SHALL USE SUITABLE ON-SITE SOILS FOR FILL OF THE TOP BERM AS IDENTIFIED ON PLANS AS IDENTIFIED IN THE GEOTECHNICAL REPORT PREPARED BY HTS, INC CONSULTANTS, REPORT NUMBER 21-S-477.
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3/2/2022

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **POND SECTIONS**

DRAWN BY:

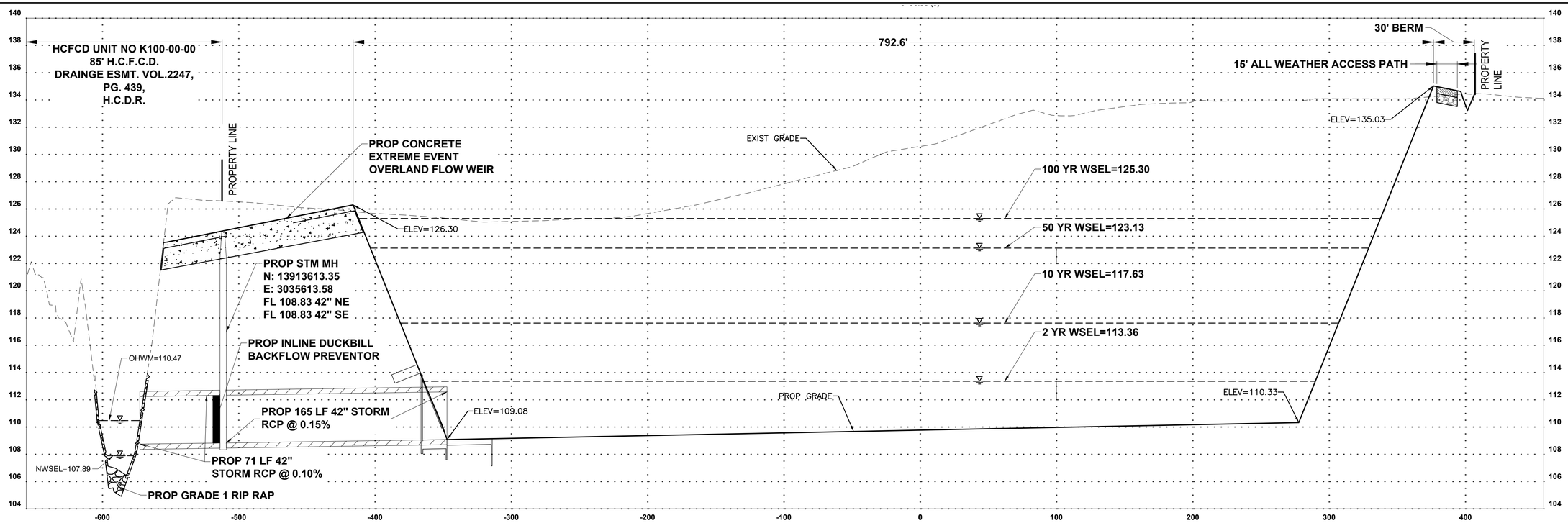
DATE: 3/2/2022

DESIGN BY:

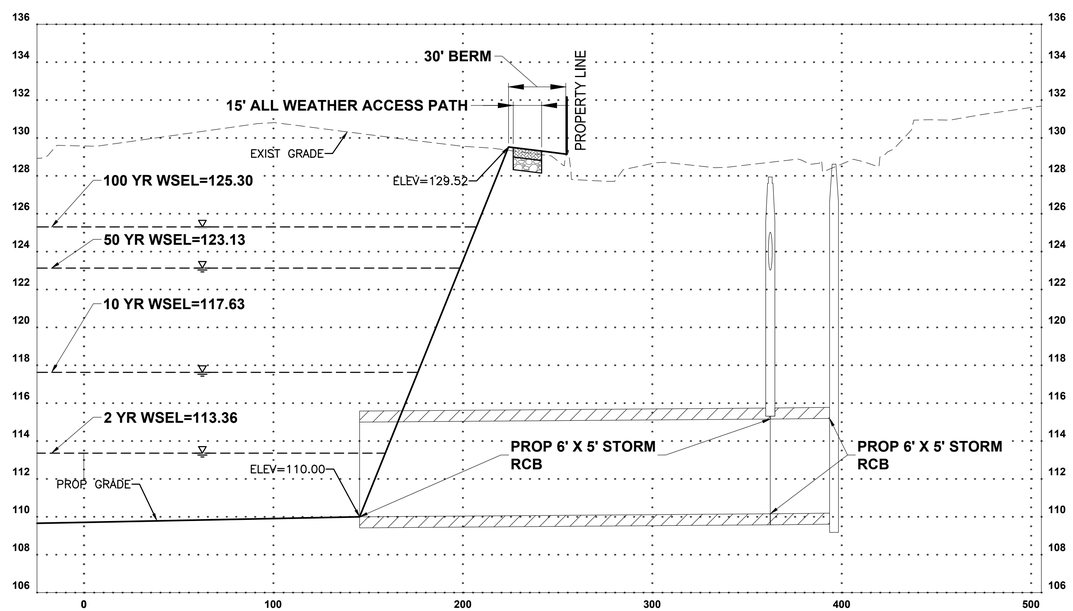
SCALE:

SHEET NO: 117OF 200

J:\190A\2102\ACAD\SHEET FILES\602X\117 POND SECTIONS.dwg



OUTFALL SECTION C–C
1"=40'



OUTFALL SECTION D–D
1"=40'

NOTES:

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***CONSTRUCTION IN HARRIS COUNTY FLOOD CONTROL DISTRICT RIGHT–OF–WAY REQUIRES:**

1.) HCFCD RIGHT–OF–WAY NOTIFICATION (PERMIT)
2.) HCFCD 48–HR PRE–CONSTRUCTION NOTIFICATION

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3/2/2022

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **POND OUTFALL SECTIONS**

DRAWN BY:

DATE: **3/2/2022**

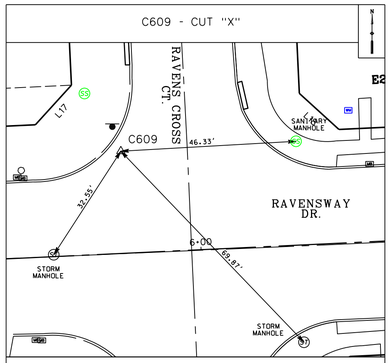
DESIGN BY:

SCALE:

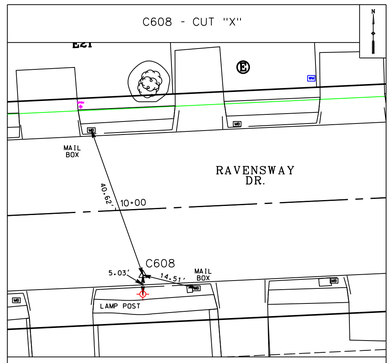
SHEET NO: **118OF 200**

J:\1994\2102\ACAD\SHEET FILES\605\118 POND OUTFALL SECTIONS.dwg

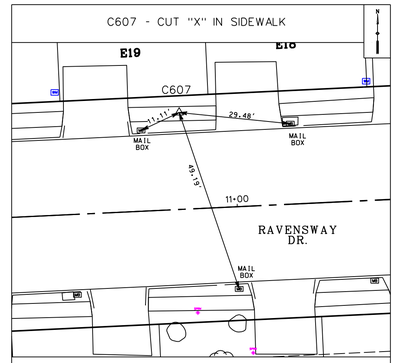
Exhibit 6
Survey Control Map



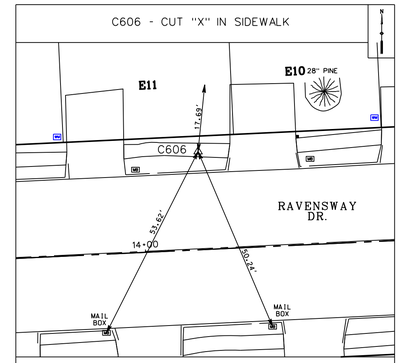
STA. 5+80.06, L 26.97 RAVENSWAY DR.



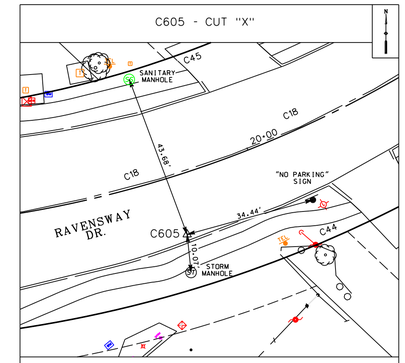
STA. 10+06.42, R 17.38' RAVENSWAY DR.



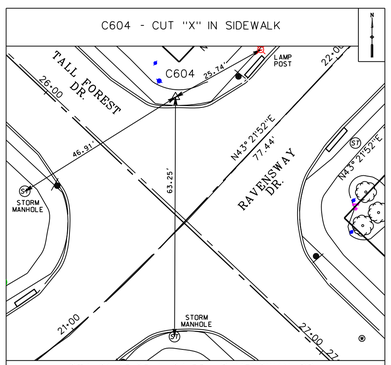
STA. 10+85.83, L 25.57' RAVENSWAY DR.



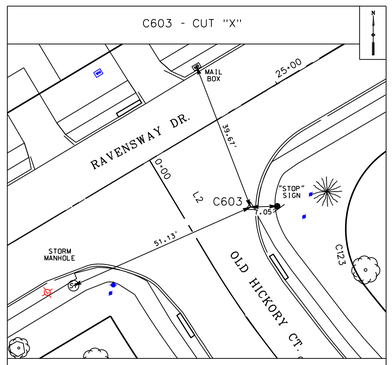
STA. 14+15.10, L 25.93' RAVENSWAY DR.



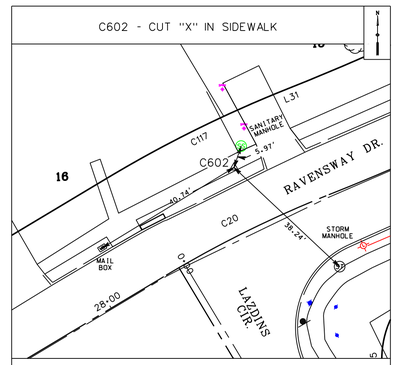
STA. 19+78.05, R 15.70' RAVENSWAY DR.



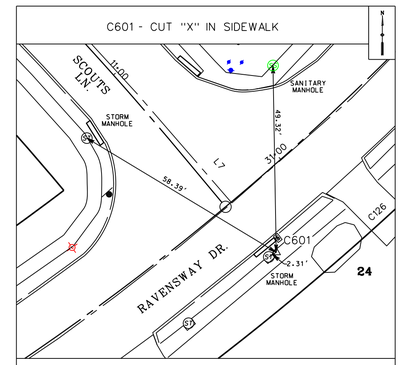
STA. 21+63.23, L 24.33 RAVENSWAY DR.
STA. 26+25.72, L 22.59 TALL FOREST DR.



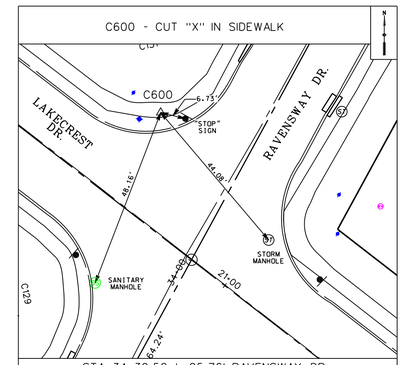
STA. 24+77.343, R 24.31' RAVENSWAY DR.



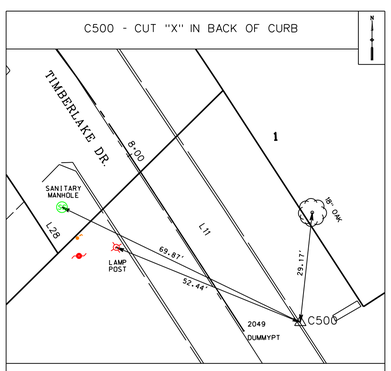
STA. 28+45.35, L 16.61' RAVENSWAY DR.



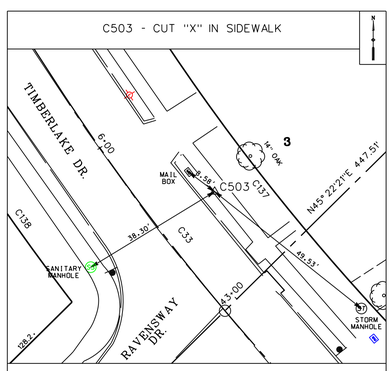
STA. 30+83.32, R 17.79' RAVENSWAY DR.



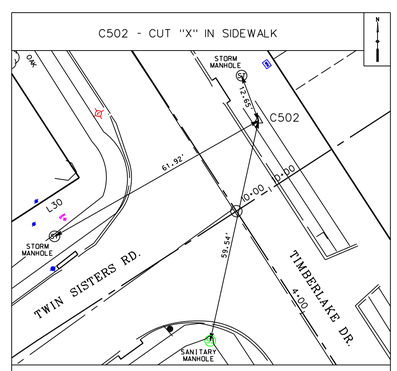
STA. 34+30.52, L 25.76' RAVENSWAY DR.
STA. 20+58.64 L 25.72' LAKECREST DR.



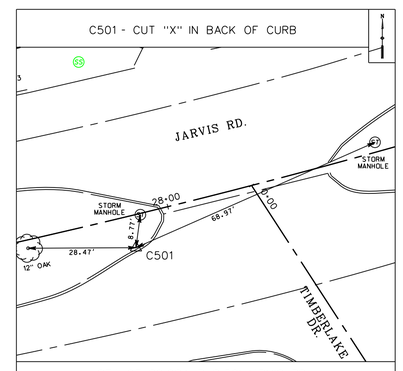
STA. OFF CHAIN TIMBERLAKE DR.



STA. 6+27.64, L 17.60' TIMBERLAKE DR.



STA. 3+51.13, L 17.92' TIMBERLAKE DR.



STA. 27+89.284, R 8.52' JARVIS RD.

LEGEND

- TYP. CREPE MRYTLE (UNLESS NOTED)
- SHRUB/BUSH
- TYP. SAGO PALM (UNLESS NOTED)
- SANITARY MANHOLE
- STORM MANHOLE
- WATER METER
- GATE VALVE
- FLUSH VALVE/FIRE HYDRANT
- BLOW-OFF VALVE
- IRRIGATION CONTROL VALVE
- IRRIGATION SPRINKLER HEAD
- TELEPHONE PEDESTAL
- TELEPHONE BOX
- TELEPHONE SIGN
- FIBER OPTIC SIGN
- LIGHT POLE (ELECTRIC)
- LIGHT POLE (NATURAL GAS)
- POWER POLE
- GUY WIRE
- GAS VALVE
- CATHODIC TEST STATION
- TYP. STANDARD MAIL BOX (UNLESS NOTED)
- TRAFFIC SIGN
- TYP. 5/8" IR (UNLESS NOTED)
- E — E — BURIED ELECTRICAL
- P — OVERHEAD ELECTRICAL
- G — BURIED NATRURAL GAS
- SANITARY LINE
- B — BURIED FIBER OPTIC
- C — BURIED CABLE TV
- // — WOOD FENCE
- STORM SEWER

Type text here

NOTES:

1. Bearings and coordinates shown hereon are based on the Texas Coordinate System (North American Datum of 1983, 2011 Adjustment), South Central Zone. Coordinates shown hereon are surface values and may be converted to grid by dividing by a combined surface adjustment factor of 1.000079000.
2. Primary Benchmark: Tropical Storm Allison Recovery Project Monument 110130, BM 110130 is a brass disc on the northeast corner of a storm sewer inlet located on the north side of Jarvis Road across from its intersection with Timberlake, immediately east of a driveway to the Timberlake Improvement District wastewater treatment plant. Elevation 127.28 feet NAVD88, 2001 adjustment.
3. To convert elevations based on NAVD88, 2001 adjustment to NAVD88, Geoid 12B elevations subtract 0.96 feet.
4. This survey substantially complies with the current Texas Society of Professional Surveyors standards and specifications for a Category 6 Condition I Survey and a Category 1B, Condition III Survey.
5. All Easements and Building Lines depicted are dedicated by subdivision plat labeled herein, unless otherwise noted.

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY
ENGINEERING DEPARTMENT

HARRIS COUNTY 1836 TEXAS

Costello
Engineering and Surveying
2107 CityWest Blvd., 3rd Floor
Houston, Texas 77042
(713) 783-7788
(713) 783-3580, Fax
TBPE FIRM REG. No. 280
TBPLS FIRM REG. No. 100486

SEE NOTE 4 FOR CERTIFICATION

STATE OF TEXAS REGISTERED DAVID E. HUNT 5198 PROFESSIONAL LAND SURVEYOR

1-14-22

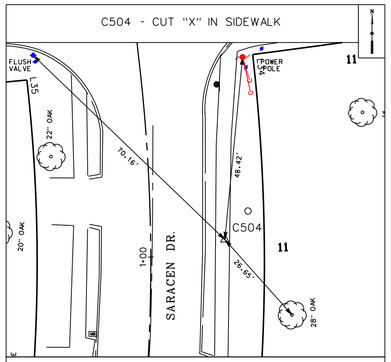
PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

UPIN 19103MF14601

SHEET DESCRIPTION: CONTROL SHEET 1

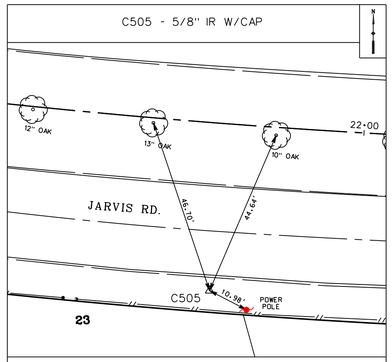
DRAWN BY: JDS		DATE: 1/3/2022
DESIGN BY:	SCALE: NOT TO SCALE	SHEET NO: 2 OF 48

C504 - CUT "X" IN SIDEWALK



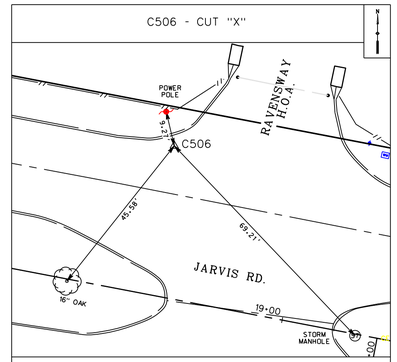
STA. 0+95.64, L 19.59' SARACEN DR.

C505 - 5/8" IR W/CAP



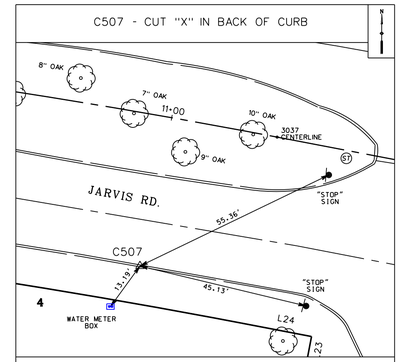
STA. 21+62.52, R 44.28' JARVIS RD.

C506 - CUT "X"



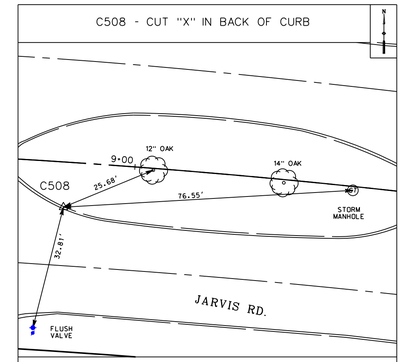
STA. 18+63.39, L 39.84' JARVIS RD.

C507 - CUT "X" IN BACK OF CURB



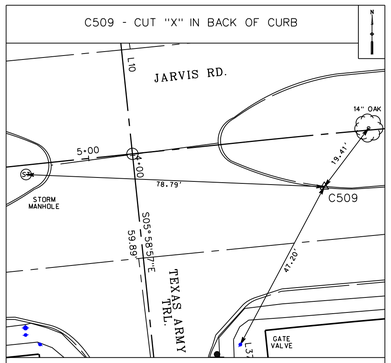
STA. 10+98.52, R 40.02' JARVIS RD.

C508 - CUT "X" IN BACK OF CURB



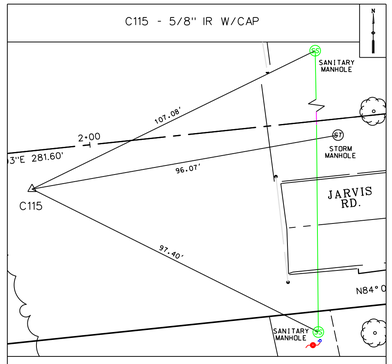
STA. 8+81.85, R 11.93' JARVIS RD.

C509 - CUT "X" IN BACK OF CURB



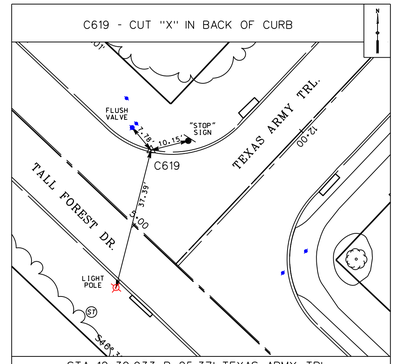
STA. 5+61.21, R 13.82' JARVIS RD.

C115 - 5/8" IR W/CAP



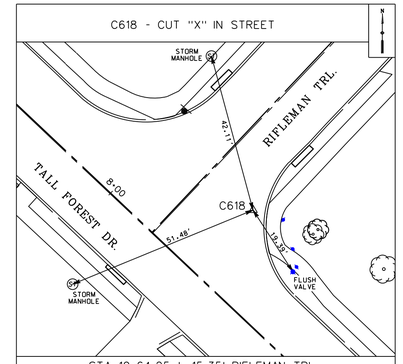
STA. 1+69.46, R 8.56' JARVIS RD.

C619 - CUT "X" IN BACK OF CURB



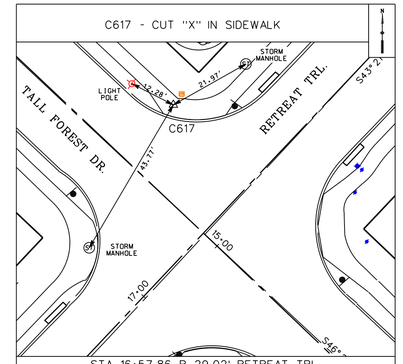
STA. 12+30.933, R 25.37' TEXAS ARMY TRL.
STA. 4+89.68, L 17.55' TALL FOREST DR.

C618 - CUT "X" IN STREET



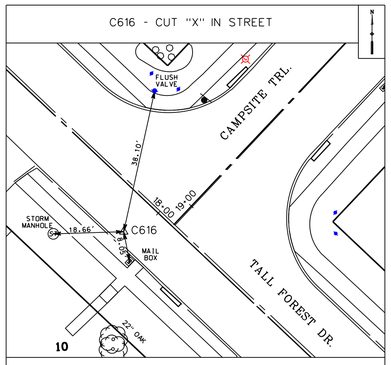
STA. 10+64.25, L 15.35' RIFLEMAN TRL.
STA. 8+30.40, L 22.55' TALL FOREST DR.

C617 - CUT "X" IN SIDEWALK



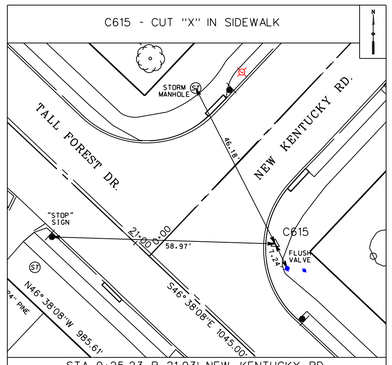
STA. 16+57.86, R 29.02' RETREAT TRL.
STA. 14+66.03, L 19.16' TALL FOREST DR.

C616 - CUT "X" IN STREET



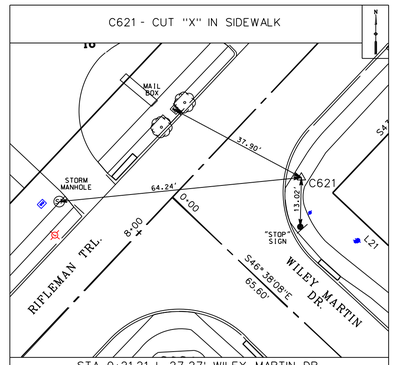
STA. 17+96.72, R 9.82' TALL FOREST DR.

C615 - CUT "X" IN SIDEWALK



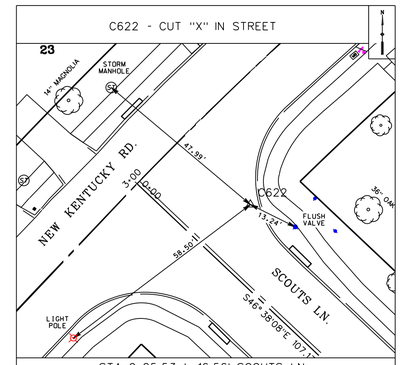
STA. 0+25.23, R 21.93' NEW KENTUCKY RD.
STA. 21+26.99, L 25.23' TALL FOREST DR.

C621 - CUT "X" IN SIDEWALK



STA. 0+21.21, L 27.27' WILEY MARTIN DR.
STA. 7+60.01, L 21.21' RIFLEMAN TRL.

C622 - CUT "X" IN STREET



STA. 0+25.53, L 16.56' SCOUTS LN.
STA. 3+17.30, L 25.15' NEW KENTUCKY RD.

LEGEND

- TYP. CREPE MRYTLE (UNLESS NOTED)
- SHRUB/BUSH
- TYP. SAGO PALM (UNLESS NOTED)
- SANITARY MANHOLE
- STORM MANHOLE
- WATER METER
- GATE VALVE
- FLUSH VALVE
- BLOW-OFF VALVE
- IRRIGATION CONTROL VALVE
- IRRIGATION SPRINKLER HEAD
- TELEPHONE PEDESTAL
- TELEPHONE BOX
- TELEPHONE SIGN
- FIBER OPTIC SIGN
- LIGHT POLE (ELECTRIC)
- LIGHT POLE (NATURAL GAS)
- POWER POLE
- GUY WIRE
- GAS VALVE
- CATHODIC TEST STATION
- TYP. STANDARD MAIL BOX (UNLESS NOTED)
- TRAFFIC SIGN
- TYP. 5/8" IR (UNLESS NOTED)
- E — BURIED ELECTRICAL
- P — OVERHEAD ELECTRICAL
- G — BURIED NATRURAL GAS
- SANITARY LINE
- B — BURIED FIBER OPTIC
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- // — WOOD FENCE
- STORM SEWER

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3. To convert elevations based on NAVD88, 2001 adjustment to NAVD88, Geoid 12B elevations subtract 0.96 feet.
4. This survey substantially complies with the current Texas Society of Professional Surveyors standards and specifications for a Category 6 Condition I Survey and a Category 1B, Condition III Survey.
5. All Easements and Building Lines depicted are dedicated by subdivision plat labeled herein, unless otherwise noted.

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY
ENGINEERING DEPARTMENT

HARRIS COUNTY 1836 TEXAS

Costello
Engineering and Surveying
2107 CityWest Blvd., 3rd Floor
Houston, Texas 77042
(713) 783-7788
(713) 783-3580, Fax
TBPE FIRM REG. No. 280
TBPLS FIRM REG. No. 100486

SEE NOTE 4 FOR CERTIFICATION

STATE OF TEXAS REGISTERED DAVID E. HUNT 5198 PROFESSIONAL LAND SURVEYOR

1-14-22

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

UPIN 19103MF14601

SHEET DESCRIPTION: CONTROL SHEET 2

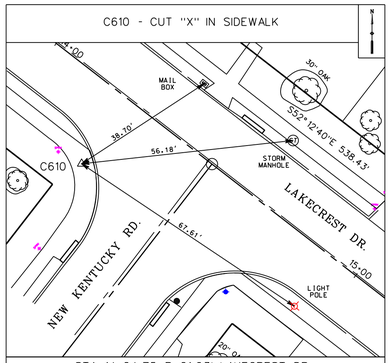
DRAWN BY: JDS

DATE: 1/3/2022

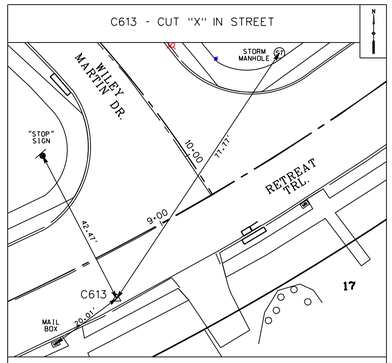
DESIGN BY:

SCALE: NOT TO SCALE

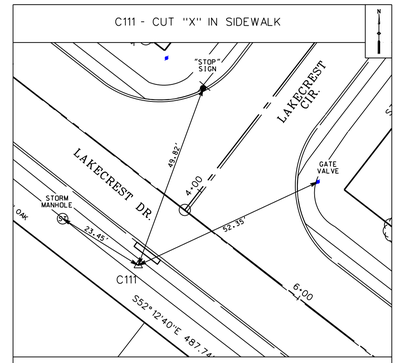
SHEET NO: 3 OF 48



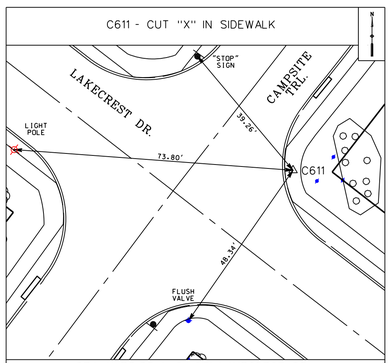
STA. 14+24.75, R 21.03' LAKECREST DR.
STA. 11+55.90, L 27.25' NEW KENTUCKY RD.



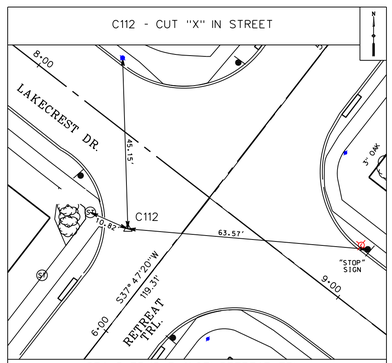
STA.9+19.49, L 11.97' RETREAT TRL.



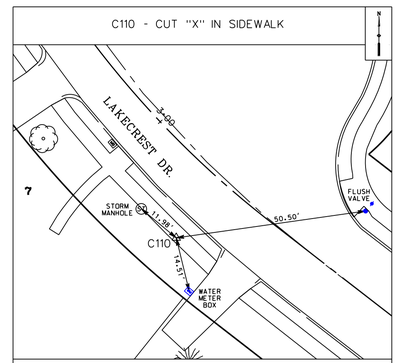
STA. 5+61.30, R 19.10' LAKECREST DR.



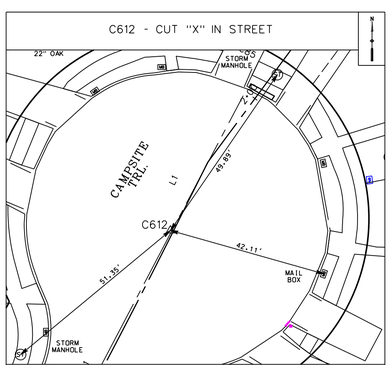
STA. 11+73.55, L 24.03' LAKECREST DR.
STA. 7+36.05, L 21.56' CAMPSITE TRL.



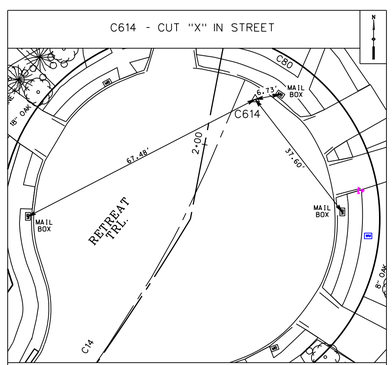
STA. 5+75.15, R 11.97' RETREAT TRL.
STA. 8+45.08, R 19.74' LAKECREST DR.



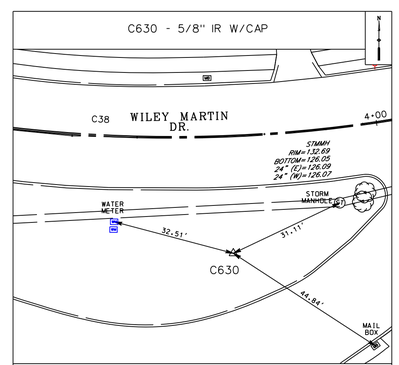
STA. 3+23.45, R 19.12' LAKECREST DR.



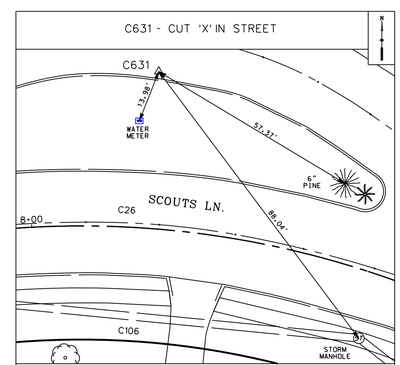
STA. 11+73.55, L 24.03' LAKECREST DR.
STA. 7+36.05, L 21.56' CAMPSITE TRL.



STA. 1+85.75, L 10.87' RETREAT TRL.



STA. 3+60.75, R 30.75' WILEY MARTIN DR.



STA. 8+30.57, L 41.48' SCOUTS LN.

NOTES:

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3. To convert elevations based on NAVD88, 2001 adjustment to NAVD88, Geoid 12B elevations subtract 0.96 feet.
4. This survey substantially complies with the current Texas Society of Professional Surveyors standards and specifications for a Category 6 Condition I Survey and a Category 1B, Condition III Survey.
5. All Easements and Building Lines depicted are dedicated by subdivision plat labeled herein, unless otherwise noted.

LEGEND

- TYP. CREPE MRYTLE (UNLESS NOTED)
- SHRUB/BUSH
- TYP. SAGO PALM (UNLESS NOTED)
- SANITARY MANHOLE
- STORM MANHOLE
- WATER METER
- GATE VALVE
- FLUSH VALVE
- BLOW-OFF VALVE
- IRRIGATION CONTROL VALVE
- IRRIGATION SPRINKLER HEAD
- TELEPHONE PEDESTAL
- TELEPHONE BOX
- TELEPHONE SIGN
- FIBER OPTIC SIGN
- LIGHT POLE (ELECTRIC)
- LIGHT POLE (NATURAL GAS)
- POWER POLE
- GUY WIRE
- GAS VALVE
- CATHODIC TEST STATION
- TYP. STANDARD MAIL BOX (UNLESS NOTED)
- TRAFFIC SIGN
- TYP. 5/8" IR (UNLESS NOTED)
- E — E — BURIED ELECTRICAL
- P — OVERHEAD ELECTRICAL
- G — BURIED NATRURAL GAS
- SANITARY LINE
- B — BURIED FIBER OPTIC
- C — BURIED CABLE TV
- // — WOOD FENCE
- STORM SEWER

NO.	REVISIONS	DATE	NAME
△			
△			
△			
△			
△			

HARRIS COUNTY
ENGINEERING DEPARTMENT

HARRIS COUNTY 1836 TEXAS

Costello
Engineering and Surveying
2107 CityWest Blvd., 3rd Floor
Houston, Texas 77042
(713) 783-7788
(713) 783-3580, Fax
TBPE FIRM REG. No. 280
TBPLS FIRM REG. No. 100486

SEE NOTE 4 FOR CERTIFICATION

STATE OF TEXAS REGISTERED DAVID E. HUNT 5198 PROFESSIONAL LAND SURVEYOR

1-14-22

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018		
UPIN 19103MF14601		
SHEET DESCRIPTION: CONTROL SHEET 3		
DRAWN BY: JDS		DATE: 1/3/2022
DESIGN BY:	SCALE: NOT TO SCALE	SHEET NO: 4 OF 48

Exhibit 7
ROW and Topographic Survey

NOTES:

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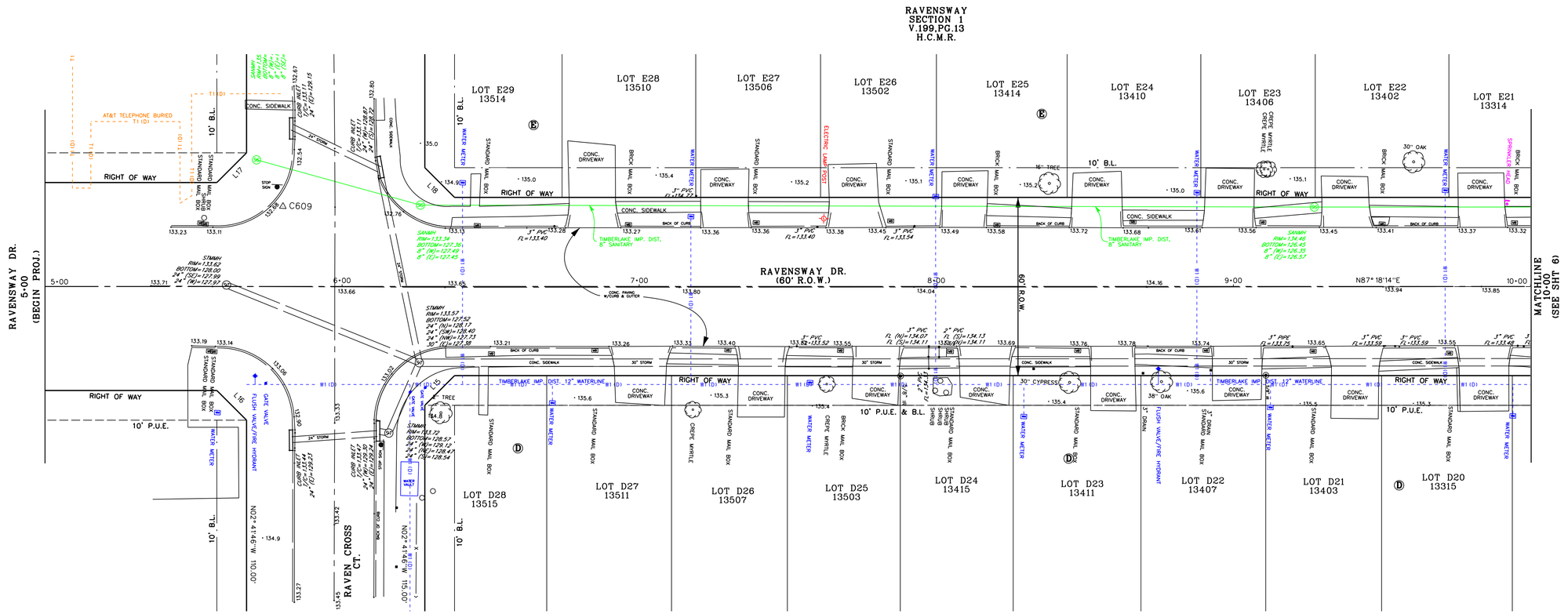
L15	S42° 18'14"W	14.14
L16	S47° 41'46"E	14.14
L17	N42° 18'14"E	14.14
L18	N47° 41'46"W	14.14

Point	North	East	Elevation	Station	Offset	Description
C606	13911938.2340	3036914.5080	134.0100	14+15.097	-25.9295	CUT "X" IN SIDEWALK
C607	13911922.3850	3036585.6270	133.9200	10+85.834	-25.5676	CUT "X" IN SIDEWALK
C608	13911875.7500	3036508.3210	133.6000	10+06.420	17.3796	CUT "X"
C609	13911899.9930	3036080.3480	132.8000	5+80.061	-26.9670	CUT "X"

STA.	North	East	Desc.
5+00	13911869.2900	3036001.6436	BEGIN PROJ.

N

BAR SCALE
0 10 20 40



LEGEND

- TYP. CREPE MYRTLE (UNLESS NOTED)
- SHRUB/BUSH
- TYP. SAGO PALM (UNLESS NOTED)
- SANITARY MANHOLE
- STORM MANHOLE
- WATER METER
- GATE VALVE
- FLUSH VALVE/FIRE HYDRANT
- BLOW-OFF VALVE
- IRRIGATION CONTROL VALVE
- IRRIGATION SPRINKLER HEAD
- TELEPHONE PEDESTAL
- TELEPHONE BOX
- TELEPHONE SIGN
- FIBER OPTIC SIGN
- LIGHT POLE (ELECTRIC)
- LIGHT POLE (NATURAL GAS)
- POWER POLE
- GUY WIRE
- GAS VALVE
- CATHODIC TEST STATION
- TYP. MAIL BOX (UNLESS NOTED)
- TRAFFIC SIGN
- TYP. 5/8" IR (UNLESS NOTED)
- E1(B) — BURIED CENTERPOINT ELECTRICAL
- OE1 — OVERHEAD CENTERPOINT ELECTRICAL
- BURIED CENTERPOINT GAS
- SANITARY LINE
- FOC1(D) — BURIED AT&T FIBER OPTIC
- T1(D) — BURIED AT&T TELEPHONE
- BURIED AT&T CABLE TV
- WOOD FENCE
- STORM SEWER

QUALITY LEVEL LEGEND

- QUALITY LEVEL "A" — QL(A) —
- QUALITY LEVEL "B" — QL(B) —
- QUALITY LEVEL "C" - - QL(C) - -
- QUALITY LEVEL "D" - - QL(D) - -

TYPICAL FOR ALL UTILITIES

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY ENGINEERING DEPARTMENT

HARRIS COUNTY 1836 TEXAS

Costello

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(713) 783-7788
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TBPE FIRM REG. No. 280
TBPLS FIRM REG. No. 100486

SEE NOTE 4 FOR CERTIFICATION

STATE OF TEXAS REGISTERED DAVID E. HUNT 5198 PROFESSIONAL LAND SURVEYOR

1-14-22

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018		
UPIN 19103MF14601		
SHEET DESCRIPTION: RAVENSWAY DRIVE 5+00 – 10+00		
DRAWN BY: JDS		DATE: 1/3/2022
DESIGN BY:	SCALE: 1" = 20'	SHEET NO: 5 OF 48

NOTES:

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L18	N47° 41'46"W	14.14

Point	North	East	Elevation	Station	Offset	Description
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C607	13911922.3850	3036585.6270	133.9200	10+85.834	-25.5676	CUT "X" IN SIDEWALK
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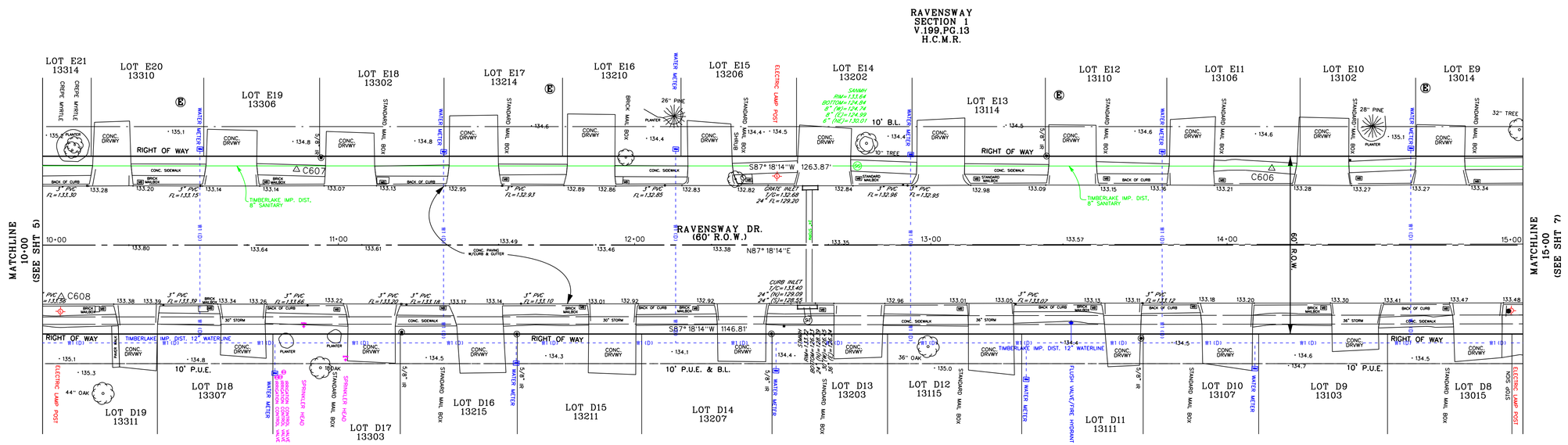
C609	13911899.9930	3036080.3480	132.8000	5+80.061	-26.9670	CUT "X"

N

BAR SCALE
0 10 20 40



LEGEND

- TYP. CREPE MYRTLE (UNLESS NOTED)
- SHRUB/BUSH
- TYP. SAGO PALM (UNLESS NOTED)
- SANITARY MANHOLE
- STORM MANHOLE
- WATER METER
- GATE VALVE
- FLUSH VALVE/FIRE HYDRANT
- BLOW-OFF VALVE
- IRRIGATION CONTROL VALVE
- IRRIGATION SPRINKLER HEAD
- TELEPHONE PEDESTAL
- TELEPHONE BOX
- TELEPHONE SIGN
- FIBER OPTIC SIGN
- LIGHT POLE (ELECTRIC)
- LIGHT POLE (NATURAL GAS)
- POWER POLE
- GUY WIRE
- GAS VALVE
- CATHODIC TEST STATION
- TYP. MAIL BOX (UNLESS NOTED)
- TRAFFIC SIGN
- TYP. 5/8" IR (UNLESS NOTED)
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- BURIED AT&T CABLE TV
- WOOD FENCE
- STORM SEWER

QUALITY LEVEL LEGEND

- QUALITY LEVEL "A" — SUE(A) —
- QUALITY LEVEL "B" — SUE(B) —
- QUALITY LEVEL "C" - - SUE(C) - -
- QUALITY LEVEL "D" - - SUE(D) - -

TYPICAL FOR ALL UTILITIES

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY ENGINEERING DEPARTMENT

Costello

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SEE NOTE 4 FOR CERTIFICATION

STATE OF TEXAS REGISTERED DAVID E. HUNT 5198 PROFESSIONAL LAND SURVEYOR

1-14-22

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

UPIN 19103MF14601

SHEET DESCRIPTION: RAVENSWAY DRIVE 10+00 – 15+00

DRAWN BY: JDS		DATE: 1/3/2022
DESIGN BY:	SCALE: 1" = 20'	SHEET NO: 6 OF 48

Point	North	East	Elevation	Station	Offset	Description
C603	13912211.2030	3037894.8360	131.9400	24+77.343	24.3078	CUT "X" IN STREET
C604	13912068.4610	3037609.7010	132.9600	21+63.225	-24.3271	CUT "X" IN SIDEWALK
C605	13911933.4290	3037481.4480	132.9800	19+78.052	15.7023	CUT "X" IN STREET
TBM5	13912036.0558	3037581.4120	132.9760	21+19.307	-22.4026	CUT BOX IN SW

N

BAR SCALE

0 10 20 40

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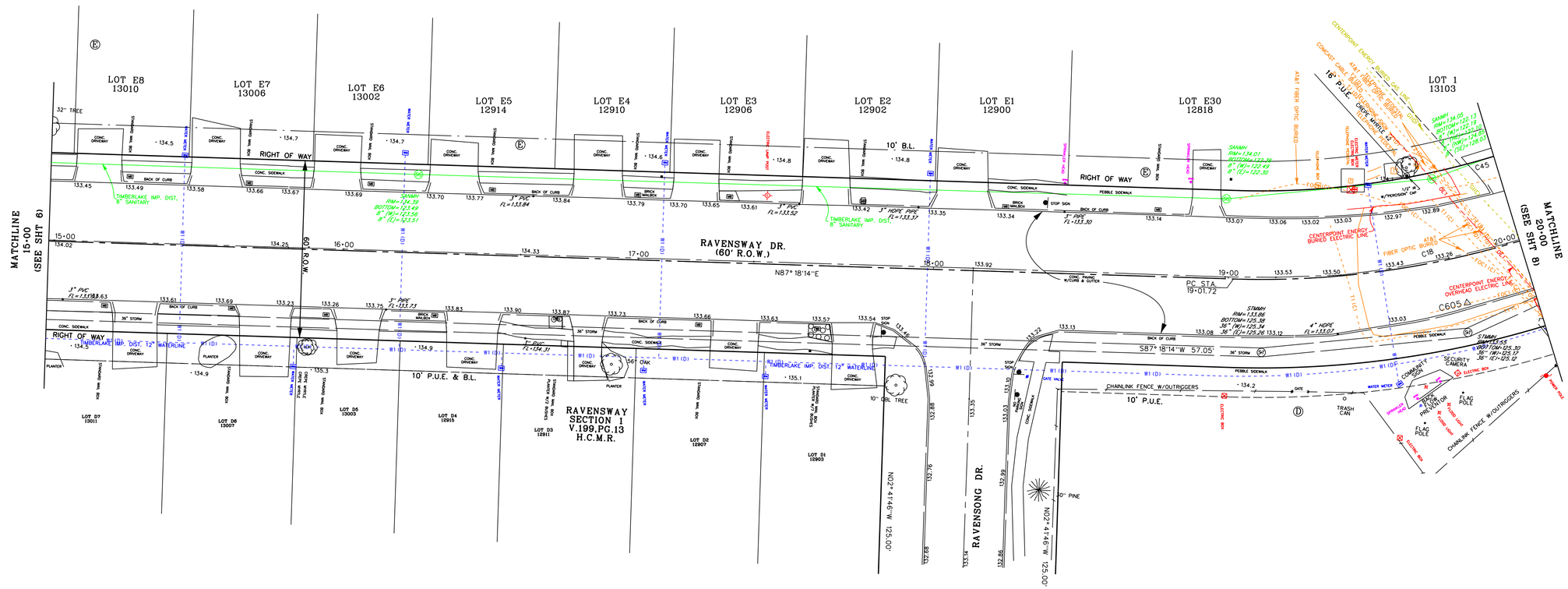

LEGEND

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- SHRUB/BUSH
- TYP. SAGO PALM (UNLESS NOTED)
- SANITARY MANHOLE
- STORM MANHOLE
- WATER METER
- GATE VALVE
- FLUSH VALVE/FIRE HYDRANT
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- IRRIGATION SPRINKLER HEAD
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- TELEPHONE BOX
- TELEPHONE SIGN
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- GUY WIRE
- GAS VALVE
- CATHODIC TEST STATION
- TYP. MAIL BOX (UNLESS NOTED)
- TRAFFIC SIGN
- TYP. 5/8" IR (UNLESS NOTED)
- E1(B) — BURIED CENTERPOINT ELECTRICAL
- OE1 — OVERHEAD CENTERPOINT ELECTRICAL
- BURIED CENTERPOINT GAS
- SANITARY LINE
- FOC1(D) — BURIED AT&T FIBER OPTIC
- T1(D) — BURIED AT&T TELEPHONE
- BURIED AT&T CABLE TV
- WOOD FENCE
- STORM SEWER

QUALITY LEVEL LEGEND

- QUALITY LEVEL "A" — QL(A) —
- QUALITY LEVEL "B" — QL(B) —
- QUALITY LEVEL "C" - - QL(C) - -
- QUALITY LEVEL "D" - - QL(D) - -

TYPICAL FOR ALL UTILITIES

NUMBER	ARC LENGTH	RADIUS	DELTA ANGLE	CHORD DIRECTION	CHORD LENGTH
C18	230.07	300.00	43° 56' 22"	N65° 20'03"E	224.47
C19	82.29	300.00	15° 43' 1"	N51° 13'23"E	82.04
C44	231.91	330.00	40° 15' 52"	N67° 10'19"E	227.16
C45	155.89	270.00	33° 4' 53"	N70° 45'48"E	153.74
C46	44.01	25.00	100° 51' 29"	N03° 47'37"E	38.54
C118	90.52	330.00	15° 43' 1"	N51° 13'23"E	90.24
C119	74.06	270.00	15° 43' 1"	N51° 13'23"E	73.83
C123	42.41	25.00	97° 11' 36"	N10° 29'05"E	37.50

NUMBER	DIRECTION	DISTANCE
L2	S30° 55'07"E	30.00

Point	North	East	Station
19+01.72	13911935.2222	3037401.8087	PC

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY ENGINEERING DEPARTMENT

HARRIS COUNTY 1836 TEXAS

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SEE NOTE 4 FOR CERTIFICATION

STATE OF TEXAS REGISTERED DAVID E. HUNT 5198 PROFESSIONAL LAND SURVEYOR

1-14-22

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

UPIN 19103MF14601

SHEET DESCRIPTION: RAVENSWAY DRIVE 15+00 – 20+00

DRAWN BY: JDS

DATE: 1/3/2022

DESIGN BY:

SCALE: 1" = 20'

SHEET NO: 7 OF 48

Point	North	East	Elevation	Station	Offset	Description
C603	13912211.2030	3037894.8360	131.9400	24+77.343	24.3078	CUT "X" IN STREET
C604	13912068.4610	3037609.7010	132.9600	21+63.225	-24.3271	CUT "X" IN SIDEWALK
C605	13911933.4290	3037481.4480	132.9800	19+78.052	15.7023	CUT "X" IN STREET
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C123	42.41	25.00	97° 11' 36"	N10° 29'05"E	37.50

STA.	North	East	Desc.
21+31.78	13912028.8988	3037605.7975	PT
21+40.63	13912035.3308	3037611.8725	CL PI
22+09.22	13912085.1957	3037658.9690	PC
22+91.51	13912136.5741	3037722.9234	PT
24+60.82	13912223.5686	3037868.1742	CL PI

NUMBER	DIRECTION	DISTANCE
L2	S30° 55'07"E	30.00

N

BAR SCALE

0 10 20 40

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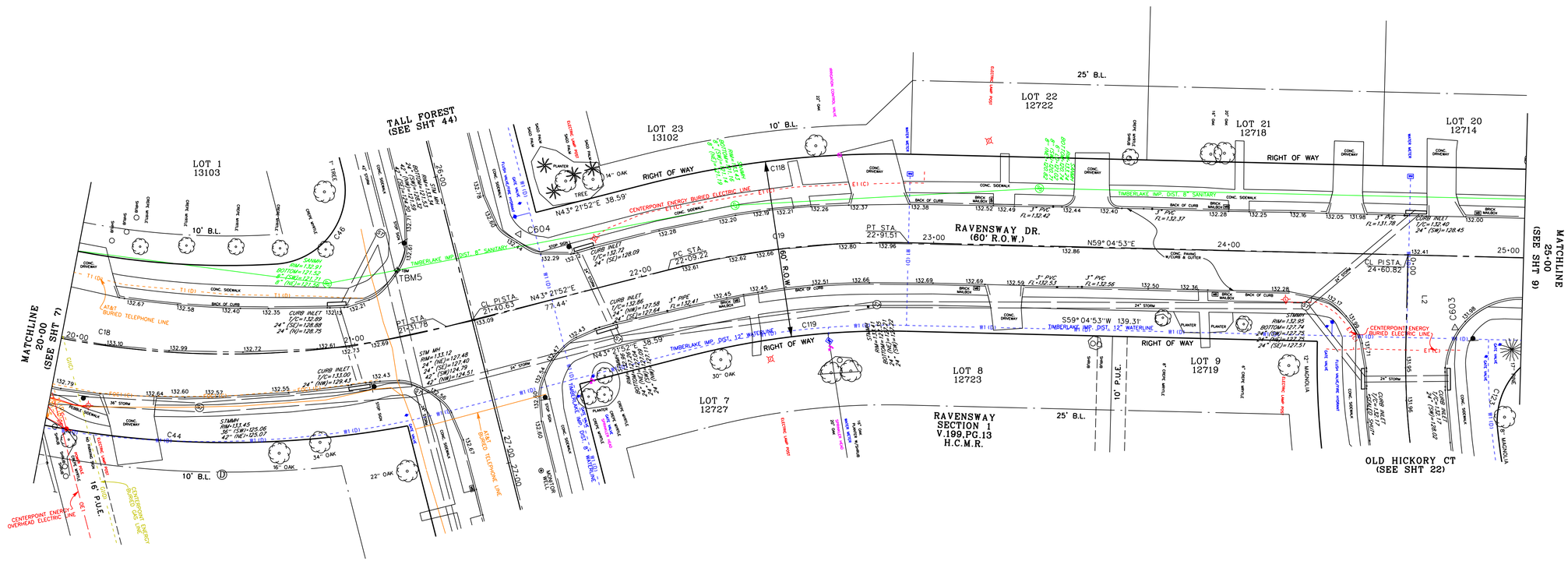

LEGEND

- TYP. CREPE MYRTLE (UNLESS NOTED)
- SHRUB/BUSH
- TYP. SAGO PALM (UNLESS NOTED)
- SANITARY MANHOLE
- STORM MANHOLE
- WATER METER
- GATE VALVE
- FLUSH VALVE/FIRE HYDRANT
- BLOW-OFF VALVE
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- IRRIGATION SPRINKLER HEAD
- TELEPHONE PEDESTAL
- TELEPHONE BOX
- TELEPHONE SIGN
- FIBER OPTIC SIGN
- LIGHT POLE (ELECTRIC)
- LIGHT POLE (NATURAL GAS)
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- GAS VALVE
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- E1(B) — BURIED CENTERPOINT ELECTRICAL
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QUALITY LEVEL LEGEND

QUALITY LEVEL "A" — SB(A) —
QUALITY LEVEL "B" — SB(B) —
QUALITY LEVEL "C" - - SB(C) - -
QUALITY LEVEL "D" - - SB(D) - -

TYPICAL FOR ALL UTILITIES

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HARRIS COUNTY ENGINEERING DEPARTMENT

HARRIS COUNTY TEXAS 1836

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1-14-22

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UPIN 19103MF14601

SHEET DESCRIPTION: RAVENSWAY DRIVE 20+00 – 25+00

DRAWN BY: JDS | DATE: 1/3/2022

DESIGN BY: | SCALE: 1" = 20' | SHEET NO: 8 OF 48

Point	North	East	Elevation	Station	Offset	Description
C600	13912829.1780	3038585.0030	132.1700	34+30.520	-25.7596	CUT "X" IN SIDEWALK
C601	13912525.7800	3038414.7380	132.6000	30+83.321	17.7934	CUT "X" IN SIDEWALK
C602	13912434.9620	3038191.5670	132.4600	28+45.349	-16.6132	CUT "X" IN SIDEWALK

BAR SCALE

0 10 20 40

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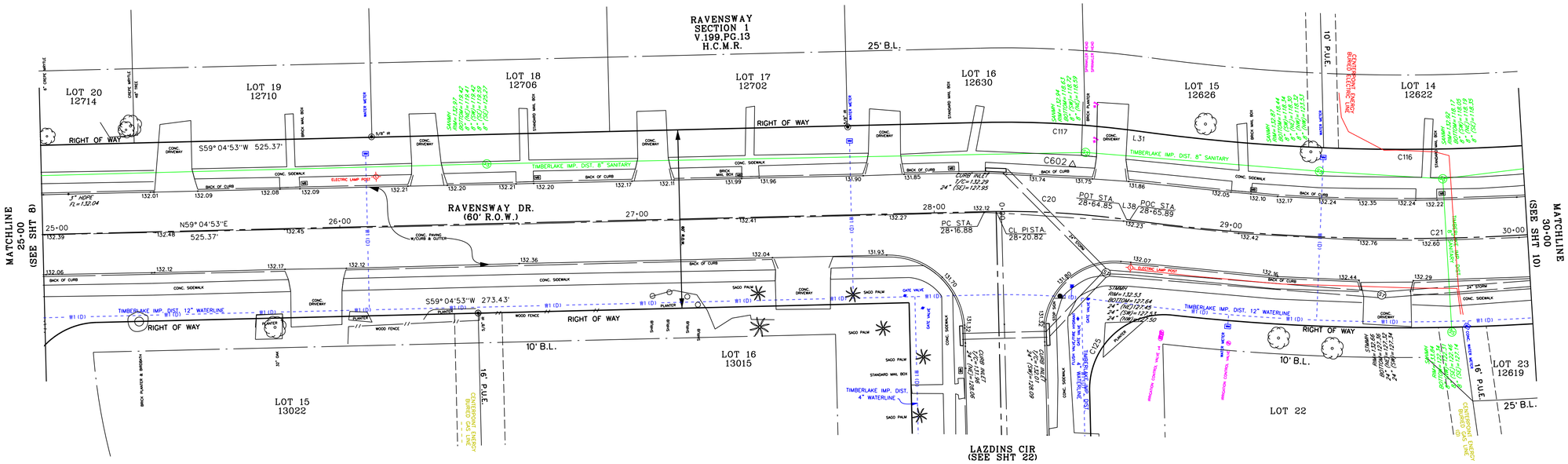

LEGEND

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- IRRIGATION CONTROL VALVE
- IRRIGATION SPRINKLER HEAD
- TELEPHONE PEDESTAL
- TELEPHONE BOX
- TELEPHONE SIGN
- FIBER OPTIC SIGN
- LIGHT POLE (ELECTRIC)
- LIGHT POLE (NATURAL GAS)
- POWER POLE
- GUY WIRE
- GAS VALVE
- CATHODIC TEST STATION
- TYP. MAIL BOX (UNLESS NOTED)
- TRAFFIC SIGN
- TYP. 5/8" IR (UNLESS NOTED)
- E1(B) — BURIED CENTERPOINT ELECTRICAL
- OE1 — OVERHEAD CENTERPOINT ELECTRICAL
- BURIED CENTERPOINT GAS
- SANITARY LINE
- FOC1(D) — BURIED AT&T FIBER OPTIC
- T1(D) — BURIED AT&T TELEPHONE
- BURIED AT&T CABLE TV
- WOOD FENCE
- STORM SEWER

QUALITY LEVEL LEGEND

QUALITY LEVEL "A" — QS(A) —
QUALITY LEVEL "B" — QS(B) —
QUALITY LEVEL "C" - - QS(C) - -
QUALITY LEVEL "D" - - QS(D) - -
TYPICAL FOR ALL UTILITIES

NUMBER	ARC LENGTH	RADIUS	DELTA ANGLE	CHORD DIRECTION	CHORD LENGTH
C20	47.97	300.00	9° 9' 40"	N63° 39'43"E	47.92
C21	214.92	680.00	18° 6' 32"	N59° 11'17"E	214.03
C22	255.26	680.00	21° 30' 28"	N39° 22'47"E	253.76
C116	175.42	650.00	15° 27' 47"	N60° 30'40"E	174.89
C117	52.77	330.00	9° 9' 42"	N63° 39'44"E	52.71
C125	42.62	25.00	97° 40' 17"	S17° 55'02"W	37.64
C126	472.13	710.00	38° 6' 0"	N47° 42'10"E	463.48
C127	43.26	25.00	99° 8' 10"	N78° 13'15"E	38.06
C129	35.27	25.00	80° 50' 13"	S11° 47'33"E	32.42
C130	213.99	650.00	18° 51' 46"	N38° 03'27"E	213.03
C131	43.27	25.00	99° 9' 46"	S78° 12'27"W	38.07

NUMBER	DIRECTION	DISTANCE
L7	S39° 51'59"E	19.43
L31	N68° 14'33"E	1.04
L38	N68° 14'33"E	1.04

STA.	North	East	Desc.
28+16.88	13912406.5188	3038173.6378	PC
28+64.85	13912427.7776	3038216.5801	CL PI

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY ENGINEERING DEPARTMENT

HARRIS COUNTY 1836 TEXAS

Costello
Engineering and Surveying
2107 CityWest Blvd., 3rd Floor
Houston, Texas 77042
(713) 783-7788
(713) 783-3580, Fax
TBPE FIRM REG. No. 280
TBPLS FIRM REG. No. 100486

SEE NOTE 4 FOR CERTIFICATION

STATE OF TEXAS REGISTERED DAVID E. HUNT 5198 PROFESSIONAL LAND SURVEYOR

1-14-22

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

UPIN 19103MF14601

SHEET DESCRIPTION: RAVENSWAY DRIVE 25+00 – 30+00

DRAWN BY: JDS

DESIGN BY:

SCALE: 1" = 20'

DATE: 1/3/2022

SHEET NO: 9 OF 48

Point	North	East	Elevation	Station	Offset	Description
C600	13912829.1780	3038585.0030	132.1700	34+30.520	-25.7596	CUT "X" IN SIDEWALK
C601	13912525.7800	3038414.7380	132.6000	30+83.321	17.7934	CUT "X" IN SIDEWALK
C602	13912434.9620	3038191.5670	132.4600	28+45.349	-16.6132	CUT "X" IN SIDEWALK

NUMBER	ARC LENGTH	RADIUS	DELTA ANGLE	CHORD DIRECTION	CHORD LENGTH
C20	47.97	300.00	9° 9' 40"	N63° 39'43"E	47.92
C21	214.92	680.00	18° 6' 32"	N59° 11'17"E	214.03
C22	255.26	680.00	21° 30' 28"	N39° 22'47"E	253.76
C116	175.42	650.00	15° 27' 47"	N60° 30'40"E	174.89
C117	52.77	330.00	9° 9' 42"	N63° 39'44"E	52.71
C125	42.62	25.00	97° 40' 17"	S17° 55'02"W	37.64

NUMBER	ARC LENGTH	RADIUS	DELTA ANGLE	CHORD DIRECTION	CHORD LENGTH
C126	472.13	710.00	38° 6' 0"	N47° 42'10"E	463.48
C127	43.26	25.00	99° 8' 10"	N78° 13'15"E	38.06
C129	35.27	25.00	80° 50' 13"	S11° 47'33"E	32.42
C130	213.99	650.00	18° 51' 46"	N38° 03'27"E	213.03
C131	43.27	25.00	99° 9' 46"	S78° 12'27"W	38.07

NUMBER	DIRECTION	DISTANCE
L7	S39° 51'59"E	19.43
L31	N68° 14'33"E	1.04
L38	N68° 14'33"E	1.04

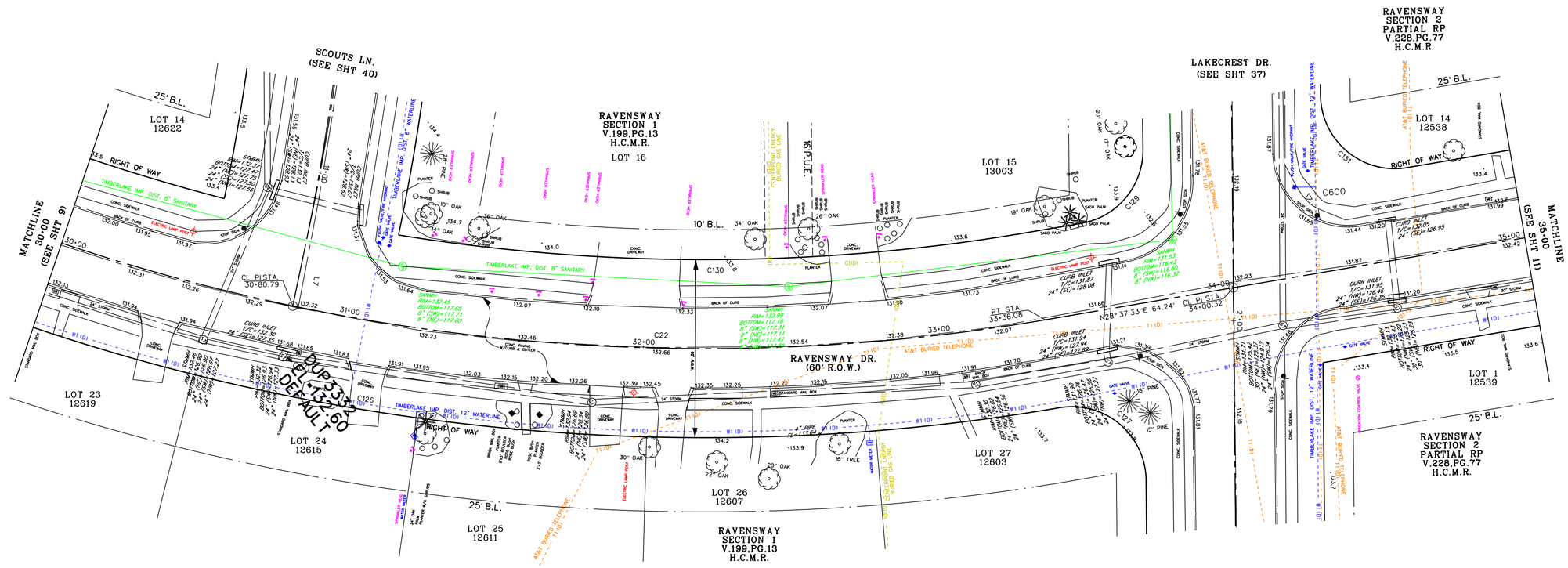
Point	North	East	Station
30+80.79	13912537.7907	3038401.3623	CL PI
33+35.04	13912733.0261	3038561.8693	PT
34+00.32	13912790.3263	3038593.1440	CL PI

BAR SCALE

0 10 20 40

NOTES:

1. Bearings and coordinates shown hereon are based on the Texas Coordinate System (North American Datum of 1983, 2011 Adjustment), South Central Zone. Coordinates shown hereon are surface values and may be converted to grid by dividing by a combined surface adjustment factor of 1.000079000.
2. Primary Benchmark: Tropical Storm Allison Recovery Project Monument 110130, BM 110130 is a brass disc on the northeast corner of a storm sewer inlet located on the north side of Jarvis Road across from its intersection with Timberlake, immediately east of a driveway to the Timberlake Improvement District wastewater treatment plant. Elevation 127.28 feet NAVD88, 2001 adjustment.
3. To convert elevations based on NAVD88, 2001 adjustment to NAVD88, Geoid 12B elevations subtract 0.96 feet.
4. This survey substantially complies with the current Texas Society of Professional Surveyors standards and specifications for a Category 6 Condition I Survey and a Category 1B, Condition III Survey.
5. All Easements and Building Lines depicted are dedicated by subdivision plat labeled herein, unless otherwise noted.



LEGEND

- TYP. CREPE MRYTLE (UNLESS NOTED)
- SHRUB/BUSH
- TYP. SAGO PALM (UNLESS NOTED)
- SANITARY MANHOLE
- STORM MANHOLE
- WATER METER
- GATE VALVE
- FLUSH VALVE/FIRE HYDRANT
- BLOW-OFF VALVE
- IRRIGATION CONTROL VALVE
- IRRIGATION SPRINKLER HEAD
- TELEPHONE PEDESTAL
- TELEPHONE BOX
- TELEPHONE SIGN
- FIBER OPTIC SIGN
- LIGHT POLE (ELECTRIC)
- LIGHT POLE (NATURAL GAS)
- POWER POLE
- GUY WIRE
- GAS VALVE
- CATHODIC TEST STATION
- TYP. MAIL BOX (UNLESS NOTED)
- TRAFFIC SIGN
- TYP. 5/8" RR (UNLESS NOTED)
- E1(B) — BURIED CENTERPOINT ELECTRICAL
- OE1 — OVERHEAD CENTERPOINT ELECTRICAL
- BURIED CENTERPOINT GAS
- SANITARY LINE
- FOC1(D) — BURIED AT&T FIBER OPTIC
- T1(D) — BURIED AT&T TELEPHONE
- BURIED AT&T CABLE TV
- WOOD FENCE
- STORM SEWER

QUALITY LEVEL LEGEND

QUALITY LEVEL "A" — QL(A) —
QUALITY LEVEL "B" — QL(B) —
QUALITY LEVEL "C" - - QL(C) - -
QUALITY LEVEL "D" - - QL(D) - -
TYPICAL FOR ALL UTILITIES

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY
ENGINEERING DEPARTMENT

HARRIS COUNTY TEXAS 1836

Costello
Engineering and Surveying
2107 CityWest Blvd., 3rd Floor
Houston, Texas 77042
(713) 783-7788
(713) 783-3580, Fax
TBPE FIRM REG. No. 280
TBPLS FIRM REG. No. 100486

SEE NOTE 4 FOR CERTIFICATION

STATE OF TEXAS REGISTERED DAVID E. HUNT 5198 PROFESSIONAL LAND SURVEYOR

1-14-22

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

UPIN 19103MF14601

SHEET DESCRIPTION: RAVENSWAY DRIVE 30+00 – 35+00

DRAWN BY: JDS — DATE: 1/3/2022

DESIGN BY: — SCALE: 1" = 20' — SHEET NO: 10 OF 48

BAR SCALE

0 10 20 40

NOTES:

1. Bearings and coordinates shown hereon are based on the Texas Coordinate System (North American Datum of 1983, 2011 Adjustment), South Central Zone. Coordinates shown hereon are surface values and may be converted to grid by dividing by a combined surface adjustment factor of 1.000079000.
2. Primary Benchmark: Tropical Storm Allison Recovery Project Monument 110130, BM 110130 is a brass disc on the northeast corner of a storm sewer inlet located on the north side of Jarvis Road across from its intersection with Timberlake, immediately east of a driveway to the Timberlake Improvement District wastewater treatment plant. Elevation 127.28 feet NAVD88, 2001 adjustment.
3. To convert elevations based on NAVD88, 2001 adjustment to NAVD88, Geoid 12B elevations subtract 0.96 feet.
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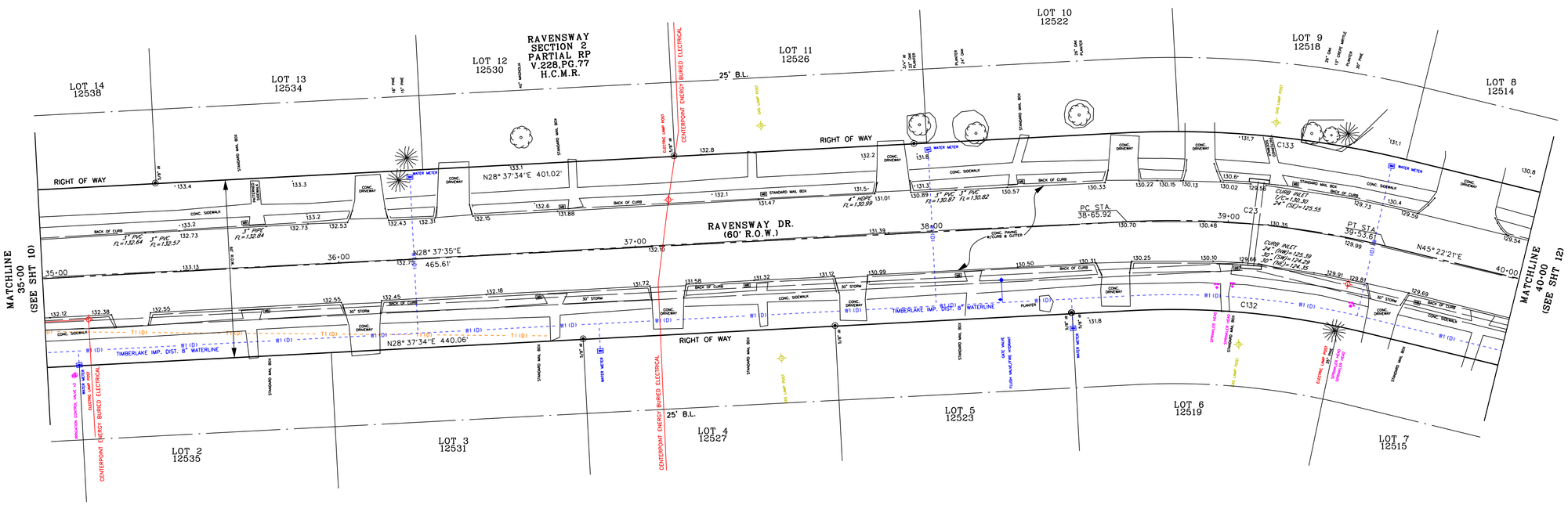


Point	North	East	Station
38+65.92	13913199.0171	3038816.2130	PC
39+53.61	13913268.7957	3038868.7939	PT

NUMBER	ARC LENGTH	RADIUS	DELTA ANGLE	CHORD DIRECTION	CHORD LENGTH
C23	87.68	300.00	16° 44' 47"	N36° 59'58"E	87.37
C33	109.70	600.00	10° 28' 31"	S38° 14'04"E	109.54
C132	78.92	270.00	16° 44' 47"	N36° 59'58"E	78.63
C133	96.45	330.00	16° 44' 47"	N36° 59'58"E	96.11
C134	40.74	25.00	93° 22' 1"	N87° 56'38"W	36.38
C137	104.21	570.00	10° 28' 31"	S38° 14'04"E	104.07
C138	50.50	630.00	4° 35' 36"	S35° 17'36"E	50.49

LEGEND

- TYP. CREPE MYRTLE (UNLESS NOTED)
- SHRUB/BUSH
- TYP. SAGO PALM (UNLESS NOTED)
- SANITARY MANHOLE
- STORM MANHOLE
- WATER METER
- GATE VALVE
- FLUSH VALVE/FIRE HYDRANT
- BLOW-OFF VALVE
- IRRIGATION CONTROL VALVE
- IRRIGATION SPRINKLER HEAD
- TELEPHONE PEDESTAL
- TELEPHONE BOX
- TELEPHONE SIGN
- FIBER OPTIC SIGN
- LIGHT POLE (ELECTRIC)
- LIGHT POLE (NATURAL GAS)
- POWER POLE
- GUY WIRE
- GAS VALVE
- CATHODIC TEST STATION
- TYP. MAIL BOX (UNLESS NOTED)
- TRAFFIC SIGN
- TYP. 5/8" IR (UNLESS NOTED)
- E1(B) — BURIED CENTERPOINT ELECTRICAL
- OE1 — OVERHEAD CENTERPOINT ELECTRICAL
- BURIED CENTERPOINT GAS
- SANITARY LINE
- FOC1(D) — BURIED AT&T FIBER OPTIC
- T1(D) — BURIED AT&T TELEPHONE
- BURIED AT&T CABLE TV
- // — WOOD FENCE
- STORM SEWER

QUALITY LEVEL LEGEND

- QUALITY LEVEL "A" — WS(A) —
- QUALITY LEVEL "B" — WS(B) —
- QUALITY LEVEL "C" - - WS(C) - -
- QUALITY LEVEL "D" - - WS(D) - -

TYPICAL FOR ALL UTILITIES

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY ENGINEERING DEPARTMENT

HARRIS COUNTY 1836 TEXAS

Costello

Engineering and Surveying
2107 CityWest Blvd., 3rd Floor
Houston, Texas 77042
(713) 783-7788
(713) 783-3580, Fax
TBPE FIRM REG. No. 280
TBPLS FIRM REG. No. 100486

SEE NOTE 4 FOR CERTIFICATION

STATE OF TEXAS REGISTERED DAVID E. HUNT 5198 PROFESSIONAL LAND SURVEYOR

1-14-22

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

UPIN 19103MF14601

SHEET DESCRIPTION: RAVENSWAY DRIVE 35+00 – 40+00

DRAWN BY: JDS

DATE: 1/3/2022

DESIGN BY:

SCALE: 1" = 20'

SHEET NO: 11 OF 48

NUMBER	ARC LENGTH	RADIUS	DELTA ANGLE	CHORD DIRECTION	CHORD LENGTH
C23	87.68	300.00	16° 44' 47"	N36°59'58"E	87.37
C33	109.70	600.00	10° 28' 31"	S38°14'04"E	109.54
C132	78.92	270.00	16° 44' 47"	N36°59'58"E	78.63
C133	96.45	330.00	16° 44' 47"	N36°59'58"E	96.11
C134	40.74	25.00	93° 22' 1"	N87°56'38"W	36.38
C137	104.21	570.00	10° 28' 31"	S38°14'04"E	104.07
C138	50.50	630.00	4° 35' 36"	S35°17'36"E	50.49

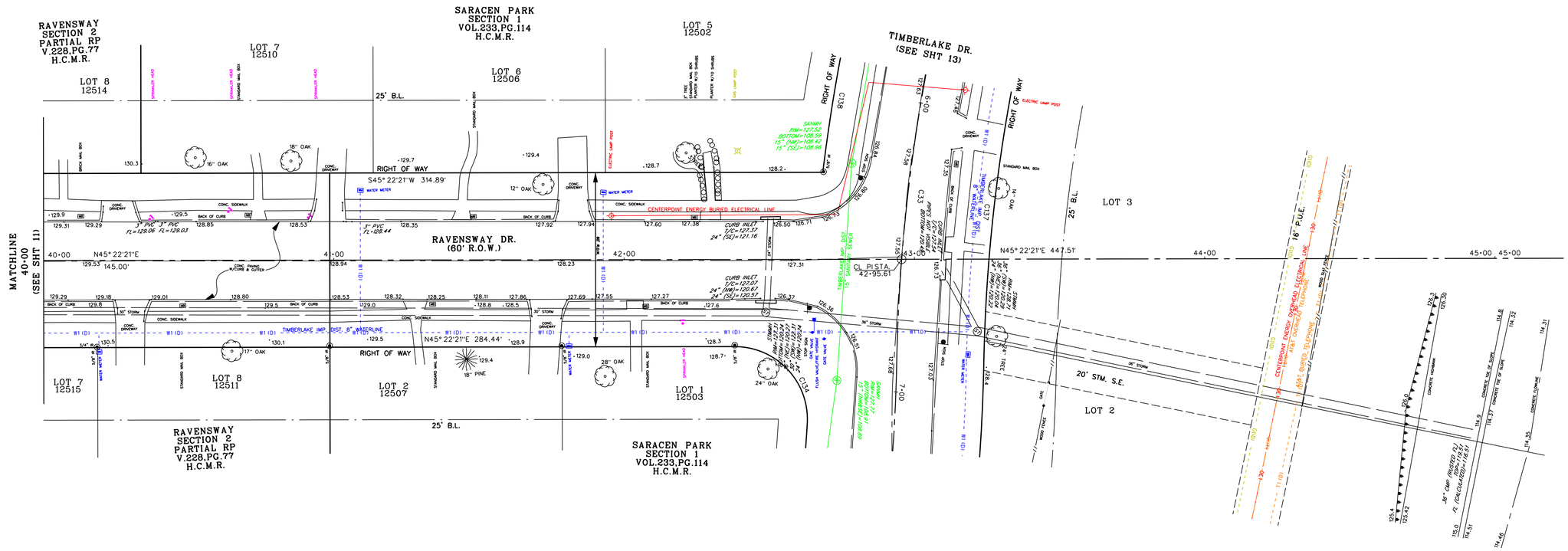
N

BAR SCALE

0 10 20 40

NOTES:

1. Bearings and coordinates shown hereon are based on the Texas Coordinate System (North American Datum of 1983, 2011 Adjustment), South Central Zone. Coordinates shown hereon are surface values and may be converted to grid by dividing by a combined surface adjustment factor of 1.000079000.
2. Primary Benchmark: Tropical Storm Allison Recovery Project Monument 110130, BM 110130 is a brass disc on the northeast corner of a storm sewer inlet located on the north side of Jarvis Road across from its intersection with Timberlake, immediately east of a driveway to the Timberlake Improvement District wastewater treatment plant. Elevation 127.28 feet NAVD88, 2001 adjustment.
3. To convert elevations based on NAVD88, 2001 adjustment to NAVD88, Geoid 12B elevations subtract 0.96 feet.
4. This survey substantially complies with the current Texas Society of Professional Surveyors standards and specifications for a Category 6 Condition I Survey and a Category 1B, Condition III Survey.
5. All Easements and Building Lines depicted are dedicated by subdivision plat labeled herein, unless otherwise noted.



STA.	North	East	Desc.
42+95.61	13913509.0473	3039112.1909	CL PI
45+96.12	13913720.1584	3039326.0658	END PROJ.

LEGEND

- TYP. CREPE MRYTLE (UNLESS NOTED)
- SHRUB/BUSH
- TYP. SAGO PALM (UNLESS NOTED)
- SANITARY MANHOLE
- STORM MANHOLE
- WATER METER
- GATE VALVE
- FLUSH VALVE/FIRE HYDRANT
- BLOW-OFF VALVE
- IRRIGATION CONTROL VALVE
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- TELEPHONE PEDESTAL
- TELEPHONE BOX
- TELEPHONE SIGN
- FIBER OPTIC SIGN
- LIGHT POLE (ELECTRIC)
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- GUY WIRE
- GAS VALVE
- CATHODIC TEST STATION
- TYP. MAIL BOX (UNLESS NOTED)
- TRAFFIC SIGN
- TYP. 5/8" IR (UNLESS NOTED)
- E1(B) — BURIED CENTERPOINT ELECTRICAL
- OE1 — OVERHEAD CENTERPOINT ELECTRICAL
- BURIED CENTERPOINT GAS
- SANITARY LINE
- FOC1(D) — BURIED AT&T FIBER OPTIC
- T1(D) — BURIED AT&T TELEPHONE
- BURIED AT&T CABLE TV
- // — WOOD FENCE
- STORM SEWER

QUALITY LEVEL LEGEND

- QUALITY LEVEL "A" — SS(A) —
- QUALITY LEVEL "B" — SS(B) —
- QUALITY LEVEL "C" - - SS(C) - -
- QUALITY LEVEL "D" - - SS(D) - -

TYPICAL FOR ALL UTILITIES

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY ENGINEERING DEPARTMENT

HARRIS COUNTY 1836 TEXAS

Costello

Engineering and Surveying
2107 CityWest Blvd., 3rd Floor
Houston, Texas 77042
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(713) 783-3580, Fax
TBPE FIRM REG. No. 280
TBPLS FIRM REG. No. 100486

SEE NOTE 4 FOR CERTIFICATION

STATE OF TEXAS REGISTERED DAVID E. HUNT 5198 PROFESSIONAL LAND SURVEYOR

1-14-22

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

UPIN 19103MF14601

SHEET DESCRIPTION: RAVENSWAY DRIVE 40+00 – 45+00

DRAWN BY: JDS		DATE: 1/3/2022
DESIGN BY:	SCALE: 1" = 20'	SHEET NO: 12 OF 48

NOTES:

1. Bearings and coordinates shown hereon are based on the Texas Coordinate System (North American Datum of 1983, 2011 Adjustment), South Central Zone. Coordinates shown hereon are surface values and may be converted to grid by dividing by a combined surface adjustment factor of 1.000079000.
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3. To convert elevations based on NAVD88, 2001 adjustment to NAVD88, Geoid 12B elevations subtract 0.96 feet.
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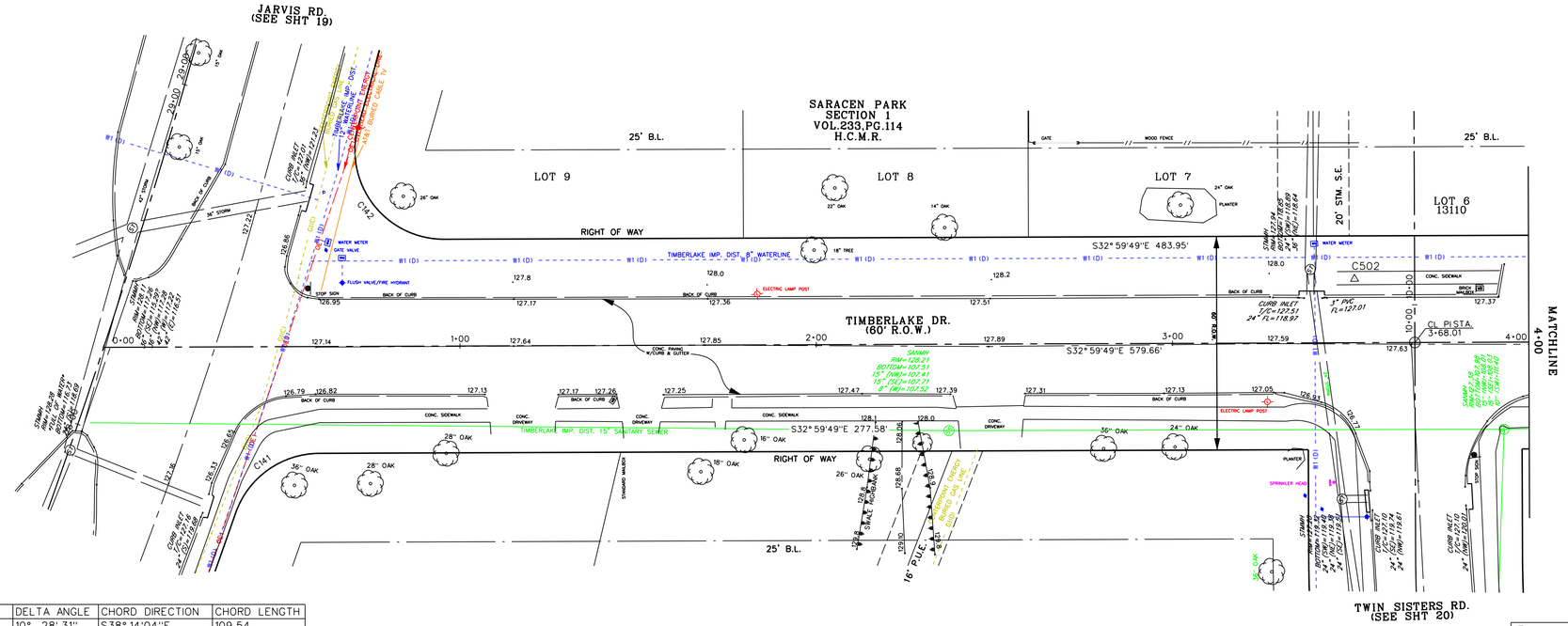


NUMBER	DIRECTION	DISTANCE
L11	S32°59'49"E	56.18
L28	S32°59'49"E	12.35

NUMBER	ARC LENGTH	RADIUS	DELTA ANGLE	CHORD DIRECTION	CHORD LENGTH
C33	109.70	600.00	10° 28' 31"	S38°14'04"E	109.54
C34	109.70	600.00	10° 28' 31"	S38°14'04"E	109.54
C134	40.74	25.00	93° 22' 1"	N87°56'38"W	36.38
C135	82.21	570.00	8° 15' 49"	S37°07'43"E	82.14
C136	115.18	630.00	10° 28' 31"	S38°14'04"E	115.02
C137	104.21	570.00	10° 28' 31"	S38°14'04"E	104.07
C138	50.50	630.00	4° 35' 36"	S35°17'36"E	50.49
C141	30.81	25.00	70° 37' 12"	S68°18'24"E	28.90
C142	46.33	25.00	106° 11' 24"	S20°05'53"W	39.98

Point	North	East	Elevation	Station	Offset	Description
C500	13913351.9269	3039248.9357	128.0700	Off Chain	Off Chain	CUT~X~BC
C502	13913770.3330	3038958.3828	128.0500	3+51.126	-17.9222	CUT "X"
C503	13913540.4838	3039109.4638	128.1100	6+27.635	-17.5989	CUT "X"

Point	North	East	Station
3019	13914055.0622	3038752.1309	0+00.000
3020	13913746.4120	3038952.5464	3+68.010
3021	13913509.0473	3039112.1909	6+54.221
3022	13913482.8555	3039135.6045	6+89.357
3023	13913396.8100	3039203.3996	7+99.054
3024	13913349.6960	3039233.9921	8+55.230

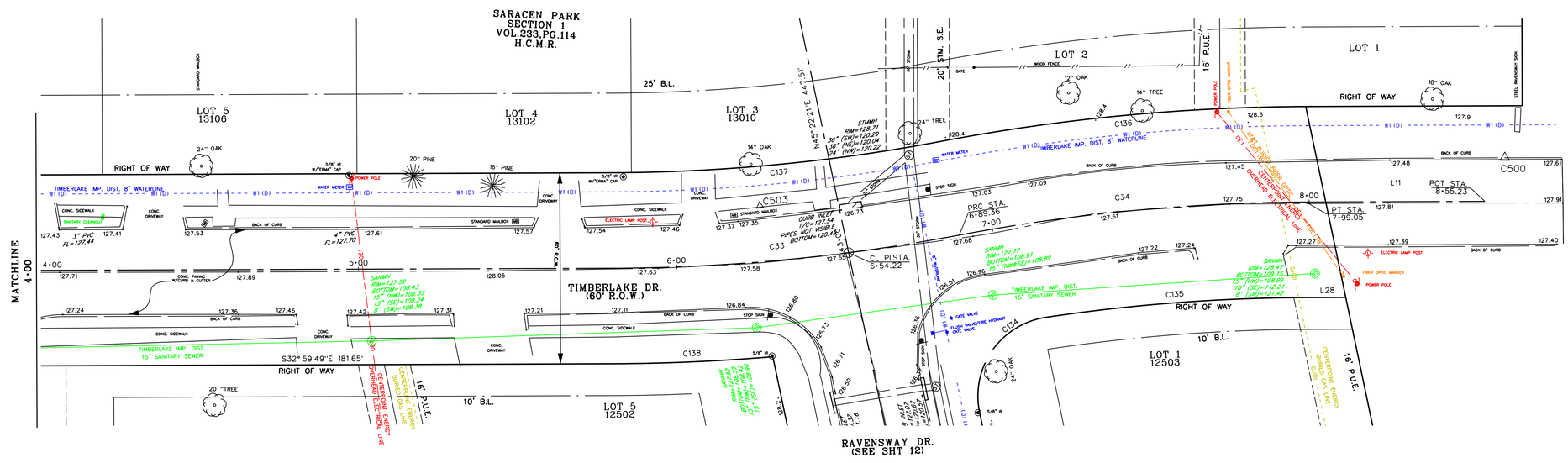
LEGEND

- TYP. CREPE MRYTLE (UNLESS NOTED)
- SHRUB/BUSH
- TYP. SAGO PALM (UNLESS NOTED)
- SANITARY MANHOLE
- STORM MANHOLE
- WATER METER
- GATE VALVE
- FLUSH VALVE/FIRE HYDRANT
- BLOW-OFF VALVE
- IRRIGATION CONTROL VALVE
- IRRIGATION SPRINKLER HEAD
- TELEPHONE PEDESTAL
- TELEPHONE BOX
- TELEPHONE SIGN
- FIBER OPTIC SIGN
- LIGHT POLE (ELECTRIC)
- LIGHT POLE (NATURAL GAS)
- POWER POLE
- GUY WIRE
- GAS VALVE
- CATHODIC TEST STATION
- TYP. MAIL BOX (UNLESS NOTED)
- TRAFFIC SIGN
- TYP. 5/8" IR (UNLESS NOTED)
- E1 (B) — BURIED CENTERPOINT ELECTRICAL
- OE1 — OVERHEAD CENTERPOINT ELECTRICAL
- BURIED CENTERPOINT GAS
- SANITARY LINE
- FOC1 (D) — BURIED AT&T FIBER OPTIC
- T1 (D) — BURIED AT&T TELEPHONE
- BURIED AT&T CABLE TV
- WOOD FENCE
- STORM SEWER

QUALITY LEVEL LEGEND

- QUALITY LEVEL "A" — SB (A) —
- QUALITY LEVEL "B" — SB (B) —
- QUALITY LEVEL "C" - - SB (C) - -
- QUALITY LEVEL "D" - - SB (D) - -

TYPICAL FOR ALL UTILITIES



NO.	REVISIONS	DATE	NAME

HARRIS COUNTY
ENGINEERING DEPARTMENT

Costello
Engineering and Surveying
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SEE NOTE 4 FOR CERTIFICATION

STATE OF TEXAS REGISTERED DAVID E. HUNT 5198 PROFESSIONAL LAND SURVEYOR

1-14-22

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

UPIN 19103MF14601

SHEET DESCRIPTION: TIMBERLAKE DRIVE

DRAWN BY: JDS | DATE: 1/3/2022

DESIGN BY: | SCALE: 1" = 20' | SHEET NO: 13 OF 48

NOTES:

1. Bearings and coordinates shown hereon are based on the Texas Coordinate System (North American Datum of 1983, 2011 Adjustment), South Central Zone. Coordinates shown hereon are surface values and may be converted to grid by dividing by a combined surface adjustment factor of 1.000079000.
2. Primary Benchmark: Tropical Storm Allison Recovery Project Monument 110130, BM 110130 is a brass disc on the northeast corner of a storm sewer inlet located on the north side of Jarvis Road across from its intersection with Timberlake, immediately east of a driveway to the Timberlake Improvement District wastewater treatment plant. Elevation 127.28 feet NAVD88, 2001 adjustment.
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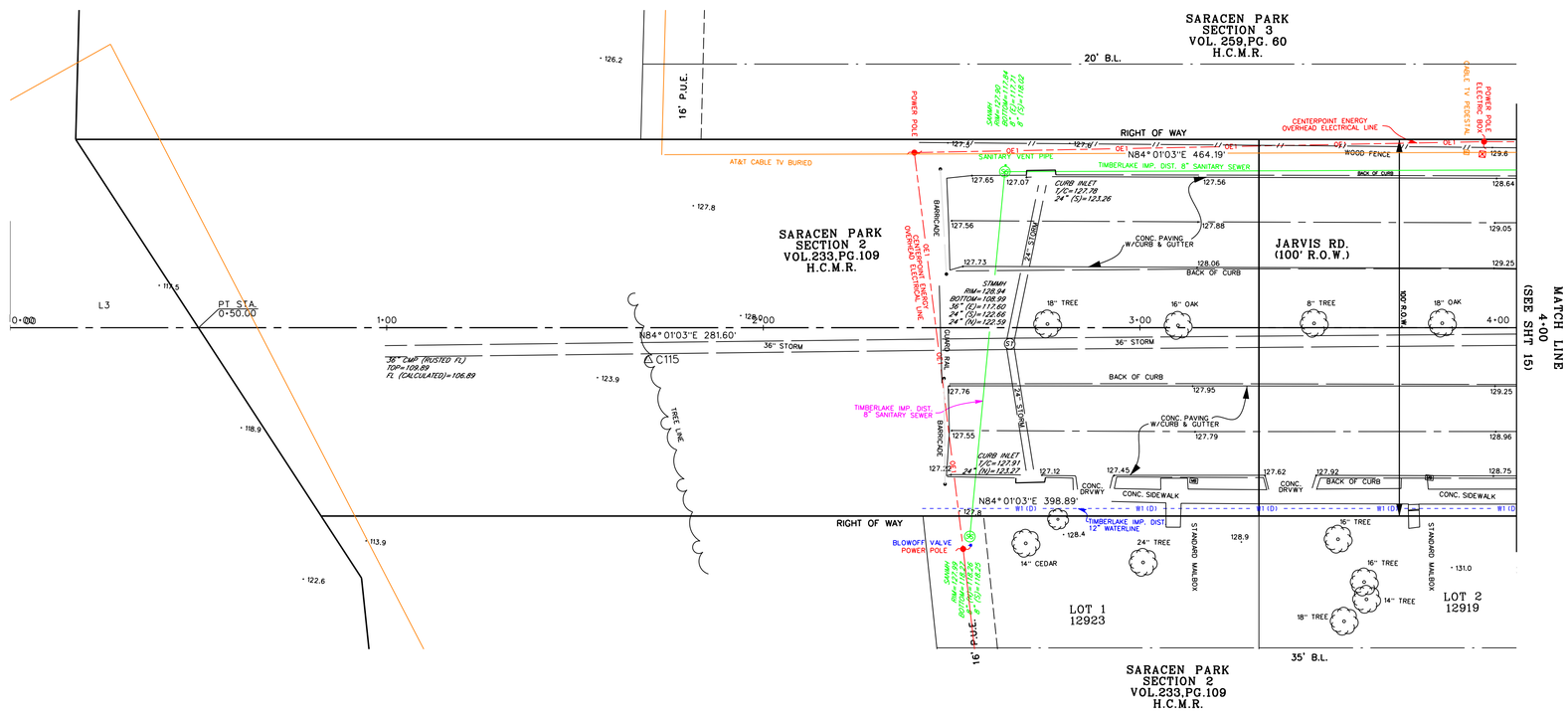
5. All Easements and Building Lines depicted are dedicated by subdivision plat labeled herein, unless otherwise noted.

Point	North	East	Elevation	Station	Offset	Description
C115	13914156.1270	3036126.3890	128.5900	1+69.460	8.5618	5/8" IR W/CAP

STA.	North	East	Desc.
0+00	13914146.9806	3035956.9596	BEGIN PROJ.

N

BAR SCALE
0 10 20 40



LEGEND

- TYP. CREPE MYRTLE (UNLESS NOTED)
- SHRUB/BUSH
- TYP. SAGO PALM (UNLESS NOTED)
- SANITARY MANHOLE
- STORM MANHOLE
- WATER METER
- GATE VALVE
- FLUSH VALVE/FIRE HYDRANT
- BLOW-OFF VALVE
- IRRIGATION CONTROL VALVE
- IRRIGATION SPRINKLER HEAD
- TELEPHONE PEDESTAL
- TELEPHONE BOX
- TELEPHONE SIGN
- FIBER OPTIC SIGN
- LIGHT POLE (ELECTRIC)
- LIGHT POLE (NATURAL GAS)
- POWER POLE
- GUY WIRE
- GAS VALVE
- CATHODIC TEST STATION
- TYP. MAIL BOX (UNLESS NOTED)
- TRAFFIC SIGN
- TYP. 5/8" IR (UNLESS NOTED)
- E1(B) — BURIED CENTERPOINT ELECTRICAL
- OE1 — OVERHEAD CENTERPOINT ELECTRICAL
- BURIED CENTERPOINT GAS
- SANITARY LINE
- FOC1(D) — BURIED AT&T FIBER OPTIC
- T1(D) — BURIED AT&T TELEPHONE
- BURIED AT&T CABLE TV
- WOOD FENCE
- STORM SEWER

QUALITY LEVEL LEGEND

QUALITY LEVEL "A"	SUE(A)
QUALITY LEVEL "B"	SUE(B)
QUALITY LEVEL "C"	SUE(C)
QUALITY LEVEL "D"	SUE(D)

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY
ENGINEERING DEPARTMENT

HARRIS COUNTY 1836 TEXAS

Costello

Engineering and Surveying
2107 CityWest Blvd., 3rd Floor
Houston, Texas 77042
(713) 783-7788
(713) 783-3580, Fax
TBPE FIRM REG. No. 280
TBPLS FIRM REG. No. 100486

SEE NOTE 4 FOR CERTIFICATION

STATE OF TEXAS REGISTERED DAVID E. HUNT 5198 PROFESSIONAL LAND SURVEYOR

1-14-22

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

UPIN 19103MF14601

SHEET DESCRIPTION: JARVIS 0+00 – 4+00

DRAWN BY: JDS		DATE: 1/3/2022
DESIGN BY:	SCALE: 1" = 20'	SHEET NO: 14 OF 48

NOTES:

1. Bearings and coordinates shown hereon are based on the Texas Coordinate System (North American Datum of 1983, 2011 Adjustment), South Central Zone. Coordinates shown hereon are surface values and may be converted to grid by dividing by a combined surface adjustment factor of 1.000079000.
2. Primary Benchmark: Tropical Storm Allison Recovery Project Monument 110130, BM 110130 is a brass disc on the northeast corner of a storm sewer inlet located on the north side of Jarvis Road across from its intersection with Timberlake, immediately east of a driveway to the Timberlake Improvement District wastewater treatment plant. Elevation 127.28 feet NAVD88, 2001 adjustment.
3. To convert elevations based on NAVD88, 2001 adjustment to NAVD88, Geoid 12B elevations subtract 0.96 feet.
4. This survey substantially complies with the current Texas Society of Professional Surveyors standards and specifications for a Category 6 Condition I Survey and a Category 1B, Condition III Survey.
5. All Easements and Building Lines depicted are dedicated by subdivision plat labeled herein, unless otherwise noted.

Point	North	East	Elevation	Station	Offset	Description
C508	13914198.1000	3036834.6050	133.3700	8+81.852	11.9294	CUT "X"
C509	13914191.6160	3036516.4320	133.5300	5+61.213	13.8220	CUT "X"
TBM2	13914154.6400	3036437.3843	134.6600	4+78.607	42.4535	NORTH BOLT TOP FLANGE

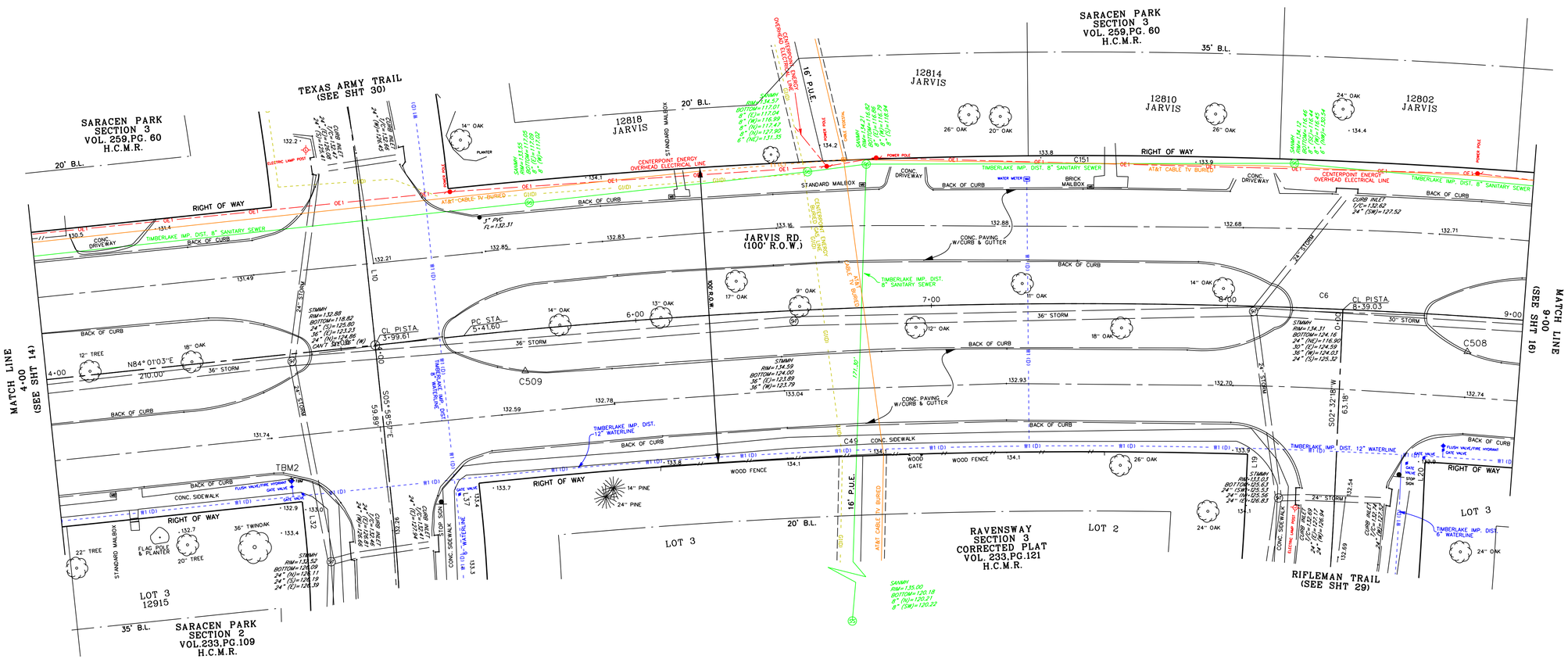
STA.	North	East	Desc.
5+11.60	13914200.3014	3036465.7773	CL PI
5+41.60	13914203.4281	3036495.6142	PC
8+39.03	13914212.3577	3036792.6357	CL PI

NUMBER	ARC LENGTH	RADIUS	DELTA ANGLE	CHORD DIRECTION	CHORD LENGTH
C6	586.69	2000.00	16° 48' 27"	S87° 34'43"E	584.59
C31	54.33	400.00	7° 46' 57"	S02° 05'28"E	54.29
C49	259.99	1950.00	7° 38' 21"	S87° 50'14"W	259.80
C151	441.34	2050.00	12° 20' 6"	S89° 48'54"E	440.49

NUMBER	DIRECTION	DISTANCE
L10	S05° 58'57"E	50.00
L19	S02° 32'18"W	13.09
L20	S02° 32'18"W	13.09
L32	N05° 58'57"W	9.89
L37	N05° 58'57"W	9.87

N

BAR SCALE
0 10 20 40



LEGEND

- TYP. CREPE MYRTLE (UNLESS NOTED)
- SHRUB/BUSH
- TYP. SAGO PALM (UNLESS NOTED)
- SANITARY MANHOLE
- STORM MANHOLE
- WATER METER
- GATE VALVE
- FLUSH VALVE/FIRE HYDRANT
- BLOW-OFF VALVE
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- IRRIGATION SPRINKLER HEAD
- TELEPHONE PEDESTAL
- TELEPHONE BOX
- TELEPHONE SIGN
- FIBER OPTIC SIGN
- LIGHT POLE (ELECTRIC)
- LIGHT POLE (NATURAL GAS)
- POWER POLE
- GUY WIRE
- GAS VALVE
- CATHODIC TEST STATION
- TYP. MAIL BOX (UNLESS NOTED)
- TRAFFIC SIGN
- TYP. 5/8" IR (UNLESS NOTED)
- E1(B) — BURIED CENTERPOINT ELECTRICAL
- OE1 — OVERHEAD CENTERPOINT ELECTRICAL
- BURIED CENTERPOINT GAS
- SANITARY LINE
- FOC1(D) — BURIED AT&T FIBER OPTIC
- T1(D) — BURIED AT&T TELEPHONE
- BURIED AT&T CABLE TV
- WOOD FENCE
- STORM SEWER

QUALITY LEVEL LEGEND

- QUALITY LEVEL "A" — QS(A) —
- QUALITY LEVEL "B" — QS(B) —
- QUALITY LEVEL "C" - - QS(C) - -
- QUALITY LEVEL "D" - - QS(D) - -

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY ENGINEERING DEPARTMENT

HARRIS COUNTY 1836 TEXAS

Costello

Engineering and Surveying
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(713) 783-3580, Fax
TBPE FIRM REG. No. 280
TBPLS FIRM REG. No. 100486

SEE NOTE 4 FOR CERTIFICATION

STATE OF TEXAS REGISTERED DAVID E. HUNT 5198 PROFESSIONAL LAND SURVEYOR

1-14-22

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

UPIN 19103MF14601

SHEET DESCRIPTION: JARVIS 4+00 – 9+00

DRAWN BY: JDS | DATE: 1/3/2022

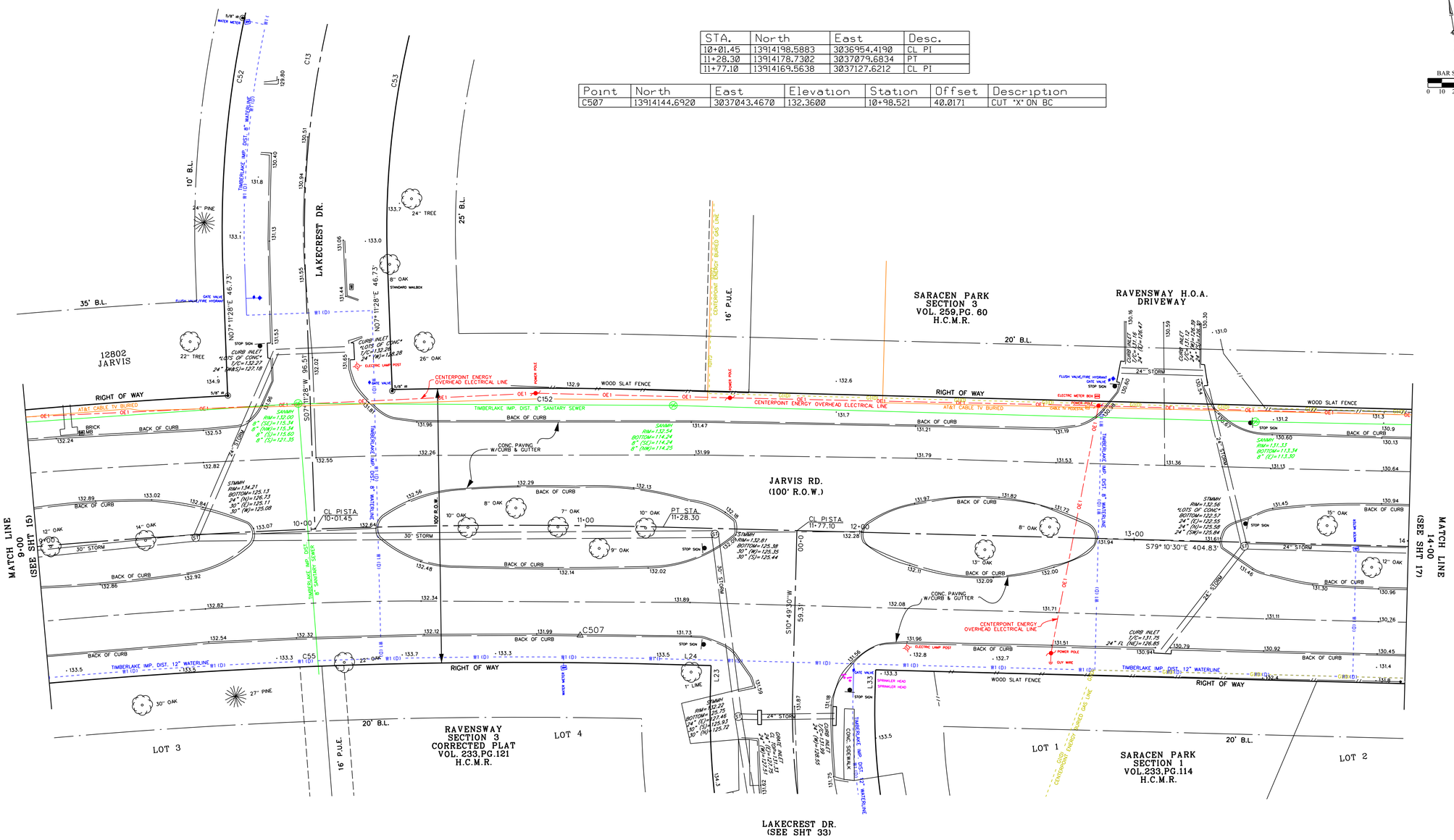
DESIGN BY: | SCALE: 1" = 20' | SHEET NO: 15 OF 48

NOTES:

1. Bearings and coordinates shown hereon are based on the Texas Coordinate System (North American Datum of 1983, 2011 Adjustment), South Central Zone. Coordinates shown hereon are surface values and may be converted to grid by dividing by a combined surface adjustment factor of 1.000079000.
2. Primary Benchmark: Tropical Storm Allison Recovery Project Monument 110130, BM 110130 is a brass disc on the northeast corner of a storm sewer inlet located on the north side of Jarvis Road across from its intersection with Timberlake, immediately east of a driveway to the Timberlake Improvement District wastewater treatment plant. Elevation 127.28 feet NAVD88, 2001 adjustment.
3. To convert elevations based on NAVD88, 2001 adjustment to NAVD88, Geoid 12B elevations subtract 0.96 feet.
4. This survey substantially complies with the current Texas Society of Professional Surveyors standards and specifications for a Category 6 Condition I Survey and a Category 1B, Condition III Survey.
5. All Easements and Building Lines depicted are dedicated by subdivision plat labeled herein, unless otherwise noted.

STA.	North	East	Desc.
10+01.45	13914198.5883	3036954.4190	CL PI
11+28.30	13914178.7302	3037079.6834	PT
11+77.10	13914169.5638	3037127.6212	CL PI

Point	North	East	Elevation	Station	Offset	Description
C507	13914144.6920	3037043.4670	132.3600	10+98.521	40.0171	CUT "X" ON BC



LEGEND

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- SHRUB/BUSH
- TYP. SAGO PALM (UNLESS NOTED)
- SANITARY MANHOLE
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- LIGHT POLE (ELECTRIC)
- LIGHT POLE (NATURAL GAS)
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- GAS VALVE
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- T1(D) — BURIED AT&T TELEPHONE
- BURIED AT&T CABLE TV
- WOOD FENCE
- STORM SEWER

QUALITY LEVEL LEGEND

- QUALITY LEVEL "A" — QLA(A) —
- QUALITY LEVEL "B" — QLB(B) —
- QUALITY LEVEL "C" - - QLC(C) - -
- QUALITY LEVEL "D" - - QLD(D) - -

NUMBER	DIRECTION	DISTANCE
L23	N10° 49'30"E	9.31
L33	N10° 49'30"E	9.31

NUMBER	ARC LENGTH	RADIUS	DELTA ANGLE	CHORD DIRECTION	CHORD LENGTH
C13	153.85	340.00	25° 55' 35"	S20° 09'16"W	152.54
C52	167.43	370.00	25° 55' 35"	N20° 09'16"E	166.00
C53	140.28	310.00	25° 55' 35"	N20° 09'16"E	139.08
C55	252.03	1950.00	7° 24' 19"	N82° 52'39"W	251.85
C152	100.02	2050.00	2° 47' 44"	N80° 34'21"W	100.01

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY ENGINEERING DEPARTMENT

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TBPE FIRM REG. No. 280
TBPLS FIRM REG. No. 100486

SEE NOTE 4 FOR CERTIFICATION

STATE OF TEXAS REGISTERED DAVID E. HUNT 5198 PROFESSIONAL LAND SURVEYOR

1-14-22

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

UPIN 19103MF14601

SHEET DESCRIPTION: JARVIS 9+00 – 14+00

DRAWN BY: JDS

DATE: 1/3/2022

DESIGN BY:

SCALE: 1" = 20'

SHEET NO: 16 OF 48

NOTES:

1. Bearings and coordinates shown hereon are based on the Texas Coordinate System (North American Datum of 1983, 2011 Adjustment), South Central Zone. Coordinates shown hereon are surface values and may be converted to grid by dividing by a combined surface adjustment factor of 1.000079000.
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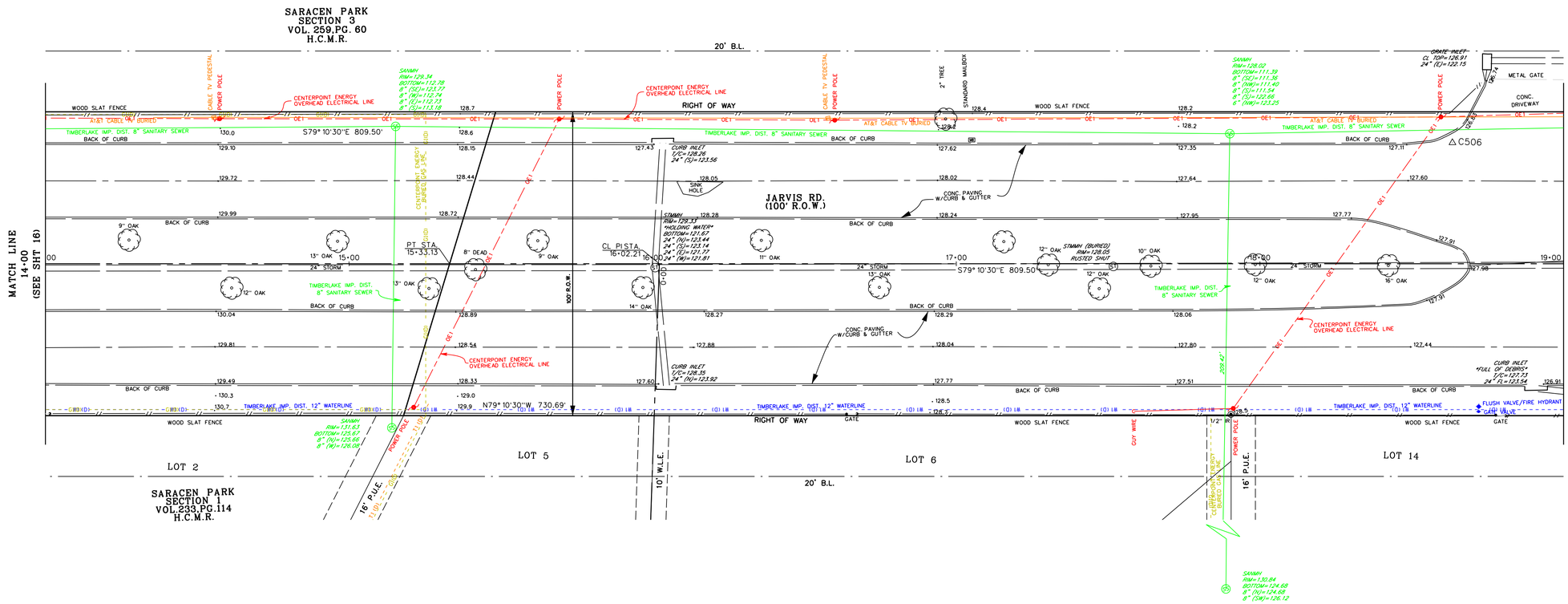
Point	North	East	Elevation	Station	Offset	Description
C506	13914079.8040	3037809.1780	127.2600	18+63.389	-39.8419	CUT "X"

NUMBER	ARC LENGTH	RADIUS	DELTA ANGLE	CHORD DIRECTION	CHORD LENGTH
C7	1143.73	2000.00	32° 45' 55"	N84°26'33"E	1128.21
C81	587.93	2050.00	16° 25' 56"	S87°23'28"E	585.92

Point	North	East	Station
16+02.21	13914089.7242	3037545.1609	CL PI

N

BAR SCALE
0 10 20 40



LEGEND

- TYP. CREPE MRYTLE (UNLESS NOTED)
- SHRUB/BUSH
- TYP. SAGO PALM (UNLESS NOTED)
- SANITARY MANHOLE
- STORM MANHOLE
- WATER METER
- GATE VALVE
- FLUSH VALVE/FIRE HYDRANT
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- IRRIGATION SPRINKLER HEAD
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- TYP. MAIL BOX (UNLESS NOTED)
- TRAFFIC SIGN
- TYP. 5/8" IR (UNLESS NOTED)
- E1(B) — BURIED CENTERPOINT ELECTRICAL
- OE1 — OVERHEAD CENTERPOINT ELECTRICAL
- BURIED CENTERPOINT GAS
- SANITARY LINE
- FOC1(D) — BURIED AT&T FIBER OPTIC
- T1(D) — BURIED AT&T TELEPHONE
- BURIED AT&T CABLE TV
- WOOD FENCE
- STORM SEWER

QUALITY LEVEL LEGEND

QUALITY LEVEL "A"	QS(A)
QUALITY LEVEL "B"	QS(B)
QUALITY LEVEL "C"	QS(C)
QUALITY LEVEL "D"	QS(D)

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY
ENGINEERING DEPARTMENT

HARRIS COUNTY 1836 TEXAS

Costello

Engineering and Surveying
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(713) 783-7788
(713) 783-3580, Fax
TBPE FIRM REG. No. 280
TBPLS FIRM REG. No. 100486

SEE NOTE 4 FOR CERTIFICATION

STATE OF TEXAS REGISTERED DAVID E. HUNT 5198 PROFESSIONAL LAND SURVEYOR

1-14-22

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

UPIN 19103MF14601

SHEET DESCRIPTION: JARVIS 14+00 – 19+00

DRAWN BY: JDS

DATE: 1/3/2022

DESIGN BY:

SCALE: 1" = 20'

SHEET NO: 17 OF 48

NOTES:

1. Bearings and coordinates shown hereon are based on the Texas Coordinate System (North American Datum of 1983, 2011 Adjustment), South Central Zone. Coordinates shown hereon are surface values and may be converted to grid by dividing by a combined surface adjustment factor of 1.000079000.
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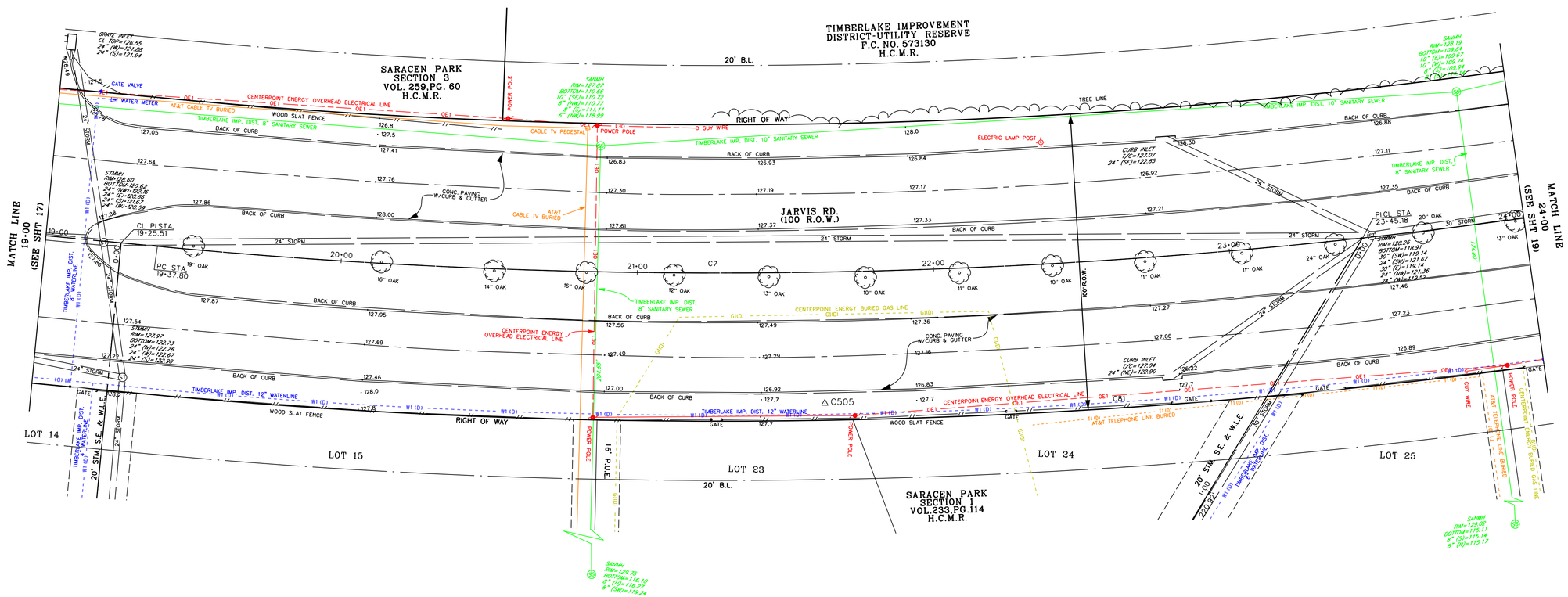
Point	North	East	Elevation	Station	Offset	Description
C505	13913952.8140	3038094.0177	127.6000	21+62.518	44.2830	5/8" IR W/CAP

NUMBER	ARC LENGTH	RADIUS	DELTA ANGLE	CHORD DIRECTION	CHORD LENGTH
C7	1143.73	2000.00	32° 45' 55"	N84°26'33"E	1128.21
C81	587.93	2050.00	16° 25' 56"	S87°23'28"E	585.92

Point	North	East	Station
19+25.51	13914029.0046	3037862.7081	CL PI
19+37.80	13914026.6966	3037874.7783	PC
23+45.18	13913991.3245	3038279.9169	CL PI

N

BAR SCALE
0 10 20 40



LEGEND

- TYP. CREPE MYRTLE (UNLESS NOTED)
- SHRUB/BUSH
- TYP. SAGO PALM (UNLESS NOTED)
- SANITARY MANHOLE
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QUALITY LEVEL LEGEND

QUALITY LEVEL "A"	QS(A)
QUALITY LEVEL "B"	QS(B)
QUALITY LEVEL "C"	QS(C)
QUALITY LEVEL "D"	QS(D)

NO.	REVISIONS	DATE	NAME

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SEE NOTE 4 FOR CERTIFICATION

STATE OF TEXAS REGISTERED DAVID E. HUNT 5198 PROFESSIONAL LAND SURVEYOR

1-14-22

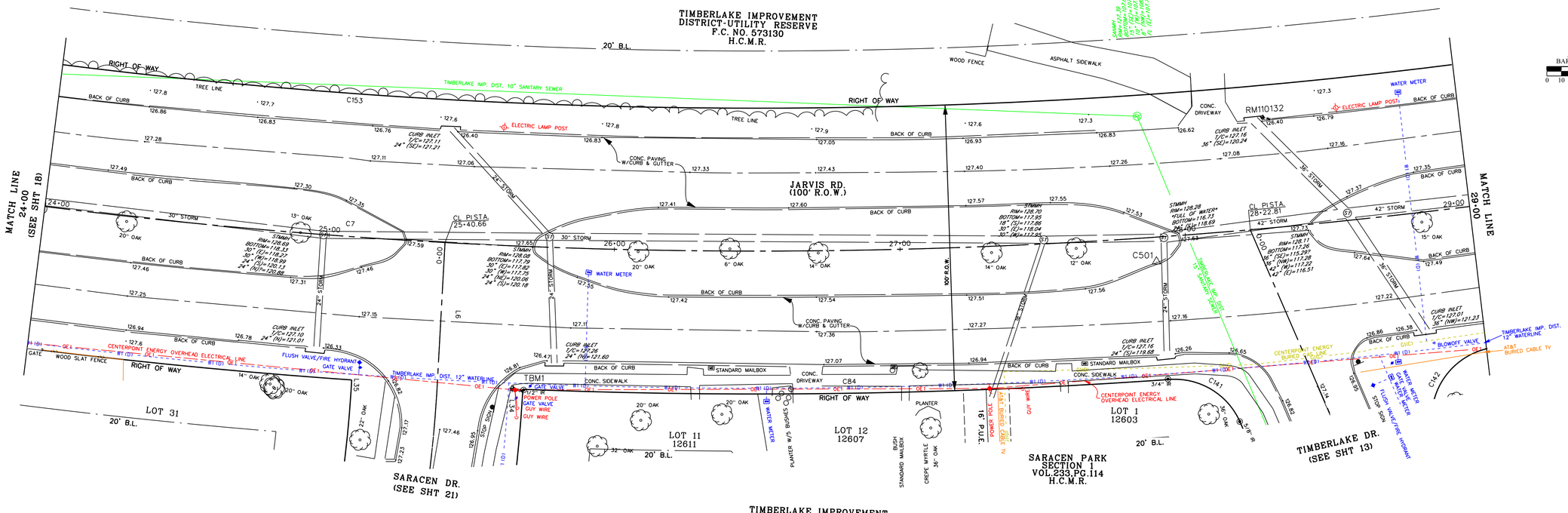
PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

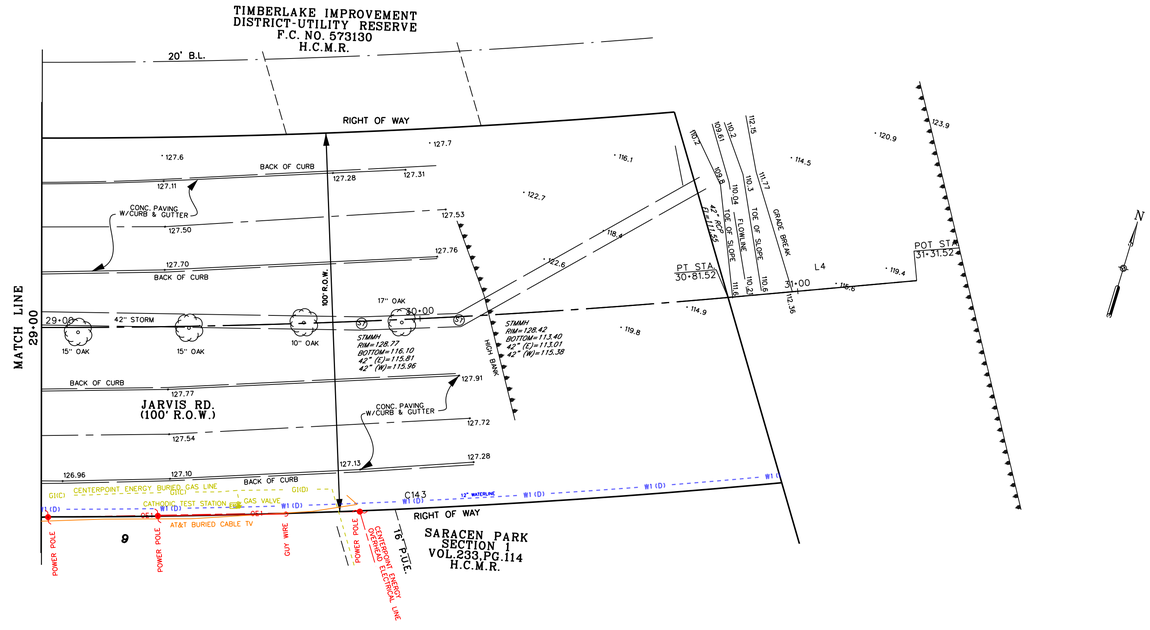
UPIN 19103MF14601

SHEET DESCRIPTION: JARVIS 19+00 – 24+00

DRAWN BY: JDS		DATE: 1/3/2022
DESIGN BY:	SCALE: 1" = 20'	SHEET NO: 18 OF 48

Point	North	East	Elevation	Station	Offset	Description
C501	13914038.6416	3038721.6067	128.1900	27+89.284	8.5203	CUT-X-BC
RM110132	13914094.5754	3038749.7998	127.2800	28+30.618	-38.8195	BRASS DISK RM110130
TBM1	13913957.2842	3038506.7564	129.4930	25+66.433	49.9150	BENCH TIE IN PP





LEGEND

- TYP. CREPE MRYTLE (UNLESS NOTED)
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- E1(B) — BURIED CENTERPOINT ELECTRICAL
- OE1 — OVERHEAD CENTERPOINT ELECTRICAL
- G1(B) — BURIED CENTERPOINT GAS
- SS1(C) — SANITARY LINE
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QUALITY LEVEL LEGEND

- QUALITY LEVEL "A" — SS(A) —
- QUALITY LEVEL "B" — SS(B) —
- QUALITY LEVEL "C" - - SS(C) - -
- QUALITY LEVEL "D" - - SS(D) - -

NOTES:

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STA.	North	East	Desc.
25+40.66	13914003.7491	3038474.9238	CL PI
28+22.81	13914055.0622	3038752.1309	CL PI
30+81.53	13914135.9592	3038997.6822	PT
31+31.53	13914154.6412	3039044.0609	END CL

NUMBER	DIRECTION	DISTANCE
L4	N68° 03'35"E	50.00
L5	N45° 22'21"E	50.00
L34	S06° 26'44"E	0.02
L35	S06° 26'44"E	0.02

NUMBER	ARC LENGTH	RADIUS	DELTA ANGLE	CHORD DIRECTION	CHORD LENGTH
C7	1143.73	2000.00	32° 45' 55"	N84° 26'33"E	1128.21
C84	226.57	2050.00	6° 19' 57"	N79° 32'58"E	226.46
C141	30.81	25.00	70° 37' 12"	S68° 18'24"E	28.90
C142	46.33	25.00	106° 11' 24"	S20° 05'53"W	39.98
C143	193.43	2050.00	5° 24' 23"	N70° 29'24"E	193.36
C153	1105.36	1950.00	32° 28' 41"	N84° 35'10"E	1090.62

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY ENGINEERING DEPARTMENT

HARRIS COUNTY TEXAS 1836

Costello

Engineering and Surveying
2107 CityWest Blvd., 3rd Floor
Houston, Texas 77042
(713) 783-7788
(713) 783-3580, Fax
TBPE FIRM REG. No. 280
TBPLS FIRM REG. No. 100486

SEE NOTE 4 FOR CERTIFICATION

STATE OF TEXAS REGISTERED DAVID E. HUNT 5198 PROFESSIONAL LAND SURVEYOR

1-14-22

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

UPIN 19103MF14601

SHEET DESCRIPTION: JARVIS 24+00 – 31+00

DRAWN BY: JDS

DATE: 1/3/2022

DESIGN BY:

SCALE: 1" = 20'

SHEET NO: 19 OF 48

NOTES:

1. Bearings and coordinates shown hereon are based on the Texas Coordinate System (North American Datum of 1983, 2011 Adjustment), South Central Zone. Coordinates shown hereon are surface values and may be converted to grid by dividing by a combined surface adjustment factor of 1.000079000.
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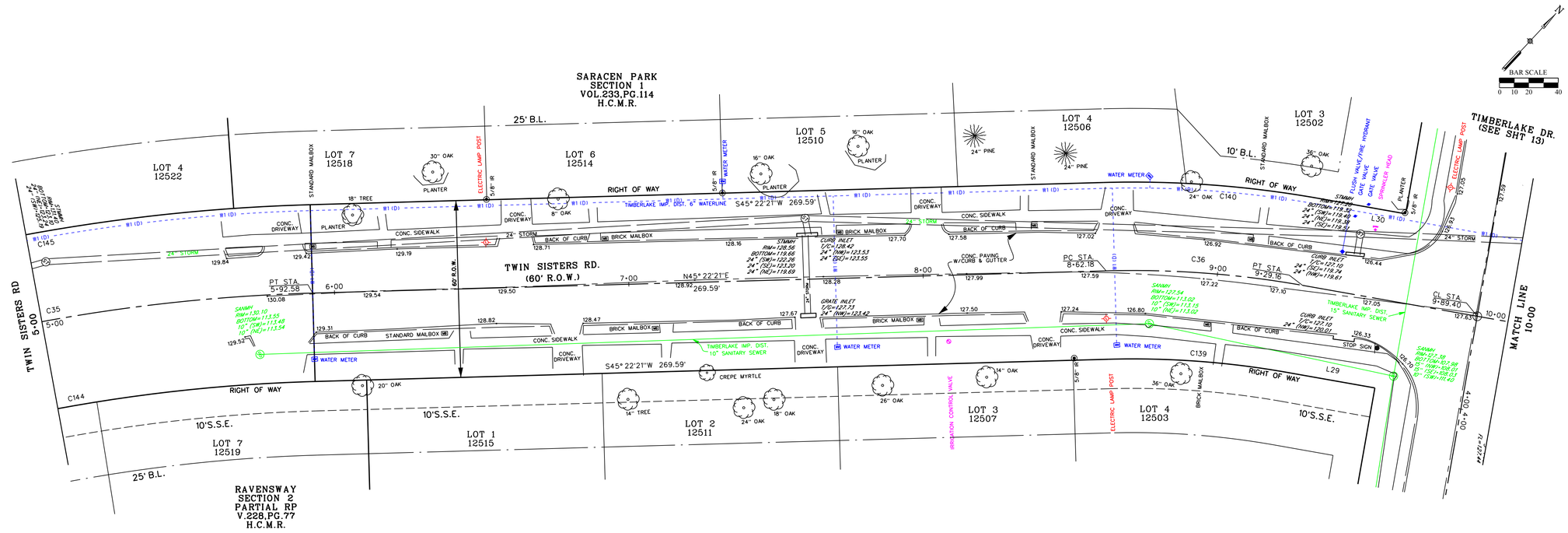
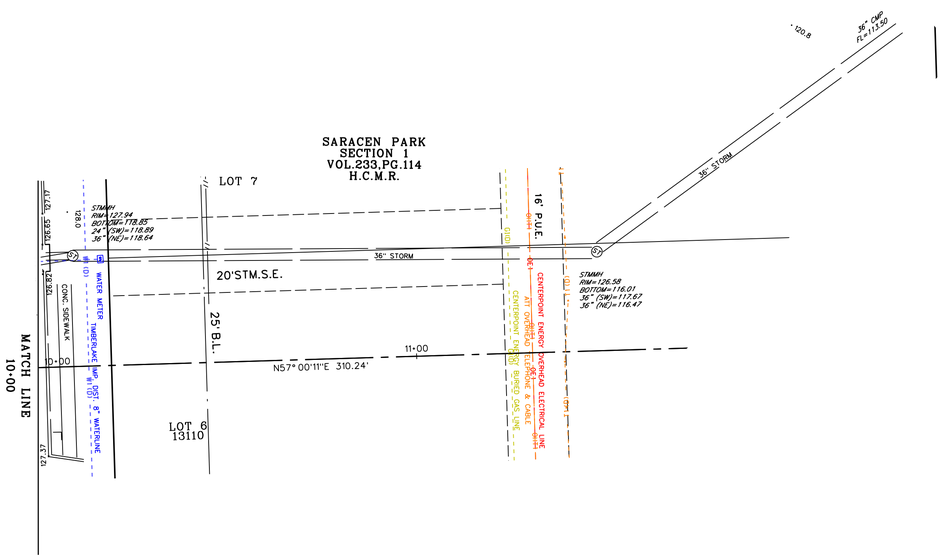
5. All Easements and Building Lines depicted are dedicated by subdivision plat labeled herein, unless otherwise noted.





NUMBER	ARC LENGTH	RADIUS	DELTA ANGLE	CHORD DIRECTION	CHORD LENGTH
C35	175.37	600.00	16° 44' 47"	N36°59'58"E	174.74
C36	66.99	330.00	11° 37' 50"	N51°11'16"E	66.87
C139	60.90	300.00	11° 37' 50"	S51°11'16"W	60.79
C140	73.08	360.00	11° 37' 50"	S51°11'16"W	72.95
C144	166.60	570.00	16° 44' 47"	N36°59'58"E	166.01
C145	184.14	630.00	16° 44' 47"	S36°59'58"W	183.48

NUMBER	DIRECTION	DISTANCE
L29	S57°00'11"W	30.24
L30	S57°00'11"W	30.24

STA.	North	East	Desc.
5+00	13913412.4481	3038597.4246	BEGIN PROJ.
5+92.58	13913482.3028	3038658.0459	PT
8+62.18	13913671.6904	3038849.9130	PC
9+29.16	13913713.6039	3038902.0202	PT
9+89.41	13913746.4120	3038952.5464	CL PI
12+89.407	13913746.4120	3038952.5464	END PROJ.

LEGEND

- TYP. CREPE MYRTLE (UNLESS NOTED)
- SHRUB/BUSH
- TYP. SAGO PALM (UNLESS NOTED)
- SANITARY MANHOLE
- STORM MANHOLE
- WATER METER
- GATE VALVE
- FLUSH VALVE/FIRE HYDRANT
- BLOW-OFF VALVE
- IRRIGATION CONTROL VALVE
- IRRIGATION SPRINKLER HEAD
- TELEPHONE PEDESTAL
- TELEPHONE BOX
- TELEPHONE SIGN
- FIBER OPTIC SIGN
- LIGHT POLE (ELECTRIC)
- LIGHT POLE (NATURAL GAS)
- POWER POLE
- GUY WIRE
- GAS VALVE
- CATHODIC TEST STATION
- TYP. MAIL BOX (UNLESS NOTED)
- TRAFFIC SIGN
- TYP. 5/8" IR (UNLESS NOTED)
- E1(B) — BURIED CENTERPOINT ELECTRICAL
- OE1 — OVERHEAD CENTERPOINT ELECTRICAL
- GH(B) — BURIED CENTERPOINT GAS
- WS1(C) — SANITARY LINE
- FOC1(D) — BURIED AT&T FIBER OPTIC
- T1(D) — BURIED AT&T TELEPHONE
- BURIED AT&T CABLE TV
- WOOD FENCE
- STORM SEWER

QUALITY LEVEL LEGEND

- QUALITY LEVEL "A" — WS(A) —
- QUALITY LEVEL "B" — WS(B) —
- QUALITY LEVEL "C" - - WS(C) - -
- QUALITY LEVEL "D" - - WS(D) - -

TYPICAL FOR ALL UTILITIES

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY
ENGINEERING DEPARTMENT

Costello

Engineering and Surveying
2107 CityWest Blvd., 3rd Floor
Houston, Texas 77042
(713) 783-7788
(713) 783-3580, Fax
TBPE FIRM REG. No. 280
TBPLS FIRM REG. No. 100486

SEE NOTE 4 FOR CERTIFICATION

STATE OF TEXAS REGISTERED DAVID E. HUNT 5198 PROFESSIONAL LAND SURVEYOR

1-14-22

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

UPIN 19103MF14601

SHEET DESCRIPTION: TWIN SISTERS ROAD

DRAWN BY: JDS | DATE: 1/3/2022

DESIGN BY: | SCALE: 1" = 20' | SHEET NO: 20 OF 48

NOTES:

1. Bearings and coordinates shown hereon are based on the Texas Coordinate System (North American Datum of 1983, 2011 Adjustment), South Central Zone. Coordinates shown hereon are surface values and may be converted to grid by dividing by a combined surface adjustment factor of 1.000079000.
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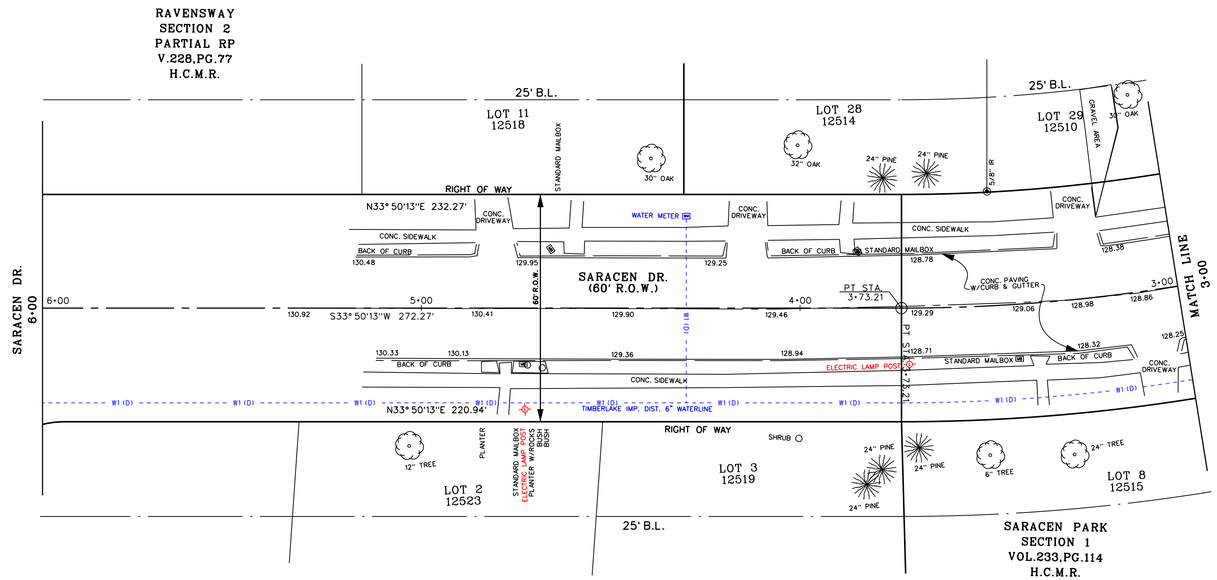
3. To convert elevations based on NAVD88, 2001 adjustment to NAVD88, Geoid 12B elevations subtract 0.96 feet.
4. This survey substantially complies with the current Texas Society of Professional Surveyors standards and specifications for a Category 6 Condition I Survey and a Category 1B, Condition III Survey.
5. All Easements and Building Lines depicted are dedicated by subdivision plat labeled herein, unless otherwise noted.

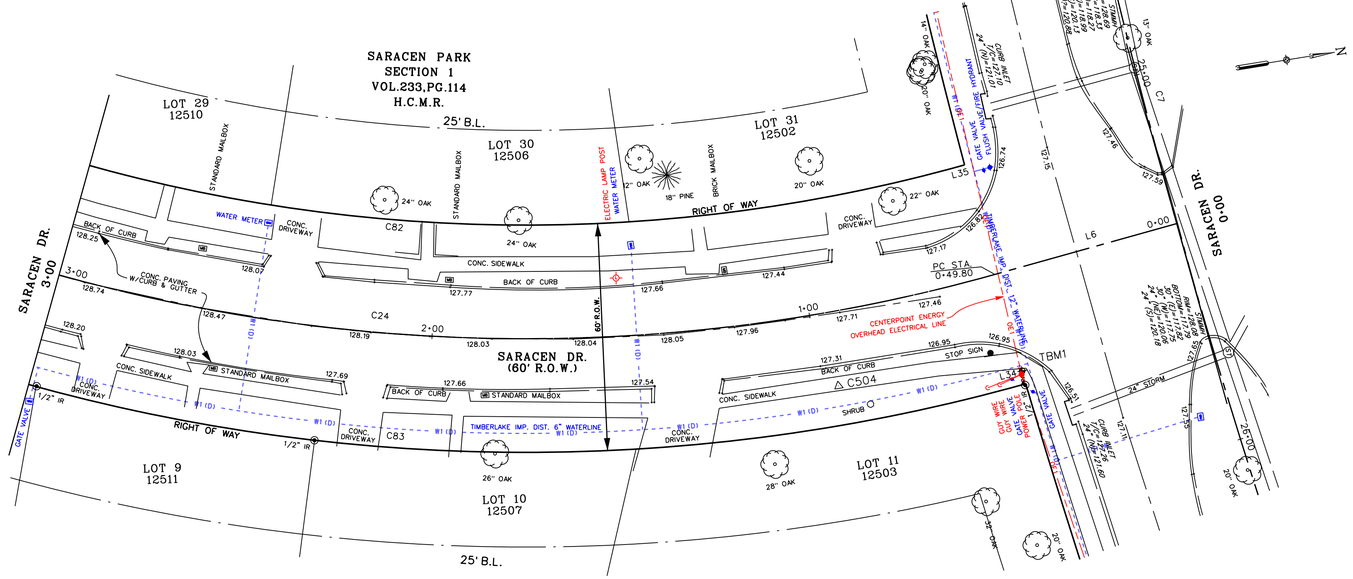
Point	North	East	Elevation	Station	Offset	Description
C504	13913908.7832	3038502.9734	128.0300	0+95.641	-19.5910	CUT "X"
TBM1	13913957.2842	3038506.7564	129.4930	0+49.745	-26.4152	BENCH TIE IN PP



STA.	North	East	Desc.
0+00	13914003.7491	3038474.9238	CL PI
0+49.80	13913954.2650	3038480.5143	PC
3+73.21	13913646.4822	3038405.5093	PT

NUMBER	DIRECTION	DISTANCE (FEET)
L6	S06° 26'44"E	49.80
L34	S06° 26'44"E	0.02
L35	S06° 26'44"E	0.02

NUMBER	ARC LENGTH (FEET)	RADIUS (FEET)	DELTA ANGLE	CHORD DIRECTION	CHORD LENGTH (FEET)
C24	323.41	460.00	40° 16' 58"	S13° 41'45"W	316.79
C82	302.32	430.00	40° 16' 58"	N13° 41'45"E	296.13
C83	344.50	490.00	40° 16' 58"	N13° 41'45"E	337.45



LEGEND

- TYP. CREPE MRYTLE (UNLESS NOTED)
- SHRUB/BUSH
- TYP. SAGO PALM (UNLESS NOTED)
- SANITARY MANHOLE
- STORM MANHOLE
- WATER METER
- GATE VALVE
- FLUSH VALVE/FIRE HYDRANT
- BLOW-OFF VALVE
- IRRIGATION CONTROL VALVE
- IRRIGATION SPRINKLER HEAD
- TELEPHONE PEDESTAL
- TELEPHONE BOX
- FIBER OPTIC SIGN
- LIGHT POLE (ELECTRIC)
- LIGHT POLE (NATURAL GAS)
- POWER POLE
- GUY WIRE
- GAS VALVE
- CATHODIC TEST STATION
- TYP. MAIL BOX (UNLESS NOTED)
- TRAFFIC SIGN
- TYP. 5/8" IR (UNLESS NOTED)
- E1(B) — BURIED CENTERPOINT ELECTRICAL
- OE1 — OVERHEAD CENTERPOINT ELECTRICAL
- BURIED CENTERPOINT GAS
- SANITARY LINE
- FOC1(D) — BURIED AT&T FIBER OPTIC
- T1(D) — BURIED AT&T TELEPHONE
- BURIED AT&T CABLE TV
- WOOD FENCE
- STORM SEWER

QUALITY LEVEL LEGEND

- QUALITY LEVEL "A" — QS(A) —
- QUALITY LEVEL "B" — QS(B) —
- QUALITY LEVEL "C" - - QS(C) - -
- QUALITY LEVEL "D" - - QS(D) - -

TYPICAL FOR ALL UTILITIES

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY
ENGINEERING DEPARTMENT

Costello
Engineering and Surveying
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Houston, Texas 77042
(713) 783-7788
(713) 783-3580, Fax
TBPE FIRM REG. No. 280
TBPLS FIRM REG. No. 100486

SEE NOTE 4 FOR CERTIFICATION

STATE OF TEXAS REGISTERED DAVID E. HUNT 5198 PROFESSIONAL LAND SURVEYOR

1-14-22

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

UPIN 19103MF14601

SHEET DESCRIPTION: SARACEN DRIVE

DRAWN BY: JDS

DATE: 1/3/2022

DESIGN BY:

SCALE: 1" = 20'

SHEET NO: 21 OF 48

NOTES:

1. Bearings and coordinates shown hereon are based on the Texas Coordinate System (North American Datum of 1983, 2011 Adjustment), South Central Zone. Coordinates shown hereon are surface values and may be converted to grid by dividing by a combined surface adjustment factor of 1.000079000.
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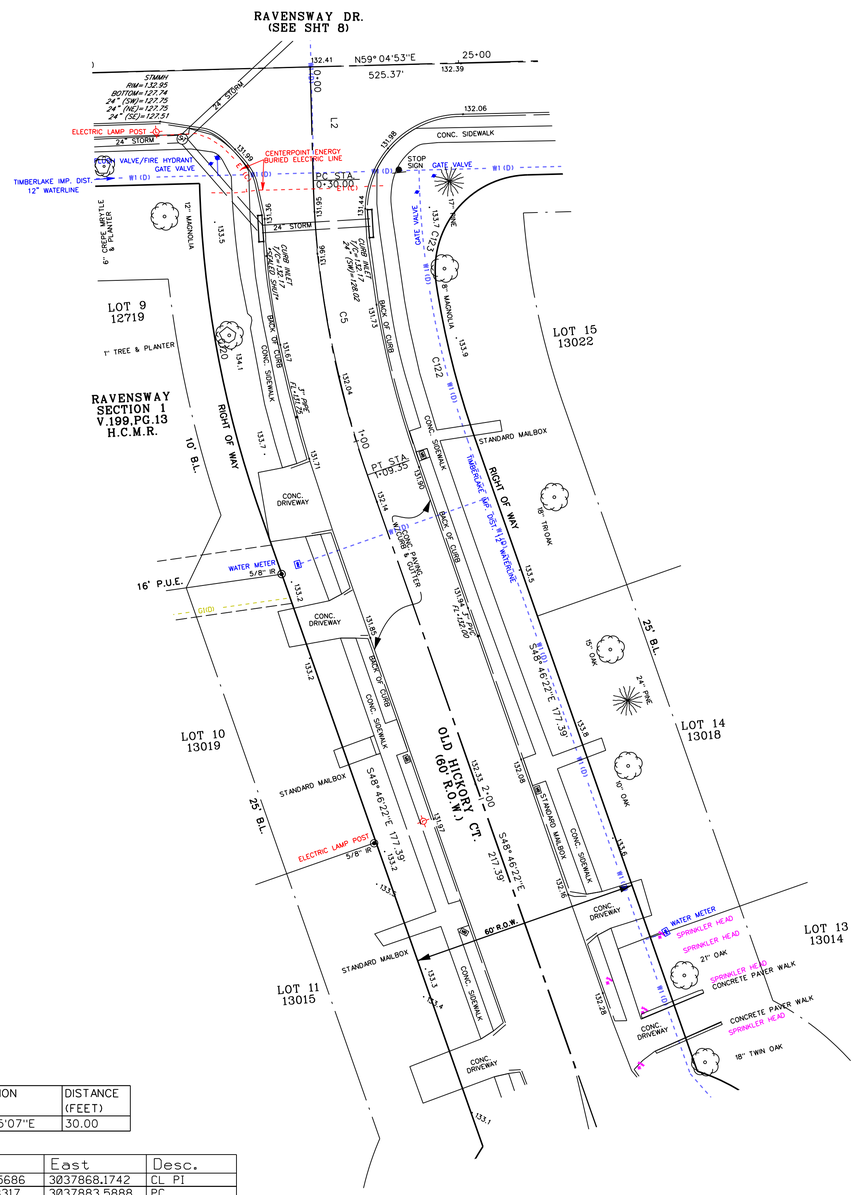

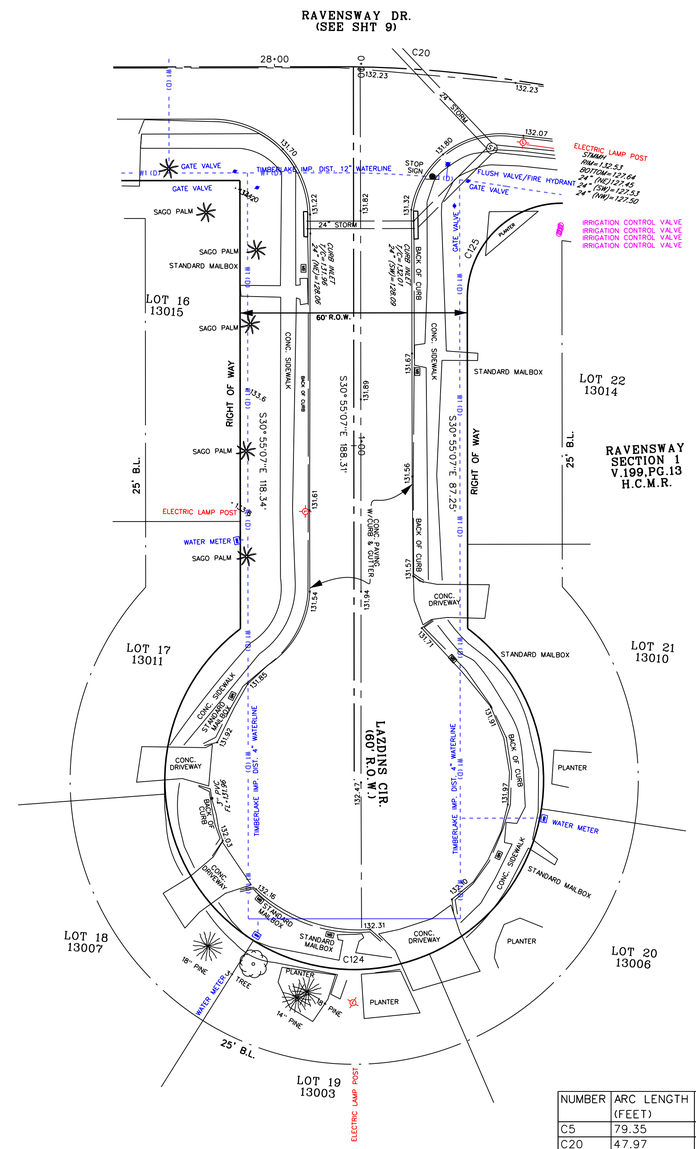

STA.	North	East	Desc.
0+00	13912408.5210	3038177.0311	CL PI
1+88.31	13912246.9700	3038273.7882	END CL

NUMBER	DIRECTION	DISTANCE (FEET)
L2	S30° 55'07"E	30.00

STA.	North	East	Desc.
0+00	13912223.5686	3037868.1742	CL PI
0+30	13912197.8317	3037883.5888	PC
1+09.35	13912137.1531	3037934.2261	PT

NUMBER	ARC LENGTH (FEET)	RADIUS (FEET)	DELTA ANGLE	CHORD DIRECTION	CHORD LENGTH (FEET)
C5	79.35	254.65	17° 51' 15"	S39° 50'44"E	79.03
C20	47.97	300.00	9° 9' 40"	N63° 39'43"E	47.92
C120	27.03	70.00	22° 7' 20"	N45° 19'27"E	26.86
C122	27.03	70.00	22° 7' 29"	N38° 36'43"W	26.86
C123	37.93	70.00	31° 2' 46"	N43° 04'21"W	37.47
C124	42.82	275.00	8° 55' 17"	N54° 08'05"W	42.78
C125	123.36	720.00	9° 49' 0"	S44° 45'57"E	123.21

LEGEND

- TYP. CREPE MRYTLE (UNLESS NOTED)
- SHRUB/BUSH
- TYP. SAGO PALM (UNLESS NOTED)
- SANITARY MANHOLE
- STORM MANHOLE
- WATER METER
- GATE VALVE
- FLUSH VALVE/FIRE HYDRANT
- BLOW-OFF VALVE
- IRRIGATION CONTROL VALVE
- IRRIGATION SPRINKLER HEAD
- TELEPHONE PEDESTAL
- TELEPHONE BOX
- TELEPHONE SIGN
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- LIGHT POLE (ELECTRIC)
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- TRAFFIC SIGN
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- T1(D) — BURIED AT&T TELEPHONE
- BURIED AT&T CABLE TV
- WOOD FENCE
- STORM SEWER

QUALITY LEVEL LEGEND

QUALITY LEVEL "A" — QS(A) —
QUALITY LEVEL "B" — QS(B) —
QUALITY LEVEL "C" - - QS(C) - -
QUALITY LEVEL "D" - - QS(D) - -
TYPICAL FOR ALL UTILITIES

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY
ENGINEERING DEPARTMENT

HARRIS COUNTY 1836 TEXAS

Costello

Engineering and Surveying
2107 CityWest Blvd., 3rd Floor
Houston, Texas 77042
(713) 783-7788
(713) 783-3580. Fax
TBPE FIRM REG. No. 280
TBPLS FIRM REG. No. 100486

SEE NOTE 4 FOR CERTIFICATION

STATE OF TEXAS REGISTERED DAVID E. HUNT 5198 PROFESSIONAL LAND SURVEYOR

1-14-22

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

UPIN 19103MF14601

SHEET DESCRIPTION: OLD HICKORY CT. & LAZDINS CIRCLE

DRAWN BY: JDS | DATE: 1/3/2022

DESIGN BY: | SCALE: 1" = 20' | SHEET NO: 22 OF 48

NOTES:

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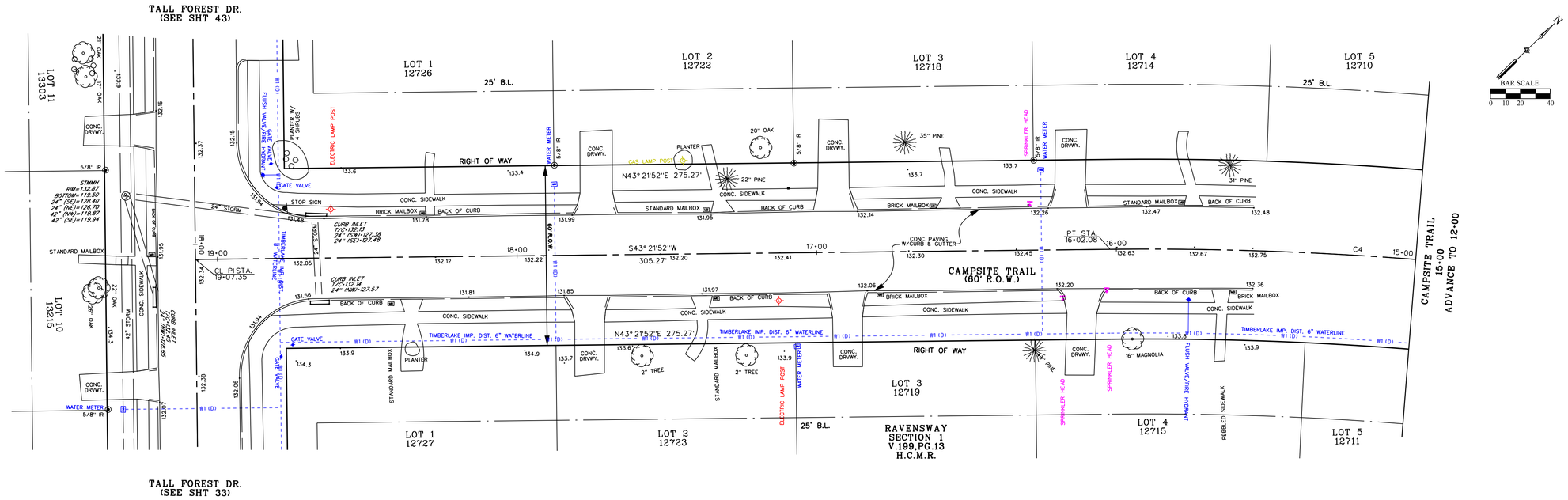
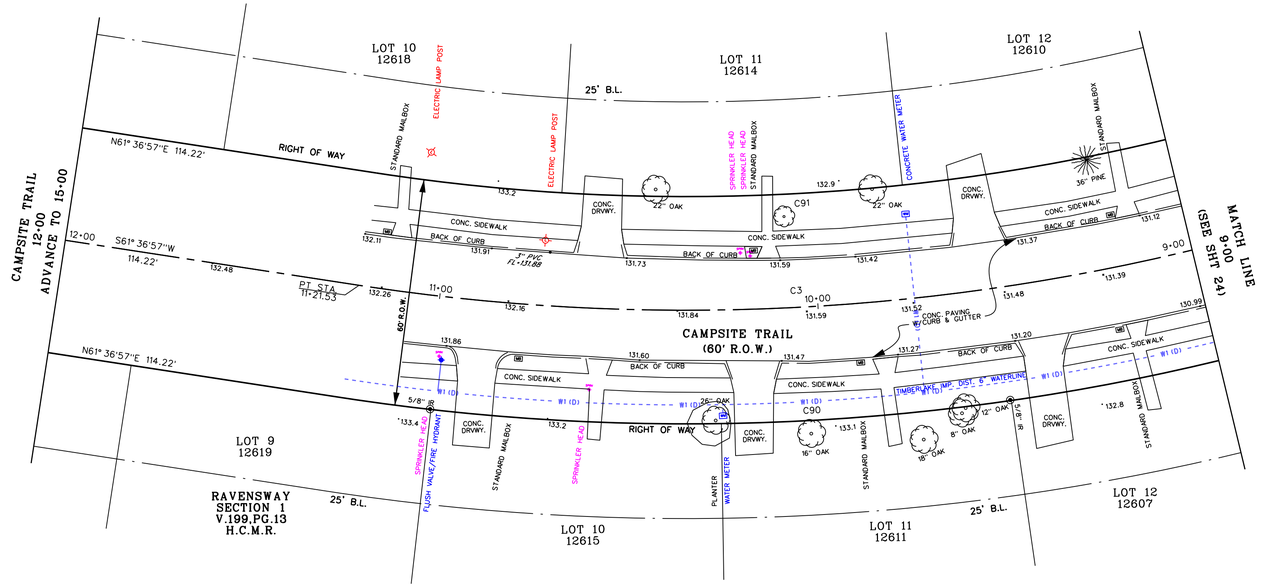


NUMBER	ARC LENGTH (FEET)	RADIUS (FEET)	DELTA ANGLE	CHORD DIRECTION	CHORD LENGTH (FEET)
C3	237.04	570.00	23° 49' 37"	S49° 42'09"W	235.34
C4	366.33	1150.00	18° 15' 5"	S52° 29'25"W	364.78
C90	249.52	600.00	23° 49' 37"	N49° 42'09"E	247.72
C91	224.56	540.00	23° 49' 37"	N49° 42'09"E	222.95

Point	North	East	Station
11+21.53	13913113.8827	3037597.0217	PT
16+02.08	13912837.4699	3037207.1689	PT
19+07.35	13912615.5387	3036997.5590	CL PI



LEGEND

- TYP. CREPE MYRTLE (UNLESS NOTED)
- SHRUB/BUSH
- TYP. SAGO PALM (UNLESS NOTED)
- SANITARY MANHOLE
- STORM MANHOLE
- WATER METER
- GATE VALVE
- FLUSH VALVE/FIRE HYDRANT
- BLOW-OFF VALVE
- IRRIGATION CONTROL VALVE
- IRRIGATION SPRINKLER HEAD
- TELEPHONE PEDESTAL
- TELEPHONE BOX
- TELEPHONE SIGN
- FIBER OPTIC SIGN
- LIGHT POLE (ELECTRIC)
- LIGHT POLE (NATURAL GAS)
- POWER POLE
- GUY WIRE
- GAS VALVE
- CATHODIC TEST STATION
- TYP. MAIL BOX (UNLESS NOTED)
- TRAFFIC SIGN
- TYP. 5/8" IR (UNLESS NOTED)
- E1 (B) — BURIED CENTERPOINT ELECTRICAL
- OE1 — OVERHEAD CENTERPOINT ELECTRICAL
- G1(B) — BURIED CENTERPOINT GAS
- SW1-(C) — SANITARY LINE
- FOC1 (D) — BURIED AT&T FIBER OPTIC
- T1 (D) — BURIED AT&T TELEPHONE
- BURIED AT&T CABLE TV
- WOOD FENCE
- STORM SEWER

QUALITY LEVEL LEGEND

- QUALITY LEVEL "A" — WS (A) —
- QUALITY LEVEL "B" — WS (B) —
- QUALITY LEVEL "C" - - WS (C) - -
- QUALITY LEVEL "D" - - WS (D) - -

TYPICAL FOR ALL UTILITES

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY
ENGINEERING DEPARTMENT

Costello

Engineering and Surveying
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TBPLS FIRM REG. No. 100486

SEE NOTE 4 FOR CERTIFICATION

STATE OF TEXAS
REGISTERED
DAVID E. HUNT
5198
PROFESSIONAL
LAND SURVEYOR

1-14-22

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

UPIN 19103MF14601

SHEET DESCRIPTION: CAMPSITE TRAIL 19+00 – 9+00

DRAWN BY: JDS		DATE: 1/3/2022
DESIGN BY:	SCALE: 1" = 20'	SHEET NO: 23 OF 48

NOTES:

1. Bearings and coordinates shown hereon are based on the Texas Coordinate System (North American Datum of 1983, 2011 Adjustment), South Central Zone. Coordinates shown hereon are surface values and may be converted to grid by dividing by a combined surface adjustment factor of 1.000079000.
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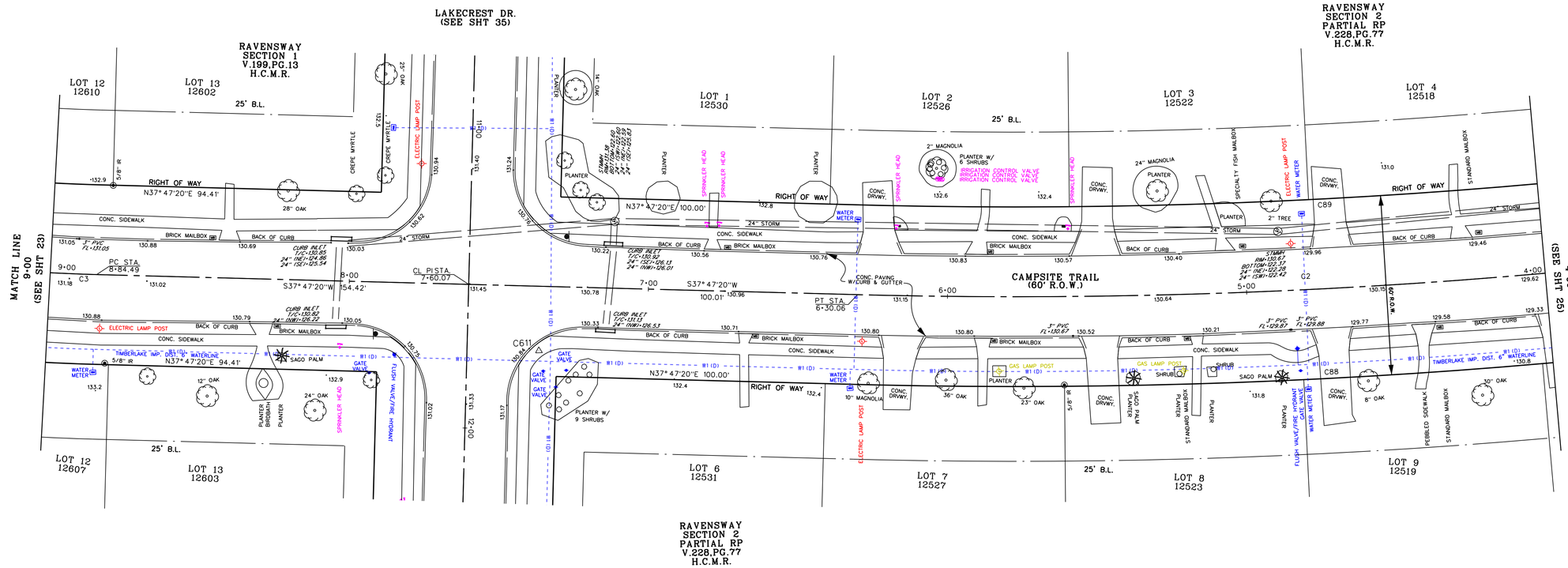
Point	North	East	Elevation	Station	Offset	Description
C611	13913370.1840	3037884.5080	131.2500	7+36.048	-21.5614	CUT "X" IN SIDEWALK
C612	13913795.7500	3038138.6090	127.8800	2+41.443	0.7718	WPL

BAR SCALE
0 10 20 40



NUMBER	ARC LENGTH (FEET)	RADIUS (FEET)	DELTA ANGLE	CHORD DIRECTION	CHORD LENGTH (FEET)
C2	305.20	1999.88	8° 44' 38"	S33°25'01"W	304.91
C3	237.04	570.00	23° 49' 37"	S49°42'09"W	235.34
C88	309.80	2030.00	8° 44' 38"	N33°25'01"E	309.50
C89	300.64	1970.00	8° 44' 38"	N33°25'01"E	300.35

Point	North	East	Station
6+30.07	13913467.1518	3037932.4106	PT
7+60.07	13913364.4094	3037852.7470	CL PI
8+84.49	13913266.0873	3037776.5108	PC

LEGEND

- TYP. CREPE MYRTLE (UNLESS NOTED)
- SHRUB/BUSH
- TYP. SAGO PALM (UNLESS NOTED)
- SANITARY MANHOLE
- STORM MANHOLE
- WATER METER
- GATE VALVE
- FLUSH VALVE/FIRE HYDRANT
- BLOW-OFF VALVE
- IRRIGATION CONTROL VALVE
- IRRIGATION SPRINKLER HEAD
- TELEPHONE PEDESTAL
- TELEPHONE BOX
- TELEPHONE SIGN
- FIBER OPTIC SIGN
- LIGHT POLE (ELECTRIC)
- LIGHT POLE (NATURAL GAS)
- POWER POLE
- GUY WIRE
- GAS VALVE
- CATHODIC TEST STATION
- TYP. MAIL BOX (UNLESS NOTED)
- TRAFFIC SIGN
- TYP. 5/8" IR (UNLESS NOTED)
- E1(B) — BURIED CENTERPOINT ELECTRICAL
- OE1 — OVERHEAD CENTERPOINT ELECTRICAL
- G1(B) — BURIED CENTERPOINT GAS
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- BURIED AT&T CABLE TV
- WOOD FENCE
- STORM SEWER

QUALITY LEVEL LEGEND

- QUALITY LEVEL "A" — QL(A) —
- QUALITY LEVEL "B" — QL(B) —
- QUALITY LEVEL "C" - - QL(C) - -
- QUALITY LEVEL "D" - - QL(D) - -

TYPICAL FOR ALL UTILITIES

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY ENGINEERING DEPARTMENT

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TBPLS FIRM REG. No. 100486

SEE NOTE 4 FOR CERTIFICATION

STATE OF TEXAS REGISTERED DAVID E. HUNT 5198 PROFESSIONAL LAND SURVEYOR

1-14-22

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

UPIN 19103MF14601

SHEET DESCRIPTION: CAMPSITE TRAIL 9+00 – 4+00

DRAWN BY: JDS | DATE: 1/3/2022

DESIGN BY: | SCALE: 1" = 20' | SHEET NO: 24 OF 48

NOTES:

1. Bearings and coordinates shown hereon are based on the Texas Coordinate System (North American Datum of 1983, 2011 Adjustment), South Central Zone. Coordinates shown hereon are surface values and may be converted to grid by dividing by a combined surface adjustment factor of 1.000079000.
2. Primary Benchmark: Tropical Storm Allison Recovery Project Monument 110130, BM 110130 is a brass disc on the northeast corner of a storm sewer inlet located on the north side of Jarvis Road across from its intersection with Timberlake, immediately east of a driveway to the Timberlake Improvement District wastewater treatment plant. Elevation 127.28 feet NAVD88, 2001 adjustment.
3. To convert elevations based on NAVD88, 2001 adjustment to NAVD88, Geoid 12B elevations subtract 0.96 feet.
4. This survey substantially complies with the current Texas Society of Professional Surveyors standards and specifications for a Category 6 Condition I Survey and a Category 1B, Condition III Survey.
5. All Easements and Building Lines depicted are dedicated by subdivision plat labeled herein, unless otherwise noted.

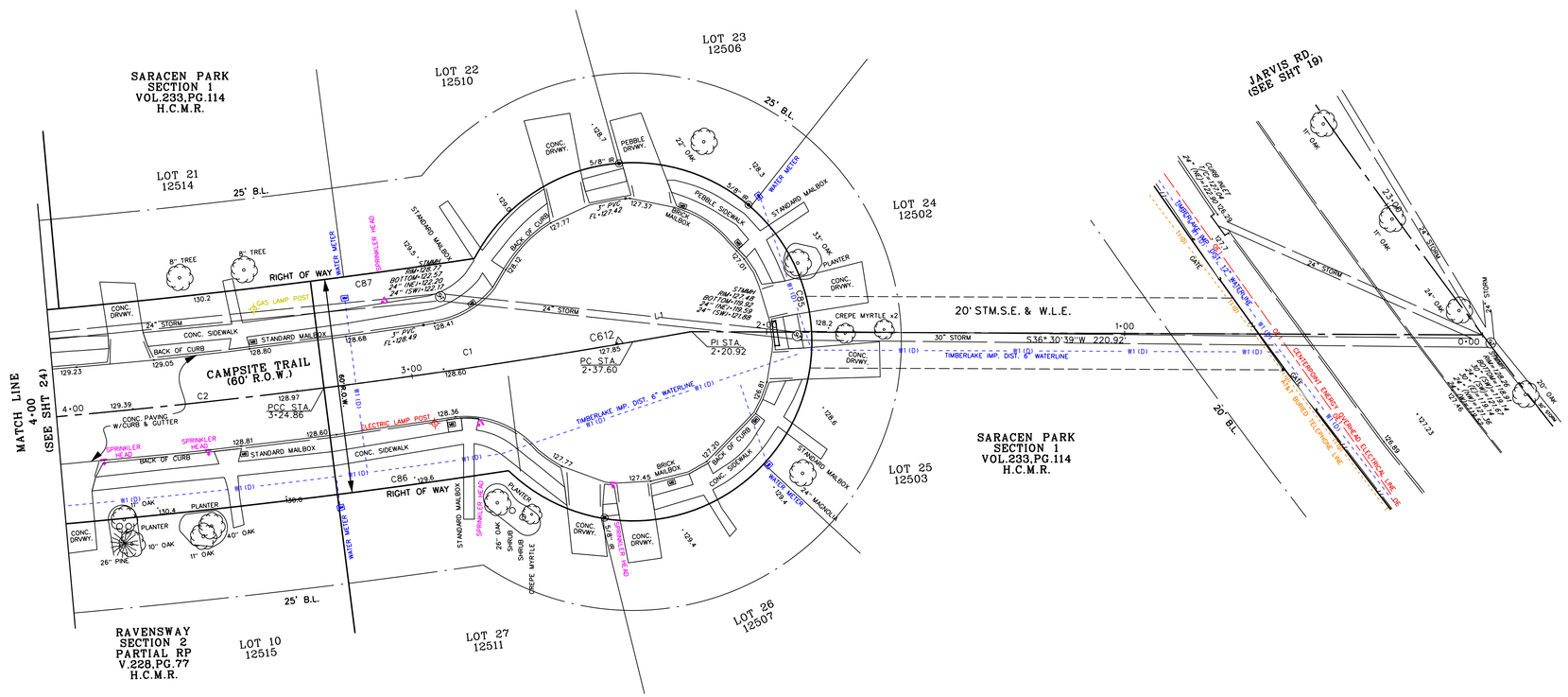
Point	North	East	Elevation	Station	Offset	Description
C611	13913370.1840	3037884.5080	131.2500	7+36.048	-21.5614	CUT "X" IN SIDEWALK
C612	13913795.7500	3038138.6090	127.8800	2+41.443	0.7718	WPL

NUMBER	ARC LENGTH (FEET)	RADIUS (FEET)	DELTA ANGLE	CHORD DIRECTION	CHORD LENGTH (FEET)
C1	87.26	2000.00	2° 29' 59''	S27° 47'43''W	87.25
C2	305.20	1999.88	8° 44' 38''	S33° 25'01''W	304.91
C85	249.81	50.00	286° 15' 21''	N62° 52'54''W	60.00
C86	48.26	2030.00	1° 21' 44''	N28° 21'50''E	48.26
C87	46.24	1970.00	1° 20' 42''	N28° 22'21''E	46.24

NUMBER	DIRECTION	DISTANCE (FEET)
L1	S26° 32'43''W	16.68

STA.	North	East	Desc.
0+00	13913991.3245	3038279.9169	CL PI
2+20.92	13913813.7576	3038148.4719	PI
2+37.60	13913798.8385	3038141.0188	PC
3+24.86	13913721.6519	3038100.3312	PCC

BAR SCALE
0 10 20 40



LEGEND

- TYP. CREPE MYRTLE (UNLESS NOTED)
- SHRUB/BUSH
- TYP. SAGO PALM (UNLESS NOTED)
- SANITARY MANHOLE
- STORM MANHOLE
- WATER METER
- GATE VALVE
- FLUSH VALVE/FIRE HYDRANT
- BLOW-OFF VALVE
- IRRIGATION CONTROL VALVE
- IRRIGATION SPRINKLER HEAD
- TELEPHONE PEDESTAL
- TELEPHONE BOX
- TELEPHONE SIGN
- FIBER OPTIC SIGN
- LIGHT POLE (ELECTRIC)
- LIGHT POLE (NATURAL GAS)
- POWER POLE
- GUY WIRE
- GAS VALVE
- CATHODIC TEST STATION
- TYP. MAIL BOX (UNLESS NOTED)
- TRAFFIC SIGN
- TYP. 5/8" IR (UNLESS NOTED)
- E1(B) — BURIED CENTERPOINT ELECTRICAL
- OE1 — OVERHEAD CENTERPOINT ELECTRICAL
- G1(B) — BURIED CENTERPOINT GAS
- WW1(C) — SANITARY LINE
- FOC1(D) — BURIED AT&T FIBER OPTIC
- T1(D) — BURIED AT&T TELEPHONE
- BURIED AT&T CABLE TV
- WOOD FENCE
- STORM SEWER

QUALITY LEVEL LEGEND

- QUALITY LEVEL "A" — WS(A) —
- QUALITY LEVEL "B" — WS(B) —
- QUALITY LEVEL "C" - - WS(C) - -
- QUALITY LEVEL "D" - - WS(D) - -

TYPICAL FOR ALL UTILITIES

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY ENGINEERING DEPARTMENT

Costello
Engineering and Surveying
2107 CityWest Blvd., 3rd Floor
Houston, Texas 77042
(713) 783-7788
(713) 783-3580. Fax
TBPE FIRM REG. No. 280
TBPLS FIRM REG. No. 100486

SEE NOTE 4 FOR CERTIFICATION

STATE OF TEXAS REGISTERED DAVID E. HUNT 5198 PROFESSIONAL LAND SURVEYOR

1-14-22

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

UPIN 19103MF14601

SHEET DESCRIPTION: CAMPSITE TRAIL 0+00 – 4+00

DRAWN BY: JDS | DATE: 1/3/2022

DESIGN BY: | SCALE: 1" = 20' | SHEET NO: 25 OF 48

NOTES:

1. Bearings and coordinates shown hereon are based on the Texas Coordinate System (North American Datum of 1983, 2011 Adjustment), South Central Zone. Coordinates shown hereon are surface values and may be converted to grid by dividing by a combined surface adjustment factor of 1.000079000.
2. Primary Benchmark: Tropical Storm Allison Recovery Project Monument 110130, BM 110130 is a brass disc on the northeast corner of a storm sewer inlet located on the north side of Jarvis Road across from its intersection with Timberlake, immediately east of a driveway to the Timberlake Improvement District wastewater treatment plant. Elevation 127.28 feet NAVD88, 2001 adjustment.
3. To convert elevations based on NAVD88, 2001 adjustment to NAVD88, Geoid 12B elevations subtract 0.96 feet.
4. This survey substantially complies with the current Texas Society of Professional Surveyors standards and specifications for a Category 6 Condition I Survey and a Category 1B, Condition III Survey.
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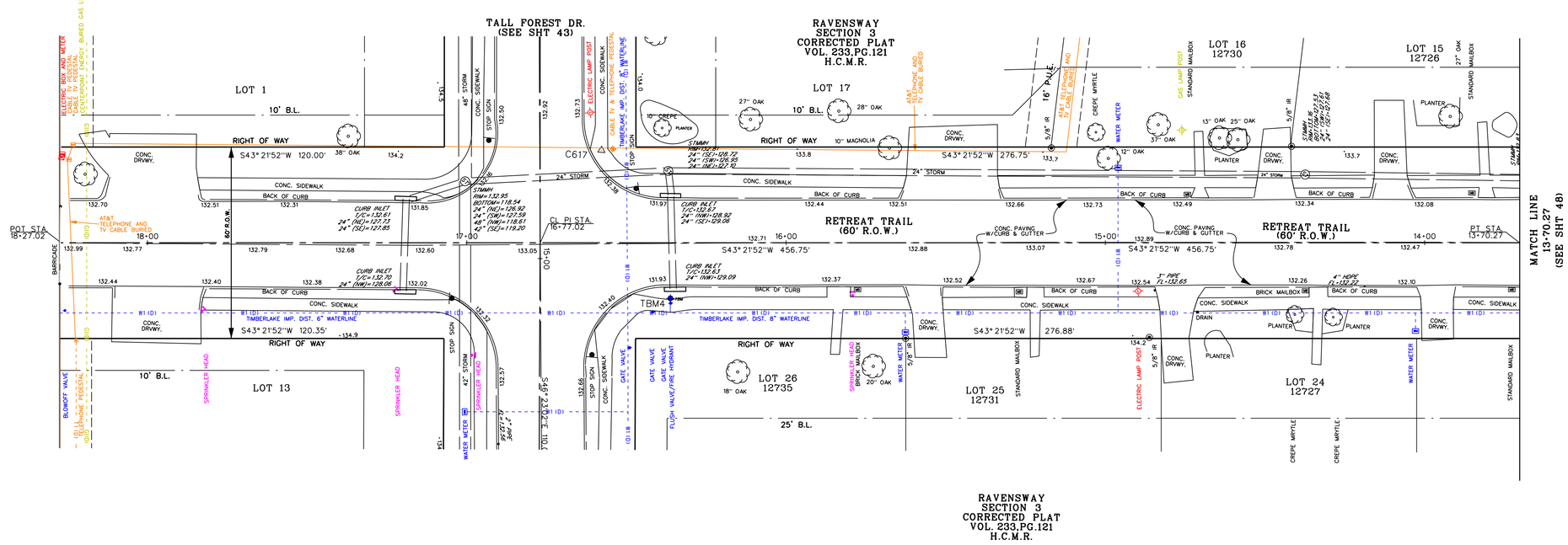
STA.	North	East	Desc.
13+70.27	13913051.7559	3036983.1480	PT
16+77.02	13912828.7475	3036772.5206	CL PI
18+27.02	13912719.6975	3036669.5250	END PROJ.

Point	North	East	Elevation	Station	Offset	Description
TBM4	13912846.4413	3036813.1613	135.9760	16+36.254	-17.3965	SOUTH BOLT TOP FLANGE
C617	13912862.6060	3036764.5800	133.0700	16+57.860	29.0214	CUT "X" IN SIDEWALK

NUMBER	ARC LENGTH (FEET)	RADIUS (FEET)	DELTA ANGLE	CHORD DIRECTION	CHORD LENGTH (FEET)
C16	350.32	950.00	21° 7' 41"	S53°55'43"W	348.33
C72	361.38	980.00	21° 7' 41"	S53°55'43"W	359.34
C73	339.25	920.00	21° 7' 41"	S53°55'43"W	337.33



LEGEND

- TYP. CREPE MYRTLE (UNLESS NOTED)
- SHRUB/BUSH
- TYP. SAGO PALM (UNLESS NOTED)
- SANITARY MANHOLE
- STORM MANHOLE
- WATER METER
- GATE VALVE
- FLUSH VALVE/FIRE HYDRANT
- BLOW-OFF VALVE
- IRRIGATION CONTROL VALVE
- IRRIGATION SPRINKLER HEAD
- TELEPHONE PEDESTAL
- TELEPHONE BOX
- TELEPHONE SIGN
- FIBER OPTIC SIGN
- LIGHT POLE (ELECTRIC)
- LIGHT POLE (NATURAL GAS)
- GUY WIRE
- GAS VALVE
- CATHODIC TEST STATION
- TYP. MAIL BOX (UNLESS NOTED)
- TRAFFIC SIGN
- TYP. 5/8" IR (UNLESS NOTED)
- E1(B) — BURIED CENTERPOINT ELECTRICAL
- OE1 — OVERHEAD CENTERPOINT ELECTRICAL
- G1(B) — BURIED CENTERPOINT GAS
- SANITARY LINE
- FOC1(D) — BURIED AT&T FIBER OPTIC
- T1(D) — BURIED AT&T TELEPHONE
- BURIED AT&T CABLE TV
- WOOD FENCE
- STORM SEWER

QUALITY LEVEL LEGEND

- QUALITY LEVEL "A" — QL(A) —
- QUALITY LEVEL "B" — QL(B) —
- QUALITY LEVEL "C" - - QL(C) - -
- QUALITY LEVEL "D" - - QL(D) - -

TYPICAL FOR ALL UTILITIES

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY
ENGINEERING DEPARTMENT

HARRIS COUNTY TEXAS 1836

Costello

Engineering and Surveying
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TBPE FIRM REG. No. 280
TBPLS FIRM REG. No. 100486

SEE NOTE 4 FOR CERTIFICATION

STATE OF TEXAS REGISTERED DAVID E. HUNT 5198 PROFESSIONAL LAND SURVEYOR

1-14-22

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

UPIN 19103MF14601

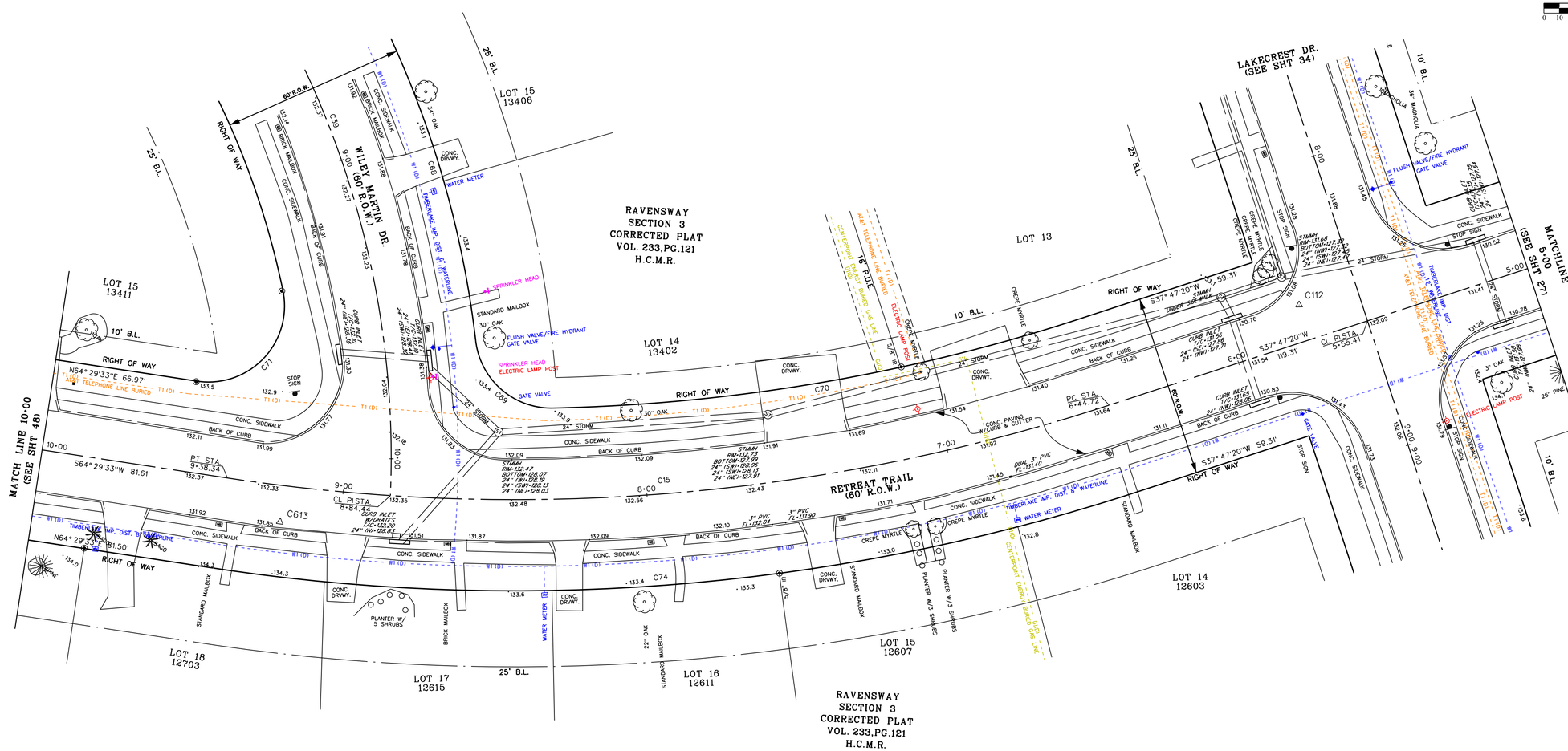
SHEET DESCRIPTION: RETREAT TRAIL 18+00 – 13+70

DRAWN BY: JDS		DATE: 1/3/2022
DESIGN BY:	SCALE: 1" = 20'	SHEET NO: 26 OF 48

NOTES:

1. Bearings and coordinates shown hereon are based on the Texas Coordinate System (North American Datum of 1983, 2011 Adjustment), South Central Zone. Coordinates shown hereon are surface values and may be converted to grid by dividing by a combined surface adjustment factor of 1.000079000.
2. Primary Benchmark: Tropical Storm Allison Recovery Project Monument 110130, BM 110130 is a brass disc on the northeast corner of a storm sewer inlet located on the north side of Jarvis Road across from its intersection with Timberlake, immediately east of a driveway to the Timberlake Improvement District wastewater treatment plant. Elevation 127.28 feet NAVD88, 2001 adjustment.
3. To convert elevations based on NAVD88, 2001 adjustment to NAVD88, Geoid 12B elevations subtract 0.96 feet.
4. This survey substantially complies with the current Texas Society of Professional Surveyors standards and specifications for a Category 6 Condition I Survey and a Category 1B, Condition III Survey.
5. All Easements and Building Lines depicted are dedicated by subdivision plat labeled herein, unless otherwise noted.

Point	North	East	Elevation	Station	Offset	Description
C112	13913536.8680	3037598.1090	131.4000	5+75.150	11.9665	CUT "X" IN STREET
C613	13913289.7250	3037360.7300	131.8900	9+19.486	-11.9722	CUT "X" IN STREET



STA.	North	East	Desc.
5+55.41	13913545.1366	3037619.6625	CL PI
6+44.72	13913474.5559	3037564.9361	PC
8+84.44	13913317.2630	3037385.9592	CL PI
9+38.34	13913291.9980	3037338.3597	PT

NUMBER	ARC LENGTH (FEET)	RADIUS (FEET)	DELTA ANGLE	CHORD DIRECTION	CHORD LENGTH (FEET)
C15	293.62	630.00	26° 42' 13"	S51° 08'27"W	290.97
C39	438.84	300.00	83° 48' 44"	S73° 36'05"E	400.75
C68	120.68	330.00	20° 57' 12"	S51° 15'04"E	120.01
C69	36.89	25.00	84° 33' 8"	N83° 03'02"W	33.64
C70	176.81	600.00	16° 53' 3"	N46° 13'52"E	176.17
C71	48.13	25.00	110° 18' 50"	S09° 20'08"W	41.04
C74	307.60	660.00	26° 42' 13"	N51° 08'27"E	304.83

LEGEND

- TYP. CREPE MRYTLE (UNLESS NOTED)
- SHRUB/BUSH
- TYP. SAGO PALM (UNLESS NOTED)
- SANITARY MANHOLE
- STORM MANHOLE
- WATER METER
- GATE VALVE
- FLUSH VALVE/FIRE HYDRANT
- BLOW-OFF VALVE
- IRRIGATION CONTROL VALVE
- IRRIGATION SPRINKLER HEAD
- TELEPHONE PEDESTAL
- TELEPHONE BOX
- TELEPHONE SIGN
- FIBER OPTIC SIGN
- LIGHT POLE (ELECTRIC)
- LIGHT POLE (NATURAL GAS)
- GUY WIRE
- GAS VALVE
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- TYP. MAIL BOX (UNLESS NOTED)
- TRAFFIC SIGN
- TYP. 5/8" IR (UNLESS NOTED)
- E1(B) — BURIED CENTERPOINT ELECTRICAL
- OE1 — OVERHEAD CENTERPOINT ELECTRICAL
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- T1(D) — BURIED AT&T TELEPHONE
- BURIED AT&T CABLE TV
- WOOD FENCE
- STORM SEWER

QUALITY LEVEL LEGEND

- QUALITY LEVEL "A" — QL(A) —
- QUALITY LEVEL "B" — QL(B) —
- QUALITY LEVEL "C" - - QL(C) - -
- QUALITY LEVEL "D" - - QL(D) - -

TYPICAL FOR ALL UTILITIES

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY ENGINEERING DEPARTMENT

HARRIS COUNTY TEXAS 1836

Costello

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TBPLS FIRM REG. No. 100486

SEE NOTE 4 FOR CERTIFICATION

STATE OF TEXAS REGISTERED DAVID E. HUNT 5198 PROFESSIONAL LAND SURVEYOR

1-14-22

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

UPIN 19103MF14601

SHEET DESCRIPTION: RETREAT TRAIL 10+00 – 5+00

DRAWN BY: JDS | DATE: 1/3/2022

DESIGN BY: | SCALE: 1" = 20' | SHEET NO: 27 OF 48

NOTES:

1. Bearings and coordinates shown hereon are based on the Texas Coordinate System (North American Datum of 1983, 2011 Adjustment), South Central Zone. Coordinates shown hereon are surface values and may be converted to grid by dividing by a combined surface adjustment factor of 1.000079000.
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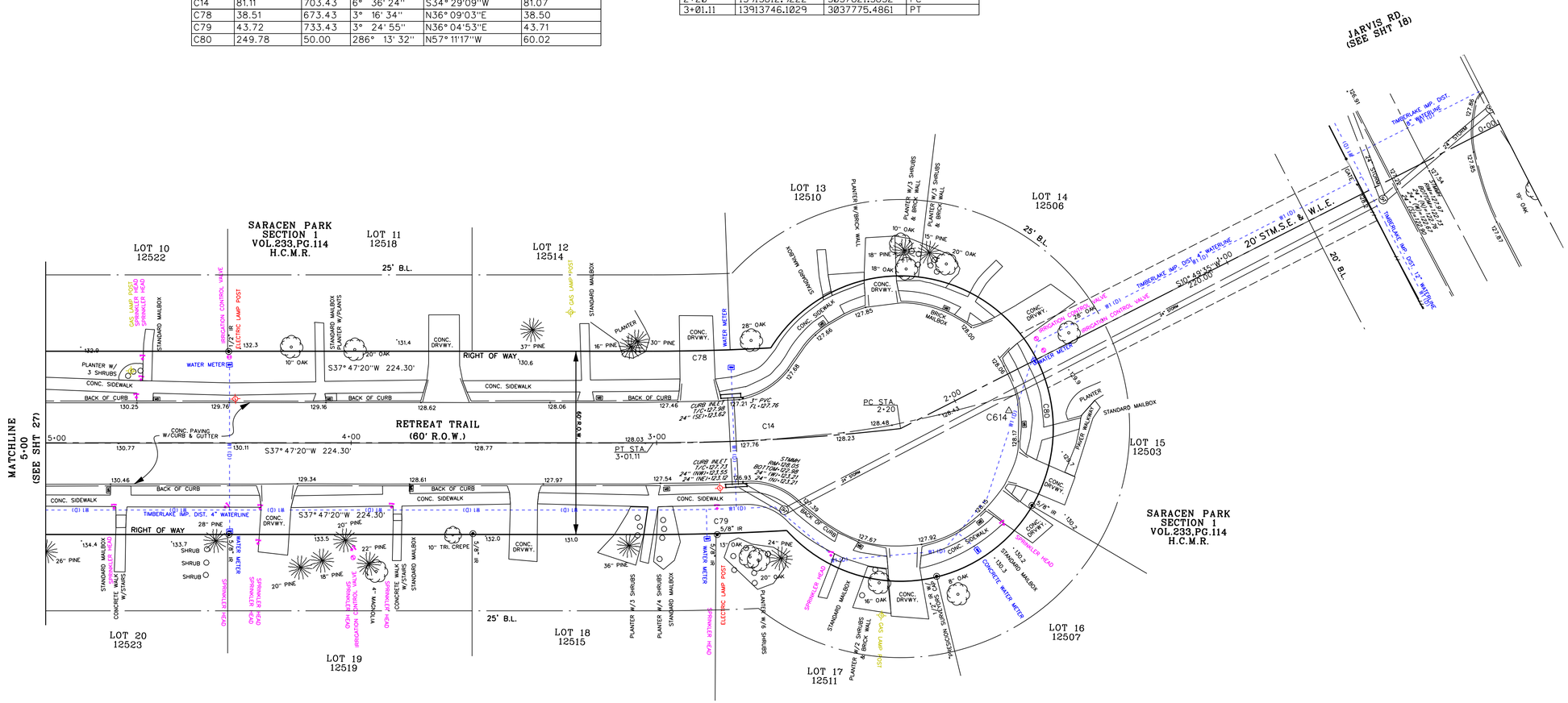
Point	North	East	Elevation	Station	Offset	Description
C614	13913844.5190	3037838.4970	128.1600	1+85.750	-10.8723	CUT "X" IN STREET

NUMBER	ARC LENGTH (FEET)	RADIUS (FEET)	DELTA ANGLE	CHORD DIRECTION	CHORD LENGTH (FEET)
C14	81.11	703.43	6° 36' 24"	S34° 29'09"W	81.07
C78	38.51	673.43	3° 16' 34"	N36° 09'03"E	38.50
C79	43.72	733.43	3° 24' 55"	N36° 04'53"E	43.71
C80	249.78	50.00	286° 13' 32"	N57° 11'17"W	60.02

STA.	North	East	Desc.
0+00	13914029.0046	3037862.7081	CL PI
2+20	13913812.9222	3037821.3852	PC
3+01.11	13913746.1029	3037775.4861	PT



LEGEND

- TYP. CREPE MRYTLE (UNLESS NOTED)
- SHRUB/BUSH
- TYP. SAGO PALM (UNLESS NOTED)
- SANITARY MANHOLE
- STORM MANHOLE
- WATER METER
- GATE VALVE
- FLUSH VALVE/FIRE HYDRANT
- BLOW-OFF VALVE
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- IRRIGATION SPRINKLER HEAD
- TELEPHONE PEDESTAL
- TELEPHONE BOX
- TELEPHONE SIGN
- FIBER OPTIC SIGN
- LIGHT POLE (ELECTRIC)
- LIGHT POLE (NATURAL GAS)
- GUY WIRE
- GAS VALVE
- CATHODIC TEST STATION
- TYP. MAIL BOX (UNLESS NOTED)
- TRAFFIC SIGN
- TYP. 5/8" IR (UNLESS NOTED)
- E1(B) — BURIED CENTERPOINT ELECTRICAL
- OE1 — OVERHEAD CENTERPOINT ELECTRICAL
- G1(B) — BURIED CENTERPOINT GAS
- SANITARY LINE
- FOC1(D) — BURIED AT&T FIBER OPTIC
- T1(D) — BURIED AT&T TELEPHONE
- BURIED AT&T CABLE TV
- WOOD FENCE
- STORM SEWER

QUALITY LEVEL LEGEND

QUALITY LEVEL "A"	SUE(A)
QUALITY LEVEL "B"	SUE(B)
QUALITY LEVEL "C"	SUE(C)
QUALITY LEVEL "D"	SUE(D)

TYPICAL FOR ALL UTILITIES

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY ENGINEERING DEPARTMENT

HARRIS COUNTY TEXAS 1836

Costello
Engineering and Surveying
2107 CityWest Blvd., 3rd Floor
Houston, Texas 77042
(713) 783-7788
(713) 783-3580, Fax
TBPE FIRM REG. No. 280
TBPLS FIRM REG. No. 100486

SEE NOTE 4 FOR CERTIFICATION

STATE OF TEXAS REGISTERED DAVID E. HUNT 5198 PROFESSIONAL LAND SURVEYOR

1-14-22

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

UPIN 19103MF14601

SHEET DESCRIPTION: RETREAT TRAIL 5+00 – 0+00

DRAWN BY: JDS | DATE: 1/3/2022

DESIGN BY: | SCALE: 1" = 20' | SHEET NO: 28 OF 48

NOTES:

1. Bearings and coordinates shown hereon are based on the Texas Coordinate System (North American Datum of 1983, 2011 Adjustment), South Central Zone. Coordinates shown hereon are surface values and may be converted to grid by dividing by a combined surface adjustment factor of 1.000079000.
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3. To convert elevations based on NAVD88, 2001 adjustment to NAVD88, Geoid 12B elevations subtract 0.96 feet.
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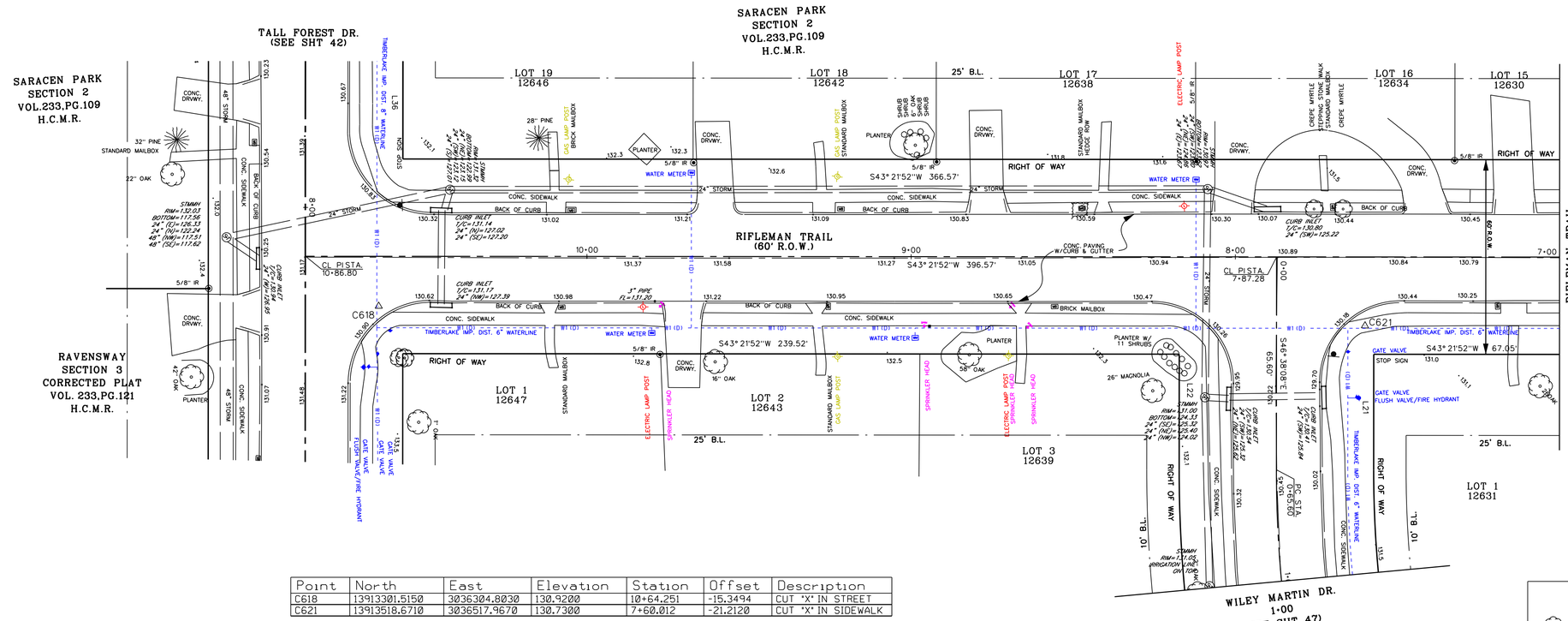
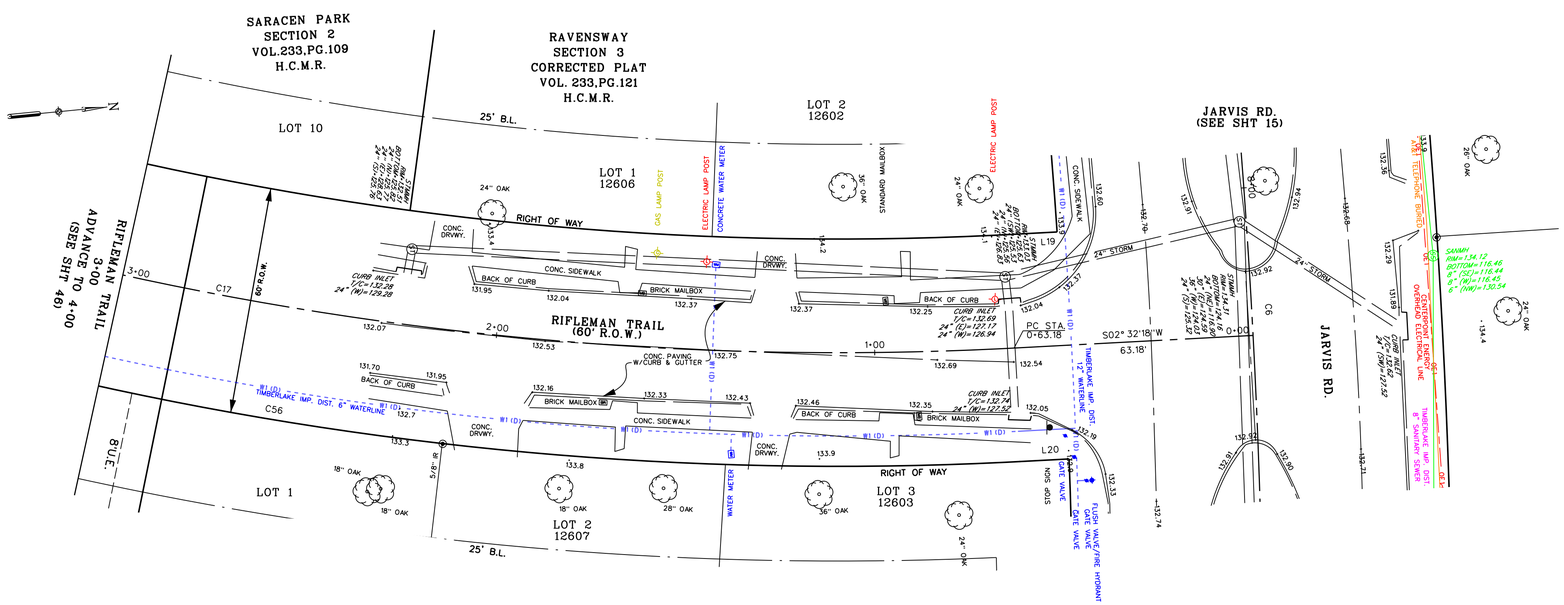


Point	North	East	Elevation	Station	Offset	Description
C618	13913301.5150	3036304.8030	130.9200	10+64.251	-15.3494	CUT "X" IN STREET
C621	13913518.6710	3036517.9670	130.7300	7+60.012	-21.2120	CUT "X" IN SIDEWALK



STA.	North	East	Desc.
0+00	13914212.3577	3036792.6357	BEGIN PROJ.
0+63.18	13914149.2350	3036789.8374	PC
7+87.28	13913513.4101	3036483.8207	CL PI
10+86.80	13913295.6612	3036278.1609	END PROJ.
0+65.60	13913468.3666	3036531.5119	PC

NUMBER	ARC LENGTH (FEET)	RADIUS (FEET)	DELTA ANGLE	CHORD DIRECTION	CHORD LENGTH (FEET)
C6	586.69	2000.00	16° 48' 27"	S87° 34'43"E	584.59
C17	627.05	880.00	40° 49' 34"	S22° 57'05"W	613.86
C37	83.27	370.00	12° 53' 41"	S53° 04'58"E	83.09
C56	395.91	910.00	24° 55' 39"	S15° 00'08"W	392.80
C162	152.20	400.00	21° 48' 3"	N57° 32'09"W	151.28

NUMBER	DIRECTION	DISTANCE
L19	S02° 32'18"W	13.09
L20	S02° 32'18"W	13.09
L21	N46° 38'08"W	35.66
L22	N46° 38'08"W	35.66
L36	N46° 38'08"W	35.00

LEGEND

- TYP. CREPE MYRTLE (UNLESS NOTED)
- SHRUB/BUSH
- TYP. SAGO PALM (UNLESS NOTED)
- SANITARY MANHOLE
- STORM MANHOLE
- WATER METER
- GATE VALVE
- FLUSH VALVE/FIRE HYDRANT
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- IRRIGATION SPRINKLER HEAD
- TELEPHONE PEDESTAL
- TELEPHONE BOX
- TELEPHONE SIGN
- FIBER OPTIC SIGN
- LIGHT POLE (ELECTRIC)
- LIGHT POLE (NATURAL GAS)
- POWER POLE
- GUY WIRE
- GAS VALVE
- CATHODIC TEST STATION
- TYP. MAIL BOX (UNLESS NOTED)
- TRAFFIC SIGN
- TYP. 5/8" IR (UNLESS NOTED)
- E1(B) — BURIED CENTERPOINT ELECTRICAL
- OE1 — OVERHEAD CENTERPOINT ELECTRICAL
- G1(B) — BURIED CENTERPOINT GAS
- SANITARY LINE
- FOC1(D) — BURIED AT&T FIBER OPTIC
- T1(D) — BURIED AT&T TELEPHONE
- BURIED AT&T CABLE TV
- WOOD FENCE
- STORM SEWER

QUALITY LEVEL LEGEND

- QUALITY LEVEL "A" — QL(A) —
- QUALITY LEVEL "B" — QL(B) —
- QUALITY LEVEL "C" - - QL(C) - -
- QUALITY LEVEL "D" - - QL(D) - -

TYPICAL FOR ALL UTILITES

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY
ENGINEERING DEPARTMENT

HARRIS COUNTY TEXAS 1836

Costello

Engineering and Surveying
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SEE NOTE 4 FOR CERTIFICATION

STATE OF TEXAS REGISTERED DAVID E. HUNT 5198 PROFESSIONAL LAND SURVEYOR

1-14-22

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

UPIN 19103MF14601

SHEET DESCRIPTION: RIFLEMAN TRAIL

DRAWN BY: JDS

DATE: 1/3/2022

DESIGN BY:

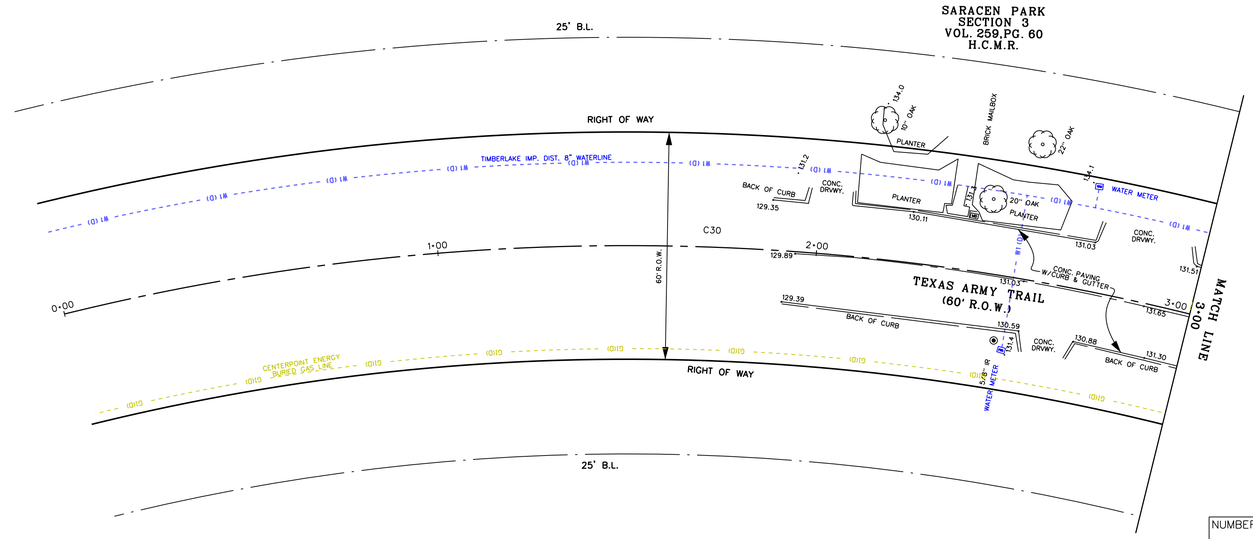
SCALE: 1" = 20'

SHEET NO: 29 OF 48

NOTES:

1. Bearings and coordinates shown hereon are based on the Texas Coordinate System (North American Datum of 1983, 2011 Adjustment), South Central Zone. Coordinates shown hereon are surface values and may be converted to grid by dividing by a combined surface adjustment factor of 1.000079000.
2. Primary Benchmark: Tropical Storm Allison Recovery Project Monument 110130, BM 110130 is a brass disc on the northeast corner of a storm sewer inlet located on the north side of Jarvis Road across from its intersection with Timberlake, immediately east of a driveway to the Timberlake Improvement District wastewater treatment plant. Elevation 127.28 feet NAVD88, 2001 adjustment.
3. To convert elevations based on NAVD88, 2001 adjustment to NAVD88, Geoid 12B elevations subtract 0.96 feet.
4. This survey substantially complies with the current Texas Society of Professional Surveyors standards and specifications for a Category 6 Condition I Survey and a Category 1B, Condition III Survey.
5. All Easements and Building Lines depicted are dedicated by subdivision plat labeled herein, unless otherwise noted.

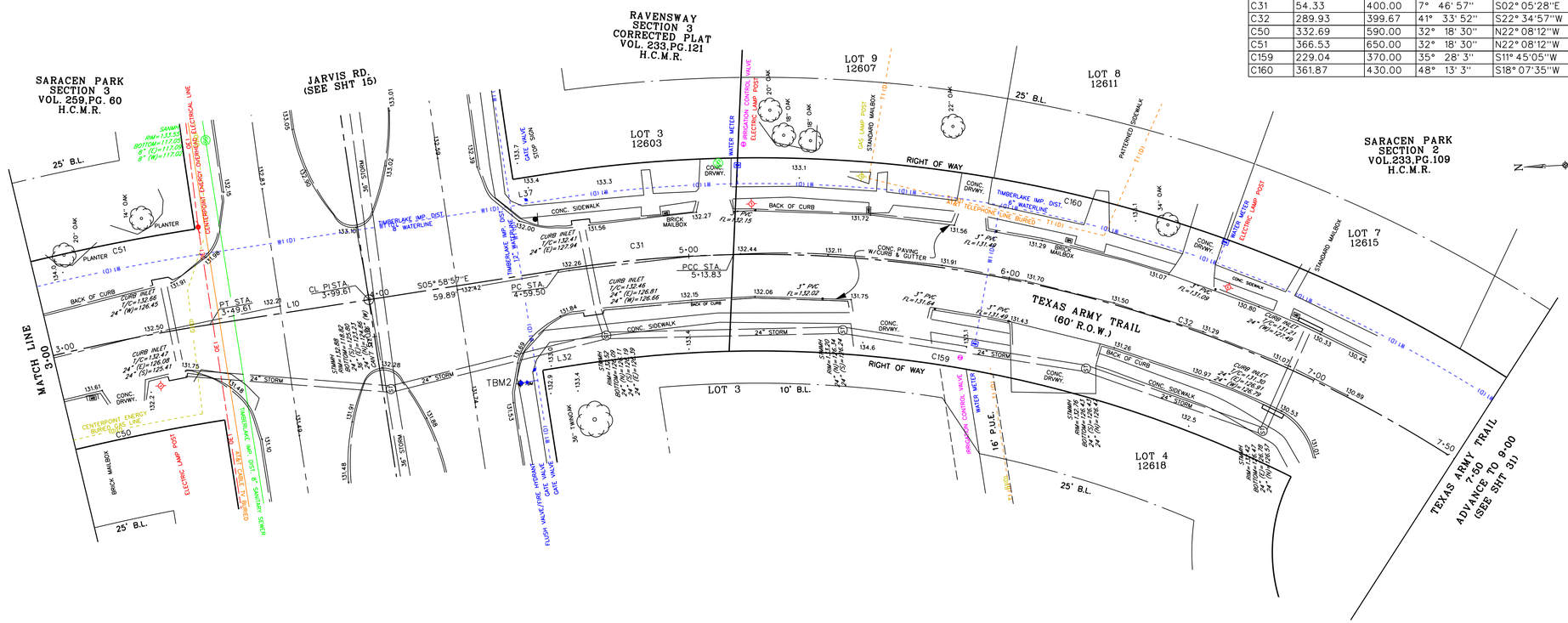
Point	North	East	Elevation	Station	Offset	Description
TBM2	13914154.6400	3036437.3843	134.6600	4+42.063	32.9974	NORTH BOLT TOP FLANGE



STA.	North	East	Desc.
0+00	13914569.5953	3036330.5662	BEGIN PROJ.
3+49.61	13914250.0291	3036460.5662	PT
3+99.61	13914200.3014	3036465.7773	CL PI
4+59.50	13914140.7365	3036472.0193	PC
5+13.85	13914086.4642	3036473.9998	PCC

NUMBER	DIRECTION	DISTANCE (FEET)
L10	S05° 58'57"E	50.00
L32	N05° 58'57"W	9.89
L37	N05° 58'57"W	9.87

NUMBER	ARC LENGTH (FEET)	RADIUS (FEET)	DELTA ANGLE	CHORD DIRECTION	CHORD LENGTH (FEET)
C30	349.61	620.00	32° 18' 30"	S22° 08'12"E	345.00
C31	54.33	400.00	7° 46' 57"	S02° 05'28"E	54.29
C32	289.93	399.67	41° 33' 52"	S22° 34'57"W	283.62
C50	332.69	590.00	32° 18' 30"	N22° 08'12"W	328.30
C51	366.53	650.00	32° 18' 30"	N22° 08'12"W	361.69
C159	229.04	370.00	35° 28' 3"	S11° 45'05"W	225.40
C160	361.87	430.00	48° 13' 3"	S18° 07'35"W	351.28



LEGEND

- TYP. CREPE MYRTLE (UNLESS NOTED)
- SHRUB/BUSH
- TYP. SAGO PALM (UNLESS NOTED)
- SANITARY MANHOLE
- STORM MANHOLE
- WATER METER
- GATE VALVE
- FLUSH VALVE/FIRE HYDRANT
- BLOW-OFF VALVE
- IRRIGATION CONTROL VALVE
- IRRIGATION SPRINKLER HEAD
- TELEPHONE PEDESTAL
- TELEPHONE BOX
- TELEPHONE SIGN
- FIBER OPTIC SIGN
- LIGHT POLE (ELECTRIC)
- LIGHT POLE (NATURAL GAS)
- POWER POLE
- GUY WIRE
- GAS VALVE
- CATHODIC TEST STATION
- TYP. MAIL BOX (UNLESS NOTED)
- TRAFFIC SIGN
- TYP. 5/8" IR (UNLESS NOTED)
- E1(B) — BURIED CENTERPOINT ELECTRICAL
- OE1 — OVERHEAD CENTERPOINT ELECTRICAL
- G1(B) — BURIED CENTERPOINT GAS
- SANITARY LINE
- FOC1(D) — BURIED AT&T FIBER OPTIC
- T1(D) — BURIED AT&T TELEPHONE
- BURIED AT&T CABLE TV
- WOOD FENCE
- STORM SEWER

QUALITY LEVEL LEGEND

- QUALITY LEVEL "A" — SS(A) —
- QUALITY LEVEL "B" — SS(B) —
- QUALITY LEVEL "C" - - SS(C) - -
- QUALITY LEVEL "D" - - SS(D) - -

TYPICAL FOR ALL UTILITIES

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY
ENGINEERING DEPARTMENT

Costello
Engineering and Surveying
2107 CityWest Blvd., 3rd Floor
Houston, Texas 77042
(713) 783-7788
(713) 783-3580, Fax
TBPE FIRM REG. No. 280
TBPLS FIRM REG. No. 100486

SEE NOTE 4 FOR CERTIFICATION

STATE OF TEXAS REGISTERED DAVID E. HUNT 5198 PROFESSIONAL LAND SURVEYOR

1-14-22

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

UPIN 19103MF14601

SHEET DESCRIPTION: TEXAS ARMY TRAIL 0+00 – 7+50

DRAWN BY: JDS | DATE: 1/3/2022

DESIGN BY: | SCALE: 1" = 20' | SHEET NO: 30 OF 48

NOTES:

1. Bearings and coordinates shown hereon are based on the Texas Coordinate System (North American Datum of 1983, 2011 Adjustment), South Central Zone. Coordinates shown hereon are surface values and may be converted to grid by dividing by a combined surface adjustment factor of 1.000079000.
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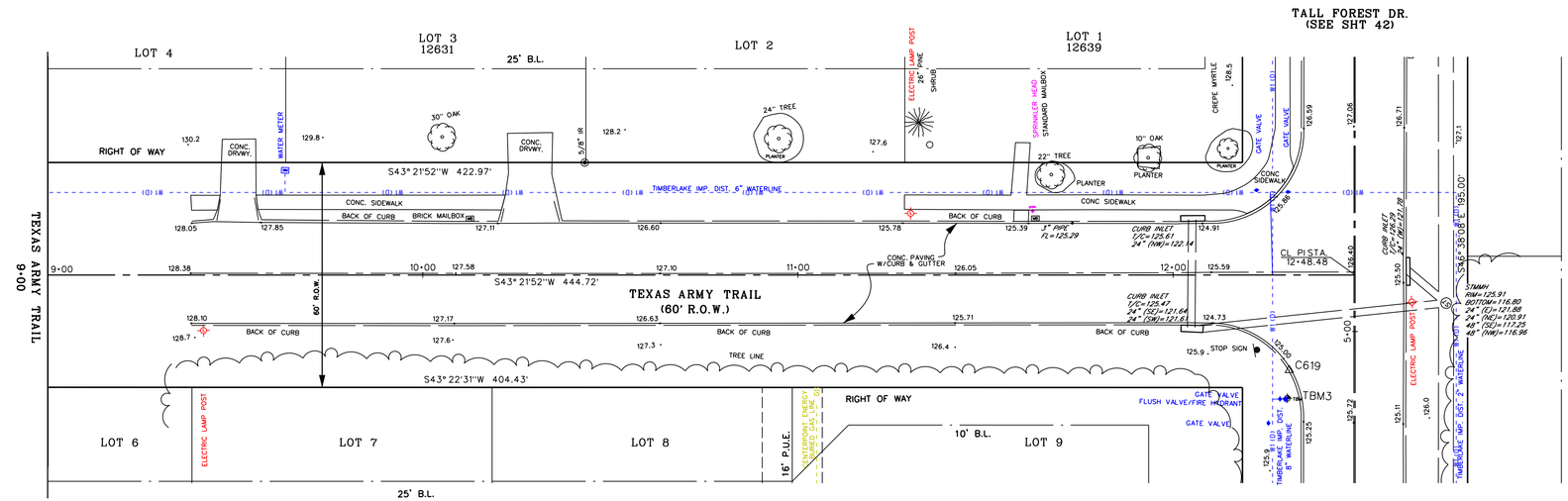
Point	North	East	Elevation	Station	Offset	Description
C619	13913531.4780	3036053.3380	125.5500	12+30.933	25.3669	CUT "X" ON BC
TBM3	13913536.9868	3036048.2455	128.3300	12+30.425	32.8517	SOUTH BOLT TOP FLANGE

STA.	North	East	Desc.
12+48.48	13913501.3016	3036059.7295	CL PI



SARACEN PARK
SECTION 2
VOL.233,PG.109
H.C.M.R.

LEGEND

- TYP. CREPE MYRTLE (UNLESS NOTED)
- SHRUB/BUSH
- TYP. SAGO PALM (UNLESS NOTED)
- SANITARY MANHOLE
- STORM MANHOLE
- WATER METER
- GATE VALVE
- FLUSH VALVE/FIRE HYDRANT
- BLOW-OFF VALVE
- IRRIGATION CONTROL VALVE
- IRRIGATION SPRINKLER HEAD
- TELEPHONE PEDESTAL
- TELEPHONE BOX
- TELEPHONE SIGN
- FIBER OPTIC SIGN
- LIGHT POLE (ELECTRIC)
- LIGHT POLE (NATURAL GAS)
- POWER POLE
- GUY WIRE
- GAS VALVE
- CATHODIC TEST STATION
- TYP. MAIL BOX (UNLESS NOTED)
- TRAFFIC SIGN
- TYP. 5/8" IR (UNLESS NOTED)
- E1(B) — BURIED CENTERPOINT ELECTRICAL
- OE1 — OVERHEAD CENTERPOINT ELECTRICAL
- G1(B) — BURIED CENTERPOINT GAS
- SANITARY LINE
- FOC1(D) — BURIED AT&T FIBER OPTIC
- T1(D) — BURIED AT&T TELEPHONE
- BURIED AT&T CABLE TV
- WOOD FENCE
- STORM SEWER

QUALITY LEVEL LEGEND

- QUALITY LEVEL "A" — SS(A) —
- QUALITY LEVEL "B" — SS(B) —
- QUALITY LEVEL "C" - - SS(C) - -
- QUALITY LEVEL "D" - - SS(D) - -

TYPICAL FOR ALL UTILITIES

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY
ENGINEERING DEPARTMENT

Costello
Engineering and Surveying
2107 CityWest Blvd., 3rd Floor
Houston, Texas 77042
(713) 783-7788
(713) 783-3580, Fax
TBPE FIRM REG. No. 280
TBPLS FIRM REG. No. 100486

SEE NOTE 4 FOR CERTIFICATION

STATE OF TEXAS
REGISTERED
DAVID E. HUNT
5198
PROFESSIONAL
LAND SURVEYOR

1-14-22

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

UPIN 19103MF14601

SHEET DESCRIPTION: TEXAS ARMY TRAIL 9+00

DRAWN BY: JDS		DATE: 1/3/2022
DESIGN BY:	SCALE: 1" = 20'	SHEET NO: 31 OF 48

NOTES:

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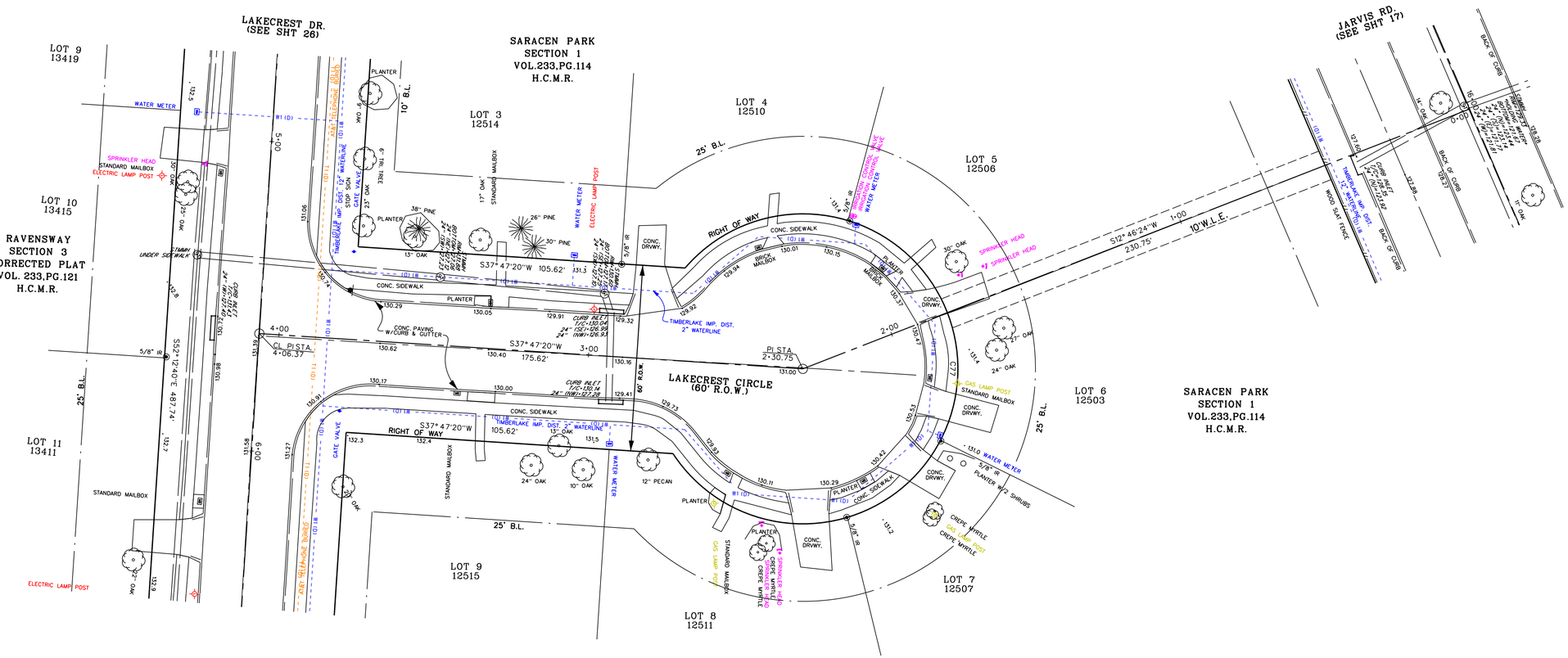
NUMBER	ARC LENGTH	RADIUS	DELTA ANGLE	CHORD DIRECTION	CHORD LENGTH
C77	249.81	50.00	286° 15' 37"	N52°12'40"W	60.00

Point	North	East	Station
0+00	13914089.7242	3037545.1609	BEGIN PROJ.
2+30.75	13913864.6871	3037494.1441	PI
4+06.37	13913725.8994	3037386.5320	PI CL



LEGEND

- TYP. CREPE MRYTLE (UNLESS NOTED)
- SHRUB/BUSH
- TYP. SAGO PALM (UNLESS NOTED)
- SANITARY MANHOLE
- STORM MANHOLE
- WATER METER
- GATE VALVE
- FLUSH VALVE/FIRE HYDRANT
- BLOW-OFF VALVE
- IRRIGATION CONTROL VALVE
- IRRIGATION SPRINKLER HEAD
- TELEPHONE PEDESTAL
- TELEPHONE BOX
- TELEPHONE SIGN
- FIBER OPTIC SIGN
- LIGHT POLE (ELECTRIC)
- LIGHT POLE (NATURAL GAS)
- POWER POLE
- GUY WIRE
- GAS VALVE
- CATHODIC TEST STATION
- TYP. MAIL BOX (UNLESS NOTED)
- TRAFFIC SIGN
- TYP. 5/8" IR (UNLESS NOTED)
- E1 (B) — BURIED CENTERPOINT ELECTRICAL
- OE1 — OVERHEAD CENTERPOINT ELECTRICAL
- G1(B) — BURIED CENTERPOINT GAS
- WW1 (C) — SANITARY LINE
- FOC1 (D) — BURIED AT&T FIBER OPTIC
- T1 (D) — BURIED AT&T TELEPHONE
- BURIED AT&T CABLE TV
- WOOD FENCE
- STORM SEWER

QUALITY LEVEL LEGEND

QUALITY LEVEL "A"	SS(A)
QUALITY LEVEL "B"	SS(B)
QUALITY LEVEL "C"	SS(C)
QUALITY LEVEL "D"	SS(D)

TYPICAL FOR ALL UTILITIES

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY ENGINEERING DEPARTMENT

HARRIS COUNTY 1836 TEXAS

Costello

Engineering and Surveying
2107 CityWest Blvd., 3rd Floor
Houston, Texas 77042
(713) 783-7788
(713) 783-3580, Fax
TBPE FIRM REG. No. 280
TBPLS FIRM REG. No. 100486

SEE NOTE 4 FOR CERTIFICATION

STATE OF TEXAS REGISTERED DAVID E. HUNT 5198 PROFESSIONAL LAND SURVEYOR

1-14-22

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

UPIN 19103MF14601

SHEET DESCRIPTION: LAKECREST CIRCLE

DRAWN BY: JDS		DATE: 1/3/2022
DESIGN BY:	SCALE: 1" = 20'	SHEET NO: 32 OF 48

NOTES:

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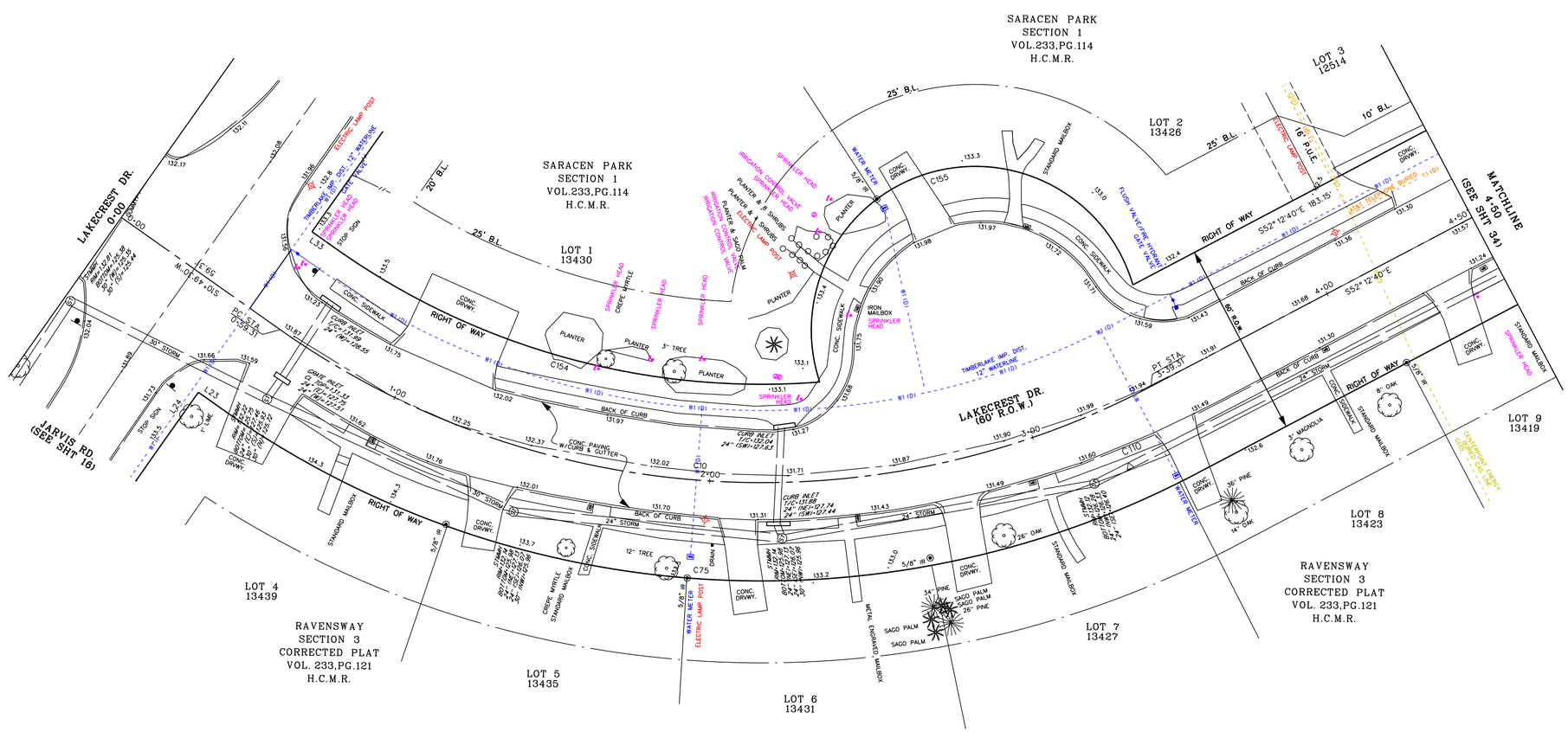
Point	North	East	Elevation	Station	Offset	Description
C110	13913858.1420	3037185.6490	132.1400	3+23.446	19.1158	CUT "X" IN STREET
C111	13913711.2680	3037374.2350	131.6600	5+61.297	19.0979	CUT "X" IN SIDEWALK
C112	13913536.8680	3037598.1090	131.4000	8+45.084	19.7414	CUT "X" IN SIDEWALK

NUMBER	ARC LENGTH (FEET)	RADIUS (FEET)	DELTA ANGLE	CHORD DIRECTION	CHORD LENGTH (FEET)
C10	280.00	254.50	63° 2' 10"	S20° 41'35"E	266.09
C75	313.00	284.50	63° 2' 10"	N20° 41'35"W	297.45
C154	155.79	224.50	39° 45' 40"	N09° 03'20"W	152.69
C155	159.14	50.00	182° 21' 27"	N41° 40'54"W	99.98

STA.	North	East	Desc.
0+00	13914169.5638	3037127.6212	BEGIN PROJ.
0+59.31	13914111.3070	3037116.4817	PC
3+39.31	13913862.3845	3037210.5067	PT

NUMBER	DIRECTION	DISTANCE
L23	N10° 49'30"E	9.31
L33	N10° 49'30"E	9.31



LEGEND

- TYP. CREPE MYRTLE (UNLESS NOTED)
- SHRUB/BUSH
- TYP. SAGO PALM (UNLESS NOTED)
- SANITARY MANHOLE
- STORM MANHOLE
- WATER METER
- GATE VALVE
- FLUSH VALVE/FIRE HYDRANT
- BLOW-OFF VALVE
- IRRIGATION CONTROL VALVE
- IRRIGATION SPRINKLER HEAD
- TELEPHONE PEDESTAL
- TELEPHONE BOX
- TELEPHONE SIGN
- FIBER OPTIC SIGN
- LIGHT POLE (ELECTRIC)
- LIGHT POLE (NATURAL GAS)
- POWER POLE
- GUY WIRE
- GAS VALVE
- CATHODIC TEST STATION
- TYP. MAIL BOX (UNLESS NOTED)
- TRAFFIC SIGN
- TYP. 5/8" IR (UNLESS NOTED)
- E1(B) — BURIED CENTERPOINT ELECTRICAL
- OE1 — OVERHEAD CENTERPOINT ELECTRICAL
- G1(B) — BURIED CENTERPOINT GAS
- SANITARY LINE
- FOC1(D) — BURIED AT&T FIBER OPTIC
- T1(D) — BURIED AT&T TELEPHONE
- BURIED AT&T CABLE TV
- WOOD FENCE
- STORM SEWER

QUALITY LEVEL LEGEND

QUALITY LEVEL "A"	SS(A)
QUALITY LEVEL "B"	SS(B)
QUALITY LEVEL "C"	SS(C)
QUALITY LEVEL "D"	SS(D)

TYPICAL FOR ALL UTILITIES

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY
ENGINEERING DEPARTMENT

Costello
Engineering and Surveying
2107 CityWest Blvd., 3rd Floor
Houston, Texas 77042
(713) 783-7788
(713) 783-3580, Fax
TBPE FIRM REG. No. 280
TBPLS FIRM REG. No. 100486

SEE NOTE 4 FOR CERTIFICATION
STATE OF TEXAS REGISTERED DAVID E. HUNT 5198 PROFESSIONAL LAND SURVEYOR
1-14-22

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018
UPIN 19103MF14601
SHEET DESCRIPTION: LAKECREST DRIVE 0+00 – 4+50
DRAWN BY: JDS
DATE: 1/3/2022
DESIGN BY:
SCALE: 1" = 20'
SHEET NO: 33 OF 48

NOTES:

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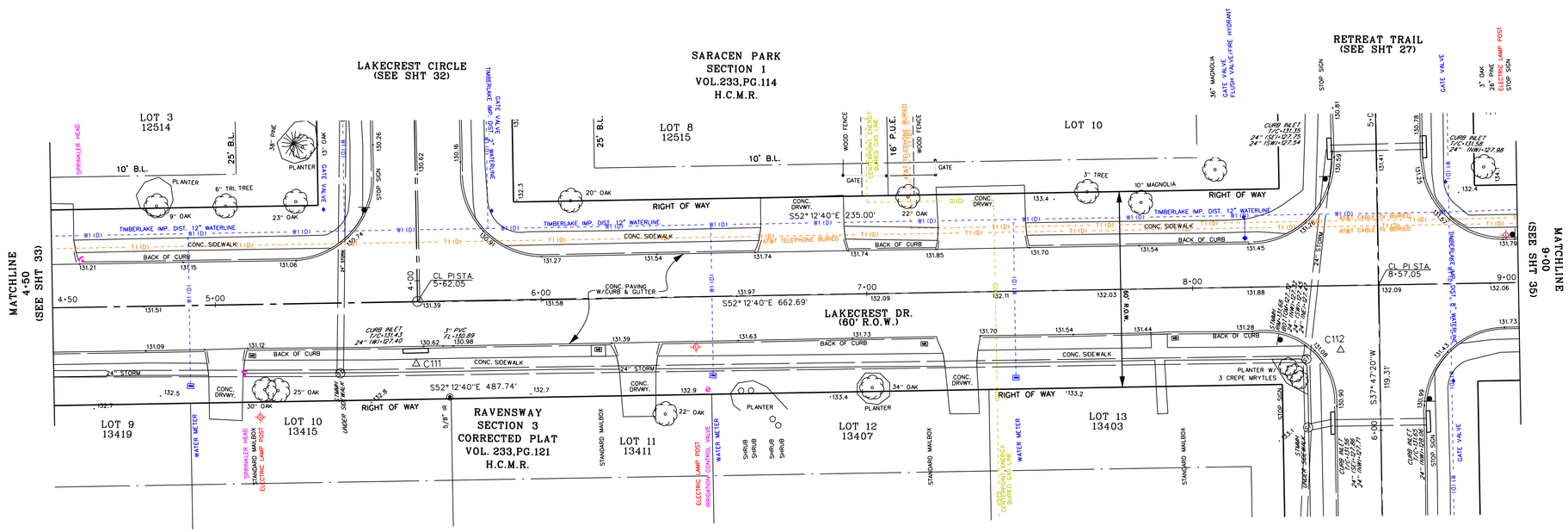
Point	North	East	Elevation	Station	Offset	Description
C111	13913711.2680	3037374.2350	131.6600	5+61.297	19.0979	CUT "X" IN SIDEWALK
C112	13913536.8680	3037598.1090	131.4000	8+45.084	19.7414	CUT "X" IN SIDEWALK

STA.	North	East	Desc.
5+62.05	13913725.8994	3037386.5320	CL PI
8+57.05	13913545.1366	3037619.6625	CL PI

BAR SCALE
0 10 20 40



LEGEND

- TYP. CREPE MRYTLE (UNLESS NOTED)
- SHRUB/BUSH
- TYP. SAGO PALM (UNLESS NOTED)
- SANITARY MANHOLE
- STORM MANHOLE
- WATER METER
- GATE VALVE
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- IRRIGATION CONTROL VALVE
- IRRIGATION SPRINKLER HEAD
- TELEPHONE PEDESTAL
- TELEPHONE BOX
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- LIGHT POLE (ELECTRIC)
- LIGHT POLE (NATURAL GAS)
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- GUY WIRE
- GAS VALVE
- CATHODIC TEST STATION
- TYP. MAIL BOX (UNLESS NOTED)
- TRAFFIC SIGN
- TYP. 5/8" IR (UNLESS NOTED)
- E1(B) — BURIED CENTERPOINT ELECTRICAL
- OE1 — OVERHEAD CENTERPOINT ELECTRICAL
- GI(B) — BURIED CENTERPOINT GAS
- SANITARY LINE
- FOC1(D) — BURIED AT&T FIBER OPTIC
- T1(D) — BURIED AT&T TELEPHONE
- BURIED AT&T CABLE TV
- // — WOOD FENCE
- STORM SEWER

QUALITY LEVEL LEGEND

QUALITY LEVEL "A"	— QB(A) —
QUALITY LEVEL "B"	— QB(B) —
QUALITY LEVEL "C"	- - QB(C) - -
QUALITY LEVEL "D"	- - QB(D) - -

TYPICAL FOR ALL UTILITIES

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY ENGINEERING DEPARTMENT

Costello
Engineering and Surveying
2107 CityWest Blvd., 3rd Floor
Houston, Texas 77042
(713) 783-7788
(713) 783-3580, Fax
TBPE FIRM REG. No. 280
TBPLS FIRM REG. No. 100486

SEE NOTE 4 FOR CERTIFICATION

STATE OF TEXAS REGISTERED DAVID E. HUNT 5198 PROFESSIONAL LAND SURVEYOR

1-14-22

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

UPIN 19103MF14601

SHEET DESCRIPTION: LAKECREST DRIVE 4+50 – 9+00

DRAWN BY: JDS		DATE: 1/3/2022
DESIGN BY:	SCALE: 1" = 20'	SHEET NO: 34 OF 48

NOTES:

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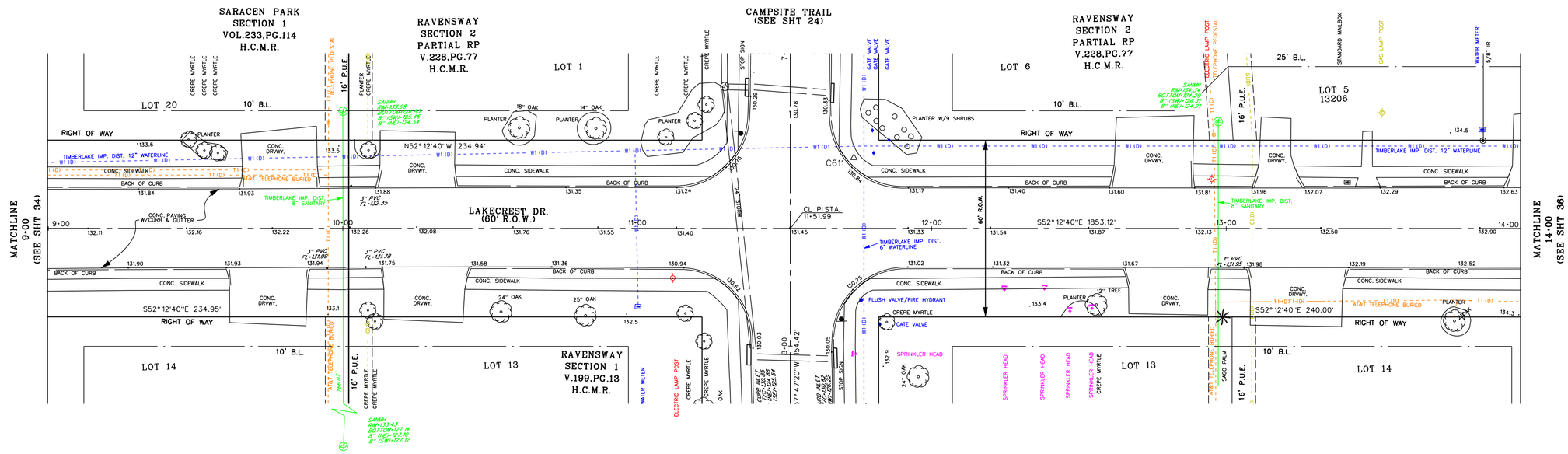

Point	North	East	Elevation	Station	Offset	Description
C611	13913370.1840	3037884.5080	131.2500	11+73.553	-24.0253	CUT "X" IN SIDEWALK

STA.	North	East	Desc.
11+51.99	13913364.4094	3037852.7470	CL PI

LEGEND

- TYP. CREPE MYRTLE (UNLESS NOTED)
- SHRUB/BUSH
- TYP. SAGO PALM (UNLESS NOTED)
- SANITARY MANHOLE
- STORM MANHOLE
- WATER METER
- GATE VALVE
- FLUSH VALVE/FIRE HYDRANT
- BLOW-OFF VALVE
- IRRIGATION CONTROL VALVE
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- LIGHT POLE (ELECTRIC)
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- POWER POLE
- GUY WIRE
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- TYP. MAIL BOX (UNLESS NOTED)
- TRAFFIC SIGN
- TYP. 5/8" IR (UNLESS NOTED)
- E1(B) — BURIED CENTERPOINT ELECTRICAL
- OE1 — OVERHEAD CENTERPOINT ELECTRICAL
- G1(B) — BURIED CENTERPOINT GAS
- SANITARY LINE
- FOC1(D) — BURIED AT&T FIBER OPTIC
- T1(D) — BURIED AT&T TELEPHONE
- BURIED AT&T CABLE TV
- WOOD FENCE
- STORM SEWER

QUALITY LEVEL LEGEND

QUALITY LEVEL "A"	SB(A)
QUALITY LEVEL "B"	SB(B)
QUALITY LEVEL "C"	SB(C)
QUALITY LEVEL "D"	SB(D)

TYPICAL FOR ALL UTILITIES

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY
ENGINEERING DEPARTMENT

Costello
Engineering and Surveying
2107 CityWest Blvd., 3rd Floor
Houston, Texas 77042
(713) 783-7788
(713) 783-3580, Fax
TBPE FIRM REG. No. 280
TBPLS FIRM REG. No. 100486

SEE NOTE 4 FOR CERTIFICATION

STATE OF TEXAS REGISTERED DAVID E. HUNT 5198 PROFESSIONAL LAND SURVEYOR

1-14-22

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

UPIN 19103MF14601

SHEET DESCRIPTION: LAKECREST DRIVE 9+00 – 14+00

DRAWN BY: JDS | DATE: 1/3/2022

DESIGN BY: | SCALE: 1" = 20' | SHEET NO: 35 OF 48

NOTES:

1. Bearings and coordinates shown hereon are based on the Texas Coordinate System (North American Datum of 1983, 2011 Adjustment), South Central Zone. Coordinates shown hereon are surface values and may be converted to grid by dividing by a combined surface adjustment factor of 1.000079000.
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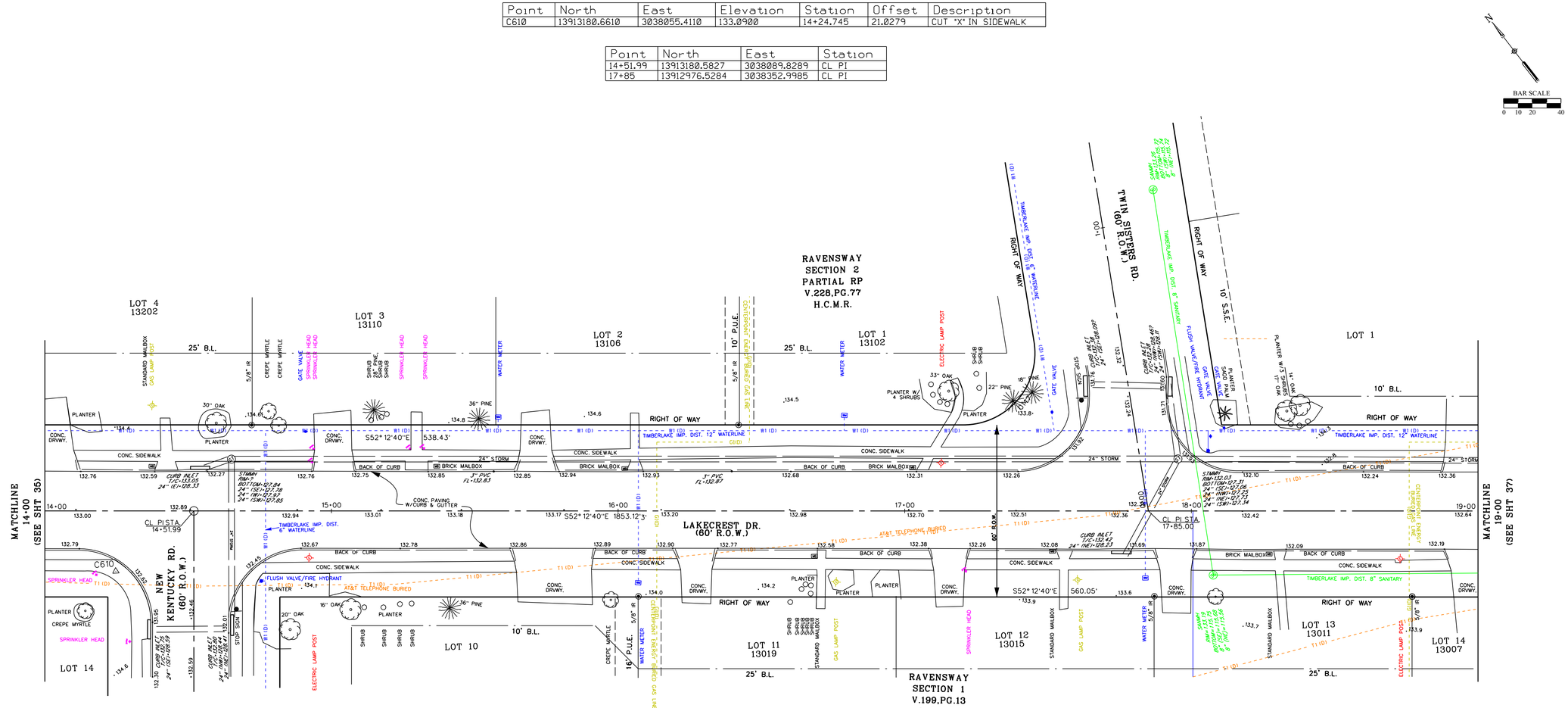
3. To convert elevations based on NAVD88, 2001 adjustment to NAVD88, Geoid 12B elevations subtract 0.96 feet.
4. This survey substantially complies with the current Texas Society of Professional Surveyors standards and specifications for a Category 6 Condition I Survey and a Category 1B, Condition III Survey.
5. All Easements and Building Lines depicted are dedicated by subdivision plat labeled herein, unless otherwise noted.

Point	North	East	Elevation	Station	Offset	Description
C610	13913180.6610	3038055.4110	133.0900	14+24.745	21.0279	CUT "X" IN SIDEWALK

Point	North	East	Station
14+51.99	13913180.5827	3038089.8289	CL PI
17+85	13912976.5284	3038352.9985	CL PI



LEGEND

- TYP. CREPE MYRTLE (UNLESS NOTED)
- SHRUB/BUSH
- TYP. SAGO PALM (UNLESS NOTED)
- SANITARY MANHOLE
- STORM MANHOLE
- WATER METER
- GATE VALVE
- FLUSH VALVE/FIRE HYDRANT
- BLOW-OFF VALVE
- IRRIGATION CONTROL VALVE
- IRRIGATION SPRINKLER HEAD
- TELEPHONE PEDESTAL
- TELEPHONE BOX
- TELEPHONE SIGN
- FIBER OPTIC SIGN
- LIGHT POLE (ELECTRIC)
- LIGHT POLE (NATURAL GAS)
- POWER POLE
- GUY WIRE
- GAS VALVE
- CATHODIC TEST STATION
- TYP. MAIL BOX (UNLESS NOTED)
- TRAFFIC SIGN
- TYP. 5/8" IR (UNLESS NOTED)
- E1(B) — BURIED CENTERPOINT ELECTRICAL
- OE1 — OVERHEAD CENTERPOINT ELECTRICAL
- G1(B) — BURIED CENTERPOINT GAS
- SANITARY LINE
- FOC1(D) — BURIED AT&T FIBER OPTIC
- T1(D) — BURIED AT&T TELEPHONE
- BURIED AT&T CABLE TV
- WOOD FENCE
- STORM SEWER

QUALITY LEVEL LEGEND

QUALITY LEVEL "A"	SS(A)
QUALITY LEVEL "B"	SS(B)
QUALITY LEVEL "C"	SS(C)
QUALITY LEVEL "D"	SS(D)

TYPICAL FOR ALL UTILITIES

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY ENGINEERING DEPARTMENT

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STATE OF TEXAS REGISTERED DAVID E. HUNT 5198 PROFESSIONAL LAND SURVEYOR

1-14-22

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

UPIN 19103MF14601

SHEET DESCRIPTION: LAKECREST DRIVE 14+00 – 19+00

DRAWN BY: JDS		DATE: 1/3/2022
DESIGN BY:	SCALE: 1" = 20'	SHEET NO: 36 OF 48

NOTES:

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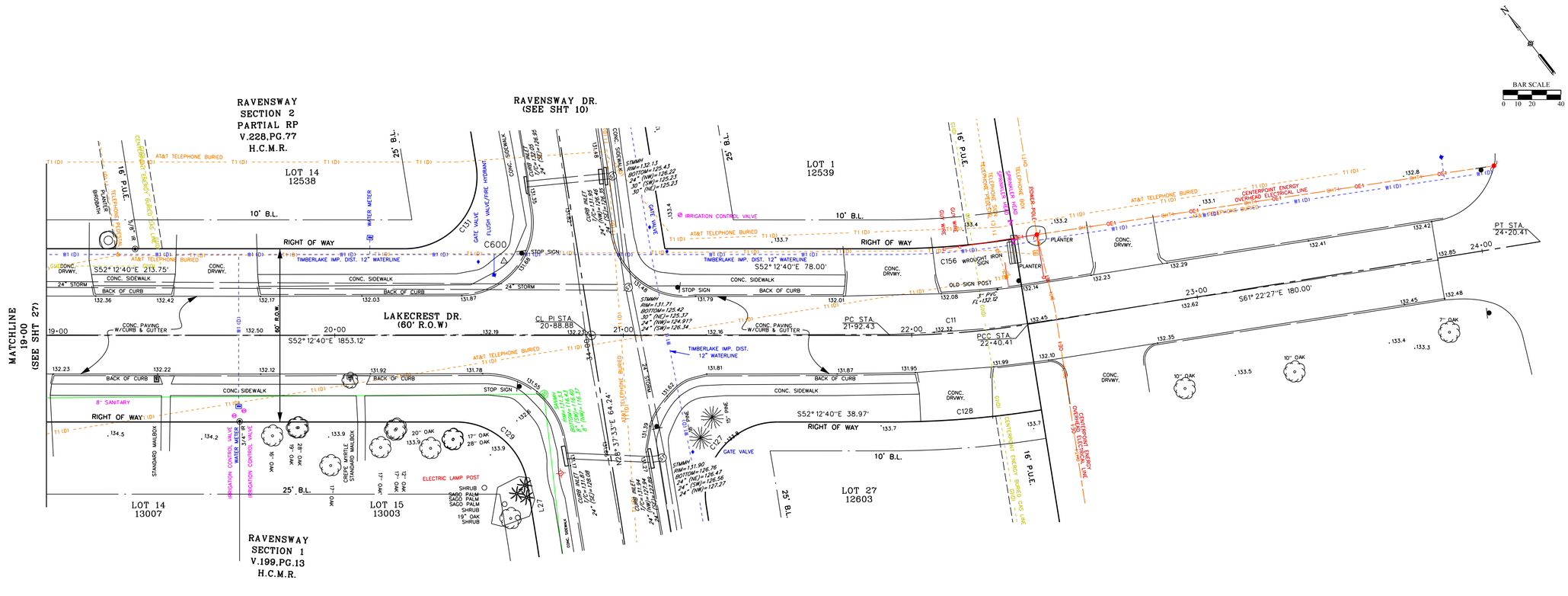

LEGEND

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- CATHODIC TEST STATION
- TYP. MAIL BOX (UNLESS NOTED)
- TRAFFIC SIGN
- TYP. 5/8" IR (UNLESS NOTED)
- E1(B) — BURIED CENTERPOINT ELECTRICAL
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- FOC1(D) — BURIED AT&T FIBER OPTIC
- T1(D) — BURIED AT&T TELEPHONE
- BURIED AT&T CABLE TV
- WOOD FENCE
- STORM SEWER

QUALITY LEVEL LEGEND

QUALITY LEVEL "A"	SS(A)
QUALITY LEVEL "B"	SS(B)
QUALITY LEVEL "C"	SS(C)
QUALITY LEVEL "D"	SS(D)

TYPICAL FOR ALL UTILITES

Point	North	East	Elevation	Station	Offset	Description
C600	13912829.1780	3038585.0030	132.1700	20+58.640	-25.7150	CUT "X" IN SIDEWALK

Point	North	East	Station
20+88.88	13912790.3263	3038593.1440	CL PI
21+92.43	13912726.8763	3038674.9757	PC
22+40.41	13912700.6282	3038715.0756	PCC
24+20.41	13912614.3922	3038873.0733	END PROJ.

NUMBER	ARC LENGTH (FEET)	RADIUS (FEET)	DELTA ANGLE	CHORD DIRECTION	CHORD LENGTH (FEET)
C11	47.98	300.00	9° 9' 47"	S56° 47'33"E	47.93
C127	43.26	25.00	99° 8' 10"	N78° 13'15"E	38.06
C128	52.78	330.00	9° 9' 47"	S56° 47'33"E	52.72
C129	35.27	25.00	80° 50' 13"	S11° 47'33"E	32.42
C131	43.27	25.00	99° 9' 46"	S78° 12'27"W	38.07
C156	43.18	270.00	9° 9' 47"	S56° 47'33"E	43.13

NUMBER	DIRECTION	DISTANCE
L27	N28° 37'33"E	17.40

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY ENGINEERING DEPARTMENT

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TBPLS FIRM REG. No. 100486

SEE NOTE 4 FOR CERTIFICATION

STATE OF TEXAS REGISTERED DAVID E. HUNT 5198 PROFESSIONAL LAND SURVEYOR

1-14-22

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

UPIN 19103MF14601

SHEET DESCRIPTION: LAKECREST DRIVE 19+00

DRAWN BY: JDS | DATE: 1/3/2022

DESIGN BY: | SCALE: 1" = 20' | SHEET NO: 37 OF 48

NOTES:

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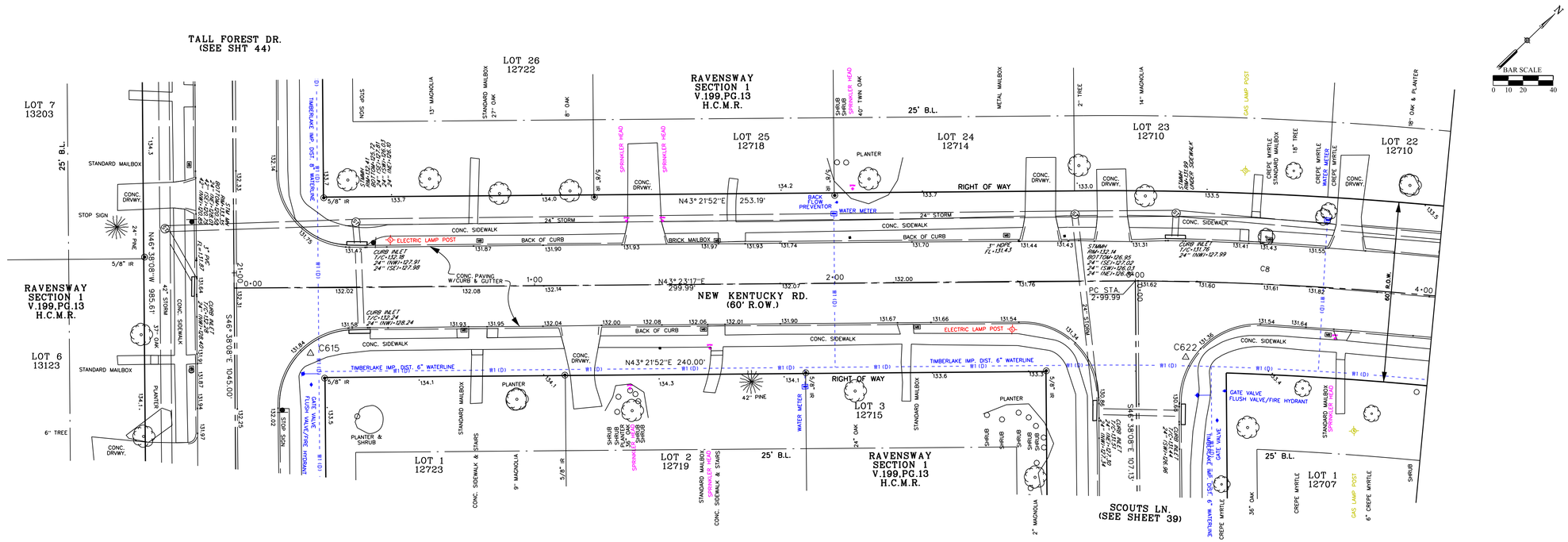

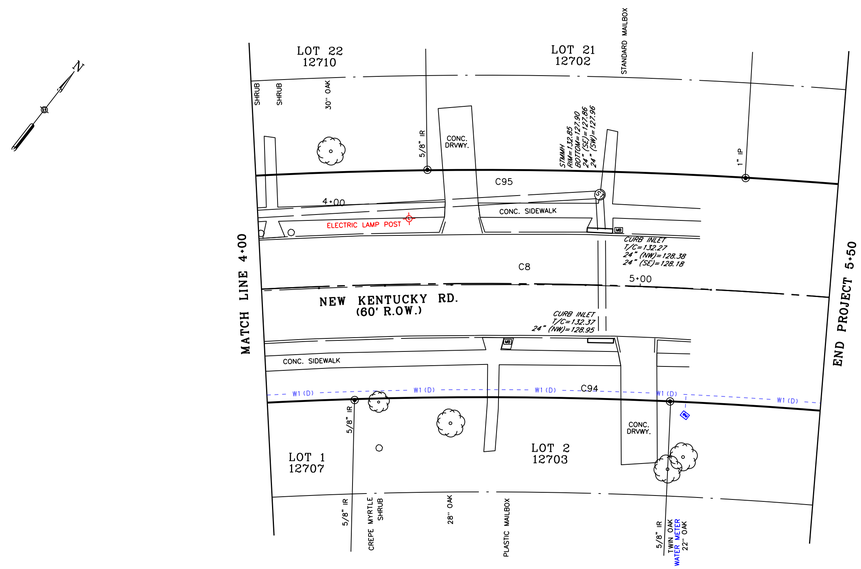

LEGEND

- TYP. CREPE MYRTLE (UNLESS NOTED)
- SHRUB/BUSH
- TYP. SAGO PALM (UNLESS NOTED)
- SANITARY MANHOLE
- STORM MANHOLE
- WATER METER
- GATE VALVE
- FLUSH VALVE/FIRE HYDRANT
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- GAS VALVE
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- TRAFFIC SIGN
- TYP. 5/8" IR (UNLESS NOTED)
- E1(B) — BURIED CENTERPOINT ELECTRICAL
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- STORM SEWER

QUALITY LEVEL LEGEND

- QUALITY LEVEL "A" — SS(A) —
- QUALITY LEVEL "B" — SS(B) —
- QUALITY LEVEL "C" - - SS(C) - -
- QUALITY LEVEL "D" - - SS(D) - -

TYPICAL FOR ALL UTILITIES

STA.	North	East	Desc.
0+00	13912409.5529	3037215.6641	BEGIN JOB
2+99.99	13912627.5624	3037421.7391	PC

NUMBER	ARC LENGTH (FEET)	RADIUS (FEET)	DELTA ANGLE	CHORD DIRECTION	CHORD LENGTH (FEET)
C8	343.83	1150.00	17° 7' 49"	N52° 46'02"E	342.55

Point	North	East	Elevation	Station	Offset	Description
C615	13912412.8230	3037248.9300	132.3800	21+26.990	-25.2266	CUT "X" IN SIDEWALK
C622	13912622.0730	3037451.6650	131.3100	21+30.700	-316.5568	CUT "X" IN STREET

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY
ENGINEERING DEPARTMENT

Costello
Engineering and Surveying
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TBPE FIRM REG. No. 280
TBPLS FIRM REG. No. 100486

SEE NOTE 4 FOR CERTIFICATION
STATE OF TEXAS REGISTERED DAVID E. HUNT 5198 PROFESSIONAL LAND SURVEYOR
1-14-22

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018
UPIN 19103MF14601
SHEET DESCRIPTION: NEW KENTUCKY ROAD
DRAWN BY: JDS
DATE: 1/3/2022
DESIGN BY:
SCALE: 1" = 20'
SHEET NO: 38 OF 48

NOTES:

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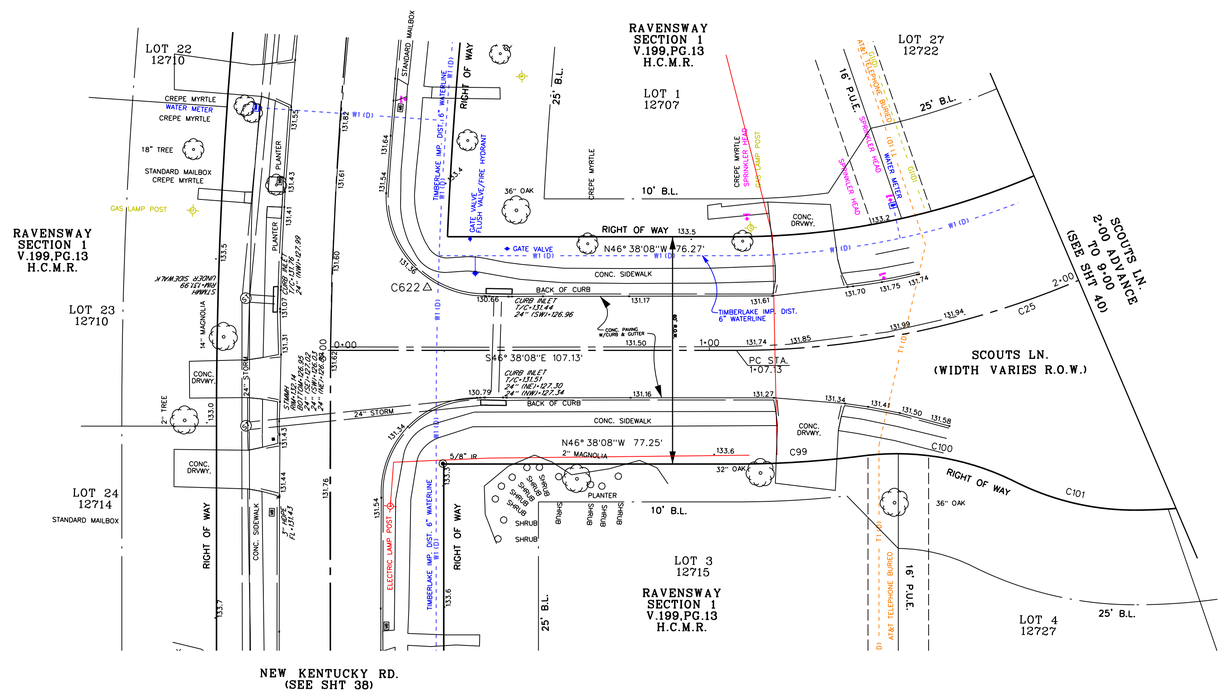
Point	North	East	Elevation	Station	Offset	Description
C622	13912622.0730	3037451.6650	131.3100	0+25.525	-16.5574	CUT "X" IN STREET

STA.	North	East	Desc.
0+00	13912627.5624	3037421.7391	BEGIN JOB
1+07.13	13912554.0029	3037499.6226	PC

NUMBER	ARC LENGTH (FEET)	RADIUS (FEET)	DELTA ANGLE	CHORD DIRECTION	CHORD LENGTH (FEET)
C25	309.00	230.00	76° 58' 36"	S85°07'26"E	286.28
C99	33.40	260.00	7° 21' 37"	S50°18'56"E	33.38
C100	41.56	70.00	34° 1' 2"	S36°59'14"E	40.95
C101	32.57	70.00	26° 39' 38"	S33°18'31"E	32.28

N

BAR SCALE
0 10 20 40



LEGEND

- TYP. CREPE MYRTLE (UNLESS NOTED)
- SHRUB/BUSH
- TYP. SAGO PALM (UNLESS NOTED)
- SANITARY MANHOLE
- STORM MANHOLE
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- STORM SEWER

QUALITY LEVEL LEGEND

- QUALITY LEVEL "A" — WS(A) —
- QUALITY LEVEL "B" — WS(B) —
- QUALITY LEVEL "C" — WS(C) — -
- QUALITY LEVEL "D" — WS(D) — -

TYPICAL FOR ALL UTILITIES

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY
ENGINEERING DEPARTMENT

HARRIS COUNTY TEXAS 1836

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STATE OF TEXAS REGISTERED DAVID E. HUNT 5198 PROFESSIONAL LAND SURVEYOR

1-14-22

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

UPIN 19103MF14601

SHEET DESCRIPTION: SCOUT LANE 0+00 – 2+00

DRAWN BY: JDS		DATE: 1/3/2022
DESIGN BY:	SCALE: 1" = 20'	SHEET NO: 39 OF 48

NOTES:

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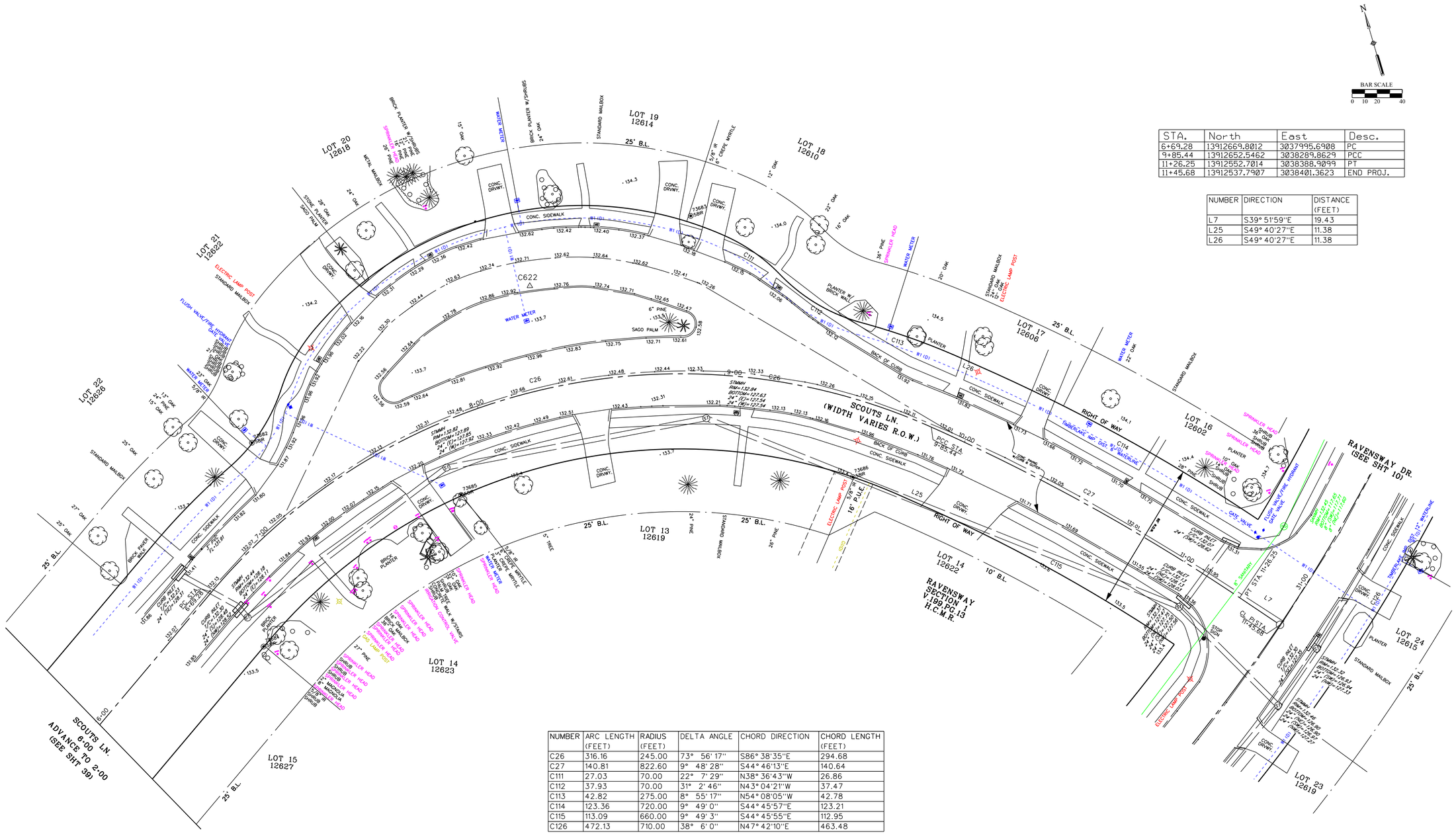

STA.	North	East	Desc.
6+69.28	13912669.8012	3037995.6908	PC
9+85.44	13912652.5462	3038289.8629	PCC
11+26.25	13912552.7014	3038388.9099	PT
11+45.68	13912537.7907	3038401.3623	END PROJ.

NUMBER	DIRECTION	DISTANCE (FEET)
L7	S39° 51'59"E	19.43
L25	S49° 40'27"E	11.38
L26	S49° 40'27"E	11.38

NUMBER	ARC LENGTH (FEET)	RADIUS (FEET)	DELTA ANGLE	CHORD DIRECTION	CHORD LENGTH (FEET)
C26	316.16	245.00	73° 56' 17"	S86° 38'35"E	294.68
C27	140.81	822.60	9° 48' 28"	S44° 46'13"E	140.64
C111	27.03	70.00	22° 7' 29"	N38° 36'43"W	26.86
C112	37.93	70.00	31° 2' 46"	N43° 04'21"W	37.47
C113	42.82	275.00	8° 55' 17"	N54° 08'05"W	42.78
C114	123.36	720.00	9° 49' 0"	S44° 45'57"E	123.21
C115	113.09	660.00	9° 49' 3"	S44° 45'55"E	112.95
C126	472.13	710.00	38° 6' 0"	N47° 42'10"E	463.48

Point	North	East	Elevation	Station	Offset	Description
C631	13912751.5120	3038151.8320	132.8500	8+30.57	-41.48	CUT "X" IN STREET

LEGEND

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- TYP. SAGO PALM (UNLESS NOTED)
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QUALITY LEVEL LEGEND

- QUALITY LEVEL "A" — QL(A)
- QUALITY LEVEL "B" — QL(B)
- QUALITY LEVEL "C" — QL(C)
- QUALITY LEVEL "D" — QL(D)

TYPICAL FOR ALL UTILITIES

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY ENGINEERING DEPARTMENT

HARRIS COUNTY 1836 TEXAS

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1-14-22

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

UPIN 19103MF14601

SHEET DESCRIPTION: SCOUT LANE 9+00

DRAWN BY: JDS

DESIGN BY:

SCALE: 1" = 20'

DATE: 1/3/2022

SHEET NO: 40 OF 48

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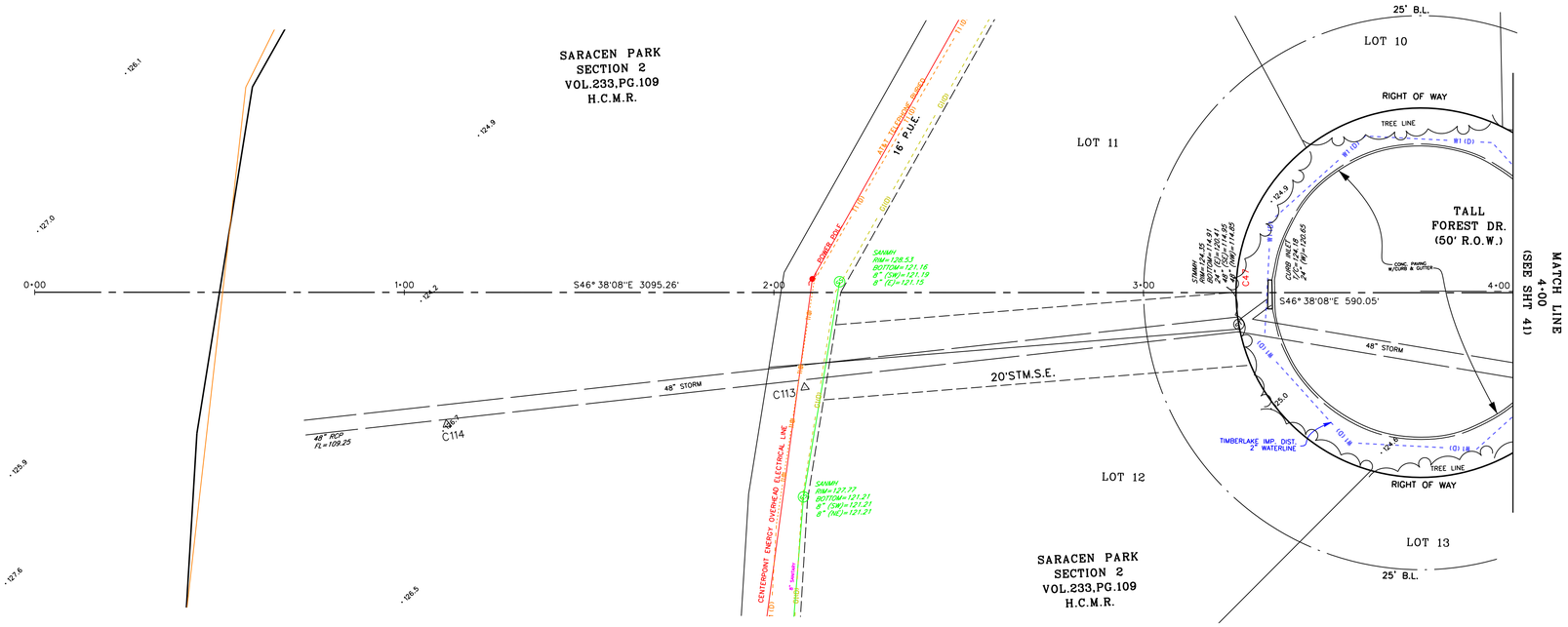
NUMBER	ARC LENGTH	RADIUS	DELTA ANGLE	CHORD DIRECTION	CHORD LENGTH
C47	249.81	50.00	286° 15' 37"	S43° 21'52"W	60.00

Point	North	East	Elevation	Station	Offset	Description
C113	13913693.2100	3035819.1480	125.8000	2+08.375	25.6750	5/8" IR W/CAP
C114	13913752.4340	3035741.8510	126.8100	1+11.515	35.6942	5/8" IR W/CAP

STA.	North	East	Desc.
0+00	13913854.9539	3035685.2889	BEGIN JOB



LEGEND

- TYP. CREPE MYRTLE (UNLESS NOTED)
- SHRUB/BUSH
- TYP. SAGO PALM (UNLESS NOTED)
- SANITARY MANHOLE
- STORM MANHOLE
- WATER METER
- GATE VALVE
- FLUSH VALVE/FIRE HYDRANT
- BLOW-OFF VALVE
- IRRIGATION CONTROL VALVE
- IRRIGATION SPRINKLER HEAD
- TELEPHONE PEDESTAL
- TELEPHONE BOX
- TELEPHONE SIGN
- FIBER OPTIC SIGN
- LIGHT POLE (ELECTRIC)
- LIGHT POLE (NATURAL GAS)
- POWER POLE
- GUY WIRE
- GAS VALVE
- CATHODIC TEST STATION
- TYP. MAIL BOX (UNLESS NOTED)
- TRAFFIC SIGN
- TYP. 5/8" IR (UNLESS NOTED)
- E1(B) — BURIED CENTERPOINT ELECTRICAL
- OE1 — OVERHEAD CENTERPOINT ELECTRICAL
- G1(B) — BURIED CENTERPOINT GAS
- SANITARY LINE
- FOC1(D) — BURIED AT&T FIBER OPTIC
- T1(D) — BURIED AT&T TELEPHONE
- BURIED AT&T CABLE TV
- WOOD FENCE
- STORM SEWER

QUALITY LEVEL LEGEND

QUALITY LEVEL "A"	— WS(A) —
QUALITY LEVEL "B"	— WS(B) —
QUALITY LEVEL "C"	- - WS(C) - -
QUALITY LEVEL "D"	- - WS(D) - -

TYPICAL FOR ALL UTILITIES

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY
ENGINEERING DEPARTMENT

Costello

Engineering and Surveying
2107 CityWest Blvd., 3rd Floor
Houston, Texas 77042
(713) 783-7788
(713) 783-3580, Fax
TBPE FIRM REG. No. 280
TBPLS FIRM REG. No. 100486

SEE NOTE 4 FOR CERTIFICATION

STATE OF TEXAS
REGISTERED
DAVID E. HUNT
5198
PROFESSIONAL
LAND SURVEYOR

1-14-22

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

UPIN 19103MF14601

SHEET DESCRIPTION: TALL FOREST DR. 0+00 – 4+00

DRAWN BY: JDS		DATE: 1/3/2022
DESIGN BY:	SCALE: 1" = 20'	SHEET NO: 41 OF 48

NOTES:

1. Bearings and coordinates shown hereon are based on the Texas Coordinate System (North American Datum of 1983, 2011 Adjustment), South Central Zone. Coordinates shown hereon are surface values and may be converted to grid by dividing by a combined surface adjustment factor of 1.000079000.
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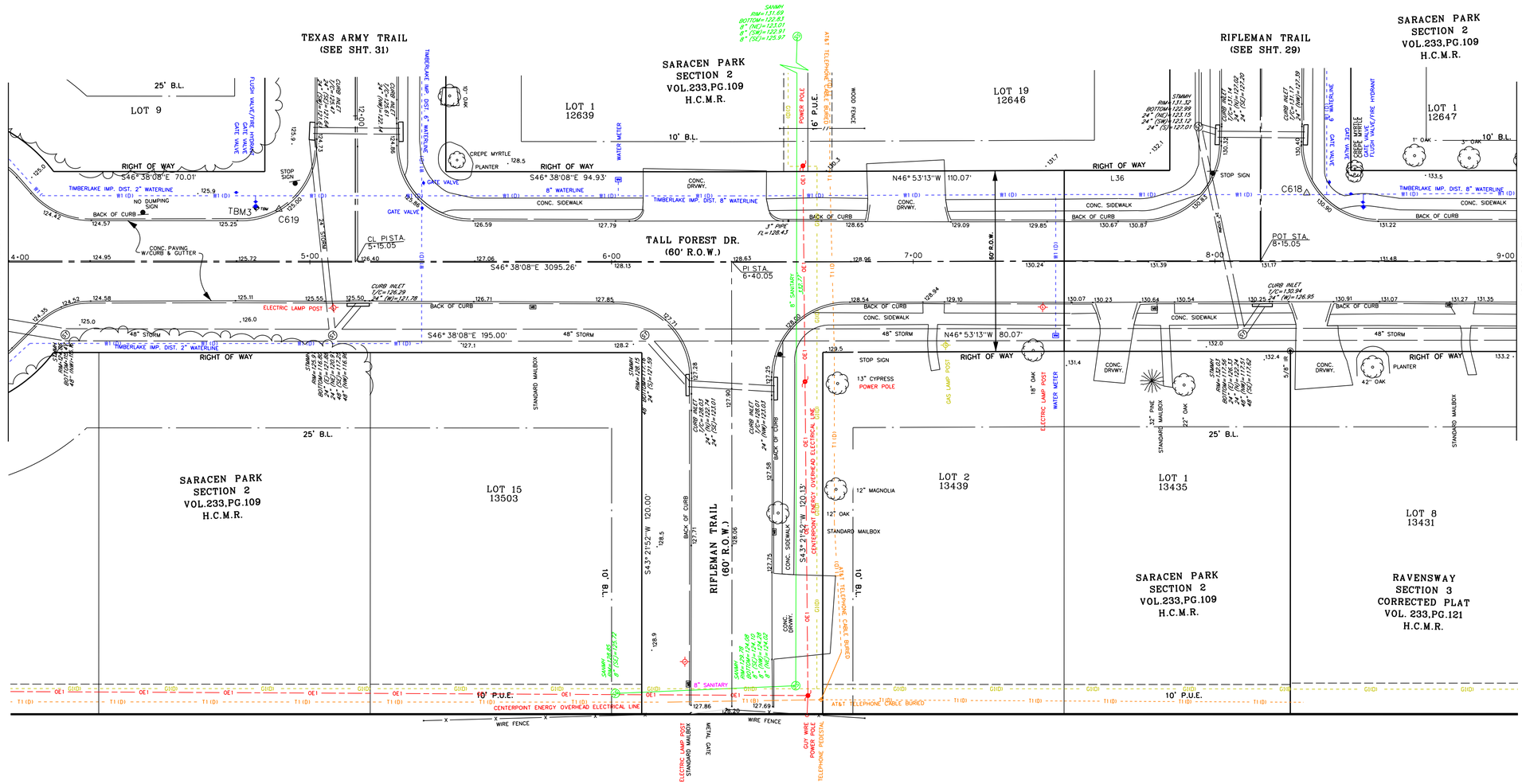
4. This survey substantially complies with the current Texas Society of Professional Surveyors standards and specifications for a Category 6 Condition I Survey and a Category 1B, Condition III Survey.
5. All Easements and Building Lines depicted are dedicated by subdivision plat labeled herein, unless otherwise noted.

Point	North	East	Elevation	Station	Offset	Description
C618	13913301.5150	3036304.8030	130.9200	8+30.400	-22.5492	CUT "X" IN STREET
C619	13913531.4780	3036053.3380	125.5500	4+89.682	-17.5496	CUT "X" ON BC
TBM3	13913536.9868	3036048.2455	128.3300	4+82.198	-18.0578	SOUTH BOLT TOP FLANGE

STA.	North	East	Desc.
5+15.05	13913501.3016	3036059.7295	CL P.I.
8+15.05	13913295.6612	3036278.1609	CL P.I.
6+40.05	13913415.4718	3036150.6044	CL P.I.

NUMBER	DIRECTION	DISTANCE
L36	N46° 38'08"W	35.00

BAR SCALE
0 10 20 40



LEGEND

- TYP. CREPE MYRTLE (UNLESS NOTED)
- SHRUB/BUSH
- TYP. SAGO PALM (UNLESS NOTED)
- SANITARY MANHOLE
- STORM MANHOLE
- WATER METER
- GATE VALVE
- FLUSH VALVE/FIRE HYDRANT
- BLOW-OFF VALVE
- IRRIGATION CONTROL VALVE
- IRRIGATION SPRINKLER HEAD
- TELEPHONE PEDESTAL
- TELEPHONE BOX
- TELEPHONE SIGN
- FIBER OPTIC SIGN
- LIGHT POLE (ELECTRIC)
- LIGHT POLE (NATURAL GAS)
- POWER POLE
- GUY WIRE
- GAS VALVE
- CATHODIC TEST STATION
- TYP. MAIL BOX (UNLESS NOTED)
- TRAFFIC SIGN
- TYP. 5/8" IR (UNLESS NOTED)
- E1(B) — BURIED CENTERPOINT ELECTRICAL
- OE1 — OVERHEAD CENTERPOINT ELECTRICAL
- G1(B) — BURIED CENTERPOINT GAS
- SANITARY LINE
- FOC1(D) — BURIED AT&T FIBER OPTIC
- T1(D) — BURIED AT&T TELEPHONE
- BURIED AT&T CABLE TV
- // — WOOD FENCE
- STORM SEWER

QUALITY LEVEL LEGEND

- QUALITY LEVEL "A" — QB(A) —
- QUALITY LEVEL "B" — QB(B) —
- QUALITY LEVEL "C" - - QB(C) - -
- QUALITY LEVEL "D" - - QB(D) - -

TYPICAL FOR ALL UTILITES

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY
ENGINEERING DEPARTMENT

HARRIS COUNTY TEXAS 1836

Costello

Engineering and Surveying
2107 CityWest Blvd., 3rd Floor
Houston, Texas 77042
(713) 783-7788
(713) 783-3580, Fax
TBPE FIRM REG. No. 280
TBPLS FIRM REG. No. 100486

SEE NOTE 4 FOR CERTIFICATION

STATE OF TEXAS REGISTERED DAVID E. HUNT 5198 PROFESSIONAL LAND SURVEYOR

1-14-22

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

UPIN 19103MF14601

SHEET DESCRIPTION: TALL FOREST DR. 4+00 – 9+00

DRAWN BY: JDS		DATE: 1/3/2022
DESIGN BY:	SCALE: 1" = 20'	SHEET NO: 42 OF 48

BAR SCALE

0 10 20 40

NOTES:

1. Bearings and coordinates shown hereon are based on the Texas Coordinate System (North American Datum of 1983, 2011 Adjustment), South Central Zone. Coordinates shown hereon are surface values and may be converted to grid by dividing by a combined surface adjustment factor of 1.000079000.
2. Primary Benchmark: Tropical Storm Allison Recovery Project Monument 110130, BM 110130 is a brass disc on the northeast corner of a storm sewer inlet located on the north side of Jarvis Road across from its intersection with Timberlake, immediately east of a driveway to the Timberlake Improvement District wastewater treatment plant. Elevation 127.28 feet NAVD88, 2001 adjustment.
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4. This survey substantially complies with the current Texas Society of Professional Surveyors standards and specifications for a Category 6 Condition I Survey and a Category 1B, Condition III Survey.
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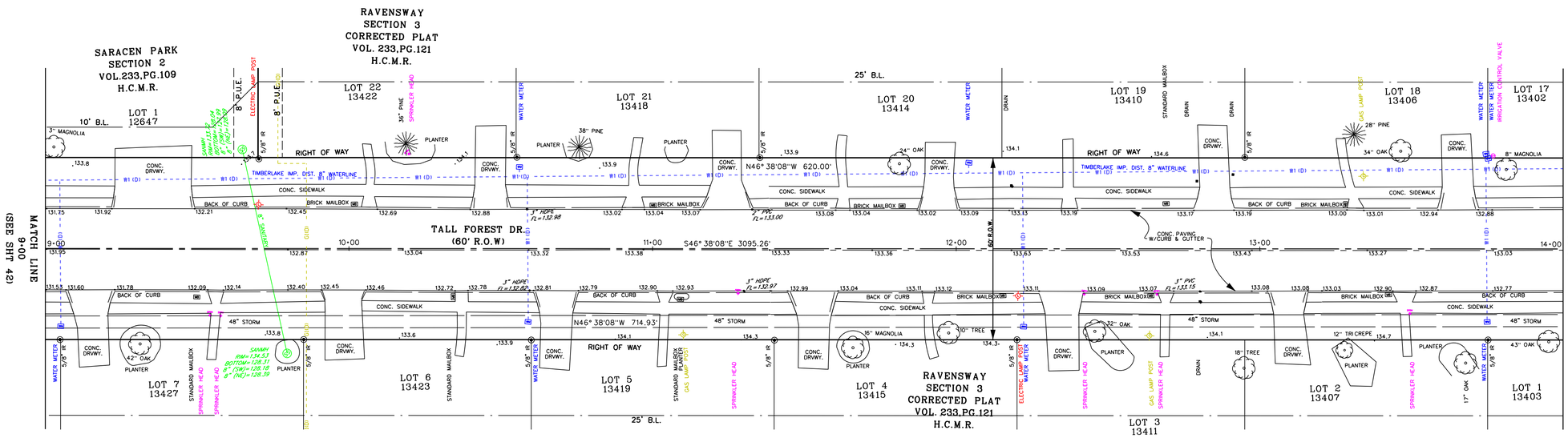


Point	North	East	Elevation	Station	Offset	Description
C616	13912614.1190	3036984.7540	132.1400	17+96.717	9.8245	CUT "X" IN STREET
C617	13912862.6060	3036764.5800	133.0700	14+66.029	-19.1628	CUT "X" IN SIDEWALK
TBM4	13912846.4413	3036813.1613	135.9760	15+12.268	-40.8448	SOUTH BOLT TOP FLANGE

STA.	North	East	Desc.
14+95.05	13912828.7475	3036772.5206	CL P.I.
16+05.05	13912752.8663	3036852.1590	CL P.I.
18+05.05	13912615.5387	3036997.5590	CL P.I.

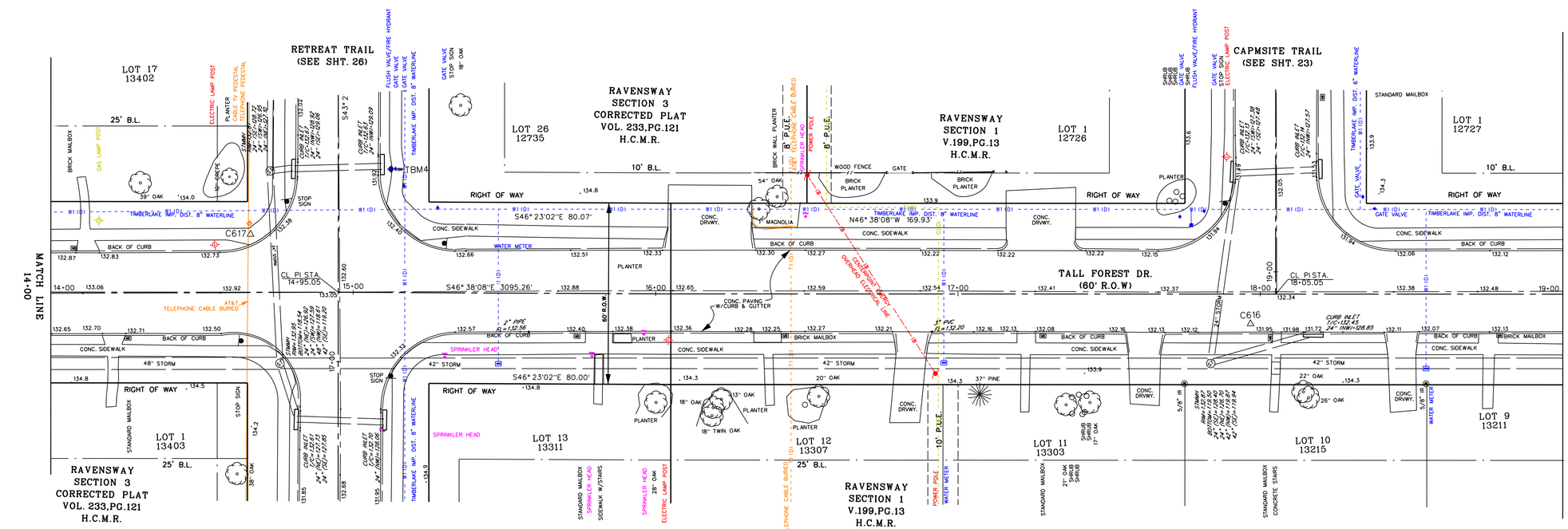
LEGEND

TYP. CREPE MRYTLE (UNLESS NOTED)
SHRUB/BUSH
TYP. SAGO PALM (UNLESS NOTED)
SANITARY MANHOLE
STORM MANHOLE
WATER METER
GATE VALVE
FLUSH VALVE/FIRE HYDRANT
BLOW-OFF VALVE
IRRIGATION CONTROL VALVE
IRRIGATION SPRINKLER HEAD
TELEPHONE PEDESTAL
TELEPHONE BOX
TELEPHONE SIGN
FIBER OPTIC SIGN
LIGHT POLE (ELECTRIC)
LIGHT POLE (NATURAL GAS)
POWER POLE
GUY WIRE
GAS VALVE
CATHODIC TEST STATION
TYP. MAIL BOX (UNLESS NOTED)
TRAFFIC SIGN
TYP. 5/8" IR (UNLESS NOTED)

E1(B) BURIED CENTERPOINT ELECTRICAL
OE1 OVERHEAD CENTERPOINT ELECTRICAL
G1(B) BURIED CENTERPOINT GAS
SANITARY LINE
FOC1(D) BURIED AT&T FIBER OPTIC
T1(D) BURIED AT&T TELEPHONE
BURIED AT&T CABLE TV
WOOD FENCE
STORM SEWER

QUALITY LEVEL LEGEND

QUALITY LEVEL "A" — SUE(A) —
QUALITY LEVEL "B" — SUE(B) —
QUALITY LEVEL "C" - - SUE(C) - -
QUALITY LEVEL "D" - - SUE(D) - -
TYPICAL FOR ALL UTILITIES



NO.	REVISIONS	DATE	NAME

HARRIS COUNTY ENGINEERING DEPARTMENT

Costello

Engineering and Surveying
2107 CityWest Blvd., 3rd Floor
Houston, Texas 77042
(713) 783-7788
(713) 783-3580, Fax
TBPE FIRM REG. No. 280
TBPLS FIRM REG. No. 100486

SEE NOTE 4 FOR CERTIFICATION

STATE OF TEXAS REGISTERED DAVID E. HUNT 5198 PROFESSIONAL LAND SURVEYOR

1-14-22

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

UPIN 19103MF14601

SHEET DESCRIPTION: TALL FOREST DR. 9+00 – 19+00

DRAWN BY: JDS | DATE: 1/3/2022

DESIGN BY: | SCALE: 1" = 20' | SHEET NO: 43 OF 48

NOTES:

1. Bearings and coordinates shown hereon are based on the Texas Coordinate System (North American Datum of 1983, 2011 Adjustment), South Central Zone. Coordinates shown hereon are surface values and may be converted to grid by dividing by a combined surface adjustment factor of 1.000079000.
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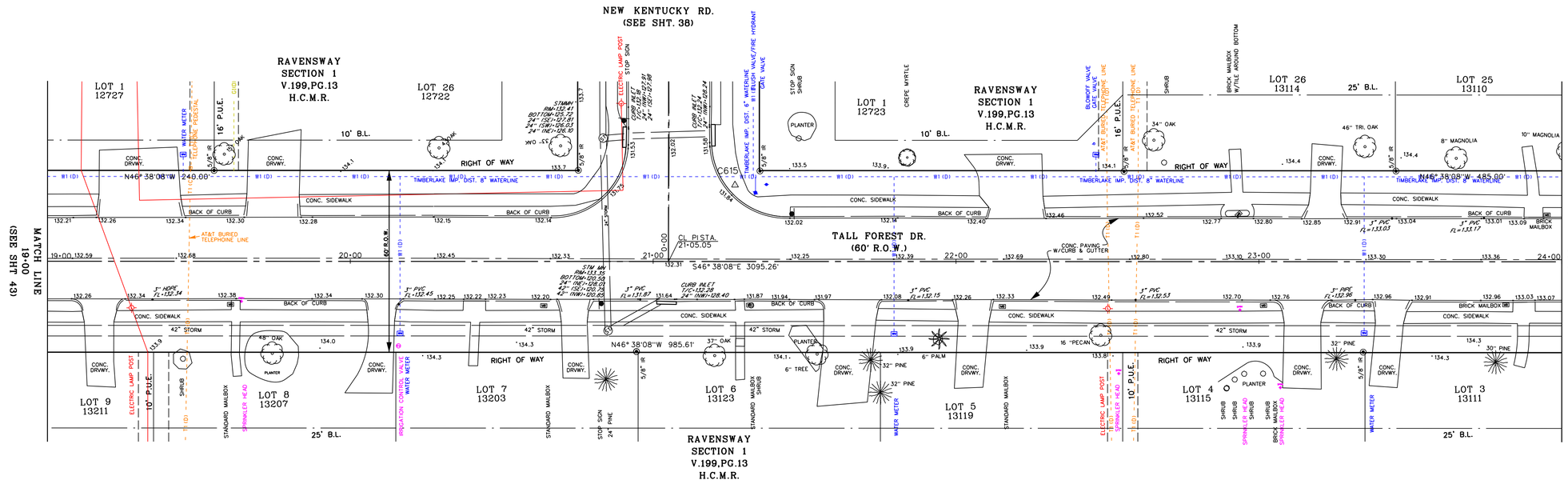

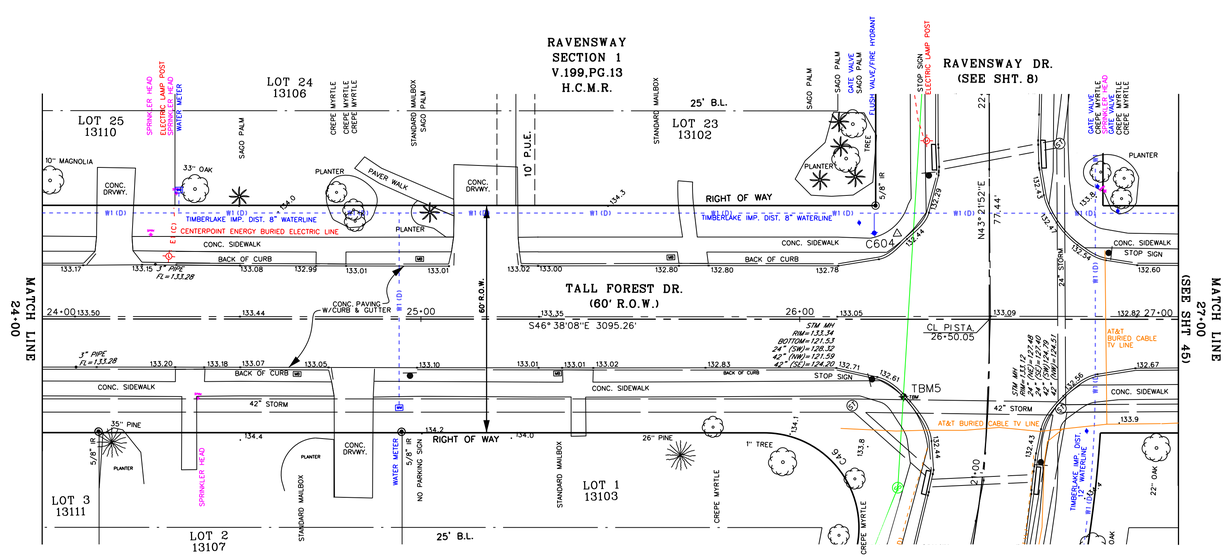

STA.	North	East	Desc.
21+05.05	13912409.5529	3037215.6641	CL P.I.
26+50.05	13912035.3308	3037611.8725	CL P.I.

NUMBER	ARC LENGTH	RADIUS	DELTA ANGLE	CHORD DIRECTION	CHORD LENGTH
C46	44.01	25.00	100° 51' 29"	N03° 47'37"E	38.54

Point	North	East	Elevation	Station	Offset	Description
C604	13912068.4610	3037609.7010	132.9600	26+25.723	-22.5946	CUT "X" IN SIDEWALK
C615	13912412.8230	3037248.9300	132.3800	21+26.990	-25.2266	CUT "X" IN SIDEWALK
TBM5	13912036.0558	3037581.4120	132.9760	26+27.407	20.3882	CUT BOX IN SW

LEGEND

- TYP. CREPE MYRTLE (UNLESS NOTED)
- SHRUB/BUSH
- TYP. SAGO PALM (UNLESS NOTED)
- SANITARY MANHOLE
- STORM MANHOLE
- WATER METER
- GATE VALVE
- FLUSH VALVE/FIRE HYDRANT
- BLOW-OFF VALVE
- IRRIGATION CONTROL VALVE
- IRRIGATION SPRINKLER HEAD
- TELEPHONE PEDESTAL
- TELEPHONE BOX
- TELEPHONE SIGN
- FIBER OPTIC SIGN
- LIGHT POLE (ELECTRIC)
- LIGHT POLE (NATURAL GAS)
- POWER POLE
- GUY WIRE
- GAS VALVE
- CATHODIC TEST STATION
- TYP. MAIL BOX (UNLESS NOTED)
- TRAFFIC SIGN
- TYP. 5/8" IR (UNLESS NOTED)
- E1(B) — BURIED CENTERPOINT ELECTRICAL
- OE1 — OVERHEAD CENTERPOINT ELECTRICAL
- G1(B) — BURIED CENTERPOINT GAS
- WW1(C) — SANITARY LINE
- FOC1(D) — BURIED AT&T FIBER OPTIC
- T1(D) — BURIED AT&T TELEPHONE
- BURIED AT&T CABLE TV
- WOOD FENCE
- STORM SEWER

QUALITY LEVEL LEGEND

- QUALITY LEVEL "A" — SUE(A) —
- QUALITY LEVEL "B" — SUE(B) —
- QUALITY LEVEL "C" - - SUE(C) - -
- QUALITY LEVEL "D" - - SUE(D) - -

TYPICAL FOR ALL UTILITIES

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY
ENGINEERING DEPARTMENT

HARRIS COUNTY 1836 TEXAS

Costello
Engineering and Surveying
2107 CityWest Blvd., 3rd Floor
Houston, Texas 77042
(713) 783-7788
(713) 783-3580, Fax
TBPE FIRM REG. No. 280
TBPLS FIRM REG. No. 100486

SEE NOTE 4 FOR CERTIFICATION

STATE OF TEXAS REGISTERED DAVID E. HUNT 5198 PROFESSIONAL LAND SURVEYOR

1-14-22

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

UPIN 19103MF14601

SHEET DESCRIPTION: TALL FOREST DR. 19+00 – 27+00

DRAWN BY: JDS | DATE: 1/3/2022

DESIGN BY: | SCALE: 1" = 20' | SHEET NO: 44 OF 48

NOTES:

1. Bearings and coordinates shown hereon are based on the Texas Coordinate System (North American Datum of 1983, 2011 Adjustment), South Central Zone. Coordinates shown hereon are surface values and may be converted to grid by dividing by a combined surface adjustment factor of 1.00007900.
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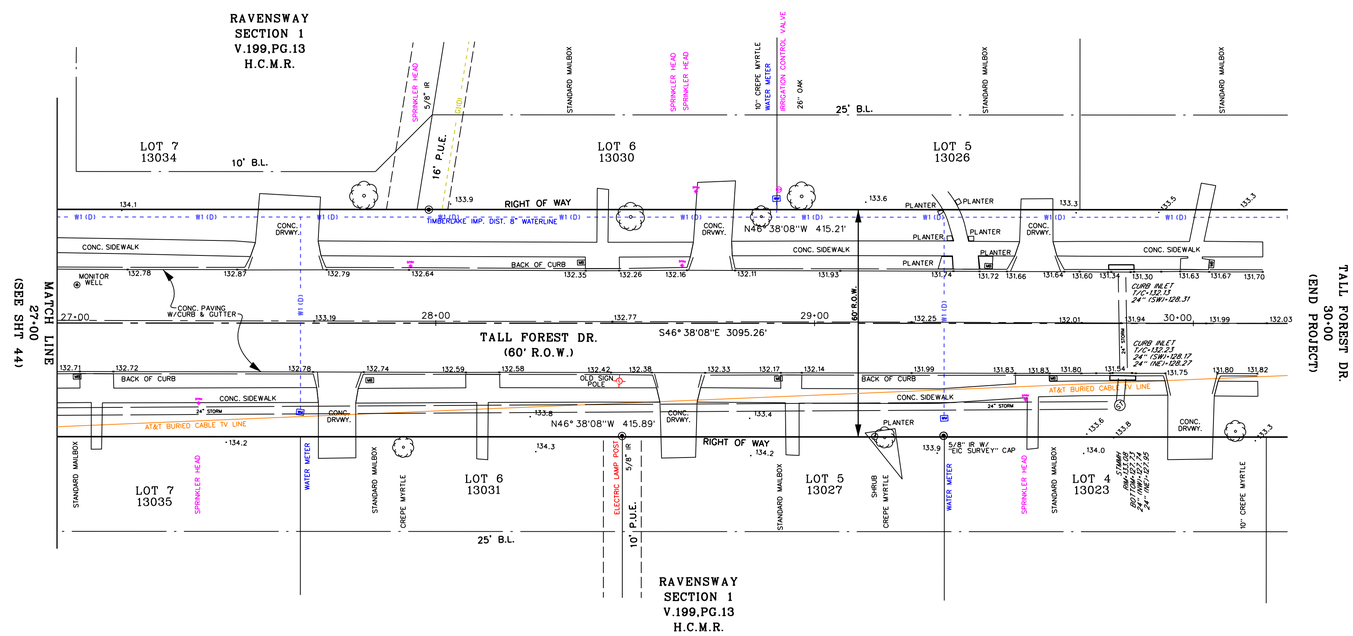
Stat.	North	East	Desc.
30+00	13911795.0417	3037866.2862	END PROJ.



BAR SCALE
0 10 20 40

LEGEND

- TYP. CREPE MYRTLE (UNLESS NOTED)
- SHRUB/BUSH
- TYP. SAGO PALM (UNLESS NOTED)
- SANITARY MANHOLE
- STORM MANHOLE
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- TELEPHONE SIGN
- FIBER OPTIC SIGN
- LIGHT POLE (ELECTRIC)
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- GAS VALVE
- CATHODIC TEST STATION
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- E1(B) — BURIED CENTERPOINT ELECTRICAL
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- T1(D) — BURIED AT&T TELEPHONE
- BURIED AT&T CABLE TV
- WOOD FENCE
- STORM SEWER

QUALITY LEVEL LEGEND

QUALITY LEVEL "A"	— WS(A) —
QUALITY LEVEL "B"	— WS(B) —
QUALITY LEVEL "C"	- - WS(C) - -
QUALITY LEVEL "D"	- - WS(D) - -

TYPICAL FOR ALL UTILITIES

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY
ENGINEERING DEPARTMENT

Costello

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Houston, Texas 77042
(713) 783-7788
(713) 783-3580, Fax
TBPE FIRM REG. No. 280
TBPLS FIRM REG. No. 100486

SEE NOTE 4 FOR CERTIFICATION

STATE OF TEXAS REGISTERED DAVID E. HUNT 5198 PROFESSIONAL LAND SURVEYOR

1-14-22

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

UPIN 19103MF14601

SHEET DESCRIPTION: TALL FOREST DR. 27+00 – 30+00

DRAWN BY: JDS		DATE: 1/3/2022
DESIGN BY:	SCALE: 1" = 20'	SHEET NO: 45 OF 48

BAR SCALE

0 10 20 40

NOTES:

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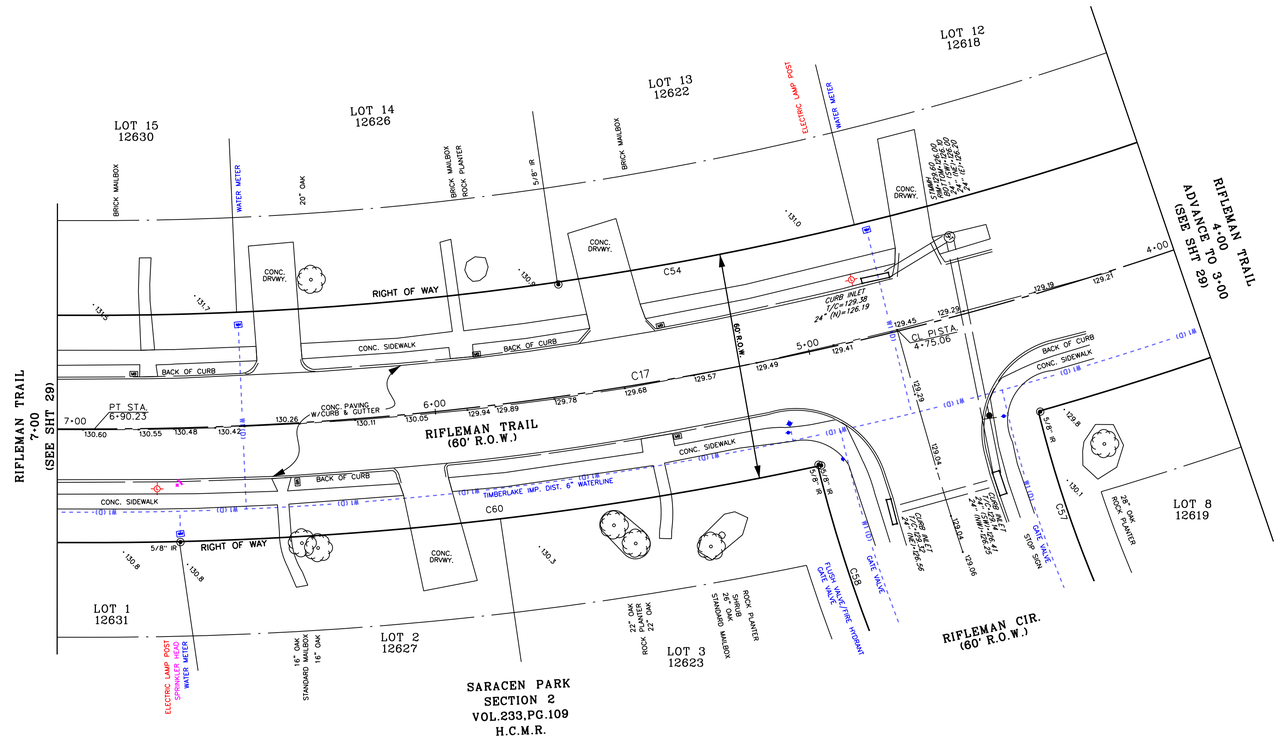

STA.	North	East	Desc.
4+75.06	13913756.8107	3036677.7055	CL PI
6+90.23	13913583.9671	3036550.4605	PT

NUMBER	ARC LENGTH (FEET)	RADIUS (FEET)	DELTA ANGLE	CHORD DIRECTION	CHORD LENGTH (FEET)
C17	627.05	880.00	40° 49' 34"	S22°57'05"W	613.86
C54	605.67	850.00	40° 49' 34"	S22°57'05"W	592.94
C57	101.15	314.58	18° 25' 19"	S69°45'48"E	100.71
C58	124.15	374.58	18° 59' 24"	S70°03'43"E	123.58
C60	192.50	910.00	12° 7' 13"	S37°18'16"W	192.14

LEGEND

- TYP. CREPE MYRTLE (UNLESS NOTED)
- SHRUB/BUSH
- TYP. SAGO PALM (UNLESS NOTED)
- SANITARY MANHOLE
- STORM MANHOLE
- WATER METER
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- POWER POLE
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- GAS VALVE
- CATHODIC TEST STATION
- TYP. MAIL BOX (UNLESS NOTED)
- TRAFFIC SIGN
- TYP. 5/8" IR (UNLESS NOTED)
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- T1(D) — BURIED AT&T TELEPHONE
- BURIED AT&T CABLE TV
- WOOD FENCE
- STORM SEWER

QUALITY LEVEL LEGEND

- QUALITY LEVEL "A" — QL(A) —
- QUALITY LEVEL "B" — QL(B) —
- QUALITY LEVEL "C" - - QL(C) - -
- QUALITY LEVEL "D" - - QL(D) - -

TYPICAL FOR ALL UTILITIES

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY
ENGINEERING DEPARTMENT

HARRIS COUNTY 1836 TEXAS

Costello

Engineering and Surveying
2107 CityWest Blvd., 3rd Floor
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(713) 783-7788
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TBPE FIRM REG. No. 280
TBPLS FIRM REG. No. 100486

SEE NOTE 4 FOR CERTIFICATION

STATE OF TEXAS REGISTERED DAVID E. HUNT 5198 PROFESSIONAL LAND SURVEYOR

1-14-22

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

UPIN 19103MF14601

SHEET DESCRIPTION: RIFLEMAN TRAIL 4+00–7+00

DRAWN BY: JDS | DATE: 1/3/2022

DESIGN BY: | SCALE: 1" = 20' | SHEET NO: 46 OF 48

N

BAR SCALE

0 10 20 40

NOTES:

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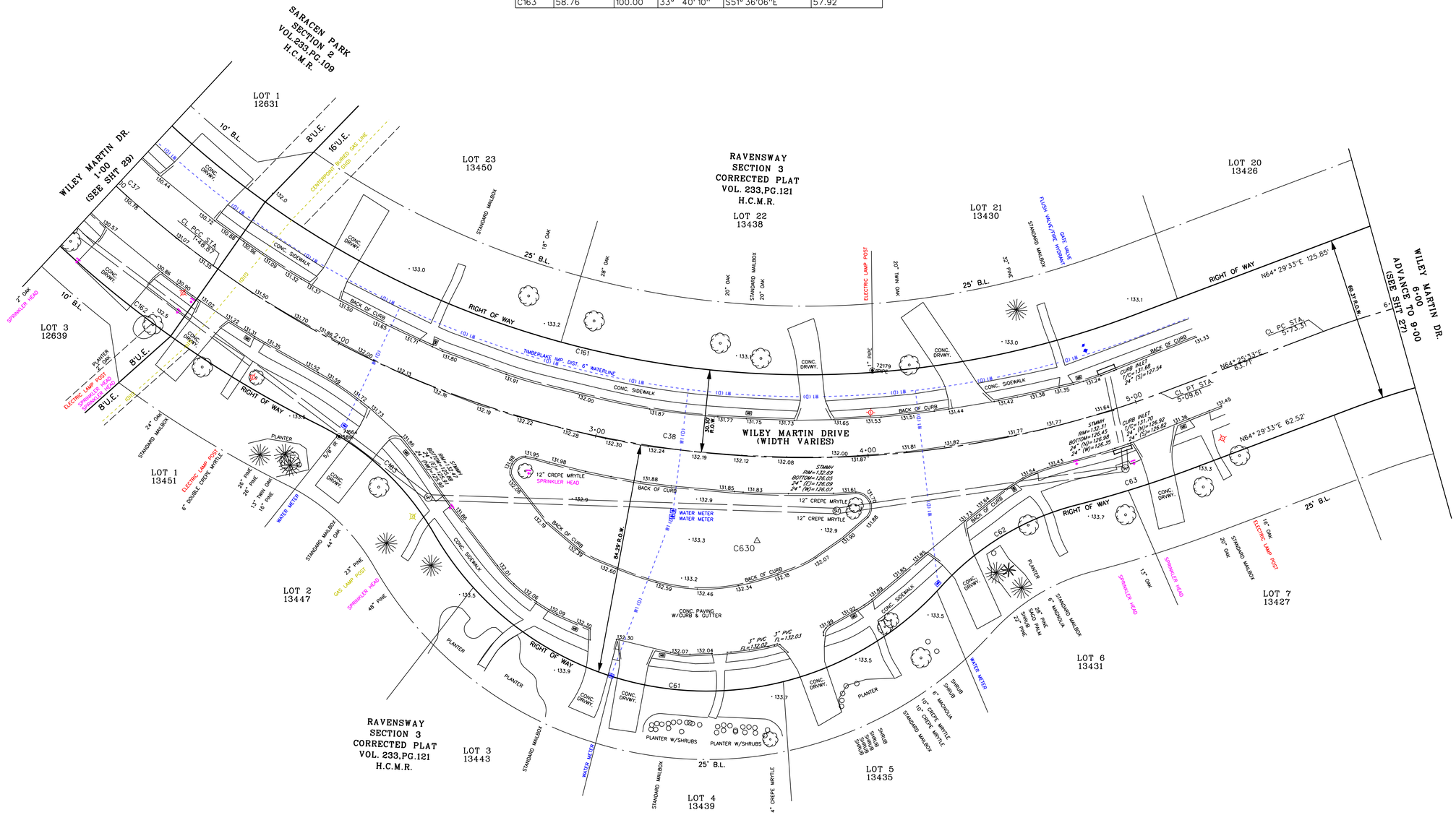
NUMBER	ARC LENGTH (FEET)	RADIUS (FEET)	DELTA ANGLE	CHORD DIRECTION	CHORD LENGTH (FEET)
C37	83.27	370.00	12° 53' 41''	S53°04'58''E	83.09
C38	360.74	367.98	56° 10' 4''	S87°25'25''E	346.47
C61	216.94	115.00	108° 4' 59''	S88°48'30''E	186.17
C62	58.81	100.00	33° 41' 44''	N53°59'52''E	57.97
C161	408.69	340.00	68° 52' 19''	N81°04'17''W	384.53
C162	152.20	400.00	21° 48' 3''	N57°32'09''W	151.28
C163	58.76	100.00	33° 40' 10''	S51°36'06''E	57.92

Point	North	East	Elevation	Station	Offset	Description
C630	13913336.5880	3036801.8050	133.25	3+60.747	30.7549	5/8" IR W/CAP

STA.	North	East	Desc.
1+48.87	13913418.4551	3036597.9462	PCC
5+09.61	13913402.8807	3036944.0615	PT
5+73.31	13913430.3817	3037001.5269	PC



LEGEND

- TYP. CREPE MRYTLE (UNLESS NOTED)
- SHRUB/BUSH
- TYP. SAGO PALM (UNLESS NOTED)
- SANITARY MANHOLE
- STORM MANHOLE
- WATER METER
- GATE VALVE
- FLUSH VALVE/FIRE HYDRANT
- BLOW-OFF VALVE
- IRRIGATION CONTROL VALVE
- IRRIGATION SPRINKLER HEAD
- TELEPHONE PEDESTAL
- TELEPHONE BOX
- TELEPHONE SIGN
- FIBER OPTIC SIGN
- LIGHT POLE (ELECTRIC)
- LIGHT POLE (NATURAL GAS)
- POWER POLE
- GUY WIRE
- GAS VALVE
- CATHODIC TEST STATION
- TYP. MAIL BOX (UNLESS NOTED)
- TRAFFIC SIGN
- TYP. 5/8" IR (UNLESS NOTED)
- E1(B) — BURIED CENTERPOINT ELECTRICAL
- OE1 — OVERHEAD CENTERPOINT ELECTRICAL
- G1(B) — BURIED CENTERPOINT GAS
- SANITARY LINE
- FOC1(D) — BURIED AT&T FIBER OPTIC
- T1(D) — BURIED AT&T TELEPHONE
- BURIED AT&T CABLE TV
- WOOD FENCE
- STORM SEWER

QUALITY LEVEL LEGEND

- QUALITY LEVEL "A" — QL(A) —
- QUALITY LEVEL "B" — QL(B) —
- QUALITY LEVEL "C" - - QL(C) - -
- QUALITY LEVEL "D" - - QL(D) - -

TYPICAL FOR ALL UTILITIES

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY ENGINEERING DEPARTMENT

HARRIS COUNTY TEXAS 1836

Costello

Engineering and Surveying
2107 CityWest Blvd., 3rd Floor
Houston, Texas 77042
(713) 783-7788
(713) 783-3580, Fax
TBPE FIRM REG. No. 280
TBPLS FIRM REG. No. 100486

SEE NOTE 4 FOR CERTIFICATION

STATE OF TEXAS REGISTERED DAVID E. HUNT 5198 PROFESSIONAL LAND SURVEYOR

1-14-22

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

UPIN 19103MF14601

SHEET DESCRIPTION: WILEY MARTIN 1+00 – 6+00

DRAWN BY: JDS

DATE: 1/3/2022

DESIGN BY:

SCALE: 1" = 20'

SHEET NO: 47 OF 48

NOTES:

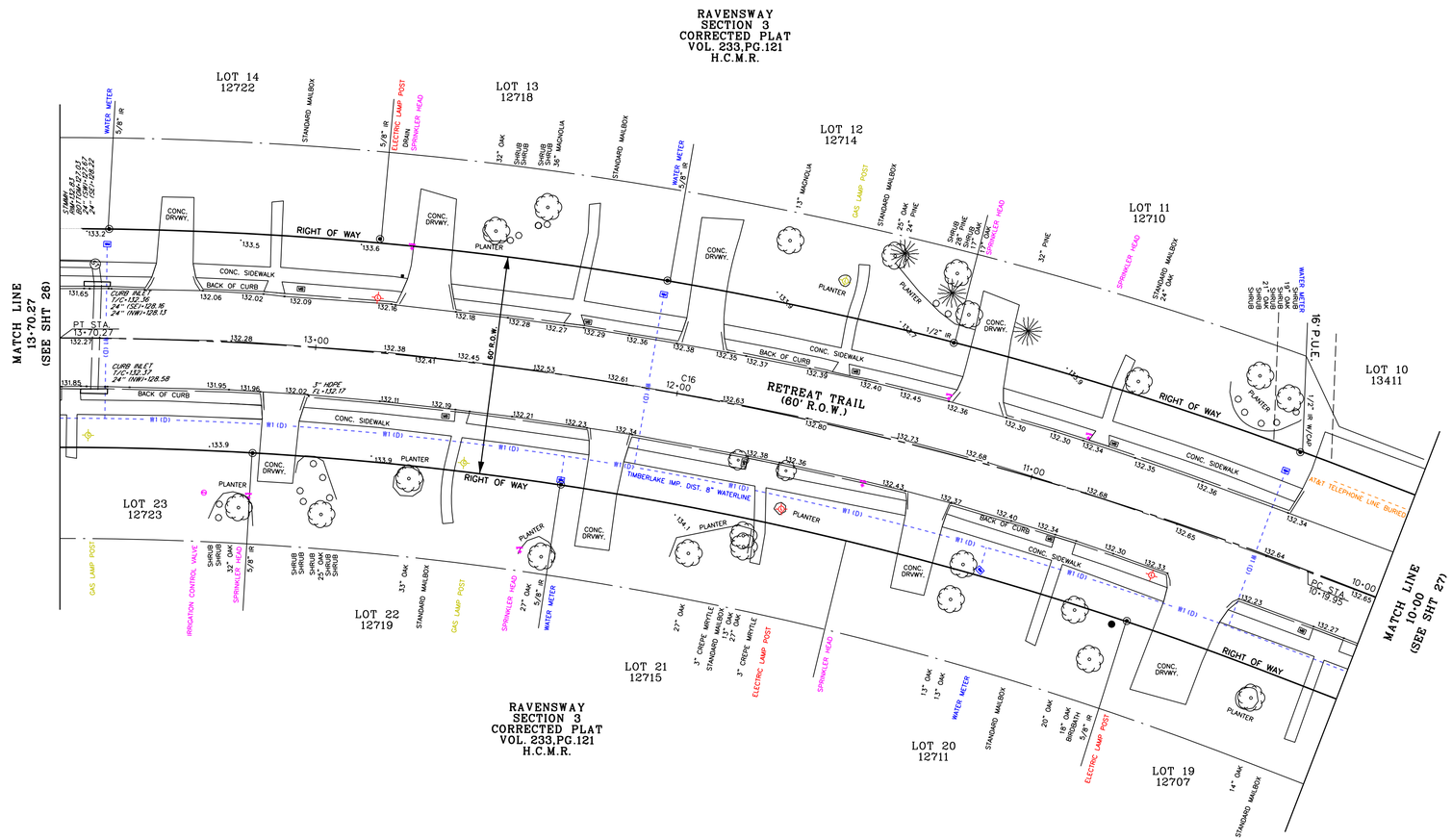
1. Bearings and coordinates shown hereon are based on the Texas Coordinate System (North American Datum of 1983, 2011 Adjustment), South Central Zone. Coordinates shown hereon are surface values and may be converted to grid by dividing by a combined surface adjustment factor of 1.000079000.
2. Primary Benchmark: Tropical Storm Allison Recovery Project Monument 110130, BM 110130 is a brass disc on the northeast corner of a storm sewer inlet located on the north side of Jarvis Road across from its intersection with Timberlake, immediately east of a driveway to the Timberlake Improvement District wastewater treatment plant. Elevation 127.28 feet NAVD88, 2001 adjustment.
3. To convert elevations based on NAVD88, 2001 adjustment to NAVD88, Geoid 12B elevations subtract 0.96 feet.
4. This survey substantially complies with the current Texas Society of Professional Surveyors standards and specifications for a Category 6 Condition I Survey and a Category 1B, Condition III Survey.
5. All Easements and Building Lines depicted are dedicated by subdivision plat labeled herein, unless otherwise noted.

STA.	North	East	Desc.
13+70.27	13913051.7559	3036983.1480	PT
10+19.95	13913256.8531	3037264.7015	PC

NUMBER	ARC LENGTH (FEET)	RADIUS (FEET)	DELTA ANGLE	CHORD DIRECTION	CHORD LENGTH (FEET)
C16	350.32	950.00	21° 7' 41''	S53°55'43''W	348.33
C72	361.38	980.00	21° 7' 41''	S53°55'43''W	359.34
C73	339.25	920.00	21° 7' 41''	S53°55'43''W	337.33

N

BAR SCALE
0 10 20 40



LEGEND

- TYP. CREPE MRYTLE (UNLESS NOTED)
- SHRUB/BUSH
- TYP. SAGO PALM (UNLESS NOTED)
- SANITARY MANHOLE
- STORM MANHOLE
- WATER METER
- GATE VALVE
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- IRRIGATION CONTROL VALVE
- IRRIGATION SPRINKLER HEAD
- TELEPHONE PEDESTAL
- TELEPHONE BOX
- TELEPHONE SIGN
- FIBER OPTIC SIGN
- LIGHT POLE (ELECTRIC)
- LIGHT POLE (NATURAL GAS)
- GUY WIRE
- GAS VALVE
- CATHODIC TEST STATION
- TYP. MAIL BOX (UNLESS NOTED)
- TRAFFIC SIGN
- TYP. 5/8" IR (UNLESS NOTED)
- E1(B) — BURIED CENTERPOINT ELECTRICAL
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- G1(B) — BURIED CENTERPOINT GAS
- SANITARY LINE
- FOC1(D) — BURIED AT&T FIBER OPTIC
- T1(D) — BURIED AT&T TELEPHONE
- BURIED AT&T CABLE TV
- WOOD FENCE
- STORM SEWER

QUALITY LEVEL LEGEND

- QUALITY LEVEL "A" — SS(A)
- QUALITY LEVEL "B" — SS(B)
- QUALITY LEVEL "C" — SS(C)
- QUALITY LEVEL "D" — SS(D)

TYPICAL FOR ALL UTILITIES

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY ENGINEERING DEPARTMENT

HARRIS COUNTY 1836 TEXAS

Costello

Engineering and Surveying
2107 City/West Blvd., 3rd Floor
Houston, Texas 77042
(713) 783-7788
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TBPE FIRM REG. No. 280
TBPLS FIRM REG. No. 100486

SEE NOTE 4 FOR CERTIFICATION

STATE OF TEXAS REGISTERED DAVID E. HUNT 5198 PROFESSIONAL LAND SURVEYOR

1-14-22

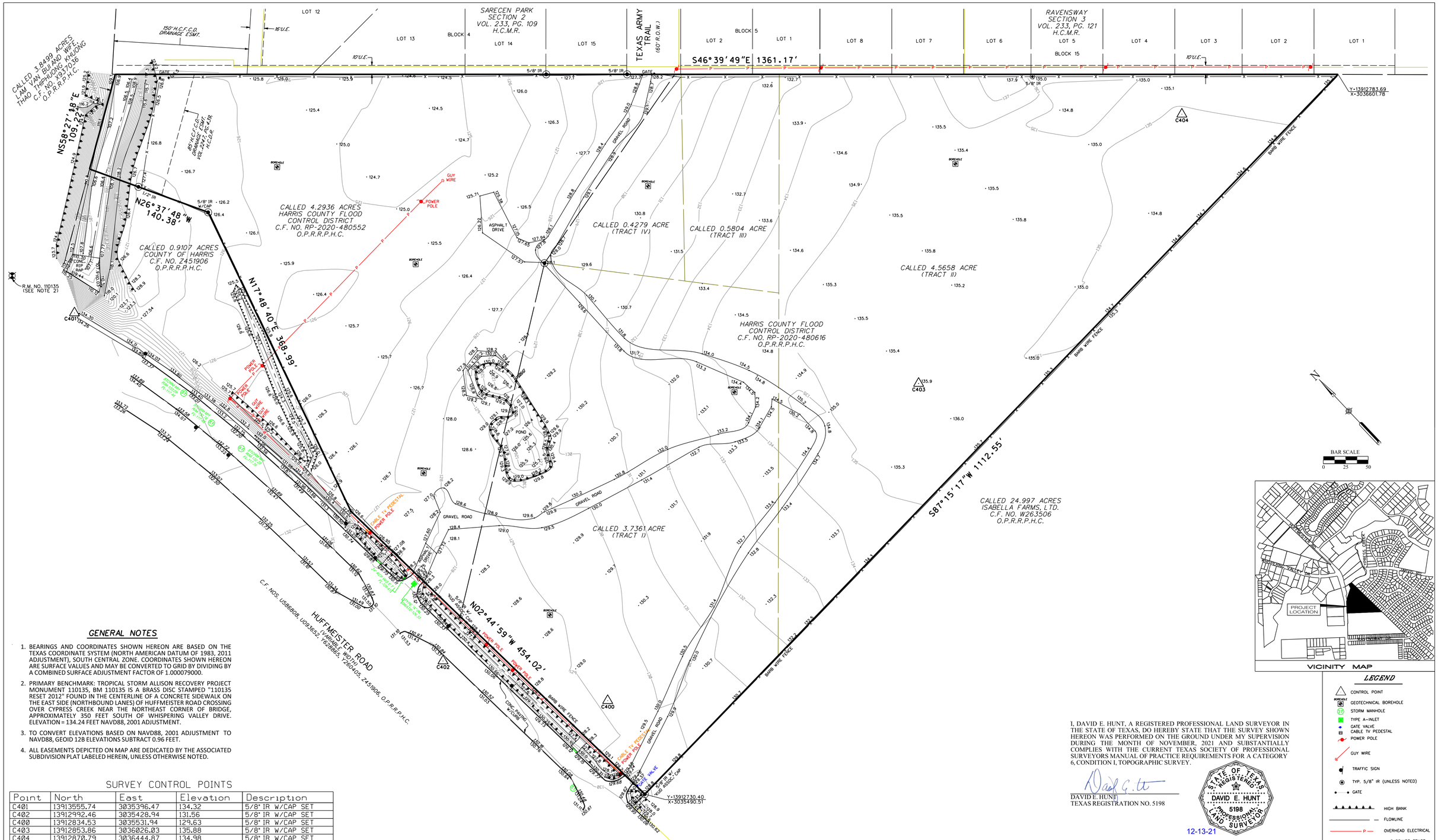
PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

UPIN 19103MF14601

SHEET DESCRIPTION: RETREAT TRAIL 18+00 – 13+70

DRAWN BY: JDS | DATE: 1/3/2022

DESIGN BY: | SCALE: 1" = 20' | SHEET NO: 48 OF 48



GENERAL NOTES

1. BEARINGS AND COORDINATES SHOWN HEREON ARE BASED ON THE TEXAS COORDINATE SYSTEM (NORTH AMERICAN DATUM OF 1983, 2011 ADJUSTMENT), SOUTH CENTRAL ZONE. COORDINATES SHOWN HEREON ARE SURFACE VALUES AND MAY BE CONVERTED TO GRID BY DIVIDING BY A COMBINED SURFACE ADJUSTMENT FACTOR OF 1.000079000.
2. PRIMARY BENCHMARK: TROPICAL STORM ALLISON RECOVERY PROJECT MONUMENT 110135, BM 110135 IS A BRASS DISC STAMPED "110135 RESET 2012" FOUND IN THE CENTERLINE OF A CONCRETE SIDEWALK ON THE EAST SIDE (NORTHBOUND LANES) OF HUFFMEISTER ROAD CROSSING OVER CYPRESS CREEK NEAR THE NORTHEAST CORNER OF BRIDGE, APPROXIMATELY 350 FEET SOUTH OF WHISPERING VALLEY DRIVE. ELEVATION = 134.24 FEET NAVD88, 2001 ADJUSTMENT.
3. TO CONVERT ELEVATIONS BASED ON NAVD88, 2001 ADJUSTMENT TO NAVD88, GEOID 12B ELEVATIONS SUBTRACT 0.96 FEET.
4. ALL EASEMENTS DEPICTED ON MAP ARE DEDICATED BY THE ASSOCIATED SUBDIVISION PLAT LABELED HEREIN, UNLESS OTHERWISE NOTED.

SURVEY CONTROL POINTS

Point	North	East	Elevation	Description
C401	13913555.74	3035396.47	134.32	5/8" IR W/CAP SET
C402	13912992.46	3035428.94	131.56	5/8" IR W/CAP SET
C400	13912834.53	3035531.94	129.63	5/8" IR W/CAP SET
C403	13912853.86	3036026.03	135.88	5/8" IR W/CAP SET
C404	13912870.79	3036444.87	134.98	5/8" IR W/CAP SET

I, DAVID E. HUNT, A REGISTERED PROFESSIONAL LAND SURVEYOR IN THE STATE OF TEXAS, DO HEREBY STATE THAT THE SURVEY SHOWN HEREON WAS PERFORMED ON THE GROUND UNDER MY SUPERVISION DURING THE MONTH OF NOVEMBER, 2021 AND SUBSTANTIALLY COMPLIES WITH THE CURRENT TEXAS SOCIETY OF PROFESSIONAL SURVEYORS MANUAL OF PRACTICE REQUIREMENTS FOR A CATEGORY 6, CONDITION I, TOPOGRAPHIC SURVEY.

DAVID E. HUNT
TEXAS REGISTRATION NO. 5198

STATE OF TEXAS REGISTERED DAVID E. HUNT 5198 PROFESSIONAL LAND SURVEYOR

12-13-21

LEGEND

- CONTROL POINT
- BORE GEOTECHNICAL BOREHOLE
- ST STORM MANHOLE
- TYPE A-INLET
- GATE VALVE
- CABLE TV PEDESTAL
- POWER POLE
- GUY WIRE
- TRAFFIC SIGN
- TYP. 5/8" IR (UNLESS NOTED)
- GATE
- HIGH BANK
- FLOWLINE
- P OVERHEAD ELECTRICAL
- x BARBWIRE FENCE

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY ENGINEERING DEPARTMENT

HARRIS COUNTY TEXAS 1836

Costello

Engineering and Surveying
2107 CityWest Blvd., 3rd Floor
Houston, Texas 77042
(713) 783-7788
(713) 783-3580, Fax
TBPE FIRM REG. No. 280
TBPLS FIRM REG. No. 100486

PROJECT TITLE:	HCED RAVENSWAY DRAINAGE IMPROVEMENTS
UPIN:	19103MF14601
SHEET DESCRIPTION:	TOPOGRAPHIC SURVEY
DRAWN BY:	DATE:
DESIGN BY:	SCALE: 1" = 50' (22"X34") 1" = 100' (11"X17") SHEET NO:

Exhibit 8
Drainage Area Map/Hydraulic Data Sheets

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY
ENGINEERING DEPARTMENT

HARRIS COUNTY TEXAS 1836

LJA Engineering, Inc.
3600 W Sam Houston Pkwy S, Suite 600
Houston, TX 77042
Phone: 713.953.5200 Fax: 713.953.5026
FIRM REGISTRATION No. F-1386
www.LJAengineering.com

STATE OF TEXAS
ISAAC MUÑIZ
125839
LICENSED
PROFESSIONAL ENGINEER
3/2/2022

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **OVERALL DRAINAGE AREA MAPS SHEET 1 OF 7**

DRAWN BY:

DATE: **3/2/2022**

DESIGN BY:

SCALE:

SHEET NO: **17 OF 200**

J:\1994\2102\ACAD\SHEET FILES\60%\17 OVERALL DRAINAGE AREA MAPS SHEET 1 OF 7.dwg

HouStorm (City Of Houston STORM DRAIN DESIGN) Version 2.1, Update: Nov/01/2007
Run @ 2/16/2022 6:48:09 PM

PROJECT NAME : RAVENSWAY
JOB NUMBER :
PROJECT DESCRIPTION :
PROJECT File: E:\Ravensway.stm

DESIGN FREQUENCY : 10 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 10 Years

Runoff Computation for Design Frequency.

ID	C Value	Area (acre)	Tc (min)	Tc Used (min)	Intensity (in/hr)	Supply Q (cfs)	Total Q (cfs)
A10	0.55	0.00	25.87	25.87	0.00	4.790	4.790
A13	0.55	0.00	25.44	0.00	0.00	3.850	3.850
A15	0.55	0.00	25.04	0.00	0.00	3.100	3.100
A17	0.55	0.00	25.23	0.00	0.00	3.440	3.440
A26	0.55	0.00	24.10	0.00	0.00	1.810	1.810
A27	0.55	0.00	24.79	0.00	0.00	2.700	2.700
A28	0.55	0.00	26.68	0.00	0.00	7.090	7.090
A29	0.55	0.00	25.18	0.00	0.00	3.340	3.340
A21A	0.55	0.00	26.41	0.00	0.00	6.230	6.230
A32	0.55	0.00	25.13	0.00	0.00	3.260	3.260
A33	0.55	0.00	26.41	0.00	0.00	6.250	6.250
A34	0.55	0.00	24.98	0.00	0.00	3.000	3.000
A35	0.55	0.00	24.34	0.00	0.00	2.080	2.080
A36	0.55	0.00	25.75	0.00	0.00	4.500	4.500
A38	0.55	0.00	25.14	0.00	0.00	3.270	3.270
A39	0.55	0.00	24.34	0.00	0.00	2.090	2.090
A40	0.55	0.00	25.60	0.00	0.00	4.170	4.170
A41	0.55	0.00	25.69	0.00	0.00	4.370	4.370
A42	0.55	0.00	24.78	0.00	0.00	2.690	2.690
A43	0.55	0.00	24.41	0.00	0.00	2.170	2.170
A44	0.55	0.00	25.42	0.00	0.00	3.790	3.790
A45	0.55	0.00	25.64	0.00	0.00	4.270	4.270
A46	0.55	0.00	26.13	0.00	0.00	5.440	5.440
A47	0.55	0.00	26.09	0.00	0.00	5.330	5.330
A48	0.55	0.00	25.33	0.00	0.00	3.630	3.630
A49	0.55	0.00	24.91	0.00	0.00	2.890	2.890
A21B	0.55	0.00	24.54	0.00	0.00	2.340	2.340
A50	0.55	0.00	25.32	0.00	0.00	3.600	3.600
A51	0.55	0.00	25.07	0.00	0.00	3.140	3.140
A52	0.55	0.00	26.17	0.00	0.00	5.560	5.560
A53	0.55	0.00	25.95	0.00	0.00	4.990	4.990
A54	0.55	0.00	24.54	0.00	0.00	2.340	2.340
A55	0.55	0.00	25.58	0.00	0.00	4.130	4.130
A56	0.55	0.00	24.61	0.00	0.00	2.440	2.440
A57	0.55	0.00	26.41	0.00	0.00	6.230	6.230
A58	0.55	0.00	26.42	0.00	0.00	6.270	6.270
H10	0.55	0.00	25.38	0.00	0.00	5.470	5.470
H12	0.55	0.00	25.17	0.00	0.00	5.490	5.490
H14	0.55	0.00	24.49	0.00	0.00	5.570	5.570
H15	0.55	0.00	24.41	0.00	0.00	5.580	5.580
H16	0.55	0.00	25.33	0.00	0.00	5.480	5.480
H17	0.55	0.00	25.31	0.00	0.00	5.480	5.480
H18	0.55	0.00	26.26	0.00	0.00	5.370	5.370
H19	0.55	0.00	26.10	0.00	0.00	5.390	5.390
H23	0.55	0.00	25.52	0.00	0.00	5.450	5.450
H24	0.55	0.00	24.75	0.00	0.00	5.540	5.540
H27	0.55	0.00	24.76	0.00	0.00	5.540	5.540
H28	0.55	0.00	25.66	0.00	0.00	5.400	5.400
H29	0.55	0.00	25.10	0.00	0.00	5.500	5.500
H3	0.55	0.00	25.39	0.00	0.00	5.470	5.470
H30	0.55	0.00	24.87	0.00	0.00	5.530	5.530
H31	0.55	0.00	25.49	0.00	0.00	5.460	5.460
H32	0.55	0.00	25.02	0.00	0.00	5.510	5.510
H33	0.55	0.00	24.46	0.00	0.00	5.570	5.570
H34	0.55	0.00	24.32	0.00	0.00	5.590	5.590
H35	0.55	0.00	24.13	0.00	0.00	5.610	5.610
H6	0.55	0.00	24.43	0.00	0.00	5.580	5.580
H8	0.55	0.00	24.40	0.00	0.00	5.580	5.580
H9	0.55	0.00	25.31	0.00	0.00	5.480	5.480
I1	0.55	0.00	24.36	0.00	0.00	5.590	5.590
I100A	0.55	0.00	23.75	0.00	0.00	5.660	5.660
I13	0.55	0.00	25.01	0.00	0.00	5.510	5.510
I14	0.55	0.00	23.06	0.00	0.00	5.750	5.750
I100B	0.55	0.00	23.75	0.00	0.00	5.660	5.660
I31	0.55	0.00	23.51	0.00	0.00	5.690	5.690
B36B	0.55	0.00	27.05	0.00	0.00	5.290	5.290
A62B	0.55	0.00	24.21	0.00	0.00	1.930	1.930
A5A	0.55	0.00	26.29	0.00	0.00	5.880	5.880
A5B	0.55	0.00	24.45	0.00	0.00	2.220	2.220
A60	0.55	0.00	25.26	0.00	0.00	3.490	3.490
A61	0.55	0.00	25.89	0.00	0.00	4.820	4.820
A62A	0.55	0.00	24.21	0.00	0.00	1.930	1.930
A64	0.55	0.00	25.72	0.00	0.00	4.430	4.430
A65	0.55	0.00	25.72	0.00	0.00	4.430	4.430
A65.1	0.55	0.00	24.27	0.00	0.00	5.600	5.600
A66	0.55	0.00	24.86	0.00	0.00	5.530	5.530
B24	0.55	0.00	24.91	0.00	0.00	5.520	5.520
B36A	0.55	0.00	27.05	0.00	0.00	5.290	5.290
I18	0.55	0.00	22.56	0.00	0.00	5.810	5.810
I19	0.55	0.00	22.94	0.00	0.00	5.760	5.760
I25	0.55	0.00	23.62	0.00	0.00	5.680	5.680
I29	0.55	0.00	26.20	0.00	0.00	5.380	5.380
I30	0.55	0.00	26.10	0.00	0.00	5.390	5.390
I32	0.55	0.00	23.80	0.00	0.00	5.650	5.650
I4	0.55	0.00	27.35	0.00	0.00	5.260	5.260
Z7	0.55	0.00	24.89	0.00	0.00	5.520	5.520
Z8	0.55	0.00	25.81	0.00	0.00	5.420	5.420

Sag Inlets Configuration Data.

Inlet ID	Inlet Type	Length/ Perim (ft)	Grate Area (sf)	Left-Slope Longi (%)	Left-Slope Transv (%)	Right-Slope Longi (%)	Right-Slope Transv (%)	Gutter n	Gutter DeprW (ft)	Head Allowed (ft)
A35	Curb	5.00	0.00	0.90	2.00	0.10	2.00	0.014	1.50	0.50
A36	Curb	5.00	0.00	0.40	2.00	0.60	2.00	0.014	1.50	0.50
A38	Curb	5.00	0.00	2.30	2.00	0.30	2.00	0.014	1.50	0.50
A39	Curb	5.00	0.00	1.90	2.00	0.20	2.00	0.014	1.50	0.50
A40	Curb	5.00	0.00	0.50	2.00	2.40	2.00	0.014	1.50	0.50
A41	Curb	5.00	0.00	0.40	2.00	0.90	2.00	0.014	1.50	0.50
A42	Curb	5.00	0.00	0.50	2.00	0.60	2.00	0.014	1.50	0.50
A43	Curb	5.00	0.00	1.70	2.00	0.10	2.00	0.014	1.50	0.50
A44	Curb	5.00	0.00	1.40	2.00	0.10	2.00	0.014	1.50	0.50
A45	Curb	5.00	0.00	0.50	2.00	0.20	2.00	0.014	1.50	0.50
A46	Curb	5.00	0.00	1.60	2.00	0.30	2.00	0.014	1.50	0.50
A47	Curb	5.00	0.00	2.40	2.00	0.30	2.00	0.014	1.50	0.50
A48	Curb	5.00	0.00	0.90	2.00	0.40	2.00	0.014	1.50	0.50
A49	Curb	5.00	0.00	1.80	2.00	1.10	2.00	0.014	1.50	0.50
A50	Curb	5.00	0.00	1.90	2.00	2.20	2.00	0.014	1.50	0.50
A51	Curb	5.00	0.00	2.90	2.00	1.40	2.00	0.014	1.50	0.50
A52	Curb	5.00	0.00	0.50	2.00	1.50	2.00	0.014	1.50	0.50
A53	Curb	5.00	0.00	0.60	2.00	1.80	2.00	0.014	1.50	0.50
A54	Curb	5.00	0.00	0.70	2.00	1.70	2.00	0.014	1.50	0.50
A55	Curb	5.00	0.00	0.70	2.00	1.60	2.00	0.014	1.50	0.50
A56	Curb	10.00	0.00	0.30	2.00	0.20	2.00	0.014	3.00	0.50
A57	Curb	10.00	0.00	1.60	2.00	0.30	2.00	0.014	3.00	0.50
A60	Curb	5.00	0.00	0.30	2.00	0.70	2.00	0.014	1.50	0.50
A5A	Curb	5.00	0.00	0.50	2.00	0.60	2.00	0.014	1.50	0.50
A58	Curb	10.00	0.00	1.90	2.00	0.40	2.00	0.014	3.00	0.50
A61	Curb	5.00	0.00	0.10	2.00	1.00	2.00	0.014	1.50	0.50
A62A	Curb	5.00	0.00	3.00	2.00	0.50	2.00	0.014	1.50	0.50
A64	Curb	5.00	0.00	1.10	2.00	3.50	2.00	0.014	1.50	0.50
A65	Curb	5.00	0.00	1.20	2.00	3.50	2.00	0.014	1.50	0.50
A65.1	Curb	5.00	0.00	1.70	2.00	0.50	2.00	0.014	1.50	0.50
A66	Curb	5.00	0.00	0.70	2.00	1.60	2.00	0.014	1.50	0.50
B24	Curb	5.00	0.00	0.70	2.00	0.30	2.00	0.014	1.50	0.50
B36A	Curb	5.00	0.00	0.70	2.00	1.60	2.00	0.014	1.50	0.50
H10	Curb	5.00	0.00	1.10	2.00	1.70	2.00	0.014	1.50	0.50
H12	Curb	5.00	0.00	0.50	2.00	0.20	2.00	0.014	1.50	0.50
H14	Curb	5.00	0.00	0.80	2.00	1.30	2.00	0.014	1.50	0.50
H15	Curb	5.00	0.00	1.30	2.00	1.30	2.00	0.014	1.50	0.50
H16	Curb	5.00	0.00	0.90	2.00	0.10	2.00	0.014	1.50	0.50
H17	Curb	5.00	0.00	0.90	2.00	0.80	2.00	0.014	1.50	0.50
H18	Curb	5.00	0.00	1.30	2.00	0.60	2.00	0.014	1.50	0.50
H19	Curb	5.00	0.00	1.00	2.00	0.40	2.00	0.014	1.50	0.50
H23	Curb	5.00	0.00	0.30	2.00	1.50	2.00	0.014	1.50	0.50
H24	Curb	5.00	0.00	0.30	2.00	2.00	2.00	0.014	1.50	0.50

H27	0.55	0.00	24.76	0.00	0.00	5.540	5.540			
H28	0.55	0.00	25.66	0.00	0.00	5.400	5.400			
H29	0.55	0.00	25.10	0.00	0.00	5.500	5.500			
H3	0.55	0.00	25.39	0.00	0.00	5.470	5.470			
H30	0.55	0.00	24.87	0.00	0.00	5.530	5.530			
H31	0.55	0.00	25.49	0.00	0.00	5.460	5.460			
H32	0.55	0.00	25.02	0.00	0.00	5.510	5.510			
H33	0.55	0.00	24.46	0.00	0.00	5.570	5.570			
H34	0.55	0.00	24.32	0.00	0.00	5.590	5.590			
H35	0.55	0.00	24.13	0.00	0.00	5.610	5.610			
H6	0.55	0.00	24.43	0.00	0.00	5.580	5.580			
H8	0.55	0.00	24.40	0.00	0.00	5.580	5.580			
H9	0.55	0.00	25.31	0.00	0.00	5.480	5.480			
I1	0.55	0.00	24.36	0.00	0.00	5.590	5.590			
I100A	0.55	0.00	23.75	0.00	0.00	5.660	5.660			
I13	0.55	0.00	25.01	0.00	0.00	5.510	5.510			
I14	0.55	0.00	23.06	0.00	0.00	5.750	5.750			
I100B	0.55	0.00	23.75	0.00	0.00	5.660	5.660			
I31	0.55	0.00	23.51	0.00	0.00	5.690	5.690			
B36B	0.55	0.00	27.05	0.00	0.00	5.290	5.290			
A62B	0.55	0.00	24.21	0.00	0.00	1.930	1.930			
A5A	0.55	0.00	26.29	0.00	0.00	5.880	5.880			
A5B	0.55	0.00	24.45	0.00	0.00	2.220	2.220			
A60	0.55	0.00	25.26	0.00	0.00	3.490	3.490			
A61	0.55	0.00	25.89	0.00	0.00	4.820	4.820			
A62A	0.55	0.00	24.21	0.00	0.00	1.930	1.930			
A64	0.55	0.00	25.72	0.00	0.00	4.430	4.430			
A65	0.55	0.00	25.72	0.00	0.00	4.430	4.430			
A65.1	0.55	0.00	24.27	0.00	0.00	5.600	5.600			
A66	0.55	0.00	24.86	0.00	0.00	5.530	5.530			
B24	0.55	0.00	24.91	0.00	0.00	5.520	5.520			
B36A	0.55	0.00	27.05	0.00	0.00	5.290	5.290			
I18	0.55	0.00	22.56	0.00	0.00	5.810	5.810			
I19	0.55	0.00	22.94	0.00	0.00	5.760	5.760			
I25	0.55	0.00	23.62	0.00	0.00	5.680	5.680			
I29	0.55	0.00	26.20	0.00	0.00	5.380	5.380			
I30	0.55	0.00	26.10	0.00	0.00	5.390	5.390			
I32	0.55	0.00	23.80	0.00	0.00	5.650	5.650			
I4	0.55	0.00	27.35	0.00	0.00	5.260	5.260			
Z7	0.55	0.00	24.89	0.00	0.00	5.520	5.520			
Z8	0.55	0.00	25.81	0.00	0.00	5.420	5.420			

Sag Inlets Configuration Data.

Inlet ID	Inlet Type	Length/ Perim (ft)	Grate Area (sf)	Left-Slope Longi (%)	Left-Slope Transv (%)	Right-Slope Longi (%)	Right-Slope Transv (%)	Gutter n	Gutter DeprW (ft)	Head Allowed (ft)
A35	Curb	5.00	0.00	0.90	2.00	0.10	2.00	0.014	1.50	0.50
A36	Curb	5.00	0.00	0.40	2.00	0.60	2.00	0.014	1.50	0.50
A38	Curb	5.00	0.00	2.30	2.00	0.30	2.00	0.014	1.50	0.50
A39	Curb	5.00	0.00	1.90	2.00	0.20	2.00	0.014	1.50	0.50
A40	Curb	5.00	0.00	0.50	2.00	2.40	2.00	0.014	1.50	0.50
A41	Curb	5.00	0.00	0.40	2.00	0.90	2.00	0.014	1.50	0.50
A42	Curb	5.00	0.00	0.50	2.00	0.60	2.00	0.014	1.50	0.50
A43	Curb	5.00	0.00	1.70	2.00	0.10	2.00	0.014	1.50	0.50
A44	Curb	5.00	0.00	1.40	2.00	0.10	2.00	0.014	1.50	0.50
A45	Curb	5.00	0.00	0.50	2.00	0.20	2.00	0.014	1.50	0.50
A46	Curb	5.00	0.00	1.60	2.00	0.30	2.00	0.014	1.50	0.50
A47	Curb	5.00	0.00	2.40	2.00	0.30	2.00	0.014	1.50	0.50
A48	Curb	5.00	0.00	0.90	2.00	0.40	2.00	0.014	1.50	0.50
A49	Curb	5.00	0.00	1.80	2.00	1.10	2.00	0.014	1.50	0.50
A50	Curb	5.00	0.00	1.90	2.00	2.20	2.00	0.014	1.50	0.50
A51	Curb	5.00	0.00	2.90	2.00	1.40	2.00	0.014	1.50	0.50
A52	Curb	5.00	0.00	0.50	2.00	1.50	2.00	0.014	1.50	0.50
A53	Curb	5.00	0.00	0.60	2.00	1.80	2.00	0.014	1.50	0.50
A54	Curb	5.00	0.00	0.70	2.00	1.70	2.00	0.014	1.50	0.50
A55	Curb	5.00	0.00	0.70	2.00	1.60	2.00	0.014	1.50	0.50
A56	Curb	10.00	0.00	0.30	2.00	0.20	2.00	0.014	3.00	0.50
A57	Curb	10.00	0.00	1.60	2.00	0.30	2.00	0.014	3.00	0.50
A60	Curb	5.00	0.00	0.30	2.00	0.70	2.00	0.014	1.50	0.50
A5A	Curb	5.00	0.00	0.50	2.00	0.60	2.00	0.014	1.50	0.50
A58	Curb	10.00	0.00	1.90	2.00	0.40	2.00	0.014	3.00	0.50
A61	Curb	5.00	0.00	0.10	2.00	1.00	2.00	0.014	1.50	0.50
A62A	Curb	5.00	0.00	3.00	2.00	0.50	2.00	0.014	1.50	0.50
A64	Curb	5.00	0.00	1.10	2.00	3.50	2.00	0.014	1.50	0.50
A65	Curb	5.00	0.00	1.20	2.00	3.50	2.00	0.014	1.50	0.50
A65.1	Curb	5.00	0.00	1.70	2.00	0.50	2.00	0.014	1.50	0.50

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY
ENGINEERING DEPARTMENT

LJA Engineering, Inc.
3600 W Sam Houston Pkwy S, Suite 600
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FIRM REGISTRATION No. F-1386
www.LJAengineering.com

STATE OF TEXAS
ISAAC MUÑIZ
125839
LICENSED
PROFESSIONAL ENGINEER
3/2/2022

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: HYDRAULIC CALCULATIONS SHEET 2 OF 7

DRAWN BY: DATE: 3/2/2022
DESIGN BY: SCALE: SHEET NO: 18 OF 200

\190A\2102\ACAD\SHEET FILES\609\18 HYDRAULIC CALCULATIONS SHEET 2 OF 7.dwg

A66	Curb	5.00	n/a	n/a	5.530	6.261	0.460	10.75	9.20
B24	Curb	5.00	n/a	n/a	5.520	6.261	0.460	10.70	12.55
B36A	Curb	5.00	n/a	n/a	5.290	6.261	0.447	10.55	9.05
H10	Curb	5.00	n/a	n/a	5.470	6.261	0.457	9.80	9.05
H12	Curb	5.00	n/a	n/a	5.490	6.261	0.458	11.40	13.55
H14	Curb	5.00	n/a	n/a	5.570	6.261	0.462	10.50	9.60
H15	Curb	5.00	n/a	n/a	5.580	6.261	0.463	9.60	9.60
H16	Curb	5.00	n/a	n/a	5.480	6.261	0.457	10.20	15.40
H17	Curb	5.00	n/a	n/a	5.480	6.261	0.457	10.20	10.45
H18	Curb	5.00	n/a	n/a	5.370	6.261	0.451	9.45	10.95
H19	Curb	5.00	n/a	n/a	5.390	6.261	0.452	9.95	11.80
H23	Curb	5.00	n/a	n/a	5.450	6.261	0.456	12.50	9.25
H24	Curb	5.00	n/a	n/a	5.540	6.261	0.461	12.60	8.80
H27	Curb	5.00	n/a	n/a	5.540	6.261	0.461	12.60	11.45
H28	Curb	5.00	n/a	n/a	5.400	6.261	0.453	8.90	10.95
H29	Curb	5.00	n/a	n/a	5.500	6.261	0.459	8.95	11.40
H3	Curb	5.00	n/a	n/a	5.470	6.261	0.457	11.85	11.40
H30	Curb	5.00	n/a	n/a	5.530	6.261	0.460	8.40	9.00
H31	Curb	5.00	n/a	n/a	5.460	6.261	0.456	9.05	8.85
H32	Curb	5.00	n/a	n/a	5.510	6.261	0.459	10.70	12.55
H33	Curb	5.00	n/a	n/a	5.570	6.261	0.462	9.60	8.45
H34	Curb	5.00	n/a	n/a	5.590	6.261	0.464	15.50	9.45
H35	Curb	5.00	n/a	n/a	5.610	6.261	0.465	10.30	12.00
H6	Curb	5.00	n/a	n/a	5.580	6.261	0.463	10.50	8.70
H8	Curb	5.00	n/a	n/a	5.580	6.261	0.463	9.75	9.75
H9	Curb	5.00	n/a	n/a	5.480	6.261	0.457	12.55	10.45
I1	Curb	5.00	n/a	n/a	5.590	6.261	0.464	8.75	12.65
I100A	Curb	5.00	n/a	n/a	5.660	6.261	0.467	11.15	10.10
I13	Curb	5.00	n/a	n/a	5.510	6.261	0.459	9.00	15.45
I14	Curb	5.00	n/a	n/a	5.750	6.261	0.472	10.00	11.60
I18	Curb	5.00	n/a	n/a	5.810	6.261	0.476	12.15	9.90
I19	Curb	5.00	n/a	n/a	5.760	6.261	0.473	9.55	10.90
I25	Curb	5.00	n/a	n/a	5.680	6.261	0.469	13.70	12.70
I29	Curb	5.00	n/a	n/a	5.380	6.261	0.452	10.35	8.55
I30	Curb	5.00	n/a	n/a	5.390	6.261	0.452	10.95	8.80
I32	Curb	5.00	n/a	n/a	5.650	6.261	0.467	12.00	12.00
I4	Curb	5.00	n/a	n/a	5.260	6.261	0.445	9.65	11.20
Z7	Curb	5.00	n/a	n/a	5.520	6.261	0.460	10.70	9.10
Z8	Curb	5.00	n/a	n/a	5.420	6.261	0.454	10.15	8.85
I100B	Curb	5.00	n/a	n/a	5.660	6.261	0.467	11.15	10.10
I31	Curb	5.00	n/a	n/a	5.690	6.261	0.469	13.70	15.65
B36B	Curb	5.00	n/a	n/a	5.290	6.261	0.447	10.55	9.05
A10	Curb	5.00	n/a	n/a	4.790	6.261	0.418	12.85	11.30
A13	Curb	5.00	n/a	n/a	3.850	6.261	0.362	9.65	9.65
A15	Curb	5.00	n/a	n/a	3.100	6.261	0.313	9.65	7.15
A17	Curb	5.00	n/a	n/a	3.440	6.261	0.335	7.70	7.70
A26	Curb	5.00	n/a	n/a	1.810	6.261	0.219	5.90	7.50
A27	Curb	5.00	n/a	n/a	2.700	6.261	0.285	10.35	8.75
A28	Curb	10.00	n/a	n/a	7.090	12.523	0.342	13.80	11.80
A29	Curb	10.00	n/a	n/a	3.340	12.523	0.207	8.65	8.65
A32	Curb	10.00	n/a	n/a	3.260	12.523	0.204	6.90	8.40
A33	Curb	10.00	n/a	n/a	6.250	12.523	0.315	8.90	10.30
A34	Curb	10.00	n/a	n/a	3.000	12.523	0.193	8.80	10.80
A62B	Curb	5.00	n/a	n/a	1.930	6.261	0.228	5.50	7.25
A21B	Curb	5.00	n/a	n/a	2.340	6.261	0.259	9.85	9.10
A5B	Curb	5.00	n/a	n/a	2.220	6.261	0.250	8.95	9.65
A21A	Curb	5.00	n/a	n/a	6.230	6.261	0.498	14.20	11.95

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error, and this length should not be used as Pay Item.

LINKS:

Type of Convey Structure	Material	Rise (ft)	Span (ft)	Number of Links of this type	Quantity (ft)

NODES:

Type of Inlet Structure	Type of Grate Inlet	Grate Length (ft)	Grate Width (ft)	Grate Length (ft)	Grate Area (ft)	Grate Perimeter (ft)	Quantity (each)
Curb In Sag		5.0	0.0	0.0	0.0	0.0	79
Curb In Sag		10.0	0.0	0.0	0.0	0.0	8
Outlet		0.0	0.0	0.0	0.0	0.0	1

END

NORMAL TERMINATION OF HOUSTORM.

Warning Messages for current project:
Computed left ponded width exceeds allowable width at inlet Id= A61
Computed right ponded width exceeds allowable width at inlet Id= H12
Computed right ponded width exceeds allowable width at inlet Id= H16
Computed left ponded width exceeds allowable width at inlet Id= H34
Computed right ponded width exceeds allowable width at inlet Id= I13
Computed left ponded width exceeds allowable width at inlet Id= I25
Computed right ponded width exceeds allowable width at inlet Id= I31
Computed left ponded width exceeds allowable width at inlet Id= I31
Computed left ponded width exceeds allowable width at inlet Id= A28
Computed left ponded width exceeds allowable width at inlet Id= A21A

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY
ENGINEERING DEPARTMENT

LJA Engineering, Inc.
3600 W Sam Houston Pkwy S, Suite 600
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FIRM REGISTRATION No. F-1386
www.LJAengineering.com

STATE OF TEXAS
ISAAC MUÑIZ
125839
LICENSED
PROFESSIONAL ENGINEER
3/2/2022

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **HYDRAULIC CALCULATIONS SHEET 3 OF 7**

DRAWN BY: | DATE: 3/2/2022

DESIGN BY: | SCALE: | SHEET NO: 19 OF 200

\\190\A\2102\ACAD\SHEET FILES\60%\19 HYDRAULIC CALCULATIONS SHEET 3 OF 7.dwg

Upstream Node Name (Model)	Downstream Node Name (Model)	Number of Barrels	Diameter or Rise	Span	Length	Conduit Slope	Upstream Invert level	Downstream Invert level	Hydraulic Gradeline Elevation	Hydraulic Gradeline Elevation	Max velocity	Max flow
			(ft)	(ft)	(ft)	(%)	(ft)	(ft)	(ft)	(ft)	(ft/s)	(cfs)
A4	A5	1	5	6	637.00	0.07	117.71	117.26	119.02	118.80	2.29	16.55
A5	A6	1	5	6	652.80	0.07	117.26	116.81	118.80	118.20	3.27	30.10
A6	A7	1	5	6	139.90	0.07	116.81	116.71	118.20	118.06	3.81	29.13
A7	A8	1	5	6	76.70	0.04	116.71	116.68	118.06	117.97	4.33	28.63
A8	A9	1	5	6	54.50	0.04	113.87	113.85	117.95	117.94	2.97	61.58
A9	A10	1	5	6	527.80	0.10	113.85	113.32	117.92	117.78	3.44	70.28
A10	A11	1	5	6	300.60	0.10	113.32	113.02	117.74	117.58	4.21	98.50
A11	A12	1	5	6	308.40	0.11	113.02	112.69	117.52	117.30	4.74	115.10
A12	A13	1	5	6	674.90	0.10	112.69	112.00	117.21	116.46	5.41	135.82
A13	A14	1	5	6	184.00	0.09	112.00	111.84	116.29	115.80	7.17	183.60
A23	A8	1	5	6	307.10	0.09	114.15	113.87	117.97	117.97	1.32	22.90
A35	A13	1	5	6	68.30	0.07	121.28	121.23	122.81	122.59	5.72	52.36
A36	A37	1	5	6	77.40	0.13	120.55	120.45	121.53	121.42	2.99	17.51
A37	A38	1	5	6	199.00	0.12	120.45	120.22	121.42	121.12	3.00	17.47
A38	A12	1	5	6	66.30	0.08	120.22	120.17	121.12	120.93	3.87	20.91
A41	A42	1	5	6	79.00	0.08	122.11	122.05	123.32	123.30	1.47	10.66
A42	A43	1	5	6	244.40	0.12	122.05	121.75	123.30	122.96	3.53	26.50
A43	A10	1	5	6	67.60	0.10	121.75	121.68	122.96	122.75	4.95	35.84
A24	A25	1	5	6	145.90	0.08	116.94	116.83	118.05	118.01	2.87	17.45
A25	A26	1	5	6	94.50	0.09	116.83	116.75	118.01	117.98	3.14	17.08
A26	A8	1	5	6	68.90	0.10	116.75	116.68	117.98	117.97	3.55	17.01
A34	A35	1	5	6	233.20	0.10	121.52	121.28	123.31	122.81	4.84	52.06
A58	A11	1	5	6	64.30	6.17	125.97	122.00	126.61	122.64	5.54	21.13
B37	Z1	1	5	6	153.10	0.09	121.74	121.60	123.48	123.40	2.80	29.19
Z1	A34	1	5	6	169.30	0.04	121.60	121.54	123.40	123.31	2.68	29.01
B24	B37	1	5	6	24.90	0.44	121.80	121.69	123.49	123.48	2.29	23.27
Z4	Z3	1	5	6	234.10	0.10	121.00	120.76	121.79	121.63	1.99	9.34
Z3	A36	1	5	6	216.70	0.10	120.76	120.55	121.63	121.53	1.76	9.22
Z5	Z4	1	5	6	46.50	0.09	121.04	121.00	121.82	121.79	2.00	9.37
Z7	Z5	1	5	6	75.90	0.11	121.12	121.04	121.88	121.82	2.06	9.42
A14	A63	1	5	6	19.2	1.772	111.84	111.5	115.593	115.52	9.046	203.7057
A63	Basin_Node	1	5	6	238.00	0.21	111.50	111.00	115.29	114.43	9.17	208.52
Basin_Node	FlapGate	1	3.5	0	165.00	0.16	109.09	108.83	112.59	112.28	4.47	43.30
A29	A30	1	5	6	109.20	0.08	122.56	122.47	123.58	123.52	2.37	13.60
A30	A31	1	5	6	146.70	0.09	122.47	122.34	123.52	123.45	2.31	13.45
A31	A33	1	5	6	216.20	0.04	122.26	122.18	123.45	123.37	1.93	13.20
A33	A34	1	5	6	65.10	0.09	122.08	122.02	123.37	123.31	3.09	23.24
H1	H2	1	4	0	96.50	0.25	121.92	121.68	124.46	124.46	2.48	10.26
H2	H3	1	4	0	127.70	0.20	121.68	121.42	124.46	124.46	1.81	9.49
H3	H4	1	4	0	110.20	0.06	121.42	121.35	124.44	124.39	4.30	30.64
H4	H5	1	4	0	122.70	0.47	121.35	120.78	124.37	124.31	4.56	29.80
H5	H6	1	4	0	50.80	0.24	120.78	120.66	124.28	124.26	3.32	30.25
H6	H7	1	4	0	53.90	0.28	120.66	120.51	124.23	124.20	3.74	34.95
H7	H8	1	4	0	40.50	0.22	120.51	120.42	124.15	124.11	4.27	46.70
H8	H9	1	4	0	453.50	0.25	120.42	119.28	124.04	123.51	4.58	50.03
H9	H10	1	4	0	334.70	0.25	119.28	118.43	123.43	123.03	4.04	51.06
H10	H11	1	4	0	64.20	0.30	118.43	118.24	122.83	122.68	5.42	70.53
H11	H12	1	4	0	135.20	0.26	118.24	117.89	122.48	122.15	5.47	70.63
H12	H13	1	4	0	60.00	0.15	117.89	117.80	121.98	121.82	5.53	70.64
H25	H26	1	4	0	331.00	0.10	121.14	120.82	124.24	124.23	1.07	6.80
H26	H7	1	4	0	300.00	0.10	120.82	120.51	124.23	124.20	1.42	11.47
H19	H20	1	4	0	102.00	0.10	121.88	121.78	124.51	124.51	2.38	13.03
H20	H21	1	4	0	109.10	0.10	121.78	121.67	124.51	124.50	2.09	12.12
H21	H22	1	4	0	98.40	0.06	121.67	121.61	124.50	124.49	1.76	11.18
H22	H24	1	4	0	110.40	0.05	121.61	121.55	124.49	124.48	1.56	11.51
H24	H3	1	4	0	50.80	0.26	121.55	121.42	124.47	124.46	3.03	20.79
I1	I2	1	5	0	228.20	0.07	114.88	114.72	118.61	118.60	1.42	21.52
I2	I3	1	5	0	191.40	0.20	114.72	114.34	118.60	118.59	1.30	21.03
I3	I4	1	5	0	90.30	0.18	114.34	114.18	118.58	118.58	1.19	21.12
I4	I5	1	5	0	211.00	0.11	114.18	113.95	118.57	118.53	1.76	32.15
I5	I6	1	5	0	152.00	0.20	113.95	113.64	118.50	118.41	3.35	62.41
I6	I7	1	5	0	83.00	0.19	113.64	113.48	118.36	118.30	3.64	69.82

Upstream Node Name (Model)	Downstream Node Name (Model)	Number of Barrels	Diameter or Rise	Span	Length	Conduit Slope	Upstream Invert level	Downstream Invert level	Hydraulic Gradeline Elevation	Hydraulic Gradeline Elevation	Max velocity	Max flow
			(ft)	(ft)	(ft)	(%)	(ft)	(ft)	(ft)	(ft)	(ft/s)	(cfs)
I7	I8	1	5	0	155.50	0.20	113.48	113.17	118.24	118.10	3.99	76.93
I8	I9	1	5	0	56.50	0.21	113.17	113.05	118.03	117.99	3.95	77.05
I9	I10	1	5	0	89.00	0.19	113.05	112.88	117.91	117.83	4.03	78.66
I10	I11	1	5	0	108.00	0.20	112.88	112.66	117.75	117.65	4.22	82.50
I11	I12	1	5	0	54.00	0.30	112.66	112.50	117.57	117.51	4.21	82.52
I20	I22	1	5	0	262.50	0.20	115.98	115.46	118.57	118.56	0.02	0.17
I22	I26	1	5	0	322.80	0.20	115.46	114.81	118.56	118.55	0.35	3.93
I26	I5	1	5	0	431.30	0.20	114.81	113.95	118.55	118.53	1.08	15.87
T1	T3	1	3	0	140.30	0.10	115.53	115.39	120.02	119.61	4.87	36.09
T3	T4	1	3	0	53.60	0.13	115.39	115.32	119.35	119.19	4.90	36.09
T4	T13	1	3	0	230.20	0.10	115.32	115.10	118.96	118.27	4.91	36.10
T13	TOUT	1	3	0	30.80	0.10	115.03	115.00	118.12	118.02	5.01	36.12
T8	T14	1	3	0	197.50	0.10	116.37	116.17	119.37	119.34	1.24	8.80
T14	T15	1	3	0	94.50	0.11	116.17	116.07	119.33	119.31	1.23	8.85
T15	T10	1	3	0	133.10	0.19	116.07	115.82	119.30	119.28	1.24	9.00
T10	T11	1	3	0	67.00	0.08	115.82	115.77	119.27	119.26	1.25	9.14
T7	T8	1	3	0	24.50	0.12	116.40	116.37	119.38	119.38	0.12	0.81
T6	T9	1	3	0	29.90	0.10	116.45	116.42	119.39	119.39	0.40	2.74
T9	T8	1	3	0	59.60	0.08	116.42	116.37	119.39	119.38	1.13	8.00
T12	T11	1	3	0	23.90	0.13	115.80	115.77	119.26	119.26	1.19	8.72
T11	T16	1	3	0	173.70	0.09	115.77	115.61	119.17	118.87	3.71	27.24
T16	KOUT	1	3	0	100.80	0.10	115.60	115.50	118.76	118.52	4.39	31.84
L8	L9	1	3	0	184.20	0.10	117.75	117.56	120.89	120.64	3.38	24.48
L9	LOUT	1	3	0	51.60	0.10	117.55	117.50	120.58	120.51	3.42	24.48
L4	L3	1	3	0	18.10	0.11	118.09	118.07	121.28	121.27	1.78	12.94
L1	L4	1	3	0	48.90	0.12	118.15	118.09	121.30	121.29	0.88	6.40
L3	L5	1	3	0	164.00	0.11	118.07	117.89	121.24	121.15	2.22	16.11
L5	L7	1	3	0	56.60	0.11	117.89	117.83	121.12	121.08	2.21	16.13
L6	L7	1	3	0	24.60	0.12	117.86	117.83	121.08	121.08	0.45	3.24
L7	L8	1	3	0	71.80	0.11	117.83	117.75	121.03	120.96	2.93	21.33
A3	A4	1	2	0	69.80	0.10	125.17	125.10	125.83	125.63	2.57	2.32
A16	A15	1	2	0	90.20	0.19	117.52	117.35	118.94	118.55	4.69	11.18
A17	A16	1	2	0	82.40	0.16	117.65	117.52	119.25	118.99	4.17	11.20
A22	A23	1	2	0	26.60	0.19	126.95	126.90	127.31	127.21	2.09	0.79
A15	A14	1	5	6	116.50	2.58	117.35	114.35	118.06	115.78	5.19	21.94
A32	A33	1	2	0	24.30	0.91	125.84	125.62	126.58	126.36	5.94	6.32
H27	H1	1	2	0	47.30	0.74	127.95	127.60	128.59	128.24	4.85	4.18
A45	A24	1	2	0	42.70	0.12	119.95	119.90	120.91	120.75	3.83	5.69
A46	A47	1	2	0	21.20	0.14	119.95	119.92	121.37	121.36	2.04	4.87
A47	A24	1	2	0	35.90	0.06	119.92	119.90	121.31	121.14	5.05	11.80
H28	H29	1	2	0	24.10	0.13	128.12	128.09	128.86	128.77	3.49	3.70
H29	H1	1	2	0	33.10	1.48	128.09	127.60	128.77	128.28	6.55	6.16
A48	A49	1	2	0	25.80	0.43	129.23	129.12	129.81	129.70	3.56	2.70
A49	A4	1	2	0	27.30	14.73	129.12	125.10	129.55	125.53	14.00	6.87
A50	A51	1	2	0	27.80	0.29	128.80	128.72	129.56	129.45	3.87	4.23
A51	A4	1	2	0	66.00	5.48	128.72	125.10	129.27	125.65	10.65	7.40
A55	A42	1	2	0	46.10	1.00	126.96	126.50	128.09	127.63	7.43	13.59
A54	A55	1	2	0	25.30	1.35	127.30	126.96	128.22	128.13	4.65	6.28
A57	A58	1	2	0	24.70	0.36	127.57	127.48	128.70	128.57	5.11	9.30
I30	I1	1	2	0	89.20	3.32	125.54	122.58	126.50	123.54	12.13	18.06
B35	B36	1	2	0	23.40	0.26	124.69	124.63	127.40	127.32	3.84	12.58
B36	B24	1	2	0	54.60	0.24	124.63	124.50	126.86	126.22	7.15	23.28
T2	T1	1	3	0	22.20	0.27	115.59	115.53	120.28	120.26	2.29	16.97
K1	K2	1	2	0	24.00	0.21	116.34	116.29	118.84	118.82	2.05	6.72
K2	K3	1	2	0	191.00	0.09	116.29	116.11	118.70	118.07	3.89	12.70
K3	FOUT	1	2	0	67.20	0.51	116.11	115.77	118.00	117.78	4.13	12.70
Z8	Z7	1	2	0	23.00	0.22	128.35	128.30	128.96	128.87	3.28	2.67
L2	L3	1	3	0	21.70	0.14	118.10	118.07	121.27	121.27	0.40	2.87
A21	A5	1	2	0	34.30	0.32	129.20	129.09	130.28	130.12	4.82	8.33
H14	H6	1	2	0	22.70	17.60	129.60	125.61	129.93	125.94	10.75	3.60

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY
ENGINEERING DEPARTMENT

HARRIS COUNTY 1836 TEXAS

LJA Engineering, Inc.
3600 W Sam Houston Pkwy S, Suite 600
Houston, TX 77042
Phone: 713.953.5200 Fax: 713.953.5026
FIRM REGISTRATION No. F-1386
www.LJAengineering.com

STATE OF TEXAS
HEATHER W. GOODPASTURE
126705
LICENSED PROFESSIONAL ENGINEER
05/02/2022

Gauge ENGINEERING
3200 Wilcrest Drive, Suite 220
Houston, TX 77042
Phone: 832.318.8800
FIRM REGISTRATION No. F-20017
www.GaugeEngineering.com

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **HYDRAULIC CALCULATIONS (2-YEAR EVENT) SHEET 4 OF 7**

DRAWN BY:

DATE: **3/2/2022**

DESIGN BY:

SCALE:

SHEET NO: **20 OF 200**

Upstream Node Name (Model)	Downstream Node Name (Model)	Number of Barrels	Diameter or Rise	Span	Length	Conduit Slope	Upstream Invert level	Downstream Invert level	Hydraulic Gradeline Elevation	Hydraulic Gradeline Elevation	Max velocity	Max flow
			(ft)	(ft)	(ft)	(%)	(ft)	(ft)	(ft)	(ft)	(ft/s)	(cfs)
H15	H8	1	2	0	24.10	2.03	126.95	126.46	127.20	126.71	1.51	0.33
H16	H9	1	2	0	29.70	0.40	125.55	125.43	125.74	125.61	1.42	0.22
H17	H10	1	2	0	23.90	1.38	121.16	120.83	123.04	123.02	2.89	7.21
I13	I1	1	2	0	23.40	1.71	126.53	126.13	126.93	126.53	4.28	1.90
I14	I6	1	2.833333333	0	40.60	0.42	121.01	120.84	121.89	121.72	4.58	7.69
I15	I6	1	2	0	48.60	3.69	121.21	119.42	121.41	119.62	0.06	0.01
I16	I7	1	2	0	42.60	3.43	121.86	120.40	122.46	121.00	9.38	7.43
I18	I9	1	2	0	40.30	2.93	119.68	118.50	120.03	118.85	4.71	1.71
I19	I10	1	2	0	42.80	2.52	121.23	120.15	121.71	120.63	6.54	3.74
I17	I10	1	3	0	44.00	2.96	120.24	118.94	120.56	119.26	0.83	0.34
A27	A26	1	2	0	33.60	0.21	127.50	127.43	127.61	127.54	0.12	0.01
A39	A38	1	2	0	32.00	1.16	129.09	128.72	129.29	128.92	0.09	0.02
A40	A41	1	2	0	23.60	0.26	125.79	125.73	126.43	126.34	3.43	2.97
A44	A43	1	2	0	21.50	-0.88	127.98	128.17	128.92	128.88	2.60	3.78
H23	H24	1	2	0	25.50	1.92	128.62	128.13	129.20	128.71	6.85	5.23
I23	I22	1	2	0	39.70	0.76	123.44	123.14	123.56	123.26	0.58	0.04
I24	I22	1	2	0	33.00	3.46	123.92	122.78	124.13	122.99	0.49	0.09
I25	I26	1	2	0	52.00	0.19	123.96	123.86	124.76	124.58	3.50	4.13
A52	A53	1	2	0	31.70	0.19	128.82	128.76	129.97	129.97	1.37	2.57
A53	A9	1	2	0	27.20	0.18	128.76	128.71	129.95	129.82	4.94	9.58
A56	A11	1	3	0	21.40	1.54	128.83	128.50	129.13	128.80	0.12	0.04
I29	I30	1	2	0	25.00	2.72	126.22	125.54	126.89	126.51	7.84	7.26
H31	H25	1	2	0	50.30	1.11	128.41	127.85	129.17	128.61	6.27	6.83
H30	H31	1	2	0	31.40	0.48	128.59	128.44	129.52	129.37	4.76	6.80
H32	H26	1	2	0	33.30	2.97	128.23	127.24	128.68	127.69	6.69	3.49
H34	H26	1	2	0	27.20	1.84	128.00	127.50	128.50	128.00	5.77	3.55
H33	H34	1	2	0	22.50	0.40	128.09	128.00	128.56	128.50	2.67	1.52
A59	A10	1	2	0	17.40	0.35	124.76	124.70	124.99	124.91	1.64	0.33
H35	H25	1	2	0	11.30	4.23	128.33	127.85	128.54	128.06	0.25	0.04
A60	A36	1	3	0	23.30	2.49	128.58	128.00	129.07	128.49	5.37	4.09
I32	I5	1	2	0	89.20	1.57	122.90	121.50	124.01	122.61	8.95	16.03
I31	I5	1	2	0	82.60	2.71	122.85	120.61	123.26	121.02	5.68	2.65
I33	I34	1	2	0	30.80	0.26	126.47	126.39	126.60	126.55	0.46	0.04
I34	I35	1	2	0	25.00	0.36	126.39	126.30	126.55	126.51	0.86	0.11
I35	I20	1	2	0	42.40	3.00	126.30	125.03	126.51	125.24	0.59	0.11
A61	A35	1	2	0	36.00	1.06	127.39	127.01	127.68	127.30	1.97	0.54
A62	A63	1	2	0	28.60	0.04	123.03	123.02	123.97	123.85	3.85	5.56
A65	A15	1	2	0	63.20	3.12	121.64	119.67	122.37	120.40	10.31	10.75
A64	A65	1	2	0	28.40	1.76	122.14	121.64	122.99	122.49	8.40	10.75
A65.1	A66	1	2	0	30.20	0.53	128.06	127.90	128.47	128.31	3.04	1.39
A66	A12	1	2	0	13.00	2.55	127.33	127.00	127.79	127.46	6.35	3.42
I38	I26	1	2	0	72.20	0.68	122.16	121.67	122.61	122.12	3.82	2.03
A1	A2	1	2	0	324.90	0.22	129.20	128.50	129.85	129.08	2.65	2.34
A2	A3	1	2	0	161.20	0.33	128.50	127.97	129.08	128.51	3.10	2.32
B1	B2	1	2	0	284.10	-0.03	127.32	127.40	129.48	129.36	1.53	4.67
B2	B3	1	2.25	0	235.00	0.43	127.40	126.40	129.32	128.83	5.18	14.20
B3	B4	1	2.25	0	100.00	0.26	126.33	126.07	128.76	128.55	3.66	14.07
J1	J2	1	2	0	176.40	0.39	125.87	125.19	126.65	125.94	3.96	4.52
J2	J3	1	2	0	260.00	0.38	123.24	122.26	124.03	123.01	3.91	4.52
J3	J4	1	2	0	189.50	0.15	119.69	119.40	121.96	121.63	3.23	9.39
J4	J5	1	2	0	57.10	0.86	119.38	118.89	121.28	120.62	7.72	23.78
J5	J6	1	2.5	0	153.90	0.63	118.64	117.67	120.24	119.27	7.20	23.92
J6	J7	1	2.5	0	60.00	4.95	116.47	113.50	117.41	116.02	14.19	23.91
A19	A1	1	2	0	30.50	0.20	129.26	129.20	129.85	129.85	0.09	0.07
A20	A1	1	2	0	34.90	0.20	129.27	129.20	129.92	129.85	2.58	2.28
B13	B4	1	2	0	28.20	1.77	127.63	127.13	128.54	128.53	0.15	0.05
B4	B5A	1	2.25	0	82.30	0.02	125.96	125.94	128.44	128.19	3.98	16.41
J8	J3	1	2	0	31.70	0.16	123.25	123.20	124.10	123.98	3.78	4.80
J9	J4	1	2	0	31.80	0.19	119.57	119.51	121.68	121.63	3.49	9.36
B18	B19	1	2	0	156.80	0.06	127.80	127.71	129.51	129.51	-0.03	0.05
B19	B1	1	2	0	22.10	1.18	127.71	127.45	129.50	129.49	2.49	4.43

Upstream Node Name (Model)	Downstream Node Name (Model)	Number of Barrels	Diameter or Rise	Span	Length	Conduit Slope	Upstream Invert level	Downstream Invert level	Hydraulic Gradeline Elevation	Hydraulic Gradeline Elevation	Max velocity	Max flow
			(ft)	(ft)	(ft)	(%)	(ft)	(ft)	(ft)	(ft)	(ft/s)	(cfs)
B20	B19	1	2	0	23.30	0.86	128.06	127.86	129.51	129.51	2.89	2.66
B21	B22	1	2	0	25.00	0.12	127.28	127.25	129.79	129.78	1.44	4.70
B22	B23	1	2	0	57.60	-0.04	127.10	127.12	129.69	129.58	3.11	10.20
B23	B2	1	2	0	69.90	-0.24	127.23	127.40	129.50	129.37	3.28	10.17
B25	B26	1	2	0	99.70	0.20	124.25	124.05	125.47	125.47	-0.01	-0.01
B29	B30	1	2	0	58.10	0.21	126.57	126.45	126.71	126.58	0.62	0.06
B30	B31	1	2	0	75.20	0.21	126.40	126.24	126.55	126.48	0.58	0.06
B34	B29	1	2	0	38.70	0.03	126.79	126.78	126.93	126.90	0.34	0.03
B38	B39	1	2	0	29.30	0.79	127.98	127.75	129.49	129.49	0.14	0.05
B39	B1	1	2	0	65.20	0.11	127.54	127.47	129.49	129.49	0.11	0.28
J11	J1	1	2	0	28.40	0.28	126.01	125.93	126.79	126.68	3.92	4.47
J10	J11	1	2	0	28.50	0.21	126.07	126.01	126.79	126.79	0.19	0.19
J12	J1	1	2	0	49.00	0.37	126.05	125.87	126.66	126.66	0.13	0.06
I37	I27	1	2	0	26.10	0.12	123.12	123.09	124.33	124.26	3.47	6.87
I36	I37	1	2	0	30.30	0.23	123.62	123.55	124.34	124.34	0.25	0.05
B6	B7	1	2.5	0	182.20	0.13	125.35	125.11	127.37	126.79	4.65	19.72
B7	B8	1	2.5	0	150.00	0.33	125.08	124.59	126.74	126.10	5.71	19.75
B8	B9	1	3	0	160.00	0.09	124.03	123.89	125.78	125.31	4.58	19.59
B9	B10	1	3	0	172.70	0.32	123.79	123.23	125.30	124.66	5.52	19.58
B10	B11	1	3	0	214.60	0.47	118.60	117.60	119.99	118.99	6.17	19.69
B11	B12	1	3	0	129.90	4.47	112.70	106.89	113.61	109.90	14.00	25.25
B5A	B5B	1	2.25	0	82.50	0.01	125.94	125.93	128.11	127.83	4.17	16.41
B14	B5B	1	2	0	33.30	3.27	128.55	127.46	128.89	127.82	4.96	1.79
B5B	B6	1	2.25	0	67.70	0.41	125.72	125.44	127.73	127.44	5.34	19.74
B15	B8	1	2	0	49.70	21.38	127.52	116.90	127.74	125.79	0.68	0.13
B16	B11	1	2	0	45.80	1.46	123.26	122.59	123.58	122.91	2.97	0.95
B17	B11	1	2	0	36.50	1.67	123.27	122.66	123.86	123.25	6.42	4.91
B26	B28	1	2	0	156.90	-0.94	124.05	125.53	125.47	125.71	-0.07	-0.13
B28	B8	1	2	0	63.00	0.38	125.56	125.32	125.78	125.79	-1.27	-0.24
B31	B32	1	2	0	77.10	0.19	126.34	126.19	126.48	126.32	0.62	0.06
B32	B10	1	2	0	68.20	0.46	126.11	125.80	126.28	125.96	1.22	0.15
B33	B32	1	2	0	37.10	3.04	127.94	126.81	128.15	127.02	0.31	0.05
B27	B28	1	2	0	37.20	0.94	127.52	127.17	127.63	127.28	0.46	0.03
I27	I28	1	2	0	202.60	0.15	123.05	122.75	124.25	123.68	3.48	6.87
I28	I26	1	2	0	60.70	1.37	122.50	121.67	123.22	122.39	6.72	6.87
B42	B7	1	2	0	56.30	0.76	127.16	126.73	127.29	126.86	0.84	0.07
B41	B42	1	2	0	21.70	0.09	127.18	127.16	127.33	127.29	0.57	0.06
B40	B42	1	2	0	27.40	0.11	128.28	128.25	128.39	128.36	0.17	0.01
B44	B10	1	2	0	65.60	0.84	125.41	124.86	125.53	124.98	0.67	0.05
B43	B44	1	2	0	29.60	1.25	126.45	126.08	126.66	126.29	0.28	0.05
I100	I20	1	2	0	43.70	0.80	126.85	126.50	126.97	126.62	0.58	0.04
I15	I7	1	2	0	51.60	2.35	121.21	120.00	121.41	120.20	0.05	0.01
A28	A29	1	2	0	26.00	0.31	125.07	124.99	125.41	125.31	2.27	0.82
H18	H19	1	2	0	26.30	0.23	128.40	128.34	128.59	128.50	1.08	0.16

NOTES:
1. The Hydraulic Data shown was developed for the Ravensway Subdivision Improvements Drainage Impact Analysis, dated February 8, 2022.

2. The purpose of the Ravensway Subdivision Improvements Drainage Impact Analysis was to size the trunklines, detention volume, and ensure that the proposed project causes no downstream impacts. While the proposed pipe geometry follows the general design concept, pipe elevations and slopes may vary from the proposed design.

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY
ENGINEERING DEPARTMENT

HARRIS COUNTY 1836 TEXAS

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STATE OF TEXAS
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05/02/2022

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PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **HYDRAULIC CALCULATIONS (2-YEAR EVENT) SHEET 5 OF 7**

DRAWN BY:
DATE: **3/2/2022**
DESIGN BY:
SCALE:
SHEET NO: **21 OF 200**

J:\190A\2102\ACAD\SHEET FILES\605\21 HYDRAULIC CALCULATIONS (2-YEAR EVENT) SHEET 5 OF 7.dwg

Upstream Node Name (Model)	Downstream Node Name (Model)	Number of Barrels	Diameter or Rise	Span	Length	Conduit Slope	Upstream Invert level	Downstream Invert level	Hydraulic Gradeline Elevation	Hydraulic Gradeline Elevation	Max velocity	Max flow
			(ft)	(ft)	(ft)	(%)	(ft)	(ft)	(ft)	(ft)	(ft/s)	(cfs)
A4	A5	1	5	6	637.00	0.07	117.71	117.26	127.16	127.19	2.86	38.19
A5	A6	1	5	6	652.80	0.07	117.26	116.81	127.16	126.55	4.14	62.61
A6	A7	1	5	6	139.90	0.07	116.81	116.71	126.53	126.39	3.87	64.84
A7	A8	1	5	6	76.70	0.04	116.71	116.68	126.37	126.30	4.16	66.13
A8	A9	1	5	6	54.50	0.04	113.87	113.85	126.19	126.09	4.57	145.80
A9	A10	1	5	6	527.80	0.10	113.85	113.32	125.94	125.50	5.08	162.01
A10	A11	1	5	6	300.60	0.10	113.32	113.02	125.27	124.65	5.99	190.79
A11	A12	1	5	6	308.40	0.11	113.02	112.69	124.32	123.71	7.11	226.00
A12	A13	1	5	6	674.90	0.10	112.69	112.00	123.39	121.40	6.93	219.63
A13	A14	1	5	6	184.00	0.09	112.00	111.84	120.57	120.27	9.57	301.14
A23	A8	1	5	6	307.10	0.09	114.15	113.87	126.47	126.30	1.72	54.15
A35	A13	1	5	6	68.30	0.07	121.28	121.23	123.49	123.25	7.24	95.99
A36	A37	1	5	6	77.40	0.13	120.55	120.45	123.84	123.85	3.78	36.94
A37	A38	1	5	6	199.00	0.12	120.45	120.22	123.85	123.73	3.87	40.45
A38	A12	1	5	6	66.30	0.08	120.22	120.17	123.72	123.67	5.41	51.27
A41	A42	1	5	6	79.00	0.08	122.11	122.05	125.59	125.55	1.84	18.05
A42	A43	1	5	6	244.40	0.12	122.05	121.75	125.55	125.56	4.62	46.40
A43	A10	1	5	6	67.60	0.10	121.75	121.68	125.55	125.49	6.16	67.10
A24	A25	1	5	6	145.90	0.08	116.94	116.83	126.83	126.53	3.44	38.17
A25	A26	1	5	6	94.50	0.09	116.83	116.75	126.52	126.34	3.54	40.72
A26	A8	1	5	6	68.90	0.10	116.75	116.68	126.32	126.30	3.85	41.56
A34	A35	1	5	6	233.20	0.10	121.52	121.28	124.09	123.49	6.16	94.81
A58	A11	1	5	6	64.30	6.17	125.97	122.00	126.68	124.60	8.37	35.78
B37	Z1	1	5	6	153.10	0.09	121.74	121.60	124.31	124.22	3.66	56.25
Z1	A34	1	5	6	169.30	0.04	121.60	121.54	124.21	124.09	3.58	56.00
B24	B37	1	5	6	24.90	0.44	121.80	121.69	124.32	124.31	2.88	41.75
Z4	Z3	1	5	6	234.10	0.10	121.00	120.76	124.05	123.94	3.43	-26.75
Z3	A36	1	5	6	216.70	0.10	120.76	120.55	123.94	123.84	-3.18	-43.99
Z5	Z4	1	5	6	46.50	0.09	121.04	121.00	124.06	124.05	2.94	-25.32
Z7	Z5	1	5	6	75.90	0.11	121.12	121.04	124.07	124.06	2.85	15.33
A14	A63	1	5	6	19.2	1.772	111.84	111.5	119.807	119.75	10.363	323.689
A63	Basin_Node	1	5	6	238.00	0.21	111.50	111.00	119.25	118.64	10.89	330.94
Basin_Node	FlapGate	1	3.5	0	165.00	0.16	109.09	108.83	117.54	117.50	1.46	15.04
A29	A30	1	5	6	109.20	0.08	122.56	122.47	124.25	124.22	2.66	22.48
A30	A31	1	5	6	146.70	0.09	122.47	122.34	124.22	124.18	2.44	22.22
A31	A33	1	5	6	216.20	0.04	122.26	122.18	124.18	124.13	1.96	21.90
A33	A34	1	5	6	65.10	0.09	122.08	122.02	124.13	124.09	3.22	38.90
H1	H2	1	4	0	96.50	0.25	121.92	121.68	132.23	132.22	2.28	21.95
H2	H3	1	4	0	127.70	0.20	121.68	121.42	132.21	132.20	1.68	22.64
H3	H4	1	4	0	110.20	0.06	121.42	121.35	132.11	131.97	4.59	61.90
H4	H5	1	4	0	122.70	0.47	121.35	120.78	131.87	131.71	4.62	62.22
H5	H6	1	4	0	50.80	0.24	120.78	120.66	131.60	131.54	4.64	62.57
H6	H7	1	4	0	53.90	0.28	120.66	120.51	131.40	131.29	5.18	69.77
H7	H8	1	4	0	40.50	0.22	120.51	120.42	131.04	130.90	6.39	86.07
H8	H9	1	4	0	453.50	0.25	120.42	119.28	130.58	128.68	6.86	92.53
H9	H10	1	4	0	334.70	0.25	119.28	118.43	128.34	126.91	6.98	93.55
H10	H11	1	4	0	64.20	0.30	118.43	118.24	126.17	125.63	9.80	130.33
H11	H12	1	4	0	135.20	0.26	118.24	117.89	124.62	123.48	9.89	130.55
H12	H13	1	4	0	60.00	0.15	117.89	117.80	122.43	121.88	10.01	130.55
H25	H26	1	4	0	331.00	0.10	121.14	120.82	131.38	131.36	0.97	11.27
H26	H7	1	4	0	300.00	0.10	120.82	120.51	131.34	131.27	1.67	21.86
H19	H20	1	4	0	102.00	0.10	121.88	121.78	132.40	132.38	2.22	19.92
H20	H21	1	4	0	109.10	0.10	121.78	121.67	132.37	132.35	1.95	19.89
H21	H22	1	4	0	98.40	0.06	121.67	121.61	132.34	132.32	1.68	19.87
H22	H24	1	4	0	110.40	0.05	121.61	121.55	132.31	132.29	1.55	20.79
H24	H3	1	4	0	50.80	0.26	121.55	121.42	132.24	132.21	3.08	41.71
I1	I2	1	5	0	228.20	0.07	114.88	114.72	123.99	123.95	1.77	36.60
I2	I3	1	5	0	191.40	0.20	114.72	114.34	123.92	123.88	1.77	36.60
I3	I4	1	5	0	90.30	0.18	114.34	114.18	123.85	123.83	1.77	36.69
I4	I5	1	5	0	211.00	0.11	114.18	113.95	123.76	123.66	2.69	55.83
I5	I6	1	5	0	152.00	0.20	113.95	113.64	123.44	123.17	5.18	107.56
I6	I7	1	5	0	83.00	0.19	113.64	113.48	122.90	122.75	5.32	110.39

Upstream Node Name (Model)	Downstream Node Name (Model)	Number of Barrels	Diameter or Rise	Span	Length	Conduit Slope	Upstream Invert level	Downstream Invert level	Hydraulic Gradeline Elevation	Hydraulic Gradeline Elevation	Max velocity	Max flow
			(ft)	(ft)	(ft)	(%)	(ft)	(ft)	(ft)	(ft)	(ft/s)	(cfs)
I7	I8	1	5	0	155.50	0.20	113.48	113.17	122.35	121.94	6.42	132.83
I8	I9	1	5	0	56.50	0.21	113.17	113.05	121.49	121.34	6.43	132.87
I9	I10	1	5	0	89.00	0.19	113.05	112.88	120.85	120.60	6.64	136.74
I10	I11	1	5	0	108.00	0.20	112.88	112.66	120.02	119.69	7.03	144.26
I11	I12	1	5	0	54.00	0.30	112.66	112.50	119.15	118.98	7.05	144.27
I20	I22	1	5	0	262.50	0.20	115.98	115.46	123.71	123.71	-0.08	-1.62
I22	I26	1	5	0	322.80	0.20	115.46	114.81	123.71	123.70	-0.44	-8.95
I26	I5	1	5	0	431.30	0.20	114.81	113.95	123.69	123.66	1.24	25.73
T1	T3	1	3	0	140.30	0.10	115.53	115.39	123.22	122.13	7.66	58.22
T3	T4	1	3	0	53.60	0.13	115.39	115.32	121.70	121.28	7.75	58.21
T4	T13	1	3	0	230.20	0.10	115.32	115.10	120.70	118.91	7.81	58.21
T13	TOUT	1	3	0	30.80	0.10	115.03	115.00	118.32	118.05	7.96	58.22
T8	T14	1	3	0	197.50	0.10	116.37	116.17	121.33	121.24	1.86	13.85
T14	T15	1	3	0	94.50	0.11	116.17	116.07	121.21	121.16	1.86	13.85
T15	T10	1	3	0	133.10	0.19	116.07	115.82	121.13	121.07	1.87	13.94
T10	T11	1	3	0	67.00	0.08	115.82	115.77	121.03	121.00	1.89	14.08
T7	T8	1	3	0	24.50	0.12	116.40	116.37	121.36	121.36	0.18	1.37
T6	T9	1	3	0	29.90	0.10	116.45	116.42	121.42	121.42	0.55	4.07
T9	T8	1	3	0	59.60	0.08	116.42	116.37	121.39	121.37	1.69	12.59
T12	T11	1	3	0	23.90	0.13	115.80	115.77	121.02	121.00	2.18	16.23
T11	T16	1	3	0	173.70	0.09	115.77	115.61	120.65	119.82	6.18	45.93
T16	KOUT	1	3	0	100.80	0.10	115.60	115.50	119.26	118.55	7.40	54.39
L8	L9	1	3	0	184.20	0.10	117.75	117.56	121.77	121.01	5.79	42.71
L9	LOUT	1	3	0	51.60	0.10	117.55	117.50	120.76	120.53	5.87	42.72
L4	L3	1	3	0	18.10	0.11	118.09	118.07	123.30	123.28	2.91	21.68
L1	L4	1	3	0	48.90	0.12	118.15	118.09	123.39	123.38	1.39	10.34
L3	L5	1	3	0	164.00	0.11	118.07	117.89	123.15	122.88	3.60	26.76
L5	L7	1	3	0	56.60	0.11	117.89	117.83	122.74	122.64	3.61	26.78
L6	L7	1	3	0	24.60	0.12	117.86	117.83	122.62	122.62	0.86	6.35
L7	L8	1	3	0	71.80	0.11	117.83	117.75	122.37	122.14	5.06	37.47
A3	A4	1	2	0	69.80	0.10	125.17	125.10	128.03	127.18	3.42	7.51
A16	A15	1	2	0	90.20	0.19	117.52	117.35	121.41	120.25	5.68	18.08
A17	A16	1	2	0	82.40	0.16	117.65	117.52	121.90	121.46	5.51	18.06
A22	A23	1	2	0	26.60	0.19	126.95	126.90	127.88	127.77	4.21	6.05
A15	A14	1	5	6	116.50	2.58	117.35	114.35	120.23	120.21	6.50	33.88
A32	A33	1	2	0	24.30	0.91	125.84	125.62	126.83	126.61	6.75	10.51
H27	H1	1	2	0	47.30	0.74	127.95	127.60	132.26	132.23	5.41	5.93
A45	A24	1	2	0	42.70	0.12	119.95	119.90	127.01	126.84	4.38	10.88
A46	A47	1	2	0	21.20	0.14	119.95	119.92	127.79	127.68	3.35	11.41
A47	A24	1	2	0	35.90	0.06	119.92	119.90	127.44	126.88	7.63	25.86
H28	H29	1	2	0	24.10	0.13	128.12	128.09	132.31	132.31	4.16	9.67
H29	H1	1	2	0	33.10	1.48	128.09	127.60	132.27	132.23	7.90	18.00
A48	A49	1	2	0	25.80	0.43	129.23	129.12	129.94	129.83	4.00	4.02
A49	A4	1	2	0	27.30	14.73	129.12	125.10	129.64	127.18	16.66	10.75
A50	A51	1	2	0	27.80	0.29	128.80	128.72	129.91	129.78	4.88	8.69
A51	A4	1	2	0	66.00	5.48	128.72	125.10	129.47	127.19	13.81	14.74
A55	A42	1	2	0	46.10	1.00	126.96	126.50	128.72	128.21	8.20	23.02
A54	A55	1	2	0	25.30	1.35	127.30	126.96	129.02	128.96	4.71	10.35
A57	A58	1	2	0	24.70	0.36	127.57	127.48	129.12	128.96	6.38	16.68
I30	I1	1	2	0	89.20	3.32	125.54	122.58	126.84	124.07	14.22	30.29
B35	B36	1	2	0	23.40	0.26	124.69	124.63	129.35	129.20	5.71	19.04
B36	B24	1	2	0	54.60	0.24	124.63	124.50	128.25	126.30	12.60	41.77
T2	T1	1	3	0	22.20	0.27	115.59	115.53	123.61	123.58	3.67	27.96
K1	K2	1	2	0	24.00	0.21	116.34	116.29	121.30	121.23	3.49	11.75
K2	K3	1	2	0	191.00	0.09	116.29	116.11	120.95	119.01	6.73	22.59
K3	FOUT	1	2	0	67.20	0.51	116.11	115.77	118.48	117.81	6.92	22.59
Z8	Z7	1	2	0	23.00	0.22	128.35	128.30	129.18	129.08	3.96	4.85
L2	L3	1	3	0	21.70	0.14	118.10	118.07	123.27	123.27	0.54	4.02
A21	A5	1	2	0	34.30	0.32	129.20	129.09	130.62	130.42	5.73	13.62
H14	H6	1	2	0	22.70	17.60	129.60	125.61	131.56	131.52	13.71	6.41

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY
ENGINEERING DEPARTMENT

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www.GaugeEngineering.com

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **HYDRAULIC CALCULATIONS (10-YEAR EVENT) SHEET 6 OF 7**

DRAWN BY:

DATE: 3/2/2022

DESIGN BY:

SCALE:

SHEET NO: 22 OF 200

J:\199A\2102\ACAD\SHEET FILES\605\22 HYDRAULIC CALCULATIONS (10-YEAR EVENT) SHEET 6 OF 7.dwg

Upstream Node Name (Model)	Downstream Node Name (Model)	Number of Barrels	Diameter or Rise	Span	Length	Conduit Slope	Upstream Invert level	Downstream Invert level	Hydraulic Gradeline Elevation	Hydraulic Gradeline Elevation	Max velocity	Max flow
			(ft)	(ft)	(ft)	(%)	(ft)	(ft)	(ft)	(ft)	(ft/s)	(cfs)
H15	H8	1	2	0	24.10	2.03	126.95	126.46	130.86	130.85	3.54	1.26
H16	H9	1	2	0	29.70	0.40	125.55	125.43	128.62	128.62	2.38	0.87
H17	H10	1	2	0	23.90	1.38	121.16	120.83	126.92	126.85	3.49	11.87
I13	I1	1	2	0	23.40	1.71	126.53	126.13	127.01	126.61	5.38	3.08
I14	I6	1	2.83333	0	40.60	0.42	121.01	120.84	123.16	123.13	5.14	13.21
I15	I6	1	2	0	48.60	3.69	121.21	119.42	122.88	122.97	-4.85	-10.33
I16	I7	1	2	0	42.60	3.43	121.86	120.40	122.95	122.72	10.32	12.15
I18	I9	1	2	0	40.30	2.93	119.68	118.50	121.29	121.27	5.59	3.91
I19	I10	1	2	0	42.80	2.52	121.23	120.15	121.84	120.76	8.12	6.55
I17	I10	1	3	0	44.00	2.96	120.24	118.94	120.68	120.51	1.94	1.07
A27	A26	1	2	0	33.60	0.21	127.50	127.43	127.67	127.58	0.91	0.11
A39	A38	1	2	0	32.00	1.16	129.09	128.72	129.30	128.93	0.15	0.02
A40	A41	1	2	0	23.60	0.26	125.79	125.73	126.64	126.54	4.11	5.25
A44	A43	1	2	0	21.50	-0.88	127.98	128.17	129.20	129.14	3.54	7.10
H23	H24	1	2	0	25.50	1.92	128.62	128.13	132.31	132.29	8.23	11.15
I23	I22	1	2	0	39.70	0.76	123.44	123.14	123.71	123.71	1.35	0.15
I24	I22	1	2	0	33.00	3.46	123.92	122.78	124.14	123.71	0.76	0.14
I25	I26	1	2	0	52.00	0.19	123.96	123.86	125.00	124.79	4.18	6.89
A52	A53	1	2	0	31.70	0.19	128.82	128.76	130.46	130.44	2.01	5.52
A53	A9	1	2	0	27.20	0.18	128.76	128.71	130.34	130.16	6.10	16.23
A56	A11	1	3	0	21.40	1.54	128.83	128.50	129.14	128.81	0.19	0.07
I29	I30	1	2	0	25.00	2.72	126.22	125.54	128.85	128.77	8.09	12.49
H31	H25	1	2	0	50.30	1.11	128.41	127.85	131.51	131.40	6.98	10.40
H30	H31	1	2	0	31.40	0.48	128.59	128.44	131.69	131.63	5.37	10.35
H32	H26	1	2	0	33.30	2.97	128.23	127.24	131.38	131.36	7.52	4.92
H34	H26	1	2	0	27.20	1.84	128.00	127.50	131.39	131.36	7.16	6.50
H33	H34	1	2	0	22.50	0.40	128.09	128.00	131.43	131.43	3.14	2.70
A59	A10	1	2	0	17.40	0.35	124.76	124.70	125.62	125.48	2.72	1.46
H35	H25	1	2	0	11.30	4.23	128.33	127.85	131.38	131.38	1.22	0.47
A60	A36	1	3	0	23.30	2.49	128.58	128.00	129.17	128.59	6.71	6.65
I32	I5	1	2	0	89.20	1.57	122.90	121.50	124.82	123.71	9.83	24.62
I31	I5	1	2	0	82.60	2.71	122.85	120.61	123.75	123.66	6.71	4.30
I33	I34	1	2	0	30.80	0.26	126.47	126.39	126.62	126.58	0.63	0.07
I34	I35	1	2	0	25.00	0.36	126.39	126.30	126.58	126.52	1.13	0.17
I35	I20	1	2	0	42.40	3.00	126.30	125.03	126.52	125.25	0.88	0.17
A61	A35	1	2	0	36.00	1.06	127.39	127.01	127.78	127.40	3.30	1.43
A62	A63	1	2	0	28.60	0.04	123.03	123.02	124.18	124.05	4.49	8.39
A65	A15	1	2	0	63.20	3.12	121.64	119.67	122.53	120.56	11.59	15.64
A64	A65	1	2	0	28.40	1.76	122.14	121.64	123.18	122.68	9.43	15.64
A65.1	A66	1	2	0	30.20	0.53	128.06	127.90	128.58	128.42	3.59	2.33
A66	A12	1	2	0	13.00	2.55	127.33	127.00	127.90	127.57	7.66	5.66
I38	I26	1	2	0	72.20	0.68	122.16	121.67	123.73	123.70	4.37	4.51
A1	A2	1	2	0	324.90	0.22	129.20	128.50	130.13	129.33	3.25	4.66
A2	A3	1	2	0	161.20	0.33	128.50	127.97	129.33	128.73	3.77	4.64
B1	B2	1	2	0	284.10	-0.03	127.32	127.40	131.34	130.99	2.45	8.14
B2	B3	1	2.25	0	235.00	0.43	127.40	126.40	130.86	130.31	5.28	16.71
B3	B4	1	2.25	0	100.00	0.26	126.33	126.07	130.17	129.94	4.04	16.74
J1	J2	1	2	0	176.40	0.39	125.87	125.19	126.90	126.33	4.55	7.29
J2	J3	1	2	0	260.00	0.38	123.24	122.26	126.28	126.02	4.35	7.78
J3	J4	1	2	0	189.50	0.15	119.69	119.40	125.91	125.14	4.35	14.81
J4	J5	1	2	0	57.10	0.86	119.38	118.89	124.24	122.32	12.28	41.34
J5	J6	1	2.5	0	153.90	0.63	118.64	117.67	121.44	119.84	8.17	41.57
J6	J7	1	2.5	0	60.00	4.95	116.47	113.50	117.77	116.43	16.06	41.56
A19	A1	1	2	0	30.50	0.20	129.26	129.20	130.13	130.13	0.42	0.55
A20	A1	1	2	0	34.90	0.20	129.27	129.20	130.19	130.13	2.97	4.13
B13	B4	1	2	0	28.20	1.77	127.63	127.13	129.92	129.92	0.14	-0.12
B4	B5A	1	2.25	0	82.30	0.02	125.96	125.94	129.73	129.42	4.56	19.07
J8	J3	1	2	0	31.70	0.16	123.25	123.20	126.05	126.02	4.31	7.17
J9	J4	1	2	0	31.80	0.19	119.57	119.51	125.31	125.14	4.80	16.34
B18	B19	1	2	0	156.80	0.06	127.80	127.71	131.47	131.47	-0.26	-0.84

Upstream Node Name (Model)	Downstream Node Name (Model)	Number of Barrels	Diameter or Rise	Span	Length	Conduit Slope	Upstream Invert level	Downstream Invert level	Hydraulic Gradeline Elevation	Hydraulic Gradeline Elevation	Max velocity	Max flow
			(ft)	(ft)	(ft)	(%)	(ft)	(ft)	(ft)	(ft)	(ft/s)	(cfs)
B19	B1	1	2	0	22.10	1.18	127.71	127.45	131.42	131.39	2.46	8.16
B20	B19	1	2	0	23.30	0.86	128.06	127.86	131.48	131.47	2.85	4.64
B21	B22	1	2	0	25.00	0.12	127.28	127.25	131.21	131.21	1.86	6.11
B22	B23	1	2	0	57.60	-0.04	127.10	127.12	131.17	131.10	4.25	14.11
B23	B2	1	2	0	69.90	-0.24	127.23	127.40	131.06	130.99	4.29	14.12
B25	B26	1	2	0	99.70	0.20	124.25	124.05	126.10	126.10	-0.02	-0.04
B29	B30	1	2	0	58.10	0.21	126.57	126.45	126.73	126.60	0.83	0.10
B30	B31	1	2	0	75.20	0.21	126.40	126.24	126.58	126.51	0.76	0.10
B34	B29	1	2	0	38.70	0.03	126.79	126.78	126.94	126.91	0.47	0.05
B38	B39	1	2	0	29.30	0.79	127.98	127.75	131.38	131.38	-0.16	-0.53
B39	B1	1	2	0	65.20	0.11	127.54	127.47	131.38	131.38	-0.33	-1.09
J11	J1	1	2	0	28.40	0.28	126.01	125.93	127.02	126.90	4.57	7.21
J10	J11	1	2	0	28.50	0.21	126.07	126.01	127.03	127.03	0.38	0.56
J12	J1	1	2	0	49.00	0.37	126.05	125.87	126.90	126.90	0.11	0.08
I37	I27	1	2	0	26.10	0.12	123.12	123.09	124.81	124.73	3.99	11.29
I36	I37	1	2	0	30.30	0.23	123.62	123.55	124.85	124.85	0.18	0.35
B6	B7	1	2.5	0	182.20	0.13	125.35	125.11	127.89	127.12	4.97	24.78
B7	B8	1	2.5	0	150.00	0.33	125.08	124.59	127.01	126.29	6.10	24.85
B8	B9	1	3	0	160.00	0.09	124.03	123.89	126.06	125.56	5.00	25.46
B9	B10	1	3	0	172.70	0.32	123.79	123.23	125.53	124.86	5.98	25.43
B10	B11	1	3	0	214.60	0.47	118.60	117.60	120.23	119.23	6.62	25.72
B11	B12	1	3	0	129.90	4.47	112.70	106.89	117.84	117.42	4.66	34.70
B5A	B5B	1	2.25	0	82.50	0.01	125.94	125.93	129.17	128.85	4.59	19.07
B14	B5B	1	2	0	33.30	3.27	128.55	127.46	129.02	128.82	5.61	2.73
B5B	B6	1	2.25	0	67.70	0.41	125.72	125.44	128.50	128.06	5.99	24.78
B15	B8	1	2	0	49.70	21.38	127.52	116.90	127.77	126.10	2.24	0.50
B16	B11	1	2	0	45.80	1.46	123.26	122.59	123.63	122.96	3.65	1.49
B17	B11	1	2	0	36.50	1.67	123.27	122.66	123.99	123.38	7.45	7.63
B26	B28	1	2	0	156.90	-0.94	124.05	125.53	126.10	126.10	-0.13	-0.35
B28	B8	1	2	0	63.00	0.38	125.56	125.32	126.10	126.10	-2.30	-0.92
B31	B32	1	2	0	77.10	0.19	126.34	126.19	126.51	126.34	0.82	0.10
B32	B10	1	2	0	68.20	0.46	126.11	125.80	126.31	125.99	1.49	0.23
B33	B32	1	2	0	37.10	3.04	127.94	126.81	128.15	127.02	0.44	0.08
B27	B28	1	2	0	37.20	0.94	127.52	127.17	127.64	127.29	0.68	0.05
I27	I28	1	2	0	202.60	0.15	123.05	122.75	124.68	123.96	4.13	11.29
I28	I26	1	2	0	60.70	1.37	122.50	121.67	123.91	123.71	7.74	11.28
B42	B7	1	2	0	56.30	0.76	127.16	126.73	127.30	127.10	1.09	0.10
B41	B42	1	2	0	21.70	0.09	127.18	127.16	127.34	127.30	0.71	0.08
B40	B42	1	2	0	27.40	0.11	128.28	128.25	128.40	128.36	0.26	0.02
B44	B10	1	2	0	65.60	0.84	125.41	124.86	125.54	124.99	0.93	0.08
B43	B44	1	2	0	29.60	1.25	126.45	126.08	126.67	126.30	0.42	0.08
I100	I20	1	2	0	43.70	0.80	126.85	126.50	126.98	126.63	0.83	0.07
I15	I7	1	2	0	51.60	2.35	121.21	120.00	122.84	122.72	5.01	10.35
A28	A29	1	2	0	26.00	0.31	125.07	124.99	125.62	125.51	3.15	2.21
H18	H19	1	2	0	26.30	0.23	128.40	128.34	132.41	132.41	1.48	0.65

NOTES:

1. The Hydraulic Data shown was developed for the Ravensway Subdivision Improvements Drainage Impact Analysis, dated February 8, 2022.

2. The purpose of the Ravensway Subdivision Improvements Drainage Impact Analysis was to size the trunklines, detention volume, and ensure that the proposed project causes no downstream impacts. While the proposed pipe geometry follows the general design concept, pipe elevations and slopes may vary from the proposed design.

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY
ENGINEERING DEPARTMENT

HARRIS COUNTY 1836 TEXAS

LJA Engineering, Inc.
3600 W Sam Houston Pkwy S, Suite 600
Houston, TX 77042
Phone 713.953.5200 Fax: 713.953.5026
FIRM REGISTRATION No. F-1386
www.LJAengineering.com

STATE OF TEXAS
HEATHER W. GOODPASTURE
126705
LICENSED PROFESSIONAL ENGINEER
03/02/2022

Gauge ENGINEERING
3200 Wilcrest Drive, Suite 220
Houston, TX 77042
Phone: 832.318.8800
FIRM REGISTRATION No. F-20017
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PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018

SHEET DESCRIPTION: **HYDRAULIC CALCULATIONS (10-YEAR EVENT) SHEET 7 OF 7**

DRAWN BY:

DATE: **3/2/2022**

DESIGN BY:

SCALE:

SHEET NO: **23 OF 200**

J:\190A\2102\ACAD\SHEET FILES\605\23 HYDRAULIC CALCULATIONS (10-YEAR EVENT) SHEET 7 OF 7.dwg

Exhibit 9
Preliminary Construction Cost Estimate

CONSTRUCTION COST ESTIMATE

Project:	**Ravensway Subdivision Drainage Improvements**
Limit From:	**East Huffman Road, West of Timberlake Drive**
Limit To:	**North of Cypress North Houston Road**
Proj Length:	**XXXX'**
Precinct:	**Three**
UPIN:	**19103MF14601**
Job No:	**This is the number avaiable when advertising project**
Prepared By:	**LJA Engineering**
Date:	**02/25/22**

Summary of Estimate		
Stage:		**Proposal**
Total Amount for Roadway:		**$14,691,541.25**
Total Amount for XXXX:		**$0.00**
Total Amount for XXXX:		**$0.00**
Total Amount for XXXX:		**$0.00**
Grant Total Amount:		**$14,691,541.25**
Contingencies:	**0%**	**$0.00**
Grand Total Project:		**$14,691,541.25**

	ITEM NO.	SPEC NO.	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
	A	**SITE PREPARATION AND EARTHWORK**					
	1	DWG	PROJECT SIGN	EA	2	$1,000.00	$2,000.00
	2	501	TREE PROTECTION FENCING	EA	9	$250.00	$2,250.00
	3	102	CLEARING AND GRUBBING (TREE REMOVAL, HAUL & DISPOSAL)	EA	25	$1,500.00	$37,500.00
	4	104	REMOVING OLD CONCRETE (SLOPE PAVING)	SY	52	$10.00	$520.00
	5	104	REMOVING OLD CONCRETE (PAVEMENT) WITH CURB	SY	26,756	$10.00	$267,560.00
	6	465	REMOVE AND DISPOSE OF EXISTING CONCRETE OR METAL PIPE (ALL SIZES)	LF	4472	$10.00	$44,720.00
	7	495	REMOVE AND HAUL AWAY EXISTING INLET	EA	98	$600.00	$58,800.00
	8	495	RELOCATION OF WATER METER	EA	23	$10.00	$230.00
	9	500	REMOVE AND RELOCATE TRAFFIC SIGNS, MAIL BOXES, AND ROADWAY SIGNS	EA	50	$250.00	$12,500.00
	10	104	REMOVE, AND HAUL AWAY EXISTING CONCRETE SIDEWALK	SY	1,589	$10.00	$15,890.00
	11	554	REMOVE AND REPLACE WOOD FENCE	LF	77	$13.00	$1,001.00
	12	COH 02222	PLUG AND ABANDON STORM SEWER (ALL SIZES)	EA	31	$250.00	$7,750.00
	13	COH 02221	DISPOSING OF 6" WATERLINE	LF	130	$10.00	$1,300.00
	14	104	REMOVE AND HAUL AWAY EXISTING CONCRETE DRIVEWAY	SY	862	$10.00	$8,620.00
1						**Subtotal of Item A**	**$460,641.00**
	B	**PAVING**					
	15	530	TYPE 7 ADA RAMP	EA	30	$1,750.00	$52,500.00
	16	530	TYPE 12 ADA RAMP	EA	20	$2,000.00	$40,000.00
	17	530	ADA RAMP - COMMERCIAL RAMP AS PER DRAWINGS	EA	1	$2,500.00	$2,500.00
	18	530	PROPOSED HIGH EARLY STRENGTH CONCRETE PAVEMENT (6") - DRIVEWAY	SY	928	$100.00	$92,800.00
	19	360	PROPOSED CONCRETE PAVEMENT (7") - ROADWAY	SY	18,472	$70.00	$1,293,040.00
	20	530	CONCRETE CURB (6")	LF	8,516	$5.00	$42,580.00
	21	530	PROPOSED CONCRETE SIDEWALK (4.5")	SY	1,589	$60.00	$95,340.00
	22	433	CEMENT STABILIZED SAND (6")	SY	18,286	$20.00	$365,720.00
2						**Subtotal of Item B**	**$1,984,480.00**
	C	**STORM SEWER**					
	23	429	TRENCH SAFETY SYSTEMS (0'-5')	LF	2,773	$2.00	$5,546.00
	24	429	TRENCH SAFETY SYSTEMS (5' - 10')	LF	4,547	$3.00	$13,641.00
	25	429	TRENCH SAFETY SYSTEMS (10' - 15')	LF	2,721	$4.00	$10,884.00
	26	429	TRENCH SAFETY SYSTEMS (GREATER THAN 20')')	LF	4,071	$5.00	$20,355.00
	27	HCFCD 2464	TIMBER BENTS	EA	2	$2,500.00	$5,000.00
	28	480	REINFORCED CONCRETE BOX CULVERT (PRECAST) (6 FT X 5 FT)	LF	6678	$700.00	$4,674,600.00
	29	480	REINFORCED CONCRETE PIPE, C76, CLASS III, (24") (0' TO 5' OF COVER)	EA	2,271	$100.00	$227,100.00
	30	480	REINFORCED CONCRETE PIPE, C76, CLASS III, (24") (5' TO 10' OF COVER)	EA	92	$125.00	$11,500.00
	31	480	REINFORCED CONCRETE PIPE, C76, CLASS III, (36") (0' TO 5' OF COVER)	EA	44	$150.00	$6,600.00
	32	480	REINFORCED CONCRETE PIPE, C76, CLASS III, (48") (5' TO 10' OF COVER)	EA	2,561	$250.00	$640,250.00
	33	480	REINFORCED CONCRETE PIPE, C76, CLASS III, (60") (5' TO 10' OF COVER)	EA	756	$300.00	$226,800.00
	34	480	REINFORCED CONCRETE PIPE, C76, CLASS III, (60") (10' TO 15' OF COVER)	EA	1,710	$325.00	$555,750.00
	35	471	PRECAST CONCRETE STANDARD MANHOLE (DEPTH < 5 FT) ON RCB	EA	26	$2,500.00	$65,000.00
	36	471	PRECAST CONCRETE STANDARD MANHOLE (10 FT ≤ DEPTH ≤ 15 FT) ON RCB	EA	9	$3,000.00	$27,000.00
	37	471	STANDARD PRECAST CONCRETE MANHOLE (DEPTH < 5') (TYPE C)	EA	10	$4,000.00	$40,000.00

CONSTRUCTION COST ESTIMATE

Project:	**Ravensway Subdivision Drainage Improvements**
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Limit To:	**North of Cypress North Houston Road**
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Grant Total Amount:		**$14,691,541.25**
Contingencies:	**0%**	**$0.00**
Grand Total Project:		**$14,691,541.25**

	ITEM NO.	SPEC NO.	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
	38	471	STANDARD PRECAST CONCRETE MANHOLE (5' < DEPTH < 10') (TYPE C)	EA	8	$4,500.00	$36,000.00
	39	471	STANDARD PRECAST CONCRETE MANHOLE (10' < DEPTH < 15') (TYPE C)	EA	34	$6,000.00	$204,000.00
	40	471	STANDARD PRECAST CONCRETE MANHOLE (15' < DEPTH < 20') (TYPE C)	EA	4	$6,500.00	$26,000.00
	41	471	PRECAST CONCRETE STANDARD JUNCTION BOX	EA	7	$30,000.00	$210,000.00
	42	471	PRECAST CONCRETE STANDARD JUNCTION BOX (15 FT ≤ DEPTH ≤ 20 FT)	EA	3	$30,000.00	$90,000.00
	43	472	INLET (PRECAST) (TYPE BB, STANDARD DEPTH)	EA	85	$3,500.00	$297,500.00
	44	480	PRECAST CONCRETE PLUG 6'X5'	EA	10	$1,500.00	$15,000.00
	45	491	REINFORCED CONCRETE SLOPE PAVING (5")	SY	379	$65.00	$24,635.00
3						**Subtotal of Item C**	**$7,433,161.00**
	D	**DETENTION POND**					
	46	HCFCD 02315	DETENTION BASIN EXCAVATION	CY	242,559.35	$15.00	$3,638,390.25
	47	HCFCD 02925	HYDROMULCH	AC	12.79	$5,000.00	$63,950.00
	48	HCFCD 02315	BACKSLOPE SWALES	LF	8,386.00	$10.00	$83,860.00
	49	HCFCD 02233	CLEARING AND GRUBBING	AC	13.00	$10,000.00	$130,000.00
	50	HCFCD 02376	URBAN BACKSLOPE INTERCEPTOR	EA	5.00	$4,000.00	$20,000.00
	51	HCFCD 02378	RIPRAP (GRADATION NO. 1)	SY	70.00	$85.00	$5,950.00
	52	HCFCD 02378	ALL WEATHER ACCESS ROAD (6" GRAVEL OR CRUSHED CONCRETE)	SY	4,734.00	$20.00	$94,680.00
	53	HCFCD 02378	3" TO 5" GRANULAR FILL	SY	4,734.00	$30.00	$142,020.00
	54	HCFCD 02376	5" CONCRETE SLAB FOR EXTREME EVENT OVERFLOW	SY	1,145.00	$65.00	$74,425.00
	55		FLOATABLE COLLECTION CONCRETE STRUCTURE AND GRATES	EA	1.00	$30,000.00	$30,000.00
	56	HCFCD 02377	REINFORCED CONCRETE PILOT CHANNEL (5")	SY	882.00	$65.00	$57,330.00
	57	HCFCD 02315	5" CLAY LINER	CY	3,074.00	$30.00	$92,220.00
	58	N/A	42" INLINE CHECK VALVE	EA	1.00	$10,000.00	$10,000.00
4						**Subtotal of Item D**	**$4,442,825.25**
	E	**TRAFFIC CONTROL PLAN**					
	59	671	TRAFFIC CONTROL - BARRICADES,BARRIERS, BARRELS, CONES AND SIGNING	MO	12.00	$5,000.00	$60,000.00
	60	671	TEMPORARY RESIDENTIAL DRIVEWAYS - FURNISH-INSTALL & REMOVE	EA	46.00	$250.00	$11,500.00
	61	696	TRAFFIC CONTROL - INSTALL LOW PROFILE CONCRETE BARRIERS	LF	2,320.00	$20.00	$46,400.00
	62	696	TRAFFIC CONTROL - REMOVE LOW PROFILE CONCRETE BARRIERS	LF	2,320.00	$20.00	$46,400.00
	63	696	TRAFFIC CONTROL - RELOCATE LOW PROFILE CONCRETE BARRIERS	LF	2,320.00	$20.00	$46,400.00
5						**Subtotal of Item E**	**$210,700.00**
	F	**STORM WATER POLLUTION PREVENTION PLAN**					
	66	700	TPDES GENERAL PERMIT NO. TXR150000; NOTICE OF INTENT (NOI) APPLICATION FEES WITH FIXED RATE $225.00/EA	EA	2.00	$225.00	$450.00
	67	730	CONCRETE TRUCK WASHOUT STRUCTURES (60% OF UNIT COST FOR FURNISH AND INSTALLATION AND 40% OF UNIT COST FOR REMOVAL)	LS	1.00	$1,500.00	$1,500.00
	68	751	SWPPP INSPECTION AND MAINTENANCE (MIN. BID $6000/MO)	MO	12.00	$4,000.00	$48,000.00
	69	713	REINFORCED FILTER FABRIC BARRIER (60% OF UNIT COST FOR FURNISH AND INSTALLATION AND 40% OF UNIT COST FOR REMOVAL)	LF	2,351.00	$4.00	$9,404.00
	70	724	STABILIZED CONSTRUCTION ACCESS (TYPE 1-ROCK; 60% OF UNIT COST FOR FURNISH AND INSTALLATION, AND 40% OF UNIT COST FOR REMOVAL))	EA	1.00	$1,000.00	$1,000.00
	71	741	INLET PROTECTION BARRIER (FOR STAGE II INLETS, GRAVEL BAGS; 60% OF UNIT COST FOR FURNISH AND INSTALLATION, AND 40% OF UNIT COST FOR REMOVAL)	EA	57.00	$100.00	$5,700.00
	72	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	57.00	$100.00	$5,700.00
	73	750	ROCK FILTER DAM (TYPE 1; 60% OF UNIT COST FOR FURNISH AND INSTALLATION, AND 40% OF UNIT COST FOR REMOVAL)	LF	318.00	$85.00	$27,030.00
8						**Subtotal of Item F**	**$98,784.00**

CONSTRUCTION COST ESTIMATE

Project:	**Ravensway Subdivision Drainage Improvements**
Limit From:	**East Huffman Road, West of Timberlake Drive**
Limit To:	**North of Cypress North Houston Road**
Proj Length:	**XXXX'**
Precinct:	**Three**
UPIN:	**19103MF14601**
Job No:	**This is the number avaiable when advertising project**
Prepared By:	**LJA Engineering**
Date:	**02/25/22**

Summary of Estimate		
Stage:		**Proposal**
Total Amount for Roadway:		**$14,691,541.25**
Total Amount for XXXX:		**$0.00**
Total Amount for XXXX:		**$0.00**
Total Amount for XXXX:		**$0.00**
Grant Total Amount:		**$14,691,541.25**
Contingencies:	**0%**	**$0.00**
Grand Total Project:		**$14,691,541.25**

ITEM NO.	SPEC NO.	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	AMOUNT
G	**** EXTRA WORK ITEMS**					
74	COH 02513	FURNISH AND INSTALL 6-INCH WET CONNECTION, COMPLETE-IN-PLACE, IN ACCORDANCE WITH THE PLANS AND SPECIFICATIONS	EA	1.00	$1,000.00	$1,000.00
75	COH 02513	FURNISH AND INSTALL 12-INCH WET CONNECTION, COMPLETE-IN-PLACE, IN ACCORDANCE WITH THE PLANS AND SPECIFICATIONS	EA	1.00	$2,000.00	$2,000.00
76	COH 02511	FURNISH AND INSTALL 6" PVC (AWWA C900) CLASS 150 WATERLINE, OPEN CUT CONSTRUCTION, INCLUDING FITTINGS, THRUST BLOCKING, RESTRAINED JOINTS, AND APPURTENANCES, COMPLETE-IN-PLACE, IN ACCORDANCE WITH THE PLANS AND SPECIFICATIONS	LF	151.00	$80.00	$12,080.00
77	COH 02222	REMOVE AND DISPOSE OF 8” EXISTING SANITARY SEWER, ALL DEPTHS, COMPLETE-IN-PLACE, IN ACCORDANCE WITH THE PLANS AND SPECIFICATIONS	LF	176.00	$15.00	$2,640.00
78	COH 02531	FURNISH AND INSTALL 8” SANITARY SEWER, ALL DEPTHS, OPEN-CUT CONSTRUCTION, COMPLETE-IN-PLACE, IN ACCORDANCE WITH THE PLANS AND SPECIFICATIONS	LF	176.00	$150.00	$26,400.00
79	COH 1506	BYPASS PUMPING, COMPLETE-IN-PLACE, IN ACCORDANCE WITH THE PLANS AND SPECIFICATIONS	LS	1.00	$10,000.00	$10,000.00
80	COH 02082	EXTRA DEPTH GREATER THAN 8-FEET REQUIRED FOR CORROSION RESISTANT SANITARY MANHOLE, COMPLETE-IN-PLACE, IN ACCORDANCE WITH THE PLANS AND SPECIFICATIONS	VF	17.00	$350.00	$5,950.00
81	COH 02260	TRENCH SAFETY SYSTEM AS REQUIRED FOR EXCAVATION, COMPLETE-IN-PLACE, IN ACCORDANCE WITH THE PLANS AND SPECIFICATIONS	LF	176.00	$5.00	$880.00
9					**Subtotal of Item G**	**$60,950.00**

Exhibit 10
Utility Conflict Table

Utility Contact/Conflict Table

Project Name: Ravensway Subdivision - Drainage Improvements - 2018

Project Limits: Ravensway Dr. from the Intersection of Raven Cross Ct. to Timberlake Dr.

UPIN No. 19103MF14601

Consultant Name/Project Mgr: Costello, Inc.

No.	Street Name	Station	Offset	Utility Type	Owner	Is Utility In An Easement?	Conflict (Yes/No)	Quality Level of Investigation	Contact Name	Address	Phone No.	Email	Describe Conflict (if applicable)
1	Ravensway Drive	5+67.85 to 43+18.17	R 33' to 25'	12" PVC Water Line	Timberlake Improvement District	No	No	QLD	Gerald L. Gehman	10377 Stella Link Road Houston, TX 77025-5445	713-942-2722	glg@as-engineers.com	Crosses Storm Sewer
2	Ravensway Drive	6+22.85	R 33'	6" PVC Waterline and Tee	Timberlake Improvement District	No	Yes	QLD	Gerald L. Gehman	10377 Stella Link Road Houston, TX 77025-5445	713-942-2722	glg@as-engineers.com	Crosses Storm Sewer
3	Ravensway Drive	6+26 to 33+79.04	L 27' to L 20'	Sanitary	Timberlake Improvement District	No	Yes	QLC	Gerald L. Gehman	10377 Stella Link Road Houston, TX 77025-5445	713-942-2722	glg@as-engineers.com	Crosses Storm Sewer
4	Ravensway Drive	6+44.38	Crossing	6" Sanitary Sewer Service Line	Timberlake Improvement District	No	Yes	QLC	Gerald L. Gehman	10377 Stella Link Road Houston, TX 77025-5445	713-942-2722	glg@as-engineers.com	Crosses Storm Sewer
5	Ravensway Drive	6+69.11	Crossing	6" Sanitary Sewer Service Line	Timberlake Improvement District	No	Yes	QLC	Gerald L. Gehman	10377 Stella Link Road Houston, TX 77025-5445	713-942-2722	glg@as-engineers.com	Crosses Storm Sewer
6	Ravensway Drive	6+89.26	Crossing	6" Sanitary Sewer Service Line	Timberlake Improvement District	No	Yes	QLC	Gerald L. Gehman	10377 Stella Link Road Houston, TX 77025-5445	713-942-2722	glg@as-engineers.com	Crosses Storm Sewer
7	Ravensway Drive	7+13.18	Crossing	6" Sanitary Sewer Service Line	Timberlake Improvement District	No	Yes	QLC	Gerald L. Gehman	10377 Stella Link Road Houston, TX 77025-5445	713-942-2722	glg@as-engineers.com	Crosses Storm Sewer
8	Ravensway Drive	7+33.60	Crossing	6" Sanitary Sewer Service Line	Timberlake Improvement District	No	Yes	QLC	Gerald L. Gehman	10377 Stella Link Road Houston, TX 77025-5445	713-942-2722	glg@as-engineers.com	Crosses Storm Sewer
9	Ravensway Drive	7+58.43	Crossing	6" Sanitary Sewer Service Line	Timberlake Improvement District	No	Yes	QLC	Gerald L. Gehman	10377 Stella Link Road Houston, TX 77025-5445	713-942-2722	glg@as-engineers.com	Crosses Storm Sewer
10	Ravensway Drive	7+84.27	Crossing	6" Sanitary Sewer Service Line	Timberlake Improvement District	No	Yes	QLC	Gerald L. Gehman	10377 Stella Link Road Houston, TX 77025-5445	713-942-2722	glg@as-engineers.com	Crosses Storm Sewer
11	Ravensway Drive	7+97.43	Crossing	6" Sanitary Sewer Service Line	Timberlake Improvement District	No	Yes	QLC	Gerald L. Gehman	10377 Stella Link Road Houston, TX 77025-5445	713-942-2722	glg@as-engineers.com	Crosses Storm Sewer
12	Ravensway Drive	8+17.01	Crossing	6" Sanitary Sewer Service Line	Timberlake Improvement District	No	Yes	QLC	Gerald L. Gehman	10377 Stella Link Road Houston, TX 77025-5445	713-942-2722	glg@as-engineers.com	Crosses Storm Sewer
13	Ravensway Drive	8+41.82	Crossing	6" Sanitary Sewer Service Line	Timberlake Improvement District	No	Yes	QLC	Gerald L. Gehman	10377 Stella Link Road Houston, TX 77025-5445	713-942-2722	glg@as-engineers.com	Crosses Storm Sewer
14	Ravensway Drive	8+59.69	Crossing	6" Sanitary Sewer Service Line	Timberlake Improvement District	No	Yes	QLC	Gerald L. Gehman	10377 Stella Link Road Houston, TX 77025-5445	713-942-2722	glg@as-engineers.com	Crosses Storm Sewer
15	Ravensway Drive	8+85.90	Crossing	6" Sanitary Sewer Service Line	Timberlake Improvement District	No	Yes	QLC	Gerald L. Gehman	10377 Stella Link Road Houston, TX 77025-5445	713-942-2722	glg@as-engineers.com	Crosses Storm Sewer
16	Ravensway Drive	9+06.25	Crossing	6" Sanitary Sewer Service Line	Timberlake Improvement District	No	Yes	QLC	Gerald L. Gehman	10377 Stella Link Road Houston, TX 77025-5445	713-942-2722	glg@as-engineers.com	Crosses Storm Sewer
17	Ravensway Drive	9+27.06	Crossing	6" Sanitary Sewer Service Line	Timberlake Improvement District	No	Yes	QLC	Gerald L. Gehman	10377 Stella Link Road Houston, TX 77025-5445	713-942-2722	glg@as-engineers.com	Crosses Storm Sewer
18	Ravensway Drive	9+54.65	Crossing	6" Sanitary Sewer Service Line	Timberlake Improvement District	No	Yes	QLC	Gerald L. Gehman	10377 Stella Link Road Houston, TX 77025-5445	713-942-2722	glg@as-engineers.com	Crosses Storm Sewer
19	Ravensway Drive	9+87.55	Crossing	6" Sanitary Sewer Service Line	Timberlake Improvement District	No	Yes	QLC	Gerald L. Gehman	10377 Stella Link Road Houston, TX 77025-5445	713-942-2722	glg@as-engineers.com	Crosses Storm Sewer
20	Ravensway Drive	10+11.10	Crossing	6" Sanitary Sewer Service Line	Timberlake Improvement District	No	Yes	QLC	Gerald L. Gehman	10377 Stella Link Road Houston, TX 77025-5445	713-942-2722	glg@as-engineers.com	Crosses Storm Sewer
21	Ravensway Drive	10+31.62	Crossing	6" Sanitary Sewer Service Line	Timberlake Improvement District	No	Yes	QLC	Gerald L. Gehman	10377 Stella Link Road Houston, TX 77025-5445	713-942-2722	glg@as-engineers.com	Crosses Storm Sewer
22	Ravensway Drive	10+52.29	Crossing	6" Sanitary Sewer Service Line	Timberlake Improvement District	No	Yes	QLC	Gerald L. Gehman	10377 Stella Link Road Houston, TX 77025-5445	713-942-2722	glg@as-engineers.com	Crosses Storm Sewer
23	Ravensway Drive	10+72.93	Crossing	6" Sanitary Sewer Service Line	Timberlake Improvement District	No	Yes	QLC	Gerald L. Gehman	10377 Stella Link Road Houston, TX 77025-5445	713-942-2722	glg@as-engineers.com	Crosses Storm Sewer

24	Ravensway Drive	10+99.63	Crossing	6" Sanitary Sewer Service Line	Timberlake Improvement District	No	Yes	QLC	Gerald L. Gehman	10377 Stella Link Road Houston, TX 77025-5445	713-942-2722	glg@as-engineers.com	Crosses Storm Sewer
25	Ravensway Drive	11+23.01	Crossing	6" Sanitary Sewer Service Line	Timberlake Improvement District	No	Yes	QLC	Gerald L. Gehman	10377 Stella Link Road Houston, TX 77025-5445	713-942-2722	glg@as-engineers.com	Crosses Storm Sewer
26	Ravensway Drive	13+16.39	Crossing	6" Sanitary Sewer Service Line	Timberlake Improvement District	No	Yes	QLC	Gerald L. Gehman	10377 Stella Link Road Houston, TX 77025-5445	713-942-2722	glg@as-engineers.com	Crosses Storm Sewer
27	Ravensway Drive	15+31.90	Crossing	6" Sanitary Sewer Service Line	Timberlake Improvement District	No	Yes	QLC	Gerald L. Gehman	10377 Stella Link Road Houston, TX 77025-5445	713-942-2722	glg@as-engineers.com	Crosses Storm Sewer
28	Ravensway Drive	15+56.80	Crossing	6" Sanitary Sewer Service Line	Timberlake Improvement District	No	Yes	QLC	Gerald L. Gehman	10377 Stella Link Road Houston, TX 77025-5445	713-942-2722	glg@as-engineers.com	Crosses Storm Sewer
29	Ravensway Drive	16+69.25	Crossing	6" Sanitary Sewer Service Line	Timberlake Improvement District	No	Yes	QLC	Gerald L. Gehman	10377 Stella Link Road Houston, TX 77025-5445	713-942-2722	glg@as-engineers.com	Crosses Storm Sewer
30	Ravensway Drive	17 +11.70	Crossing	6" Sanitary Sewer Service Line	Timberlake Improvement District	No	Yes	QLC	Gerald L. Gehman	10377 Stella Link Road Houston, TX 77025-5445	713-942-2722	glg@as-engineers.com	Crosses Storm Sewer
31	Ravensway Drive	19+40	L 22'	Buried Electric	Centerpoint Energy	No	Yes	QLC	Cynthia Martinez	1111 Louisiana St 7th Floor, Houston, Texas 77002	713-207-6555	cynthia.martinez@centerpointenergy.com	Crosses Storm Sewer
32	Ravensway Drive	19+40.02	Crossing	Buried Telephone Line	AT&T	No	Yes	QLD	LaKeesha Upchurch	13430 Northwest Freeway, Suite 1100, Houston, TX 77040	713-660-5328	lakeesha.upchurch@att.com	Crosses Storm Sewer
33	Ravensway Drive	19+44.10 to 21+12.97	R 21'	Buried Telephone Line and Buried Television Cable	AT&T	No	Yes	QLC	LaKeesha Upchurch	13430 Northwest Freeway, Suite 1100, Houston, TX 77040	713-660-5328	lakeesha.upchurch@att.com	One buried telephone line and one buried televistion cable running on top of existing storm sewer.
34	Ravensway Drive	19+82.10	Crossing	Buried Fiber Optic Line	AT&T	No	Yes	QLC	LaKeesha Upchurch	13430 Northwest Freeway, Suite 1100, Houston, TX 77040	713-660-5328	lakeesha.upchurch@att.com	Crosses Storm Sewer
35	Ravensway Drive	19+86.38	Crossing	Buried Telephone Line	AT&T	No	Yes	QLD	LaKeesha Upchurch	13430 Northwest Freeway, Suite 1100, Houston, TX 77040	713-660-5328	lakeesha.upchurch@att.com	Crosses Storm Sewer
36	Ravensway Drive	19+88.86	Crossing	Buried Fiber Optic Line	AT&T	No	Yes	QLD	LaKeesha Upchurch	13430 Northwest Freeway, Suite 1100, Houston, TX 77040	713-660-5328	lakeesha.upchurch@att.com	Crosses Storm Sewer
37	Ravensway Drive	19+90.66	Crossing	Buried Fiber Optic Line	AT&T	No	Yes	QLD	LaKeesha Upchurch	13430 Northwest Freeway, Suite 1100, Houston, TX 77040	713-660-5328	lakeesha.upchurch@att.com	Crosses Storm Sewer
38	Ravensway Drive	19+91	Crossing	Buried Telephone Line	AT&T	No	Yes	QLD	LaKeesha Upchurch	13430 Northwest Freeway, Suite 1100, Houston, TX 77040	713-660-5328	lakeesha.upchurch@att.com	Crosses storm.
39	Ravensway Drive	19+91.16	Crossing	8" Sanitary Sewer	Timberlake Improvement District	No	Yes	QLC	Gerald L. Gehman	10377 Stella Link Road Houston, TX 77025-5445	713-942-2722	glg@as-engineers.com	Crosses Storm Sewer
40	Ravensway Drive	19+91.45	Crossing	Overhead Electric	Centerpoint Energy	No	No	QLC	Cynthia Martinez	1111 Louisiana St 7th Floor, Houston, Texas 77002	713-207-6555	cynthia.martinez@centerpointenergy.com	Crosses Storm Sewer
41	Ravensway Drive	19+92.27	Crossing	Buried Cable Line	AT&T	No	Yes	QLD	LaKeesha Upchurch	13430 Northwest Freeway, Suite 1100, Houston, TX 77040	713-660-5328	lakeesha.upchurch@att.com	Crosses Storm Sewer
42	Ravensway Drive	20+00.76	Crossing	Buried Gas Line	Centerpoint Energy	No	Yes	QLC	Michael Brower	1111 Louisiana St 7th Floor, Houston, Texas 77002	713-845-6654	michael.brower@centerpointenergy.com	Crosses Storm Sewer
43	Ravensway Drive	21+11.79	Crossing	Buried Telephone Line	AT&T	No	No	QLD	LaKeesha Upchurch	13430 Northwest Freeway, Suite 1100, Houston, TX 77040	713-660-5328	lakeesha.upchurch@att.com	Parallel To Storm sewer
44	Ravensway Drive	21+68.63	R 18.9'	8" PVC Waterline	Timberlake Improvement District	No	Yes	QlD	Gerald L. Gehman	10377 Stella Link Road Houston, TX 77025-5445	713-942-2722	glg@as-engineers.com	Crosses Storm Sewer
45	Ravensway Drive	21+89.04 To 22+96.28	L 17.5' to 20.3'	Buried Electric	Centerpoint Energy	No	No	QLC	Cynthia Martinez	1111 Louisiana St 7th Floor, Houston, Texas 77002	713-207-6555	cynthia.martinez@centerpointenergy.com	Crosses Storm Sewer
46	Ravensway Drive	24+19.46 to 24+43.15	R 17' to 32.5'	Buried Electric	Centerpoint Energy	No	Yes	QLC	Cynthia Martinez	1111 Louisiana St 7th Floor, Houston, Texas 77002	713-207-6555	cynthia.martinez@centerpointenergy.com	Parallel and Crosses Storm Sewer
47	Ravensway Drive	24+52.84	R 27'	8" PVC Water Line	Timberlake Improvement District	No	Yes	QLD	Gerald L. Gehman	10377 Stella Link Road Houston, TX 77025-5445	713-942-2722	glg@as-engineers.com	Crosses Storm Sewer
48	Ravensway Drive	28+32.38	R 27'	12" PVC Water Line	Timberlake Improvement District	No	Yes	QLD	Gerald L. Gehman	10377 Stella Link Road Houston, TX 77025-5445	713-942-2722	glg@as-engineers.com	Crosses Storm Sewer
49	Ravensway Drive	29+72.69	R 17.5'	8" Sanitary Sewer	Timberlake Improvement District	No	Yes	QLC	Gerald L. Gehman	10377 Stella Link Road Houston, TX 77025-5445	713-942-2722	glg@as-engineers.com	Crosses Storm Sewer
50	Ravensway Drive	30+60.88	L 23.3'	8" Sanitary Sewer	Timberlake Improvement District	No	Yes	QLC	Gerald L. Gehman	10377 Stella Link Road Houston, TX 77025-5445	713-942-2722	glg@as-engineers.com	Crosses Storm Sewer

51	Ravensway Drive	31+05.80	R 18.9'	6" PVC Waterline	Timberlake Improvement District	No	Yes	QLD	Gerald L. Gehman	10377 Stella Link Road Houston, TX 77025-5445	713-942-2722	glg@as-engineers.com	Crosses Storm Sewer
52	Ravensway Drive	32+62 to 32+72	Crossing	Buried Telephone Line	AT&T	No	Yes	QLD	LaKeesha Upchurch	13430 Northwest Freeway, Suite 1100, Houston, TX 77040	713-660-5328	lakeesha.upchurch@att.com	Crosses Storm Sewer
53	Ravensway Drive	33+97	Crossing	Buried Telephone Line	AT&T	No	Yes	QLD	LaKeesha Upchurch	13430 Northwest Freeway, Suite 1100, Houston, TX 77040	713-660-5328	lakeesha.upchurch@att.com	Crosses Storm Sewer
54	Ravensway Drive	34+28.79	Crossing	Buried Telephone Line	AT&T	No	Yes	QLD	LaKeesha Upchurch	13430 Northwest Freeway, Suite 1100, Houston, TX 77040	713-660-5328	lakeesha.upchurch@att.com	Crosses Storm Sewer
55	Ravensway Drive	34+65.80	Crossing	Buried Telephone Line	AT&T	No	Yes	QLD	LaKeesha Upchurch	13430 Northwest Freeway, Suite 1100, Houston, TX 77040	713-660-5328	lakeesha.upchurch@att.com	Crosses Storm Sewer
56	Ravensway Drive	34+28.68	R 15.6'	12" PVC Waterline	Timberlake Improvement District	No	Yes	QLD	Gerald L. Gehman	10377 Stella Link Road Houston, TX 77025-5445	713-942-2722	glg@as-engineers.com	Crosses Storm Sewer
57	Ravensway Drive	42+76.16	R 20.6'	15" Sanitary Sewer	Timberlake Improvement District	No	Yes	QLC	Gerald L. Gehman	10377 Stella Link Road Houston, TX 77025-5445	713-942-2722	glg@as-engineers.com	Crosses Storm Sewer
58	Ravensway Drive	43+13.15	R 23'	8" PVC Water Line	Timberlake Improvement District	No	Yes	QLD	Gerald L. Gehman	10377 Stella Link Road Houston, TX 77025-5445	713-942-2722	glg@as-engineers.com	Crosses Storm Sewer
59	Ravensway Drive	44+35	Crossing	Overhead Electric	Centerpoint Energy	Yes	No	QLC	Cynthia Martinez	1111 Louisiana St 7th Floor, Houston, Texas 77002	713-207-6555	cynthia.martinez@centerpointenergy.com	No conflict
60	Ravensway Drive	44+32.08	R 47.9'	Buried Telephone Line	AT&T	Yes	Yes	QLD	LaKeesha Upchurch	13430 Northwest Freeway, Suite 1100, Houston, TX 77040	713-660-5328	lakeesha.upchurch@att.com	Crosses Storm Sewer

Utility Contact/Conflict Table

Project Name: Ravensway Subdivision - Drainage Improvements - 2018

Project Limits: Ravensway Dr. from the Intersection of Raven Cross Ct. to Timberlake Dr.

UPIN No. 19103MF14601

61	Campsite Trail	6+77.74	Crossing	6" Waterline	Timberlake Improvement District	No	Yes	QLD	Gerald L. Gehman	10379 Stella Link Road Houston, TX 77025-5445	713-942-2724	glg@as-engineers.com	Crosses Storm Sewer
62	Campsite Trail	0+63.80	Crossing	Underground Cable	AT&T	No	No	QLD	LaKeesha Upchurch	13430 Northwest Freeway, Suite 1100, Houston, TX 77040	713-660-5328	lakeesha.upchurch@att.com	None
63	Jarvis Road	5+26.78	R 33'	Overhead Electric	Centerpoint Energy	No	Yes	QLC	Cynthia Martinez	1111 Louisiana St 7th Floor, Houston, Texas 77002	713-207-6555	cynthia.martinez@centerpointenergy.com	Crosses Storm Sewer
64	Jarvis Road	5+16.09	R 34'	8" Sanitary	Timberlake Improvement District	Yes	Yes	QLC	Gerald L. Gehman	10377 Stella Link Road Houston, TX 77025-5445	713-942-2722	glg@as-engineers.com	Crosses Storm Sewer
65	Jarvis Road	7+88.77	R 33'	8" Sanitary	Timberlake Improvement District	Yes	Yes	QLC	Gerald L. Gehman	10377 Stella Link Road Houston, TX 77025-5445	713-942-2722	glg@as-engineers.com	Crosses Storm Sewer
66	Jarvis Road	8+00	R 33'	Overhead Electric	Centerpoint Energy	No	Yes	QLC	Cynthia Martinez	1111 Louisiana St 7th Floor, Houston, Texas 77002	713-207-6555	cynthia.martinez@centerpointenergy.com	Crosses Storm Sewer
67	Jarvis Road	9+07	R 33"	8" Waterline	Timberlake Improvement District	No	Yes	QLD	Gerald L. Gehman	10377 Stella Link Road Houston, TX 77025-5445	713-942-2722	glg@as-engineers.com	Runs Parallel and Crosses Storm Leads
68	Jarvis Road	10+84.44	R 33'	Overhead Electric	Centerpoint Energy	No	No	QLC	Cynthia Martinez	1111 Louisiana St 7th Floor, Houston, Texas 77002	713-207-6555	cynthia.martinez@centerpointenergy.com	No conflict
69	Jarvis Road	10+80.43	R 33'	Buried Cable Line	AT&T	No	Yes	QLD	LaKeesha Upchurch	13430 Northwest Freeway, Suite 1100, Houston, TX 77040	713-660-5328	lakeesha.upchurch@att.com	Crosses Storm Sewer
70	Jarvis Road	10+84.96	R 34'	8" Sanitary	Timberlake Improvement District	Yes	Yes	QLC	Gerald L. Gehman	10377 Stella Link Road Houston, TX 77025-5445	713-942-2722	glg@as-engineers.com	Crosses Storm Sewer
71	Jarvis Road	13+83.39	R 34'	8" Sanitary	Timberlake Improvement District	Yes	Yes	QLC	Gerald L. Gehman	10377 Stella Link Road Houston, TX 77025-5445	713-942-2722	glg@as-engineers.com	Crosses Storm Sewer
72	Jarvis Road	18+10.49	R 35'	15" Sanitary	Timberlake Improvement District	No	Yes	QLC	Gerald L. Gehman	10377 Stella Link Road Houston, TX 77025-5445	713-942-2722	glg@as-engineers.com	Crosses Storm Sewer
73	Jarvis Road	15+16.62	R 1.35'	8" Sanitary	Timberlake Improvement District	No	Yes	QLC	Gerald L. Gehman	10377 Stella Link Road Houston, TX 77025-5445	713-942-2722	glg@as-engineers.com	Crosses Storm Sewer
74	Jarvis Road	15+44.48	R 1.32'	Overhead Electric	Centerpoint Energy	No	No	QLC	Cynthia Martinez	1111 Louisiana St 7th Floor, Houston, Texas 77002	713-207-6555	cynthia.martinez@centerpointenergy.com	No conflict
75	Jarvis Road	17+90.27	Crossing	8" Sanitary	Timberlake Improvement District	No	Yes	QLC	Gerald L. Gehman	10377 Stella Link Road Houston, TX 77025-5445	713-942-2722	glg@as-engineers.com	Crosses Storm Sewer

76	Jarvis Road	18+25.16	Crossing	Overhead Electric	Centerpoint Energy	No	No	QLC	Cynthia Martinez	1111 Louisiana St 7th Floor, Houston, Texas 77002	713-207-6555	cynthia.martinez@centerpointenergy.com	No conflict
77	Tall Forest Drive	4+73.65	R 17'	8" Waterline	Timberlake Improvement District	No	Yes	QLD	Gerald L. Gehman	10379 Stella Link Road Houston, TX 77025-5445	713-942-2724	glg@as-engineers.com	Crosses Storm Sewer
78	Tall Forest Drive	4+84.73	R 7'	8" Waterline	Timberlake Improvement District	No	Yes	QLD	Gerald L. Gehman	10379 Stella Link Road Houston, TX 77025-5445	713-942-2724	glg@as-engineers.com	Crosses Storm Sewer
79	Tall Forest Drive	6+13.10	R 7'	8" Sanitary Sewer	Timberlake Improvement District	No	Yes	QLC	Gerald L. Gehman	10377 Stella Link Road Houston, TX 77025-5445	713-942-2722	glg@as-engineers.com	Crosses Storm Sewer
80	Tall Forest Drive	19+82.10	R 7'	Light Pole	Centerpoint Energy	No	Yes	QLC	Cynthia Martinez	1111 Louisiana St 7th Floor, Houston, Texas 77002	713-207-6555	cynthia.martinez@centerpointenergy.com	Crosses Storm Sewer
81	Tall Forest Drive	6+07.85	Crossing	Buried Comcast	Comcast	No	Yes	QLD	LaKeesha Upchurch	13430 Northwest Freeway, Suite 1100, Houston, TX 77040	713-660-5328	lakeesha.upchurch@att.com	Crosses Storm Sewer
82	Tall Forest Drive	6+23.24	Crossing	Buried Telephone Line	AT&T	No	Yes	QLD	LaKeesha Upchurch	13430 Northwest Freeway, Suite 1100, Houston, TX 77040	713-660-5328	lakeesha.upchurch@att.com	Crosses storm sewer. To review upon receipt of proposed design.
83	Tall Forest Drive	9+23.29	R 6'	8" Sanitary Sewer	Timberlake Improvement District	No	Yes	QLC	Gerald L. Gehman	10377 Stella Link Road Houston, TX 77025-5445	713-942-2722	glg@as-engineers.com	Crosses Storm Sewer
84	Tall Forest Drive	14+15.10	Crossing	Buried Telephone Line	AT&T	No	Yes	QLD	LaKeesha Upchurch	13430 Northwest Freeway, Suite 1100, Houston, TX 77040	713-660-5328	lakeesha.upchurch@att.com	Crosses storm sewer. To review upon receipt of proposed design.
85	Tall Forest Drive	14+64.69	R 6'	8" Waterline	Timberlake Improvement District	No	Yes	QLD	Gerald L. Gehman	10379 Stella Link Road Houston, TX 77025-5445	713-942-2724	glg@as-engineers.com	Crosses Storm Sewer
86	Tall Forest Drive	15+94.80	Crossing	Buried Telephone Line	AT&T	Yes	Yes	QLD	LaKeesha Upchurch	13430 Northwest Freeway, Suite 1100, Houston, TX 77040	713-660-5328	lakeesha.upchurch@att.com	Crosses storm sewer. To review upon receipt of proposed design.
87	Tall Forest Drive	16+26.60	R 5'	Light Pole	Centerpoint Energy	No	Yes	QLC	Cynthia Martinez	1111 Louisiana St 7th Floor, Houston, Texas 77002	713-207-6555	cynthia.martinez@centerpointenergy.com	Close to construction perimeter of propsoed storm
88	Tall Forest Drive	18+69.47	Crossing	Buried Comcast	Comcast	No	Yes	QLD	LaKeesha Upchurch	13430 Northwest Freeway, Suite 1100, Houston, TX 77040	713-660-5328	lakeesha.upchurch@att.com	Crosses Storm Sewer
89	Tall Forest Drive	18+96.58	Crossing	Buried Telephone Line	AT&T	Yes	Yes	QLD	LaKeesha Upchurch	13430 Northwest Freeway, Suite 1100, Houston, TX 77040	713-660-5328	lakeesha.upchurch@att.com	Crosses storm sewer.
90	Tall Forest Drive	22+00.00	Crossing	Buried Telephone Line	AT&T	Yes	Yes	QLD	LaKeesha Upchurch	13430 Northwest Freeway, Suite 1100, Houston, TX 77040	713-660-5328	lakeesha.upchurch@att.com	Crosses storm sewer.
91	Tall Forest Drive	22+09.56	Crossing	Buried Telephone Line	AT&T	Yes	Yes	QLD	LaKeesha Upchurch	13430 Northwest Freeway, Suite 1100, Houston, TX 77040	713-660-5328	lakeesha.upchurch@att.com	Crosses storm sewer.
92	Tall Forest Drive	25+78.17	R 7'	8" Sanitary Sewer	Timberlake Improvement District	No	Yes	QLC	Gerald L. Gehman	10377 Stella Link Road Houston, TX 77025-5445	713-942-2722	glg@as-engineers.com	Crosses Storm Sewer
93	Tall Forest Drive	26+10.12	R 10'	Buried Television Cable	AT&T	No	Yes	QLC	LaKeesha Upchurch	13430 Northwest Freeway, Suite 1100, Houston, TX 77040	713-660-5328	lakeesha.upchurch@att.com	Crossing storm sewer
94	Rifleman Trail (Outfall to Proposed Detension Pond)	1+61.34	R 1'	8" Sanitary Sewer	Timberlake Improvement District	No	Yes	QLC	Gerald L. Gehman	10377 Stella Link Road Houston, TX 77025-5445	713-942-2722	glg@as-engineers.com	Crosses Storm Sewer
95	Rifleman Trail (Outfall to Proposed Detension Pond)	1+58.89	R 0.32'	Light Pole	Centerpoint Energy	No	Yes	QLC	Cynthia Martinez	1111 Louisiana St 7th Floor, Houston, Texas 77002	713-207-6555	cynthia.martinez@centerpointenergy.com	Close to construction perimeter of proposed storm
96	Rifleman Trail (Outfall to Proposed Detension Pond)	1+57.52	Crossing	Buried Telephone Line	AT&T	Yes	Yes	QLD	LaKeesha Upchurch	13430 Northwest Freeway, Suite 1100, Houston, TX 77040	713-660-5328	lakeesha.upchurch@att.com	Crosses storm sewer.
97	Rifleman Trail (Outfall to Proposed Detension Pond)	1+54.54	Crossing	Buried Telephone Line	AT&T	Yes	Yes	QLD	LaKeesha Upchurch	13430 Northwest Freeway, Suite 1100, Houston, TX 77040	713-660-5328	lakeesha.upchurch@att.com	Crosses storm sewer.
98	Rifleman Trail	0+47.00	L 21'	8" Waterline	Timberlake Improvement District	No	Yes	QLD	Gerald L. Gehman	10379 Stella Link Road Houston, TX 77025-5445	713-942-2724	glg@as-engineers.com	Crosses Storm Sewer
99	Rifleman Trail	1+48.67	L 25'	Water Meter	Timberlake Improvement District	No	Yes	QLD	Gerald L. Gehman	10379 Stella Link Road Houston, TX 77025-5445	713-942-2724	glg@as-engineers.com	Crosses Storm Sewer
100	Rifleman Trail	6+39.20	L 25'	Water Meter	Timberlake Improvement District	No	Yes	QLD	Gerald L. Gehman	10379 Stella Link Road Houston, TX 77025-5445	713-942-2724	glg@as-engineers.com	Crosses Storm Sewer
101	Wiley Martin Drive	0+49.61	R 22'	8" Waterline	Timberlake Improvement District	No	Yes	QLD	Gerald L. Gehman	10379 Stella Link Road Houston, TX 77025-5445	713-942-2724	glg@as-engineers.com	Crosses Storm Sewer
102	Wiley Martin Drive	1+61.11	Crossing	Buried Comcast	Comcast	No	Yes	QLD	LaKeesha Upchurch	13430 Northwest Freeway, Suite 1100, Houston, TX 77040	713-660-5328	lakeesha.upchurch@att.com	Crosses Storm Sewer
103	Wiley Martin Drive	1+85.53	Crossing	Buried Comcast	Comcast	Yes	Yes	QLD	LaKeesha Upchurch	13430 Northwest Freeway, Suite 1100, Houston, TX 77040	713-660-5328	lakeesha.upchurch@att.com	Crosses Storm Sewer
104	Wiley Martin Drive	1+87.51	Crossing	Buried Gas Line	Centerpoint Energy	Yes	Yes	QLC	Michael Brower	1111 Louisiana St 7th Floor, Houston, Texas 77002	713-845-6654	michael.brower@centerpointenergy.com	Crosses Storm Sewer
105	Wiley Martin Drive	2+46.62	L 21'	Water Meter	Timberlake Improvement District	No	Yes	QLD	Gerald L. Gehman	10379 Stella Link Road Houston, TX 77025-5445	713-942-2724	glg@as-engineers.com	Crosses Storm Sewer
106	Wiley Martin Drive	3+63.45	L 21'	Water Meter	Timberlake Improvement District	No	Yes	QLD	Gerald L. Gehman	10379 Stella Link Road Houston, TX 77025-5445	713-942-2724	glg@as-engineers.com	Crosses Storm Sewer
107	Wiley Martin Drive	4+51.87	L 25'	Water Meter	Timberlake Improvement District	No	Yes	QLD	Gerald L. Gehman	10379 Stella Link Road Houston, TX 77025-5445	713-942-2724	glg@as-engineers.com	Crosses Storm Sewer
108	Retreat Trail	1+72.12	L 22'	8" Waterline	Timberlake Improvement District	No	Yes	QLD	Gerald L. Gehman	10379 Stella Link Road Houston, TX 77025-5445	713-942-2724	glg@as-engineers.com	Crosses Storm Sewer
109	Retreat Trail	3+30.97	L 22'	Water Meter	Timberlake Improvement District	No	Yes	QLD	Gerald L. Gehman	10379 Stella Link Road Houston, TX 77025-5445	713-942-2724	glg@as-engineers.com	Crosses Storm Sewer
110	Retreat Trail	4+69.40	L 22'	Water Meter	Timberlake Improvement District	No	Yes	QLD	Gerald L. Gehman	10379 Stella Link Road Houston, TX 77025-5445	713-942-2724	glg@as-engineers.com	Crosses Storm Sewer
111	Retreat Trail	6+18.84	L 22'	Water Meter	Timberlake Improvement District	No	Yes	QLD	Gerald L. Gehman	10379 Stella Link Road Houston, TX 77025-5445	713-942-2724	glg@as-engineers.com	Crosses Storm Sewer
112	Retreat Trail	7+92.07	L 21'	Water Meter	Timberlake Improvement District	No	Yes	QLD	Gerald L. Gehman	10379 Stella Link Road Houston, TX 77025-5445	713-942-2724	glg@as-engineers.com	Crosses Storm Sewer
113	Retreat Trail	9+29.85	Crossing	Buried Telephone Line	AT&T	Yes	Yes	QLD	LaKeesha Upchurch	13430 Northwest Freeway, Suite 1100, Houston, TX 77040	713-660-5328	lakeesha.upchurch@att.com	Crosses storm sewer.
114	New Kentucky Road	0+53.13	L 21'	8" Waterline	Timberlake Improvement District	No	Yes	QLD	Gerald L. Gehman	10379 Stella Link Road Houston, TX 77025-5445	713-942-2724	glg@as-engineers.com	Crosses Storm Sewer

115	New Kentucky Road	2+29.78	L 22'	Water Meter	Timberlake Improvement District	No	Yes	QLD	Gerald L. Gehman	10379 Stella Link Road Houston, TX 77025-5445	713-942-2724	glg@as-engineers.com	Crosses Storm Sewer
116	New Kentucky Road	3+15.29	R 26'	8" Waterline	Timberlake Improvement District	No	Yes	QLD	Gerald L. Gehman	10379 Stella Link Road Houston, TX 77025-5445	713-942-2724	glg@as-engineers.com	Crosses Storm Sewer Lead
117	Scouts Lane	1+87.35	R 19'	Water Meter	Timberlake Improvement District	No	Yes	QLD	Gerald L. Gehman	10379 Stella Link Road Houston, TX 77025-5445	713-942-2724	glg@as-engineers.com	Crosses Storm Sewer
118	Scouts Lane	5+35.42	R 23'	8" Sanitary Sewer	Timberlake Improvement District	No	Yes	QLC	Gerald L. Gehman	10377 Stella Link Road Houston, TX 77025-5445	713-942-2722	glg@as-engineers.com	Crosses Storm Sewer
119	Lakecrest Drive	1+60.47	R 26'	Buried Telephone Line	AT&T	Yes	Yes	QLD	LaKeesha Upchurch	13430 Northwest Freeway, Suite 1100, Houston, TX 77040	713-660-5328	lakeesha.upchurch@att.com	Crosses Storm Sewer
120	Lakecrest Drive	1+64.14	L 19'	8" Waterline	Timberlake Improvement District	No	Yes	QLD	Gerald L. Gehman	10379 Stella Link Road Houston, TX 77025-5445	713-942-2724	glg@as-engineers.com	Crosses Storm Sewer
121	Lakecrest Drive	4+76.24	L 2'	Buried Telephone Line	AT&T	Yes	Yes	QLD	LaKeesha Upchurch	13430 Northwest Freeway, Suite 1100, Houston, TX 77040	713-660-5328	lakeesha.upchurch@att.com	Crosses Storm sewer lead
122	Lakecrest Drive	4+84.62	L 23'	12" Waterline	Timberlake Improvement District	No	Yes	QLD	Gerald L. Gehman	10379 Stella Link Road Houston, TX 77025-5445	713-942-2724	glg@as-engineers.com	Crosses Storm Sewer
123	Lakecrest Drive	5+64.25	L 18'	Buried Telephone Line	AT&T	Yes	Yes	QLD	LaKeesha Upchurch	13430 Northwest Freeway, Suite 1100, Houston, TX 77040	713-660-5328	lakeesha.upchurch@att.com	Crosses Storm Sewer

Exhibit 11
Regional General Permit- Drainage Outfall

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS, GALVESTON DISTRICT
2000 FORT POINT RD
GALVESTON, TEXAS 77550

June 6, 2022

Policy Analysis Branch

SUBJECT: Permit No. SWG-2021-00785; Regional General Permit SWG-2011-00629, PCN 7, Harris County, Texas

Brady Johnson
Harris County Engineering Department
1001 Preston, 7th Floor
Houston, Texas 77002

Dear Mr. Johnson:

This is in reference to your May 12, 2022, request to perform work under RGP 2001-00629, #7 along Cypress Creek (G103-05-00). The Ravensway Subdivision Drainage Improvements - 2018 - K100-00-00-HC005 project is located along a segment of Cypress Creek, north of Ravensway Drive, and east of Huffmeister Road, and south of Cypress Creek, in Cypress, north Harris County, Texas.

The proposed project involves expanding the existing bridge and G103-05-00 and will be matching the existing slope paving of the existing bridge, which will extend down below the OHWM of G103-05-00. The proposed project will be constructing detention facilities required to mitigate the increased impervious cover and fill within the floodplain. These facilities will require outfall and overflow structures of which the required erosion protection for the outfalls and overflow structures will impact G103-05-00 (northern detention) and G103-04-00 (southern detention). The proposed outfalls will fill and impact 0.013 acre of Cypress Creek. No jurisdictional wetlands will be impacted by this project.

This project has been verified under Regional General Permit (RGP) SWG-2011-00629 pursuant to Section 404 of the Clean Water Act. The time limit for completing the work authorized ends 2 years from the date of this letter. A copy of your plans in 1 sheet is enclosed. This authorization is subject to all conditions of RGP SWG- 2011-00629, which can be found at: http://www.swg.usace.army.mil/Business-With-Us/Regulatory/Permits/Regional-General-Permits/.

Corps determinations are conducted to identify the limits of the Corps Clean Water Act jurisdiction for sites. This determination may not be valid for the wetland conservation provisions of the Food Security Act of 1985, as amended. If you or your tenant are USDA program participants, or anticipate participation in USDA programs, you should request a certified wetland determination from the local office of the Natural Resources Conservation Service prior to starting work.

If you have any question regarding this verification, please contact Dwayne Johnson at the letterhead address or by telephone at 409-766-6353. Please notify the Chief of the Compliance Branch in the Galveston District Regulatory Division in writing at the letterhead address, upon completion of the authorized project.

FOR THE DISTRICT COMMANDER:

Sincerely,

Robert W. Heinly

Robert W. Heinly
Chief, Policy Analysis Branch

cc w/Encl.

Brady Johnson, HCED, by electronic mail: Brady.Johnson@eng.hctx.net

Appendix A
Environmental Investigations

Project No. ASF21-116-00
November 12, 2021

3602 Westchase Drive
Houston, TX 77042

P 713.996.8990
F 713.996.8993
TBPE Firm F-3257

WWW.RKCI.COM

Mr. Isaac Muñiz, P.E.
Project Manager – Water Resources
LJA Engineering
3600 W. Sam Houston Parkway S., Suite 600
Houston, Texas 77042

RE: Threatened and Endangered Species Habitat Evaluation
Ravensway Subdivision Drainage Improvements
Precinct 3, Harris County, Texas
Lat/Long 29°57'39.23"N / 95°37'26.58"W

Dear Mr. Muñiz:

Raba Kistner, Inc. (RKI) is pleased to submit the attached Threatened and Endangered Species Habitat Evaluation report for the above-referenced property. This report was prepared for LJA Engineering (CLIENT), and may not provide adequate information for other purposes or parties. If other parties wish to rely on this report, please have them contact us so that a mutual understanding and agreement of the terms and conditions for our services can be established prior to their use of this information.

We appreciate the opportunity to have been of professional service on this important project. Should there be any questions or additional information required, please contact our office at your earliest convenience.

Very truly yours,

RABA KISTNER, INC.

Jaimie Galm
Environmental Scientist I

Brittney Davis
Senior Project Manager

JG/BD/srw

Attachments

Copies submitted: Above (1 Electronic PDF Copy)

THREATENED AND ENDANGERED SPECIES HABITAT EVALUATION

Ravensway Subdivision Drainage Improvements
Harris County, Texas

RKI Project No: ASF21-116-00

Prepared for:

LJA Engineering
3600 W. Sam Houston Parkway S., Suite 600
Houston, Texas 77042

Prepared by:

RABA KISTNER
3602 Westchase Drive
Houston, Texas 77042

November 12, 2021

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Appendix E IPaC Report (USFWS)

EXECUTIVE SUMMARY

Harris County Engineering Department is proposing drainage improvements in the Ravensway Subdivision located along Huffmeister Road between Cypress N. Houston and Kluge Road in Cypress, Harris County, Texas. As shown in **Figure 1**, the Review Area is approximately 18.7 acres in cumulative size. The proposed improvements consist of an approximate 13.7-acre detention area and three outfall locations. **Raba Kistner, Inc.** (**RKI**) conducted a state and federal listed species habitat evaluation within the Review Area (**Figure 1**).

RKI staff conducted field reconnaissance and habitat assessment activities within the Review Area on October 28, 2021. The habitat evaluation included a visual inspection of the habitat within the Review Area to determine the potential presence of federal and/or state threatened/endangered, protected flora/fauna, or critical habitats. Field assessment activities were accomplished by characterizing the environment (ground surface, vegetation communities, water features, etc.) to identify conditions that may be consistent with known habitat parameters of threatened and endangered species listed for the county.

Based on the information reviewed:

- No designated critical habitat occurs in the Review Area.
- *No effect* on federally-listed species is anticipated.
- Potential habitat exists for the following state-threatened species:
    - Rafinesque's Big-Eared Bat (*Corynorhinus rafinesquii)*
    - Louisiana Pig Toe (*Pleurobema riddellii*)
    - Sandbank Pocketbook (*Lampsilis satura*)
    - Alligator Snapping Turtle (*Macrochelys temminckii*)
- Best Management Practices (BMPs) outlined in **Section 3.2** may be considered to avoid impacting these species.
- There is the potential to encounter migratory birds. **Section 3.2** also includes recommendations related to migratory birds.

1.0 INTRODUCTION

1.1 Purpose

Species listed by the U.S. Fish and Wildlife Service (USFWS) are protected by the Endangered Species Act (ESA) and therefore a "take" of threatened or endangered species is illegal. A "take" is defined as "harm, harass, pursue, shoot, wound, kill, trap, capture, or collect, or engage in any such conduct." Thus, the removal of species habitat would be considered a take, violating the ESA. Threats considered to be potentially endangering to listed species include the following: (i) destruction and/or deterioration of habitat by commercial, residential, and road construction; (ii) filling of caves, (iii) loss of permeable cover; (iv) contamination from anthropogenic sources such as septic effluent, sewage leaks, stormwater runoff, and pesticides; (v) predation by and competition with non-native fire ants; and (vi) vandalism (TPWD 2021a).

In addition, Chapter 68 of the Texas Parks and Wildlife Code protects species considered to be threatened with extinction within Texas. Any take of state-listed species is prohibited by state law. State-listed species may only be handled (including relocation) by persons with a scientific collecting permit obtained through the Texas Parks and Wildlife Department (TPWD).

The purpose of this report is to document a desktop and field evaluation conducted by **RKI** with the goal of identifying potential impact-causing activities related to the proposed project within the Review Area.

1.2 Project Location

As shown in **Figure 1**, the Review Area consists of an approximate 13.7-acre proposed detention area to the west along Huffmeister Road and three outfall locations in Harris County, Texas. The adjacent properties consist of single-family residential homes within the Ravensway Subdivision, Huffmeister Road running along the west side of the detention area, and undeveloped, forested land leading to Cypress Creek on the east side of the Review Area.

2.0 DESKTOP REVIEW AND FIELD OBSERVATIONS

Prior to initiating the field survey, **RKI** reviewed available topographic maps, aerial photography, TPWD, and USFWS published species lists, the Texas Natural Diversity Database (TXNDD), the USFWS Critical Habitat Portal, and other desktop resources. These published resources were reviewed to gather information regarding the ecological setting and potential habitats that could support threatened or endangered species in the Review Area.

RKI staff conducted field reconnaissance and habitat assessment activities within the Review Area on October 28, 2021. The habitat evaluation included a visual inspection of the Review Area to determine the potential presence of federal and/or state threatened/endangered, protected flora/fauna, and critical habitats. Field assessment activities were accomplished by characterizing the environment (ground surface, vegetation communities, water features, etc.) to identify conditions that may be consistent with known habitat parameters of threatened and endangered species listed for the county. Photographs taken during the field assessment are included as **Appendix A**.

2.1 Topography and Drainage

Topographic maps are helpful in examining historic natural drainage patterns and landscape features such as vegetative cover. The *U.S. Geological Survey (USGS) 7.5-Minute Series, Cypress and Satsuma, Texas Quadrangles* (**Figure 2**) depicts the Review Area to the west containing the detention area and the reinforced concrete box (RCB) outfall with a residential neighborhood to the east, Cypress Creek intersecting in the north, a paved ROW (Huffmeister Road) west adjacent and undeveloped land to the south. The eastern Review Areas are intersected by a tributary with the residential neighborhood to the west and undeveloped land north, east and south. The Review Area is approximately 125 to 135 feet above mean sea level (amsl).

2.2 Aerial Photography

Aerial photographs provide a historical record of site use and development, help track natural and man-made changes to the landscape over time, and reveal surface features that may be indicative of saturated surface conditions. **RKI** reviewed representative aerial photographs dated 1930, 1953, 1957, 1968, 1978, 1995, 2010, and 2018. All historical images are included as **Appendix B**.

<u>1930</u>: The Review Area is depicted within a primarily undeveloped, forested area with an existing roadway along the west side of the Review Area.

<u>1953</u>: A man-made tributary, Cypress Creek, is shown intersecting the northwest portion of the Review Area. A paved ROW is seen to the west of the Review Area.

<u>1957 and 1968</u>: Within the eastern portion of the Review Area, a man-made drainage feature is seen extending from Cypress Creek. Residential developments appear south of the eastern Review Area.

<u>1978</u>: A residential neighborhood has developed between the west and east Review Area. The Review Area remains unchanged from previous years.

<u>1995, 2010, and 2018</u>: Vegetation cover has increased within the Review Area, all other features remain the same.

2.3 Ecological Setting

2.3.1 Climate

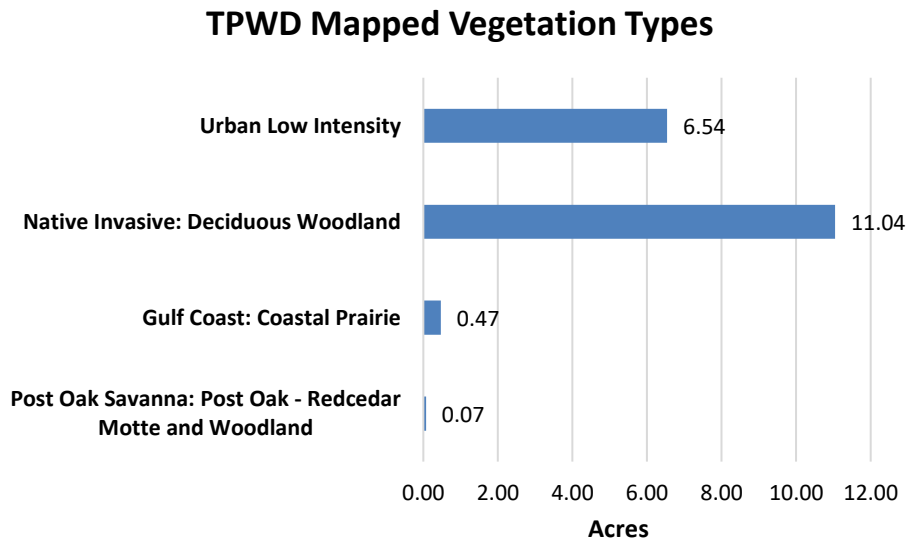
Climate data from the Southern Regional Climate Center (SRCC) database was reviewed for the weather station, Houston Hook Memorial Airport, approximately 8.6 miles northeast of the Review Area. This is the closest weather station with available data. The temperature in 2021 averaged 71.7° (F), with an average high of 88° (F) in June and an average low of 18.5° (F) in February. Monthly rainfall amounts in 2021 were highest in May measuring 2.5 inches (SRCC). Total rainfall was recorded at approximately 48.1 inches.

During field studies, conducted on October 28, 2021, the weather was sunny and windy with a temperature of 80° (F). As shown in **Appendix C** (USACE Antecedent Precipitation Tool data), the surveys were conducted within the wet season. However, recent precipitation trends, in this area, depict normal conditions

2.3.2 Vegetation

According to the TPWD map publication titled Natural Regions of Texas (TPWD 2011), the Review Area is located in the northern portion of the Gulf Coast Prairies and Marshes ecoregion. This ecoregion is characterized as nearly level, slowly drained plain less than 150 feet in elevation, dissected by streams and rivers flowing into the Gulf of Mexico. The region includes barrier islands along the coast, salt grass marshes surrounding bays and estuaries, remnant tallgrass prairies, oak parklands and oak mottes scattered along the coast, and tall woodlands in the river bottomlands. Average annual rainfall varies from 30 to 50 inches per year distributed fairly uniformly throughout the year. The growing season is usually more than 300 days, with high humidity and warm temperatures. Soils are acidic sands and sandy loams, with clays occurring primarily in the river bottoms. Native vegetation consists of tallgrass prairies and live oak woodlands. Brush species such as mesquite and acacias are more common now than in the past.

RKI reviewed data from the TPWD's Ecological Mapping System of Texas (EMST), which classifies existing vegetation and models the ecological systems by overlaying data such as land position, slope, aspect, and soil type. Based on this review, the following vegetation types are mapped:



Native Invasive: Deciduous Woodland and Urban Low Intensity vegetation types were observed during field observations, Gulf Coast: Coastal Prairies were not seen in the Review Area.

2.3.3 Riparian Buffers

Riparian buffers are those areas located along streams and rivers, where vegetation is strongly influenced by the presence of water. Although they comprise a relatively small proportion of the total habitat in Texas, these areas are some of the most productive for wildlife. Their value is especially important in agricultural settings where wildlife habitat is limited or non-existent. Therefore, TPWD considers conservation of riparian buffers to be critical for the success of flora and fauna species.

Riparian buffers were observed surrounding Cypress Creek in the northwest portion of the Review Area and to the east of the eastern Review Area. These areas consisted of cedar elm (*Ulmus crassifolia*), Chinese tallow (*Triadica sebifera*), Southern live oak (*Quercus virginiana*), and loblolly pine (*Pinus taeda*). Mowed and cleared vegetation was observed in many portions of the understory during field investigation. This area did not contain old growth forest.

2.4 Wetlands

Since the 1970s, the U.S. Army Corps of Engineers (USACE) and the U.S. Environmental Protection Agency (EPA) have defined 'wetlands' as:

> *"…areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas (EPA, USACE 2019)."*

In addition to flood water absorption and excess nutrient and pollutant absorption, wetlands play important roles in watershed ecology by providing habitat for plants and animals.

The National Wetlands Inventory (NWI) (**Figure 3**), published by the USFWS, was reviewed for information on possible wetlands and other surface water features in the Review Area. These maps were created using stereoscopic analysis of high-altitude photographs. NWI maps assign wetland classification codes to prominent surface water features. The codes are based on the 1979 USFWS publication titled *Classification of Wetlands and Deepwater Habitats of the United States*, and are a series of letter and number codes that adapted the national wetland classification system to map form. These alpha-numeric codes correspond to the classification nomenclature that best describes the feature (e.g. PFO1A). Although NWI maps provide a good screening method for identifying potential features, a detailed on-the-ground and historical analysis of a site is required.

RKI reviewed NWI data for the Review Area and adjacent areas (USFWS 2021b). Four NWI features were identified within the Review Area.

Riverine, Lower Perennial, Unconsolidated Bottom, Permanently Flooded, Excavated (R2UBHx): This feature (Cypress Creek) intersects the northwestern Review Area.

Riverine, Intermittent, Streambed, Seasonally Flooded, Excavated (R4SBCx): This feature was identified within the northeastern Review Area.

Palustrine, Forested, Broad-Leaved Deciduous, Temporarily Flooded, Excavated (PFO1Ax): This feature was identified within the southeastern Review Area.

Palustrine, Forested, Broad-leaved Deciduous, Seasonally Flooded (PFO1C): This feature was identified along the eastern edge of the southeastern Review Area.

2.5 TPWD Annotated List of Rare Species

RKI reviewed the TPWD *Annotated List of Rare Species for Harris County* (last revision October 1, 2021) (TPWD 2021b). This list describes state and federal listed species that have the potential to occur in Harris County along with their listing status. Pertinent data for each listed species, including reference to Best Management Practices (BMPs) that may be considered[1] to minimize species impacts, are included in the table below. The *Annotated List of Rare Species for Harris County* is included as **Appendix D**.

Table 1. State and Federal Threatened or Endangered Species, General Habitat Information and Information Pertaining to Review Area Habitat

Scientific Name	Description	Impact / Effect?	Pertinent Information
AMPHIBIANS			
Houston Toad *Anaxyrus houstonensis* LE, E	Endemic; sandy substrate, water in pools, ephemeral pools, stock tanks; breeds in spring especially after rains; burrows in soil of adjacent uplands when inactive; breeds February-June; associated with soils of the Sparta, Carrizo, Goliad, Queen City, Recklaw, Weches, and Willis geologic formations.	No Effect	The Review Area does not contain stock tanks or pooled water that would support this species. Additionally, the Review Area is in the Lissie geologic formation, one not associated with this species. No effect is expected.
BIRDS			
Black Rail *Laterallus jamaicensis* PT	Salt, brackish, and freshwater marshes, pond borders, wet meadows, grassy swamps; nests in or along edge of marsh, sometimes on damp ground, but usually on mat of previous years dead grass; nest usually hidden in marsh grass or at base of Salicornia.	No Effect	There are no marshes or swamps with marsh grass or Salicornia within the Review Area. No effect is expected.

[1] These BMPs are used by the Texas Department of Transportation and, although they are not required, they may be considered to avoid/minimize potential impacts to state and federal listed species.

Scientific Name	Description	Impact / Effect?	Pertinent Information
Piping Plover *Charadrius melodus* LT, T	Beaches, sand flats, and dunes along Gulf Coast beaches and adjacent offshore islands. Also spoil islands in the Intracoastal Waterway. Sand flats often appear to be preferred over algal flats when both are available, but large portions of sand flats along the Texas coast are available only during low-very low tides and are often completely unavailable during extreme high tides or strong north winds. Beaches appear to serve as a secondary habitat to the flats associated with the primary bays, lagoons, and inter-island passes. Beaches are rarely used on the southern Texas coast, where bayside habitat is always available, and are abandoned as bayside habitats become available on the central and northern coast. However, beaches are probably a vital habitat along the central and northern coast (i.e. north of Padre Island) during periods of extreme high tides that cover the flats. Optimal site characteristics appear to be large in area, sparsely vegetated, continuously available or in close proximity to secondary habitat, and with limited human disturbance.	No Effect	No suitable habitat for this species within the Review Area. The surrounding area is primarily residential land and does not contain beaches or flats. No effect is expected.
Red-cockaded Woodpecker *Picoides borealis* LE, E	Cavity nests in older pine (60+ years); forages in younger pine (30+ years); prefers longleaf, shortleaf, and loblolly.	No Effect	While there are pine species in and adjacent to the Review Area, the trees are not old enough (indicated by diameters less than 24”) to support this species. May migrate over the site, but is not expected to inhabit the Review Area.
Reddish Egret *Egretta rufescens* T	Resident of the Texas Gulf Coast; brackish marshes and shallow salt ponds and tidal flats; nests on ground or in trees or bushes, on dry coastal islands in brushy thickets of yucca and prickly pear.	No Impact	The Review Area is inland in a primarily residential area. There is no suitable marsh, salt pond, or flat habitat for this species. No impact is expected.
Red Knot *Calidris canutus rufa* LT	Breeds in drier tundra areas, such as sparsely vegetated hillsides. Outside of breeding season, it is found primarily in intertidal, marine habitats, especially near coastal inlets, estuaries, and bays (Cornell 2021a).	No Effect	There is no marine/tidal habitat within the Review Area. Species may migrate over site, but no effect is expected.

Scientific Name	Description	Impact / Effect?	Pertinent Information
Swallow-tailed Kite *Elanoides forficatus* T	Lowland forested regions, especially swampy areas, ranging into open woodland; marshes, along rivers, lakes, and ponds; nests high in tall tree in clearing or on forest woodland edge, usually in pine, cypress, or various deciduous trees.	No Impact	The Review Area does not contain swampy areas or marshes. No suitable habitat for this species is present. No impact is expected.
White-faced Ibis *Plegadis chihi* T	Prefers freshwater marshes, sloughs, and irrigated rice fields, but will attend brackish and saltwater habitats; currently confined to near-coastal rookeries in so-called hog-wallow prairies. Nests in marshes, in low trees, on the ground in bulrushes or reeds, or on floating mats.	No Impact	Review Area is inland and consists of a freshwater drainage channel. The surrounding area is primarily residential. There are no suitable marshes, sloughs, or rice fields for this species. No impact is expected.
White-tailed Hawk *Buteo albicaudatus* T	Near coast on prairies, cordgrass flats, and scrub-live oak; further inland on prairies, mesquite and oak savannas, and mixed savanna-chaparral; breeding March-May.	No Impact	Review Area is inland in a residential area with no prairies or scrub oak areas. There is no suitable habitat for this species. May fly over during migration but no impact is expected.
Whooping Crane *Grus americana* LE, E	Potential migrant via plains throughout most of state to coast; winters in coastal marshes of Aransas, Calhoun, and Refugio counties.	No Effect	This species does not inhabit areas outside Aransas, Calhoun, and Refugio counties. May migrate over the site, but is not expected to inhabit the Review Area.
Wood Stork *Mycteria Americana* T	Prefers to nest in large tracts of bald cypress (Taxodium distichum) or red mangrove (Rhizophora mangle); forages in prairie ponds, flooded pastures or fields, ditches, and other shallow standing water, including salt-water; usually roosts communally in tall snags, sometimes in association with other wading birds (i.e. active heronries); breeds in Mexico and birds move into Gulf States in search of mud flats and other wetlands, even those associated with forested areas; formerly nested in Texas, but no breeding records since 1960.	No Impact	The Review Area does not consist of bald cypress or red mangrove. Preferred habitat not present for this species. No impact is expected.
FISH			
Oceanic Whitetip Shark *Carcharhinus longimanus* LT, T	Inhabits tropical and subtropical warm waters, remaining in the open ocean, on the outer continental shelf, or around oceanic islands in water depths greater than 600 feet.	No Effect	The Review Area is inland and does not have the marine habitat this species requires. No effect Is expected.

Scientific Name	Description	Impact / Effect?	Pertinent Information
Shortfin Mako Shark *Isurus oxyrinchus* T	Inhabits the Atlantic from New England to Florida, the Gulf of Mexico from Florida to Texas, and the Caribbean Sea. They are highly migratory and can travel across entire oceans. Mating occurs from summer to fall.	No Impact	The Review Area is inland and does not have the marine habitat this species requires. No impact is expected.
Western Creek Chubsucker *Erimyzon claviformis* T	Eastern Texas streams from the Red River to the San Jacinto drainage. Habitat includes silt-, sand-, and gravel-bottomed pools of clear headwaters, creeks, and small rivers; often near vegetation; occasionally in lakes. Spawning occurs in river mouths or pools, riffles, lake outlets, or upstream creeks. Prefers headwaters, but seldom occurs in springs.	No Impact	The Review Area contains a large tributary, Cypress Creek; however, it does not contain clear headwaters or lake outlets. Habitat for this species is not present. No impact is expected.
MAMMALS			
Blue Whale *Balaenoptera musculus* LE, E	Inhabits tropical, subtropical, temperate, and subpolar waters worldwide, but are infrequently sighted in the Gulf of Mexico. They migrate seasonally between summer feeding grounds and winter breeding grounds, but specifics vary. Commonly observed at the surface in open ocean.	No Effect	The Review Area is inland and does not have the marine habitat this species requires. No effect is expected.
Gulf of Mexico Bryde's Whale *Balaenoptera edeni* LE, E	Occur in the northeastern Gulf of Mexico, along the shelf break in waters 100 to 400 meters deep in the De Soto Canyon region off the Florida Panhandle.	No Effect	The Review Area is inland and does not have the marine habitat this species requires. No effect is expected.
Humpback Whale *Megaptera novaeangliae* LE	Inhabits tropical, subtropical, temperate, and subpolar waters worldwide. Migrate up to 5,000 miles between colder water (feeding grounds) and warmer water (calving grounds) each year. They will use both open ocean and coastal waters, sometimes including inshore areas such as bays, and are often found near the surface; however, this species is rare in the Gulf of Mexico. The northwest Atlantic/Gulf of Mexico distinct population segment is not considered at risk of extinction and is not listed as Endangered on the ESA.	No Effect	The Review Area is inland and does not have the marine habitat this species requires. No effect is expected.
Louisiana Black Bear *Ursus americanus luteolus* T	Bottomland hardwoods, floodplain forests, upland hardwoods with mixed pine; marsh. Possible as transient; bottomland hardwoods and large tracts of inaccessible forested areas.	No Impact	The Review Area is within a residential community in a primarily developed area and does not contain large tracts of inaccessible forested areas. No impact is expected.

Scientific Name	Description	Impact / Effect?	Pertinent Information
North Atlantic Right Whale *Eubalaena glacialis* LE, E	Inhabits subtropical and temperate waters in the northern Atlantic. Commonly found in coastal waters or close to the continental shelf near the surface. They migrate from feeding grounds in cooler waters (Canada and New England) to warmer waters of the southeast US (South Carolina, Georgia, and Florida) to give birth in the fall/winter - both areas are identified as critical habitat by NOAA-NMFS. Nursery areas are in shallow, coastal waters. This species is very rare in the Gulf of Mexico and the few reported sightings are likely vagrants (Ward-Geiger et al 2011).	No Effect	The Review Area is inland and does not have the marine habitat this species requires. No effect is expected.
Rafinesque's Big-eared Bat *Corynorhinus rafinesquii* T	Historically, lowland pine and hardwood forests with large hollow trees. Roosts in cavity trees of bottomland hardwoods, concrete culverts, and abandoned man-made structures.	May Impact	There are multiple large metal and concrete culverts within the Review Area that could provide a potential roost area. No individuals of this species were observed during field activities. Recommended BMPs for avoiding impacts to this species are discussed in **Section 3.2.** Potential habitat within the Review Area for this species is identified in **Figure 4**.
Sei Whale *Balaenoptera borealis* LE, E	These whales are found in all oceans and adjoining seas, except polar and tropical regions. These animals occupy temperate and subpolar regions in the summer, but migrate to sub-tropical waters during the winter.	No Effect	The Review Area is inland and does not have the marine habitat this species requires. No effect is expected.
Sperm Whale *Physeter microcephalus* LE, E	Inhabits tropical, subtropical, and temperate waters worldwide, avoiding icy waters. Distribution is highly dependent on their food source (squids, sharks, skates, and fish), breeding, and composition of the pod. In general, this species migrates from north to south in the winter and south to north in the summer; however, individuals in tropical and temperate waters don't seem to migrate at all. Routinely dive to catch their prey (2,000-10,000 feet) and generally occupies water at least 3,300 feet deep near ocean trenches.	No Effect	The Review Area is inland and does not have the marine habitat this species requires. No effect is expected.

Scientific Name	Description	Impact / Effect?	Pertinent Information
MOLLUSKS			
Louisiana Pigtoe *Pleurobema riddellii* T	Occurs in small streams to large rivers in slow to moderate currents in substrates of clay, mud, sand, and gravel.	May Impact	Cypress Creek, found within the Review Area, has a slow but steady flow that could potentially support this species. Recommended BMPs for avoiding impacts to this species are discussed in **Section 3.2.** Potential habitat within the Review Area for this species is identified in **Figure 4.**
Sandbank Pocketbook *Lampsilis satura* T	Occurs in small streams to large rivers in slow to moderate current in sandy mud to sand and gravel substrate. Can occur in a variety of habitats but most common in littoral habitats such as banks or backwaters or in protected areas along point bars.	May Impact	Cypress Creek found within the Review Area has a slow but steady flow that could potentially support this species. Recommended BMPs for avoiding impacts to this species are discussed in **Section 3.2.** Potential habitat within the Review Area for this species is identified in **Figure 4.**
REPTILES			
Alligator snapping turtle *Macrochelys temminckii* T	Perennial water bodies; deep water of rivers, canals, lakes, and oxbows; also swamps, bayous, and ponds near deep running water; sometimes enters brackish coastal waters; usually in water with mud bottom and abundant aquatic vegetation; may migrate several miles along rivers; active March-October; breeds April-October.	May Impact	The perennial waters of Cypress Creek could contain habitat for this species. Recommended BMPs for avoiding impacts to this species are discussed in **Section 3.2.** Potential habitat within the Review Area for this species is identified in **Figure 4.**
Loggerhead sea turtle *Caretta caretta* LT, T	Gulf and bay system primarily for juveniles, adults are most pelagic of the sea turtles; omnivorous, shows a preference for mollusks, crustaceans, and coral; nests from April through November.	No Effect	The Review Area is inland and does not have the marine habitat this species requires. No effect is expected.
Texas horned lizard *Phrynosoma cornutum* T	Open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rock when inactive; breeds March-September.	No Impact	The Review Area does not consist of open/sparsely vegetated space. There would be no impact on this species.

Scientific Name	Description	Impact / Effect?	Pertinent Information
PLANTS			
Houston Daisy *Rayjacksonia aurea* T	On and around naturally barren or sparsely vegetated saline slick spots or pimple mounds on coastal prairies, usually on sandy to sandy loam soils, occasionally in pastures and on roadsides in similar soil types where mowing may mimic natural prairie disturbance regimes; flowering late September-November (-December).	No Impact	The Review Area is inland and consists mainly of forested habitat in a primarily residential area. Naturally barren or sparsely vegetated saline slick spots or pimple mounds are not present. No impact is expected.
Texas Prairie Dawn *Hymenoxys texana* LE, E	In poorly drained, sparsely vegetated areas (slick spots) at the base of mima mounds in open grassland or almost barren areas on slightly saline soils that are sticky when wet and powdery when dry; flowering late February-early April.	No Effect	The Review Area consists mainly of forested habitat in a primarily residential area. Open grassland or almost barren areas on slightly saline soils that are sticky when wet and powdery when dry are not present. No effect is expected.

Status Key:
LE, LT - Federally Listed Endangered/Threatened
E, T - State Listed Endangered/Threatened
C - Candidate for Endangered Status
DL – Federal De-Listed

2.6 Texas Natural Diversity Database (TXNDD)

RKI reviewed data from the TXNDD on October 28, 2021 (TPWD 2021c) to identify known occurrences of listed species occurring near the Review Area. The TXNDD provides Element of Occurrence (EO) and Source Feature (SF) records, which includes known occurrences of species that are tracked by TPWD and maintained in a database. The Cypress and Satsuma, Texas Quadrangles and adjacent *USGS 7.5 minute quadrangles* were searched. Information from the TXNDD cannot be used to determine the presence/absence of species, but it can provide valuable information about potential use of the surrounding environment by species.

The TPWD provides TXNDD data in Geographic Information System (GIS) shapefile (.shp) format for analysis by the end user. Individual species occurrences are generally provided as circular shapes, centered on the species' reported location. The circular shapes are generally sized based on the degree of location accuracy, where smaller circles indicate higher degree of location certainty (e.g. collected using GPS devices) and larger circles indicate less accurate location data.

The TXNDD indicates 11 occurrences of seven different species within a three-mile radius of the Review Area (**Figure 5**) and are identified as follows.

- Southern Crawfish Frog (*Lithobates areolatus areolatus*) (EO ID No. 4660) last observed in 1960 east and south of the Review Area.
- Eastern Spotted Skunk (*Spilogale putorius*) (EO ID No. 12770) last observed in 1980 within the Review Area.

- Houston Daisy (*Rayjacksonia aurea*) (EO ID No. 3573) last observed in 1980 west of the Review Area.
- Panicled Indigobush (*Amorpha paniculata*) (EO ID No. 11233) last observed in 1992 north east of the Review Area.
- Plains Spotted Skunk (*Spilogale putorius interrupta*) (EO ID No. 2880) last observed 1988 south east of the Review Area.
- Eastern Box Turtle (*Terrapene Carolina*) (SF ID 40205 and 39945) last recorded in 2020 north east of the Review Area.
- Alligator Snapping Turtle (*Macrochelys temminckii*) (SF ID 38726, 38741, and 38744) last recorded in 2019 south, north east and north west respectively of the Review Area.

None of the above listed occurrences relate to a listed federal or state threatened or endangered species. No impact to these species is expected.

2.7 USFWS Critical Habitat

When a species is proposed for listing as Endangered or Threatened under the ESA, the USFWS must consider whether there are areas of habitat believed to be essential to the species' conservation. Those areas may be proposed for designation as "critical habitat." Federal agencies and project developers proposing activities that would require a federal permit (e.g. USACE 404 permit), must make special efforts to protect the important characteristics of these areas. Based on a review of the USFWS Information, Planning, and Conservation (IPaC) report (below) (USFWS, 2021c), and the USFWS Critical Habitat Mapper tool (http://ecos.fws.gov/crithab/flex/crithabMapper.jsp?), there is no designated critical habitat within the Review Area (**Figure 6**).

2.8 USFWS IPaC

RKI reviewed information from the USFWS IPaC decision support system dated November 1, 2021 to identify whether endangered species, migratory birds, critical habitat, wildlife refuges, or wetlands could be affected by the proposed project.

2.8.1 IPaC Threatened and Endangered Species

According to the IPaC, one endangered, four threatened, and one candidate species were listed as potentially occurring in the Review Area. See the table below for effect determinations based on field observations. No critical habitat or wildlife refuge areas were identified within or near the Review Area. The IPaC also reports species of migratory birds with the potential to occur in the Review Area (See **Table 2**). The complete IPaC report is included as **Appendix E.**

Table 2. USFWS IPaC Trust Resource Report and Effect Determination

Species Name	Status	Condition Info	Effect?	Pertinent Information
BIRDS				
Piping Plover *Charadrius melodus*	Threatened	Open sandy beaches, especially above tideline, and alkali flats (Cornell 2021b).	No	This species only needs to be considered for wind related projects within the migratory route. Since the project is not wind related, no effect is expected.

Species Name	Status	Condition Info	Effect?	Pertinent Information
Red Knot *Calidris canutus rufa*	Threatened	Breeds in drier tundra areas, such as sparsely vegetated hillsides. Outside of breeding season, it is found primarily in intertidal, marine habitats, especially near coastal inlets, estuaries, and bays (Cornell 2021a).	No	This species only needs to be considered for wind related projects within the migratory route. Since the project is not wind related, no effect is expected.
Eastern Black Rail *Laterallus jamaicensis ssp. jamaicensis*	Threatened	Found in salt and brackish marshes with dense cover but also found in upland areas of these marshes.	No	No suitable habitat for this species within the Review Area. Area is primarily residential and does not contain salt or brackish marshes. No effect is expected.
INSECTS				
Monarch Butterfly *Danaus plexippus*	Candidate	Found statewide. Adults are found in a variety of habitats including native prairies, pastures, open woodlands, and savannas, desert scrub, roadsides and other habitats with abundant nectar plants, including urbanized areas. Although adults may be present year round, they are primarily encountered between march and November, and are most commonly observed in the summer and fall during breeding and migration. Caterpillars are found on various species of the family Asclepiadaceae (occasionally treated as subfamily of Apocynaceae). Common host plants in Texas include milkweeds (*Asclepias spp.*) milkweed vines (*Matelea spp.*) climbing milkweed (*Funastrum spp.*), swallowworts (*Cynanchum spp.*), and Anglepod (*Gonolobus suberosus*). Caterpillars are most frequently observed between April and September.	No	During field reconnaissance and habitat assessment, this species was not observed nor any of its suitable habitat within the Review Area. No effect is expected.
MAMMALS				
West Indian Manatee *Trichechus manatus*	Threatened	Found in marine, estuarine, and freshwater environments. Prefers slow-moving waters of rivers, estuaries, salt-water bays, canals, and coastal areas (National Wildlife Federation [NWF] 2021).	No	The Review Area does not contain suitable habitat for this species. No effect is expected.

Species Name	Status	Condition Info	Effect?	Pertinent Information
FLOWERING PLANTS				
Texas prairie dawn *Hymenoxys texana*	Endangered	Texas endemic; in poorly drained, sparsely vegetated areas (slick spots) at the base of mima mounds in open grassland or almost barren areas on slightly saline soils that are sticky when wet and powdery when dry; flowering late February-early April.	No	The Review Area does not consist of barren areas and does not have the salinity that the species prefers. There will be no effect on this species.

2.8.2 Migratory Birds

The Migratory Bird Treaty Act (MBTA) of 1918 (*16 USC § 703 – 705*) prohibits the take, possession, import, export, transport, selling, purchase, barter or offering for sale, purchase, or barter, of migratory birds, their eggs, parts, and nest except as authorized under a valid permit. It prohibits the "taking" any native birds; "taking" can mean killing a wild bird or possessing parts of a wild bird, including feathers, nests, or eggs.

The USFWS identified migratory bird species with a potential to occur within the Review Area, but others may occur. A complete species list and their seasonal occurrence can be seen in **Appendix E.** One inactive nest was observed in the south central portion of the proposed detention area within the Review Area (See **Figure 4**).

See **Section 3.2** for recommendations for federally-protected migratory birds.

2.8.3 Refuges

The proposed project does not occur on National Wildlife Refuge lands; therefore, it is not subject to the “Compatibility Determination” process by any refuges.

3.0 CONCLUSIONS AND RECOMMENDATIONS

3.1 Conclusions

The Review Area consists of approximate 13.7-acre proposed detention area to the west along Huffmeister Road and three outfall locations in Cypress, Harris County, Texas. The adjacent properties consist of single-family residential homes within the Ravensway Subdivision, Huffmeister Road running along the west side of the detention area, and undeveloped, forested land leading to Cypress Creek on the east side of the Review Area.

Based on the information reviewed:

- No designated critical habitat occurs in the Review Area.
- *No effect* on federally-listed species is anticipated.
- Potential habitat exists for the following state-threatened species:
    - Rafinesque's Big-Eared Bat (*Corynorhinus rafinesquii)*
    - Louisiana Pig Toe (*Pleurobema riddellii*)
    - Sandbank Pocketbook (*Lampsilis satura*)
    - Alligator Snapping Turtle (*Macrochelys temminckii*)
- BMPs outlined in **Section 3.2** may be considered to avoid impacting these species.
- There is the potential to encounter migratory birds. **Section 3.2** also includes recommendations related to migratory birds.

3.2 Recommendations

BMPs may be considered to minimize potential impacts to state-listed species and other wildlife. The following BMPs, established under a Programmatic Agreement between the TPWD and the Texas Department of Transportation (TxDOT), have been successfully used on transportation projects statewide. They are relevant to the proposed project, and may be considered, but are not required since this is not a TxDOT project.

3.2.1 Migratory Birds

The USFWS typically recommends that activities requiring vegetation removal or disturbance avoid the *peak nesting period* (March through August) to avoid destruction of individuals, nests, or eggs. If project activities must be conducted during this time, the USFWS recommends surveying for nests prior to commencing work. If a nest is found, and if possible, the USFWS recommends that specific vegetation buffers (>50m for songbirds; >180m for birds of prey) remain around the nest until young have fledged or the nest is abandoned.

3.2.2 Rafinesque's Big-Eared Bat

The following survey and exclusion protocols should be followed prior to commencement of construction activities. For the purposes of this document, structures are defined as bridges, culverts (concrete or metal), wells, and buildings.

- Inform TPWD WHAB during initial collaborative review phase for projects that may impact the following bat species:
    - Any *Myotis spp.*
    - Tricolored bat (*Perimyotis subflavus*)
- If identification of a bat species is in question, consult with TPWD or a qualified TxDOT biologist during initial collaborative review phase
- For roosts where occupancy is strongly suspected but unconfirmed during the initial survey, revisit feature(s) at most four weeks prior to scheduled disturbance to confirm absence of bats.
- If bats are present or recent signs of occupation (i.e., piles of guano, distinct musky odor, or staining and rub marks at potential entry points) are observed, take appropriate measures to ensure that bats are not harmed, such as implementing non-lethal exclusion activities or timing or phasing of construction.
- Exclusion devices can be installed by a qualified individual between September 1 and March 31. Exclusion devices should be used for a minimum of seven days when minimum nighttime temperatures are above 50°F AND minimum daytime temperatures are above 70°F. Prior to exclusion, ensure that alternate roosting habitat is available in the immediate area. If no suitable roosting habitat is available, installation of alternate roosts is recommended to replace the loss of an occupied roost. If alternate roost sites are not provided, bats may seek shelter in other inappropriate sites, such as buildings, in the surrounding area.
- If feature(s) used by bats are removed as a result of construction, replacement structures should incorporate bat-friendly design or artificial roosts should be constructed to replace these features
- Conversion of property containing cave or cliff features to transportation purposes should be avoided.
- Large hollow trees, snags (dead standing trees), and trees with shaggy bark should be surveyed for colonies and, if found, should not be disturbed until the bats are no longer occupying these features. Post-occupancy surveys should be conducted by a qualified biologist prior to tree removal from the landscape.
- Retain mature, large diameter hardwood forest species and native/ornamental palm trees.
- In all instances, avoid harm or death to bats. Bats should only be handled as a last resort and after communication with TPWD.
- Coordinate with TPWD about the latest bat handling restrictions and protocols involving COVID19 and bat handling. In general, all staff must follow the guidelines listed below:
    - Do not handle bats if not part of a critical or time-sensitive research project. Contact TPWD to discuss your project needs before beginning work.
    - All participants must follow CDC social-distancing guidelines.
    - Wear a face mask to minimize the exchange of respiratory droplets such as a surgical mask, dust mask, or cloth mask when within 6 feet of a living bat.
    - Use disposable exam gloves or other reusable gloves (e.g., rubber dish-washing gloves) that can be decontaminated to prevent spread of pathogens. Do not touch your face or other potentially contaminated surfaces with your gloves prior to handling bats.
    - Limit handling to as few handlers as possible.
    - Do not blow on bats for any reason.
    - Use separate temporary holding containers for each bat such as disposable paper bags.
    - Caves housing bats should be avoided unless absolutely necessary.
    - Implement additional disinfection, quarantine, and cleaning procedures.
- Bat surveys of structures should include visual inspections of structural fissures (cracked or spalled concrete, damaged or split beams, split or damaged timber railings), crevices (expansion joints, space between parallel beams, spaces above support piers), and alternative structures (drainage

pipes, bolt cavities, open sections between support beams, swallow nests) for the presence of bats.

- Before excluding bats from any occupied structure, bat species, weather, temperature, season, and geographic location must be incorporated into any exclusion plans to avoid unnecessary harm or death to bats. Winter exclusion must entail a survey to confirm either, 1) bats are absent or 2) present but active (i.e., continuously active – not intermittently active due to arousals from hibernation).
    - Avoid using materials that degrade quickly, like paper, steel wool or rags, to close holes.
    - Avoid using products or making structural modifications that may block natural ventilation, like hanging plastic sheeting over an active roost entrance, thereby altering roost microclimate.
    - Avoid using chemical and ultrasonic repellents.
    - Avoid use of silicone, polyurethane or similar non-water-based caulk products.
    - Avoid use of expandable foam products at occupied sites.
    - Avoid the use of flexible netting attached with duct tape.
- In order to avoid entombing bats, exclusion activities should be only implemented by a qualified individual. A qualified individual or company should possess at least the following minimum qualifications:
    - Experience in bat exclusion (the individual, not just the company).
    - Proof of rabies pre-exposure vaccinations.
    - Demonstrated knowledge of the relevant bat species, including maternity season date range and habitat requirements.
    - Demonstrated knowledge of rabies and histoplasmosis in relation to bat roosts.
- Contact TPWD for additional resources and information to assist in executing successful bat exclusions that will avoid unnecessary harm or death in bats.

3.2.3 Louisiana Pig-Toe

When work is adjacent to the water: Water Quality BMP implemented as part of the Texas Commission on Environmental Quality (TCEQ) Stormwater Pollution Prevention Plan (SWPPP) for a construction general permit or any conditions of the 401 Water Quality Certification for the project will be implemented.

In addition to BMP required for a TCEQ Storm Water Pollution Prevention Plan and/or 401 Water Quality Certification:

- Minimize the use of equipment in streams and riparian areas during construction. When possible, equipment access should be from banks, bridge decks, or barges.
- When temporary stream crossings are unavoidable, remove stream crossings once they are no longer needed and stabilize banks and soils around the crossing.
- Wet-Bottomed detention ponds are recommended to benefit wildlife and downstream water quality. Consider potential wildlife-vehicle interactions when siting detention ponds.
- Rubbish found near bridges on TxDOT ROW should be removed and disposed of properly to minimize the risk of pollution. Rubbish does not include brush piles or snags.
- Use spanning bridges rather than culverts.
- If using a culvert, staggered culverts that concentrate low flows but provide conveyance of higher flows through staggered culverts placed at higher elevations is recommended.

- Bottomless culverts are recommended to allow for fish and other aquatic wildlife passage in the low flow channel. If bottomless culverts are not used, making a low flow channel for fish passage is recommended.
- Avoid placing riprap across stream channels and instead use alternative stabilization such as biotechnical stream bank stabilization methods including live native vegetation or a combination of vegetative and structural materials. When riprap or other bank stabilization devices are necessary, their placement should not impede the movement of aquatic and terrestrial wildlife underneath the bridge. In some instances, rip rap may be buried, back-filled with topsoil and planted with native vegetation.

3.2.4 Sandbank Pocketbook

See above referenced BMPs for this species.

3.2.5 Alligator Snapping Turtle

- Minimize impacts to wetland and riverine habitats
- For projects within existing right-of-way (ROW) when work is in water or will permanently impact a water feature and potential habitat exists for the target species complete the following:
    - Minimize impacts to wetlands, temporary and permanent open water features, including depressions, and riverine habitats.
    - Maintain the existing hydrologic regime and any connections between wetlands and other aquatic features.
    - Use barrier fencing to direct animal movements away from construction activities and areas of potential wildlife-vehicle collisions in construction areas directly adjacent, or that may directly impact, potential habitat for the target species.
    - Apply hydromulching and/or hydroseeding in areas for soil stabilization and/or revegetation of disturbed areas around wetlands and in riparian areas. If erosion control blankets or mats will be used, the product should not contain netting, but should only contain loosely woven natural fiber netting in which the mesh design allows the threads to move, therefore allowing expansion of the mesh openings. Plastic netting should be avoided.
    - Project specific locations (PSLs) proposed within state-owned ROW should be located in uplands away from aquatic features.
    - When work is directly adjacent to the water, minimize impacts to shoreline basking sites (e.g., downed trees, sand bars, exposed bedrock) and refugia/overwinter sites (e.g., brush and debris piles, crayfish burrows, aquatic logjams, and leaf packs).
    - If gutters and curbs are part of the roadway design, install gutters that do not include the side box inlet and include sloped (i.e., mountable) curbs to allow small animals to leave roadway. If this modification to the entire curb system is not possible, install sections of sloped curb on either side of the storm water drain for several feet to allow small animals to leave the roadway. Priority areas for these design recommendations are those with nearby wetlands or other aquatic features.
- For projects that require acquisition of additional ROW and work within that new ROW is in water or will permanently impact a water feature, implement BMP for projects within existing ROW above plus those below:
    - For sections of roadway adjacent to wetlands or other aquatic features, install wildlife barriers that prevent climbing. Barriers should terminate at culvert openings in order to

funnel animals under the road. The barriers should be of the same length as the adjacent feature or 80 feet long in each direction, or whichever is the lesser of the two.

  - For culvert extensions and culvert replacement/installation, incorporate measures to funnel animals toward culverts such as concrete wingwalls and barrier walls with overhangs.
  - When riprap or other bank stabilization devices are necessary, their placement should not impede the movement of terrestrial or aquatic wildlife through the water feature. Biotechnical streambank stabilization methods using live native vegetation or a combination of vegetative and structural materials should be used.

- Minimize the use of equipment in streams and riparian areas during construction. When possible, equipment access should be from banks, bridge decks, or barges.
- When temporary stream crossings are unavoidable, remove stream crossings once they are no longer needed and stabilize banks and soils around the crossing.
- Wet-Bottomed detention ponds are recommended to benefit wildlife and downstream water quality. Consider potential wildlife-vehicle interactions when siting detention ponds.
- Rubbish found near bridges should be removed and disposed of properly to minimize the risk of pollution. Rubbish does not include brush piles or snags.

4.0 REFERENCES

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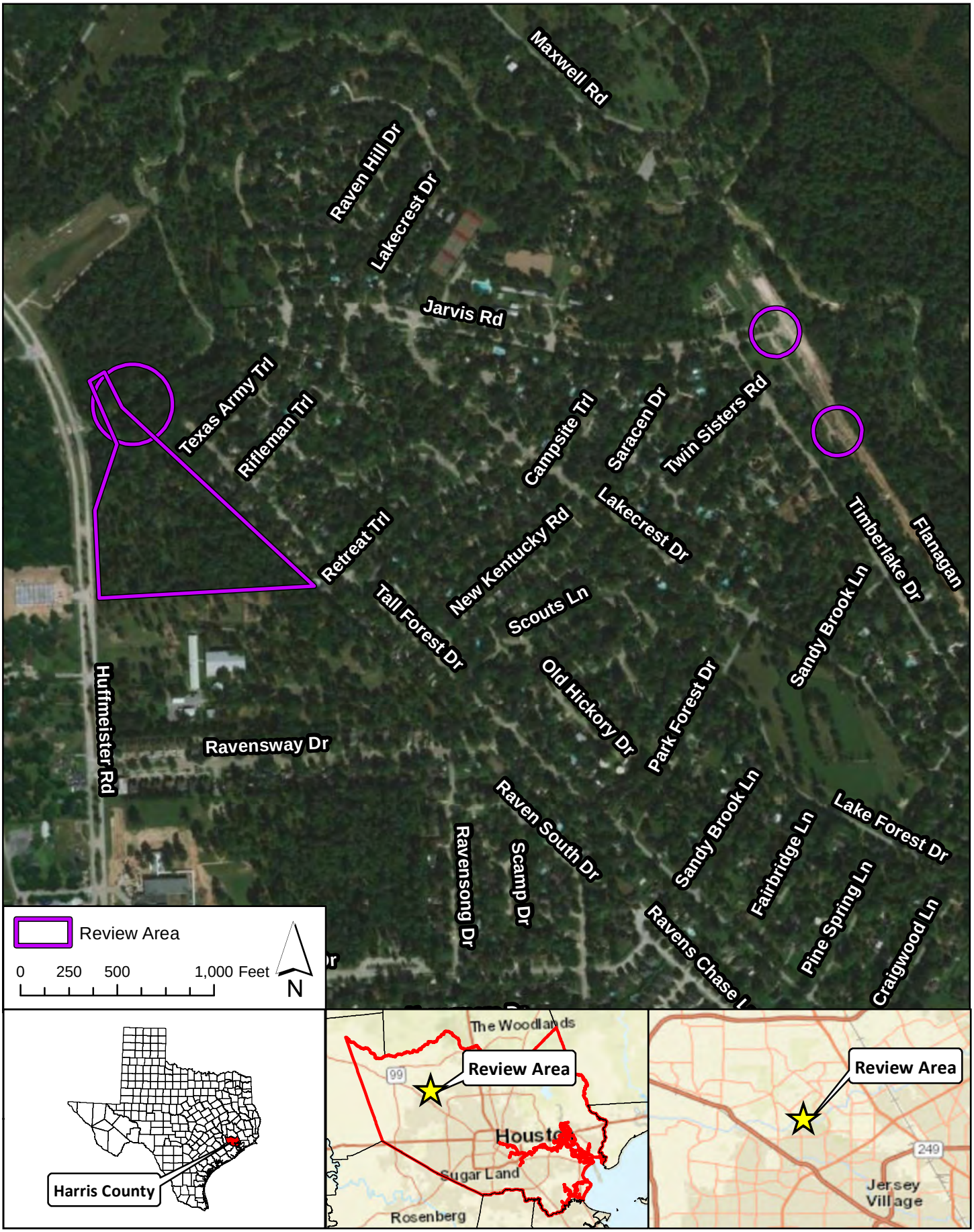
5.0 ACRONYMS

.shp	shapefile
BMP	Best Management Practices
RCB	Reinforced Concrete Box
EMST	Ecological Mapping System of Texas
EO	Element of Occurrence
SF	Source Feature
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
GIS	Geographic Information System
IPaC	Information, Planning, and Conservation
MBTA	Migratory Bird Treaty Act
NWF	National Wildlife Federation
NWI	National Wetlands Inventory
RKI	Raba Kistner, Inc.
SRCC	Southern Regional Climate Center
TPWD	Texas Parks and Wildlife Department
TXNDD	Texas Natural Diversity Database
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
USACE	U.S. Army Corps of Engineers

FIGURES



Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea,

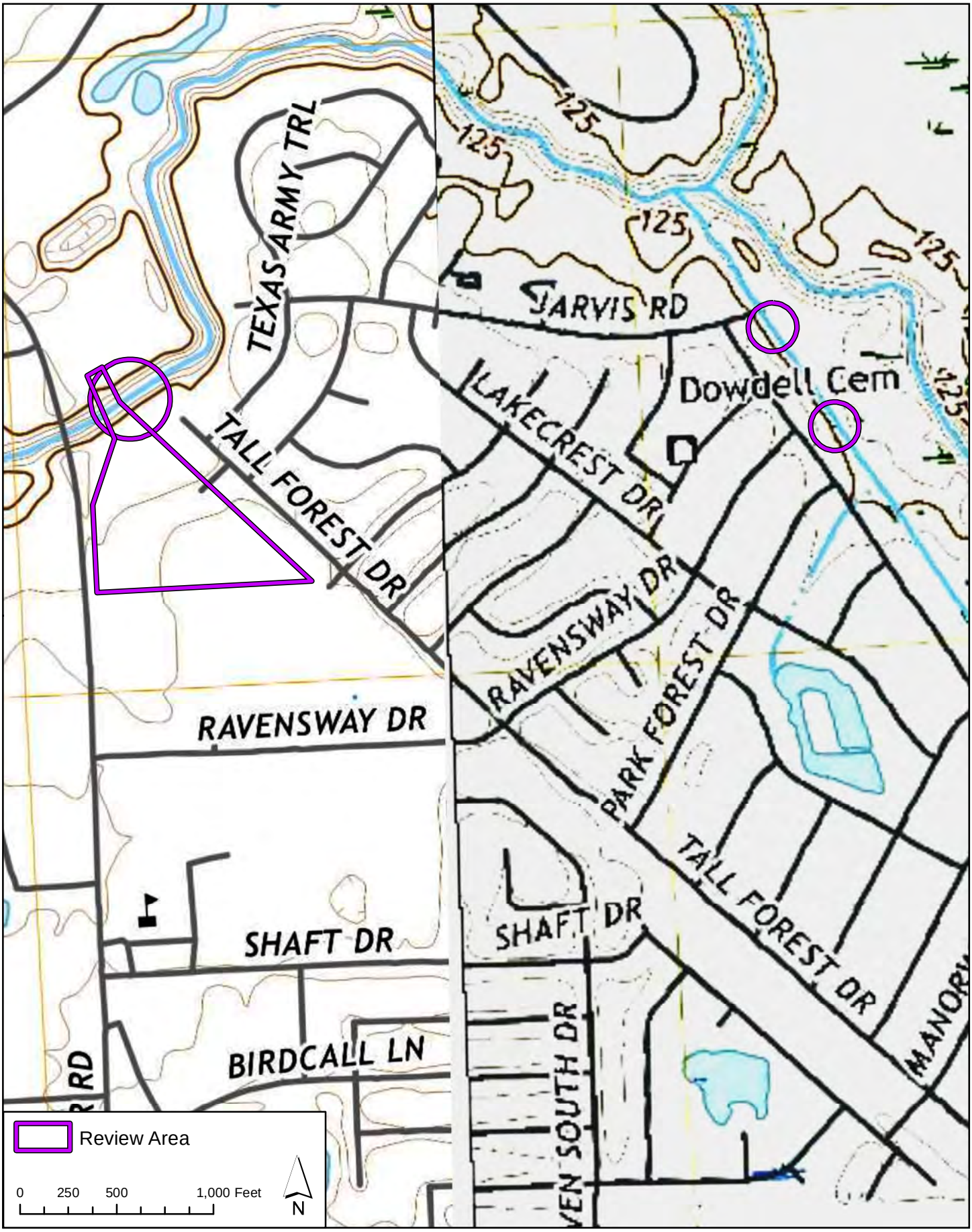
RABA KISTNER

PROJECT LOCATION

Ravensway Subdivision Drainage Improvements
Harris County, Texas
RKI Project No. ASF21-116-00

FIGURE

1



SOURCE: USGS 7.5 Minute Topographic Map, Cypress Texas Quadrangle (2019), Satsuma Texas Quadrangle (2019)

USGS TOPOGRAPHIC

Ravensway Subdivision Drainage Improvements
Harris County, Texas
RKI Project No. ASF21-116-00

FIGURE

2

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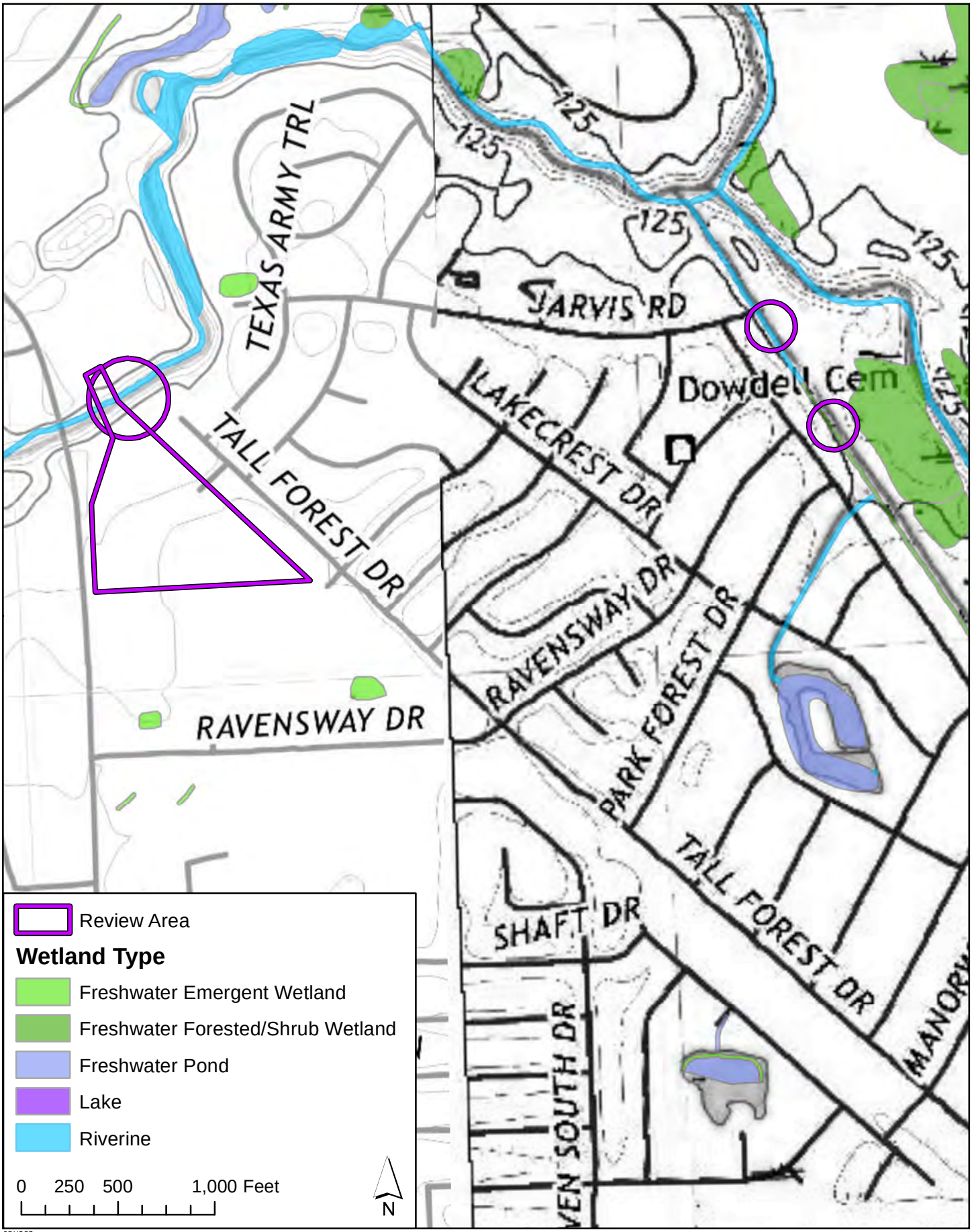


SOURCE:
1) USGS 7.5 Minute Topographic Map, Cypress Texas Quadrangle (2019), Satsuma Texas Quadrangle (2019)
2) USFWS National Wetlands Inventory Data - Spring Watershed (Downloaded 4/27/2021)

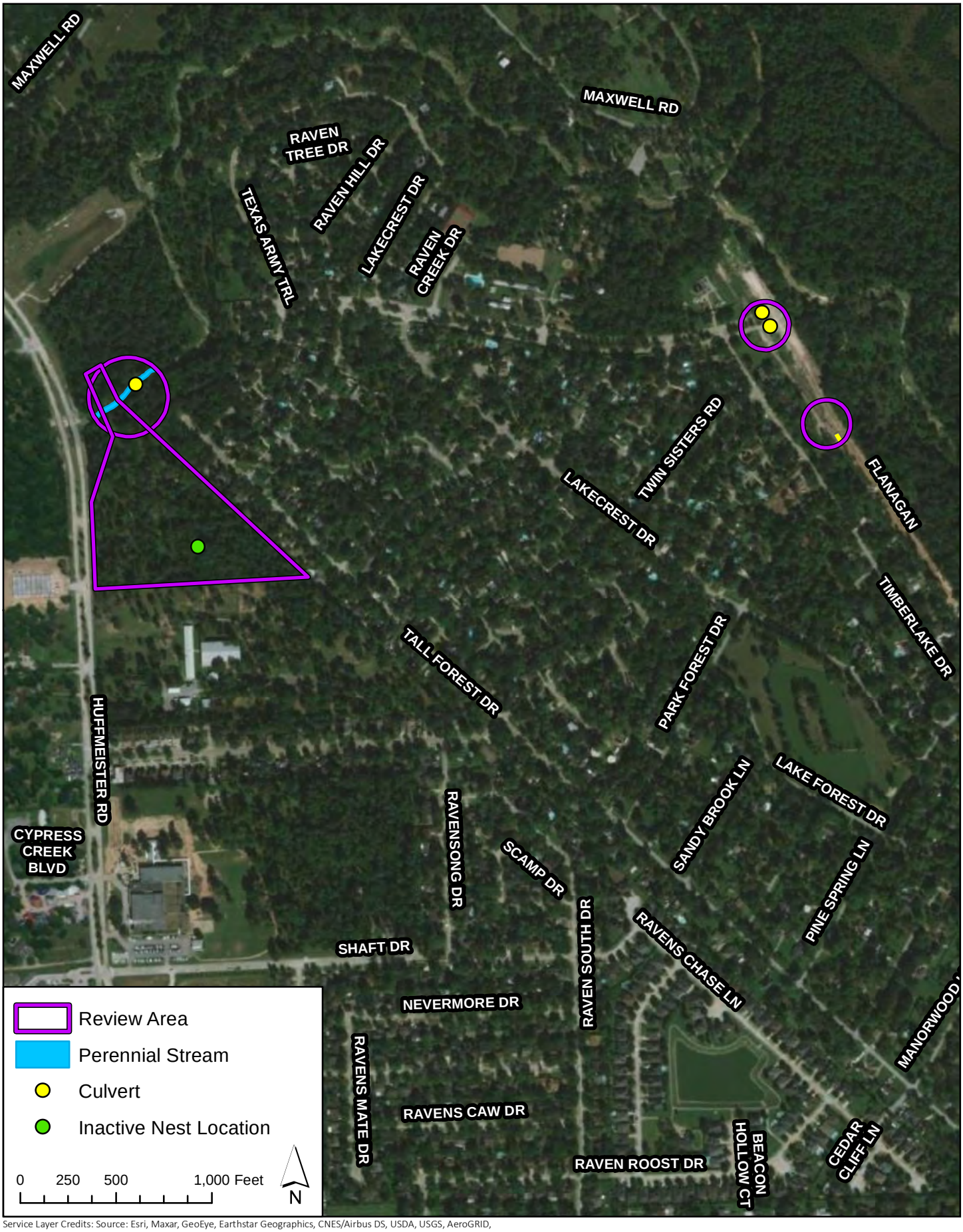
NATIONAL WETLANDS INVENTORY

Ravensway Subdivision Drainage Improvements
Harris County, Texas
RKI Project No. ASF21-116-00

FIGURE

3

RABA KISTNER



Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID,

POTENTIAL THREATENED AND ENDANGERED SPECIES HABITAT

Ravensway Subdivision Drainage Improvements
Harris County, Texas
RKI Project No. ASF21-116-00

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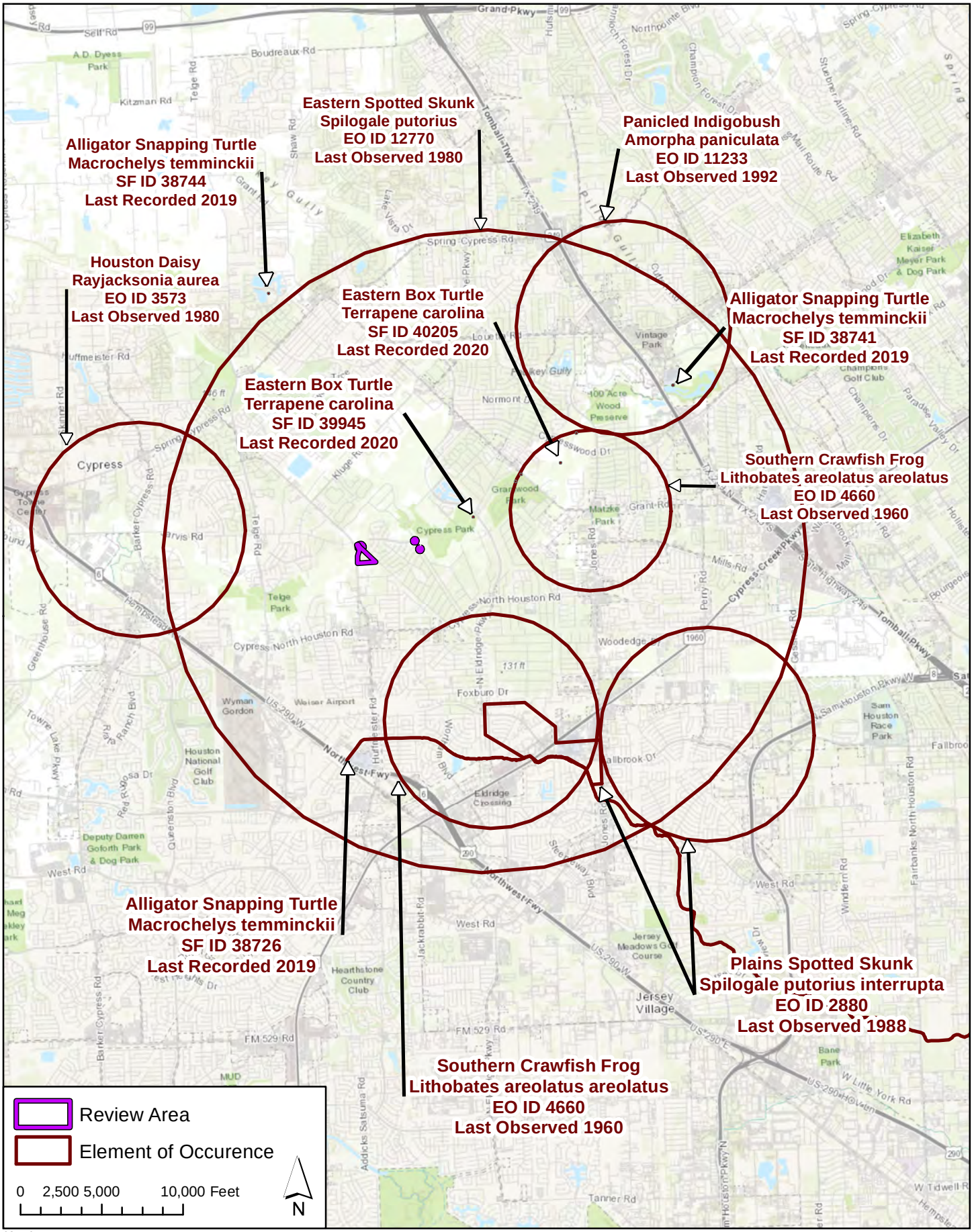
FIGURE 4



SOURCE:
1.) ESRI, Garmin, Intermap, USGS, FAO, NPS, NRCAN, GeoBase
2.) NDD data via TPWD 2019

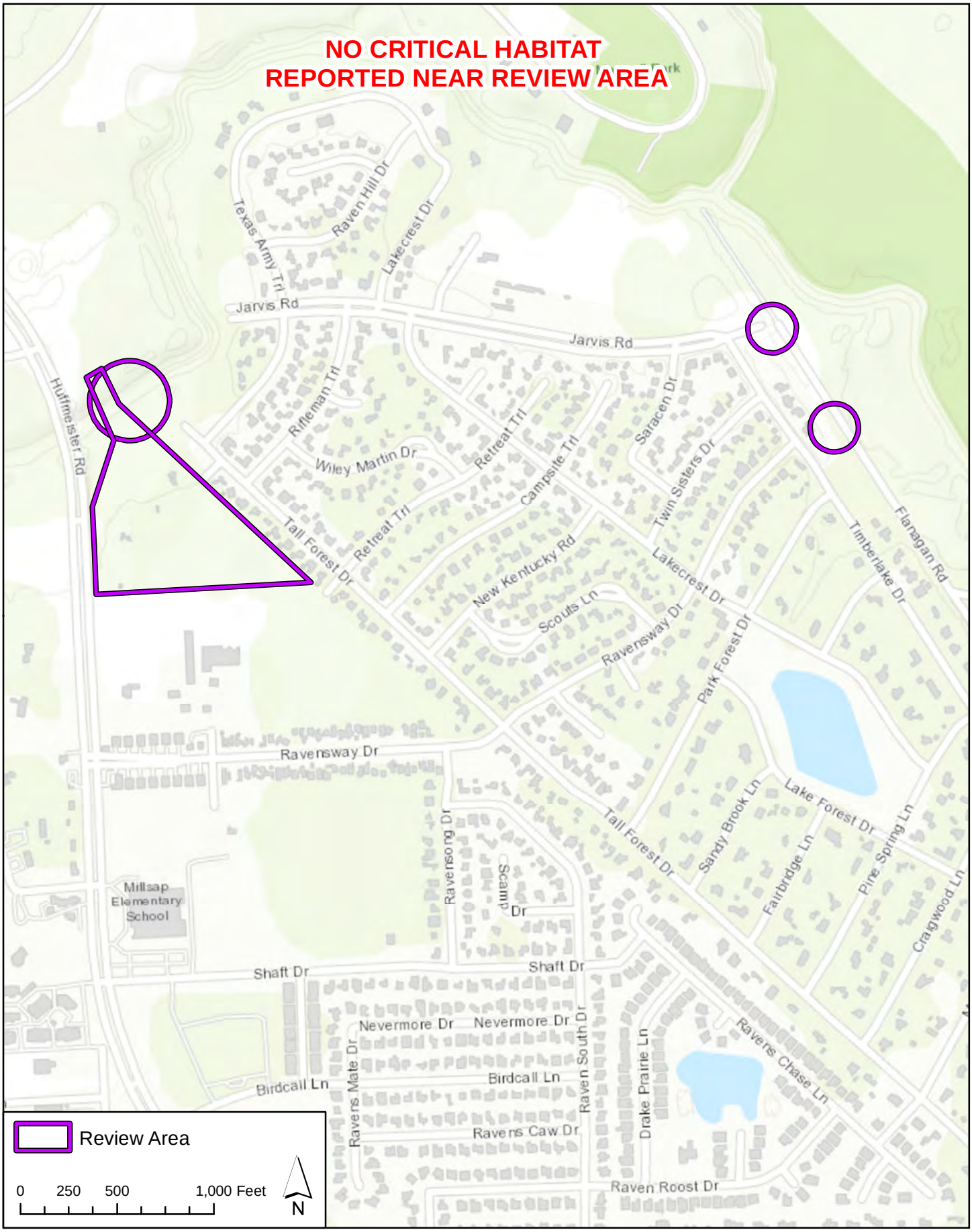
TPWD NATURAL DIVERSITY DATABASE

Ravensway Subdivision Drainage Improvements
Harris County, Texas
RKI Project No. ASF21-116-00

FIGURE

5

RABA KISTNER



Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase,

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USFWS CRITICAL HABITAT

Ravensway Subdivision Drainage Improvements
Harris County, Texas
RKI Project No. ASF21-116-00

FIGURE

6

APPENDIX A

PHOTOGRAPHS

Photo 1: Metal culvert located in the north eastern Review Area.

Photo 2: Large concrete culvert located within the southeastern Review Area.

Photo 3: Metal culvert on the south side of Cypress Creek in the northwest portion of the Review Area.

Photo 4: View of Cypress Creek facing east in the northwest portion of the Review Area.

Photo 5: Huffmeister Road crossing Cypress Creek in the northwest portion of the Review Area.

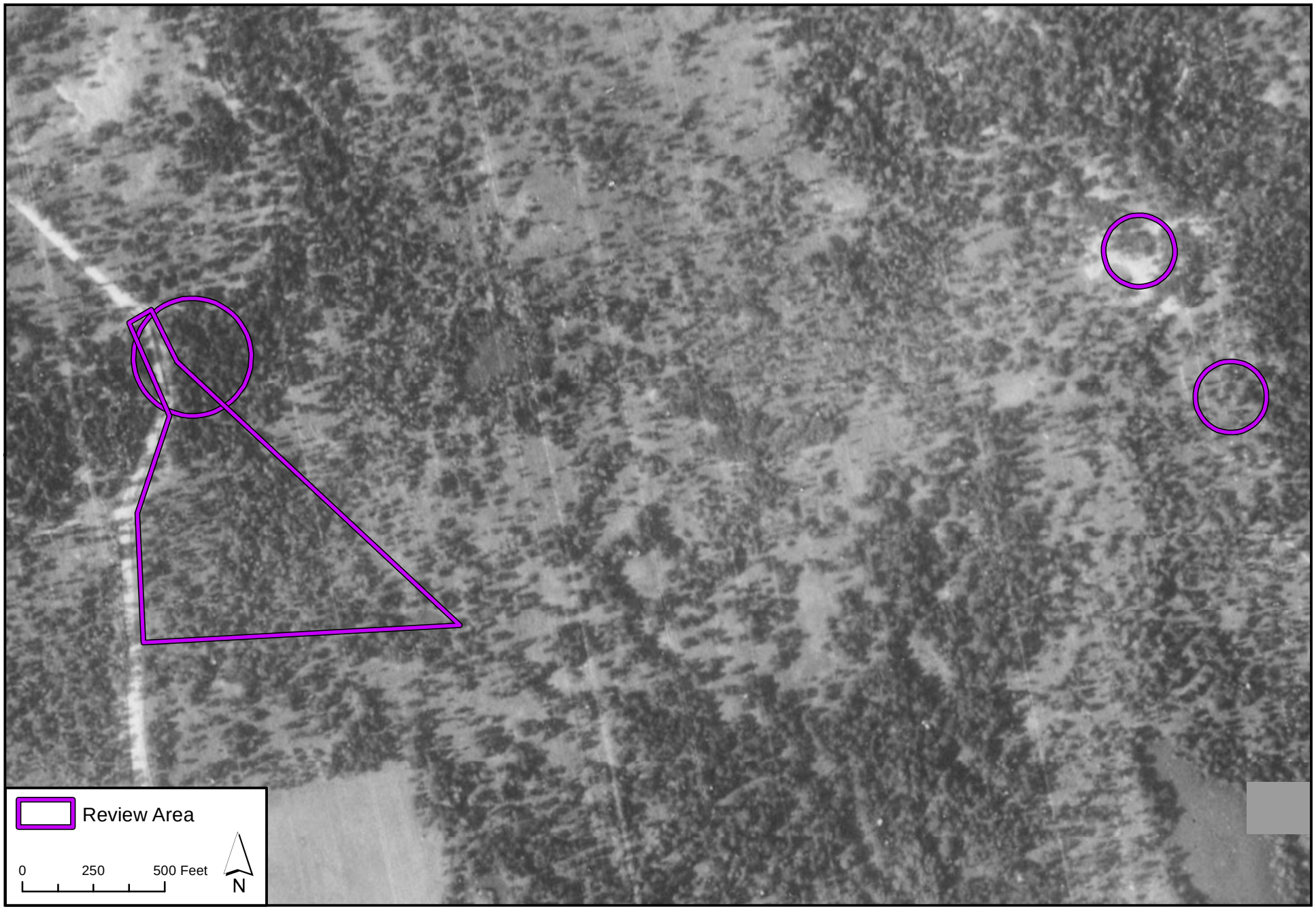
Photo 6: View within the riparian buffer on the north side of Cypress Creek on the northwest side of the Review Area.

Photo 7: Inactive nest in the south central portion of the proposed detention area within the Review Area (See **Figure 4**).

Photo 8: View within the proposed detention area within the western portion of the Review Area.

APPENDIX B

HISTORICAL AERIAL PHOTOGRAPHS



1930 HISTORIC AERIAL PHOTOGRAPH

Ravensway Subdivision Drainage Improvements
Harris County, Texas
RKI Project No. ASF21-116-00

APPENDIX

B

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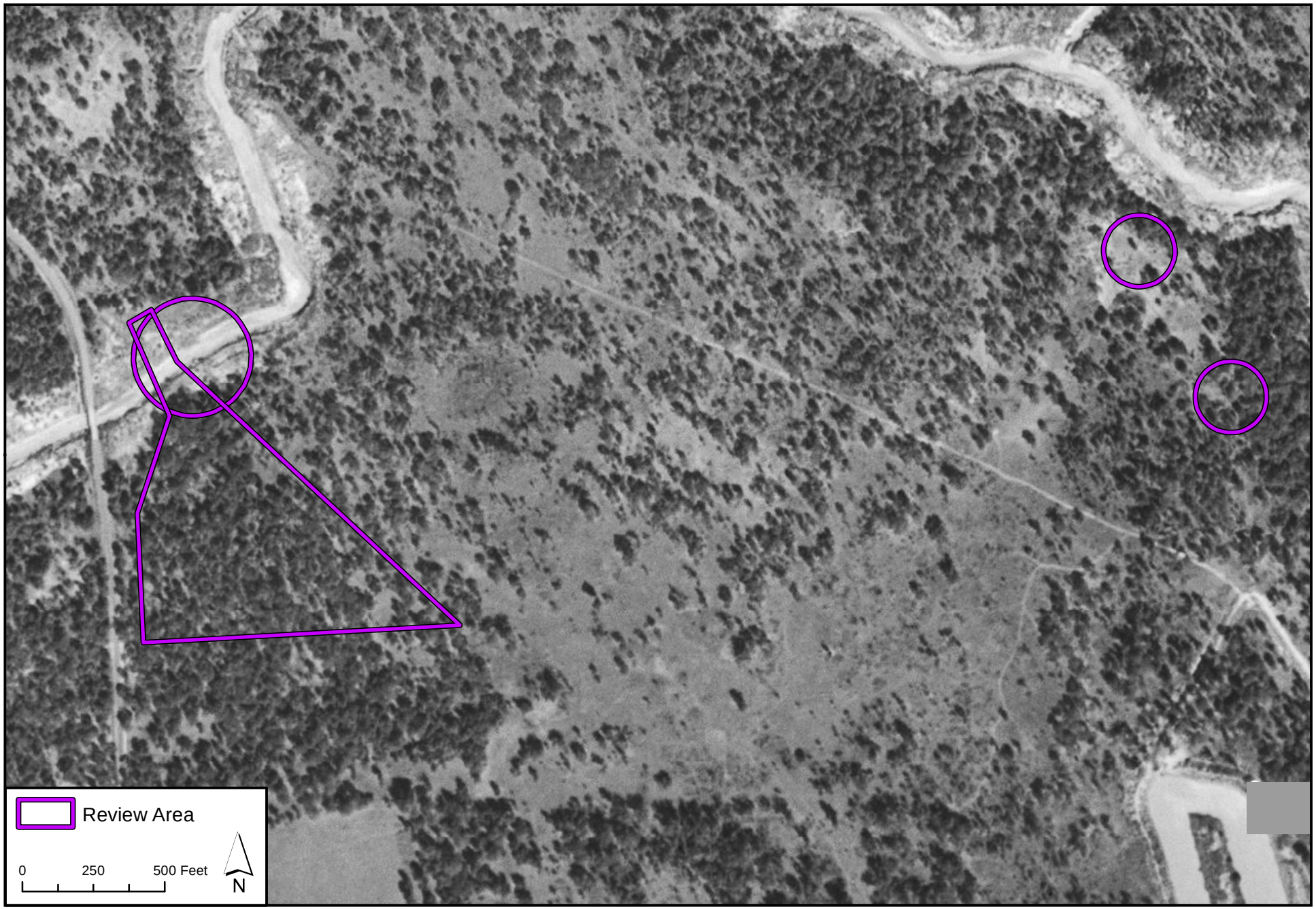

1953 HISTORIC AERIAL PHOTOGRAPH

Ravensway Subdivision Drainage Improvements
Harris County, Texas
RKI Project No. ASF21-116-00

APPENDIX

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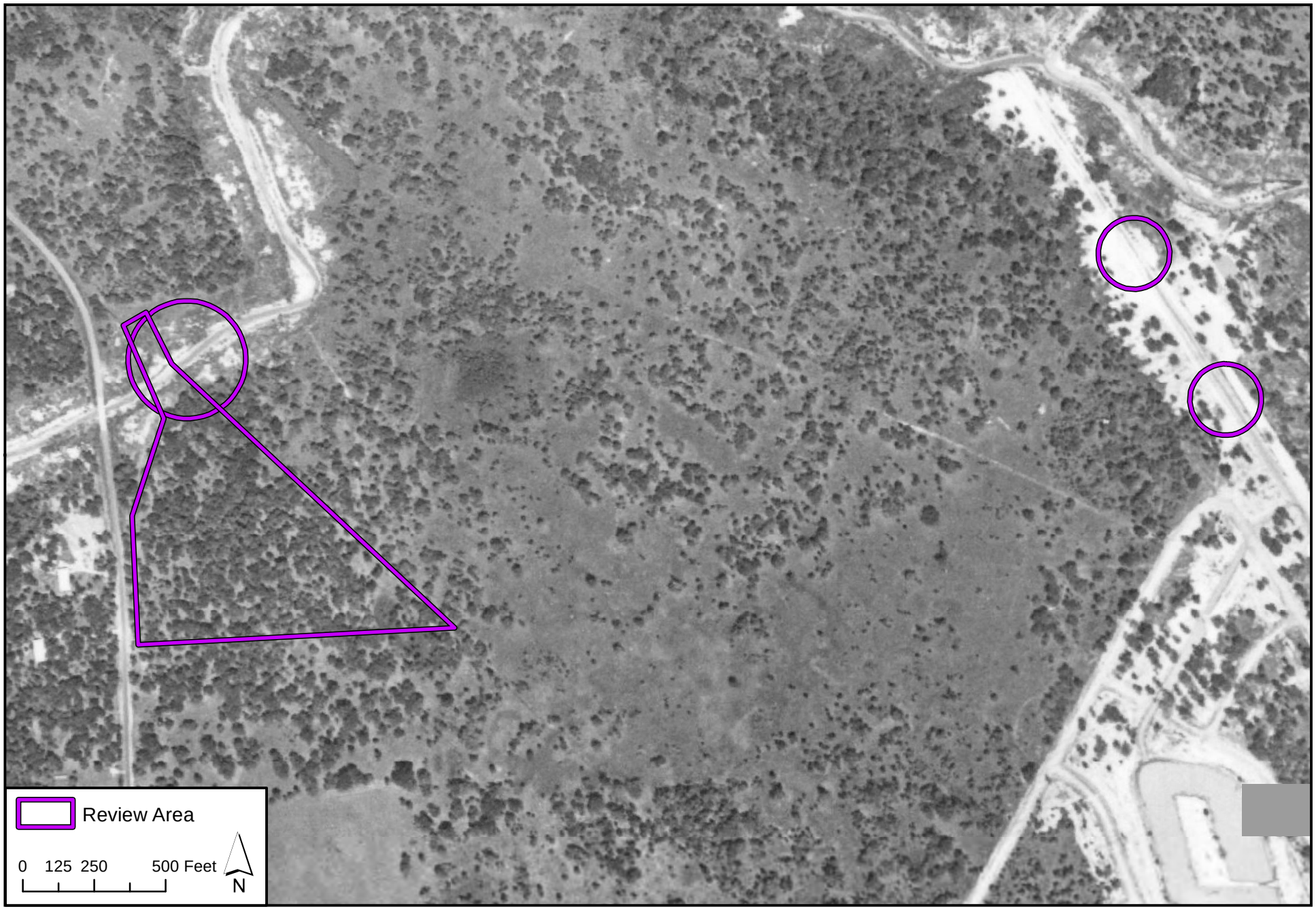

1957 HISTORIC AERIAL PHOTOGRAPH

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RKI Project No. ASF21-116-00

APPENDIX

B

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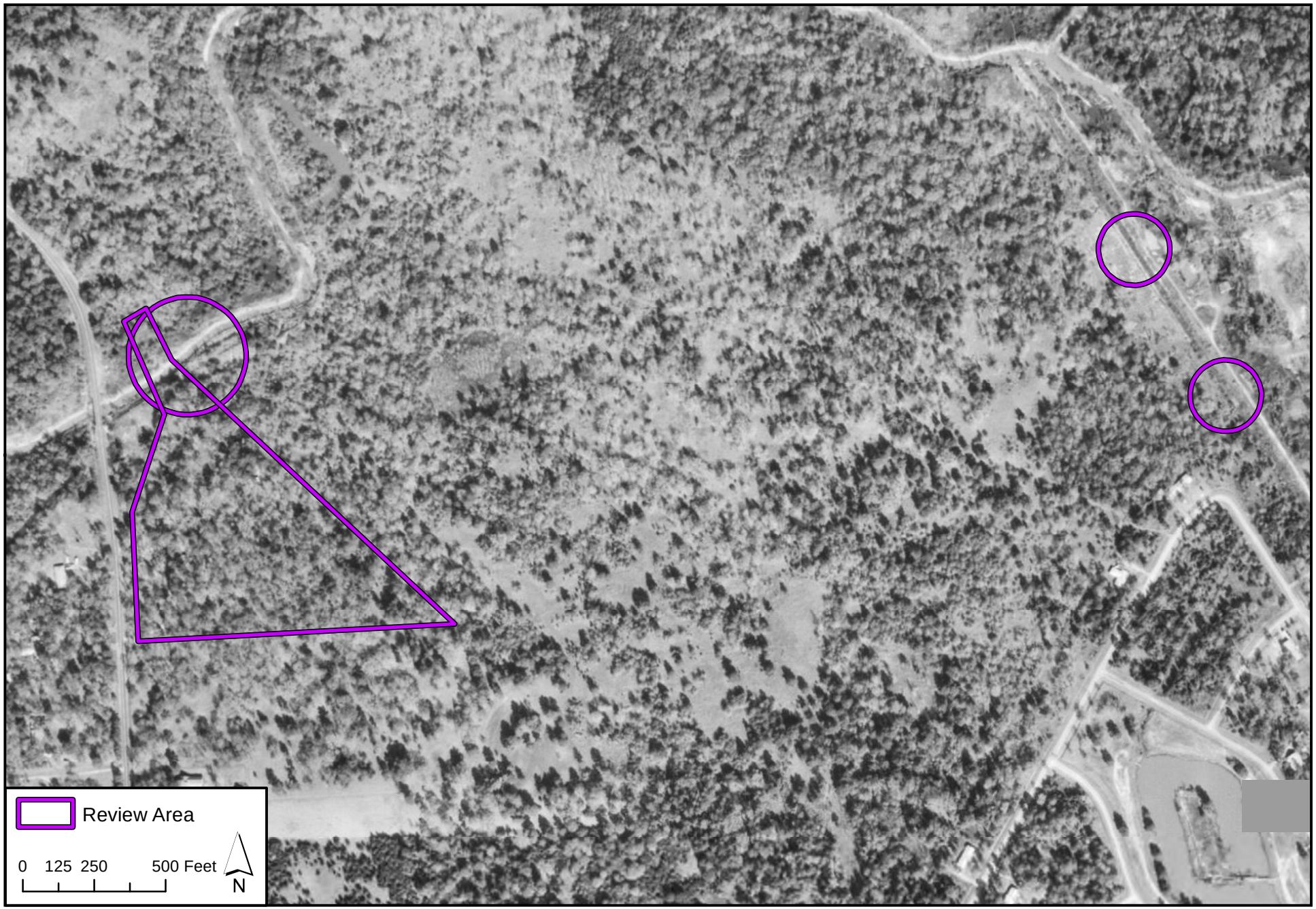

1968 HISTORIC AERIAL PHOTOGRAPH

Ravensway Subdivision Drainage Improvements
Harris County, Texas
RKI Project No. ASF21-116-00

APPENDIX

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1978 HISTORIC AERIAL PHOTOGRAPH

Ravensway Subdivision Drainage Improvements
Harris County, Texas
RKI Project No. ASF21-116-00

APPENDIX

B

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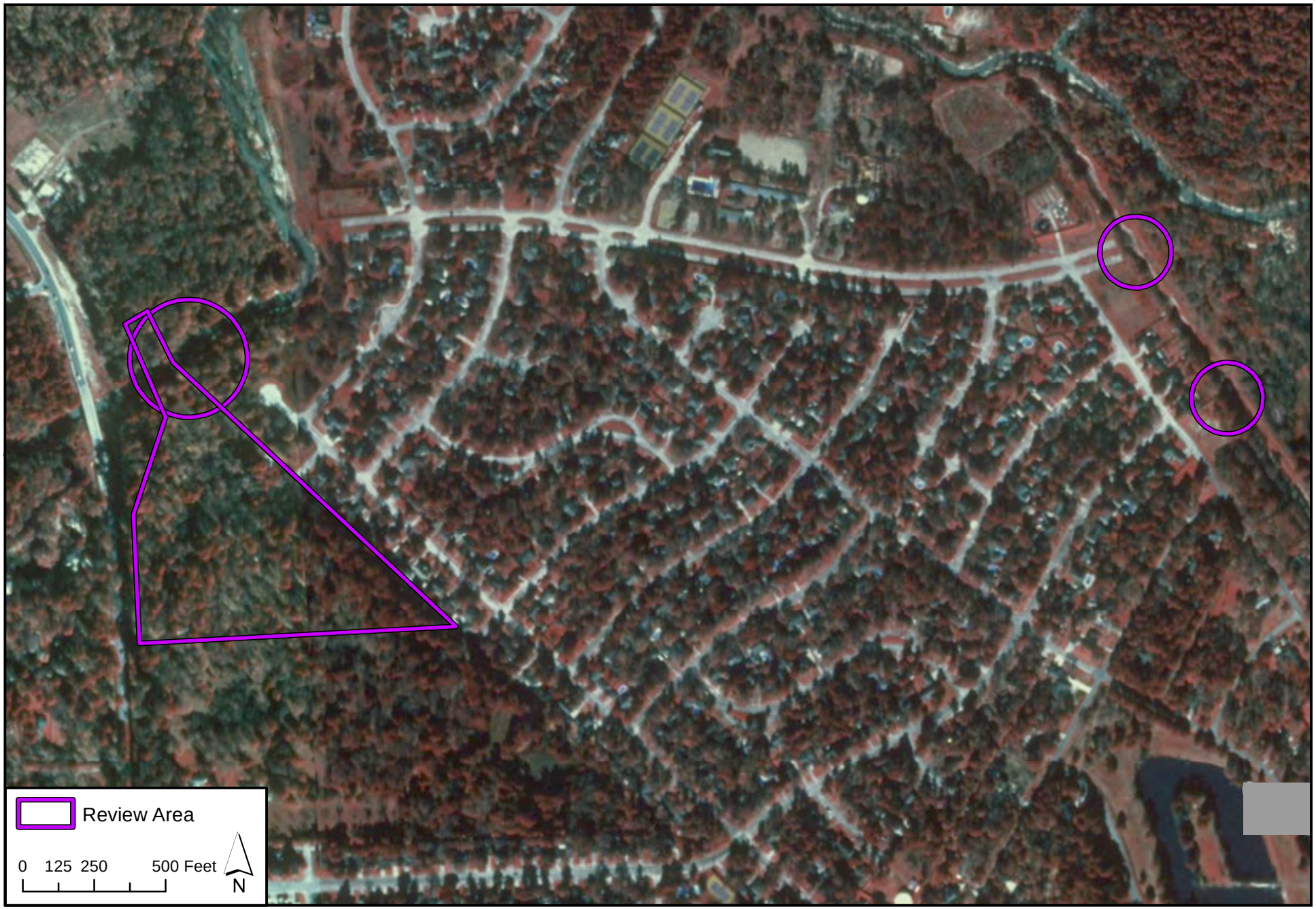

1995 HISTORIC AERIAL PHOTOGRAPH

Ravensway Subdivision Drainage Improvements
Harris County, Texas
RKI Project No. ASF21-116-00

APPENDIX

B

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2010 HISTORIC AERIAL PHOTOGRAPH

Ravensway Subdivision Drainage Improvements
Harris County, Texas
RKI Project No. ASF21-116-00

APPENDIX

B

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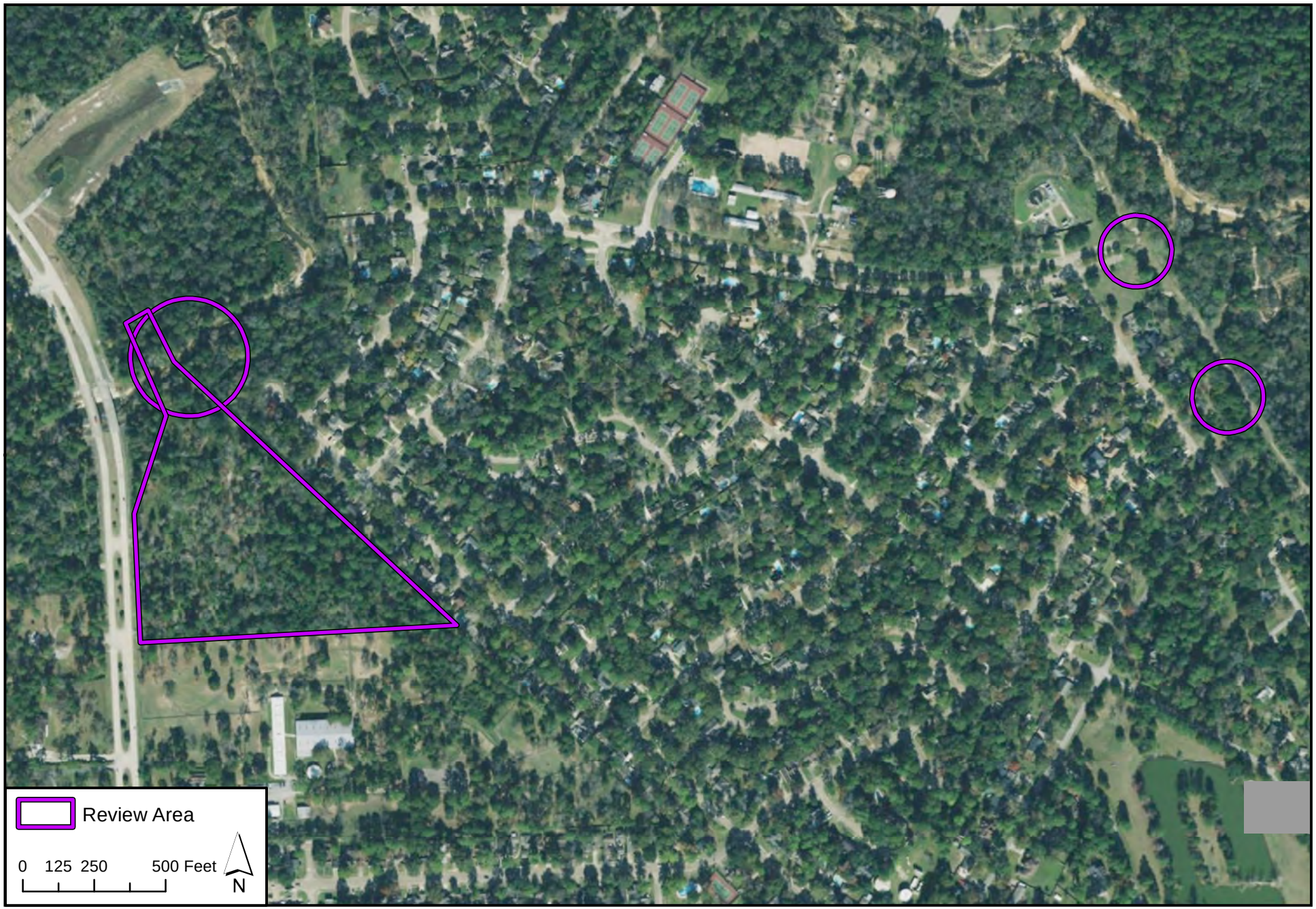

2018 HISTORIC AERIAL PHOTOGRAPH

Ravensway Subdivision Drainage Improvements
Harris County, Texas
RKI Project No. ASF21-116-00

APPENDIX

B

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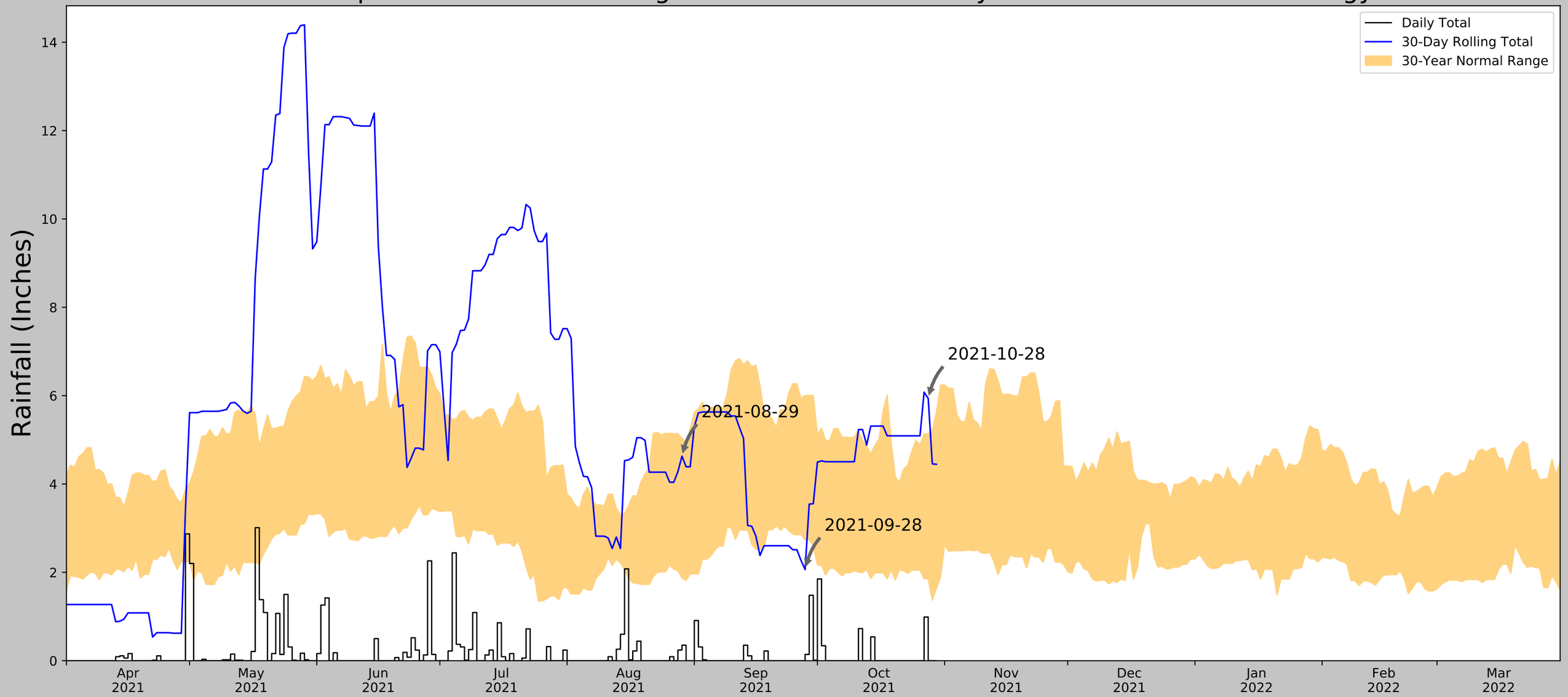
APPENDIX C

ANTECEDENT PRECIPITATION TOOL DATA

Antecedent Precipitation vs Normal Range based on NOAA's Daily Global Historical Climatology Network



Coordinates	29.960289, -95.629658
Observation Date	2021-10-28
Elevation (ft)	130.73
Drought Index (PDSI)	Severe wetness (2021-09)
WebWIMP H_2O Balance	Wet Season

30 Days Ending	30th %ile (in)	70th %ile (in)	Observed (in)	Wetness Condition	Condition Value	Month Weight	Product
2021-10-28	1.853543	5.132677	5.937008	Wet	3	3	9
2021-09-28	2.730709	6.003543	2.062992	Dry	1	2	2
2021-08-29	1.869685	5.037008	4.629921	Normal	2	1	2
Result							Normal Conditions - 13

Figure and tables made by the
Antecedent Precipitation Tool
Version 1.0

Written by Jason Deters
U.S. Army Corps of Engineers

Weather Station Name	Coordinates	Elevation (ft)	Distance (mi)	Elevation Δ	Weighted Δ	Days Normal	Days Antecedent
HOUSTON HOOKS MEM AP	30.0675, -95.5561	151.903	8.616	21.173	4.06	8578	90
TOMBALL	30.1003, -95.6114	209.974	4.008	58.071	2.036	2775	0

APPENDIX D

ANNOTATED LIST OF RARE SPECIES FOR HARRIS COUNTY (TPWD)

Last Update: 10/1/2021

HARRIS COUNTY

AMPHIBIANS

Houston toad *Anaxyrus houstonensis*

Terrestrial and aquatic: Primary terrestrial habitat is forests with deep sandy soils. Juveniles and adults are presumed to move through areas of less suitable soils using riparian corridors. Aquatic habitats can include any water body from a tire rut to a large lake.

Federal Status: LE	State Status: E	SGCN: Y
Endemic: Y	Global Rank: G1	State Rank: S1

southern crawfish frog *Lithobates areolatus areolatus*

Terrestrial and aquatic: The terrestial habitat is primarily grassland and can vary from pasture to intact prairie; it can also include small prairies in the middle of large forested areas. Aquatic habitat is any body of water but preferred habitat is ephemeral wetlands.

Federal Status:	State Status:	SGCN: Y
Endemic: N	Global Rank: G4T4	State Rank: S3

spotted dusky salamander *Desmognathus conanti*

This species occurs in association with aquatic habitats in forested areas. Small, clear, spring fed streams with sandy substrate bordered with ferns and moss as well as murky, stagnant water bodies in cypress swamps, baygalls, and flood plains in bottomland forests support populations of this species.

Federal Status:	State Status:	SGCN: Y
Endemic: N	Global Rank: G5	State Rank: S1

Strecker's chorus frog *Pseudacris streckeri*

Terrestrial and aquatic: Wooded floodplains and flats, prairies, cultivated fields and marshes. Likes sandy substrates.

Federal Status:	State Status:	SGCN: Y
Endemic: N	Global Rank: G5	State Rank: S3

Woodhouse's toad *Anaxyrus woodhousii*

Terrestrial and aquatic: A wide variety of terrestrial habitats are used by this species, including forests, grasslands, and barrier island sand dunes. Aquatic habitats are equally varied.

Federal Status:	State Status:	SGCN: Y
Endemic: N	Global Rank: G5	State Rank: SU

BIRDS

bald eagle *Haliaeetus leucocephalus*

Found primarily near rivers and large lakes; nests in tall trees or on cliffs near water; communally roosts, especially in winter; hunts live prey, scavenges, and pirates food from other birds

Federal Status:	State Status:	SGCN: Y
Endemic: N	Global Rank: G5	State Rank: S3B,S3N

DISCLAIMER

The information on this web application is provided "as is" without warranty as to the currentness, completeness, or accuracy of any specific data. The data provided are for planning, assessment, and informational purposes. Refer to the Frequently Asked Questions (FAQs) on the application website for further information.

HARRIS COUNTY

BIRDS

Black Rail *Laterallus jamaicensis*

Salt, brackish, and freshwater marshes, pond borders, wet meadows, and grassy swamps; nests in or along edge of marsh, sometimes on damp ground, but usually on mat of previous years dead grasses; nest usually hidden in marsh grass or at base of Salicornia

Federal Status: LT	State Status: T	SGCN: Y
Endemic: N	Global Rank: G3	State Rank: S2

Franklin's gull *Leucophaeus pipixcan*

This species is only a spring and fall migrant throughout Texas. It does not breed in or near Texas. Winter records are unusual consisting of one or a few individuals at a given site (especially along the Gulf coastline). During migration, these gulls fly during daylight hours but often come down to wetlands, lake shore, or islands to roost for the night.

Federal Status:	State Status:	SGCN: Y
Endemic: N	Global Rank: G5	State Rank: S2N

mountain plover *Charadrius montanus*

Breeding: nests on high plains or shortgrass prairie, on ground in shallow depression; nonbreeding: shortgrass plains and bare, dirt (plowed) fields; primarily insectivorous

Federal Status:	State Status:	SGCN: Y
Endemic: N	Global Rank: G3	State Rank: S2

piping plover *Charadrius melodus*

Beaches, sandflats, and dunes along Gulf Coast beaches and adjacent offshore islands. Also spoil islands in the Intracoastal Waterway. Based on the November 30, 1992 Section 6 Job No. 9.1, Piping Plover and Snowy Plover Winter Habitat Status Survey, algal flats appear to be the highest quality habitat. Some of the most important aspects of algal flats are their relative inaccessibility and their continuous availability throughout all tidal conditions. Sand flats often appear to be preferred over algal flats when both are available, but large portions of sand flats along the Texas coast are available only during low-very low tides and are often completely unavailable during extreme high tides or strong north winds. Beaches appear to serve as a secondary habitat to the flats associated with the primary bays, lagoons, and inter-island passes. Beaches are rarely used on the southern Texas coast, where bayside habitat is always available, and are abandoned as bayside habitats become available on the central and northern coast. However, beaches are probably a vital habitat along the central and northern coast (i.e. north of Padre Island) during periods of extreme high tides that cover the flats. Optimal site characteristics appear to be large in area, sparsely vegetated, continuously available or in close proximity to secondary habitat, and with limited human disturbance.

Federal Status: LT	State Status: T	SGCN: Y
Endemic: N	Global Rank: G3	State Rank: S2N

red-cockaded woodpecker *Dryobates borealis*

Cavity nests in older pine (60+ years); forages in younger pine (30+ years); prefers longleaf, shortleaf, and loblolly

Federal Status: LE	State Status: E	SGCN: Y
Endemic: N	Global Rank: G3	State Rank: S2

reddish egret *Egretta rufescens*

Resident of the Texas Gulf Coast; brackish marshes and shallow salt ponds and tidal flats; nests on ground or in trees or bushes, on dry coastal islands in brushy thickets of yucca and prickly pear

Federal Status:	State Status: T	SGCN: Y
Endemic: N	Global Rank: G4	State Rank: S2B

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HARRIS COUNTY

BIRDS

Rufa Red Knot *Calidris canutus rufa*

Habitat: Primarily seacoasts on tidal flats and beaches, herbaceous wetland, and Tidal flat/shore. Bolivar Flats in Galveston County, sandy beaches Mustang Island, few on outer coastal and barrier beaches, tidal mudflats and salt marshes

Federal Status: LT	State Status: T	SGCN: Y
Endemic: N	Global Rank: G4T2	State Rank: S2N

swallow-tailed kite *Elanoides forficatus*

Lowland forested regions, especially swampy areas, ranging into open woodland; marshes, along rivers, lakes, and ponds; nests high in tall tree in clearing or on forest woodland edge, usually in pine, cypress, or various deciduous trees

Federal Status:	State Status: T	SGCN: Y
Endemic: N	Global Rank: G5	State Rank: S2B

western burrowing owl *Athene cunicularia hypugaea*

Open grasslands, especially prairie, plains, and savanna, sometimes in open areas such as vacant lots near human habitation or airports; nests and roosts in abandoned burrows

Federal Status:	State Status:	SGCN: Y
Endemic: N	Global Rank: G4T4	State Rank: S2

white-faced ibis *Plegadis chihi*

Prefers freshwater marshes, sloughs, and irrigated rice fields, but will attend brackish and saltwater habitats; currently confined to near-coastal rookeries in so-called hog-wallow prairies. Nests in marshes, in low trees, on the ground in bulrushes or reeds, or on floating mats.

Federal Status:	State Status: T	SGCN: Y
Endemic: N	Global Rank: G5	State Rank: S4B

white-tailed hawk *Buteo albicaudatus*

Near coast on prairies, cordgrass flats, and scrub-live oak; further inland on prairies, mesquite and oak savannas, and mixed savanna-chaparral; breeding March-May

Federal Status:	State Status: T	SGCN: Y
Endemic: N	Global Rank: G4G5	State Rank: S4B

whooping crane *Grus americana*

Small ponds, marshes, and flooded grain fields for both roosting and foraging. Potential migrant via plains throughout most of state to coast; winters in coastal marshes of Aransas, Calhoun, and Refugio counties.

Federal Status: LE	State Status: E	SGCN: Y
Endemic: N	Global Rank: G1	State Rank: S1S2N

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HARRIS COUNTY

BIRDS

wood stork *Mycteria americana*

Prefers to nest in large tracts of baldcypress (Taxodium distichum) or red mangrove (Rhizophora mangle); forages in prairie ponds, flooded pastures or fields, ditches, and other shallow standing water, including salt-water; usually roosts communally in tall snags, sometimes in association with other wading birds (i.e. active heronries); breeds in Mexico and birds move into Gulf States in search of mud flats and other wetlands, even those associated with forested areas; formerly nested in Texas, but no breeding records since 1960

Federal Status:	State Status: T	SGCN: Y
Endemic: N	Global Rank: G4	State Rank: SHB,S2N

CRUSTACEANS

Houston burrowing crayfish *Fallicambarus houstonensis*

All species in the genus <i>Fallicambarus </i>are primary burrowers (Guiasu, 2007). It is clearly a primary burrower with 100% of adult and subadult specimens known from excavated burrows. Large numbers of juveniles were collected from Temporary pools (October through February) (Johnson, 2008).

Federal Status:	State Status:	SGCN: Y
Endemic:	Global Rank: G2	State Rank: S3

FISH

alligator gar *Atractosteus spatula*

From the Red River to the Rio Grande (Hubbs et al. 2008); occurs in the Trinity River upstream of Lake Livingston. Found in rivers, streams, lakes, swamps, bayous, bays and estuaries typically in pools and backwater habitats. Floodplains inundated with flood waters provide spawning and nursery habitats.

Federal Status:	State Status:	SGCN: Y
Endemic: N	Global Rank: G3G4	State Rank: S4

Mississippi silvery minnow *Hybognathus nuchalis*

Found in eastern Texas streams, from the Brazos River eastward and northward to the Red River; found in moderate current; silty, muddy, or rocky substrate. In Texas, adults likely to inhabit smaller tributary streams.

Federal Status:	State Status:	SGCN: Y
Endemic:	Global Rank: G5	State Rank: S4

Oceanic Whitetip Shark *Carcharhinus longimanus*

Habitat description is not available at this time.

Federal Status: LT	State Status: T	SGCN: Y
Endemic: N	Global Rank: GNR	State Rank: S2

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HARRIS COUNTY

FISH

Sabine shiner *Notropis sabinae*

Inhabits small streams and large rivers of eastern Texas from San Jacinto drainage northward along the Gulf Coast to the Sabine River Basin; Habitat generalist with affinities for shallow, moving water and rarely found in pools and backwater areas;
closely restricted to substrate of fine, silt free sand in small creeks and rivers having slight to moderate current.

Federal Status:	State Status:	SGCN: Y
Endemic: N	Global Rank: G4	State Rank: S3

saltmarsh topminnow *Fundulus jenkinsi*

Occupies estuaries and the edges of saltmarsh habitats along the Gulf coast in salinities of 4-20 ppt in Spartina dominated tidal creeks and wetlands (Peterson & Ross 1991; Peterson & Turner 1994; Lopez et al. 2010; and Griffith 1974). Requires access to small interconnected tidal creeks for feeding and reproduction. Spawning occurs from March to August during high tide events (Robertson Thesis, 2016). Non-migratory.

Federal Status:	State Status:	SGCN: Y
Endemic: N	Global Rank: G3	State Rank: S1

Shortfin Mako Shark *Isurus oxyrinchus*

Habitat description is not available at this time.

Federal Status:	State Status: T	SGCN: Y
Endemic: N	Global Rank: GNR	State Rank: S2

silverband shiner *Notropis shumardi*

In Texas, found from Red River to Lavaca River; Main channel with moderate to swift current velocities and moderate to deep depths; associated with turbid water over silt, sand, and gravel.

Federal Status:	State Status:	SGCN: Y
Endemic: N	Global Rank: G5	State Rank: S4

southern flounder *Paralichthys lethostigma*

This is an estuarine-dependent species that inhabits riverine, estuarine and coastal waters, and prefers muddy, sandy, or silty substrates (Reagan and Wingo 1985). Individuals can tolerate wide temperature (~5-35°C) and salinity ranges (0-60 ppt). Southern Flounder spawn in offshore waters of the Gulf of Mexico from October to February (Reagan and Wingo 1985). The oceanic larval stage is pelagic and lasts 30–60 days. Metamorphosing individuals enter estuaries and migrate towards low-salinity headwaters, where settlement occurs (Burke et al. 1991, Walsh et al. 1999). The young fish enter the bays during late winter and early spring, occupying seagrass; some may move further into coastal rivers and bayous. Juveniles remain in estuaries until the onset of sexual maturation (approximately two years), at which time they migrate out of estuaries to join adults on the inner continental shelf. Adult southern flounder leave the bays during the fall for spawning in the Gulf of Mexico. They spawn for the first time when two years old at depths of 50 to 100 feet. Although most of the adults leave the bays and enter the Gulf for spawning during the winter, some remain behind and spend winter in the bays. Those in the Gulf will reenter the bays in the spring. The spring influx is gradual and does not occur with large concentrations that characterize the fall emigration.

Federal Status:	State Status:	SGCN: Y
Endemic: N	Global Rank: G5	State Rank: S5

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HARRIS COUNTY

FISH

western creek chubsucker *Erimyzon claviformis*

Eastern Texas streams from the Red River to the San Jacinto drainage. Habitat includes silt-, sand-, and gravel-bottomed pools of clear headwaters, creeks, and small rivers; often near vegetation; occasionally in lakes. Spawning occurs in river mouths or pools, riffles, lake outlets, or upstream creeks. Prefers headwaters, but seldom occurs in springs.

Federal Status:	State Status: T	SGCN: Y
Endemic: N	Global Rank: G5	State Rank: S2S3

INSECTS

American bumblebee *Bombus pensylvanicus*

Habitat description is not available at this time.

Federal Status:	State Status:	SGCN: Y
Endemic:	Global Rank: G3G4	State Rank: SNR

bay skipper *Euphyes bayensis*

Apparently tidal sawgrass marsh only, probably covers same range of salinity as saw grass, nectarivore (butterfly), herbivore (caterpillar), larval foodplant is so far unconfirmed but is probably sawgrass, diurnal; two well separated broods apparently peaking in late May and in September which suggests the larvae may well aestivate in summer and the next brood hibernate

Federal Status:	State Status:	SGCN: Y
Endemic: N	Global Rank: G2G3	State Rank: S1

MAMMALS

big brown bat *Eptesicus fuscus*

Any wooded areas or woodlands except south Texas. Riparian areas in west Texas.

Federal Status:	State Status:	SGCN: Y
Endemic: N	Global Rank: G5	State Rank: S5

big free-tailed bat *Nyctinomops macrotis*

Habitat data sparse but records indicate that species prefers to roost in crevices and cracks in high canyon walls, but will use buildings, as well; reproduction data sparse, gives birth to single offspring late June-early July; females gather in nursery colonies; winter habits undetermined, but may hibernate in the Trans-Pecos; opportunistic insectivore

Federal Status:	State Status:	SGCN: Y
Endemic: N	Global Rank: G5	State Rank: S3

blue whale *Balaenoptera musculus*

Inhabits tropical, subtropical, temperate, and subpolar waters worldwide, but are infrequently sighted in the Gulf of Mexico. They migrate seasonally between summer feeding grounds and winter breeeding grounds, but specifics vary. Commonly observed at the surface in open ocean.

Federal Status: LE	State Status: E	SGCN: Y
Endemic: N	Global Rank: G3G4	State Rank: SH

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HARRIS COUNTY

MAMMALS

eastern red bat *Lasiurus borealis*

Red bats are migratory bats that are common across Texas. They are most common in the eastern and central parts of the state, due to their requirement of forests for foliage roosting. West Texas specimens are associated with forested areas (cottonwoods). Also common along the coastline. These bats are highly mobile, seasonally migratory, and practice a type of "wandering migration". Associations with specific habitat is difficult unless specific migratory stopover sites or wintering grounds are found. Likely associated with any forested area in East, Central, and North Texas but can occur statewide.

Federal Status:	State Status:	SGCN: Y
Endemic: N	Global Rank: G3G4	State Rank: S4

eastern spotted skunk *Spilogale putorius*

Generalist; open fields prairies, croplands, fence rows, farmyards, forest edges & woodlands. Prefer wooded, brushy areas & tallgrass prairies. S.p. ssp. interrupta found in wooded areas and tallgrass prairies, preferring rocky canyons and outcrops when such sites are available.

Federal Status:	State Status:	SGCN: Y
Endemic: N	Global Rank: G4	State Rank: S1S3

Gulf of Mexico Bryde's Whale *Balaenoptera edeni*

Habitat description is not available at this time.

Federal Status: LE	State Status: E	SGCN: N
Endemic: N	Global Rank: G4	State Rank: SNR

hoary bat *Lasiurus cinereus*

Hoary bats are highly migratory, high-flying bats that have been noted throughout the state. Females are known to migrate to Mexico in the winter, males tend to remain further north and may stay in Texas year-round. Commonly associated with forests (foliage roosting species) but are found in unforested parts of the state and lowland deserts. Tend to be captured over water and large, open flyways.

Federal Status:	State Status:	SGCN: Y
Endemic: N	Global Rank: G3G4	State Rank: S4

humpback whale *Megaptera novaeangliae*

Inhabits tropical, subtropical, temperate, and subpolar waters world wide. Migrate up to 5,000 miles between colder water (feeding grounds) and warmer water (calving grounds) each year. They will use both open ocean and coastal waters, sometimes including inshore areas such as bays, and are often found near the surface; however, this species is rare in the Gulf of Mexico. The northwest Atlantic/Gulf of Mexico distinct population segment is not considered at risk of extinction and is not listed as Endangered on the Endangered Species Act.

Federal Status: LE	State Status:	SGCN: Y
Endemic: N	Global Rank: G4	State Rank: SNR

long-tailed weasel *Mustela frenata*

Includes brushlands, fence rows, upland woods and bottomland hardwoods, forest edges & rocky desert scrub. Usually live close to water.

Federal Status:	State Status:	SGCN: Y
Endemic: N	Global Rank: G5	State Rank: S5

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HARRIS COUNTY

MAMMALS

Louisiana black bear *Ursus americanus luteolus*

Bottomland hardwoods, floodplain forests, upland hardwoods with mixed pine; marsh. Possible as transient; bottomland hardwoods and large tracts of inaccessible forested areas.

Federal Status:	State Status: T	SGCN: Y
Endemic: N	Global Rank: G5T2	State Rank: SNA

mountain lion *Puma concolor*

Generalist; found in a wide range of habitats statewide. Found most frequently in rugged mountains & riparian zones.

Federal Status:	State Status:	SGCN: Y
Endemic: N	Global Rank: G5	State Rank: S2S3

Muskrat *Ondatra zibethicus*

Found in fresh or brackish marshes, lakes, ponds, swamps, and other bodies of slow-moving water. Most abundant in areas with cattail. Dens in bank burrow or conical house of vegetation in shallow vegetated water. It is primarily found in the Rio Grande near El Paso and in SE Texas in the Houston area.

Federal Status:	State Status:	SGCN: Y
Endemic: N	Global Rank: G5	State Rank: S5

North Atlantic right whale *Eubalaena glacialis*

Inhabits subtropical and temperate waters in the northern Atlantic. Commonly found in coastal waters or clsoe to the continental shelf near the surface. They migrate from feeding grounds in cooler waters (Canada and New England) to warmer waters of the southeast US (South Carolina, Georgia, and Florida) to give birth in the fall/winter - both areas are identified as critical habitat by NOAA-NMFS. Nursery areas are in shallow, coastal waters. This species is very rare in the Gulf of Mexico and the few reported sightings are likely vagrants (Ward-Geiger etal 2011).

Federal Status: LE	State Status: E	SGCN: Y
Endemic: N	Global Rank: G1	State Rank: S1

Northern yellow bat *Lasiurus intermedius*

Occurs mainly along the Gulf Coast but inland specimens are not uncommon. Prefers roosting in spanish moss and in the hanging fronds of palm trees. Common where this vegtation occurs. Found near water and forages over grassy, open areas. Males usually roost solitarily, whereas females roost in groups of several individuals.

Federal Status:	State Status:	SGCN: Y
Endemic: N	Global Rank: G5	State Rank: S4

Rafinesque's big-eared bat *Corynorhinus rafinesquii*

Historically, lowland pine and hardwood forests with large hollow trees. roosts in cavity trees of bottomland hardwoods, concrete culverts, and abandoned man-made structures

Federal Status:	State Status: T	SGCN: Y
Endemic: N	Global Rank: G3G4	State Rank: S2

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HARRIS COUNTY

MAMMALS

Sei Whale *Balaenoptera borealis*

Habitat description is not available at this time.

Federal Status: LE	State Status: E	SGCN: N
Endemic: N	Global Rank: G3	State Rank: SNR

southeastern myotis bat *Myotis austroriparius*

Caves are rare in Texas portion of range; buildings, hollow trees are probably important. Historically, lowland pine and hardwood forests with large hollow trees; associated with ecological communities near water. Roosts in cavity trees of bottomland hardwoods, concrete culverts, and abandoned man-made structures.

Federal Status:	State Status:	SGCN: Y
Endemic: N	Global Rank: G4	State Rank: S3?

sperm whale *Physeter macrocephalus*

Inhabits tropical, subtropical, and temperate waters world wide, avoiding icey waters. Distribution is highly dependent on their food source (squids, sharks, skates, and fish), breeding, and composition of the pod. In general, this species migrates from north to south in the winter and south to north in the summer; however, individuals in tropical and temperate waters don't seem to migrate at all. Routinely dive to catch their prey (2,000-10,000 feet) and generally occupies water at least 3,300 feet deep near ocean trenches.

Federal Status: LE	State Status: E	SGCN: Y
Endemic: N	Global Rank: G3G4	State Rank: S1

swamp rabbit *Sylvilagus aquaticus*

Primarily found in lowland areas near water including: cypress bogs and marshes, floodplains, creeks and rivers.

Federal Status:	State Status:	SGCN: Y
Endemic: N	Global Rank: G5	State Rank: S5

tricolored bat *Perimyotis subflavus*

Forest, woodland and riparian areas are important. Caves are very important to this species.

Federal Status:	State Status:	SGCN: Y
Endemic: N	Global Rank: G2G3	State Rank: S2

western hog-nosed skunk *Conepatus leuconotus*

Habitats include woodlands, grasslands & deserts, to 7200 feet, most common in rugged, rocky canyon country; little is known about the habitat of the ssp. telmalestes

Federal Status:	State Status:	SGCN: Y
Endemic: N	Global Rank: G4	State Rank: S4

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HARRIS COUNTY

MOLLUSKS

Louisiana Pigtoe *Pleurobema riddellii*

Occurs in small streams to large rivers in slow to moderate currents in substrates of clay, mud, sand, and gravel. Not known from impoundments (Howells 2010f; Randklev et al. 2013b; Troia et al. 2015). [Mussels of Texas 2019]

Federal Status:	State Status: T	SGCN: Y
Endemic: N	Global Rank: G1G2	State Rank: S1

Sandbank Pocketbook *Lampsilis satura*

Occurs in small streams to large rivers in slow to moderate current in sandy mud to sand and gravel substrate. Can occur in a variety of habitats but most common in littoral habitats such as banks or backwaters or in protected areas along point bars (Randklev et al. 2013b; Randklev et al. 2014a; Troia et al. 2015). [Mussels of Texas 2019]

Federal Status:	State Status: T	SGCN: Y
Endemic:	Global Rank: G2?	State Rank: S1

REPTILES

alligator snapping turtle *Macrochelys temminckii*

Aquatic: Perennial water bodies; rivers, canals, lakes, and oxbows; also swamps, bayous, and ponds near running water; sometimes enters brackish coastal waters. Females emerge to lay eggs close to the waters edge.

Federal Status:	State Status: T	SGCN: Y
Endemic: N	Global Rank: G3	State Rank: S2

common garter snake *Thamnophis sirtalis*

Terrestrial and aquatic: Habitats used include the grasslands and modified open areas in the vicinity of aquatic features, such as ponds, streams or marshes. Damp soils and debris for cover are thought to be critical.

Federal Status:	State Status:	SGCN: N
Endemic:	Global Rank: G5	State Rank: S2

eastern box turtle *Terrapene carolina*

Terrestrial: Eastern box turtles inhabit forests, fields, forest-brush, and forest-field ecotones. In some areas they move seasonally from fields in spring to forest in summer. They commonly enters pools of shallow water in summer. For shelter, they burrow into loose soil, debris, mud, old stump holes, or under leaf litter. They can successfully hibernate in sites that may experience subfreezing temperatures.

Federal Status:	State Status:	SGCN: Y
Endemic: N	Global Rank: G5	State Rank: S3

loggerhead sea turtle *Caretta caretta*

Inhabits tropical, subtropical, and temperate waters worldwide, including the Gulf of Mexico. They migrate from feeding grounds to nesting beaches/barrier islands and some nesting does occur in Texas (April to September). Beaches that are narrow, steeply sloped, with coarse-grain sand are preffered for nesting. Newly hatched individuals depend on floating alage/seaweed for protection and foraging, which eventually transport them offshore and into open ocean. Juveniles and young adults spend their lives in open ocean, offshore before migrating to coastal areas to breed and nest. Foraging areas for adults include shallow continental shelf waters.

Federal Status: LT	State Status: T	SGCN: Y
Endemic: N	Global Rank: G3	State Rank: S4

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HARRIS COUNTY

REPTILES

Pigmy Rattlesnake *Sistrurus miliarius*

The pygmy rattlesnake occurs in a variety of wooded habitats from bottomland coastal hardwood forests to upland savannas. The species is frequently found in association with standing water.

Federal Status:	State Status:	SGCN: Y
Endemic: N	Global Rank: G5	State Rank: S2S3

Prairie Skink *Plestiodon septentrionalis*

The prairie skink can occur in any native grassland habitat across the Rolling Plains, Blackland Prairie, Post Oak Savanna and Pineywoods ecoregions.

Federal Status:	State Status:	SGCN: Y
Endemic: N	Global Rank: G5	State Rank: S5

slender glass lizard *Ophisaurus attenuatus*

Terrestrial: Habitats include open grassland, prairie, woodland edge, open woodland, oak savannas, longleaf pine flatwoods, scrubby areas, fallow fields, and areas near streams and ponds, often in habitats with sandy soil.

Federal Status:	State Status:	SGCN: Y
Endemic: N	Global Rank: G5	State Rank: S3

smooth softshell *Apalone mutica*

Aquatic: Large rivers and streams; in some areas also found in lakes and impoundments (Ernst and Barbour 1972). Usually in water with sandy or mud bottom and few aquatic plants. Often basks on sand bars and mudflats at edge of water. Eggs are laid in nests dug in high open sandbars and banks close to water, usually within 90 m of water (Fitch and Plummer 1975).

Federal Status:	State Status:	SGCN: Y
Endemic: N	Global Rank: G5	State Rank: S3

Texas diamondback terrapin *Malaclemys terrapin littoralis*

Coastal marshes, tidal flats, coves, estuaries, and lagoons behind barrier beaches; brackish and salt water; burrows into mud when inactive. Bay islands are important habitats. Nests on oyster shell beaches.

Federal Status:	State Status:	SGCN: Y
Endemic: Y	Global Rank: G4T3Q	State Rank: S2

Texas horned lizard *Phrynosoma cornutum*

Terrestrial: Open habitats with sparse vegetation, including grass, prairie, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rock when inactive. Occurs to 6000 feet, but largely limited below the pinyon-juniper zone on mountains in the Big Bend area.

Federal Status:	State Status: T	SGCN: Y
Endemic: N	Global Rank: G4G5	State Rank: S3

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HARRIS COUNTY

REPTILES

timber (canebrake) rattlesnake *Crotalus horridus*

Terrestrial: Swamps, floodplains, upland pine and deciduous woodland, riparian zones, abandoned farmland. Limestone bluffs, sandy soil or black clay. Prefers dense ground cover, i.e. grapevines, palmetto.

Federal Status:	State Status:	SGCN: Y
Endemic: N	Global Rank: G4	State Rank: S4

western box turtle *Terrapene ornata*

Terrestrial: Ornate or western box trutles inhabit prairie grassland, pasture, fields, sandhills, and open woodland. They are essentially terrestrial but sometimes enter slow, shallow streams and creek pools. For shelter, they burrow into soil (e.g., under plants such as yucca) (Converse et al. 2002) or enter burrows made by other species.

Federal Status:	State Status:	SGCN: Y
Endemic: N	Global Rank: G5	State Rank: S3

western chicken turtle *Deirochelys reticularia miaria*

Aquatic and terrestrial: This species uses aquatic habitats in the late winter, spring and early summer and then terrestrial habitats the remainder of the year. Preferred aquatic habitats seem to be highly vegetated shallow wetlands with gentle slopes. Specific terrestrial habitats are not well known.

Federal Status:	State Status:	SGCN: Y
Endemic: N	Global Rank: G5T5	State Rank: S2S3

western hognose snake *Heterodon nasicus*

Terrestrial: Shortgrass or mixed grass prairie, with gravel or sandy soils. Often found associated with draws, floodplains, and more mesic habitats within the arid landscape. Frequently occurs in shrub encroached grasslands.

Federal Status:	State Status:	SGCN: Y
Endemic: N	Global Rank: G5	State Rank: S4

PLANTS

awnless bluestem *Bothriochloa exaristata*

Coastal prairies on black clay; Perennial; Flowering April-Dec; Fruiting April- Dec

Federal Status:	State Status:	SGCN: Y
Endemic: N	Global Rank: G4	State Rank: S3

coastal gay-feather *Liatris bracteata*

Coastal prairie grasslands of various types, from salty prairie on low- lying somewhat saline clay loams to upland prairie on nonsaline clayey to sandy loams; flowering in fall

Federal Status:	State Status:	SGCN: Y
Endemic: Y	Global Rank: G2G3	State Rank: S2S3

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HARRIS COUNTY

PLANTS

corkwood *Leitneria pilosa ssp. pilosa*

Wet or saturated silty soils along brackish or freshwater swamps and ponds and other low, poorly drained sites; flowers in early spring, fruiting as early as May

Federal Status:	State Status:	SGCN: Y
Endemic: N	Global Rank: G2G3T2	State Rank: S2

Correll's false dragon-head *Physostegia correllii*

Wet, silty clay loams on streamsides, in creek beds, irrigation channels and roadside drainage ditches; or seepy, mucky, sometimes gravelly soils along riverbanks or small islands in the Rio Grande; or underlain by Austin Chalk limestone along gently flowing spring-fed creek in central Texas; flowering May-September

Federal Status:	State Status:	SGCN: Y
Endemic: N	Global Rank: G2	State Rank: S2

giant sharpstem umbrella-sedge *Cyperus cephalanthus*

In Texas on saturated, fine sandy loam soils, along nearly level fringes of deep prairie depressions; also in depressional area within coastal prairie remnant on heavy black clay; in Louisiana, most sites are coastal prairie on poorly drained sites, some on slightly elevated areas surrounded by standing shallow water, and on moderately drained sites; soils include very strongly acid to moderately alkaline silt loams and silty clay loams; flowering/fruiting May-June, August-September, and possibly other times in response to rainfall

Federal Status:	State Status:	SGCN: Y
Endemic: N	Global Rank: G3?Q	State Rank: S1

goldenwave tickseed *Coreopsis intermedia*

In deep sandy soils of sandhills in openings in or along margins of post oak woodlands and pine-oak forests of east Texas; Perennial; Flowering/Fruiting May-Aug

Federal Status:	State Status:	SGCN: Y
Endemic: N	Global Rank: G3	State Rank: S3

Houston daisy *Rayjacksonia aurea*

On and around naturally barren or sparsely vegetated saline slick spots or pimple mounds on coastal prairies, usually on sandy to sandy loam soils, occasionally in pastures and on roadsides in similar soil types where mowing may mimic natural prairie disturbance regimes; flowering late September-November (-December)

Federal Status:	State Status: T	SGCN: Y
Endemic: Y	Global Rank: G1	State Rank: S1

Indianola beakrush *Rhynchospora indianolensis*

Locally abundant in cattle pastures in some areas (at least during wet years), possibly becoming a management problem in such sites; Perennial; Flowering/Fruiting April-Nov

Federal Status:	State Status:	SGCN: Y
Endemic: Y	Global Rank: G3Q	State Rank: S3

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HARRIS COUNTY

PLANTS

Oklahoma grass pink *Calopogon oklahomensis*

Mesic, acidic, sandy to loamy prairies, pine savannas, oak woodlands, edges of bogs, and frequently mowed meadows (Goldman, Magrath & Catling 2002). Flowering March-July.

Federal Status:	State Status:	SGCN: Y
Endemic: N	Global Rank: G2	State Rank: S1S2

panicled indigobush *Amorpha paniculata*

A stout shrub, 3 m (9 ft) tall that grows in acid seep forests, peat bogs, wet floodplain forests, and seasonal wetlands on the edge of Saline Prairies in East Texas. It is distinguished from other Amorpha species by its fuzzy leaflets with prominent raised veins underneath, and the flower panicles, which are 8 to 16 inches long and slender, held above the foliage. Perennial; Flowering summer

Federal Status:	State Status:	SGCN: Y
Endemic: N	Global Rank: G2G3	State Rank: S2

Shinner's sunflower *Helianthus occidentalis ssp. plantagineus*

Mostly in prairies on the Coastal Plain, with several slightly disjunct populations in the Pineywoods and South Texas Brush Country.

Federal Status:	State Status:	SGCN: Y
Endemic: N	Global Rank: G5T2T3	State Rank: S4

South Texas false cudweed *Pseudognaphalium austrotexanum*

In sandy grasslands on eroded area above saline flats; along edge of sendero through mesquite woodland and shrub mottes on sandy loam; on gravel and silt bars and flats in scour plain of streams (TEX-LL specimens Carr 23682, 29264, 22647, 27206). Oct-Jan, sometimes in spring.

Federal Status:	State Status:	SGCN: Y
Endemic: N	Global Rank: G3	State Rank: S3

Texas ladies'-tresses *Spiranthes brevilabris*

Sandy soils in moist prairies, incl. blackland/Fleming prairies, calcareous prairie pockets surrounded by pines, pine-hardwood forest, open pinelands, wetland pine savannahs/flatwoods, and dry to moist fields, meadows, and roadsides. Delicate, nearly ephemeral orchid, producing winter rosettes, flowers Feb-Apr. Historically endemic to SE coastal plain.

Federal Status:	State Status:	SGCN: Y
Endemic: N	Global Rank: G1G2	State Rank: S1

Texas meadow-rue *Thalictrum texanum*

Mostly found in woodlands and woodland margins on soils with a surface layer of sandy loam, but it also occurs on prairie pimple mounds; both on uplands and creek terraces, but perhaps most common on claypan savannas; soils are very moist during its active growing season; flowering/fruiting (January-)February-May, withering by midsummer, foliage reappears in late fall(November) and may persist through the winter

Federal Status:	State Status:	SGCN: Y
Endemic: Y	Global Rank: G2Q	State Rank: S2

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HARRIS COUNTY

PLANTS

Texas prairie dawn *Hymenoxys texana*

In poorly drained, sparsely vegtated areas (slick spots) at the base of mima mounds in open grassland or almost barren areas on slightly saline soils that are sticky when wet and powdery when dry; flowering late February-early April

Federal Status: LE	State Status: E	SGCN: Y
Endemic: Y	Global Rank: G2	State Rank: S2

Texas tauschia *Tauschia texana*

Occurs in loamy soils in deciduous forests or woodlands on river and stream terraces; Perennial; Flowering/Fruiting Feb-April

Federal Status:	State Status:	SGCN: Y
Endemic: Y	Global Rank: G3	State Rank: S3

Texas willkommia *Willkommia texana var. texana*

Mostly in sparsely vegetated shortgrass patches within taller prairies on alkaline or saline soils on the Coastal Plain (Carr 2015).

Federal Status:	State Status:	SGCN: Y
Endemic: Y	Global Rank: G3G4T3	State Rank: S3

Texas windmill grass *Chloris texensis*

Sandy to sandy loam soils in relatively bare areas in coastal prairie grassland remnants, often on roadsides where regular mowing may mimic natural prairie fire regimes; flowering in fall

Federal Status:	State Status:	SGCN: Y
Endemic: Y	Global Rank: G2	State Rank: S2

Tharp's dropseed *Sporobolus tharpii*

Occurs on barrier islands, shores of lagoons and bays protected by the barrier islands, and on shores of a few near-coastal ponds. Plants occur at the bases of dunes, in interdune swales and sandflats, and on upper beaches. The substrate is of Holocene age.

Federal Status:	State Status:	SGCN: Y
Endemic: Y	Global Rank: G3	State Rank: S3

threeflower broomweed *Thurovia triflora*

Near coast in sparse, low vegetation on a veneer of light colored silt or fine sand over saline clay along drier upper margins of ecotone between between salty prairies and tidal flats; further inland associated with vegetated slick spots on prairie mima mounds; flowering September-November

Federal Status:	State Status:	SGCN: Y
Endemic: Y	Global Rank: G2G3	State Rank: S2S3

DISCLAIMER

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APPENDIX E

IPaC REPORT (USFWS)

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Texas Coastal Ecological Services Field Office
4444 Corona Drive, Suite 215
Corpus Christi, TX 78411
Phone: (281) 286-8282 Fax: (281) 488-5882
http://www.fws.gov/southwest/es/TexasCoastal/
http://www.fws.gov/southwest/es/ES_Lists_Main2.html

In Reply Refer To: November 01, 2021
Consultation Code: 02ETTX00-2022-SLI-0349
Event Code: 02ETTX00-2022-E-00816
Project Name: Ravensway Drainage Improvements

Subject: List of threatened and endangered species that may occur in your proposed project location or may be affected by your proposed project

To Whom It May Concern:

The U.S. Fish and Wildlife Service (Service) field offices in Clear Lake, Tx, and Corpus Christi, Tx, have combined administratively to form the Texas Coastal Ecological Services Field Office. A map of the Texas Coastal Ecological Services Field Office area of responsibility can be found at: http://www.fws.gov/southwest/es/TexasCoastal/Map.html. All project related correspondence should be sent to the field office responsible for the area in which your project occurs. For projects located in southeast Texas please write to: Field Supervisor; U.S. Fish and Wildlife Service; 17629 El Camino Real Ste. 211; Houston, Texas 77058. For projects located in southern Texas please write to: Field Supervisor; U.S. Fish and Wildlife Service; P.O. Box 81468; Corpus Christi, Texas 78468-1468. For projects located in six counties in southern Texas (Cameron, Hidalgo, Starr, Webb, Willacy, and Zapata) please write: Santa Ana NWR, ATTN: Ecological Services Sub Office, 3325 Green Jay Road, Alamo, Texas 78516.

The enclosed species list identifies federally threatened, endangered, and proposed to be listed species; designated critical habitat; and candidate species that may occur within the boundary of your proposed project and/or may be affected by your proposed project.

New information from updated surveys, changes in the abundance and distribution of species, changes in habitat conditions, or other factors could change the list. Please note that under 50 CFR 402.12(e) of the regulations implementing section 7 of the Act, the accuracy of this species list should be verified after 90 days. The Service recommends that verification be completed by visiting the ECOS-IPaC website http://ecos.fws.gov/ipac/ at regular intervals during project planning and implementation for updates to species list and information. An updated list may be requested through the ECOS-IPaC system by completing the same process used to receive the enclosed list.

Candidate species have no protection under the Act but are included for consideration because they could be listed prior to the completion of your project. The other species information should help you determine if suitable habitat for these listed species exists in any of the proposed project areas or if project activities may affect species on-site, off-site, and/or result in "take" of a federally listed species.

"Take" is defined as harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. In addition to the direct take of an individual animal, habitat destruction or modification can be considered take, regardless of whether it has been formally designated as critical habitat, if the activity results in the death or injury of wildlife by removing essential habitat components or significantly alters essential behavior patterns, including breeding, feeding, or sheltering.

Section 7

Section 7 of the Act requires that all Federal agencies consult with the Service to ensure that actions authorized, funded or carried out by such agencies do not jeopardize the continued existence of any listed threatened or endangered species or adversely modify or destroy critical habitat of such species. It is the responsibility of the Federal action agency to determine if the proposed project may affect threatened or endangered species. If a "may affect" determination is made, the Federal agency shall initiate the section 7 consultation process by writing to the office that has responsibility for the area in which your project occurs.

Is not likely to adversely affect - the project may affect listed species and/or critical habitat; however, the effects are expected to be discountable, insignificant, or completely beneficial. Certain avoidance and minimization measures may need to be implemented in order to reach this level of effects. The Federal agency or the designated non-Federal representative should seek written concurrence from the Service that adverse effects have been eliminated. Be sure to include all of the information and documentation used to reach your decision with your request for concurrence. The Service must have this documentation before issuing a concurrence.

Is likely to adversely affect - adverse effects to listed species may occur as a direct or indirect result of the proposed action or its interrelated or interdependent actions, and the effect is not discountable, insignificant, or beneficial. If the overall effect of the proposed action is beneficial to the listed species but also is likely to cause some adverse effects to individuals of that species, then the proposed action "is likely to adversely affect" the listed species. An "is likely to adversely affect" determination requires the Federal action agency to initiate formal section 7 consultation with this office.

No effect - the proposed action will not affect federally listed species or critical habitat (i.e., suitable habitat for the species occurring in the project county is not present in or adjacent to the action area). No further coordination or contact with the Service is necessary. However, if the project changes or additional information on the distribution of listed or proposed species becomes available, the project should be reanalyzed for effects not previously considered.

Regardless of your determination, the Service recommends that you maintain a complete record of the evaluation, including steps leading to the determination of affect, the qualified personnel conducting the evaluation, habitat conditions, site photographs, and any other related articles.

Please be advised that while a Federal agency may designate a non-Federal representative to conduct informal consultations with the Service, assess project effects, or prepare a biological assessment, the Federal agency must notify the Service in writing of such a designation. The Federal agency shall also independently review and evaluate the scope and contents of a biological assessment prepared by their designated non-Federal representative before that document is submitted to the Service.

The Service's Consultation Handbook is available online to assist you with further information on definitions, process, and fulfilling Act requirements for your projects at: http://www.fws.gov/endangered/esa-library/pdf/esa_section7_handbook.pdf

Section 10

If there is no federal involvement and the proposed project is being funded or carried out by private interests and/or non-federal government agencies, and the project as proposed may affect listed species, a section 10(a)(1)(B) permit is recommended. The Habitat Conservation Planning Handbook is available at: http://www.fws.gov/endangered/esa-library/pdf/HCP_Handbook.pdf

Service Response

Please note that the Service strives to respond to requests for project review within 30 days of receipt, however, this time period is not mandated by regulation. Responses may be delayed due to workload and lack of staff. Failure to meet the 30-day timeframe does not constitute a concurrence from the Service that the proposed project will not have impacts to threatened and endangered species.

Proposed Species and/or Proposed Critical Habitat

While consultations are required when the proposed action may affect listed species, section 7(a)(4) was added to the ESA to provide a mechanism for identifying and resolving potential conflicts between a proposed action and proposed species or proposed critical habitat at an early planning stage. The action agency should seek conference from the Service to assist the action agency in determining effects and to advise the agency on ways to avoid or minimize adverse effect to proposed species or proposed critical habitat.

Candidate Species

Candidate species are species that are being considered for possible addition to the threatened and endangered species list. They currently have no legal protection under the ESA. If you find you have potential project impacts to these species the Service would like to provide technical assistance to help avoid or minimize adverse effects. Addressing potential impacts to these species at this stage could better provide for overall ecosystem healh in the local area and ay avert potential future listing.

Several species of freshwater mussels occur in Texas and four are candidates for listing under the ESA. The Service is also reviewing the status of six other species for potential listing under the ESA. One of the main contributors to mussel die offs is sedimentation, which smothers and suffocates mussels. To reduce sedimentation within rivers, streams, and tributaries crossed by a

project, the Service recommends that that you implement the best management practices found at: http://www.fws.gov/southwest/es/TexasCoastal/FreshwaterMussels.html.

Candidate Conservation Agreements (CCAs) or Candidate Conservation Agreements with Assurances (CCAAs) are voluntary agreements between the Service and public or private entities to implement conservation measures to address threats to candidate species. Implementing conservation efforts before species are listed increases the likelihood that simpler, flexible, and more cost-effective conservation options are available. A CCAA can provide participants with assurances that if they engage in conservation actions, they will not be required to implement additional conservation measures beyond those in the agreement. For additional information on CCAs/CCAAs please visit the Service's website at http://www.fws.gov/endangered/what-we-do/cca.html.

Migratory Birds

The Migratory Bird Treaty Act (MBTA) implements various treaties and conventions for the protection of migratory birds. Under the MBTA, taking, killing, or possessing migratory birds is unlawful. Many may nest in trees, brush areas or other suitable habitat. The Service recommends activities requiring vegetation removal or disturbance avoid the peak nesting period of March through August to avoid destruction of individuals or eggs. If project activities must be conducted during this time, we recommend surveying for active nests prior to commencing work. A list of migratory birds may be viewed at http://www.fws.gov/migratorybirds/regulationspolicies/mbta/mbtandx.html.

The bald eagle (*Haliaeetus leucocephalus*) was delisted under the Act on August 9, 2007. Both the bald eagle and the goden eagle (*Aquila chrysaetos*) are still protected under the MBTA and BGEPA. The BGEPA affords both eagles protection in addition to that provided by the MBTA, in particular, by making it unlawful to "disturb" eagles. Under the BGEPA, the Service may issue limited permits to incidentally "take" eagles (e.g., injury, interfering with normal breeding, feeding, or sheltering behavior nest abandonment). For more information on bald and golden eagle management guidlines, we recommend you review information provided at http://www.fws.gov/midwest/eagle/pdf/NationalBaldEagleManagementGuidelines.pdf.

The construction of overhead power lines creates threats of avian collision and electrocution. The Service recommends the installation of underground rather than overhead power lines whenever possible. For new overhead lines or retrofitting of old lines, we recommend that project developers implement, to the maximum extent practicable, the Avian Power Line Interaction Committee guidelines found at http://www.aplic.org/.

Meteorological and communication towers are estimated to kill millions of birds per year. We recommend following the guidance set forth in the Service Interim Guidelines for Recommendations on Communications Tower Siting, Constructions, Operation and Decommissioning, found online at: http://www.fws.gov/habitatconservation/communicationtowers.html, to minimize the threat of avian mortality at these towers. Monitoring at these towers would provide insight into the effectiveness of the minimization measures. We request the results of any wildlife mortality monitoring at towers associated with this project.

We request that you provide us with the final location and specifications of your proposed towers, as well as the recommendations implemented. A Tower Site Evaluation Form is also available via the above website; we recommend you complete this form and keep it in your files. If meteorological towers are to be constructed, please forward this completed form to our office.

More information concerning sections 7 and 10 of the Act, migratory birds, candidate species, and landowner tools can be found on our website at: http://www.fws.gov/southwest/es/TexasCoastal/ProjectReviews.html.

Wetlands and Wildlife Habitat

Wetlands and riparian zones provide valuable fish and wildlife habitat as well as contribute to flood control, water quality enhancement, and groundwater recharge. Wetland and riparian vegetation provides food and cover for wildlife, stabilizes banks and decreases soil erosion. These areas are inherently dynamic and very sensitive to changes caused by such activities as overgrazing, logging, major construction, or earth disturbance. Executive Order 11990 asserts that each agency shall provide leadership and take action to minimize the destruction, loss or degradation of wetlands, and to preserve and enhance the natural and beneficial value of wetlands in carrying out the agency's responsibilities. Construction activities near riparian zones should be carefully designed to minimize impacts. If vegetation clearing is needed in these riparian areas, they should be re-vegetated with native wetland and riparian vegetation to prevent erosion or loss of habitat. We recommend minimizing the area of soil scarification and initiating incremental re-establishment of herbaceous vegetation at the proposed work sites. Denuded and/or disturbed areas should be re-vegetated with a mixture of native legumes and grasses. Species commonly used for soil stabilization are listed in the Texas Department of Agriculture's (TDA) Native Tree and Plant Directory, available from TDA at P.O. Box 12847, Austin, Texas 78711. The Service also urges taking precautions to ensure sediment loading does not occur to any receiving streams in the proposed project area. To prevent and/or minimize soil erosion and compaction associated with construction activities, avoid any unnecessary clearing of vegetation, and follow established rights-of-way whenever possible. All machinery and petroleum products should be stored outside the floodplain and/or wetland area during construction to prevent possible contamination of water and soils.

Wetlands and riparian areas are high priority fish and wildlife habitat, serving as important sources of food, cover, and shelter for numerous species of resident and migratory wildlife. Waterfowl and other migratory birds use wetlands and riparian corridors as stopover, feeding, and nesting areas. We strongly recommend that the selected project site not impact wetlands and riparian areas, and be located as far as practical from these areas. Migratory birds tend to concentrate in or near wetlands and riparian areas and use these areas as migratory flyways or corridors. After every effort has been made to avoid impacting wetlands, you anticipate unavoidable wetland impacts will occur; you should contact the appropriate U.S. Army Corps of Engineers office to determine if a permit is necessary prior to commencement of construction activities.

If your project will involve filling, dredging, or trenching of a wetland or riparian area it may require a Clean Water Act Section 404 permit from the U.S. Army Corps of Engineers (COE).

For permitting requirements please contact the U.S. Corps of Engineers, District Engineer, P.O. Box 1229, Galveston, Texas 77553-1229, (409) 766-3002.

Beneficial Landscaping

In accordance with Executive Order 13112 on Invasive Species and the Executive Memorandum on Beneficial Landscaping (42 C.F.R. 26961), where possible, any landscaping associated with project plans should be limited to seeding and replanting with native species. A mixture of grasses and forbs appropriate to address potential erosion problems and long-term cover should be planted when seed is reasonably available. Although Bermuda grass is listed in seed mixtures, this species and other introduced species should be avoided as much as possible. The Service also recommends the use of native trees, shrubs, and herbaceous species that are adaptable, drought tolerant and conserve water.

State Listed Species

The State of Texas protects certain species. Please contact the Texas Parks and Wildlife Department (Endangered Resources Branch), 4200 Smith School Road, Austin, Texas 78744 (telephone 512/389-8021) for information concerning fish, wildlife, and plants of State concern or visit their website at: http://www.tpwd.state.tx.us/huntwild/wild/wildlife_diversity/texas_rare_species/listed_species/.

If we can be of further assistance, or if you have any questions about these comments, please contact 281/286-8282 if your project is in southeast Texas, or 361/994-9005, ext. 246, if your project is in southern Texas. Please refer to the Service consultation number listed above in any future correspondence regarding this project.

Attachment(s):

- Official Species List

Official Species List

This list is provided pursuant to Section 7 of the Endangered Species Act, and fulfills the requirement for Federal agencies to "request of the Secretary of the Interior information whether any species which is listed or proposed to be listed may be present in the area of a proposed action".

This species list is provided by:

Texas Coastal Ecological Services Field Office
4444 Corona Drive, Suite 215
Corpus Christi, TX 78411
(281) 286-8282

Project Summary

Consultation Code: 02ETTX00-2022-SLI-0349
Event Code: Some(02ETTX00-2022-E-00816)
Project Name: Ravensway Drainage Improvements
Project Type: LAND - DRAINAGE
Project Description: Proposed drainage improvements in the Ravensway Subdivision located along Huffmeister Road between Cypress N. Houston and Kluge Road in Harris County, Texas.
Project Location:

Approximate location of the project can be viewed in Google Maps: https://www.google.com/maps/@29.9606846,-95.62984956149961,14z

Counties: Harris County, Texas

Endangered Species Act Species

There is a total of 6 threatened, endangered, or candidate species on this species list.

Species on this list should be considered in an effects analysis for your project and could include species that exist in another geographic area. For example, certain fish may appear on the species list because a project could affect downstream species. Note that 2 of these species should be considered only under certain conditions.

IPaC does not display listed species or critical habitats under the sole jurisdiction of NOAA Fisheries[1], as USFWS does not have the authority to speak on behalf of NOAA and the Department of Commerce.

See the "Critical habitats" section below for those critical habitats that lie wholly or partially within your project area under this office's jurisdiction. Please contact the designated FWS office if you have questions.

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1. NOAA Fisheries, also known as the National Marine Fisheries Service (NMFS), is an office of the National Oceanic and Atmospheric Administration within the Department of Commerce.

Mammals

NAME	STATUS
West Indian Manatee *Trichechus manatus* There is **final** critical habitat for this species. The location of the critical habitat is not available. ***This species is also protected by the Marine Mammal Protection Act, and may have additional consultation requirements.*** Species profile: https://ecos.fws.gov/ecp/species/4469	Threatened

Birds

NAME	STATUS
Eastern Black Rail *Laterallus jamaicensis ssp. jamaicensis* No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/10477	Threatened
Piping Plover *Charadrius melodus* Population: [Atlantic Coast and Northern Great Plains populations] - Wherever found, except those areas where listed as endangered. There is **final** critical habitat for this species. The location of the critical habitat is not available. This species only needs to be considered under the following conditions: ▪ Wind related projects within migratory route. Species profile: https://ecos.fws.gov/ecp/species/6039	Threatened
Red Knot *Calidris canutus rufa* There is **proposed** critical habitat for this species. The location of the critical habitat is not available. This species only needs to be considered under the following conditions: ▪ Wind related projects within migratory route. Species profile: https://ecos.fws.gov/ecp/species/1864	Threatened

Insects

NAME	STATUS
Monarch Butterfly *Danaus plexippus* No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/9743	Candidate

Flowering Plants

NAME	STATUS
Texas Prairie Dawn-flower *Hymenoxys texana* No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/6471	Endangered

Critical habitats

THERE ARE NO CRITICAL HABITATS WITHIN YOUR PROJECT AREA UNDER THIS OFFICE'S JURISDICTION.

ARCHAEOLOGICAL SITE ASSESSMENT DESKTOP STUDY

Ravensway Subdivision Drainage Improvements – Precinct 3 Project
Harris County, Texas

Prepared for:
LIA Engineering.
3600 W. Sam Houston Parkway South, Suite 600
Houston, Texas 77042

Prepared by:
Jason M. Whitaker

RABA KISTNER, INC.
12821 West Golden Lane
San Antonio, Texas 78249

RKI Project No. ASF21-116-00

November 29, 2021

Introduction and Project Description

Raba Kistner, Inc. (RKI) was contracted by LIA Engineering (CLIENT), to conduct an archaeological background study in anticipation of drainage improvements for the Ravensway Subdivision in northwestern Harris County, Texas (**Figure 1**). The Project Area is located east of Huffmeister Road at its intersection with Ravensway Drive. Improvements will occur at three outfall locations into existing drainages, and the construction of a new detention pond near the western boundary of the existing development. Since the project will take place on county-owned land, the proposed project is subject to review under the jurisdiction of the Antiquities Code of Texas (ACT; Texas Natural Resources Code, Title 9, Chapter 191). Furthermore, as the project has the potential to impact known waterways, the undertaking is potentially subject to review under Section 106 of the National Historic Preservation Act (NHPA) (16 United States Code 470) and its implementing regulations (36 Code of Federal Regulation 800). Compliance with Section 106 is regulated by the U.S. Army Corps of Engineers (USACE).

The purpose of this background study is to summarize the findings of previous archaeological investigations within the vicinity of the APE. Documentation reviewed during this study includes historic maps, historical aerial photographs, and the THC-maintained Texas Historical Sites Atlas (*Atlas*). The depth of impacts is currently unknown, but the Area of Potential Effects (APE) for this background review will encompass the entire 153-acre development area. The APE is depicted on the *Cypress* (2995-343-134), *Texas* 7.5-minute U.S. Geological Survey (USGS) topographic quadrangle map to the west, and the *Satsuma* (299-344) map to the east.

Geology and Soils

The APE is entirely underlain by the Pleistocene and Holocene-age Lissie Formation (Ql) (United States Geological Survey [USGS] 2021) (**Figure 2**). The Lissie Formation consists of sand, silt, clay, and minor amounts of gravel. The upper part of the Lissie Formation may be locally calcareous, and is composed of clay, silt, sand, and a very small amount of siliceous gravel. The topography is fairly flat and featureless except for numerous rounded shallow depressions and pimple mounds. The lower part of the Lissie formation is composed of clay, silt, sand, and has a minor gravel component that is slightly coarser than that of the upper part (USGS 2021).

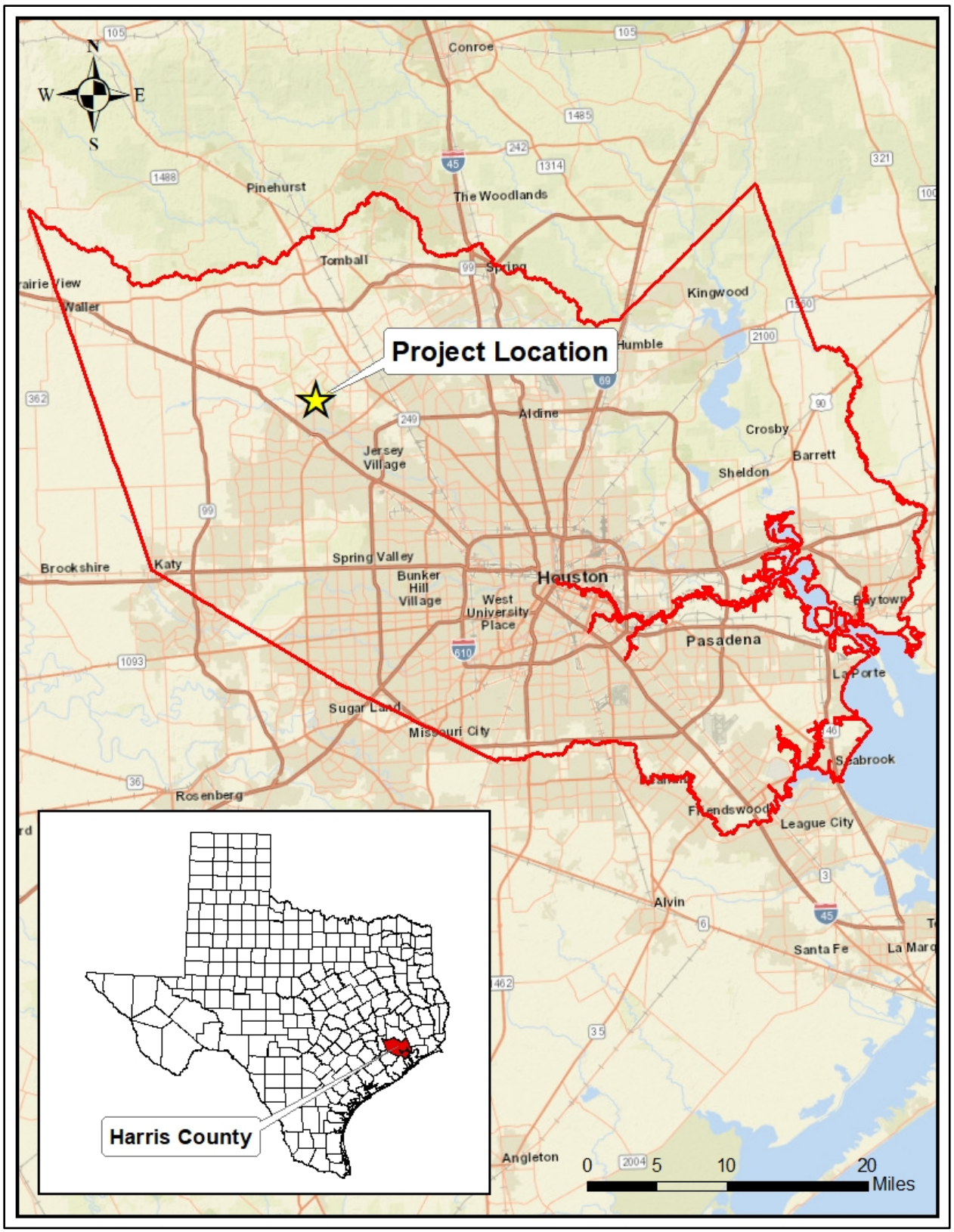

Figure 1. Project location map.

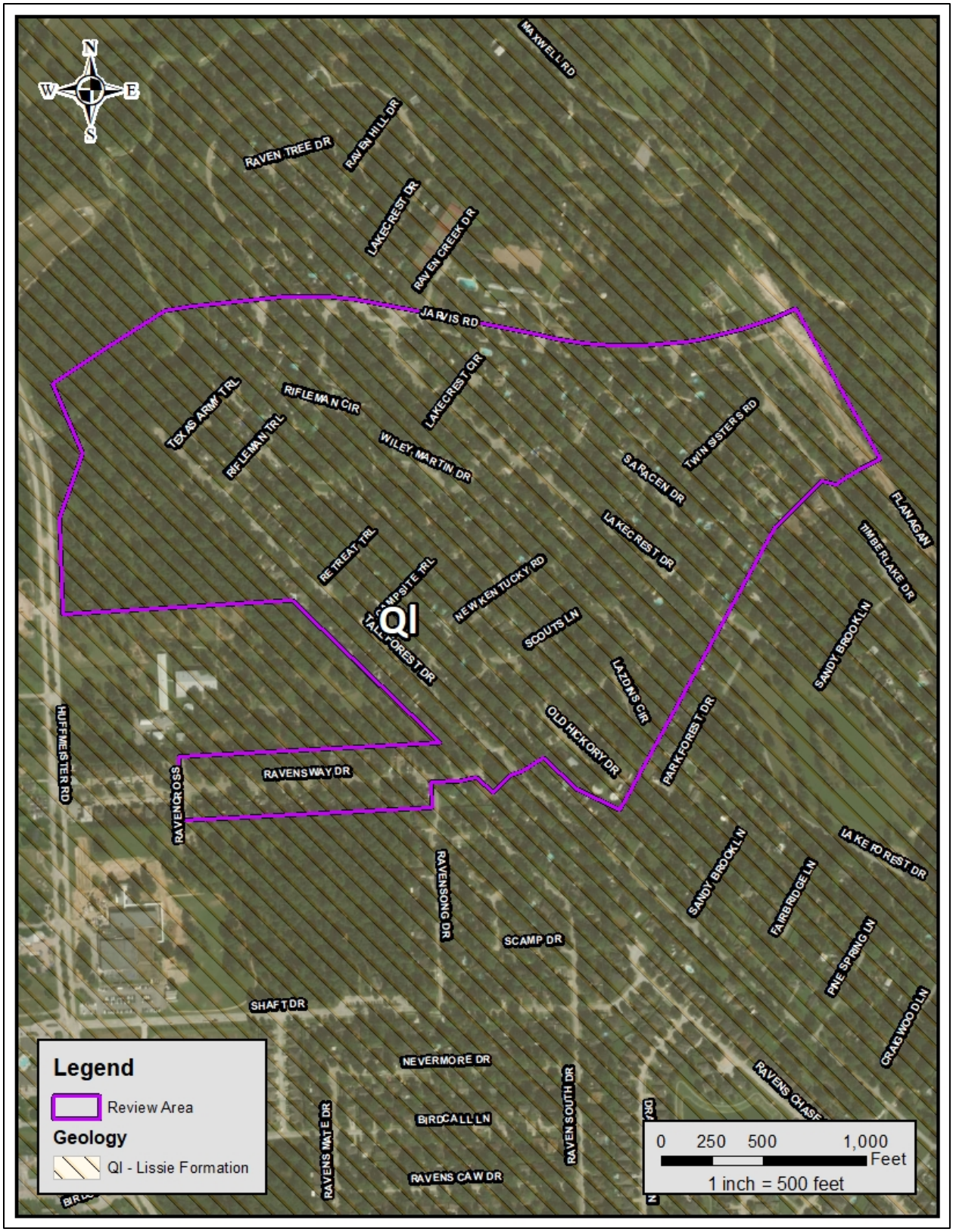

Figure 2. Underlying geology of APE.

Information provided by the Natural Resources Conservation Service (NRCS) shows that four soils are mapped within the APE: Wockley fine sandy loam 0 to 1-percent slopes (Wo), Hatliff-Pluck-Kian Complex, 0 to 1-percent slopes (HatA), Clodine fine sandy loam, 0 to 1-percent slopes (Cd), and what the NRCS labels as Pits (PITX) (NRCS 2021) (**Figure 3**). Soils of the Wockley Series are somewhat poorly drained and formed from late Pliocene to early Pleistocene loamy fluviomarine deposits derived from igneous, metamorphic, and sedimentary rock (NRCS 2021). Clodine Series soils are somewhat poorly drained and formed from loamy fluviomarine deposits derived from igneous, metamorphic, and sedimentary rock. The Hatliff-Pluck-Kian Complex consists of the soils of the Hatliff, Pluck, and Kian Series'. Hatliff Series soils are well drained and formed from Holocene-age clayey alluvium derived from igneous, metamorphic, and sedimentary rock, whereas soils of both the Pluck and Kian Series are poorly drained and formed from loamy alluvium derived from igneous, metamorphic, and sedimentary rock (NRCS 2021).

Known Cultural Resources and Archaeological Investigations

A review of the Texas Archeological Sites Atlas (*Atlas*) shows that there are no previously recorded sites within the APE boundaries (**Figure 4**). The nearest previously recorded archaeological site is 41HR366, which is located approximately 422 feet (128.6 meters [m]) northeast of the APE. Site 41HR366 was recorded as a Late Prehistoric campsite and is listed as eligible for listing on the National Register of Historic Places (NRHP). In addition to site 41HR366, there are also 18 other previously recorded archaeological sites within 1 mile (1.6 kilometers [km]) of the APE's boundaries (**see Figure 4; Table 1**). Two of these sites (Knigge-Telge Cemetery and the Borgstedt Cemetery) are listed as cemeteries and are located 0.61 and 0.23 mile from the APE, respectively (**Table 2**). Both of these cemeteries contain graves dating from the early twentieth to early twenty first centuries (findagrave.com 2021a and b). There are also two other cemeteries both within and within 1 mile (1.6 km) of the APE. The Dowdell Cemetery is located within the boundaries of the APE and is located along Saracen Drive approximately 358 feet (109 m) south/southwest of its intersection with Jarvis Road. Burials within this cemetery date from the late nineteenth to early twentieth centuries (findagrave.com 2021c). Finally, the Hoffmeister Cemetery is located approximately 0.45 mile (0.72 km) south of the APE. An examination of burials in this cemetery show that they date from the late nineteenth to mid-twentieth centuries (findagrave.com 2021c).

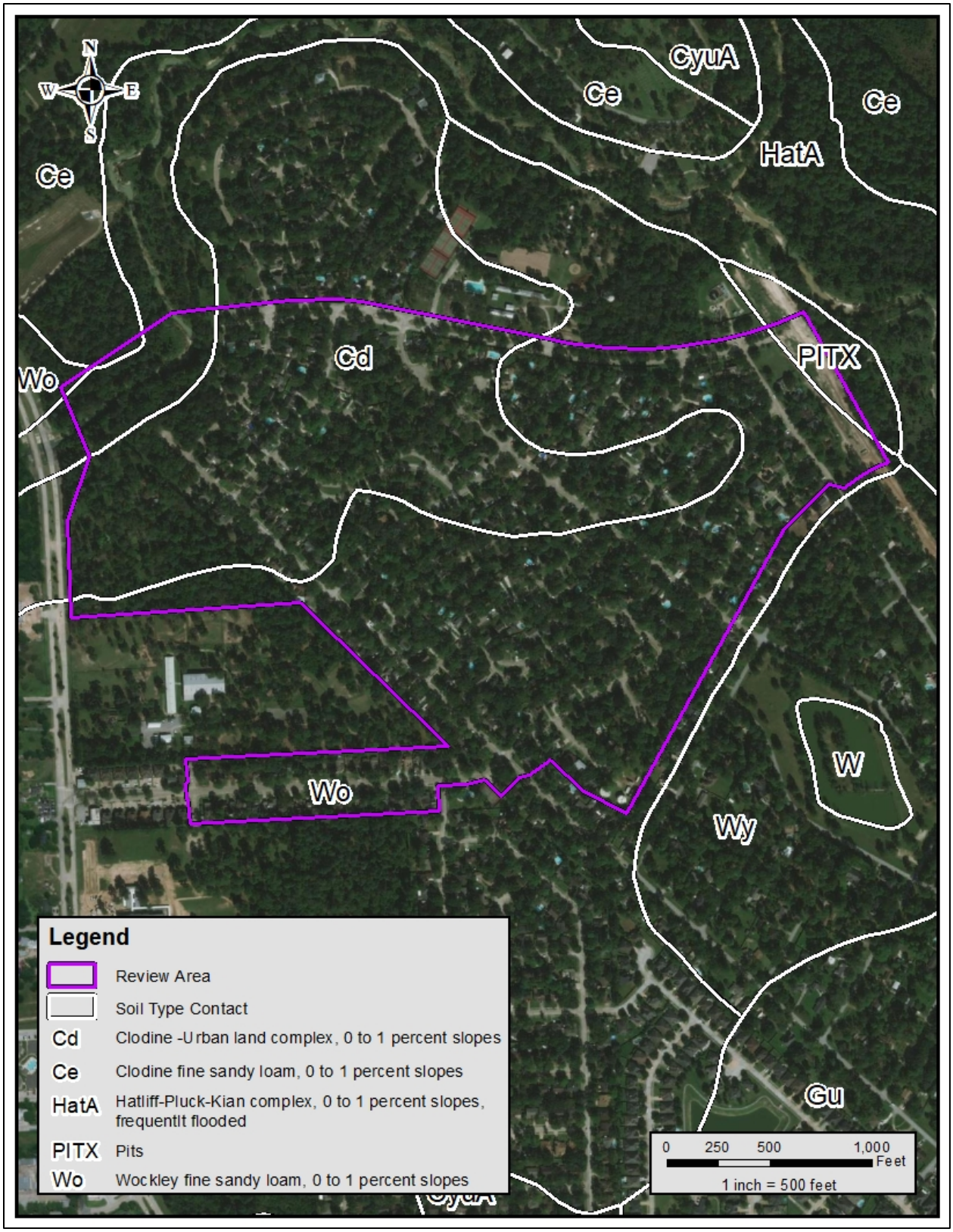

Figure 3. Soils mapped within the APE.

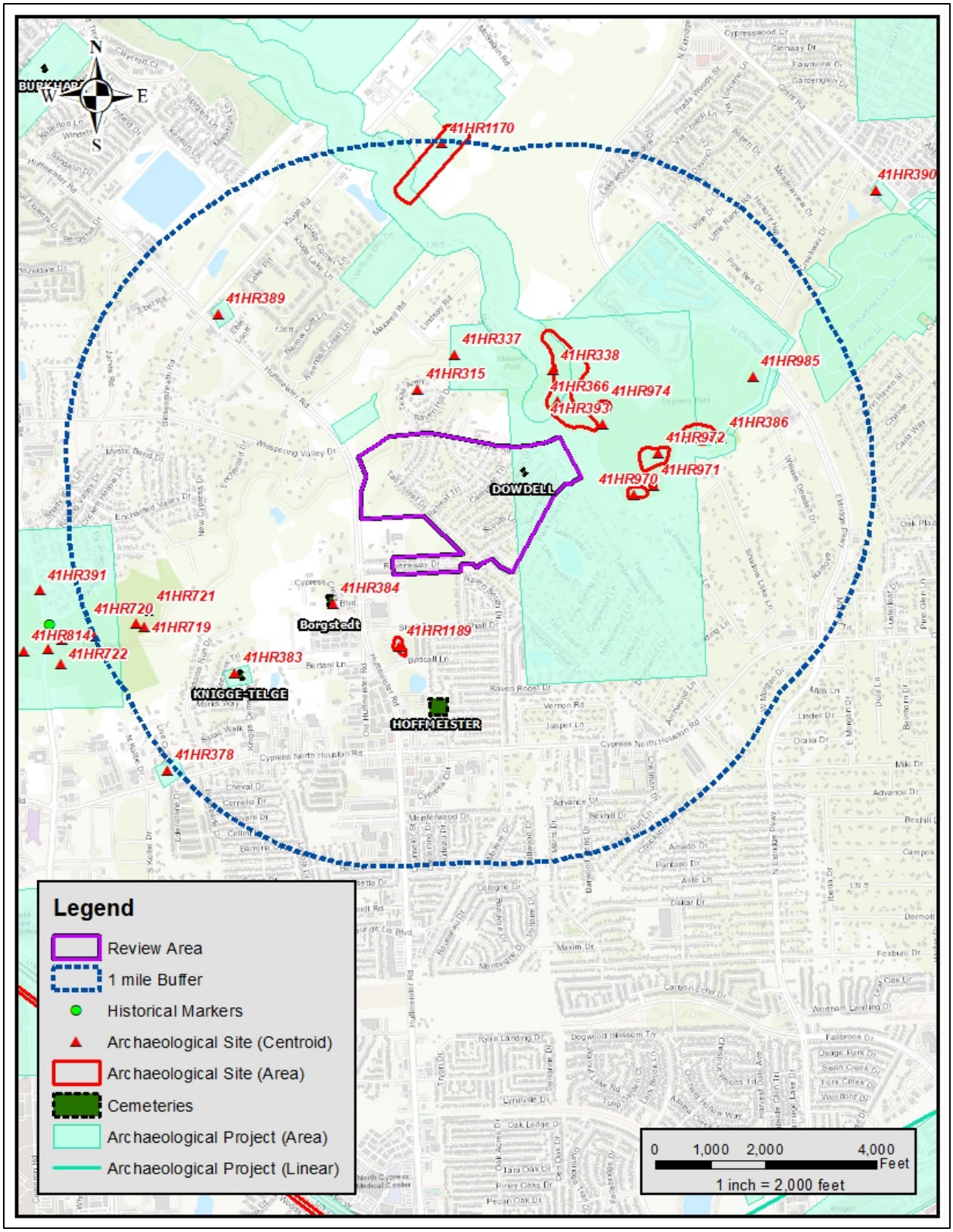

Figure 4. Previously documented cultural resources and conducted archaeological investigations within 1 mile (1.6 km) of the APE.

A review of the Atlas shows that the eastern section of the APE has been previously surveyed (**see Figure 4**). The first of these covered a large portion of the APE's eastern section and was conducted in 1977 under the sponsorship of the USACE-Galveston District. Sites recorded during this survey included both 41HR337 and 41HR338 (**Table 3**). The second survey conducted within the APE was conducted in 2003 by Moore Archaeological Consultants under TAC Permit 3114. Archaeological sites recorded during this survey include: 41HR970, 41HR971, and 41HR972. Examination of information provided in the Atlas shows that there were eight additional areal surveys within a 1-mile (1.6-km) radius of the APE. The closest of these was a survey conducted in 2020 by Terracon Consultants, Inc. under TAC Permit number 9170.

A review of the Potential Archeological Liability Maps (PALM) determined that the APE covers three areas of recommendation (**Figure 5**). Specifically, a majority of the southeastern half of the APE is demarcated as 4. No Survey Recommended. However, most of the northwestern portion of the APE is classified as 2. Surface Survey Recommended with no deep reconnaissance recommended. The portions of the APE located immediately adjacent to the drainage are demarcated as 1. Surface Survey Recommended with deep reconnaissance recommended if deep impacts are anticipated.

Table 1. Previously documented archaeological sites within 1 mile (1.6 km) of the APE.

Site Trinomial	Site Name	Distance from Review Area (miles/feet)	Brief Description	NRHP and SAL Eligibility
41HR315	-	0.14 mile N	Late Archaic and Woodland open campsite	Unknown
41HR337	-	0.29 mile N	Lithic and Sherd scatter time-period unknown	Unknown
41HR338	-	0.24 mile N/NE	Unknown prehistoric lithic and sherd scatter	Unknown
41HR366	-	422 feet NE	Late Prehistoric campsite	Eligible
41HR383	Knigge-Telge Cemetery	0.61 mile SW	Nineteenth and twentieth century cemetery	Unknown
41HR384	Borgstedt Cemetery	0.23 mile SW	Late nineteenth to twentieth century cemetery	Unknown
41HR389	-	0.68 mile NW	Early twentieth-century singe story structure and cemetery (not recorded)	Unknown

Site Trinomial	Site Name	Distance from Review Area (miles/feet)	Brief Description	NRHP and SAL Eligibility
41HR393	-	0.16 mile NE	Twentieth century historic camp	Unknown
41HR717	-	0.94 mile SW	Unknown prehistoric campsite	Unknown
41HR719	-	0.92 mile SW	Unknown prehistoric campsite	Not eligible
41HR720	-	0.93 mile SW	Late Prehistoric campsite	Unknown
41HR721	-	0.89 mile SW	Unknown prehistoric campsite	Not eligible
41HR970	-	0.18 mile SE	Late Prehistoric campsite	Eligible
41HR971	-	0.25 mile SE	Unknown prehistoric open campsite	Ineligible
41HR972	-	0.22 mile E	Unknown prehistoric campsite	Eligible
41HR974	-	0.17 mile NE	Unknown prehistoric campsite	Unknown
41HR1170	-	0.79 mile N	Unknown prehistoric subsurface lithic scatter	Not eligible
41HR1189	-	0.24 mile S	Late nineteenth to early twentieth century farmstead	Unknown

Table 2. Cemeteries recorded within1 mile (1.6 km) of APE.

Resource Type	ID No.	Name	Distance from Review Area (miles)	Time-Period
Cemetery	HR-C078	Dowdell Cemetery	Within Review Area	Late nineteenth to early twentieth centuries
Cemetery	HR-C500	Borgstedt Cemetery/Burnett-Borgstedt Cemetery	0.16 SW	Early twentieth to early twenty-first centuries

Resource Type	ID No.	Name	Distance from Review Area (miles)	Time-Period
Cemetery	HR-C074	Knigge-Telge	0.61 SW	Early twentieth to early twenty-first centuries
Cemetery	HR-C226	Hoffmeister	0.45 S	Late nineteenth to mid-twentieth centuries

Table 3. Previously conducted archaeological investigations within 1 mile (1.6 km) of the Review Area.

Survey Type	Distance from Review Area	Year Conducted	Investigating Firm	TAC Permit No.	Sites Recorded
Areal	Within Review Area	1977	Sponsored by the United States Army Corps of Engineers (USACE)-Galveston District	-	41HR337, 41HR338
Areal	Within Review Area	2003	Moore Archaeological Consultants, Inc.	3114	41HR970, 41HR971, 41HR972
Areal	Adjacent to northern Review Area boundary	2020	Terracon Consultants, Inc.	9170	-
Areal	0.12 N	2006	HRA Gray and Pape	4115	-
Areal	0.67 NW	1978	Sponsored by the USACE-Galveston District	-	41HR389

Survey Type	Distance from Review Area	Year Conducted	Investigating Firm	TAC Permit No.	Sites Recorded
Areal	0.61 SW	1978	Sponsored by the USACE-Galveston District	-	41HR383 (Knigge-Telge Cemetery)
Areal	0.86 W	1978	Sponsored by the USACE-Galveston District	-	41HR391, 41HR394
Areal	0.87 NE	2017	Stone Point Services, LLC	8116	-
Areal	0.50 N	2014	SWCA Environmental Consultants, Inc.	-	-

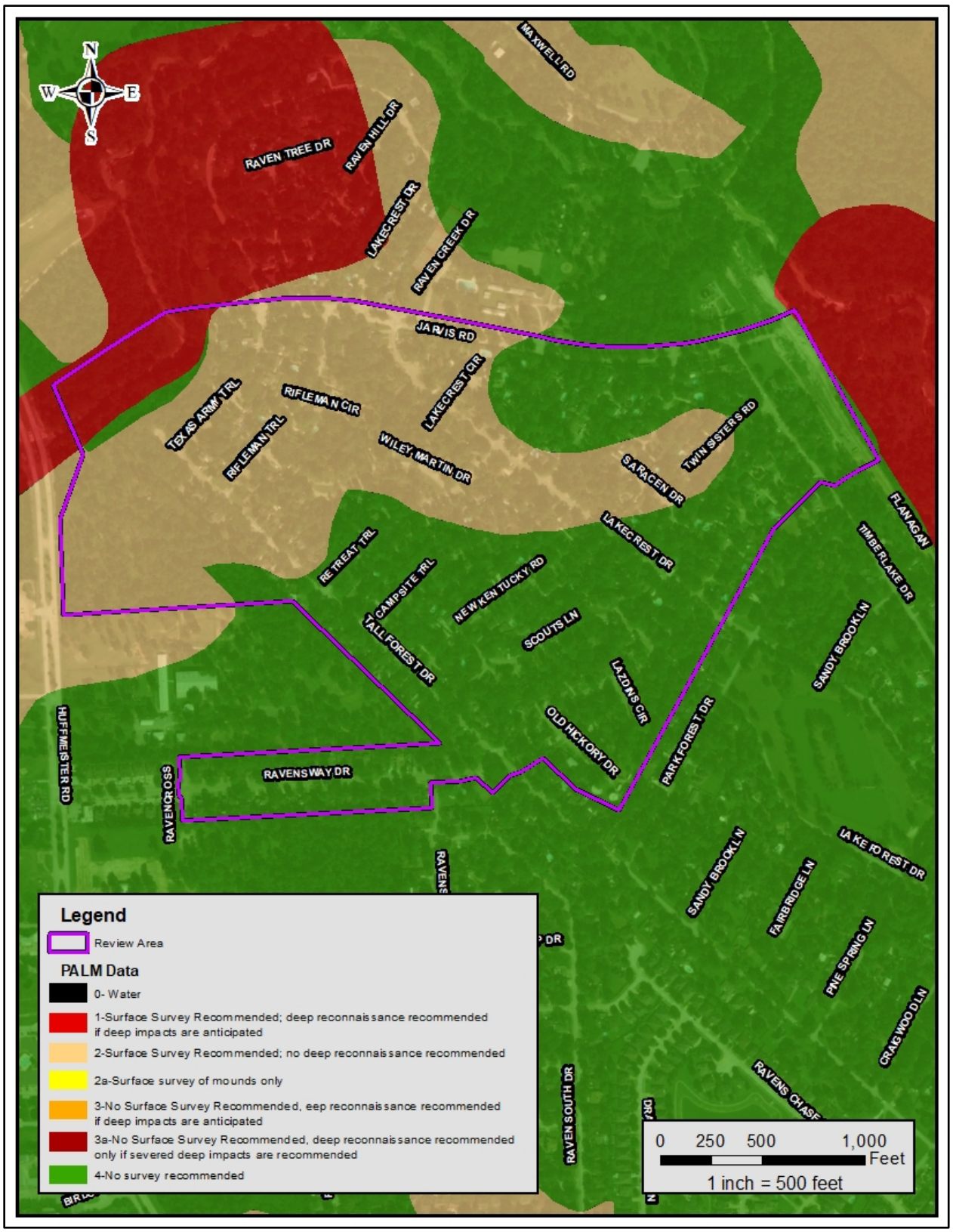

Figure 5. APE on PALM database map.

Summary and Recommendations

An assessment of both geology and soils of the review area shows that the APE is underlain by Pleistocene and Holocene-age deposits. Examination of soil survey data shows that soils of the Clodine and Wockley Series are mapped in the APE, as well as Hatliff-Pluck-Kian Complex and Pits. Of these, soils of the Hatliff-Pluck-Kian Complex are formed from Holocene-age clayey alluvium derived from igneous, metamorphic, and sedimentary rock. Furthermore, they are mapped in the northwest section of the APE, which is near a creek and is relatively undeveloped.

A review of information provided in the *Atlas* shows that no archaeological sites have been recorded within the boundaries of the APE. The nearest recorded archaeological site is 41HR366, a Late Prehistoric campsite near the banks of Cypress Creek, located approximately 422 feet (128.6 m) northeast of the APE. In addition to this site, the review of the *Atlas* showed that an additional 18 archaeological sites have been recorded within a 1-mile (1.6 km) radius of the APE . Many of these sites were recorded along the banks of Cypress Creek. A further review of the Atlas shows that a single cemetery (Dowdell Cemetery) has been recorded within the boundaries of the APE, which contains burials dating from the late nineteenth to early twentieth centuries. Two surveys have been conducted within the eastern section of the APE, limited to the eastern end of the APE. The remainder of the APE has not been surveyed.

Based on the background review, the APE has the potential to contain intact cultural deposits; however, a majority of the APE has been significantly impacted by residential development. As such, **RKI** recommends no further work within the areas already developed. However, **RKI** does recommend both surface and subsurface investigations for the northwestern portions of the APE and areas of impacts located within undeveloped areas within the APE. Additional work should include a pedestrian survey augmented by both shovel testing and backhoe trenching in order to determine the presence/absence of both surface and subsurface cultural materials. The exact scope of work will be determined once the horizontal and vertical areas of impacts are provided for the APE. **RKI** further recommends that this desktop be submitted to the reviewing agencies for review and consultation prior to any improvements in order to comply with ACT and Section 106 regulations.

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ARCHAEOLOGICAL INVESTIGATIONS FOR THE PROPOSED RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – PRECINCT 3 PROJECT, HARRIS COUNTY, TEXAS

DRAFT REPORT

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Texas Antiquities Committee Permit Number 30608

Cultural Resources Report No. 22-007

ASF21-116-01

June 3, 2022

ABSTRACT

Raba Kistner, Inc. (RKI) was contracted by LJA Engineering (CLIENT), on behalf of Harris County Flood Control District and Harris County Engineering Department, to conduct archaeological investigations for proposed drainage improvements for the Ravensway Subdivision in northwestern Harris County, Texas. The proposed Ravensway Subdivision Drainage Improvements – Precinct 3 Project will involve construction of a detention basin and associated drainage improvements adjacent to Cypress Creek. The proposed undertaking will take place on county-owned land. As such, the proposed project is subject to review under the jurisdiction of the Antiquities Code of Texas (ACT; Texas Natural Resources Code, Title 9, Chapter 191). These legislations call for the assessment of all proposed improvement activities that have a potential to disturb historically significant resources and significant subsurface deposits on lands owned by the State. Oversight of compliance with the ACT is administered by the Texas Historical Commission (THC). Furthermore, as the project has the potential to impact known waterways, the undertaking is potentially subject to review under Section 106 of the National Historic Preservation Act (NHPA) (16 United States Code 470) and its implementing regulations (36 Code of Federal Regulation 800). Compliance with Section 106 is regulated by the U.S. Army Corps of Engineers (USACE). All work was conducted in accordance with the Archeological Survey Standards of Texas as set forth by the CTA and adopted by the THC, under Texas Antiquities Committee Permit Number 30608.

Investigations consisted of an intensive pedestrian survey augmented by shovel testing, mechanical backhoe trenching, hand augering, and a windshield survey within the Project Area. Archaeological investigations of the 153.1-acre Project Area was conducted from May 2–5, 2022. Kirsten M. Atwood served as Principal Investigator and Project Manager for the duration of the project, and all fieldwork was conducted by Adam Birge, Jason M. Whitaker, and Christopher Mathews. Disturbances observed during the course of the survey consisted of road and culvert construction, fence installation, vegetation clearance, installation of utilities, and residential construction. No historic or prehistoric cultural materials or features were encountered.

As part of the pedestrian survey, 45 shovel tests (AB01–15, CM01–26, and JW01–04) were excavated within the boundaries of the 22.3-acre northwestern Project Area. Depths of shovel tests varied between 7.9 inches (20 centimeters [cm]) and 3.3 feet (1 meter [m]) below surface. Shovel tests were terminated

due to reaching maximum depth, impassible roots, impassible rocks, and compacted redoximorphic soils. No cultural resources were encountered during shovel testing.

The 6.3-acre area adjacent to Cypress Creek was selected for deep testing due to deep alluvial soils and proximity to fresh water, which indicated a strong potential for deeply buried cultural deposits. In addition to shovel testing and pedestrian survey, five mechanical backhoe trenches (BHT1–BHT5) and 13 hand auger tests (AT1–AT13) were placed within this 6.3-acre area of the northwestern portion of the Project Area near Cypress Creek. Depths of backhoe trenches varied between 12.8 feet (3.9 meters [m]) to 13.1 feet (4 m) below surface. Generally, soils within the backhoe trenches were a grayish brown (10YR 5/2) to a dark grayish brown (10YR 4/2) sandy loam over similarly colored sandy clay loam with pronounced ferrous redoximorphic features and lens of light gray (10YR 7/2) to very pale brown (10YR 7/3) sand. All backhoe trenches were terminated when the mechanical backhoe could no longer significantly excavate into the heavily compacted clay. Backhoe trenching was limited to the area south of Cypress Creek.

Due to difficulties accessing the area north of Cypress Creek with a mechanical backhoe, 13 hand auger tests (AT1-AT13) were excavated in this area. Depths of hand auger tests varied between 59.1 inches (150 cm) and 9.8 feet (3 m) below surface. Generally, hand auger tests encountered soils similar to those found within the backhoe trenches: a brown (10YR 5/3) sandy loam with increasing clay with depth and alternating layers of light gray (10YR 7/2). Hand auger tests were terminated mainly due to depth, but four were terminated due to compacted soils and one due to root impasse.

Finally, the windshield survey of the remaining 130.8-acres of the Project Area indicated a circa 1970s and later residential development displaying numerous impacts associated with the construction of houses. This include installation of utilities, roads, fence construction, and the grading and leveling of land.

RKI has made a reasonable and good faith effort to identify cultural resources within the given Project Area. No archaeological deposits or features were identified during the pedestrian survey or subsurface testing of the Project Area. As such, **RKI** recommends no further archaeological investigations within the Project Area. However, should changes be made to the Project Area, further work may be required. All field records and photographs produced during investigations will be permanently housed at the Center for Archaeological Research at the University of Texas at San Antonio.

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CHAPTER 1. INTRODUCTION

Raba Kistner, Inc. (RKI) was contacted by LJA Engineering (CLIENT), on behalf of Harris County Flood Control District and Harris County Engineering Department, to conduct archaeological investigations in advance of proposed drainage improvement for the Ravensway Subdivision in northwestern Harris County, Texas (**Figure 1-1**). The proposed Ravensway Subdivision Drainage Improvements – Precinct 3 Project will involve construction of a detention basin and associated drainage improvements adjacent to Cypress Creek. The proposed undertaking will take place on county-owned land. As such, the proposed project is subject to review under the jurisdiction of the Antiquities Code of Texas (ACT; Texas Natural Resources Code, Title 9, Chapter 191). These legislations call for the assessment of all proposed improvement activities that have a potential to disturb historically significant resources and significant subsurface deposits on lands owned by the State. Oversight of compliance with the ACT is administered by the Texas Historical Commission (THC). Furthermore, as the project has the potential to impact known waterways, the undertaking is potentially subject to review under Section 106 of the National Historic Preservation Act (NHPA) (16 United States Code 470) and its implementing regulations (36 Code of Federal Regulation 800). Compliance with Section 106 is regulated by the U.S. Army Corps of Engineers (USACE).

The purpose of the investigations was to identify any surface-exposed and/or buried cultural deposits and assess their significance and eligibility for inclusion in the National Register of Historic Places (NRHP) and for formal designation as State Antiquities Landmarks (SAL). The investigations were conducted on behalf of LJA Engineering to satisfy the requirements of the ACT, and potentially Section 106 of the NRHP. All work was conducted in accordance with the Archeological Survey Standards for Texas as set forth by the Council of Texas Archeologists (CTA) and the THC under Texas Antiquities Permit Number 30608.

Project Area and Project Description

The Project Area occupies approximately 153.1-acres east of Huffmeister Road at its intersection with Ravensway Drive, in close proximity to the confluence of Cypress Creek and Little Cypress Creek (**Figure 1-2**). The Project Area consists of undeveloped, heavily vegetated land that is intersected by Cypress Creek, and a heavily developed suburban residential area. As part of the project, a detention basin is to be constructed west of existing suburban development, and improvements will be conducted at three outfall locations leading to existing drainages. Impacts are expected to extend up to 25-feet (7.6 meters

[m]) below surface. The Project Area is depicted on the *Cypress (2995-343), Texas.* 7.5-minute U.S. Geological Survey (USGS) topographic quadrangle map to the west, and the *Satsuma (2995-344), Texas.* topographic map to the east (**Figure 1-3**).

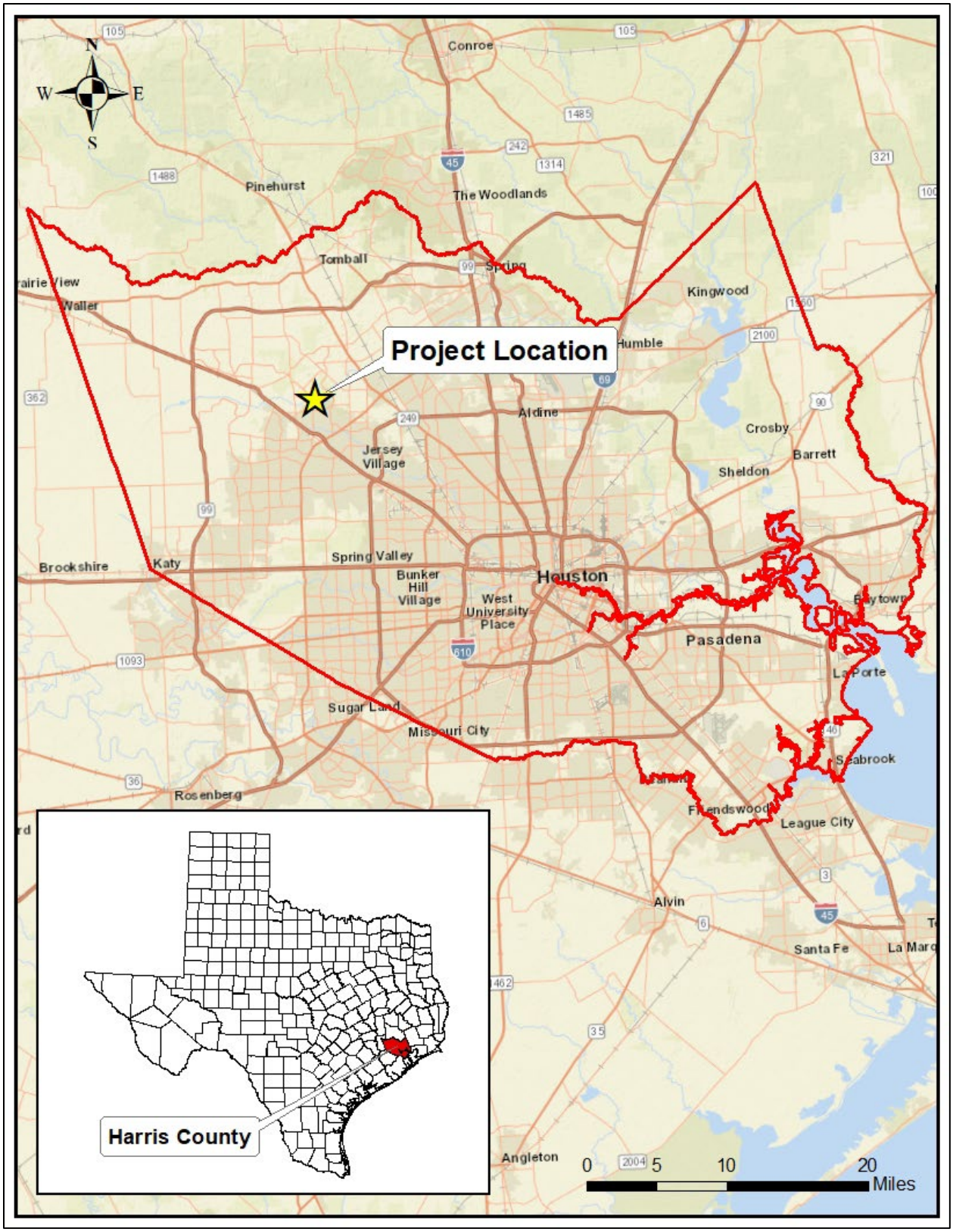

Figure 1-1. Project Area location within Harris County, Texas.

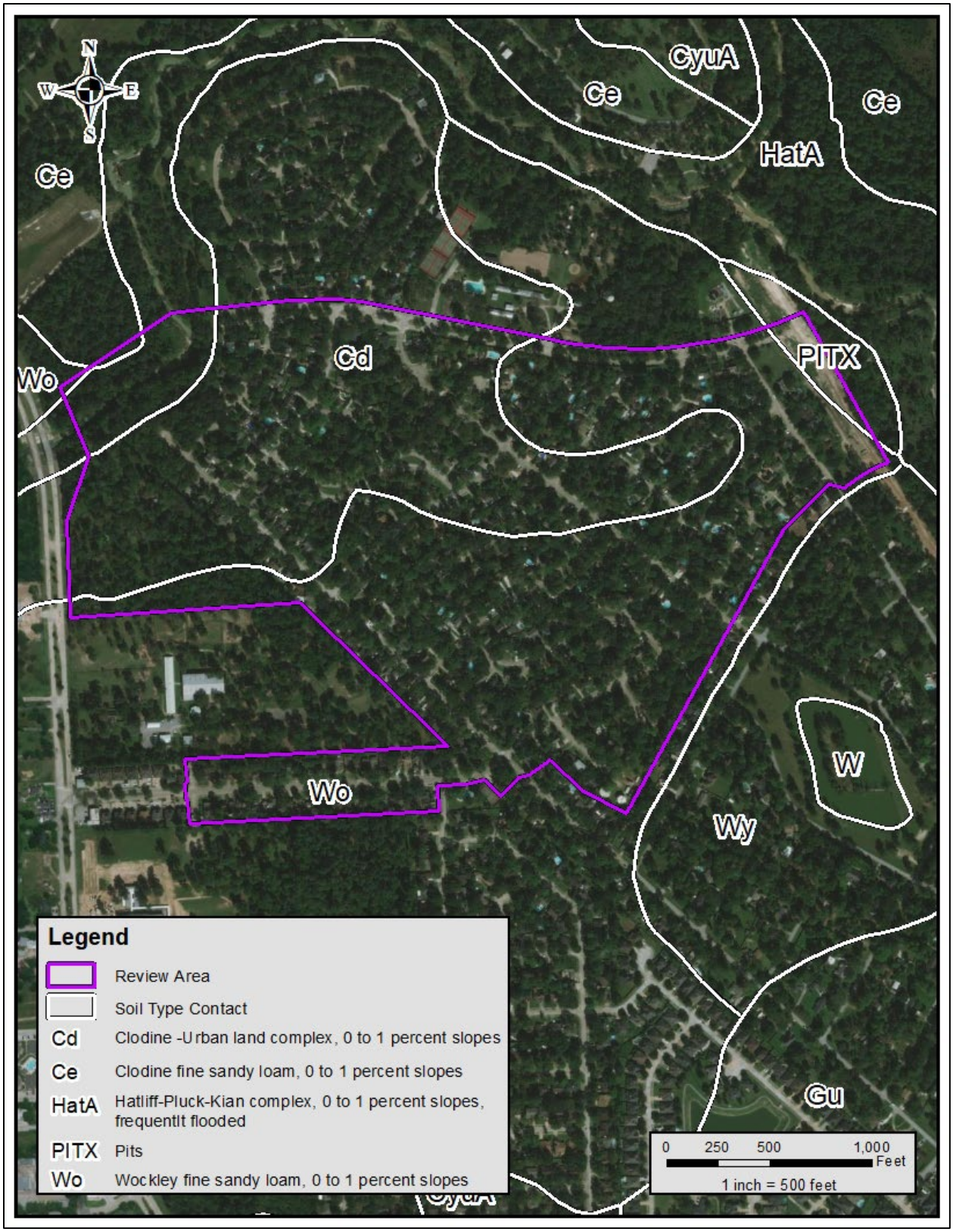

Figure 1-2. Project Area depicted on circa 2019 aerial imagery.

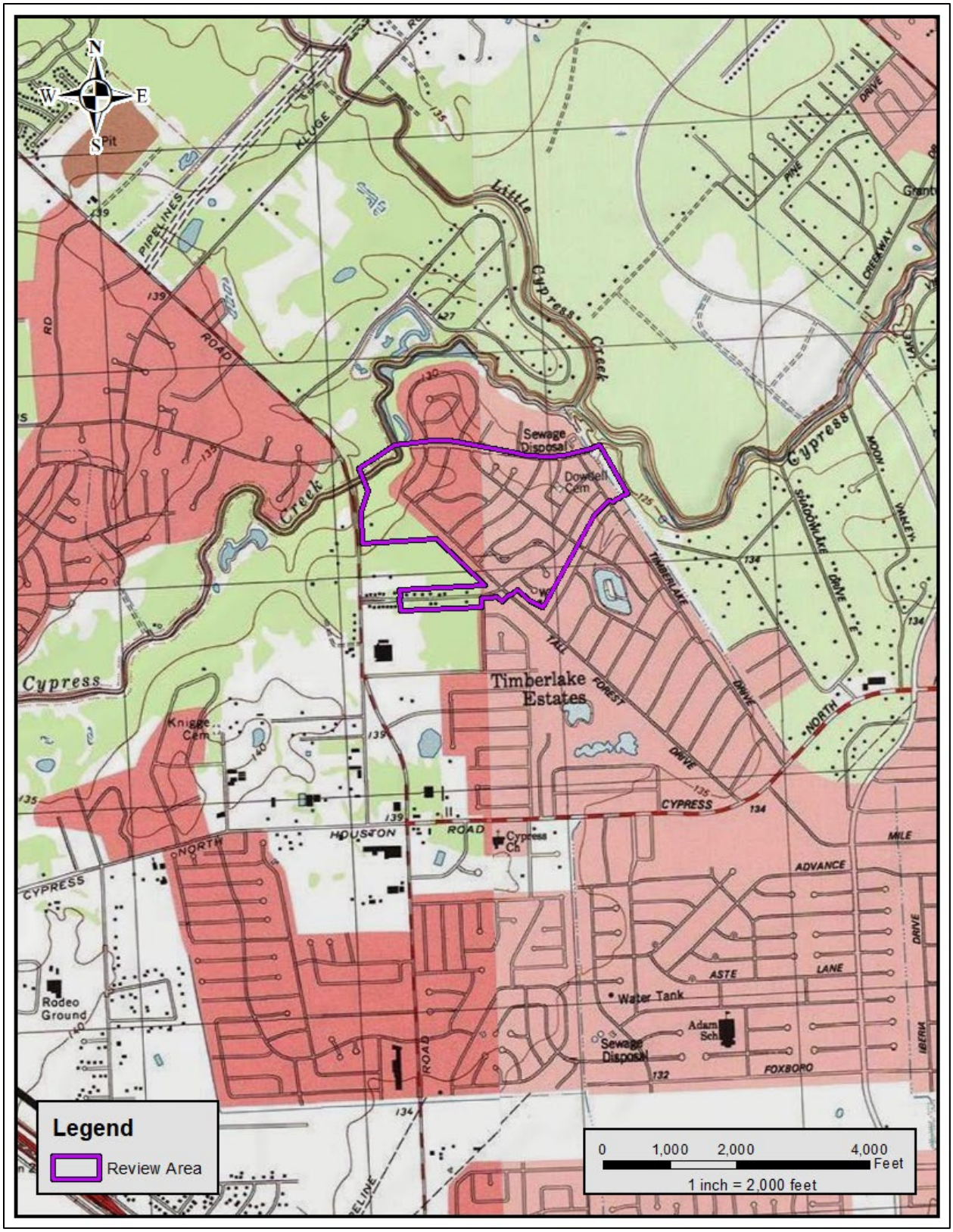

Figure 1-3. Project Area depicted on the *Cypress (2995-343*) and *Satsuma (2995-344), Texas.* USGS 7.5-minute topographic quadrangle maps.

CHAPTER 2. ENVIRONMENTAL SETTING

The Project Area is mapped within the Northern Humid Gulf Coast Prairies ecoregion, a subdivision of the Western Gulf Coastal Plain ecoregion of southeast Texas (Griffith et al. 2007). The Western Gulf Coastal Plains are characteristically flat and suitable for grassland natural vegetation. The Northern Humid Gulf Coast Prairies ecoregion is a largely flat to gently sloping coastal plain that has poor drainage due to its low topographic relief and clayey subsoils. Surface soils of the ecoregion often consist of fine textured clay, clay loam, or sandy clay loam. The natural vegetation was largely tallgrass grasslands, which are occasionally interspersed with oak mottes; however, the ecoregion has been strongly impacted by development and historically native vegetation has largely been extirpated from much of the area.

Geology

The Project Area is entirely underlain by the Pleistocene and Holocene-age Lissie Formation (Ql) (United States Geological Survey [USGS] 2022). The Lissie Formation consists of sand, silt, clay, and minor amounts of gravel. The upper part of the Lissie Formation may be locally calcareous, and is composed of clay, silt, sand, and a very small amount of siliceous gravel. The topography is fairly flat and featureless except for numerous rounded shallow depressions and pimple mounds. The lower part of the Lissie formation is composed of clay, silt, and sand, and has a minor gravel component that is slightly coarser than that of the upper part (USGS 2022).

Soils

Information provided by the Natural Resources Conservation Service (NRCS) shows that five soils are mapped within the Project Area: Clodine-Urban land complex, 0 to 1 percent slopes (Ce); Wockley fine sandy loam 0 to 1 percent slopes (Wo); Hatliff-Pluck-Kian Complex, 0 to 1 percent slopes (HatA); Clodine fine sandy loam, 0 to 1 percent slopes (Cd); and what the NRCS labels as Pits (PITX) (NRCS 2022) (**Figure 2-1**). Soils of the Clodine-Urban land complex consist of Clodine loam, urban land, Katy fine sandy loam, and Gessner loam. The Clodine series are somewhat poorly drained and formed from loamy fluviomarine deposits derived from igneous, metamorphic, and sedimentary rock. Urban soils are found in areas of high population density in built-up environments. These soils can be formed from human-transported materials, human-altered materials, or minimally altered intact soils. Katy soils are moderately well drained, moderately slow permeable soils that formed in loamy sediments derived from the Lissie

Formation. Gessner loams are poorly drained, very slowly permeable soils that formed in loamy fluviomarinde deposits derived from the Lissie Formation of Pleistocene-age. Intact soils of the Clodine-Urban land complex extend approximately 80 inches (203 centimeters [cm]) below surface (NRCS 2022) Soils of the Wockley Series are somewhat poorly drained and formed from late Pliocene to early Pleistocene loamy fluviomarine deposits derived from igneous, metamorphic, and sedimentary rock. They extend approximately 80 inches (203 cm) below surface (NRCS 2022). The Hatliff-Pluck-Kian Complex consists of the soils of the Hatliff, Pluck, and Kian Series. Hatliff Series soils are well drained and formed from Holocene-age clayey alluvium derived from igneous, metamorphic, and sedimentary rock, whereas soils of both the Pluck and Kian Series are poorly drained and formed from loamy alluvium derived from igneous, metamorphic, and sedimentary rock. All three soils extend approximately 80 inches (203 cm) below surface (NRCS 2022). Pits are not defined by the NRCS, but a review of historical aerial photography indicates them to disturbed by previous excavation.

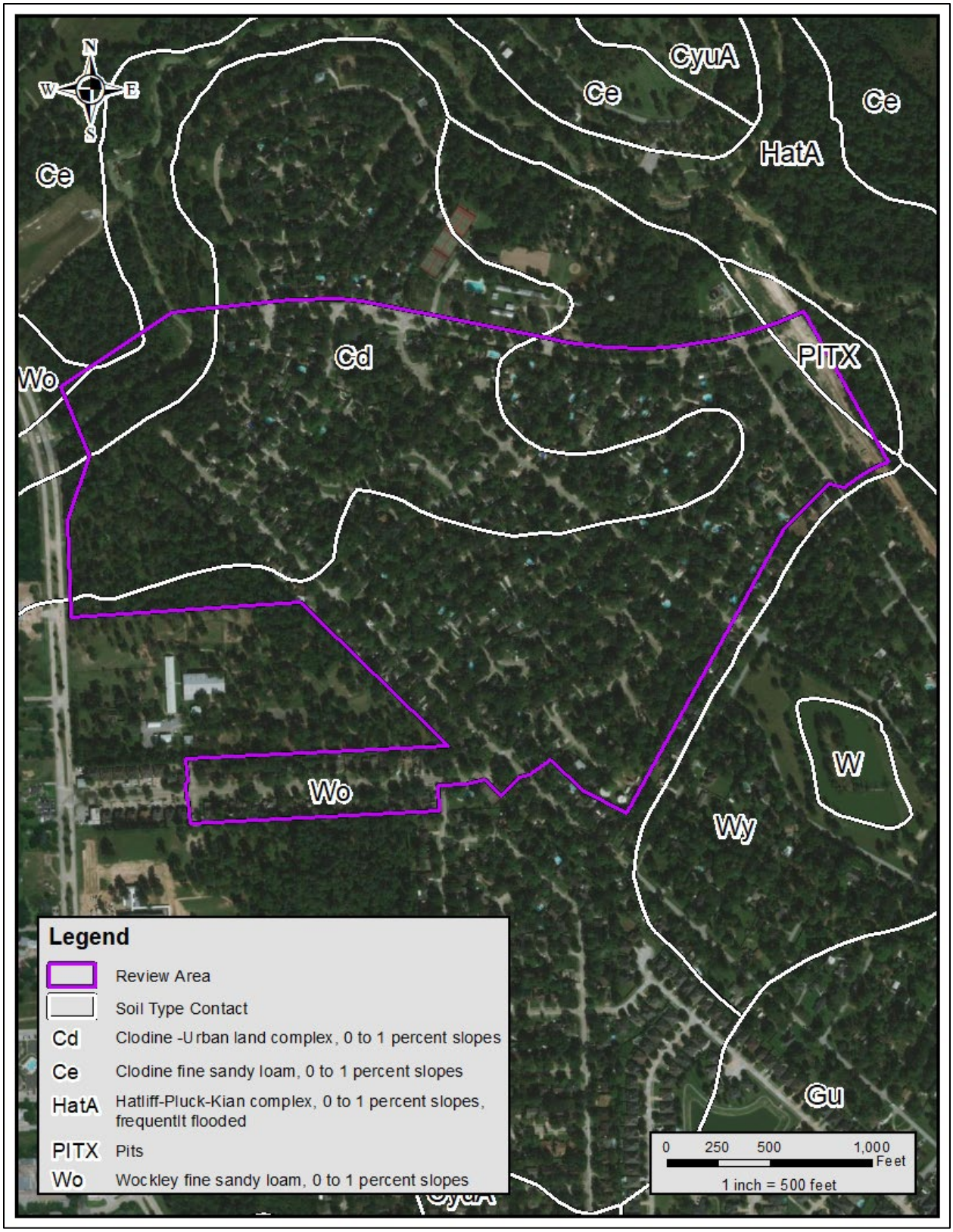

Figure 2-1. Soils mapped within the Project Area.

Predictive Archaeological Liability Map

A review of the Texas Department of Transportation's (TxDOT's) Potential Archeological Liability Map (PALM) determined that the Project Area covers three areas of recommendation (**Figure 2-2**). Specifically, a majority of the southeastern half of the Project Area is demarcated as Class 4 (No Survey Recommended). However, most of the northwestern portion of the Project Area is classified as Class 2 (Surface Survey Recommended with no deep reconnaissance recommended). The portions of the Project Area located immediately adjacent to portion of Cypress Creek that intersects the Project Area are demarcated as Class 1 (Surface Survey Recommended with deep reconnaissance recommended if deep impacts are anticipated).

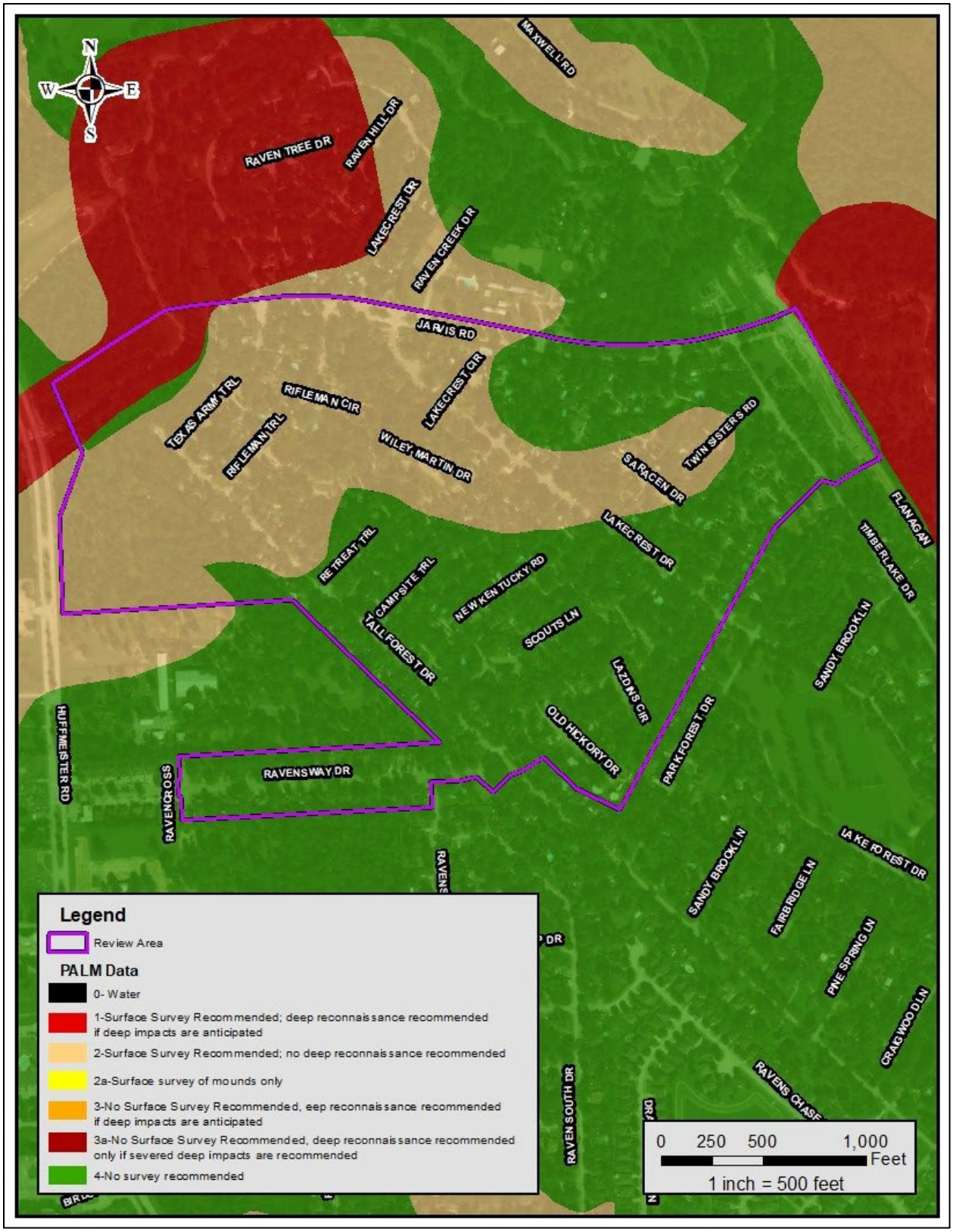

Figure 2-2. Project Area projected onto TxDOT PALM database map.

CHAPTER 3. CULTURAL CONTEXT

The Project Area lies within the Southeast Texas archaeological region (Pertulla 2004). Humans have inhabited the southeast region of Texas for at least 11,500 years, adapting to changes in climatic and biotic conditions as they occurred. Archaeologists researching long-term change in settlement structures, subsistence choices, and technological innovation have identified distinct coastal and inland adaptions in this region (Ricklis 2004; Story 1990). Southeastern Texas coastal populations took advantage of the abundant resources of the coastal prairie and nearby estuaries. The cultural chronology of the region is divided into six major time periods: Paleoindian (11,500 to 7,000 BC); Archaic (7,000 to 500 BC); Transitional Late Archaic or Early Ceramic Period (500 BC to AD 700); Late Prehistoric (AD 700 to 1700); Protohistoric (AD 1528–1700) and Historic (AD 1700 to Present). An overview of the sequence of human occupation within the region is presented below.

Paleoindian Period (11,500 BC–7000 BC)

The Paleoindian Period marks the first human occupation in the New World, starting at the end of the Pleistocene epoch. This period, lasting for approximately 4,500 years, is best known for the decline of the megafauna as continental climate became warmer and wetter. While evidence indicates that Clovis groups did traverse wide ranges in order to hunt big game, it is disputed whether these hunters contributed to mega fauna extinction (Koch and Barnosky 2006). The diverse biotic communities present at the end of the Pleistocene in Texas may have led Paleoindian populations to practice generalized subsistence strategies, which included a reliance on smaller game and plant resources.

Unfortunately, the Paleoindian Period is poorly represented across the state, including Southeast Texas. This can be attributed to two different factors: issues pertaining to projectile point temporal classifications, and climatic and geologic processes during the Pleistocene-Holocene transition. Typological issues have made it difficult to distinguish between point types and styles in the region (see Bousman et al. 2004 and Story 1990). Furthermore, the number of Paleoindian sites in Southeast Texas is small, relative to the numerous sites in the Balcones Escarpment. Geologic explorations of ancient shorelines indicate that Paleoindian sites are most likely submerged due to the advance of the Gulf of Mexico inland. The occasional Paleoindian artifact and remains of Pleistocene fauna which wash ashore at McFaddin Beach, Texas, confirms the presence of sites offshore (Abbott 2001:105-107; Story 1990:24-25).

Archaic Period (7,000 BC–500 BC)

The Archaic Period in the inland region of Southeast Texas is divided into three sub-periods: Early, Middle and Late. The divisions are based on climatic and cultural shifts. However, sub-periods can be difficult to parse out in the archaeological record due to depositional processes which mix assemblages. What is known, however, is that Archaic populations utilized mobility and subsistence strategies which took advantage of seasonal resources. A few of the settlement and subsistence strategies established during the Paleoindian period continued into the Early Archaic in the inland region. Archaeologists interpret the continuation of low site densities from this time period as an indicator of low population densities (Story 1990). Archaeological data suggests that Early Archaic people traveled in small bands, migrated seasonally, and maintained a generalized subsistence practice. The food choices of Early Archaic populations can be interpreted through their lithic assemblages. Projectile points from this time period include Neches River, Trinity, and other early stemmed points (Ricklis 2004:185; Story 1990).

Pre-Late Archaic mortuary remains are scarce within the region. However, the Buckeye Knoll site proves a strong exception. Over 116 individuals were found at this site, largely dating to the Early Archaic. Moreover, the human remains are especially notable for being placed within a true formal cemetery, rather than placed individually within the general boundaries of a residential campsite (Ricklis et al. 2012). Stable isotope data indicates that the inhabitants of the Buckeye Knoll site were hunter-gatherers who exploited both coastal resources and interior prairie-riverine resources of the San Antonio and Guadalupe Rivers. The people of Buckeye Knoll also seem to have directly or indirectly traded with people living as far away as the Mississippi Valley. The existence of a formal cemetery at the sites suggests that the Early Archaic inhabitants of Buckeye Knoll were motivated to demonstrate their entitlement to this territory by creating a distinct resting place of their ancestors, and a generating a corresponding legitimacy to their claim to the land and its resources. Buckeye Knoll thus suggests that emergent, incipient socio-cultural complexity and human-ecological and demographic conditions favoring the establishment of cemeteries were in place in Texas earlier than previously believed (Ricklis et al. 2012). Whether this relatively large, dense, and comparatively immobile human population was a generalized phenomenon that refutes the belief that Early Archaic populations were small and highly mobile, or was a localized concentration of people allowed by abundant resources has not been determined (Ricklis et al 2012). At present, the belief that most Early Archaic peoples of Texas lived in small, highly mobile groups prevails.

The Texas coastline stabilized during the Middle Archaic. Abundant estuarine resources led to changes in seasonal subsistence strategies among coastal hunter-gatherers (Ricklis 2004:188). Although the acidic soils have made it difficult to find botanical and faunal remains at inland sites, coastal sites in Harris County and changes in projectile point technology at inland sites have provided insight into Middle and Late Archaic subsistence strategies. The seasonal exploitation of coastal resources coupled with technological changes in the interior suggests that group size and mobility were altered during this time period. Calf Creek and Bell projectile points mark the transition into the Middle Archaic, followed by Yarborough, Bulverde, Pedernales and Travis points. The Late Archaic assemblage includes Kent, Gary, Ensor and Goldey (Ricklis 2004:185). Projectile points such as Kent, Pedernales, Morhiss, Pontchatrain, and Nechez River show that inland assemblages tend to resemble those of the Central Texas Coast, rather than those of Northeast Texas (Story 1990:222). Additionally, the shift to using local materials for lithic production may indicate that group mobility was greatly reduced during the Late Archaic (Ricklis 2004:185).

Large cemeteries located in the coastal plain have provided insight into the Middle and Late Archaic. The Harris County Boy's School site provided insight into how evolving estuaries changed site function and use over time. During the Middle Archaic, the site was located inland from the Galveston Bay estuary. Estuaries were exploited during mid-summer, but by late summer to early fall, people moved inland. The exploration of shell middens and fish otolith studies revealed that this subsistence strategy continued through the Late Archaic (Aten 1983:158-159). The Ernest Witte Site (41AU36) provided insight into long-distance trade during the Late Archaic. Items such as stingray spines and columella atlatl weights from either the Texas or Florida Gulf Coast, corner tang knives from the Edwards Plateau, and stone gorgets from the Ouachita Mountains of Arkansas, were found at the site (Story 1990:237-243).

Transitional Late Archaic/Early Ceramic Period (500 BC–AD 700)

Although Ricklis (2004:189) argues that the introduction of pottery into the region marks the end of the Archaic period, archaeological evidence indicates that there was cultural and technological continuity throughout this time period. The earliest pottery in Southeast Texas assemblages appears around 200 BC. Tchefuncte ceramics, typically thick-walled vessels, date to AD 200 and are found in the Galveston Bay area. In the inland region, sandy paste ceramics were adopted around AD 500 (Ricklis 2004:200). The adoption of ceramics does indicate a change in how people stored, processed, and prepared plant and

animal resources. In addition, the rapid innovations of ceramic technology in the region provide further evidence of distinct ethnic groups inhabiting the coastal and the inland regions.

Late Prehistoric Period (AD 700–AD 1528)

The beginning of the Late Prehistoric period is marked by the adoption of the bow and arrow (Ricklis 2004:194). Scallorn points, along with other thin arrow point types indicate that a new hunting strategy was widely practiced across the region. By the end of the Late Prehistoric, deposits of bison bone along with Perdiz arrow points, thin alternately beveled knives, scrapers, thin blades, and other tools suggest that subsistence now focused on bison hunting and processing. In the inland region, the appearance of this toolkit marks the beginning of the Toyah phase or horizon (Ricklis 2004:194-195). The Toyah (AD 1275-AD 1700) spanned from inland Southeast Texas, through Central Texas, towards the Texas and New Mexico border. The connecting of hunter-gatherer groups through similar ideas on technology, subsistence, and settlement patterns perhaps represents an emergence of sociopolitical complexity in the region (Arnn 2012).

Protohistoric (AD 1528–1700) and Historic Period (AD 1700–Present)

The Protohistoric period is marked by the first European contact with indigenous populations in Texas. During this period, there was intermittent contact between the indigenous groups and Spanish explorers. The protohistoric period encompasses the approximately 175 years before the Spanish significantly impacted the indigenous groups in the area. A few encounters between the indigenous communities and Europeans were recorded, including those of Cabeza de Vaca (1528-1536) and the French settlement of Fort Saint Louis established by Rene Robert Cavelier, Sieur de La Salle (1685-1689) (Weddle 2001).

French explorers and traders encountered Atakapan groups, including the Arkokisas (Orcoquisacs) and Bidai in the 1730s and 1740s. French trade items, including glass beads and nails, are found at Arkokisas sites from this time period (Ricklis 2004:198). From early ethnohistoric accounts, it is clear that sub-groups of the Atakapans utilized coastal and inland resources, and the confluences of streams and rivers for camps (Anderson 1999:154-176; Aulbach 2012:15). A French presence in the region spurred the Spanish to establish missions and marks the start of the Historic period. However, these settlements were short-lived and the Spanish left the region by 1756.

In 1824, Stephen F. Austin issued land grants along the Brazos, Colorado, and San Bernard Rivers to Anglo immigrants who are called the Old Three Hundred (Long 2019). Part of this settlement included future Harris County, which would become the southeastern border for Austin's colony (Henson 2020). In 1826, John R. Harris founded Harrisburg near Brays Bayou and Buffalo Bayou, which was later established as a port of entry for the region in 1833. Due to its location and port, Harrisburg served as the home for President David G. Burnet and Vice President Lorenzo de Zavala of the Republic of Texas. Harrisburg was burned down by Santa Anna shortly before the battle of San Jacinto. Following the Texas Revolution, the county of Harrisburg—later Harris County—was created and the small city of Houston was recognized as a county seat. Development of the area through railroads, canals, and industry started following the Civil War.

Harris County truly emerged as an important industrial zone in 1911 with the approval for the formation of the Harris County Ship Channel Navigation District. By 1914, the U.S. Army Corps of Engineers had completed a 50-mile long and 25-feet deep channel that ran from the Gulf of Mexico to its terminus at the Port of Houston (Henson 2020). The addition of oil refineries in the area along Buffalo Bayou and the San Jacinto River prompted both the deepening and widening of the channel to accommodate larger vessels. The Harris County Navigation District has since become highly profitable and owns several facilities related to shipping such as the Long Reach Docks, the container facility at the Bayport Industrial Complex, and a bulk handling plant at Greens Bayou. Additionally, the Harris County Navigation District partnered with both the national and state government in the 1950s to construct the Washburn Tunnell under Buffalo Bayou and the Baytown-La Porte Tunnel beneath the San Jacinto River (Henson 2020). Another engineering feat accomplished in Harris County was the construction of the Houston Astrodome in 1965, which was the first stadium of its kind with air conditioning and facilities for multiple sports (Chandler 2017). The Houston Astrodome was listed as a National Register District in 2013 for its significant contributions to the nation under criterion A (significant events) and criterion C (architecture). Also in the 1960s, the land east of Webster, Texas became the home of the National Aeronautics and Space Administration (NASA) Manned Spacecraft Center, which was later renamed the Lyndon B. Johnson Space Center in 1973 (Alexander and Kleiner 2020).

The ship channel attracted numerous industries, which caused a surge in population. The census of 1930 recorded 359,328 people in Harris County, which surpassed both Dallas and Bexar Counties by more than 100,000 people (Henson 2020). By 1960, the population of Harris County was over 1 million people. In

1990, the population of Harris County reached a number of 2,818,199 people, the majority of which were both Anglo and Hispanic. The most recent population estimate for Harris County shows that it has approximately 4,713,325 people living within the county (United States Census Bureau 2021).

Previous Archaeological Investigations and Cultural Resources

A review of the Texas Archeological Sites Atlas (*Atlas*) shows that there are no previously recorded archaeological sites within the boundaries of the Project Area (**Figure 3-1**) (THC 2022). The nearest previously recorded archaeological site is 41HR366, which is located approximately 422 feet (128.6 m) northeast of the Project Area. Site 41HR366 was recorded as a Late Prehistoric campsite and was listed as eligible for listing on the National Register of Historic Places (NRHP) in 2006, and as a State Antiquities Landmark (SAL) in 2005. In addition to site 41HR366, there are also 18 other previously recorded archaeological sites within 1 mile (1.6 kilometers [km]) of the Project Area's boundaries (**see Figure 3-1; Table 3-1**). Two of these sites (Knigge-Telge Cemetery and the Borgstedt Cemetery) are listed as cemeteries and are located 0.61 mile and 0.23 mile from the Project Area, respectively (**Table 3-2**). Both of these cemeteries contain graves dating from the early twentieth to early twenty-first centuries (findagrave.com 2022a and b). There are also two other cemeteries both within and within 1 mile (1.6 km) of the Project Area. The Dowdell Cemetery is located within the boundaries of the Project Area and is located along Saracen Drive approximately 358 feet (109 m) south/southwest of its intersection with Jarvis Road. Burials within this cemetery date from the late nineteenth to early twentieth centuries (findagrave.com 2022c). Finally, the Hoffmeister Cemetery is located approximately 0.45 mile (0.72 km) south of the Project Area. An examination of burials in this cemetery show that they date from the late nineteenth to mid-twentieth centuries (findagrave.com 2022d).

A review of the *Atlas* shows that the eastern section of the Project Area has been previously surveyed (**see Figure 3-1**). The first of these surveys covered a large portion of the Project Area's eastern section and was conducted in 1977 under the sponsorship of the USACE-Galveston District. Sites recorded during this survey included both 41HR337 and 41HR338 (**Table 3-3**). The second survey conducted within the Project Area was conducted in 2003 by Moore Archaeological Consultants under TAC Permit 3114 (Blaine et al 2006). Archaeological sites recorded during this survey include: 41HR970, 41HR971, and 41HR972. Examination of information provided in the *Atlas* shows that there are eight additional areal surveys

within a 1-mile (1.6 km) radius of the Project Area. The closest of these was a survey conducted in 2020 by Terracon Consultants, Inc. under TAC Permit number 9170.

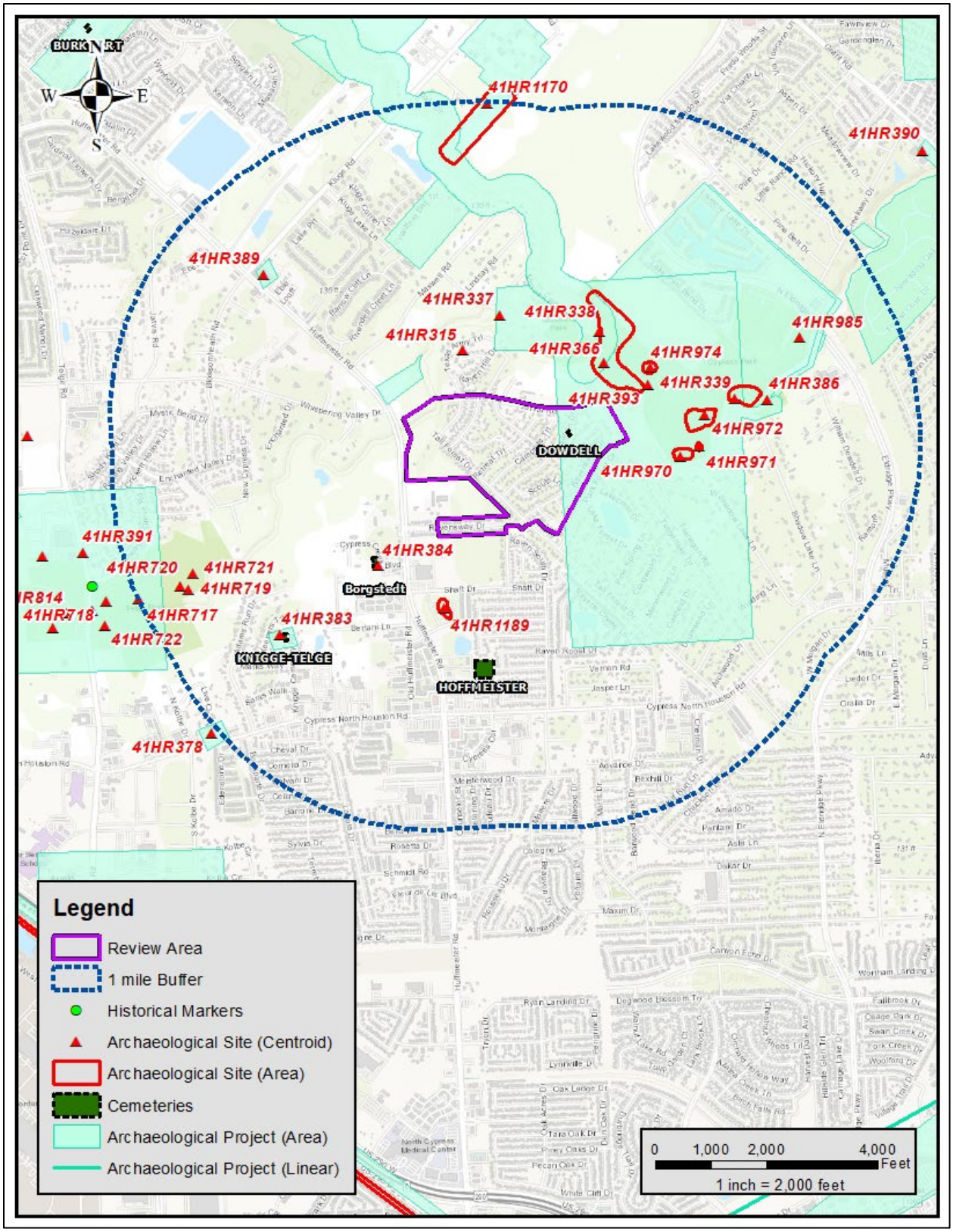

Figure 3-1. Cultural resources and investigations recorded within a 1-mile (1.61 km) radius of the Project Area.

Table 3-1. Previously Documented Archaeological Sites within 1-mile (1.6 km) of the Project Area.

Site Trinomial	Site Name	Distance from Review Area (miles/feet)	Brief Description	NRHP and SAL Eligibility
41HR315	—	0.14 mile N	Late Archaic and Woodland open campsite	No determination
41HR337	—	0.29 mile N	Lithic and Sherd scatter time-period unknown	No determination
41HR338	—	0.24 mile N/NE	Unknown prehistoric lithic and sherd scatter	No determination
41HR366	—	422 feet NE	Late Prehistoric campsite	NRHP Eligible (2006)/Listed SAL (2005)
41HR383	Knigge-Telge Cemetery	0.61 mile SW	Nineteenth and twentieth century cemetery	No determination
41HR384	Borgstedt Cemetery	0.23 mile SW	Late nineteenth to twentieth century cemetery	No determination
41HR389	—	0.68 mile NW	Early twentieth-century singe story structure and cemetery (not recorded)	No determination
41HR393	—	0.16 mile NE	Twentieth century historic camp	No determination
41HR717	—	0.94 mile SW	Unknown prehistoric campsite	No determination
41HR719	—	0.92 mile SW	Unknown prehistoric campsite	No determination
41HR720	—	0.93 mile SW	Late Prehistoric campsite	No determination
41HR721	—	0.89 mile SW	Unknown prehistoric campsite	No determination
41HR970	—	0.18 mile SE	Late Prehistoric campsite	Eligible (2006)
41HR971	—	0.25 mile SE	Unknown prehistoric open campsite	Ineligible (2006)
41HR972	—	0.22 mile E	Unknown prehistoric campsite	Eligible (2006)
41HR974	—	0.17 mile NE	Unknown prehistoric campsite	No determination
41HR1170	—	0.79 mile N	Unknown prehistoric subsurface lithic scatter	No determination
41HR1189	—	0.24 mile S	Late nineteenth to early twentieth century farmstead	No determination

Table 3-2. Cemeteries Recorded within 1-mile (1.6 km) of the Project Area.

Resource Type	ID No.	Name	Distance from Review Area (miles)	Time-Period
Cemetery	HR-C078	Dowdell Cemetery	Within Review Area	Late nineteenth to early twentieth centuries
Cemetery	HR-C500	Borgstedt Cemetery/Burnett-Borgstedt Cemetery	0.16 mile SW	Early twentieth to early twenty-first centuries
Cemetery	HR-C074	Knigge-Telge	0.61 mile SW	Early twentieth to early twenty-first centuries
Cemetery	HR-C226	Hoffmeister	0.45 mile S	Late nineteenth to mid-twentieth centuries

Table 3-3. Previously Conducted Archaeological Investigations within 1-mile (1.6 km) of the Project Area.

Survey Type	Distance from Review Area	Year Conducted	Investigating Firm	TAC Permit No.	Sites Recorded
Areal	Within Review Area	1977	Sponsored by the United States Army Corps of Engineers (USACE)-Galveston District	—	41HR337, 41HR338
Areal	Within Review Area	2003	Moore Archaeological Consultants, Inc.	3114	41HR970, 41HR971, 41HR972
Areal	Adjacent to northern Review Area boundary	2020	Terracon Consultants, Inc.	9170	—
Areal	0.12 mile N	2006	HRA Gray and Pape	4115	—
Areal	0.67 mile NW	1978	Sponsored by the USACE-Galveston District	—	41HR389
Areal	0.61 mile SW	1978	Sponsored by the USACE-Galveston District	—	41HR383 (Knigge-Telge Cemetery)
Areal	0.86 mile W	1978	Sponsored by the USACE-Galveston District	—	41HR391, 41HR394
Areal	0.87 mile NE	2017	Stone Point Services, LLC	8116	—
Areal	0.50 mile N	2014	SWCA Environmental Consultants, Inc.	—	—

Historical Map and Aerial Photography Review

A review of available historical and more recent topographic maps and aerial photographs was conducted in order to establish the development history, potential historical resources, and potential disturbances within and immediately adjacent to the Project Area.

Available topographical maps date to 1915, 1916, 1918, 1920, 1955, 1957, 1961, 1970, 1982, 1995, 2010, 2013, 2016, and 2019. The 1915 and 1916 topographic maps show that Huffmeister Road was in place by 1915, and no structures or other development are depicted within or immediately adjacent to the Project Area. Dowdell Cemetery first appears on the 1955 topographic map. The 1961 map continues to depict the Project Area and immediately adjacent areas as undeveloped apart from Huffmeister Road and Dowdell Cemetery. The 1970 topographic maps are the first maps to show substantial development near and within the Project Area. On these maps, the majority of the Project Area is depicted as undeveloped, but an artificial drainage is depicted near the eastern extent of the Project Area, paralleling Timberlake Drive. One to two structures are depicted as within or adjacent to the southeast extent of the Project Area, and a structure is depicted within the western Project Area. Ravensway Drive is depicted. The 1982 and later maps show substantial residential development of the eastern and southern Project Area, and the western Project Area as largely undeveloped.

Available aerial photographs date to 1944, 1957, 1964, 1968, 1973, 1979, 1981, 1982, 1983, 1995, 2002, 2004, 2009, 2010, 2012, 2014, 2016, 2018, and 2019. The 1944 photograph shows Huffmeister Road in place. The Project Area is undeveloped and vegetated with grassy and bushy and/or woody vegetation. A portion of the southwestern Project Area at Ravensway Drive is depicted as cleared of most woody and bushy vegetation. The 1953 photograph shows impacts to the area adjacent to Cypress Creek. These impacts appear to be vegetation clearance and land modification, such as berm installation. An insubstantial road is shown to direct through the eastern Project Area (**Figure 3-2**). The 1957 map depicts the artificial drainage channel and associated intense soil disturbances at the eastern extent of the Project Area. Park Forrest Drive is depicted south of the Project Area, but no structures were yet built along it. A structure was built along Park Forrest Drive adjacent to the Project Area by 1964, and, by 1968, several more structures were constructed adjacent to the Project Area in this vicinity. A structure was constructed in the western Project Area by 1968. The 1973 shows radical change to the Project Area in the form of road construction in the western and southern portion of the Project Area. The current residential areas

of the Project Area were occupied by both homes and roads. A small amount of residential development is depicted within the western Project area.

Overall, apart from the installation of Huffmeister Road and Dowdell Cemetery, the Project Area and vicinity seem to have been comparatively undisturbed and undeveloped until the early 1950s, when land modification and vegetation clearance took place along Cypress Creek. By the late 1950s, the installation of the artificial drainage channel that parallels Timberlake Drive east of the Project Area resulted in additional disturbances. However, despite the construction of a home within and several homes in the vicinity of the Project Area by 1968, development within and near the Project Area was minimal until the early 1970s, when substantial road construction began in the western and southern portions of the Project Area in preparation for residential development. By 1976, the Project Area reached its approximate current form, with much of the eastern and southern area developed into inhabited residential areas, and the western Project Area comparatively undeveloped and well vegetated.

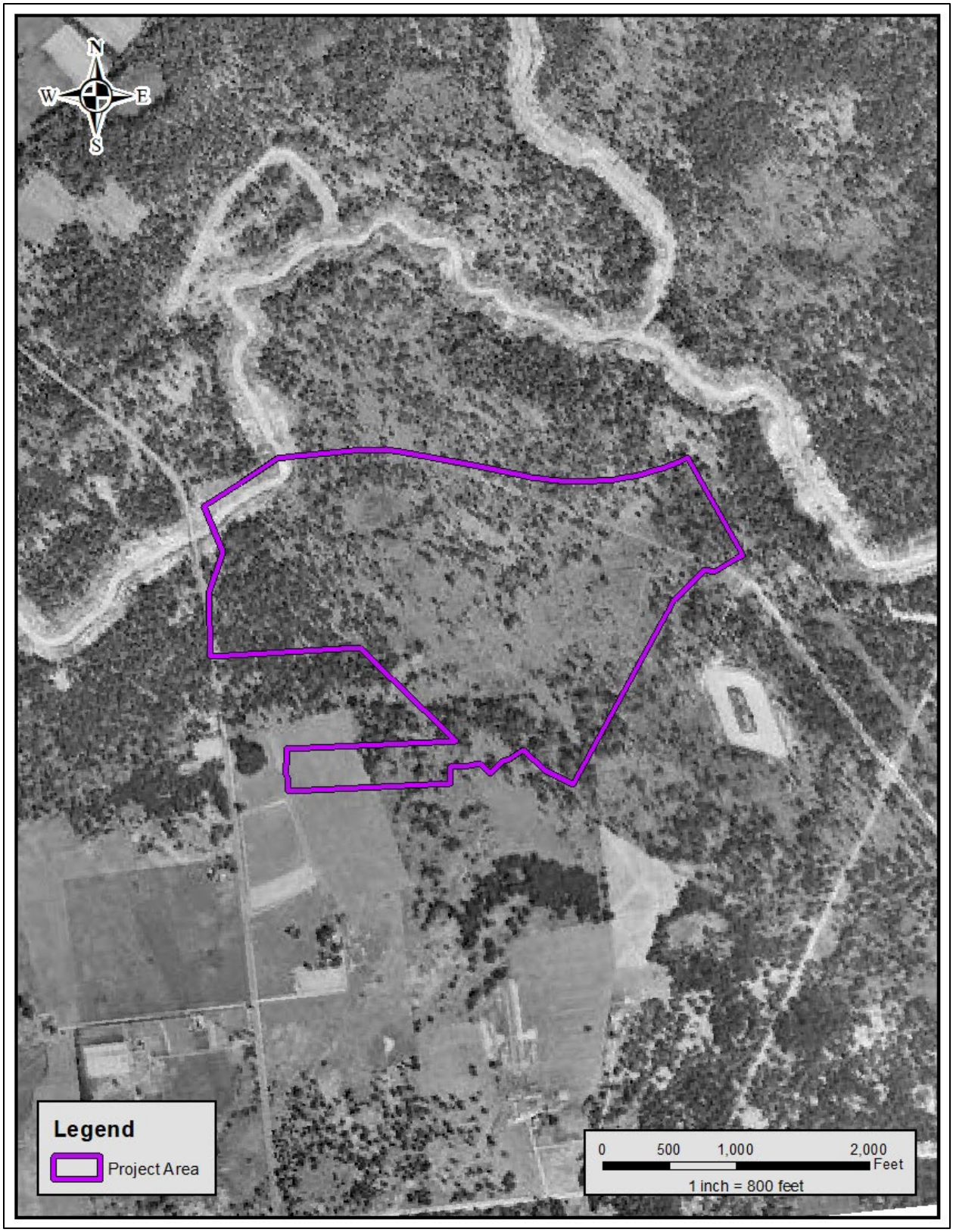

Figure 3-2. Project Area projected on the 1953 aerial photograph.

CHAPTER 4. METHODS OF INVESTIGATION

To ensure that the project met the requirements of the regulating agency, **RKI** performed an intensive pedestrian survey augmented with shovel testing, mechanical backhoe trench investigations, and hand augering within undeveloped portions of the Project Area, and a windshield survey within developed portions of the Project Area. Investigations ensured that if surface and subsurface historic or prehistoric deposits and/or features were present in the Project Area, they were properly recorded and evaluated prior to any negative impacts associated with the proposed project. All work complied with both CTA and THC standards and Occupational Safety and Health Administration (OSHA) guidelines for the project.

Pedestrian Survey and Shovel Testing

The approximately 22.3 undeveloped acres of the northwestern Project Area was subjected to intensive pedestrian survey augmented with shovel testing. This 22.3-acre Project Area was visually inspected in order to detect surface visible cultural materials. Per the CTA and THC minimum standards for areal projects less than 25 acres, at least two shovel tests should be excavated per acre. As such, forty-five (45) shovel tests were excavated as part of the pedestrian survey. Shovel tests were excavated to a maximum depth of 3.3 feet (1 m) and an average depth of 31.5 inches (80 cm). Shovel tests ranged from 13 to 14 inches (32 to 35 cm) in diameter, and were excavated in 7.87-inch (20 cm) levels. A shovel test form was completed for each excavated shovel test. Data collected from the shovel tests included the final excavation depth, reason for termination, a tally of all materials observed from each 8-inch (20-cm) level, and a brief soil description (texture, consistency, Munsell color, inclusions). Shovel test locations were recorded using a sub-meter accurate, hand-held Trimble Geo 7x© Global Positioning System (GPS) unit. Any additional observations considered pertinent were included as comments on the standard shovel test excavation form. A shovel test log containing data from each shovel test is provided in **Appendix A**.

Mechanical Backhoe Trenching

RKI archaeologists conducted five (5) backhoe trench excavations within approximately 6.3-acres of the northwestern Project Area adjacent to Cypress Creek. This area was recommended for deep testing according to TxDOT's PALM map. However, due to access issues, backhoe trench excavations were only conducted to the south of Cypress Creek. The placement of trenches was determined by the attending

Archaeologists based on local circumstances. Backhoe trenches were excavated by a professional backhoe operator and all excavations were performed in accordance with OSHA guidelines (26 CFR Part 1926) and the Texas Trench Safety Act (H.B. 1569). Prior to excavations, **RKI** performed a One Call (Texas 811) to verify that there are no existing utilities within the excavation area.

Backhoe trenches ranged from 13 to 16 feet (4 to 4.6 m) in length and were approximately 3 feet (1 m) wide to allow ease of access. The trenches attempted to reach a maximum depth of the backhoe, approximately 13 feet (4 m) below surface. As per OSHA guidelines, **RKI** archaeologists did not enter non-benched trenches at depths greater than 4.5-feet (1.4 m) below surface. As per CTA standards, **RKI** archaeologists excavated the backhoe trenches with a smooth-bladed bucket in approximately 5-cm-thick levels with inspection of walls. Additionally, all spoils were examined for cultural materials. All trench excavations were photo-documented and profiles were examined to identify any exposed cultural materials and/or features. Documentation of trenches consisted of careful examination of profile walls as well as clearing of a representative segment, which was then photographed with a scale and a detailed drawing was made that highlighted soil strata. All backhoe trenches were negative for subsurface cultural materials. The location of each backhoe trench was recorded with a Trimble Geo 7x© GPS unit. A backhoe trench log is provided in **Appendix B**.

Hand Augering

An approximately 2.6-acre area of the 6.3-acre Project Area recommended for backhoe trenching to the north of Cypress Creek was inaccessible to the backhoe due to lack of right of entry, steep side channels of the creek, and generally overgrown nature of this area. Per requirements of the THC's minimum standards for augering, hand augering using a 3-inch or 4-inche bucket auger will require two augers per one shovel tests. As such, the 2.6-acre area was subjected to thirteen (13) hand auger tests, exceeding the minimum requirement. All spoils removed from the tests were screened for cultural material.

The initial 31.5-inches (80 cm) of hand auger tests were excavated via shovel. Below this depth, hand auger tests were excavated using a 3-inch bucket. Hand auger tests were planned to a maximum depth of 9 feet (2.74 m). A hand auger test form was filled out for each excavated unit, which contained information on the soils encountered, any artifacts recovered, the disturbances noted, and references to samples retained and photographs taken. An auger test log containing data from each auger test is provided in **Appendix C.**

Windshield Survey

The approximately 130.8-acre developed portion of the Project Area was subjected to a windshield survey. This area was found to be heavily disturbed by residential construction and the installation of utilities, including an artificial drainage ditch; as such, this portion of the Project Area was not subject to any intensive cultural resources investigations. The goal of the windshield survey was to photo-document disturbances and locate any cultural resources present.

Laboratory Methods and Artifact Collection Policy

The project adhered to a temporally diagnostic artifact collection only policy. No diagnostic artifacts were identified during the course of the investigations, thus, no artifacts were collected. All project-related documentation produced during the survey were prepared in accordance with federal regulation 36 CFR Part 79, and THC requirements for State Held-in-Trust collections. Field notes, field forms, photographs, and field drawings were placed into labeled archival folders and converted into electronic files. Digital photographs were printed on acid-free paper, labeled with archivally appropriate materials, and were placed in archival-quality plastic sleeves when needed. All field forms were completed with pencil. A copy of the report and all digital materials were saved onto a CD and stored with field notes and documents. Records will be permanently housed at the Center for Archaeological Research at the University of Texas at San Antonio.

CHAPTER 5. RESULTS OF INVESTIGATIONS

From May 2 through 5, 2022, **RKI** conducted archaeological investigations within the 153.1-acre Project Area of the proposed drainage improvements for the Ravensway Subdivision. The Project Area was divided into two separate areas based on previous impacts: one 130.8-acre windshield survey area heavily impacted by development of circa early 1970s residential subdivision, and one 22.3-acre intensive investigation area in the northwest Project Area with relatively few previous impacts (**Figure 5-1**). Kirsten M. Atwood, Ph.D., served as Principal Investigator and Project Manager throughout the duration of the project, and fieldwork was conducted by Adam T. Birge, M.A., Jason Whitaker, M.A., and Christopher Matthews, B.A. The investigations consisted of a pedestrian survey augmented by shovel testing, backhoe trenching, hand augering, and a windshield survey. As a result of the investigations, 45 shovel tests, 5 backhoe trenches, and 13 hand auger tests were excavated within the Project Area (**see Figure 5-2**). No historical or prehistoric cultural materials were encountered on the surface or within excavated tests in the Project Area. As such, no archaeological sites were recorded.

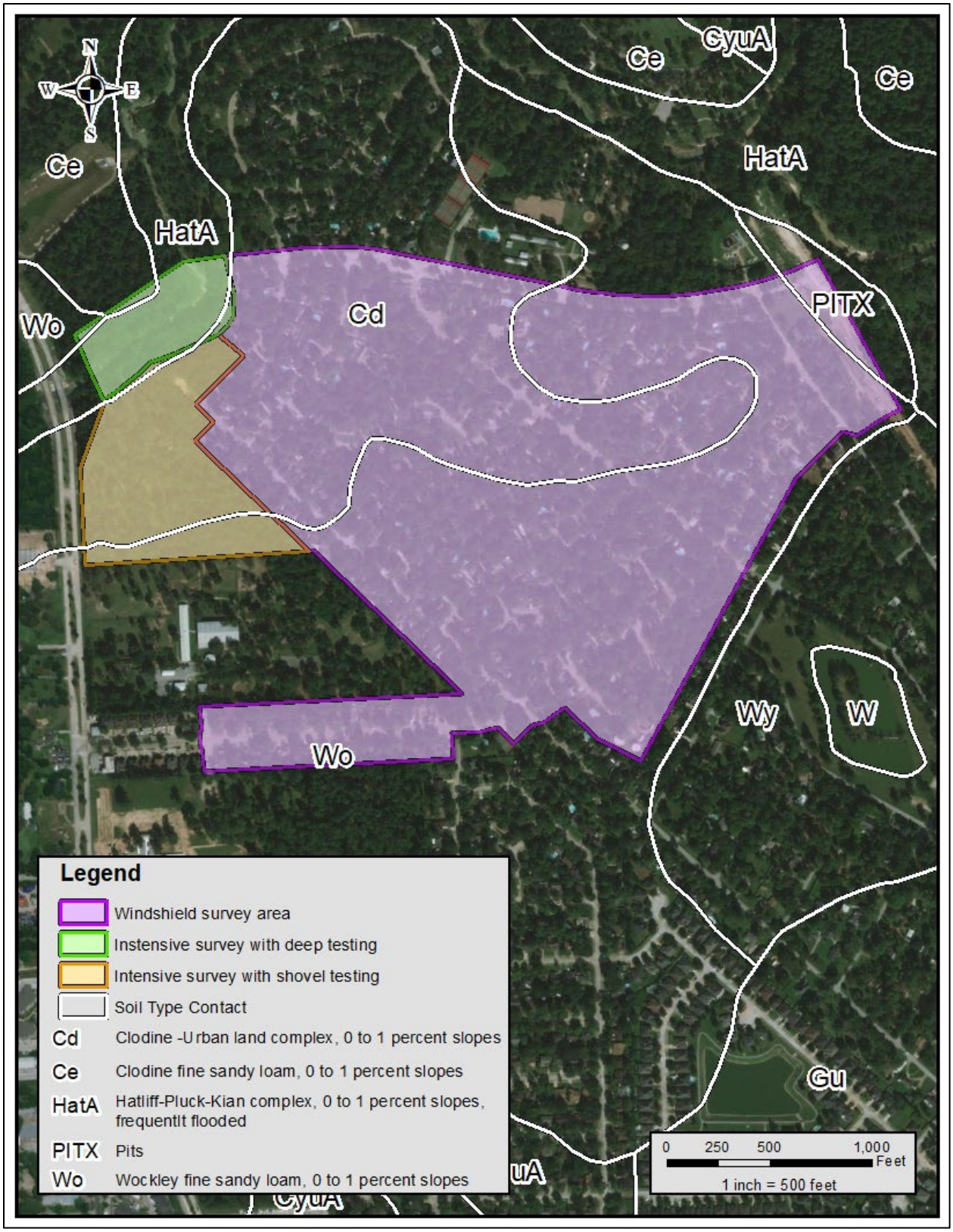

Figure 5-1. Project Area overview.

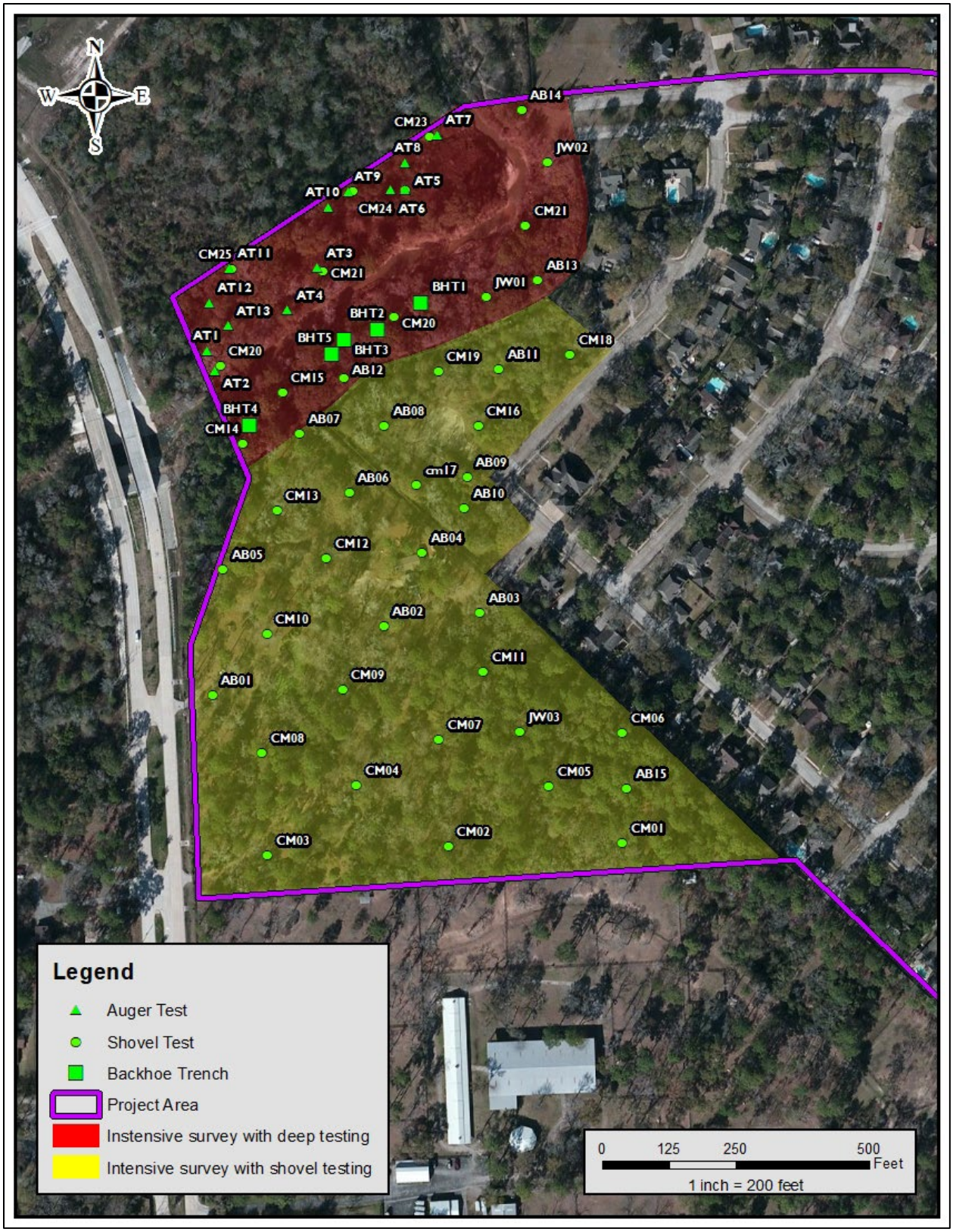

Figure 5-2. Results of investigations within northern Project Area.

Pedestrian Survey and Shovel Testing

The entire 22.3-acre intensive investigation area of the Project Area underwent a pedestrian survey augmented by shovel testing, which showed that the area was overall moderately to heavily vegetated with various grass and tree species (**Figures 5-3 and 5-4**). Western portions of this area were relatively well maintained and cleared of dense vegetation. As these areas previously had two residential complexes that were demolished within the last year, as indicated by review of aerial photographs (**Figure 5-5 and Figure 5-6**). Impacts associated with these residences include a stock pond (**Figure 5-7**), asphalt and cement fragments (**Figure 5-8**), and a pole-mounted transformer (**Figure 5-9**). Outside of this relatively maintained area, the Project Area was found to be previously impacted by the installation of utilities, including sewer lines and fiber optic lines (**Figure 5-10 and Figure 5-11**). Closer to Cypress Creek, the Project Area was heavily vegetated and overgrown. This area had been modified by the construction of two artificial berms around the upper bank of the creek (**Figure 5-12**). These artificial berms are likely intended to provide flood control, as this portion of the Project Area near Cypress Creek is frequently inundated, as evidence by pooled standing water encountered during investigations to the north of the creek (**Figure 5-13**). In addition, an August 30, 2017, aerial photograph from Google Earth shows severe flooding of the northwestern Project Area following Hurricane Harvey (**Figure 5-14**) (Google Earth 2022).

As a result of the survey, forty-five shovel tests (AB01–15, CM01–26, and JW01–04) were excavated in the 22.3-acre intensive investigation portion of the Project Area (**see Figure 5-2; see Appendix A**). Shovel test depths varied between 7.9 and 39.4 inches (20 and 100 cm) below surface, and were most often excavated to 31.5 inches (80 cm) below surface. Shovel tests were terminated due to compact gravels, impassible roots, impassible rocks, and reaching maximum depth. A typical shovel test profile consisted of a yellowish brown (10YR 5/4) sandy loam underlain by a light yellowish brown (10YR 6/4) sandy loam with ferrous redox that increased with depth (**see Figure 15**). At the more frequently inundated area north of Cypress Creek, shovel and auger tests encountered dark grey (10YR 4/1) sandy clay loam underlain by gray (10YR 5/1) sandy clay loam with ferrous redox that increased with depth (**see Figure 16**). No cultural materials were encountered during shovel testing.

Figure 5-3. Overview of the Project Area near Cypress Creek, facing northeast.

Figure 5-4. Overview of the Project Area near Cypress Creek, facing southwest.

Figure 5-5. Overview of cleared area in Project Area, facing south.

Figure 5-6.Overview of cleared area in Project Area, facing south.

Figure 5-7. Stock pond in cleared area, facing south.

Figure 5-8. Cement and asphalt from removed residential structures, facing west.

Figure 5-9. Pole-mounted transformer in cleared area, facing north.

Figure 5-10. Utility impacts in intensive investigations portion of Project Area, facing south.

Figure 5-11. Utility impacts in the intensive investigation portion of Project Area, facing northwest.

Figure 5-12. Overview of berm north of Cypress Creek, facing east.

Figure 5-13. Standing water to the north of Cypress Creek, facing southeast.

Figure 5-14. View of northwestern Project Area in August 2017 with severe flooding.

Figure 5-15. Shovel test AB08 south of Cypress Creek, facing north.

Figure 5-16. Shovel test CM21 north of Cypress Creek, facing west.

Deep Investigation Area

Based on deep alluvial soil, proximity to water, and TxDOT's PALM data, approximately 6.3-acres of the 22.3-acre intensive investigation area was selected for deep testing in addition to pedestrian survey and shovel testing (**see Figures 2-2 and 5-2**). Within this area, five backhoe trenches were excavated within the approximately 2.7-acre area south of Cypress Creek. The backhoe was unable to access the area north of Cypress Creek due to lack of right of entry from the north, the generally overgrown vegetation of this area, side channels of Cypress Creek, and existing utilities(**Figure 5-17, Figure 5-18, and Figure 5-19**) . As such, thirteen hand auger tests were placed in this approximately 2.6-acre area north of Cypress Creek. Seven of these hand auger tests were placed within previously excavated shovel tests, and six were independently excavated. Surface, shallow, and deep investigations did not yield historic or prehistoric cultural material within the deep investigation area.

Mechanical Backhoe Trench Investigations

RKI excavated five (5) mechanical backhoe trenches (BHT1–BHT5) in a 2.7-acre area of the Project Area south of Cypress Creek (**see Figure 5-2**). The mechanical backhoe trenches south of Cypress Creek were placed on upper terraces and behind existing artificial berms. Depths of backhoe trenches varied between 12.8-feet (3.9 m) to 13.1-feet (4 m) below surface (**see Appendix B**). All backhoe trenches were terminated when the mechanical backhoe could no longer excavate due to heavily compacted clay. All backhoe trenches were negative for archaeological cultural materials.

Figure 5-17.Overview of north area near creek, facing east.

Figure 5-18. Utility adjacent to north Cypress Creek, facing south.

Figure 5-19. Overview of north Cypress Creek area, facing north.

BHT1 had evidence of frequent flooding, with numerous sandy lens separated by clay stratum (**Figure 5-20 and Figure 5-21**). The first layer was an organic layer consisting of brown (7.5YR 5/2) sandy loam with 10% roots to a depth of 3.9 inches (10 cm) below surface. The next stratum was a yellowish brown (10YR 5/4) sandy loam with 5% roots from 3.9 inches (10 cm) to 13.4 inches (34 cm) below surface. Below this, soils became increasingly mottled and with ferrous redoximorphic features. From 13.4 inches (34 cm) to 22.4 inches (57 cm) below surface, the soil was pale brown (10YR 6/3) sandy loam with 7% redoximorphic feature, 5% roots, and 7% mottled with a light gray (10YR 7/2) sand. To 27.6 inches (70 cm) below surface, the soil was a dark brown (7.5YR 4/3) sandy clay with 7% ferrous redoximorphic feature and 3% roots. Next to 31.9 inches (81 cm) below surface, the soil was a brown (10YR 5/3) sandy clay with 7-10% redoximorphic feature, 3% roots, and 2-3% mottles of light yellowish gray (10YR 6/2) sand. The next stratum to 34.6 inches (88 cm) below surface was a very pale brown (10YR 7/3) sand with 2-3% roots. To 43.3 inches (110 cm) below surface, the soil was a brown (10YR 5/3) sandy loam with 10% mottles of light gray (10YR 7/1) sand, 3-5% redoximorphic feature, and 1-3% roots. The following stratum to 98.4 inches (250 cm) below surface was a dark brown (10YR 4/3) sandy clay with 5-7% redoximorphic feature, 1% mottles of light gray (10YR 7/1), and 1-3% roots. Finally, to the bottom of BHT1 at 153.5 inches (390 cm) below surface, the soil was a light gray (7.5YR 7/1) clay loam with 5-10% mottles of very dark grayish brown (10YR 3/2) clay loam.

Figure 5-20. Profile of BHT1 at approximately 54 inches (137 cm) below surface, facing northwest.

Figure 5-21. Profile of BHT1, facing northwest.

BHT2 was very similar to BHT1, with lenses of sand and ferrous redoximorphic features (**Figures 5-22 and 5-23**). To 5.9 inches (15 cm) below surface, the soil was a dark grayish brown (10YR 4/2) sandy loam with 15-20% roots. To 11.8 inches (30 cm), the soil was a yellowish brown (10YR 5/4) sand with 10-15% roots. Next to 19.3 inches (49 cm) was a very dark brown (10YR 2/2) sandy loam with 2-3% roots. To 29.9 inches (76 cm), the soil was a brown (10YR 5/3) sandy loam with lens of very pale brown (10YR 7/3) sand. Following this to 40.6 inches (103 cm) was a light gray (10YR 7/2) sandy clay. To 44.5 inches (113 cm) was a very dark grayish brown (10YR 3/2) sandy clay loam with less than 12% roots and 5% mottles of dark gray (10YR 4/1) clay loam. To 48.4 inches (123 cm) was a pale brown (10YR 6/3) sandy clay with less than 1% roots and 15% mottles of yellowish brown (10YR 5/4) clay loam. The next strata to 57.9 inches (147 cm) was a grayish brown (10YR 5/2) sandy loam with 15% ferrous redoximorphic features. Following this to 66.9 inches (170 cm) was a brown (10YR 5/3) clay loam with 20-25% ferrous redoximorphic features. To 98.4 inches (250 cm) was a grayish brown (10YR 5/2) sand with less than 1% roots, 1% ferrous redoximorphic features, and 1-10% mottles of gray (7.5YR 5/1) sand. Next to 118.1 inches (300 cm) was a dark gray (10YR 4/1) clay loam with less than 1% roots, 1-2% ferrous redoximorphic features, and mottled with light gray (10YR 7/1) sand. Finally to the bottom at 157 inches (400 cm) was a light gray (10YR 7/1) sandy clay loam with less than 1% calcium carbonate and 1-2% ferrous redoximorphic features.

Figure 5-22. Profile of BHT2 at 54 inches (137 cm) below surface, facing northwest.

Figure 5-23. Profile of BHT2, facing west.

BHT3 was similar to the other trenches, with lenses of sand and redoximorphic features (**Figure 5-24 and Figure 5-25**). From surface to 8.3 inches (21 cm) below surface was a grayish brown (10YR 5/2) sandy loam with 5-7% roots. To 15 inches (38 cm) was a grayish brown (10YR 5/2) sandy clay loam with 5% roots, less than 1% redoximorphic features, and 1-2% mottles of light grayish brown (10YR 6/2) sand. To 19.3 inches (49 cm) was a grayish brown (10YR 5/2) sandy clay loam with 1% roots, 7-10% redoximorphic features, and mottles of light grayish brown (10YR 6/2) sand. Next to 24 inches (61 cm) was a dark grayish brown (10YR 4/2) sandy clay loam with 1% roots, 7-10% redoximorphic features, and mottles of light grayish brown (10YR 6/2) sand. To 42.9 inches (109 cm) was a light gray (10YR 7/2) sandy loam with less than 1% roots with 2-3% redoximorphic features. To 66.9 inches (170 cm) was a brown (7.5YR 5/3) sandy clay loam with less than 1% roots, less than 1% calcium carbonate, and less than 1% redoximorphic features. To 110.2 inches (280 cm) was a light grayish brown (10YR 6/2) sandy clay loam with less than 1% roots, less than 1% calcium carbonate, and less than 1% redoximorphic features. To 133.9 inches (340 cm) was a light grayish brown (10YR 6/2) sand with less than 1% roots and 2% large manganese redoximorphic features. Finally to the bottom at 157.5 inches (400 cm) was a light gray (10YR 7/1) sandy clay loam with 3-5% redoximorphic features.

Figure 5-24. Profile of BHT3, facing southwest.

Figure 5-25. Profile of BHT3, facing southwest.

BHT4 was generally fairly sandy with redoximorphic features **(Figure 5-26 and Figure 5-27**). From surface to (27 cm) below surface was a pale brown (10YR 6/3) sandy loam with 1% roots and less than 1% mottles of brown (10YR 4/3) clay. To 11.8 inches (30 cm) was a dark grayish brown (10YR 4/2) sandy clay loam with 1% roots, less than 1% charcoal, and less than 1% redoximorphic features. To 26.4 inches (67 cm) was a grayish brown (10YR 5/2) sandy clay loam with 5% roots and 5-7% redoximorphic features. To 31.9 inches (81 cm) was a brown (7.5YR 4/2) sandy clay loam with 3% roots, 3-5% redoximorphic features, and 1% mottles of light grayish brown (10YR 6/2) sand. To 50 inches (127 cm) was a brown (7.5YR 4/2) sandy clay with 1-2% roots, 5-7% redoximorphic features, and 1% mottles of pale brown (10YR 6/3) sand. To 78.7 inches (200 cm) was a brown (7.5YR 5/2) sandy clay loam with 1% roots and 3% redoximorphic features. To 137.8 inches (350 cm) was a pinkish gray (7.5YR 6/2) sandy clay loam with less than 1% roots, 5% redoximorphic features, and mottles of dark gray (10YR 4/1) sandy clay. Finally to the floor at 157.5 inches (400 cm) was a pinkish gray (10YR 6/2) sandy loam with less than 1% roots and 20-25% redoximorphic features.

Figure 5-26. Profile of BHT4 at approximately 54 inches (137 cm) below surface, facing southwest.

Figure 5-27. Profile of BHT4, facing southwest.

BHT5 was also generally sandy with lesser amounts of redoximorphic features (**Figure 5-28 and 5-29**). From surface to 5.5 inches (14 cm) below surface, the soil was a pale brown (10YR 6/3) sandy loam with 1% redoximorphic features and 7-10% roots. To 24 inches (61 cm) was a light gray (7.5YR 7/1) sandy loam with 7-10% redoximorphic feature and 3-5% roots. To 41.7 inches (106 cm) was a grayish brown (10YR 5/2) sandy loam with 5% roots, 7-10% redoximorphic features, and 3% mottles of dark gray (10YR 4/1) clay. To 42.9 inches (109 cm) was a dark gray (10YR 4/1) sandy clay loam with 5% redoximorphic features and 5-7% roots. To 90.6 inches (230 cm) was a grayish brown (10YR 5/2) sandy clay with less than 1% mottles of a light gray (10YR 7/2) sand, 3-5% redoximorphic features, and less than 1% roots. To 122 inches (310 cm) was a light grayish brown (10YR 6/2) sandy clay loam with 2-3% calcium carbonate, 1% redoximorphic features, and less than 1% roots. To 145.7 inches (370 cm) was a light gray (10YR 7/1) sand with less than 1% roots, 3% redoximorphic features, and 3% calcium carbonate. Finally to the bottom of BHT5 at 157.5 inches (400 cm) was a gray (7.5YR 6/1) sandy loam with 3% redoximorphic features and less than 1% roots.

BHT5 was found to contain a chunk of concrete extending from 3.05 to 4.0 feet (93 to 122 cm) below surface within it northwestern profile (**Figure 5-30)** . Based on its orientation and lack of additional cultural material or architectural features, it was assessed as not significant.

Figure 5-28. Profile of BHT5 at 54 inches (137 cm) below surface, facing northwest.

Figure 5-29. Profile of BHT5, facing north.

Figure 5-30. Concrete chunk within BHT5.

Hand Augering

Due to difficulties accessing the portion of the deep investigation area north of Cypress Creek, thirteen hand augers (AT1–13) were excavated within the approximately 2.7-acre area north of Cypress Creek (**see Figure 5-2 and Appendix C**) in lieu of backhoe trenching. Seven hand auger tests (AT2, AT3, AT5, AT7, AT9, AT11 and AT13) were placed within the lower extent of previously excavated shovel tests, and six (AT1, AT4, AT6, AT8, AT10, AT12) were independently excavated by digging a shovel test to 80 cm, then proceeding to excavate with an augur. All soils were screened. Depths of hand augers varied from 59 inches (150 cm) to 9.8 feet (3 m) below surface, and were most often excavated to 9.8 feet (3 m) below surface. Auger tests were terminated mainly due to depth, however four (AT5, AT6, AT10, AT13) were terminated due to compacted soils and one (AT12) was terminated due to root impasse. The typical auger test encountered a grayish brown (10YR 5/2) to brown (10YR 5/3) sandy loam extending from surface to approximately 47.2 inches (120 cm) below surface. Clay content increased with depth. Below this was alternating flood deposits. To approximately 70.9 inches (160 cm) was a light gray (10YR 7/2) sandy clay. Underlying this to 94.5 inches (200 cm) was a grayish brown (10YR 5/2) sandy clay. A lighter sand level was again typically encountered again to depths of 94.5 inches (240 cm) and consisted of light gray (10YR

7/2) sand. Below this to depth of 118 inches (300 cm) were darker clay loams that ranged from black (10YR 2/1) to darky grayish brown (10YR 4/2).

No cultural materials were encountered during hand auger testing.

Windshield Survey

The 130.8-acre residential subdivision portion of the Project Area was heavily impacted by construction activities including road and utility installation and housing construction (**see Figure 5-1, Figure 5-31, and Figure 5-32**). This area primarily consisted of residential structures with manicured lawns and associated utility impacts. In addition, any previous landforms appear to have been heavily impacted by grading and leveling that would have destroyed any cultural resource deposits. No cultural resources were observed. Historical aerial photographs show the Project Area as generally undeveloped through 1968, and indicate that this area entered into development as a residential subdivision sometime between 1968 and 1973.

Figure 5-31. Overview of windshield survey area, facing southeast.

Figure 5-32. Overview of windshield survey area, facing north.

CHAPTER 6. SUMMARY AND RECOMMENDATIONS

Raba Kistner, Inc. (RKI), was contacted by LJA Engineering (CLIENT), on behalf of Harris County Flood Control District and Harris County Engineering Department, to conduct archaeological investigations in advance of proposed drainage improvement for the Ravensway Subdivision in northwestern Harris County, Texas. The proposed Ravensway Subdivision Drainage Improvements – Precinct 3 Project will involve construction of a detention basin and associated drainage improvements adjacent to Cypress Creek. The entire Project Area encompasses approximately 153.1-acres east of Huffmeister Road at its intersection with Ravensway Drive, in close proximity to the confluence of Cypress Creek and Little Cypress Creek.

The proposed undertaking will take place on county-owned land. As such, the proposed project is subject to review under the jurisdiction of the ACT (Texas Natural Resources Code, Title 9, Chapter 191). These legislations call for the assessment of all proposed improvement activities that have a potential to disturb historically significant resources and significant subsurface deposits on lands owned by the State. Oversight of compliance with the ACT is administered by the THC. Furthermore, as the project has the potential to impact known waterways, the undertaking is potentially subject to review under Section 106 of the NHPA (16 United States Code 470) and its implementing regulations (36 Code of Federal Regulation 800). Compliance with Section 106 is regulated by the USACE. All work was conducted in accordance with the Archeological Survey Standards for Texas as set forth by the CTA and the THC under Texas Antiquities Permit Number 30608.

Investigations consisted of an intensive pedestrian survey augmented by shovel testing, mechanical backhoe trenching, hand augering, and a windshield survey within the Project Area. Archaeological investigation of the 153.1-acre Project Area was conducted from May 2–5, 2022. Kirsten M. Atwood served as Principal Investigator and Project Manager for the duration of the project, and all fieldwork was conducted by Adam Birge, Jason M. Whitaker, and Christopher Mathews. Disturbances observed during the course of the survey consisted of road and culvert construction, fence installation, vegetation clearance, installation of utilities, and residential construction. No historic or prehistoric cultural materials and/or features were recorded.

As part of the pedestrian survey, 45 shovel tests (AB01–15, CM01–26, and JW01–04) were excavated within the boundaries of the 22.3-acre northwestern Project Area. Depths of shovel tests varied between

7.9-inches (20 cm) and 39.4-inches (100 cm) below surface, and were most often excavated to 31.3 inches (80 cm) below surface. Shovel tests were terminated due to reaching maximum depth, impassible roots, impassible rocks, and compacted redoximorphic soils. No cultural resources were encountered during shovel testing.

The northwest 6.3-acres of the Project Area was selected for deep testing in addition to pedestrian survey and shovel testing due to the presence of deep alluvial soils and proximity to Cypress Creek. In addition to pedestrian survey and shovel testing, five mechanical backhoe trenches (BHT1–BHT5) and 13 hand auger tests (AT1–13) were conducted here. No cultural resources were encountered during deep investigations.

Five mechanical backhoe trenches were placed within an approximately 2.7-acre area of south of Cypress Creek. Depths of backhoe trenches varied between 12.8 feet (3.9 m) to 13.1 feet (4 m) below surface. Generally, the backhoe trenches had a grayish brown (10YR 5/2) to a dark grayish brown (10YR 4/2) sandy loam over similar colored sandy clay loam with pronounced ferrous redoximorphic features and lens of light gray (10YR 7/2) to very pale brown (10YR 7/3) sand. All backhoe trenches were terminated when the mechanical backhoe could no longer significantly excavate into the heavily compacted clay.

Due to difficulties accessing the area north of Cypress Creek via mechanical backhoe, 13 hand auger tests (AT1-13) were excavated in this area, in addition to intensive pedestrian survey with shovel testing. Depths of hand augers varied between 59.1 inches (150 cm) and 9.8 feet (3 m) below surface. Generally, hand auger tests encountered soils similar to those found within the backhoe trenches: a brown (10YR 5/3) sandy loam with increasing clay with depth and alternating layers of light gray (10YR 7/2). Hand auger tests were mainly terminated due to depth, but four were terminated due to compacted soils and one due to root impasse.

Finally, the windshield survey of the remaining 130.8-acres of the Project Area indicated a circa-early 1970s and later residential development with numerous impacts associated with construction of houses. This include installation of utilities, fence construction, and grading and leveling of land. No historic or prehistoric cultural resources were identified.

RKI has made a reasonable and good faith effort to identify cultural resources within the given Project Area. No significant deposits or features were identified during the pedestrian survey of the Project Area.

As such, **RKI** recommends no further archaeological investigations within the Project Area. However, should changes be made to the Project Area, further work may be required. All field records and photographs produced during investigations will be permanently housed at the Center for Archaeological Research at the University of Texas at San Antonio.

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APPENDIX A:
Shovel Test Log

Shovel Test Log

Shovel Test No.	Depth (cm)	Munsell	Soil Color	Soil Texture	Inclusions	Positive/ Negative	Cultural Materials	Reason for Termination / Comments
AB01	0–20	10YR 4/3	Brown	Sandy Loam	—	Negative	—	—
	20–40	10YR 4/3	Brown	Sandy Loam	—	Negative	—	—
	40–60	10YR 6/3	Pale Brown	Sandy Loam	—	Negative	—	—
	60–80	10YR 6/3	Pale Brown	Sandy Loam	—	Negative	—	Depth
AB02	0–20	10YR 4/3	Brown	Sandy Loam	—	Negative	—	—
	20–40	10YR 5/4	Yellowish Brown	Sandy Loam	—	Negative	—	—
	40–60	10YR 6/3	Pale Brown	Sandy Clay Loam	10% ferrous redoximorphic features	Negative	Cement chunk at 60 cm	Very hard soil at 60 cm
	60–80	10YR 6/3	Pale Brown	Sandy Clay Loam	20 % ferrous redoximorphic features	Negative	—	Depth
AB03	0–20	10YR 5/4	Yellowish Brown	Sandy Loam	—	Negative	—	—
	20–40	10YR 6/4	Light Yellowish Brown	Sandy Loam	Ferrous redoximorphic features	Negative	—	—
	40–60	10YR 6/4	Light Yellowish Brown	Sandy Clay Loam	Ferrous redoximorphic features	Negative	—	—
	60–80	10YR 6/4	Light Yellowish Brown	Sandy Clay	Ferrous redoximorphic features	Negative	—	Depth
AB04	0–20	10YR 4/2	Dark Grayish Brown	Sandy Loam	—	Negative	—	—
	20–40	10YR 4/2	Dark Grayish Brown	Sandy Loam	—	Negative	—	—
	40–60	10YR 3/3	Dark Brown	Sandy Loam	—	Negative	—	—
	60–80	10YR 3/3	Dark Brown	Sandy Loam	—	Negative	—	Depth
AB05	0–20	10YR 4/3	Brown	Sandy Loam	—	Negative	—	—
	20–40	10YR 4/3	Brown	Sandy Loam	—	Negative	—	—
	40–60	10YR 5/2	Grayish Brown	Sandy Clay Loam	—	Negative	—	—
	60–80	10YR 5/2	Grayish Brown	Sandy Clay Loam	Ferrous redoximorphic features	Negative	—	Depth
AB06	0–20	10YR 5/2	Grayish Brown	Sandy Loam	—	Negative	—	—
	20–40	10YR 6/2	Light Brownish Gray	Sandy Loam	—	Negative	—	—

Shovel Test No.	Depth (cm)	Munsell	Soil Color	Soil Texture	Inclusions	Positive/ Negative	Cultural Materials	Reason for Termination / Comments
	40–60	10YR 6/2	Light Brownish Gray	Sandy Clay Loam	—	Negative	—	—
	60–80	10YR 7/1	Light Gray	Sandy Loam	—	Negative	—	Depth
AB07	0–20	10YR 5/3	Brown	Sandy Loam	—	Negative	—	—
	20–40	10YR 6/2	Light Brownish Gray	Sandy Loam	—	Negative	—	—
	40–60	10YR 6/2	Light Brownish Gray	Sand	—	Negative	—	—
	60–80	10YR 7/1	Light Gray	Sand	—	Negative	—	Depth
AB08	0–20	10YR 5/3	Brown	Sandy Loam	—	Negative	—	—
	20–40	10YR 5/3	Brown	Sandy Loam	—	Negative	—	—
	40–60	10YR 5/3	Brown	Sandy Loam	—	Negative	—	—
	60–80	10YR 5/3	Brown	Sandy Loam	—	Negative	—	Depth
AB09	0–20	10YR 5/3	Brown	Sandy Loam	—	Negative	—	1
	20–40	10YR 5/3	Brown	Sandy Loam	—	Negative	—	—
	40–60	10YR 6/2	Light Brownish Gray	Sandy Loam	—	Negative	—	Root Impasse
AB10	0–20	10YR 5/3	Brown	Sandy Loam	—	Negative	—	—
	20–40	10YR 5/3	Brown	Sandy Loam	—	Negative	—	—
	40–60	10YR 6/2	Light Brownish Gray	Sandy Loam	—	Negative	—	—
	60–80	10YR 7/1	Light Gray	Sandy Loam	—	Negative	Compact cemente d soils at 65	Compact soil
AB11	0–20	10YR 5/3	Brown	Sandy Loam	—	Negative	—	—
	20–40	10YR 5/3	Brown	Sandy Loam	—	Negative	—	—
	40–60	10YR 6/2	Light Brownish Gray	Sandy Loam	—	Negative	—	—
	60–80	10YR 6/2	Light Brownish Gray	Sandy Loam	—	Negative	—	Depth
AB12	0–20	10YR 5/3	Brown	Sandy Loam	—	Negative	—	—
	20–40	10YR 5/3	Brown	Sandy Loam	—	Negative	—	Root Impasse
AB13	0–20	10YR 5/3	Brown	Sandy Loam	—	Negative	—	—

Shovel Test No.	Depth (cm)	Munsell	Soil Color	Soil Texture	Inclusions	Positive/ Negative	Cultural Materials	Reason for Termination / Comments
	20–40	10YR 5/3	Brown	Sandy Loam	—	Negative	—	—
	40–60	10YR 5/3	Brown	Sandy Loam	10YR 7/2 (light gray) lens 50%	Negative	—	—
	60–80	10YR 5/3	Brown	Sandy Loam	10YR 7/2 (light gray) lens 50%	Negative	—	Depth
AB14	0–20	10YR 8/2	Very Pale Brown	Sand	—	Negative	—	—
	20–40	10YR 8/2	Very Pale Brown	Sandy	—	Negative	—	—
	40–60	10YR 8/2	Very Pale Brown	Sandy Loam	10% ferrous redoximorphic features	Negative	—	—
	60–80	10YR 8/2	Very Pale Brown	Sandy Clay Loam	15% ferrous redoximorphic features	Negative	—	Depth
AB15	0–20	10YR 6/2	Light Brownish Gray	Sandy Loam	—	Negative	—	—
	20–40	10YR 6/4	Light Yellowish Brown	Sandy Loam	—	Negative	—	—
	40–60	10YR 7/2	Light Gray	Sandy Loam	5% ferrous redoximorphic features	Negative	—	—
	60–80	10YR 7/2	Light Gray	Sandy Clay Loam	20% ferrous redoximorphic features	Negative	—	Depth
CM01	0–10	10YR 6/2	Light Brownish Gray	Sandy Loam	—	Negative	—	—
	10–53	10YR 5/3	Brown	Sandy Loam	—	Negative	—	Root Impasse
CM02	0–10	10YR 6/3	Pale Brown	Sandy Loam		Negative	—	—
	10–60	10YR 5/3	Brown	Sandy Loam		Negative	—	—
	60–80	10YR 6/2	Light Brownish Gray	Sandy Loam	< 5% redoximorphic features	Negative	—	Depth
CM03	0–10	10YR 6/2	Light Brownish Gray	Sandy Loam	—	Negative	—	—
	10–70	10YR 6/3	Pale Brown	Sandy Loam	< 5% redoximorphic features	Negative	—	—
	70–80	10YR 7/2	Light Gray	Sandy Clay	> 5% redoximorphic features	Negative	—	Depth. Hydric clay at depth.
CM04	0–10	10YR 6/4	Light Yellowish Brown	Sandy Loam	—	Negative	—	—
	10–70	10YR 4/3	Brown	Sandy Loam	< 5% redoximorphic features	Negative	—	—
	70–80	10YR 7/2	Light Gray	Sandy Clay	5% redoximorphic features	Negative	—	Depth. Hydric clay at 70 cm.

Shovel Test No.	Depth (cm)	Munsell	Soil Color	Soil Texture	Inclusions	Positive/ Negative	Cultural Materials	Reason for Termination / Comments
CM05	0–10	10YR 5/2	Grayish Brown	Sandy Loam	—	Negative	—	—
	10–45	10YR 5/3	Brown	Sandy Loam	—	Negative	—	—
	45–58	10YR 5/3	Brown	Sandy Loam	—	Negative	—	Root Impasse
CM06	0–10	10YR 5/2	Grayish Brown	Sandy Loam	—	Negative	—	—
	10–70	10YR 6/3	Pale Brown	Sandy Loam	—	Negative	—	—
	70–75	10YR 7/1	Light Gray	Sand	< 5% redoximorphic features	Negative	—	—
	75–80	10YR 7/2	Light Gray	Sandy Clay	5% redoximorphic features	Negative	—	Depth. Clay is hydric.
CM07	0–35	10YR 5/4	Yellowish Brown	Sandy Loam	—	Negative	—	—
	35–70	10YR 6/3	Pale Brown	Sandy Loam	—	Negative	—	—
	70–80	10YR 7/2	Light Gray	Sandy Clay	< 5% redoximorphic features	Negative	—	Depth. Hydric clay at 70 cm.
CM08	0–10	10YR 5/4	Yellowish Brown	Sandy Loam	—	Negative	—	—
	10–50	10YR 6/3	Pale Brown	Sandy Loam	—	Negative	—	—
	50–80	10YR 6/4	Light Yellowish Brown	Sandy Loam	< 5% redoximorphic features	Negative	—	Depth
CM09	0–10	10YR 5/4	Yellowish Brown	Sandy Clay Loam	> 15% gravels; mottled with 5YR 6/6 (reddish yellow)	Negative	—	—
	10–15	10YR 6/6	Brownish Yellow	Sandy Clay Loam	15% gravels; mottled with 10YR 6/4 (light yellowish brown)	Negative	—	—
	15–20	10YR 6/1	Gray	Sandy Clay	> 25% gravels; mottled with 10YR 7/2 (light gray)	Negative	—	Compact gravels
CM10	0–20	10YR 5/4	Yellowish Brown	Sandy Clay Loam	> 10% gravels	Negative	—	—
	20–65	10YR 4/3	Brown	Sandy Clay Loam	< 5% gravels	Negative	—	—
	65–80	10YR 6/3	Pale Brown	Sandy Clay	< 5% redoximorphic features; mottled with 10YR 6/6 (brownish yellow)	Negative	—	Depth

Shovel Test No.	Depth (cm)	Munsell	Soil Color	Soil Texture	Inclusions	Positive/ Negative	Cultural Materials	Reason for Termination / Comments
CM11	0–20	10YR 5/4	Yellowish Brown	Sandy Loam	—	Negative	—	—
	20–65	10YR 6/3	Pale Brown	Sandy Loam	< 5% redoximorphic features	Negative	—	—
	65–80	10YR 6/3	Pale Brown	Sandy Clay	> 5% redoximorphic features; mottled with 10YR 6/6 (brownish yellow)	Negative	—	Depth
CM12	0–35	10YR 5/4	Yellowish Brown	Sandy Clay Loam	> 10% gravels; mottled with 10YR 6/6 (brownish yellow) and 10YR 2/1	Negative	—	—
	35–80	10YR 6/4	Light Yellowish Brown	Sandy Loam	—	Negative	—	Depth
CM13	0–30	10YR 5/4	Yellowish Brown	Sandy Loam	< 5% gravel	Negative	—	—
	30–80	10YR 6/2	Light Brownish Gray	Sandy Loam	—	Negative	—	Depth
CM14	0–25	10YR 5/4	Yellowish Brown	Sandy Loam	5% gravels	Negative	—	—
	25–45	10YR 8/4	Very Pale Brown	Sandy Loam	—	Negative	—	—
	45–55	10YR 7/1	Light Gray	Sandy Loam	—	Negative	—	—
	55–80	10YR 6/2	Light Brownish Gray	Sandy Loam	—	Negative	—	Depth
CM15	0–20	10YR 6/4	Light Yellowish Brown	Sandy Loam	> 5% gravels	Negative	—	—
	20–30	10YR 5/3	Brown	Sandy Clay Loam	—	Negative	—	—
	30–60	10YR 6/3	Pale Brown	Sandy Loam	< 5% redoximorphic features	Negative	—	—
	60–80	10YR 6/2	Light Brownish Gray	Sandy Loam	> 5% redoximorphic features	Negative	—	Depth
CM16	0–20	10YR 5/4	Yellowish Brown	Sandy Loam	5% gravels	Negative	—	—
	20–40	10YR 6/4	Light Yellowish Brown	Sandy Loam	< 5% redoximorphic features	Negative	—	—
	40–45	10YR 6/2	Light Brownish Gray	Sandy Clay Loam	> 5% redoximorphic features	Negative	—	Rocky Impasse
CM17	0–25	10YR 5/4	Yellowish Brown	Sandy Loam	< 5% gravels	Negative	—	—

Shovel Test No.	Depth (cm)	Munsell	Soil Color	Soil Texture	Inclusions	Positive/ Negative	Cultural Materials	Reason for Termination / Comments
	25–55	10YR 6/4	Light Yellowish Brown	Sandy Loam	—	Negative	—	—
	55–80	10YR 6/3	Pale Brown	Sandy Loam	< 5% redoximorphic features	Negative	—	Depth
CM18	0–70	10YR 5/4	Yellowish Brown	Sandy Loam	—	Negative	—	—
	70–80	10YR 5/4	Yellowish Brown	Sandy Clay	> 5% redoximorphic features	Negative	—	Depth
CM19	0–10	10YR 5/4	Yellowish Brown	Sandy Loam	—	Negative	—	—
	10–60	10YR 6/3	Pale Brown	Sandy Loam	< 5% redoximorphic features	Negative	—	—
	60–80	10YR 6/2	Light Brownish Gray	Sandy Clay Loam	> 5% redoximorphic features	Negative	—	Depth
CM20	0–15	10YR 5/1	Gray	Sandy Loam	< 5% gravels	Negative	—	—
	15–60	10YR 6/3	Pale Brown	Sandy Loam	—	Negative	—	—
	60–65	10YR 7/1	Light Gray	Sandy Loam	< 5% redoximorphic features	Negative	—	—
	65–80	10YR 4/1	Dark Gray	Sandy Clay Loam	> 5% redoximorphic features	Negative	—	Depth
CM21	0–80	10YR 6/3	Pale Brown	Sandy Loam	—	Negative	—	Depth
CM22	0–40	10YR 6/3	Pale Brown	Sandy Loam	—	Negative	—	—
	40–45	10YR 7/1	Light Gray	Sandy Loam	—	Negative	—	—
	45–80	10YR 6/3	Pale Brown	Sandy Loam	< 5% redoximorphic features	Negative	—	Depth
CM23	0–15	10YR 5/4	Yellowish Brown	Sandy Loam	—	Negative	—	—
	15–60	10YR 6/3	Pale Brown	Sandy Loam	< 5% redoximorphic features; mottled with 10YR 6/2 (light brownish gray)	Negative	—	—
	60–80	10YR 4/1	Dark Gray	Sandy Clay Loam	—	Negative	—	Depth
CM24	0–40	10YR 6/3	Pale Brown	Sandy Loam	—	Negative	—	—
	40–70	10YR 4/1	Dark Gray	Sandy Clay Loam	—	Negative	—	—
	70–80	10YR 6/3	Pale Brown	Sandy Clay	< 1% redoximorphic features	Negative	—	Depth

Shovel Test No.	Depth (cm)	Munsell	Soil Color	Soil Texture	Inclusions	Positive/ Negative	Cultural Materials	Reason for Termination / Comments
CM25	0–25	10YR 5/1	Gray	Sandy Clay Loam	—	Negative	—	—
	25–40	10YR 4/1	Dark Gray	Sandy Clay Loam	Mottled with 10YR 7/2 (light gray)	Negative	—	—
	40–50	10YR 4/1	Dark Gray	Sandy Clay Loam	—	Negative	—	—
	50–80	10YR 4/2	Dark Grayish Brown	Sandy Clay Loam	Mottled with 10YR 7/1 (light gray)	Negative	—	Depth
CM26	0–40	10YR 4/1	Dark Gray	Sandy Clay Loam	—	Negative	—	—
	40–50	10YR 5/1	Gray	Sandy Clay Loam	Mottled with 10YR 6/1 (gray)	Negative	—	—
	50–65	10YR 4/1	Dark Gray	Sandy Clay Loam	< 5% redoximorphic features	Negative	—	—
	65–80	10YR 6/2	Light Brownish Gray	Sandy Clay Loam	< 5% redoximorphic features	Negative	—	Depth
JW01	0–20	10YR 5/3	Brown	Sandy Loam	2% roots	Negative	—	—
	20–40	7.5YR 4/2	Brown	Sandy Clay Loam	2% redoximorphic features	Negative	—	—
	40–60	10YR 5/2	Grayish Brown	Sandy Clay Loam	1% redoximorphic features	Negative	—	—
	60–80	10YR 5/2	Grayish Brown	Sandy Clay Loam	1% redoximorphic features	Negative	—	Compact soils
JW02	0–20	10YR 7/2	Light Gray	Sandy Loam	1% roots	Negative	—	—
	20–40	10YR 5/3	Brown	Sandy Clay Loam	1% roots	Negative	—	—
	40–60	10YR 5/3	Brown	Sandy Clay Loam	1% roots	Negative	—	—
	60–80	10YR 4/2	Dark Grayish Brown	Clay Loam	2–3% redoximorphic features	Negative	—	Compact Soils
JW03	0–20	7.5YR 5/3	Brown	Sandy Loam	2% roots	Negative	—	—
	20–40	7.5YR 6/4	Light Brown	Sandy Loam	< 1% roots	Negative	—	—
	40–60	7.5YR 6/4	Light Brown	Sandy Loam	< 1% roots	Negative	—	—
	60–80	7.5YR 6/2	Pinkish Gray	Sandy Clay	20% redoximorphic features, < 1% roots	Negative	—	—
	80–100	7.5YR 6/2	Pinkish Gray	Sandy Clay	20% redoximorphic	Negative	—	Depth

Shovel Test No.	Depth (cm)	Munsell	Soil Color	Soil Texture	Inclusions	Positive/ Negative	Cultural Materials	Reason for Termination / Comments
					features, < 1% roots			
JW04	0–60	10YR 5/2	Grayish Brown	Sandy Loam	< 1% redoximorphic features	Negative	—	—
	60–80	10YR 6/2	Light Brownish Gray	Sandy Loam	1% redoximorphic features; mottled with 1% 10YR 5/2 (grayish brown) clay	Negative	—	Depth

APPENDIX B:
Backhoe Trench Log

Backhoe Trench Log

Backhoe Trench No.	Depth (cm)	Munsell	Soil Color	Soil Texture	Inclusions	Positive/ Negative	Cultural materials	Reason for Termination / Comments
BHT 1	0–10	10YR 5/2	Grayish Brown	Sandy Loam	10% roots	Negative	—	BHT shows flooding evidence: sandy lenses separated by clay
	10–34	10YR 5/4	Yellowish Brown	Sandy Loam	10% roots	Negative	—	—
	34–57	10YR 6/3	Pale Brown	Sandy Loam	3 to 5 % roots; 7% redoximorphic features; mottled with 5 to 7% 10YR 7/2 (light gray) sand	Negative	—	—
	57–70	7.5YR 4/3	Brown	Sandy Clay	3% roots, 7 to 10% redoximorphic features	Negative	—	—
	70–81	10YR 5/3	Brown	Sandy Clay	3% roots, 10 to 15% redox, mottled with 2 to 3 % 10YR 8/2 (very pale brown) sand	Negative	—	—
	81–88	10YR 7/3	Very Pale Brown	Sand	2 to 3% roots	Negative	—	—
	88–110	10YR 5/3	Brown	Sandy Loam	1 to 3% roots; 3 to 5% redoximorphic features	Negative	—	—
	110–250	10YR 4/3	Brown	Sandy Clay Loam	1 to 3% roots 5 to 7% redoximorphic features, mottled with 10% 10YR 7/1 (light gray) sand	Negative	—	—
	250–390	7.5YR 7/1	Light Gray	Sand	Mottled with 1% 10YR 5/2 (grayish brown) sand	Negative	—	—
	390–430	10YR 4/2	Dark Grayish Brown	Sandy Clay Loam	< 1% roots, mottled with 1–5% 7.5YR 7/1 (light gray) sand	Negative	—	Depth
BHT 2	0–15	10YR 4/2	Dark Grayish Brown	Sandy Loam	15 to 20 % roots	Negative	—	—

Backhoe Trench No.	Depth (cm)	Munsell	Soil Color	Soil Texture	Inclusions	Positive/ Negative	Cultural materials	Reason for Termination / Comments
	15–30	10YR 5/4	Yellowish Brown	Sand	10 to 15% roots	Negative	—	—
	39–49	10YR 2/2	Very Dark Brown	Sandy Loam	2 to 3% roots	Negative	—	—
	49–76	10YR 5/3 transitioning to 10YR 7/3	Brown transitioning to Very Pale Brown	Sandy Lom	< 1% redoximorphic features, mottled with 1 to 2% 10YR 2/2 (very dark brown)	Negative	—	Banded from flooding episodes
	76–103	10YR 7/2	Light Gray	Sandy Loam	—	Negative	—	Banded from flooding episodes
	103–113	10YR 3/2	Very Dark Grayish Brown	Sandy Clay Loam	< 12% roots; mottled with 5% 10YR 4/1 (dark gray)	Negative	—	—
	113–123	10YR 6/3	Pale Brown	Sandy Clay	< 1% roots; mottled with 15% 10YR 5/4 (yellowish brown)	Negative	—	—
	123–147	10YR 5/2	Grayish Brown	Sandy Loam	15% ferrous (5YR 4/6; yellowish red) redoximorphic features	Negative	—	—
	147–170	10YR 5/3	Brown	Clay Loam	20 to 25% ferrous redoximorphic features	Negative	—	—
	170–250	10YR 5/2	Grayish Brown	Sand	< 1% roots; 1% redoximorphic features; mottled with 1 to 10% 7.5YR 5/1 (gray)	Negative	—	—
	250–300	10YR 4/1	Dark Gray	Clay Loam	< 1% roots; 1 to 2% redoximorphic features; mottled with 10YR 7/1 (light gray) sand	Negative	—	—
	300–400	10YR 7/1	Light Gray	Sandy Clay Loam	< 1% fine tendrils of calcium carbonate; 1 to 2 % redoximorphic features	Negative	—	Depth
BHT 3	0–21	10YR 5/2	Grayish Brown	Sandy Loam	5 to 7% roots	Negative	—	—

Backhoe Trench No.	Depth (cm)	Munsell	Soil Color	Soil Texture	Inclusions	Positive/ Negative	Cultural materials	Reason for Termination / Comments
	21–38	10YR 5/2	Grayish Brown	Sandy Clay Loam	5% roots; < 1% redoximorphic features; mottled with 1 to 2% 10YR 6/2 (light brownish gray) sand	Negative	—	—
	38–49	10YR 5/2	Grayish Brown	Sandy Clay Loam	1% roots; mottled with 1% 10YR 4/2 (dark grayish brown) clay and < 1%10YR 6/2 (light brownish gray) sand	Negative	—	—
	49–61	10YR 4/2	Dark Grayish Brown	Sandy Clay Loam	1 % roots; 7 to 10% redoximorphic features; mottled with 10YR 6/2 (light brownish gray) sand	Negative	—	—
	61–109	10YR 7/2	Light Gray	Sandy Loam	< 1% roots; 2 to 3% redoximorphic features	Negative	—	—
	109–170	7.5YR 5/3	Brown	Sandy Clay Loam	< 1% roots; 1 to 2% redoximorphic features; mottled with 1% 10YR 7/2 (light gray) sand	Negative	—	—
	170–280	10YR 6/2	Light Brownish Gray	Sandy Clay Loam	< 1% roots, < 1% calcium carbonate; < 1% redoximorphic features	Negative	—	—
	280–340	10YR 6/2	Light Brownish Gray	Sandy	< 1% roots; 2% large manganese redoximorphic features	Negative	—	—
	340–400	10YR 7/1	Light Gray	Sandy Clay Loam	3 to 5% redoximorphic features	Negative	—	Depth
BHT4	0–27	10YR 6/3	Pale Brown	Sandy Loam	1% roots; mottled with < 1% 10YR 4/3 (brown) clay	Negative	—	Trench soil nearly saturated

Backhoe Trench No.	Depth (cm)	Munsell	Soil Color	Soil Texture	Inclusions	Positive/ Negative	Cultural materials	Reason for Termination / Comments
	27–30	10YR 4/2	Dark Grayish Brown	Sandy Clay Loam	1% roots; < 1% charcoal; < 1% redoximorphic features	Negative	—	—
	30–67	10YR 5/2	Grayish Brown	Sandy Clay Loam	5% roots; 5 to 7% redoximorphic features	Negative	—	—
	67–81	7.5YR 4/2	Brown	Sandy Clay Loam	3% roots; 3 to 5% redoximorphic features; mottled with 1%10YR 6/2	Negative	—	—
	81–127	7.5YR 4/2	Brown	Sandy Clay	1 to 2% roots; 5 to 7% redoximorphic features; mottled with 1% 10YR 6/3 (pale brown) sand	Negative	—	—
	127–200	7.5YR 5/2	Brown	Sandy Clay Loam	1% roots; 3% redoximorphic features	Negative	—	—
	200–350	7.5YR 6/2	Pinkish Gray	Sandy Clay Loam	< 1% roots; 5% redoximorphic features; mottled with 10YR 4/1 (dark gray) sandy clay	Negative	—	—
	350–400	10YR 6/2	Light Brownish Gray	Sandy Loam	< 1% roots; 20–25% redoximorphic features	Negative	—	Depth
BHT5	0–14	10YR 6/3	Pale Brown	Sandy Loam	7 to 10% roots; 1% redoximorphic features	Negative	—	—
	14–61	7.5YR 7/1	Light Gray	Sandy Loam	3 to 5% roots; 7 to 10 redoximorphic features	Negative	—	—
	61–106	10YR 5/2	Grayish Brown	Sandy Loam	5% roots; burned root present; 7 to 10% redoximorphic features; mottled with 3% 10YR 4/1 (dark gray) unevenly distributed clay pockets	Negative	Concrete chunk from 93 to 122 cmbs. 51 cm long, 32 cm wide, 15 cm thick	—

Backhoe Trench No.	Depth (cm)	Munsell	Soil Color	Soil Texture	Inclusions	Positive/ Negative	Cultural materials	Reason for Termination / Comments
	106–109	10YR 4/1	Dark Gray	Sandy Clay loam	5% roots; 5 to 7 % redoximorphic features	Negative		—
	109–230	10YR 5/2	Grayish Brown	Sandy Clay	1% roots; 3 to 5% redoximorphic features; mottled with < 1% 10YR 7/2 (light gray) sand and 1 to 2% 10YR 4/1 (dark gray) clay bands	Negative		—
	230–310	10YR 6/2	Light Brownish Gray	Sandy Clay Loam	< 1% roots; 1% redoximorphic features; 2 to 3 percent calcium carbonate	Negative	—	—
	310–370	10YR 7/1	Light Gray	Sandy Loam	< 1% roots; 7% redoximorphic features; 3% calcium carbonate	Negative	—	—
	370–400	7.5YR 6/1	Gray	Sandy Loam	< 1% roots; 3% redoximorphic features	Negative	—	Depth

APPENDIX C:
Hand Auger Test Log

Auger Test Log

Auger Test No.	Depth (cm)	Munsell	Soil Color	Soil Texture	Inclusions	Positive/ Negative	Reason for Termination/ Comments
AT1	0–40	10YR 5/3	Brown	Sandy Loam	Roots	Negative	Clay and sandy lenses throughout
	40–80	10YR 5/3	Brown	Sandy Loam	—	Negative	Clay and sandy lenses throughout
	80–100	10YR 5/3	Brown	Sandy Clay Loam	—	Negative	—
	100–120	10YR 5/3	Brown	Sandy Clay Loam	Roots	Negative	—
	120–140	10YR 7/2	Light Gray	Sandy Clay Loam	Roots	Negative	—
	140–160	10YR 7/2	Light Gray	Sandy Clay Loam	—	Negative	—
	160–200	10YR 5/2	Grayish Brown	Sandy Clay	—	Negative	—
	200–220	10YR 7/2	Light Gray	Sand	—	Negative	—
	220–240	10YR 7/2	Light Gray	Sand	Roots	Negative	—
	240–260	10YR 5/3	Brown	Sandy Clay	Roots	Negative	—
	260–280	10YR 4/3	Brown	Sandy Clay	Roots	Negative	—
	280–300	10YR 5/3	Brown	Sandy Clay	Redoximorphic features present	Negative	Depth
AT2	80–260	10YR 7/2	Light Gray	Sand	—	Negative	See ST CM20 for upper soil data
	260–300	10YR 7/2	Light Gray	Sand	5 to 20% ferrous redoximorphic features	Negative	Depth
AT3	80–140	10YR 6/3	Pale Brown	Sandy Clay	Roots	Negative	See CM 21 for upper spoil data
	140–160	10YR 5/3	Brown	Sandy Clay	Roots	Negative	—
	160–180	10YR 7/2	Light Gray	Sandy Clay	Roots	Negative	—
	180–200	10YR 7/2	Light Gray	Sandy Clay	—	Negative	—
	200–220	10YR 7/2 and 10YR 5/2	Light Gray and Grayish Brown	Sandy Clay	—	Negative	—
	220–240	10YR 7/2 and 10YR 5/2	Light Gray and Grayish Brown	Sandy Clay	—	Negative	—
	240–300	10YR 7/2	Light Gray	Sand	—	Negative	Depth

Auger Test No.	Depth (cm)	Munsell	Soil Color	Soil Texture	Inclusions	Positive/ Negative	Reason for Termination/ Comments
AT4	0–60	10YR 6/2	Light Brownish Gray	Sandy clay loam	Clay lumps	Negative	Clay lumps present, soil seems disturbed
	60–120	10YR 7/2	Light Gray	Fine Sand	—	Negative	Possible flood deposit
	120–180	10YR 7/2	Light Gray	Sandy Clay	—	Negative	—
	180–300	10YR 7/1	Light Gray	Sand	—	Negative	Depth
AT5	80–210	10YR 2/2	Very Dark Brown	Sandy Clay Loam	Roots	Negative	See ST CM22 for upper soil data
	210–250	10YR 5/2	Grayish Brown	Sandy Clay Loam	1 to 2 % redoximorphic features	Negative	Compacted soil
AT6	0–100	10YR 5/3	Brown	Sandy Clay	—	Negative	Possible ponded or frequently inundated area
	100–140	10YR 4/3	Brown	Clay	Very small sand percentage	Negative	—
	140–255	10YR 6/2	Light Brownish Gray	Sand	2 to 5% redoximorphic features	Negative	Compacted soil
AT7	80–120	10YR 6/2	Light Brownish Gray	Sand	—	Negative	See ST CM23 for upper soil data; possible flood deposit
	120–160	10YR 4/1	Dark Gray	Sandy Clay	—	Negative	—
	160–210	10YR 6/3	Pale Brown	Sandy Clay	—	Negative	—
	210–250	10YR 4/1	Dark Gray	Sandy Clay	—	Negative	—
	250–300	10YR 6/3	Pale Brown	Sand	—	Negative	Depth
AT8	0–20	10YR 4/4	Dark Yellowish Brown	Sandy Clay Loam	Roots	Negative	—
	20–40	10YR 6/3	Pale Brown	Sandy Loam	—	Negative	—
	40–80	10YR 4/3	Brown	Sandy Clay Loam	10YR 6/3 (pale brown) mottles	Negative	—
	80–120	10YR 6/3	Pale Brown	Sandy Loam	—	Negative	—
	120–140	10YR 7/4	Very Pale Brown	Sand	—	Negative	—
	140–170	10YR 7/4	Very Pale Brown	Sandy Loam	3 to 5% redoximorphic features; mottled with 10YR 5/3 (brown) clay	Negative	—

Auger Test No.	Depth (cm)	Munsell	Soil Color	Soil Texture	Inclusions	Positive/ Negative	Reason for Termination/ Comments
	170–200	10YR 4/3	Brown	Sandy Clay Lom	2 to 3% redoximorphic features; mottled with 10YR 7/4 (very pale brown)	Negative	—
	200–230	10YR 5/4	Yellowish Brown	Sandy Clay Loam	—	Negative	—
	230–250	10YR 7/2	Light Gray	Sandy Clay Loam	1 to 2 % redoximorphic features	Negative	—
	250–260	10YR 2/1	Black	Clay Loam	2 to 3% redoximorphic features; mottled with 10YR 4/2 (dark grayish brown)	Negative	—
	260–300	10YR 4/2	Dark Grayish Brown	Clay Loam	—	Negative	Depth
AT9	80–130	10YR 4/1	Dark Gray	Sandy Clay	—	Negative	See ST CM24 for upper soil data
	130–170	10YR 6/2	Light Brownish Gray	Sandy Clay	—	Negative	—
	170–300	10YR 6/2	Light Brownish Gray	Sandy Clay	> 5% redoximorphic features	Negative	Depth
AT10	0–40	10YR 5/2	Grayish Brown	Sandy Clay	Roots; 10YR 6/2 (light brownish gray) lumps of clay present	Negative	Clay lumps present, soil seems disturbed
	40–100	10YR 3/3	Dark Brown	Sandy Clay	—	Negative	—
	100–180	10YR 4/2	Dark Grayish Brown	Sandy Clay	Calcium carbonate present	Negative	—
	180–220+	10YR 5/2	Grayish Brown	Clay	Heavy redoximorphic features	Negative	Compacted soil
AT11	80–125	10YR 6/4	Light Yellowish Brown	Sandy Clay	< 5% redoximorphic features	Negative	See ST CM25 for upper soil data
	125–190	10YR 6/3	Pale Brown	Sandy Clay	< 5% redoximorphic features	Negative	—
	190–300	10YR 6/3	Pale Brown	Sandy Clay	> 5% redoximorphic features	Negative	Depth
AT12	0–40	10YR 5/2	Grayish Brown	Sandy Loam	—	Negative	—
	40–100	10YR 6/2	Light Brownish Gray	Sandy Loam	5% redoximorphic features	Negative	—
	100–166	10YR 6/3	Pale Brown	Sandy Loam	2 to 3% redoximorphic features	Negative	Root impasse
AT13	80–110	10YR 6/2	Light Brownish Gray	Sandy Loam	1% redoximorphic features; mottled with 1% 10YR 5/2 (grayish brown) clay	Negative	See ST JW04 for upper soil data

Auger Test No.	Depth (cm)	Munsell	Soil Color	Soil Texture	Inclusions	Positive/ Negative	Reason for Termination/ Comments
	110–150	10YR 5/1	Gray	Sandy Clay Loam	2 to 3 percent redoximorphic features; mottled with 3 to 5% 10YR 6/2 (light brownish gray)	Negative	Compacted soil

Project No. ASF21-116-00
December 3, 2021

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RE: Waters of the U.S. Delineation
Ravensway Subdivision Drainage Improvements
Precinct 3
Harris County, Texas
Lat/Long 29°57'39.23"N / 95°37'26.58"W

Dear Mr. Muñiz:

Raba Kistner, Inc. (RKI) is pleased to submit the attached Waters of the U.S. Delineation report for the above-referenced property. This report was prepared for LJA Engineering (CLIENT), and may not provide adequate information for other purposes or parties. If other parties wish to rely on this report, please have them contact us so that a mutual understanding and agreement of the terms and conditions for our services can be established prior to their use of this information.

We appreciate the opportunity to have been of professional service on this important project. Should there be any questions or additional information required, please contact our office at your earliest convenience.

Very truly yours,

RABA KISTNER, INC.

Alex Ramirez
Environmental Scientist II

Brittney Davis, AICP, ENV SP
Senior Project Manager, NEPA/ Natural Resources

AR/BD/srw

Attachments

Copies submitted: Above (1 Electronic PDF Copy)

WATERS OF THE U.S. DELINEATION REPORT

Ravensway Subdivision Drainage Improvements
Harris County, Texas

RKI Project No: ASF21-116-00

Prepared for:

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December 3, 2021

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1.0 INTRODUCTION

1.1 Background

Harris County Engineering Department is proposing drainage improvements in the Ravensway Subdivision located along Huffmeister Road between Cypress N. Houston and Kluge Road within Houston, Harris County, Texas. As shown in **Figure 1**, the Review Area is approximately 18.7 acres in cumulative size. The proposed improvements consist of an approximate 13.7-acre detention area and three outfall locations. Waters of the U.S., including wetlands (WOUS), are protected under several federal statutes described in the following section. **Raba Kistner, Inc.** (**RKI**) conducted a delineation of WOUS on October 28, 2021.

The delineation was performed to determine the presence or absence of jurisdictional WOUS and, if present, to delineate their boundaries within the Review Area. It is anticipated that this report will be used in support of the jurisdictional determination process for on-site surface aquatic features. If it is determined that Clean Water Act (CWA) jurisdiction exists and WOUS will be impacted, this report will also support applications for regulatory permits that may be required from the United States Army Corps of Engineers (USACE) prior to construction activities. It should be noted that consultants may render an opinion on jurisdiction and the USACE relies on these during project reviews; however, final authority concerning jurisdiction rests with the USACE. Conclusions rendered as a result of this investigation are included in **Section 5.0**.

1.2 Regulatory Background

1.2.1 Section 404 - Clean Water Act

Section 404 of the CWA establishes a program to regulate the discharge of dredged or fill material into WOUS, including wetlands. Activities in WOUS regulated under this program include fill for development, infrastructure development, and others. Section 404 requires a permit before dredged or fill material may be discharged into WOUS for certain activities. Proposed activities are regulated through a permit review process, which is administered by the USACE.

1.2.2 Section 10 - Rivers and Harbors Act of 1899

Under Section 10 of the Rivers and Harbors Act of 1899 (RHA), a USACE permit is required for work or structures in, over, or under navigable WOUS.

Section 10 of the RHA requires authorization from the USACE for the construction of any structure in or over any navigable WOUS. This includes structures or work affecting the course, location, condition, or physical capacity of such waters. The RHA applies to any dredging or disposal of dredged materials, excavation, filling, rechannelization, or any other modification of a navigable WOUS, and applies to all structures, from the smallest floating dock to the largest commercial undertaking. It further includes, without limitation, any wharf, dolphin, weir, boom breakwater, jetty, groin, bank protection (e.g. riprap, revetment, bulkhead), mooring structures such as pilings, aerial or subaqueous power transmission lines, intake or outfall pipes, permanently moored floating vessel, tunnel, artificial canal, boat ramp, aids to navigation, and any other permanent, or semi-permanent obstacle or obstruction to navigation.

1.2.3 Rapanos

On August 30, 2021, the U.S. District Court for the District of Arizona ordered to vacate the 2020 Navigable Waters Protection Rule (NWPR) nationwide. In light of this order, Federal agencies (i.e., USACE or U.S. Environmental Protection Agency [EPA]) have halted the implementation of the NWPR and are interpreting WOUS consistent with the pre-2015 regulatory regime until further notice (herein referred to as "Rapanos") which addresses the jurisdiction over WOUS under the CWA. Below is a summary of key points included in the Rapanos guidelines.

The agencies will assert jurisdiction over the following waters:

- Traditional navigable waters (TNW) and adjacent wetlands,
- Non-navigable tributaries of TNWs that are relatively permanent where the tributaries typically flow year-round or have seasonally continuous flow (e.g., typically three months), and
- Wetlands that directly abut such tributaries.

The agencies will decide jurisdiction over the following waters based on a fact-specific analysis to determine whether they have a significant nexus with a TNW:

- Non-navigable tributaries that are not relatively permanent,
- Wetlands adjacent to non-navigable tributaries that are not relatively permanent, and
- Wetlands adjacent to but that do not directly abut a relatively permanent non-navigable tributary.

The agencies generally will not assert jurisdiction over the following features:

- Swales or erosional features (e.g., gullies, small washes characterized by low volume, infrequent, or short duration flow), and
- Ditches (including roadside ditches) excavated wholly in and draining only uplands and that do not carry a relatively permanent flow of water.

The agencies will apply the significant nexus standard as follows:

- A significant nexus analysis will assess the flow characteristics and functions of the tributary itself and the functions performed by all wetlands adjacent to the tributary to determine if they significantly affect the chemical, physical and biological integrity of downstream TNWs, and
- The significant nexus includes consideration of hydrologic and ecological factors.

2.0 DESKTOP RESOURCES REVIEW

Published desktop resources were reviewed to gather information regarding the vegetation, hydrology, and soils in the Review Area. These reviews are summarized in the following sections. Geographic Information System (GIS) desktop activities were used to identify watercourses, interpret land use, and prepare field maps and appendices.

2.1 Ecological Setting

According to the Texas Parks and Wildlife Department (TPWD) map publication titled *Natural Regions of Texas* (TPWD 2011), the Review Area is located in the northern portion of the Gulf Coast Prairies and Marshes ecoregion. According to Texas A&M Forest Service, this ecoregion is characterized as nearly level, slowly drained plain less than 150 feet in elevation, dissected by streams and rivers flowing into the Gulf of Mexico. The region includes barrier islands along the coast, salt grass marshes surrounding bays and estuaries, remnant tallgrass prairies, oak parklands and oak mottes scattered along the coast, and tall woodlands in the river bottomlands. Average annual rainfall varies from 30 to 50 inches per year distributed fairly uniformly throughout the year. The growing season is usually more than 300 days, with high humidity and warm temperatures. Soils are acidic sands and sandy loams, with clays occurring primarily in the river bottoms. Native vegetation consists of tallgrass prairies and live oak woodlands. Brush species such as mesquite and acacias are more common now than in the past. . The Review Area is located in the Little Cypress Creek-Cypress Creek Watershed – Hydrologic Unit Code (HUC) 12040102 (U.S. Geological Survey [USGS] 2021).

2.2 Climate

Climate data from the Southern Regional Climate Center (SRCC) database was reviewed for the weather station, Houston Hook Memorial Airport, approximately 8.6 miles northeast of the Review Area. This is the closest weather station with available data. The temperature in 2021 averaged 71.7° (F), with an average high of 88° (F) in June and an average low of 18.5° (F) in February. Monthly rainfall amounts in 2021 were highest in May measuring 2.5 inches (SRCC). Total rainfall was recorded at approximately 48.1 inches.

During field studies, conducted on October 28, 2021, the weather was sunny and windy with a temperature of 80° (F). As shown in **Appendix A** (USACE Antecedent Precipitation Tool data), the surveys were conducted within the wet season. However, recent precipitation trends, in this area, depict normal conditions.

2.3 Topographic Maps

Historical topographic maps are helpful in examining historic natural drainage patterns. These maps depict changes in the landscape over time and provide insight into how these changes may have influenced surface waters in the vicinity. Historical topographic maps (*USGS 7.5-Minute Series, Cypress, Satsuma, Addicks, Texas Quadrangles*) dated 1920, 1955, 1970, 1982, 1995, and 2013 (**Appendix B** and **Figure 2**) were reviewed and are summarized below.

All historic topographic maps show the Review Area at approximately 125 ft. to 135 ft. above sea level.

- 1920-1955: In these topographic maps, the western portion of the Review Area is within a primarily forested area along Cypress Creek. The eastern portion of the Review Area is adjacent west of Cypress Creek. No other ecological features are mapped within the Review Area.

- 1970: In this map, the western portion of the Review Area is still within a primarily forested area along Cypress Creek. However, within the eastern portion of the Review Area, an additional drainage feature extending from Cypress Creek has been constructed. This drainage feature appears to be constructed in conjunction with residential developments at the north and southeast portions of the map. No other ecological features are mapped within the Review Area.

- 1982-1995: In these topographic maps, ecological features within the Review Area remain similar to years past. Additional large residential developments and a sewage disposal site, near Cypress Creek, have been constructed adjacent to the Review Area.

- 2013: In this topographic map, the Review Area remains similar to years past and is surrounded by the Ravensway subdivision.

2.4 Aerial Photography

Aerial photographs provide a historical record of site use and development, help track natural and man-made changes to the landscape over time, and reveal surface features that may be indicative of saturated surface conditions. **RKI** reviewed representative aerial photographs dated 1930, 1953, 1968, 1995, 2010, and 2018. All historical images are included as **Appendix C**.

- 1930: The Review Area is depicted within a primarily forested area. There is an apparent forested wetland depicted on the northern portion of the western Review Area. No other ecological features are visible within the Review Area.

- 1953-1968: The forested wetland identified in years past is no longer visible and Cypress Creek is shown to be formed in its previous location. The other portions of the Review Areas remain within a primarily forested area.

- 1995-2018: In this map, the western portion of the Review Area is still within a primarily forested area along Cypress Creek. However, within the eastern portion of the Review Area, an additional drainage feature extending from Cypress Creek has been constructed in conjunction with residential developments at the north and southeast portions of the map.

2.5 National Wetlands Inventory

National Wetlands Inventory (NWI) maps, published by the U.S. Fish and Wildlife Service (USFWS), were reviewed for information on possible wetlands and other surface water features in the Review Area. These maps were created using stereoscopic analysis of high-altitude photographs. NWI maps assign wetland classification codes to prominent surface water features. The codes are based on the USFWS publication titled *Classification of Wetlands and Deepwater Habitats of the United States* (USFWS 1979), and are a series of letter and number codes that adapted the national wetland classification system to map form. Although NWI maps provide a good screening method for identifying potential features, a detailed on-the-ground and historical analysis of a site is required. NWI maps also do not define the jurisdictional limits of federal, state, or local governments.

RKI reviewed NWI data (USFWS 2021) for the Review Area and adjacent areas (**Figure 3**). Three (3) NWI features are identified within the Review Area and are described below:

- Riverine, Lower Perennial, Unconsolidated Bottom, Permanently Flooded, Excavated (R2UBHx): This feature (Cypress Creek) intersects the northwestern portion of the Review Area. It was observed to have a perennial flow during the field investigation.

- Riverine, Intermittent, Streambed, Seasonally Flooded, Excavated (R4SBCx): This feature was identified within the eastern portion of the Review Area. It was identified as a man-made drainage feature with a stream bed constructed of rip-rap and contained a relatively non-permanent flow during the field investigation.

- Palustrine, Forested, Broad-Leaved Deciduous, Temporary Flooded, Excavated (PFO1Ax): This feature was not identified within the southeastern Review Area. It has recently been cleared for construction access along the man-made drainage feature.

2.6 Floodplains

The Federal Emergency Management Agency (FEMA) performs hydrologic and hydraulic studies (Flood Insurance Studies [FIS]) that identify flood-prone areas and provide flood risk data. Using FIS results, FEMA prepares a Flood Insurance Rate Map (FIRM) that depicts the spatial extent of Special Flood Hazard Areas (SFHAs) and other thematic features related to flood risk assessment. These maps also provide clues regarding general hydrology and conditions that may support wetlands.

According to the available floodplain data (FIRM Panel 48201C0410M and 48201C0430M, Effective October 16, 2013), the Review Area is almost entirely within the 100-year floodplain (Zone AE), with the southeastern portion of the Review area outside of this zone (**Figure 4**).

2.7 Soils

According to the U.S. Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS), *Web Soil Survey*, there are four (4) soil types listed within the Review Area (**Figure 5**). A brief description of referenced soil is provided below:

- Clodine fine sandy loam, 0 to 1 percent slopes (Cd): This soil is formed from loamy fluviomarine deposits derived from igneous, metamorphic and sedimentary rock. It consists of up to 85 percent of Clodine soil type and similar soils and up to 15 percent of minor components. This soil is listed as a hydric soil with the USDA.

- Hatliff-Pluck-Kian complex, 0 to 1 percent slopes, frequently flooded (HatA): This soil is formed from loamy alluvium derived from igneous, metamorphic and sedimentary rock. It consists of up to 38 percent of Hatliff soil type, up to 35 percent of Pluck soil type, up to 24 percent of Kian soil type, and up to 3 percent of minor components. This soil is not listed as a hydric soil with the USDA.

- Pits (PITX): This soil is formed by pits or dumps. This soil is not listed as a hydric soil with the USDA.

- Wockley fine sandy loam, 0 to 1 percent slopes (Wo): This soil is formed from late Pliocene to early Pleistocene loamy fluviomarine deposits derived from igneous, metamorphic and sedimentary rock. It consists of up to 90 percent of Wockley soil type and up to 10 percent of minor components. This soil is not listed as a hydric soil with the USDA.

Soil characteristics were also evaluated in the field for the presence of WOUS criteria (non-wetland and wetland). See **Section 3.1** for non-wetland criteria and **Section 3.2** for wetland criteria.

3.0 FIELD INVESTIGATION

RKI conducted fieldwork on October 28, 2021. The general field methodology included walking the Review Area in three (3) transects and completing Wetland Determination Data Forms at representative points along each transect. Geospatial data was collected utilizing a Trimble R1 Global Positioning System (GPS) with sub-meter accuracy. All geospatial data was collected in accordance with the April 21, 2016 memorandum from the Galveston District of the USACE entitled, Standard Operating Procedure, Recording Jurisdictional Delineations using GPS.

3.1 Non-Wetland Waters

Non-wetland waters (i.e. streams) were delineated according to USACE Regulatory Guidance Letter (RGL) 05-05 Ordinary High Water Mark (OHWM) Identification for non-tidal waters.

Regulatory Guidance Letter (RGL) No. 05-05 on the subject of *Ordinary High Water Mark Identification* provides the criteria for examining non-wetland conditions[1]. Specifically, the RGL defines the term 'ordinary high water mark' (OHWM) as the line on the shore established by the fluctuations of water and indicated by physical characteristics established by the fluctuations of water such as:

- a clear, natural line impressed on the bank,
- shelving,
- changes in the character of soil,
- destruction of terrestrial vegetation,
- the presence of litter and debris, or
- other appropriate means that consider the characteristics of the surrounding areas.

The presence of one or more of the above conditions indicates that an OHWM is present for the purpose of determining the limits of CWA jurisdiction.

The following table summarizes non-wetland waters identified in the field (**Table 1**).

[1] *RGL 05-05* addresses the identification of an Ordinary High Water Mark in situations where no such adjacent wetlands exist. Wetland boundaries are identified using the 1987 USACE Wetland Delineation Manual described in Section 3.2.

Table 1. Non-Wetland Water Summary

Stream #	Name	Type	Latitude, Longitude (Decimal Degrees)	Acres within Review Area	Linear feet (LF) within Review Area	OHWM Line Present?	Appendix D - Photo #
DF-1	Drainage Feature	Man-made Ditch	29.96229°, -95.619685°	-	55	No	Photo 11
DF-2	Drainage Feature	Man-made Ditch	29.962824°, -95.618712°	-	441	Yes	Photos 3 & 5
PS-1	Cypress Creek	Perennial Stream	29.961830°, -95.630159°	-	412	Yes	Photo 12
W-1	Unnamed	Waterbody	29.960105°, -95.630181°	0.14	-	No	Photo 13

Key: PS: Perennial Stream; DF: Drainage Feature; W: Waterbodies

See **Figure 6**, for the location of the field verified features described above. Site photographs of these locations can be found in **Appendix D.**

3.2 Wetlands

According to the USACE and EPA "wetlands" are those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. A wetland determination was conducted using guidance from the USACE *Wetland Delineation Manual* (hereinafter, *1987 Manual*) and the *Atlantic and Gulf Coastal Plain Regional Supplement 2.0* (hereinafter, *Regional Supplement*).[2] According to the *1987 Manual*, wetland identification is based on a three-factor approach involving indicators of hydrophytic vegetation, hydric soil, and wetland hydrology, which are described in the following sub-sections. In the absence of mapped or observed wetland conditions, sampling points were taken to verify the absence of wetland conditions in certain areas. Each sample point (SP) represents a single observation point for each of the three wetland factors using prescribed Wetland Determination Data Forms (**Appendix E**)**.** Sampling point locations are shown in **Figure 6**.

3.2.1 Hydrophytic Vegetation

TPWD's 1984 map publication titled *The Vegetation Types of Texas* describes vegetation on a large scale and provides basic information on the general vegetation assemblages one might encounter in a specific region. According to this map, the Review Area is located within Map Unit 42 (Pine – Hardwood Forest) (TPWD 1984).

According to the *Regional Supplement*, "hydrophytic vegetation" is defined as a community of macrophytes that occurs in areas where inundation or soil saturation is either permanent or of sufficient frequency and duration to exert a controlling influence on the plant species present (USACE 2010). Hydrophytic vegetation is present when the plant community is dominated by species that require or can tolerate prolonged inundation or soil saturation during the growing season (USACE 2010).

[2] The *Regional Supplement* presents wetland indicators, delineation guidance, and other information specific to the Galveston District. It was designed to be used in conjunction with the *1987 Manual*; however, where differences in the two documents occur, the Regional Supplement takes precedence over the *1987 Manual*.

Hydrophytic vegetation is identified by using the indicators described in the *Regional Supplement* and documented in Wetland Determination Data Forms (**Table 2** and **Appendix E**). Wetland plant indicator codes are used to describe plants for the purposes of identifying wetlands. These status codes are defined in the following table:

Table 2. Wetland Indicator Status Codes for Plants

Indicator Code	Indicator Status	Designation	Comment
OBL	Obligate Wetland	Hydrophyte[3]	Almost always occur in wetlands
FACW	Facultative Wetland	Hydrophyte	Usually occur in wetlands, but may occur in non-wetlands
FAC	Facultative	Hydrophyte	Occur in wetlands and non-wetlands
FACU	Facultative Upland	Non-hydrophyte	Usually occur in non-wetlands, but may occur in wetlands
UPL	Obligate Upland	Non-hydrophyte	Almost never occur in wetlands

Source: https://plants.usda.gov/wetinfo.html#new_categories (Accessed November 2, 2021).

Fifteen (15) sampling points (SPs) were taken within the Review Area determine the presence or absence of hydrophytic vegetation, hydric soils, and hydrology. Hydrophytic vegetation was present as summarized in **Table 3** and **Appendix E.**

3.2.2 Wetland Hydrology

In general, the term "wetland hydrology" encompasses all hydrologic characteristics in areas that are periodically inundated or have soils saturated to the surface at some time during the growing season. Areas with evident wetland hydrology characteristics include those where the presence of water has an overriding influence on characteristics of vegetation and soils due to anaerobic and reducing conditions, respectively. According to the *Regional Supplement*, wetland hydrology indicators may include (a) direct observation of surface water or groundwater during a site visit; (b) evidence that the site is subject to flooding or ponding (e.g. water marks, drift deposits, sediment deposits, etc.); (c) other evidence of current/recent soil saturation (e.g. oxidized rhizospheres on living roots, reduced iron or sulfur in the soil profile, etc.); and (d) landscape and vegetation features that indicate contemporary wet conditions. Specific wetland hydrology indicators are defined in Wetland Determination Data Forms.

The *Regional Supplement* divides wetland hydrology indicators into two categories – primary and secondary. One primary indicator from any group or a minimum of two from the secondary group is sufficient to conclude that wetland hydrology is present. Wetland hydrology was not present within any SPs (See **Table 3** and **Appendix E**).

3.2.3 Hydric Soils

Hydric soils are those that are saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions in their upper parts. Typical field indicators of hydric soils are the presence of thick organic layers; or in the case of predominantly mineral soils, a low chroma matrix (gray color) and/or bright mottling, and/or other redoximorphic (redox) features – all soil color changes resulting from prolonged anaerobic conditions.

[3] A "hydrophyte" is any plant adapted to grow completely or partly submerged in water or wet habitats.

As noted in **Section 2.7**, the soils on site are Clodine fine sandy loam, 0 to 1 percent slopes (Cd), Hatliff-Pluck-Kian complex, 0 to 1 percent slopes, frequently flooded (HatA), Pits (PITX), and Wockley fine sandy loam, 0 to 1 percent slopes (Wo). According to the USDA's National List of Hydric Soils (updated March 2014), only the Clodine fine sandy loam, 0 to 1 percent slopes soil series is classified as a hydric soil within the Review Area. During the wetland determination, efforts were made to excavate the upper 18 inches of soil using a "sharpshooter" shovel.

Hydric soil determinations were made using the methodology and field indicators described in the *1987 Manual* and *Regional Supplement*. Hydric soil was not present for any SPs (See **Table 3** and **Appendix E**).

3.2.4 Wetland Summary

The following table summarizes the locations and results of the wetlands sampling and analysis.

Table 3. Wetland Sample Points Summary

Sample Point	Location	Presence of Wetland Criteria (Y=Yes / N=No)			
		Hydrophytic Vegetation	Hydric Soils	Wetland Hydrology	Is it a wetland?
SP-1	Located along an access road east of the drainage feature channel (DF-2) within the northeastern portion of the Review Area.	N	N	N	N
SP-2	Located along an access road east of the drainage feature channel (DF-2), approximately 130 ft. north of SP-1, within the northeastern portion of the Review Area.	N	N	N	N
SP-3	Located along an access road west of the drainage feature channel (DF-2) within the northeastern portion of the Review Area.	N	N	N	N
SP-4	Located along an access road east of the drainage feature channel (DF-2) within the southeastern portion of the Review Area.	N	N	N	N
SP-5	Located along an access road west of the drainage feature channel (DF-2) within the southeastern portion of the Review Area.	N	N	N	N
SP-6	Located at the northern portion of the western Review Area on transect 1, along the perennial stream (PS-1).	N	N	N	N
SP-7	Located at the southwestern portion of the western Review Area along transect 1.	N	N	N	N
SP-8	Located at the northwestern portion of the western Review Area along transect 1, approximately 300 ft. north of SP-7.	Y	N	N	N

Sample Point	Location	Presence of Wetland Criteria (Y=Yes / N=No)			
		Hydrophytic Vegetation	Hydric Soils	Wetland Hydrology	Is it a wetland?
SP-9	Located at the southeastern portion of the western Review Area along transect 3.	Y	N	N	N
SP-10	Located at the southern portion of the western Review Area along transect 2.	Y	N	N	N
SP-11	Located approximately 159 ft. north of the perennial stream channel (PS-1) on the western portion of the Review Area.	N	N	N	N
SP-12	Located approximately 173 ft. east of SP-11 within the western portion of the Review Area.	N	N	N	N
SP-13	Located approximately 176 ft. east of SP-6 within the western portion of the Review Area.	N	N	N	N
SP-14	Located at the northern portion of the western Review Area along transect 2, approximately 464 ft. north of SP-10.	N	N	N	N
SP-15	Located approximately 80 ft. southeast of SP-4, demonstrating upland conditions within the southeastern Review Area.	N	N	N	N

4.0 RESULTS

Based on the investigation and current regulatory guidance, the following features were identified.

Table 4. Potential Jurisdictional Findings

Feature	Size	Location	Potentially Jurisdictional?	Description
PS-1	412 LF	Northwest portion of the Review Area	Y	During the time of field surveys, the stream contained high, perennial flowing surface water throughout the Review Area. Since this feature is a RPW with perennial flow and transports flow directly or indirectly into a TNW, it is regulated under the CWA.
DF-1	55 LF	Northeastern portion of the Review Area	N	This feature did not contain an OHWM throughout the Review Area. Since this feature was excavated wholly in and draining only uplands and does not carry a relatively permanent flow of water, it is not regulated under the CWA.
DF-2	441 LF	Northeastern and southeastern portions of the Review Area	N	During the time of field surveys, the stream appeared to be a man-made drainage feature with a stream bed constructed of rip-rap and contained a non-RPW flow. Since this feature was excavated wholly in and draining only uplands and does not carry a relatively permanent flow of water, it is not regulated under the CWA.
W-1	0.14 acre	Central portion of the western Review Area	N	This feature is an impounded waterbody that was not created from a WOUS. It was excavated wholly in uplands and does not contain a significant nexus with a RPW or TNW; therefore, it is not regulated under the CWA.

The significant nexus determination for an RPW and their adjacent wetlands was used to identify the particular reach of waters that were evaluated within the Review Area. A significant nexus exists if the tributary, in combination with all of its adjacent wetlands, has more than a speculative or insubstantial effect on the chemical, physical, and/or biological integrity of the TNW. The observed perennial stream met the criteria for a significant nexus to a TNW because this feature contributes flow of pollutants and has a direct connection into a TNW. It should be noted that consultants may render an opinion on jurisdiction and the USACE relies on these during project reviews; however, final authority concerning jurisdiction rests with the USACE.

A total of 0.14 acre of a non-wetland waters (waterbody) and 908 LF of non-wetland waters (streams) were identified within the Review Area.

5.0 CONCLUSION

RKI conducted a wetland delineation and determination survey for the Ravensway Subdivision Drainage Improvements project on October 28, 2021. Based on the investigation, 412 LF of potentially jurisdictional non-wetland water (Cypress Creek, PS-1) was identified within the Review Area, which is regulated under Section 404 of the CWA. There were also 496 LF (drainage features) and 0.14 acre (waterbodies) of potentially non-jurisdictional non-wetland waters within the Review Area that are not regulated under Section 404 the CWA. These features are described in **Table 4** and shown in **Figure 6**.

This delineation was limited to the identification and quantification of potential WOUS that exist in the Review Area. Final authority concerning the jurisdiction of all non-wetland and wetland features rests with the USACE under Section 404 of the CWA. Section 10 of the RHA does not apply to the proposed project activities because there are no navigable waters that will be affected within the Review Area.

6.0 REFERENCES

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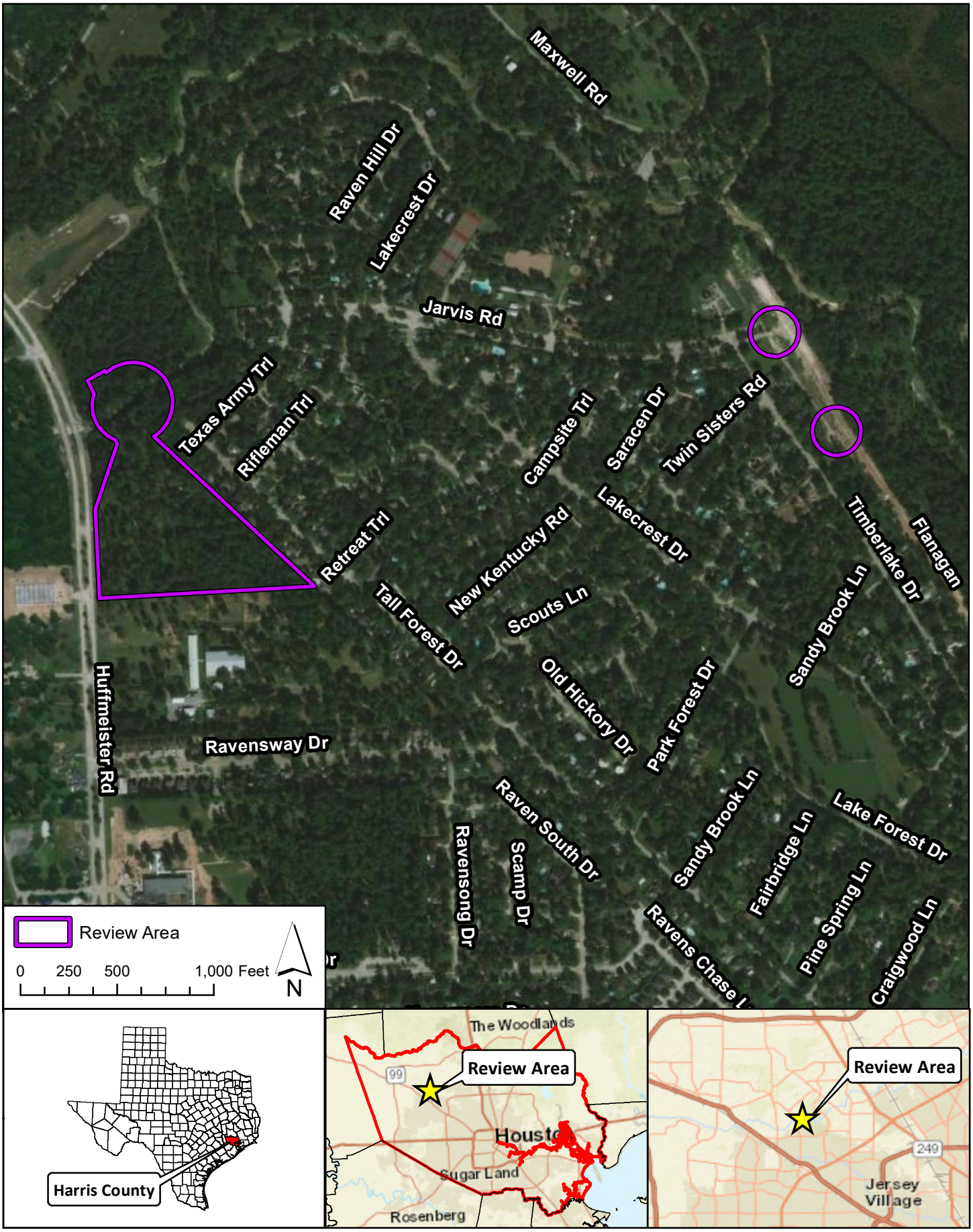
7.0 ACRONYMS AND ABBREVIATIONS

CWA	Clean Water Act
EPA	U.S. Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Studies
GIS	Geographic Information System
GPS	Global Positioning System
HUC	Hydrologic Unit Code
LF	linear feet
NRCS	Natural Resources Conservation Service
NWI	National Wetlands Inventory
NWPR	Navigable Waters Protection Rule
OHWM	Ordinary High Water Mark
RGL	Regulatory Guidance Letter
RHA	Rivers and Harbors Act
RKI	Raba Kistner, Inc.
RPW	Relatively Permanent Water
SFHA	Special Flood Hazard Area
SP	Sample Point
SRCC	Southern Regional Climate Center
TPWD	Texas Parks and Wildlife Department
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WOUS	Waters of the U.S.

FIGURES



Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea,

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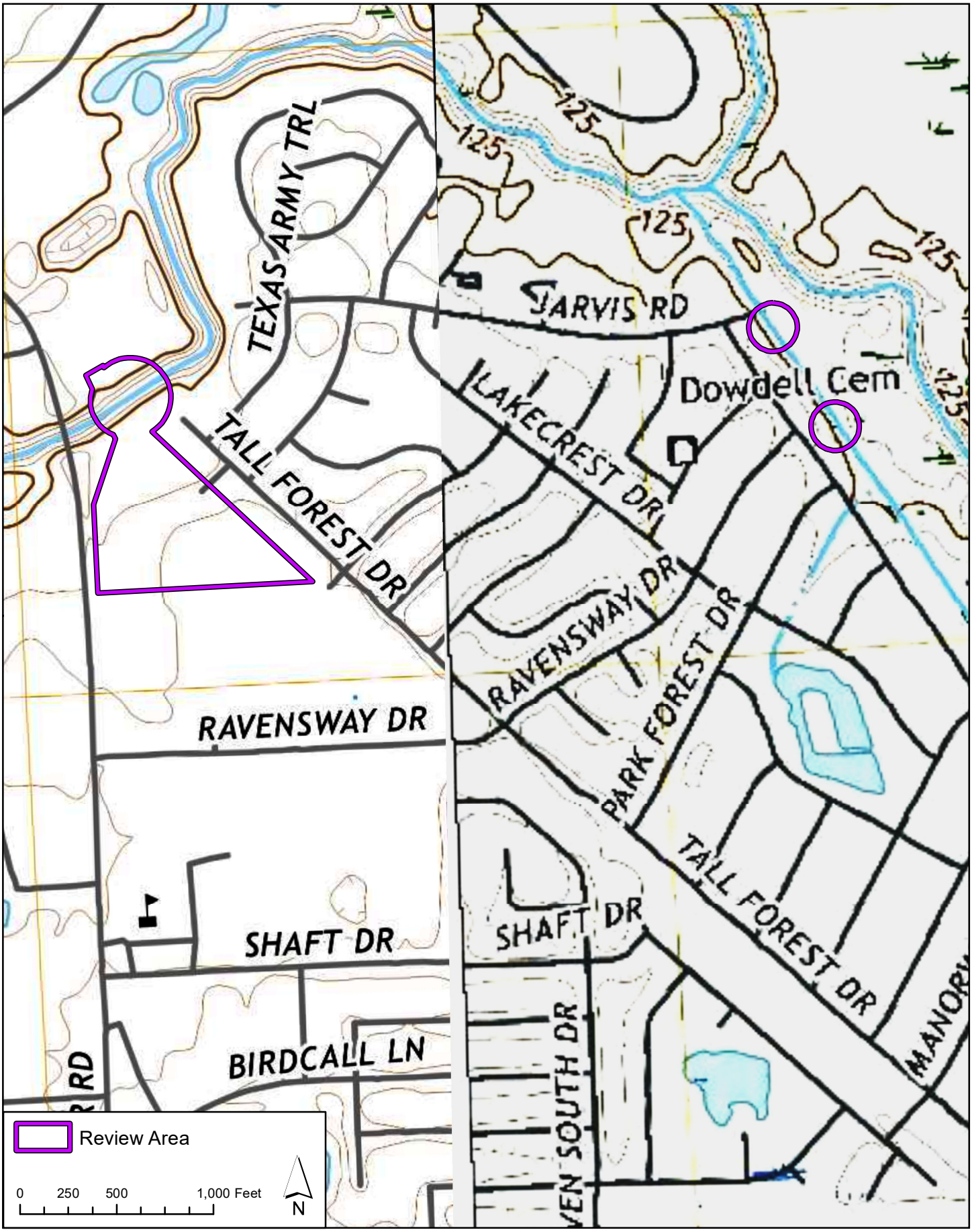
PROJECT LOCATION

Ravensway Subdivision Drainage Improvements
Harris County, Texas
RKI Project No. ASF21-116-00

FIGURE

1



SOURCE: USGS 7.5 Minute Topographic Map, Cypress Texas Quadrangle (2019), Satsuma Texas Quadrangle (2019)

USGS TOPOGRAPHIC

Ravensway Subdivision Drainage Improvements
Harris County, Texas
RKI Project No. ASF21-116-00

FIGURE

2

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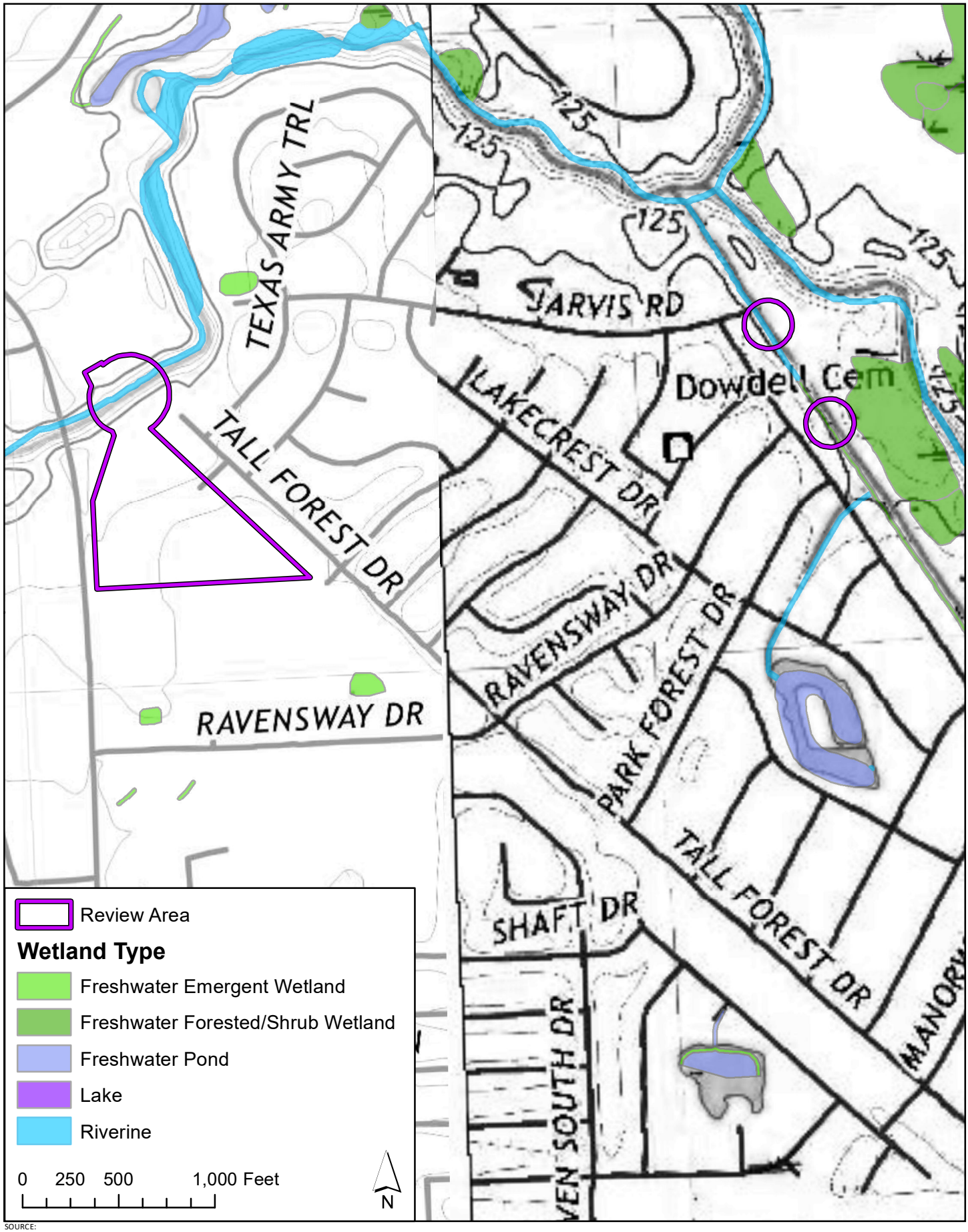

SOURCE:
1) USGS 7.5 Minute Topographic Map, Cypress Texas Quadrangle (2019), Satsuma Texas Quadrangle (2019)
2) USFWS National Wetlands Inventory Data - Spring Watershed (Downloaded 4/27/2021)

NATIONAL WETLANDS INVENTORY

Ravensway Subdivision Drainage Improvements
Harris County, Texas
RKI Project No. ASF21-116-00

FIGURE

3

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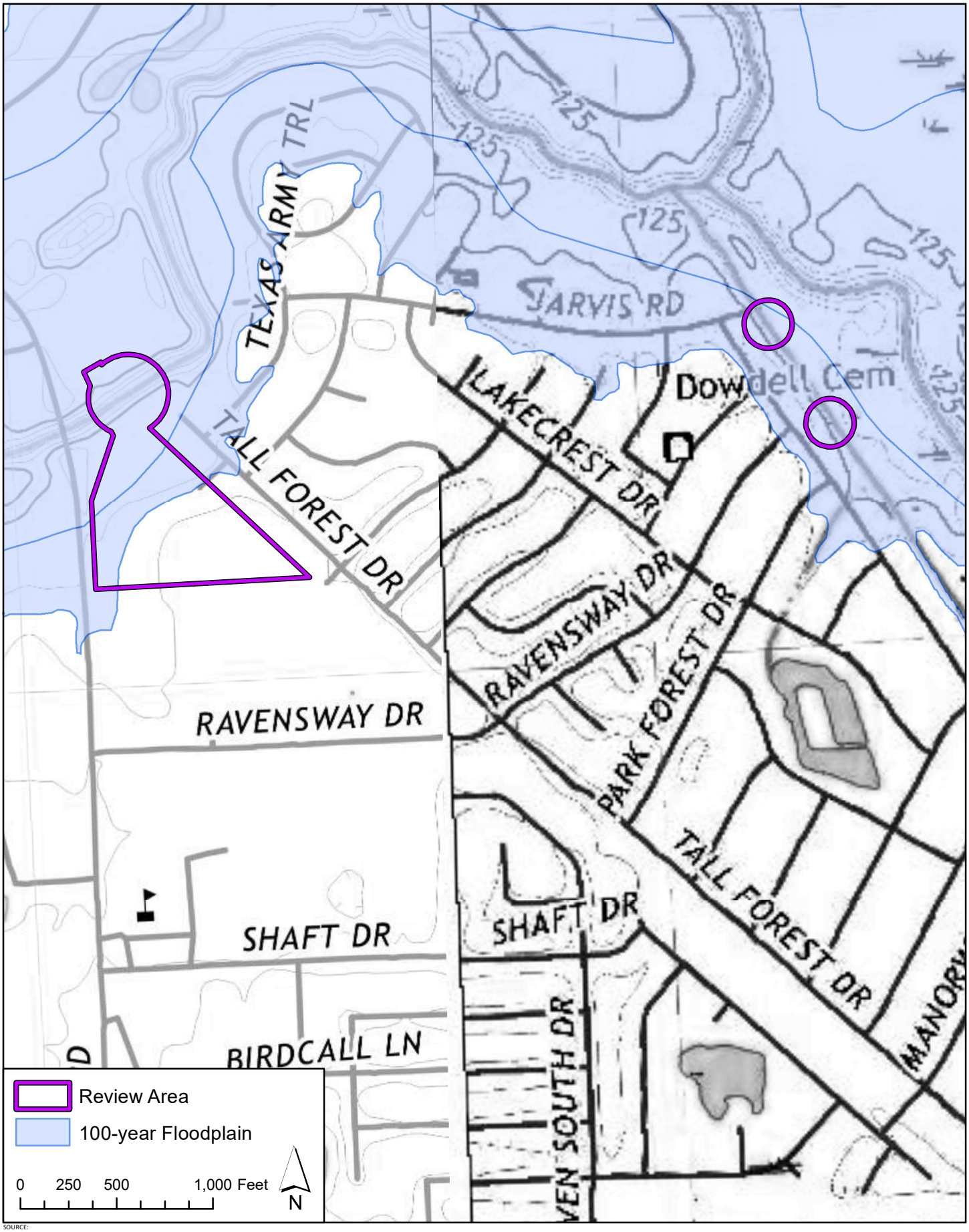

SOURCE:
1) USGS 7.5 Minute Topographic Map, Seguin, Texas Quadrangle (2019)
2) FEMA - Panel Number 48201C0410M, Effective 10/15/2013, 48201C0430M, Effective 10/15/2013

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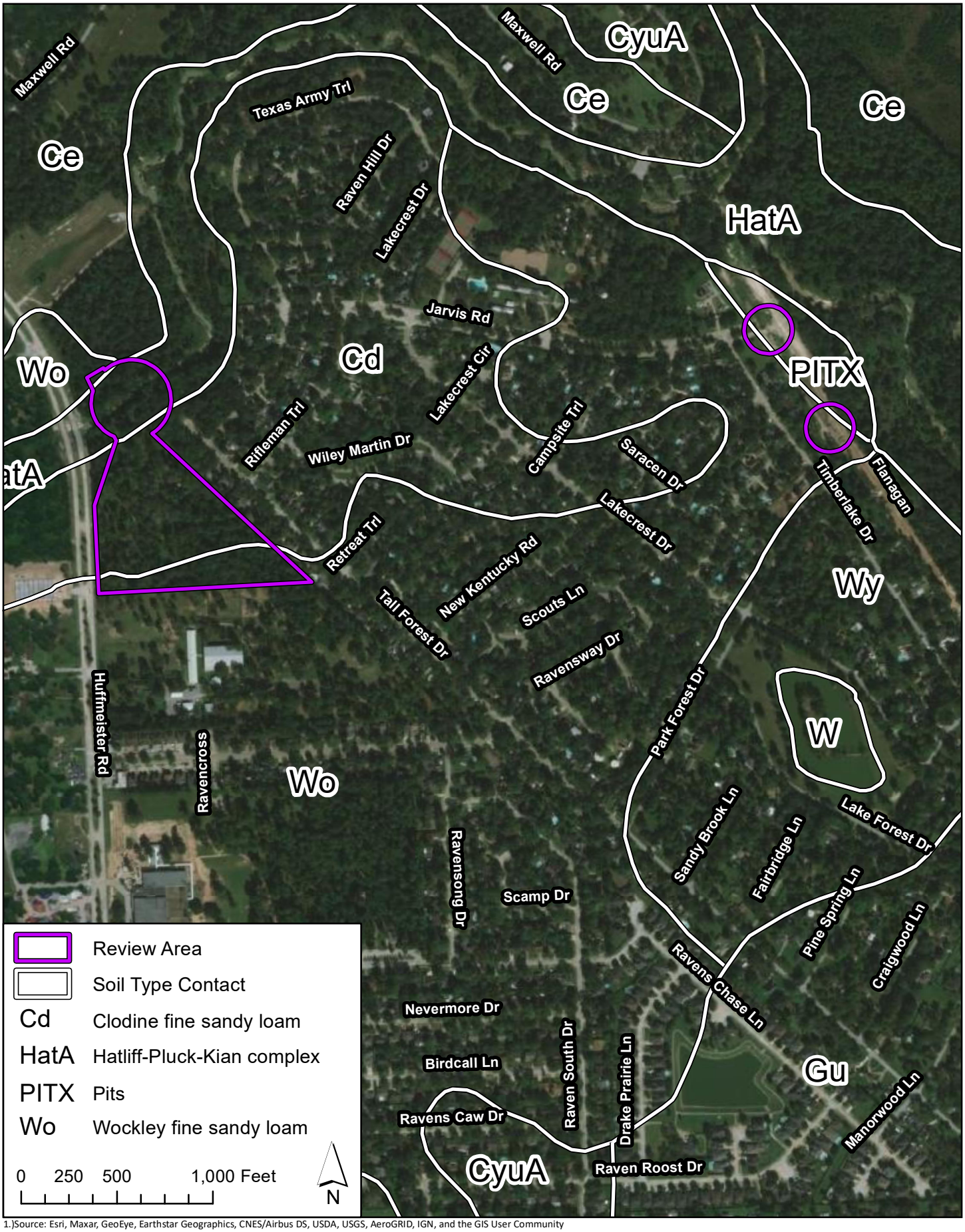
FEMA FLOODPLAIN

Ravensway Subdivision Drainage Improvements
Harris County, Texas
RKI Project No. ASF21-116-00

FIGURE

4



1.)Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
2.)USDA Natural Resources Conservation Service

USDA SOILS

Ravensway Subdivision Drainage Improvements
Harris County, Texas
RKI Project No. ASF21-116-00

FIGURE

5

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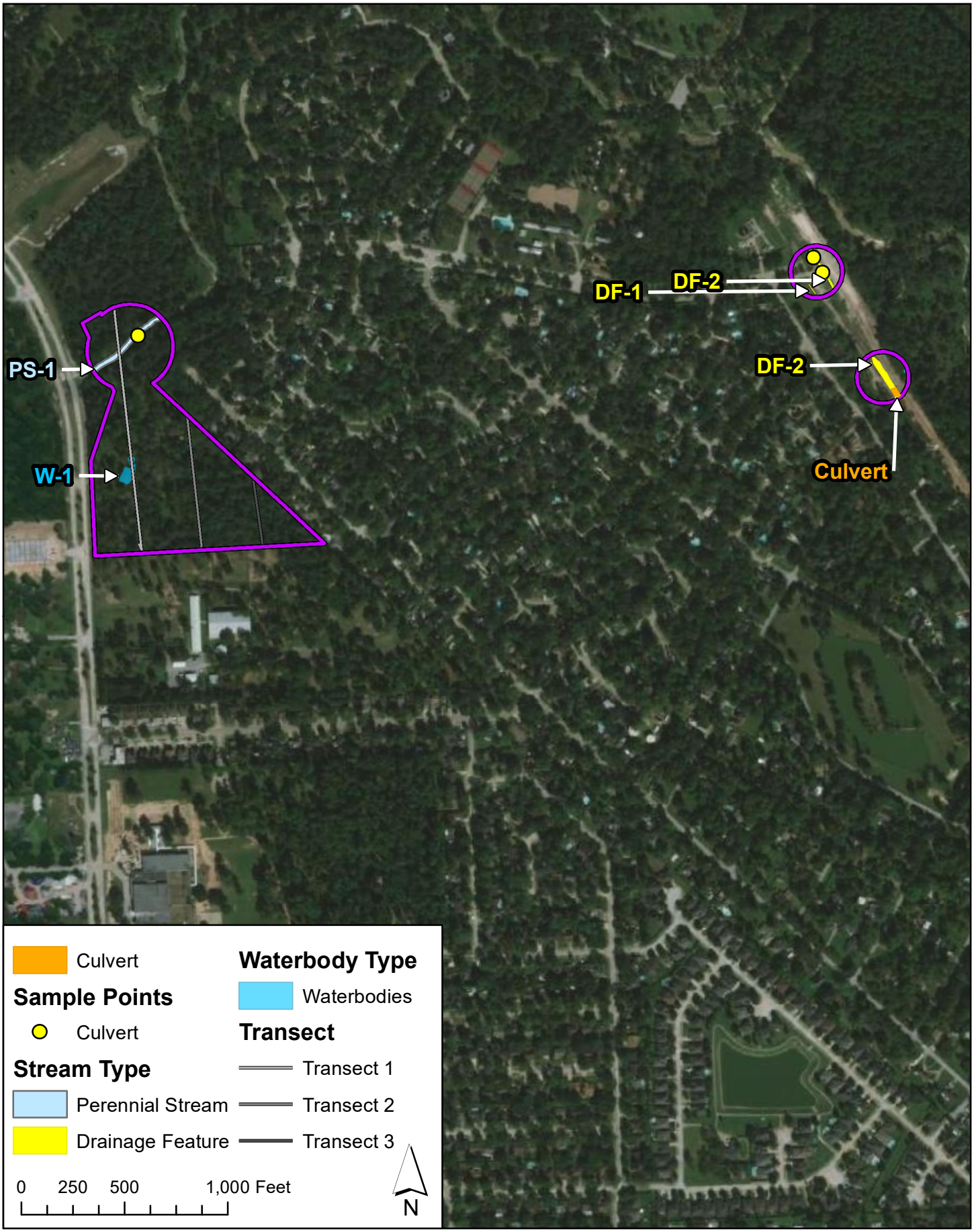


SOURCE: 1) Aerial basemap from ESRI

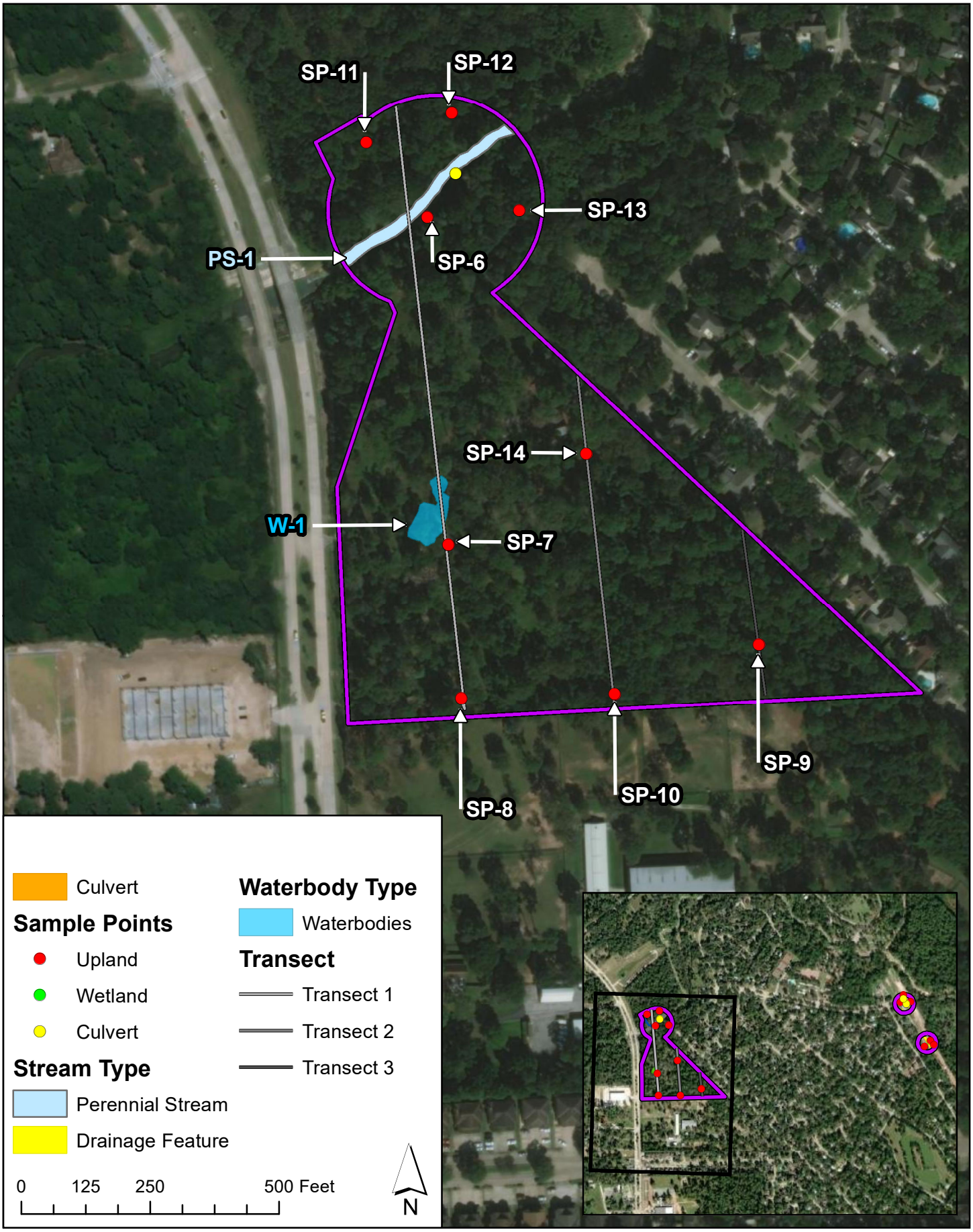
POTENTIAL WATERS OF THE U.S.

Ravensway Subdivision Drainage Improvements
Harris County, Texas
RKI Project No. ASF21-116-00

FIGURE

6a

RABA KISTNER



SOURCE: 1) Aerial basemap from ESRI

POTENTIAL WATERS OF THE U.S.

Ravensway Subdivision Drainage Improvements
Harris County, Texas
RKI Project No. ASF21-116-00

FIGURE

6b

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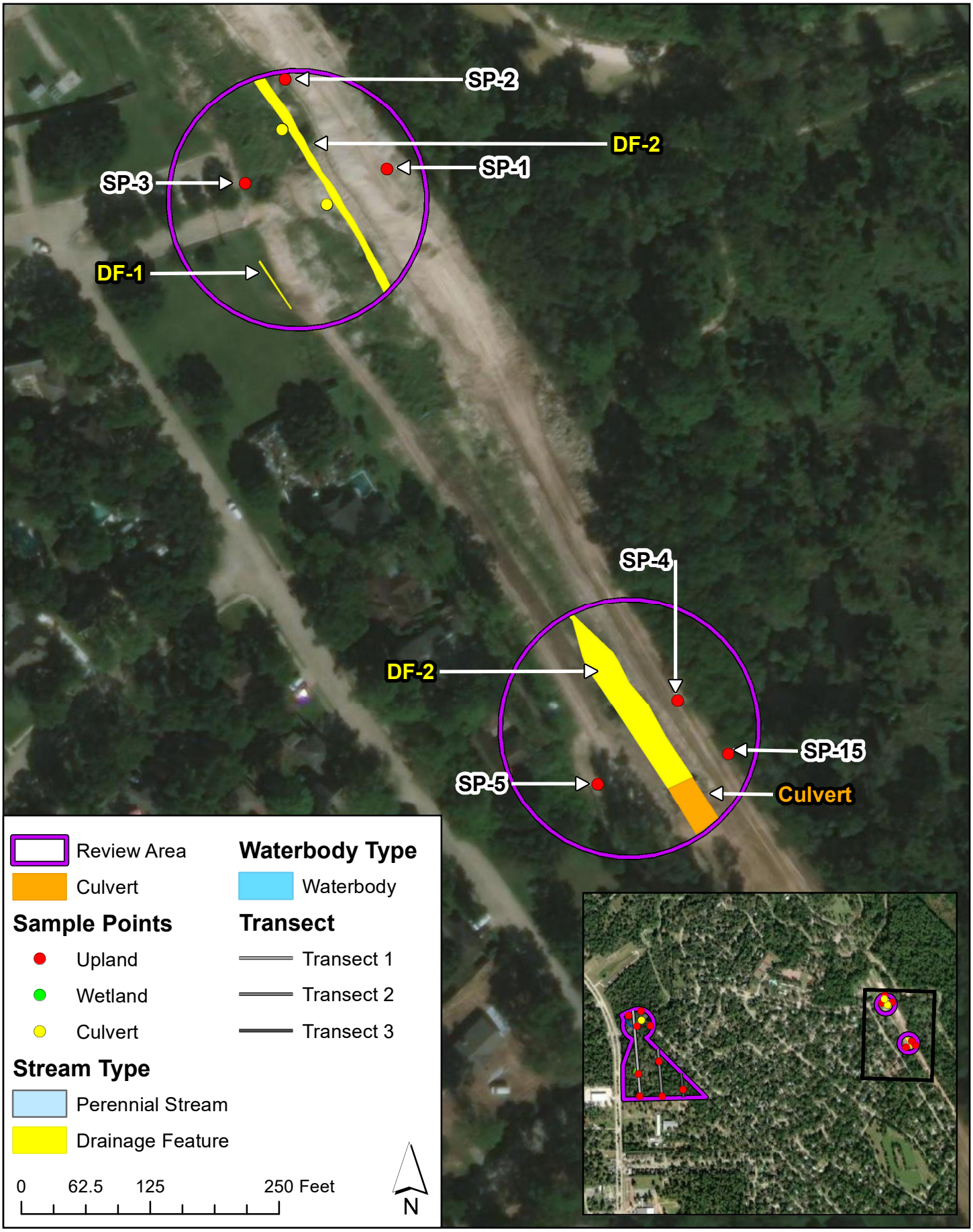

SOURCE: 1) Aerial basemap from ESRI

POTENTIAL WATERS OF THE U.S.

Ravensway Subdivision Drainage Improvements
Harris County, Texas
RKI Project No. ASF21-116-00

FIGURE

6c

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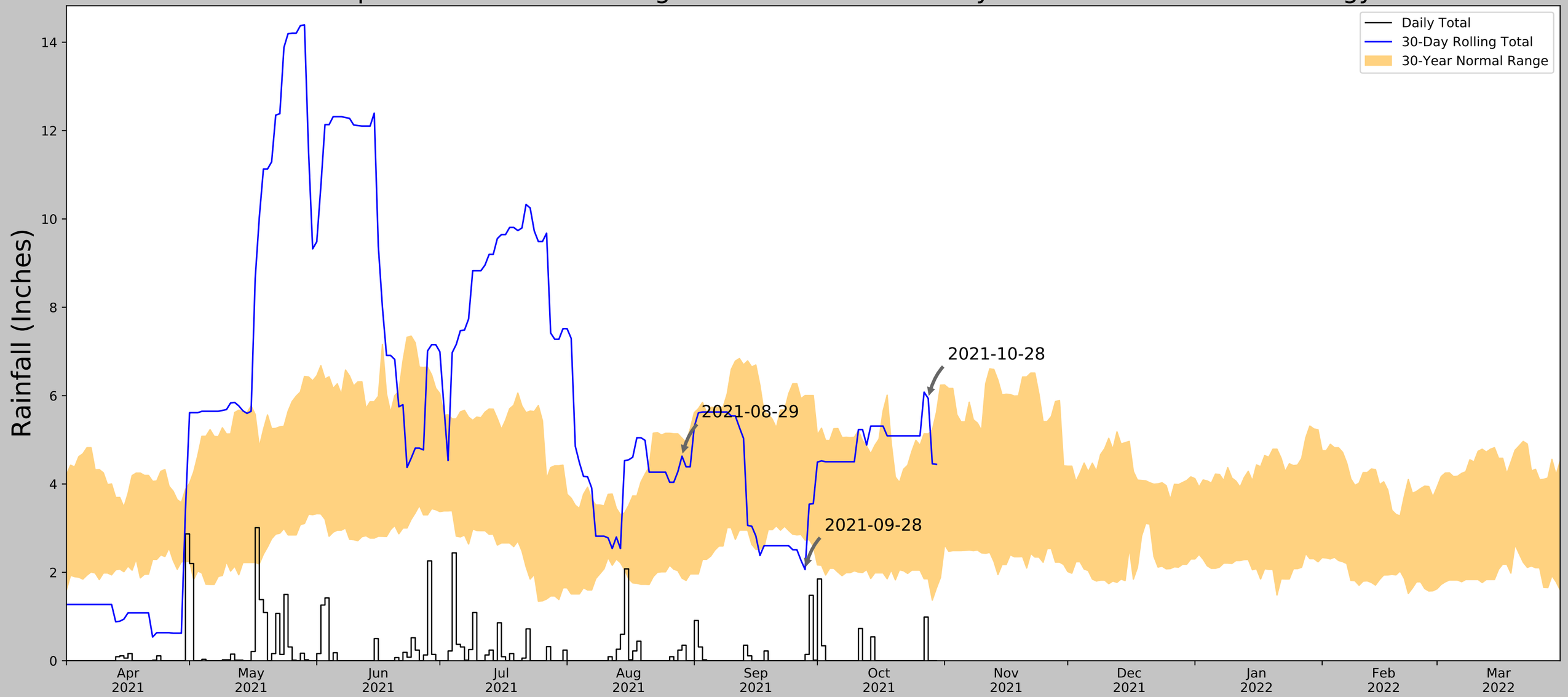
APPENDIX A

ANTECEDENT PRECIPITATION TOOL DATA

Antecedent Precipitation vs Normal Range based on NOAA's Daily Global Historical Climatology Network



Coordinates	29.960289, -95.629658
Observation Date	2021-10-28
Elevation (ft)	130.73
Drought Index (PDSI)	Severe wetness (2021-09)
WebWIMP H_2O Balance	Wet Season

30 Days Ending	30th %ile (in)	70th %ile (in)	Observed (in)	Wetness Condition	Condition Value	Month Weight	Product
2021-10-28	1.853543	5.132677	5.937008	Wet	3	3	9
2021-09-28	2.730709	6.003543	2.062992	Dry	1	2	2
2021-08-29	1.869685	5.037008	4.629921	Normal	2	1	2
Result							Normal Conditions - 13

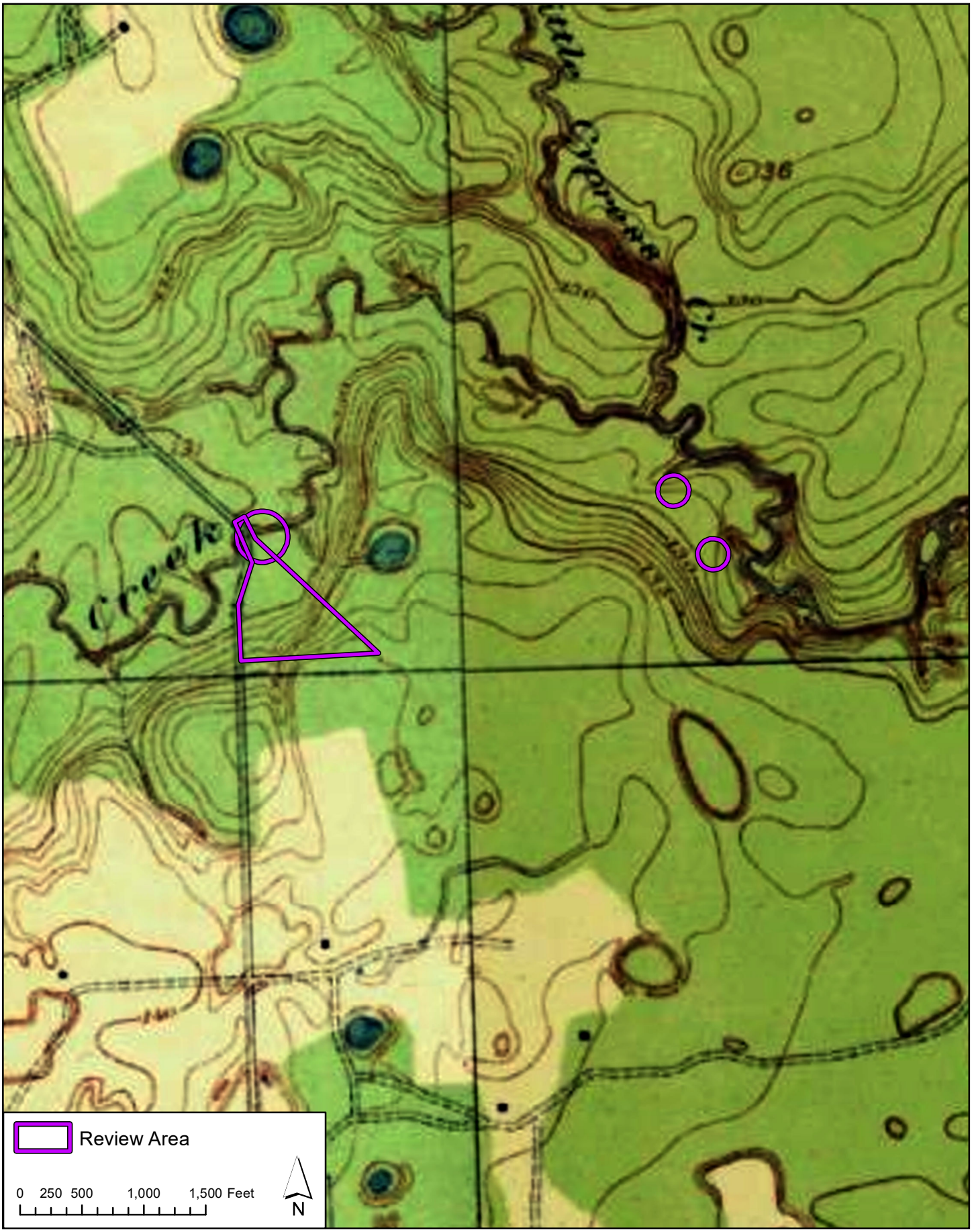
Figure and tables made by the
Antecedent Precipitation Tool
Version 1.0

Written by Jason Deters
U.S. Army Corps of Engineers

Weather Station Name	Coordinates	Elevation (ft)	Distance (mi)	Elevation Δ	Weighted Δ	Days Normal	Days Antecedent
HOUSTON HOOKS MEM AP	30.0675, -95.5561	151.903	8.616	21.173	4.06	8578	90
TOMBALL	30.1003, -95.6114	209.974	4.008	58.071	2.036	2775	0

APPENDIX B

HISTORICAL TOPOGRAPHIC MAPS



SOURCE: USGS 7.5 Minute Topographic Map, Cypress Texas Quadrangle (1920-2013), Satsuma Texas Quadrangle (1920-2013), Addicks Texas Quadrangle (1955)

1920 USGS HISTORIC TOPOGRAPHIC

Ravensway Subdivision Drainage Improvements
Harris County, Texas
RKI Project No. ASF21-116-00

APPENDIX

B

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SOURCE: USGS 7.5 Minute Topographic Map, Cypress Texas Quadrangle (1920-2013), Satsuma Texas Quadrangle (1920-2013), Addicks Texas Quadrangle (1955)

1955 USGS HISTORIC TOPOGRAPHIC

Ravensway Subdivision Drainage Improvements
Harris County, Texas
RKI Project No. ASF21-116-00

APPENDIX

B

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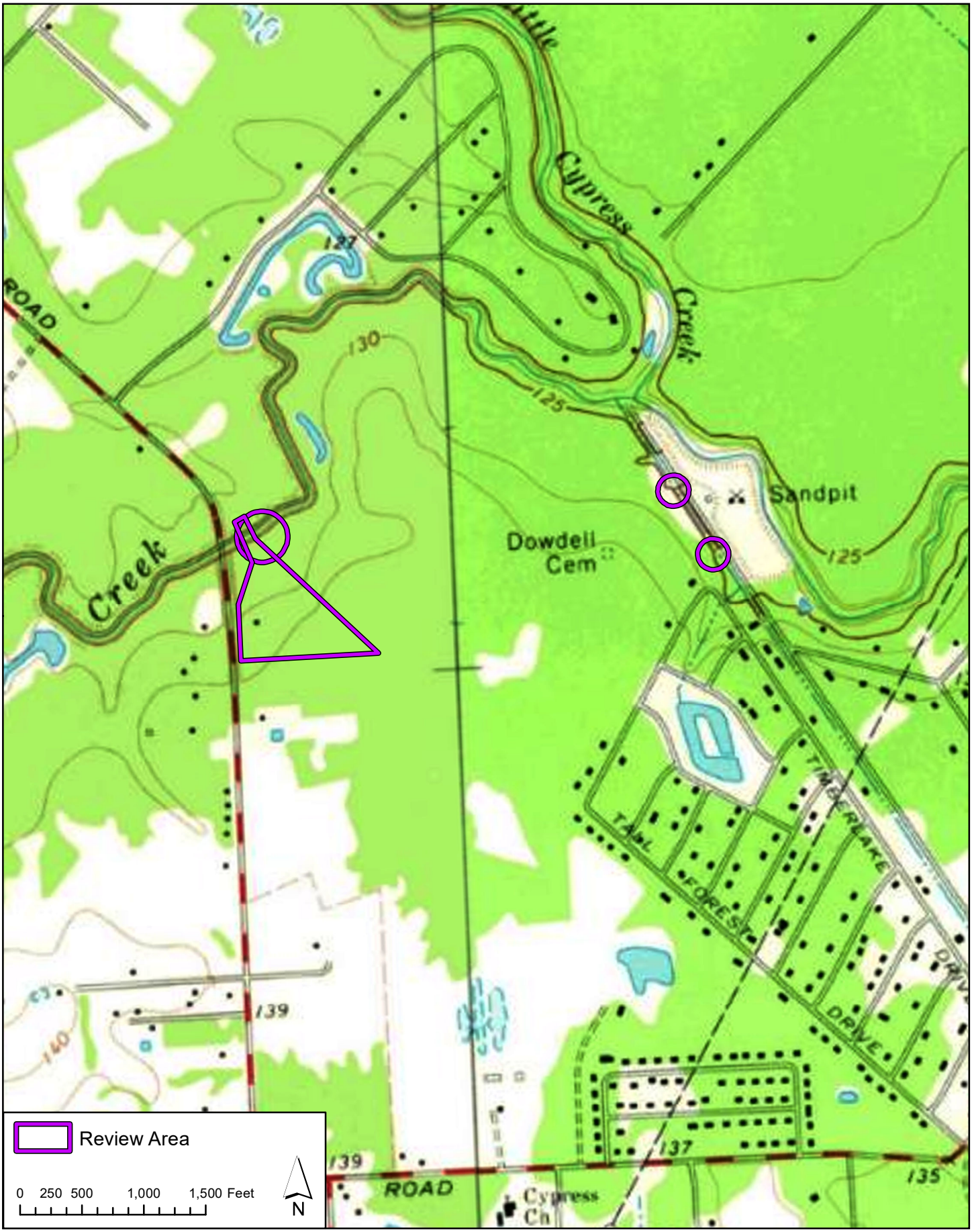

SOURCE: USGS 7.5 Minute Topographic Map, Cypress Texas Quadrangle (1920-2013), Satsuma Texas Quadrangle (1920-2013), Addicks Texas Quadrangle (1955)

1970 USGS HISTORIC TOPOGRAPHIC

Ravensway Subdivision Drainage Improvements
Harris County, Texas
RKI Project No. ASF21-116-00

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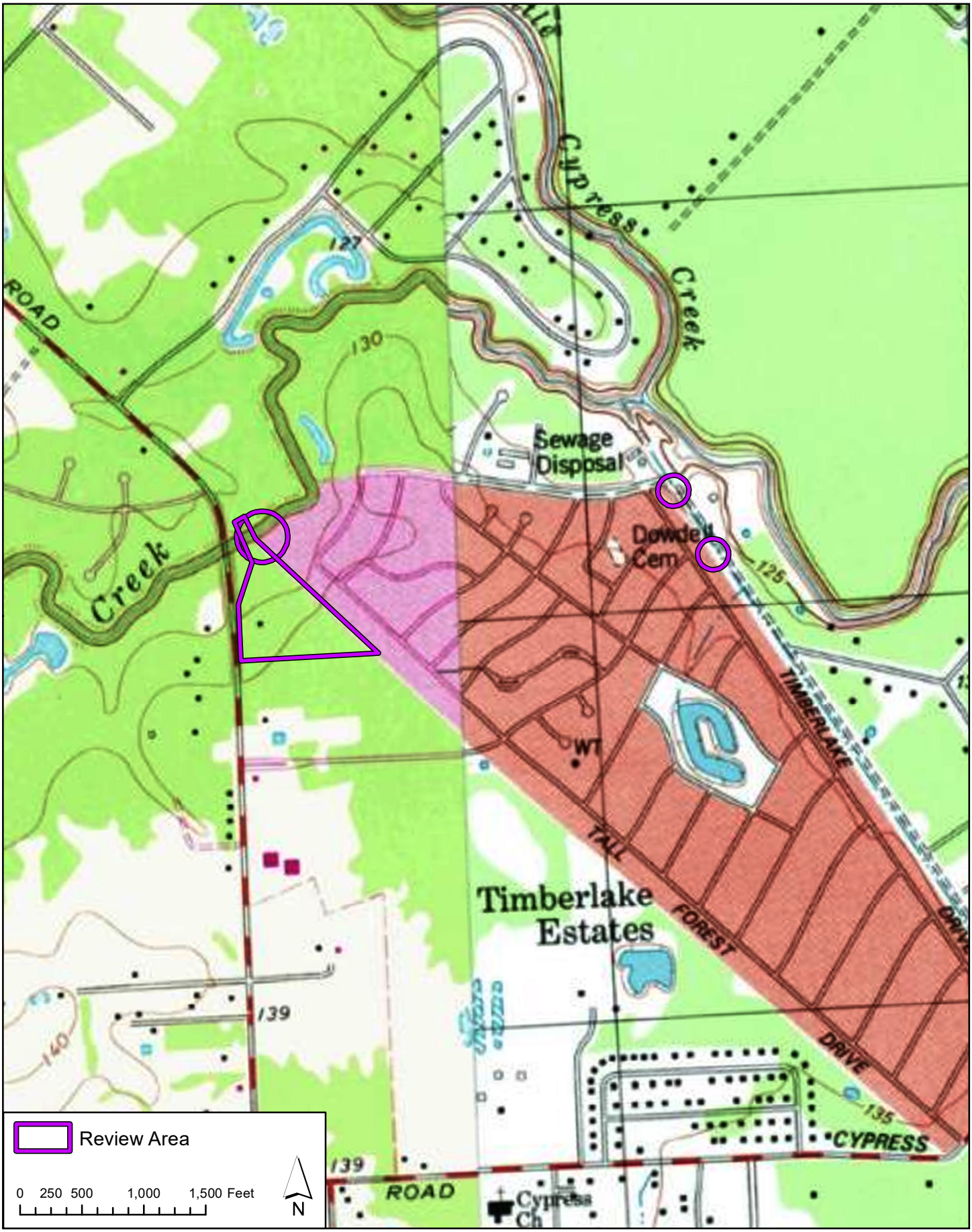

SOURCE: USGS 7.5 Minute Topographic Map, Cypress Texas Quadrangle (1920-2013), Satsuma Texas Quadrangle (1920-2013), Addicks Texas Quadrangle (1955)

1982 USGS HISTORIC TOPOGRAPHIC

Ravensway Subdivision Drainage Improvements
Harris County, Texas
RKI Project No. ASF21-116-00

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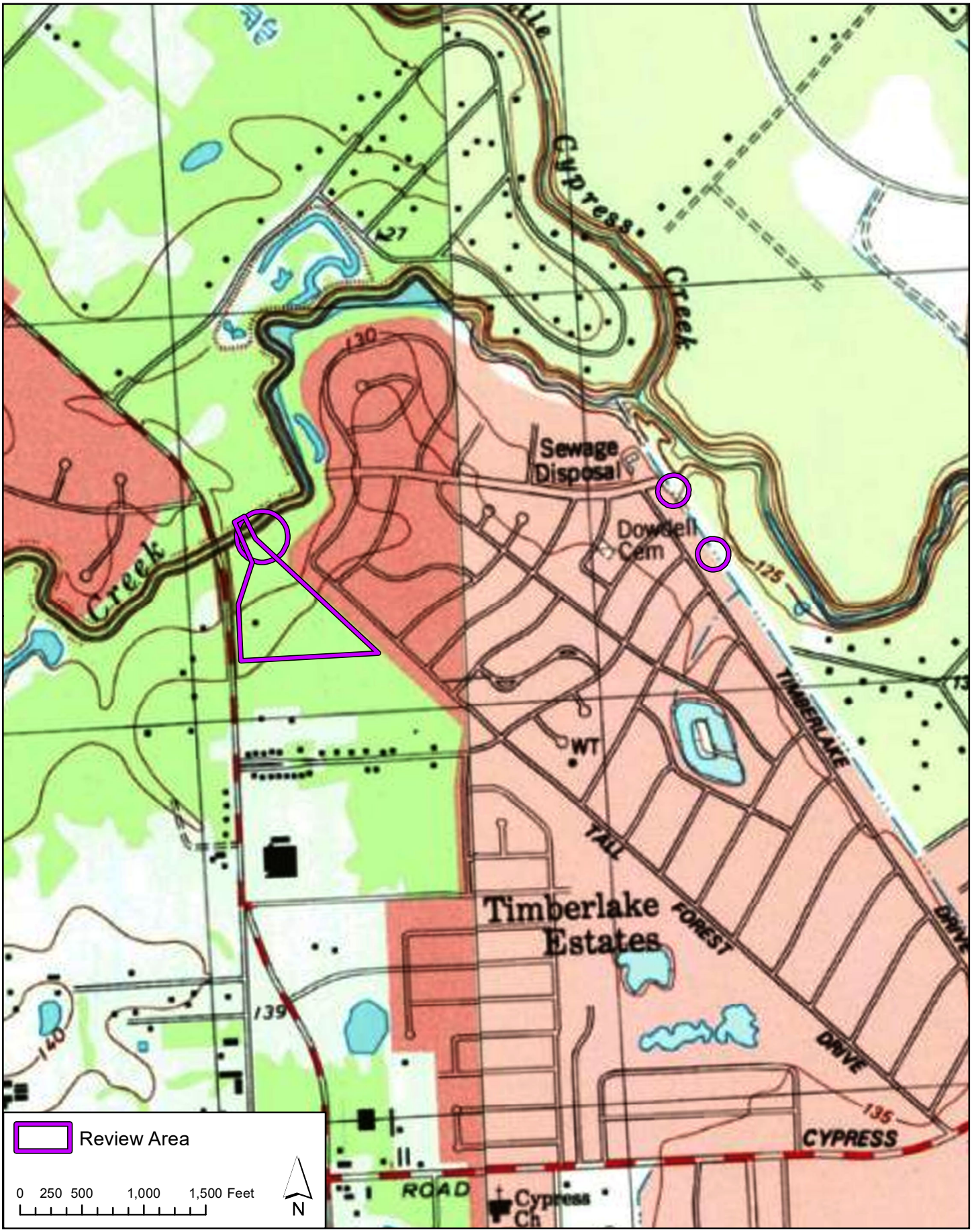

SOURCE: USGS 7.5 Minute Topographic Map, Cypress Texas Quadrangle (1920-2013), Satsuma Texas Quadrangle (1920-2013), Addicks Texas Quadrangle (1955)

1995 USGS HISTORIC TOPOGRAPHIC

Ravensway Subdivision Drainage Improvements
Harris County, Texas
RKI Project No. ASF21-116-00

APPENDIX

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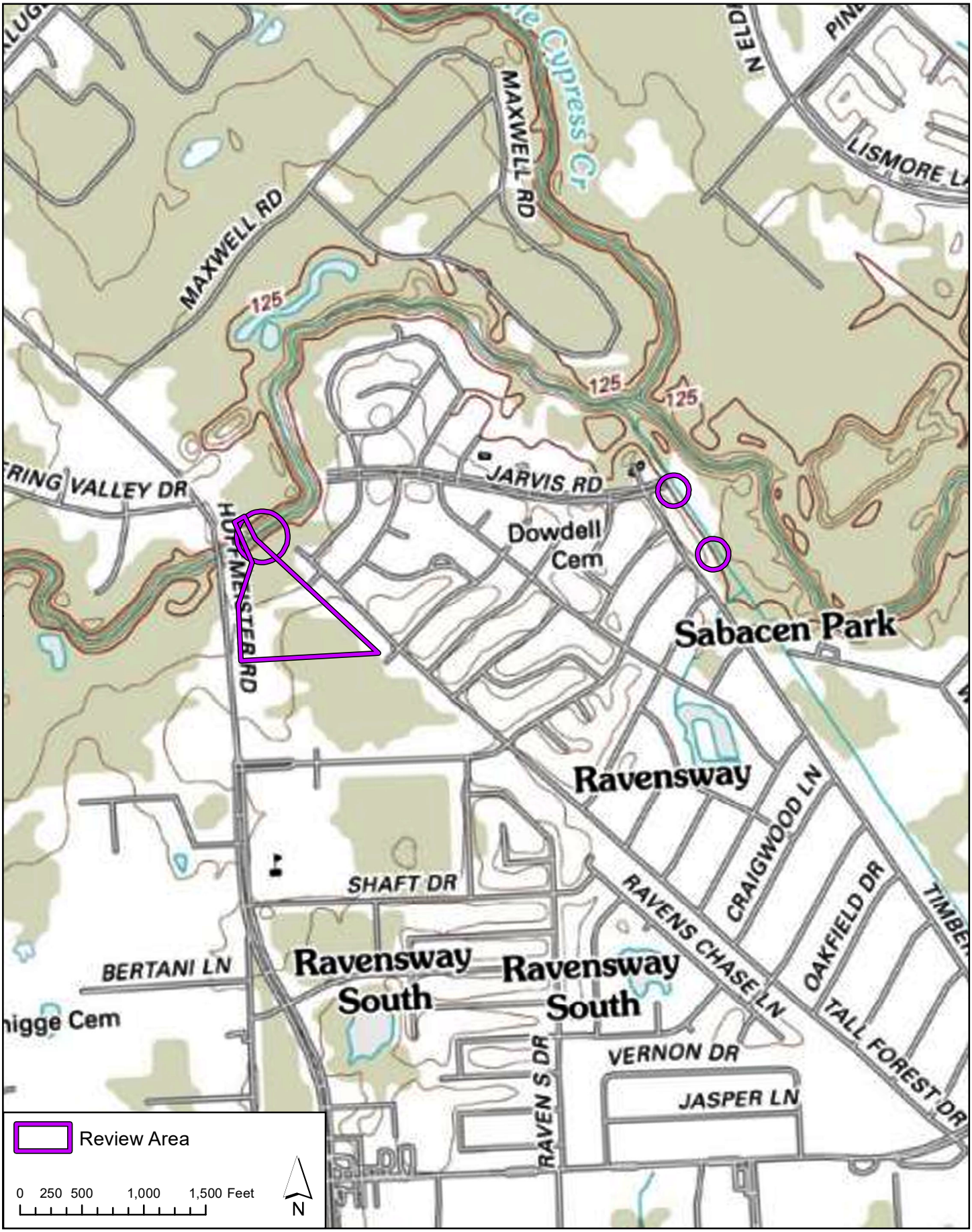

SOURCE: USGS 7.5 Minute Topographic Map, Cypress Texas Quadrangle (1920-2013), Satsuma Texas Quadrangle (1920-2013), Addicks Texas Quadrangle (1955)

2013 USGS HISTORIC TOPOGRAPHIC

Ravensway Subdivision Drainage Improvements
Harris County, Texas
RKI Project No. ASF21-116-00

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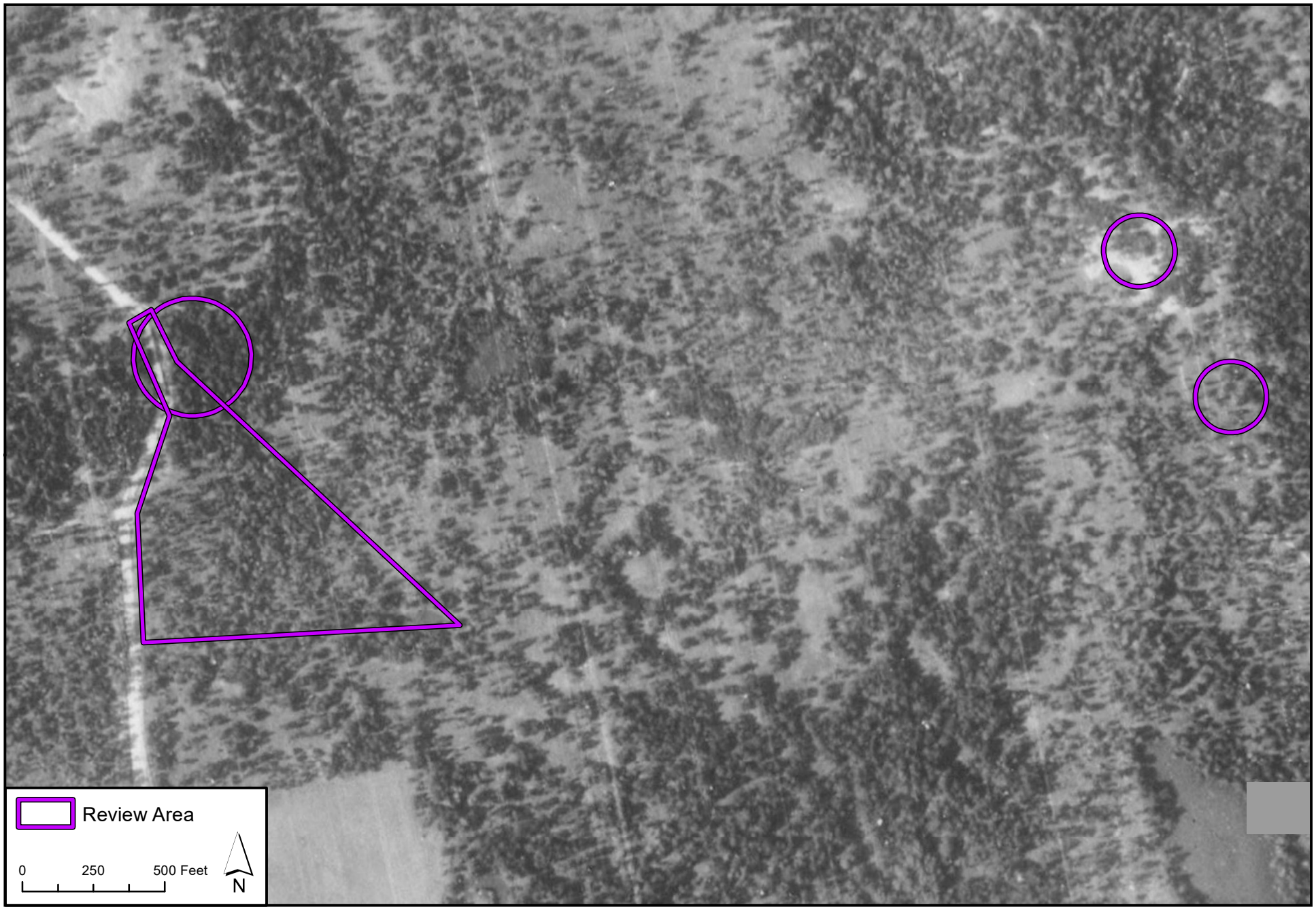
APPENDIX

B

APPENDIX C

HISTORICAL AERIAL PHOTOGRAPHS



1930 HISTORIC AERIAL PHOTOGRAPH

Ravensway Subdivision Drainage Improvements
Harris County, Texas
RKI Project No. ASF21-116-00

APPENDIX

C

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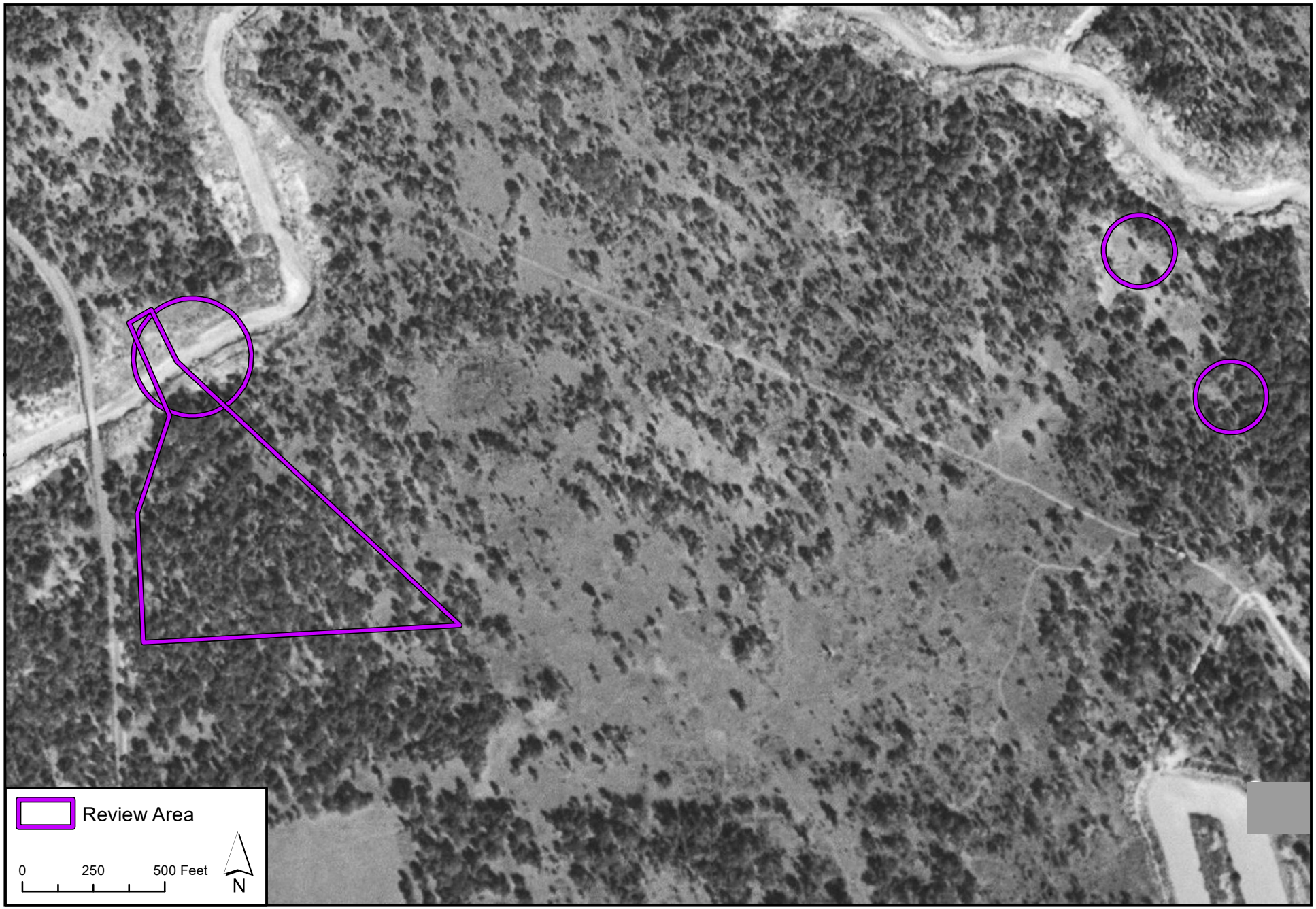

1953 HISTORIC AERIAL PHOTOGRAPH

Ravensway Subdivision Drainage Improvements
Harris County, Texas
RKI Project No. ASF21-116-00

APPENDIX

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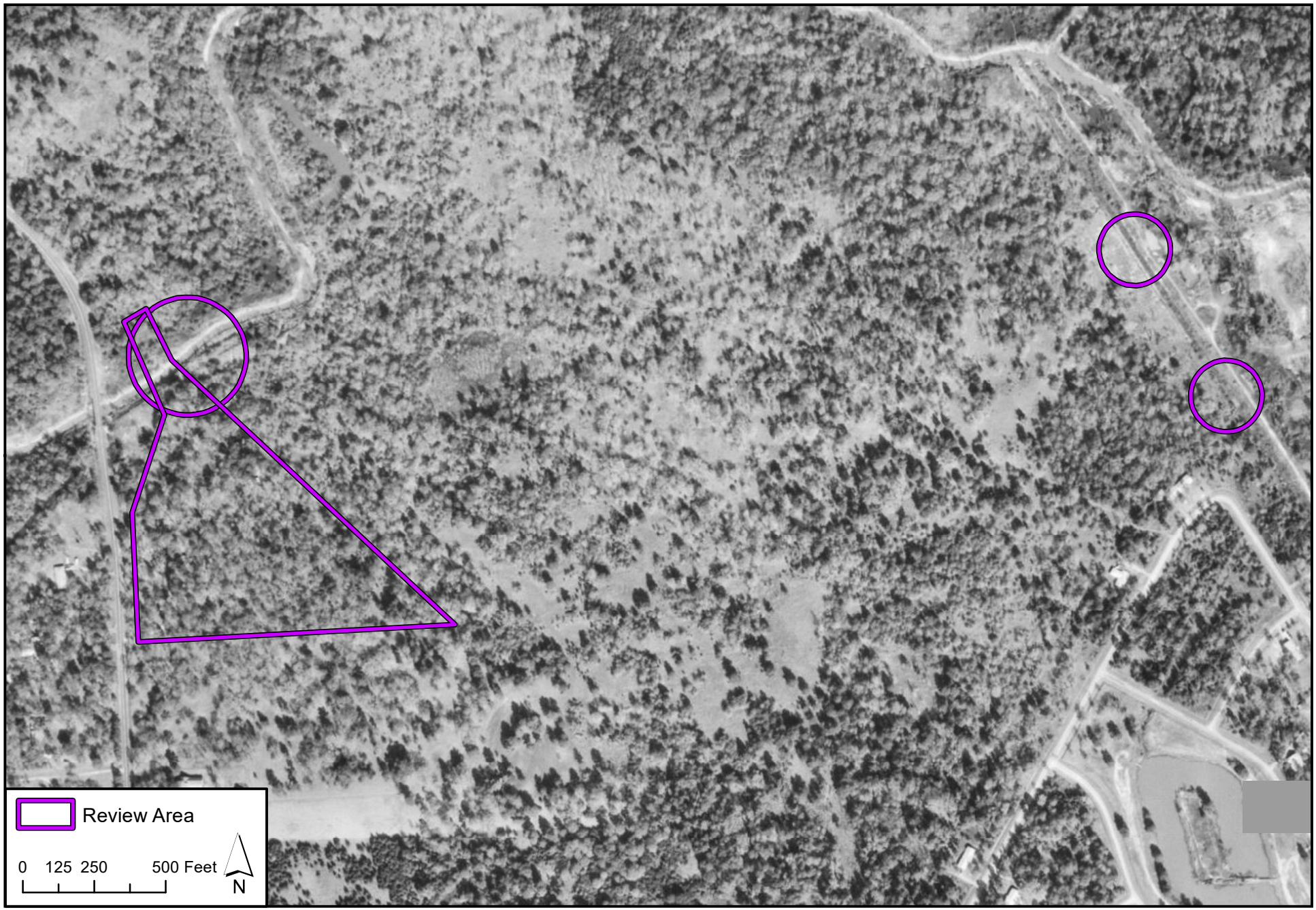

1968 HISTORIC AERIAL PHOTOGRAPH

Ravensway Subdivision Drainage Improvements
Harris County, Texas
RKI Project No. ASF21-116-00

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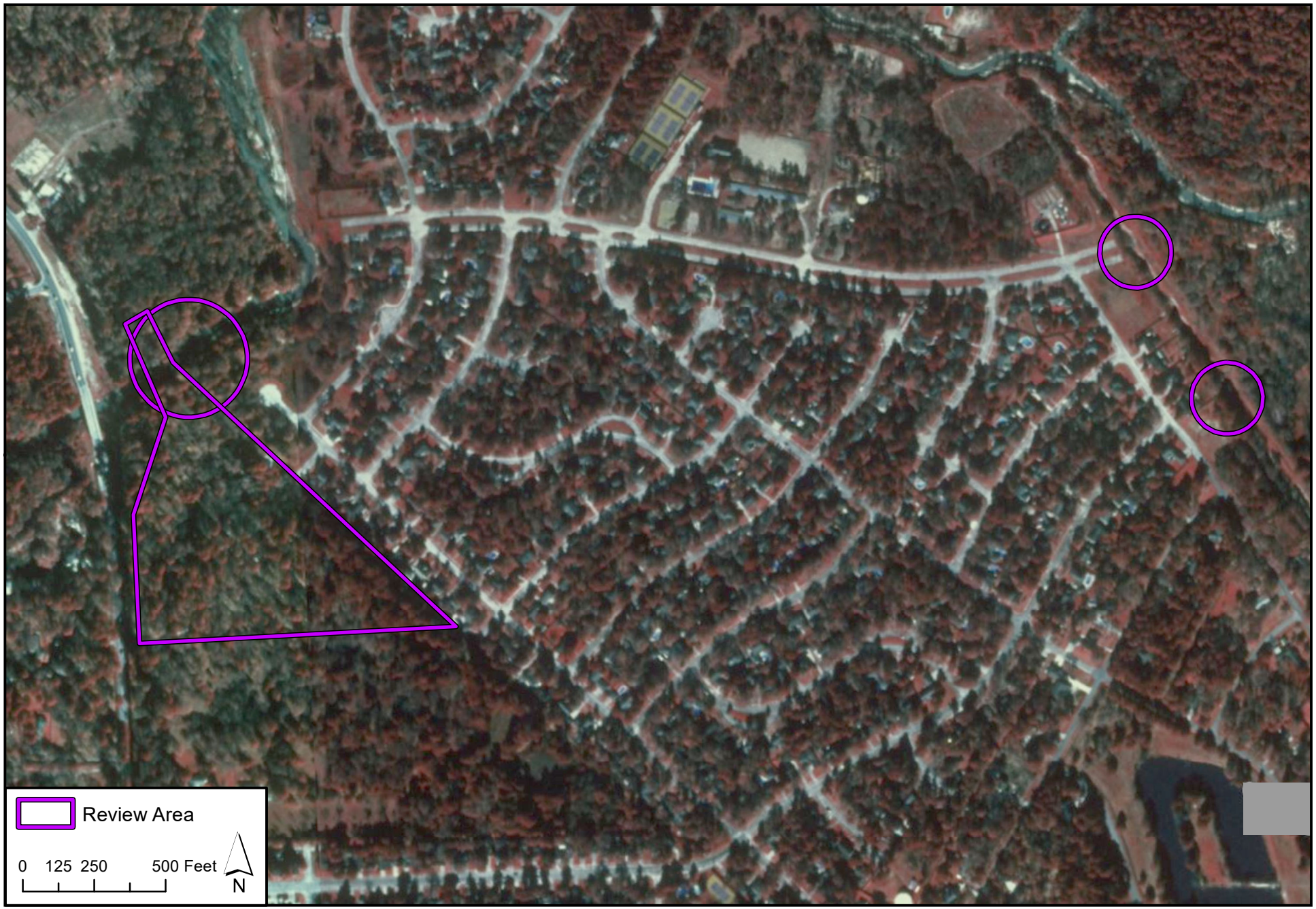

1995 HISTORIC AERIAL PHOTOGRAPH

Ravensway Subdivision Drainage Improvements
Harris County, Texas
RKI Project No. ASF21-116-00

APPENDIX

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2010 HISTORIC AERIAL PHOTOGRAPH

Ravensway Subdivision Drainage Improvements
Harris County, Texas
RKI Project No. ASF21-116-00

APPENDIX

C

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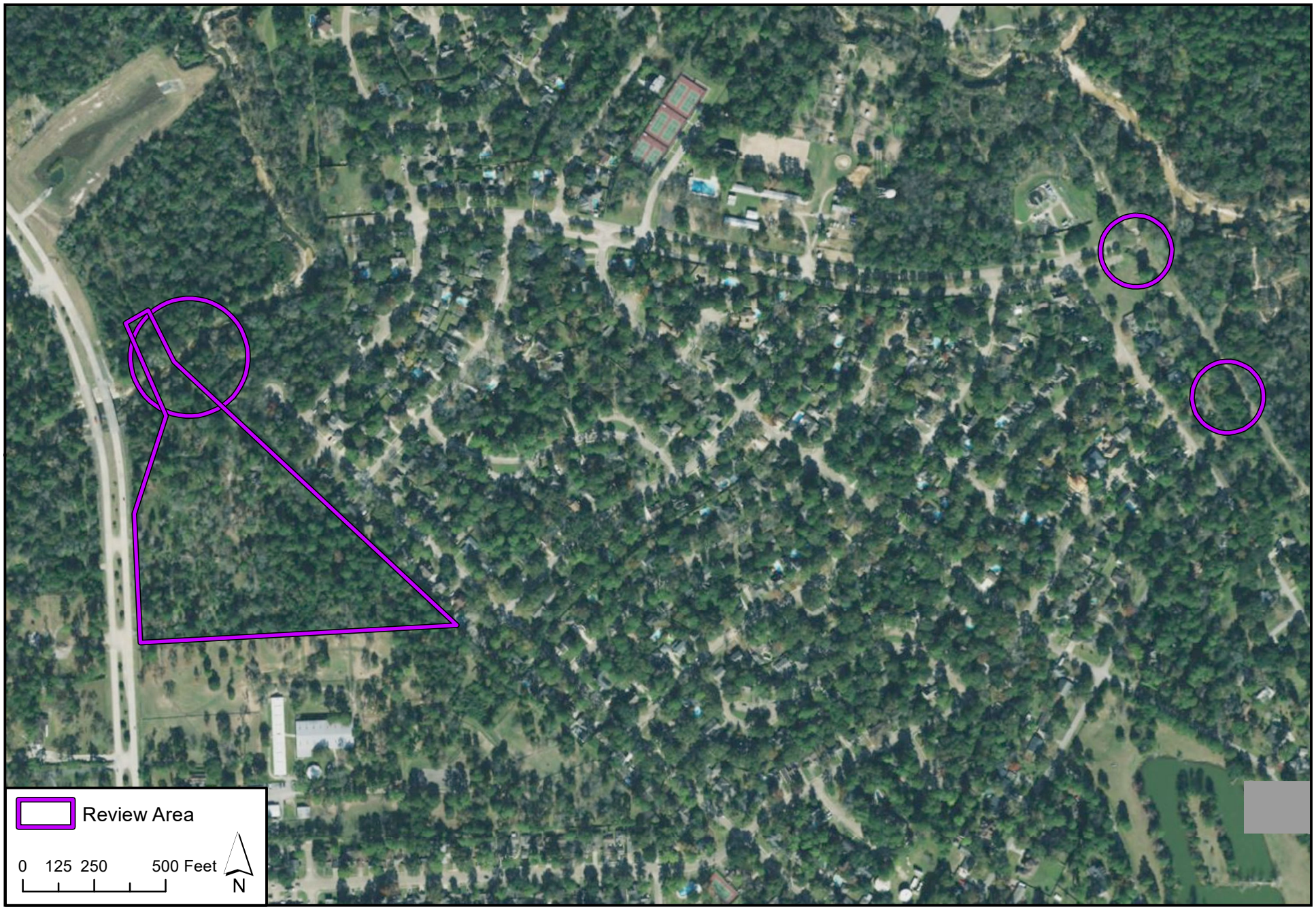

2018 HISTORIC AERIAL PHOTOGRAPH

Ravensway Subdivision Drainage Improvements
Harris County, Texas
RKI Project No. ASF21-116-00

APPENDIX

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APPENDIX D

SITE PHOTOGRAPHS

Photo 1: View north of access road from SP-1 along the drainage feature (DF-2).

Photo 2: View south of access road from SP-3 along the drainage feature (DF-2).

Photo 3: View north of rip rap within the drainage feature (DF-2) at the northeastern portion of the Review Area.

Photo 4: View south of access road and active construction of SP-4 along the drainage feature (DF-2).

Photo 5: View southeast of the drainage feature (DF-2) within the eastern Review Area.

Photo 6: View southeast of the large, concrete culvert within DF-2 on the southeast Review Area.

Photo 7: View southeast of SP-5 of active construction.

Photo 8: View south of forested upland area of SP-8 at the southwest portion of the Review Area.

Photo 9: View southeast of a forested upland of SP-9 at the southeast corner of the Review Area.

Photo 10: View southeast of forested uplands from SP-13 south of the perennial stream, Cypress Creek (PS-1) in the northwest Review Area.

Photo 11: View south of the drainage feature (DF-1) within the northeast Review Area.

Photo 12: View of the perennial stream, Cypress Creek (PS-1) within the northwest Review Area.

Photo 13: View of the aquatic vegetated pond (W-1) within the central portion of the western Review Area.

Photo 14: View south of a culvert that drains into the perennial stream, Cypress Creek (PS-1) within the northwest portion of the western Review Area.

APPENDIX E

WETLAND DETERMINATION DATA FORMS

WETLAND DETERMINATION DATA FORM – Atlantic and Gulf Coastal Plain Region

Project/Site: Ravensway Subdivision Drainage Improvements City/County: Cypress/Harris Sampling Date: 10/28/2021

Applicant/Owner: LJA Engineering State: TX Sampling Point: SP-1

Investigator(s): B. O'Neal Section, Township, Range: N/A

Landform (hillslope, terrace, etc.): Hilltop Local relief (concave, convex, none): None Slope (%): 0-1

Subregion (LRR or MLRA): LRR T Lat: 29.962601°N Long: -95.619332°W Datum: NAD83

Soil Map Unit Name: Pits (PITX) NWI classification: UPL

Are climatic / hydrologic conditions on the site typical for this time of year? Yes X No _____ (If no, explain in Remarks.)

Are Vegetation Y, Soil Y, or Hydrology Y significantly disturbed? Are "Normal Circumstances" present? Yes X No _____

Are Vegetation N, Soil N, or Hydrology N naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes _____	No X	**Is the Sampled Area within a Wetland?** **Yes** _____ **No** X
Hydric Soil Present?	Yes _____	No X	
Wetland Hydrology Present?	Yes _____	No X	

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ☐ Surface Water (A1)
- ☐ High Water Table (A2)
- ☐ Saturation (A3)
- ☐ Water Marks (B1)
- ☐ Sediment Deposits (B2)
- ☐ Drift Deposits (B3)
- ☐ Algal Mat or Crust (B4)
- ☐ Iron Deposits (B5)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Water-Stained Leaves (B9)
- ☐ Aquatic Fauna (B13)
- ☐ Marl Deposits (B15) **(LRR U)**
- ☐ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres along Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Tilled Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ☐ Surface Soil Cracks (B6)
- ☐ Sparsely Vegetated Concave Surface (B8)
- ☐ Drainage Patterns (B10)
- ☐ Moss Trim Lines (B16)
- ☐ Dry-Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Geomorphic Position (D2)
- ☐ Shallow Aquitard (D3)
- ☐ FAC-Neutral Test (D5)
- ☐ Sphagnum moss (D8) **(LRR T, U)**

Field Observations:

Surface Water Present?	Yes _____	No X	Depth (inches): _____
Water Table Present?	Yes _____	No X	Depth (inches): _____
Saturation Present? (includes capillary fringe)	Yes _____	No X	Depth (inches): _____

Wetland Hydrology Present? **Yes** _____ **No** X

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

Active grading and construction activities have caused surface level hydrology disturbance at the sampling location.

VEGETATION (Four Strata) – Use scientific names of plants.

Sampling Point: SP-1

Tree Stratum (Plot size: _____)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
	_____ = Total Cover		
50% of total cover: _____	20% of total cover: _____		

Sapling/Shrub Stratum (Plot size: _____)			
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
	_____ = Total Cover		
50% of total cover: _____	20% of total cover: _____		

Herb Stratum (Plot size: 5')			
1. Cynodon dactylon	5	Y	FACU
2. Sorghum halepense	5	Y	FACU
3. Paspalum notatum	5	Y	FACU
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
	15 = Total Cover		
50% of total cover: 7.5	20% of total cover: 3		

Woody Vine Stratum (Plot size: _____)			
1.			
2.			
3.			
4.			
5.			
	_____ = Total Cover		
50% of total cover: _____	20% of total cover: _____		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 0 (A)

Total Number of Dominant Species Across All Strata: 3 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 0% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species	_____	x 1 = _____
FACW species	_____	x 2 = _____
FAC species	_____	x 3 = _____
FACU species	_____	x 4 = _____
UPL species	_____	x 5 = _____
Column Totals:	_____ (A)	_____ (B)

Prevalence Index = B/A = _____

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation

___ 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Four Vegetation Strata:

Tree – Woody plants, excluding vines, 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

Sapling/Shrub – Woody plants, excluding vines, less than 3 in. DBH and greater than 3.28 ft (1 m) tall.

Herb – All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.28 ft tall.

Woody vine – All woody vines greater than 3.28 ft in height.

Hydrophytic Vegetation Present? **Yes** _____ **No** X

Remarks: (If observed, list morphological adaptations below).

Active grading and construction activities have caused surface level vegetation disturbance at the sampling location. Bare ground surface encompassed 85% of the plot area.

SOIL

Sampling Point: SP-1

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-18	7.5YR 5/4	50					SCL	Fill/construction material
	7.5YR 6/8	50					SCL	Fill/construction material

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5)
- ☐ Organic Bodies (A6) **(LRR P, T, U)**
- ☐ 5 cm Mucky Mineral (A7) **(LRR P, T, U)**
- ☐ Muck Presence (A8) **(LRR U)**
- ☐ 1 cm Muck (A9) **(LRR P, T)**
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Coast Prairie Redox (A16) **(MLRA 150A)**
- ☐ Sandy Mucky Mineral (S1) **(LRR O, S)**
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Dark Surface (S7) **(LRR P, S, T, U)**
- ☐ Polyvalue Below Surface (S8) **(LRR S, T, U)**
- ☐ Thin Dark Surface (S9) **(LRR S, T, U)**
- ☐ Loamy Mucky Mineral (F1) **(LRR O)**
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)
- ☐ Marl (F10) **(LRR U)**
- ☐ Depleted Ochric (F11) **(MLRA 151)**
- ☐ Iron-Manganese Masses (F12) **(LRR O, P, T)**
- ☐ Umbric Surface (F13) **(LRR P, T, U)**
- ☐ Delta Ochric (F17) **(MLRA 151)**
- ☐ Reduced Vertic (F18) **(MLRA 150A, 150B)**
- ☐ Piedmont Floodplain Soils (F19) **(MLRA 149A)**
- ☐ Anomalous Bright Loamy Soils (F20) **(MLRA 149A, 153C, 153D)**

Indicators for Problematic Hydric Soils[3]:

- ☐ 1 cm Muck (A9) **(LRR O)**
- ☐ 2 cm Muck (A10) **(LRR S)**
- ☐ Reduced Vertic (F18) **(outside MLRA 150A,B)**
- ☐ Piedmont Floodplain Soils (F19) **(LRR P, S, T)**
- ☐ Anomalous Bright Loamy Soils (F20) **(MLRA 153B)**
- ☐ Red Parent Material (TF2)
- ☐ Very Shallow Dark Surface (TF12)
- ☐ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: _____

Depth (inches): _____

Hydric Soil Present? **Yes** _____ **No** X

Remarks:

Active grading and construction activities have caused surface level soil disturbance at the sampling location.

WETLAND DETERMINATION DATA FORM – Atlantic and Gulf Coastal Plain Region

Project/Site: Ravensway Subdivision Drainage Improvements City/County: Cypress/Harris Sampling Date: 10/28/2021

Applicant/Owner: LJA Engineering State: TX Sampling Point: SP-2

Investigator(s): B. O'Neal Section, Township, Range: N/A

Landform (hillslope, terrace, etc.): Hilltop Local relief (concave, convex, none): None Slope (%): 0-1

Subregion (LRR or MLRA): LRR T Lat: 29.962601°N Long: -95.619332°W Datum: NAD83

Soil Map Unit Name: Pits (PITX) NWI classification: UPL

Are climatic / hydrologic conditions on the site typical for this time of year? Yes X No _____ (If no, explain in Remarks.)

Are Vegetation Y, Soil Y, or Hydrology Y significantly disturbed? Are "Normal Circumstances" present? Yes X No _____

Are Vegetation N, Soil N, or Hydrology N naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes _____	No X	**Is the Sampled Area within a Wetland?** **Yes** _____ **No** X
Hydric Soil Present?	Yes _____	No X	
Wetland Hydrology Present?	Yes _____	No X	

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ☐ Surface Water (A1)
- ☐ High Water Table (A2)
- ☐ Saturation (A3)
- ☐ Water Marks (B1)
- ☐ Sediment Deposits (B2)
- ☐ Drift Deposits (B3)
- ☐ Algal Mat or Crust (B4)
- ☐ Iron Deposits (B5)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Water-Stained Leaves (B9)
- ☐ Aquatic Fauna (B13)
- ☐ Marl Deposits (B15) **(LRR U)**
- ☐ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres along Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Tilled Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ☐ Surface Soil Cracks (B6)
- ☐ Sparsely Vegetated Concave Surface (B8)
- ☐ Drainage Patterns (B10)
- ☐ Moss Trim Lines (B16)
- ☐ Dry-Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Geomorphic Position (D2)
- ☐ Shallow Aquitard (D3)
- ☐ FAC-Neutral Test (D5)
- ☐ Sphagnum moss (D8) **(LRR T, U)**

Field Observations:

Surface Water Present?	Yes _____	No X	Depth (inches): _____
Water Table Present?	Yes _____	No X	Depth (inches): _____
Saturation Present? (includes capillary fringe)	Yes _____	No X	Depth (inches): _____

Wetland Hydrology Present? **Yes** _____ **No** X

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

Active grading and construction activities have caused surface level hydrology disturbance at the sampling location.

VEGETATION (Four Strata) – Use scientific names of plants.

Sampling Point: SP-2

Tree Stratum (Plot size: _____)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
	_____ = Total Cover		
50% of total cover: _____	20% of total cover: _____		

Sapling/Shrub Stratum (Plot size: _____)			
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
	_____ = Total Cover		
50% of total cover: _____	20% of total cover: _____		

Herb Stratum (Plot size: 5')			
1. Cynodon dactylon	5	Y	FACU
2. Sorghum halepense	5	Y	FACU
3. Paspalum notatum	5	Y	FACU
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
	15 = Total Cover		
50% of total cover: 7.5	20% of total cover: 3		

Woody Vine Stratum (Plot size: _____)			
1.			
2.			
3.			
4.			
5.			
	_____ = Total Cover		
50% of total cover: _____	20% of total cover: _____		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 0 (A)

Total Number of Dominant Species Across All Strata: 3 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 0% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species	_____	x 1 = _____
FACW species	_____	x 2 = _____
FAC species	_____	x 3 = _____
FACU species	_____	x 4 = _____
UPL species	_____	x 5 = _____
Column Totals:	_____ (A)	_____ (B)

Prevalence Index = B/A = _____

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation

___ 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Four Vegetation Strata:

Tree – Woody plants, excluding vines, 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

Sapling/Shrub – Woody plants, excluding vines, less than 3 in. DBH and greater than 3.28 ft (1 m) tall.

Herb – All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.28 ft tall.

Woody vine – All woody vines greater than 3.28 ft in height.

Hydrophytic Vegetation Present? **Yes** _____ **No** X

Remarks: (If observed, list morphological adaptations below).

Active grading and construction activities have caused surface level vegetation disturbance at the sampling location. Bare ground surface encompassed 85% of the plot area.

SOIL

Sampling Point: SP-2

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-18	7.5YR 5/4	50					SCL	Fill/construction material
	7.5YR 6/8	50					SCL	Fill/construction material

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5)
- ☐ Organic Bodies (A6) **(LRR P, T, U)**
- ☐ 5 cm Mucky Mineral (A7) **(LRR P, T, U)**
- ☐ Muck Presence (A8) **(LRR U)**
- ☐ 1 cm Muck (A9) **(LRR P, T)**
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Coast Prairie Redox (A16) **(MLRA 150A)**
- ☐ Sandy Mucky Mineral (S1) **(LRR O, S)**
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Dark Surface (S7) **(LRR P, S, T, U)**
- ☐ Polyvalue Below Surface (S8) **(LRR S, T, U)**
- ☐ Thin Dark Surface (S9) **(LRR S, T, U)**
- ☐ Loamy Mucky Mineral (F1) **(LRR O)**
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)
- ☐ Marl (F10) **(LRR U)**
- ☐ Depleted Ochric (F11) **(MLRA 151)**
- ☐ Iron-Manganese Masses (F12) **(LRR O, P, T)**
- ☐ Umbric Surface (F13) **(LRR P, T, U)**
- ☐ Delta Ochric (F17) **(MLRA 151)**
- ☐ Reduced Vertic (F18) **(MLRA 150A, 150B)**
- ☐ Piedmont Floodplain Soils (F19) **(MLRA 149A)**
- ☐ Anomalous Bright Loamy Soils (F20) **(MLRA 149A, 153C, 153D)**

Indicators for Problematic Hydric Soils[3]:

- ☐ 1 cm Muck (A9) **(LRR O)**
- ☐ 2 cm Muck (A10) **(LRR S)**
- ☐ Reduced Vertic (F18) **(outside MLRA 150A,B)**
- ☐ Piedmont Floodplain Soils (F19) **(LRR P, S, T)**
- ☐ Anomalous Bright Loamy Soils (F20) **(MLRA 153B)**
- ☐ Red Parent Material (TF2)
- ☐ Very Shallow Dark Surface (TF12)
- ☐ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: _____

Depth (inches): _____

Hydric Soil Present? **Yes** _____ **No** X

Remarks:

Active grading and construction activities have caused surface level soil disturbance at the sampling location.

WETLAND DETERMINATION DATA FORM – Atlantic and Gulf Coastal Plain Region

Project/Site: Ravensway Subdivision Drainage Improvements City/County: Cypress/Harris Sampling Date: 10/28/2021

Applicant/Owner: LJA Engineering State: TX Sampling Point: SP-3

Investigator(s): B. O'Neal Section, Township, Range: N/A

Landform (hillslope, terrace, etc.): Hillslope Local relief (concave, convex, none): None Slope (%): 0-1

Subregion (LRR or MLRA): LRR T Lat: 29.962572°N Long: -95.619769°W Datum: NAD83

Soil Map Unit Name: Pits (PITX) NWI classification: UPL

Are climatic / hydrologic conditions on the site typical for this time of year? Yes X No _____ (If no, explain in Remarks.)

Are Vegetation Y, Soil Y, or Hydrology Y significantly disturbed? Are "Normal Circumstances" present? Yes X No _____

Are Vegetation N, Soil N, or Hydrology N naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes _____	No X	**Is the Sampled Area within a Wetland?** **Yes** _____ **No** X
Hydric Soil Present?	Yes _____	No X	
Wetland Hydrology Present?	Yes _____	No X	

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ☐ Surface Water (A1)
- ☐ High Water Table (A2)
- ☐ Saturation (A3)
- ☐ Water Marks (B1)
- ☐ Sediment Deposits (B2)
- ☐ Drift Deposits (B3)
- ☐ Algal Mat or Crust (B4)
- ☐ Iron Deposits (B5)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Water-Stained Leaves (B9)
- ☐ Aquatic Fauna (B13)
- ☐ Marl Deposits (B15) **(LRR U)**
- ☐ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres along Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Tilled Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ☐ Surface Soil Cracks (B6)
- ☐ Sparsely Vegetated Concave Surface (B8)
- ☐ Drainage Patterns (B10)
- ☐ Moss Trim Lines (B16)
- ☐ Dry-Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Geomorphic Position (D2)
- ☐ Shallow Aquitard (D3)
- ☐ FAC-Neutral Test (D5)
- ☐ Sphagnum moss (D8) **(LRR T, U)**

Field Observations:

Surface Water Present?	Yes _____	No X	Depth (inches): _____
Water Table Present?	Yes _____	No X	Depth (inches): _____
Saturation Present? (includes capillary fringe)	Yes _____	No X	Depth (inches): _____

Wetland Hydrology Present? **Yes** _____ **No** X

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

Active grading and construction activities have caused surface level hydrology disturbance at the sampling location.

VEGETATION (Four Strata) – Use scientific names of plants.

Sampling Point: SP-3

Tree Stratum (Plot size: _____)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
	_____ = Total Cover		
50% of total cover: _____	20% of total cover: _____		

Sapling/Shrub Stratum (Plot size: _____)			
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
	_____ = Total Cover		
50% of total cover: _____	20% of total cover: _____		

Herb Stratum (Plot size: _____)			
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
	_____ = Total Cover		
50% of total cover: _____	20% of total cover: _____		

Woody Vine Stratum (Plot size: _____)			
1.			
2.			
3.			
4.			
5.			
	_____ = Total Cover		
50% of total cover: _____	20% of total cover: _____		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 0 (A)

Total Number of Dominant Species Across All Strata: 0 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 0% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species	_____	x 1 = _____
FACW species	_____	x 2 = _____
FAC species	_____	x 3 = _____
FACU species	_____	x 4 = _____
UPL species	_____	x 5 = _____
Column Totals:	_____ (A)	_____ (B)

Prevalence Index = B/A = _____

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation

___ 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Four Vegetation Strata:

Tree – Woody plants, excluding vines, 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

Sapling/Shrub – Woody plants, excluding vines, less than 3 in. DBH and greater than 3.28 ft (1 m) tall.

Herb – All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.28 ft tall.

Woody vine – All woody vines greater than 3.28 ft in height.

Hydrophytic Vegetation Present? **Yes** _____ **No** X

Remarks: (If observed, list morphological adaptations below).

Active grading and construction activities have caused surface level vegetation disturbance at the sampling location. Bare ground surface encompassed 100% of the plot area.

SOIL

Sampling Point: SP-3

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-18	7.5YR 5/4	50					SCL	Fill/construction material
	7.5YR 6/8	50					SCL	Fill/construction material

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5)
- ☐ Organic Bodies (A6) **(LRR P, T, U)**
- ☐ 5 cm Mucky Mineral (A7) **(LRR P, T, U)**
- ☐ Muck Presence (A8) **(LRR U)**
- ☐ 1 cm Muck (A9) **(LRR P, T)**
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Coast Prairie Redox (A16) **(MLRA 150A)**
- ☐ Sandy Mucky Mineral (S1) **(LRR O, S)**
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Dark Surface (S7) **(LRR P, S, T, U)**
- ☐ Polyvalue Below Surface (S8) **(LRR S, T, U)**
- ☐ Thin Dark Surface (S9) **(LRR S, T, U)**
- ☐ Loamy Mucky Mineral (F1) **(LRR O)**
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)
- ☐ Marl (F10) **(LRR U)**
- ☐ Depleted Ochric (F11) **(MLRA 151)**
- ☐ Iron-Manganese Masses (F12) **(LRR O, P, T)**
- ☐ Umbric Surface (F13) **(LRR P, T, U)**
- ☐ Delta Ochric (F17) **(MLRA 151)**
- ☐ Reduced Vertic (F18) **(MLRA 150A, 150B)**
- ☐ Piedmont Floodplain Soils (F19) **(MLRA 149A)**
- ☐ Anomalous Bright Loamy Soils (F20) **(MLRA 149A, 153C, 153D)**

Indicators for Problematic Hydric Soils[3]:

- ☐ 1 cm Muck (A9) **(LRR O)**
- ☐ 2 cm Muck (A10) **(LRR S)**
- ☐ Reduced Vertic (F18) **(outside MLRA 150A,B)**
- ☐ Piedmont Floodplain Soils (F19) **(LRR P, S, T)**
- ☐ Anomalous Bright Loamy Soils (F20) **(MLRA 153B)**
- ☐ Red Parent Material (TF2)
- ☐ Very Shallow Dark Surface (TF12)
- ☐ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: _____

Depth (inches): _____

Hydric Soil Present? **Yes** _____ **No** X

Remarks:

Active grading and construction activities have caused surface level soil disturbance at the sampling location.

WETLAND DETERMINATION DATA FORM – Atlantic and Gulf Coastal Plain Region

Project/Site: Ravensway Subdivision Drainage Improvements City/County: Cypress/Harris Sampling Date: 10/28/2021

Applicant/Owner: LJA Engineering State: TX Sampling Point: SP-4

Investigator(s): B. O'Neal Section, Township, Range: N/A

Landform (hillslope, terrace, etc.): Hillslope Local relief (concave, convex, none): None Slope (%): 0-1

Subregion (LRR or MLRA): LRR T Lat: 29.961161°N Long: -95.618489°W Datum: NAD83

Soil Map Unit Name: Wockley fine sandy loam, 0 to 1 percent slopes (Wo) NWI classification: UPL

Are climatic / hydrologic conditions on the site typical for this time of year? Yes X No _____ (If no, explain in Remarks.)

Are Vegetation Y, Soil Y, or Hydrology Y significantly disturbed? Are "Normal Circumstances" present? Yes X No _____

Are Vegetation N, Soil N, or Hydrology N naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes _____	No X	**Is the Sampled Area within a Wetland?** **Yes** _____ **No** X
Hydric Soil Present?	Yes _____	No X	
Wetland Hydrology Present?	Yes _____	No X	

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ☐ Surface Water (A1)
- ☐ High Water Table (A2)
- ☐ Saturation (A3)
- ☐ Water Marks (B1)
- ☐ Sediment Deposits (B2)
- ☐ Drift Deposits (B3)
- ☐ Algal Mat or Crust (B4)
- ☐ Iron Deposits (B5)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Water-Stained Leaves (B9)
- ☐ Aquatic Fauna (B13)
- ☐ Marl Deposits (B15) **(LRR U)**
- ☐ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres along Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Tilled Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ☐ Surface Soil Cracks (B6)
- ☐ Sparsely Vegetated Concave Surface (B8)
- ☐ Drainage Patterns (B10)
- ☐ Moss Trim Lines (B16)
- ☐ Dry-Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Geomorphic Position (D2)
- ☐ Shallow Aquitard (D3)
- ☐ FAC-Neutral Test (D5)
- ☐ Sphagnum moss (D8) **(LRR T, U)**

Field Observations:

Surface Water Present?	Yes _____	No X	Depth (inches): _____
Water Table Present?	Yes _____	No X	Depth (inches): _____
Saturation Present? (includes capillary fringe)	Yes _____	No X	Depth (inches): _____

Wetland Hydrology Present? **Yes** _____ **No** X

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

Active grading and construction activities have caused surface level hydrology disturbance at the sampling location.

VEGETATION (Four Strata) – Use scientific names of plants.

Sampling Point: SP-4

Tree Stratum (Plot size: _____)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
	_____ = Total Cover		
50% of total cover: _____	20% of total cover: _____		

Sapling/Shrub Stratum (Plot size: _____)			
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
	_____ = Total Cover		
50% of total cover: _____	20% of total cover: _____		

Herb Stratum (Plot size: _____)			
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
	_____ = Total Cover		
50% of total cover: _____	20% of total cover: _____		

Woody Vine Stratum (Plot size: _____)			
1.			
2.			
3.			
4.			
5.			
	_____ = Total Cover		
50% of total cover: _____	20% of total cover: _____		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 0 (A)

Total Number of Dominant Species Across All Strata: 0 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 0% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species	_____	x 1 = _____
FACW species	_____	x 2 = _____
FAC species	_____	x 3 = _____
FACU species	_____	x 4 = _____
UPL species	_____	x 5 = _____
Column Totals:	_____ (A)	_____ (B)

Prevalence Index = B/A = _____

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation

___ 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Four Vegetation Strata:

Tree – Woody plants, excluding vines, 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

Sapling/Shrub – Woody plants, excluding vines, less than 3 in. DBH and greater than 3.28 ft (1 m) tall.

Herb – All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.28 ft tall.

Woody vine – All woody vines greater than 3.28 ft in height.

Hydrophytic Vegetation Present? **Yes** _____ **No** X

Remarks: (If observed, list morphological adaptations below).

Active grading and construction activities have caused surface level vegetation disturbance at the sampling location. Bare ground surface encompassed 100% of the plot area.

SOIL

Sampling Point: SP-4

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-18	7.5YR 5/4	50					SCL	Fill/construction material
	7.5YR 6/8	50					SCL	Fill/construction material

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5)
- ☐ Organic Bodies (A6) **(LRR P, T, U)**
- ☐ 5 cm Mucky Mineral (A7) **(LRR P, T, U)**
- ☐ Muck Presence (A8) **(LRR U)**
- ☐ 1 cm Muck (A9) **(LRR P, T)**
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Coast Prairie Redox (A16) **(MLRA 150A)**
- ☐ Sandy Mucky Mineral (S1) **(LRR O, S)**
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Dark Surface (S7) **(LRR P, S, T, U)**
- ☐ Polyvalue Below Surface (S8) **(LRR S, T, U)**
- ☐ Thin Dark Surface (S9) **(LRR S, T, U)**
- ☐ Loamy Mucky Mineral (F1) **(LRR O)**
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)
- ☐ Marl (F10) **(LRR U)**
- ☐ Depleted Ochric (F11) **(MLRA 151)**
- ☐ Iron-Manganese Masses (F12) **(LRR O, P, T)**
- ☐ Umbric Surface (F13) **(LRR P, T, U)**
- ☐ Delta Ochric (F17) **(MLRA 151)**
- ☐ Reduced Vertic (F18) **(MLRA 150A, 150B)**
- ☐ Piedmont Floodplain Soils (F19) **(MLRA 149A)**
- ☐ Anomalous Bright Loamy Soils (F20) **(MLRA 149A, 153C, 153D)**

Indicators for Problematic Hydric Soils[3]:

- ☐ 1 cm Muck (A9) **(LRR O)**
- ☐ 2 cm Muck (A10) **(LRR S)**
- ☐ Reduced Vertic (F18) **(outside MLRA 150A,B)**
- ☐ Piedmont Floodplain Soils (F19) **(LRR P, S, T)**
- ☐ Anomalous Bright Loamy Soils (F20) **(MLRA 153B)**
- ☐ Red Parent Material (TF2)
- ☐ Very Shallow Dark Surface (TF12)
- ☐ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: _____

Depth (inches): _____

Hydric Soil Present? **Yes** _____ **No** X

Remarks:

Active grading and construction activities have caused surface level soil disturbance at the sampling location.

WETLAND DETERMINATION DATA FORM – Atlantic and Gulf Coastal Plain Region

Project/Site: Ravensway Subdivision Drainage Improvements City/County: Cypress/Harris Sampling Date: 10/28/2021

Applicant/Owner: LJA Engineering State: TX Sampling Point: SP-5

Investigator(s): B. O'Neal Section, Township, Range: N/A

Landform (hillslope, terrace, etc.): Hillslope Local relief (concave, convex, none): None Slope (%): 0-1

Subregion (LRR or MLRA): LRR T Lat: 29.961161°N Long: -95.618489°W Datum: NAD83

Soil Map Unit Name: Wockley fine sandy loam, 0 to 1 percent slopes (Wo) NWI classification: UPL

Are climatic / hydrologic conditions on the site typical for this time of year? Yes X No _____ (If no, explain in Remarks.)

Are Vegetation Y, Soil Y, or Hydrology Y significantly disturbed? Are "Normal Circumstances" present? Yes X No _____

Are Vegetation N, Soil N, or Hydrology N naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes _____	No X	**Is the Sampled Area within a Wetland?** **Yes** _____ **No** X
Hydric Soil Present?	Yes _____	No X	
Wetland Hydrology Present?	Yes _____	No X	

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ☐ Surface Water (A1)
- ☐ High Water Table (A2)
- ☐ Saturation (A3)
- ☐ Water Marks (B1)
- ☐ Sediment Deposits (B2)
- ☐ Drift Deposits (B3)
- ☐ Algal Mat or Crust (B4)
- ☐ Iron Deposits (B5)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Water-Stained Leaves (B9)
- ☐ Aquatic Fauna (B13)
- ☐ Marl Deposits (B15) **(LRR U)**
- ☐ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres along Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Tilled Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ☐ Surface Soil Cracks (B6)
- ☐ Sparsely Vegetated Concave Surface (B8)
- ☐ Drainage Patterns (B10)
- ☐ Moss Trim Lines (B16)
- ☐ Dry-Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Geomorphic Position (D2)
- ☐ Shallow Aquitard (D3)
- ☐ FAC-Neutral Test (D5)
- ☐ Sphagnum moss (D8) **(LRR T, U)**

Field Observations:

Surface Water Present?	Yes _____	No X	Depth (inches): _____
Water Table Present?	Yes _____	No X	Depth (inches): _____
Saturation Present? (includes capillary fringe)	Yes _____	No X	Depth (inches): _____

Wetland Hydrology Present? **Yes** _____ **No** X

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

Active grading and construction activities have caused surface level hydrology disturbance at the sampling location.

VEGETATION (Four Strata) – Use scientific names of plants.

Sampling Point: SP-5

Tree Stratum (Plot size: _____)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
	_____ = Total Cover		
50% of total cover: _____	20% of total cover: _____		

Sapling/Shrub Stratum (Plot size: _____)			
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
	_____ = Total Cover		
50% of total cover: _____	20% of total cover: _____		

Herb Stratum (Plot size: _____)			
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
	_____ = Total Cover		
50% of total cover: _____	20% of total cover: _____		

Woody Vine Stratum (Plot size: _____)			
1.			
2.			
3.			
4.			
5.			
	_____ = Total Cover		
50% of total cover: _____	20% of total cover: _____		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 0 (A)

Total Number of Dominant Species Across All Strata: 0 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 0% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species	_____	x 1 = _____
FACW species	_____	x 2 = _____
FAC species	_____	x 3 = _____
FACU species	_____	x 4 = _____
UPL species	_____	x 5 = _____
Column Totals:	_____ (A)	_____ (B)

Prevalence Index = B/A = _____

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation

___ 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Four Vegetation Strata:

Tree – Woody plants, excluding vines, 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

Sapling/Shrub – Woody plants, excluding vines, less than 3 in. DBH and greater than 3.28 ft (1 m) tall.

Herb – All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.28 ft tall.

Woody vine – All woody vines greater than 3.28 ft in height.

Hydrophytic Vegetation Present? **Yes** _____ **No** X

Remarks: (If observed, list morphological adaptations below).

Active grading and construction activities have caused surface level vegetation disturbance at the sampling location. Bare ground surface encompassed 100% of the plot area.

SOIL

Sampling Point: SP-5

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-18	7.5YR 5/4	50					SCL	Fill/construction material
	7.5YR 6/8	50					SCL	Fill/construction material

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5)
- ☐ Organic Bodies (A6) **(LRR P, T, U)**
- ☐ 5 cm Mucky Mineral (A7) **(LRR P, T, U)**
- ☐ Muck Presence (A8) **(LRR U)**
- ☐ 1 cm Muck (A9) **(LRR P, T)**
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Coast Prairie Redox (A16) **(MLRA 150A)**
- ☐ Sandy Mucky Mineral (S1) **(LRR O, S)**
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Dark Surface (S7) **(LRR P, S, T, U)**
- ☐ Polyvalue Below Surface (S8) **(LRR S, T, U)**
- ☐ Thin Dark Surface (S9) **(LRR S, T, U)**
- ☐ Loamy Mucky Mineral (F1) **(LRR O)**
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)
- ☐ Marl (F10) **(LRR U)**
- ☐ Depleted Ochric (F11) **(MLRA 151)**
- ☐ Iron-Manganese Masses (F12) **(LRR O, P, T)**
- ☐ Umbric Surface (F13) **(LRR P, T, U)**
- ☐ Delta Ochric (F17) **(MLRA 151)**
- ☐ Reduced Vertic (F18) **(MLRA 150A, 150B)**
- ☐ Piedmont Floodplain Soils (F19) **(MLRA 149A)**
- ☐ Anomalous Bright Loamy Soils (F20) **(MLRA 149A, 153C, 153D)**

Indicators for Problematic Hydric Soils[3]:

- ☐ 1 cm Muck (A9) **(LRR O)**
- ☐ 2 cm Muck (A10) **(LRR S)**
- ☐ Reduced Vertic (F18) **(outside MLRA 150A,B)**
- ☐ Piedmont Floodplain Soils (F19) **(LRR P, S, T)**
- ☐ Anomalous Bright Loamy Soils (F20) **(MLRA 153B)**
- ☐ Red Parent Material (TF2)
- ☐ Very Shallow Dark Surface (TF12)
- ☐ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: _____

Depth (inches): _____

Hydric Soil Present? **Yes** _____ **No** X

Remarks:

Active grading and construction activities have caused surface level soil disturbance at the sampling location.

WETLAND DETERMINATION DATA FORM – Atlantic and Gulf Coastal Plain Region

Project/Site: Ravensway Subdivision Drainage Improvements City/County: Cypress/Harris Sampling Date: 10/28/2021

Applicant/Owner: LJA Engineering State: TX Sampling Point: SP-6

Investigator(s): B. O'Neal Section, Township, Range: N/A

Landform (hillslope, terrace, etc.): Hillslope Local relief (concave, convex, none): None Slope (%): 1-3

Subregion (LRR or MLRA): LRR T Lat: 29.961702°N Long: -95.630179°W Datum: NAD83

Soil Map Unit Name: Hatliff-Pluck-Kian complex, 0 to 1 percent slopes, frequently flooded (HatA) NWI classification: UPL

Are climatic / hydrologic conditions on the site typical for this time of year? Yes X No _____ (If no, explain in Remarks.)

Are Vegetation N, Soil N, or Hydrology N significantly disturbed? Are "Normal Circumstances" present? Yes X No _____

Are Vegetation N, Soil N, or Hydrology N naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes _____	No X	**Is the Sampled Area within a Wetland?** **Yes** _____ **No** X
Hydric Soil Present?	Yes _____	No X	
Wetland Hydrology Present?	Yes _____	No X	

Remarks:

Sampling point taken adjacent to Cypress Creek.

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ☐ Surface Water (A1)
- ☐ High Water Table (A2)
- ☐ Saturation (A3)
- ☐ Water Marks (B1)
- ☐ Sediment Deposits (B2)
- ☐ Drift Deposits (B3)
- ☐ Algal Mat or Crust (B4)
- ☐ Iron Deposits (B5)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Water-Stained Leaves (B9)
- ☐ Aquatic Fauna (B13)
- ☐ Marl Deposits (B15) **(LRR U)**
- ☐ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres along Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Tilled Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ☐ Surface Soil Cracks (B6)
- ☐ Sparsely Vegetated Concave Surface (B8)
- ☐ Drainage Patterns (B10)
- ☐ Moss Trim Lines (B16)
- ☐ Dry-Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Geomorphic Position (D2)
- ☐ Shallow Aquitard (D3)
- ☐ FAC-Neutral Test (D5)
- ☐ Sphagnum moss (D8) **(LRR T, U)**

Field Observations:

Surface Water Present?	Yes _____	No X	Depth (inches): _____
Water Table Present?	Yes _____	No X	Depth (inches): _____
Saturation Present? (includes capillary fringe)	Yes _____	No X	Depth (inches): _____

Wetland Hydrology Present? **Yes** _____ **No** X

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

VEGETATION (Four Strata) – Use scientific names of plants.

Sampling Point: SP-6

Tree Stratum (Plot size: 30')	Absolute % Cover	Dominant Species?	Indicator Status
1. Ulmus crassifolia	20	Y	FAC
2. Triadica sebifera	20	Y	FAC
3. Quercus virginiana	20	Y	FACU
4. Pinus taeda	5	N	FAC
5.			
6.			
7.			
8.			
	65 = Total Cover		

50% of total cover: 32.5 20% of total cover: 13

Sapling/Shrub Stratum (Plot size: 15')			
1. Ilex vomitoria	15	Y	FAC
2. Ligustrum sinense	15	Y	FAC
3. Quercus virginiana	15	Y	FACU
4. Pinus taeda	5	N	FAC
5.			
6.			
7.			
8.			
	50 = Total Cover		

50% of total cover: 25 20% of total cover: 10

Herb Stratum (Plot size: 5')			
1. Paspalum notatum	5	Y	FACU
2. Sorghum halepense	5	Y	FACU
3. Cynodon dactylon	5	Y	FACU
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
	15 = Total Cover		

50% of total cover: 7.5 20% of total cover: 3

Woody Vine Stratum (Plot size:)			
1.			
2.			
3.			
4.			
5.			
	= Total Cover		

50% of total cover: 20% of total cover:

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 4 (A)

Total Number of Dominant Species Across All Strata: 9 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 44% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species		x 1 =
FACW species		x 2 =
FAC species		x 3 =
FACU species		x 4 =
UPL species		x 5 =
Column Totals:	(A)	(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation

___ 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Four Vegetation Strata:

Tree – Woody plants, excluding vines, 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

Sapling/Shrub – Woody plants, excluding vines, less than 3 in. DBH and greater than 3.28 ft (1 m) tall.

Herb – All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.28 ft tall.

Woody vine – All woody vines greater than 3.28 ft in height.

Hydrophytic Vegetation Present? **Yes** ____ **No** X

Remarks: (If observed, list morphological adaptations below).

SOIL

Sampling Point: SP-6

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-18	7.5YR 3/2	100					CL	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5)
- ☐ Organic Bodies (A6) **(LRR P, T, U)**
- ☐ 5 cm Mucky Mineral (A7) **(LRR P, T, U)**
- ☐ Muck Presence (A8) **(LRR U)**
- ☐ 1 cm Muck (A9) **(LRR P, T)**
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Coast Prairie Redox (A16) **(MLRA 150A)**
- ☐ Sandy Mucky Mineral (S1) **(LRR O, S)**
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Dark Surface (S7) **(LRR P, S, T, U)**
- ☐ Polyvalue Below Surface (S8) **(LRR S, T, U)**
- ☐ Thin Dark Surface (S9) **(LRR S, T, U)**
- ☐ Loamy Mucky Mineral (F1) **(LRR O)**
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)
- ☐ Marl (F10) **(LRR U)**
- ☐ Depleted Ochric (F11) **(MLRA 151)**
- ☐ Iron-Manganese Masses (F12) **(LRR O, P, T)**
- ☐ Umbric Surface (F13) **(LRR P, T, U)**
- ☐ Delta Ochric (F17) **(MLRA 151)**
- ☐ Reduced Vertic (F18) **(MLRA 150A, 150B)**
- ☐ Piedmont Floodplain Soils (F19) **(MLRA 149A)**
- ☐ Anomalous Bright Loamy Soils (F20) **(MLRA 149A, 153C, 153D)**

Indicators for Problematic Hydric Soils[3]:

- ☐ 1 cm Muck (A9) **(LRR O)**
- ☐ 2 cm Muck (A10) **(LRR S)**
- ☐ Reduced Vertic (F18) **(outside MLRA 150A,B)**
- ☐ Piedmont Floodplain Soils (F19) **(LRR P, S, T)**
- ☐ Anomalous Bright Loamy Soils (F20) **(MLRA 153B)**
- ☐ Red Parent Material (TF2)
- ☐ Very Shallow Dark Surface (TF12)
- ☐ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: _____

Depth (inches): _____

Hydric Soil Present? **Yes** _____ **No** X

Remarks:

WETLAND DETERMINATION DATA FORM – Atlantic and Gulf Coastal Plain Region

Project/Site: Ravensway Subdivision Drainage Improvements City/County: Cypress/Harris Sampling Date: 10/28/2021

Applicant/Owner: LJA Engineering State: TX Sampling Point: SP-7

Investigator(s): B. O'Neal Section, Township, Range: N/A

Landform (hillslope, terrace, etc.): Flatwoods Local relief (concave, convex, none): None Slope (%): 0-1

Subregion (LRR or MLRA): LRR T Lat: 29.959961°N Long: -95.630108°W Datum: NAD83

Soil Map Unit Name: Clodine fine sandy loam, 0 to 1 percent slopes (Cd) NWI classification: UPL

Are climatic / hydrologic conditions on the site typical for this time of year? Yes X No _____ (If no, explain in Remarks.)

Are Vegetation N, Soil N, or Hydrology N significantly disturbed? Are "Normal Circumstances" present? Yes X No _____

Are Vegetation N, Soil N, or Hydrology N naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes _____	No X	**Is the Sampled Area within a Wetland?** **Yes** _____ **No** X
Hydric Soil Present?	Yes _____	No X	
Wetland Hydrology Present?	Yes _____	No X	

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ☐ Surface Water (A1)
- ☐ High Water Table (A2)
- ☐ Saturation (A3)
- ☐ Water Marks (B1)
- ☐ Sediment Deposits (B2)
- ☐ Drift Deposits (B3)
- ☐ Algal Mat or Crust (B4)
- ☐ Iron Deposits (B5)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Water-Stained Leaves (B9)
- ☐ Aquatic Fauna (B13)
- ☐ Marl Deposits (B15) **(LRR U)**
- ☐ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres along Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Tilled Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ☐ Surface Soil Cracks (B6)
- ☐ Sparsely Vegetated Concave Surface (B8)
- ☐ Drainage Patterns (B10)
- ☐ Moss Trim Lines (B16)
- ☐ Dry-Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Geomorphic Position (D2)
- ☐ Shallow Aquitard (D3)
- ☐ FAC-Neutral Test (D5)
- ☐ Sphagnum moss (D8) **(LRR T, U)**

Field Observations:

Surface Water Present?	Yes _____	No X	Depth (inches): _____
Water Table Present?	Yes _____	No X	Depth (inches): _____
Saturation Present? (includes capillary fringe)	Yes _____	No X	Depth (inches): _____

Wetland Hydrology Present? **Yes** _____ **No** X

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

VEGETATION (Four Strata) – Use scientific names of plants.

Sampling Point: SP-7

Tree Stratum (Plot size: 30')	Absolute % Cover	Dominant Species?	Indicator Status
1. Quercus nigra	20	Y	FAC
2. Quercus virginiana	20	Y	FACU
3. Pinus taeda	5	N	FAC
4.			
5.			
6.			
7.			
8.			
	45 = Total Cover		
50% of total cover: 22.5	20% of total cover: 9		

Sapling/Shrub Stratum (Plot size: 15')			
1. Ilex vomitoria	15	Y	FAC
2. Ligustrum sinense	15	Y	FAC
3.			
4.			
5.			
6.			
7.			
8.			
	30 = Total Cover		
50% of total cover: 15	20% of total cover: 6		

Herb Stratum (Plot size: 5')			
1. Iva annua	30	Y	FAC
2. Sorghum halepense	20	Y	FACU
3. Cynodon dactylon	20	Y	FACU
4. Paspalum notatum	20	Y	FACU
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
	90 = Total Cover		
50% of total cover: 45	20% of total cover: 18		

Woody Vine Stratum (Plot size:)			
1.			
2.			
3.			
4.			
5.			
	= Total Cover		
50% of total cover:	20% of total cover:		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 4 (A)

Total Number of Dominant Species Across All Strata: 8 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 50% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species		x 1 =
FACW species		x 2 =
FAC species		x 3 =
FACU species		x 4 =
UPL species		x 5 =
Column Totals:	(A)	(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation

___ 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Four Vegetation Strata:

Tree – Woody plants, excluding vines, 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

Sapling/Shrub – Woody plants, excluding vines, less than 3 in. DBH and greater than 3.28 ft (1 m) tall.

Herb – All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.28 ft tall.

Woody vine – All woody vines greater than 3.28 ft in height.

Hydrophytic Vegetation Present? **Yes** ____ **No** X

Remarks: (If observed, list morphological adaptations below).

SOIL

Sampling Point: SP-7

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-18	7.5YR 3/2	100					CL	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5)
- ☐ Organic Bodies (A6) **(LRR P, T, U)**
- ☐ 5 cm Mucky Mineral (A7) **(LRR P, T, U)**
- ☐ Muck Presence (A8) **(LRR U)**
- ☐ 1 cm Muck (A9) **(LRR P, T)**
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Coast Prairie Redox (A16) **(MLRA 150A)**
- ☐ Sandy Mucky Mineral (S1) **(LRR O, S)**
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Dark Surface (S7) **(LRR P, S, T, U)**
- ☐ Polyvalue Below Surface (S8) **(LRR S, T, U)**
- ☐ Thin Dark Surface (S9) **(LRR S, T, U)**
- ☐ Loamy Mucky Mineral (F1) **(LRR O)**
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)
- ☐ Marl (F10) **(LRR U)**
- ☐ Depleted Ochric (F11) **(MLRA 151)**
- ☐ Iron-Manganese Masses (F12) **(LRR O, P, T)**
- ☐ Umbric Surface (F13) **(LRR P, T, U)**
- ☐ Delta Ochric (F17) **(MLRA 151)**
- ☐ Reduced Vertic (F18) **(MLRA 150A, 150B)**
- ☐ Piedmont Floodplain Soils (F19) **(MLRA 149A)**
- ☐ Anomalous Bright Loamy Soils (F20) **(MLRA 149A, 153C, 153D)**

Indicators for Problematic Hydric Soils[3]:

- ☐ 1 cm Muck (A9) **(LRR O)**
- ☐ 2 cm Muck (A10) **(LRR S)**
- ☐ Reduced Vertic (F18) **(outside MLRA 150A,B)**
- ☐ Piedmont Floodplain Soils (F19) **(LRR P, S, T)**
- ☐ Anomalous Bright Loamy Soils (F20) **(MLRA 153B)**
- ☐ Red Parent Material (TF2)
- ☐ Very Shallow Dark Surface (TF12)
- ☐ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: _____

Depth (inches): _____

Hydric Soil Present? **Yes** _____ **No** X

Remarks:

WETLAND DETERMINATION DATA FORM – Atlantic and Gulf Coastal Plain Region

Project/Site: Ravensway Subdivision Drainage Improvements City/County: Cypress/Harris Sampling Date: 10/28/2021

Applicant/Owner: LJA Engineering State: TX Sampling Point: SP-8

Investigator(s): B. O'Neal Section, Township, Range: N/A

Landform (hillslope, terrace, etc.): Flatwoods Local relief (concave, convex, none): None Slope (%): 0-1

Subregion (LRR or MLRA): LRR T Lat: 29.959134°N Long: 29.959134°W Datum: NAD83

Soil Map Unit Name: Wockley fine sandy loam, 0 to 1 percent slopes (Wo) NWI classification: UPL

Are climatic / hydrologic conditions on the site typical for this time of year? Yes X No ____ (If no, explain in Remarks.)

Are Vegetation N, Soil N, or Hydrology N significantly disturbed? Are "Normal Circumstances" present? Yes X No ____

Are Vegetation N, Soil N, or Hydrology N naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No ____	**Is the Sampled Area within a Wetland?** **Yes** ____ **No** X
Hydric Soil Present?	Yes ____	No X	
Wetland Hydrology Present?	Yes ____	No X	

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ☐ Surface Water (A1)
- ☐ High Water Table (A2)
- ☐ Saturation (A3)
- ☐ Water Marks (B1)
- ☐ Sediment Deposits (B2)
- ☐ Drift Deposits (B3)
- ☐ Algal Mat or Crust (B4)
- ☐ Iron Deposits (B5)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Water-Stained Leaves (B9)
- ☐ Aquatic Fauna (B13)
- ☐ Marl Deposits (B15) **(LRR U)**
- ☐ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres along Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Tilled Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ☐ Surface Soil Cracks (B6)
- ☐ Sparsely Vegetated Concave Surface (B8)
- ☐ Drainage Patterns (B10)
- ☐ Moss Trim Lines (B16)
- ☐ Dry-Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Geomorphic Position (D2)
- ☐ Shallow Aquitard (D3)
- ☐ FAC-Neutral Test (D5)
- ☐ Sphagnum moss (D8) **(LRR T, U)**

Field Observations:

Surface Water Present?	Yes ____	No X	Depth (inches): ____
Water Table Present?	Yes ____	No X	Depth (inches): ____
Saturation Present? (includes capillary fringe)	Yes ____	No X	Depth (inches): ____

Wetland Hydrology Present? **Yes** ____ **No** X

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

VEGETATION (Four Strata) – Use scientific names of plants.

Sampling Point: SP-8

Tree Stratum (Plot size: 30')	Absolute % Cover	Dominant Species?	Indicator Status
1. Quercus nigra	20	Y	FAC
2. Quercus virginiana	20	Y	FACU
3. Pinus taeda	20	Y	FAC
4.			
5.			
6.			
7.			
8.			
	60 = Total Cover		
50% of total cover: 30	20% of total cover: 12		

Sapling/Shrub Stratum (Plot size: 15')			
1. Ilex vomitoria	30	Y	FAC
2. Ligustrum sinense	15	Y	FAC
3.			
4.			
5.			
6.			
7.			
8.			
	45 = Total Cover		
50% of total cover: 22.5	20% of total cover: 9		

Herb Stratum (Plot size: 5')			
1. Paspalum notatum	30	Y	FAC
2. Sorghum halepense	20	Y	FACU
3. Cynodon dactylon	20	Y	FACU
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
	70 = Total Cover		
50% of total cover: 35	20% of total cover: 14		

Woody Vine Stratum (Plot size:)			
1.			
2.			
3.			
4.			
5.			
	= Total Cover		
50% of total cover:	20% of total cover:		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 5 (A)

Total Number of Dominant Species Across All Strata: 8 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 63% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species		x 1 =
FACW species		x 2 =
FAC species		x 3 =
FACU species		x 4 =
UPL species		x 5 =
Column Totals:	(A)	(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- X 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Four Vegetation Strata:

Tree – Woody plants, excluding vines, 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

Sapling/Shrub – Woody plants, excluding vines, less than 3 in. DBH and greater than 3.28 ft (1 m) tall.

Herb – All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.28 ft tall.

Woody vine – All woody vines greater than 3.28 ft in height.

Hydrophytic Vegetation Present? **Yes** X **No** ___

Remarks: (If observed, list morphological adaptations below).

SOIL

Sampling Point: SP-8

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-18	7.5YR 4/2	100					CL	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5)
- ☐ Organic Bodies (A6) **(LRR P, T, U)**
- ☐ 5 cm Mucky Mineral (A7) **(LRR P, T, U)**
- ☐ Muck Presence (A8) **(LRR U)**
- ☐ 1 cm Muck (A9) **(LRR P, T)**
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Coast Prairie Redox (A16) **(MLRA 150A)**
- ☐ Sandy Mucky Mineral (S1) **(LRR O, S)**
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Dark Surface (S7) **(LRR P, S, T, U)**
- ☐ Polyvalue Below Surface (S8) **(LRR S, T, U)**
- ☐ Thin Dark Surface (S9) **(LRR S, T, U)**
- ☐ Loamy Mucky Mineral (F1) **(LRR O)**
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)
- ☐ Marl (F10) **(LRR U)**
- ☐ Depleted Ochric (F11) **(MLRA 151)**
- ☐ Iron-Manganese Masses (F12) **(LRR O, P, T)**
- ☐ Umbric Surface (F13) **(LRR P, T, U)**
- ☐ Delta Ochric (F17) **(MLRA 151)**
- ☐ Reduced Vertic (F18) **(MLRA 150A, 150B)**
- ☐ Piedmont Floodplain Soils (F19) **(MLRA 149A)**
- ☐ Anomalous Bright Loamy Soils (F20) **(MLRA 149A, 153C, 153D)**

Indicators for Problematic Hydric Soils[3]:

- ☐ 1 cm Muck (A9) **(LRR O)**
- ☐ 2 cm Muck (A10) **(LRR S)**
- ☐ Reduced Vertic (F18) **(outside MLRA 150A,B)**
- ☐ Piedmont Floodplain Soils (F19) **(LRR P, S, T)**
- ☐ Anomalous Bright Loamy Soils (F20) **(MLRA 153B)**
- ☐ Red Parent Material (TF2)
- ☐ Very Shallow Dark Surface (TF12)
- ☐ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: _____

Depth (inches): _____

Hydric Soil Present? **Yes** _____ **No** X

Remarks:

WETLAND DETERMINATION DATA FORM – Atlantic and Gulf Coastal Plain Region

Project/Site: Ravensway Subdivision Drainage Improvements City/County: Cypress/Harris Sampling Date: 10/28/2021

Applicant/Owner: LJA Engineering State: TX Sampling Point: SP-9

Investigator(s): B. O'Neal Section, Township, Range: N/A

Landform (hillslope, terrace, etc.): Flatwoods Local relief (concave, convex, none): None Slope (%): 0-1

Subregion (LRR or MLRA): LRR T Lat: 29.959385°N Long: -95.628229°W Datum: NAD83

Soil Map Unit Name: Wockley fine sandy loam, 0 to 1 percent slopes (Wo) NWI classification: UPL

Are climatic / hydrologic conditions on the site typical for this time of year? Yes X No _____ (If no, explain in Remarks.)

Are Vegetation N, Soil N, or Hydrology N significantly disturbed? Are "Normal Circumstances" present? Yes X No _____

Are Vegetation N, Soil N, or Hydrology N naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No _____	**Is the Sampled Area within a Wetland?** **Yes** _____ **No** X
Hydric Soil Present?	Yes _____	No X	
Wetland Hydrology Present?	Yes _____	No X	

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ☐ Surface Water (A1)
- ☐ High Water Table (A2)
- ☐ Saturation (A3)
- ☐ Water Marks (B1)
- ☐ Sediment Deposits (B2)
- ☐ Drift Deposits (B3)
- ☐ Algal Mat or Crust (B4)
- ☐ Iron Deposits (B5)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Water-Stained Leaves (B9)
- ☐ Aquatic Fauna (B13)
- ☐ Marl Deposits (B15) **(LRR U)**
- ☐ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres along Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Tilled Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ☐ Surface Soil Cracks (B6)
- ☐ Sparsely Vegetated Concave Surface (B8)
- ☐ Drainage Patterns (B10)
- ☐ Moss Trim Lines (B16)
- ☐ Dry-Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Geomorphic Position (D2)
- ☐ Shallow Aquitard (D3)
- ☐ FAC-Neutral Test (D5)
- ☐ Sphagnum moss (D8) **(LRR T, U)**

Field Observations:

Surface Water Present?	Yes _____	No X	Depth (inches): _____
Water Table Present?	Yes _____	No X	Depth (inches): _____
Saturation Present? (includes capillary fringe)	Yes _____	No X	Depth (inches): _____

Wetland Hydrology Present? **Yes** _____ **No** X

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

VEGETATION (Four Strata) – Use scientific names of plants.

Sampling Point: SP-9

Tree Stratum (Plot size: 30')	Absolute % Cover	Dominant Species?	Indicator Status
1. Pinus taeda	25	Y	FAC
2. Quercus virginiana	20	Y	FACU
3. Quercus nigra	5	N	FAC
4.			
5.			
6.			
7.			
8.			
	50 = Total Cover		
50% of total cover: 25	20% of total cover: 10		

Sapling/Shrub Stratum (Plot size: 15')			
1. Ilex vomitoria	20	Y	FAC
2. Ligustrum sinense	15	Y	FAC
3. Pinus taeda	15	Y	FAC
4.			
5.			
6.			
7.			
8.			
	50 = Total Cover		
50% of total cover: 25	20% of total cover: 10		

Herb Stratum (Plot size:)			
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
	= Total Cover		
50% of total cover:	20% of total cover:		

Woody Vine Stratum (Plot size:)			
1.			
2.			
3.			
4.			
5.			
	= Total Cover		
50% of total cover:	20% of total cover:		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 4 (A)

Total Number of Dominant Species Across All Strata: 5 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 80% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species		x 1 =
FACW species		x 2 =
FAC species		x 3 =
FACU species		x 4 =
UPL species		x 5 =
Column Totals:	(A)	(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

- ___ 1 - Rapid Test for Hydrophytic Vegetation
- X 2 - Dominance Test is >50%
- ___ 3 - Prevalence Index is ≤3.0[1]
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Four Vegetation Strata:

Tree – Woody plants, excluding vines, 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

Sapling/Shrub – Woody plants, excluding vines, less than 3 in. DBH and greater than 3.28 ft (1 m) tall.

Herb – All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.28 ft tall.

Woody vine – All woody vines greater than 3.28 ft in height.

Hydrophytic Vegetation Present? **Yes** X **No** ___

Remarks: (If observed, list morphological adaptations below).

SOIL

Sampling Point: SP-9

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-18	7.5YR 4/2	100					CL	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5)
- ☐ Organic Bodies (A6) **(LRR P, T, U)**
- ☐ 5 cm Mucky Mineral (A7) **(LRR P, T, U)**
- ☐ Muck Presence (A8) **(LRR U)**
- ☐ 1 cm Muck (A9) **(LRR P, T)**
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Coast Prairie Redox (A16) **(MLRA 150A)**
- ☐ Sandy Mucky Mineral (S1) **(LRR O, S)**
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Dark Surface (S7) **(LRR P, S, T, U)**
- ☐ Polyvalue Below Surface (S8) **(LRR S, T, U)**
- ☐ Thin Dark Surface (S9) **(LRR S, T, U)**
- ☐ Loamy Mucky Mineral (F1) **(LRR O)**
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)
- ☐ Marl (F10) **(LRR U)**
- ☐ Depleted Ochric (F11) **(MLRA 151)**
- ☐ Iron-Manganese Masses (F12) **(LRR O, P, T)**
- ☐ Umbric Surface (F13) **(LRR P, T, U)**
- ☐ Delta Ochric (F17) **(MLRA 151)**
- ☐ Reduced Vertic (F18) **(MLRA 150A, 150B)**
- ☐ Piedmont Floodplain Soils (F19) **(MLRA 149A)**
- ☐ Anomalous Bright Loamy Soils (F20) **(MLRA 149A, 153C, 153D)**

Indicators for Problematic Hydric Soils[3]:

- ☐ 1 cm Muck (A9) **(LRR O)**
- ☐ 2 cm Muck (A10) **(LRR S)**
- ☐ Reduced Vertic (F18) **(outside MLRA 150A,B)**
- ☐ Piedmont Floodplain Soils (F19) **(LRR P, S, T)**
- ☐ Anomalous Bright Loamy Soils (F20) **(MLRA 153B)**
- ☐ Red Parent Material (TF2)
- ☐ Very Shallow Dark Surface (TF12)
- ☐ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: _____

Depth (inches): _____

Hydric Soil Present? **Yes** _____ **No** X

Remarks:

WETLAND DETERMINATION DATA FORM – Atlantic and Gulf Coastal Plain Region

Project/Site: Ravensway Subdivision Drainage Improvements City/County: Cypress/Harris Sampling Date: 10/28/2021

Applicant/Owner: LJA Engineering State: TX Sampling Point: SP-10

Investigator(s): B. O'Neal Section, Township, Range: N/A

Landform (hillslope, terrace, etc.): Flatwoods Local relief (concave, convex, none): None Slope (%): 0-1

Subregion (LRR or MLRA): LRR T Lat: 29.959165°N Long: -95.629062°W Datum: NAD83

Soil Map Unit Name: Wockley fine sandy loam, 0 to 1 percent slopes (Wo) NWI classification: UPL

Are climatic / hydrologic conditions on the site typical for this time of year? Yes X No _____ (If no, explain in Remarks.)

Are Vegetation N, Soil N, or Hydrology N significantly disturbed? Are "Normal Circumstances" present? Yes X No _____

Are Vegetation N, Soil N, or Hydrology N naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes X	No _____	**Is the Sampled Area within a Wetland?** **Yes** _____ **No** X
Hydric Soil Present?	Yes _____	No X	
Wetland Hydrology Present?	Yes _____	No X	

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ☐ Surface Water (A1)
- ☐ High Water Table (A2)
- ☐ Saturation (A3)
- ☐ Water Marks (B1)
- ☐ Sediment Deposits (B2)
- ☐ Drift Deposits (B3)
- ☐ Algal Mat or Crust (B4)
- ☐ Iron Deposits (B5)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Water-Stained Leaves (B9)
- ☐ Aquatic Fauna (B13)
- ☐ Marl Deposits (B15) **(LRR U)**
- ☐ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres along Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Tilled Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ☐ Surface Soil Cracks (B6)
- ☐ Sparsely Vegetated Concave Surface (B8)
- ☐ Drainage Patterns (B10)
- ☐ Moss Trim Lines (B16)
- ☐ Dry-Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Geomorphic Position (D2)
- ☐ Shallow Aquitard (D3)
- ☐ FAC-Neutral Test (D5)
- ☐ Sphagnum moss (D8) **(LRR T, U)**

Field Observations:

Surface Water Present?	Yes _____	No X	Depth (inches): _____
Water Table Present?	Yes _____	No X	Depth (inches): _____
Saturation Present? (includes capillary fringe)	Yes _____	No X	Depth (inches): _____

Wetland Hydrology Present? **Yes** _____ **No** X

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

VEGETATION (Four Strata) – Use scientific names of plants.

Sampling Point: SP-10

Tree Stratum (Plot size: 30')	Absolute % Cover	Dominant Species?	Indicator Status
1. Quercus nigra	20	Y	FAC
2. Quercus virginiana	20	Y	FACU
3. Pinus taeda	20	Y	FAC
4.			
5.			
6.			
7.			
8.			
	60 = Total Cover		
50% of total cover: 30	20% of total cover: 12		

Sapling/Shrub Stratum (Plot size: 15')			
1. Ilex vomitoria	30	Y	FAC
2. Ligustrum sinense	15	Y	FAC
3.			
4.			
5.			
6.			
7.			
8.			
	45 = Total Cover		
50% of total cover: 22.5	20% of total cover: 9		

Herb Stratum (Plot size: 5')			
1. Paspalum notatum	30	Y	FAC
2. Sorghum halepense	20	Y	FACU
3. Cynodon dactylon	20	Y	FACU
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
	70 = Total Cover		
50% of total cover: 35	20% of total cover: 14		

Woody Vine Stratum (Plot size:)			
1.			
2.			
3.			
4.			
5.			
	= Total Cover		
50% of total cover:	20% of total cover:		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 5 (A)

Total Number of Dominant Species Across All Strata: 8 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 63% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species		x 1 =
FACW species		x 2 =
FAC species		x 3 =
FACU species		x 4 =
UPL species		x 5 =
Column Totals:	(A)	(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation

X 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Four Vegetation Strata:

Tree – Woody plants, excluding vines, 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

Sapling/Shrub – Woody plants, excluding vines, less than 3 in. DBH and greater than 3.28 ft (1 m) tall.

Herb – All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.28 ft tall.

Woody vine – All woody vines greater than 3.28 ft in height.

Hydrophytic Vegetation Present? **Yes** X **No** ___

Remarks: (If observed, list morphological adaptations below).

SOIL

Sampling Point: SP-10

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-18	7.5YR 4/2	100					CL	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5)
- ☐ Organic Bodies (A6) **(LRR P, T, U)**
- ☐ 5 cm Mucky Mineral (A7) **(LRR P, T, U)**
- ☐ Muck Presence (A8) **(LRR U)**
- ☐ 1 cm Muck (A9) **(LRR P, T)**
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Coast Prairie Redox (A16) **(MLRA 150A)**
- ☐ Sandy Mucky Mineral (S1) **(LRR O, S)**
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Dark Surface (S7) **(LRR P, S, T, U)**
- ☐ Polyvalue Below Surface (S8) **(LRR S, T, U)**
- ☐ Thin Dark Surface (S9) **(LRR S, T, U)**
- ☐ Loamy Mucky Mineral (F1) **(LRR O)**
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)
- ☐ Marl (F10) **(LRR U)**
- ☐ Depleted Ochric (F11) **(MLRA 151)**
- ☐ Iron-Manganese Masses (F12) **(LRR O, P, T)**
- ☐ Umbric Surface (F13) **(LRR P, T, U)**
- ☐ Delta Ochric (F17) **(MLRA 151)**
- ☐ Reduced Vertic (F18) **(MLRA 150A, 150B)**
- ☐ Piedmont Floodplain Soils (F19) **(MLRA 149A)**
- ☐ Anomalous Bright Loamy Soils (F20) **(MLRA 149A, 153C, 153D)**

Indicators for Problematic Hydric Soils[3]:

- ☐ 1 cm Muck (A9) **(LRR O)**
- ☐ 2 cm Muck (A10) **(LRR S)**
- ☐ Reduced Vertic (F18) **(outside MLRA 150A,B)**
- ☐ Piedmont Floodplain Soils (F19) **(LRR P, S, T)**
- ☐ Anomalous Bright Loamy Soils (F20) **(MLRA 153B)**
- ☐ Red Parent Material (TF2)
- ☐ Very Shallow Dark Surface (TF12)
- ☐ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: _____

Depth (inches): _____

Hydric Soil Present? **Yes** _____ **No** X

Remarks:

WETLAND DETERMINATION DATA FORM – Atlantic and Gulf Coastal Plain Region

Project/Site: Ravensway Subdivision Drainage Improvements City/County: Cypress/Harris Sampling Date: 10/28/2021

Applicant/Owner: LJA Engineering State: TX Sampling Point: SP-11

Investigator(s): B. O'Neal Section, Township, Range: N/A

Landform (hillslope, terrace, etc.): Flatwoods Local relief (concave, convex, none): None Slope (%): 0-1

Subregion (LRR or MLRA): LRR T Lat: 29.962102°N Long: -95.630656°W Datum: NAD83

Soil Map Unit Name: Wockley fine sandy loam, 0 to 1 percent slopes (Wo) NWI classification: UPL

Are climatic / hydrologic conditions on the site typical for this time of year? Yes X No _____ (If no, explain in Remarks.)

Are Vegetation N, Soil N, or Hydrology N significantly disturbed? Are "Normal Circumstances" present? Yes X No _____

Are Vegetation N, Soil N, or Hydrology N naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes _____	No X	**Is the Sampled Area within a Wetland?** **Yes** _____ **No** X
Hydric Soil Present?	Yes _____	No X	
Wetland Hydrology Present?	Yes _____	No X	

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ☐ Surface Water (A1)
- ☐ High Water Table (A2)
- ☐ Saturation (A3)
- ☐ Water Marks (B1)
- ☐ Sediment Deposits (B2)
- ☐ Drift Deposits (B3)
- ☐ Algal Mat or Crust (B4)
- ☐ Iron Deposits (B5)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Water-Stained Leaves (B9)
- ☐ Aquatic Fauna (B13)
- ☐ Marl Deposits (B15) **(LRR U)**
- ☐ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres along Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Tilled Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ☐ Surface Soil Cracks (B6)
- ☐ Sparsely Vegetated Concave Surface (B8)
- ☐ Drainage Patterns (B10)
- ☐ Moss Trim Lines (B16)
- ☐ Dry-Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Geomorphic Position (D2)
- ☐ Shallow Aquitard (D3)
- ☐ FAC-Neutral Test (D5)
- ☐ Sphagnum moss (D8) **(LRR T, U)**

Field Observations:

Surface Water Present?	Yes _____	No X	Depth (inches): _____
Water Table Present?	Yes _____	No X	Depth (inches): _____
Saturation Present? (includes capillary fringe)	Yes _____	No X	Depth (inches): _____

Wetland Hydrology Present? **Yes** _____ **No** X

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

VEGETATION (Four Strata) – Use scientific names of plants.

Sampling Point: SP-11

Tree Stratum (Plot size: 30')	Absolute % Cover	Dominant Species?	Indicator Status
1. Quercus virginiana	25	Y	FACU
2. Pinus taeda	20	Y	FAC
3. Triadica sebifera	5	N	FAC
4.			
5.			
6.			
7.			
8.			
	50 = Total Cover		
50% of total cover: 25	20% of total cover: 10		

Sapling/Shrub Stratum (Plot size: 15')			
1. Ilex vomitoria	30	Y	FAC
2. Ligustrum sinense	15	Y	FAC
3. Quercus virginiana	15	Y	FACU
4. Triadica sebifera	5	N	FAC
5.			
6.			
7.			
8.			
	65 = Total Cover		
50% of total cover: 32.5	20% of total cover: 13		

Herb Stratum (Plot size: 5')			
1. Paspalum notatum	10	Y	FAC
2. Sorghum halepense	10	Y	FACU
3. Cynodon dactylon	10	Y	FACU
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
	30 = Total Cover		
50% of total cover: 15	20% of total cover: 6		

Woody Vine Stratum (Plot size:)			
1.			
2.			
3.			
4.			
5.			
	= Total Cover		
50% of total cover:	20% of total cover:		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 4 (A)

Total Number of Dominant Species Across All Strata: 8 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 50% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species		x 1 =
FACW species		x 2 =
FAC species		x 3 =
FACU species		x 4 =
UPL species		x 5 =
Column Totals:	(A)	(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation

___ 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Four Vegetation Strata:

Tree – Woody plants, excluding vines, 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

Sapling/Shrub – Woody plants, excluding vines, less than 3 in. DBH and greater than 3.28 ft (1 m) tall.

Herb – All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.28 ft tall.

Woody vine – All woody vines greater than 3.28 ft in height.

Hydrophytic Vegetation Present? **Yes** ___ **No** X

Remarks: (If observed, list morphological adaptations below).

Mowing/shredding activities often occur at the sampling location.

SOIL

Sampling Point: SP-11

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-18	7.5YR 4/3	100					CL	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5)
- ☐ Organic Bodies (A6) **(LRR P, T, U)**
- ☐ 5 cm Mucky Mineral (A7) **(LRR P, T, U)**
- ☐ Muck Presence (A8) **(LRR U)**
- ☐ 1 cm Muck (A9) **(LRR P, T)**
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Coast Prairie Redox (A16) **(MLRA 150A)**
- ☐ Sandy Mucky Mineral (S1) **(LRR O, S)**
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Dark Surface (S7) **(LRR P, S, T, U)**
- ☐ Polyvalue Below Surface (S8) **(LRR S, T, U)**
- ☐ Thin Dark Surface (S9) **(LRR S, T, U)**
- ☐ Loamy Mucky Mineral (F1) **(LRR O)**
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)
- ☐ Marl (F10) **(LRR U)**
- ☐ Depleted Ochric (F11) **(MLRA 151)**
- ☐ Iron-Manganese Masses (F12) **(LRR O, P, T)**
- ☐ Umbric Surface (F13) **(LRR P, T, U)**
- ☐ Delta Ochric (F17) **(MLRA 151)**
- ☐ Reduced Vertic (F18) **(MLRA 150A, 150B)**
- ☐ Piedmont Floodplain Soils (F19) **(MLRA 149A)**
- ☐ Anomalous Bright Loamy Soils (F20) **(MLRA 149A, 153C, 153D)**

Indicators for Problematic Hydric Soils[3]:

- ☐ 1 cm Muck (A9) **(LRR O)**
- ☐ 2 cm Muck (A10) **(LRR S)**
- ☐ Reduced Vertic (F18) **(outside MLRA 150A,B)**
- ☐ Piedmont Floodplain Soils (F19) **(LRR P, S, T)**
- ☐ Anomalous Bright Loamy Soils (F20) **(MLRA 153B)**
- ☐ Red Parent Material (TF2)
- ☐ Very Shallow Dark Surface (TF12)
- ☐ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: _____

Depth (inches): _____

Hydric Soil Present? **Yes** _____ **No** X

Remarks:

WETLAND DETERMINATION DATA FORM – Atlantic and Gulf Coastal Plain Region

Project/Site: Ravensway Subdivision Drainage Improvements City/County: Cypress/Harris Sampling Date: 10/28/2021

Applicant/Owner: LJA Engineering State: TX Sampling Point: SP-12

Investigator(s): B. O'Neal Section, Township, Range: N/A

Landform (hillslope, terrace, etc.): Flatwoods Local relief (concave, convex, none): None Slope (%): 0-1

Subregion (LRR or MLRA): LRR T Lat: 29.962265°N Long: -95.630012°W Datum: NAD83

Soil Map Unit Name: Clodine-Urban land complex, 0 to 1 percent slopes (Ce) NWI classification: UPL

Are climatic / hydrologic conditions on the site typical for this time of year? Yes X No _____ (If no, explain in Remarks.)

Are Vegetation N, Soil N, or Hydrology N significantly disturbed? Are "Normal Circumstances" present? Yes X No _____

Are Vegetation N, Soil N, or Hydrology N naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes _____	No X	**Is the Sampled Area within a Wetland?** **Yes** _____ **No** X
Hydric Soil Present?	Yes _____	No X	
Wetland Hydrology Present?	Yes _____	No X	

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ☐ Surface Water (A1)
- ☐ High Water Table (A2)
- ☐ Saturation (A3)
- ☐ Water Marks (B1)
- ☐ Sediment Deposits (B2)
- ☐ Drift Deposits (B3)
- ☐ Algal Mat or Crust (B4)
- ☐ Iron Deposits (B5)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Water-Stained Leaves (B9)
- ☐ Aquatic Fauna (B13)
- ☐ Marl Deposits (B15) **(LRR U)**
- ☐ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres along Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Tilled Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ☐ Surface Soil Cracks (B6)
- ☐ Sparsely Vegetated Concave Surface (B8)
- ☐ Drainage Patterns (B10)
- ☐ Moss Trim Lines (B16)
- ☐ Dry-Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Geomorphic Position (D2)
- ☐ Shallow Aquitard (D3)
- ☐ FAC-Neutral Test (D5)
- ☐ Sphagnum moss (D8) **(LRR T, U)**

Field Observations:

Surface Water Present?	Yes _____	No X	Depth (inches): _____
Water Table Present?	Yes _____	No X	Depth (inches): _____
Saturation Present? (includes capillary fringe)	Yes _____	No X	Depth (inches): _____

Wetland Hydrology Present? **Yes** _____ **No** X

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

VEGETATION (Four Strata) – Use scientific names of plants.

Sampling Point: SP-12

Tree Stratum (Plot size: 30')	Absolute % Cover	Dominant Species?	Indicator Status
1. Quercus virginiana	25	Y	FACU
2. Pinus taeda	20	Y	FAC
3. Triadica sebifera	5	N	FAC
4.			
5.			
6.			
7.			
8.			
	50 = Total Cover		
50% of total cover: 25	20% of total cover: 10		

Sapling/Shrub Stratum (Plot size: 15')			
1. Ilex vomitoria	30	Y	FAC
2. Ligustrum sinense	15	Y	FAC
3. Quercus virginiana	15	Y	FACU
4. Triadica sebifera	5	N	FAC
5.			
6.			
7.			
8.			
	65 = Total Cover		
50% of total cover: 32.5	20% of total cover: 13		

Herb Stratum (Plot size: 5')			
1. Paspalum notatum	10	Y	FAC
2. Sorghum halepense	10	Y	FACU
3. Cynodon dactylon	10	Y	FACU
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
	30 = Total Cover		
50% of total cover: 15	20% of total cover: 6		

Woody Vine Stratum (Plot size:)			
1.			
2.			
3.			
4.			
5.			
	= Total Cover		
50% of total cover:	20% of total cover:		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 4 (A)

Total Number of Dominant Species Across All Strata: 8 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 50% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species		x 1 =
FACW species		x 2 =
FAC species		x 3 =
FACU species		x 4 =
UPL species		x 5 =
Column Totals:	(A)	(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation

___ 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Four Vegetation Strata:

Tree – Woody plants, excluding vines, 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

Sapling/Shrub – Woody plants, excluding vines, less than 3 in. DBH and greater than 3.28 ft (1 m) tall.

Herb – All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.28 ft tall.

Woody vine – All woody vines greater than 3.28 ft in height.

Hydrophytic Vegetation Present? **Yes** ___ **No** X

Remarks: (If observed, list morphological adaptations below).

Mowing/shredding activities often occur at the sampling location.

SOIL

Sampling Point: SP-12

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-18	7.5YR 4/3	100					CL	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5)
- ☐ Organic Bodies (A6) **(LRR P, T, U)**
- ☐ 5 cm Mucky Mineral (A7) **(LRR P, T, U)**
- ☐ Muck Presence (A8) **(LRR U)**
- ☐ 1 cm Muck (A9) **(LRR P, T)**
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Coast Prairie Redox (A16) **(MLRA 150A)**
- ☐ Sandy Mucky Mineral (S1) **(LRR O, S)**
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Dark Surface (S7) **(LRR P, S, T, U)**
- ☐ Polyvalue Below Surface (S8) **(LRR S, T, U)**
- ☐ Thin Dark Surface (S9) **(LRR S, T, U)**
- ☐ Loamy Mucky Mineral (F1) **(LRR O)**
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)
- ☐ Marl (F10) **(LRR U)**
- ☐ Depleted Ochric (F11) **(MLRA 151)**
- ☐ Iron-Manganese Masses (F12) **(LRR O, P, T)**
- ☐ Umbric Surface (F13) **(LRR P, T, U)**
- ☐ Delta Ochric (F17) **(MLRA 151)**
- ☐ Reduced Vertic (F18) **(MLRA 150A, 150B)**
- ☐ Piedmont Floodplain Soils (F19) **(MLRA 149A)**
- ☐ Anomalous Bright Loamy Soils (F20) **(MLRA 149A, 153C, 153D)**

Indicators for Problematic Hydric Soils[3]:

- ☐ 1 cm Muck (A9) **(LRR O)**
- ☐ 2 cm Muck (A10) **(LRR S)**
- ☐ Reduced Vertic (F18) **(outside MLRA 150A,B)**
- ☐ Piedmont Floodplain Soils (F19) **(LRR P, S, T)**
- ☐ Anomalous Bright Loamy Soils (F20) **(MLRA 153B)**
- ☐ Red Parent Material (TF2)
- ☐ Very Shallow Dark Surface (TF12)
- ☐ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: _____

Depth (inches): _____

Hydric Soil Present? **Yes** _____ **No** X

Remarks:

WETLAND DETERMINATION DATA FORM – Atlantic and Gulf Coastal Plain Region

Project/Site: Ravensway Subdivision Drainage Improvements City/County: Cypress/Harris Sampling Date: 10/28/2021

Applicant/Owner: LJA Engineering State: TX Sampling Point: SP-13

Investigator(s): B. O'Neal Section, Township, Range: N/A

Landform (hillslope, terrace, etc.): Flatwoods Local relief (concave, convex, none): None Slope (%): 0-1

Subregion (LRR or MLRA): LRR T Lat: 29.961735°N Long: -95.629600°W Datum: NAD83

Soil Map Unit Name: Hatliff-Pluck-Kian complex, 0 to 1 percent slopes, frequently flooded (HatA) NWI classification: UPL

Are climatic / hydrologic conditions on the site typical for this time of year? Yes X No _____ (If no, explain in Remarks.)

Are Vegetation N, Soil N, or Hydrology N significantly disturbed? Are "Normal Circumstances" present? Yes X No _____

Are Vegetation N, Soil N, or Hydrology N naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes _____	No X	**Is the Sampled Area within a Wetland?** **Yes** _____ **No** X
Hydric Soil Present?	Yes _____	No X	
Wetland Hydrology Present?	Yes _____	No X	

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ☐ Surface Water (A1)
- ☐ High Water Table (A2)
- ☐ Saturation (A3)
- ☐ Water Marks (B1)
- ☐ Sediment Deposits (B2)
- ☐ Drift Deposits (B3)
- ☐ Algal Mat or Crust (B4)
- ☐ Iron Deposits (B5)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Water-Stained Leaves (B9)
- ☐ Aquatic Fauna (B13)
- ☐ Marl Deposits (B15) **(LRR U)**
- ☐ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres along Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Tilled Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ☐ Surface Soil Cracks (B6)
- ☐ Sparsely Vegetated Concave Surface (B8)
- ☐ Drainage Patterns (B10)
- ☐ Moss Trim Lines (B16)
- ☐ Dry-Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Geomorphic Position (D2)
- ☐ Shallow Aquitard (D3)
- ☐ FAC-Neutral Test (D5)
- ☐ Sphagnum moss (D8) **(LRR T, U)**

Field Observations:

Surface Water Present?	Yes _____	No X	Depth (inches): _____
Water Table Present?	Yes _____	No X	Depth (inches): _____
Saturation Present? (includes capillary fringe)	Yes _____	No X	Depth (inches): _____

Wetland Hydrology Present? **Yes** _____ **No** X

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

VEGETATION (Four Strata) – Use scientific names of plants.

Sampling Point: SP-13

Tree Stratum (Plot size: 30')	Absolute % Cover	Dominant Species?	Indicator Status
1. Quercus virginiana	25	Y	FACU
2. Pinus taeda	20	Y	FAC
3. Triadica sebifera	5	N	FAC
4.			
5.			
6.			
7.			
8.			
	50 = Total Cover		

50% of total cover: 25 20% of total cover: 10

Sapling/Shrub Stratum (Plot size: 15')			
1. Ilex vomitoria	30	Y	FAC
2. Ligustrum sinense	15	Y	FAC
3. Quercus virginiana	15	Y	FACU
4. Triadica sebifera	5	N	FAC
5.			
6.			
7.			
8.			
	65 = Total Cover		

50% of total cover: 32.5 20% of total cover: 13

Herb Stratum (Plot size: 5')			
1. Paspalum notatum	10	Y	FAC
2. Sorghum halepense	10	Y	FACU
3. Cynodon dactylon	10	Y	FACU
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
	30 = Total Cover		

50% of total cover: 15 20% of total cover: 6

Woody Vine Stratum (Plot size:)			
1.			
2.			
3.			
4.			
5.			
	= Total Cover		

50% of total cover: 20% of total cover:

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 4 (A)

Total Number of Dominant Species Across All Strata: 8 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 50% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species		x 1 =
FACW species		x 2 =
FAC species		x 3 =
FACU species		x 4 =
UPL species		x 5 =
Column Totals:	(A)	(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation

___ 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Four Vegetation Strata:

Tree – Woody plants, excluding vines, 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

Sapling/Shrub – Woody plants, excluding vines, less than 3 in. DBH and greater than 3.28 ft (1 m) tall.

Herb – All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.28 ft tall.

Woody vine – All woody vines greater than 3.28 ft in height.

Hydrophytic Vegetation Present? **Yes** ___ **No** X

Remarks: (If observed, list morphological adaptations below).

Mowing/shredding activities often occur at the sampling location.

SOIL

Sampling Point: SP-13

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-18	7.5YR 4/3	100					CL	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5)
- ☐ Organic Bodies (A6) **(LRR P, T, U)**
- ☐ 5 cm Mucky Mineral (A7) **(LRR P, T, U)**
- ☐ Muck Presence (A8) **(LRR U)**
- ☐ 1 cm Muck (A9) **(LRR P, T)**
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Coast Prairie Redox (A16) **(MLRA 150A)**
- ☐ Sandy Mucky Mineral (S1) **(LRR O, S)**
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Dark Surface (S7) **(LRR P, S, T, U)**
- ☐ Polyvalue Below Surface (S8) **(LRR S, T, U)**
- ☐ Thin Dark Surface (S9) **(LRR S, T, U)**
- ☐ Loamy Mucky Mineral (F1) **(LRR O)**
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)
- ☐ Marl (F10) **(LRR U)**
- ☐ Depleted Ochric (F11) **(MLRA 151)**
- ☐ Iron-Manganese Masses (F12) **(LRR O, P, T)**
- ☐ Umbric Surface (F13) **(LRR P, T, U)**
- ☐ Delta Ochric (F17) **(MLRA 151)**
- ☐ Reduced Vertic (F18) **(MLRA 150A, 150B)**
- ☐ Piedmont Floodplain Soils (F19) **(MLRA 149A)**
- ☐ Anomalous Bright Loamy Soils (F20) **(MLRA 149A, 153C, 153D)**

Indicators for Problematic Hydric Soils[3]:

- ☐ 1 cm Muck (A9) **(LRR O)**
- ☐ 2 cm Muck (A10) **(LRR S)**
- ☐ Reduced Vertic (F18) **(outside MLRA 150A,B)**
- ☐ Piedmont Floodplain Soils (F19) **(LRR P, S, T)**
- ☐ Anomalous Bright Loamy Soils (F20) **(MLRA 153B)**
- ☐ Red Parent Material (TF2)
- ☐ Very Shallow Dark Surface (TF12)
- ☐ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: _____

Depth (inches): _____

Hydric Soil Present? **Yes** _____ **No** X

Remarks:

WETLAND DETERMINATION DATA FORM – Atlantic and Gulf Coastal Plain Region

Project/Site: Ravensway Subdivision Drainage Improvements City/County: Cypress/Harris Sampling Date: 10/28/2021

Applicant/Owner: LJA Engineering State: TX Sampling Point: SP-14

Investigator(s): B. O'Neal Section, Township, Range: N/A

Landform (hillslope, terrace, etc.): Flatwoods Local relief (concave, convex, none): None Slope (%): 0-1

Subregion (LRR or MLRA): LRR T Lat: 29.961735°N Long: -95.629600°W Datum: NAD83

Soil Map Unit Name: Hatliff-Pluck-Kian complex, 0 to 1 percent slopes, frequently flooded (HatA) NWI classification: UPL

Are climatic / hydrologic conditions on the site typical for this time of year? Yes X No _____ (If no, explain in Remarks.)

Are Vegetation N, Soil N, or Hydrology N significantly disturbed? Are "Normal Circumstances" present? Yes X No _____

Are Vegetation N, Soil N, or Hydrology N naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes _____	No X	**Is the Sampled Area within a Wetland?** **Yes** _____ **No** X
Hydric Soil Present?	Yes _____	No X	
Wetland Hydrology Present?	Yes _____	No X	

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ☐ Surface Water (A1)
- ☐ High Water Table (A2)
- ☐ Saturation (A3)
- ☐ Water Marks (B1)
- ☐ Sediment Deposits (B2)
- ☐ Drift Deposits (B3)
- ☐ Algal Mat or Crust (B4)
- ☐ Iron Deposits (B5)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Water-Stained Leaves (B9)
- ☐ Aquatic Fauna (B13)
- ☐ Marl Deposits (B15) **(LRR U)**
- ☐ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres along Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Tilled Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ☐ Surface Soil Cracks (B6)
- ☐ Sparsely Vegetated Concave Surface (B8)
- ☐ Drainage Patterns (B10)
- ☐ Moss Trim Lines (B16)
- ☐ Dry-Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Geomorphic Position (D2)
- ☐ Shallow Aquitard (D3)
- ☐ FAC-Neutral Test (D5)
- ☐ Sphagnum moss (D8) **(LRR T, U)**

Field Observations:

Surface Water Present?	Yes _____	No X	Depth (inches): _____
Water Table Present?	Yes _____	No X	Depth (inches): _____
Saturation Present? (includes capillary fringe)	Yes _____	No X	Depth (inches): _____

Wetland Hydrology Present? **Yes** _____ **No** X

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

VEGETATION (Four Strata) – Use scientific names of plants.

Sampling Point: SP-14

Tree Stratum (Plot size: 30')	Absolute % Cover	Dominant Species?	Indicator Status
1. Quercus virginiana	20	Y	FACU
2. Pinus taeda	20	Y	FAC
3.			
4.			
5.			
6.			
7.			
8.			
	40 = Total Cover		
50% of total cover: 20	20% of total cover: 8		

Sapling/Shrub Stratum (Plot size: 15')			
1. Ilex vomitoria	20	Y	FAC
2. Quercus virginiana	20	Y	FACU
3.			
4.			
5.			
6.			
7.			
8.			
	40 = Total Cover		
50% of total cover: 20	20% of total cover: 8		

Herb Stratum (Plot size: 5')			
1. Paspalum notatum	10	Y	FAC
2. Sorghum halepense	10	Y	FACU
3. Cynodon dactylon	10	Y	FACU
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
	30 = Total Cover		
50% of total cover: 15	20% of total cover: 6		

Woody Vine Stratum (Plot size:)			
1.			
2.			
3.			
4.			
5.			
	= Total Cover		
50% of total cover:	20% of total cover:		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 3 (A)

Total Number of Dominant Species Across All Strata: 7 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 43% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species		x 1 =
FACW species		x 2 =
FAC species		x 3 =
FACU species		x 4 =
UPL species		x 5 =
Column Totals:	(A)	(B)

Prevalence Index = B/A =

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation

___ 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Four Vegetation Strata:

Tree – Woody plants, excluding vines, 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

Sapling/Shrub – Woody plants, excluding vines, less than 3 in. DBH and greater than 3.28 ft (1 m) tall.

Herb – All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.28 ft tall.

Woody vine – All woody vines greater than 3.28 ft in height.

Hydrophytic Vegetation Present? **Yes** ___ **No** X

Remarks: (If observed, list morphological adaptations below).

Mowing/shredding activities often occur at the sampling location.

SOIL

Sampling Point: SP-14

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-18	7.5YR 3/3	100					CL	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5)
- ☐ Organic Bodies (A6) **(LRR P, T, U)**
- ☐ 5 cm Mucky Mineral (A7) **(LRR P, T, U)**
- ☐ Muck Presence (A8) **(LRR U)**
- ☐ 1 cm Muck (A9) **(LRR P, T)**
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Coast Prairie Redox (A16) **(MLRA 150A)**
- ☐ Sandy Mucky Mineral (S1) **(LRR O, S)**
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Dark Surface (S7) **(LRR P, S, T, U)**
- ☐ Polyvalue Below Surface (S8) **(LRR S, T, U)**
- ☐ Thin Dark Surface (S9) **(LRR S, T, U)**
- ☐ Loamy Mucky Mineral (F1) **(LRR O)**
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)
- ☐ Marl (F10) **(LRR U)**
- ☐ Depleted Ochric (F11) **(MLRA 151)**
- ☐ Iron-Manganese Masses (F12) **(LRR O, P, T)**
- ☐ Umbric Surface (F13) **(LRR P, T, U)**
- ☐ Delta Ochric (F17) **(MLRA 151)**
- ☐ Reduced Vertic (F18) **(MLRA 150A, 150B)**
- ☐ Piedmont Floodplain Soils (F19) **(MLRA 149A)**
- ☐ Anomalous Bright Loamy Soils (F20) **(MLRA 149A, 153C, 153D)**

Indicators for Problematic Hydric Soils[3]:

- ☐ 1 cm Muck (A9) **(LRR O)**
- ☐ 2 cm Muck (A10) **(LRR S)**
- ☐ Reduced Vertic (F18) **(outside MLRA 150A,B)**
- ☐ Piedmont Floodplain Soils (F19) **(LRR P, S, T)**
- ☐ Anomalous Bright Loamy Soils (F20) **(MLRA 153B)**
- ☐ Red Parent Material (TF2)
- ☐ Very Shallow Dark Surface (TF12)
- ☐ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: _____

Depth (inches): _____

Hydric Soil Present? **Yes** _____ **No** X

Remarks:

WETLAND DETERMINATION DATA FORM – Atlantic and Gulf Coastal Plain Region

Project/Site: Ravensway Subdivision Drainage Improvements City/County: Cypress/Harris Sampling Date: 10/28/2021

Applicant/Owner: LJA Engineering State: TX Sampling Point: SP-15

Investigator(s): B. O'Neal Section, Township, Range: N/A

Landform (hillslope, terrace, etc.): Hillslope Local relief (concave, convex, none): None Slope (%): 0-1

Subregion (LRR or MLRA): LRR T Lat: 29.961013°N Long: -95.618340°W Datum: NAD83

Soil Map Unit Name: Wockley fine sandy loam, 0 to 1 percent slopes (Wo) NWI classification: UPL

Are climatic / hydrologic conditions on the site typical for this time of year? Yes X No _____ (If no, explain in Remarks.)

Are Vegetation Y, Soil Y, or Hydrology Y significantly disturbed? Are "Normal Circumstances" present? Yes X No _____

Are Vegetation N, Soil N, or Hydrology N naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes _____	No X	**Is the Sampled Area within a Wetland?** **Yes** _____ **No** X
Hydric Soil Present?	Yes _____	No X	
Wetland Hydrology Present?	Yes _____	No X	

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ☐ Surface Water (A1)
- ☐ High Water Table (A2)
- ☐ Saturation (A3)
- ☐ Water Marks (B1)
- ☐ Sediment Deposits (B2)
- ☐ Drift Deposits (B3)
- ☐ Algal Mat or Crust (B4)
- ☐ Iron Deposits (B5)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Water-Stained Leaves (B9)
- ☐ Aquatic Fauna (B13)
- ☐ Marl Deposits (B15) **(LRR U)**
- ☐ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres along Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Tilled Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ☐ Surface Soil Cracks (B6)
- ☐ Sparsely Vegetated Concave Surface (B8)
- ☐ Drainage Patterns (B10)
- ☐ Moss Trim Lines (B16)
- ☐ Dry-Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Geomorphic Position (D2)
- ☐ Shallow Aquitard (D3)
- ☐ FAC-Neutral Test (D5)
- ☐ Sphagnum moss (D8) **(LRR T, U)**

Field Observations:

Surface Water Present?	Yes _____	No X	Depth (inches): _____
Water Table Present?	Yes _____	No X	Depth (inches): _____
Saturation Present? (includes capillary fringe)	Yes _____	No X	Depth (inches): _____

Wetland Hydrology Present? **Yes** _____ **No** X

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

Active grading and construction activities have caused surface level hydrology disturbance at the sampling location.

VEGETATION (Four Strata) – Use scientific names of plants.

Sampling Point: SP-15

Tree Stratum (Plot size: _____)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
	_____ = Total Cover		
50% of total cover: _____	20% of total cover: _____		

Sapling/Shrub Stratum (Plot size: _____)			
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
	_____ = Total Cover		
50% of total cover: _____	20% of total cover: _____		

Herb Stratum (Plot size: _____)			
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
	_____ = Total Cover		
50% of total cover: _____	20% of total cover: _____		

Woody Vine Stratum (Plot size: _____)			
1.			
2.			
3.			
4.			
5.			
	_____ = Total Cover		
50% of total cover: _____	20% of total cover: _____		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 0 (A)

Total Number of Dominant Species Across All Strata: 0 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 0% (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species	_____	x 1 = _____
FACW species	_____	x 2 = _____
FAC species	_____	x 3 = _____
FACU species	_____	x 4 = _____
UPL species	_____	x 5 = _____
Column Totals:	_____ (A)	_____ (B)

Prevalence Index = B/A = _____

Hydrophytic Vegetation Indicators:

___ 1 - Rapid Test for Hydrophytic Vegetation

___ 2 - Dominance Test is >50%

___ 3 - Prevalence Index is ≤3.0[1]

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Definitions of Four Vegetation Strata:

Tree – Woody plants, excluding vines, 3 in. (7.6 cm) or more in diameter at breast height (DBH), regardless of height.

Sapling/Shrub – Woody plants, excluding vines, less than 3 in. DBH and greater than 3.28 ft (1 m) tall.

Herb – All herbaceous (non-woody) plants, regardless of size, and woody plants less than 3.28 ft tall.

Woody vine – All woody vines greater than 3.28 ft in height.

Hydrophytic Vegetation Present? **Yes** _____ **No** X

Remarks: (If observed, list morphological adaptations below).

Active grading and construction activities have caused surface level vegetation disturbance at the sampling location. Bare ground surface encompassed 100% of the plot area.

SOIL

Sampling Point: SP-15

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-18	7.5YR 5/4	50					SCL	Fill/construction material
	7.5YR 6/8	50					SCL	Fill/construction material

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5)
- ☐ Organic Bodies (A6) **(LRR P, T, U)**
- ☐ 5 cm Mucky Mineral (A7) **(LRR P, T, U)**
- ☐ Muck Presence (A8) **(LRR U)**
- ☐ 1 cm Muck (A9) **(LRR P, T)**
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Coast Prairie Redox (A16) **(MLRA 150A)**
- ☐ Sandy Mucky Mineral (S1) **(LRR O, S)**
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Dark Surface (S7) **(LRR P, S, T, U)**
- ☐ Polyvalue Below Surface (S8) **(LRR S, T, U)**
- ☐ Thin Dark Surface (S9) **(LRR S, T, U)**
- ☐ Loamy Mucky Mineral (F1) **(LRR O)**
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)
- ☐ Marl (F10) **(LRR U)**
- ☐ Depleted Ochric (F11) **(MLRA 151)**
- ☐ Iron-Manganese Masses (F12) **(LRR O, P, T)**
- ☐ Umbric Surface (F13) **(LRR P, T, U)**
- ☐ Delta Ochric (F17) **(MLRA 151)**
- ☐ Reduced Vertic (F18) **(MLRA 150A, 150B)**
- ☐ Piedmont Floodplain Soils (F19) **(MLRA 149A)**
- ☐ Anomalous Bright Loamy Soils (F20) **(MLRA 149A, 153C, 153D)**

Indicators for Problematic Hydric Soils[3]:

- ☐ 1 cm Muck (A9) **(LRR O)**
- ☐ 2 cm Muck (A10) **(LRR S)**
- ☐ Reduced Vertic (F18) **(outside MLRA 150A,B)**
- ☐ Piedmont Floodplain Soils (F19) **(LRR P, S, T)**
- ☐ Anomalous Bright Loamy Soils (F20) **(MLRA 153B)**
- ☐ Red Parent Material (TF2)
- ☐ Very Shallow Dark Surface (TF12)
- ☐ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: _____

Depth (inches): _____

Hydric Soil Present? **Yes** _____ **No** X

Remarks:

Active grading and construction activities have caused surface level soil disturbance at the sampling location.

Appendix B
Geotechnical Report

REPORT
GEOTECHNICAL INVESTIGATION
PROPOSED RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS - 2018
PRECINCT 3
HARRIS COUNTY, TEXAS
UPIN# 19103MF14601

PREPARED FOR:

Harris County Engineering Department
c/o LJA Engineering, Inc.
3600 W. Sam Houston Parkway S., Suite 600
Houston, Texas 77042

PREPARED BY:

HTS, Inc. Consultants
416 Pickering Street
Houston, Texas 77091-3312

HTS Project No.: 21-S-477 Revision 2

March 2, 2022

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Excellence in Engineering, Consulting, Testing and Inspection

March 2, 2022

Harris County Engineering Department
c/o LJA Engineering, Inc.
3600 W. Sam Houston Parkway S., Suite 600
Houston, Texas 77042

Attn: Mr. Isaac Muniz, P.E.
Project Manager

Re: Report
Geotechnical Services for
Proposed Ravensway Subdivision Drainage
Improvements - 2018
Precinct 3
Harris County, Texas
UPIN No. 19103MF14601

HTS Project No.: 21-S-477 Revision 2

Dear Mr. Muniz:

HTS, Inc. Consultants is pleased to transmit this report of the geotechnical investigation for the above referenced project. This report includes the results of field and laboratory testing, geotechnical design parameters, and recommendations pertaining to the proposed development.

We appreciate the opportunity to perform this geotechnical investigation and look forward to continued participation during the design and construction phases of this project. If you have any questions pertaining to this report, or if we may be of further service, please contact us at your convenience.

Very truly yours,
HTS, Inc. Consultants

Ashique Ahmed, Ph.D., P.E.
Project Engineer

STATE OF TEXAS
JUBAIR HOSSAIN
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LICENSED
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3-2-22

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REPORT
GEOTECHNICAL INVESTIGATION
PROPOSED RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS - 2018
PRECINCT 3
HARRIS COUNTY, TEXAS
UPIN# 19103MF14601

EXECUTIVE SUMMARY

This executive summary presents the primary findings, conclusions, and recommendations of the geotechnical investigation pertaining to the design and construction of the proposed detention basin as part of the Ravensway Subdivision Drainage Improvements Project – 2018 near Harris County Flood Control District (HCFCD) Unit K100-01-00 (Cypress Creek) in Harris County, Texas.

The proposed basin is located south of the existing HCFCD Unit K100-00-00, east of Huffmeister Road, and west of the existing Ravensway residential subdivision. The proposed detention basin area was heavily wooded with an approximate size of 10.5-acres and can be found in Key Map 368 Square K. The surface elevation of the natural ground within the area of the proposed development varies between Elv. +126 and Elv. +133 feet above MSL and the toe of the proposed basin at this location will be at about Elv. +110 feet above MSL. The toe elevation of the existing HCFCD Unit K100-00-00 located north of the proposed basin is approximately at Elv. +106 feet above MSL. HTS, Inc. Consultants (HTS) understands that the proposed development will include construction of a dry bottom detention basin as part of the Ravensway Subdivision Drainage Improvements Project – 2018. HTS also understands that outfall structures consisting of 42-inch pipe and concrete weir will be constructed as part of the proposed development.

The findings, conclusions, and recommendations of this geotechnical investigation are summarized below.

- **Subgrade Soil and Groundwater Conditions**
  Data from the 7 geotechnical borings for the current investigation drilled at the site of the proposed detention basin suggest that the upper 50 feet of overburden soils are composed of 8 separate soil layers. HTS has designated these 8 soil layers as Layers I through VIII. Descriptions of each soil layer are provided below:

  Layer I-A very loose to loose SILTY SAND (0 to 2 feet below existing ground surface),

  Layer I-B medium dense SANDY SILT (0 to 4 feet below existing ground surface),

  Layer II very stiff to hard SANDY LEAN CLAY (2 to 10 feet below existing ground surface),

Layer III loose to medium dense CLAYEY SAND (2 to 14 feet below existing ground surface),

Layer IV hard SANDY FAT CLAY (2 to 4 feet below existing ground surface),

Layer V-A medium dense to very dense SILTY SAND, POORLY GRADED SAND, POORLY GRADED SAND WITH SILT, and SILTY CLAYEY SAND (6 to 50 feet below existing ground surface),

Layer V-B SANDY SILT (23 to 28 feet below existing ground surface),

Layer VI-A firm to hard SANDY LEAN CLAY and LEAN CLAY WITH SAND (12 to 50 feet below existing ground surface),

Layer VI-B very stiff SILTY CLAY WITH SAND (23 to 28 feet below existing ground surface),

Layer VII medium dense to very dense CLAYEY SAND (16 to 38 feet below existing ground surface), and

Layer VIII very stiff to hard FAT CLAY and FAT CLAY WITH SAND (38 to 50 feet below existing ground surface).

During drilling, groundwater was encountered at depths ranging from 18.4 to 27.0 feet (Elevation +109.5 to +98.8 feet above MSL) beneath the existing ground surface in 3 of the 7 geotechnical borings. Approximately 24 hours after the completion of drilling, groundwater was measured at depths ranging from 11.7 to 18.0 feet (Elevation +120.5 to +110.2 feet above MSL) beneath the existing ground surface. Groundwater levels were measured in the piezometers (PZ-1 and PZ-2) which ranged from Elevation +106.1 to +119.3 feet above MSL. The water level data obtained between 1 and 4 weeks from the piezometers indicate that the groundwater level is around Elv. +106 feet above MSL.

- **Stability of Slopes of the Proposed Detention Basin**
  Stability analyses for the excavation of the proposed detention basin were performed using critical section slope configurations (Section A-A with 3.9H:1V and Section C-C with highest vertical height) with differing subsurface soil conditions defined by the geotechnical Boring Nos. 4 and 2, located near critical slope section within the proposed detention basin areas. The results of the analyses suggest that the proposed basin with a slope no steeper than 3.9 horizontal to 1 vertical (3.9H:1V) will be stable in the short term, long term, and rapid drawdown conditions with a 5-foot clay liner added to encapsulate exposed on-site dispersive soils on the side slopes and bottom of the pond.

- **Recommended Site and Subgrade Preparation for the Proposed Detention Basin**
  It is our understanding that the proposed basin will be excavated to a minimum elevation of about +109.08 feet above MSL which will expose Layers I through VI-A sandy/silty soils and dispersive sandy lean clay/lean clay with sand soils. The bottom of the excavation may be seated on Layer V sands/silt and/or Layer VI-A dispersive lean clay soils. Subgrade

preparation for the excavation of the embankment of the proposed basin is typically limited to excavating to the desired base elevation, verifying that a firm and stable base is present, and verifying that no evidence of seepage or raveling is present within the side slopes or bottom before erosion control is implemented. Detailed recommendations are provided in Section 1.4.2 of the report.

- **Suitability of Excavated Materials as Imported Select Fill**
  The results of the laboratory testing performed on the subsurface soils indicate that most of the soils encountered within the limits of the proposed basin depth do not meet the requirements for imported select fill material except for the Layer VI-A lean clay with sand encountered at depths between 14 to 18 feet (Elv +114.9 to +110.9 above MSL) near Boring No. 3. These materials can be used as fill material if it is non-dispersive in nature.

  However, Layer II and Layer VI-A sandy lean clay soils can be used as "fill material excavation on-site" as per Sub-Section 2.2 of Section 02314 titled "Fill Material" of the 2020 HCFCD Standard Specifications Book. If client intends to use these soils as fill material, HTS recommends performing additional testing during construction to verify dispersivity of the on-site excavated lean clay/sandy lean/lean clay with sand soils.

- **Lateral Earth Pressures**
  Below ground structures may be designed by using equivalent fluid pressures, earth pressure coefficients, and soil shear strength properties. Long term, effective stress, and shear strength parameters are provided in Section 1.4.4 of this report and should be used for the design of permanent underground structures.

- **Excavation Dewatering Requirements**
  During drilling, groundwater was encountered at depths ranging from 18.4 to 27.0 feet (Elevation +109.5 to +98.8 feet above MSL) beneath the existing ground surface in 3 of the 7 geotechnical borings. Approximately 24 hours after the completion of drilling, the water levels were measured at depths ranging from 11.7 to 18.0 feet (Elevation +120.5 to +110.2 feet above MSL) beneath the existing ground surface. Groundwater levels were measured in the piezometers (PZ-1 and PZ-2) which ranged from Elevation +106.1 to +119.3 feet above MSL. The water level data obtained at between 1 and 4 weeks from the piezometers indicates that the groundwater level is around Elv. +106 feet above MSL. Changes in groundwater conditions may occur with seasonal and climatic variations and these changes could result in wet conditions at the base of the excavations.

  It is our understanding that the proposed basin will be excavated to an elevation of about +109.08 feet above MSL. Therefore, it is not anticipated that groundwater will be encountered during the excavations. However, groundwater conditions may change due to seasonal and climatic variations and if perched water or groundwater seepage is present during the excavation operations and the exposed soil consist of Layer II and Layer VI lean clays, and Layer IV fat clays, the use of sumps and pumps may be used to dewatering water seepage entering the excavations.

If the exposed soils consist of the sands and silts and water is observed rising through the bottom of the excavations, more extensive groundwater efforts such as well points, vacuum well points, or any other suitable dewatering system may be required for groundwater dewatering of excavations. Care and control of groundwater and surface water during construction should be performed in accordance with Section 02241 titled "Care and Control of Water" from the 2020 HCFCD Standard Specifications Book.

This executive summary should not be used alone as a basis for design. The geotechnical report, which contains details of the findings, conclusions, and recommendations of the geotechnical study, should be read in its entirety and serve as the basis for design.

REPORT
GEOTECHNICAL INVESTIGATION
PROPOSED RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS - 2018
PRECINCT 3
HARRIS COUNTY, TEXAS
UPIN# 19103MF14601

1.0 INTRODUCTION AND SUMMARY

1.1 Introduction

This report presents the results of the geotechnical investigation pertaining to the design and construction activities associated with the construction of a detention basin as part of the Ravensway Subdivision Drainage Improvements Project – 2018 near Harris County Flood Control District (HCFCD) Unit K100-01-00 (Cypress Creek) in Harris County, Texas.

The detention basin is located south of the existing HCFCD Unit K100-00-00, east of Huffmeister Road, and west of the existing Ravensway residential subdivision. The proposed detention basin area is heavily wooded with an approximate size of 10.5-acres and can be found in Key Map 368 Square K.

This geotechnical investigation was performed by HTS, Inc. Consultants (HTS) for the Harris County Engineering Department (HCED) and LJA Engineering, Inc. (LJA) in accordance with HTS Proposal No. 21-05055 Revision 1 dated September 28, 2021 and authorization through email on October 18, 2021. The geotechnical investigation is conducted following the latest HCED and HCFCD geotechnical investigation guidelines.

The scope of work for this geotechnical investigation consisted of the following activities:

- Drilling and sampling a total of 7 geotechnical borings (Boring Nos. 1 through 7) to a depth of 50 feet beneath the surface within the area of the proposed detention basin (see Figure 2).

- Obtaining both disturbed and relatively undisturbed soil samples from the borings with continuous samples being taken from the ground surface to a depth of 20 feet and at 5-foot intervals thereafter.

- Measuring groundwater levels in the borings during drilling and within approximately 24 hours after the completion of drilling. In order to assure that accurate 24-hour water level measurements are obtained, the top of the borings were provided with protective cover in order to preclude surface water from entering the borings.

- Converting 2 borings (Boring Nos. 2 and 6) into piezometers to record long term water level readings in accordance with Item 3.2 of the HCFCD "Geotechnical Investigation Guidelines" dated October 2018.

- Measuring groundwater levels in the piezometers at 1 day, 1 week, 2 weeks, and 4 weeks after the installation of the piezometers.

- Backfilling the borings with soil cuttings after obtaining 24-hour groundwater level measurements.

- Performing geotechnical laboratory tests on soil samples recovered during drilling in order to properly classify the site soils, identify dispersive soils, develop engineering design parameters for use in our engineering analyses, and develop engineering design parameters that will support our conclusions and recommendations. Laboratory testing will include Atterberg limits tests, tests to determine percent soil finer than the No. 200 sieve, sieve analyses including hydrometer analyses, crumb tests, permeability tests, double hydrometer tests, unconfined compression tests, unconsolidated undrained triaxial tests, and consolidated undrained triaxial tests. Soil classification will be performed in strict accordance with ASTM D 2487.

- Preparing "GINT" boring logs based on the results of the laboratory tests and visual soil classifications.

- Characterizing the site subsoil and groundwater conditions and provide the results on both the boring logs and soil profiles.

- Determining the potential use of the excavated soils as fill material based on HCFCD requirements.

- Performing slope stability analyses in order to determine the stability of the side slopes of the proposed detention basin in the short-term, rapid drawdown, and long term conditions using subsoil parameters, peak and residual, derived from field and laboratory tests. Slope stability analyses was performed on sections defined by the geotechnical borings within the proposed detention basin. For our slope stability analyses, we determined the steepest stable side slopes for the proposed basin.

- Performing engineering analyses in order to determine the stability of the basin with regard to the ability of the site soils to adequately support the construction equipment during construction, evaluate the potential for bottom blowup at the basin as a result of the presence of high groundwater table, and suggest measures to adequately control groundwater during the construction operations and/or any needed treatments to provide for stable working surface during construction.

- Providing recommended subgrade preparation and construction requirements for the detention basin facilities.

- Developing and providing recommendations for appropriate methods for the proposed control structure at detention basin outfall as well as groundwater control during construction, measures to minimize ground movement during and after the construction operations, and design parameters and considerations for control structure including but not limited to bearing capacity,

earth pressure, and settlement analyses.

- Analyzing erosion potential as a result of water flow velocities, wave action, rainfall, runoff, and dispersive soils and provide erosion control recommendations, as needed, in accordance with Item 5.3 in the HCFCD "Geotechnical Investigation Guidelines" dated October 2018.

- Preparing a report in the format that contains the information as required by Part 6 of the October 2018 HCFCD "Geotechnical Investigation Guidelines". The report presents a description of the field investigation, laboratory test results, engineering analyses, the results of the analyses, and design recommendations as required by the work scope items described above. All engineering calculations that form the basis of the recommendations are included as an appendix to the report. HTS provided copies of the draft report for review. The final report will incorporate responses to the HCED's review comments on the draft report and will be submitted within 2 weeks upon receipt of the HCED's review comments. Both the draft and final reports will be sealed by a professional engineer licensed in the State of Texas. Electronic files of the project will be submitted to LJA and HCED after the completion of the project.

1.2 Description of Existing Site Conditions and Proposed Project

The proposed basin is located south of the existing HCFCD Unit K100-00-00, east of Huffmeister Road, and west of the existing Ravensway residential subdivision. The proposed detention basin area is heavily wooded with an approximate size of 10.5-acres and can be found in Key Map 368 Square K. The surface elevation of the natural ground within the area of the proposed development varies between Elv. +126 and Elv. +133 feet above MSL and the toe of the proposed basin at this location will be at about Elv. +110 feet above MSL. The toe elevation of the existing HCFCD Unit K100-00-00 located north of the proposed basin is approximately at Elv. +106 feet above MSL. HTS understands that the proposed development will include construction of a dry bottom detention basin as part of the Ravensway Subdivision Drainage Improvements Project – 2018. HTS also understands that outfall structures consisting of 42-inch pipe and concrete weir will be constructed as part of the proposed development.

1.3 Summary of Findings

The pertinent findings of this geotechnical investigation that pertains to the design and construction of the proposed detention basin construction are provided below.

1.3.1 Subsurface Soil Strata

The subsurface soil strata at the boring locations within the location of the proposed detention basin area are described:

- by the laboratory test results presented in Tables 1 through 4, and Figures 4 through 11,
- on the boring logs for Boring Nos. 1 through 7 in Appendix A, and
- on the soil profiles presented for Sections A-A through C-C in Figures 3A and 3B.

Data from the 7 geotechnical borings for the current investigation drilled at the site of the proposed detention basin suggest that the upper 50 feet of overburden soils are composed of 8 separate soil layers. HTS has designated these 8 soil layers as Layers I through VIII. Descriptions of each soil layer are provided below:

Layer	Depth * (ft.)	Elevation (ft. above MSL)	Soil Description
I-A	0 – 2	+134.3 to +125.9	SILTY SAND, very loose to loose, no plasticity, dark gray, gray, light gray, and tan, moist with small roots and clay pockets (encountered in Boring Nos. 1 through 5).
I-B	0 – 4	+125.8 to +121.6	SANDY SILT, medium dense, no plasticity, dark gray, gray, and light gray, moist with small roots and clay pockets (encountered in Boring Nos. 6 and 7 only).
II	2 – 10	+131.5 to +119.6	SANDY LEAN CLAY, very stiff to hard, slight to high plasticity, light gray, light tan, and reddish brown, moist with ferrous nodules (encountered in Boring Nos. 1, 6, and 7 only).
III	2 – 14	+132.3 to +118.9	CLAYEY SAND, loose to medium dense, slight to high plasticity, light gray, gray, and light tan, moist with ferrous nodules and silt pockets (encountered in Boring Nos. 2 through 5 and 7).
IV	2 – 4	+125.9 to +123.9	SANDY FAT CLAY, hard, very high plasticity, gray and tan, moist with ferrous nodules (encountered in Boring No. 5 only).
V-A	6 – 50	+124.3 to +75.8	SILTY SAND, POORLY GRADED SAND, POORLY GRADED SAND WITH SILT, and SILTY CLAYEY SAND, medium dense to very dense, no plasticity to slight plasticity, light gray and light tan, moist to wet with clay pockets and small pieces of gravel.
V-B	23 – 28	+102.6 to +97.6	SANDY SILT, no plasticity, light gray and light tan, wet with clay pockets (encountered in Boring No. 6 only).
VI-A	12 – 50	+118.3 to +78.9	SANDY LEAN CLAY and LEAN CLAY WITH SAND, firm to hard, slight to high plasticity, light gray, light tan, and reddish brown, moist with sand fissures and silt pockets (encountered in all borings except Boring No. 1).
VI-B	23 – 28	+105.9 to +100.9	SILTY CLAY WITH SAND, very stiff, slight plasticity, light gray, and light tan, moist (encountered in Boring No. 3 only).
VII	16 – 38	+114.3 to +89.9	CLAYEY SAND, medium dense to very dense, slight to medium plasticity, light gray and light tan, moist to wet with ferrous nodules (encountered in Boring Nos. 1, 4, and 5 only).

Layer	Depth * (ft.)	Elevation (ft. above MSL)	Soil Description
VIII	38 – 50	+87.6 to +80.3	FAT CLAY, FAT CLAY WITH SAND, and SANDY FAT CLAY, very stiff to hard, high to very high plasticity, reddish brown and light gray, moist with ferrous nodules and slickensides (encountered in Boring Nos. 1, 4, and 6 only).

* Measured below ground surface

Laboratory testing was performed on selected samples of the subsurface materials obtained to classify the soils in accordance with ASTM D 2487 and to define the engineering properties of the soils. Portions of the test results indicating the high and low values of specific testing are provided in the table below:

Layer	Depth (ft)	Liquid Limit (%)		Plasticity Index (%)		Moisture Content (%)		Passing No. 200 Sieve (%)		Shear Strength (tsf)	
		High	Low	High	Low	High	Low	High	Low	High	Low
I-A	0 – 2	NP				13.5	8.0	37.5	28.4	N/A	
I-B	0 – 4	NP				10.1	7.4	52.9	50.3	N/A	
II	2 – 10	44	22	26	9	14.7	10.2	57.0	54.4	1.7	
III	2 – 14	37	22	21	8	17.2	8.0	49.0	22.1	3.3	2.0
IV	2 – 4	63		41		16.5		53.2		2.7	
V-A	6 – 50	20	7	NP	NP	19.7	2.8	44.5	4.9	1.9	N/A
V-B	23 – 28	15		3		13.8		57.5		--	
VI-A	12 – 50	48	21	28	8	20.8	8.7	80.4	50.9	3.6	0.7
VI-B	23 – 28	18		6		14.2		75.6		--	
VII	16 – 38	26	22	11	8	17.1	7.5	46.0	34.2	--	
VIII	38 – 50	78	52	55	32	33.9	18.4	99.1	65.3	2.3	1.3

-- No sample was tested. N/A = Not Applicable for Disturbed Samples. NP = Non Plastic

<u>Crumb Testing on Clayey Soil Test Results</u>

Crumb testing, a test to determine dispersibility of clayey soils, was also performed on selected soil sample obtained from the field investigation. The result of the test is summarized below and is shown on the boring logs provided in Appendix A, as well as in Table 2.

Boring No.	Depth (ft.)	Soil Layer No.	Type of Material	Dispersion Characteristic
2	8 – 10	III	Clayey Sand (SC)	Grade 4 (Highly Dispersive)

Double Hydrometer Testing on Clayey Soil Test Results:

Double hydrometer, another test to determine dispersibility of clayey soils, was also performed on selected soil samples obtained from the field investigation. The results of the tests are summarized below and are shown on the boring logs provided in Appendix A, as well as in Figures 4A through 4C.

Boring No.	Depth (ft.)	Soil Layer No.	Type of Material	% Dispersion	Remarks	Reference (ASTM D 4221-18)
1	23 – 25	VII	Clayey Sand (SC)	86.6	Dispersive soil (dispersion > 55%)	< 30% = Nondispersive 30-50% = Intermediate > 50% = Dispersive
3	18 – 20	VI-A	Sandy Lean Clay (CL)	94.1	Dispersive soil (dispersion > 55%)	
5	4 – 6	III	Clayey Sand (SC)	80.0	Dispersive soil (dispersion > 55%)	

Particle Size Analysis Test Results

Selected samples of the site sands were also tested for particle size analysis per ASTM D-6913 and D-7928. A hydrometer test was performed on sandy soils to determine D_{10} value that may be required to estimate permeability of the sandy soil layers during dewatering operations, if needed. Additionally, D_{50} and D_{95} values are reported that may be required to design erosion control systems. Other required values can be obtained using the particle size distribution curves, provided in Figures 5 through 10.

Based on the results of the particle size analysis for the site sands, values of D_{10}, D_{50} and D_{95} were obtained and the results are as follows:

Boring No.	Depth (ft.)	Type of Material	D10 (mm)	D50 (mm)	D95 (mm)
6	2 – 4	Sandy Silt (ML)	0.005	0.075	0.190
6	10 – 12	Silty Sand (SM)	0.016	0.090	0.200
6	16 – 18	Silty Clayey Sand (SC-SM)	--*	0.086	0.245
6	23 – 25	Sandy Silt (ML)	0.0044	0.067	0.200
6	28 – 30	Silty Sand (SM)	0.0057	0.142	0.390
6	43 – 45	Sandy Lean Clay (CL)	--*	0.054	0.190

* *Value unavailable from particle size analysis test.*

Consolidated Undrained Triaxial Compression Test Results

For our slope stability analysis, consolidated undrained (CU) triaxial compression tests were performed on samples obtained at various depths from Boring No. 7. The test results are summarized below and shown in Figure 11.

Type of Material (Boring No., Depth)	LL	PI	Pass #200 Sieve (%)	Total Stress	Effective Stress
Sandy Lean Clay (Boring No. 7, 14' - 16')	32	16	55.6	C_{tot} = 380 psf $Ø_{tot}$ = 21°	C_{eff} = 330 psf $Ø_{eff}$ = 27.6°

1.3.2 Groundwater Conditions

The groundwater depths were measured when encountered during drilling, approximately 10 minutes after the groundwater was encountered, and within 24 hours after drilling operations were complete. The following table presents the results of the groundwater measurements:

BORING NO.	TOTAL DEPTH OF BORING (FT.)	ELEV. OF TOP OF BORING (FT-ABOVE MSL)	DEPTH TO WATER DURING DRILLING (FT.)*	ELEV. OF WATER LEVEL DURING DRILLING (FT-ABOVE MSL)	DEPTH TO WATER APPROX. 24 HOURS AFTER DRILLING (FT.)	ELEV. OF WATER LEVEL APPROX. 24 HOURS AFTER DRILLING (FT-ABOVE MSL)**
1	50	+133.5	--*	--*	14.1	+119.4
2	50	+134.3	--*	--*	13.8	+120.5
3	50	+128.9	--*	--*	18.0	+110.9
4	50	+130.3	--*	--*	17.1	+113.2
5	50	+127.9	18.4	+109.5	11.7	+116.2
6	50	+125.6	23.0	+102.6	13.0	+112.6
7	50	+125.8	27.0	+98.8	15.6	+110.2

* *Depths are referenced from the existing ground surface elevation at the time the borings were drilled.*

** *GW was encountered prior to introduction of drilling fluid.*

1.3.3 Groundwater Levels in the Piezometers

Piezometers (identified as PZ-1 and PZ-2) were installed at 2 different boring locations (Boring Nos. 2 and 6, respectively) to define groundwater level conditions in a longer period of time. As of this report, the water levels were measured at 4 different occasions and the results are as provided below.

AFTER THE PIEZOMETER INSTALLATION	PZ-1 (BORING NO. 2) (+137.3' ABOVE MSL WITH 3 FT OF STICKUP)		PZ-2 (BORING NO. 6) (+128.6' ABOVE MSL WITH 3 FT OF STICKUP)	
	DTW*	Elev.	DTW*	Elev.
After Installation (11/13/2021)	18.0	+116.3	23.9	+101.7
1 Day (11/14/2021)	15.0	+119.3	20.9	+104.7
1 Week (11/22/2021)	28.0	+106.3	19.2	+106.4
2 Week (11/29/2021)	28.2	+106.1	19.4	+106.2
4 Week (12/13/2021)	19.6	+114.7	22.6	+103

* Depth to water measured below the existing ground surface.

Piezometer Installation Diagrams are shown in Appendix B.

1.3.4 Geology

As per USGS Texas Pocket Geology, the geologic unit of primary interest at the proposed site is the Lissie Formation. The Lissie Formation is unconformably contained between the Goliad Sand and the overlying Beaumont Clay. The Lissie Formation crops out in a band parallel to the coast and is about 30 miles wide from the Sabine River to the Rio Grande. The sediments of the Lissie Formation in the outcrop are partly continental deposits laid down on flood plains and partly delta sands, silts, and mud at the mouth of rivers. The Lissie Formation hosts flatter, gently undulating topography, and has much lower-dipping beds than the Goliad Sand. Lissie Formation sediments consist of reddish, orange, and gray fine-to-coarse grained, cross-bedded sands.

1.3.5 Geologic Fault Assessment

Based on the desktop review of published and proprietary records on surface faults in the location of the proposed development, the closest known faults to the project site are a group of faults (including Brittmore, Woodland Tails, White Oak, and other faults) near Jersey Village, Texas, located approximately 8.0 miles southeast of the project site.

1.3.6 Environmental Concern

There were no environmental concerns evident during field investigation for this project.

1.3.7 Slope Stability Analyses Assumptions and Safety Factor Design Requirements

Slope stability analyses for this project was performed using the subsoil profiles defined by 7 geotechnical borings (Boring Nos. 1 through 7) within the proposed detention basin location and 4 section configurations (see LJA provided drawings, presented in Appendix C) for the proposed excavation. For slope stability analyses, critical Section A-A associated with Boring No. 2 and Section C-C with highest vertical height associated with Boring No. 4 were used.

As required by the HCFCD, the minimum acceptable factors of safety against slope stability failures used for basin side slope design purposes are provided in the following table:

MINIMUM ACCEPTABLE FACTORS OF SAFETY	
Condition	**Factor of Safety**
Short Term Condition (End of Construction)	1.30
Intermediate Condition (Rapid Drawdown)	1.25
Long Term Condition	1.50

Soil Parameters Used in Slope Stability Analyses – For our slope stability, we have developed soil parameters based on laboratory/field test data and established references.

The short term shear strengths of the clays/cohesive soils are based on the shear strength parameters from unconsolidated undrained (UU) triaxial tests and unconfined compression tests performed for the current study. The short term values of angle of internal friction of sands/silts/cohesionless soils are based on the corresponding values obtained from field standard penetration tests and correlations from established references. Parameter selection calculations with referenced figures are shown in Appendix D.

The shear strengths parameters used for long term and rapid drawdown analyses are obtained primarily from consolidated undrained (CU) triaxial tests. In the absence of a CU test, the shear strength values are estimated from published correlations with Atterberg limits and soil type present. Parameter selection calculations with referenced figures are shown in Appendix D.

Given below is a table of the short term, intermediate term, and long term parameters used for the various layers of the subsurface soils.

SECTION C-C with Boring No. 2						
Depth	**Type of Material In Layer**	**Moist Density (pcf.)**	**Short Term Parameters**	**Long Term Parameters**	**Rapid Drawdown Condition Parameters**	
					Total	**Effective**
0 – 2	Silty Sand	115.0	C = 0 psf φ = 29.5°	C = 0 psf φ = 29.5°	C = 0 psf φ = 29.5°	
2 – 10	Clayey Sand	138.4	C = 0 psf φ = 30°	C = 0 psf φ = 30°	C = 0 psf φ = 30°	
10 – 23	Poorly Graded Sand With Silt	125.0	C = 0 psf φ = 33°	C = 0 psf φ = 33°	C = 0 psf φ = 33°	
23 – 28	Sandy Lean Clay	136.7	C =1,000 psf φ = 0°	C = 330 psf φ = 25°	C = 380 psf φ = 21°	C = 330 psf φ = 25°
28 – 50	Lean Clay With Sand	142.0	C =2,000 psf φ = 0°	C = 280 psf φ = 23.0°	C = 330 psf φ = 20°	C = 280 psf φ = 23.0°

SECTION A-A with Boring No. 4						
Depth	**Type of Material In Layer**	**Moist Density (pcf.)**	**Short Term Parameters**	**Long Term Parameters**	**Rapid Drawdown Condition Parameters**	
					Total	**Effective**
0 – 2	Silty Sand	115.0	C = 0 psf φ = 29.5°	C = 0 psf φ = 29.5°	C = 0 psf φ = 29.5°	
2 – 8	Clayey Sand	137.2	C = 0 psf φ = 30°	C = 0 psf φ = 30°	C = 0 psf φ = 30°	
8 – 12	Silty Sand	125.0	C = 0 psf φ = 33°	C = 0 psf φ = 33°	C = 0 psf φ = 33°	
12 – 16	Sandy Lean Clay	136.7	C =1,000 psf φ = 0°	C = 330 psf φ = 25°	C = 380 psf φ = 21°	C = 330 psf φ = 25°
16 – 18	Clayey Sand	136.1	C = 0 psf φ = 33°	C = 0 psf φ = 33°	C = 0 psf φ = 33°	
18 – 43	Silty Sand	120.0	C = 0 psf φ = 36°	C = 0 psf φ = 36°	C = 0 psf φ = 36°	
43 – 50	Fat Clay With Sand/Sandy Fat clay	128.9	C =2,000 psf φ = 0°	C = 230 psf φ = 19.0°	C = 270 psf φ = 15°	C = 230 psf φ = 19.0°

Due to presence of dispersive soils on the crest, side slope, and at the bottom of the slope, slope stability conditions were checked for stability with 5.0 feet clay liner added as per recommendations provided in Section 1.4.2. The clay liner properties used are shown below:

CLAY LINER				
Moist Density (pcf.)	Short Term Parameters	Long Term Parameters	Rapid Drawdown Condition Parameters	
			Total	Effective
125.0	C = 1000 psf φ = 0°	C = 270 psf φ = 24°	C = 300 psf φ = 18°	C = 270 psf φ = 24°

Calculations pertaining to the selection of soil parameters for slope stability analyses in the short term, intermediate term, and long term conditions are shown in Appendix D.

The results of the slope stability analyses for the provided section configurations, as described above, are shown in Appendix E, and are discussed in detail in the following section.

1.3.8 Slope Stability Analyses Results

Slope stability analyses were performed as per sections provided by LJA with assumptions and parameters presented in Section 1.3.7. The results of these analyses are shown below and in Appendix E (Plates E-1 through E-20). Corresponding reports are attached in Appendix F (Reports F-1 through F-20).

CONDITIONS	FACTOR OF SAFETY – GLOBAL SLIDE		FACTOR OF SAFETY – LOCAL SLIDE	
	Boring No. 4 and Section A-A	Boring No. 2 and Section C-C	Boring No. 4 and Section A-A	Boring No. 2 and Section C-C
Short Term Condition with Water From Top to Along the Slope	1.89	2.47	2.39	2.42
Short Term Condition with Water at Bottom of the Slope	2.83	3.08	3.43	3.56
Long Term Condition	2.72	2.37	2.92	2.50
Rapid Drawdown Condition with Total Soil Parameters	1.83	1.85	1.88	1.72
Rapid Drawdown Condition with Effective Soil Parameters	1.82	1.79	1.89	1.74

The results of the stability analyses, as shown above, suggest that the slopes of the section configurations provided by LJA will be stable with a clay liner (in accordance with the recommendations presented in Section 1.4.2) in the short term, rapid drawdown, and long term conditions.

1.4 Summary of Recommendations

The recommendations, as summarized below, are provided for use in the design and construction of the proposed detention basin in Harris County, Texas.

1.4.1 Suitability of Excavated Materials

The following table presents the various soil layers (types) and the suitability of these soils as fill material in accordance with the requirements of Section 02314 titled "Fill Material" of the 2020 HCFCD Standard Specifications Book.

SUITABILITY OF EXCAVATED MATERIALS					
LAYER	DEPTH	ELEVATION ABOVE MSL (FT.)	BORING NO.	SOIL TYPE	IMPORTED FILL MATERIAL PER HCFCD SPECIFICATION SECTION 02314
I-A	0 – 2	+134.3 to +125.9	1 through 5	SILTY SAND	Not Suitable
I-B	0 – 4	+125.8 to +121.6	6 and 7	SANDY SILT	Not Suitable
II	2 – 10	+131.5 to +119.6	1, 6, and 7	SANDY LEAN CLAY	Not Suitable due to -200 value being less than 60%
III	2 – 14	+132.3 to +118.9	2 through 5	CLAYEY SAND	Not Suitable
IV	2 – 4	+125.9 to +123.9	5	SANDY FAT CLAY	Not Suitable
V-A	6 – 50	+124.3 to +75.8	1 through 7	SILTY SAND, POORLY GRADED SAND, POORLY GRADED SAND WITH SILT, and SILTY CLAYEY SAND	Not Suitable
V-B	23 – 28	+102.6 to +97.6	6	SANDY SILT	Not Suitable
VI-A	12 – 50	+118.3 to +78.9	2 through 7	SANDY LEAN CLAY and LEAN CLAY WITH SAND	Not Suitable except for one sample obtained between 14' -18' in Boring No. 3
VI-B	23 – 28	+105.9 to +100.9	3	SILTY CLAY WITH SAND	Not expected to excavate

SUITABILITY OF EXCAVATED MATERIALS					
LAYER	**DEPTH**	**ELEVATION ABOVE MSL (FT.)**	**BORING NO.**	**SOIL TYPE**	**IMPORTED FILL MATERIAL PER HCFCD SPECIFICATION SECTION 02314**
VII	16 – 38	+114.3 to +89.9	1 and 5	CLAYEY SAND	Not expected to excavate
VIII	38 – 50	+87.6 to +80.3	1, 4, and 6	FAT CLAY and FAT CLAY WITH SAND	Not excavated to excavate

As per Section 02314 titled "Imported Select Fill Material" from the 2020 HCFCD Standard Specifications Book, the imported select fill material should have the following engineering properties:

- maximum liquid limit (ASTM D 4318) of 45%,
- plasticity index (ASTM D 4318) not less than 12% and not more than 30%,
- percent soil particles passing the No. 200 sieve (ASTM D 1140) not less than 60% and not more than 85%, and
- fill materials should be non-dispersive (ND1 or ND2 as per ASTM D4647).

As per Section 02314 titled "Fill Material Excavation On-Site" from the 2020 HCFCD Standard Specifications Book, the fill material should be the soils categorized as CL soils (sandy lean clay, lean clay with sand, and lean clay).

Imported select fill material should be free of organic matter or other deleterious substances. Imported select fill material should only be obtained from on-site soils or borrow sources that have been evaluated with regard to their suitability. Borrow sources should be utilized only as approved by the HCFCD.

Laboratory tests were performed on selected soil samples from the geotechnical borings to determine the physical properties of the site soils and aid in the soil classification. The results of these tests were also used to qualify the soils as suitable earth fill per Section 02314 of the 2020 HCFCD Standard Specifications Book. The results of our evaluations on the Layers II and VI-A lean clays are as follows:

- Layer II Sandy Lean Clays – Laboratory tests revealed that plasticity indices and percent particle passing No. 200 sieve does not satisfy the imported fill

requirements. Based on these test results, it could be concluded that all of the Layer II sandy lean clays are not suitable as imported select fill material.

- Layer VI-A Sandy Lean Clays/Lean Clay with Sands – Dispersion tests indicated that the Layer VI-A sandy lean clays are more than 55% dispersive in accordance with Double Hydrometer testing. Laboratory tests revealed only few samples (collected with 14 to 18 feet below existing ground surface in Boring No. 3 location) tested exhibited plasticity indices that satisfy the plasticity index range of 12 to 30 and % passing No. 200 sieve values of required range of 60 to 85%. Based on these test results, it could be concluded that the site Layer VI-A sandy lean clays are not suitable as imported select fill material. Layer VI-A lean clay from near Boring No. 3 location can be used as fill material if it is non-dispersive in nature.

However, Layer II and Layer VI-A sandy lean clay soils can be used as "fill material excavation on-site" as per Sub-Section 2.2 of Section 02314 titled "Fill Material" of the 2020 HCFCD Standard Specifications Book. If client intends to use these soils as fill material, HTS recommends performing additional testing during construction to verify dispersivity of the on-site excavated lean clay/sandy lean/lean clay with sand soils.

Earth fill placement and compaction should comply with the requirements of Section 02315 titled "Excavating and Backfilling" from the 2020 HCFCD Standard Specifications Book.

1.4.2 Recommended Site and Subgrade Preparation for the Proposed Detention Basin

It is our understanding that the proposed basin will be excavated to a minimum elevation of about +109.08 feet above MSL. As shown in Figures 3A and 3B, excavating to that depth will expose Layers I through VI-A as shown in the Table below:

Boring No.	Bottom of the Excavation/Elevation Above MSL (FT.)	Exposed Soil Layers at Side Slope	Exposed Soil Layer at Bottom
1	109.08	Silty Sand, Sandy Lean Clay, Poorly Graded Sand With Silt, and Silty Sand	Clayey Sand
2		Silty Sand, Clayey Sand, Poorly Graded Sand, and Sandy Lean Clay	Sandy Lean Clay
3		Silty Sand, Clayey Sand, Poorly Graded Sand With Silt, Lean Clay With Sand, and Sandy Lean Clay	Sandy Lean Clay

Boring No.	Bottom of the Excavation/Elevation Above MSL (FT.)	Exposed Soil Layers at Side Slope	Exposed Soil Layer at Bottom
4	109.08	Silty Sand, Clayey Sand, and Sandy Lean Clayey Sand	Silty Sand
5		Silty Sand, Sandy Fat Clay, Clayey Sand, and Sandy Lean Clay	Sandy Lean Clay
6		Sandy Silt, Sandy Lean Clay, Silty Sand, Silty Clayey Sand	Silty Clayey Sand
7		Sandy Silt, Sandy Lean Clay, Clayey Sand, and Sandy Lean Clay	Sandy Lean Clay

The exposed soils on the side slope and bottom are mostly dispersive sandy soils and Sandy Lean Clays. These sandy lean clays showed dispersive characteristics as shown in double hydrometer test results for Boring No. 3 in Section 1.3.1.

Subgrade preparation for the excavations of the proposed basin is typically limited to excavating to the desired base elevation, verifying that a firm and stable base is present, and verifying that no evidence of seepage or raveling is present within the side slopes or bottom before erosion control is implemented. Recommendations presented herein address subgrade preparation that will be needed before erosion control elements are implemented. Additional subgrade preparation will be needed based on the erosion control methods implemented in the design. Subgrade preparation should include the following procedures:

- Establish site drainage and install storm water drainage structures, if required to provide drainage away from the project area.

- Excavate the site in situ soils as necessary to achieve the desired final grade.

Fill material should comply with the requirements and guidelines of Section 02314 titled "Fill Material" and be placed/compacted in accordance with Section 02315 titled "Excavating and Backfilling" of the 2020 HCFCD Standard Specifications Book.

Depending on weather conditions, difficulty may be encountered in adequately densifying/compacting the surficial soils. If the surficial soils are unsuitably wet, excess pore pressures ("pumping") may develop and excess displacement of the subgrade soils may occur during site preparation. If the site subgrade soils become unsuitably wet, the construction contractor should:

- dry the soils to within ± 2% of the optimum moisture content by discing these materials,

- dry the soils by blending a stabilizing agent (lime or fly ash) with the unsuitably wet soil, or

- remove the unsuitably wet soils and replace with properly compacted suitable earth fill having an acceptable moisture content.

As discussed earlier in this section, the Layers I through VI-A sands/silts and dispersive lean clay soils which will be exposed during construction, have relatively high permeabilities and are highly erosive soils and these soils may become unstable when wet that may trigger slope stability failure. Therefore, it is recommended that these soils be overexcavated by at least 5 feet which is measured perpendicular to the exposed surface and replaced with suitable fill materials that satisfy the requirements provided in Section 02314 titled "Fill Material" and placed/ compacted in accordance with Section 02315 titled "Excavating and Backfilling" of the 2020 HCFCD Standard Specifications Book. The over-excavation and replacement procedure should extend to a width of at least 10 feet beyond the toe and crest of the slopes.

Alternatively, it is recommended that these soils be protected using 1-foot thick riprap and geotextile lining combined with 6 inch of top soil. The top soil should be vegetated immediately according to Section 02925 titled "Hydromulch-Hydroseeding", of the 2020 HCFCD Standard Specifications Book.

Materials and placement of riprap with geotextile lining and top soil should comply with the requirements of Section 02379 titled "Geotextiles for Erosion Control Systems", Section 02378 titled "Riprap and Granular Fill", Section 02911 titled "Top Soil" respectively, of the 2020 HCFCD Standard Specifications Book.

1.4.3 Additional Considerations for Slope Stability

The slope stability analyses discussed in Section 1.3.8 did not consider the potential slope instability that may occur because of the presence of erosive soils (i.e., the Layer I through VI-A sands/silts and sandy lean clay) at the project site, especially Layer V sands/silts may lie near the toe of the basin. Erosion of the Layer V sands/silts may result in the loss of support at the toe of the slopes and the progressive failure of the slopes. In order to preclude instability due to the erosion/loss at the toes of the side slopes, it will be necessary to provide slope protection over the surface of the basin side slopes and be extended beyond the toe and crest of the slopes as recommended in Section 1.4.2.

1.4.4 Recommended Earth Pressure Design Parameters for Design of Below Ground Structures

Outfall Structures (RCB and RCP) and other below ground/earth retaining structures may be built as part of the project. These structures should be designed as earth retaining structures. The following recommendations are for typical earth retaining structures constructed with backfill behind the structures.

The earth pressure on the structures depends on the extent, degree of compaction, and the type of backfill that will be placed behind the wall or around the structure. The equivalent fluid pressure values for various backfill material types based on in-situ soil present are shown in the table below. The following table shows active, at rest, and passive earth pressure coefficients. Active earth pressure condition is applicable if horizontal movement can occur along the structure height. If the structures are restrained at the top, at-rest earth pressure condition is applicable.

- The equivalent fluid pressure values shown in the below table are applicable for horizontal backfill surface. Also, the values are applicable if the backfill behind the walls/structures extend to a minimum distance equal to the wall height. For sloping backfill, the lateral earth pressure values could be significantly different.

- The earth pressure values for the above water table condition correspond to the total unit weight of soil and the earth pressure values for the below water table condition correspond to the buoyant or submerged unit weight of soil.

- Any additional lateral loads due to surcharge and live loads should also be included in the design. A minimum uniform surcharge pressure of 250 psf should be included in the design for the pavement and traffic loads. The lateral pressure on the wall due a uniform surcharge load can be taken as earth pressure coefficient values shown in the table multiplied by the surcharge pressure.

- Drainage systems should be provided to collect/remove water and to prevent hydrostatic pressure on the walls. If provisions to prevent accumulation of water behind the walls are not provided, the walls should be designed to resist the hydrostatic head in addition to the buoyant lateral earth pressures. The hydrostatic pressures should be accounted for the full height of the wall.

- Placement and compaction of backfill materials in layers alongside a vertical structure tend to produce greater at-rest pressures than uncompacted fill and natural deposits. Lateral pressures change gradually in accordance with wall movement and reach the full active or passive condition only when adequate movement occurs. For compacted backfill material at-rest earth pressure should be considered for the design of the wall.

Equivalent Fluid Pressures for soils above RCB and RCP near Boring Nos. 4 and 6 (Pounds per Square Foot per Foot of Wall Height)				
Type of Properly Compacted Backfill Behind the Retaining System Soil Parameters	**Active Condition (Horizontal Backfill)**		**At Rest Condition (Horizontal Backfill)**	
	Above W.T.	**Below W.T.**	**Above W.T.**	**Below W.T.**
Select Fill Wet unit weight of 125 pcf, Effective Cohesion (c') of 0 psf and Effective Friction Angle (φ') of 25°	51	25	72	36
Silty Sands/Clayey Sands/Silty Clayey Sands/Silts (Encountered up to an elevation of 108.0 feet above MSL) Moist unit weight of 125 pcf, Effective Cohesion (c') of 0 psf and Effective Friction Angle (φ') of 30°	42	21	62	31
Sandy Lean Clay (Encountered up to an elevation of 108.0 feet above MSL) Moist unit weight of 136.7 pcf, Effective Cohesion (c') of 0 psf and Effective Friction Angle (φ') of 25°	55	30	79	43

Notes: (W.T.): Water Table

a) *Buoyant lateral earth equivalent fluid pressures; does not include the hydrostatic fluid weight effect of 62.4 pcf (Pertains to Below W.T. only)*
b) *Values provided assume that the materials are compacted to at least 95 percent of the Standard Proctor maximum dry density (ASTM D 698) within 3 percentage points of the optimum moisture content.*
c) *If granular soils are used, a minimum of 2 feet of clay should be placed over the granular soils.*

Lateral Earth Pressure Coefficients For Soils above RCB and RCP near Boring Nos. 4 and 6			
Type of Properly Compacted Backfill Behind the Retaining System Soil Parameters	**Active Condition (Horizontal Backfill)**	**At-Rest Condition (Horizontal Backfill)**	**Passive Condition (Horizontal Backfill)**
Select Fill Wet unit weight of 125 pcf, Effective Cohesion (c') of 0 psf and Effective Friction Angle (φ') of 25°	0.41	0.58	2.46
Silty Sands/Clayey Sands (Encountered up to an elevation of 108.0 feet above MSL) Moist unit weight of 125 pcf, Effective Cohesion (c') of 0 psf and Effective Friction Angle (φ') of 30°	0.33	0.50	3.00
Sandy Lean Clay (Encountered up to an elevation of 108.0 feet above MSL) Moist unit weight of 136.7 pcf, Effective Cohesion (c') of 0 psf and Effective Friction Angle (φ') of 25°	0.41	0.58	2.46

Note: Values provided assume that the materials are compacted to at least 95% of the Standard Proctor maximum dry density (ASTM D 698), within 3 percentage points of the optimum moisture content.

The weights of equivalent fluid for the passive case and the passive earth pressure coefficients shown above do not include a safety factor. It is recommended that for design purposes, a factor of safety of 2 be applied to the weights of equivalent fluid for the passive case and the passive earth pressure coefficients.

1.4.5 Temporary Bracing for Open Cut Excavations

The contractor should ensure designing and constructing stable protection systems for excavations such as support systems, sloping and benching systems, shield systems, and other systems that provide protection.

Temporary special shoring, for use in the installation of structures or utilities that will require excavations deeper than 5 feet, should consist of vertical or sloped cuts, benches, shields, support systems, or other systems that will provide necessary protection in accordance with OSHA Standards and Interpretations, 29 CFR 1926, Subpart P, "Excavations".

If OSHA Standards and Interpretations, 29 CFR 1926, Subpart P, "Excavations" is used for the design of temporary excavation protection systems, the clay layers should be categorized as Type B soils while the silty clays/sands/silts should be categorized as Type C soils. The definitions of Type B and Type C soils are provided in Appendix A of the OSHA Standards and Interpretations, 29 CFR 1926, Subpart P, "Excavations". In order to eliminate the potential for caving of trench excavations, trench safety shall be implemented for trench excavations that are deeper than 5 feet.

1.4.6 Computation of Bracing Pressures for Temporary Structures

Lateral pressures resulting from construction equipment, traffic loads, or other surcharge loads should be taken into account by adding the equivalent uniformly distributed surcharge to the design lateral pressures. Hydrostatic pressure, if any, should also be considered. The active earth pressure at depth z can be determined by Equation (1) as provided below and using the soil parameters presented in Section 1.4.4.

$$p_a = (q_s + \gamma h_1 + \gamma' h_2)\, K_a + \gamma_w h_2 \qquad \text{Equation (1)}$$

where,

p_a	=	active earth pressure, psf
q_s	=	uniform surcharge pressure, minimum 250 psf
γ, γ'	=	wet unit weight and buoyant unit weight of soil
h_1	=	depth from ground surface to groundwater table
h_2	=	$z-h_1$, depth from groundwater table to the point under consideration
z	=	depth below ground surface for the point under consideration
K_a	=	coefficient of active earth pressure
γ_w	=	unit weight of water, 62.4 pcf

If there is water behind the bracing, hydrostatic pressure should be included in the design. If excavations are located close to existing structures, we recommend using the coefficient of at-rest earth pressure (K_0) for design instead of the use of active earth pressure coefficient (K_a) to reduce the potential for distress to the existing structures.

1.4.7 Excavation Dewatering Requirements

During drilling, groundwater was encountered at depths ranging from 18.4 to 27.0 feet (Elevation +109.5 to +98.8 feet above MSL) beneath the existing ground surface in 3 of the 7 geotechnical borings. Approximately 24 hours after the completion of drilling, the water levels were measured at depths ranging from 11.7 to 18.0 feet (Elevation +120.5 to +110.2 feet above MSL) beneath the existing ground surface. Groundwater levels were measured in the piezometers (PZ-1 and PZ-2) which ranged from Elevation +106.1 to +119.3 feet above MSL. The water level data obtained at between 1 and 4 weeks from the piezometers indicates that the groundwater level is around Elv. +106 feet above MSL. Changes in groundwater conditions may occur with seasonal and climatic variations and these changes could result in wet conditions at the base of the excavations.

It is our understanding that the proposed basin will be excavated to an elevation of about +109.08 feet above MSL. Therefore, it is not anticipated that groundwater will be encountered during the excavations. However, groundwater conditions may change due to seasonal and climatic variations and if perched water or groundwater seepage is present during the excavation operations and the exposed soil consist of Layer II and Layer VI lean clays, and Layer IV fat clays, the use of sumps and pumps may be used to dewatering water seepage entering the excavations.

If the exposed soils consist of the sands and silts and water is observed rising through the bottom of the excavations, more extensive groundwater efforts such as well points, vacuum well points, or any other suitable dewatering system may be required for groundwater dewatering of excavations. Care and control of groundwater and surface water during construction should be performed in accordance with Section 02241 titled "Care and Control of Water" from the 2020 HCFCD Standard Specifications Book.

1.4.8 Storm Sewer Design and Bedding Requirements

The provided drawings show that a 42-inch diameter reinforced concrete pipe (RCP) outfall near the HCFCD Unit No. K100-00-00 (see Section C-C attached in Appendix C) and a reinforced concrete box (RCB) outfall structure (see Section D-D attached in Appendix C) will be constructed as part of the proposed detention basin. HTS understands that these structures will be installed using open cut excavations. Storm sewers may be designed by using conventional conduit formulas and assuming a negative projection condition for computation of loadings.

The total load on storm sewers will consist of the weight of the compacted backfill above the pipe, the weight of the pavement, and live loadings where applicable.

Earthwork should conform to applicable provisions of Section 02316 titled "Structural Excavation and Backfilling", Section 02611 titled "Reinforced Concrete Pipe", and Section 02631 titled "Storm Sewers and Outfalls" from the 2020 HCFCD Standard Specifications Book.

The following items should be designed and performed in accordance with the applicable requirements of Section 02316 titled "Structural Excavating and Backfilling" and Section 02631 titled "Storm Sewers and Outfalls" of the 2020 HCFCD Standard Specifications Book:

- Trench widths for storm sewer excavations.
- Trench foundation preparation prior to storm sewer installation.
- Bedding requirements for storm sewers.
- Backfill materials and placement.

1.4.9 Design Parameters and Considerations for Box Culvert Outfall (RCB)

HTS understands that the proposed 6-foot by 5-foot RCB outfall structure will be founded at about an Elevation between +109.5 and +111.5 feet above MSL, and will be located on the east side of the detention basin (see Appendix C).

Bearing Capacity and Settlement

It is anticipated that the founding materials for the box culverts at these depths will be the silty sandy or sandy soils. The box culverts should be designed for maximum allowable net bearing pressures of 4,000 psf for axial compression dead loads plus sustained live loads and 6,000 psf for axial compression dead loads plus sustained and transient live loads.

The above values consider a safety factor of at least 3 and 2, respectively, against a bearing capacity failure.

Utilizing the design criteria provided herein, the total settlement of the precast reinforced concrete box culvert should be less than 1-inch.

A sliding co-efficient of 0.45 should be used for the box culverts seated on the site sands. A recommended factor of safety of at least 1.5 and 2.0 against sliding and overturning or tipping, respectively, should be used for the proposed box culvert to be stable and be capable of resisting the potential for sliding and overturning or tipping.

Installation of the box culvert should be in accordance with 2005 HCFCD standard Specifications Book Sections 02612 titled "Precast Reinforced Concrete Box", 02631 titled "Storm Sewers and Outfalls", and 02321 titled "Cement Stabilized Sand".

Erosion Protection of Box Culverts

The head and tail of the culverts should be protected from erosion if founded on sand layers, which is expected based on soil layers encountered Boring Nos. 4 and 6 at an elevation between +109.5 and +111.5 feet above MSL.

Ideally the rip rap toe should be trenched below the depth of potential for riprap degradation and contraction scour to mitigate the potential for undermining of the riprap toe due to wave action or flow at the siphon intake/discharge structure areas. The riprap should also be underlain by a geotextile filter fabric to prevent the underlying soils from moving into or through the riprap. Riprap with geotextile lining should comply with the requirements of Section 02379 titled "Geotextiles for Erosion Control Systems" and Section 02378 titled "Riprap and Granular Fill", of the 2020 HCFCD Standard Specifications Book.

1.4.10 Design Considerations for Weir

HTS understands that a weir with 5-inch concrete lining will be constructed near the HCFCD Unit No. K100-00-00 (see Appendix C) with a 5H:1V side slope. The bottom of the proposed weir will be at an elevation of +126.31 feet above MSL and the crest of the weir will be at an elevation of +127.95 feet above MSL.

The head and tail of the weir should be protected from erosion due to presence of erosive sandy soil at the weir location using geotextile and riprap. Ideally the rip rap toe should be trenched below the depth of potential for riprap degradation and contraction scour to mitigate the potential for undermining of the riprap toe due to wave action or flow at the siphon intake/discharge structure areas. The riprap should also be underlain by a geotextile filter fabric to prevent the underlying soils from moving into or through the riprap. Riprap with geotextile lining should comply with the requirements of Section 02379 titled "Geotextiles for Erosion Control Systems" and Section 02378 titled "Riprap and Granular Fill", of the 2020 HCFCD Standard Specifications Book.

1.4.11 Design Recommendation For All Weather Access Path

HTS understands that an all-weather access path will be constructed around the entire detention pond. This access path should be constructed with crushed limestone or concrete paving as recommended in Section 16.3.5 of Policy Criteria & Procedure Manuel (PCPM) by HCFCD, dated October 2018.

2.0 FIELD INVESTIGATION

2.1 Subsurface Investigation

For this geotechnical investigation, a total of 7 geotechnical borings (Borings Nos. 1 through 7) were drilled and sampled between October 25 and 30, 2021 at the locations shown in Figure 2. The boring locations, as shown in Figure 2, were selected and located/staked in the field by HTS during drilling. Drilling, sampling, and testing were performed in accordance with applicable ASTM procedures using conventional auger and wet rotary drilling methods. After the drilling of the borings was complete, the boring locations were staked with stakes that extend at least 3 feet above the ground surface, survey flaggings were tied near the top of the stakes, and the stakes were marked with each boring number. GPS coordinates of the boring locations were also obtained in case any of the stakes are missing. The depths, approximate ground elevations, as well as their co-ordinates, are shown in the table below.

SUMMARY OF SOIL BORINGS				
BORING NO.	TOTAL DEPTH OF BORING (FT.)	APPROXIMATE SURFACE ELEVATION ABOVE MSL (FEET)	STATE PLANE EASTING, X (SURVEYED) (FEET)	STATE PLANE NORTHING, Y (SURVEYED) (FEET)
1	50	133.5100	3035989.024	13911915.733
2	50	134.2820	3035611.911	13911871.511
3	50	128.8570	3035291.365	13911849.134
4	50	130.2890	3035721.66	13912124.288
5	50	127.9120	3035313.449	13912059.971
6	50	125.6420	3035429.815	13912419.049
8	50	125.7840	3035467.527	13912240.253

Soil sampling during the drilling of the geotechnical borings consisted of continuous sampling to a depth of 20 feet and sampling on 5-foot intervals thereafter, with both disturbed samples and relatively undisturbed soil samples being obtained.

Disturbed samples of soils were taken by utilizing the standard penetration testing procedures. The standard penetration test (SPT) blow count is defined as the number of SPT hammer blows which are required to advance a split spoon sampler 1 foot into the soil. One SPT hammer blow consists of a 140-pound hammer free falling for a distance of 30 inches. The results of the standard penetration tests provide a basis for estimating the relative strength and compressibility of the soil profile components. The samples recovered were removed from the split spoon sampler and placed into airtight plastic bags.

Relatively undisturbed samples were obtained by hydraulically forcing sections of 3-inch O.D. tubing (Shelby tube) into the subsoils. The tube samples were extruded in the field, sealed with foil, and placed into airtight plastic bags. Estimates of the unconfined compressive strengths of the

cohesive soils were obtained with pocket penetrometer readings being taken on the tube samples.

All samples were transported to HTS' laboratory for purposes of performing laboratory tests on selected samples.

2.2 Piezometer Installation

A total of 2 piezometers (labeled as PZ-1 and PZ-2) were installed on November 13, 2021 at the locations of Boring Nos. 2 and 6, respectively. The piezometer installation reports are shown in Figures B-1 and B-2 in Appendix B.

3.0 LABORATORY TESTING

For the current geotechnical study, a laboratory testing program was conducted to obtain engineering properties for use in performing engineering analyses and to adjust field soil classifications. The following laboratory tests were performed:

LABORATORY TEST	TEST STANDARD
Moisture Content of Soils	ASTM D 2216
Moisture Content and In Situ Dry Density of Soils	ASTM D 2937
Percent Soil Particles Passing a No. 200 Sieve	ASTM D 1140
Liquid Limit, Plastic Limit, and Plasticity Index of Soils	ASTM D 4318
Double Hydrometer Test	ASTM D 4221
Particle Size Analysis of Soils (with hydrometer)	ASTM D 6913 and D 7928
Crumb Test of Clayey Soils	ASTM D 6572
Unconfined Compressive Strength of Cohesive Soils	ASTM D 2166
Unconsolidated Undrained Triaxial Compression Test	ASTM D 2850
Consolidated Undrained Triaxial Compression Test	ASTM D 4767

The number of tests and the test results are presented in the attached Tables 1 and 2, Figures 4 through 13, and on the boring logs provided in Appendix A. All tests were performed in accordance with applicable ASTM procedures and methods and soil classifications were completed in accordance with the procedures and guidelines of ASTM D 2487 and ASTM D 2488.

4.0 SUBSURFACE CONDITIONS

4.1 Subsoils

The subsurface soil conditions as determined from the drilling of the geotechnical borings are provided in:

- Section 1.3.1 of this report,
- the boring logs in Appendix A, and
- the soil profiles (Sections A-A, B-B, and C-C) in Figures 3A and 3B.

The boring logs were prepared by using both field visual classifications and the results of laboratory testing. The stratification lines shown on the boring logs and in the soil profiles represent the approximate boundaries between soil types and the transitions between soil types may be gradual.

4.2 Groundwater

Groundwater conditions are described in Section 1.3.2 of this report, on the boring logs provided in Appendix A, and on the soil profiles provided in Figures 3A and 3B. The depth to groundwater was obtained by:

- observing the drilling operations and the free moisture contained in the samples recovered during drilling, and

- obtaining water level measurements in the borings during drilling and within 24 hours after the completion of drilling.

It is possible that seasonal variations will cause fluctuations in the water levels measured at the time of our field investigation. Additionally, perched water may be encountered in discontinuous zones within the overburden. We recommend that the contractor determine the groundwater level at the site at the time of construction in order to determine the impact, if any, of the groundwater to the construction activities. It should be noted that recommendations contained in this report are based on groundwater depths at the time of this geotechnical investigation and that an accurate determination of the true groundwater levels may require several days or even months of observations.

5.0 ENGINEERING ANALYSES

Engineering analyses were performed in order to determine design parameters that can be used for the design of the proposed dry bottom detention basin. Analyses performed included:

- analyses of subsurface soil grain size and plasticity characteristics and site groundwater levels as necessary to identify potential dewatering requirements,

- analyses to determine lateral earth pressure design parameters that can be used in the design of below ground structures associated with the construction of the proposed basin,

- slope stability analyses to determine the factor of safety of the side slopes of the proposed basin, and

- analyses to determine potential for bottom blowout of a clay liner and/or clay bottom constructed over the sands/silts.

5.1 Potential Dewatering Requirements

Potential dewatering requirements were developed based upon measured groundwater level depths, the types of subsurface soils encountered, and the grain size characteristics of the subsurface soils. The use of well points, vacuum well points, or a comparable dewatering system should provide for the effective dewatering of sandy soils which occur below the groundwater table and are found to contain less than 15 to 20% soil particles passing a No. 200 sieve. Sumps and sump pumps may be used to effectively dewater sandy soils that occur below the groundwater table and contain more than 20% soil particles passing a No. 200 sieve. Based on the results of the groundwater level measurements, where the proposed elevation of the bottom of the pond is lower than the measured groundwater levels in the geotechnical borings, it will be necessary that groundwater dewatering be performed in order to complete the excavation and allow the construction of the basin.

5.2 Lateral Earth Pressure Analyses for Design of Below Ground Structures

Earth pressure coefficients may be used to define the lateral loads exerted by the overburden soils on underground structures. The earth pressure coefficients for the clays and sands as provided in this report were computed by using Rankine's methods. The recommended lateral earth pressure coefficients, equivalent fluid weight values, and earth pressure, provided in this report, are based on soil properties as summarized in Section 1.4.6 of this report. Earth pressure design parameters, provided in this report for use in designing permanent below ground structures, are based on effective stress and shear strength parameters.

5.3 Slope Stability Analyses for Side Slopes

Engineering analyses were performed in order to determine the factors of safety of the side slopes of the proposed detention basin against a slope stability failure. Slope stability analyses involve the determination of the most likely sliding surface by comparing the developed shear stresses with the weight forces associated with the sliding soil. Slope stability analyses were performed to check the stability of the soil slope. The method involves the determination of the factor of safety along the surface where the soil mass may slide. The failing or sliding surface is typically assumed to be circular. The analyses included the determination of a particular circle (i.e., sliding surface or critical circle) that has a least factor of safety against sliding.

Recommendations concerning side slope inclinations were based on results of slope stability analyses performed using the SLOPE/W computer program. The Spencer method was adopted in the analyses to determine the factor of safety against sliding. The SLOPE/W computer program searches for the critical slope failure plane and computes the minimum factor of safety for the given slope geometry and subsurface soil conditions.

For the slope stability analyses, 3 conditions were analyzed for the section configuration. The 3 different conditions are:

1) Short Term or Undrained Condition - This condition occurs when the pore pressures within the soil mass are not dissipated. Typically, this condition corresponds to the state of the soils, which exist during and immediately after performing any cut/fill during the construction of any slope. For this condition, slopes were be analyzed using undrained soil parameters obtained from our

laboratory testing program and the corresponding friction values obtained from field standard penetration tests and typical values from various references. In the short term condition, a distributed load of 250 psf was applied at the top of the embankment to simulate equipment loadings.

2) Long Term or Drained Condition - This condition occurs when the pore pressures within the soil mass are dissipated. Typically, this condition corresponds to the state of the soils a few months or years after the construction is complete. For this condition, slopes were be analyzed using drained or effective stress soil parameters based on results of laboratory testing program included in the current geotechnical investigation and the corresponding friction values obtained from field standard penetration tests and typical values from various references. In the long term condition, each configuration will consist of the slope section in a consolidated and drained condition and effective shear strength parameters prevail. The peak shear strength values were normally used for low to medium plasticity lean clays. In the long term condition, a distributed load of 250 psf will be applied at the top of the embankment to simulate equipment loadings.

3) Rapid Drawdown Condition – This condition occurs when the water level in the basin rises during a flood, saturating the slope and then drains rapidly after the flood recedes. The state of stress within the soils of the slope after a flood event depends largely on the permeability and drainage characteristics of the slope. When the water levels are lowered rapidly against a clay slope, excess pore pressures may not have enough time to dissipate, and an undrained strength analysis is required. For this condition, slopes were analyzed using total stress soil parameters and effective stress soil parameters based on results of laboratory testing programs included in the current geotechnical investigation and corresponding friction values obtained from field standard penetration tests and typical values from various references. Each configuration analyzed for the intermediate condition will consist of a fully saturated slope section. The peak shear strength values are normally used for low to medium plasticity lean clays.

6.0 CONSTRUCTION CONSIDERATIONS

The recommendations provided below should be followed with regard to the construction of the proposed basin addressed by this report:

6.1 Side Slope Construction

- Dewatering for construction purposes may consist of using sumps and sump pumps or a construction dewatering system may be required.

- Fill material and fill compaction should comply with the recommendations provided in Section 1.4.1 and 1.4.2 of this report.
- Materials testing should be performed to assure that acceptable materials and construction methods are provided by the contractor.

6.2 Backfill Placement

Backfill placement operations should be monitored and the backfill tested to assure compliance with the 2020 HCFCD Standard Specifications Book.

7.0 CLOSING REMARKS

HTS has performed a geotechnical investigation and provided recommendations pertaining to the design and construction activities associated with the construction of a detention basin as part of the Ravensway Subdivision Drainage Improvements Project – 2018 at the proposed tract near HCFCD Unit K100-01-00 (Cypress Creek) in Harris County, Texas. The location is located south of the existing HCFCD Unit K100-00-00, east of Huffmeister Road, and west of the existing Ravensway residential subdivision. The proposed tract is heavily wooded with an approximate size of 9.5-acres and could be found in Key Map 368 Square K. This report has been prepared for the exclusive use of LJA and HCED in accordance with generally accepted soil and foundation engineering practices. No other warranty, expressed or implied, is made.

In the event that changes are made in the nature, design, or location of the proposed detention basin as well as the associated structures, the conclusions and recommendations contained in this report shall not be considered valid unless the changes are reviewed and the findings and recommendations of this report are modified or verified in writing. The analyses and recommendations presented in this report are based upon data obtained from 7 geotechnical borings that were drilled on October 25 through 30, 2021. The nature and extent of variations within the subsurface materials may not become evident until after construction is initiated. If significant variations in the subsurface materials are encountered during construction, it may be necessary to re-evaluate the recommendations provided in this report.

REFERENCES

1. HCFCD Geotechnical Guidelines, 2019.
2. Harris County Flood Control District (HCFCD) 2020 Standard Specifications Book.
3. Principles of Foundation Engineering, 7th Edition, Braja M. Das, 2011.
4. Soil Mechanics In Practice, 3rd Edition, Karl Terzaghi, Ralph B. Peck, Gholamreza Mesri, 1996.
5. Backfill For Subsurface Structures, ARMY TM 5 818-4, Air Force AFM 88-5, 1983.
6. USACE New Orleans District "Hurricane and Storm Damage Reduction System Design Guidelines Interim", dated June 12, 2008.
7. US Navy Naval Facilities Engineering Command Design Manual 7.2 (NAVFAC DM-7.2), dated September 1986.
8. OSHA Standards and Interpretations, 29 CFR 1926, Subpart P, Excavations.
9. Policy Criteria & Procedure Manuel (PCPM) by HCFCD, dated October 2018.

TABLES

TABLE 1

LABORATORY TEST SUMMARY

PROJECT: Proposed Ravensway Subdivision Drainage Improvements - 2018 (UPIN# 19103MF14601)

HTS PROJECT NO.: 21-S-477

LOCATION: Harris County, Texas

CLIENT: Harris County Engineering Department

Boring No.	Sample Depth (feet)	Type of Material	Moisture Content (%)	Dry Density (pcf)	Atterberg Limits (%)			-200 Sieve (%)	Compressive Strength (tsf)	Strain (%)	Lateral Pressure (psi)	Remarks
					LL	PL	PI					
1	0-2	Silty Sand (SM)	12.5					37.5				(1) Sample bulged at failure.
	4-6	Sandy Lean Clay (CL)	12.5	117.5	38	18	20	57.0	3.4 (1)	15.0	4	(2) Sample failed along slickensides.
	10-12	Silty Sand (SM)	8.2					26.6				(3) Sample failed along diagonal shear planes.
	14-16	Poorly Graded Sand With Silt (SP-SM)	4.1					10.4				
	23-25	Clayey Sand (SC)	10.8		26	15	11	46.0				
	28-30	Silty Clayey Sand (SC-SM)	13.1	119.2	20	14	6		3.9 (1)	14.1	17	
	38-40	Silty Clayey Sand (SC-SM)	15.2					35.2				
	48-50	Fat Clay (CH)	33.9	93.5	78	23	55	99.1	2.8 (2)	10.1	25	
2	0-2	Silty Sand (SM)	8.0					29.7				
	6-8	Clayey Sand (SC)	9.5	126.4	32	16	16	31.6	6.6 (3)	10.8	5	
	8-10	Clayey Sand (SC)	8.0		22	14	8	22.1				
	16-18	Poorly Graded Sand (SP)	2.8					4.9				
	23-25	Sandy Lean Clay (CL)	12.9		26	15	11	50.9				
	28-30	Sandy Lean Clay (CL)	17.9					69.1				
	33-35	Lean Clay With Sand (CL)	13.7	125.3	26	15	11	80.4	4.8 (1)	15.0	19	
	38-40	Lean Clay With Sand (CL)	18.0		48	20	28	79.9				
3	0-2	Silty Sand (SM)	11.6					28.4				
	4-6	Clayey Sand (SC)	10.9		25	14	11	25.4				
	6-8	Clayey Sand (SC)	17.2		37	16	21	42.2				
	10-12	Poorly Graded Sand With Silt (SP-SM)	5.9					6.5				
	14-16	Lean Clay With Sand (CL)	14.5	122.3	41	18	23	76.8	5.4 (1)	15.0	12	
	18-20	Sandy Lean Clay	17.1		33	15	18	61.1				

TABLE 1

LABORATORY TEST SUMMARY

PROJECT: Proposed Ravensway Subdivision Drainage Improvements - 2018 (UPIN# 19103MF14601)

HTS PROJECT NO.: 21-S-477

LOCATION: Harris County, Texas

CLIENT: Harris County Engineering Department

Boring No.	Sample Depth (feet)	Type of Material	Moisture Content (%)	Dry Density (pcf)	Atterberg Limits (%)			-200 Sieve (%)	Compressive Strength (tsf)	Strain (%)	Lateral Pressure (psi)	Remarks
					LL	PL	PI					
3	23-25	Silty Clay With Sand (CL-ML)	14.2		18	12	6	75.6				(4) Sample failed along sand fissures.
	28-30	Lean Clay With Sand (CL)	16.6		23	13	10	72.9				
	38-40	Silty Sand (SM)	14.8					28.1				
	43-45	Sandy Lean Clay (CL)	16.0	117.8	37	17	20	57.7	5.2 (1)	9.4	0	
4	0-2	Silty Sand (SM)	13.5					29.1				
	4-6	Clayey Sand (SC)	9.4	125.4	27	15	12	27.3	6.1 (3)	6.8	4	
	10-12	Silty Sand (SM)	6.2					12.4				
	14-16	Sandy Lean Clay (CL)	8.7	125.8	23	14	9	53.0	7.3 (1)	7.8	11	
	16-18	Clayey Sand (SC)	7.5		22	14	8	34.2				
	28-30	Silty Sand (SM)	13.5					43.2				
	33-35	Silty Sand (SM)	14.6		15	13	2	29.8				
	43-45	Fat Clay With Sand (CH)	19.7	108.5	54	20	34	76.1	4.6 (2)	9.3	25	
	48-50	Sandy Fat Clay (CH)	18.4	108.9	52	20	32	65.3	3.7 (2)	10.8	27	
5	2-4	Sandy Fat Clay (CH)	16.5	110.7	63	22	41	53.2	5.4 (2)	2.3	2.5	
	4-6	Clayey Sand (SC)	10.2		37	17	20	38.6				
	8-10	Silty Sand (SM)	8.6		Non Plastic			12.9				
	14-16	Silty Sand (SM)	11.4									
	23-25	Sandy Lean Clay (CL)	13.1	129.6	26	14	12	62.6	1.5 (sf)	3.2	0	
	33-35	Clayey Sand (SC)	17.1					35.0				
	43-45	Sandy Lean Clay (CL)	17.4	116.4	38	18	20	57.0	3.9 (1)	14.8	22	
	48-50	Silty Sand (SM)	16.7					15.2				
6	2-4	Sandy Silt (ML)	10.1		Non Plastic			50.3				
	4-6	Sandy Lean Clay (CL)	10.3		22	13	9	54.4				

TABLE 1

LABORATORY TEST SUMMARY

PROJECT: Proposed Ravensway Subdivision Drainage Improvements - 2018 (UPIN# 19103MF14601)

HTS PROJECT NO.: 21-S-477

LOCATION: Harris County, Texas

CLIENT: Harris County Engineering Department

Boring No.	Sample Depth (feet)	Type of Material	Moisture Content (%)	Dry Density (pcf)	Atterberg Limits (%)			-200 Sieve (%)	Compressive Strength (tsf)	Strain (%)	Lateral Pressure (psi)	Remarks
					LL	PL	PI					
6	10-12	Silty Sand (SM)	7.6					40.4				
	16-18	Silty Clayey Sand (SC-SM)	14.8	116.8	19	12	7	44.5	2.0 (1)	13.8	0	
	18-20	Sandy Lean Clay (CL)	14.9		21	13	8	66.7				
	23-25	Sandy Silt (ML)	13.8		15	12	3	57.5				
	28-30	Silty Sand (SM)	15.0					27.0				
	33-35	Sandy Lean Clay (CL)	16.6		32	15	17	58.7				
	38-40	Fat Clay With Sand (CH)	28.6	100.3	59	21	38	76.5	2.7 (3)	13.1	0	
	43-45	Sandy Lean Clay (CL)	20.8					53.3				
	48-50	Poorly Graded Sand With Silt (SP-SM)	19.5		Non Plastic			11.7				
7	0-2	Sandy Silt (ML)	7.4					52.9				
	4-6	Sandy Lean Clay (CL)	14.7		44	18	26	56.7				
	10-12	Clayey Sand (SC)	12.3	121.2	28	14	14	49.0	4.1 (1)	13.3	0	
	12-14	Clayey Sand (SC)	13.2		30	15	15	45.6				
	14-16	Sandy Lean Clay (CL)	15.7		32	16	16	55.6				
	23-25	Lean Clay With Sand (CL)	14.8		24	13	11	75.2				
	33-35	Silty Sand (SM)	16.0					22.9				
	43-45	Sandy Lean Clay (CL)	20.0	110.0	47	20	27	62.9	3.7 (3)	11.8	0	
	48-50	Silty Sand (SM)	19.7					17.2				

TABLE 2

CRUMB TEST FOR DETERMINATION OF DISPERSIBILITY OF CLAYEY SOILS (ASTM D 6572, METHOD A)

HTS CONSULTANTS
416 Pickering St
Houston, TX 77091

PROJECT : Ravensway Subdivision Drainage Improvements - 2018			PROJECT NO : 21-S-477
LOCATION : Harris County, Texas	CLIENT : HCED UPIN# 19103MF14601		PAGE NO: 1 OF 1

SPECIMEN DATA

Sample Condition: ☐ Disturbed ☑ Undisturbed

Specimen Type: ☑ Natural irregularly shaped crumbs ☐ Remolded crumb cubes

Moisture Content: ☑ Natural ☐ Air-dried ☐ Distilled water added to remolded specimen

Curing Time: 0 minutes **Water Used:** ☑ Distilled ☐ Distilled and demineralized

Initial Water Temperature: 21.6 °C **Date of Test:** 11-12-21

Time of Test: 9:05 a.m.

TEST DATA

Test No.	Boring Number	Depth (feet)	2-Minute		1-Hour		6-Hour	
			Grade *	°C	Grade *	°C	Grade *	°C
1	2	8 - 10	3	21.6	4	21.4	4	21.2
2								
3								
4								
5								
6								
7								

* Grade 1 ---> Non-Dispersive
Grade 2 ---> Intermediate
Grade 3 ---> Dispersive
Grade 4 ---> Highly Dispersive

Tested By: J.C. Date : 11-12-21

Checked By: A.A. Date : 12-6-21

HTS CONSULTANTS

HTS, Inc. Consultants
416 Pickering Street
Houston, Texas 77091
Tel: (713) 692-8373 Fax: (713) 692-8501

TABLE 3

MEASUREMENT OF HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER (ASTM D 5084)
METHOD C - FALLING HEAD, RISING TAILWATER ELEVATION

Project No:	21-S-477	Sample Identification:	B-6, 18' - 20'
Technician:	ER	Sample Description:	Sandy Lean Clay

Project : Ravensway Subdivision Drainage Improvements - 2018, UPIN No. 19103MF14601

INITIAL CONDITIONS				FINAL CONDITIONS			
WATER CONTENT		SPECIMEN DATA		WATER CONTENT		SPECIMEN DATA	
Tare No.:	1	Length, in:	2.143	Tare No.:	39	Length (L), in:	2.147
Wet+Tare, gms:	535.66	Diameter, in:	2.779	Wet+Tare, gms:	207.01	Diameter, in:	2.779
Dry+Tare, gms:	503.70	Wet mass, gms:	475.88	Dry+Tare, gms:	183.50	Wet mass, gms:	475.80
Tare Weight, gms:	299.30	Area, cm^2:	39.13	Tare Weight, gms:	30.77	Area (A), cm^2:	39.13
Moisture, %	15.6	Volume, cc:	213.0	Moisture, %	15.4	Volume, cc:	213.4
		Unit wet wt, pcf:	139.4			Unit wet wt, pcf:	139.1
Specific Gravity:	2.70	Unit dry wt, pcf:	120.6	Specific Gravity:	2.70	Unit dry wt, pcf:	120.6
Saturation, %:	106.2	Void Ratio:	0.397	Saturation, %:	104.6	Void Ratio:	0.397
Perm. Cell No.:	#1	Burret diam, cm:	1.08	Burret area (a), cm^2:	0.9160906	Burret factor,cm/cc:	1.009
Cell Pressure, psi:	8	Head Pressure, psi:	5.0	Tail Pressure, psi:	4.0		

PERMEABILITY MEASUREMENTS

Date and Time	Elapsed Time (Dt) (sec)	Temp (C)	Pressure Diff. (psi)	Head Rdg (cc)	Tail Rdg (cc)	Head Change (cm)	Tail Change (cm)	Total Head (h_1, h_2) (cm)	Permeability Kt (cm/sec)	Permeability K_{20} (cm/sec)
11/28/21 9:45 AM	0	21.5	1.0	2.0	20.0	0.000	0.000	88.46	0.00E+00	0.00E+00
11/28/21 12:45 PM	10800	21.6	1.0	4.5	17.5	2.523	2.523	83.42	3.47E-07	3.35E-07
11/28/21 2:45 PM	7200	21.5	1.0	6.0	16.0	1.514	1.514	80.39	3.28E-07	3.17E-07
11/28/21 5:00 PM	8100	21.5	1.0	8.0	14.0	2.018	2.018	76.35	4.06E-07	3.93E-07
11/29/21 6:00 AM	46800	21.2	1.0	20.0	2.0	12.108	12.108	52.14	5.20E-07	5.07E-07
11/29/21 6:15 AM	900	21.2	1.0	2.0	20.0	0.000	0.000	88.46	0.00E+00	0.00E+00
11/29/21 8:20 AM	7500	21.5	1.0	4.6	17.4	2.623	2.623	83.22	5.20E-07	5.04E-07
11/29/21 10:30 AM	7800	21.5	1.0	7.5	14.5	2.926	2.926	77.36	5.97E-07	5.78E-07
11/29/21 5:10 PM	24000	21.5	1.0	13.5	8.5	6.054	6.054	65.26	4.53E-07	4.38E-07
11/30/21 5:00 AM	42600	21.2	1.0	20.0	2.0	6.559	6.559	52.14	3.36E-07	3.28E-07
11/30/21 6:30 AM	5400	21.2	1.0	2.0	20.0	0.000	0.000	88.46	0.00E+00	0.00E+00
11/30/21 9:50 AM	12000	21.5	1.0	5.5	16.5	3.532	3.532	81.40	4.43E-07	4.28E-07
11/30/21 5:55 PM	29100	21.5	1.0	13.0	9.0	5.550	5.550	66.26	4.51E-07	4.37E-07

Coefficient of Permeability, k = **4.26E-07** cm/sec

Computed By: AA Date: 12/2/2021 Checked By: JH Date: 12/02/21

HTS, Inc. Consultants
416 Pickering Street
Houston, Texas 77091
Tel: (713) 692-8373 Fax: (713) 692-8501

TABLE 4

MEASUREMENT OF HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER (ASTM D 5084)
METHOD C - FALLING HEAD, RISING TAILWATER ELEVATION

Project No:	21-S-477	Sample Identification:	B-6, 33' - 35'
Technician:	ER	Sample Description:	Sandy Lean Clay

Project : Ravensway Subdivision Drainage Improvements - 2018, UPIN No. 19103MF14601

INITIAL CONDITIONS				FINAL CONDITIONS			
WATER CONTENT		SPECIMEN DATA		WATER CONTENT		SPECIMEN DATA	
Tare No.:	42	Length, in:	2.190	Tare No.:	16	Length (L), in:	2.190
Wet+Tare, gms:	591.74	Diameter, in:	2.796	Wet+Tare, gms:	220.96	Diameter, in:	2.797
Dry+Tare, gms:	561.78	Wet mass, gms:	474.95	Dry+Tare, gms:	195.22	Wet mass, gms:	478.42
Tare Weight, gms:	358.17	Area, cm^2:	39.61	Tare Weight, gms:	30.63	Area (A), cm^2:	39.64
Moisture, %	14.7	Volume, cc:	220.3	Moisture, %	15.6	Volume, cc:	220.5
		Unit wet wt, pcf:	134.5			Unit wet wt, pcf:	135.4
Specific Gravity:	2.70	Unit dry wt, pcf:	117.2	Specific Gravity:	2.70	Unit dry wt, pcf:	117.1
Saturation, %:	90.9	Void Ratio:	0.437	Saturation, %:	96.2	Void Ratio:	0.439
Perm. Cell No.:	#2	Burret diam, cm:	1.06	Burret area (a), cm^2:	0.8824754	Burret factor,cm/cc:	1.009
Cell Pressure, psi:	8	Head Pressure, psi:	5.0	Tail Pressure, psi:	4.0		

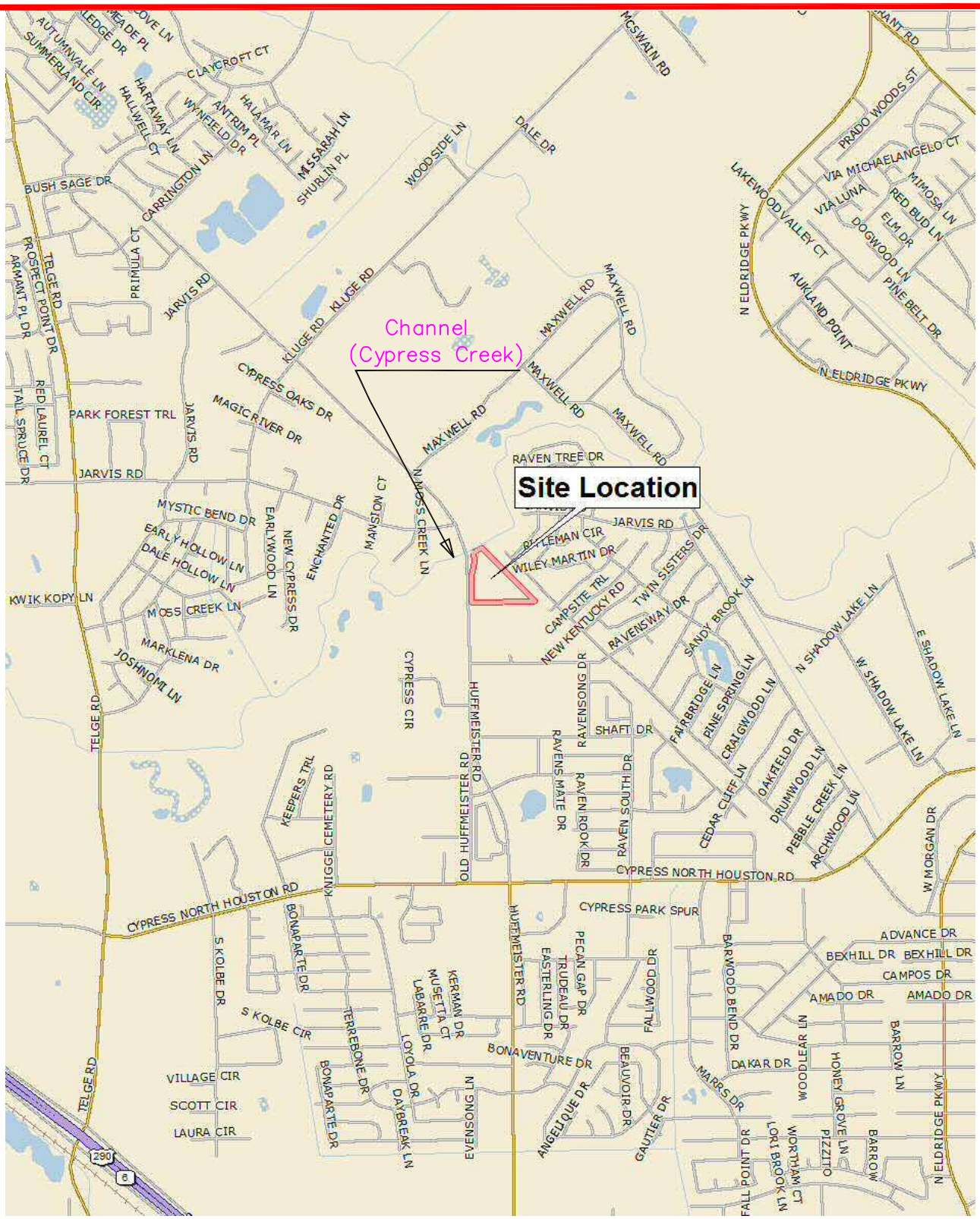
PERMEABILITY MEASUREMENTS

Date and Time	Elapsed Time (Dt) (sec)	Temp (C)	Pressure Diff. (psi)	Head Rdg (cc)	Tail Rdg (cc)	Head Change (cm)	Tail Change (cm)	Total Head (h_1, h_2) (cm)	Permeability Kt (cm/sec)	Permeability K_{20} (cm/sec)
11/28/21 9:25 AM	0	21.2	1.0	2.0	20.0	0.000	0.000	88.46	0.00E+00	0.00E+00
11/28/21 11:25 AM	7200	21.5	1.0	8.5	13.5	6.559	6.559	75.35	1.38E-06	1.34E-06
11/28/21 2:25 PM	10800	21.5	1.0	15.2	6.8	6.760	6.760	61.82	1.13E-06	1.10E-06
11/28/21 5:00 PM	9300	21.5	1.0	19.5	2.5	4.339	4.339	53.15	1.01E-06	9.74E-07
11/29/21 6:20 AM	48000	21.1	1.0	2.0	20.0	0.000	0.000	88.46	0.00E+00	0.00E+00
11/29/21 8:20 AM	7200	21.5	1.0	7.0	15.0	5.045	5.045	78.37	1.04E-06	1.01E-06
11/29/21 10:30 AM	7800	21.5	1.0	10.6	11.4	3.632	3.632	71.11	7.72E-07	7.47E-07
11/29/21 5:10 PM	24000	21.5	1.0	20.0	2.0	9.485	9.485	52.14	8.01E-07	7.75E-07
11/29/21 5:15 PM	300	21.5	1.0	2.0	20.0	0.000	0.000	88.46	0.00E+00	0.00E+00
11/30/21 6:05 AM	46200	21.2	1.0	20.0	2.0	18.162	18.162	52.14	7.09E-07	6.91E-07
11/30/21 6:30 AM	1500	21.2	1.0	2.0	20.0	0.000	0.000	88.46	0.00E+00	0.00E+00
11/30/21 9:50 AM	12000	21.5	1.0	7.3	14.7	5.348	5.348	77.77	6.65E-07	6.43E-07
11/30/21 5:55 PM	29100	21.5	1.0	17.1	4.9	9.888	9.888	57.99	6.24E-07	6.04E-07

Coefficient of Permeability, k = **8.75E-07** cm/sec

Computed By: AA Date: 12/2/2021 Checked By: JH Date: 12/02/21

FIGURES



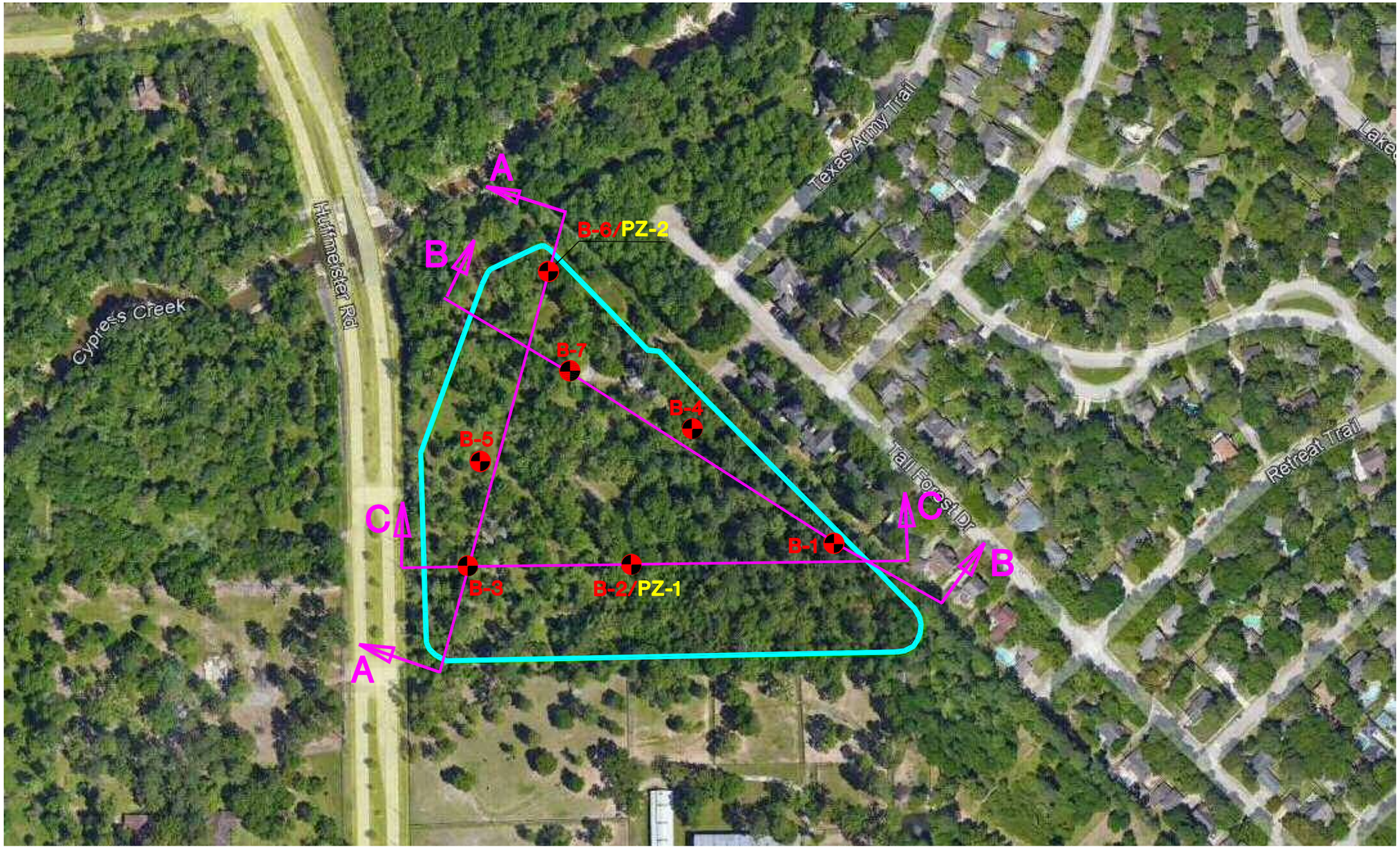
KEY MAP: 368 (K)

CHANNEL ID: K100-00-00
(CYPRESS CREEK)
(Proposed Alternate Location)

HTS, Inc. Consultants

Proposed Ravensway Subdivision Drainage Improvements - 2018
Precinct 3
Harris County, Texas
UPIN No. 19103MF14601

DRAWN BY:	IAT	DATE:	11-25-21	SCALE: NTS
CHECKED BY:	JH	DATE:	11-25-21	
HTS PROPOSAL NO.:	21-S-477			FIGURE: 1
Vicinity Map				



B-1
29°57'35.18"N
95°37'42.34"W

B-2
29°57'34.85"N
95°37'46.64"W

B-3
29°57'34.72"N
95°37'50.29"W

B-4
29°57'37.32"N
95°37'45.31"W

B-5
29°57'36.80"N
95°37'49.97"W

B-6
29°57'40.32"N
95°37'48.53"W

B-7
29°57'38.54"N
95°37'48.16"W

Legend

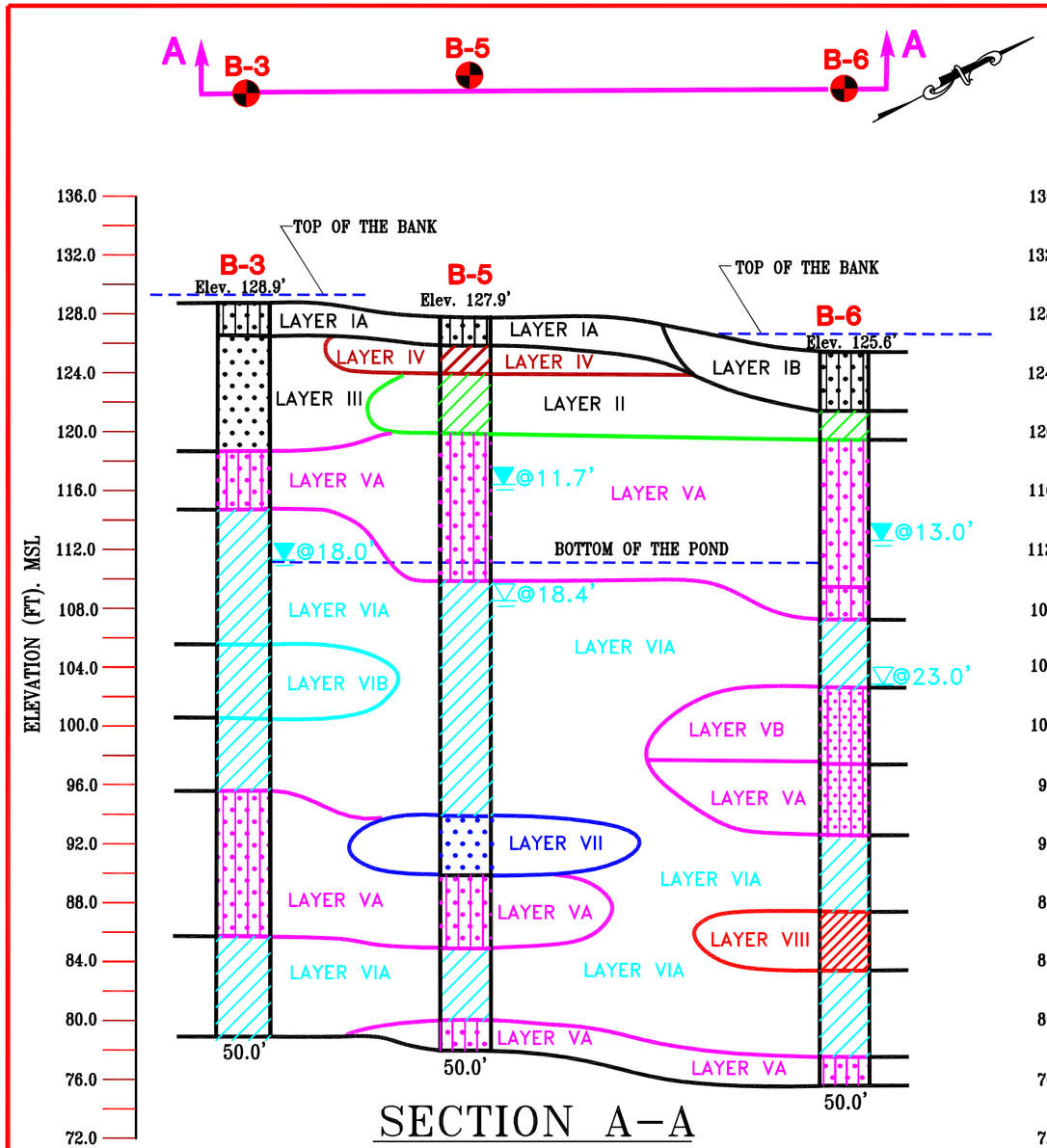
Geotechnical Borings Included in the Study

HTS, Inc. Consultants

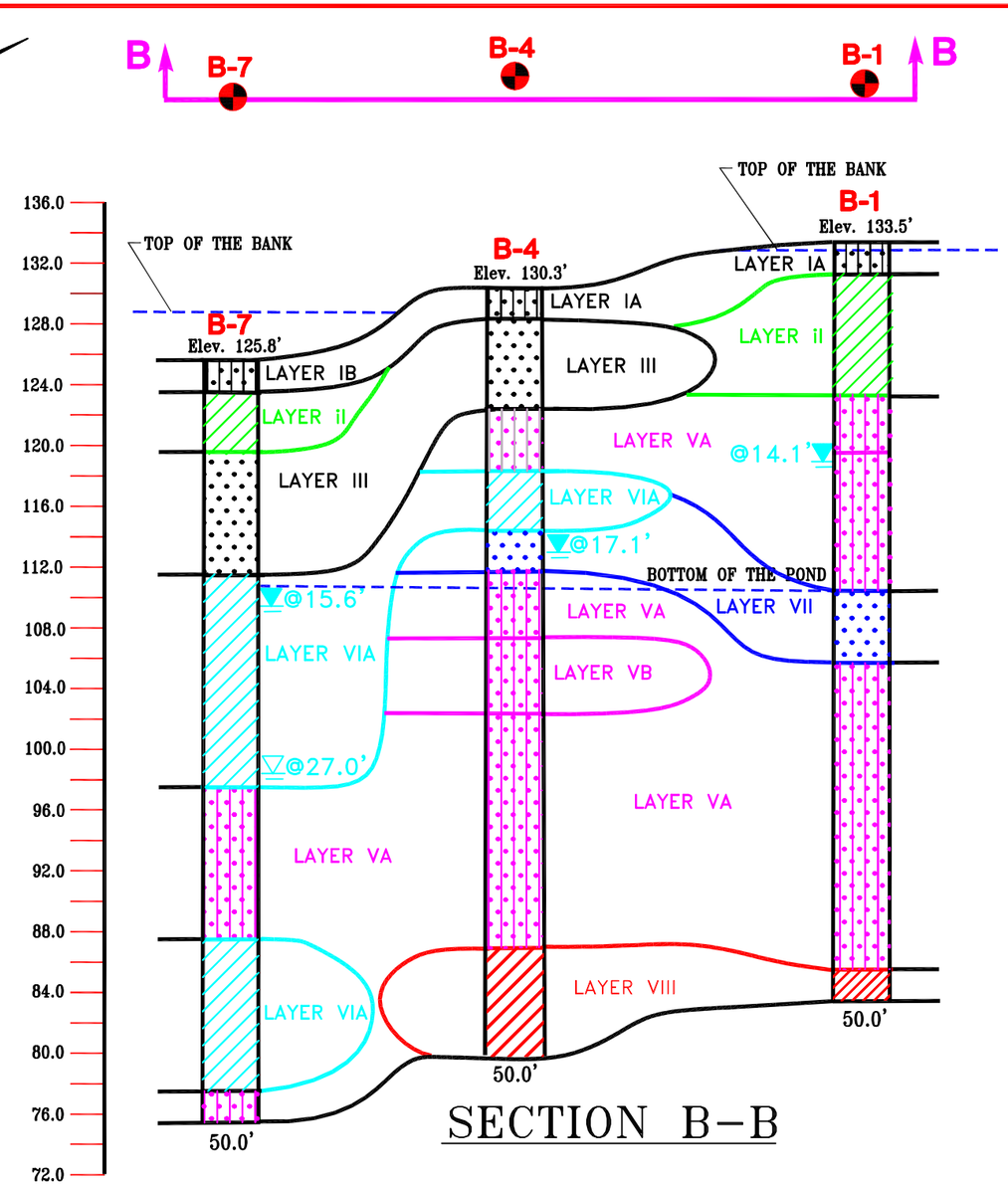
Proposed Ravensway Subdivision Drainage Improvements - 2018
Precinct 3
Harris County, Texas
UPIN No. 19103MF14601

DRAWN BY:	IAT	DATE:	02-25-22	SCALE: 1"=300'
CHECKED BY:	JH	DATE:	02-25-22	
HTS PROject NO.:	21-S-477			FIGURE: 2

Alternate Boring Locations



SECTION A–A



SECTION B–B

LAYER IA

SILTY SAND, VERY LOOSE TO LOOSE.

LAYER IB

SANDY SILT, MEDIUM DENSE.

LAYER II

SANDY LEAN CLAY, VERY STIFF TO HARD.

LAYER III

CLAYEY SAND, LOOSE TO MEDIUM DENSE.

LAYER IV

SANDY FAT CLAY, HARD.

LAYER VA

SILTY SAND, POORLY GRADED SAND, POORLY GRADED SAND WITH SILT, AND SILTY CLAYEY SAND.

LAYER VB

SANDY SILT.

LAYER VIA

SANDY LEAN CLAY AND LEAN CLAY WITH SAND, FIRM TO HARD.

LAYER VIB

SILTY CLAY WITH SAND, VERY STIFF.

LAYER VII

CLAYEY SAND, MEDIUM DENSE TO VERY DENSE.

LAYER VIII

FAT CLAY AND FAT CLAY WITH SAND, VERY STIFF TO HARD.

LEGEND

- GEOTECHNICAL BORINGS INCLUDED IN THE STUDY
- GROUNDWATER MEASURED DURING DRILLING
- GROUNDWATER MEASURED 24 HOURS AFTER COMPLETION OF DRILLING

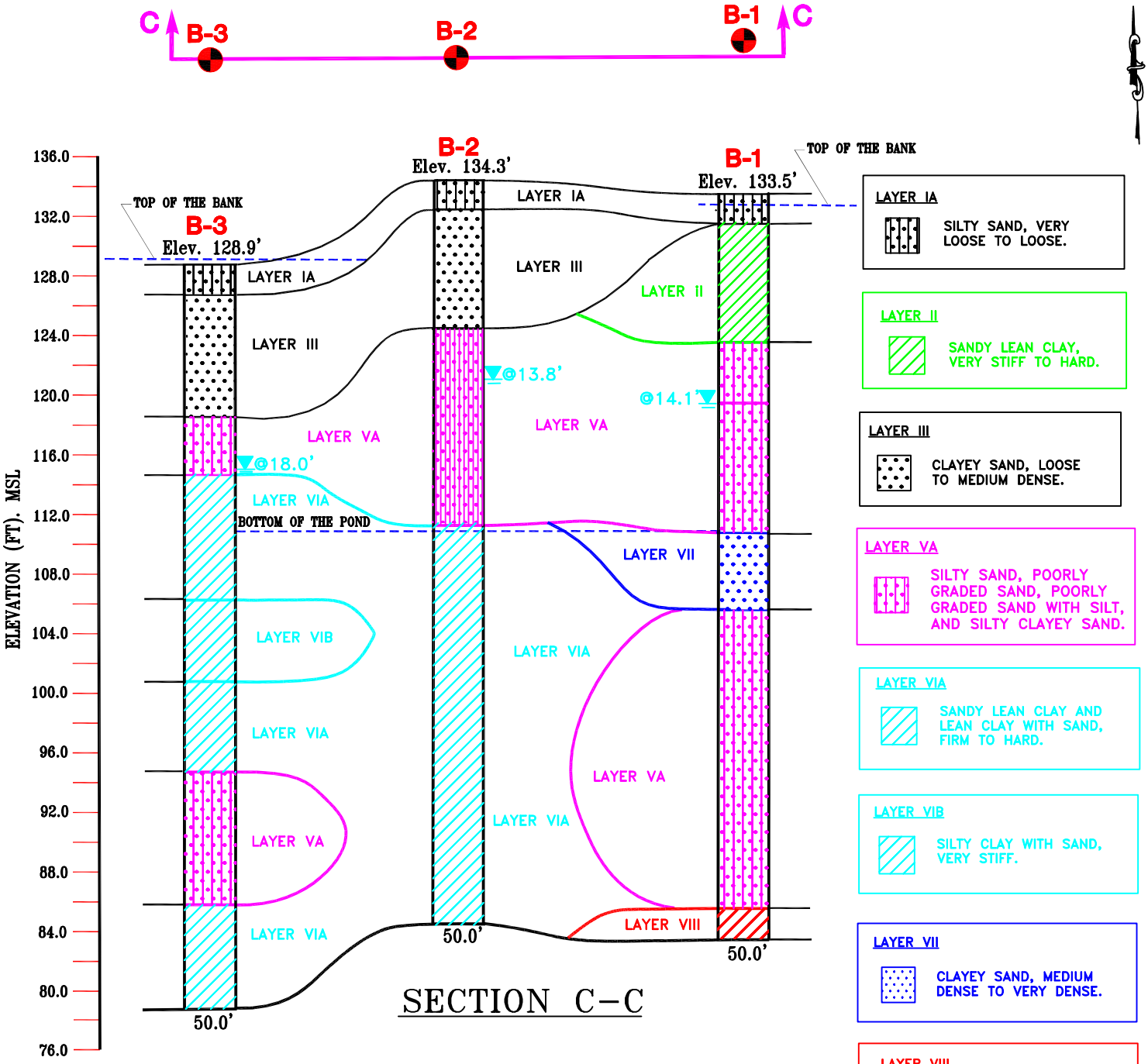
NOTES

1) SEE FIGURE 2 FOR LOCATION OF SECTIONS A–A AND B–B.
2) THE STRATIFICATION LINES SHOWN ARE OUR ESTIMATION BETWEEN BORINGS AND DO NOT REPRESENT ACTUAL SUBSOIL CONDITIONS BETWEEN BORINGS.
3) SEE CORRESPONDING BORING LOGS FOR DETAILED SUBSOIL AND GROUNDWATER INFORMATION.
4) TOP OF THE BANK AND BOTTOM OF THE POND ARE DRAWN APPROXIMATELY BASED ON CLIENT PROVIDED DRAWING PRESENTED IN APPENDIX C.
5) ELEVATIONS ARE REPORTED AS FEET ABOVE MSL.

HTS, Inc. Consultants

Proposed Ravensway Subdivision Drainage Improvements - 2018
Precinct 3
UPIN #19103MF14601
Harris County, Texas

DRAWN BY:	IAT	DATE:	01–25–22	SCALE: Hor.: 1"=30' Vert.: 1"=10'
CHECKED BY:	JH	DATE:	01–25–22	
HTS PROJECT NO.:	21-S-477			
Soil Profile Sections A-A and B-B (Boring Nos. 1 and 3 trough 7)				FIGURE: 3A



LEGEND

- GEOTECHNICAL BORINGS INCLUDED IN THE STUDY
- GROUNDWATER MEASURED DURING DRILLING
- GROUNDWATER MEASURED 24 HOURS AFTER COMPLETION OF DRILLING

NOTES

1) SEE FIGURE 2 FOR LOCATION OF SECTION C-C
2) THE STRATIFICATION LINES SHOWN ARE OUR ESTIMATION BETWEEN BORINGS AND DO NOT REPRESENT ACTUAL SUBSOIL CONDITIONS BETWEEN BORINGS.
3) SEE CORRESPONDING BORING LOGS FOR DETAILED SUBSOIL AND GROUNDWATER INFORMATION.
4) TOP OF THE BANK AND BOTTOM OF THE POND ARE DRAWN APPROXIMATELY BASED ON CLIENT PROVIDED DRAWING PRESENTED IN APPENDIX C.
5) ELEVATIONS ARE REPORTED AS FEET ABOVE MSL.

HTS, Inc. Consultants

Proposed Ravensway Subdivision Drainage Improvements - 2018 Precinct 3

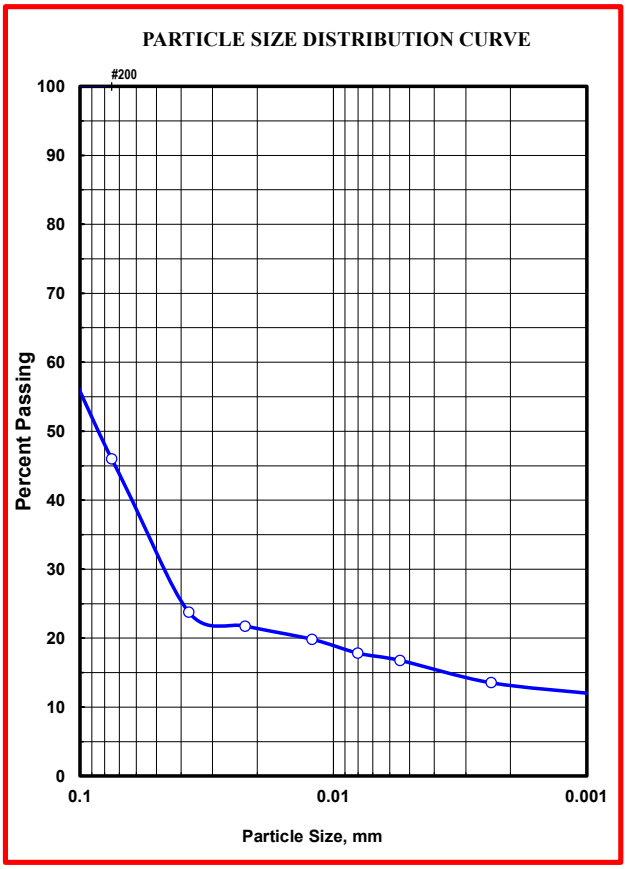
UPIN #19103MF14601

Harris County, Texas

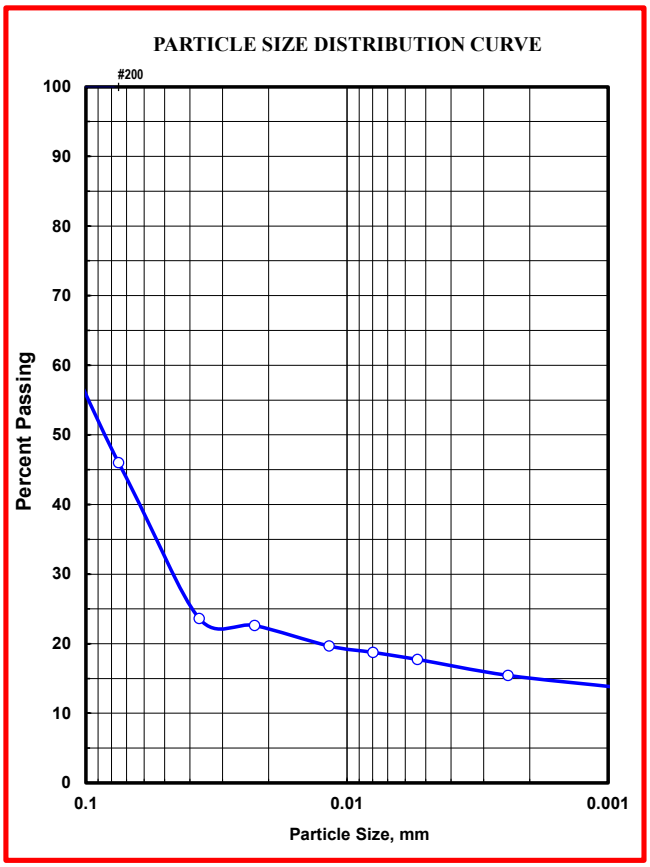
DRAWN BY:	IAT	DATE:	01-25-22	SCALE: Hor.: 1"=20' Vert.: 1"=10'
CHECKED BY:	JH	DATE:	01-25-22	
HTS PROJECT NO.:	21-S-477			
Soil Profile Sectino C-C (Boring Nos. 1 Trough 3)				FIGURE: 3B

HTS, Inc. Consultants

Pickering Street 416
Houston, Texas 77091
Ph: 713-692-8373 Fax: 713-692-8502



Without Dispersion Agent



With Dispersion Agent

Nm,2µm,nd = mass percent finer than 2-µm not dispersed, nearest 1 % = 13%

Nm,2µm,d = mass percent finer than 2-µm dispersed, nearest 1 % = 15%

*% Dispersion = (Nm,2µm,nd / Nm,2µm,d)*100 = 86.6%*

ASTM D-4221-18 Dispersive Characteristics of Clay Soil by Double Hydrometer

Project:	**Proposed Ravensway Subdivision Drainage Improvements - 2018 (UPIN# 19103MF14601)**	Liquid Limit:	**26**	% Pass No. 200:	**46.0**
Client:	**Harris County Engineering Department**	Plastic Limit:	**15**	% Moisture:	**10.8**
Project No.:	**21-S-477**	Plasticity Index:	**11**	Date Test Started:	**11/16/2021**
Sample ID:	**B-1, 23'-25'**	Tested By	**JC**	Date Checked	**11/24/2021**
Remarks:	**Dispersive Soil (Dispersion is > 50%)**	Checked By	**AA**	**Figure 4A**	
Description:	**CLAYEY SAND (SC)**	Test Method	**ASTM D-4221-18**		

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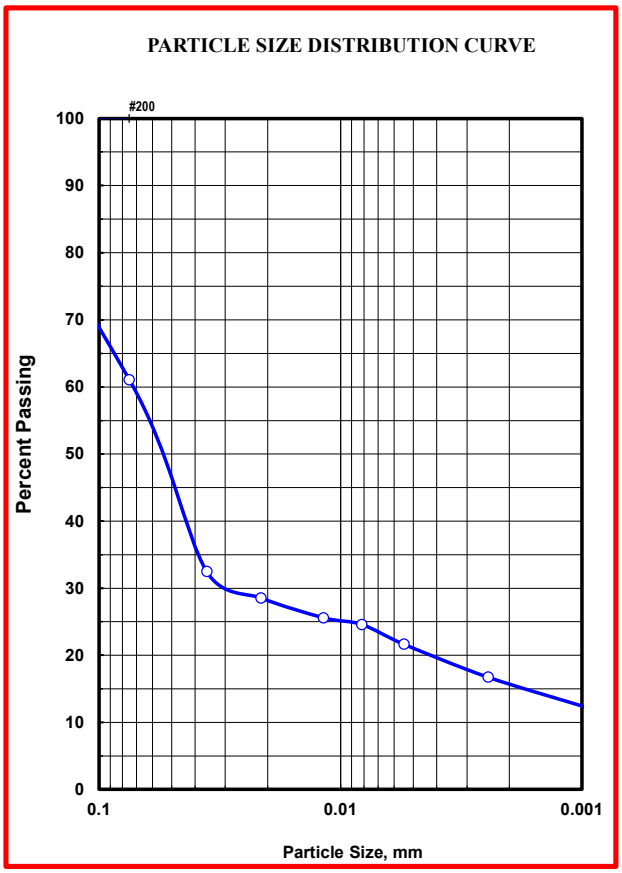
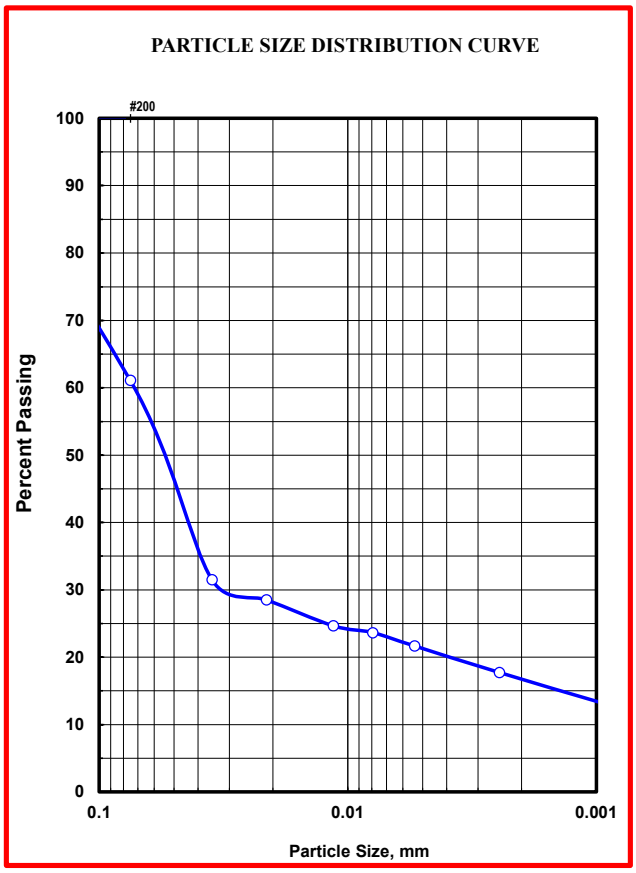


Without Dispersion



With Dispersion Agent

Nm,2µm,nd = mass percent finer than 2-µm not dispersed, nearest 1 % = 16%

Nm,2µm,d = mass percent finer than 2-µm dispersed, nearest 1 % = 17%

*% Dispersion = (Nm,2µm,nd / Nm,2µm,d)*100 = 94.1%*

ASTM D-4221-18 Dispersive Characteristics of Clay Soil by Double Hydrometer

Project:	**Proposed Ravensway Subdivision Drainage Improvements - 2018 (UPIN# 19103MF14601)**	Liquid Limit:	**33**	% Pass No. 200:	**61.1**
Client:	**Harris County Engineering Department**	Plastic Limit:	**15**	% Moisture:	**17.1**
Project No.:	**21-S-477**	Plasticity Index:	**18**	Date Test Started:	**11/16/2021**
Sample ID:	**B-3, 18'-20'**	Tested By	**ER**	Date Checked	**12/2/2021**
Remarks:	**Dispersive Soil (Dispersion is > 50%)**	Checked By	**AA**	**Figure 4B**	
Description:	**Sandy Lean Clay (CL)**	Test Method	**ASTM D-4221-18**		

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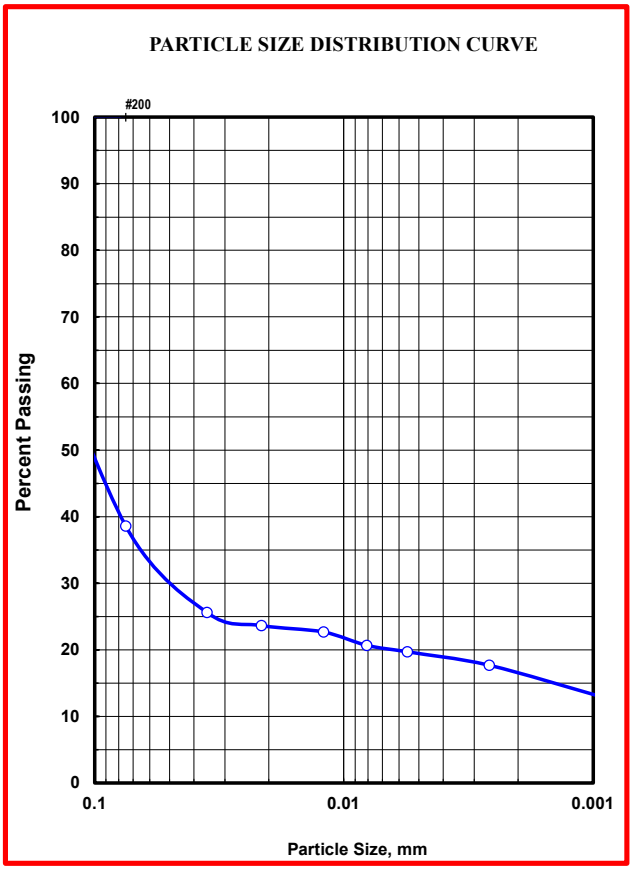
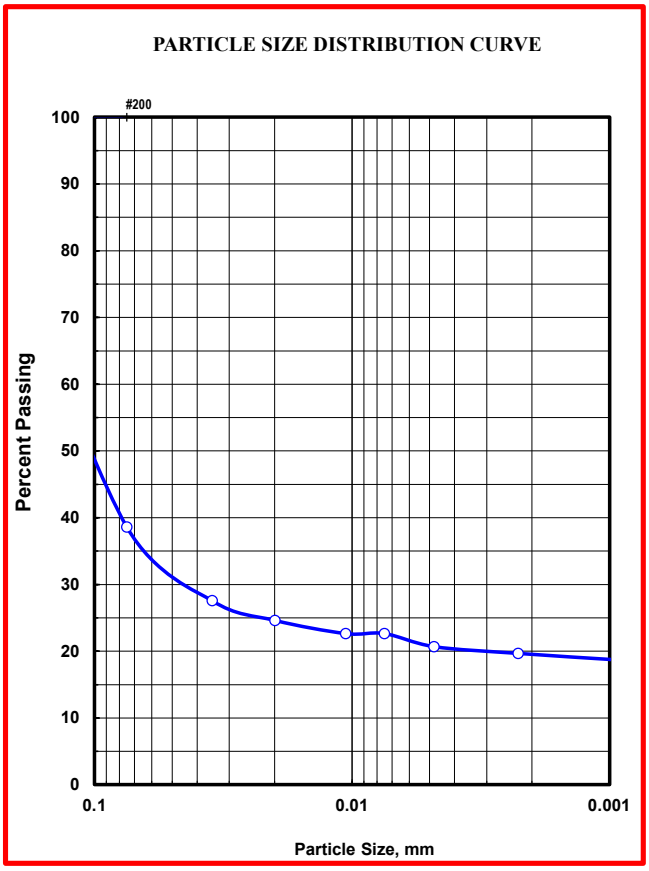


Without Dispersion Agent



With Dispersion Agent

Nm,2µm,nd = mass percent finer than 2-µm not dispersed, nearest 1 % = 16%

Nm,2µm,d = mass percent finer than 2-µm dispersed, nearest 1 % = 20%

*% Dispersion = (Nm,2µm,nd / Nm,2µm,d)*100 = 80%*

ASTM D-4221-18 Dispersive Characteristics of Clay Soil by Double Hydrometer

Project:	**Proposed Ravensway Subdivision Drainage Improvements - 2018 (UPIN# 19103MF14601)**	Liquid Limit:	**37**	% Pass No. 200:	**38.6**
Client:	**Harris County Engineering Department**	Plastic Limit:	**17**	% Moisture:	**10.2**
Project No.:	**21-S-477**	Plasticity Index:	**20**	Date Test Started:	**11/16/2021**
Sample ID:	**B-5, 4'-6'**	Tested By	**ER**	Date Checked	**12/2/2021**
Remarks:	**Dispersive Soil (Dispersion is > 50%)**	Checked By	**AA**	**Figure 4C**	
Description:	**CLAYEY SAND (SC)**	Test Method	**ASTM D-4221-18**		

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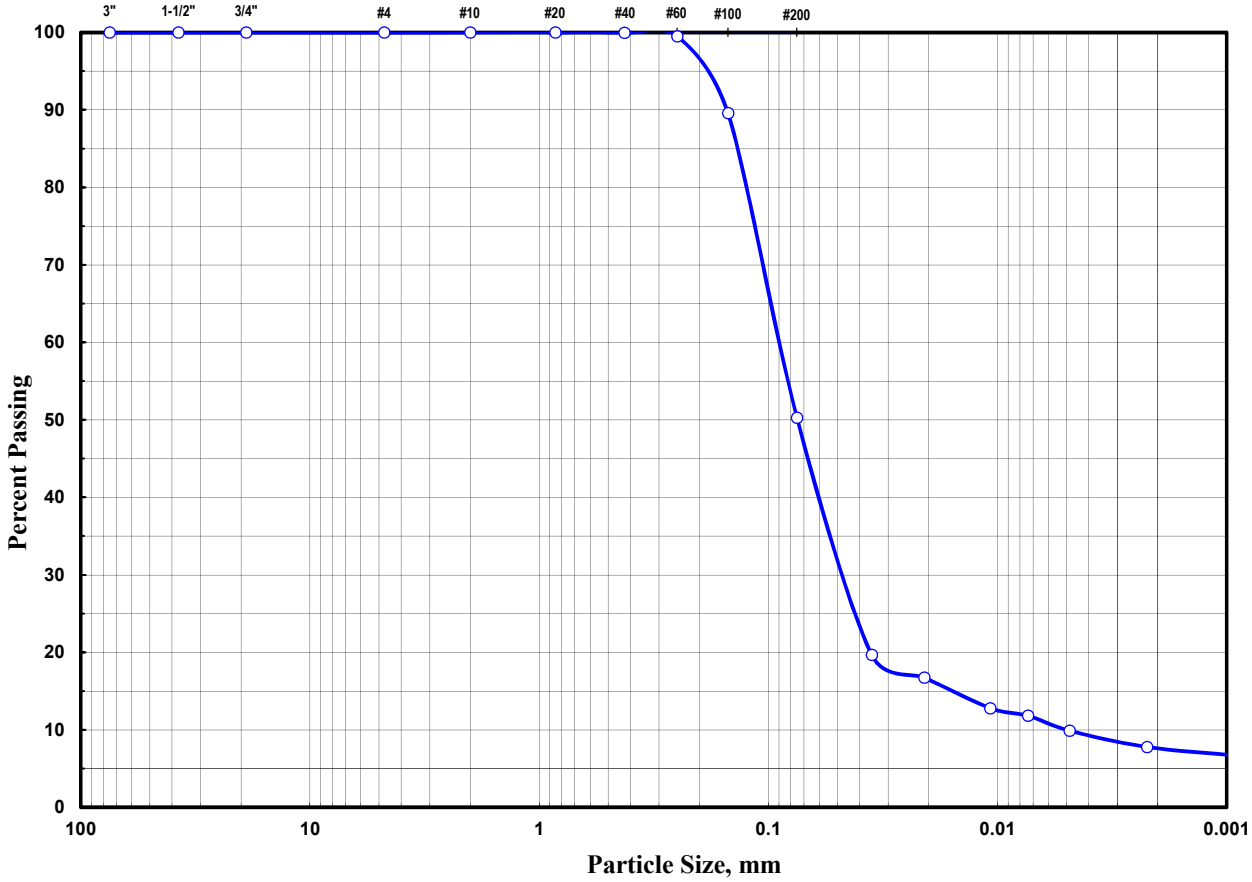
PARTICLE SIZE DISTRIBUTION CURVE

(ASTM D-6913 & D-7928)



COBBLES	GRAVEL		SAND			SILT	CLAY
	Coarse	Fine	Coarse	Medium	Fine		

ASTM D-2487 SOIL CLASSIFICATION

Project:	**Proposed Ravensway Subdivision Drainage Improvements - 2018 (UPIN# 19103MF14601)**	Liquid Limit:	**Non Plastic**	% Pass No. 200:	**50.3**
Client:	**Harris County Engineering Department**	Plastic Limit:		% Moisture:	**10.1**
Project No.:	**21-S-477**	Plasticity Index:		Test Method:	**ASTM**
Sample ID:	**Boring No. 6, Depth 2' - 4'**	Tested By:	**MW**	Date Tested:	**11/14/2021**
Remarks:	**D10 = 0.005 mm, D50 = 0.075 mm, D95 = 0.190 mm**	Checked By:	**AA**	**Figure 5**	
Description:	**Sandy Silt (ML)**	Date Checked:	**11/19/2021**		

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PARTICLE SIZE DISTRIBUTION CURVE

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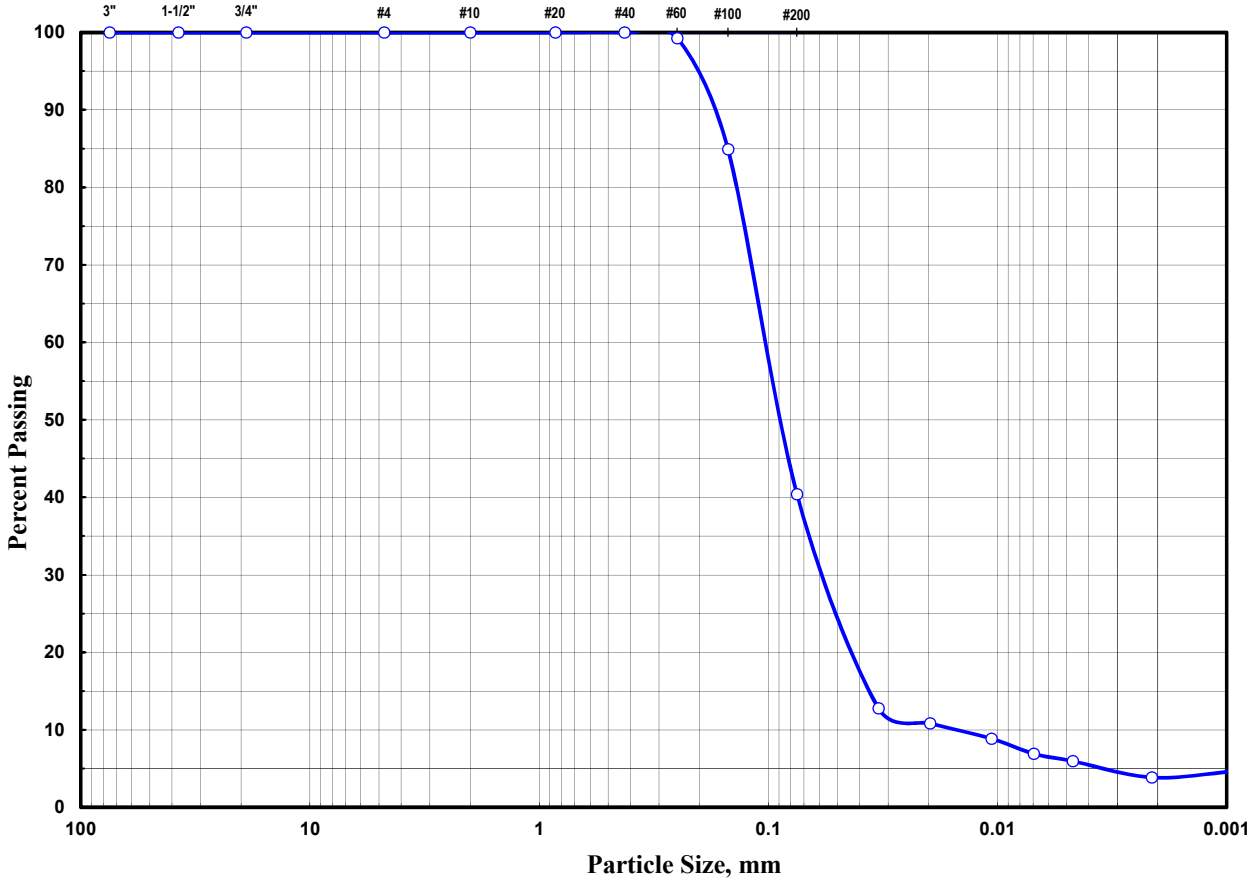

COBBLES	GRAVEL		SAND			SILT	CLAY
	Coarse	Fine	Coarse	Medium	Fine		

ASTM D-2487 SOIL CLASSIFICATION

Project:	**Proposed Ravensway Subdivision Drainage Improvements - 2018 (UPIN# 19103MF14601)**	Liquid Limit:		% Pass No. 200:	**40.4**
Client:	**Harris County Engineering Department**	Plastic Limit:		% Moisture:	**7.9**
Project No.:	**21-S-477**	Plasticity Index:		Test Method:	**ASTM**
Sample ID:	**Boring No. 6, Depth 10' - 12'**	Tested By:	**MW**	Date Tested:	**11/14/2021**
Remarks:	**D10 = 0.016 mm, D50 = 0.090, D95 = 0.200 mm**	Checked By:	**AA**	**Figure 6**	
Description:	**Silty Sand (SM)**	Date Checked:	**11/19/2021**		

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PARTICLE SIZE DISTRIBUTION CURVE

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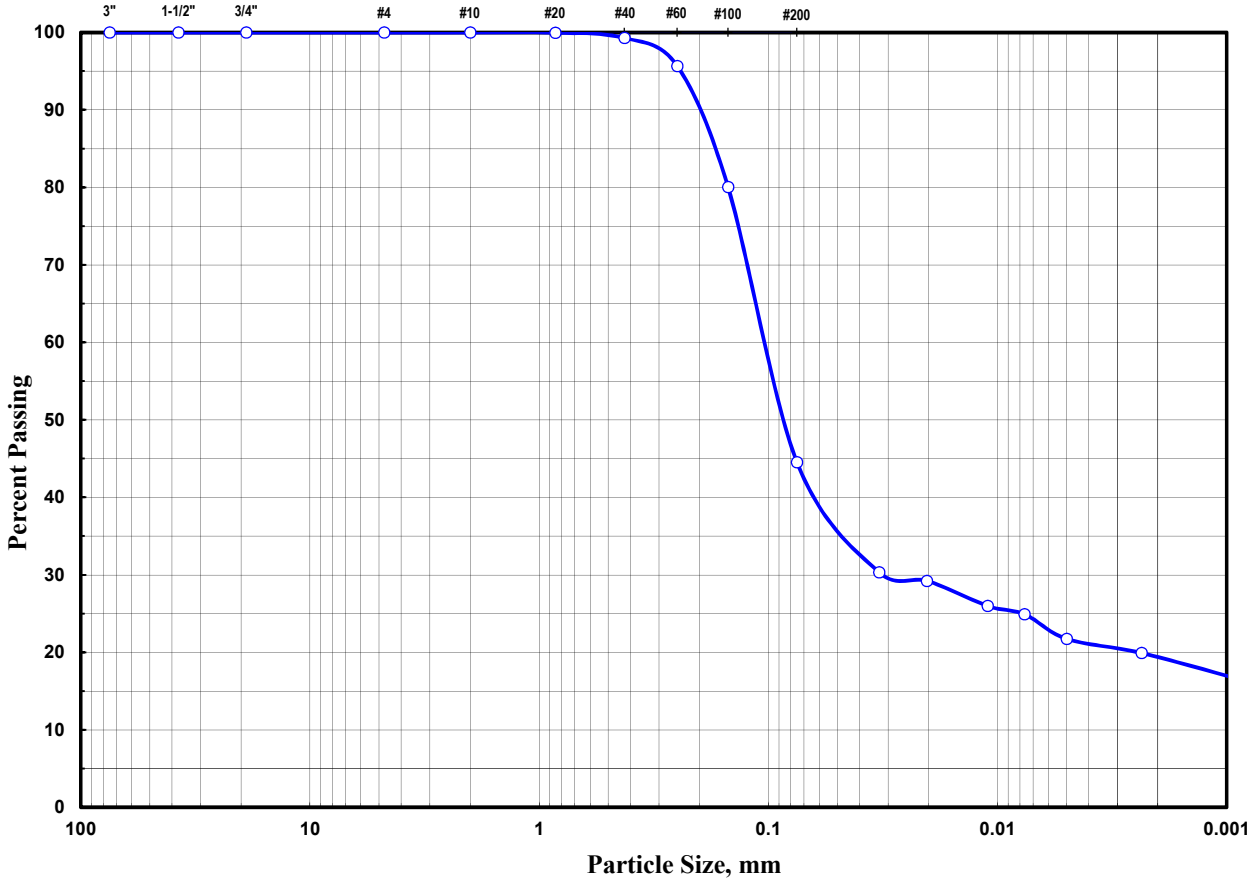

COBBLES	GRAVEL		SAND			SILT	CLAY
	Coarse	Fine	Coarse	Medium	Fine		

ASTM D-2487 SOIL CLASSIFICATION

Project:	Proposed Ravensway Subdivision Drainage Improvements - 2018 (UPIN# 19103MF14601)	Liquid Limit:	19	% Pass No. 200:	44.5
Client:	Harris County Engineering Department	Plastic Limit:	12	% Moisture:	14.8
Project No.:	21-S-477	Plasticity Index:	7	Test Method:	ASTM
Sample ID:	Boring No. 6, Depth 16' - 18'	Tested By:	MW	Date Tested:	11/24/2021
Remarks:	D50 = 0.086 mm, D95 = 0.245 mm	Checked By:	AA	Figure 7	
Description:	Silty Clayey Sand (SC-SM)	Date Checked:	11/29/2021		

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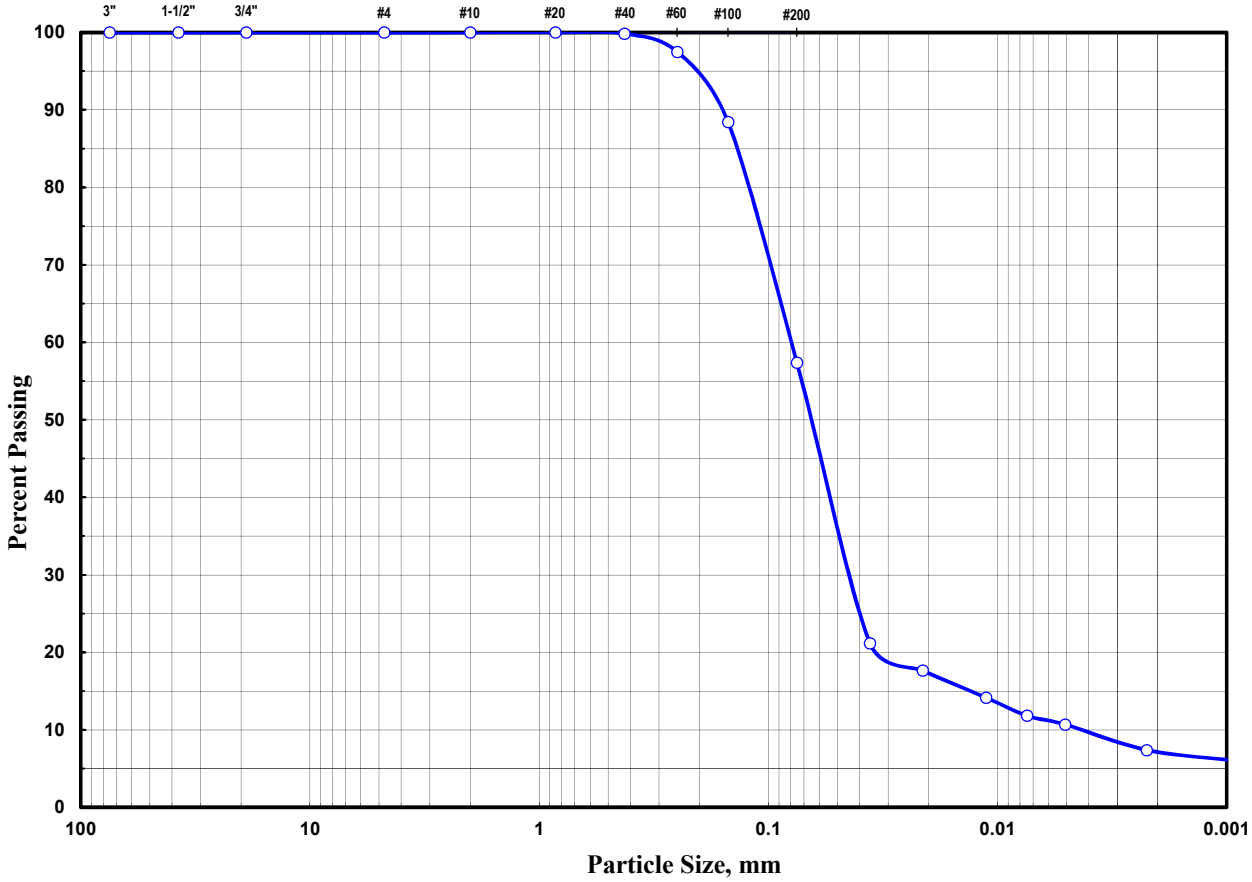
PARTICLE SIZE DISTRIBUTION CURVE

(ASTM D-6913 & D-7928)



COBBLES	GRAVEL		SAND			SILT	CLAY
	Coarse	Fine	Coarse	Medium	Fine		

ASTM D-2487 SOIL CLASSIFICATION

Project:	**Proposed Ravensway Subdivision Drainage Improvements - 2018 (UPIN# 19103MF14601)**	Liquid Limit:	**15**	% Pass No. 200:	**57.4**
Client:	**Harris County Engineering Department**	Plastic Limit:	**12**	% Moisture:	**14.8**
Project No.:	**21-S-477**	Plasticity Index:	**3**	Test Method:	**ASTM**
Sample ID:	**Boring No. 6, Depth 23' - 25'**	Tested By:	**MW**	Date Tested:	**11/24/2021**
Remarks:	**D10= 0.0044 mm, D50 = 0.067 mm, D95 = 0.200 mm**	Checked By:	**AA**	**Figure 8**	
Description:	**Sandy Silt (ML)**	Date Checked:	**11/29/2021**		

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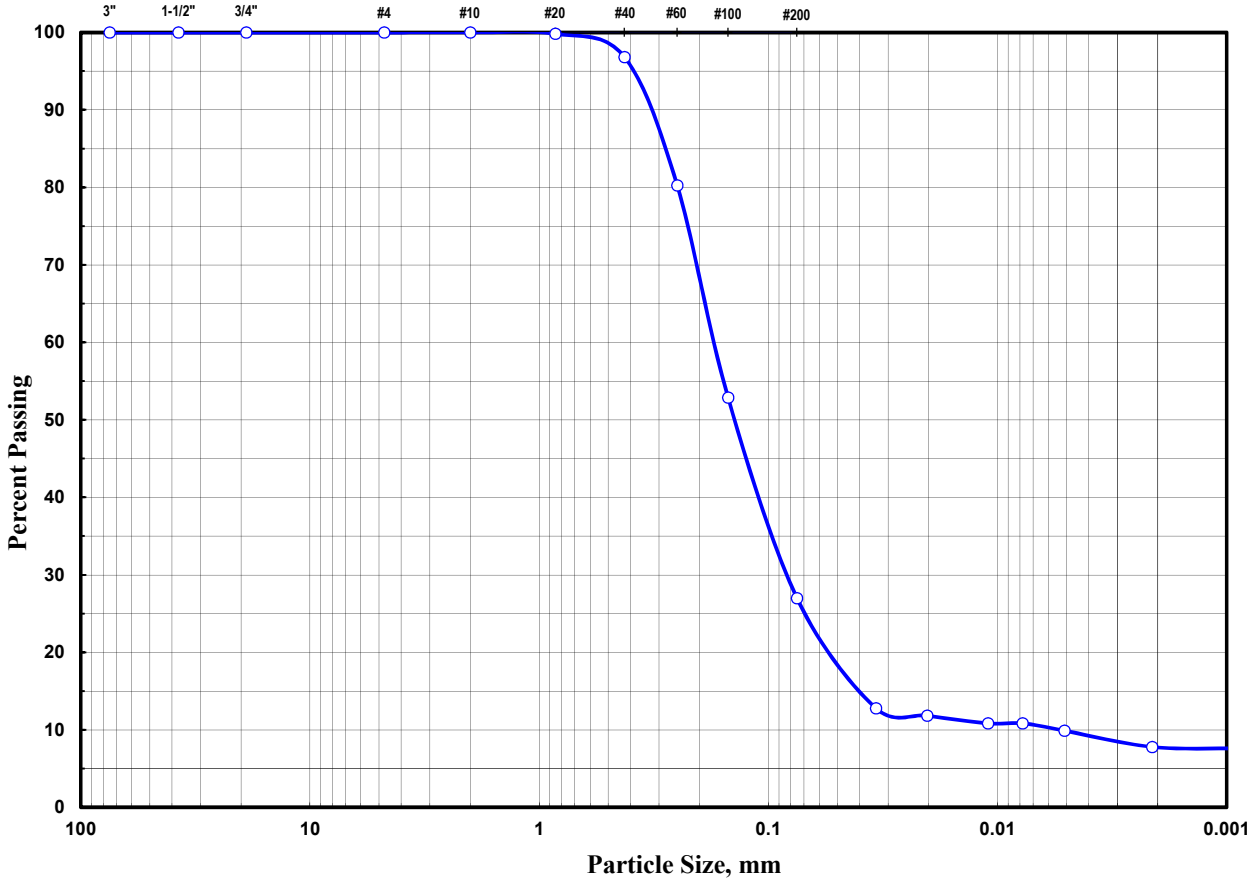
PARTICLE SIZE DISTRIBUTION CURVE

(ASTM D-6913 & D-7928)



COBBLES	GRAVEL		SAND			SILT	CLAY
	Coarse	Fine	Coarse	Medium	Fine		

ASTM D-2487 SOIL CLASSIFICATION

Project:	**Proposed Ravensway Subdivision Drainage Improvements - 2018 (UPIN# 19103MF14601)**	Liquid Limit:		% Pass No. 200:	**27.0**
Client:	**Harris County Engineering Department**	Plastic Limit:		% Moisture:	**15.0**
Project No.:	**21-S-477**	Plasticity Index:		Test Method:	**ASTM**
Sample ID:	**Boring No. 6, Depth 28' - 30'**	Tested By:	**MW**	Date Tested:	**11/14/2021**
Remarks:	**D10 = 0.0057 mm, D50 = 0.142 mm, D95 = 0.390 mm**	Checked By:	**AA**	**Figure 9**	
Description:	**Silty Sand (SM)**	Date Checked:	**11/19/2021**		

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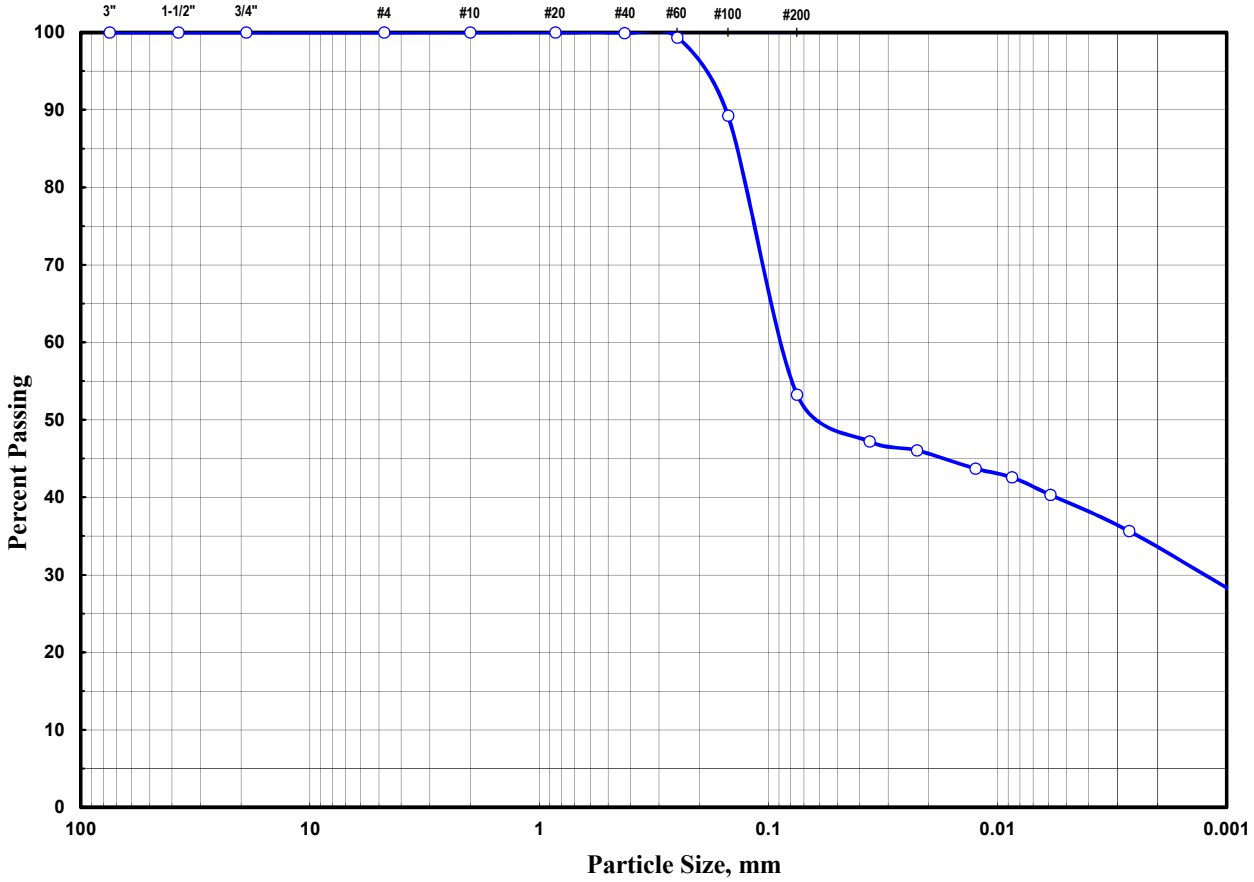
PARTICLE SIZE DISTRIBUTION CURVE

(ASTM D-6913 & D-7928)



COBBLES	GRAVEL		SAND			SILT	CLAY
	Coarse	Fine	Coarse	Medium	Fine		

ASTM D-2487 SOIL CLASSIFICATION

Project:	**Proposed Ravensway Subdivision Drainage Improvements - 2018 (UPIN# 19103MF14601)**	Liquid Limit:		% Pass No. 200:	**53.3**
Client:	**Harris County Engineering Department**	Plastic Limit:		% Moisture:	**20.8**
Project No.:	**21-S-477**	Plasticity Index:		Test Method:	**ASTM**
Sample ID:	**Boring No. 6, Depth 43' - 45'**	Tested By:	**MW**	Date Tested:	**11/24/2021**
Remarks:	**D50 = 0.054 mm, D95 = 0.190 mm**	Checked By:	**AA**	**Figure 10**	
Description:	**Sandy Lean Clay (CL)**	Date Checked:	**11/29/2021**		

SAMPLE DATA

Consolidated Undrained Triaxial Test with Pore Pressure Measurements (ASTM D 4767)

Project Name: *Laboratory Testing* *Classification:* *Sandy Lean Clay (CL)*

Project Number: *21-S-477* *Boring Number:* *B-7* *Depth, feet:* *14* *Sample No./ID:*

Liquid Limit: *32* *Plastic Limit:* *16* *Plasticity Index:* *16* *Percent Passing No. 200:* *55.6%*

Specimen/Stage Data	Before Test			After Consolidation or Shear		
Specimen/Stage No.	1	2	3	1	2	3
Diameter (D),in.:	2.785	2.788	2.780	2.865	2.855	2.805
Height (H), in.:	5.596	5.610	5.610	5.405	5.378	5.390
Cross-Sectional Area, in^2	6.092	6.105	6.070	6.445	6.401	6.180
Vol. (Vo, Vf), cm^3:	563.0	561.2	558.0	570.9	564.2	545.8
Moisture, {Wo, Wf} %:	14.2%	14.9%	15.6%	15.5%	15.6%	15.4%
Wet Soil Wt. {Mo, Mf}, ,gm:	1221.68	1213.40	1185.81	1235.64	1220.40	1183.40
Wet Unit Weight, pcf:	135.4	134.91	132.6	135.1	134.99	135.3
Dry Unit Weight, pcf:	118.5	117.4	114.7	116.9	116.8	117.3
Specific Gravity (Estimated):	2.643	2.643	2.643	2.643	2.643	2.643
Void Ratio, eo, ef:	0.39	0.41	0.44	0.41	0.41	0.41
Degree of Saturation, So, Sf:	0.96	0.97	0.94	1.00	1.00	1.00

Description		Saturation/Consolidation		
Specimen/Stage No.		1	2	3
Method		Wet Mounting Method		
Cell Pressure, lbs/in^2		28.1	38.2	58.1
Back Pressure, lbs/in^2		17.9	17.8	17.8
B-Parameter		0.95	0.95	0.95
Consolidation Pressure, lbs/in^2		10.2	20.4	40.3
Volume Change After (ΔV), cm^3		1.45	28.9	30.98
Time for Consolidation, min.		3180	7690	3180
Failure Type:	*1*	*Bulge*		
	2		*Bulge*	
	3			*Bulge*

Equipment	Specimen/Stage		
	1	2	3
Oven:	B33ER01048	B33ER01048	B33ER01048
Scale:	AE444189	AE444189	AE444189
Calipers:	7174871	7174871	7174871
Digital Dial:	2123	2123	2123
Load Frame:	Load Frame	0	Load Frame
Load Cell ID:	2000K (3298)	230905 (2000K)	2000K (3298)
DCDT:	LPT 496	LPT-352	LPT 496
Cell Pressure Transducer:	ID-3188	PS3-305	ID-3188
Pore Pressure Transducer:	ID3189	PS3-304	ID3189
Radial Drainage Fliter Strip:	Yes	Yes	Yes

Shear Data	Specimen/Stage		
	1	2	3
Total Shearing Time, min	900	900	900
Strain Rate, %/hr	1.0	1.0	1.0
Axial Strain at Failure, %	4.70	3.70	3.40
Deviator Stress, lbs/in^2 ($\Delta\sigma$)	19.10	34.48	52.67
Excess Pore Pressure, lbs/in^2 (u)	3.46	7.99	13.98
A-Parameter, ($u/\Delta\sigma$)	0.18	0.23	0.27
Total Major Pincipal Stress, lbs/in^2 ($\sigma 1 = \sigma 3 + \Delta\sigma$)	29.26	54.85	92.86
Total Minor Pincipal Stress, lbs/in^2 ($\sigma 3$)	10.16	20.37	40.19
Effectivel Major Pincipal Stress, lbs/in^2 ($\bar{\sigma}\,\bar{1} = \sigma 1 - u$)	25.80	46.86	78.88
Effectivel Minor Pincipal Stress, lbs/in^2 ($\bar{\sigma}\,\bar{3} = \sigma 3 - u$)	6.70	12.38	26.21

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FIGURE - 11A

MOHR CIRCLES

Project Name:	*Laboratory Testing*			*Classification:*	*Sandy Lean Clay (CL)*		
Project Number:	*21-S-477*	*Boring Number:*	*Boring-7*	*Depth, feet:*	*14*	*Sample No./ID:*	*0*
Cohesion (C_T), ksf:	*0.38*	*Friction Angle(ϕ_T), deg:*	*21.0*	*Cohesion (C_d), ksf:*	*0.33*	*Friction Angle(ϕ_d), deg:*	*27.6*
Remarks:							

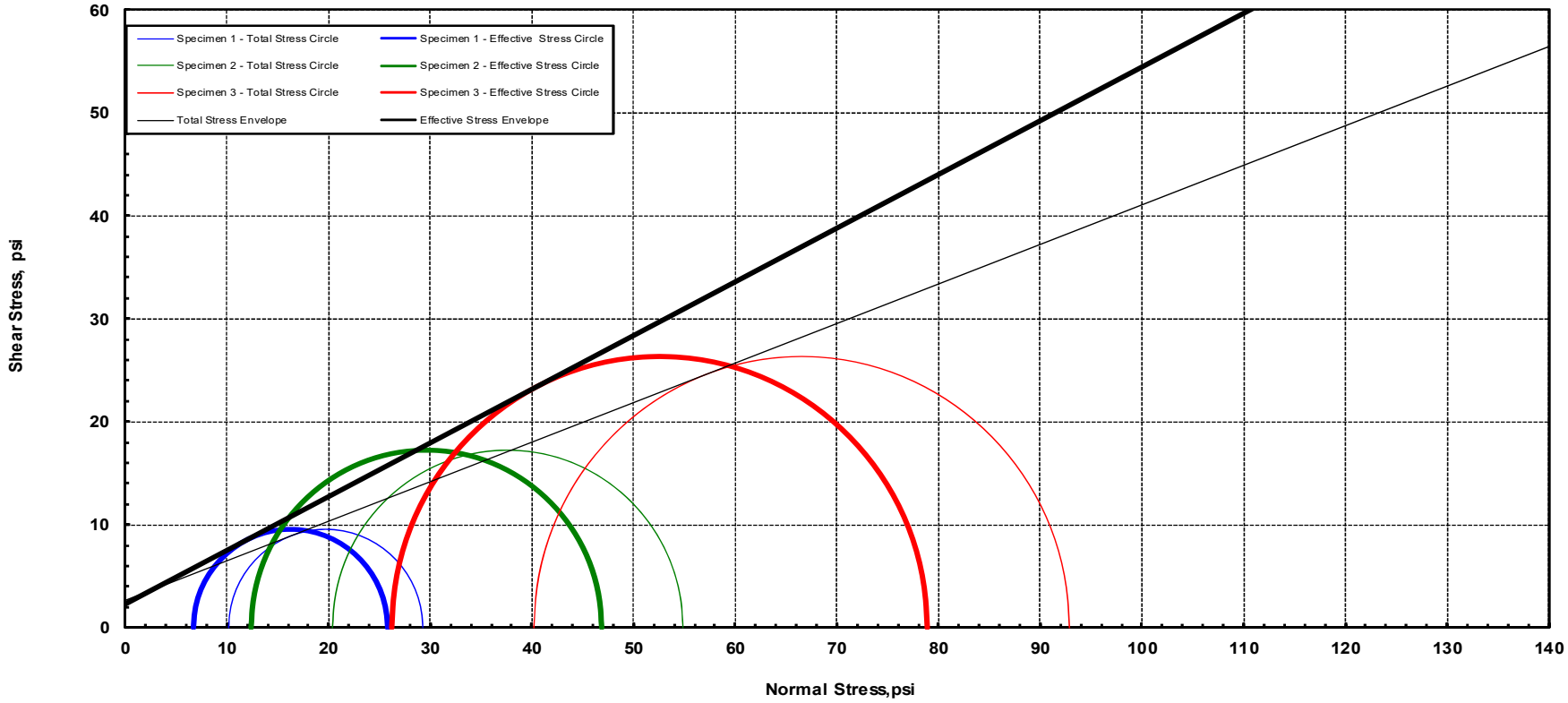

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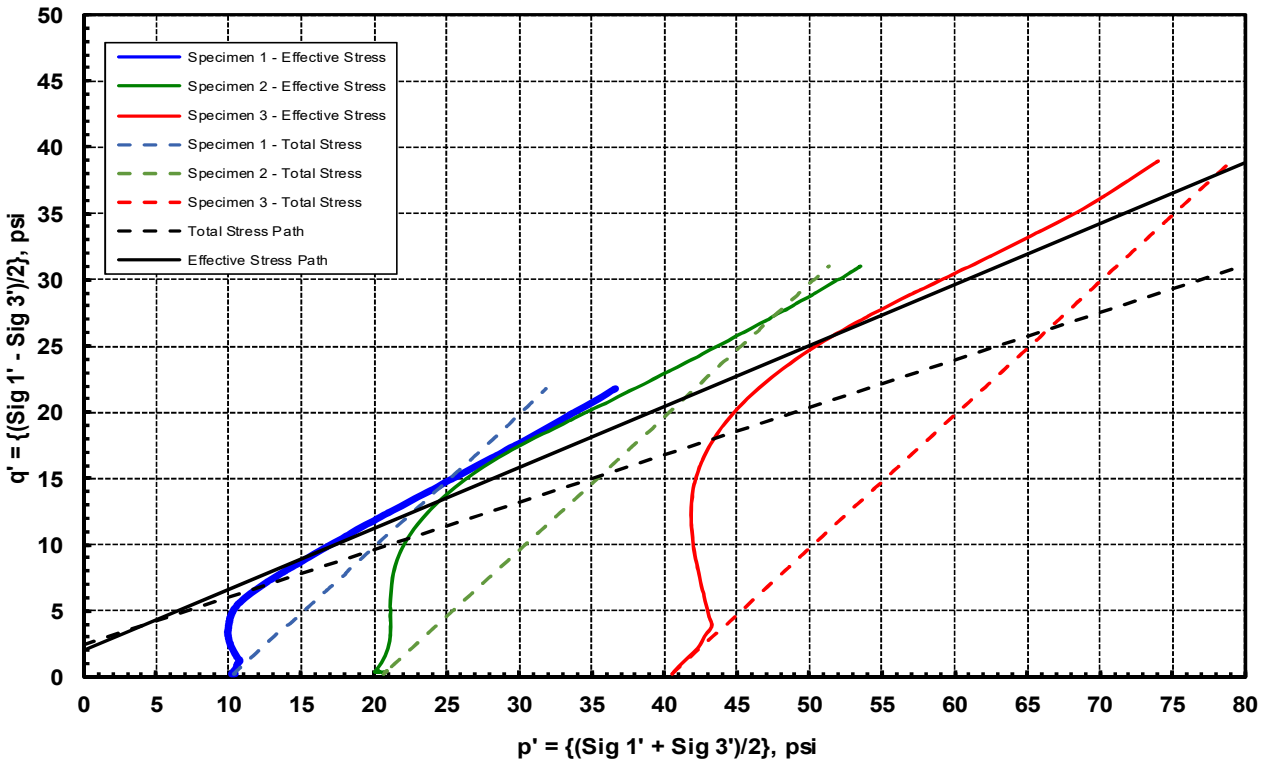
FIGURE - 11B

STRESS PATHS

Project Name:	*Laboratory Testing*				*Classification:*	*Sandy Lean Clay (CL)*	
Project Number:	*21-S-477*	*Boring Number:*	*Boring-7*	*Depth, feet:*	*14*	*Sample No./ID:*	*0*
a, ksf:	*0.35*	*ψ, deg:*	*19.7*	*a', ksf:*	*0.29*	*ψ', deg:*	*24.7*

Remarks:



HARRIS COUNTY ENGINEERING DEPARTMENT	PROPOSED RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENT - 2018, HARRIS COUNTY, TEXAS	HTS PROJECT NO. 21-S-477

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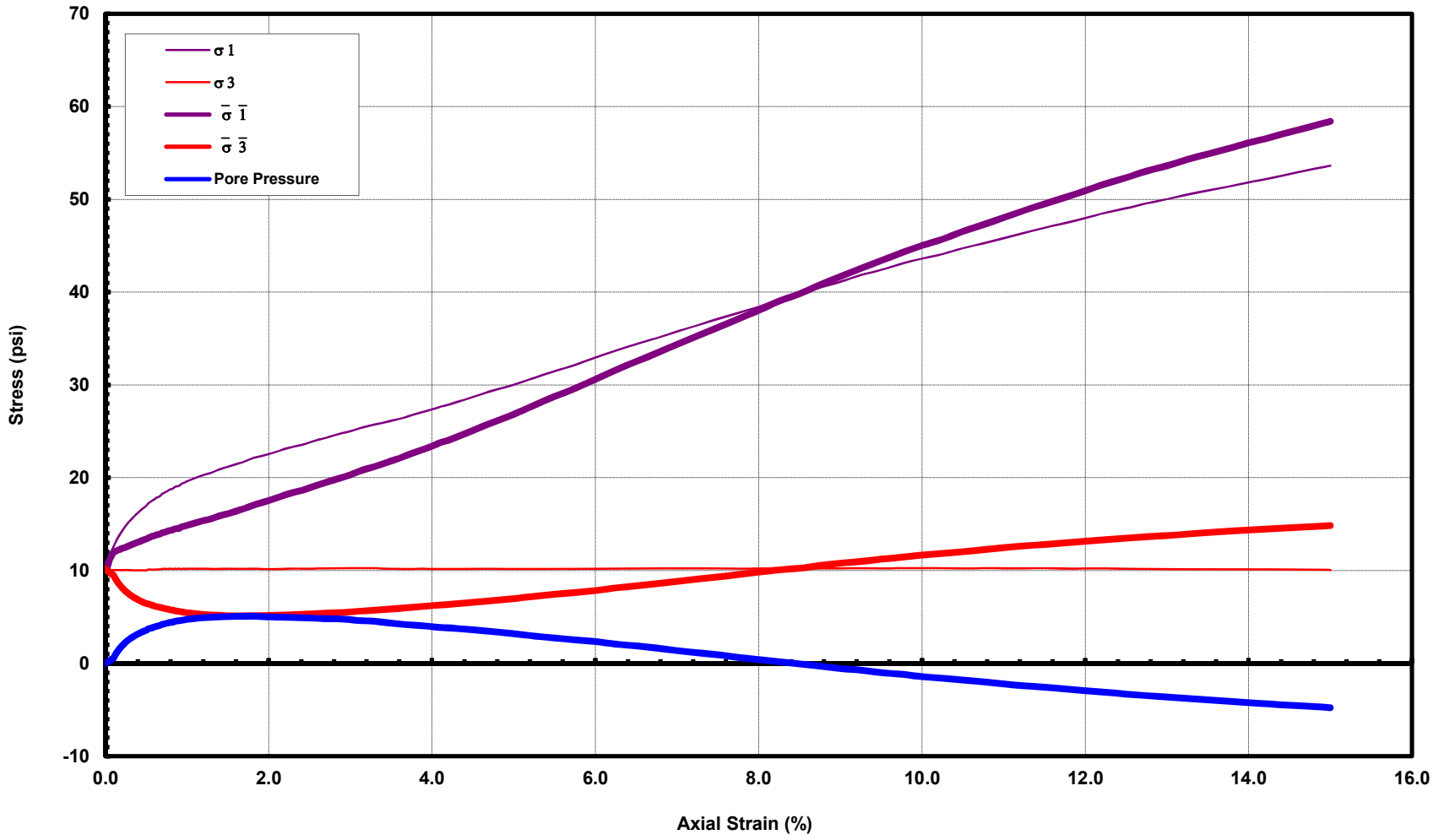
FIGURE - 11C

AXIAL STRAIN VS STRESS - PHASE 1



HARRIS COUNTY ENGINEERING DEPARTMENT	PROPOSED RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENT - 2018, HARRIS COUNTY, TEXAS	HTS PROJECT NO. 21-S-477

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FIGURE - 11D

AXIAL STRAIN VS STRESS - PHASE 2

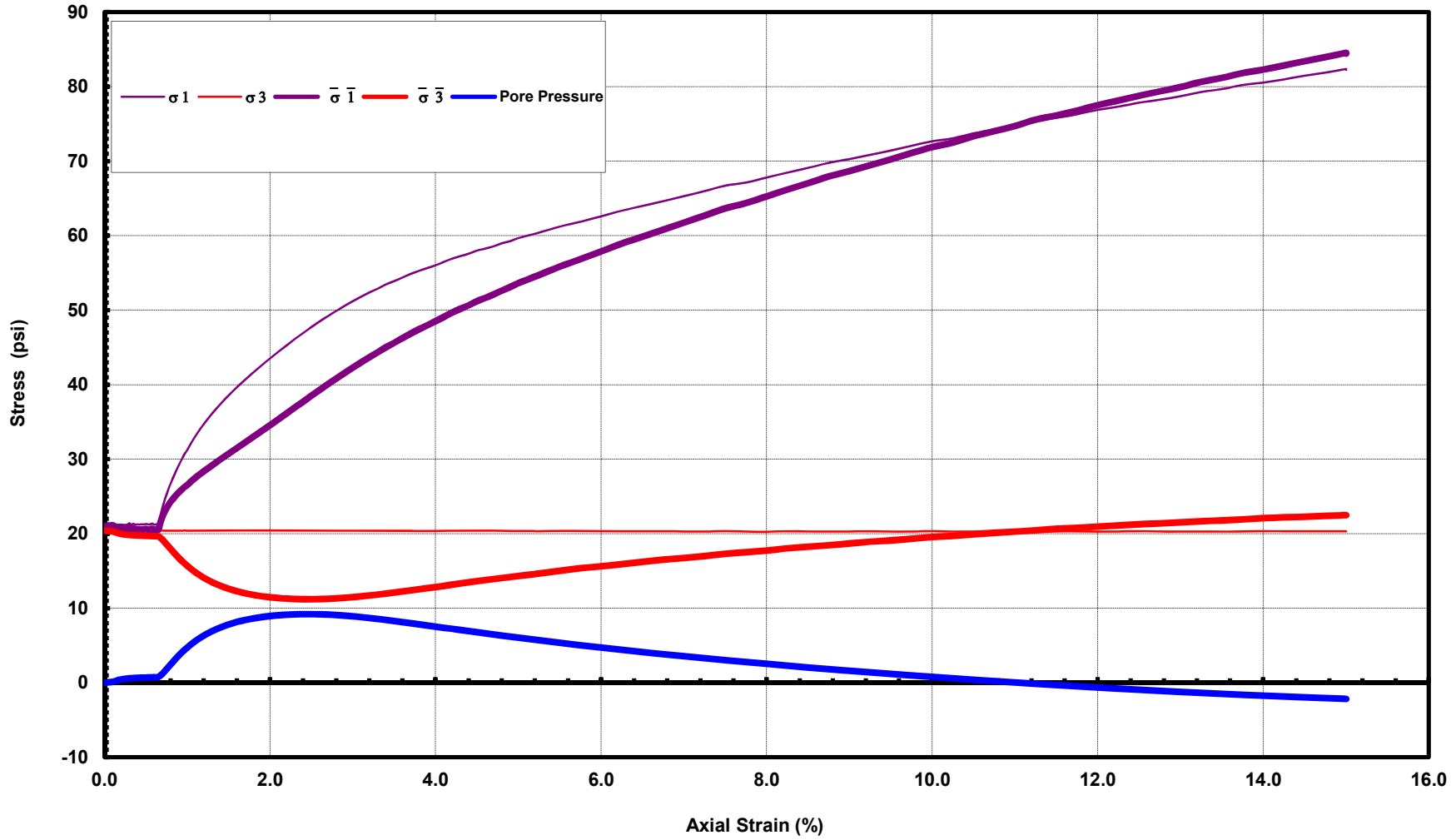

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FIGURE - 11E

AXIAL STRAIN VS STRESS - PHASE 3

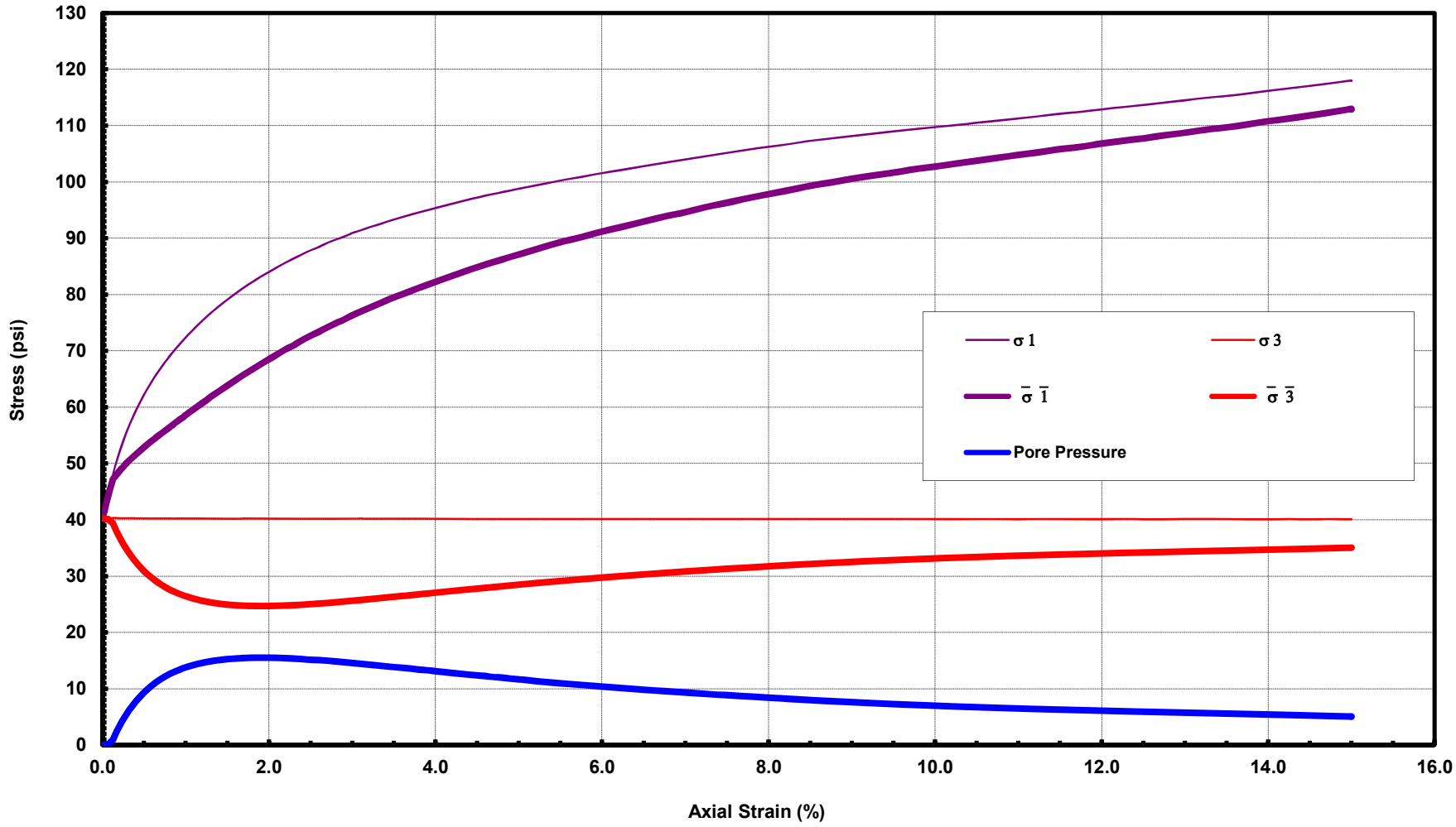

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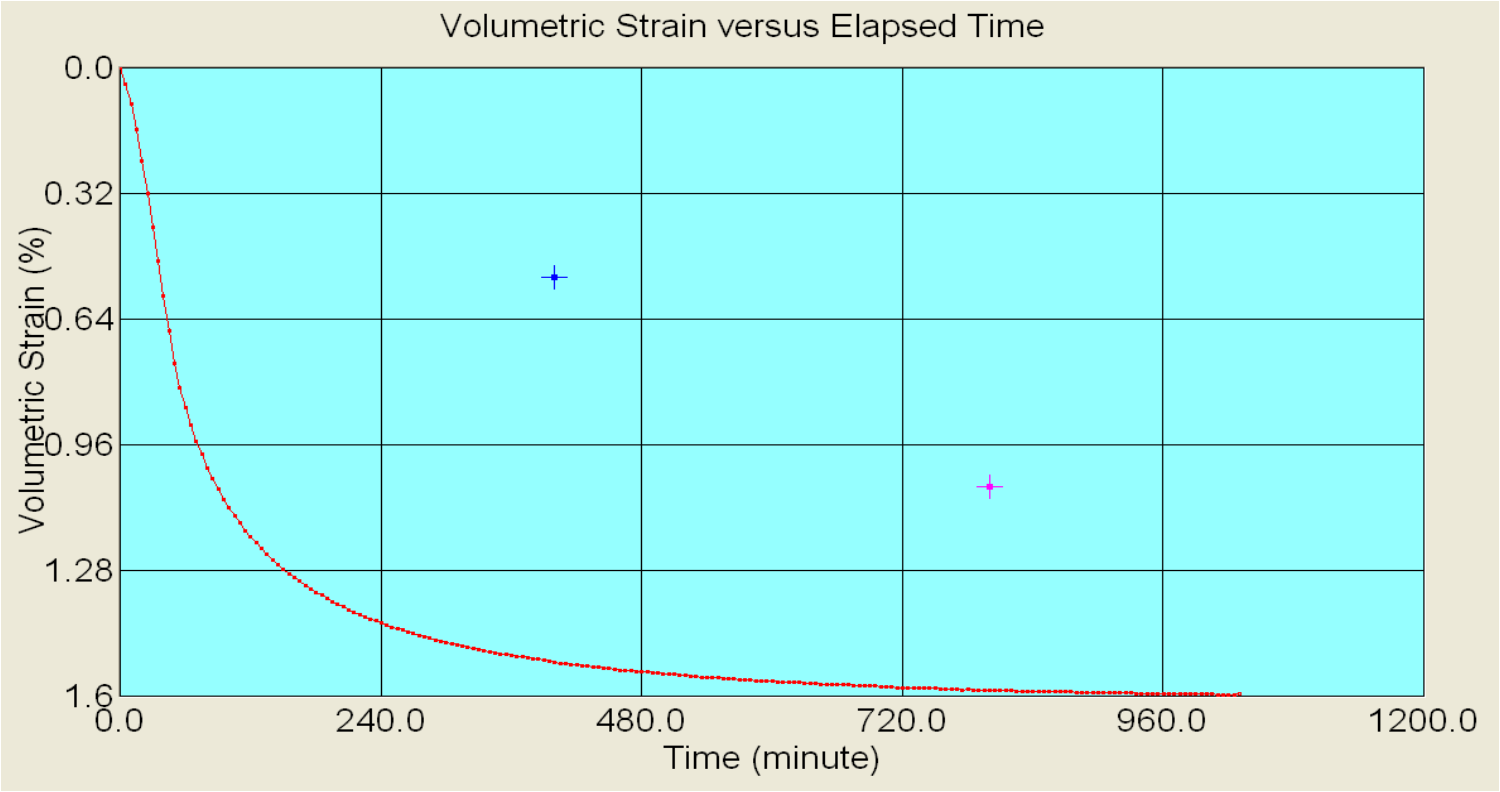
FIGURE - 11F

CONSOLIDATION - PHASE 1



HARRIS COUNTY ENGINEERING DEPARTMENT	PROPOSED RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENT - 2018, HARRIS COUNTY, TEXAS	HTS PROJECT NO. 21-S-477

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FIGURE - 11G

CONSOLIDATION - PHASE 2

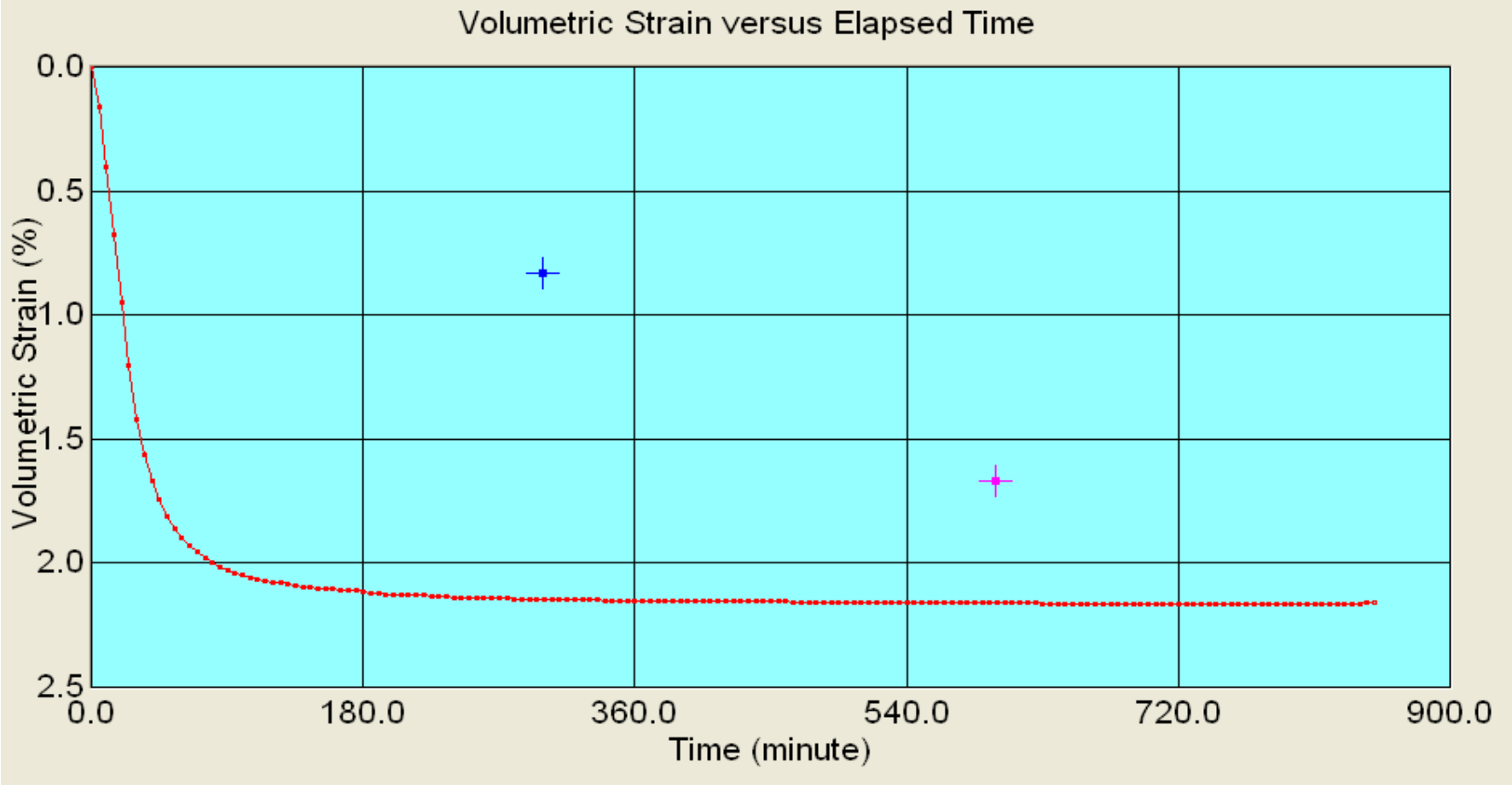

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FIGURE - 11H

CONSOLIDATION - PHASE 3

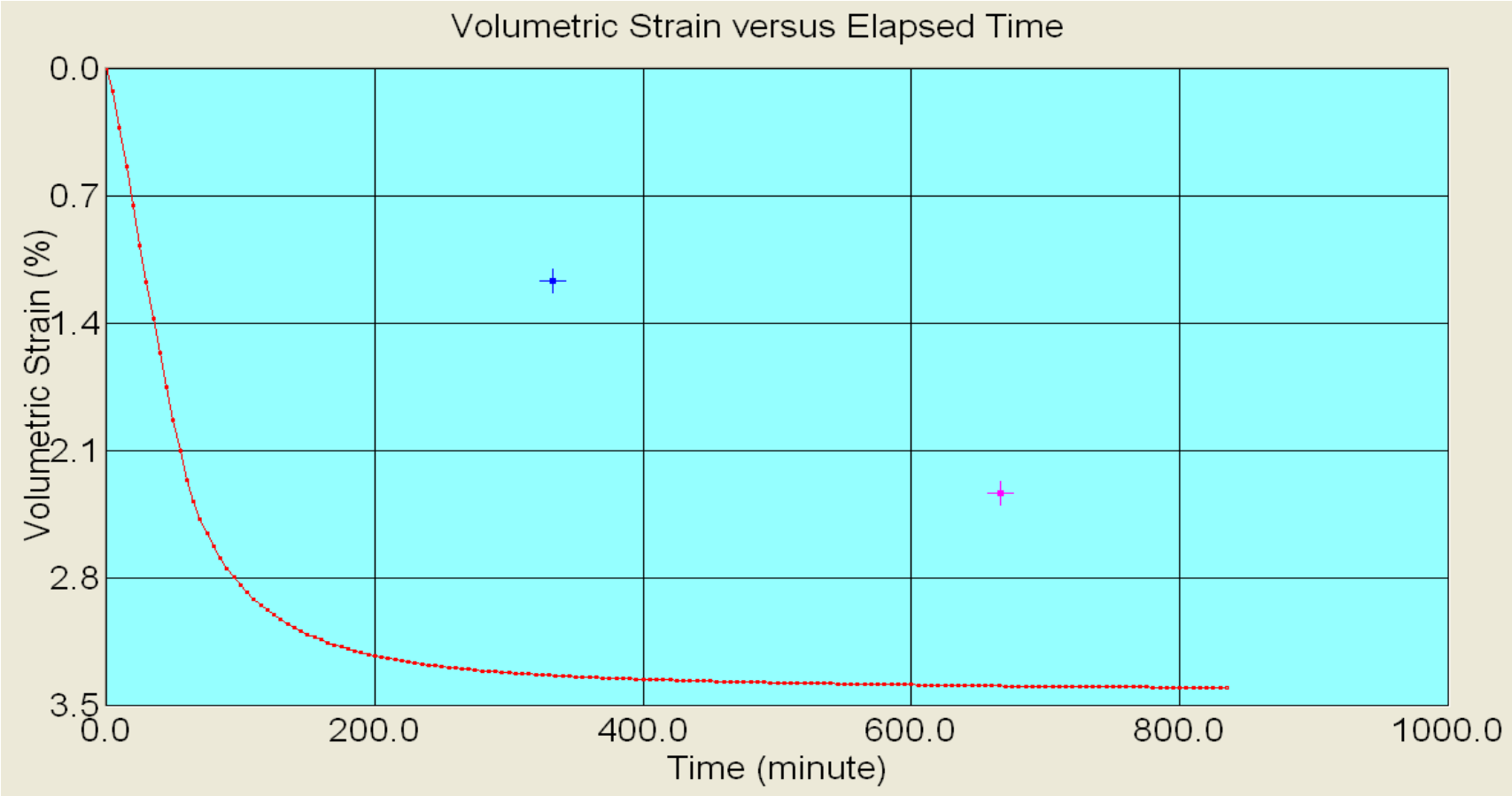

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FIGURE - 11I

EFFECTIVE STRESS OBLIQUITY CURVE

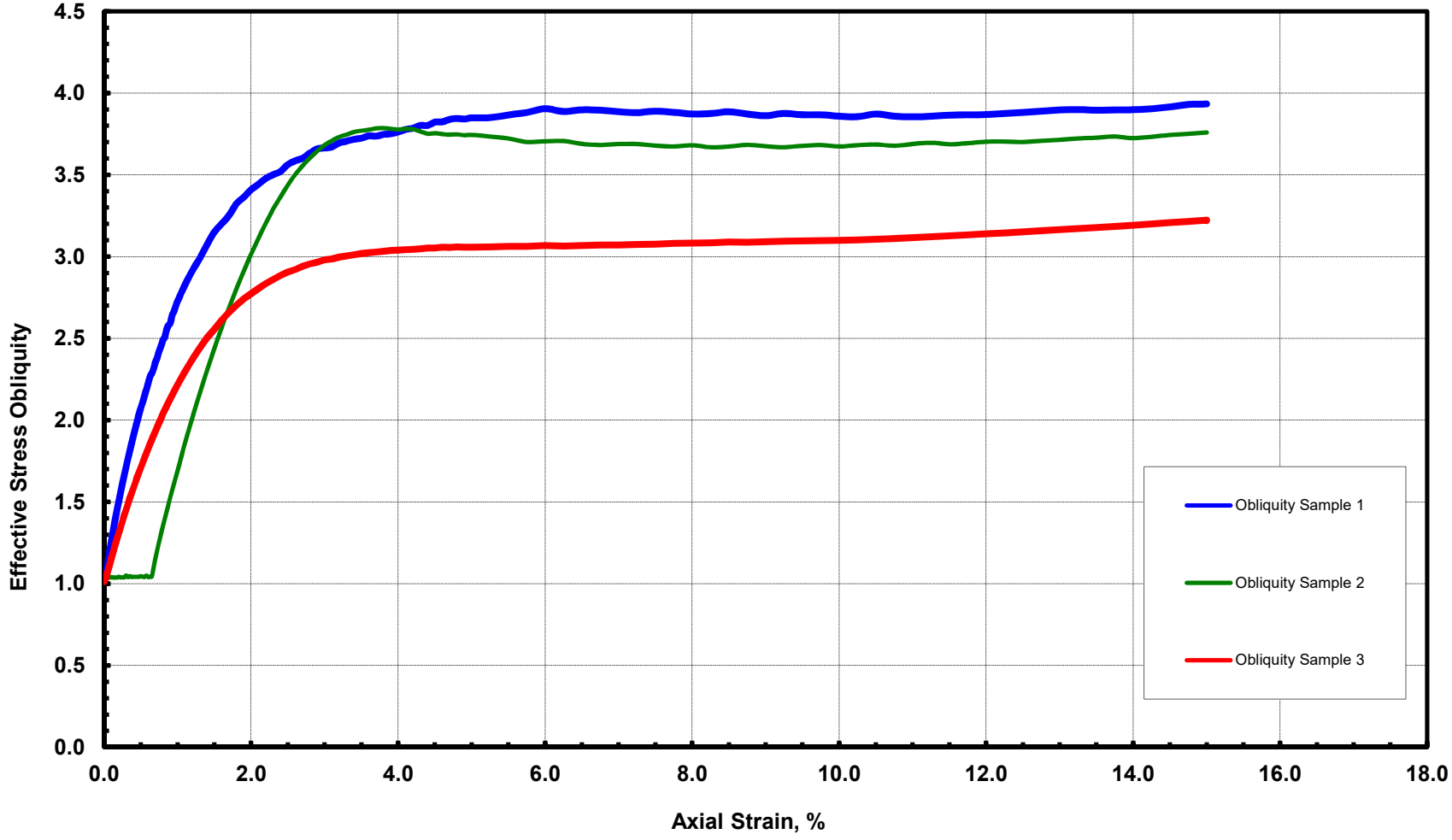

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FIGURE - 11J

APPENDIX A

BORING LOGS
(Boring Nos. 1 through 7)

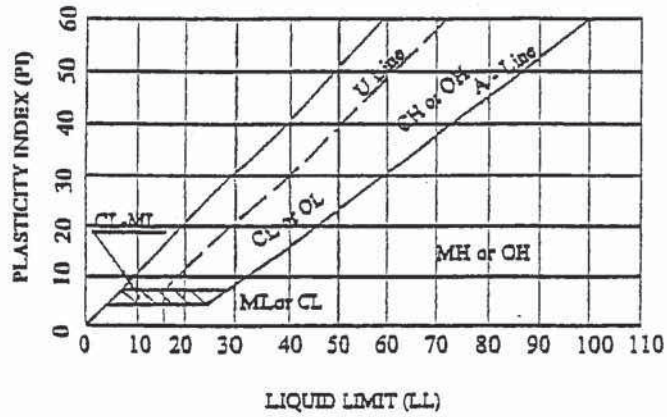
CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES

ASTM Designation D-2487

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

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

PLASTICITY CHART



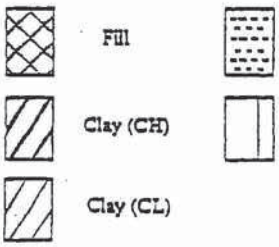
Equation of A-Line Horizontal at PI=4 to LL=25.5, then PI=0.73(LL-20)

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

DEGREE OF PLASTICITY OF COHESIVE SOILS

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

SOIL SYMBOLS



TERMS USED ON BORING LOGS

SOIL GRAIN SIZE

U.S. STANDARD SIEVE

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

BOULDERS	COBBLES	GRAVEL		SAND			SILT	CLAY
		COARSE	FINE	COARSE	MEDIUM	FINE		

152	76.2	19.1	4.76	2.00	0.420	0.074	0.002

SOIL GRAIN SIZE IN MILLIMETERS

STRENGTH OF COHESIVE SOILS

Consistency	Undrained Shear Strength, Kips per Sq. ft
Very Soft	less than 0.25
Soft	0.25 to 0.50
Firm	0.50 to 1.00
Stiff	1.00 to 2.00
Very Stiff	2.00 to 4.00
Hard	greater than 4.00

RELATIVE DENSITY OF COHESIONLESS SOILS FROM STANDARD PENETRATION TEST

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

(bpf = blow per foot, ASTM D 1586)

SPLIT-BARREL SAMPLER DRIVING RECORD

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

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

DRY STRENGTH ASTM D2488

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

MOISTURE CONDITION ASTM D2488

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

SOIL STRUCTURE

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

HTS, Inc. Consultants
416 Pickering Street
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LOG OF BORING NO. B-1

PROJECT: Proposed Ravensway Subdivision Drainage Improvements-2018
Precinct 3, UPIN #19103MF14601, Harris County, Texas

PROJECT NO.: 21-S-477 BORING TYPE: Auger (0'-25') : Rotary (25'-50')

DATE 10/30//21

SURFACE ELEVATION +133.5' above MSL

LOCATION

Northing, Y (Feet): 13911915.733
Easting, X (Feet): 3035989.024

See Figure 2

MATERIAL DESCRIPTION

Depth (ft.)	USC	Material Description	Field Strength Data	Dry Density (pcf)	Shear Strength (tsf)	Failure Strain (%)	Confining Pressure (psi)	Moisture Content (%)	Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)	Passing #200 Sieve (%)	Estimated Angle of Internal Friction (°), Other Tests & Remarks
0	SM	**SILTY SAND (SM),** loose, no plasticity, gray and tan, moist w/ small roots	N = 9					12.5				37.5	
2'	CL	**SANDY LEAN CLAY (CL),** very stiff to hard, high plasticity, light gray and light tan, moist w/ ferrous nodules - reddish brown at 4'	P = 3.25										
5			P = 4.50	117.5	1.70	15.0	4	12.5	41	18	23	57.0	
			P = 4.50										
10'			P = 4.50										
10	SM	**SILTY SAND (SM),** medium dense to dense, no plasticity, light gray, moist w/ clay pockets	N = 27					8.2				26.6	
14'			N = 31										
15	SP SM	**POORLY GRADED SAND WITH SILT (SP-SM),** medium dense, no plasticity, light gray and light tan, wet	N = 24					4.1				10.4	
			N = 23										
20			N = 25										
23'	SC	**CLAYEY SAND (SC),** medium plasticity, light gray and light tan, wet w/ ferrous nodules	P = 4.50					10.8	26	15	11	46.0	Dispersive Soil % Dispersion= 86.6 (1)
25													
28'	SC SM	**SILTY CLAYEY SAND (SC-SM),** dense to very dense, slight plasticity,	P = 4.50	119.2	1.95	14.1	17	13.1	20	14	6		

Water Level Est.: ▽ Measured: ▼ Perched: ▼

Water Observations: GW was not encountered during drilling prior to the introduction of drilling fluid. 24 hours after the completion of drilling, GW was measured at a depth of 14.1' below existing ground surface.

Sample Key: SPT Shelby Tube Disturbed No Recovery

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psi)
C_u - Undrained Cohesion (tsf)
SS - Shear Strength (P/2, tsf)

Notes:
(1) See Figures for Double Hydrometer Test Results.

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LOG OF BORING NO. B-1

PROJECT: Proposed Ravensway Subdivision Drainage Improvements-2018
Precinct 3, UPIN #19103MF14601, Harris County, Texas

PROJECT NO.: 21-S-477 BORING TYPE: Auger (0'-25') : Rotary (25'-50')

DATE 10/30//21

SURFACE ELEVATION +133.5' above MSL

LOCATION

Northing, Y (Feet): 13911915.733
Easting, X (Feet): 3035989.024

See Figure 2

MATERIAL DESCRIPTION

DEPTH (ft.)	SAMPLES	USC	WATER LEVEL	MATERIAL DESCRIPTION	FIELD STRENGTH DATA	DRY DENSITY (pcf)	SHEAR STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	MOISTURE CONTENT (%)	LIQUID LIMIT (LL)	PLASTIC LIMIT (PL)	PLASTICITY INDEX (PI)	PASSING #200 SIEVE (%)	ESTIMATED ANGLE OF INTERNAL FRICTION (°), OTHER TESTS & REMARKS
30				**SILTY CLAYEY SAND (SC-SM),** dense to very dense, slight plasticity, light gray and light tan, wet w/ clay pockets											
					P = 4.50										
35					P = 4.25										
40					N = 57					15.2				35.2	
45					N = 50										
		CH		48' **FAT CLAY (CH),** very stiff, very high plasticity, reddish brown and light gray, moist w/ slickensides											
50				50' Boring terminated at 50'	P = 3.50	93.5	1.40	10.1	25	33.9	78	23	55	99.1	

Natural Moisture Content and Atterberg Limits: Plastic Limit, Moisture Content, Liquid Limit (20, 40, 60, 80)

Water Level Est.: ▽ Measured: ▼ Perched: ▼

Water Observations: GW was not encountered during drilling prior to the introduction of drilling fluid. 24 hours after the completion of drilling, GW was measured at a depth of 14.1' below existing ground surface.

Sample Key: ☒ SPT ⧄ Shelby Tube ⧈ Disturbed ⧈ No Recovery

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psf)
C_u - Undrained Cohesion (tsf)
SS - Shear Strength (P/2, tsf)

Notes:
(1) See Figures for Double Hydrometer Test Results.

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LOG OF BORING NO. B-2

PROJECT: Proposed Ravensway Subdivision Drainage Improvements-2018
Precinct 3, UPIN #19103MF14601, Harris County, Texas

PROJECT NO.: 21-S-477 BORING TYPE: Auger (0'-30') : Rotary (30'-50')

DATE 10/30//21

SURFACE ELEVATION +134.3' above MSL

LOCATION

Northing, Y (Feet): 13911871.511
Easting, X (Feet): 3035611.911

See Figure 2

MATERIAL DESCRIPTION

DEPTH (ft.)	USC	MATERIAL DESCRIPTION	FIELD STRENGTH DATA	DRY DENSITY (pcf)	SHEAR STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	MOISTURE CONTENT (%)	LIQUID LIMIT (LL)	PLASTIC LIMIT (PL)	PLASTICITY INDEX (PI)	PASSING #200 SIEVE (%)	ESTIMATED ANGLE OF INTERNAL FRICTION (°), OTHER TESTS & REMARKS
0	SM	**SILTY SAND (SM),** loose, no plasticity, gray and tan, moist w/ small roots	N = 6					8.0				29.7	
2'	SC	**CLAYEY SAND (SC),** medium dense, slight to medium plasticity, light gray and light tan, moist w/ ferrous nodules	P = 4.50										
5			P = 4.50										
		- w/ silt pockets at 8'	P = 4.50	126.4	3.30	10.8	5	9.5	32	16	16	31.6	8'-10' Grade 4 (Hihgly Dispersive) (1)
10'			N = 28					8.0	22	14	8	22.1	
10	SP	**POORLY GRADED SAND (SP),** medium dense, no plasticity, light gray and light tan, moist to wet w/ clay pockets	N = 24										
			N = 21										
15			N = 23										
			N = 20					2.8				4.9	
20			N = 18										
23'	CL	**SANDY LEAN CLAY (CL),** medium plasticity, light gray, moist	N = 27					12.9	26	15	11	50.9	
25			N = 19					17.9				69.1	

Water Level Est.: ▽ Measured: ▼ Perched: ▼

Water Observations: GW was not encountered during drilling prior to the introduction of drilling fluid. 24 hours after the completion of drilling, GW was measured at a depth of 13.8' below existing ground surface.

Sample Key: ☒ SPT ☐ Shelby Tube ☐ Disturbed ☐ No Recovery

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psf)
C_u - Undrained Cohesion (tsf)
SS - Shear Strength (P/2, tsf)

Notes:
(1) See Tables for Crumb Test Results.

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LOG OF BORING NO. B-2

PROJECT: Proposed Ravensway Subdivision Drainage Improvements-2018
Precinct 3, UPIN #19103MF14601, Harris County, Texas

PROJECT NO.: 21-S-477 BORING TYPE: Auger (0'-30') : Rotary (30'-50')

DATE 10/30//21

SURFACE ELEVATION +134.3' above MSL

LOCATION

Northing, Y (Feet): 13911871.511
Easting, X (Feet): 3035611.911

See Figure 2

MATERIAL DESCRIPTION

DEPTH (ft.)	SAMPLES	USC	WATER LEVEL	MATERIAL DESCRIPTION	FIELD STRENGTH DATA	DRY DENSITY (pcf)	SHEAR STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	MOISTURE CONTENT (%)	LIQUID LIMIT (LL)	PLASTIC LIMIT (PL)	PLASTICITY INDEX (PI)	PASSING #200 SIEVE (%)	ESTIMATED ANGLE OF INTERNAL FRICTION (°), OTHER TESTS & REMARKS
30				**SANDY LEAN CLAY (CL),** medium plasticity, light gray, moist											
				33'											
35		CL		**LEAN CLAY WITH SAND (CL),** very stiff to hard, medium to high plasticity, light gray and light tan, moist w/ sand fissures	P = 3.25	125.3	2.40	15.0	19	13.7	26	15	11	80.4	
40					P = 4.5					18.0	48	20	28	79.9	
45					P = 3.25										
50				50'	P = 4.50										
				Boring terminated at 50'											

Natural Moisture Content and Atterberg Limits: Plastic Limit, Moisture Content, Liquid Limit (20 40 60 80)

Water Level Est.: ▽ Measured: ▼ Perched: ▼

Water Observations: GW was not encountered during drilling prior to the introduction of drilling fluid. 24 hours after the completion of drilling, GW was measured at a depth of 13.8' below existing ground surface.

Sample Key: ☒ SPT ☒ Shelby Tube ☒ Disturbed ☒ No Recovery

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psf)
C_u - Undrained Cohesion (tsf)
SS - Shear Strength (P/2, tsf)

Notes:
(1) See Tables for Crumb Test Results.

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LOG OF BORING NO. B-3

PROJECT: Proposed Ravensway Subdivision Drainage Improvements-2018
Precinct 3, UPIN #19103MF14601, Harris County, Texas

PROJECT NO.: 21-S-477 BORING TYPE: Auger (0'-30') : Rotary (30'-50')

DATE 10/25//21

SURFACE ELEVATION +128.9' above MSL

LOCATION

Northing, Y (Feet): 13911849.134
Easting, X (Feet): 3035291.365

See Figure 2

MATERIAL DESCRIPTION

Depth (ft.)	USC	Material Description
0	SM	**SILTY SAND (SM),** loose, no plasticity, dark gray, moist w/ small roots
2'	SC	**CLAYEY SAND (SC),** loose to medium dense, medium to high plasticity, gray and light tan, moist w/ ferrous nodules
10'	SP SM	**POORLY GRADED SAND WITH SILT (SP-SM),** medium dense, no plasticity, light gray and light tan, moist - w/ clay pockets at 12'
14'	CL	**LEAN CLAY WITH SAND (CL),** hard, high plasticity, light gray and light tan, moist
18'	CL	**SANDY LEAN CLAY (CL),** hard, medium plasticity, light gray and light tan, moist
23'	CL ML	**SILTY CLAY WITH SAND (CL-ML),** very stiff, slight plasticity, light gray and light tan, moist
28'	CL	**LEAN CLAY WITH SAND (CL),** hard, slight plasticity, light gray

Water Level Est.: ▽ Measured: ▼ Perched: ▼

Water Observations: GW was not encountered during drilling prior to the introduction of drilling fluid. 24 hours after the completion of drilling, GW was measured at a depth of 18' below existing ground surface.

Sample Key: ☒ SPT ☐ Shelby Tube ☐ Disturbed ☐ No Recovery

Field Strength Data	Dry Density (pcf)	Shear Strength (tsf)	Failure Strain (%)	Confining Pressure (psi)	Moisture Content (%)	Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)	Passing #200 Sieve (%)	Estimated Angle of Internal Friction (°), Other Tests & Remarks
N = 7					11.6				28.4	
N = 9										
P = 4.00					10.9	25	14	11	25.4	
P = 3.25					17.2	37	16	21	42.2	
P = 4.50										
N = 23										
N = 17					5.9				6.5	
N = 29										
P = 4.50					14.5	41	18	23	76.8	
P = 4.25										Dispersive Soil % Dispersion =94.1 (1)
P = 4.50					17.1	33	15	18	61.1	
P = 2.50					14.2	18	12	6	75.6	
N = 38										
P = 4.50					16.6	23	13	10	72.9	

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psi)
C_u - Undrained Cohesion (tsf)
SS - Shear Strength (P/2, tsf)

Notes:
(1) See Figures for Double Hydrometer Test Results.

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LOG OF BORING NO. B-3

PROJECT: Proposed Ravensway Subdivision Drainage Improvements-2018
Precinct 3, UPIN #19103MF14601, Harris County, Texas

PROJECT NO.: 21-S-477 BORING TYPE: Auger (0'-30') : Rotary (30'-50')

DATE 10/25//21

SURFACE ELEVATION +128.9' above MSL

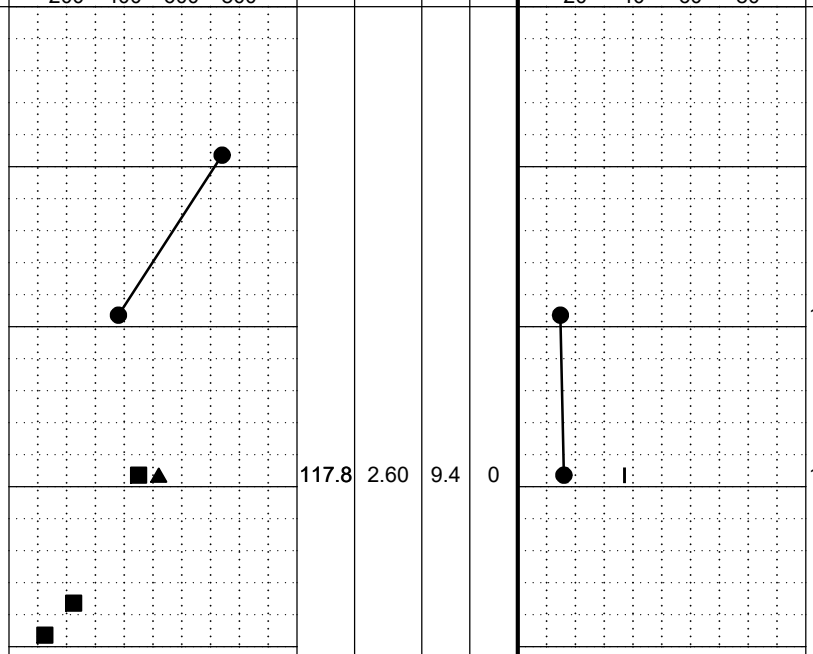
LOCATION

Northing, Y (Feet): 13911849.134
Easting, X (Feet): 3035291.365

See Figure 2

MATERIAL DESCRIPTION

DEPTH (ft.)	SAMPLES	USC	WATER LEVEL	MATERIAL DESCRIPTION	FIELD STRENGTH DATA	DRY DENSITY (pcf)	SHEAR STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	MOISTURE CONTENT (%)	LIQUID LIMIT (LL)	PLASTIC LIMIT (PL)	PLASTICITY INDEX (PI)	PASSING #200 SIEVE (%)	ESTIMATED ANGLE OF INTERNAL FRICTION (°), OTHER TESTS & REMARKS
30				**LEAN CLAY WITH SAND (CL),** hard, slight plasticity, light gray and light tan, moist w/ silt pockets											
				33'											
		SM		**SILTY SAND (SM),** dense to very dense, no plasticity, light gray, wet w/ clay pockets											
35					N = 74										
40					N = 38					14.8				28.1	
				43'											
		CL		**SANDY LEAN CLAY (CL),** stiff to hard, medium plasticity, light gray and light tan, moist											
45					P = 4.50	117.8	2.60	9.4	0	16.0	37	17	20	57.7	
				- w/ silt pockets at 48'	P = 2.25										
50					P = 1.25										
				50'											
				Boring terminated at 50'											



Water Level Est.: ▽ Measured: ▼ Perched: ▼

Water Observations: GW was not encountered during drilling prior to the introduction of drilling fluid. 24 hours after the completion of drilling, GW was measured at a depth of 18' below existing ground surface.

Sample Key: ☒ SPT ☐ Shelby Tube ☐ Disturbed ☐ No Recovery

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psf)
C_u - Undrained Cohesion (tsf)
SS - Shear Strength (P/2, tsf)

Notes:
(1) See Figures for Double Hydrometer Test Results.

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Houston, Texas 77091

LOG OF BORING NO. B-4

PROJECT: Proposed Ravensway Subdivision Drainage Improvements-2018
Precinct 3, UPIN #19103MF14601, Harris County, Texas

PROJECT NO.: 21-S-477 BORING TYPE: Auger (0'-30') : Rotary (30'-50')

DATE 10/30//21

SURFACE ELEVATION +130.3' above MSL

LOCATION

Northing, Y (Feet): 13912124.288
Easting, X (Feet): 3035721.66

See Figure 2

MATERIAL DESCRIPTION

Depth (ft.)	USC	Material Description
0	SM	**SILTY SAND (SM),** very loose, no plasticity, light gray and light tan, moist w/ small roots
2'	SC	**CLAYEY SAND (SC),** medium plasticity, light gray and light tan, moist w/ ferrous nodules
8'	SM	**SILTY SAND (SM),** medium dense, no plasticity, light gray and light tan, moist w/ clay pockets
12'	CL	**SANDY LEAN CLAY (CL),** hard, slight plasticity, light gray and light tan, moist w/ ferrous nodules and calcareous nodules
16'	SC	**CLAYEY SAND (SC),** medium dense, slight plasticity, light gray and light tan, moist to wet
18'	SM	**SILTY SAND (SM),** dense to very dense, no plasticity, light gray and light tan, wet
		- w/ clay pockets at 28'

Water Level: Est. ▽ Measured: ▼ Perched: ▼

Water Observations: GW was not encountered during drilling prior to the introduction of drilling fluid. 24 hours after the completion of drilling, GW was measured at a depth of 17.1' below existing ground surface.

Sample Key: SPT, Shelby Tube, Disturbed, No Recovery

Depth (ft.)	Field Strength Data	Dry Density (pcf)	Shear Strength (tsf)	Failure Strain (%)	Confining Pressure (psi)	Moisture Content (%)	Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)	Passing #200 Sieve (%)
0	N = 4					13.5				29.1
	P = 4.50									
	P = 4.50									
5	P = 4.50	125.4	3.05	6.8	4	9.4	27	15	12	27.3
8'	P = 4.50									
10	N = 21									
12'	N = 19					6.2				12.4
	N = 28									
	P = 4.50									
16'	P = 4.50	125.8	3.65	7.8	11	8.7	23	14	9	53.0
18'	N = 26					7.5	22	14	8	34.2
20	N = 38									
25	N = 57									
	N = 37					13.5				43.2

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psi)
C_u - Undrained Cohesion (tsf)
SS - Shear Strength (P/2, tsf)

Notes:

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LOG OF BORING NO. B-4

PROJECT: Proposed Ravensway Subdivision Drainage Improvements-2018
Precinct 3, UPIN #19103MF14601, Harris County, Texas

PROJECT NO.: 21-S-477 BORING TYPE: Auger (0'-30') : Rotary (30'-50')

DATE 10/30//21

SURFACE ELEVATION +130.3' above MSL

LOCATION

Northing, Y (Feet): 13912124.288
Easting, X (Feet): 3035721.66

See Figure 2

DEPTH (ft.)	SAMPLES	USC	WATER LEVEL	MATERIAL DESCRIPTION	FIELD STRENGTH DATA	DRY DENSITY (pcf)	SHEAR STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	MOISTURE CONTENT (%)	LIQUID LIMIT (LL)	PLASTIC LIMIT (PL)	PLASTICITY INDEX (PI)	PASSING #200 SIEVE (%)	ESTIMATED ANGLE OF INTERNAL FRICTION (°), OTHER TESTS & REMARKS
30				**SILTY SAND (SM),** dense to very dense, no plasticity, light gray and light tan, wet											
35					N = 74					14.6	15	13	2	29.8	
40					N = 39										
				43'											
45		CH		**FAT CLAY WITH SAND (CH),** hard, high plasticity, light gray and light tan, moist w/ ferrous nodules and slickensides	P = 4.50	108.5	2.30	9.3	25	19.7	54	20	34	76.1	
				48'											
50		CH		**SANDY FAT CLAY (CH),** very stiff, high plasticity, reddish brown, moist w/ slickensides	P = 3.50	108.9	1.85	10.8	27	18.4	52	20	32	65.3	
				50' Boring terminated at 50'											

FIELD STRENGTH DATA: ● BLOW COUNT ● (20 40 60 80); ▲ C_u (tsf) ▲ (1.0 2.0 3.0 4.0); ■ SS (tsf) ■ (1.0 2.0 3.0 4.0); ◆ Torvane (psf) ◆ (200 400 600 800)

Natural Moisture Content and Atterberg Limits: Plastic Limit — Moisture Content — Liquid Limit (20 40 60 80)

Water Level Est.: ▽ Measured: ▼ Perched: ▼

Water Observations: GW was not encountered during drilling prior to the introduction of drilling fluid. 24 hours after the completion of drilling, GW was measured at a depth of 17.1' below existing ground surface.

Sample Key: ☒ SPT ☐ Shelby Tube ☐ Disturbed ☐ No Recovery

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psf)
C_u - Undrained Cohesion (tsf)
SS - Shear Strength (P/2, tsf)

Notes:

HTS, Inc. Consultants
416 Pickering Street
Houston, Texas 77091

LOG OF BORING NO. B-5

PROJECT: Proposed Ravensway Subdivision Drainage Improvements-2018
Precinct 3, UPIN #19103MF14601, Harris County, Texas

PROJECT NO.: 21-S-477 BORING TYPE: Auger (0'-20') : Rotary (20'-50')

DATE 10/25//21

SURFACE ELEVATION +127.9' above MSL

LOCATION

Northing, Y (Feet): 13912059.971
Easting, X (Feet): 3035313.449

See Figure 2

MATERIAL DESCRIPTION

Depth (ft.)	USC	Material Description
0	SM	**SILTY SAND (SM),** loose, no plasticity, gray and light gray, moist w/ small roots
2'	CH	**SANDY FAT CLAY (CH),** hard, very high plasticity, gray and tan, moist w/ ferrous nodules
4'	CL	**CLAYEY SAND (SC),** medium plasticity, gray and tan, moist
8'	SM	**SILTY SAND (SM),** medium dense, no plasticity, light gray and tan, moist to wet w/ small pieces of gravel
18'	CL	**SANDY LEAN CLAY (CL),** stiff to very stiff, medium plasticity, reddish brown and gray, moist

Depth (ft.)	Field Strength Data	Dry Density (pcf)	Shear Strength (tsf)	Failure Strain (%)	Confining Pressure (psi)	Moisture Content (%)	Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)	Passing #200 Sieve (%)	Estimated Angle of Internal Friction (°), Other Tests & Remarks
0	N = 6										
	P = 4.50					16.5	63	22	41	53.2	Dispersive Soil % Dispersion =80 (1)
5	P = 4.50					10.2	37	17	20	38.6	
	P = 4.50										
10	N = 19					8.6				12.9	Non Ploastic
	N = 16										
	N = 18										
15	N = 24					11.4					
	N = 26										
	N = 14										
20											
25	P = 2.50	129.6	0.75	3.2	0	13.1	26	14	12	62.6	
	N = 28										

Field Strength Data: ● BLOW COUNT (20 40 60 80); ▲ C_u (tsf) (1.0 2.0 3.0 4.0); ■ SS (tsf) (1.0 2.0 3.0 4.0); ◆ Torvane (psf) (200 400 600 800)

Natural Moisture Content and Atterberg Limits: Plastic Limit — Moisture Content — Liquid Limit (20 40 60 80)

Water Level Est.: ▽ Measured: ▼ Perched: ▼

Water Observations: GW was encountered at a depth of 18.4' during drilling. 24 hours after the completion of drilling, GW was measured at a depth of 11.7' below existing ground surface.

Sample Key: ☒ SPT ☐ Shelby Tube ☐ Disturbed ☐ No Recovery

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psf)
C_u - Undrained Cohesion (tsf)
SS - Shear Strength (P/2, tsf)

Notes:
(1) See Figures for Double Hydrometer Test Results.

HTS, Inc. Consultants
416 Pickering Street
Houston, Texas 77091

LOG OF BORING NO. B-5

PROJECT: Proposed Ravensway Subdivision Drainage Improvements-2018
Precinct 3, UPIN #19103MF14601, Harris County, Texas

PROJECT NO.: 21-S-477 BORING TYPE: Auger (0'-20') : Rotary (20'-50')

DATE 10/25//21

SURFACE ELEVATION +127.9' above MSL

LOCATION

Northing, Y (Feet): 13912059.971
Easting, X (Feet): 3035313.449

See Figure 2

MATERIAL DESCRIPTION

DEPTH (ft.)	SAMPLES	USC	WATER LEVEL	MATERIAL DESCRIPTION	FIELD STRENGTH DATA	DRY DENSITY (pcf)	SHEAR STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	MOISTURE CONTENT (%)	LIQUID LIMIT (LL)	PLASTIC LIMIT (PL)	PLASTICITY INDEX (PI)	PASSING #200 SIEVE (%)	ESTIMATED ANGLE OF INTERNAL FRICTION (°), OTHER TESTS & REMARKS
30				**SANDY LEAN CLAY (CL),** stiff to very stiff, medium plasticity, reddish brown and gray, moist											
				33'											
35		SC		**CLAYEY SAND (SC),** very dense, light gray and light tan, wet	N = 100					17.1				35.0	
				38'											
40		SM		**SILTY SAND (SM),** medium dense, no plasticity, light gray and light tan, wet	N = 19										
				43'											
45		CL		**SANDY LEAN CLAY (CL),** very stiff, medium plasticity, light gray and light tan, moist w/ ferrous nodules	P = 2.75	116.4	1.95	14.8	22	17.4	38	18	20	57.0	
				48'											
50		SM		50' **SILTY SAND (SM),** very dense, no plasticity, light gray and light tan, wet w/ clay pockets	N = 88					16.7				15.2	

Boring terminated at 50'

FIELD STRENGTH DATA: ● BLOW COUNT ● (20 40 60 80); ▲ C_u (tsf) ▲ (1.0 2.0 3.0 4.0); ■ SS (tsf) ■ (1.0 2.0 3.0 4.0); ◆ Torvane (psf) ◆ (200 400 600 800)

Natural Moisture Content and Atterberg Limits: Plastic Limit, Moisture Content, Liquid Limit (20 40 60 80)

Water Level Est.: ▽ Measured: ▼ Perched: ▼

Water Observations: GW was encountered at a depth of 18.4' during drilling. 24 hours after the completion of drilling, GW was measured at a depth of 11.7' below existing ground surface.

Sample Key: ☒ SPT ☒ Shelby Tube ☒ Disturbed ☒ No Recovery

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psf)
C_u - Undrained Cohesion (tsf)
SS - Shear Strength (P/2, tsf)

Notes:
(1) See Figures for Double Hydrometer Test Results.

HTS, Inc. Consultants
416 Pickering Street
Houston, Texas 77091

LOG OF BORING NO. B-6

PROJECT: Proposed Ravensway Subdivision Drainage Improvements-2018
Precinct 3, UPIN #19103MF14601, Harris County, Texas

PROJECT NO.: 21-S-477 BORING TYPE: Auger (0'-25') : Rotary (25'-50')

DATE 10/29//21

SURFACE ELEVATION +125.6' above MSL

LOCATION

Northing, Y (Feet): 13912419.049
Easting, X (Feet): 3035429.815

See Figure 2

MATERIAL DESCRIPTION

Depth (ft.)	USC	Material Description	Field Strength Data	Dry Density (pcf)	Shear Strength (tsf)	Failure Strain (%)	Confining Pressure (psi)	Moisture Content (%)	Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)	Passing #200 Sieve (%)	Estimated Angle of Internal Friction (°), Other Tests & Remarks
0	ML	**SANDY SILT (ML),** medium dense, no plasticity, dark gray and gray, moist w/ clay pockets and small roots	P = 2.00										Non Plastic
4'	CL	**SANDY LEAN CLAY (CL),** slight plasticity, light gray and light tan, moist	N = 14					10.1				50.3	
6'	SM	**SILTY SAND (SM),** medium dense, no plasticity, light gray and light tan, moist to wet w/ clay pockets	N = 16					10.3	22	13	9	54.4	
			N = 13										
			N = 14										
10			N = 29					7.6				40.4	
			N = 28										
15			N = 22										
16'	SC SM	**SILTY CLAYEY SAND (SC-SM),** slight plasticity, light gray and light tan, wet	P = 2.75	116.8	1.00	13.8	0	14.8	19	12	7	44.5	
18'	CL	**SANDY LEAN CLAY (CL),** very stiff, slight plasticity, light gray and tan, moist w/ silt pockets	P = 2.50					14.9	21	13	8	66.7	
20													
23'	ML	**SANDY SILT (ML),** no plasticity, light gray and light tan, wet w/ clay pockets	P = 3.50					13.8	15	12	3	57.5	
25													
28'	SM	**SILTY SAND (SM),** dense, no plasticity, light gray and light tan,	N = 47					15.0				27.0	

Field Strength Data: ● BLOW COUNT ● (20 40 60 80); ▲ C_u (tsf) ▲ (1.0 2.0 3.0 4.0); ■ SS (tsf) ■ (1.0 2.0 3.0 4.0); ◆ Torvane (psf) ◆ (200 400 600 800)

Natural Moisture Content and Atterberg Limits: Plastic Limit — Moisture Content — Liquid Limit (20 40 60 80)

Water Level Est.: ▽ Measured: ▼ Perched: ▼

Water Observations: GW was encountered at a depth of 23' during drilling. 24 hours after the completion of drilling, GW was measured at a depth of 13.0' below existing ground surface.

Sample Key: ☒ SPT ☐ Shelby Tube ☐ Disturbed ☐ No Recovery

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psf)
C_u - Undrained Cohesion (tsf)
SS - Shear Strength (P/2, tsf)

Notes:

HTS, Inc. Consultants
416 Pickering Street
Houston, Texas 77091

LOG OF BORING NO. B-6

PROJECT: Proposed Ravensway Subdivision Drainage Improvements-2018
Precinct 3, UPIN #19103MF14601, Harris County, Texas

PROJECT NO.: 21-S-477 BORING TYPE: Auger (0'-25') : Rotary (25'-50')

DATE 10/29//21

SURFACE ELEVATION +125.6' above MSL

LOCATION

Northing, Y (Feet): 13912419.049
Easting, X (Feet): 3035429.815

See Figure 2

DEPTH (ft.)	SAMPLES	USC	WATER LEVEL	MATERIAL DESCRIPTION	FIELD STRENGTH DATA	DRY DENSITY (pcf)	SHEAR STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	MOISTURE CONTENT (%)	LIQUID LIMIT (LL)	PLASTIC LIMIT (PL)	PLASTICITY INDEX (PI)	PASSING #200 SIEVE (%)	ESTIMATED ANGLE OF INTERNAL FRICTION (°), OTHER TESTS & REMARKS
30															
				33' **SILTY SAND (SM),** dense, no plasticity, light gray and light tan, wet w/ clay pockets											
35		CL		**SANDY LEAN CLAY (CL),** very stiff, medium plasticity, light gray and light tan, moist w/ ferrous nodules	P = 3.75					16.6	32	15	17	58.7	
				38'											
40		CH		**FAT CLAY WITH SAND (CH),** very stiff, high plasticity, light gray, light tan, and reddish brown, moist w/ ferrous nodules	P = 3.00	100.3	1.35	13.1	0	28.6	59	21	38	76.5	
				43'											
45		CL		**SANDY LEAN CLAY (CL),** light gray and light tan, moist	N = 25										
				48'											
50		SP SM		50' **POORLY GRADED SAND WITH SILT (SP-SM),** dense, no plasticity, light gray and light tan, wet	N = 50				19.5					11.7	Non Plastic
				Boring terminated at 50'											

Natural Moisture Content and Atterberg Limits: Plastic Limit, Moisture Content, Liquid Limit (20, 40, 60, 80)

Water Level Est.: ▽ Measured: ▼ Perched: ▼

Water Observations: GW was encountered at a depth of 23' during drilling. 24 hours after the completion of drilling, GW was measured at a depth of 13.0' below existing ground surface.

Sample Key: ☒ SPT ☒ Shelby Tube ☒ Disturbed ☒ No Recovery

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psf)
C_u - Undrained Cohesion (tsf)
SS - Shear Strength (P/2, tsf)

Notes:

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416 Pickering Street
Houston, Texas 77091

LOG OF BORING NO. B-7

PROJECT: Proposed Ravensway Subdivision Drainage Improvements-2018
Precinct 3, UPIN #19103MF14601, Harris County, Texas

PROJECT NO.: 21-S-477 BORING TYPE: Auger (0'-30') : Rotary (30'-50')

DATE 10/29//21

SURFACE ELEVATION +125.8' above MSL

LOCATION

Northing, Y (Feet): 13912240.253
Easting, X (Feet): 3035467.527

See Figure 2

MATERIAL DESCRIPTION

DEPTH (ft.)	USC	MATERIAL DESCRIPTION	FIELD STRENGTH DATA	DRY DENSITY (pcf)	SHEAR STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	MOISTURE CONTENT (%)	LIQUID LIMIT (LL)	PLASTIC LIMIT (PL)	PLASTICITY INDEX (PI)	PASSING #200 SIEVE (%)	ESTIMATED ANGLE OF INTERNAL FRICTION (°), OTHER TESTS & REMARKS
0	ML	**SANDY SILT (ML),** medium dense, no plasticity, gray and light gray, moist	N = 20					7.4				52.9	
2'	CL	**SANDY LEAN CLAY (CL),** high plasticity, light gray and light tan, moist w/ ferrous nodules	N = 25										
5			N = 22					14.7	44	18	26	56.7	
6'	SC	**CLAYEY SAND (SC),** medium plasticity, light gray and light tan, moist w/ ferrous nodules	P = 4.50										
			P = 3.75										
10			P = 4.50	121.2	2.05	13.3	0	12.3	28	14	14	49.0	
14'	CL	**SANDY LEAN CLAY (CL),** stiff to very stiff, medium plasticity, light gray and light tan, moist	P = 3.75					13.2	30	15	15	45.6	14'-16' CU $C_{tot.}$=380 psf $Ø_{tot.}$=21° $C_{eff.}$=330 psf $Ø_{eff.}$=27.6° (1)
15		- w/ silt pockets at 18'	P = 2.25					15.7	32	16	16	55.2	
			P = 2.00										
20			P = 1.50										
23'	CL	**LEAN CLAY WITH SAND (CL),** firm, medium plasticity, light gray and light tan, moist w/ silt pockets	P = 0.75					14.8	24	13	11	75.2	
25													
28'	SM	**SILTY SAND (SM),** dense, no plasticity, light gray and light tan,	N = 50										

Water Level Est.: ▽ Measured: ▼ Perched: ▼

Water Observations: GW was encountered at a depth of 27' during drilling. 24 hours after the completion of drilling, GW was measured at a depth of 15.6' below existing ground surface.

Sample Key: ☒ SPT ☒ Shelby Tube ☒ Disturbed ☒ No Recovery

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psi)
C_u - Undrained Cohesion (tsf)
SS - Shear Strength (P/2, tsf)

Notes:
(1) Refer to Figures for Results of CU Triaxial Test ASTM (D 4767).

HTS, Inc. Consultants
416 Pickering Street
Houston, Texas 77091

LOG OF BORING NO. B-7

PROJECT: Proposed Ravensway Subdivision Drainage Improvements-2018
Precinct 3, UPIN #19103MF14601, Harris County, Texas

PROJECT NO.: 21-S-477 BORING TYPE: Auger (0'-30') : Rotary (30'-50')

DATE 10/29//21

SURFACE ELEVATION +125.8' above MSL

LOCATION

Northing, Y (Feet): 13912240.253
Easting, X (Feet): 3035467.527

See Figure 2

DEPTH (ft.)	SAMPLES	USC	WATER LEVEL	MATERIAL DESCRIPTION	FIELD STRENGTH DATA	DRY DENSITY (pcf)	SHEAR STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	MOISTURE CONTENT (%)	LIQUID LIMIT (LL)	PLASTIC LIMIT (PL)	PLASTICITY INDEX (PI)	PASSING #200 SIEVE (%)	ESTIMATED ANGLE OF INTERNAL FRICTION (°), OTHER TESTS & REMARKS
30				**SILTY SAND (SM),** dense, no plasticity, light gray and light tan, wet w/ clay pockets											
35	X				N = 41					16.0				22.9	
		CL		38' **SANDY LEAN CLAY (CL),** very stiff to hard, high plasticity, light gray and light tan, moist w/ ferrous nodules											
40					P = 4.25										
45					P = 2.25	110.0	1.85	11.8	0	20.0	47	20	27	62.9	
		SM		48' **SILTY SAND (SM),** very dense, no plasticity, light gray and light tan, wet w/ clay pockets											
50	X			50' Boring terminated at 50'	N = 51					19.7				17.2	

Natural Moisture Content and Atterberg Limits: Plastic Limit, Moisture Content, Liquid Limit (20, 40, 60, 80)

Water Level Est.: ▽ Measured: ▼ Perched: ▼

Water Observations: GW was encountered at a depth of 27' during drilling. 24 hours after the completion of drilling, GW was measured at a depth of 15.6' below existing ground surface.

Sample Key: ☒ SPT ☒ Shelby Tube ☒ Disturbed ☒ No Recovery

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psf)
C_u - Undrained Cohesion (tsf)
SS - Shear Strength (P/2, tsf)

Notes:
(1) Refer to Figures for Results of CU Triaxial Test ASTM (D 4767).

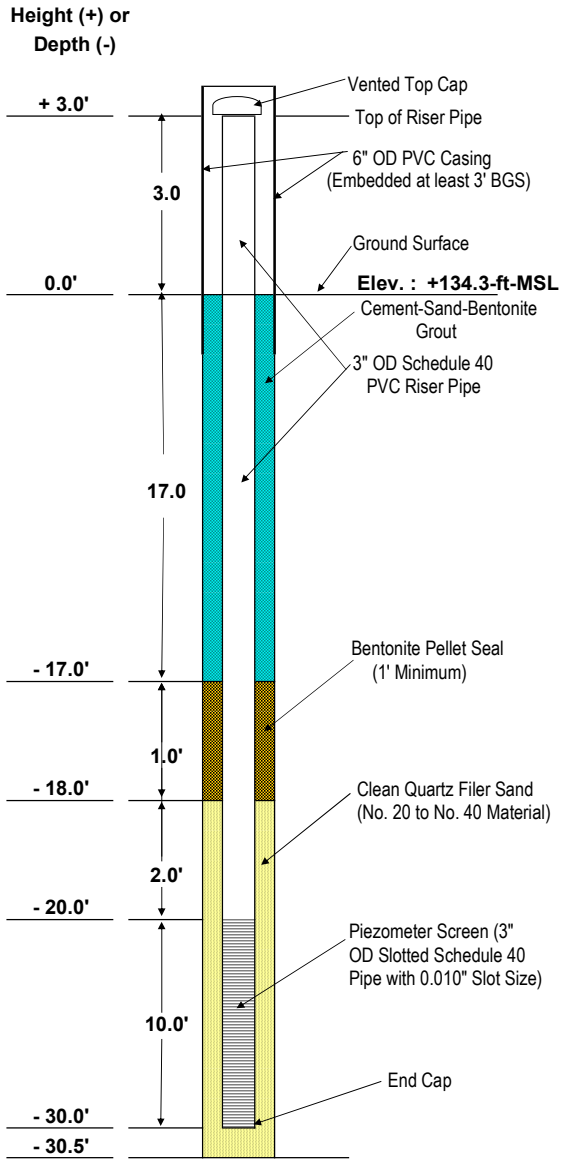
APPENDIX B

Piezometer Installation Data

HTS, Inc. Consultants

416 Pickering, Houston, Texas 77091
Tel: (713) 692-8373 Fax: (713) 692-8502

PIEZOMETER INSTALLATION DATA



Installation and Development Details

Piezometer No:	PZ-1	
Location:	Boring No. 2	
Installation Date:	11/13/21	
Drilling Method:	Dry Auger	x
	Wet Rotary	x
Development Date:	11/13/21	
Development Method:	Pumping	

Water Level Data	Depth Below Grade (ft)	Elevation (ft-MSL)
24 Hours After Drilling	13.8	120.5
After Installation:	18.0	116.3
After 1 day:	15.0	119.3
After 1 Week:	28.0	106.3
After 2 Weeks:	28.2	106.1
After 4 Weeks:	19.6	114.7

NOTES: Height above the ground surface is shown as a positive number (+) and depth below ground is shown as a negative number (-).

Piezometer Installation

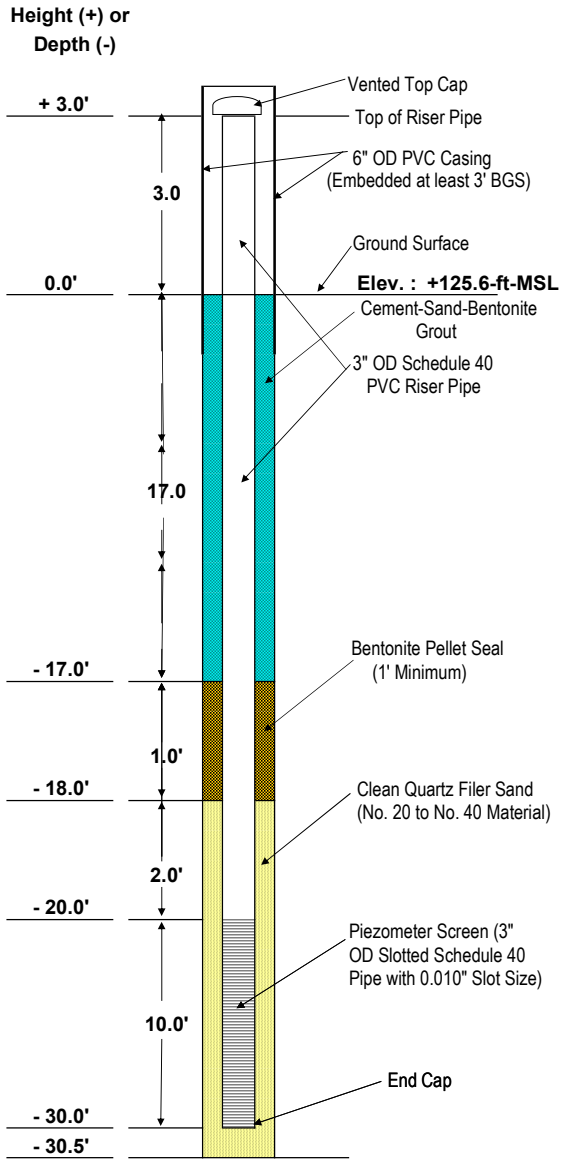
PROPOSED RAVENSWAY SUBDIVISION
IMPROVEMENTS - 2018
PRECINCT 3
HARRIS COUNTY, TEXAS
UPIN# 19103MF14601

Drawn By: AA	Date: 12/1/2021	Scale: Not To Scale
Checked By: JH	Date: 12/6/2021	PLATE B-1
HTS Project No:	21-S-477	

HTS, Inc. Consultants

416 Pickering, Houston, Texas 77091
Tel: (713) 692-8373 Fax: (713) 692-8502

PIEZOMETER INSTALLATION DATA



Installation and Development Details

Piezometer No:	PZ-2	
Location:	Boring No. 6	
Installation Date:	11/13/21	
Drilling Method:	Dry Auger	x
	Wet Rotary	x
Development Date:	11/13/21	
Development Method:	Pumping	

Water Level Data	Depth Below Grade (ft)	Elevation (ft-MSL)
During Drilling:	23.0	102.6
24 Hours After Drilling	13.0	112.6
After Installation:	23.9	101.7
After 1 day:	20.9	104.7
After 1 Week:	19.2	106.4
After 2 Weeks:	19.4	106.2
After 4 Weeks:	22.6	103.0

NOTES: Height above the ground surface is shown as a positive number (+) and depth below ground is shown as a negative number (-).

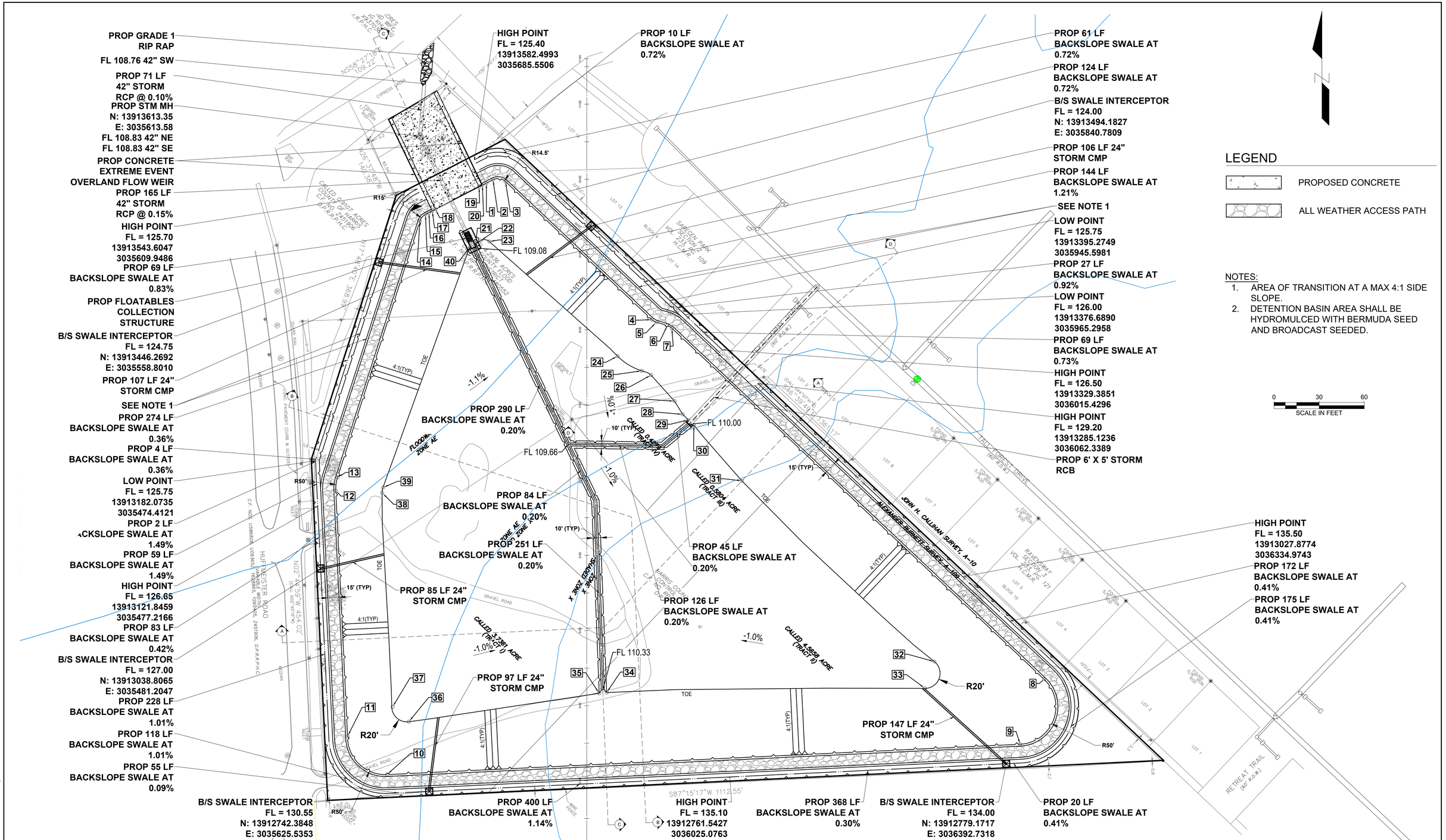
Piezometer Installation

PROPOSED RAVENSWAY SUBDIVISION
IMPROVEMENTS - 2018
PRECINCT 3
HARRIS COUNTY, TEXAS
UPIN# 19103MF14601

Drawn By: AA	Date: 12/1/2021	Scale: Not To Scale
Checked By: JH	Date: 12/6/2021	PLATE B-2
HTS Project No:	21-S-477	

APPENDIX C

Drawings and Pertinent Data Provided to HTS by LJA



NO.	REVISIONS	DATE	NAME

HARRIS COUNTY ENGINEERING DEPARTMENT

LJA Engineering, Inc.
3600 W Sam Houston Pkwy S, Suite 600
Houston, TX 77042
Phone: 713.953.5200 Fax: 713.953.5026
FIRM REGISTRATION No. F-1386
www.LJAengineering.com

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ISAAC MUÑIZ, P.E.
TEXAS P.E. #125839

ISSUED ON:
FEB 23 2022

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018 – UPIN 19103MF14601

SHEET DESCRIPTION: OVERALL POND PLAN

DRAWN BY:
DATE: 2/23/2022
DESIGN BY:
SCALE:
SHEET NO: 108 OF 163

J:\1994\2102\ACAD\SHEET FILES\60%\108 OVERALL POND PLAN.dwg

PLATE C-1

Point Table

Point #	Raw Description	Northing	Easting	Elevation
1	TOP OF BANK	13913551.3765	3035701.5622	128.50
2	TOP OF BANK	13913555.8713	3035710.2989	128.50
3	TOP OF BANK	13913553.5237	3035726.8829	128.50
4	TOP OF BANK	13913369.8181	3035921.5782	128.50
5	TOP OF BANK	13913366.3662	3035927.5441	128.50
6	TOP OF BANK	13913361.9575	3035942.1729	128.50
7	TOP OF BANK	13913358.5056	3035948.1388	128.50
8	TOP OF BANK	13912891.3988	3036443.1892	135.59
9	TOP OF BANK	13912805.0893	3036411.2699	135.31
10	TOP OF BANK	13912764.7242	3035569.4506	130.71
11	TOP OF BANK	13912815.6442	3035516.9513	129.04
12	TOP OF BANK	13913142.3371	3035501.2612	128.50
13	TOP OF BANK	13913160.0297	3035503.6002	128.50
14	TOP OF BANK	13913500.9480	3035613.1301	128.50
15	TOP OF BANK	13913509.6769	3035620.5080	128.50
16	TOP OF BANK	13913512.0464	3035625.1137	128.50
17	TOP OF BANK	13913514.3346	3035629.5614	127.30
18	TOP OF BANK	13913516.6213	3035634.0061	126.30
19	TOP OF BANK	13913546.3639	3035691.8188	126.30
20	TOP OF BANK	13913548.6521	3035696.2666	127.30

Point Table

Point #	Raw Description	Northing	Easting	Elevation
21	TOE OF SLOPE	13913471.1688	3035687.4321	110.10
22	TOE OF SLOPE	13913474.8931	3035693.8832	110.18
23	TOE OF SLOPE	13913473.6709	3035705.4419	110.28
24	TOE OF SLOPE	13913321.2543	3035875.9490	111.84
25	TOE OF SLOPE	13913301.7621	3035908.0490	111.63
26	TOE OF SLOPE	13913296.0161	3035920.5616	111.58
27	TOE OF SLOPE	13913261.3719	3035951.6989	111.27
28	TOE OF SLOPE	13913243.8074	3035962.6707	111.11
29	TOE OF SLOPE	13913236.4533	3035970.0673	111.05
30	TOE OF SLOPE	13913229.5400	3035977.4065	111.06
31	TOE OF SLOPE	13913155.4188	3036041.2762	112.13
32	TOE OF SLOPE	13912914.9468	3036297.2841	115.52
33	TOE OF SLOPE	13912879.3706	3036284.7038	115.46
34	TOE OF SLOPE	13912873.8161	3035861.4871	111.34
35	TOE OF SLOPE	13912872.8127	3035851.5187	111.35
36	TOE OF SLOPE	13912835.0270	3035598.3603	113.85
37	TOE OF SLOPE	13912854.6602	3035576.7424	114.01
38	TOE OF SLOPE	13913139.6436	3035562.8590	113.14
39	TOE OF SLOPE	13913146.5406	3035564.0453	113.08
40	TOE OF SLOPE	13913465.5354	3035679.0444	110.10

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NO.	REVISIONS	DATE	NAME

HARRIS COUNTY
ENGINEERING DEPARTMENT

HARRIS COUNTY 1836 TEXAS

LJA Engineering, Inc.
3600 W Sam Houston Pkwy S, Suite 600
Houston, TX 77042
Phone 713.953.5200 Fax 713.953.5026
FIRM REGISTRATION No. F-1386
www.LJAengineering.com

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ISAAC MUÑIZ, P.E.
TEXAS P.E. #125839

ISSUED ON:
FEB 23 2022

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018 – UPIN 19103MF14601

SHEET DESCRIPTION: POND POINTS

DRAWN BY:

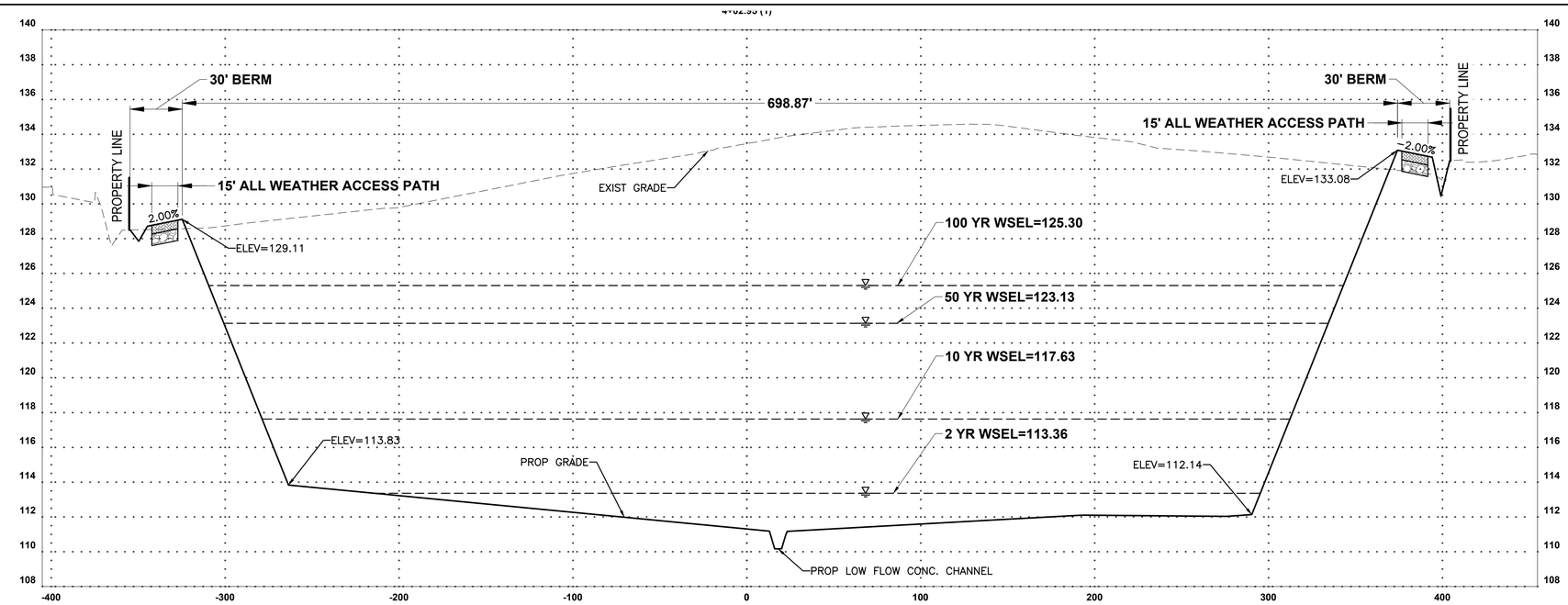
DATE: 2/23/2022

DESIGN BY:

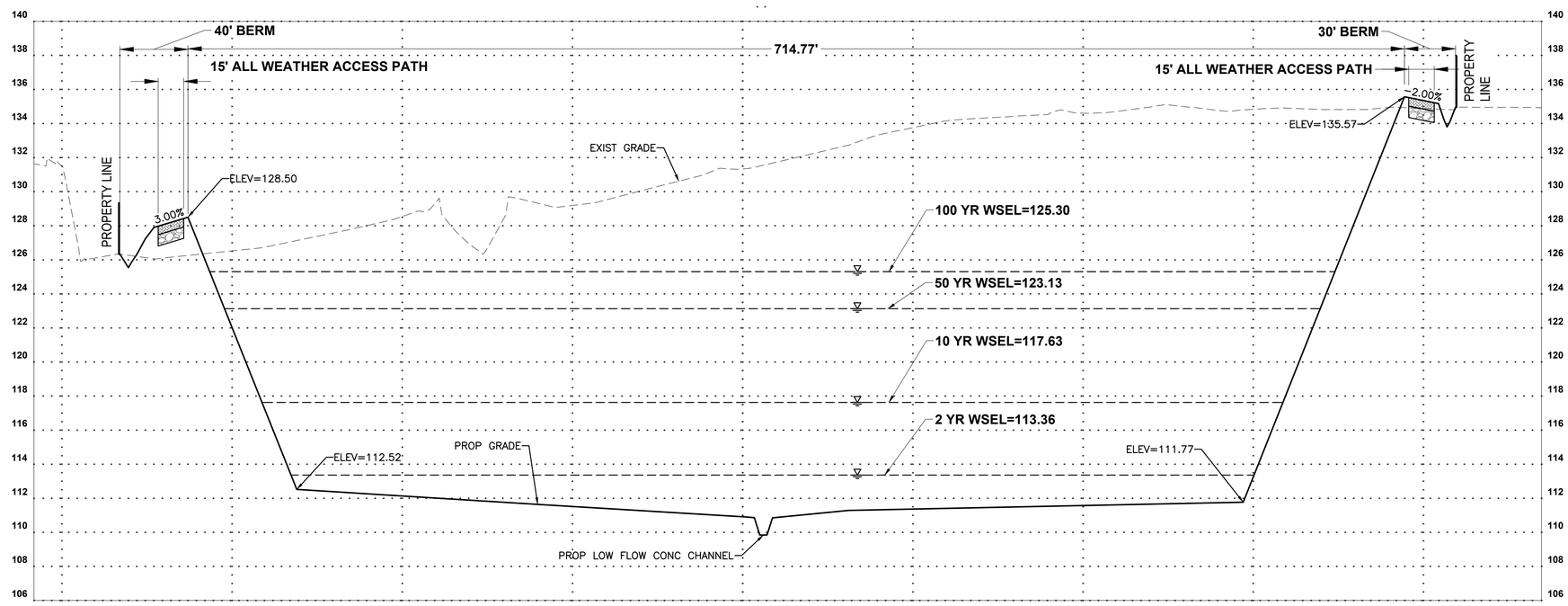
SCALE:

SHEET NO: 109 OF 163

PLATE C-2



SECTION A–A
1"=40'



SECTION B–B
1"=40'

NOTES:

1. FOR LIMITS OF PAVEMENT REPAIR, CONTRACTOR SHALL GO TO NEAREST JOINT TO DOWEL IN AND IF JOINT IS BEYOND 10', CONTRACTOR SHALL SET NEW JOINT AS LIMITS SHOWN ON PLANS.
2. THE LOCATION OF EXISTING WATER LINE WAS BASED ON RECORD DRAWINGS PROVIDED BY TIMBERLAKE MUNICIPAL UTILITY DISTRICT.

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY
ENGINEERING DEPARTMENT

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3600 W Sam Houston Pkwy S, Suite 600
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TEXAS P.E. #125839

ISSUED ON:
FEB 23 2022

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018 – UPIN 19103MF14601

SHEET DESCRIPTION: POND SECTIONS

DRAWN BY:
DATE: 2/23/2022
DESIGN BY:
SCALE:
SHEET NO: 110 OF 163

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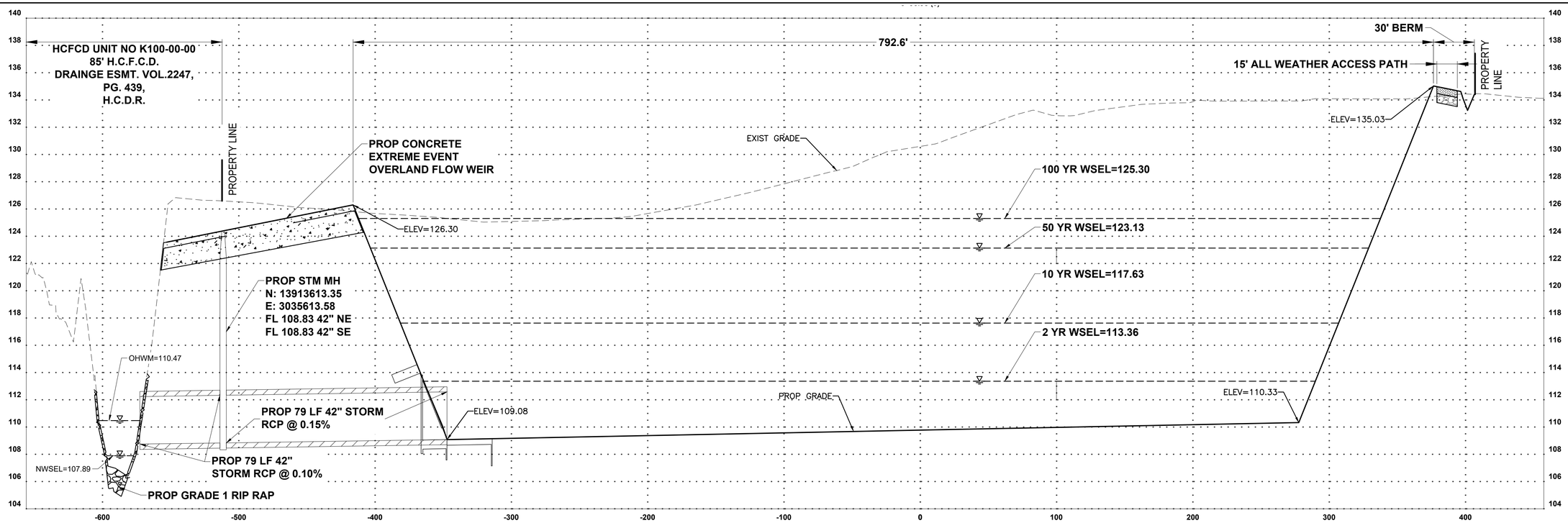
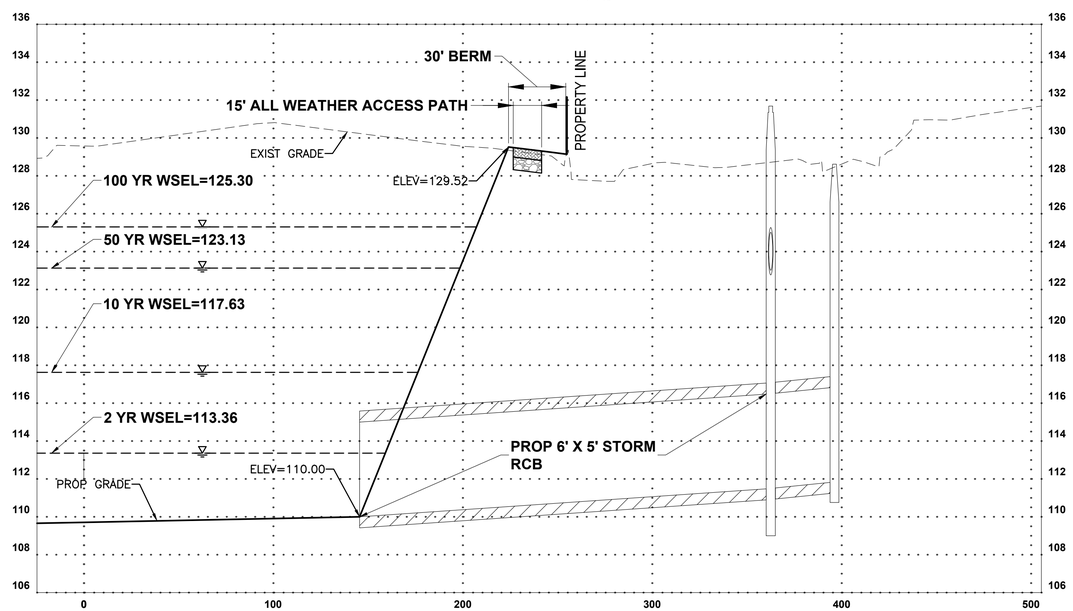
PLATE C-3



OUTFALL SECTION C–C
1"=40'



OUTFALL SECTION D–D
1"=40'

NOTES:

1. FOR LIMITS OF PAVEMENT REPAIR, CONTRACTOR SHALL GO TO NEAREST JOINT TO DOWEL IN AND IF JOINT IS BEYOND 10', CONTRACTOR SHALL SET NEW JOINT AS LIMITS SHOWN ON PLANS.
2. THE LOCATION OF EXISTING WATER LINE WAS BASED ON RECORD DRAWINGS PROVIDED BY TIMBERLAKE MUNICIPAL UTILITY DISTRICT.

NO.	REVISIONS	DATE	NAME

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ISAAC MUÑIZ, P.E.
TEXAS P.E. #125839

ISSUED ON:
FEB 23 2022

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018 – UPIN 19103MF14601

SHEET DESCRIPTION: POND OUTFALL SECTIONS

DRAWN BY:
DATE: 2/23/2022
DESIGN BY:
SCALE:
SHEET NO: 111 OF 163

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PLATE C-4

APPENDIX D

Calculations

Selection of Soil Parameters for Clay soils

Boring No. 2

Sandy Lean clay, 23'-28'

Undrained SS = 1000 psf (Based on UU test on nearest Boring No. 1, 4'-6' and Boring No. 4, 14'-16'. Reduced value used as per HCFCD experience on the area soil.)

$C_e' = 330$ psf $\phi_e' = 25°$
$C_t = 380$ psf $\phi_t = 21°$
} Based on CU test on similar soil in Boring No. 7

$\gamma = 136.7$ pcf (Test on similar soil Boring No 4, 14'-16').

Lean clay with sand, 28'-50' (Boring No. 2)

$\phi_{PI}' = 27°$ (Terzaghi, Peck, Mesri)

$\phi_e' = 23°$ $\phi_t = 20°$
$C_e' = 280$ psf $C_t = 330$ psf
} ← values are based on
1) Based on CU test on Sandy Lean clay
2) C value reduced, though higher PI can result in higher C value

$\gamma = 142.0$ (Lab Test)

Sandy Lean clay Boring No. 4, 12'-16'

Undrained SS = 1000 PSF (Based on UU test).

$\gamma = 136.7$ pcf (Lab Test)

$C_e' = 330$ psf $C_t = 380$
$\phi_e' = 25°$ $\phi_t = 21°$
} CU test on Boring No. 7

Fat clay with sand / Sandy Fat clay Boring No. 4, 43'-50'

$\gamma = 128.9$ pcf (Lab test)

$C_e' = 230$ psf $C_t = 270$ psf
$\phi_e' = 19°$ $\phi_t = 15°$

$\phi_{PI}' = 24°$

→ values are based on Army / NAVFAC Table and experience with similar soils.

HTS, INC. Consultants

Clay Liner Properties

$\gamma = 125$ pcf (Assumed)

Undrained SS = 1000 psf (Army/NAVFAC provides 1800 psf for compacted lean clay. Value is reduced for analysis).

$c_e' = 270$ psf $\quad c_t = 300$ psf

$\phi_e' = 24°$ $\quad \phi_t = 18°$

Assumed Based on:

1) Effective parameters provided for compacted lean clay in Army/NAVFAC Table.
2) Site sandy lean clay CU result.

HTS, INC. Consultants

TABLE 1
Typical Properties of Compacted Soils

Group Symbol	Soil Type	Range of Maximum Dry Unit Weight, pcf	Range of Optimum Moisture, Percent	Typical Value of Compression		Typical Strength Characteristics				Typical Coefficient of Permeability ft./min.	Range of CBR Values	Range of Subgrade Modulus k lbs/cu in.
				At 1.4 tsf (20 psi)	At 3.6 tsf (50 psi)	Cohesion (as compacted) psf	Cohesion (saturated) psf	ϕ (Effective Stress Envelope Degrees)	Tan ϕ			
				Percent of Original Height								
GW	Well graded clean gravels, gravel-sand mixtures.	125 - 135	11 - 8	0.3	0.6	0	0	>38	>0.79	5×10^{-2}	40 - 80	300 - 500
GP	Poorly graded clean gravels, gravel-sand mix	115 - 125	14 - 11	0.4	0.9	0	0	>37	>0.74	10^{-1}	30 - 60	250 - 400
GM	Silty gravels, poorly graded gravel-sand-silt.	120 - 135	12 - 8	0.5	1.1	.....	.....	>34	>0.67	$>10^{-6}$	20 - 60	100 - 400
GC	Clayey gravels, poorly graded gravel-sand-clay.	115 - 130	14 - 9	0.7	1.6	.....	.....	>31	>0.60	$>10^{-7}$	20 - 40	100 - 300
SW	Well graded clean sands, gravelly sands.	110 - 130	16 - 9	0.6	1.2	0	0	38	0.79	$>10^{-3}$	20 - 40	200 - 300
SP	Poorly graded clean sands, sand-gravel mix.	100 - 320	21 - 12	0.8	1.4	0	0	37	0.74	$>10^{-3}$	10 - 40	200 - 300
SM	Silty sands, poorly graded sand-silt mix.	110 - 125	16 - 11	0.8	1.6	1050	420	34	0.67	$5 \times >10^{-5}$	10 - 40	100 - 300
SM-SC	Sand-silt clay mix with slightly plastic fines.	110 - 130	15 - 11	0.8	1.4	1050	300	33	0.66	$2 \times >10^{-6}$	5 - 30	100 - 300
SC	Clayey sands, poorly graded sand-clay-mix.	105 - 125	19 - 11	1.1	2.2	1550	230	31	0.60	$5 \times >10^{-7}$	5 - 20	100 - 300
ML	Inorganic silts and clayey silts.	95 - 120	24 - 12	0.9	1.7	1400	190	32	0.62	$>10^{-5}$	15 or less	100 - 200
ML-CL	Mixture of inorganic silt and clay.	100 - 120	22 - 12	1.0	2.2	1350	460	32	0.62	$5 \times >10^{-7}$	.....	
CL	Inorganic clays of low to medium plasticity.	95 - 120	24 - 12	1.3	2.5	1800	270	28	0.54	$>10^{-7}$	15 or less	50 - 200
OL	Organic silts and silt-clays, low plasticity.	80 - 100	33 - 21	.....	.....	.....	.....	.....	.....	.....	5 or less	50 - 100
MH	Inorganic clayey silts, elastic silts.	70 - 95	40 - 24	2.0	3.8	1500	420	25	0.47	$5 \times >10^{-7}$	10 or less	50 - 100
CH	Inorganic clays of high plasticity	75 - 105	36 - 19	2.6	3.9	2150	230	19	0.35	$>10^{-7}$	15 or less	50 - 150
OH	Organic clays and silty clays	65 - 100	45 - 21	.....	.....	.....	.....	.....	.....	.....	5 or less	25 - 100

Notes:

1. All properties are for condition of "Standard Proctor" maximum density, except values of k and CBR which are for "modified Proctor" maximum density.
2. Typical strength characteristics are for effective strength envelopes and are obtained from USBR data.
3. Compression values are for vertical loading with complete lateral confinement.
4. (>) indicates that typical property is greater than the value shown.
   (..) indicates insufficient data available for an estimate.

NAVFAC

water content after placement. This situation could result from an increase in the groundwater level after construction.

(*c*) Density control of placed backfill in the field can be facilitated by the use of rapid compaction check tests (para 7-5c). A direct rapid test is the one-point impact compaction test. Rapid indirect tests, such as the Proctor needle penetration for cohesive soils or the tone resistance load for cohesionless soils, can also be used when correlations with CE 55 maximum density have been established.

(3) *Shear strength testing.* When backfill is to be placed behind structure walls or bulkheads or as foundation support for a structure, and when fills are to be placed with unrestrained slopes, shear tests should be performed on representative samples of the backfill materials compacted to expected field densities and water contents to estimate as-constructed shear strengths. The appropriate type of test required for the conditions to be analyzed is presented in TM 5-818-1/AFM 88-3, Chapter 7. Procedures for shear strength testing are described in EM 1110-2-1906.

Table 3-1. Typical Engineering Properties of Compacted Materials [a]

Group Symbol	Soil Type	Range of Maximum Dry Unit Weight, pcf	Range of Optimum Water, Content Percent	Typical Value of Compression: At 2.5 ksf (20 psi) Percent of Original Height	Typical Value of Compression: At 7.2 ksf (50 psi) Percent of Original Height	Typical Strength Characteristics: Cohesion (As Compacted) psf	Typical Strength Characteristics: Cohesion (Saturated) psf	Typical Strength Characteristics: ϕ (Effective Stress Envelope) deg	Typical Coefficient of Permeability ft/min	Range of CBR Values	Range of Subgrade Modulus k lb/cu in.	Potential[b] Frost Action
GW	Well-graded clean gravels, gravel-sand mixtures	125-135	11-8	0.3	0.6	0	0	>38	5×10^{-2}	40-80	300-500	None to very slight
GP	Poorly graded clean gravels, gravel-sand mix	115-125	14-11	0.4	0.9	0	0	>37	10^{-1}	30-60	250-400	None to very slight
GM	Silty gravels, poorly graded gravel-sand-silt	120-135	12-8	0.5	1.1	--	--	>34	$>10^{-6}$	20-60	100-400	Slight to medium
GC	Clayey gravels, poorly graded gravel-sand-clay	115-130	14-9	0.7	1.6	--	--	>31	$>10^{-7}$	20-40	100-300	Slight to medium
SW	Well-graded clean sands, gravelly sands	110-130	16-9	0.6	1.2	0	0	38	$>10^{-3}$	20-40	200-300	None to slight
SP	Poorly graded clean sands, sand-gravel mix	100-120	21-12	0.8	1.4	0	0	37	$>10^{-3}$	10-40	200-300	None to slight
SM	Silty sands, poorly graded sand-silt mix	110-125	16-11	0.8	1.6	1050	420	34	5×10^{-5}	10-40	100-300	Slight to medium
SM-SC	Sand-silt clay mix with slightly plastic fines	110-130	15-11	0.8	1.4	1050	300	33	2×10^{-6}	--		
SC	Clayey sands, poorly graded sand-clay mix	105-125	19-11	1.1	2.2	1550	230	31	5×10^{-7}	5-20	100-300	Slight to high
ML	Inorganic silts and clayey silts	95-120	24-12	0.9	1.7	1400	190	32	10^{-5}	15 or less	100-200	Medium to very high
ML-CL	Mixture of inorganic silt and clay	100-120	22-12	1.0	2.2	1350	460	32	5×10^{-7}	--	100-200	
CL	Inorganic clays of low to medium plasticity	95-120	24-12	1.3	2.5	1800	270	28	10^{-7}	15 or less	50-200	Medium to high
OL	Organic silts and silt-clays, low plasticity	80-100	33-21	--	--	--	--	--	--	5 or less	50-100	Medium to high
MH	Inorganic clayey silts, elastic silts	75-95	40-24	2.0	3.8	1500	420	25	5×10^{-7}	10 or less	50-100	Medium to very high
CH	Inorganic clays of high plasticity	80-105	36-19	2.6	3.9	2150	230	19	10^{-7}	15 or less	50-150	Medium
OH	Organic clays and silty clays	75-100	45-21	--	--	--	--	--	--	5 or less	25-100	Medium

Notes:
1. All properties are for condition of "standard Proctor" maximum density, except values of k and CBR which are for CE55 maximum density.
2. Typical strength characteristics are for effective strength envelopes and are obtained from USER data.
3. Compression values are for vertical loading with complete lateral confinement.
4. (>) indicates that typical property is greater then the value shown. (-) indicates insufficient data available for an estimate.

[a] After DM-7.

[b] From TM 5-18-2/AP 88-6. Chapter 4.

ARMY/AFM

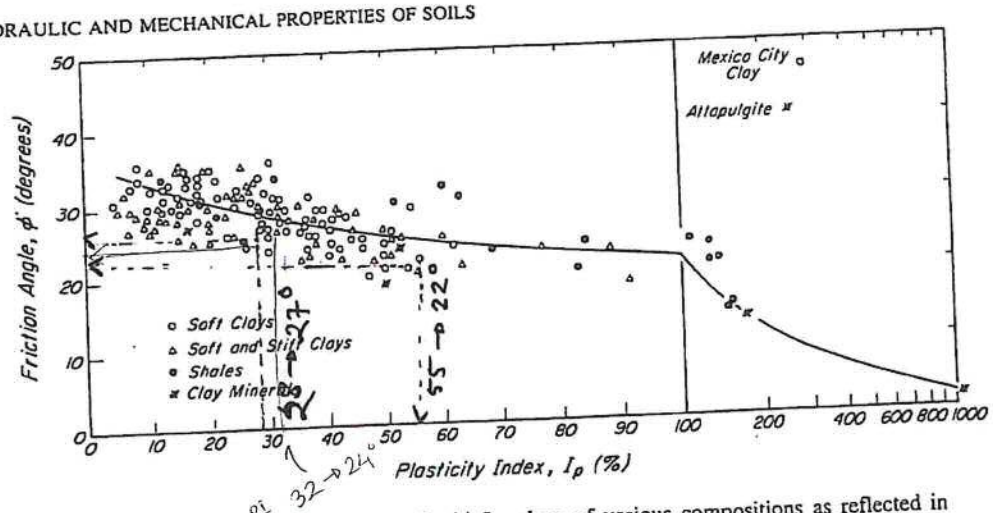


Figure 19.7 Values of friction angle ϕ' for clays of various compositions as reflected in plasticity index.

textured diatom shell fragments that make up the matrix of Mexico City clay are capable of generating unusually large friction angles while retaining an exceptionally large amount of water. At each plasticity index, different values of ϕ' result from the difference in clay size fraction of soils and from the difference in effective normal stress at which ϕ' was measured. The high values of ϕ' correspond to soils with clay size fraction of less than 20% and effective normal stresses less than 50 kPa. The low values are representative of soils with clay size fraction of greater than 50%, subjected to effective normal stresses of higher than 400 kPa. Torsional ring-shear tests by Stark and Eid (1994) show that ϕ' may decrease by 4° as the clay size fraction increases from less than 20% to more than 50% or as effective normal stress increases from less than 50 kPa to more than 400 kPa. Although there is a strong correlation between friction angle and plasticity index, the significant scatter of the data around the empirical relationship shown in Fig. 19.7 indicates that ϕ' should be measured directly on major projects. The drained triaxial compression test on specimens normally consolidated under an equal all-around pressure is most suitable for determining ϕ'.

The drained shear strength of an overconsolidated clay should ordinarily be greater than the drained strength of the same constituents in a normally consolidated state, mainly because the overconsolidated clay has a smaller preshear void ratio. However, the mobilized or available drained shear strength of heavily overconsolidated clays strongly depends on their condition before shear and when they reach failure. An overconsolidated clay mobilizes its intact strength at failure only if it has remained in an intact condition during geological unloading and associated swelling, remains intact in response to a construction operation that eventually leads to a failure, and reaches its peak resistance at the instant of a global instability. On the other hand, an overconsolidated clay has available at the instant of slip only its fully softened shear strength if it has been badly fissured and jointed during the removal of overburden or of lateral support by erosion, has softened further in response to an excavation process that leads to a long-term drained failure, or has been involved in severe progressive failure. An overconsolidated clay mass that has already experienced large displacements along a major plane of shear can mobilize only the residual shear strength if movements are reactivated along the preexisting shear surface. The presence in the fabric of an overconsolidated cohesive soil of discontinuities, such as brecciations, slickensides, fissures, joints, and shears, becomes an increasingly important factor in relation to the available drained shear strength at failure as preconsolidation pressure, overconsolidation ratio, plasticity, and, therefore, stiffness and brittleness increase.

19.2.1 *Intact Shear Strength*

The drained intact shear strength of a saturated overconsolidated clay is commonly expressed in terms of the intercept c' and the angle ϕ' of a failure envelope in the Mohr diagram, as

$$s = c' + \sigma' \tan \phi' \tag{19.7}$$

In general the angle ϕ' in Eq. 19.7 is not comparable to the friction angle in Eq. 19.6. An example of a failure envelope for an intact sample of an overconsolidated London clay is shown in Fig. 19.8. The sample was taken from a depth of 35 m below ground level, and the best estimates of σ'_{vo} and σ'_p are 390 kPa and 4100 kPa, respectively. London clay was deposited under marine conditions in the Eocene period about 30 million years ago. Subsequently, uplift and erosion in Tertiary and Pleistocene times removed 170 m to 340 m of overlying sediments. The failure envelope of the overconsolidated clay

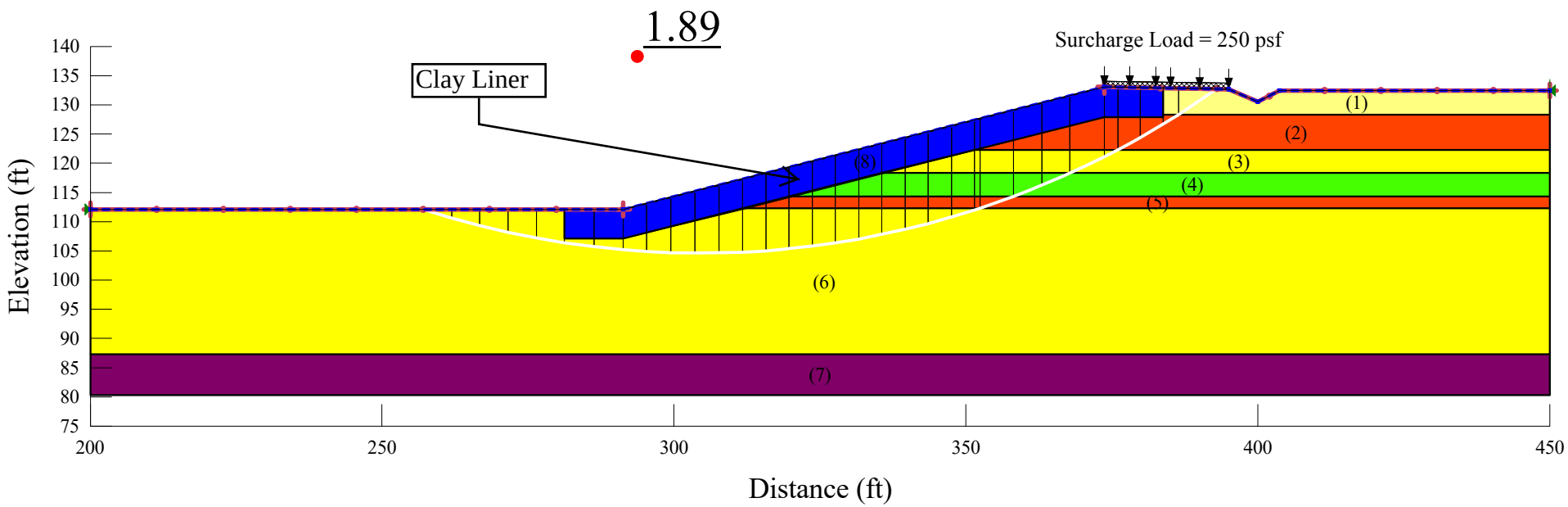
Terzaghi, Peck, Mesri

APPENDIX E

Results of Slope Stability Analyses Using GEOSTUDIO SLOPE/W

SLOPE STABILITY ANALYSIS
CONDITIONS: GLOBAL SLIDE - SHORT TERM - WATER FROM TOP TO ALONG THE SLOPE
SECTION: A-A WITH SLOPE ABOUT 3.9H:1V
SOIL PROFILE: BORING NO. 4

SOIL TYPES:
(1) SILTY SAND: Moist Unit Wt = 115 pcf, C = 0, Phi = 29.5 deg
(2) CLAYEY SAND: Moist Unit Wt = 137.2 pcf, C = 0, Phi = 30 deg
(3) SILTY SAND: Moist Unit Wt = 125 pcf, C = 0, Phi = 33 deg
(4) SANDY LEAN CLAY: Moist Unit Wt = 136.7 pcf, C = 1000 psf, Phi = 0 deg
(5) CLAYEY SAND: Moist Unit Wt = 136.1 pcf, C = 0, Phi = 33 deg
(6) SILTY SAND: Moist Unit Wt = 120 pcf, C = 0, Phi = 36 deg
(7) FAT CLAY WITH SAND/SANDY FAT CLAY: Moist Unit Wt = 128.9 pcf, C = 2000 psf, Phi = 0 deg
(8) CLAY LINER: Moist Unit Wt = 125 pcf, C = 1000 psf, Phi = 0 deg



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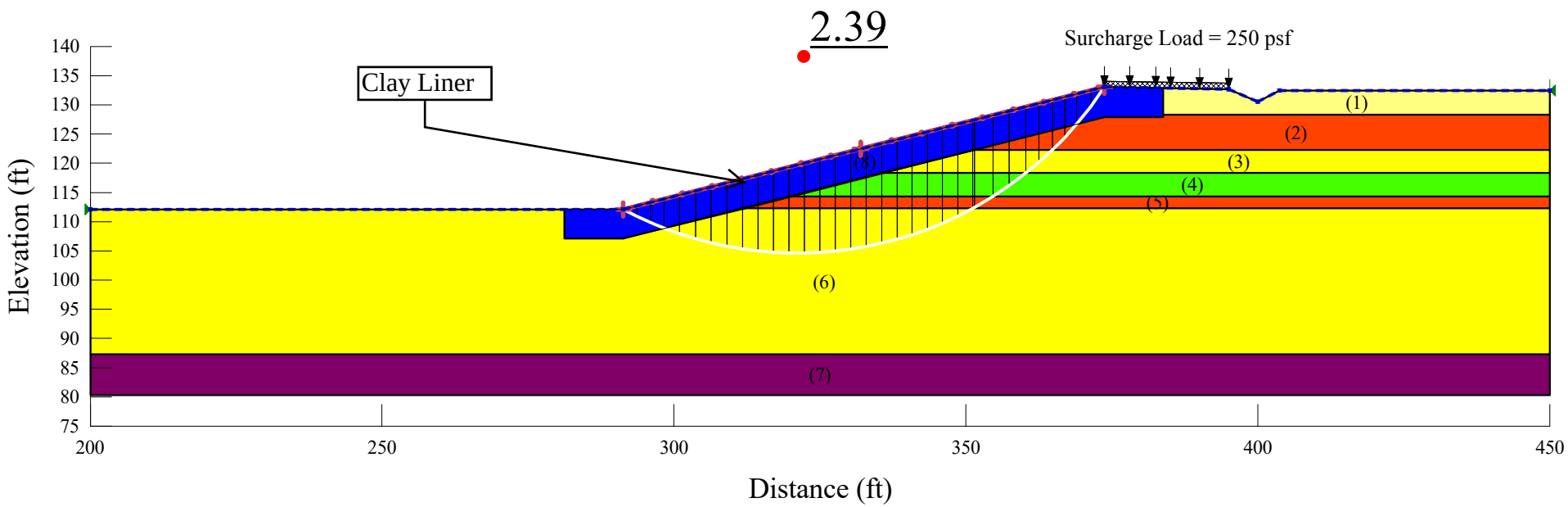
PROPOSED RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS - 2018
PRECINCT 3, HARRIS COUNTY, TEXAS
UPIN# 19103MF14601
DATE: 3/2/2022

SLOPE STABILITY ANALYSIS
CONDITIONS: LOCAL SLIDE - SHORT TERM - WATER FROM TOP TO ALONG THE SLOPE
SECTION: A-A WITH SLOPE ABOUT 3.9H:1V
SOIL PROFILE: BORING NO. 4

SOIL TYPES:
(1) SILTY SAND: Moist Unit Wt = 115 pcf, C = 0, Phi = 29.5 deg
(2) CLAYEY SAND: Moist Unit Wt = 137.2 pcf, C = 0, Phi = 30 deg
(3) SILTY SAND: Moist Unit Wt = 125 pcf, C = 0, Phi = 33 deg
(4) SANDY LEAN CLAY: Moist Unit Wt = 136.7 pcf, C = 1000 psf, Phi = 0 deg
(5) CLAYEY SAND: Moist Unit Wt = 136.1 pcf, C = 0, Phi = 33 deg
(6) SILTY SAND: Moist Unit Wt = 120 pcf, C = 0, Phi = 36 deg
(7) FAT CLAY WITH SAND/SANDY FAT CLAY: Moist Unit Wt = 128.9 pcf, C = 2000 psf, Phi = 0 deg
(8) CLAY LINER: Moist Unit Wt = 125 pcf, C = 1000 psf, Phi = 0 deg



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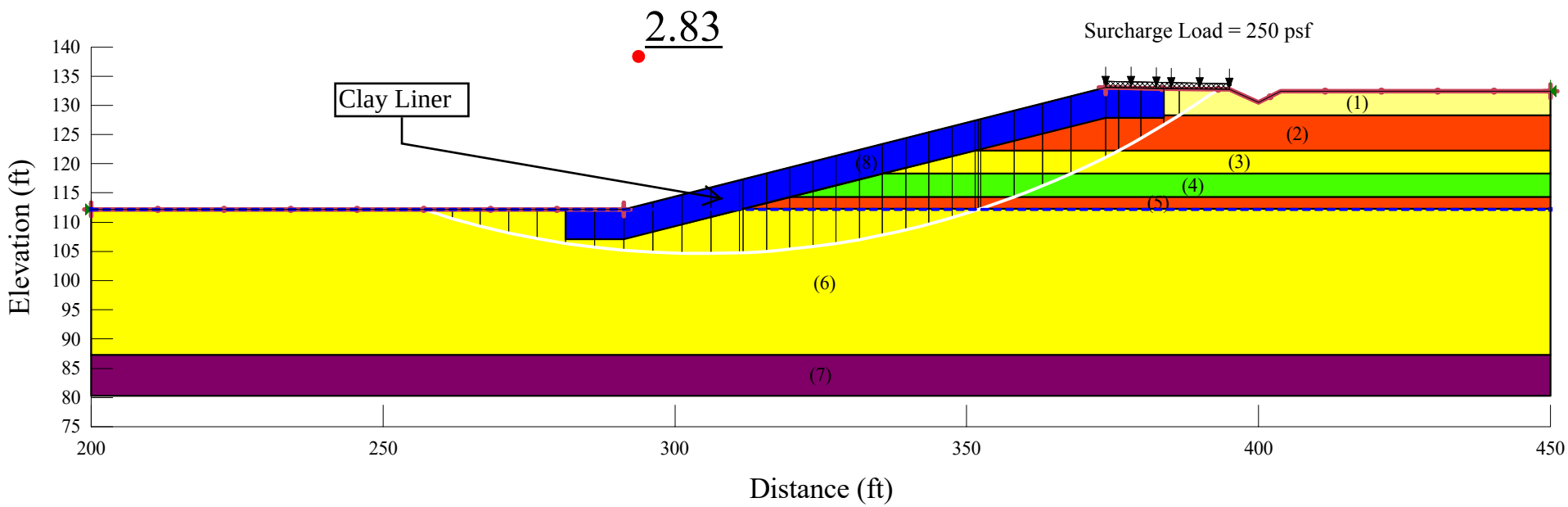
UPIN# 19103MF14601
DATE: 3/2/2022

SLOPE STABILITY ANALYSIS
CONDITIONS: GLOBAL SLIDE - SHORT TERM - WATER AT THE BOTTOM OF THE SLOPE
SECTION: A-A WITH SLOPE ABOUT 3.9H:1V
SOIL PROFILE: BORING NO. 4

SOIL TYPES:
(1) SILTY SAND: Moist Unit Wt = 115 pcf, C = 0, Phi = 29.5 deg
(2) CLAYEY SAND: Moist Unit Wt = 137.2 pcf, C = 0, Phi = 30 deg
(3) SILTY SAND: Moist Unit Wt = 125 pcf, C = 0, Phi = 33 deg
(4) SANDY LEAN CLAY: Moist Unit Wt = 136.7 pcf, C = 1000 psf, Phi = 0 deg
(5) CLAYEY SAND: Moist Unit Wt = 136.1 pcf, C = 0, Phi = 33 deg
(6) SILTY SAND: Moist Unit Wt = 120 pcf, C = 0, Phi = 36 deg
(7) FAT CLAY WITH SAND/SANDY FAT CLAY: Moist Unit Wt = 128.9 pcf, C = 2000 psf, Phi = 0 deg
(8) CLAY LINER: Moist Unit Wt = 125 pcf, C = 1000 psf, Phi = 0 deg



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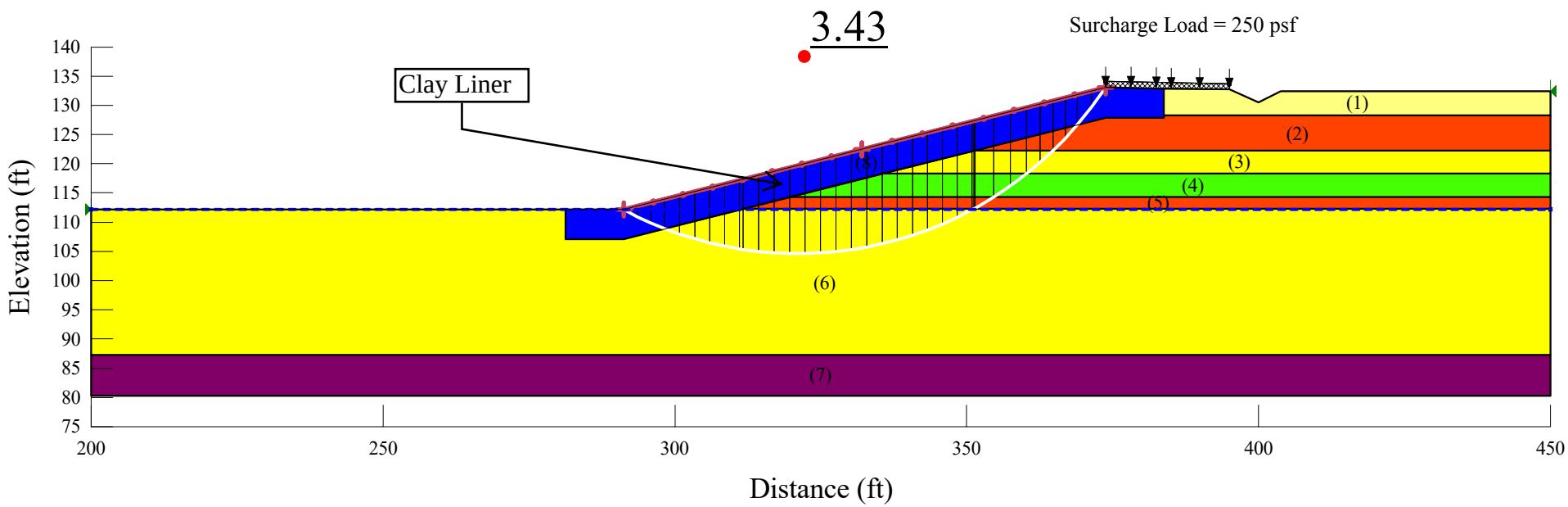
PROPOSED RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS - 2018
PRECINCT 3, HARRIS COUNTY, TEXAS
UPIN# 19103MF14601
DATE: 3/2/2022

PLATE E-3

SLOPE STABILITY ANALYSIS
CONDITIONS: LOCAL SLIDE - SHORT TERM - WATER AT THE BOTTOM OF THE SLOPE
SECTION: A-A WITH SLOPE ABOUT 3.9H:1V
SOIL PROFILE: BORING NO. 4

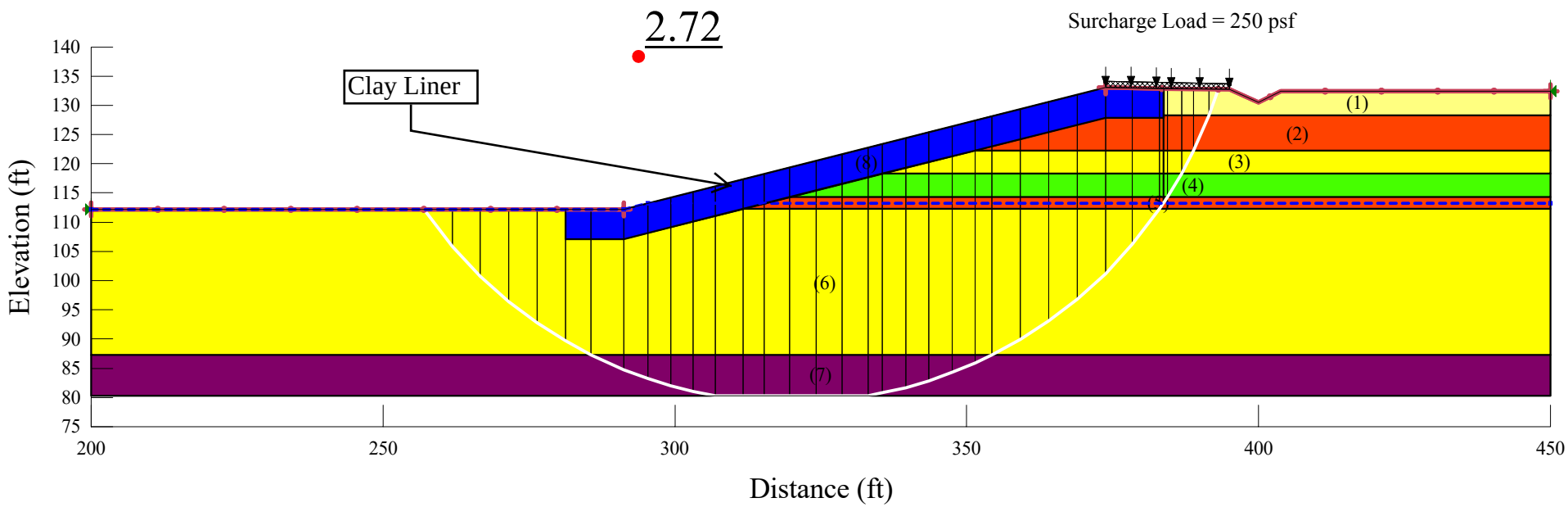
SOIL TYPES:
(1) SILTY SAND: Moist Unit Wt = 115 pcf, C = 0, Phi = 29.5 deg
(2) CLAYEY SAND: Moist Unit Wt = 137.2 pcf, C = 0, Phi = 30 deg
(3) SILTY SAND: Moist Unit Wt = 125 pcf, C = 0, Phi = 33 deg
(4) SANDY LEAN CLAY: Moist Unit Wt = 136.7 pcf, C = 1000 psf, Phi = 0 deg
(5) CLAYEY SAND: Moist Unit Wt = 136.1 pcf, C = 0, Phi = 33 deg
(6) SILTY SAND: Moist Unit Wt = 120 pcf, C = 0, Phi = 36 deg
(7) FAT CLAY WITH SAND/SANDY FAT CLAY: Moist Unit Wt = 128.9 pcf, C = 2000 psf, Phi = 0 deg
(8) CLAY LINER: Moist Unit Wt = 125 pcf, C = 1000 psf, Phi = 0 deg



HTS INC. CONSULTANTS
PROJECT NO: 21-S-477 (REPORT VERSION: REV 2)
PROPOSED RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS - 2018
PRECINCT 3, HARRIS COUNTY, TEXAS
UPIN# 19103MF14601
DATE: 3/2/2022

SLOPE STABILITY ANALYSIS
CONDITIONS: GLOBAL SLIDE - LONG TERM CONDITION
SECTION: A-A WITH SLOPE ABOUT 3.9H:1V
SOIL PROFILE: BORING NO. 4

SOIL TYPES:
(1) SILTY SAND: Moist Unit Wt = 115 pcf, C = 0, Phi = 29.5 deg
(2) CLAYEY SAND: Moist Unit Wt = 137.2 pcf, C = 0, Phi = 30 deg
(3) SILTY SAND: Moist Unit Wt = 125 pcf, C = 0, Phi = 33 deg
(4) SANDY LEAN CLAY: Moist Unit Wt = 136.7 pcf, C = 330 psf, Phi = 25 deg
(5) CLAYEY SAND: Moist Unit Wt = 136.1 pcf, C = 0, Phi = 33 deg
(6) SILTY SAND: Moist Unit Wt = 120 pcf, C = 0, Phi = 36 deg
(7) FAT CLAY WITH SAND/SANDY FAT CLAY: Moist Unit Wt = 128.9 pcf, C = 230 psf, Phi = 19 deg
(8) CLAY LINER: Moist Unit Wt = 125 pcf, C = 270 psf, Phi = 24 deg

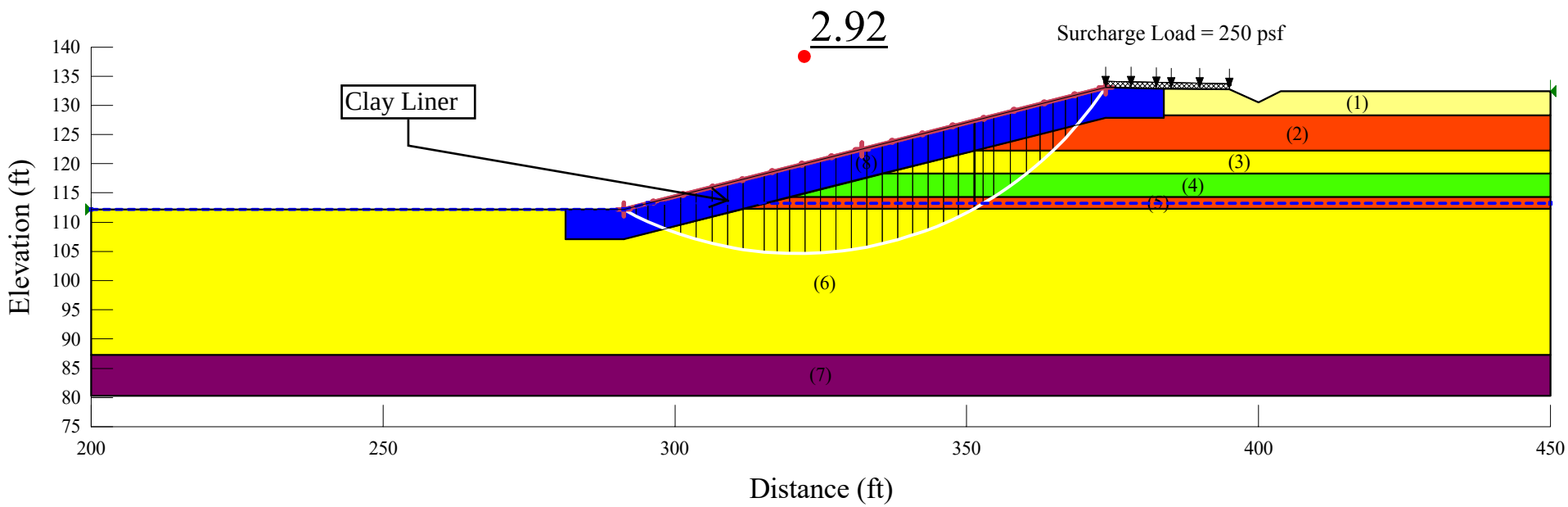


HTS INC. CONSULTANTS
PROJECT NO: 21-S-477 (REPORT VERSION: REV 2)
PROPOSED RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS - 2018
PRECINCT 3, HARRIS COUNTY, TEXAS
UPIN# 19103MF14601
DATE: 3/2/2022

PLATE E-5

SLOPE STABILITY ANALYSIS
CONDITIONS: LOCAL SLIDE - LONG TERM CONDITION
SECTION: A-A WITH SLOPE ABOUT 3.9H:1V
SOIL PROFILE: BORING NO. 4

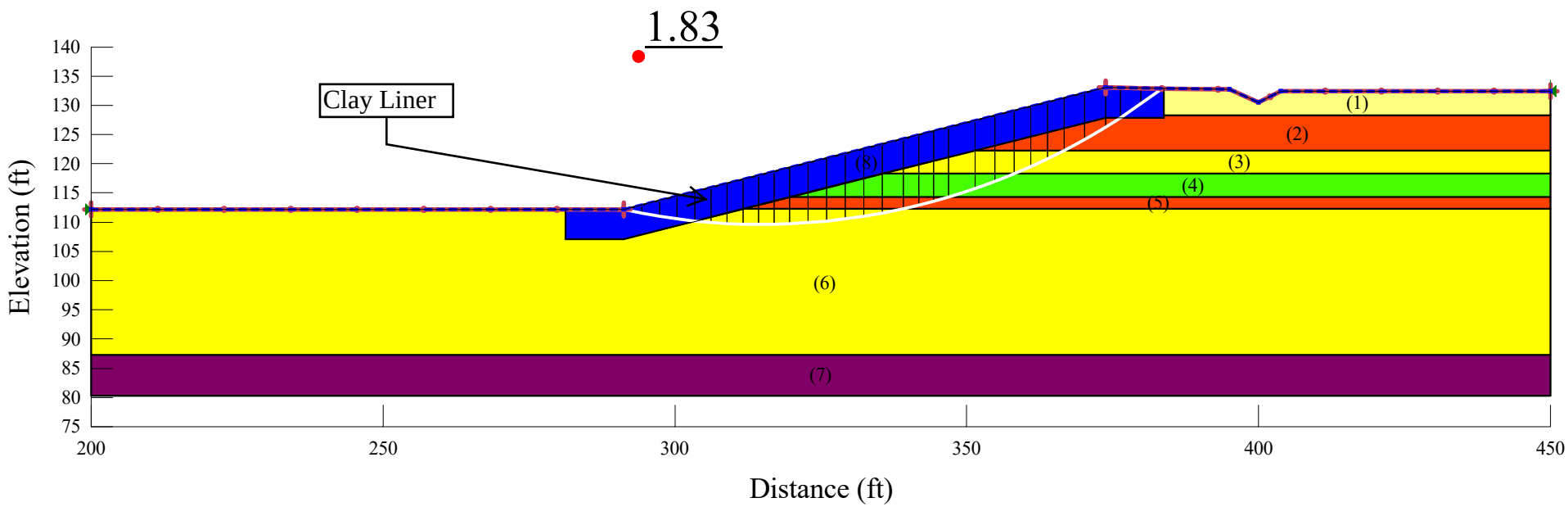
SOIL TYPES:
(1) SILTY SAND: Moist Unit Wt = 115 pcf, C = 0, Phi = 29.5 deg
(2) CLAYEY SAND: Moist Unit Wt = 137.2 pcf, C = 0, Phi = 30 deg
(3) SILTY SAND: Moist Unit Wt = 125 pcf, C = 0, Phi = 33 deg
(4) SANDY LEAN CLAY: Moist Unit Wt = 136.7 pcf, C = 330 psf, Phi = 25 deg
(5) CLAYEY SAND: Moist Unit Wt = 136.1 pcf, C = 0, Phi = 33 deg
(6) SILTY SAND: Moist Unit Wt = 120 pcf, C = 0, Phi = 36 deg
(7) FAT CLAY WITH SAND/SANDY FAT CLAY: Moist Unit Wt = 128.9 pcf, C = 230 psf, Phi = 19 deg
(8) CLAY LINER: Moist Unit Wt = 125 pcf, C = 270 psf, Phi = 24 deg



HTS INC. CONSULTANTS
PROJECT NO: 21-S-477 (REPORT VERSION: REV 2)
PROPOSED RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS - 2018
PRECINCT 3, HARRIS COUNTY, TEXAS
UPIN# 19103MF14601
DATE: 3/2/2022

SLOPE STABILITY ANALYSIS
CONDITIONS: GLOBAL SLIDE - RAPID DRAWDOWN WITH EFFECTIVE SOIL PARAMETERS
SECTION: A-A WITH SLOPE ABOUT 3.9H:1V
SOIL PROFILE: BORING NO. 4

SOIL TYPES:
(1) SILTY SAND: Moist Unit Wt = 115 pcf, C = 0, Phi = 29.5 deg
(2) CLAYEY SAND: Moist Unit Wt = 137.2 pcf, C = 0, Phi = 30 deg
(3) SILTY SAND: Moist Unit Wt = 125 pcf, C = 0, Phi = 33 deg
(4) SANDY LEAN CLAY: Moist Unit Wt = 136.7 pcf, C = 330 psf, Phi = 25 deg
(5) CLAYEY SAND: Moist Unit Wt = 136.1 pcf, C = 0, Phi = 33 deg
(6) SILTY SAND: Moist Unit Wt = 120 pcf, C = 0, Phi = 36 deg
(7) FAT CLAY WITH SAND/SANDY FAT CLAY: Moist Unit Wt = 128.9 pcf, C = 230 psf, Phi = 19 deg
(8) CLAY LINER: Moist Unit Wt = 125 pcf, C = 270 psf, Phi = 24 deg



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PROPOSED RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS - 2018
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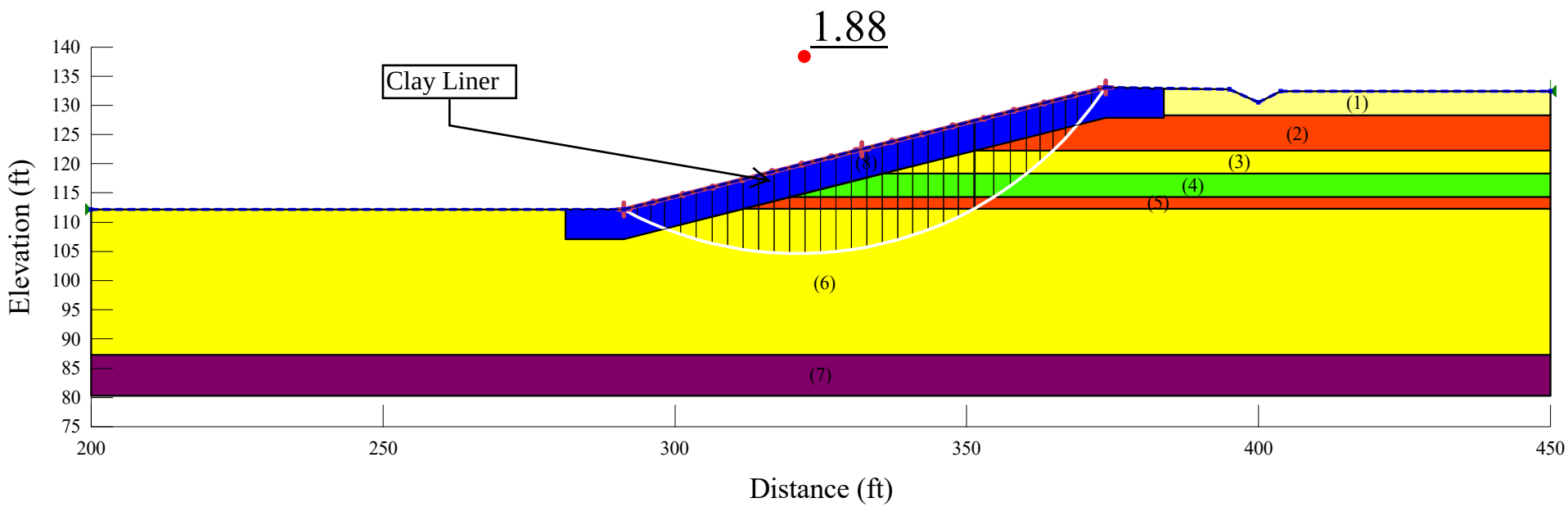
PLATE E-7

SLOPE STABILITY ANALYSIS
CONDITIONS: LOCAL SLIDE - RAPID DRAWDOWN WITH EFFECTIVE SOIL PARAMETERS
SECTION: A-A WITH SLOPE ABOUT 3.9H:1V
SOIL PROFILE: BORING NO. 4

SOIL TYPES:
(1) SILTY SAND: Moist Unit Wt = 115 pcf, C = 0, Phi = 29.5 deg
(2) CLAYEY SAND: Moist Unit Wt = 137.2 pcf, C = 0, Phi = 30 deg
(3) SILTY SAND: Moist Unit Wt = 125 pcf, C = 0, Phi = 33 deg
(4) SANDY LEAN CLAY: Moist Unit Wt = 136.7 pcf, C = 330 psf, Phi = 25 deg
(5) CLAYEY SAND: Moist Unit Wt = 136.1 pcf, C = 0, Phi = 33 deg
(6) SILTY SAND: Moist Unit Wt = 120 pcf, C = 0, Phi = 36 deg
(7) FAT CLAY WITH SAND/SANDY FAT CLAY: Moist Unit Wt = 128.9 pcf, C = 230 psf, Phi = 19 deg
(8) CLAY LINER: Moist Unit Wt = 125 pcf, C = 270 psf, Phi = 24 deg



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PRECINCT 3, HARRIS COUNTY, TEXAS
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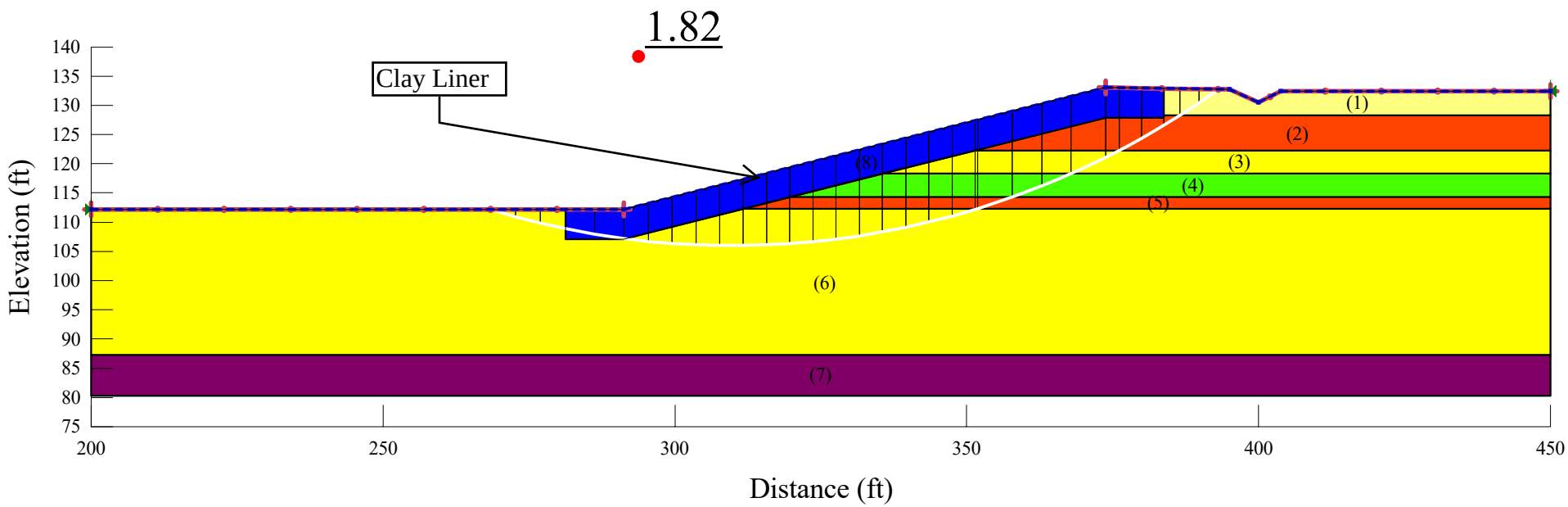
PLATE E-8

SLOPE STABILITY ANALYSIS
CONDITIONS: GLOBAL SLIDE - RAPID DRAWDOWN WITH TOTAL SOIL PARAMETERS
SECTION: A-A WITH SLOPE ABOUT 3.9H:1V
SOIL PROFILE: BORING NO. 4

SOIL TYPES:
(1) SILTY SAND: Moist Unit Wt = 115 pcf, C = 0, Phi = 29.5 deg
(2) CLAYEY SAND: Moist Unit Wt = 137.2 pcf, C = 0, Phi = 30 deg
(3) SILTY SAND: Moist Unit Wt = 125 pcf, C = 0, Phi = 33 deg
(4) SANDY LEAN CLAY: Moist Unit Wt = 136.7 pcf, C = 380 psf, Phi = 21 deg
(5) CLAYEY SAND: Moist Unit Wt = 136.1 pcf, C = 0, Phi = 33 deg
(6) SILTY SAND: Moist Unit Wt = 120 pcf, C = 0, Phi = 36 deg
(7) FAT CLAY WITH SAND/SANDY FAT CLAY: Moist Unit Wt = 128.9 pcf, C = 270 psf, Phi = 15 deg
(8) CLAY LINER: Moist Unit Wt = 125 pcf, C = 300 psf, Phi = 18 deg



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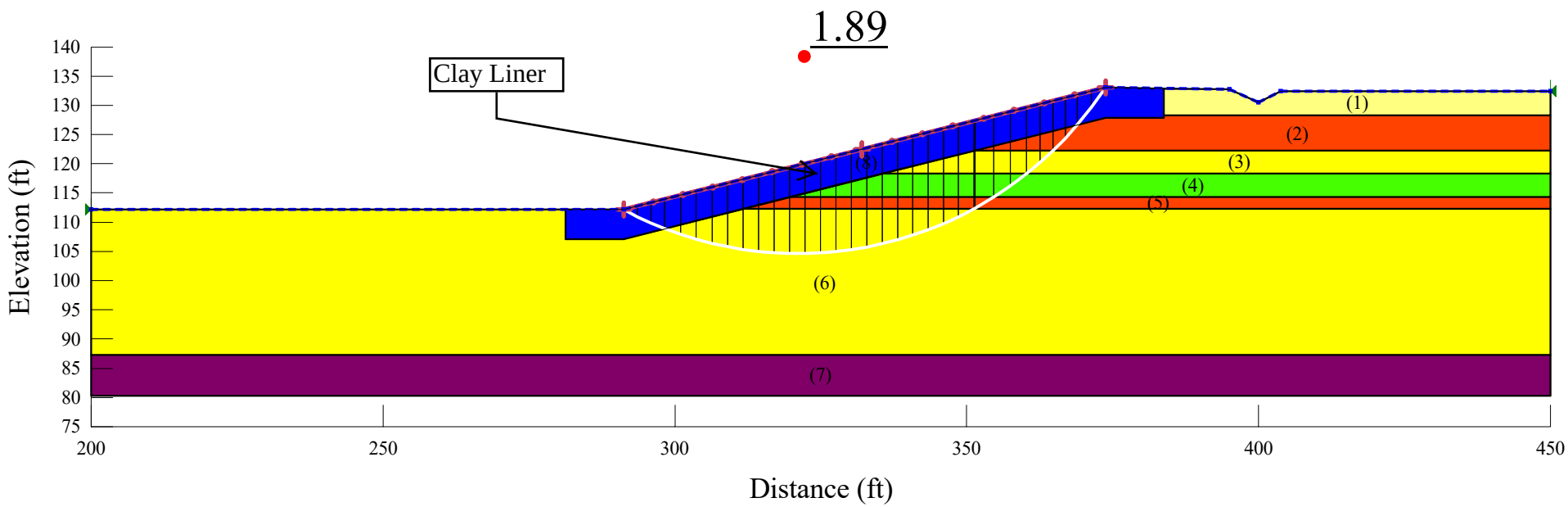
PRECINCT 3, HARRIS COUNTY, TEXAS
UPIN# 19103MF14601
DATE: 3/2/2022

SLOPE STABILITY ANALYSIS
CONDITIONS: LOCAL SLIDE - RAPID DRAWDOWN WITH TOTAL SOIL PARAMETERS
SECTION: A-A WITH SLOPE ABOUT 3.9H:1V
SOIL PROFILE: BORING NO. 4

SOIL TYPES:
(1) SILTY SAND: Moist Unit Wt = 115 pcf, C = 0, Phi = 29.5 deg
(2) CLAYEY SAND: Moist Unit Wt = 137.2 pcf, C = 0, Phi = 30 deg
(3) SILTY SAND: Moist Unit Wt = 125 pcf, C = 0, Phi = 33 deg
(4) SANDY LEAN CLAY: Moist Unit Wt = 136.7 pcf, C = 380 psf, Phi = 21 deg
(5) CLAYEY SAND: Moist Unit Wt = 136.1 pcf, C = 0, Phi = 33 deg
(6) SILTY SAND: Moist Unit Wt = 120 pcf, C = 0, Phi = 36 deg
(7) FAT CLAY WITH SAND/SANDY FAT CLAY: Moist Unit Wt = 128.9 pcf, C = 270 psf, Phi = 15 deg
(8) CLAY LINER: Moist Unit Wt = 125 pcf, C = 300 psf, Phi = 18 deg



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PRECINCT 3, HARRIS COUNTY, TEXAS
UPIN# 19103MF14601
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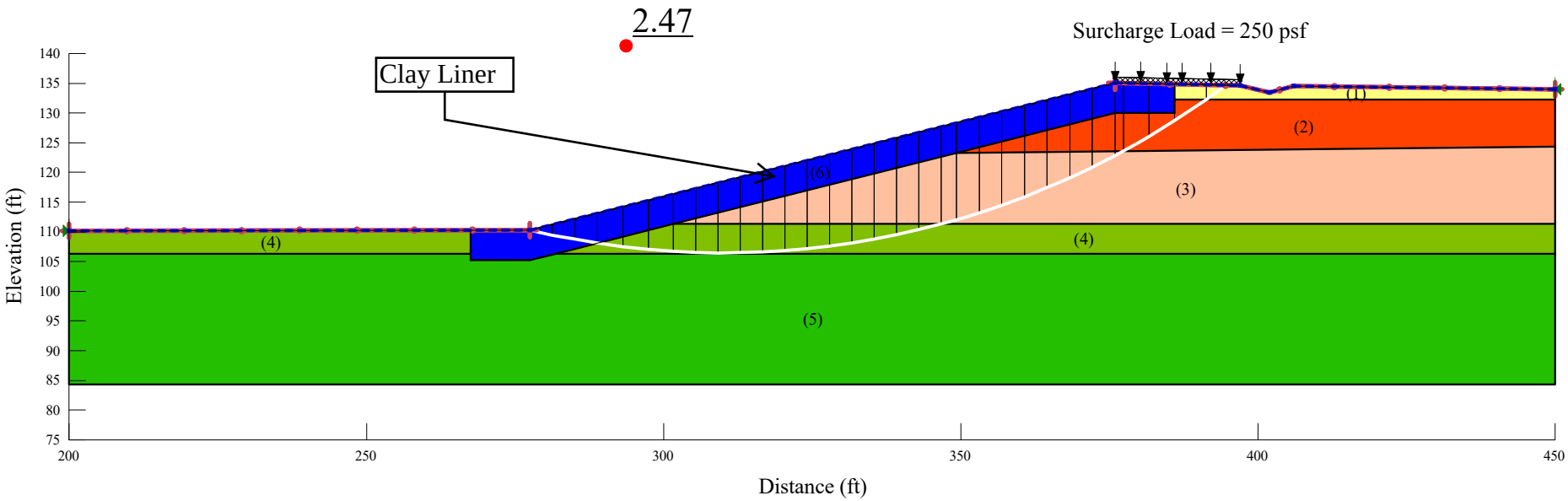
SLOPE STABILITY ANALYSIS
CONDITIONS: GLOBAL SLIDE - SHORT TERM - WATER FROM TOP TO ALONG THE SLOPE
SECTION: C-C WITH SLOPE ABOUT 4H:1V
SOIL PROFILE: BORING NO. 2

SOIL TYPES:
(1) SILTY SAND: Moist Unit Wt = 115 pcf, C = 0, Phi = 29.5 deg
(2) CLAYEY SAND: Moist Unit Wt = 138.4 pcf, C = 0, Phi = 30 deg
(3) POORLY GRADED SAND WITH SILT: Moist Unit Wt = 125 pcf, C = 0, Phi = 33 deg
(4) SANDY LEAN CLAY: Moist Unit Wt = 132.2 pcf, C = 1000 psf, Phi = 0 deg
(5) LEAN CLAY WITH SAND: Moist Unit Wt = 142 pcf, C = 2000 psf, Phi = 0 deg
(6) CLAY LINER: Moist Unit Wt = 125 pcf, C = 1000 psf, Phi = 0 deg



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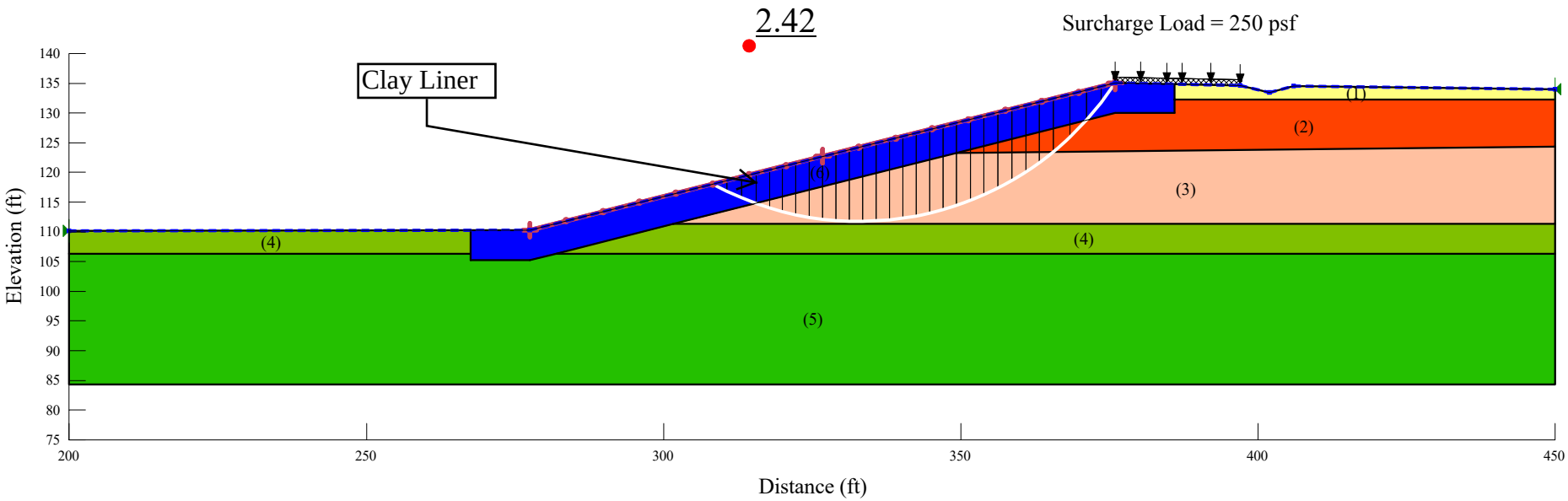
PRECINCT 3, HARRIS COUNTY, TEXAS
UPIN# 19103MF14601
DATE: 3/2/2022

SLOPE STABILITY ANALYSIS
CONDITIONS: LOCAL SLIDE - SHORT TERM - WATER FROM TOP TO ALONG THE SLOPE
SECTION: C-C WITH SLOPE ABOUT 4H:1V
SOIL PROFILE: BORING NO. 2

SOIL TYPES:
(1) SILTY SAND: Moist Unit Wt = 115 pcf, C = 0, Phi = 29.5 deg
(2) CLAYEY SAND: Moist Unit Wt = 138.4 pcf, C = 0, Phi = 30 deg
(3) POORLY GRADED SAND WITH SILT: Moist Unit Wt = 125 pcf, C = 0, Phi = 33 deg
(4) SANDY LEAN CLAY: Moist Unit Wt = 132.2 pcf, C = 1000 psf, Phi = 0 deg
(5) LEAN CLAY WITH SAND: Moist Unit Wt = 142 pcf, C = 2000 psf, Phi = 0 deg
(6) CLAY LINER: Moist Unit Wt = 125 pcf, C = 1000 psf, Phi = 0 deg



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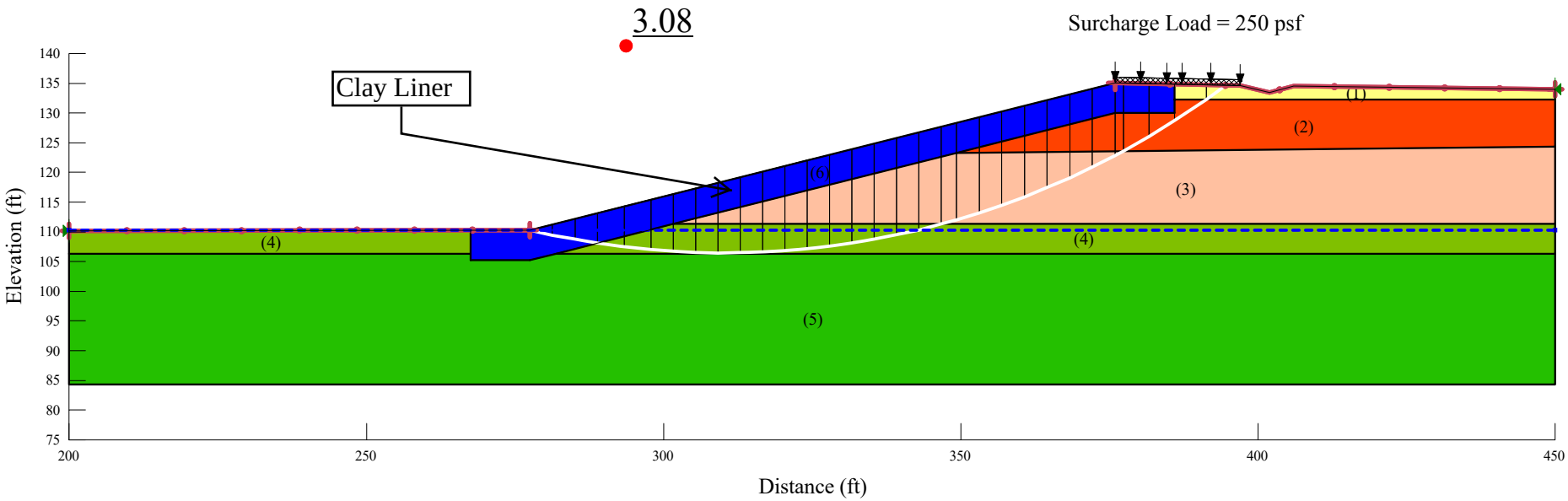
PROPOSED RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS - 2018
PRECINCT 3, HARRIS COUNTY, TEXAS
UPIN# 19103MF14601
DATE: 3/2/2022

SLOPE STABILITY ANALYSIS
CONDITIONS: GLOBAL SLIDE - SHORT TERM - WATER AT THE BOTTOM OF THE SLOPE
SECTION: C-C WITH SLOPE ABOUT 4H:1V
SOIL PROFILE: BORING NO. 2

SOIL TYPES:
(1) SILTY SAND: Moist Unit Wt = 115 pcf, C = 0, Phi = 29.5 deg
(2) CLAYEY SAND: Moist Unit Wt = 138.4 pcf, C = 0, Phi = 30 deg
(3) POORLY GRADED SAND WITH SILT: Moist Unit Wt = 125 pcf, C = 0, Phi = 33 deg
(4) SANDY LEAN CLAY: Moist Unit Wt = 132.2 pcf, C = 1000 psf, Phi = 0 deg
(5) LEAN CLAY WITH SAND: Moist Unit Wt = 142 pcf, C = 2000 psf, Phi = 0 deg
(6) CLAY LINER: Moist Unit Wt = 125 pcf, C = 1000 psf, Phi = 0 deg



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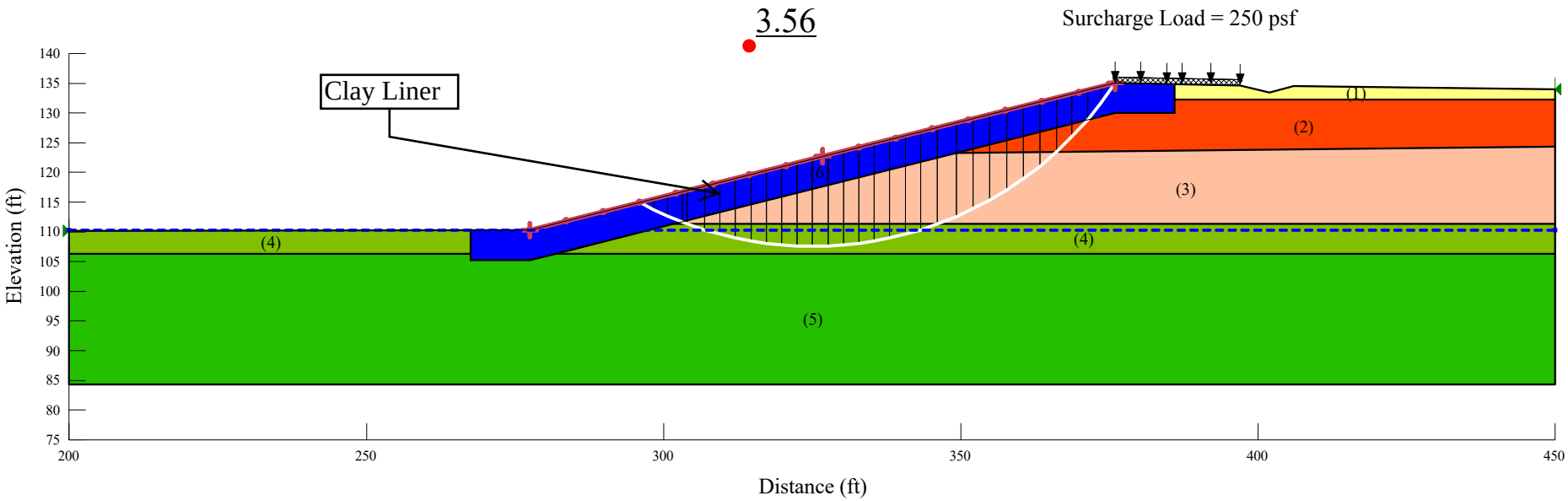
PRECINCT 3, HARRIS COUNTY, TEXAS
UPIN# 19103MF14601
DATE: 3/2/2022

SLOPE STABILITY ANALYSIS
CONDITIONS: LOCAL SLIDE - SHORT TERM - WATER AT THE BOTTOM OF THE SLOPE
SECTION: C-C WITH SLOPE ABOUT 4H:1V
SOIL PROFILE: BORING NO. 2

SOIL TYPES:
(1) SILTY SAND: Moist Unit Wt = 115 pcf, C = 0, Phi = 29.5 deg
(2) CLAYEY SAND: Moist Unit Wt = 138.4 pcf, C = 0, Phi = 30 deg
(3) POORLY GRADED SAND WITH SILT: Moist Unit Wt = 125 pcf, C = 0, Phi = 33 deg
(4) SANDY LEAN CLAY: Moist Unit Wt = 132.2 pcf, C = 1000 psf, Phi = 0 deg
(5) LEAN CLAY WITH SAND: Moist Unit Wt = 142 pcf, C = 2000 psf, Phi = 0 deg
(6) CLAY LINER: Moist Unit Wt = 125 pcf, C = 1000 psf, Phi = 0 deg



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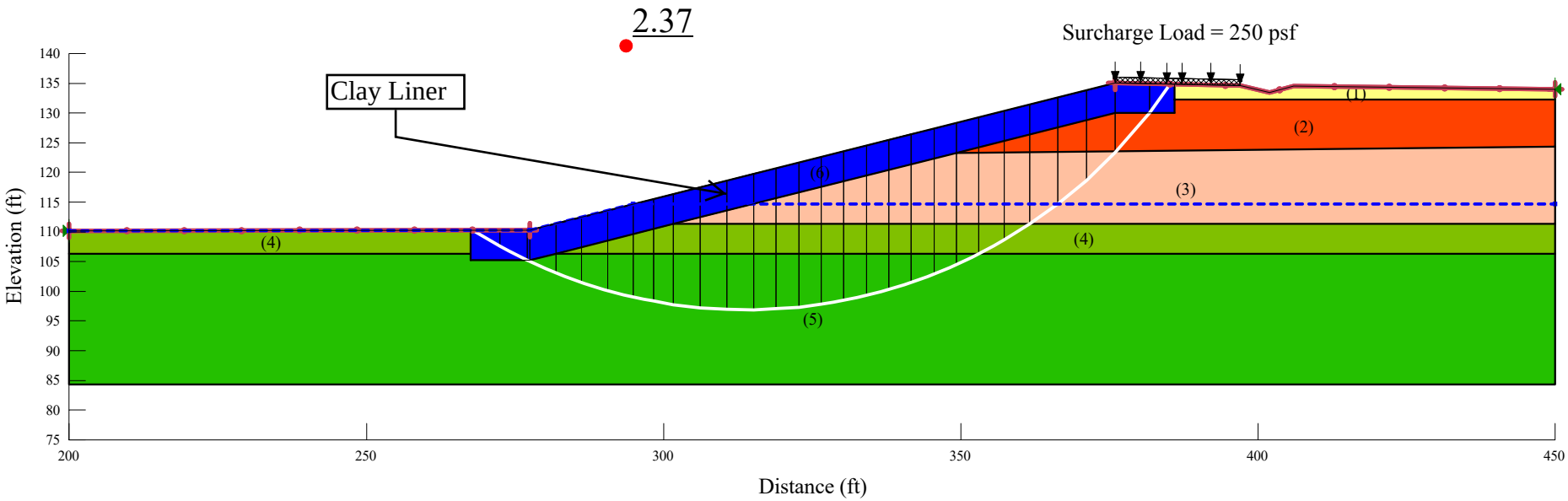
UPIN# 19103MF14601
DATE: 3/2/2022

SLOPE STABILITY ANALYSIS
CONDITIONS: GLOBAL SLIDE - LONG TERM
SECTION: C-C WITH SLOPE ABOUT 4H:1V
SOIL PROFILE: BORING NO. 2

SOIL TYPES:
(1) SILTY SAND: Moist Unit Wt = 115 pcf, C = 0, Phi = 29.5 deg
(2) CLAYEY SAND: Moist Unit Wt = 138.4 pcf, C = 0, Phi = 30 deg
(3) POORLY GRADED SAND WITH SILT: Moist Unit Wt = 125 pcf, C = 0, Phi = 33 deg
(4) SANDY LEAN CLAY: Moist Unit Wt = 136.7 pcf, C = 330 psf, Phi = 25 deg
(5) LEAN CLAY WITH SAND: Moist Unit Wt = 142 pcf, C = 280 psf, Phi = 23 deg
(6) CLAY LINER: Moist Unit Wt = 125 pcf, C = 270 psf, Phi = 24 deg



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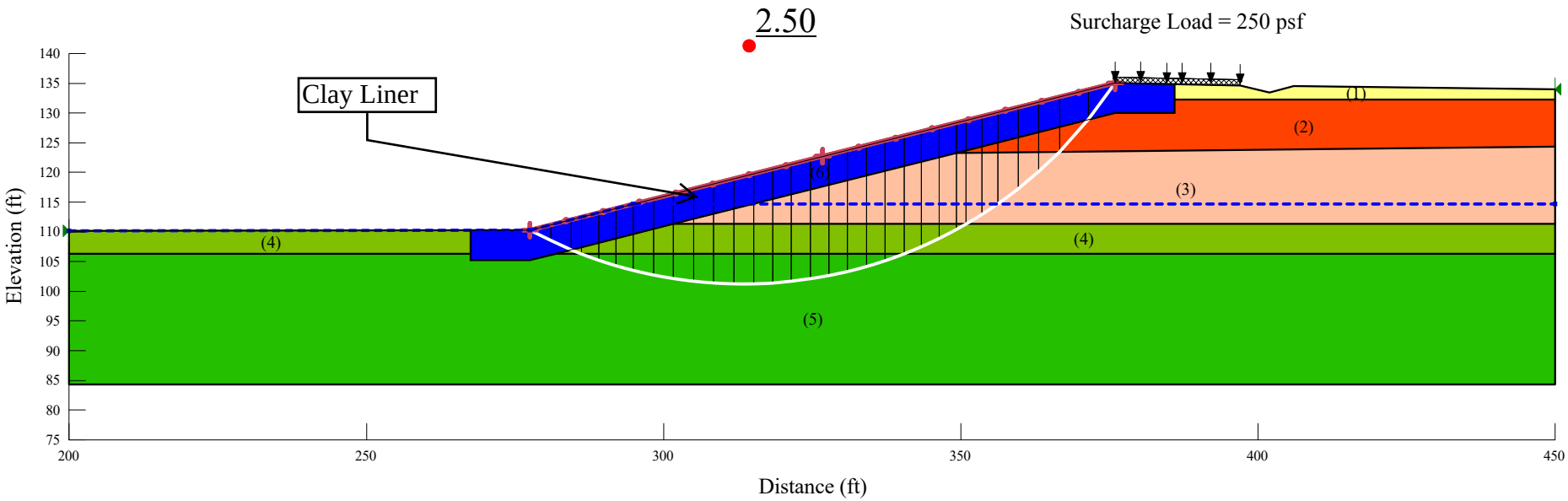
UPIN# 19103MF14601
DATE: 3/2/2022

SLOPE STABILITY ANALYSIS
CONDITIONS: LOCAL SLIDE - LONG TERM
SECTION: C-C WITH SLOPE ABOUT 4H:1V
SOIL PROFILE: BORING NO. 2

SOIL TYPES:
(1) SILTY SAND: Moist Unit Wt = 115 pcf, C = 0, Phi = 29.5 deg
(2) CLAYEY SAND: Moist Unit Wt = 138.4 pcf, C = 0, Phi = 30 deg
(3) POORLY GRADED SAND WITH SILT: Moist Unit Wt = 125 pcf, C = 0, Phi = 33 deg
(4) SANDY LEAN CLAY: Moist Unit Wt = 136.7 pcf, C = 330 psf, Phi = 25 deg
(5) LEAN CLAY WITH SAND: Moist Unit Wt = 142 pcf, C = 280 psf, Phi = 23 deg
(6) CLAY LINER: Moist Unit Wt = 125 pcf, C = 270 psf, Phi = 24 deg



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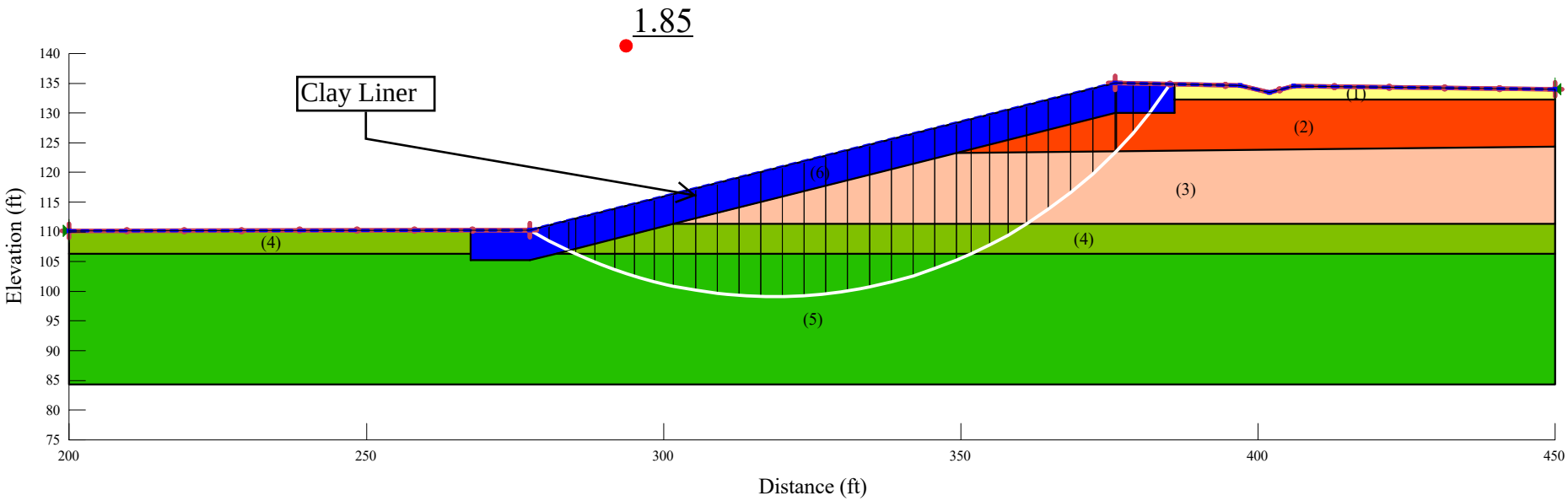
UPIN# 19103MF14601
DATE: 3/2/2022

SLOPE STABILITY ANALYSIS
CONDITIONS: GLOBAL SLIDE - RAPID DRAWDOWN WITH EFFECTIVE SOIL PARAMETERS
SECTION: C-C WITH SLOPE ABOUT 4H:1V
SOIL PROFILE: BORING NO. 2

SOIL TYPES:
(1) SILTY SAND: Moist Unit Wt = 115 pcf, C = 0, Phi = 29.5 deg
(2) CLAYEY SAND: Moist Unit Wt = 138.4 pcf, C = 0, Phi = 30 deg
(3) POORLY GRADED SAND WITH SILT: Moist Unit Wt = 125 pcf, C = 0, Phi = 33 deg
(4) SANDY LEAN CLAY: Moist Unit Wt = 136.7 pcf, C = 330 psf, Phi = 25 deg
(5) LEAN CLAY WITH SAND: Moist Unit Wt = 142 pcf, C = 280 psf, Phi = 23 deg
(6) CLAY LINER: Moist Unit Wt = 125 pcf, C = 270 psf, Phi = 24 deg



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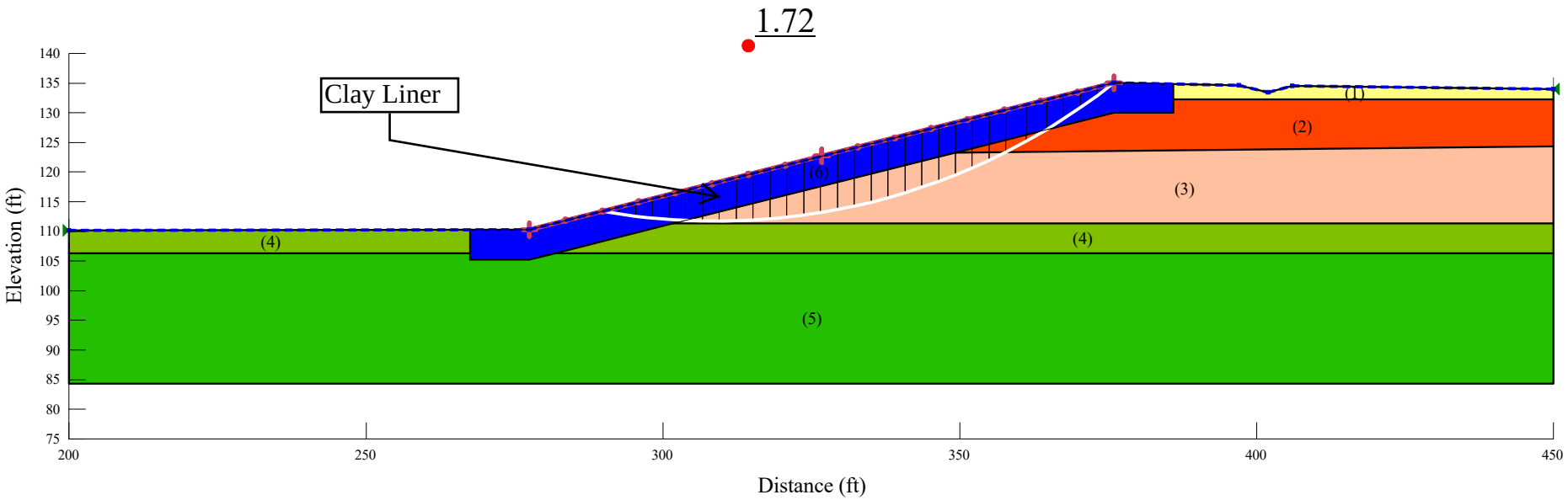
PRECINCT 3, HARRIS COUNTY, TEXAS
UPIN# 19103MF14601
DATE: 3/2/2022

SLOPE STABILITY ANALYSIS
CONDITIONS: LOCAL SLIDE - RAPID DRAWDOWN WITH EFFECTIVE SOIL PARAMETERS
SECTION: C-C WITH SLOPE ABOUT 4H:1V
SOIL PROFILE: BORING NO. 2

SOIL TYPES:
(1) SILTY SAND: Moist Unit Wt = 115 pcf, C = 0, Phi = 29.5 deg
(2) CLAYEY SAND: Moist Unit Wt = 138.4 pcf, C = 0, Phi = 30 deg
(3) POORLY GRADED SAND WITH SILT: Moist Unit Wt = 125 pcf, C = 0, Phi = 33 deg
(4) SANDY LEAN CLAY: Moist Unit Wt = 136.7 pcf, C = 330 psf, Phi = 25 deg
(5) LEAN CLAY WITH SAND: Moist Unit Wt = 142 pcf, C = 280 psf, Phi = 23 deg
(6) CLAY LINER: Moist Unit Wt = 125 pcf, C = 270 psf, Phi = 24 deg



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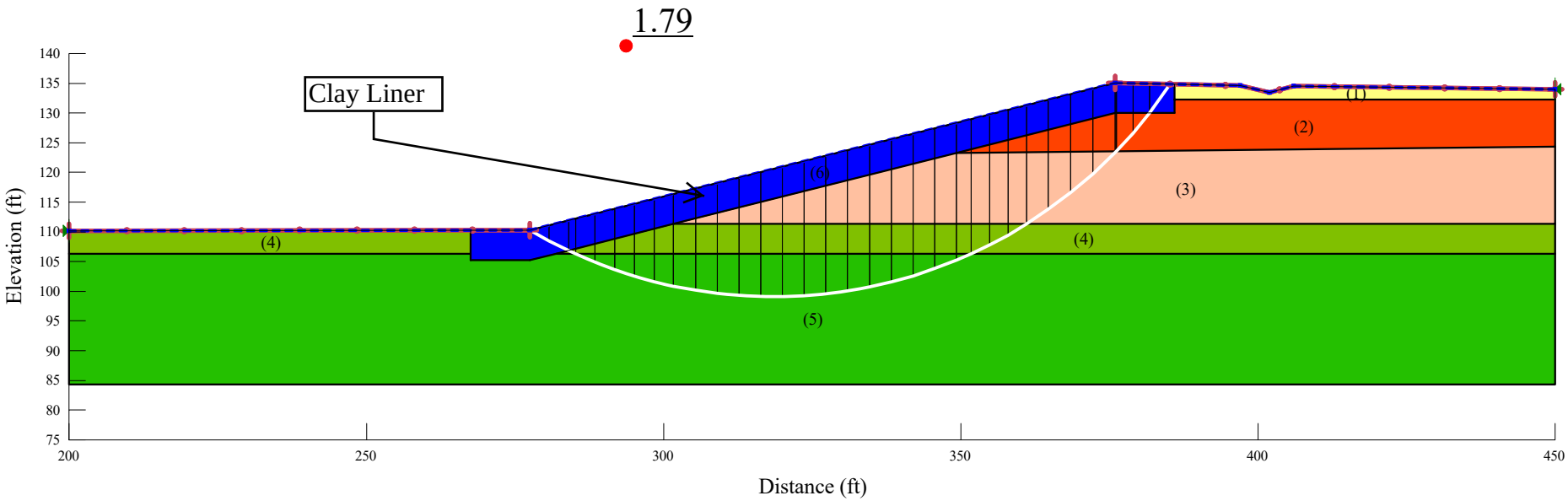
UPIN# 19103MF14601
DATE: 3/2/2022

SLOPE STABILITY ANALYSIS
CONDITIONS: GLOBAL SLIDE - RAPID DRAWDOWN WITH TOTAL SOIL PARAMETERS
SECTION: C-C WITH SLOPE ABOUT 4H:1V
SOIL PROFILE: BORING NO. 2

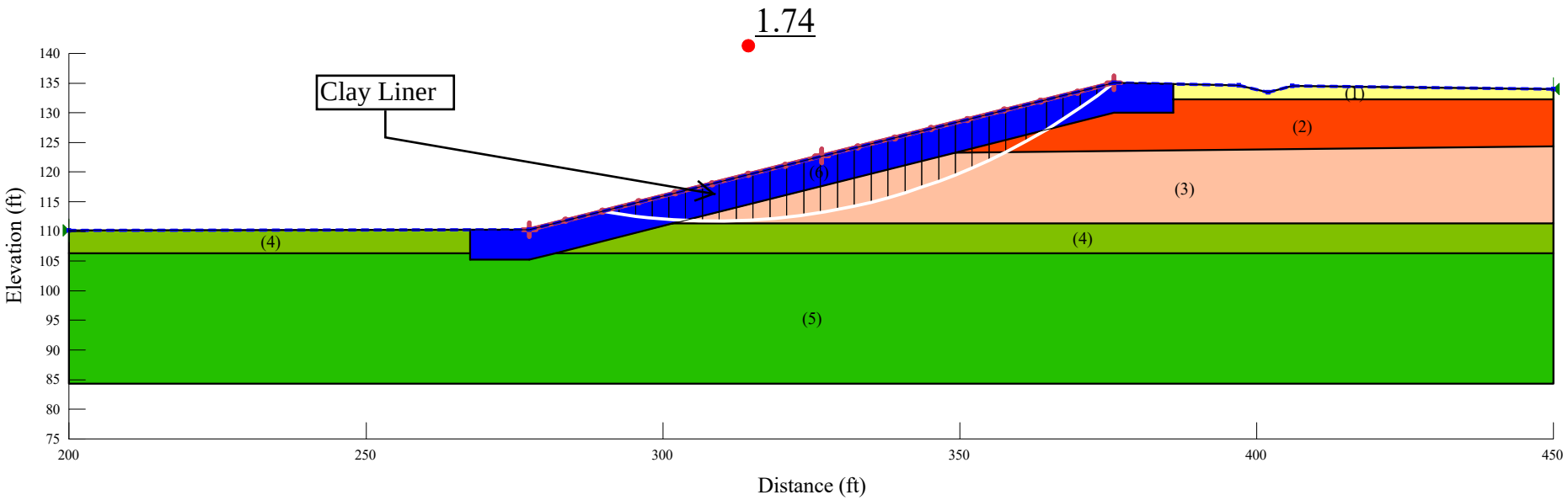
SOIL TYPES:
(1) SILTY SAND: Moist Unit Wt = 115 pcf, C = 0, Phi = 29.5 deg
(2) CLAYEY SAND: Moist Unit Wt = 138.4 pcf, C = 0, Phi = 30 deg
(3) POORLY GRADED SAND WITH SILT: Moist Unit Wt = 125 pcf, C = 0, Phi = 33 deg
(4) SANDY LEAN CLAY: Moist Unit Wt = 136.7 pcf, C = 380 psf, Phi = 21 deg
(5) LEAN CLAY WITH SAND: Moist Unit Wt = 142 pcf, C = 330 psf, Phi = 20 deg
(6) CLAY LINER: Moist Unit Wt = 125 pcf, C = 300 psf, Phi = 18 deg



HTS INC. CONSULTANTS
PROJECT NO: 21-S-477 (REPORT VERSION: REV 2)
PROPOSED RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS - 2018
PRECINCT 3, HARRIS COUNTY, TEXAS
UPIN# 19103MF14601
DATE: 3/2/2022

SLOPE STABILITY ANALYSIS
CONDITIONS: LOCAL SLIDE - RAPID DRAWDOWN WITH TOTAL SOIL PARAMETERS
SECTION: C-C WITH SLOPE ABOUT 4H:1V
SOIL PROFILE: BORING NO. 2

SOIL TYPES:
(1) SILTY SAND: Moist Unit Wt = 115 pcf, C = 0, Phi = 29.5 deg
(2) CLAYEY SAND: Moist Unit Wt = 138.4 pcf, C = 0, Phi = 30 deg
(3) POORLY GRADED SAND WITH SILT: Moist Unit Wt = 125 pcf, C = 0, Phi = 33 deg
(4) SANDY LEAN CLAY: Moist Unit Wt = 136.7 pcf, C = 380 psf, Phi = 21 deg
(5) LEAN CLAY WITH SAND: Moist Unit Wt = 142 pcf, C = 330 psf, Phi = 20 deg
(6) CLAY LINER: Moist Unit Wt = 125 pcf, C = 300 psf, Phi = 18 deg



HTS INC. CONSULTANTS
PROJECT NO: 21-S-477 (REPORT VERSION: REV 2)
PROPOSED RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS - 2018
PRECINCT 3, HARRIS COUNTY, TEXAS
UPIN# 19103MF14601
DATE: 3/2/2022

APPENDIX F

Slope Stability Analyses Reports

REPORT F-1
WITH REFERENCE TO SLOPE STABILITY ANALYSIS RESULT PRESENTED IN PLATE E-1
CONDITIONS: GLOBAL SLIDE - SHORT TERM - WATER FROM TOP TO ALONG THE SLOPE
SECTION: A-A WITH SLOPE ABOUT 3.9H:1V
SOIL PROFILE: BORING NO. 4

SLOPE/W Analysis

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File Information

File Version: 11.00
Revision Number: 17
Date: 03/02/2022
Time: 02:24:36 PM
Tool Version: 11.0.1.21429
File Name: 1. G-ST - Top - AA - B4 - Clay Liner.gsz
Directory: H:\2021\450-499\21-S-477 Ravensway Drainage Improvements-HCED\Calculation\Slope Stability\Report 3 on 2-2022\Global Stability\
Last Solved Date: 03/02/2022
Last Solved Time: 02:24:39 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

SLOPE/W Analysis

Kind: SLOPE/W
Method: Spencer
Settings
- PWP Conditions from: Piezometric Line
  - Apply Phreatic Correction: No
  - Use Staged Rapid Drawdown: No
- Unit Weight of Water: 62.430189 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 ft
  - Number of Slices: 30
- Factor of Safety Convergence Settings

Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

(1)

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 29.5 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(2)

Model: Mohr-Coulomb
Unit Weight: 137.2 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(3)

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 33 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(4)

Model: Undrained (Phi=0)
Unit Weight: 136.7 pcf
Cohesion: 1,000 psf
Pore Water Pressure
Piezometric Line: 1

(5)

Model: Mohr-Coulomb

Unit Weight: 136.1 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 33 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(6)

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 36 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(7)

Model: Undrained (Phi=0)
Unit Weight: 128.9 pcf
Cohesion: 2,000 psf
Pore Water Pressure
Piezometric Line: 1

(8)

Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 1,000 psf
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (200, 112.14) ft
Left-Zone Right Coordinate: (291.25, 112.14) ft
Left-Zone Increment: 8
Right Type: Range
Right-Zone Left Coordinate: (373.75, 133.08) ft
Right-Zone Right Coordinate: (450, 132.45) ft
Right-Zone Increment: 8
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (200, 112.14) ft
Right Coordinate: (450, 132.45) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	200 ft	112.14 ft
Coordinate 2	291.25 ft	112.14 ft
Coordinate 3	373.75 ft	133.08 ft
Coordinate 4	395 ft	132.7 ft
Coordinate 5	400 ft	130.5 ft
Coordinate 6	403.75 ft	132.45 ft
Coordinate 7	450 ft	132.45 ft

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X	Y
	373.75 ft	134.08 ft
	395 ft	133.7 ft

Geometry

Name: 2D Geometry

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	281.25 ft	112.14 ft
Point 2	281.25 ft	107.14 ft
Point 3	291.25 ft	107.14 ft

Point 4	373.75 ft	127.906 ft
Point 5	383.75 ft	127.906 ft
Point 6	383.75 ft	132.90059 ft
Point 7	395 ft	132.7 ft
Point 8	400 ft	130.5 ft
Point 9	403.75 ft	132.45 ft
Point 10	450 ft	132.45 ft
Point 11	450 ft	128.3 ft
Point 12	383.75 ft	128.3 ft
Point 13	450 ft	122.3 ft
Point 14	351.47831 ft	122.30001 ft
Point 15	450 ft	118.3 ft
Point 16	335.58529 ft	118.29959 ft
Point 17	450 ft	114.3 ft
Point 18	319.69675 ft	114.3003 ft
Point 19	450 ft	112.3 ft
Point 20	311.75019 ft	112.30008 ft
Point 21	450 ft	87.3 ft
Point 22	200 ft	87.3 ft
Point 23	200 ft	112.14 ft
Point 24	450 ft	80.3 ft
Point 25	200 ft	80.3 ft
Point 26	373.75 ft	133.08 ft
Point 27	291.25 ft	112.14 ft

Regions

	Material	Points	Area
Region 1	(1)	6,7,8,9,10,11,12	270.97 ft²
Region 2	(2)	5,12,11,13,14,4	515.99 ft²
Region 3	(3)	14,13,15,16	425.89 ft²
Region 4	(4)	16,15,17,18	489.39 ft²
Region 5	(5)	18,17,19,20	268.57 ft²
Region 6	(6)	20,19,21,22,23,1,2,3	6,132.5 ft²
Region 7	(7)	22,21,24,25	1,750 ft²
Region 8	(8)	1,2,3,20,18,16,14,4,5,12,6,26,27	520.52 ft²

Slip Results

Slip Surfaces Analysed: 314 of 405 converged

Current Slip Surface

Slip Surface: 237
Factor of Safety: 1.89
Volume: 1,370.3951 ft³
Weight: 172,914.8 lbf
Resisting Moment: 10,364,336 lbf·ft
Activating Moment: 5,477,849.6 lbf·ft
Resisting Force: 64,694.212 lbf
Activating Force: 34,197.736 lbf
Slip Rank: 1 of 405 slip surfaces
Exit: (257.03125, 112.14) ft
Entry: (393.04509, 132.73486) ft
Radius: 153.55319 ft
Center: (304.48488, 258.17676) ft

Slip Slices

	X	Y	PWP	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	259.45313 ft	111.39697 ft	46.387288 psf	43.356992 psf	0 psf	0 psf	(6)
Slice 2	264.29688 ft	109.99711 ft	133.78122 psf	121.0667 psf	0 psf	0 psf	(6)
Slice 3	269.14063 ft	108.76735 ft	210.55526 psf	184.74181 psf	0 psf	0 psf	(6)
Slice 4	273.98438 ft	107.70352 ft	276.97008 psf	235.89545 psf	0 psf	0 psf	(6)
Slice 5	278.82813 ft	106.80213 ft	333.24435 psf	275.79331 psf	0 psf	0 psf	(6)
Slice 6	283.75 ft	106.05089 ft	380.1444 psf	327.09156 psf	0 psf	0 psf	(6)
Slice 7	288.75 ft	105.45257 ft	417.49776 psf	347.4426 psf	0 psf	0 psf	(6)
Slice 8	293.30002 ft	105.04526 ft	475.41034 psf	383.26057 psf	0 psf	0 psf	(6)
Slice 9	297.40006 ft	104.80083 ft	555.63906 psf	434.9795 psf	0 psf	0 psf	(6)

Slice 10	301.50009 ft	104.66627 ft	629.00823 psf	479.41784 psf	0 psf	0 psf	(6)
Slice 11	305.60013 ft	104.64131 ft	695.53588 psf	517.00335 psf	0 psf	0 psf	(6)
Slice 12	309.70017 ft	104.72587 ft	755.22537 psf	548.11766 psf	0 psf	0 psf	(6)
Slice 13	313.73683 ft	104.91547 ft	807.35309 psf	578.85706 psf	0 psf	0 psf	(6)
Slice 14	317.71011 ft	105.20716 ft	852.10334 psf	609.44354 psf	0 psf	0 psf	(6)
Slice 15	321.68282 ft	105.60278 ft	890.35559 psf	634.67507 psf	0 psf	0 psf	(6)
Slice 16	325.65495 ft	106.10313 ft	922.061 psf	654.78452 psf	0 psf	0 psf	(6)
Slice 17	329.62709 ft	106.70928 ft	947.16118 psf	669.77303 psf	0 psf	0 psf	(6)
Slice 18	333.59922 ft	107.4225 ft	965.57638 psf	679.84049 psf	0 psf	0 psf	(6)
Slice 19	337.57192 ft	108.24447 ft	977.21182 psf	681.14287 psf	0 psf	0 psf	(6)
Slice 20	341.54517 ft	109.17701 ft	981.95322 psf	674.02504 psf	0 psf	0 psf	(6)
Slice 21	345.51843 ft	110.22211 ft	979.66749 psf	662.72456 psf	0 psf	0 psf	(6)
Slice 22	349.49168 ft	111.38217 ft	970.2044 psf	647.38319 psf	0 psf	0 psf	(6)
Slice 23	351.95329 ft	112.14566 ft	961.546 psf	637.37018 psf	0 psf	0 psf	(6)
Slice 24	355.28064 ft	113.30013 ft	942.19678 psf	552.82197 psf	0 psf	0 psf	(5)
Slice 25	360.55801 ft	115.25161 ft	903.99089 psf	0 psf	1,000 psf	0 psf	(4)
Slice 26	365.40804 ft	117.25135 ft	855.99946 psf	0 psf	1,000 psf	0 psf	(4)
Slice 27	370.79153 ft	119.71648 ft	787.40766 psf	426.75635 psf	0 psf	0 psf	(3)
Slice 28	374.88086 ft	121.71663 ft	708.15506 psf	517.67117 psf	0 psf	0 psf	(3)

Slice 29	377.9463 ft	123.3541 ft	602.50476 psf	406.25381 psf	0 psf	0 psf	(2)
Slice 30	381.81543 ft	125.53607 ft	461.96477 psf	326.35893 psf	0 psf	0 psf	(2)
Slice 31	385.07659 ft	127.48197 ft	336.84114 psf	238.96238 psf	0 psf	0 psf	(2)
Slice 32	389.72414 ft	130.51743 ft	142.14833 psf	157.73534 psf	0 psf	0 psf	(1)

REPORT F-2
WITH REFERENCE TO SLOPE STABILITY ANALYSIS RESULT PRESENTED IN PLATE E-2
CONDITIONS: LOCAL SLIDE - SHORT TERM - WATER FROM TOP TO ALONG THE SLOPE
SECTION: A-A WITH SLOPE ABOUT 3.9H:1V
SOIL PROFILE: BORING NO. 4

SLOPE/W Analysis

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File Information

File Version: 11.00
Revision Number: 23
Date: 03/02/2022
Time: 02:47:30 PM
Tool Version: 11.0.1.21429
File Name: 2. L-ST - Top - AA - B4 - Clay Liner.gsz
Directory: H:\2021\450-499\21-S-477 Ravensway Drainage Improvements-HCED\Calculation\Slope Stability\Report 3 on 2-2022\Local Stability\
Last Solved Date: 03/02/2022
Last Solved Time: 02:47:33 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

SLOPE/W Analysis

Kind: SLOPE/W
Method: Spencer
Settings
- PWP Conditions from: Piezometric Line
  - Apply Phreatic Correction: No
  - Use Staged Rapid Drawdown: No
- Unit Weight of Water: 62.430189 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 ft
  - Number of Slices: 30
- Factor of Safety Convergence Settings

Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

(1)

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 29.5 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(2)

Model: Mohr-Coulomb
Unit Weight: 137.2 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(3)

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 33 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(4)

Model: Undrained (Phi=0)
Unit Weight: 136.7 pcf
Cohesion: 1,000 psf
Pore Water Pressure
Piezometric Line: 1

(5)

Model: Mohr-Coulomb

Unit Weight: 136.1 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 33 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(6)

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 36 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(7)

Model: Undrained (Phi=0)
Unit Weight: 128.9 pcf
Cohesion: 2,000 psf
Pore Water Pressure
Piezometric Line: 1

(8)

Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 1,000 psf
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (291.25, 112.14) ft
Left-Zone Right Coordinate: (332, 122.48309) ft
Left-Zone Increment: 8
Right Type: Range
Right-Zone Left Coordinate: (332, 122.48309) ft
Right-Zone Right Coordinate: (373.75, 133.08) ft
Right-Zone Increment: 8
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (200, 112.14) ft
Right Coordinate: (450, 132.45) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	200 ft	112.14 ft
Coordinate 2	291.25 ft	112.14 ft
Coordinate 3	373.75 ft	133.08 ft
Coordinate 4	395 ft	132.7 ft
Coordinate 5	400 ft	130.5 ft
Coordinate 6	403.75 ft	132.45 ft
Coordinate 7	450 ft	132.45 ft

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X	Y
	373.75 ft	134.08 ft
	395 ft	133.7 ft

Geometry

Name: 2D Geometry

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	281.25 ft	112.14 ft
Point 2	281.25 ft	107.14 ft
Point 3	291.25 ft	107.14 ft

Point 4	373.75 ft	127.906 ft
Point 5	383.75 ft	127.906 ft
Point 6	383.75 ft	132.90059 ft
Point 7	395 ft	132.7 ft
Point 8	400 ft	130.5 ft
Point 9	403.75 ft	132.45 ft
Point 10	450 ft	132.45 ft
Point 11	450 ft	128.3 ft
Point 12	383.75 ft	128.3 ft
Point 13	450 ft	122.3 ft
Point 14	351.47831 ft	122.30001 ft
Point 15	450 ft	118.3 ft
Point 16	335.58529 ft	118.29959 ft
Point 17	450 ft	114.3 ft
Point 18	319.69675 ft	114.3003 ft
Point 19	450 ft	112.3 ft
Point 20	311.75019 ft	112.30008 ft
Point 21	450 ft	87.3 ft
Point 22	200 ft	87.3 ft
Point 23	200 ft	112.14 ft
Point 24	450 ft	80.3 ft
Point 25	200 ft	80.3 ft
Point 26	373.75 ft	133.08 ft
Point 27	291.25 ft	112.14 ft

Regions

	Material	Points	Area
Region 1	(1)	6,7,8,9,10,11,12	270.97 ft²
Region 2	(2)	5,12,11,13,14,4	515.99 ft²
Region 3	(3)	14,13,15,16	425.89 ft²
Region 4	(4)	16,15,17,18	489.39 ft²
Region 5	(5)	18,17,19,20	268.57 ft²
Region 6	(6)	20,19,21,22,23,1,2,3	6,132.5 ft²
Region 7	(7)	22,21,24,25	1,750 ft²
Region 8	(8)	1,2,3,20,18,16,14,4,5,12,6,26,27	520.52 ft²

Slip Results

Slip Surfaces Analysed: 308 of 405 converged

Current Slip Surface

Slip Surface: 43
Factor of Safety: 2.39
Volume: 965.99978 ft³
Weight: 121,957.23 lbf
Resisting Moment: 3,896,032 lbf·ft
Activating Moment: 1,628,938.5 lbf·ft
Resisting Force: 54,576.358 lbf
Activating Force: 22,820.824 lbf
Slip Rank: 1 of 405 slip surfaces
Exit: (291.25, 112.14) ft
Entry: (373.75, 133.08) ft
Radius: 62.985841 ft
Center: (321.07666, 167.616) ft

Slip Slices

	X	Y	PWP	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	292.41928 ft	111.54242 ft	55.835338 psf	0 psf	1,000 psf	0 psf	(8)
Slice 2	294.75784 ft	110.40692 ft	163.78156 psf	0 psf	1,000 psf	0 psf	(8)
Slice 3	297.09639 ft	109.38745 ft	264.48361 psf	0 psf	1,000 psf	0 psf	(8)
Slice 4	299.61412 ft	108.41703 ft	364.96312 psf	335.87496 psf	0 psf	0 psf	(6)
Slice 5	302.31103 ft	107.50717 ft	464.50069 psf	408.5227 psf	0 psf	0 psf	(6)
Slice 6	305.00793 ft	106.73031 ft	555.73495 psf	470.53392 psf	0 psf	0 psf	(6)
Slice 7	307.70483 ft	106.08141 ft	638.98112 psf	523.11366 psf	0 psf	0 psf	(6)
Slice 8	310.40174 ft	105.55643 ft	714.4903 psf	567.21621 psf	0 psf	0 psf	(6)
Slice 9	313.07462 ft	105.15481 ft	781.91795 psf	607.61376 psf	0 psf	0 psf	(6)

Slice 10	315.72347 ft	104.87213 ft	841.53878 psf	644.81361 psf	0 psf	0 psf	(6)
Slice 11	318.37232 ft	104.70221 ft	894.12091 psf	675.34398 psf	0 psf	0 psf	(6)
Slice 12	321.0208 ft	104.6441 ft	939.71587 psf	699.77008 psf	0 psf	0 psf	(6)
Slice 13	323.66888 ft	104.69748 ft	978.34503 psf	718.43012 psf	0 psf	0 psf	(6)
Slice 14	326.31698 ft	104.86259 ft	1,009.9982 psf	731.45958 psf	0 psf	0 psf	(6)
Slice 15	328.96506 ft	105.14034 ft	1,034.6199 psf	739.09223 psf	0 psf	0 psf	(6)
Slice 16	331.61316 ft	105.53223 ft	1,052.1157 psf	741.51855 psf	0 psf	0 psf	(6)
Slice 17	334.26124 ft	106.04044 ft	1,062.3492 psf	738.89149 psf	0 psf	0 psf	(6)
Slice 18	336.88644 ft	106.66143 ft	1,065.1796 psf	728.84493 psf	0 psf	0 psf	(6)
Slice 19	339.48875 ft	107.39673 ft	1,060.5101 psf	711.68915 psf	0 psf	0 psf	(6)
Slice 20	342.09105 ft	108.25519 ft	1,048.1528 psf	690.09971 psf	0 psf	0 psf	(6)
Slice 21	344.69336 ft	109.24223 ft	1,027.7676 psf	664.11625 psf	0 psf	0 psf	(6)
Slice 22	347.29566 ft	110.36452 ft	998.93845 psf	633.7589 psf	0 psf	0 psf	(6)
Slice 23	349.89797 ft	111.63023 ft	961.15599 psf	599.03001 psf	0 psf	0 psf	(6)
Slice 24	351.33871 ft	112.37653 ft	937.39403 psf	522.65266 psf	0 psf	0 psf	(5)
Slice 25	353.04534 ft	113.37661 ft	902.00179 psf	491.88166 psf	0 psf	0 psf	(5)
Slice 26	356.02358 ft	115.24186 ft	832.74711 psf	0 psf	1,000 psf	0 psf	(4)
Slice 27	358.84601 ft	117.24159 ft	752.62758 psf	0 psf	1,000 psf	0 psf	(4)
Slice 28	361.39848 ft	119.25115 ft	667.61681 psf	320.56602 psf	0 psf	0 psf	(3)

Slice 29	363.681 ft	121.25131 ft	578.91467 psf	273.78363 psf	0 psf	0 psf	(3)
Slice 30	365.85772 ft	123.34746 ft	482.54392 psf	199.4518 psf	0 psf	0 psf	(2)
Slice 31	367.92864 ft	125.54813 ft	377.97147 psf	144.4716 psf	0 psf	0 psf	(2)
Slice 32	370.16058 ft	128.19095 ft	248.34674 psf	0 psf	1,000 psf	0 psf	(8)
Slice 33	372.55353 ft	131.38028 ft	87.154905 psf	0 psf	1,000 psf	0 psf	(8)

REPORT F-3
WITH REFERENCE TO SLOPE STABILITY ANALYSIS RESULT PRESENTED IN PLATE E-3
CONDITIONS: GLOBAL SLIDE - SHORT TERM - WATER AT THE BOTTOM OF THE SLOPE
SECTION: A-A WITH SLOPE ABOUT 3.9H:1V
SOIL PROFILE: BORING NO. 4

SLOPE/W Analysis

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File Information

File Version: 11.00
Revision Number: 20
Date: 03/02/2022
Time: 02:29:15 PM
Tool Version: 11.0.1.21429
File Name: 3. G-ST - BOT - AA - B4 - Clay Liner.gsz
Directory: H:\2021\450-499\21-S-477 Ravensway Drainage Improvements-HCED\Calculation\Slope Stability\Report 3 on 2-2022\Global Stability\
Last Solved Date: 03/02/2022
Last Solved Time: 02:29:18 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

SLOPE/W Analysis

Kind: SLOPE/W
Method: Spencer
Settings
- PWP Conditions from: Piezometric Line
  - Apply Phreatic Correction: No
  - Use Staged Rapid Drawdown: No
- Unit Weight of Water: 62.430189 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 ft
  - Number of Slices: 30
- Factor of Safety Convergence Settings

Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

(1)

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 29.5 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(2)

Model: Mohr-Coulomb
Unit Weight: 137.2 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(3)

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 33 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(4)

Model: Undrained (Phi=0)
Unit Weight: 136.7 pcf
Cohesion: 1,000 psf
Pore Water Pressure
Piezometric Line: 1

(5)

Model: Mohr-Coulomb

Unit Weight: 136.1 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 33 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(6)

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 36 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(7)

Model: Undrained (Phi=0)
Unit Weight: 128.9 pcf
Cohesion: 2,000 psf
Pore Water Pressure
Piezometric Line: 1

(8)

Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 1,000 psf
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (200, 112.14) ft
Left-Zone Right Coordinate: (291.25, 112.14) ft
Left-Zone Increment: 8
Right Type: Range
Right-Zone Left Coordinate: (373.75, 133.08) ft
Right-Zone Right Coordinate: (450, 132.45) ft
Right-Zone Increment: 8
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (200, 112.14) ft
Right Coordinate: (450, 132.45) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	200 ft	112.14 ft
Coordinate 2	450 ft	112.14 ft

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X	Y
	373.75 ft	134.08 ft
	395 ft	133.7 ft

Geometry

Name: 2D Geometry

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	281.25 ft	112.14 ft
Point 2	281.25 ft	107.14 ft
Point 3	291.25 ft	107.14 ft
Point 4	373.75 ft	127.906 ft
Point 5	383.75 ft	127.906 ft
Point 6	383.75 ft	132.90059 ft
Point 7	395 ft	132.7 ft
Point 8	400 ft	130.5 ft

Point 9	403.75 ft	132.45 ft
Point 10	450 ft	132.45 ft
Point 11	450 ft	128.3 ft
Point 12	383.75 ft	128.3 ft
Point 13	450 ft	122.3 ft
Point 14	351.47831 ft	122.30001 ft
Point 15	450 ft	118.3 ft
Point 16	335.58529 ft	118.29959 ft
Point 17	450 ft	114.3 ft
Point 18	319.69675 ft	114.3003 ft
Point 19	450 ft	112.3 ft
Point 20	311.75019 ft	112.30008 ft
Point 21	450 ft	87.3 ft
Point 22	200 ft	87.3 ft
Point 23	200 ft	112.14 ft
Point 24	450 ft	80.3 ft
Point 25	200 ft	80.3 ft
Point 26	373.75 ft	133.08 ft
Point 27	291.25 ft	112.14 ft

Regions

	Material	Points	Area
Region 1	(1)	6,7,8,9,10,11,12	270.97 ft²
Region 2	(2)	5,12,11,13,14,4	515.99 ft²
Region 3	(3)	14,13,15,16	425.89 ft²
Region 4	(4)	16,15,17,18	489.39 ft²
Region 5	(5)	18,17,19,20	268.57 ft²
Region 6	(6)	20,19,21,22,23,1,2,3	6,132.5 ft²
Region 7	(7)	22,21,24,25	1,750 ft²
Region 8	(8)	1,2,3,20,18,16,14,4,5,12,6,26,27	520.52 ft²

Slip Results

Slip Surfaces Analysed: 314 of 405 converged

Current Slip Surface

Slip Surface: 237
Factor of Safety: 2.83
Volume: 1,370.3163 ft³
Weight: 172,905.35 lbf
Resisting Moment: 15,476,987 lbf·ft
Activating Moment: 5,477,451 lbf·ft
Resisting Force: 96,366.542 lbf
Activating Force: 34,107.281 lbf
Slip Rank: 1 of 405 slip surfaces
Exit: (257.03125, 112.14) ft
Entry: (393.04509, 132.73486) ft
Radius: 153.55319 ft
Center: (304.48488, 258.17676) ft

Slip Slices

	X	Y	PWP	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	259.45313 ft	111.39697 ft	46.387288 psf	40.62162 psf	0 psf	0 psf	(6)
Slice 2	264.29688 ft	109.99711 ft	133.78122 psf	114.10946 psf	0 psf	0 psf	(6)
Slice 3	269.14063 ft	108.76735 ft	210.55526 psf	175.10255 psf	0 psf	0 psf	(6)
Slice 4	273.98438 ft	107.70352 ft	276.97008 psf	224.76554 psf	0 psf	0 psf	(6)
Slice 5	278.82813 ft	106.80213 ft	333.24435 psf	264.08709 psf	0 psf	0 psf	(6)
Slice 6	283.75 ft	106.05089 ft	380.1444 psf	314.66962 psf	0 psf	0 psf	(6)
Slice 7	288.75 ft	105.45257 ft	417.49776 psf	335.7996 psf	0 psf	0 psf	(6)
Slice 8	293.73303 ft	105.02068 ft	444.46033 psf	408.07465 psf	0 psf	0 psf	(6)
Slice 9	298.69908 ft	104.75273 ft	461.18856 psf	529.36103 psf	0 psf	0 psf	(6)
Slice 10	303.66514 ft	104.64584 ft	467.86206 psf	639.7031 psf	0 psf	0 psf	(6)
Slice 11	308.63119 ft	104.69966 ft	464.50185 psf	739.72683 psf	0 psf	0 psf	(6)

Slice 12	311.4322 ft	104.78114 ft	459.41487 psf	792.6488 psf	0 psf	0 psf	(6)
Slice 13	313.73683 ft	104.91547 ft	451.02865 psf	838.66851 psf	0 psf	0 psf	(6)
Slice 14	317.71011 ft	105.20716 ft	432.81864 psf	915.70804 psf	0 psf	0 psf	(6)
Slice 15	321.68282 ft	105.60278 ft	408.11969 psf	986.95819 psf	0 psf	0 psf	(6)
Slice 16	325.65495 ft	106.10313 ft	376.88298 psf	1,052.6157 psf	0 psf	0 psf	(6)
Slice 17	329.62709 ft	106.70928 ft	339.04104 psf	1,112.6539 psf	0 psf	0 psf	(6)
Slice 18	333.59922 ft	107.4225 ft	294.51412 psf	1,167.2374 psf	0 psf	0 psf	(6)
Slice 19	337.57192 ft	108.24447 ft	243.19856 psf	1,212.4722 psf	0 psf	0 psf	(6)
Slice 20	341.54517 ft	109.17701 ft	184.9801 psf	1,248.6345 psf	0 psf	0 psf	(6)
Slice 21	345.51843 ft	110.22211 ft	119.73449 psf	1,279.9338 psf	0 psf	0 psf	(6)
Slice 22	349.49168 ft	111.38217 ft	47.311536 psf	1,306.4793 psf	0 psf	0 psf	(6)
Slice 23	351.70841 ft	112.06563 ft	4.6428301 psf	1,320.2711 psf	0 psf	0 psf	(6)
Slice 24	352.18339 ft	112.22003 ft	-4.9961775 psf	1,320.2735 psf	0 psf	0 psf	(6)
Slice 25	355.28064 ft	113.30013 ft	-72.427383 psf	1,151.0421 psf	0 psf	0 psf	(5)
Slice 26	360.55801 ft	115.25161 ft	-194.25813 psf	0 psf	1,000 psf	0 psf	(4)
Slice 27	365.40804 ft	117.25135 ft	-319.10271 psf	0 psf	1,000 psf	0 psf	(4)
Slice 28	370.79153 ft	119.71648 ft	-473.00079 psf	917.77059 psf	0 psf	0 psf	(3)
Slice 29	374.88086 ft	121.71663 ft	-597.8706 psf	961.1875 psf	0 psf	0 psf	(3)
Slice 30	377.9463 ft	123.3541 ft	-700.09865 psf	742.10246 psf	0 psf	0 psf	(2)

Slice 31	381.81543 ft	125.53607 ft	-836.31914 psf	583.45929 psf	0 psf	0 psf	(2)
Slice 32	385.07659 ft	127.48197 ft	-957.80201 psf	425.94201 psf	0 psf	0 psf	(2)
Slice 33	389.72414 ft	130.51743 ft	-1,147.3063 psf	236.83243 psf	0 psf	0 psf	(1)

REPORT F-4
WITH REFERENCE TO SLOPE STABILITY ANALYSIS RESULT PRESENTED IN PLATE E-4
CONDITIONS: LOCAL SLIDE - SHORT TERM - WATER AT THE BOTTOM OF THE SLOPE
SECTION: A-A WITH SLOPE ABOUT 3.9H:1V
SOIL PROFILE: BORING NO. 4

SLOPE/W Analysis

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File Information

File Version: 11.00
Revision Number: 24
Date: 03/02/2022
Time: 02:49:01 PM
Tool Version: 11.0.1.21429
File Name: 4. L-ST - BOT - AA - B4 - Clay Liner.gsz
Directory: H:\2021\450-499\21-S-477 Ravensway Drainage Improvements-HCED\Calculation\Slope Stability\Report 3 on 2-2022\Local Stability\
Last Solved Date: 03/02/2022
Last Solved Time: 02:49:03 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

SLOPE/W Analysis

Kind: SLOPE/W
Method: Spencer
Settings
- PWP Conditions from: Piezometric Line
  - Apply Phreatic Correction: No
  - Use Staged Rapid Drawdown: No
- Unit Weight of Water: 62.430189 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 ft
  - Number of Slices: 30
- Factor of Safety Convergence Settings

Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

(1)

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 29.5 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(2)

Model: Mohr-Coulomb
Unit Weight: 137.2 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(3)

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 33 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(4)

Model: Undrained (Phi=0)
Unit Weight: 136.7 pcf
Cohesion: 1,000 psf
Pore Water Pressure
Piezometric Line: 1

(5)

Model: Mohr-Coulomb

Unit Weight: 136.1 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 33 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(6)

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 36 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(7)

Model: Undrained (Phi=0)
Unit Weight: 128.9 pcf
Cohesion: 2,000 psf
Pore Water Pressure
Piezometric Line: 1

(8)

Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 1,000 psf
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (291.25, 112.14) ft
Left-Zone Right Coordinate: (332, 122.48309) ft
Left-Zone Increment: 8
Right Type: Range
Right-Zone Left Coordinate: (332, 122.48309) ft
Right-Zone Right Coordinate: (373.75, 133.08) ft
Right-Zone Increment: 8
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (200, 112.14) ft
Right Coordinate: (450, 132.45) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	200 ft	112.14 ft
Coordinate 2	450 ft	112.14 ft

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X	Y
	373.75 ft	134.08 ft
	395 ft	133.7 ft

Geometry

Name: 2D Geometry

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	281.25 ft	112.14 ft
Point 2	281.25 ft	107.14 ft
Point 3	291.25 ft	107.14 ft
Point 4	373.75 ft	127.906 ft
Point 5	383.75 ft	127.906 ft
Point 6	383.75 ft	132.90059 ft
Point 7	395 ft	132.7 ft
Point 8	400 ft	130.5 ft

Point 9	403.75 ft	132.45 ft
Point 10	450 ft	132.45 ft
Point 11	450 ft	128.3 ft
Point 12	383.75 ft	128.3 ft
Point 13	450 ft	122.3 ft
Point 14	351.47831 ft	122.30001 ft
Point 15	450 ft	118.3 ft
Point 16	335.58529 ft	118.29959 ft
Point 17	450 ft	114.3 ft
Point 18	319.69675 ft	114.3003 ft
Point 19	450 ft	112.3 ft
Point 20	311.75019 ft	112.30008 ft
Point 21	450 ft	87.3 ft
Point 22	200 ft	87.3 ft
Point 23	200 ft	112.14 ft
Point 24	450 ft	80.3 ft
Point 25	200 ft	80.3 ft
Point 26	373.75 ft	133.08 ft
Point 27	291.25 ft	112.14 ft

Regions

	Material	Points	Area
Region 1	(1)	6,7,8,9,10,11,12	270.97 ft²
Region 2	(2)	5,12,11,13,14,4	515.99 ft²
Region 3	(3)	14,13,15,16	425.89 ft²
Region 4	(4)	16,15,17,18	489.39 ft²
Region 5	(5)	18,17,19,20	268.57 ft²
Region 6	(6)	20,19,21,22,23,1,2,3	6,132.5 ft²
Region 7	(7)	22,21,24,25	1,750 ft²
Region 8	(8)	1,2,3,20,18,16,14,4,5,12,6,26,27	520.52 ft²

Slip Results

Slip Surfaces Analysed: 320 of 405 converged

Current Slip Surface

Slip Surface: 43
Factor of Safety: 3.43
Volume: 966.02873 ft³
Weight: 121,960.7 lbf
Resisting Moment: 5,580,761.2 lbf·ft
Activating Moment: 1,628,990.4 lbf·ft
Resisting Force: 79,268.473 lbf
Activating Force: 23,137.733 lbf
Slip Rank: 1 of 405 slip surfaces
Exit: (291.25, 112.14) ft
Entry: (373.75, 133.08) ft
Radius: 62.985841 ft
Center: (321.07666, 167.616) ft

Slip Slices

	X	Y	PWP	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	292.41928 ft	111.54242 ft	37.307046 psf	0 psf	1,000 psf	0 psf	(8)
Slice 2	294.75784 ft	110.40692 ft	108.19668 psf	0 psf	1,000 psf	0 psf	(8)
Slice 3	297.09639 ft	109.38745 ft	171.84215 psf	0 psf	1,000 psf	0 psf	(8)
Slice 4	299.55053 ft	108.43853 ft	231.08322 psf	438.58074 psf	0 psf	0 psf	(6)
Slice 5	302.12024 ft	107.56556 ft	285.58287 psf	539.9306 psf	0 psf	0 psf	(6)
Slice 6	304.68994 ft	106.81369 ft	332.52258 psf	631.02506 psf	0 psf	0 psf	(6)
Slice 7	307.25965 ft	106.17845 ft	372.1805 psf	712.927 psf	0 psf	0 psf	(6)
Slice 8	309.82936 ft	105.65626 ft	404.78103 psf	786.49036 psf	0 psf	0 psf	(6)
Slice 9	311.4322 ft	105.37375 ft	422.41796 psf	829.05339 psf	0 psf	0 psf	(6)
Slice 10	313.07462 ft	105.15481 ft	436.08689 psf	872.73909 psf	0 psf	0 psf	(6)
Slice 11	315.72347 ft	104.87213 ft	453.73421 psf	939.71253 psf	0 psf	0 psf	(6)

Slice 12	318.37232 ft	104.70221 ft	464.34283 psf	999.52389 psf	0 psf	0 psf	(6)
Slice 13	321.0208 ft	104.6441 ft	467.97032 psf	1,052.731 psf	0 psf	0 psf	(6)
Slice 14	323.66888 ft	104.69748 ft	464.63807 psf	1,099.6687 psf	0 psf	0 psf	(6)
Slice 15	326.31698 ft	104.86259 ft	454.3298 psf	1,140.4704 psf	0 psf	0 psf	(6)
Slice 16	328.96506 ft	105.14034 ft	436.99012 psf	1,175.3604 psf	0 psf	0 psf	(6)
Slice 17	331.61316 ft	105.53223 ft	412.52448 psf	1,204.5166 psf	0 psf	0 psf	(6)
Slice 18	334.26124 ft	106.04044 ft	380.79657 psf	1,228.0756 psf	0 psf	0 psf	(6)
Slice 19	336.86179 ft	106.65448 ft	342.46209 psf	1,243.3317 psf	0 psf	0 psf	(6)
Slice 20	339.4148 ft	107.37359 ft	297.5681 psf	1,250.6697 psf	0 psf	0 psf	(6)
Slice 21	341.9678 ft	108.21107 ft	245.28364 psf	1,253.1458 psf	0 psf	0 psf	(6)
Slice 22	344.52081 ft	109.17204 ft	185.2903 psf	1,250.7646 psf	0 psf	0 psf	(6)
Slice 23	347.07381 ft	110.26271 ft	117.19963 psf	1,243.5047 psf	0 psf	0 psf	(6)
Slice 24	349.62682 ft	111.49066 ft	40.538322 psf	1,231.3184 psf	0 psf	0 psf	(6)
Slice 25	351.05122 ft	112.22003 ft	-4.9961997 psf	1,219.6615 psf	0 psf	0 psf	(6)
Slice 26	351.33871 ft	112.37653 ft	-14.766753 psf	1,090.1166 psf	0 psf	0 psf	(5)
Slice 27	353.04534 ft	113.37661 ft	-77.202013 psf	1,034.1639 psf	0 psf	0 psf	(5)
Slice 28	356.02358 ft	115.24186 ft	-193.64968 psf	0 psf	1,000 psf	0 psf	(4)
Slice 29	358.84601 ft	117.24159 ft	-318.49316 psf	0 psf	1,000 psf	0 psf	(4)
Slice 30	361.39848 ft	119.25115 ft	-443.95019 psf	706.53168 psf	0 psf	0 psf	(3)

Slice 31	363.681 ft	121.25131 ft	-568.82087 psf	604.33468 psf	0 psf	0 psf	(3)
Slice 32	365.85772 ft	123.34746 ft	-699.68375 psf	443.18114 psf	0 psf	0 psf	(2)
Slice 33	367.92864 ft	125.54813 ft	-837.07189 psf	332.64874 psf	0 psf	0 psf	(2)
Slice 34	370.16058 ft	128.19095 ft	-1,002.0637 psf	0 psf	1,000 psf	0 psf	(8)
Slice 35	372.55353 ft	131.38028 ft	-1,201.174 psf	0 psf	1,000 psf	0 psf	(8)

REPORT F-5
WITH REFERENCE TO SLOPE STABILITY ANALYSIS RESULT PRESENTED IN PLATE E-5
CONDITIONS: GLOBAL SLIDE - LONG TERM
SECTION: A-A WITH SLOPE ABOUT 3.9H:1V
SOIL PROFILE: BORING NO. 4

SLOPE/W Analysis

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File Information

File Version: 11.00
Revision Number: 25
Date: 03/02/2022
Time: 02:32:15 PM
Tool Version: 11.0.1.21429
File Name: 5. G-LT - 24H - AA - B4 - Clay Liner.gsz
Directory: H:\2021\450-499\21-S-477 Ravensway Drainage Improvements-HCED\Calculation\Slope Stability\Report 3 on 2-2022\Global Stability\
Last Solved Date: 03/02/2022
Last Solved Time: 02:32:18 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

SLOPE/W Analysis

Kind: SLOPE/W
Method: Spencer
Settings
- PWP Conditions from: Piezometric Line
  - Apply Phreatic Correction: No
  - Use Staged Rapid Drawdown: No
- Unit Weight of Water: 62.430189 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 ft
  - Number of Slices: 30
- Factor of Safety Convergence Settings

Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

(1)

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 29.5 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(2)

Model: Mohr-Coulomb
Unit Weight: 137.2 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(3)

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 33 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(4)

Model: Mohr-Coulomb
Unit Weight: 136.7 pcf
Effective Cohesion: 330 psf
Effective Friction Angle: 25 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(5)

Model: Mohr-Coulomb
Unit Weight: 136.1 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 33 °
Phi-B: 0 °
Pore Water Pressure
    Piezometric Line: 1

(6)

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 36 °
Phi-B: 0 °
Pore Water Pressure
    Piezometric Line: 1

(7)

Model: Mohr-Coulomb
Unit Weight: 128.9 pcf
Effective Cohesion: 230 psf
Effective Friction Angle: 19 °
Phi-B: 0 °
Pore Water Pressure
    Piezometric Line: 1

(8)

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effective Cohesion: 270 psf
Effective Friction Angle: 24 °
Phi-B: 0 °
Pore Water Pressure
    Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (200, 112.14) ft
Left-Zone Right Coordinate: (291.25, 112.14) ft
Left-Zone Increment: 8
Right Type: Range
Right-Zone Left Coordinate: (373.75, 133.08) ft
Right-Zone Right Coordinate: (450, 132.45) ft
Right-Zone Increment: 8
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (200, 112.14) ft
Right Coordinate: (450, 132.45) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	200 ft	112.14 ft
Coordinate 2	291.25 ft	112.14 ft
Coordinate 3	295.43 ft	113.2 ft
Coordinate 4	450 ft	113.2 ft

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X	Y
	373.75 ft	134.08 ft
	395 ft	133.7 ft

Geometry

Name: 2D Geometry

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	281.25 ft	112.14 ft
Point 2	281.25 ft	107.14 ft

Point 3	291.25 ft	107.14 ft
Point 4	373.75 ft	127.906 ft
Point 5	383.75 ft	127.906 ft
Point 6	383.75 ft	132.90059 ft
Point 7	395 ft	132.7 ft
Point 8	400 ft	130.5 ft
Point 9	403.75 ft	132.45 ft
Point 10	450 ft	132.45 ft
Point 11	450 ft	128.3 ft
Point 12	383.75 ft	128.3 ft
Point 13	450 ft	122.3 ft
Point 14	351.47831 ft	122.30001 ft
Point 15	450 ft	118.3 ft
Point 16	335.58529 ft	118.29959 ft
Point 17	450 ft	114.3 ft
Point 18	319.69675 ft	114.3003 ft
Point 19	450 ft	112.3 ft
Point 20	311.75019 ft	112.30008 ft
Point 21	450 ft	87.3 ft
Point 22	200 ft	87.3 ft
Point 23	200 ft	112.14 ft
Point 24	450 ft	80.3 ft
Point 25	200 ft	80.3 ft
Point 26	373.75 ft	133.08 ft
Point 27	291.25 ft	112.14 ft

Regions

	Material	Points	Area
Region 1	(1)	6,7,8,9,10,11,12	270.97 ft^2
Region 2	(2)	5,12,11,13,14,4	515.99 ft^2
Region 3	(3)	14,13,15,16	425.89 ft^2
Region 4	(4)	16,15,17,18	489.39 ft^2
Region 5	(5)	18,17,19,20	268.57 ft^2
Region 6	(6)	20,19,21,22,23,1,2,3	6,132.5 ft^2
Region 7	(7)	22,21,24,25	1,750 ft^2
Region 8	(8)	1,2,3,20,18,16,14,4,5,12,6,26,27	520.52 ft^2

Slip Results

Slip Surfaces Analysed: 313 of 405 converged

Current Slip Surface

Slip Surface: 239
Factor of Safety: 2.72
Volume: 4,062.6368 ft³
Weight: 502,741.3 lbf
Resisting Moment: 15,442,768 lbf·ft
Activating Moment: 5,673,464.6 lbf·ft
Resisting Force: 167,284.51 lbf
Activating Force: 61,457.669 lbf
Slip Rank: 1 of 405 slip surfaces
Exit: (257.03125, 112.14) ft
Entry: (393.04509, 132.73486) ft
Radius: 76.601619 ft
Center: (319.99038, 155.77434) ft

Slip Slices

	X	Y	PWP	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	259.45312 ft	109.00516 ft	195.70836 psf	306.21221 psf	0 psf	0 psf	(6)
Slice 2	264.29687 ft	103.29988 ft	551.89008 psf	717.15079 psf	0 psf	0 psf	(6)
Slice 3	269.14062 ft	98.576361 ft	846.78056 psf	973.25789 psf	0 psf	0 psf	(6)
Slice 4	273.98437 ft	94.601862 ft	1,094.9093 psf	1,149.5319 psf	0 psf	0 psf	(6)
Slice 5	278.82812 ft	91.235786 ft	1,305.054 psf	1,275.5841 psf	0 psf	0 psf	(6)
Slice 6	283.45138 ft	88.495565 ft	1,476.1265 psf	1,386.6679 psf	0 psf	0 psf	(6)
Slice 7	288.45138 ft	86.03436 ft	1,629.7801 psf	649.19577 psf	230 psf	0 psf	(7)
Slice 8	293.34 ft	83.992764 ft	1,790.3253 psf	693.75748 psf	230 psf	0 psf	(7)
Slice 9	297.3412 ft	82.625045 ft	1,908.8002 psf	745.71922 psf	230 psf	0 psf	(7)

Slice 10	301.16359 ft	81.548522 ft	1,976.0078 psf	799.83249 psf	230 psf	0 psf	(7)
Slice 11	304.98599 ft	80.681881 ft	2,030.1123 psf	847.6493 psf	230 psf	0 psf	(7)
Slice 12	309.32369 ft	80.3 ft	2,053.9532 psf	842.2453 psf	230 psf	0 psf	(7)
Slice 13	313.53781 ft	80.3 ft	2,053.9532 psf	889.5777 psf	230 psf	0 psf	(7)
Slice 14	317.51109 ft	80.3 ft	2,053.9532 psf	937.44025 psf	230 psf	0 psf	(7)
Slice 15	321.92789 ft	80.3 ft	2,053.9532 psf	990.76305 psf	230 psf	0 psf	(7)
Slice 16	326.39016 ft	80.3 ft	2,053.9532 psf	1,044.7513 psf	230 psf	0 psf	(7)
Slice 17	330.85244 ft	80.3 ft	2,053.9532 psf	1,098.7395 psf	230 psf	0 psf	(7)
Slice 18	334.33443 ft	80.538482 ft	2,039.0648 psf	1,067.8268 psf	230 psf	0 psf	(7)
Slice 19	337.57192 ft	81.245614 ft	1,994.9183 psf	1,072.6452 psf	230 psf	0 psf	(7)
Slice 20	341.54517 ft	82.297048 ft	1,929.2771 psf	1,072.6349 psf	230 psf	0 psf	(7)
Slice 21	345.51843 ft	83.582329 ft	1,849.0368 psf	1,067.1392 psf	230 psf	0 psf	(7)
Slice 22	349.49168 ft	85.114264 ft	1,753.3978 psf	1,055.9732 psf	230 psf	0 psf	(7)
Slice 23	352.90316 ft	86.621851 ft	1,659.2789 psf	1,043.417 psf	230 psf	0 psf	(7)
Slice 24	356.75576 ft	88.629318 ft	1,533.9523 psf	2,077.986 psf	0 psf	0 psf	(6)
Slice 25	361.61125 ft	91.531497 ft	1,352.7687 psf	2,012.9544 psf	0 psf	0 psf	(6)
Slice 26	366.46675 ft	94.959717 ft	1,138.7443 psf	1,927.599 psf	0 psf	0 psf	(6)
Slice 27	371.32225 ft	99.010504 ft	885.85292 psf	1,819.2318 psf	0 psf	0 psf	(6)
Slice 28	376.07753 ft	103.71347 ft	592.24586 psf	1,774.0172 psf	0 psf	0 psf	(6)

Slice 29	380.7326 ft	109.26052 ft	245.94225 psf	1,522.7771 psf	0 psf	0 psf	(6)
Slice 30	383.36561 ft	112.75002 ft	28.092376 psf	1,258.6535 psf	0 psf	0 psf	(5)
Slice 31	383.71055 ft	113.25913 ft	-3.691438 psf	1,234.7744 psf	0 psf	0 psf	(5)
Slice 32	384.07151 ft	113.8092 ft	-38.032757 psf	1,176.1874 psf	0 psf	0 psf	(5)
Slice 33	385.59628 ft	116.29996 ft	-193.53123 psf	706.57551 psf	330 psf	0 psf	(4)
Slice 34	387.84521 ft	120.29989 ft	-443.24746 psf	733.91118 psf	0 psf	0 psf	(3)
Slice 35	390.19314 ft	125.3 ft	-755.40548 psf	398.11962 psf	0 psf	0 psf	(2)
Slice 36	392.27025 ft	130.51743 ft	-1,081.1303 psf	153.05745 psf	0 psf	0 psf	(1)

REPORT F-6
WITH REFERENCE TO SLOPE STABILITY ANALYSIS RESULT PRESENTED IN PLATE E-6
CONDITIONS: LOCAL SLIDE - LONG TERM
SECTION: A-A WITH SLOPE ABOUT 3.9H:1V
SOIL PROFILE: BORING NO. 4

SLOPE/W Analysis

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File Information

File Version: 11.00
Revision Number: 29
Date: 03/02/2022
Time: 02:50:22 PM
Tool Version: 11.0.1.21429
File Name: 6. L-LT - 24H - AA - B4 - Clay Liner.gsz
Directory: H:\2021\450-499\21-S-477 Ravensway Drainage Improvements-HCED\Calculation\Slope Stability\Report 3 on 2-2022\Local Stability\
Last Solved Date: 03/02/2022
Last Solved Time: 02:50:25 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

SLOPE/W Analysis

Kind: SLOPE/W
Method: Spencer
Settings
- PWP Conditions from: Piezometric Line
  - Apply Phreatic Correction: No
  - Use Staged Rapid Drawdown: No
- Unit Weight of Water: 62.430189 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 ft
  - Number of Slices: 30
- Factor of Safety Convergence Settings

Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

(1)

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 29.5 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(2)

Model: Mohr-Coulomb
Unit Weight: 137.2 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(3)

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 33 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(4)

Model: Mohr-Coulomb
Unit Weight: 136.7 pcf
Effective Cohesion: 330 psf
Effective Friction Angle: 25 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(5)

Model: Mohr-Coulomb
Unit Weight: 136.1 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 33 °
Phi-B: 0 °
Pore Water Pressure
    Piezometric Line: 1

(6)

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 36 °
Phi-B: 0 °
Pore Water Pressure
    Piezometric Line: 1

(7)

Model: Mohr-Coulomb
Unit Weight: 128.9 pcf
Effective Cohesion: 230 psf
Effective Friction Angle: 19 °
Phi-B: 0 °
Pore Water Pressure
    Piezometric Line: 1

(8)

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effective Cohesion: 270 psf
Effective Friction Angle: 24 °
Phi-B: 0 °
Pore Water Pressure
    Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (291.25, 112.14) ft
Left-Zone Right Coordinate: (332, 122.48309) ft
Left-Zone Increment: 8
Right Type: Range
Right-Zone Left Coordinate: (332, 122.48309) ft
Right-Zone Right Coordinate: (373.75, 133.08) ft
Right-Zone Increment: 8
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (200, 112.14) ft
Right Coordinate: (450, 132.45) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	200 ft	112.14 ft
Coordinate 2	291.25 ft	112.14 ft
Coordinate 3	295.43 ft	113.2 ft
Coordinate 4	450 ft	113.2 ft

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X	Y
	373.75 ft	134.08 ft
	395 ft	133.7 ft

Geometry

Name: 2D Geometry

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	281.25 ft	112.14 ft
Point 2	281.25 ft	107.14 ft

Point 3	291.25 ft	107.14 ft
Point 4	373.75 ft	127.906 ft
Point 5	383.75 ft	127.906 ft
Point 6	383.75 ft	132.90059 ft
Point 7	395 ft	132.7 ft
Point 8	400 ft	130.5 ft
Point 9	403.75 ft	132.45 ft
Point 10	450 ft	132.45 ft
Point 11	450 ft	128.3 ft
Point 12	383.75 ft	128.3 ft
Point 13	450 ft	122.3 ft
Point 14	351.47831 ft	122.30001 ft
Point 15	450 ft	118.3 ft
Point 16	335.58529 ft	118.29959 ft
Point 17	450 ft	114.3 ft
Point 18	319.69675 ft	114.3003 ft
Point 19	450 ft	112.3 ft
Point 20	311.75019 ft	112.30008 ft
Point 21	450 ft	87.3 ft
Point 22	200 ft	87.3 ft
Point 23	200 ft	112.14 ft
Point 24	450 ft	80.3 ft
Point 25	200 ft	80.3 ft
Point 26	373.75 ft	133.08 ft
Point 27	291.25 ft	112.14 ft

Regions

	Material	Points	Area
Region 1	(1)	6,7,8,9,10,11,12	270.97 ft^2
Region 2	(2)	5,12,11,13,14,4	515.99 ft^2
Region 3	(3)	14,13,15,16	425.89 ft^2
Region 4	(4)	16,15,17,18	489.39 ft^2
Region 5	(5)	18,17,19,20	268.57 ft^2
Region 6	(6)	20,19,21,22,23,1,2,3	6,132.5 ft^2
Region 7	(7)	22,21,24,25	1,750 ft^2
Region 8	(8)	1,2,3,20,18,16,14,4,5,12,6,26,27	520.52 ft^2

Slip Results

Slip Surfaces Analysed: 386 of 405 converged

Current Slip Surface

Slip Surface: 43
Factor of Safety: 2.92
Volume: 966.02752 ft³
Weight: 121,961.29 lbf
Resisting Moment: 4,761,369.8 lbf·ft
Activating Moment: 1,629,017.3 lbf·ft
Resisting Force: 69,091.083 lbf
Activating Force: 23,637.367 lbf
Slip Rank: 1 of 405 slip surfaces
Exit: (291.25, 112.14) ft
Entry: (373.75, 133.08) ft
Radius: 62.985841 ft
Center: (321.07666, 167.616) ft

Slip Slices

	X	Y	PWP	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	292.295 ft	111.60304 ft	50.06664 psf	68.979778 psf	270 psf	0 psf	(8)
Slice 2	294.385 ft	110.57706 ft	147.20646 psf	124.17355 psf	270 psf	0 psf	(8)
Slice 3	296.84784 ft	109.49698 ft	231.18033 psf	192.00441 psf	270 psf	0 psf	(8)
Slice 4	299.61412 ft	108.41703 ft	298.60191 psf	416.42807 psf	0 psf	0 psf	(6)
Slice 5	302.31103 ft	107.50717 ft	355.40457 psf	526.1621 psf	0 psf	0 psf	(6)
Slice 6	305.00793 ft	106.73031 ft	403.90392 psf	622.62721 psf	0 psf	0 psf	(6)
Slice 7	307.70483 ft	106.08141 ft	444.41518 psf	707.50164 psf	0 psf	0 psf	(6)
Slice 8	310.40174 ft	105.55643 ft	477.18945 psf	782.10104 psf	0 psf	0 psf	(6)
Slice 9	313.53781 ft	105.10888 ft	505.13004 psf	862.66099 psf	0 psf	0 psf	(6)

Slice 10	316.41826 ft	104.81222 ft	523.65061 psf	931.73764 psf	0 psf	0 psf	(6)
Slice 11	318.60392 ft	104.68822 ft	531.39208 psf	977.51133 psf	0 psf	0 psf	(6)
Slice 12	321.0208 ft	104.6441 ft	534.14632 psf	1,022.4016 psf	0 psf	0 psf	(6)
Slice 13	323.66888 ft	104.69748 ft	530.81407 psf	1,065.4763 psf	0 psf	0 psf	(6)
Slice 14	326.31698 ft	104.86259 ft	520.5058 psf	1,102.1544 psf	0 psf	0 psf	(6)
Slice 15	328.96506 ft	105.14034 ft	503.16612 psf	1,132.751 psf	0 psf	0 psf	(6)
Slice 16	331.61316 ft	105.53223 ft	478.70048 psf	1,157.5254 psf	0 psf	0 psf	(6)
Slice 17	334.26124 ft	106.04044 ft	446.97257 psf	1,176.6889 psf	0 psf	0 psf	(6)
Slice 18	336.88644 ft	106.66143 ft	408.20436 psf	1,187.7265 psf	0 psf	0 psf	(6)
Slice 19	339.48875 ft	107.39673 ft	362.29893 psf	1,191.0162 psf	0 psf	0 psf	(6)
Slice 20	342.09105 ft	108.25519 ft	308.70568 psf	1,189.4762 psf	0 psf	0 psf	(6)
Slice 21	344.69336 ft	109.24223 ft	247.08464 psf	1,183.1763 psf	0 psf	0 psf	(6)
Slice 22	347.29566 ft	110.36452 ft	177.01955 psf	1,172.1629 psf	0 psf	0 psf	(6)
Slice 23	349.89797 ft	111.63023 ft	98.001175 psf	1,156.4613 psf	0 psf	0 psf	(6)
Slice 24	351.33871 ft	112.37653 ft	51.409247 psf	1,031.8834 psf	0 psf	0 psf	(5)
Slice 25	352.13714 ft	112.8265 ft	23.317446 psf	1,023.3823 psf	0 psf	0 psf	(5)
Slice 26	353.70417 ft	113.75011 ft	-34.343459 psf	985.24511 psf	0 psf	0 psf	(5)
Slice 27	356.02358 ft	115.24186 ft	-127.47368 psf	641.57849 psf	330 psf	0 psf	(4)
Slice 28	358.84601 ft	117.24159 ft	-252.31716 psf	556.68954 psf	330 psf	0 psf	(4)

Slice 29	361.39848 ft	119.25115 ft	-377.77419 psf	677.79079 psf	0 psf	0 psf	(3)
Slice 30	363.681 ft	121.25131 ft	-502.64487 psf	577.22003 psf	0 psf	0 psf	(3)
Slice 31	365.85772 ft	123.34746 ft	-633.50775 psf	421.67077 psf	0 psf	0 psf	(2)
Slice 32	367.92864 ft	125.54813 ft	-770.89589 psf	315.04271 psf	0 psf	0 psf	(2)
Slice 33	370.16058 ft	128.19095 ft	-935.8877 psf	126.41923 psf	270 psf	0 psf	(8)
Slice 34	372.55353 ft	131.38028 ft	-1,134.998 psf	18.743262 psf	270 psf	0 psf	(8)

REPORT F-7
WITH REFERENCE TO SLOPE STABILITY ANALYSIS RESULT PRESENTED IN PLATE E-7
CONDITIONS: GLOBAL SLIDE - RAPID DRAWDOWN WITH EFFECTIVE SOIL PARAMETERS
SECTION: A-A WITH SLOPE ABOUT 3.9H:1V
SOIL PROFILE: BORING NO. 4

SLOPE/W Analysis

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File Information

File Version: 11.00
Revision Number: 28
Date: 03/02/2022
Time: 02:33:46 PM
Tool Version: 11.0.1.21429
File Name: 7. G-RD - EF - AA - B4 - Clay Liner.gsz
Directory: H:\2021\450-499\21-S-477 Ravensway Drainage Improvements-HCED\Calculation\Slope Stability\Report 3 on 2-2022\Global Stability\
Last Solved Date: 03/02/2022
Last Solved Time: 02:33:48 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

SLOPE/W Analysis

Kind: SLOPE/W
Method: Spencer
Settings
- PWP Conditions from: Piezometric Line
  - Apply Phreatic Correction: No
  - Use Staged Rapid Drawdown: No
- Unit Weight of Water: 62.430189 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 ft
  - Number of Slices: 30
- Factor of Safety Convergence Settings

Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

(1)

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 29.5 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(2)

Model: Mohr-Coulomb
Unit Weight: 137.2 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(3)

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 33 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(4)

Model: Mohr-Coulomb
Unit Weight: 136.7 pcf
Effective Cohesion: 330 psf
Effective Friction Angle: 25 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(5)

Model: Mohr-Coulomb
Unit Weight: 136.1 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 33 °
Phi-B: 0 °
Pore Water Pressure
    Piezometric Line: 1

(6)

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 36 °
Phi-B: 0 °
Pore Water Pressure
    Piezometric Line: 1

(7)

Model: Mohr-Coulomb
Unit Weight: 128.9 pcf
Effective Cohesion: 230 psf
Effective Friction Angle: 19 °
Phi-B: 0 °
Pore Water Pressure
    Piezometric Line: 1

(8)

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effective Cohesion: 270 psf
Effective Friction Angle: 24 °
Phi-B: 0 °
Pore Water Pressure
    Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (200, 112.14) ft
Left-Zone Right Coordinate: (291.25, 112.14) ft
Left-Zone Increment: 8
Right Type: Range
Right-Zone Left Coordinate: (373.75, 133.08) ft
Right-Zone Right Coordinate: (450, 132.45) ft
Right-Zone Increment: 8
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (200, 112.14) ft
Right Coordinate: (450, 132.45) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	200 ft	112.14 ft
Coordinate 2	291.25 ft	112.14 ft
Coordinate 3	373.75 ft	133.08 ft
Coordinate 4	395 ft	132.7 ft
Coordinate 5	400 ft	130.5 ft
Coordinate 6	403.75 ft	132.45 ft
Coordinate 7	450 ft	132.45 ft

Geometry

Name: 2D Geometry

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	281.25 ft	112.14 ft
Point 2	281.25 ft	107.14 ft
Point 3	291.25 ft	107.14 ft
Point 4	373.75 ft	127.906 ft
Point 5	383.75 ft	127.906 ft
Point 6	383.75 ft	132.90059 ft
Point 7	395 ft	132.7 ft
Point 8	400 ft	130.5 ft
Point 9	403.75 ft	132.45 ft
Point 10	450 ft	132.45 ft

Point 11	450 ft	128.3 ft
Point 12	383.75 ft	128.3 ft
Point 13	450 ft	122.3 ft
Point 14	351.47831 ft	122.30001 ft
Point 15	450 ft	118.3 ft
Point 16	335.58529 ft	118.29959 ft
Point 17	450 ft	114.3 ft
Point 18	319.69675 ft	114.3003 ft
Point 19	450 ft	112.3 ft
Point 20	311.75019 ft	112.30008 ft
Point 21	450 ft	87.3 ft
Point 22	200 ft	87.3 ft
Point 23	200 ft	112.14 ft
Point 24	450 ft	80.3 ft
Point 25	200 ft	80.3 ft
Point 26	373.75 ft	133.08 ft
Point 27	291.25 ft	112.14 ft

Regions

	Material	Points	Area
Region 1	(1)	6,7,8,9,10,11,12	270.97 ft^2
Region 2	(2)	5,12,11,13,14,4	515.99 ft^2
Region 3	(3)	14,13,15,16	425.89 ft^2
Region 4	(4)	16,15,17,18	489.39 ft^2
Region 5	(5)	18,17,19,20	268.57 ft^2
Region 6	(6)	20,19,21,22,23,1,2,3	6,132.5 ft^2
Region 7	(7)	22,21,24,25	1,750 ft^2
Region 8	(8)	1,2,3,20,18,16,14,4,5,12,6,26,27	520.52 ft^2

Slip Results

Slip Surfaces Analysed: 269 of 405 converged

Current Slip Surface

Slip Surface: 367
Factor of Safety: 1.83
Volume: 767.67847 ft^3

Weight: 98,056.772 lbf
Resisting Moment: 4,503,435 lbf·ft
Activating Moment: 2,463,478.3 lbf·ft
Resisting Force: 38,236.831 lbf
Activating Force: 20,918.203 lbf
Slip Rank: 1 of 405 slip surfaces
Exit: (291.25, 112.14) ft
Entry: (383.39753, 132.90691) ft
Radius: 112.57105 ft
Center: (314.85835, 222.20765) ft

Slip Slices

	X	Y	PWP	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	292.77688 ft	111.83453 ft	43.265466 psf	53.037992 psf	270 psf	0 psf	(8)
Slice 2	295.83065 ft	111.26718 ft	127.07498 psf	94.03876 psf	270 psf	0 psf	(8)
Slice 3	298.88441 ft	110.7864 ft	205.47996 psf	130.70908 psf	270 psf	0 psf	(8)
Slice 4	301.93818 ft	110.39107 ft	278.55018 psf	163.32135 psf	270 psf	0 psf	(8)
Slice 5	304.84591 ft	110.09132 ft	343.33902 psf	290.19717 psf	0 psf	0 psf	(6)
Slice 6	307.60762 ft	109.87887 ft	400.36409 psf	327.84157 psf	0 psf	0 psf	(6)
Slice 7	310.36933 ft	109.73463 ft	453.13122 psf	360.65933 psf	0 psf	0 psf	(6)
Slice 8	313.07462 ft	109.65853 ft	500.75 psf	392.70072 psf	0 psf	0 psf	(6)
Slice 9	315.72347 ft	109.64771 ft	543.39843 psf	424.21773 psf	0 psf	0 psf	(6)
Slice 10	318.37232 ft	109.69926 ft	582.15396 psf	451.74631 psf	0 psf	0 psf	(6)
Slice 11	321.2856 ft	109.8315 ft	620.06186 psf	477.68244 psf	0 psf	0 psf	(6)
Slice 12	324.46331 ft	110.05845 ft	656.24705 psf	501.33555 psf	0 psf	0 psf	(6)
Slice 13	327.64102 ft	110.37614 ft	686.76746 psf	520.06741 psf	0 psf	0 psf	(6)

Slice 14	330.81873 ft	110.78534 ft	711.57462 psf	534.12351 psf	0 psf	0 psf	(6)
Slice 15	333.99644 ft	111.28707 ft	730.60524 psf	543.72509 psf	0 psf	0 psf	(6)
Slice 16	337.39314 ft	111.93063 ft	744.25108 psf	545.44575 psf	0 psf	0 psf	(6)
Slice 17	340.48823 ft	112.60107 ft	751.44048 psf	480.99963 psf	0 psf	0 psf	(5)
Slice 18	343.0627 ft	113.23523 ft	752.64432 psf	469.09195 psf	0 psf	0 psf	(5)
Slice 19	345.63717 ft	113.93432 ft	749.79513 psf	454.6071 psf	0 psf	0 psf	(5)
Slice 20	349.20136 ft	115.02984 ft	737.87904 psf	302.17594 psf	330 psf	0 psf	(4)
Slice 21	353.14972 ft	116.36412 ft	717.14539 psf	279.05589 psf	330 psf	0 psf	(4)
Slice 22	356.49253 ft	117.63423 ft	690.82194 psf	258.28162 psf	330 psf	0 psf	(4)
Slice 23	359.59167 ft	118.918 ft	659.78434 psf	350.52016 psf	0 psf	0 psf	(3)
Slice 24	362.44714 ft	120.20242 ft	624.8454 psf	330.13634 psf	0 psf	0 psf	(3)
Slice 25	365.30262 ft	121.58426 ft	583.82473 psf	307.38196 psf	0 psf	0 psf	(3)
Slice 26	368.48526 ft	123.25104 ft	530.19948 psf	245.43653 psf	0 psf	0 psf	(2)
Slice 27	371.99509 ft	125.23608 ft	461.88932 psf	203.86978 psf	0 psf	0 psf	(2)
Slice 28	375.04275 ft	127.08805 ft	372.63559 psf	154.6776 psf	0 psf	0 psf	(2)
Slice 29	378.10101 ft	129.10528 ft	243.28531 psf	49.961659 psf	270 psf	0 psf	(8)
Slice 30	381.63203 ft	131.60573 ft	83.239298 psf	-3.002513 psf	270 psf	0 psf	(8)

REPORT F-8
WITH REFERENCE TO SLOPE STABILITY ANALYSIS RESULT PRESENTED IN PLATE E-8
CONDITIONS: LOCAL SLIDE - RAPID DRAWDOWN WITH EFFECTIVE SOIL PARAMETERS
SECTION: A-A WITH SLOPE ABOUT 3.9H:1V
SOIL PROFILE: BORING NO. 4

SLOPE/W Analysis

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File Information

File Version: 11.00
Revision Number: 30
Date: 03/02/2022
Time: 02:51:35 PM
Tool Version: 11.0.1.21429
File Name: 8. L-RD - EF - AA - B4 - Clay Liner.gsz
Directory: H:\2021\450-499\21-S-477 Ravensway Drainage Improvements-HCED\Calculation\Slope Stability\Report 3 on 2-2022\Local Stability\
Last Solved Date: 03/02/2022
Last Solved Time: 02:51:38 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

SLOPE/W Analysis

Kind: SLOPE/W
Method: Spencer
Settings
- PWP Conditions from: Piezometric Line
  - Apply Phreatic Correction: No
  - Use Staged Rapid Drawdown: No
- Unit Weight of Water: 62.430189 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 ft
  - Number of Slices: 30
- Factor of Safety Convergence Settings

Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

(1)

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 29.5 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(2)

Model: Mohr-Coulomb
Unit Weight: 137.2 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(3)

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 33 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(4)

Model: Mohr-Coulomb
Unit Weight: 136.7 pcf
Effective Cohesion: 330 psf
Effective Friction Angle: 25 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(5)

Model: Mohr-Coulomb
Unit Weight: 136.1 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 33 °
Phi-B: 0 °
Pore Water Pressure
    Piezometric Line: 1

(6)

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 36 °
Phi-B: 0 °
Pore Water Pressure
    Piezometric Line: 1

(7)

Model: Mohr-Coulomb
Unit Weight: 128.9 pcf
Effective Cohesion: 230 psf
Effective Friction Angle: 19 °
Phi-B: 0 °
Pore Water Pressure
    Piezometric Line: 1

(8)

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effective Cohesion: 270 psf
Effective Friction Angle: 24 °
Phi-B: 0 °
Pore Water Pressure
    Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (291.25, 112.14) ft
Left-Zone Right Coordinate: (332, 122.48309) ft
Left-Zone Increment: 8
Right Type: Range
Right-Zone Left Coordinate: (332, 122.48309) ft
Right-Zone Right Coordinate: (373.75, 133.08) ft
Right-Zone Increment: 8
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (200, 112.14) ft
Right Coordinate: (450, 132.45) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	200 ft	112.14 ft
Coordinate 2	291.25 ft	112.14 ft
Coordinate 3	373.75 ft	133.08 ft
Coordinate 4	395 ft	132.7 ft
Coordinate 5	400 ft	130.5 ft
Coordinate 6	403.75 ft	132.45 ft
Coordinate 7	450 ft	132.45 ft

Geometry

Name: 2D Geometry

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	281.25 ft	112.14 ft
Point 2	281.25 ft	107.14 ft
Point 3	291.25 ft	107.14 ft
Point 4	373.75 ft	127.906 ft
Point 5	383.75 ft	127.906 ft
Point 6	383.75 ft	132.90059 ft
Point 7	395 ft	132.7 ft
Point 8	400 ft	130.5 ft
Point 9	403.75 ft	132.45 ft
Point 10	450 ft	132.45 ft

Point 11	450 ft	128.3 ft
Point 12	383.75 ft	128.3 ft
Point 13	450 ft	122.3 ft
Point 14	351.47831 ft	122.30001 ft
Point 15	450 ft	118.3 ft
Point 16	335.58529 ft	118.29959 ft
Point 17	450 ft	114.3 ft
Point 18	319.69675 ft	114.3003 ft
Point 19	450 ft	112.3 ft
Point 20	311.75019 ft	112.30008 ft
Point 21	450 ft	87.3 ft
Point 22	200 ft	87.3 ft
Point 23	200 ft	112.14 ft
Point 24	450 ft	80.3 ft
Point 25	200 ft	80.3 ft
Point 26	373.75 ft	133.08 ft
Point 27	291.25 ft	112.14 ft

Regions

	Material	Points	Area
Region 1	(1)	6,7,8,9,10,11,12	270.97 ft²
Region 2	(2)	5,12,11,13,14,4	515.99 ft²
Region 3	(3)	14,13,15,16	425.89 ft²
Region 4	(4)	16,15,17,18	489.39 ft²
Region 5	(5)	18,17,19,20	268.57 ft²
Region 6	(6)	20,19,21,22,23,1,2,3	6,132.5 ft²
Region 7	(7)	22,21,24,25	1,750 ft²
Region 8	(8)	1,2,3,20,18,16,14,4,5,12,6,26,27	520.52 ft²

Slip Results

Slip Surfaces Analysed: 389 of 405 converged

Current Slip Surface

Slip Surface: 43
Factor of Safety: 1.88
Volume: 965.99978 ft³

Weight: 121,957.23 lbf
Resisting Moment: 3,069,430.4 lbf·ft
Activating Moment: 1,628,938.5 lbf·ft
Resisting Force: 44,940.455 lbf
Activating Force: 23,848.069 lbf
Slip Rank: 1 of 405 slip surfaces
Exit: (291.25, 112.14) ft
Entry: (373.75, 133.08) ft
Radius: 62.985841 ft
Center: (321.07666, 167.616) ft

Slip Slices

	X	Y	PWP	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	292.41928 ft	111.54242 ft	55.835338 psf	98.451822 psf	270 psf	0 psf	(8)
Slice 2	294.75784 ft	110.40692 ft	163.78156 psf	160.30096 psf	270 psf	0 psf	(8)
Slice 3	297.09639 ft	109.38745 ft	264.48361 psf	213.60812 psf	270 psf	0 psf	(8)
Slice 4	299.61412 ft	108.41703 ft	364.96312 psf	393.26924 psf	0 psf	0 psf	(6)
Slice 5	302.31103 ft	107.50717 ft	464.50069 psf	469.86441 psf	0 psf	0 psf	(6)
Slice 6	305.00793 ft	106.73031 ft	555.73495 psf	532.31423 psf	0 psf	0 psf	(6)
Slice 7	307.70483 ft	106.08141 ft	638.98112 psf	582.75413 psf	0 psf	0 psf	(6)
Slice 8	310.40174 ft	105.55643 ft	714.4903 psf	622.81544 psf	0 psf	0 psf	(6)
Slice 9	313.07462 ft	105.15481 ft	781.91795 psf	658.13752 psf	0 psf	0 psf	(6)
Slice 10	315.72347 ft	104.87213 ft	841.53878 psf	689.48902 psf	0 psf	0 psf	(6)
Slice 11	318.37232 ft	104.70221 ft	894.12091 psf	713.31183 psf	0 psf	0 psf	(6)
Slice 12	321.0208 ft	104.6441 ft	939.71587 psf	730.43062 psf	0 psf	0 psf	(6)
Slice 13	323.66888 ft	104.69748 ft	978.34503 psf	741.38564 psf	0 psf	0 psf	(6)

Slice 14	326.31698 ft	104.86259 ft	1,009.9982 psf	746.47623 psf	0 psf	0 psf	(6)
Slice 15	328.96506 ft	105.14034 ft	1,034.6199 psf	746.08444 psf	0 psf	0 psf	(6)
Slice 16	331.61316 ft	105.53223 ft	1,052.1157 psf	740.53125 psf	0 psf	0 psf	(6)
Slice 17	334.26124 ft	106.04044 ft	1,062.3492 psf	730.08777 psf	0 psf	0 psf	(6)
Slice 18	336.88644 ft	106.66143 ft	1,065.1796 psf	712.56609 psf	0 psf	0 psf	(6)
Slice 19	339.48875 ft	107.39673 ft	1,060.5101 psf	688.42324 psf	0 psf	0 psf	(6)
Slice 20	342.09105 ft	108.25519 ft	1,048.1528 psf	660.37719 psf	0 psf	0 psf	(6)
Slice 21	344.69336 ft	109.24223 ft	1,027.7676 psf	628.566 psf	0 psf	0 psf	(6)
Slice 22	347.29566 ft	110.36452 ft	998.93845 psf	593.11468 psf	0 psf	0 psf	(6)
Slice 23	349.89797 ft	111.63023 ft	961.15599 psf	554.14049 psf	0 psf	0 psf	(6)
Slice 24	351.33871 ft	112.37653 ft	937.39403 psf	480.25193 psf	0 psf	0 psf	(5)
Slice 25	353.04534 ft	113.37661 ft	902.00179 psf	448.15419 psf	0 psf	0 psf	(5)
Slice 26	356.02358 ft	115.24186 ft	832.74711 psf	259.59005 psf	330 psf	0 psf	(4)
Slice 27	358.84601 ft	117.24159 ft	752.62758 psf	211.8217 psf	330 psf	0 psf	(4)
Slice 28	361.39848 ft	119.25115 ft	667.61681 psf	278.10977 psf	0 psf	0 psf	(3)
Slice 29	363.681 ft	121.25131 ft	578.91467 psf	234.10223 psf	0 psf	0 psf	(3)
Slice 30	365.85772 ft	123.34746 ft	482.54392 psf	167.85162 psf	0 psf	0 psf	(2)
Slice 31	367.92864 ft	125.54813 ft	377.97147 psf	118.83453 psf	0 psf	0 psf	(2)
Slice 32	370.16058 ft	128.19095 ft	248.34674 psf	11.495887 psf	270 psf	0 psf	(8)

Slice 33	372.55353 ft	131.38028 ft	87.154905 psf	-31.969397 psf	270 psf	0 psf	(8)

REPORT F-9
WITH REFERENCE TO SLOPE STABILITY ANALYSIS RESULT PRESENTED IN PLATE E-9
CONDITIONS: GLOBAL SLIDE - RAPID DRAWDOWN WITH TOTAL SOIL PARAMETERS
SECTION: A-A WITH SLOPE ABOUT 3.9H:1V
SOIL PROFILE: BORING NO. 4

SLOPE/W Analysis

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File Information

File Version: 11.00
Revision Number: 28
Date: 03/02/2022
Time: 02:35:50 PM
Tool Version: 11.0.1.21429
File Name: 9. G-RD - TOT - AA - B4 - Clay Liner.gsz
Directory: H:\2021\450-499\21-S-477 Ravensway Drainage Improvements-HCED\Calculation\Slope Stability\Report 3 on 2-2022\Global Stability\
Last Solved Date: 03/02/2022
Last Solved Time: 02:35:53 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

SLOPE/W Analysis

Kind: SLOPE/W
Method: Spencer
Settings
- PWP Conditions from: Piezometric Line
  - Apply Phreatic Correction: No
  - Use Staged Rapid Drawdown: No
- Unit Weight of Water: 62.430189 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 ft
  - Number of Slices: 30
- Factor of Safety Convergence Settings

Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

(1)

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 29.5 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(2)

Model: Mohr-Coulomb
Unit Weight: 137.2 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(3)

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 33 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(4)

Model: Mohr-Coulomb
Unit Weight: 136.7 pcf
Effective Cohesion: 380 psf
Effective Friction Angle: 21 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(5)

Model: Mohr-Coulomb
Unit Weight: 136.1 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 33 °
Phi-B: 0 °
Pore Water Pressure
    Piezometric Line: 1

(6)

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 36 °
Phi-B: 0 °
Pore Water Pressure
    Piezometric Line: 1

(7)

Model: Mohr-Coulomb
Unit Weight: 128.9 pcf
Effective Cohesion: 270 psf
Effective Friction Angle: 15 °
Phi-B: 0 °
Pore Water Pressure
    Piezometric Line: 1

(8)

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effective Cohesion: 300 psf
Effective Friction Angle: 18 °
Phi-B: 0 °
Pore Water Pressure
    Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (200, 112.14) ft
Left-Zone Right Coordinate: (291.25, 112.14) ft
Left-Zone Increment: 8
Right Type: Range
Right-Zone Left Coordinate: (373.75, 133.08) ft
Right-Zone Right Coordinate: (450, 132.45) ft
Right-Zone Increment: 8
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (200, 112.14) ft
Right Coordinate: (450, 132.45) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	200 ft	112.14 ft
Coordinate 2	291.25 ft	112.14 ft
Coordinate 3	373.75 ft	133.08 ft
Coordinate 4	395 ft	132.7 ft
Coordinate 5	400 ft	130.5 ft
Coordinate 6	403.75 ft	132.45 ft
Coordinate 7	450 ft	132.45 ft

Geometry

Name: 2D Geometry

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	281.25 ft	112.14 ft
Point 2	281.25 ft	107.14 ft
Point 3	291.25 ft	107.14 ft
Point 4	373.75 ft	127.906 ft
Point 5	383.75 ft	127.906 ft
Point 6	383.75 ft	132.90059 ft
Point 7	395 ft	132.7 ft
Point 8	400 ft	130.5 ft
Point 9	403.75 ft	132.45 ft
Point 10	450 ft	132.45 ft

Point 11	450 ft	128.3 ft
Point 12	383.75 ft	128.3 ft
Point 13	450 ft	122.3 ft
Point 14	351.47831 ft	122.30001 ft
Point 15	450 ft	118.3 ft
Point 16	335.58529 ft	118.29959 ft
Point 17	450 ft	114.3 ft
Point 18	319.69675 ft	114.3003 ft
Point 19	450 ft	112.3 ft
Point 20	311.75019 ft	112.30008 ft
Point 21	450 ft	87.3 ft
Point 22	200 ft	87.3 ft
Point 23	200 ft	112.14 ft
Point 24	450 ft	80.3 ft
Point 25	200 ft	80.3 ft
Point 26	373.75 ft	133.08 ft
Point 27	291.25 ft	112.14 ft

Regions

	Material	Points	Area
Region 1	(1)	6,7,8,9,10,11,12	270.97 ft²
Region 2	(2)	5,12,11,13,14,4	515.99 ft²
Region 3	(3)	14,13,15,16	425.89 ft²
Region 4	(4)	16,15,17,18	489.39 ft²
Region 5	(5)	18,17,19,20	268.57 ft²
Region 6	(6)	20,19,21,22,23,1,2,3	6,132.5 ft²
Region 7	(7)	22,21,24,25	1,750 ft²
Region 8	(8)	1,2,3,20,18,16,14,4,5,12,6,26,27	520.52 ft²

Slip Results

Slip Surfaces Analysed: 259 of 405 converged

Current Slip Surface

Slip Surface: 282
Factor of Safety: 1.82
Volume: 1,233.5161 ft³

Weight: 156,433.49 lbf
Resisting Moment: 8,169,605.9 lbf·ft
Activating Moment: 4,476,350.1 lbf·ft
Resisting Force: 55,257.352 lbf
Activating Force: 30,280.047 lbf
Slip Rank: 1 of 405 slip surfaces
Exit: (268.4375, 112.14) ft
Entry: (393.04509, 132.73486) ft
Radius: 142.71633 ft
Center: (309.87136, 248.70935) ft

Slip Slices

	X	Y	PWP	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	270.57292 ft	111.52826 ft	38.19077 psf	35.439949 psf	0 psf	0 psf	(6)
Slice 2	274.84375 ft	110.37582 ft	110.13827 psf	99.094247 psf	0 psf	0 psf	(6)
Slice 3	279.11458 ft	109.36377 ft	173.32057 psf	151.37755 psf	0 psf	0 psf	(6)
Slice 4	283.75 ft	108.42692 ft	231.80825 psf	108.40648 psf	300 psf	0 psf	(8)
Slice 5	288.75 ft	107.58724 ft	284.22976 psf	123.35749 psf	300 psf	0 psf	(8)
Slice 6	293.37641 ft	106.96562 ft	356.73259 psf	305.06819 psf	0 psf	0 psf	(6)
Slice 7	297.53374 ft	106.54192 ft	449.06107 psf	369.41667 psf	0 psf	0 psf	(6)
Slice 8	301.59558 ft	106.24769 ft	531.79336 psf	423.39661 psf	0 psf	0 psf	(6)
Slice 9	305.65742 ft	106.06971 ft	607.26816 psf	469.40451 psf	0 psf	0 psf	(6)
Slice 10	309.71927 ft	106.00755 ft	675.51266 psf	507.96166 psf	0 psf	0 psf	(6)
Slice 11	313.73683 ft	106.05922 ft	735.94894 psf	545.44755 psf	0 psf	0 psf	(6)
Slice 12	317.71011 ft	106.22234 ft	788.72524 psf	582.10851 psf	0 psf	0 psf	(6)
Slice 13	321.68282 ft	106.49659 ft	834.55526 psf	612.62566 psf	0 psf	0 psf	(6)

Slice 14	325.65495 ft	106.88256 ft	873.40073 psf	637.31157 psf	0 psf	0 psf	(6)
Slice 15	329.62709 ft	107.38121 ft	905.21204 psf	656.23356 psf	0 psf	0 psf	(6)
Slice 16	333.59922 ft	107.99374 ft	929.91435 psf	669.65239 psf	0 psf	0 psf	(6)
Slice 17	337.57192 ft	108.72174 ft	947.4157 psf	673.72689 psf	0 psf	0 psf	(6)
Slice 18	341.54517 ft	109.56708 ft	957.60087 psf	668.86925 psf	0 psf	0 psf	(6)
Slice 19	345.51843 ft	110.53182 ft	960.33191 psf	659.4135 psf	0 psf	0 psf	(6)
Slice 20	349.49168 ft	111.61848 ft	955.45131 psf	645.53598 psf	0 psf	0 psf	(6)
Slice 21	351.65374 ft	112.24634 ft	950.51343 psf	637.11384 psf	0 psf	0 psf	(6)
Slice 22	354.84055 ft	113.30013 ft	935.22315 psf	553.44095 psf	0 psf	0 psf	(5)
Slice 23	360.35092 ft	115.24539 ft	901.09718 psf	298.58241 psf	380 psf	0 psf	(4)
Slice 24	365.34889 ft	117.24514 ft	855.45004 psf	271.37524 psf	380 psf	0 psf	(4)
Slice 25	370.79894 ft	119.69334 ft	788.96956 psf	427.36905 psf	0 psf	0 psf	(3)
Slice 26	374.93405 ft	121.69349 ft	709.54014 psf	382.83217 psf	0 psf	0 psf	(3)
Slice 27	378.02607 ft	123.33722 ft	603.4698 psf	286.07211 psf	0 psf	0 psf	(2)
Slice 28	381.84202 ft	125.48884 ft	464.88344 psf	208.88 psf	0 psf	0 psf	(2)
Slice 29	385.11714 ft	127.45163 ft	338.69013 psf	122.68457 psf	0 psf	0 psf	(2)
Slice 30	388.12449 ft	129.37556 ft	215.22115 psf	69.558256 psf	0 psf	0 psf	(1)
Slice 31	391.40489 ft	131.59299 ft	73.124453 psf	23.031567 psf	0 psf	0 psf	(1)

REPORT F-10
WITH REFERENCE TO SLOPE STABILITY ANALYSIS RESULT PRESENTED IN PLATE E-10
CONDITIONS: LOCAL SLIDE - RAPID DRAWDOWN WITH TOTAL SOIL PARAMETERS
SECTION: A-A WITH SLOPE ABOUT 3.9H:1V
SOIL PROFILE: BORING NO. 4

SLOPE/W Analysis

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File Information

File Version: 11.00
Revision Number: 30
Date: 03/02/2022
Time: 02:55:37 PM
Tool Version: 11.0.1.21429
File Name: 10. L-RD - TOT - AA - B4 - Clay Liner.gsz
Directory: H:\2021\450-499\21-S-477 Ravensway Drainage Improvements-HCED\Calculation\Slope Stability\Report 3 on 2-2022\Local Stability\
Last Solved Date: 03/02/2022
Last Solved Time: 02:55:40 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

SLOPE/W Analysis

Kind: SLOPE/W
Method: Spencer
Settings
- PWP Conditions from: Piezometric Line
  - Apply Phreatic Correction: No
  - Use Staged Rapid Drawdown: No
- Unit Weight of Water: 62.430189 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 ft
  - Number of Slices: 30
- Factor of Safety Convergence Settings

Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

(1)

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 29.5 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(2)

Model: Mohr-Coulomb
Unit Weight: 137.2 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(3)

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 33 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(4)

Model: Mohr-Coulomb
Unit Weight: 136.7 pcf
Effective Cohesion: 380 psf
Effective Friction Angle: 21 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(5)

Model: Mohr-Coulomb
Unit Weight: 136.1 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 33 °
Phi-B: 0 °
Pore Water Pressure
    Piezometric Line: 1

(6)

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 36 °
Phi-B: 0 °
Pore Water Pressure
    Piezometric Line: 1

(7)

Model: Mohr-Coulomb
Unit Weight: 128.9 pcf
Effective Cohesion: 270 psf
Effective Friction Angle: 15 °
Phi-B: 0 °
Pore Water Pressure
    Piezometric Line: 1

(8)

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effective Cohesion: 300 psf
Effective Friction Angle: 18 °
Phi-B: 0 °
Pore Water Pressure
    Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (291.25, 112.14) ft
Left-Zone Right Coordinate: (332, 122.48309) ft
Left-Zone Increment: 8
Right Type: Range
Right-Zone Left Coordinate: (332, 122.48309) ft
Right-Zone Right Coordinate: (373.75, 133.08) ft
Right-Zone Increment: 8
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (200, 112.14) ft
Right Coordinate: (450, 132.45) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	200 ft	112.14 ft
Coordinate 2	291.25 ft	112.14 ft
Coordinate 3	373.75 ft	133.08 ft
Coordinate 4	395 ft	132.7 ft
Coordinate 5	400 ft	130.5 ft
Coordinate 6	403.75 ft	132.45 ft
Coordinate 7	450 ft	132.45 ft

Geometry

Name: 2D Geometry

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	281.25 ft	112.14 ft
Point 2	281.25 ft	107.14 ft
Point 3	291.25 ft	107.14 ft
Point 4	373.75 ft	127.906 ft
Point 5	383.75 ft	127.906 ft
Point 6	383.75 ft	132.90059 ft
Point 7	395 ft	132.7 ft
Point 8	400 ft	130.5 ft
Point 9	403.75 ft	132.45 ft
Point 10	450 ft	132.45 ft

Point 11	450 ft	128.3 ft
Point 12	383.75 ft	128.3 ft
Point 13	450 ft	122.3 ft
Point 14	351.47831 ft	122.30001 ft
Point 15	450 ft	118.3 ft
Point 16	335.58529 ft	118.29959 ft
Point 17	450 ft	114.3 ft
Point 18	319.69675 ft	114.3003 ft
Point 19	450 ft	112.3 ft
Point 20	311.75019 ft	112.30008 ft
Point 21	450 ft	87.3 ft
Point 22	200 ft	87.3 ft
Point 23	200 ft	112.14 ft
Point 24	450 ft	80.3 ft
Point 25	200 ft	80.3 ft
Point 26	373.75 ft	133.08 ft
Point 27	291.25 ft	112.14 ft

Regions

	Material	Points	Area
Region 1	(1)	6,7,8,9,10,11,12	270.97 ft²
Region 2	(2)	5,12,11,13,14,4	515.99 ft²
Region 3	(3)	14,13,15,16	425.89 ft²
Region 4	(4)	16,15,17,18	489.39 ft²
Region 5	(5)	18,17,19,20	268.57 ft²
Region 6	(6)	20,19,21,22,23,1,2,3	6,132.5 ft²
Region 7	(7)	22,21,24,25	1,750 ft²
Region 8	(8)	1,2,3,20,18,16,14,4,5,12,6,26,27	520.52 ft²

Slip Results

Slip Surfaces Analysed: 382 of 405 converged

Current Slip Surface

Slip Surface: 43
Factor of Safety: 1.89
Volume: 965.99978 ft³

Weight: 121,957.23 lbf
Resisting Moment: 3,079,537.4 lbf·ft
Activating Moment: 1,628,938.5 lbf·ft
Resisting Force: 45,003.908 lbf
Activating Force: 23,803.524 lbf
Slip Rank: 1 of 405 slip surfaces
Exit: (291.25, 112.14) ft
Entry: (373.75, 133.08) ft
Radius: 62.985841 ft
Center: (321.07666, 167.616) ft

Slip Slices

	X	Y	PWP	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	292.41928 ft	111.54242 ft	55.835338 psf	71.928059 psf	300 psf	0 psf	(8)
Slice 2	294.75784 ft	110.40692 ft	163.78156 psf	114.56997 psf	300 psf	0 psf	(8)
Slice 3	297.09639 ft	109.38745 ft	264.48361 psf	151.75405 psf	300 psf	0 psf	(8)
Slice 4	299.61412 ft	108.41703 ft	364.96312 psf	391.87925 psf	0 psf	0 psf	(6)
Slice 5	302.31103 ft	107.50717 ft	464.50069 psf	468.39024 psf	0 psf	0 psf	(6)
Slice 6	305.00793 ft	106.73031 ft	555.73495 psf	530.83795 psf	0 psf	0 psf	(6)
Slice 7	307.70483 ft	106.08141 ft	638.98112 psf	581.33406 psf	0 psf	0 psf	(6)
Slice 8	310.40174 ft	105.55643 ft	714.4903 psf	621.4932 psf	0 psf	0 psf	(6)
Slice 9	313.07462 ft	105.15481 ft	781.91795 psf	656.93405 psf	0 psf	0 psf	(6)
Slice 10	315.72347 ft	104.87213 ft	841.53878 psf	688.41913 psf	0 psf	0 psf	(6)
Slice 11	318.37232 ft	104.70221 ft	894.12091 psf	712.39258 psf	0 psf	0 psf	(6)
Slice 12	321.0208 ft	104.6441 ft	939.71587 psf	729.67323 psf	0 psf	0 psf	(6)
Slic	323.66888	104.69748	978.34503	740.7969 psf	0 psf	0 psf	(6)

e 13	ft	ft	psf				
Slice 14	326.31698 ft	104.86259 ft	1,009.9982 psf	746.05945 psf	0 psf	0 psf	(6)
Slice 15	328.96506 ft	105.14034 ft	1,034.6199 psf	745.83979 psf	0 psf	0 psf	(6)
Slice 16	331.61316 ft	105.53223 ft	1,052.1157 psf	740.45626 psf	0 psf	0 psf	(6)
Slice 17	334.26124 ft	106.04044 ft	1,062.3492 psf	730.17754 psf	0 psf	0 psf	(6)
Slice 18	336.88644 ft	106.66143 ft	1,065.1796 psf	712.81258 psf	0 psf	0 psf	(6)
Slice 19	339.48875 ft	107.39673 ft	1,060.5101 psf	688.81558 psf	0 psf	0 psf	(6)
Slice 20	342.09105 ft	108.25519 ft	1,048.1528 psf	660.90333 psf	0 psf	0 psf	(6)
Slice 21	344.69336 ft	109.24223 ft	1,027.7676 psf	629.21206 psf	0 psf	0 psf	(6)
Slice 22	347.29566 ft	110.36452 ft	998.93845 psf	593.86481 psf	0 psf	0 psf	(6)
Slice 23	349.89797 ft	111.63023 ft	961.15599 psf	554.9767 psf	0 psf	0 psf	(6)
Slice 24	351.33871 ft	112.37653 ft	937.39403 psf	481.05812 psf	0 psf	0 psf	(5)
Slice 25	353.04534 ft	113.37661 ft	902.00179 psf	448.98784 psf	0 psf	0 psf	(5)
Slice 26	356.02358 ft	115.24186 ft	832.74711 psf	213.88 psf	380 psf	0 psf	(4)
Slice 27	358.84601 ft	117.24159 ft	752.62758 psf	173.75027 psf	380 psf	0 psf	(4)
Slice 28	361.39848 ft	119.25115 ft	667.61681 psf	278.92168 psf	0 psf	0 psf	(3)
Slice 29	363.681 ft	121.25131 ft	578.91467 psf	234.85883 psf	0 psf	0 psf	(3)
Slice 30	365.85772 ft	123.34746 ft	482.54392 psf	168.45916 psf	0 psf	0 psf	(2)
Slice 31	367.92864 ft	125.54813 ft	377.97147 psf	119.32693 psf	0 psf	0 psf	(2)
Slic	370.16058	128.19095	248.34674	5.1632303 psf	300 psf	0 psf	(8)

e 32	ft	ft	psf				
Slice 33	372.55353 ft	131.38028 ft	87.154905 psf	-28.758588 psf	300 psf	0 psf	(8)

REPORT F-11
WITH REFERENCE TO SLOPE STABILITY ANALYSIS RESULT PRESENTED IN PLATE E-11
CONDITIONS: GLOBAL SLIDE - SHORT TERM - WATER FROM TOP TO ALONG THE SLOPE
SECTION: C-C WITH SLOPE ABOUT 4H:1V
SOIL PROFILE: BORING NO. 2

Slope Stability Section 2

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File Information

File Version: 11.00
Revision Number: 35
Date: 03/02/2022
Time: 02:37:37 PM
Tool Version: 11.0.1.21429
File Name: 11. G - ST -TOP - CC - Clay Liner.gsz
Directory: H:\2021\450-499\21-S-477 Ravensway Drainage Improvements-HCED\Calculation\Slope Stability\Report 3 on 2-2022\Global Stability\
Last Solved Date: 03/02/2022
Last Solved Time: 02:37:40 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

Slope Stability Section 2

Kind: SLOPE/W
Method: Spencer
Settings
- PWP Conditions from: Piezometric Line
  - Apply Phreatic Correction: No
  - Use Staged Rapid Drawdown: No
- Unit Weight of Water: 62.430189 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 ft
  - Number of Slices: 30
- Factor of Safety Convergence Settings

Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

(1)

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 29.5 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(2)

Model: Mohr-Coulomb
Unit Weight: 138.4 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(3)

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 33 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(4)

Model: Undrained (Phi=0)
Unit Weight: 136.7 pcf
Cohesion: 1,000 psf
Pore Water Pressure
Piezometric Line: 1

(5)

Model: Undrained (Phi=0)

Unit Weight: 142 pcf
Cohesion: 2,000 psf
Pore Water Pressure
Piezometric Line: 1

(6)

Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 1,000 psf
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (200, 110.15) ft
Left-Zone Right Coordinate: (277.5, 110.33) ft
Left-Zone Increment: 8
Right Type: Range
Right-Zone Left Coordinate: (376, 135.03) ft
Right-Zone Right Coordinate: (450, 134) ft
Right-Zone Increment: 8
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (200, 110.15) ft
Right Coordinate: (450, 134) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	200 ft	110.15 ft
Coordinate 2	277.5 ft	110.33 ft
Coordinate 3	376 ft	135.03 ft
Coordinate 4	397 ft	134.6 ft
Coordinate 5	402 ft	133.5 ft
Coordinate 6	406 ft	134.5 ft
Coordinate 7	450 ft	134 ft

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X	Y
	376 ft	136.03 ft
	397 ft	135.6 ft

Geometry

Name: 2D Geometry

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	267.5 ft	105.2 ft
Point 2	277.5 ft	105.2 ft
Point 3	376 ft	130.03 ft
Point 4	386 ft	130.03 ft
Point 5	386 ft	134.82394 ft
Point 6	376 ft	135.03 ft
Point 7	277.5 ft	110.33 ft
Point 8	267.50091 ft	110.30555 ft
Point 9	397 ft	134.6 ft
Point 10	402 ft	133.5 ft
Point 11	406 ft	134.5 ft
Point 12	450 ft	134 ft
Point 13	450 ft	132.3 ft
Point 14	386 ft	132.3 ft
Point 15	450 ft	124.3 ft
Point 16	349.2913 ft	123.29724 ft
Point 17	450 ft	111.3 ft
Point 18	301.70191 ft	111.30085 ft

Point 19	450 ft	106.3 ft
Point 20	281.86632 ft	106.30067 ft
Point 21	267.50091 ft	110.3 ft
Point 22	267.5002 ft	106.3 ft
Point 23	200 ft	106.3 ft
Point 24	200 ft	110.15 ft
Point 25	200 ft	84.3 ft
Point 26	450 ft	84.3 ft

Regions

	Material	Points	Area
Region 1	(6)	1,2,20,18,16,3,4,14,5,6,7,8,21,22	599.05 ft²
Region 2	(1)	5,9,10,11,12,13,14	127.88 ft²
Region 3	(2)	14,13,15,16,3,4	682.92 ft²
Region 4	(3)	16,15,17,18	1,544.1 ft²
Region 5	(4)	18,17,19,20	791.1 ft²
Region 6	(4)	22,21,8,24,23	265.13 ft²
Region 7	(5)	1,22,23,25,26,19,20,2	5,486.7 ft²

Slip Results

Slip Surfaces Analysed: 315 of 405 converged

Current Slip Surface

Slip Surface: 372
Factor of Safety: 2.47
Volume: 1,323.285 ft³
Weight: 169,308.21 lbf
Resisting Moment: 13,046,852 lbf·ft
Activating Moment: 5,292,373.8 lbf·ft
Resisting Force: 90,167.54 lbf
Activating Force: 36,568.701 lbf
Slip Rank: 1 of 405 slip surfaces
Exit: (277.5, 110.33) ft
Entry: (394.55858, 134.6497) ft
Radius: 140.27853 ft
Center: (310.21543, 246.74029) ft

Slip Slices

	X	Y	PWP	Frictional	Cohesiv	Suction	Base

				Strength	e Strength	Strength	Material
Slice 1	279.40696 ft	109.90066 ft	56.657228 psf	0 psf	1,000 psf	0 psf	(6)
Slice 2	283.22087 ft	109.09733 ft	166.51647 psf	0 psf	1,000 psf	0 psf	(6)
Slice 3	287.03479 ft	108.4038 ft	269.52122 psf	0 psf	1,000 psf	0 psf	(6)
Slice 4	291.06844 ft	107.7912 ft	370.91304 psf	0 psf	1,000 psf	0 psf	(4)
Slice 5	295.32183 ft	107.27104 ft	469.9739 psf	0 psf	1,000 psf	0 psf	(4)
Slice 6	299.57522 ft	106.88213 ft	560.84021 psf	0 psf	1,000 psf	0 psf	(4)
Slice 7	303.57856 ft	106.63144 ft	639.16364 psf	0 psf	1,000 psf	0 psf	(4)
Slice 8	307.33186 ft	106.50396 ft	705.88072 psf	0 psf	1,000 psf	0 psf	(4)
Slice 9	311.08516 ft	106.47701 ft	766.32155 psf	0 psf	1,000 psf	0 psf	(4)
Slice 10	314.83846 ft	106.55053 ft	820.48975 psf	0 psf	1,000 psf	0 psf	(4)
Slice 11	318.59176 ft	106.72469 ft	868.37543 psf	0 psf	1,000 psf	0 psf	(4)
Slice 12	322.34506 ft	106.99985 ft	909.95509 psf	0 psf	1,000 psf	0 psf	(4)
Slice 13	326.09837 ft	107.37662 ft	945.19134 psf	0 psf	1,000 psf	0 psf	(4)
Slice 14	329.85167 ft	107.85583 ft	974.03252 psf	0 psf	1,000 psf	0 psf	(4)
Slice 15	333.60497 ft	108.43854 ft	996.4121 psf	0 psf	1,000 psf	0 psf	(4)
Slice 16	337.35827 ft	109.12607 ft	1,012.2479 psf	0 psf	1,000 psf	0 psf	(4)
Slice 17	341.11157 ft	109.91999 ft	1,021.4413 psf	0 psf	1,000 psf	0 psf	(4)
Slice 18	344.86487 ft	110.82218 ft	1,023.8757 psf	0 psf	1,000 psf	0 psf	(4)

Slice 19	348.01641 ft	111.65735 ft	1,021.0735 psf	584.51849 psf	0 psf	0 psf	(3)
Slice 20	351.19906 ft	112.59697 ft	1,012.2374 psf	574.02364 psf	0 psf	0 psf	(3)
Slice 21	355.01459 ft	113.82284 ft	995.43885 psf	561.04181 psf	0 psf	0 psf	(3)
Slice 22	358.83012 ft	115.17076 ft	971.02052 psf	544.07385 psf	0 psf	0 psf	(3)
Slice 23	362.64565 ft	116.64452 ft	938.74532 psf	523.21491 psf	0 psf	0 psf	(3)
Slice 24	366.46118 ft	118.24848 ft	898.3426 psf	498.55658 psf	0 psf	0 psf	(3)
Slice 25	370.27671 ft	119.98756 ft	849.50346 psf	470.18869 psf	0 psf	0 psf	(3)
Slice 26	374.09224 ft	121.86744 ft	791.87497 psf	438.20139 psf	0 psf	0 psf	(3)
Slice 27	376.68155 ft	123.21004 ft	737.05113 psf	544.11365 psf	0 psf	0 psf	(3)
Slice 28	379.52233 ft	124.80403 ft	633.90683 psf	428.15465 psf	0 psf	0 psf	(2)
Slice 29	383.84078 ft	127.36299 ft	468.62983 psf	332.54835 psf	0 psf	0 psf	(2)
Slice 30	388.6709 ft	130.49734 ft	266.77722 psf	224.59795 psf	0 psf	0 psf	(2)
Slice 31	392.95019 ft	133.47485 ft	75.420243 psf	135.88796 psf	0 psf	0 psf	(1)

REPORT F-12
WITH REFERENCE TO SLOPE STABILITY ANALYSIS RESULT PRESENTED IN PLATE E-12
CONDITIONS: LOCAL SLIDE - SHORT TERM - WATER FROM TOP TO ALONG THE SLOPE
SECTION: C-C WITH SLOPE ABOUT 4H:1V
SOIL PROFILE: BORING NO. 2

Slope Stability Section 2

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File Information

File Version: 11.00
Revision Number: 37
Date: 03/02/2022
Time: 02:56:52 PM
Tool Version: 11.0.1.21429
File Name: 12. L - ST -TOP - CC - Clay Liner.gsz
Directory: H:\2021\450-499\21-S-477 Ravensway Drainage Improvements-HCED\Calculation\Slope Stability\Report 3 on 2-2022\Local Stability\
Last Solved Date: 03/02/2022
Last Solved Time: 02:56:55 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

Slope Stability Section 2

Kind: SLOPE/W
Method: Spencer
Settings
- PWP Conditions from: Piezometric Line
  - Apply Phreatic Correction: No
  - Use Staged Rapid Drawdown: No
- Unit Weight of Water: 62.430189 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 ft
  - Number of Slices: 30
- Factor of Safety Convergence Settings

Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

(1)

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 29.5 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(2)

Model: Mohr-Coulomb
Unit Weight: 138.4 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(3)

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 33 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(4)

Model: Undrained (Phi=0)
Unit Weight: 136.7 pcf
Cohesion: 1,000 psf
Pore Water Pressure
Piezometric Line: 1

(5)

Model: Undrained (Phi=0)

Unit Weight: 142 pcf
Cohesion: 2,000 psf
Pore Water Pressure
Piezometric Line: 1

(6)

Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 1,000 psf
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (277.5, 110.33) ft
Left-Zone Right Coordinate: (326.75, 122.68) ft
Left-Zone Increment: 8
Right Type: Range
Right-Zone Left Coordinate: (326.75, 122.68) ft
Right-Zone Right Coordinate: (376, 135.03) ft
Right-Zone Increment: 8
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (200, 110.15) ft
Right Coordinate: (450, 134) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	200 ft	110.15 ft
Coordinate 2	277.5 ft	110.33 ft
Coordinate 3	376 ft	135.03 ft
Coordinate 4	397 ft	134.6 ft
Coordinate 5	402 ft	133.5 ft
Coordinate 6	406 ft	134.5 ft
Coordinate 7	450 ft	134 ft

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X	Y
	376 ft	136.03 ft
	397 ft	135.6 ft

Geometry

Name: 2D Geometry

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	267.5 ft	105.2 ft
Point 2	277.5 ft	105.2 ft
Point 3	376 ft	130.03 ft
Point 4	386 ft	130.03 ft
Point 5	386 ft	134.82394 ft
Point 6	376 ft	135.03 ft
Point 7	277.5 ft	110.33 ft
Point 8	267.50091 ft	110.30555 ft
Point 9	397 ft	134.6 ft
Point 10	402 ft	133.5 ft
Point 11	406 ft	134.5 ft
Point 12	450 ft	134 ft
Point 13	450 ft	132.3 ft
Point 14	386 ft	132.3 ft
Point 15	450 ft	124.3 ft
Point 16	349.2913 ft	123.29724 ft
Point 17	450 ft	111.3 ft
Point 18	301.70191 ft	111.30085 ft

Point 19	450 ft	106.3 ft
Point 20	281.86632 ft	106.30067 ft
Point 21	267.50091 ft	110.3 ft
Point 22	267.5002 ft	106.3 ft
Point 23	200 ft	106.3 ft
Point 24	200 ft	110.15 ft
Point 25	200 ft	84.3 ft
Point 26	450 ft	84.3 ft

Regions

	Material	Points	Area
Region 1	(6)	1,2,20,18,16,3,4,14,5,6,7,8,21,22	599.05 ft²
Region 2	(1)	5,9,10,11,12,13,14	127.88 ft²
Region 3	(2)	14,13,15,16,3,4	682.92 ft²
Region 4	(3)	16,15,17,18	1,544.1 ft²
Region 5	(4)	18,17,19,20	791.1 ft²
Region 6	(4)	22,21,8,24,23	265.13 ft²
Region 7	(5)	1,22,23,25,26,19,20,2	5,486.7 ft²

Slip Results

Slip Surfaces Analysed: 320 of 405 converged

Current Slip Surface

Slip Surface: 268
Factor of Safety: 2.42
Volume: 651.7088 ft³
Weight: 82,050.62 lbf
Resisting Moment: 2,122,388.5 lbf·ft
Activating Moment: 877,177.16 lbf·ft
Resisting Force: 35,787.139 lbf
Activating Force: 14,788.1 lbf
Slip Rank: 1 of 405 slip surfaces
Exit: (308.28125, 118.04875) ft
Entry: (376, 135.03) ft
Radius: 51.55075 ft
Center: (332.91409, 163.33344) ft

Slip Slices

	X	Y	PWP	Frictional	Cohesiv	Suction	Base

				Strength	e Strength	Strength	Material
Slice 1	309.49365 ft	117.43017 ft	57.598215 psf	0 psf	1,000 psf	0 psf	(6)
Slice 2	311.91844 ft	116.27072 ft	167.94349 psf	0 psf	1,000 psf	0 psf	(6)
Slice 3	314.34323 ft	115.26148 ft	268.91083 psf	0 psf	1,000 psf	0 psf	(6)
Slice 4	316.68014 ft	114.41989 ft	358.0357 psf	274.83961 psf	0 psf	0 psf	(3)
Slice 5	318.92919 ft	113.72963 ft	436.3376 psf	327.37389 psf	0 psf	0 psf	(3)
Slice 6	321.17823 ft	113.14962 ft	507.75716 psf	372.79191 psf	0 psf	0 psf	(3)
Slice 7	323.42728 ft	112.67605 ft	572.53133 psf	411.73919 psf	0 psf	0 psf	(3)
Slice 8	325.67633 ft	112.30595 ft	630.84553 psf	444.73432 psf	0 psf	0 psf	(3)
Slice 9	327.92537 ft	112.03708 ft	682.83989 psf	472.19742 psf	0 psf	0 psf	(3)
Slice 10	330.17442 ft	111.86786 ft	728.61363 psf	494.47064 psf	0 psf	0 psf	(3)
Slice 11	332.42346 ft	111.79729 ft	768.22817 psf	511.83321 psf	0 psf	0 psf	(3)
Slice 12	334.67251 ft	111.82497 ft	801.70886 psf	524.51255 psf	0 psf	0 psf	(3)
Slice 13	336.92155 ft	111.95107 ft	829.04578 psf	532.6927 psf	0 psf	0 psf	(3)
Slice 14	339.1706 ft	112.1763 ft	850.19339 psf	536.52053 psf	0 psf	0 psf	(3)
Slice 15	341.41964 ft	112.50199 ft	865.06928 psf	536.11057 psf	0 psf	0 psf	(3)
Slice 16	343.66869 ft	112.9301 ft	873.55161 psf	531.54845 psf	0 psf	0 psf	(3)
Slice 17	345.91773 ft	113.46326 ft	875.47537 psf	522.8935 psf	0 psf	0 psf	(3)
Slice 18	348.16678 ft	114.10489 ft	870.62699 psf	510.18056 psf	0 psf	0 psf	(3)

Slice 19	350.45531 ft	114.87466 ft	858.39748 psf	495.27314 psf	0 psf	0 psf	(3)
Slice 20	352.78334 ft	115.78239 ft	838.17283 psf	477.90597 psf	0 psf	0 psf	(3)
Slice 21	355.11136 ft	116.82432 ft	809.57049 psf	455.99617 psf	0 psf	0 psf	(3)
Slice 22	357.43938 ft	118.00973 ft	772.01069 psf	429.47044 psf	0 psf	0 psf	(3)
Slice 23	359.76741 ft	119.35026 ft	724.76629 psf	398.22543 psf	0 psf	0 psf	(3)
Slice 24	362.09543 ft	120.86068 ft	666.91607 psf	362.12662 psf	0 psf	0 psf	(3)
Slice 25	364.42345 ft	122.55996 ft	597.27489 psf	321.00801 psf	0 psf	0 psf	(3)
Slice 26	366.99268 ft	124.69901 ft	503.95524 psf	236.30344 psf	0 psf	0 psf	(2)
Slice 27	369.80311 ft	127.38031 ft	380.55846 psf	163.30565 psf	0 psf	0 psf	(2)
Slice 28	372.40624 ft	130.25218 ft	242.01996 psf	0 psf	1,000 psf	0 psf	(6)
Slice 29	374.80208 ft	133.35612 ft	85.747088 psf	0 psf	1,000 psf	0 psf	(6)

REPORT F-13
WITH REFERENCE TO SLOPE STABILITY ANALYSIS RESULT PRESENTED IN PLATE E-13
CONDITIONS: GLOBAL SLIDE - SHORT TERM - WATER AT THE BOTTOM OF THE SLOPE
SECTION: C-C WITH SLOPE ABOUT 4H:1V
SOIL PROFILE: BORING NO. 2

Slope Stability Section 2

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File Information

File Version: 11.00
Revision Number: 37
Date: 03/02/2022
Time: 02:40:43 PM
Tool Version: 11.0.1.21429
File Name: 13. G - ST -BOT - CC - Clay Liner.gsz
Directory: H:\2021\450-499\21-S-477 Ravensway Drainage Improvements-HCED\Calculation\Slope Stability\Report 3 on 2-2022\Global Stability\
Last Solved Date: 03/02/2022
Last Solved Time: 02:40:46 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

Slope Stability Section 2

Kind: SLOPE/W
Method: Spencer
Settings
- PWP Conditions from: Piezometric Line
  - Apply Phreatic Correction: No
  - Use Staged Rapid Drawdown: No
- Unit Weight of Water: 62.430189 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 ft
  - Number of Slices: 30
- Factor of Safety Convergence Settings

Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

(1)

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 29.5 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(2)

Model: Mohr-Coulomb
Unit Weight: 138.4 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(3)

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 33 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(4)

Model: Undrained (Phi=0)
Unit Weight: 136.7 pcf
Cohesion: 1,000 psf
Pore Water Pressure
Piezometric Line: 1

(5)

Model: Undrained (Phi=0)

Unit Weight: 142 pcf
Cohesion: 2,000 psf
Pore Water Pressure
Piezometric Line: 1

(6)

Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 1,000 psf
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (200, 110.15) ft
Left-Zone Right Coordinate: (277.5, 110.33) ft
Left-Zone Increment: 8
Right Type: Range
Right-Zone Left Coordinate: (376, 135.03) ft
Right-Zone Right Coordinate: (450, 134) ft
Right-Zone Increment: 8
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (200, 110.15) ft
Right Coordinate: (450, 134) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	200 ft	110.33 ft
Coordinate 2	450 ft	110.33 ft

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf

Direction: Vertical

Coordinates

	X	Y
	376 ft	136.03 ft
	397 ft	135.6 ft

Geometry

Name: 2D Geometry

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	267.5 ft	105.2 ft
Point 2	277.5 ft	105.2 ft
Point 3	376 ft	130.03 ft
Point 4	386 ft	130.03 ft
Point 5	386 ft	134.82394 ft
Point 6	376 ft	135.03 ft
Point 7	277.5 ft	110.33 ft
Point 8	267.50091 ft	110.30555 ft
Point 9	397 ft	134.6 ft
Point 10	402 ft	133.5 ft
Point 11	406 ft	134.5 ft
Point 12	450 ft	134 ft
Point 13	450 ft	132.3 ft
Point 14	386 ft	132.3 ft
Point 15	450 ft	124.3 ft
Point 16	349.2913 ft	123.29724 ft
Point 17	450 ft	111.3 ft
Point 18	301.70191 ft	111.30085 ft
Point 19	450 ft	106.3 ft
Point 20	281.86632 ft	106.30067 ft
Point 21	267.50091 ft	110.3 ft

Point 22	267.5002 ft	106.3 ft
Point 23	200 ft	106.3 ft
Point 24	200 ft	110.15 ft
Point 25	200 ft	84.3 ft
Point 26	450 ft	84.3 ft

Regions

	Material	Points	Area
Region 1	(6)	1,2,20,18,16,3,4,14,5,6,7,8,21,22	599.05 ft²
Region 2	(1)	5,9,10,11,12,13,14	127.88 ft²
Region 3	(2)	14,13,15,16,3,4	682.92 ft²
Region 4	(3)	16,15,17,18	1,544.1 ft²
Region 5	(4)	18,17,19,20	791.1 ft²
Region 6	(4)	22,21,8,24,23	265.13 ft²
Region 7	(5)	1,22,23,25,26,19,20,2	5,486.7 ft²

Slip Results

Slip Surfaces Analysed: 316 of 405 converged

Current Slip Surface

Slip Surface: 372
Factor of Safety: 3.08
Volume: 1,323.2829 ft³
Weight: 169,307.93 lbf
Resisting Moment: 16,319,801 lbf·ft
Activating Moment: 5,292,300.2 lbf·ft
Resisting Force: 111,516.95 lbf
Activating Force: 36,156.553 lbf
Slip Rank: 1 of 405 slip surfaces
Exit: (277.5, 110.33) ft
Entry: (394.55858, 134.6497) ft
Radius: 140.27853 ft
Center: (310.21543, 246.74029) ft

Slip Slices

	X	Y	PWP	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice	279.40696	109.90066	26.803652	0 psf	1,000	0 psf	(6)

1	ft	ft	psf		psf		
Slice 2	283.22087 ft	109.09733 ft	76.955747 psf	0 psf	1,000 psf	0 psf	(6)
Slice 3	287.03479 ft	108.4038 ft	120.25334 psf	0 psf	1,000 psf	0 psf	(6)
Slice 4	291.16895 ft	107.77898 ft	159.26044 psf	0 psf	1,000 psf	0 psf	(4)
Slice 5	295.62337 ft	107.24074 ft	192.8629 psf	0 psf	1,000 psf	0 psf	(4)
Slice 6	299.77624 ft	106.86405 ft	216.37963 psf	0 psf	1,000 psf	0 psf	(4)
Slice 7	303.57595 ft	106.63153 ft	230.89609 psf	0 psf	1,000 psf	0 psf	(4)
Slice 8	307.32404 ft	106.50409 ft	238.85259 psf	0 psf	1,000 psf	0 psf	(4)
Slice 9	311.07213 ft	106.47689 ft	240.55024 psf	0 psf	1,000 psf	0 psf	(4)
Slice 10	314.82021 ft	106.54989 ft	235.9927 psf	0 psf	1,000 psf	0 psf	(4)
Slice 11	318.5683 ft	106.72325 ft	225.17017 psf	0 psf	1,000 psf	0 psf	(4)
Slice 12	322.31639 ft	106.99733 ft	208.05933 psf	0 psf	1,000 psf	0 psf	(4)
Slice 13	326.06448 ft	107.37273 ft	184.62303 psf	0 psf	1,000 psf	0 psf	(4)
Slice 14	329.81256 ft	107.85027 ft	154.80996 psf	0 psf	1,000 psf	0 psf	(4)
Slice 15	333.56065 ft	108.43101 ft	118.55401 psf	0 psf	1,000 psf	0 psf	(4)
Slice 16	337.30874 ft	109.11627 ft	75.773556 psf	0 psf	1,000 psf	0 psf	(4)
Slice 17	341.05682 ft	109.9076 ft	26.370503 psf	0 psf	1,000 psf	0 psf	(4)
Slice 18	344.83619 ft	110.8153 ft	-30.297116 psf	0 psf	1,000 psf	0 psf	(4)
Slice 19	348.01641 ft	111.65735 ft	-82.86678 psf	1,238.5135 psf	0 psf	0 psf	(3)
Slice	351.19906	112.59697	-141.52754	1,219.8792	0 psf	0 psf	(3)

20	ft	ft	psf	psf			
Slice 21	355.01459 ft	113.82284 ft	-218.05852 psf	1,193.2522 psf	0 psf	0 psf	(3)
Slice 22	358.83012 ft	115.17076 ft	-302.20927 psf	1,157.8953 psf	0 psf	0 psf	(3)
Slice 23	362.64565 ft	116.64452 ft	-394.21688 psf	1,113.8191 psf	0 psf	0 psf	(3)
Slice 24	366.46118 ft	118.24848 ft	-494.35202 psf	1,061.015 psf	0 psf	0 psf	(3)
Slice 25	370.27671 ft	119.98756 ft	-602.92357 psf	999.45661 psf	0 psf	0 psf	(3)
Slice 26	374.09224 ft	121.86744 ft	-720.28448 psf	929.09906 psf	0 psf	0 psf	(3)
Slice 27	376.68155 ft	123.21004 ft	-804.10328 psf	1,001.6049 psf	0 psf	0 psf	(3)
Slice 28	379.52233 ft	124.80403 ft	-903.61612 psf	778.75154 psf	0 psf	0 psf	(2)
Slice 29	383.84078 ft	127.36299 ft	-1,063.3727 psf	590.72179 psf	0 psf	0 psf	(2)
Slice 30	388.6709 ft	130.49734 ft	-1,259.0508 psf	371.39979 psf	0 psf	0 psf	(2)
Slice 31	392.95019 ft	133.47485 ft	-1,444.9374 psf	177.89022 psf	0 psf	0 psf	(1)

REPORT F-14
WITH REFERENCE TO SLOPE STABILITY ANALYSIS RESULT PRESENTED IN PLATE E-14
CONDITIONS: LOCAL SLIDE - SHORT TERM - WATER AT THE BOTTOM OF THE SLOPE
SECTION: C-C WITH SLOPE ABOUT 4H:1V
SOIL PROFILE: BORING NO. 2

Slope Stability Section 2

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File Information

File Version: 11.00
Revision Number: 40
Date: 03/02/2022
Time: 02:58:05 PM
Tool Version: 11.0.1.21429
File Name: 14. L - ST -BOT - CC - Clay Liner.gsz
Directory: H:\2021\450-499\21-S-477 Ravensway Drainage Improvements-HCED\Calculation\Slope Stability\Report 3 on 2-2022\Local Stability\
Last Solved Date: 03/02/2022
Last Solved Time: 02:58:08 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

Slope Stability Section 2

Kind: SLOPE/W
Method: Spencer
Settings
- PWP Conditions from: Piezometric Line
  - Apply Phreatic Correction: No
  - Use Staged Rapid Drawdown: No
- Unit Weight of Water: 62.430189 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 ft
  - Number of Slices: 30
- Factor of Safety Convergence Settings

Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

(1)

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 29.5 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(2)

Model: Mohr-Coulomb
Unit Weight: 138.4 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(3)

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 33 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(4)

Model: Undrained (Phi=0)
Unit Weight: 136.7 pcf
Cohesion: 1,000 psf
Pore Water Pressure
Piezometric Line: 1

(5)

Model: Undrained (Phi=0)

Unit Weight: 142 pcf
Cohesion: 2,000 psf
Pore Water Pressure
Piezometric Line: 1

(6)

Model: Undrained (Phi=0)
Unit Weight: 125 pcf
Cohesion: 1,000 psf
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (277.5, 110.33) ft
Left-Zone Right Coordinate: (326.75, 122.68) ft
Left-Zone Increment: 8
Right Type: Range
Right-Zone Left Coordinate: (326.75, 122.68) ft
Right-Zone Right Coordinate: (376, 135.03) ft
Right-Zone Increment: 8
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (200, 110.15) ft
Right Coordinate: (450, 134) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	200 ft	110.33 ft
Coordinate 2	450 ft	110.33 ft

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf

Direction: Vertical

Coordinates

	X	Y
	376 ft	136.03 ft
	397 ft	135.6 ft

Geometry

Name: 2D Geometry

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	267.5 ft	105.2 ft
Point 2	277.5 ft	105.2 ft
Point 3	376 ft	130.03 ft
Point 4	386 ft	130.03 ft
Point 5	386 ft	134.82394 ft
Point 6	376 ft	135.03 ft
Point 7	277.5 ft	110.33 ft
Point 8	267.50091 ft	110.30555 ft
Point 9	397 ft	134.6 ft
Point 10	402 ft	133.5 ft
Point 11	406 ft	134.5 ft
Point 12	450 ft	134 ft
Point 13	450 ft	132.3 ft
Point 14	386 ft	132.3 ft
Point 15	450 ft	124.3 ft
Point 16	349.2913 ft	123.29724 ft
Point 17	450 ft	111.3 ft
Point 18	301.70191 ft	111.30085 ft
Point 19	450 ft	106.3 ft
Point 20	281.86632 ft	106.30067 ft
Point 21	267.50091 ft	110.3 ft

Point 22	267.5002 ft	106.3 ft
Point 23	200 ft	106.3 ft
Point 24	200 ft	110.15 ft
Point 25	200 ft	84.3 ft
Point 26	450 ft	84.3 ft

Regions

	Material	Points	Area
Region 1	(6)	1,2,20,18,16,3,4,14,5,6,7,8,21,22	599.05 ft²
Region 2	(1)	5,9,10,11,12,13,14	127.88 ft²
Region 3	(2)	14,13,15,16,3,4	682.92 ft²
Region 4	(3)	16,15,17,18	1,544.1 ft²
Region 5	(4)	18,17,19,20	791.1 ft²
Region 6	(4)	22,21,8,24,23	265.13 ft²
Region 7	(5)	1,22,23,25,26,19,20,2	5,486.7 ft²

Slip Results

Slip Surfaces Analysed: 333 of 405 converged

Current Slip Surface

Slip Surface: 178
Factor of Safety: 3.56
Volume: 910.44458 ft³
Weight: 115,645.78 lbf
Resisting Moment: 5,141,467.1 lbf·ft
Activating Moment: 1,442,936.6 lbf·ft
Resisting Force: 75,638.533 lbf
Activating Force: 21,230.773 lbf
Slip Rank: 1 of 405 slip surfaces
Exit: (295.96875, 114.96125) ft
Entry: (376, 135.03) ft
Radius: 60.923613 ft
Center: (325.08029, 168.47952) ft

Slip Slices

	X	Y	PWP	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice	297.15882	114.34741	-250.80749	0 psf	1,000	0 psf	(6)

1	ft	ft	psf		psf		
Slice 2	299.53897 ft	113.18386 ft	-178.16724 psf	0 psf	1,000 psf	0 psf	(6)
Slice 3	301.91912 ft	112.14488 ft	-113.30338 psf	0 psf	1,000 psf	0 psf	(6)
Slice 4	303.57945 ft	111.47822 ft	-71.683468 psf	514.74577 psf	0 psf	0 psf	(3)
Slice 5	305.47764 ft	110.81542 ft	-30.304754 psf	0 psf	1,000 psf	0 psf	(4)
Slice 6	308.20377 ft	109.95564 ft	23.371382 psf	0 psf	1,000 psf	0 psf	(4)
Slice 7	310.80015 ft	109.26819 ft	66.288949 psf	0 psf	1,000 psf	0 psf	(4)
Slice 8	313.39654 ft	108.70137 ft	101.67583 psf	0 psf	1,000 psf	0 psf	(4)
Slice 9	315.99293 ft	108.25176 ft	129.74508 psf	0 psf	1,000 psf	0 psf	(4)
Slice 10	318.58932 ft	107.91674 ft	150.66002 psf	0 psf	1,000 psf	0 psf	(4)
Slice 11	321.18571 ft	107.69443 ft	164.53915 psf	0 psf	1,000 psf	0 psf	(4)
Slice 12	323.7821 ft	107.58358 ft	171.45968 psf	0 psf	1,000 psf	0 psf	(4)
Slice 13	326.37849 ft	107.58358 ft	171.45968 psf	0 psf	1,000 psf	0 psf	(4)
Slice 14	328.97488 ft	107.69443 ft	164.53915 psf	0 psf	1,000 psf	0 psf	(4)
Slice 15	331.57126 ft	107.91674 ft	150.66002 psf	0 psf	1,000 psf	0 psf	(4)
Slice 16	334.16765 ft	108.25176 ft	129.74508 psf	0 psf	1,000 psf	0 psf	(4)
Slice 17	336.76404 ft	108.70137 ft	101.67583 psf	0 psf	1,000 psf	0 psf	(4)
Slice 18	339.36043 ft	109.26819 ft	66.288949 psf	0 psf	1,000 psf	0 psf	(4)
Slice 19	341.95682 ft	109.95564 ft	23.371382 psf	0 psf	1,000 psf	0 psf	(4)
Slice	344.68262	110.8153 ft	-30.297229	0 psf	1,000	0 psf	(4)

20	ft		psf		psf		
Slice 21	347.70076 ft	111.93691 ft	-100.31958 psf	1,175.7494 psf	0 psf	0 psf	(3)
Slice 22	350.69483 ft	113.22384 ft	-180.66326 psf	1,117.9983 psf	0 psf	0 psf	(3)
Slice 23	353.50188 ft	114.61504 ft	-267.51575 psf	1,054.0387 psf	0 psf	0 psf	(3)
Slice 24	356.30893 ft	116.19389 ft	-366.08389 psf	977.80783 psf	0 psf	0 psf	(3)
Slice 25	359.11598 ft	117.97809 ft	-477.47163 psf	888.7794 psf	0 psf	0 psf	(3)
Slice 26	361.92303 ft	119.99042 ft	-603.10194 psf	786.2878 psf	0 psf	0 psf	(3)
Slice 27	364.73008 ft	122.26089 ft	-744.84774 psf	669.50242 psf	0 psf	0 psf	(3)
Slice 28	367.44088 ft	124.73073 ft	-899.04051 psf	481.06829 psf	0 psf	0 psf	(2)
Slice 29	370.05543 ft	127.42878 ft	-1,067.4799 psf	342.44665 psf	0 psf	0 psf	(2)
Slice 30	372.52203 ft	130.30166 ft	-1,246.8345 psf	0 psf	1,000 psf	0 psf	(6)
Slice 31	374.84068 ft	133.38615 ft	-1,439.3996 psf	0 psf	1,000 psf	0 psf	(6)

REPORT F-15
WITH REFERENCE TO SLOPE STABILITY ANALYSIS RESULT PRESENTED IN PLATE E-15
CONDITIONS: GLOBAL SLIDE - LONG TERM
SECTION: C-C WITH SLOPE ABOUT 4H:1V
SOIL PROFILE: BORING NO. 2

Slope Stability Section 2

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File Information

File Version: 11.00
Revision Number: 38
Date: 03/02/2022
Time: 02:42:20 PM
Tool Version: 11.0.1.21429
File Name: 15. G - LT -PZW - CC - Clay Liner.gsz
Directory: H:\2021\450-499\21-S-477 Ravensway Drainage Improvements-HCED\Calculation\Slope Stability\Report 3 on 2-2022\Global Stability\
Last Solved Date: 03/02/2022
Last Solved Time: 02:42:23 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

Slope Stability Section 2

Kind: SLOPE/W
Method: Spencer
Settings
- PWP Conditions from: Piezometric Line
  - Apply Phreatic Correction: No
  - Use Staged Rapid Drawdown: No
- Unit Weight of Water: 62.430189 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 ft
  - Number of Slices: 30
- Factor of Safety Convergence Settings

Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

(1)

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 29.5 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(2)

Model: Mohr-Coulomb
Unit Weight: 138.4 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(3)

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 33 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(4)

Model: Mohr-Coulomb
Unit Weight: 136.7 pcf
Effective Cohesion: 330 psf
Effective Friction Angle: 25 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(5)

Model: Mohr-Coulomb
Unit Weight: 142 pcf
Effective Cohesion: 280 psf
Effective Friction Angle: 23 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(6)

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effective Cohesion: 270 psf
Effective Friction Angle: 24 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (200, 110.15) ft
Left-Zone Right Coordinate: (277.5, 110.33) ft
Left-Zone Increment: 8
Right Type: Range
Right-Zone Left Coordinate: (376, 135.03) ft
Right-Zone Right Coordinate: (450, 134) ft
Right-Zone Increment: 8
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (200, 110.15) ft
Right Coordinate: (450, 134) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	200 ft	110.15 ft
Coordinate 2	277.5 ft	110.33 ft

Coordinate 3	294.94 ft	114.7 ft
Coordinate 4	450 ft	114.7 ft

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X	Y
	376 ft	136.03 ft
	397 ft	135.6 ft

Geometry

Name: 2D Geometry

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	267.5 ft	105.2 ft
Point 2	277.5 ft	105.2 ft
Point 3	376 ft	130.03 ft
Point 4	386 ft	130.03 ft
Point 5	386 ft	134.82394 ft
Point 6	376 ft	135.03 ft
Point 7	277.5 ft	110.33 ft
Point 8	267.50091 ft	110.30555 ft
Point 9	397 ft	134.6 ft
Point 10	402 ft	133.5 ft
Point 11	406 ft	134.5 ft
Point 12	450 ft	134 ft
Point 13	450 ft	132.3 ft
Point 14	386 ft	132.3 ft

Point 15	450 ft	124.3 ft
Point 16	349.2913 ft	123.29724 ft
Point 17	450 ft	111.3 ft
Point 18	301.70191 ft	111.30085 ft
Point 19	450 ft	106.3 ft
Point 20	281.86632 ft	106.30067 ft
Point 21	267.50091 ft	110.3 ft
Point 22	267.5002 ft	106.3 ft
Point 23	200 ft	106.3 ft
Point 24	200 ft	110.15 ft
Point 25	200 ft	84.3 ft
Point 26	450 ft	84.3 ft

Regions

	Material	Points	Area
Region 1	(6)	1,2,20,18,16,3,4,14,5,6,7,8,21,22	599.05 ft²
Region 2	(1)	5,9,10,11,12,13,14	127.88 ft²
Region 3	(2)	14,13,15,16,3,4	682.92 ft²
Region 4	(3)	16,15,17,18	1,544.1 ft²
Region 5	(4)	18,17,19,20	791.1 ft²
Region 6	(4)	22,21,8,24,23	265.13 ft²
Region 7	(5)	1,22,23,25,26,19,20,2	5,486.7 ft²

Slip Results

Slip Surfaces Analysed: 330 of 405 converged

Current Slip Surface

Slip Surface: 323
Factor of Safety: 2.37
Volume: 2,016.7077 ft³
Weight: 265,697.89 lbf
Resisting Moment: 10,646,290 lbf·ft
Activating Moment: 4,500,908.2 lbf·ft
Resisting Force: 112,061.51 lbf
Activating Force: 47,374.272 lbf
Slip Rank: 1 of 405 slip surfaces
Exit: (267.8125, 110.30631) ft
Entry: (385.27927, 134.83879) ft

Radius: 86.017094 ft
Center: (313.94552, 182.90579) ft

Slip Slices

	X	Y	PWP	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	270.12367 ft	108.93709 ft	85.890184 psf	109.84344 psf	270 psf	0 psf	(6)
Slice 2	274.74601 ft	106.38393 ft	245.95443 psf	200.43705 psf	270 psf	0 psf	(6)
Slice 3	277.27859 ft	105.09566 ft	326.74851 psf	231.89887 psf	280 psf	0 psf	(5)
Slice 4	279.68316 ft	104.04284 ft	426.6603 psf	295.63739 psf	280 psf	0 psf	(5)
Slice 5	284.04527 ft	102.28623 ft	604.56394 psf	401.4726 psf	280 psf	0 psf	(5)
Slice 6	288.40316 ft	100.80025 ft	765.50611 psf	488.17055 psf	280 psf	0 psf	(5)
Slice 7	292.76105 ft	99.568504 ft	910.57615 psf	559.78015 psf	280 psf	0 psf	(5)
Slice 8	296.63048 ft	98.667139 ft	1,000.9345 psf	624.73534 psf	280 psf	0 psf	(5)
Slice 9	300.01143 ft	98.0421 ft	1,039.9559 psf	686.61092 psf	280 psf	0 psf	(5)
Slice 10	303.9493 ft	97.501486 ft	1,073.7065 psf	746.25346 psf	280 psf	0 psf	(5)
Slice 11	308.44408 ft	97.094356 ft	1,099.1237 psf	801.63051 psf	280 psf	0 psf	(5)
Slice 12	312.93887 ft	96.923962 ft	1,109.7614 psf	846.51102 psf	280 psf	0 psf	(5)
Slice 13	317.08098 ft	96.966778 ft	1,107.0884 psf	879.4483 psf	280 psf	0 psf	(5)
Slice 14	320.87043 ft	97.188978 ft	1,093.2164 psf	902.3544 psf	280 psf	0 psf	(5)
Slice 15	324.65988 ft	97.57997 ft	1,068.8067 psf	918.8781 psf	280 psf	0 psf	(5)
Slice 16	328.44933 ft	98.142094 ft	1,033.7132 psf	929.22135 psf	280 psf	0 psf	(5)

Slice 17	332.23878 ft	98.878793 ft	987.72094 psf	933.5411 psf	280 psf	0 psf	(5)
Slice 18	336.02823 ft	99.794718 ft	930.53957 psf	931.95417 psf	280 psf	0 psf	(5)
Slice 19	339.81768 ft	100.89589 ft	861.79329 psf	924.54084 psf	280 psf	0 psf	(5)
Slice 20	343.60713 ft	102.18991 ft	781.00759 psf	911.34751 psf	280 psf	0 psf	(5)
Slice 21	347.39658 ft	103.68624 ft	687.59091 psf	892.38865 psf	280 psf	0 psf	(5)
Slice 22	351.17954 ft	105.39335 ft	581.01619 psf	869.97971 psf	280 psf	0 psf	(5)
Slice 23	355.20261 ft	107.46792 ft	451.49995 psf	919.09662 psf	330 psf	0 psf	(4)
Slice 24	359.47225 ft	109.96798 ft	295.42073 psf	882.12318 psf	330 psf	0 psf	(4)
Slice 25	363.98178 ft	113.00025 ft	106.11551 psf	1,171.6462 psf	0 psf	0 psf	(3)
Slice 26	368.76737 ft	116.69622 ft	-124.62423 psf	1,040.1222 psf	0 psf	0 psf	(3)
Slice 27	373.58912 ft	121.0158 ft	-394.29689 psf	819.4424 psf	0 psf	0 psf	(3)
Slice 28	378.8958 ft	126.68459 ft	-748.20006 psf	530.22308 psf	0 psf	0 psf	(2)
Slice 29	383.53544 ft	132.4344 ft	-1,107.1617 psf	126.2326 psf	270 psf	0 psf	(6)

REPORT F-16
WITH REFERENCE TO SLOPE STABILITY ANALYSIS RESULT PRESENTED IN PLATE E-16
CONDITIONS: LOCAL SLIDE - LONG TERM
SECTION: C-C WITH SLOPE ABOUT 4H:1V
SOIL PROFILE: BORING NO. 2

Slope Stability Section 2

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File Information

File Version: 11.00
Revision Number: 40
Date: 03/02/2022
Time: 03:01:00 PM
Tool Version: 11.0.1.21429
File Name: 16. L - LT -PZW - CC - Clay Liner.gsz
Directory: H:\2021\450-499\21-S-477 Ravensway Drainage Improvements-HCED\Calculation\Slope Stability\Report 3 on 2-2022\Local Stability\
Last Solved Date: 03/02/2022
Last Solved Time: 03:01:02 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

Slope Stability Section 2

Kind: SLOPE/W
Method: Spencer
Settings
- PWP Conditions from: Piezometric Line
  - Apply Phreatic Correction: No
  - Use Staged Rapid Drawdown: No
- Unit Weight of Water: 62.430189 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 ft
  - Number of Slices: 30
- Factor of Safety Convergence Settings

Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

(1)

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 29.5 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(2)

Model: Mohr-Coulomb
Unit Weight: 138.4 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(3)

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 33 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(4)

Model: Mohr-Coulomb
Unit Weight: 136.7 pcf
Effective Cohesion: 330 psf
Effective Friction Angle: 25 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(5)

Model: Mohr-Coulomb
Unit Weight: 142 pcf
Effective Cohesion: 280 psf
Effective Friction Angle: 23 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(6)

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effective Cohesion: 270 psf
Effective Friction Angle: 24 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (277.5, 110.33) ft
Left-Zone Right Coordinate: (326.75, 122.68) ft
Left-Zone Increment: 8
Right Type: Range
Right-Zone Left Coordinate: (326.75, 122.68) ft
Right-Zone Right Coordinate: (376, 135.03) ft
Right-Zone Increment: 8
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (200, 110.15) ft
Right Coordinate: (450, 134) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	200 ft	110.15 ft
Coordinate 2	277.5 ft	110.33 ft

Coordinate 3	294.94 ft	114.7 ft
Coordinate 4	450 ft	114.7 ft

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X	Y
	376 ft	136.03 ft
	397 ft	135.6 ft

Geometry

Name: 2D Geometry

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	267.5 ft	105.2 ft
Point 2	277.5 ft	105.2 ft
Point 3	376 ft	130.03 ft
Point 4	386 ft	130.03 ft
Point 5	386 ft	134.82394 ft
Point 6	376 ft	135.03 ft
Point 7	277.5 ft	110.33 ft
Point 8	267.50091 ft	110.30555 ft
Point 9	397 ft	134.6 ft
Point 10	402 ft	133.5 ft
Point 11	406 ft	134.5 ft
Point 12	450 ft	134 ft
Point 13	450 ft	132.3 ft
Point 14	386 ft	132.3 ft

Point 15	450 ft	124.3 ft
Point 16	349.2913 ft	123.29724 ft
Point 17	450 ft	111.3 ft
Point 18	301.70191 ft	111.30085 ft
Point 19	450 ft	106.3 ft
Point 20	281.86632 ft	106.30067 ft
Point 21	267.50091 ft	110.3 ft
Point 22	267.5002 ft	106.3 ft
Point 23	200 ft	106.3 ft
Point 24	200 ft	110.15 ft
Point 25	200 ft	84.3 ft
Point 26	450 ft	84.3 ft

Regions

	Material	Points	Area
Region 1	(6)	1,2,20,18,16,3,4,14,5,6,7,8,21,22	599.05 ft^2
Region 2	(1)	5,9,10,11,12,13,14	127.88 ft^2
Region 3	(2)	14,13,15,16,3,4	682.92 ft^2
Region 4	(3)	16,15,17,18	1,544.1 ft^2
Region 5	(4)	18,17,19,20	791.1 ft^2
Region 6	(4)	22,21,8,24,23	265.13 ft^2
Region 7	(5)	1,22,23,25,26,19,20,2	5,486.7 ft^2

Slip Results

Slip Surfaces Analysed: 387 of 405 converged

Current Slip Surface

Slip Surface: 43
Factor of Safety: 2.50
Volume: 1,378.6902 ft^3
Weight: 179,255.36 lbf
Resisting Moment: 6,733,026.6 lbf·ft
Activating Moment: 2,693,683.8 lbf·ft
Resisting Force: 81,693.479 lbf
Activating Force: 32,682.361 lbf
Slip Rank: 1 of 405 slip surfaces
Exit: (277.5, 110.33) ft
Entry: (376, 135.03) ft

Radius: 74.982909 ft
Center: (313.32959, 176.19863) ft

Slip Slices

	X	Y	PWP	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	279.25558 ft	109.43402 ft	83.399086 psf	95.904124 psf	270 psf	0 psf	(6)
Slice 2	282.76673 ft	107.75412 ft	243.20192 psf	185.31113 psf	270 psf	0 psf	(6)
Slice 3	285.35476 ft	106.63542 ft	353.5278 psf	267.61091 psf	330 psf	0 psf	(4)
Slice 4	287.64601 ft	105.76868 ft	443.48189 psf	286.32632 psf	280 psf	0 psf	(5)
Slice 5	290.56361 ft	104.77173 ft	551.36213 psf	346.11761 psf	280 psf	0 psf	(5)
Slice 6	293.4812 ft	103.90625 ft	651.03567 psf	397.88162 psf	280 psf	0 psf	(5)
Slice 7	296.63048 ft	103.11944 ft	722.97681 psf	457.57276 psf	280 psf	0 psf	(5)
Slice 8	300.01143 ft	102.42796 ft	766.14577 psf	524.2711 psf	280 psf	0 psf	(5)
Slice 9	303.38745 ft	101.89723 ft	799.27929 psf	580.13719 psf	280 psf	0 psf	(5)
Slice 10	306.75854 ft	101.52337 ft	822.61937 psf	625.99047 psf	280 psf	0 psf	(5)
Slice 11	310.12963 ft	101.30304 ft	836.37495 psf	664.79387 psf	280 psf	0 psf	(5)
Slice 12	313.50071 ft	101.23487 ft	840.63072 psf	696.97862 psf	280 psf	0 psf	(5)
Slice 13	316.76658 ft	101.31125 ft	835.86247 psf	722.25825 psf	280 psf	0 psf	(5)
Slice 14	319.92722 ft	101.5234 ft	822.61775 psf	741.29264 psf	280 psf	0 psf	(5)
Slice 15	323.08787 ft	101.8705 ft	800.94836 psf	755.25688 psf	280 psf	0 psf	(5)
Slice 16	326.24851 ft	102.35445 ft	770.73528 psf	764.3072 psf	280 psf	0 psf	(5)

Slice 17	329.40916 ft	102.97797 ft	731.8088 psf	768.56748 psf	280 psf	0 psf	(5)
Slice 18	332.5698 ft	103.74467 ft	683.94349 psf	768.13274 psf	280 psf	0 psf	(5)
Slice 19	335.73045 ft	104.65916 ft	626.85136 psf	763.07182 psf	280 psf	0 psf	(5)
Slice 20	338.89109 ft	105.72722 ft	560.17238 psf	753.42955 psf	280 psf	0 psf	(5)
Slice 21	341.94139 ft	106.90742 ft	486.49207 psf	809.60022 psf	330 psf	0 psf	(4)
Slice 22	344.88136 ft	108.19645 ft	406.01766 psf	792.65927 psf	330 psf	0 psf	(4)
Slice 23	347.82132 ft	109.64027 ft	315.88004 psf	771.62648 psf	330 psf	0 psf	(4)
Slice 24	350.08994 ft	110.8513 ft	240.27488 psf	754.06159 psf	330 psf	0 psf	(4)
Slice 25	352.22367 ft	112.11082 ft	161.64312 psf	1,033.9849 psf	0 psf	0 psf	(3)
Slice 26	354.89385 ft	113.81053 ft	55.529528 psf	1,010.6723 psf	0 psf	0 psf	(3)
Slice 27	357.96432 ft	115.98642 ft	-80.31122 psf	931.88712 psf	0 psf	0 psf	(3)
Slice 28	361.43507 ft	118.72535 ft	-251.30348 psf	792.86848 psf	0 psf	0 psf	(3)
Slice 29	364.90582 ft	121.82393 ft	-444.74843 psf	637.98707 psf	0 psf	0 psf	(3)
Slice 30	369.07636 ft	126.18427 ft	-716.96496 psf	371.18077 psf	0 psf	0 psf	(2)
Slice 31	373.75576 ft	131.96427 ft	-1,077.8117 psf	56.34739 psf	270 psf	0 psf	(6)

REPORT F-17
WITH REFERENCE TO SLOPE STABILITY ANALYSIS RESULT PRESENTED IN PLATE E-17
CONDITIONS: GLOBAL SLIDE - RAPID DRAWDOWN WITH EFFECTIVE SOIL PARAMETERS
SECTION: A-A WITH SLOPE ABOUT 4H:1V
SOIL PROFILE: BORING NO. 2

Slope Stability Section 2

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File Information

File Version: 11.00
Revision Number: 41
Date: 03/02/2022
Time: 02:44:08 PM
Tool Version: 11.0.1.21429
File Name: 17. G - RD -EF - CC - Clay Liner.gsz
Directory: H:\2021\450-499\21-S-477 Ravensway Drainage Improvements-HCED\Calculation\Slope Stability\Report 3 on 2-2022\Global Stability\
Last Solved Date: 03/02/2022
Last Solved Time: 02:44:10 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

Slope Stability Section 2

Kind: SLOPE/W
Method: Spencer
Settings
- PWP Conditions from: Piezometric Line
  - Apply Phreatic Correction: No
  - Use Staged Rapid Drawdown: No
- Unit Weight of Water: 62.430189 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 ft
  - Number of Slices: 30
- Factor of Safety Convergence Settings

Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

(1)

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 29.5 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(2)

Model: Mohr-Coulomb
Unit Weight: 138.4 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(3)

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 33 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(4)

Model: Mohr-Coulomb
Unit Weight: 136.7 pcf
Effective Cohesion: 330 psf
Effective Friction Angle: 25 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(5)

Model: Mohr-Coulomb
Unit Weight: 142 pcf
Effective Cohesion: 280 psf
Effective Friction Angle: 23 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(6)

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effective Cohesion: 270 psf
Effective Friction Angle: 24 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (200, 110.15) ft
Left-Zone Right Coordinate: (277.5, 110.33) ft
Left-Zone Increment: 8
Right Type: Range
Right-Zone Left Coordinate: (376, 135.03) ft
Right-Zone Right Coordinate: (450, 134) ft
Right-Zone Increment: 8
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (200, 110.15) ft
Right Coordinate: (450, 134) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	200 ft	110.15 ft
Coordinate 2	277.5 ft	110.33 ft

Coordinate 3	376 ft	135.03 ft
Coordinate 4	397 ft	134.6 ft
Coordinate 5	402 ft	133.5 ft
Coordinate 6	406 ft	134.5 ft
Coordinate 7	450 ft	134 ft

Geometry

Name: 2D Geometry

Settings

View: 2D

Element Thickness: 1 ft

Points

	X	Y
Point 1	267.5 ft	105.2 ft
Point 2	277.5 ft	105.2 ft
Point 3	376 ft	130.03 ft
Point 4	386 ft	130.03 ft
Point 5	386 ft	134.82394 ft
Point 6	376 ft	135.03 ft
Point 7	277.5 ft	110.33 ft
Point 8	267.50091 ft	110.30555 ft
Point 9	397 ft	134.6 ft
Point 10	402 ft	133.5 ft
Point 11	406 ft	134.5 ft
Point 12	450 ft	134 ft
Point 13	450 ft	132.3 ft
Point 14	386 ft	132.3 ft
Point 15	450 ft	124.3 ft
Point 16	349.2913 ft	123.29724 ft
Point 17	450 ft	111.3 ft
Point 18	301.70191 ft	111.30085 ft
Point 19	450 ft	106.3 ft
Point 20	281.86632 ft	106.30067 ft
Point 21	267.50091 ft	110.3 ft
Point 22	267.5002 ft	106.3 ft

Point 23	200 ft	106.3 ft
Point 24	200 ft	110.15 ft
Point 25	200 ft	84.3 ft
Point 26	450 ft	84.3 ft

Regions

	Material	Points	Area
Region 1	(6)	1,2,20,18,16,3,4,14,5,6,7,8,21,22	599.05 ft²
Region 2	(1)	5,9,10,11,12,13,14	127.88 ft²
Region 3	(2)	14,13,15,16,3,4	682.92 ft²
Region 4	(3)	16,15,17,18	1,544.1 ft²
Region 5	(4)	18,17,19,20	791.1 ft²
Region 6	(4)	22,21,8,24,23	265.13 ft²
Region 7	(5)	1,22,23,25,26,19,20,2	5,486.7 ft²

Slip Results

Slip Surfaces Analysed: 332 of 405 converged

Current Slip Surface

Slip Surface: 368
Factor of Safety: 1.85
Volume: 1,797.7601 ft³
Weight: 235,406.22 lbf
Resisting Moment: 6,725,799.2 lbf·ft
Activating Moment: 3,636,859.4 lbf·ft
Resisting Force: 77,737.95 lbf
Activating Force: 42,033.287 lbf
Slip Rank: 1 of 405 slip surfaces
Exit: (277.5, 110.33) ft
Entry: (385.27927, 134.83879) ft
Radius: 80.270754 ft
Center: (318.48092, 179.35143) ft

Slip Slices

	X	Y	PWP	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	279.13368 ft	109.41092 ft	82.953441 psf	125.3241 psf	270 psf	0 psf	(6)

Slice 2	282.40103 ft	107.66956 ft	242.81757 psf	220.73144 psf	270 psf	0 psf	(6)
Slice 3	284.62217 ft	106.57397 ft	345.98798 psf	310.12745 psf	330 psf	0 psf	(4)
Slice 4	286.85887 ft	105.59359 ft	442.20899 psf	326.22285 psf	280 psf	0 psf	(5)
Slice 5	290.15732 ft	104.26441 ft	576.82725 psf	404.85065 psf	280 psf	0 psf	(5)
Slice 6	293.45577 ft	103.10103 ft	701.09468 psf	471.85745 psf	280 psf	0 psf	(5)
Slice 7	296.75423 ft	102.09595 ft	815.47999 psf	528.69528 psf	280 psf	0 psf	(5)
Slice 8	300.05268 ft	101.24303 ft	920.36551 psf	576.5022 psf	280 psf	0 psf	(5)
Slice 9	303.53227 ft	100.50689 ft	1,020.7958 psf	615.37463 psf	280 psf	0 psf	(5)
Slice 10	307.19299 ft	99.899818 ft	1,116.0045 psf	645.31636 psf	280 psf	0 psf	(5)
Slice 11	310.85372 ft	99.465018 ft	1,200.4581 psf	667.1987 psf	280 psf	0 psf	(5)
Slice 12	314.51444 ft	99.199683 ft	1,274.3319 psf	681.64693 psf	280 psf	0 psf	(5)
Slice 13	318.17516 ft	99.10213 ft	1,337.7311 psf	689.16911 psf	280 psf	0 psf	(5)
Slice 14	321.83588 ft	99.171744 ft	1,390.694 psf	690.18021 psf	280 psf	0 psf	(5)
Slice 15	325.4966 ft	99.408962 ft	1,433.1933 psf	685.01983 psf	280 psf	0 psf	(5)
Slice 16	329.15733 ft	99.815289 ft	1,465.1352 psf	673.96564 psf	280 psf	0 psf	(5)
Slice 17	332.81805 ft	100.39334 ft	1,486.3563 psf	657.24358 psf	280 psf	0 psf	(5)
Slice 18	336.47877 ft	101.14693 ft	1,496.6183 psf	635.03578 psf	280 psf	0 psf	(5)
Slice 19	340.13949 ft	102.08121 ft	1,495.6 psf	607.48677 psf	280 psf	0 psf	(5)
Slice 20	343.80022 ft	103.20285 ft	1,482.8849 psf	574.70857 psf	280 psf	0 psf	(5)

Slice 21	347.46094 ft	104.52029 ft	1,457.9458 psf	536.78502 psf	280 psf	0 psf	(5)
Slice 22	350.52146 ft	105.76476 ft	1,428.1657 psf	503.10475 psf	280 psf	0 psf	(5)
Slice 23	353.30202 ft	107.04705 ft	1,391.6423 psf	512.59368 psf	330 psf	0 psf	(4)
Slice 24	356.40281 ft	108.62499 ft	1,341.6743 psf	471.88085 psf	330 psf	0 psf	(4)
Slice 25	359.5036 ft	110.37839 ft	1,280.7521 psf	427.35803 psf	330 psf	0 psf	(4)
Slice 26	362.92224 ft	112.54329 ft	1,199.1165 psf	551.36157 psf	0 psf	0 psf	(3)
Slice 27	366.65875 ft	115.18888 ft	1,092.4469 psf	484.32922 psf	0 psf	0 psf	(3)
Slice 28	370.39525 ft	118.17715 ft	964.38397 psf	411.90951 psf	0 psf	0 psf	(3)
Slice 29	374.13175 ft	121.5617 ft	811.58069 psf	334.47761 psf	0 psf	0 psf	(3)
Slice 30	376.09911 ft	123.46298 ft	722.00456 psf	292.77043 psf	0 psf	0 psf	(3)
Slice 31	377.60159 ft	125.09433 ft	618.23841 psf	217.64256 psf	0 psf	0 psf	(2)
Slice 32	380.40835 ft	128.32675 ft	412.84964 psf	127.97595 psf	0 psf	0 psf	(2)
Slice 33	383.5455 ft	132.4344 ft	152.39841 psf	-17.863172 psf	270 psf	0 psf	(6)

REPORT F-18
WITH REFERENCE TO SLOPE STABILITY ANALYSIS RESULT PRESENTED IN PLATE E-18
CONDITIONS: LOCAL SLIDE - RAPID DRAWDOWN WITH EFFECTIVE SOIL PARAMETERS
SECTION: A-A WITH SLOPE ABOUT 4H:1V
SOIL PROFILE: BORING NO. 2

Slope Stability Section 2

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File Information

File Version: 11.00
Revision Number: 43
Date: 03/02/2022
Time: 03:02:20 PM
Tool Version: 11.0.1.21429
File Name: 18. L - RD -EF - CC - Clay Liner.gsz
Directory: H:\2021\450-499\21-S-477 Ravensway Drainage Improvements-HCED\Calculation\Slope Stability\Report 3 on 2-2022\Local Stability\
Last Solved Date: 03/02/2022
Last Solved Time: 03:02:23 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

Slope Stability Section 2

Kind: SLOPE/W
Method: Spencer
Settings
- PWP Conditions from: Piezometric Line
  - Apply Phreatic Correction: No
  - Use Staged Rapid Drawdown: No
- Unit Weight of Water: 62.430189 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 ft
  - Number of Slices: 30
- Factor of Safety Convergence Settings

Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

(1)

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 29.5 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(2)

Model: Mohr-Coulomb
Unit Weight: 138.4 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(3)

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 33 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(4)

Model: Mohr-Coulomb
Unit Weight: 136.7 pcf
Effective Cohesion: 330 psf
Effective Friction Angle: 25 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(5)

Model: Mohr-Coulomb
Unit Weight: 142 pcf
Effective Cohesion: 280 psf
Effective Friction Angle: 23 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(6)

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effective Cohesion: 270 psf
Effective Friction Angle: 24 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (277.5, 110.33) ft
Left-Zone Right Coordinate: (326.75, 122.68) ft
Left-Zone Increment: 8
Right Type: Range
Right-Zone Left Coordinate: (326.75, 122.68) ft
Right-Zone Right Coordinate: (376, 135.03) ft
Right-Zone Increment: 8
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (200, 110.15) ft
Right Coordinate: (450, 134) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	200 ft	110.15 ft
Coordinate 2	277.5 ft	110.33 ft

Coordinate 3	376 ft	135.03 ft
Coordinate 4	397 ft	134.6 ft
Coordinate 5	402 ft	133.5 ft
Coordinate 6	406 ft	134.5 ft
Coordinate 7	450 ft	134 ft

Geometry

Name: 2D Geometry

Settings

View: 2D

Element Thickness: 1 ft

Points

	X	Y
Point 1	267.5 ft	105.2 ft
Point 2	277.5 ft	105.2 ft
Point 3	376 ft	130.03 ft
Point 4	386 ft	130.03 ft
Point 5	386 ft	134.82394 ft
Point 6	376 ft	135.03 ft
Point 7	277.5 ft	110.33 ft
Point 8	267.50091 ft	110.30555 ft
Point 9	397 ft	134.6 ft
Point 10	402 ft	133.5 ft
Point 11	406 ft	134.5 ft
Point 12	450 ft	134 ft
Point 13	450 ft	132.3 ft
Point 14	386 ft	132.3 ft
Point 15	450 ft	124.3 ft
Point 16	349.2913 ft	123.29724 ft
Point 17	450 ft	111.3 ft
Point 18	301.70191 ft	111.30085 ft
Point 19	450 ft	106.3 ft
Point 20	281.86632 ft	106.30067 ft
Point 21	267.50091 ft	110.3 ft
Point 22	267.5002 ft	106.3 ft

Point 23	200 ft	106.3 ft
Point 24	200 ft	110.15 ft
Point 25	200 ft	84.3 ft
Point 26	450 ft	84.3 ft

Regions

	Material	Points	Area
Region 1	(6)	1,2,20,18,16,3,4,14,5,6,7,8,21,22	599.05 ft²
Region 2	(1)	5,9,10,11,12,13,14	127.88 ft²
Region 3	(2)	14,13,15,16,3,4	682.92 ft²
Region 4	(3)	16,15,17,18	1,544.1 ft²
Region 5	(4)	18,17,19,20	791.1 ft²
Region 6	(4)	22,21,8,24,23	265.13 ft²
Region 7	(5)	1,22,23,25,26,19,20,2	5,486.7 ft²

Slip Results

Slip Surfaces Analysed: 389 of 405 converged

Current Slip Surface

Slip Surface: 132
Factor of Safety: 1.72
Volume: 569.15233 ft³
Weight: 71,357.982 lbf
Resisting Moment: 3,074,713.7 lbf·ft
Activating Moment: 1,785,400.7 lbf·ft
Resisting Force: 26,932.272 lbf
Activating Force: 15,639.632 lbf
Slip Rank: 1 of 405 slip surfaces
Exit: (289.8125, 113.4175) ft
Entry: (376, 135.03) ft
Radius: 108.30134 ft
Center: (308.88258, 220.02665) ft

Slip Slices

	X	Y	PWP	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	291.21624 ft	113.18539 ft	36.466303 psf	45.249812 psf	270 psf	0 psf	(6)

Slice 2	294.02371 ft	112.75883 ft	107.04764 psf	78.437793 psf	270 psf	0 psf	(6)
Slice 3	296.83119 ft	112.40719 ft	172.95187 psf	108.17372 psf	270 psf	0 psf	(6)
Slice 4	299.63867 ft	112.12974 ft	234.22477 psf	134.64557 psf	270 psf	0 psf	(6)
Slice 5	302.44614 ft	111.92589 ft	290.90202 psf	158.02065 psf	270 psf	0 psf	(6)
Slice 6	305.26993 ft	111.79491 ft	343.28565 psf	244.76902 psf	0 psf	0 psf	(3)
Slice 7	308.11001 ft	111.73738 ft	391.3391 psf	273.53329 psf	0 psf	0 psf	(3)
Slice 8	310.9501 ft	111.75437 ft	434.74051 psf	297.94775 psf	0 psf	0 psf	(3)
Slice 9	313.79019 ft	111.84591 ft	473.48767 psf	318.23534 psf	0 psf	0 psf	(3)
Slice 10	316.63028 ft	112.01218 ft	507.56874 psf	334.59652 psf	0 psf	0 psf	(3)
Slice 11	319.47037 ft	112.25355 ft	536.96212 psf	347.21221 psf	0 psf	0 psf	(3)
Slice 12	322.31046 ft	112.57051 ft	561.63618 psf	356.24617 psf	0 psf	0 psf	(3)
Slice 13	325.15055 ft	112.96373 ft	581.549 psf	361.84727 psf	0 psf	0 psf	(3)
Slice 14	327.99064 ft	113.43406 ft	596.64783 psf	364.15128 psf	0 psf	0 psf	(3)
Slice 15	330.83072 ft	113.98253 ft	606.86857 psf	363.28256 psf	0 psf	0 psf	(3)
Slice 16	333.67081 ft	114.61036 ft	612.13503 psf	359.35555 psf	0 psf	0 psf	(3)
Slice 17	336.5109 ft	115.31897 ft	612.35801 psf	352.47608 psf	0 psf	0 psf	(3)
Slice 18	339.35099 ft	116.11003 ft	607.43426 psf	342.74266 psf	0 psf	0 psf	(3)
Slice 19	342.19108 ft	116.98542 ft	597.24514 psf	330.24762 psf	0 psf	0 psf	(3)
Slice 20	345.03117 ft	117.94732 ft	581.65506 psf	315.07826 psf	0 psf	0 psf	(3)

Slice 21	347.87126 ft	118.99821 ft	560.50962 psf	297.31805 psf	0 psf	0 psf	(3)
Slice 22	350.70258 ft	120.13709 ft	533.73432 psf	279.67149 psf	0 psf	0 psf	(3)
Slice 23	353.52515 ft	121.36652 ft	501.16765 psf	262.11086 psf	0 psf	0 psf	(3)
Slice 24	356.34771 ft	122.69333 ft	462.52222 psf	242.06634 psf	0 psf	0 psf	(3)
Slice 25	359.46863 ft	124.28486 ft	412.02146 psf	189.57226 psf	0 psf	0 psf	(2)
Slice 26	362.8879 ft	126.17191 ft	347.74152 psf	150.73816 psf	0 psf	0 psf	(2)
Slice 27	366.02285 ft	128.04104 ft	280.12912 psf	65.769478 psf	270 psf	0 psf	(6)
Slice 28	368.87346 ft	129.87488 ft	210.26853 psf	39.229763 psf	270 psf	0 psf	(6)
Slice 29	371.72408 ft	131.839 ft	132.27484 psf	11.127777 psf	270 psf	0 psf	(6)
Slice 30	374.57469 ft	133.94233 ft	45.590225 psf	-18.469113 psf	270 psf	0 psf	(6)

REPORT F-19
WITH REFERENCE TO SLOPE STABILITY ANALYSIS RESULT PRESENTED IN PLATE E-19
CONDITIONS: GLOBAL SLIDE - RAPID DRAWDOWN WITH TOTAL SOIL PARAMETERS
SECTION: C-C WITH SLOPE ABOUT 4H:1V
SOIL PROFILE: BORING NO. 2

Slope Stability Section 2

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File Information

File Version: 11.00
Revision Number: 43
Date: 03/02/2022
Time: 02:45:34 PM
Tool Version: 11.0.1.21429
File Name: 19. G - RD -TOT - CC - Clay Liner.gsz
Directory: H:\2021\450-499\21-S-477 Ravensway Drainage Improvements-HCED\Calculation\Slope Stability\Report 3 on 2-2022\Global Stability\
Last Solved Date: 03/02/2022
Last Solved Time: 02:45:36 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

Slope Stability Section 2

Kind: SLOPE/W
Method: Spencer
Settings
- PWP Conditions from: Piezometric Line
  - Apply Phreatic Correction: No
  - Use Staged Rapid Drawdown: No
- Unit Weight of Water: 62.430189 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 ft
  - Number of Slices: 30
- Factor of Safety Convergence Settings

Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

(1)

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 29.5 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(2)

Model: Mohr-Coulomb
Unit Weight: 138.4 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(3)

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 33 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(4)

Model: Mohr-Coulomb
Unit Weight: 136.7 pcf
Effective Cohesion: 380 psf
Effective Friction Angle: 21 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(5)

Model: Mohr-Coulomb
Unit Weight: 142 pcf
Effective Cohesion: 330 psf
Effective Friction Angle: 20 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(6)

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effective Cohesion: 300 psf
Effective Friction Angle: 18 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (200, 110.15) ft
Left-Zone Right Coordinate: (277.5, 110.33) ft
Left-Zone Increment: 8
Right Type: Range
Right-Zone Left Coordinate: (376, 135.03) ft
Right-Zone Right Coordinate: (450, 134) ft
Right-Zone Increment: 8
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (200, 110.15) ft
Right Coordinate: (450, 134) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	200 ft	110.15 ft
Coordinate 2	277.5 ft	110.33 ft

Coordinate 3	376 ft	135.03 ft
Coordinate 4	397 ft	134.6 ft
Coordinate 5	402 ft	133.5 ft
Coordinate 6	406 ft	134.5 ft
Coordinate 7	450 ft	134 ft

Geometry

Name: 2D Geometry

Settings

View: 2D

Element Thickness: 1 ft

Points

	X	Y
Point 1	267.5 ft	105.2 ft
Point 2	277.5 ft	105.2 ft
Point 3	376 ft	130.03 ft
Point 4	386 ft	130.03 ft
Point 5	386 ft	134.82394 ft
Point 6	376 ft	135.03 ft
Point 7	277.5 ft	110.33 ft
Point 8	267.50091 ft	110.30555 ft
Point 9	397 ft	134.6 ft
Point 10	402 ft	133.5 ft
Point 11	406 ft	134.5 ft
Point 12	450 ft	134 ft
Point 13	450 ft	132.3 ft
Point 14	386 ft	132.3 ft
Point 15	450 ft	124.3 ft
Point 16	349.2913 ft	123.29724 ft
Point 17	450 ft	111.3 ft
Point 18	301.70191 ft	111.30085 ft
Point 19	450 ft	106.3 ft
Point 20	281.86632 ft	106.30067 ft
Point 21	267.50091 ft	110.3 ft
Point 22	267.5002 ft	106.3 ft

Point 23	200 ft	106.3 ft
Point 24	200 ft	110.15 ft
Point 25	200 ft	84.3 ft
Point 26	450 ft	84.3 ft

Regions

	Material	Points	Area
Region 1	(6)	1,2,20,18,16,3,4,14,5,6,7,8,21,22	599.05 ft²
Region 2	(1)	5,9,10,11,12,13,14	127.88 ft²
Region 3	(2)	14,13,15,16,3,4	682.92 ft²
Region 4	(3)	16,15,17,18	1,544.1 ft²
Region 5	(4)	18,17,19,20	791.1 ft²
Region 6	(4)	22,21,8,24,23	265.13 ft²
Region 7	(5)	1,22,23,25,26,19,20,2	5,486.7 ft²

Slip Results

Slip Surfaces Analysed: 333 of 405 converged

Current Slip Surface

Slip Surface: 368
Factor of Safety: 1.79
Volume: 1,797.7601 ft³
Weight: 235,406.22 lbf
Resisting Moment: 6,509,855.3 lbf·ft
Activating Moment: 3,636,859.4 lbf·ft
Resisting Force: 75,081.98 lbf
Activating Force: 41,944.366 lbf
Slip Rank: 1 of 405 slip surfaces
Exit: (277.5, 110.33) ft
Entry: (385.27927, 134.83879) ft
Radius: 80.270754 ft
Center: (318.48092, 179.35143) ft

Slip Slices

	X	Y	PWP	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slic	279.13368	109.41092 ft	82.953441	92.595754	300 psf	0 psf	(6)

e 1	ft		psf	psf			
Slice 2	282.40103 ft	107.66956 ft	242.81757 psf	158.21981 psf	300 psf	0 psf	(6)
Slice 3	284.62217 ft	106.57397 ft	345.98798 psf	257.11477 psf	380 psf	0 psf	(4)
Slice 4	286.85887 ft	105.59359 ft	442.20899 psf	282.347 psf	330 psf	0 psf	(5)
Slice 5	290.15732 ft	104.26441 ft	576.82725 psf	348.08029 psf	330 psf	0 psf	(5)
Slice 6	293.45577 ft	103.10103 ft	701.09468 psf	404.36145 psf	330 psf	0 psf	(5)
Slice 7	296.75423 ft	102.09595 ft	815.47999 psf	452.31249 psf	330 psf	0 psf	(5)
Slice 8	300.05268 ft	101.24303 ft	920.36551 psf	492.81806 psf	330 psf	0 psf	(5)
Slice 9	303.53227 ft	100.50689 ft	1,020.7958 psf	525.91202 psf	330 psf	0 psf	(5)
Slice 10	307.19299 ft	99.899818 ft	1,116.0045 psf	551.5534 psf	330 psf	0 psf	(5)
Slice 11	310.85372 ft	99.465018 ft	1,200.4581 psf	570.42556 psf	330 psf	0 psf	(5)
Slice 12	314.51444 ft	99.199683 ft	1,274.3319 psf	583.02222 psf	330 psf	0 psf	(5)
Slice 13	318.17516 ft	99.10213 ft	1,337.7311 psf	589.74473 psf	330 psf	0 psf	(5)
Slice 14	321.83588 ft	99.171744 ft	1,390.694 psf	590.92042 psf	330 psf	0 psf	(5)
Slice 15	325.4966 ft	99.408962 ft	1,433.1933 psf	586.8162 psf	330 psf	0 psf	(5)
Slice 16	329.15733 ft	99.815289 ft	1,465.1352 psf	577.64884 psf	330 psf	0 psf	(5)
Slice 17	332.81805 ft	100.39334 ft	1,486.3563 psf	563.5927 psf	330 psf	0 psf	(5)
Slice 18	336.47877 ft	101.14693 ft	1,496.6183 psf	544.78578 psf	330 psf	0 psf	(5)
Slice 19	340.13949 ft	102.08121 ft	1,495.6 psf	521.33434 psf	330 psf	0 psf	(5)
Slic	343.80022	103.20285 ft	1,482.8849	493.31668	330 psf	0 psf	(5)

e 20	ft		psf	psf			
Slice 21	347.46094 ft	104.52029 ft	1,457.9458 psf	460.78618 psf	330 psf	0 psf	(5)
Slice 22	350.52146 ft	105.76476 ft	1,428.1657 psf	431.81492 psf	330 psf	0 psf	(5)
Slice 23	353.30202 ft	107.04705 ft	1,391.6423 psf	423.33977 psf	380 psf	0 psf	(4)
Slice 24	356.40281 ft	108.62499 ft	1,341.6743 psf	389.62526 psf	380 psf	0 psf	(4)
Slice 25	359.5036 ft	110.37839 ft	1,280.7521 psf	352.61342 psf	380 psf	0 psf	(4)
Slice 26	362.92224 ft	112.54329 ft	1,199.1165 psf	550.32028 psf	0 psf	0 psf	(3)
Slice 27	366.65875 ft	115.18888 ft	1,092.4469 psf	483.30994 psf	0 psf	0 psf	(3)
Slice 28	370.39525 ft	118.17715 ft	964.38397 psf	410.95406 psf	0 psf	0 psf	(3)
Slice 29	374.13175 ft	121.5617 ft	811.58069 psf	333.62711 psf	0 psf	0 psf	(3)
Slice 30	376.09911 ft	123.46298 ft	722.00456 psf	291.98925 psf	0 psf	0 psf	(3)
Slice 31	377.60159 ft	125.09433 ft	618.23841 psf	217.21705 psf	0 psf	0 psf	(2)
Slice 32	380.40835 ft	128.32675 ft	412.84964 psf	127.75431 psf	0 psf	0 psf	(2)
Slice 33	383.5455 ft	132.4344 ft	152.39841 psf	-19.389012 psf	300 psf	0 psf	(6)

REPORT F-20
WITH REFERENCE TO SLOPE STABILITY ANALYSIS RESULT PRESENTED IN PLATE E-20
CONDITIONS: LOCAL SLIDE - RAPID DRAWDOWN WITH TOTAL SOIL PARAMETERS
SECTION: C-C WITH SLOPE ABOUT 4H:1V
SOIL PROFILE: BORING NO. 2

Slope Stability Section 2

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File Information

File Version: 11.00
Revision Number: 45
Date: 03/02/2022
Time: 03:03:34 PM
Tool Version: 11.0.1.21429
File Name: 20. L - RD -TOT - CC - Clay Liner.gsz
Directory: H:\2021\450-499\21-S-477 Ravensway Drainage Improvements-HCED\Calculation\Slope Stability\Report 3 on 2-2022\Local Stability\
Last Solved Date: 03/02/2022
Last Solved Time: 03:03:36 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

Slope Stability Section 2

Kind: SLOPE/W
Method: Spencer
Settings
- PWP Conditions from: Piezometric Line
  - Apply Phreatic Correction: No
  - Use Staged Rapid Drawdown: No
- Unit Weight of Water: 62.430189 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 ft
  - Number of Slices: 30
- Factor of Safety Convergence Settings

Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

(1)

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 29.5 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(2)

Model: Mohr-Coulomb
Unit Weight: 138.4 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(3)

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 33 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(4)

Model: Mohr-Coulomb
Unit Weight: 136.7 pcf
Effective Cohesion: 380 psf
Effective Friction Angle: 21 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(5)

Model: Mohr-Coulomb
Unit Weight: 142 pcf
Effective Cohesion: 330 psf
Effective Friction Angle: 20 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

(6)

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effective Cohesion: 300 psf
Effective Friction Angle: 18 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (277.5, 110.33) ft
Left-Zone Right Coordinate: (326.75, 122.68) ft
Left-Zone Increment: 8
Right Type: Range
Right-Zone Left Coordinate: (326.75, 122.68) ft
Right-Zone Right Coordinate: (376, 135.03) ft
Right-Zone Increment: 8
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (200, 110.15) ft
Right Coordinate: (450, 134) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	200 ft	110.15 ft
Coordinate 2	277.5 ft	110.33 ft

Coordinate 3	376 ft	135.03 ft
Coordinate 4	397 ft	134.6 ft
Coordinate 5	402 ft	133.5 ft
Coordinate 6	406 ft	134.5 ft
Coordinate 7	450 ft	134 ft

Geometry

Name: 2D Geometry

Settings

View: 2D

Element Thickness: 1 ft

Points

	X	Y
Point 1	267.5 ft	105.2 ft
Point 2	277.5 ft	105.2 ft
Point 3	376 ft	130.03 ft
Point 4	386 ft	130.03 ft
Point 5	386 ft	134.82394 ft
Point 6	376 ft	135.03 ft
Point 7	277.5 ft	110.33 ft
Point 8	267.50091 ft	110.30555 ft
Point 9	397 ft	134.6 ft
Point 10	402 ft	133.5 ft
Point 11	406 ft	134.5 ft
Point 12	450 ft	134 ft
Point 13	450 ft	132.3 ft
Point 14	386 ft	132.3 ft
Point 15	450 ft	124.3 ft
Point 16	349.2913 ft	123.29724 ft
Point 17	450 ft	111.3 ft
Point 18	301.70191 ft	111.30085 ft
Point 19	450 ft	106.3 ft
Point 20	281.86632 ft	106.30067 ft
Point 21	267.50091 ft	110.3 ft
Point 22	267.5002 ft	106.3 ft

Point 23	200 ft	106.3 ft
Point 24	200 ft	110.15 ft
Point 25	200 ft	84.3 ft
Point 26	450 ft	84.3 ft

Regions

	Material	Points	Area
Region 1	(6)	1,2,20,18,16,3,4,14,5,6,7,8,21,22	599.05 ft²
Region 2	(1)	5,9,10,11,12,13,14	127.88 ft²
Region 3	(2)	14,13,15,16,3,4	682.92 ft²
Region 4	(3)	16,15,17,18	1,544.1 ft²
Region 5	(4)	18,17,19,20	791.1 ft²
Region 6	(4)	22,21,8,24,23	265.13 ft²
Region 7	(5)	1,22,23,25,26,19,20,2	5,486.7 ft²

Slip Results

Slip Surfaces Analysed: 386 of 405 converged

Current Slip Surface

Slip Surface: 132
Factor of Safety: 1.74
Volume: 569.15233 ft³
Weight: 71,357.982 lbf
Resisting Moment: 3,111,119.8 lbf·ft
Activating Moment: 1,785,400.7 lbf·ft
Resisting Force: 27,208.734 lbf
Activating Force: 15,615.043 lbf
Slip Rank: 1 of 405 slip surfaces
Exit: (289.8125, 113.4175) ft
Entry: (376, 135.03) ft
Radius: 108.30134 ft
Center: (308.88258, 220.02665) ft

Slip Slices

	X	Y	PWP	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slic	291.21624	113.18539	36.466303	33.581483 psf	300 psf	0 psf	(6)

e 1	ft	ft	psf				
Slice 2	294.02371 ft	112.75883 ft	107.04764 psf	57.079806 psf	300 psf	0 psf	(6)
Slice 3	296.83119 ft	112.40719 ft	172.95187 psf	78.247793 psf	300 psf	0 psf	(6)
Slice 4	299.63867 ft	112.12974 ft	234.22477 psf	97.195484 psf	300 psf	0 psf	(6)
Slice 5	302.44614 ft	111.92589 ft	290.90202 psf	114.02113 psf	300 psf	0 psf	(6)
Slice 6	305.26993 ft	111.79491 ft	343.28565 psf	243.9185 psf	0 psf	0 psf	(3)
Slice 7	308.11001 ft	111.73738 ft	391.3391 psf	272.70881 psf	0 psf	0 psf	(3)
Slice 8	310.9501 ft	111.75437 ft	434.74051 psf	297.18452 psf	0 psf	0 psf	(3)
Slice 9	313.79019 ft	111.84591 ft	473.48767 psf	317.56199 psf	0 psf	0 psf	(3)
Slice 10	316.63028 ft	112.01218 ft	507.56874 psf	334.03583 psf	0 psf	0 psf	(3)
Slice 11	319.47037 ft	112.25355 ft	536.96212 psf	346.78162 psf	0 psf	0 psf	(3)
Slice 12	322.31046 ft	112.57051 ft	561.63618 psf	355.95837 psf	0 psf	0 psf	(3)
Slice 13	325.15055 ft	112.96373 ft	581.549 psf	361.71052 psf	0 psf	0 psf	(3)
Slice 14	327.99064 ft	113.43406 ft	596.64783 psf	364.16979 psf	0 psf	0 psf	(3)
Slice 15	330.83072 ft	113.98253 ft	606.86857 psf	363.45675 psf	0 psf	0 psf	(3)
Slice 16	333.67081 ft	114.61036 ft	612.13503 psf	359.68226 psf	0 psf	0 psf	(3)
Slice 17	336.5109 ft	115.31897 ft	612.35801 psf	352.94876 psf	0 psf	0 psf	(3)
Slice 18	339.35099 ft	116.11003 ft	607.43426 psf	343.35147 psf	0 psf	0 psf	(3)
Slice 19	342.19108 ft	116.98542 ft	597.24514 psf	330.97952 psf	0 psf	0 psf	(3)
Slic	345.03117	117.94732	581.65506	315.91709 psf	0 psf	0 psf	(3)

e 20	ft	ft	psf				
Slice 21	347.87126 ft	118.99821 ft	560.50962 psf	298.24446 psf	0 psf	0 psf	(3)
Slice 22	350.70258 ft	120.13709 ft	533.73432 psf	280.66592 psf	0 psf	0 psf	(3)
Slice 23	353.52515 ft	121.36652 ft	501.16765 psf	263.15256 psf	0 psf	0 psf	(3)
Slice 24	356.34771 ft	122.69333 ft	462.52222 psf	243.12893 psf	0 psf	0 psf	(3)
Slice 25	359.46863 ft	124.28486 ft	412.02146 psf	190.51527 psf	0 psf	0 psf	(2)
Slice 26	362.8879 ft	126.17191 ft	347.74152 psf	151.5941 psf	0 psf	0 psf	(2)
Slice 27	366.02285 ft	128.04104 ft	280.12912 psf	47.528698 psf	300 psf	0 psf	(6)
Slice 28	368.87346 ft	129.87488 ft	210.26853 psf	27.455482 psf	300 psf	0 psf	(6)
Slice 29	371.72408 ft	131.839 ft	132.27484 psf	6.0871781 psf	300 psf	0 psf	(6)
Slice 30	374.57469 ft	133.94233 ft	45.590225 psf	-16.543306 psf	300 psf	0 psf	(6)

REPORT
GEOTECHNICAL INVESTIGATION
PROPOSED PAVEMENT AND STORM SEWER
RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS - 2018
PRECINCT 3
HARRIS COUNTY, TEXAS
UPIN# 19103MF14601

PREPARED FOR:

Harris County Engineering Department
c/o LJA Engineering, Inc.
3600 W. Sam Houston Parkway S., Suite 600
Houston, Texas 77042

PREPARED BY:

HTS, Inc. Consultants
416 Pickering Street
Houston, Texas 77091-3312

HTS Project No.: 22-S-148

March 28, 2022

HTS, Inc. Consultants
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Excellence in Engineering, Consulting, Testing and Inspection

March 28, 2022

Harris County Engineering Department
c/o LJA Engineering, Inc.
3600 W. Sam Houston Parkway S., Suite 600
Houston, Texas 77042

Attn: Mr. Isaac Muniz, P.E.
Project Manager

Re: Report
Geotechnical Services for
Proposed Pavement and Storm Sewer
Ravensway Subdivision Drainage
Improvements - 2018
Precinct 3
Harris County, Texas
UPIN No. 19103MF14601

HTS Project No.: 22-S-148

Dear Mr. Muniz:

HTS, Inc. Consultants is pleased to transmit this report of the geotechnical investigation for the above referenced project. This report includes the results of field and laboratory testing, geotechnical design parameters, and recommendations pertaining to the proposed development.

We appreciate the opportunity to perform this geotechnical investigation and look forward to continued participation during the design and construction phases of this project. If you have any questions pertaining to this report, or if we may be of further service, please contact us at your convenience.

Very truly yours,
HTS, Inc. Consultants

STATE OF TEXAS
JUBAIR HOSSAIN
122131
LICENSED
PROFESSIONAL ENGINEER
3-28-22

Ashique Ahmed, Ph.D., P.E.
Project Engineer

Jubair Hossain, Ph.D., P.E.
President

HTS, Inc. Consultants
F-3478

AA:JH/rg

H:\2022\100-149\22-S-148 Ravensway Sub. Drainage Improvements-2018 PCT. 1-LJA Engineering\Report\22-148.doc

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APPENDICES

Appendix A – Boring Logs (Boring Nos. 1 through 15)

REPORT
GEOTECHNICAL INVESTIGATION
PROPOSED PAVEMENT AND STORM SEWER
RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS - 2018
PRECINCT 3
HARRIS COUNTY, TEXAS
UPIN# 19103MF14601

EXECUTIVE SUMMARY

This executive summary presents the primary findings, conclusions, and recommendations of the geotechnical investigation pertaining to the design and construction activities associated with the construction of storm sewer lines underneath the existing pavement as part of the Ravensway Subdivision Drainage Improvements Project – 2018. Based on the information provided by LJA, HTS understands that part of the existing pavement will be demolished which will be reconstructed after installation of storm sewer utility lines. The proposed improvement location addressed by this proposal is located east of the Huffmeister Road and Ravensway Drive intersection in Harris County, Texas. The proposed area of improvement can be found in Harris County Key Map 368 Squares F, G, K, and L. Based on the information provided by LJA, HTS also understands that the existing surface elevation of the natural ground within the proposed development varies between Elv. +128 feet (above MSL) and Elv. +132 feet (above MSL). The proposed development will include construction of underground utility lines that will consist of Reinforced Concrete Pipe (RCP) with diameters of 24, 48, and 60-inches. The construction will also include installation of a 60-inch and 6-foot by 5-foot Reinforced Concrete Box (RCB). The bottom of the proposed utility lines varies between Elv. +110 feet (above MSL) and Elv. +122 feet (above MSL).

Groundwater was not encountered during drilling nor after completion of drilling at all boring locations except for Boring No. 13. Groundwater was encountered at a depth of 22.5 feet (elevation about +107.5 feet above MSL) during drilling in Boring No. 13. 24 hours after the completion of drilling, groundwater was encountered at a depth of 21.5 feet below existing ground surface (elevation about +108.5 feet above MSL). It is our understanding that the proposed storm sewers will be installed at an elevation of about +110.0 feet to +122.0 feet above MSL. Therefore, it is not anticipated that groundwater will be encountered during the excavations. However, groundwater conditions may change due to seasonal and climatic variations and if perched water or groundwater seepage is present during the excavation operations and the exposed soil consist of site lean clays, the use of sumps and pumps may be used to dewatering water seepage entering the excavations.

Concrete pavement thickness and stabilization recommendations are provided in Sections 1.4.7 and 1.4.8.

This executive summary should not be used alone as a basis for design. The geotechnical report, which contains details of the findings, conclusions, and recommendations of the geotechnical study, should be read in its entirety and serve as the basis for design.

REPORT
GEOTECHNICAL INVESTIGATION
PROPOSED PAVEMENT AND STORM SEWER
RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS - 2018
PRECINCT 3
HARRIS COUNTY, TEXAS
UPIN# 19103MF14601

1.0 INTRODUCTION AND SUMMARY

1.1 Introduction

This report presents the results of the geotechnical investigation pertaining to the design and construction activities associated with the construction of storm sewer lines underneath the existing pavement as part of the Ravensway Subdivision Drainage Improvements Project – 2018. Based on the information provided by LJA, HTS understands that part of the existing pavement will be demolished which will be reconstructed after installation of storm sewer utility lines. The proposed improvement location addressed by this proposal is located east of the Huffmeister Road and Ravensway Drive intersection in Harris County, Texas. The proposed area of improvement can be found in Harris County Key Map 368 Squares F, G, K, and L.

This geotechnical investigation was performed by HTS, Inc. Consultants (HTS) for the Harris County Engineering Department (HCED) and LJA Engineering, Inc. (LJA) in accordance with HTS Proposal No. 22-05141 Revision 2 dated February 9, 2022 and work authorization through email on February 22, 2022. The geotechnical investigation is conducted following the latest HCED and HCFCD geotechnical investigation guidelines.

The purpose of this geotechnical investigation was to provide:

- thickness of existing pavement sections,
- recommendations as per OSHA trench safety guidelines, and
- construction recommendations for the proposed utility lines.

The scope of work for this geotechnical investigation consisted of the following activities:

- Coring the existing pavement at 15 locations and measure the pavement thicknesses. The coring were performed along the area of the proposed utility lines.

- Drilling and sampling a total of 15 geotechnical borings (Boring Nos. 1 through 15): 8 borings (Boring Nos. 1 through 6, 8, and 10) were drilled to a depth of 30 feet below existing ground surface, 4 borings (Boring Nos. 12 through 15) were drilled to a depth of 25 feet below existing ground surface, and 3 borings (Boring Nos. 7, 9, and 11) were drilled to a depth of 15 feet below existing ground surface at the previously cored locations.

- Obtaining both disturbed and relatively undisturbed soil samples from the borings with continuous samples being taken from the ground surface to a depth of 20 feet and at 5-foot intervals thereafter.

- Measuring groundwater levels in the borings during drilling and within approximately 24 hours after the completion of drilling.

- Backfilling the borings with cement grout after obtaining 24-hour groundwater level measurements.

- Performing geotechnical laboratory tests on soil samples recovered during drilling in order to properly classify the site soils, develop engineering design parameters for use in our engineering analyses, and develop engineering design parameters that will support our conclusions and recommendations. Laboratory testing included Atterberg limits tests, tests to determine percent soil finer than the No. 200 sieve, unconfined compressive strength, and unconsolidated undrained triaxial tests. Soil classification was performed in strict accordance with ASTM D 2487.

- Preparing "gINT" boring logs based on the results of the laboratory tests and visual soil classifications.

- Characterizing the site subsoil and groundwater conditions and provide the results on both the boring logs and soil profiles.

- Performing engineering analyses as necessary to develop recommendations pertaining to potential uplift of underground structures due to upward acting hydrostatic pressures caused by groundwater conditions, lateral earth pressures on underground structures, dewatering requirements for excavations, utility trench shoring and bracing requirements, OSHA soil type classifications pertinent to trench shoring and bracing design, excavation/backfill requirements, and utility bedding requirements.

- Providing active, passive, and at-rest earth pressure coefficients and equivalent fluid unit weights to be used for the design of underground structures.

- Submitting a pdf file of the report that presents the results of the geotechnical investigation.

1.2 Description of Existing Site Conditions and Proposed Project

Based on the information provided by LJA, HTS understands that part of the existing pavement will be demolished which will be reconstructed after installation of storm sewer utility lines. The proposed improvement location addressed by this proposal is located east of the Huffmeister Road and Ravensway Drive intersection in Harris County, Texas. The proposed area of improvement can be found in Harris County Key Map 368 Squares F, G, K, and L.

Based on the information provided by LJA, HTS also understands that the existing surface elevation of the natural ground within the proposed development varies between Elv. +128 feet (above MSL) and Elv. +132 feet (above MSL). The proposed development will include construction of underground utility lines that will consist of Reinforced Concrete Pipe (RCP) with diameters of 24, 48, and 60-inches. The construction will also include installation of a 60-inch and 6-foot by 5-foot Reinforced Concrete Box (RCB). The bottom of the proposed utility lines varies between Elv. +110 feet (above MSL) and Elv. +122 feet (above MSL).

1.3 Summary of Findings

The pertinent findings of this geotechnical investigation that pertains to the design and construction of the proposed pavement and storm sewer construction are provided below.

1.3.1 Existing Pavement Thicknesses and Subsurface Soil Strata

The existing pavement thickness and subsurface soil strata at the boring locations within the location of the proposed pavement and storm sewer area are described:

- field measurements of the pavement section depths,
- by the laboratory test results presented in Table 1,
- on the boring logs for Boring Nos. 1 through 15 in Appendix A, and
- on the soil profiles presented for Sections A-A through E-E in Figures 3A and 3B.

Core Conditions – For the current investigation, 15 locations were cored and sampled on March 7, 2022. At each location, the existing pavement was cored and thickness (or depths) were measured. The pavement section at the 15 coring locations is provided in the table below:

CORING NO.	STREET NAME	PAVEMENT THICKNESS	
		CONCRETE (INCH)	STABILZED SUBGRADE
1	Ravensway Drive	6.00	None
2	Ravensway Drive	5.50	None
3	Ravensway Drive	6.00	None
4	Ravensway Drive	6.50	None
5	Tall Forest Drive	6.25	None
6	Tall Forest Drive	6.25	None
7	New Kentucky Rd	5.50	None
8	Tall Forest Drive	6.50	None
9	Retreat Trail	7.00	None
10	Tall Forest Drive	6.50	None
11	Rifleman Trail	6.50	None
12	Ravensway Drive	6.00	8.00 inches of crushed concrete base layer with clay
13	Ravensway Drive	5.00	None
14	Lakecrest Drive	7.50	None
15	Jarvis Rd	7.00	None

Subsurface Soil Conditions: Data from the 15 geotechnical borings (drilled at cored locations) for the current investigation drilled at the site of the proposed pavement and storm sewer suggest that the upper 30 feet of overburden soils are composed of 4 separate soil layers. HTS has designated these 8 soil layers as Layers I through IV. Descriptions of each soil layer are provided below:

Layer	Depth * (ft)	Elevation (ft-above MSL)	Soil Description
I	0 – 14	+135 to +115	SANDY LEAN CLAY and LEAN CLAY WITH SAND, soft to hard, medium to high plasticity, brown, tan, light tan, and light gray, with ferrous nodules, moist.
II	2 – 30	+133 to +100	POORLY GRADED SAND WITH SILT, POORLY GRADED SAND, and SILTY SAND, loose to dense, no plasticity, light tan and light gray, with clay pockets, moist to wet.
III	0 – 6	+135 to +126	CLAYEY SAND, loose, slight plasticity, brown, with ferrous nodules and clay pockets, moist (encountered only in Boring Nos. 1, 8, and 11).
IV	18 – 30	+116 to +104	LEAN CLAY WITH SAND, stiff to hard, medium plasticity, light gray and light tan, with ferrous nodules and silt pockets, moist (encountered only in Boring No. 6).

* Measured below pavement bottom

Laboratory testing was performed on selected samples of the subsurface materials obtained to classify the soils in accordance with ASTM D 2487 and to define the engineering properties of the soils. Portions of the test results indicating the high and low values of specific testing are provided in the table below:

Layer	Depth (ft)	Liquid Limit (%)		Plasticity Index (%)		Moisture Content (%)		Passing No. 200 Sieve (%)		Compressive Strength (tsf)	
		High	Low	High	Low	High	Low	High	Low	High	Low
I	0 – 14	48	27	29	12	24.7	9.4	76.8	50.3	7.2	0.5
II	2 – 30	Non Plastic				15.1	4.4	49.1	4.8	N/A	
III	0 – 6	38	23	20	10	14.1	10.8	48.7	36.5	1.8	
IV	18 – 30	32		16		14.1		73.1		1.9	

1.3.2 Groundwater Conditions

Groundwater was not encountered during drilling nor after completion of drilling at all boring locations except for Boring No. 13. Groundwater was encountered at

a depth of 22.5 feet (elevation about +107.5 feet above MSL) during drilling in Boring No. 13. 24 hours after the completion of drilling, groundwater was encountered at a depth of 21.5 feet below existing ground surface (elevation about +108.5 feet above MSL).

1.3.3 Geology

As per USGS Texas Pocket Geology, the geologic unit of primary interest at the proposed site is the Lissie Formation. The Lissie Formation is unconformably contained between the Goliad Sand and the overlying Beaumont Clay. The Lissie Formation crops out in a band parallel to the coast and is about 30 miles wide from the Sabine River to the Rio Grande. The sediments of the Lissie Formation in the outcrop are partly continental deposits laid down on flood plains and partly delta sands, silts, and mud at the mouth of rivers. The Lissie Formation hosts flatter, gently undulating topography, and has much lower-dipping beds than the Goliad Sand. Lissie Formation sediments consist of reddish, orange, and gray fine-to-coarse grained, cross-bedded sands.

1.3.4 Geologic Fault Assessment

Based on the desktop review of published and proprietary records on surface faults in the location of the proposed development, the closest known faults to the project site are a group of faults (including Brittmore, Woodland Tails, White Oak, and other faults) near Jersey Village, Texas, located approximately 8.0 miles southeast of the project site.

1.3.5 Environmental Concern

There were no environmental concerns evident during field investigation for this project.

1.4 Summary of Recommendations

The recommendations, as summarized below, are provided for use in the design and re-construction of the proposed pavement and storm sewer in Harris County, Texas.

1.4.1 Recommended Earth Pressure Design Parameters for Design of Permanent Below Ground Structures

Below ground or earth retaining structures may be built as part of the project. These structures should be designed as earth retaining structures. The following recommendations are for typical earth retaining structures constructed with backfill behind the structures.

The earth pressure on the structures depends on the extent, degree of compaction, and the type of backfill that will be placed behind the wall or around the structure. The equivalent fluid pressure values for various back-fill material types based on in-situ soil present are shown in the table below. The following table shows

active, at rest, and passive earth pressure coefficients. Active earth pressure condition is applicable if horizontal movement can occur along the structure height. If the structures are restrained at the top, at-rest earth pressure condition is applicable.

- The equivalent fluid pressure values shown in the below table are applicable for horizontal backfill surface. Also, the values are applicable if the backfill behind the walls/structures extend to a minimum distance equal to the wall height. For sloping backfill, the lateral earth pressure values could be significantly different.

- The earth pressure values for the above water table condition correspond to the total unit weight of soil and the earth pressure values for the below water table condition correspond to the buoyant or submerged unit weight of soil.

- Any additional lateral loads due to surcharge and live loads should also be included in the design. A minimum uniform surcharge pressure of 250 psf should be included in the design for the pavement and traffic loads. The lateral pressure on the wall due a uniform surcharge load can be taken as earth pressure coefficient values shown in the table multiplied by the surcharge pressure.

- Drainage systems should be provided to collect/remove water and to prevent hydrostatic pressure on the walls. If provisions to prevent accumulation of water behind the walls are not provided, the walls should be designed to resist the hydrostatic head in addition to the buoyant lateral earth pressures. The hydrostatic pressures should be accounted for the full height of the wall.

- Placement and compaction of backfill materials in layers alongside a vertical structure tend to produce greater at-rest pressures than uncompacted fill and natural deposits. Lateral pressures change gradually in accordance with wall movement and reach the full active or passive condition only when adequate movement occurs. For compacted backfill material at-rest earth pressure should be considered for the design of the wall.

Equivalent Fluid Pressures (Pounds per Square Foot per Foot of Wall Height)				
Type of Properly Compacted Backfill Behind the Retaining System Soil Parameters	**Active Condition (Horizontal Backfill)**		**At Rest Condition (Horizontal Backfill)**	
	Above W.T.	**Below W.T.**	**Above W.T.**	**Below W.T.**
Select Fill Wet unit weight of 125 pcf, Effective Cohesion (c') of 0 psf and Effective Friction Angle (φ') of 25°	51	25	72	36

Equivalent Fluid Pressures (Pounds per Square Foot per Foot of Wall Height)				
Type of Properly Compacted Backfill Behind the Retaining System Soil Parameters	**Active Condition (Horizontal Backfill)**		**At Rest Condition (Horizontal Backfill)**	
	Above W.T.	**Below W.T.**	**Above W.T.**	**Below W.T.**
Cement Stabilized Sands Wet unit weight of 125 pcf, Effective Cohesion (c') of 0 psf and Effective Friction Angle (φ') of 45°	21	11	37	18
On-site Lean Clays Wet unit weight of 134 pcf, Effective Cohesion (c') of 0 psf and Effective Friction Angle (φ') of 20°	66	35	88	47
On-Site Sands Wet unit weight of 120 pcf, Effective Cohesion (c') of 0 psf and Effective Friction Angle (φ') of 30°	40	19	60	29

Notes: (W.T.): Water Table

a) *Buoyant lateral earth equivalent fluid pressures; does not include the hydrostatic fluid weight effect of 62.4 pcf (Pertains to Below W.T. only)*
b) *Values provided assume that the materials are compacted to at least 95 percent of the Standard Proctor maximum dry density (ASTM D 698) within 2 percentage points of the optimum moisture content.*
c) *If granular soils are used, a minimum of 2 feet of clay should be placed over the granular soils.*

Lateral Earth Pressure Coefficients			
Type of Properly Compacted Backfill Behind the Retaining System Soil Parameters	**Active Condition (Horizontal Backfill)**	**At-Rest Condition (Horizontal Backfill)**	**Passive Condition (Horizontal Backfill)**
Select Fill Wet unit weight of 125 pcf, Effective Cohesion (c') of 0 psf and Effective Friction Angle (φ') of 25°	0.41	0.58	2.46
Cement Stabilized Sands Wet unit weight of 125 pcf, Effective Cohesion (c') of 0 psf and Effective Friction Angle (φ') of 45°	0.17	0.29	5.83
On-site Lean Clays Wet unit weight of 134 pcf, Effective Cohesion (c') of 0 psf and Effective Friction Angle (φ') of 20°	0.49	0.66	2.04
On-Site Sands Wet unit weight of 120 pcf, Effective Cohesion (c') of 0 psf and Effective Friction Angle (φ') of 30°	0.33	0.50	3.00

Note: Values provided assume that the materials are compacted to at least 95% of the Standard Proctor maximum dry density (ASTM D 698), within 2 percentage points of the optimum moisture content.

The weights of equivalent fluid for the passive case and the passive earth pressure coefficients shown above do not include a safety factor. It is recommended that for design purposes, a factor of safety of 2 be applied to the weights of equivalent fluid for the passive case and the passive earth pressure coefficients.

1.4.2 Storm Sewer Design, Bedding, and Backfill Requirements

Proposed RCP and RCB Storm sewers may be designed using conventional conduit formulas and assuming a negative projection condition for computation of loadings.

The total load on storm sewers will consist of the weight of the compacted backfill above the pipe, the weight of the pavement, and live loadings where applicable.

Storm sewer line trenches should be excavated with trench widths that comply with the requirements of Item 430 titled "Construction of Underground Utilities" from the most recent revision of "Specifications for the Construction of Road and Bridges within Harris County, Texas" of the HCED Specifications.

Bedding for the proposed storm sewers should be designed and installed as specified by the above-referenced HCED Specifications.

Bedding and backfill for the proposed storm sewers should be designed and installed as specified in most recent version of HCED Drawings titled "Storm Sewer Standards" and Item 430 titled "Construction of Underground Utilities".

1.4.3 Design Parameters and Considerations for Box Culvert (RCB)

HTS understands that the proposed 6-foot by 5-foot RCB structure will be founded at about an Elevation between +110.0 and +122.0 feet above MSL.

Bearing Capacity and Settlement

It is anticipated that the founding materials for the box culverts at these depths will be the silty sandy or sandy soils. The box culverts should be designed for maximum allowable net bearing pressures of 4,000 psf for axial compression dead loads plus sustained live loads and 6,000 psf for axial compression dead loads plus sustained and transient live loads.

The above values consider a safety factor of at least 3 and 2, respectively, against a bearing capacity failure.

Utilizing the design criteria provided herein, the total settlement of the precast reinforced concrete box culvert should be less than 1-inch.

A sliding co-efficient of 0.33 should be used for the box culverts seated on the site clays and a sliding co-efficient of 0.45 should be used for the box culverts seated on the site sands. A recommended factor of safety of at least 1.5 and 2.0 against sliding and overturning or tipping, respectively, should be used for the proposed box culvert to be stable and be capable of resisting the potential for sliding and overturning or tipping.

Installation of the box culvert should be in accordance with 2020 HCFCD standard Specifications Book Sections 02612 titled "Precast Reinforced Concrete Box", 02631 titled "Storm Sewers and Outfalls", and 02321 titled "Cement Stabilized Sand".

1.4.4 Recommended Design Requirements for Temporary Shoring and Bracing for Excavations

The contractor is solely responsible for designing and constructing stable protection systems for excavations such as support systems, sloping and benching systems, shield systems, and other systems that provide protection.

Temporary special shoring, for use in the installation of structures or utilities that will require excavations deeper than 5 feet, should consist of vertical or sloped cuts, benches, shields, support systems, or other systems that will provide necessary protection in accordance with OSHA Standards and Interpretations, 29 CFR 1926, Subpart P, "Excavations".

If OSHA Standards and Interpretations, 29 CFR 1926, Subpart P, "Excavations" is used for the design of temporary excavation protection systems, the site clay layers should be categorized as Type B soils while the site sands should be categorized as Type C soils.

The definitions of Type B and Type C soils are provided in Appendix A of the OSHA Standards and Interpretations, 29 CFR 1926, Subpart P, "Excavations[5]" (www.osha.gov). In order to eliminate the potential for caving of trench excavations, trench safety shall be implemented for trench excavations that are deeper than 5 feet. The diagrams of maximum allowable slopes for trench excavation are presented in Figure 4 and the diagram to use with a combination of bracing and open cuts for trench excavation are presented in Figure 5.

1.4.5 Computation of Bracing Pressures for Temporary Structures

Lateral pressures resulting from construction equipment, traffic loads, or other surcharge loads should be taken into account by adding the equivalent uniformly distributed surcharge to the design lateral pressures. Hydrostatic pressure, if any, should also be considered. The active earth pressure at depth z can be determined by Equation (1) as provided below and using the soil parameters presented in Section 1.4.4.

$$p_a = (q_s + \gamma h_1 + \gamma' h_2)\, K_a + \gamma_w h_2 \qquad \text{Equation (1)}$$

where,

p_a	=	active earth pressure, psf
q_s	=	uniform surcharge pressure, minimum 250 psf
γ, γ'	=	wet unit weight and buoyant unit weight of soil
h_1	=	depth from ground surface to groundwater table
h_2	=	$z-h_1$, depth from groundwater table to the point under consideration
z	=	depth below ground surface for the point under consideration
K_a	=	coefficient of active earth pressure
γ_w	=	unit weight of water, 62.4 pcf

If there is water behind the bracing, hydrostatic pressure should be included in the design. If excavations are located close to existing structures, we recommend using the coefficient of at-rest earth pressure (K_0) for design instead of the use of active earth pressure coefficient (K_a) to reduce the potential for distress to the existing structures.

1.4.6 Excavation Dewatering Requirements

Groundwater was not encountered during drilling nor after completion of drilling at all boring locations except for Boring No. 13. Groundwater was encountered at a depth of 22.5 feet (elevation about +107.5 feet above MSL) during drilling in Boring No. 13. 24 hours after the completion of drilling, groundwater was encountered at a depth of 21.5 feet below existing ground surface (elevation about +108.5 feet above MSL). Changes in groundwater conditions may occur with seasonal and climatic variations and these changes could result in wet conditions at the base of the excavations.

It is our understanding that the proposed storm sewers will be installed at an elevation of about +110.0 feet to +122.0 feet above MSL. Therefore, it is not anticipated that groundwater will be encountered during the excavations. However, groundwater conditions may change due to seasonal and climatic variations and if perched water or groundwater seepage is present during the excavation operations and the exposed soil consist of site lean clays, the use of sumps and pumps may be used to dewatering water seepage entering the excavations.

If the exposed soils consist of the site sands and water is observed rising through the bottom of the excavations, more extensive groundwater efforts such as well points, vacuum well points, or any other suitable dewatering system may be required for groundwater dewatering of excavations. Care and control of groundwater and surface water during construction should be performed in accordance with Section 02241 titled "Care and Control of Water" from the 2020 HCFCD Standard Specifications Book.

1.4.7 Recommendation for Proposed Re-construction of Pavement

The rigid pavement section for full roadway reconstruction may consist of the following thicknesses as per existing pavement structure and HCED guidelines.

RIGID PAVEMENT SECTION (ALL RESINDETIAL ROADWAYS WITHIN SCOPE EXCEPT LAKECREST DR AND JARVIS RD)	
Material	**Minimum Thickness, inches**
Reinforced Concrete Pavement	6.0
Stabilized and Compacted Subgrade	6.0

RIGID PAVEMENT SECTION (LAKECREST DR AND JARVIS RD)	
Material	**Minimum Thickness, inches**
Reinforced Concrete Pavement	7.0
Stabilized and Compacted Subgrade	8.0

The minimum recommended thicknesses as per Regulations of Harris County, Texas for The Approval and Acceptance of Infrastructure, 2011 the following are recommended minimum thicknesses based on roadway class:

RIGID PAVEMENT SECTION					
Material	**Minimum Thickness, inches**				
	Local	**Collector**	**Thoroughfare**	**Principal Thoroughfare (1)***	**Principal Thoroughfare (2)**
Reinforced Concrete Pavement	6.0	6.0	7.0	8.0	10.0
Stabilized and Compacted Subgrade	6.0	6.0	8.0	8.0	8.0

* *8-inch concrete thickness for principal thoroughfare is based on a 28-day compressive strength of 4500 psi. All other concrete thicknesses are based on a 28-day compressive strength of 3000 psi.*

Pavement subgrade soil preparation should comply with the recommendations provided in Section 1.4.8 of this report.

All related civil design factors such as drainage, cross-sectional configurations, surface elevations and environmental factors which will significantly affect the service life of the pavement should be included in the preparation of the construction drawings and specifications. Design of concrete pavement slabs should ensure adequate steel reinforcement. Proper finishing of concrete pavements require the use of sawed and sealed joints, which should be designed in accordance with current HCED guidelines.

Typical longitudinal and transverse reinforcement requirements, required spacing, and details for applicable precinct can be found in HCED Standard Civil Drawing No. CP-13 dated November 5, 2018.

1.4.8 Recommended Pavement Subgrade Soil Preparation and Stabilization Requirements

It is recommended that roadway subgrade soils be prepared and stabilized as described below.

- Establish site drainage in order to preclude the inundation of the site area with storm water or the lateral seepage of water into the pavement subgrade soils.

- Strip any vegetation and organic top soil to a depth of 6 inches or as necessary.

- Proofroll the exposed subgrade soil with a 15-ton roller, or equivalent equipment, and observe the soils during proofrolling so as to detect any wet, soft, or unstable soils. Wet, soft, or unstable soils should be treated with suitable drying or stabilizing agents or the unsuitable soils should be removed and replaced with properly compacted select fill.

- Compact the exposed subgrade soil to an in-place dry density equal to at least 95% of the maximum dry density at a moisture content within 0 to 3% of the optimum moisture content in accordance with Standard Proctor (ASTM D 698) criteria.

- If it is necessary to place fill to bring the pavement subgrade soil to the desired grade elevation, borrow material conforming HCED items 225 and 130 should be utilized. Fill should consist of a clayey sand or inactive lean clay with a maximum liquid limit of 45 and a plasticity index range of 12 to 20. Compaction of the fill material should be performed in accordance with HCED items 130 and 132. Fill materials should be placed in 8-inch thick loose lifts (6-inch compacted lifts) and compacted to an in-place dry density equal to at least 95% of the maximum dry density at a moisture content within ± 3% of the optimum moisture content as determined by ASTM D 698. The layers shall not

exceed 6 inches in depth where pneumatic tire rolling is to be used and shall not exceed 8 inches in depth for rolling with other types of rollers.

- After the pavement subgrade is brought to grade, the upper 6 or 8 inches should be stabilized. Stabilization procedures should be performed in accordance with Item 223 titled "Lime-Fly Ash or Fly Ash Stabilized Subgrade" or Item 220 titled "Lime Stabilized Subgrade" from the most recent revision of the Harris County Engineering Department (HCED) Specifications titled "Specifications for the Construction of Roads and Bridges within Harris County, Texas[2]".

- Lime-fly ash treated subgrade: subgrade with select fill soil/on-site soil with plasticity index less than 22 should be stabilized with lime-fly ash.

  - Stabilize the upper 6 inches (for pavement with concrete thickness 6-inch) of the pavement subgrade soils with lime and fly ash (3% hydrated lime by dry soil weight or 16 pounds of lime per square yard of surface area and 8% fly ash by dry soil weight or 43 pounds of fly ash per square yard of surface area for a depth of 6 inches). The blended soil-lime-fly ash mixture should be compacted to an in-place dry density equal to at least 95% of the maximum dry density in accordance with Standard Proctor (ASTM D 698) criteria.

  - Stabilize the upper 8 inches (for pavement with concrete thickness of 7-inch) of the pavement subgrade soils with lime and fly ash (3% hydrated lime by dry soil weight or 22 pounds of lime per square yard of surface area and 8% fly ash by dry soil weight or 58 pounds of fly ash per square yard of surface area for a depth of 8 inches). The blended soil-lime-fly ash mixture should be compacted to an in-place dry density equal to at least 95% of the maximum dry density in accordance with Standard Proctor (ASTM D 698) criteria.

- Lime-treated subgrade: Subgrade with on-site soils with a plasticity index more than 22 should be stabilized with lime. The amount of lime should be determined for subgrade soils by conducting laboratory tests just prior to construction. Based on the test results during this investigation, we recommend that about 6 percent lime by dry weight be used for estimating and planning.

  - Stabilize the upper 6 inches (for pavement with concrete thickness 6-inch) of the pavement subgrade soils with lime (6% hydrated lime by dry soil weight based on test results prior to construction). The blended soil-lime mixture should be compacted to an in-place dry density equal to at least 95% of the maximum standard dry density in accordance with Standard Proctor (ASTM D 698) criteria. The percentages are given as application by dry weight and are typically equivalent to about 32 pounds of lime per square yard per 6-inch depth.

- Stabilize the upper 8 inches (for pavement with concrete thickness 7-inch) of the pavement subgrade soils with lime (6% hydrated lime by dry soil weight based on test results prior to construction). The blended soil-lime mixture should be compacted to an in-place dry density equal to at least 95% of the maximum standard dry density in accordance with Standard Proctor (ASTM D 698) criteria. The percentages are given as application by dry weight and are typically equivalent to about 43 pounds of lime per square yard per 8-inch depth.

The required quantities of lime-fly ash or lime for use in stabilization, as recommended above, are estimated values only. The actual quantities of lime-fly ash or lime should be based upon tests performed on the subgrade soils at the time of construction.

Stabilization should extend a minimum of 1-foot beyond the edges of the pavement in order to preclude edge failure of the pavement.

The construction contractor may encounter difficulty in densifying and preparing the surficial soils depending upon weather conditions. If inclement weather causes the surficial soils to become unsuitably wet, the construction contractor should:

- adequately dry the surficial soils by discing the soils,
- adequately dry the surficial soils by blending a stabilizing agent (lime or fly ash) with the unsuitably wet soils,
- remove the unsuitably wet soils and replace them with suitable earth fill or select fill having an acceptable moisture content, or
- stabilize the pavement subgrade soils to a depth of 12 inches rather than to a depth of 8 or 10 inches.

2.0 FIELD INVESTIGATION

For this geotechnical investigation, a total of 15 geotechnical borings (Borings Nos. 1 through 15) were drilled and sampled between March 9 and 23, 2022 at the locations shown in Figure 2. The boring locations, as shown in Figure 2, were selected and located/staked in the field by HTS during drilling. Drilling, sampling, and testing were performed in accordance with applicable ASTM procedures using conventional auger and wet rotary drilling methods. The depths, approximate ground elevations, as well as their co-ordinates, are shown in the table below.

SUMMARY OF SOIL BORINGS				
CORING /BORING NO.	TOTAL DEPTH OF BORING (FT.)	APPROXIMATE SURFACE ELEVATION ABOVE MSL (FEET)	STATE PLANE EASTING, X (SURVEYED) (FEET)	STATE PLANE NORTHING, Y (SURVEYED) (FEET)
1	30.0	135	3036090.510	13910776.703
2	30.0	135	3036594.948	13910800.349
3	30.0	135	3037102.902	13910824.104
4	30.0	134	3037565.432	13911079.998
5	30.0	135	3037197.289	13911090.59
6	30.0	134	3036839.927	13911428.926
7	15.0	133	3037212.133	13911551.844
8	30.0	134	3036483.451	13911767.29
9	15.0	134	3036885.904	13912092.183
10	30.0	133	3036114.411	13912114.391
11	15.0	132	3036220.382	13912406.473
12	25.0	133	3038153.548	13911434.602
13	25.0	130	3038750.282	13912284.489
14	25.0	133	3037618.422	13912292.205
15	25.0	129	3037737.932	13912876.742

Soil sampling during the drilling of the geotechnical borings consisted of continuous sampling to a depth of 5-foot, with both disturbed samples and relatively undisturbed soil samples being obtained.

Disturbed samples of soils were taken by utilizing the standard penetration testing procedures. The standard penetration test (SPT) blow count is defined as the number of SPT hammer blows which are required to advance a split spoon sampler 1 foot into the soil. One SPT hammer blow consists of a 140-pound hammer free falling for a distance of 30 inches. The results of the standard penetration tests provide a basis for estimating the relative strength and compressibility of the soil profile components. The samples recovered were removed from the split spoon sampler and placed into airtight plastic bags.

Relatively undisturbed samples were obtained by hydraulically forcing sections of 3-inch O.D. tubing (Shelby tube) into the subsoils. The tube samples were extruded in the field, sealed with foil, and placed into airtight plastic bags. Estimates of the unconfined compressive strengths of the cohesive soils were obtained with pocket penetrometer readings being taken on the tube samples.

All samples were transported to HTS' laboratory for purposes of performing laboratory tests on selected samples.

3.0 LABORATORY TESTING

For the current geotechnical study, a laboratory testing program was conducted to obtain engineering properties for use in performing engineering analyses and to adjust field soil classifications. The following laboratory tests were performed:

LABORATORY TEST	TEST STANDARD
Moisture Content of Soils	ASTM D 2216
Moisture Content and In Situ Dry Density of Soils	ASTM D 2937
Percent Soil Particles Passing a No. 200 Sieve	ASTM D 1140
Liquid Limit, Plastic Limit, and Plasticity Index of Soils	ASTM D 4318
Unconfined Compressive Strength of Cohesive Soils	ASTM D 2166
Unconsolidated Undrained Triaxial Compression Test	ASTM D 2850

The number of tests and the test results are presented in the attached Tables 1 and 2, Figures 4 through 13, and on the boring logs provided in Appendix A. All tests were performed in accordance with applicable ASTM procedures and methods and soil classifications were completed in accordance with the procedures and guidelines of ASTM D 2487 and ASTM D 2488.

4.0 SUBSURFACE CONDITIONS

4.1 Subsoils

The subsurface soil conditions as determined from the drilling of the geotechnical borings are provided in:

- Section 1.3.1 of this report,
- the boring logs in Appendix A, and
- the soil profiles (Sections A-A, B-B, C-C, D-D, and E-E) in Figures 3A and 3B.

The boring logs were prepared by using both field visual classifications and the results of laboratory testing. The stratification lines shown on the boring logs and in the soil profiles represent the approximate boundaries between soil types and the transitions between soil types may be gradual.

4.2 Groundwater

Groundwater conditions are described in Section 1.3.2 of this report, on the boring logs provided in Appendix A, and on the soil profiles provided in Figures 3A and 3B. The depth to groundwater was obtained by:

- observing the drilling operations and the free moisture contained in the samples recovered during drilling, and

- obtaining water level measurements in the borings during drilling and within 24 hours after the completion of drilling.

It is possible that seasonal variations will cause fluctuations in the water levels measured at the time of our field investigation. Additionally, perched water may be encountered in discontinuous zones within the overburden. We recommend that the contractor determine the groundwater level at the site at the time of construction in order to determine the impact, if any, of the groundwater to the construction activities. It should be noted that recommendations contained in this report are based on groundwater depths at the time of this geotechnical investigation and that an accurate determination of the true groundwater levels may require several days or even months of observations.

5.0 ENGINEERING ANALYSES

Engineering analyses were performed in order to determine design parameters that can be used for the design and re-construction of the proposed pavement and storm sewer in Harris County, Texas. Analyses performed included:

- analyses of subsurface soil grain size and plasticity characteristics and site groundwater levels as necessary to identify potential dewatering requirements, and

- analyses to determine lateral earth pressure design parameters that can be used in the design of below ground structures associated with the construction of the proposed storm sewer.

5.1 Potential Dewatering Requirements

Potential dewatering requirements were developed based upon measured groundwater level depths, the types of subsurface soils encountered, and the grain size characteristics of the subsurface soils. The use of well points, vacuum well points, or a comparable dewatering system should provide for the effective dewatering of sandy soils which occur below the groundwater table and are found to contain less than 15 to 20% soil particles passing a No. 200 sieve. Sumps and sump pumps may be used to effectively dewater sandy soils that occur below the groundwater table and contain more than 20% soil particles passing a No. 200 sieve. Based on the results of the groundwater level measurements, where the proposed elevation of the bottom of the pond is lower than the measured groundwater levels in the geotechnical borings, it will be necessary that groundwater dewatering be performed in order to complete the excavation and allow the construction of the basin.

5.2 Lateral Earth Pressure Analyses for Design of Below Ground Structures

Earth pressure coefficients may be used to define the lateral loads exerted by the overburden soils on underground structures. The earth pressure coefficients for the clays and sands as provided in this report were computed by using Rankine's methods. The recommended lateral earth pressure coefficients, equivalent fluid weight values, and earth pressure, provided in this report, are based on soil properties as summarized in Section 1.4.6 of this report. Earth pressure design parameters, provided in this report for use in designing permanent below ground structures, are based on effective stress and shear strength parameters.

6.0 CONSTRUCTION CONSIDERATIONS

The recommendations provided below should be followed with regard to the construction of the proposed storm sewers and pavement addressed by this report:

- Dewatering for construction purposes may consist of using sumps and sump pumps or a construction dewatering system may be required.

- Fill material and fill compaction should comply with the recommendations provided in Section 1.4 of this report.

- Materials testing should be performed to assure that acceptable materials and construction methods are provided by the contractor.

- Backfill placement operations should be monitored and the backfill tested to assure compliance with the 2020 HCFCD Standard Specifications Book.

7.0 CLOSING REMARKS

HTS has performed a geotechnical investigation and provided recommendations pertaining to the design and construction activities associated with the construction of storm sewer lines underneath the existing pavement as part of the Ravensway Subdivision Drainage Improvements Project – 2018 in Harris County, Texas. The proposed tract could be found in Key Map 368 Squares F, G, K, and L. This report has been prepared for the exclusive use of LJA and HCED in accordance with generally accepted soil and foundation engineering practices. No other warranty, expressed or implied, is made.

In the event that changes are made in the nature, design, or location of the proposed pavement and storm sewer as well as the associated structures, the conclusions and recommendations contained in this report shall not be considered valid unless the changes are reviewed and the findings and recommendations of this report are modified or verified in writing. The analyses and recommendations presented in this report are based upon data obtained from 15 pavement corings and 15 geotechnical borings that were cored and drilled between March 9 through 23, 2022. The nature and extent of variations within the subsurface materials may not become evident until after construction is initiated. If significant variations in the subsurface materials are encountered during construction, it may be necessary to re-evaluate the recommendations provided in this report.

REFERENCES

1. HCFCD Geotechnical Guidelines, 2022.
2. Harris County Flood Control District (HCFCD) 2020 Standard Specifications Book.
3. OSHA Standards and Interpretations, 29 CFR 1926, Subpart P, Excavations.

TABLES

TABLE 1

LABORATORY TEST SUMMARY

PROJECT: Pavement and Storm Sewer
Ravensway Subdivison Drainage
LOCATION: Improvements - 2018 Pct. 1
Harris County, Texas
CLIENT: LJA Engineering, Inc.

HTS PROJECT NO.: 22-S-148

Boring No.	Sample Depth (feet)	Type of Material	Moisture Content (%)	Dry Density (pcf)	Atterberg Limits (%)			-200 Sieve (%)	Compressive Strength (tsf)	Strain (%)	Lateral Pressure (psi)	Remarks
					LL	PL	PI					
1	0-2	Clayey Sand (SC)	10.8		23	13	10	48.7				(1) Sample failed along diagonal shear planes.
	4-6	Sandy Lean Clay (CL)	10.4	122.4	32	15	17		7.6 (1)	2.3	4.3	(2) Sample failed along vertical shear planes.
	13-15	Poorly Graded Sand With Silt (SP-SM)	6.9		Non Plastic			9.8				(3) Sample bulged at failure.
												(4)Sample failed along sand fissures.
2	2-4	Sandy Lean Clay (CL)	14.8	114.7	35	17	18		2.8 (2)	5.9	0	
	6-8	Sandy Lean Clay (CL)	14.3	117.1	35	17	18	50.3	3.3 (3)	11.8	6.1	
	18-20	Poorly Graded Sand With Silt (SP-SM)	12.0		Non Plastic							
3	4-6	Sandy Lean Clay (CL)	12.2	123.4	34	18	16	66.4	5.2 (2)	6.9	0	
	8-10	Sandy Lean Clay (CL)	14.0		28	15	13					
	23-25	Poorly Graded Sand (SP)	4.4		Non Plastic			4.8				
4	0-2	Sandy Lean Clay (CL)	24.7	107.0	48	19	29		1.6 (1)	13.6	0	
	10-12	Sandy Lean Clay (CL)	18.2	102.2	33	16	17	51.9	1.1 (1)	14.6	9.5	
	16-18	Silty Sand (SM)	6.2		Non Plastic			22.1				
5	2-4	Sandy Lean Clay (CL)	10.5	122.0	37	17	20	65.4	14.4 (2)	3.7	0	
	8-10	Sandy Lean Clay (CL)	9.4		31	15	16					
	28-30	Poorly Graded Sand With Silt (SP-SM)	5.1		Non Plastic			8.9				
6	4-6	Sandy Lean Clay (CL)	14.4	118.0				60.0	2.1 (1)	7.1	0	
	8-10	Sandy Lean Clay (CL)	15.5		27	15	12					
	18-20	Lean Clay With Sand (CL)	14.1	121.3	32	16	16	73.1	3.8 (3)	12.6	16.5	
7	0-2	Lean Clay With Sand (CL)	14.9	120.1	30	15	15	71.7	4.0 (2)	7.1	0	
	6-8	Lean Clay With Sand (CL)	18.4	109.5	32	16	16		2.1 (3)	15.0	6	

TABLE 1

LABORATORY TEST SUMMARY

PROJECT: Pavement and Storm Sewer Ravensway Subdivison Drainage Improvements - 2018 Pct. 1

LOCATION: Harris County, Texas

CLIENT: LJA Engineering, Inc.

HTS PROJECT NO.: 22-S-148

Boring No.	Sample Depth (feet)	Type of Material	Moisture Content (%)	Dry Density (pcf)	Atterberg Limits (%)			-200 Sieve (%)	Compressive Strength (tsf)	Strain (%)	Lateral Pressure (psi)	Remarks
					LL	PL	PI					
7	13-15	Silty Sand (SM)	9.2		Non Plastic			21.1				
8	0-2	Clayey Sand (SC)	12.4		23	13	10	47.5				
	4-6	Sandy Lean Clay (CL)	9.8		37	18	19					
	18-20	Silty Sand (SM)	15.1		Non Plastic			49.1				
9	2-4	Lean Clay With Sand (CL)	12.0	123.4	43	18	25		9.2 (1)	15.0	0	
	6-8	Lean Clay With Sand (CL)	12.4	116.7	41	18	23		5.3 (2)	10.3	6.1	
	13-15	Silty Sand (SM)	7.5		Non Plastic			34.2				
10	4-6	Lean Clay With Sand (CL)	10.7	127.9	37	17	20		11.7 (1)	5.9	0	
	8-10	Lean Clay With Sand (CL)	15.8	114.0	44	19	25	76.8	4.5 (1)	5.8	7.8	
	23-25	Poorly Graded Sand With Silt (SP-SM)	4.4		Non Plastic			9.4				
11	6-8	Clayey Sand (SC)	14.1	119.7	38	18	20	36.5	3.6 (3)	10.1	6.1	
	13-15	Poorly Graded Sand With Silt (SP-SM)	6.7		Non Plastic			7.3				
12	2-4	Sandy Lean Clay (CL)	9.5		34	15	19	55.8				
	4-6	Sandy Lean Clay (CL)	10.7	124.7	39	18	21	59.8	7.1 (4)	4.3	0.0	
	10-12	Sandy Lean Clay (CL)	10.6		33	14	19	34.8				
	16-18	Silty Sand (SM)	7.8		Non Plastic			22.6				
	23-25	Silty Sand (SM)	6.0		Non Plastic			14.4				
13	0-2	Sandy Lean Clay (CL)	18.7	112.1	47	20	27	60.6	3.5 (3)	14.4	0	
	12-14	Sandy Lean Clay (CL)	17.3	111.5	35	17	18	56.6	2.9 (3)	14.8	11.3	

HTS CONSULTANTS

TABLE 1

LABORATORY TEST SUMMARY

PROJECT: Pavement and Storm Sewer
Ravensway Subdivison Drainage
LOCATION: Improvements - 2018 Pct. 1
Harris County, Texas
CLIENT: LJA Engineering, Inc.

HTS PROJECT NO.: 22-S-148

Boring No.	Sample Depth (feet)	Type of Material	Moisture Content (%)	Dry Density (pcf)	Atterberg Limits (%)			-200 Sieve (%)	Compressive Strength (tsf)	Strain (%)	Lateral Pressure (psi)	Remarks
					LL	PL	PI					
14	4-6	Sandy Lean Clay (CL)	10.6	125.2				58.6	9.7 (1)	6.1	4.3	
	8-10	Sandy Lean Clay (CL)	11.7	120.9	33	16	17		4.6 (1)	8.3	7.8	
	18-20	Poorly Graded Sand With Silt (SP-SM)	4.8		Non Plastic			9.8				
15	0-2	Sandy Lean Clay (CL)	15.1		39	18	21	54.7				
	4-6	Poorly Graded Sand With Silt (SP-SM)	6.9		Non Plastic			5.2				
	14-16	Silty Sand (SM)	5.8		Non Plastic			30.5				

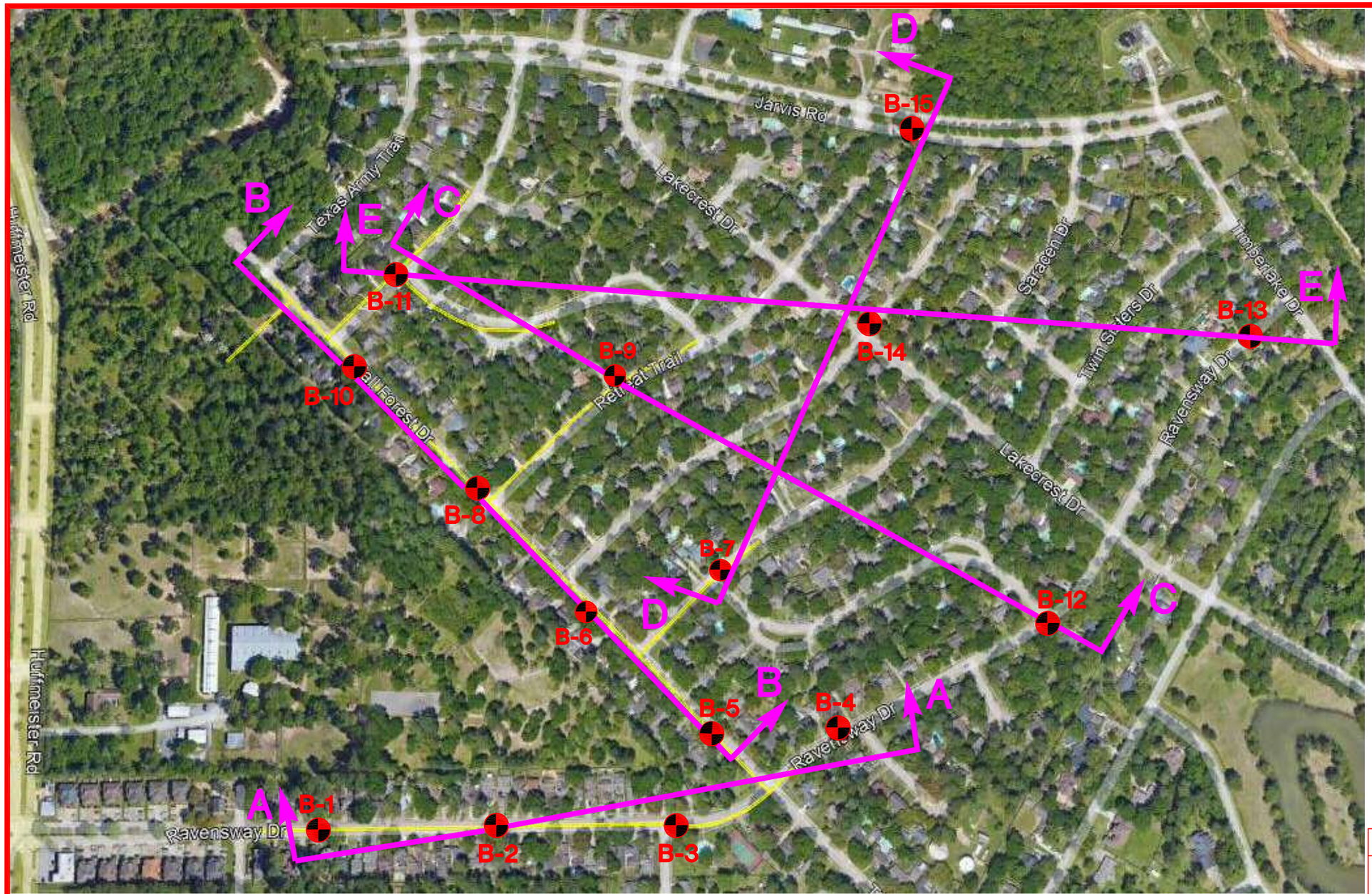
FIGURES

KEY MAP: 368 (Squares F, G, K, and L)

HTS, Inc. Consultants

Geotechnical Services for Proposed Pavement and Storm Sewer Ravensway Subdivision Drainage Improvements - 2018
Precinct 3
Harris County, Texas
UPIN No. 19103MF14601

DRAWN BY:	IAT	DATE:	03-20-22	SCALE: NTS
CHECKED BY:	JH	DATE:	03-20-22	
HTS PROJECT NO.:	22-S-148			FIGURE: 1
Vicinity Map				



Legend

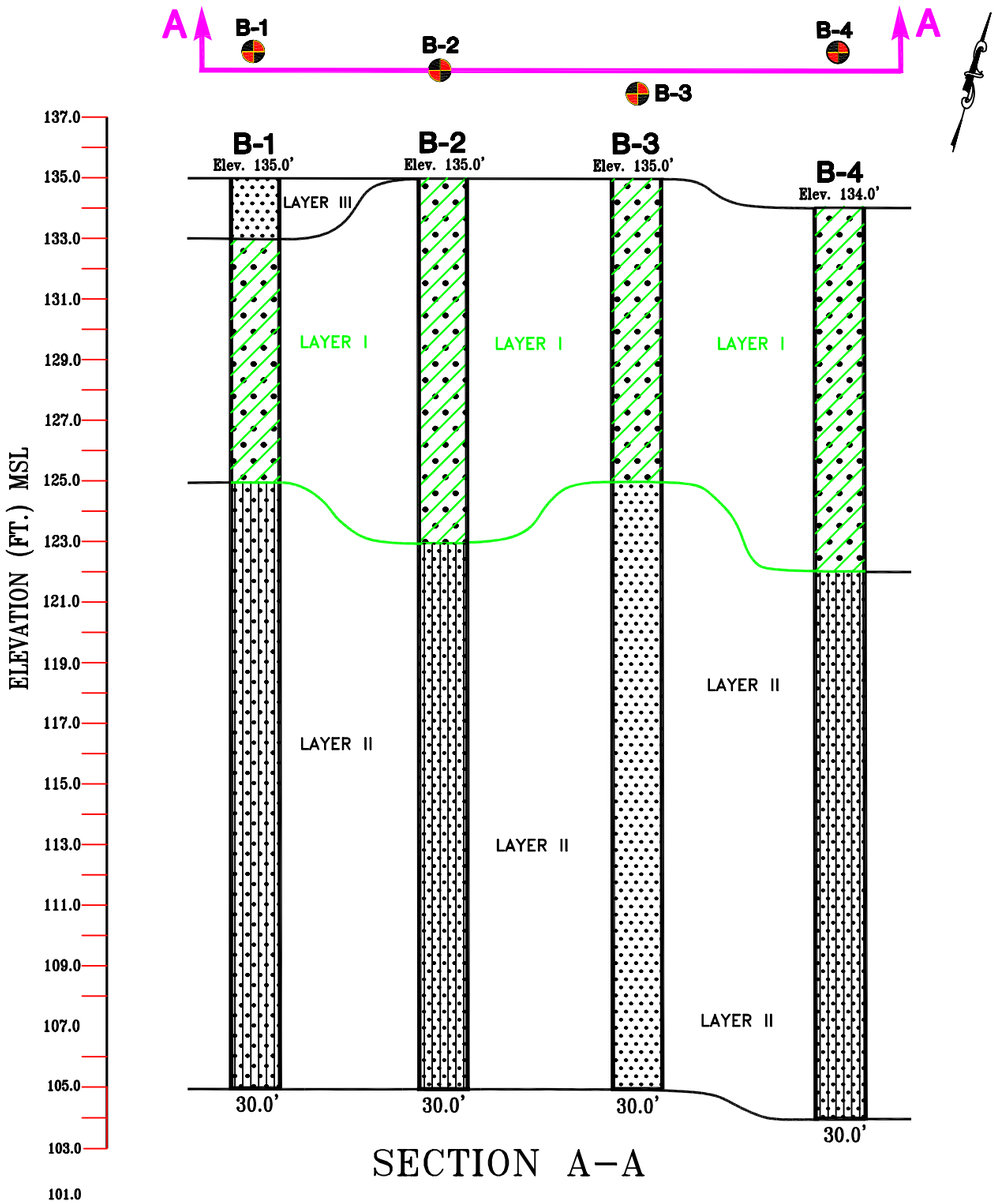
Geotechical Boring and Coring Locations

HTS, Inc. Consultants

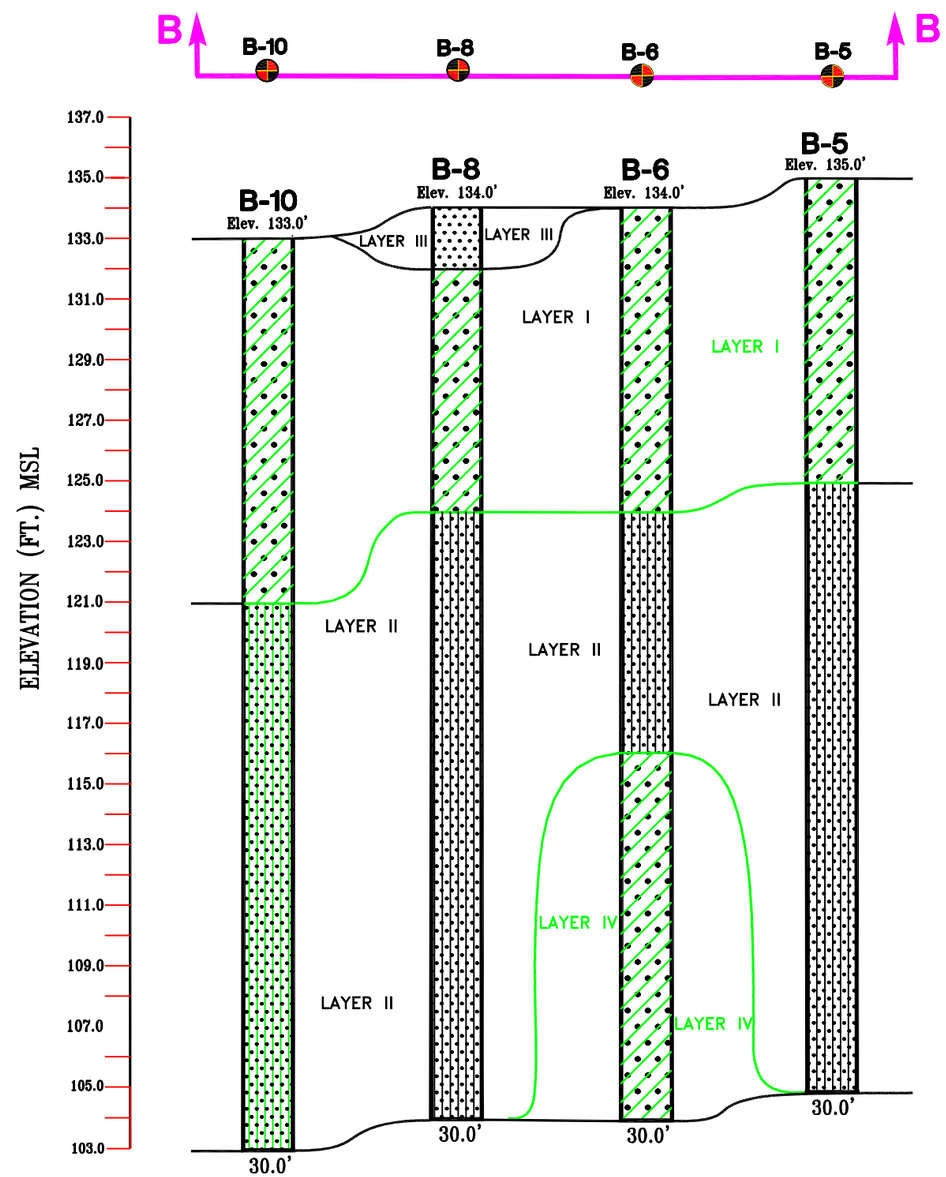
Geotechnical Services for Proposed Pavement and Storm Sewer Ravensway Subdivision Drainage Improvements - 2018
Precinct 3
Harris County, Texas
UPIN No. 19103MF14601

DRAWN BY:	IAT	DATE:	03-18-22	SCALE: Approx. 1"=300'
CHECKED BY:	JH	DATE:	03-18-22	
HTS PROJECT NO.:	22-S-148			FIGURE: 2

Boring/Coring Locations



SECTION A–A



SECTION B–B

LAYER I

SANDY LEAN CLAY, AND LEAN CLAY WITH SAND, STIFF TO HARD.

LAYER II

POORLY GRADED SAND WITH SILT, POORLY GRADED SAND, AND SILTY SAND, LOOSE TO DENSE.

LAYER III

CLAYEY SAND, LOOSE.

LAYER IV

LEAN CLAY WITH SAND, STIFF TO HARD.

LEGEND

- GROUNDWATER WAS NOT ENCOUTERED DURING DRILLING
- NOR 24 HOURS AFTER THE COMPLETION OF DRILLING

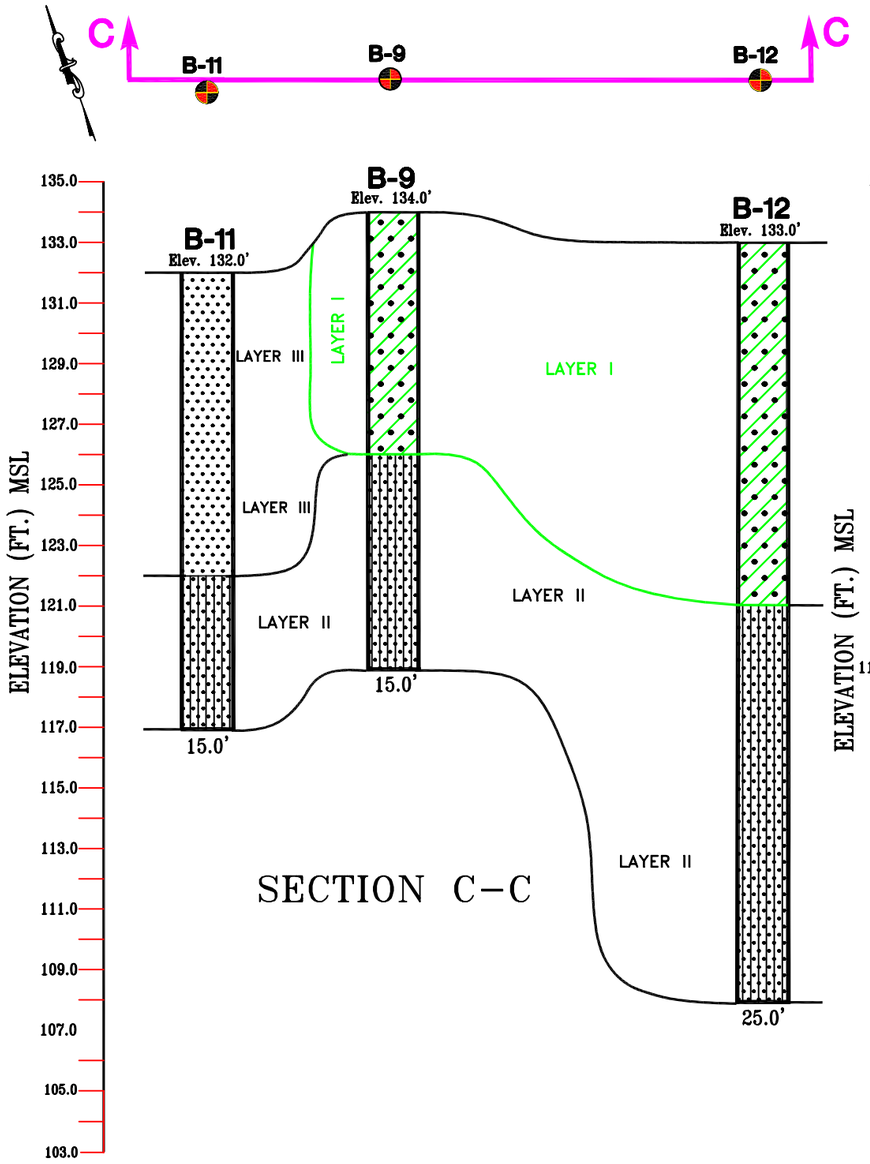
NOTES

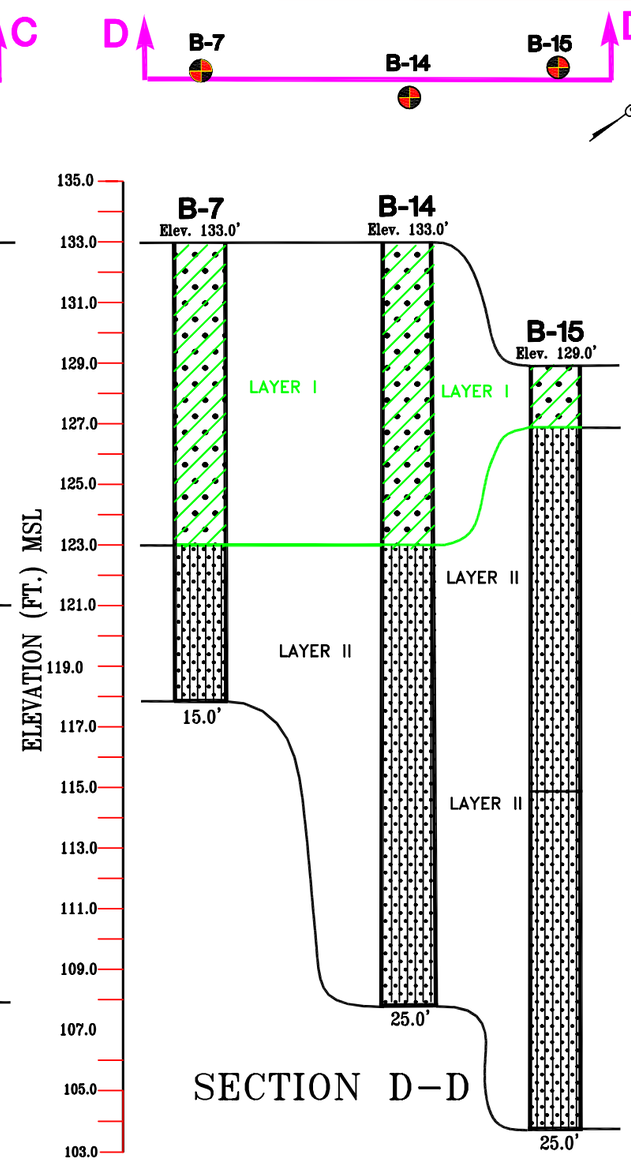
1) SEE FIGURE 2 FOR LOCATION OF SECTION A–A.
2) THE STRATIFICATION LINES SHOWN ARE OUR ESTIMATION BETWEEN BORINGS AND DO NOT REPRESENT ACTUAL SUBSOIL CONDITIONS BETWEEN BORINGS.
3) SEE CORRESPONDING BORING LOGS FOR DETAILED SUBSOIL AND GROUNDWATER INFORMATION.

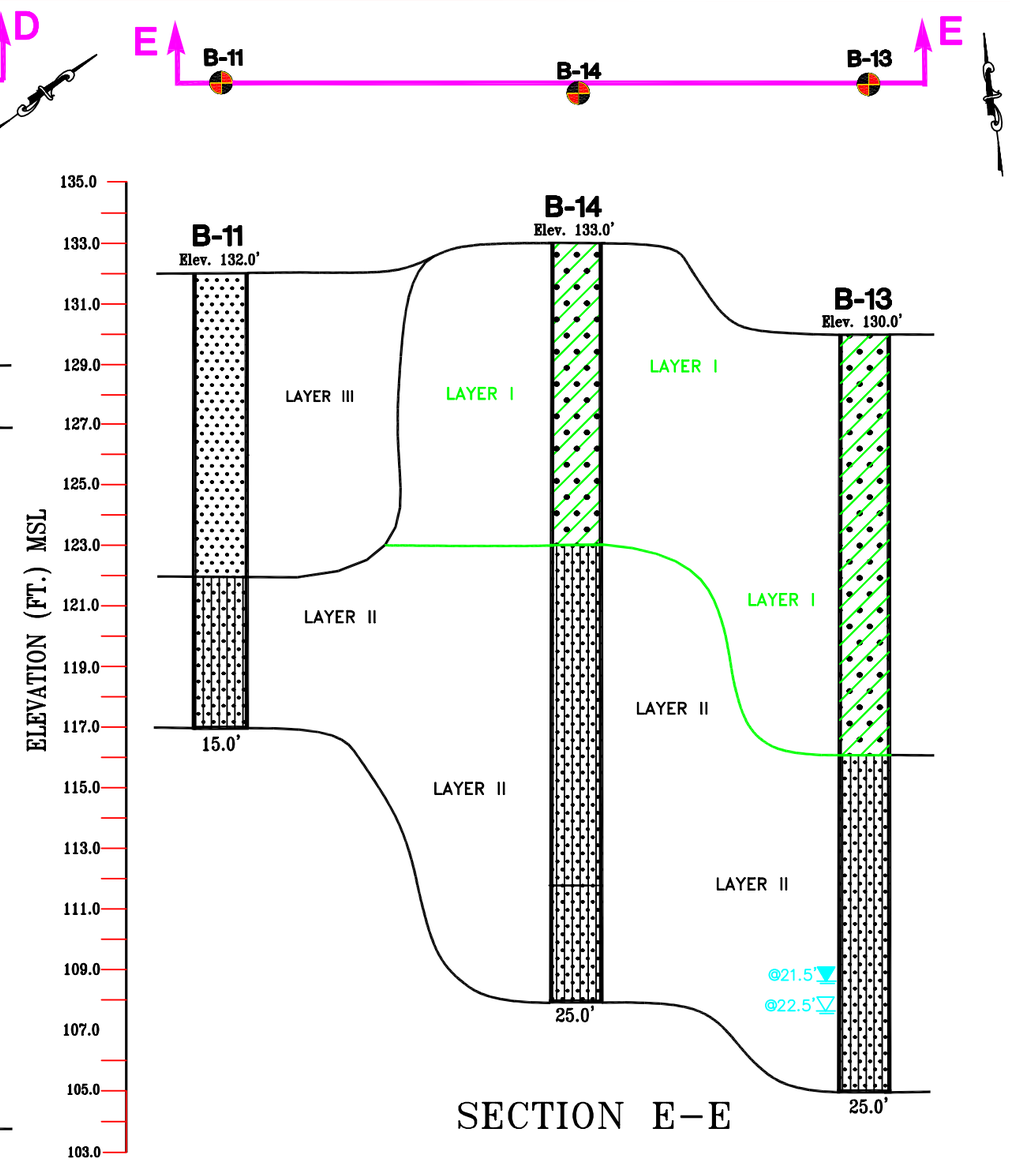
HTS, Inc. Consultants

Proposed Pavement and Storm Sewer
Ravensway Subdivision Drainage Improvements
Improvements - 2018
Precinct 3
Harris County, Texas
UPIN No. 19103MF14601

DRAWN BY: IAT	DATE: 3–10–22	SCALE: Hor.: 1"=400' Vert.: 1"=5'	
CHECKED BY: JH	DATE: 3–10–22		
HTS PROJECT NO.: 22-148		FIGURE: 3A	
Soil Profile Sections A-A and B-B			







LEGEND

- GROUNDWATER MEASURED DURING DRILLING
- GROUNDWATER MEASURED 24 HOURS AFTER THE COMPLETION OF DRILLING

NOTES

1) SEE FIGURE 2 FOR LOCATION OF SECTION A–A.
2) THE STRATIFICATION LINES SHOWN ARE OUR ESTIMATION BETWEEN BORINGS AND DO NOT REPRESENT ACTUAL SUBSOIL CONDITIONS BETWEEN BORINGS.
3) SEE CORRESPONDING BORING LOGS FOR DETAILED SUBSOIL AND GROUNDWATER INFORMATION.

LAYER I
SANDY LEAN CLAY AND LEAN CLAY WITH SAND, STIFF TO HARD.

LAYER II
POORLY GRADED SAND WITH SILT, POORLY GRADED SAND, AND SILTY SAND, LOOSE TO DENSE.

LAYER III
CLAYEY SAND, LOOSE.

HTS, Inc. Consultants

Proposed Pavement and Storm Sewer
Ravensway Subdivision Drainage Improvements
Improvements - 2018
Precinct 3
Harris County, Texas
UPIN No. 19103MF14601

DRAWN BY: IAT	DATE: 3–20–22	SCALE: Hor.: 1"=600' Vert.: 1"=5'	
CHECKED BY: JH	DATE: 3–20–22		
HTS PROJECT NO.: 22-S-148		FIGURE: 3B	
Soil Profile Sections C-C, D-D, and E-E			

APPENDIX A

BORING LOGS
(Boring Nos. 1 through 15)

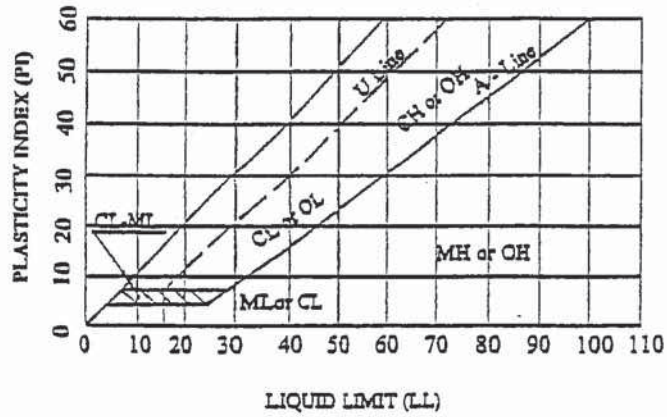
CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES

ASTM Designation D-2487

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

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

PLASTICITY CHART



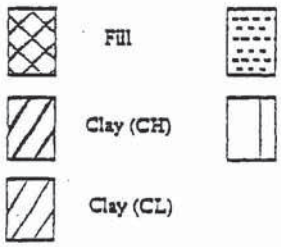
Equation of A-Line Horizontal at PI=4 to LL=25.5, then PI=0.73(LL-20)

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

DEGREE OF PLASTICITY OF COHESIVE SOILS

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

SOIL SYMBOLS



TERMS USED ON BORING LOGS

SOIL GRAIN SIZE

U.S. STANDARD SIEVE

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

BOULDERS	COBBLES	GRAVEL		SAND			SILT	CLAY
		COARSE	FINE	COARSE	MEDIUM	FINE		

152	76.2	19.1	4.76	1.00	0.420	0.074	0.002

SOIL GRAIN SIZE IN MILLIMETERS

STRENGTH OF COHESIVE SOILS

Consistency	Undrained Shear Strength, Kips per Sq. ft
Very Soft	less than 0.25
Soft	0.25 to 0.50
Firm	0.50 to 1.00
Stiff	1.00 to 2.00
Very Stiff	2.00 to 4.00
Hard	greater than 4.00

RELATIVE DENSITY OF COHESIONLESS SOILS FROM STANDARD PENETRATION TEST

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

(bpf = blow per foot, ASTM D 1586)

SPLIT-BARREL SAMPLER DRIVING RECORD

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

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

DRY STRENGTH ASTM D2488

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

MOISTURE CONDITION ASTM D2488

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

SOIL STRUCTURE

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

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LOG OF BORING NO. B-1

PROJECT: Pavement and Storm Sewer Ravensway Subdivision Drainage Improvement, UPIN # 19103MF14601, Harris County, Texas

PROJECT NO.: 22-S-148 BORING TYPE: Auger (0'-30')

DATE 03/09//22

SURFACE ELEVATION +135' above MSL

LOCATION

Northing, Y (Feet): 13910776.703
Easting, X (Feet): 3036090.51

See Figure 2

MATERIAL DESCRIPTION

Depth (ft.)	USC	Material Description	Field Strength Data	Dry Density (pcf)	Shear Strength (tsf)	Failure Strain (%)	Confining Pressure (psi)	Moisture Content (%)	Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)	Passing #200 Sieve (%)	Estimated Angle of Internal Friction (°), Other Tests & Remarks
0–2'	SC	**CLAYEY SAND (SC),** slight plasticity, brown, with ferrous nodules, moist	P = 4.50					10.8	23	13	10	48.7	
2'–10'	CL	**SANDY LEAN CLAY (CL),** hard, medium plasticity, brown and tan, with ferrous nodules, moist	P = 4.50; P = 4.50; P = 4.50; P = 4.50; P = 4.50	122.4	3.80	2.3	4.3	10.4	32	15	17		(1)
10'–30'	SP SM	**POORLY GRADED SAND WITH SILT (SP-SM),** loose to medium dense, no plasticity, light tan and light gray, with clay pockets, moist	N = 29; N = 27; N = 21; N = 18; N = 22; N = 16; N = 6					6.9				9.80	Non Plastic

30' Boring terminated at 30'

Water Level Est.: ▽ Measured: ▼ Perched: ▼

Water Observations: GW was not encountered during drilling nor 24 hours after the completion of drilling.

Sample Key: ☒ SPT ⧄ Shelby Tube ⧈ Disturbed ⧈ No Recovery

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psf)
C_u - Undrained Cohesion (tsf)
SS - Shear Strength (P/2, tsf)

Notes:
(1) Sample failed along diagonal shear planes.

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LOG OF BORING NO. B-2

PROJECT: Pavement and Storm Sewer Ravensway Subdivision Drainage Improvement, UPIN # 19103MF14601, Harris County, Texas

PROJECT NO.: 22-S-148 BORING TYPE: Auger (0'-30')

DATE 03/09//22

SURFACE ELEVATION +135' above MSL

LOCATION

Northing, Y (Feet): 13910800.349
Easting, X (Feet): 3036594.948

See Figure 2

MATERIAL DESCRIPTION

Depth (ft.)	USC	Material Description	Field Strength Data	Dry Density (pcf)	Shear Strength (tsf)	Failure Strain (%)	Confining Pressure (psi)	Moisture Content (%)	Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)	Passing #200 Sieve (%)	Estimated Angle of Internal Friction (°), Other Tests & Remarks
0	CL	**SANDY LEAN CLAY (CL),** very stiff to hard, medium plasticity, brown and tan, with ferrous nodules, moist	P = 3.25										
			P = 4.50	114.7	1.40	5.9	0	14.8	35	17	18		(2)
5			P = 2.75										
			P = 2.25	117.1	1.65	11.8	6.1	14.3	35	17	18	50.3	(3)
10			P = 2.50										
12'			P = 3.75										
	SP SM	**POORLY GRADED SAND WITH SILT (SP-SM),** medium dense, no plasticity, light tan and light gray, with clay pockets, moist	N = 19										
15			N = 20										
			N = 22										
20			N = 20					12.0					Non Plastic
25			N = 21										
30			N = 23										
30'		Boring terminated at 30'											

Field Strength Data: ● BLOW COUNT ● (20 40 60 80); ▲ C_u (tsf) ▲ (1.0 2.0 3.0 4.0); ■ SS (tsf) ■ (1.0 2.0 3.0 4.0); ◆ Torvane (psf) ◆ (200 400 600 800)

Natural Moisture Content and Atterberg Limits: Plastic Limit — Moisture Content — Liquid Limit (20 40 60 80)

Water Level Est.: ▽ Measured: ▼ Perched: ▼

Water Observations: GW was not encountered during drilling nor 24 hours after the completion of drilling.

Sample Key: ☒ SPT ☒ Shelby Tube ☒ Disturbed ☒ No Recovery

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psf)
C_u - Undrained Cohesion (tsf)
SS - Shear Strength (P/2, tsf)

Notes:
(2) Sample failed along vertical shear planes. (3) Sample bulged at failure.

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LOG OF BORING NO. B-3

PROJECT: Pavement and Storm Sewer Ravensway Subdivision Drainage Improvement, UPIN # 19103MF14601, Harris County, Texas

PROJECT NO.: 22-S-148 BORING TYPE: Auger (0'-30')

DATE 03/10/22

SURFACE ELEVATION +135' above MSL

LOCATION

Northing, Y (Feet): 13910824.104
Easting, X (Feet): 3037102.902

See Figure 2

DEPTH (ft.)	USC	MATERIAL DESCRIPTION	FIELD STRENGTH DATA	DRY DENSITY (pcf)	SHEAR STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	MOISTURE CONTENT (%)	LIQUID LIMIT (LL)	PLASTIC LIMIT (PL)	PLASTICITY INDEX (PI)	PASSING #200 SIEVE (%)	ESTIMATED ANGLE OF INTERNAL FRICTION (°), OTHER TESTS & REMARKS
0	CL	**SANDY LEAN CLAY (CL),** stiff to hard, medium plasticity, brown and tan, with ferrous nodules, moist	P = 1.75										
			P = 3.50										
5			P = 4.50	123.4	2.60	6.9	0	12.2	34	18	16	66.4	(2)
			P = 4.50										
10		10'	P = 3.25					14.0	28	15	13		
	SP	**POORLY GRADED SAND (SP),** medium dense, no plasticity, light tan and light gray, with clay pockets, moist	N = 22										
			N = 17										
15			N = 20										
			N = 16										
20			N = 21										
25			N = 22					4.4				4.8	Non Plastic
30		30'	N = 22										
		Boring terminated at 30'											

Natural Moisture Content and Atterberg Limits: Plastic Limit — Moisture Content — Liquid Limit (20 40 60 80)

Water Level Est.: ▽ Measured: ▼ Perched: ▼

Water Observations: GW was not encountered during drilling nor 24 hours after the completion of drilling.

Sample Key: ☒ SPT ☒ Shelby Tube ☒ Disturbed ☒ No Recovery

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psf)
C_u - Undrained Cohesion (tsf)
SS - Shear Strength (P/2, tsf)

Notes:
(2) Sample failed along vertical shear planes.

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LOG OF BORING NO. B-4

PROJECT: Pavement and Storm Sewer Ravensway Subdivision Drainage Improvement, UPIN # 19103MF14601, Harris County, Texas

PROJECT NO.: 22-S-148 BORING TYPE: Auger (0'-30')

DATE 03/10/22

SURFACE ELEVATION +134' above MSL

LOCATION

Northing, Y (Feet): 13911079.998
Easting, X (Feet): 3037565.432

See Figure 2

MATERIAL DESCRIPTION

DEPTH (ft.)	USC	MATERIAL DESCRIPTION	FIELD STRENGTH DATA	DRY DENSITY (pcf)	SHEAR STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	MOISTURE CONTENT (%)	LIQUID LIMIT (LL)	PLASTIC LIMIT (PL)	PLASTICITY INDEX (PI)	PASSING #200 SIEVE (%)	ESTIMATED ANGLE OF INTERNAL FRICTION (°), OTHER TESTS & REMARKS
0	CL	**SANDY LEAN CLAY (CL),** stiff to very stiff, medium to high plasticity, brown, tan, and light gray, with ferrous nodules, moist	P = 1.25	107.0	0.80	13.6	0	24.7	48	19	29		(1)
			P = 2.50										
5			P = 3.25										
			P = 3.25										
			P = 1.75										
10		12'	P = 1.25	102.2	0.55	14.6	9.5	18.2	33	16	17	51.9	(1)
	SM	**SILTY SAND (SM),** medium dense, no plasticity, light tan and light gray, with clay pockets, moist	N = 19										
15			N = 16										
			N = 20					6.2				22.1	Non Plastic
20			N = 12										
25			N = 16										
30		30'	N = 14										
		Boring terminated at 30'											

Natural Moisture Content and Atterberg Limits: Plastic Limit, Moisture Content, Liquid Limit (20, 40, 60, 80)

Water Level Est.: ▽ Measured: ▼ Perched: ▼

Water Observations: GW was not encountered during drilling nor 24 hours after the completion of drilling.

Sample Key: ☒ SPT ☒ Shelby Tube ☒ Disturbed ☒ No Recovery

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psf)
C_u - Undrained Cohesion (tsf)
SS - Shear Strength (P/2, tsf)

Notes:
(1) Sample failed along diagonal shear planes.

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LOG OF BORING NO. B-5

PROJECT: Pavement and Storm Sewer Ravensway Subdivision Drainage Improvement, UPIN # 19103MF14601, Harris County, Texas

PROJECT NO.: 22-S-148 BORING TYPE: Auger (0'-30')

DATE 03/10/22

SURFACE ELEVATION +135' above MSL

LOCATION

Northing, Y (Feet): 13911090.59
Easting, X (Feet): 3037197.289

See Figure 2

MATERIAL DESCRIPTION

DEPTH (ft.)	USC	MATERIAL DESCRIPTION	FIELD STRENGTH DATA	DRY DENSITY (pcf)	SHEAR STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	MOISTURE CONTENT (%)	LIQUID LIMIT (LL)	PLASTIC LIMIT (PL)	PLASTICITY INDEX (PI)	PASSING #200 SIEVE (%)	ESTIMATED ANGLE OF INTERNAL FRICTION (°), OTHER TESTS & REMARKS
0	CL	**SANDY LEAN CLAY (CL),** hard, medium plasticity, brown and tan, with ferrous nodules, moist	P = 4.50										
			P = 4.50	>>122.0	7.20	3.7	0	10.5	37	17	20	65.4	(2)
5			P = 4.50										
			P = 4.50										
10		10'	P = 4.50					9.4	31	15	16		
	SP SM	**POORLY GRADED SAND WITH SILT (SP-SM),** medium dense, no plasticity, light tan and light gray, with clay pockets, moist	N = 22										
			N = 23										
15			N = 20										
			N = 18										
20			N = 26										
25			N = 26										
30		30'	N = 30					5.1				8.9	Non Plastic
		Boring terminated at 30'											

Field strength data: ● BLOW COUNT ● (20 40 60 80); ▲ C_u (tsf) ▲ (1.0 2.0 3.0 4.0); ■ SS (tsf) ■ (1.0 2.0 3.0 4.0); ◆ Torvane (psf) ◆ (200 400 600 800)

Natural Moisture Content and Atterberg Limits: Plastic Limit — Moisture Content — Liquid Limit (20 40 60 80)

Water Level Est.: ▽ Measured: ▼ Perched: ▼

Water Observations: GW was not encountered during drilling nor 24 hours after the completion of drilling.

Sample Key: ☒ SPT ⧄ Shelby Tube ⧈ Disturbed ⧈ No Recovery

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psf)
C_u - Undrained Cohesion (tsf)
SS - Shear Strength (P/2, tsf)

Notes:
(2) Sample failed along vertical shear planes.

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LOG OF BORING NO. B-6

PROJECT: Pavement and Storm Sewer Ravensway Subdivision Drainage Improvement, UPIN # 19103MF14601, Harris County, Texas

PROJECT NO.: 22-S-148 BORING TYPE: Auger (0'-30')

DATE 03/10/22

SURFACE ELEVATION +134' above MSL

LOCATION

Northing, Y (Feet): 13911428.926
Easting, X (Feet): 3036839.927

See Figure 2

MATERIAL DESCRIPTION

Depth (ft.)	USC	Material Description	Field Strength Data	Dry Density (pcf)	Shear Strength (tsf)	Failure Strain (%)	Confining Pressure (psi)	Moisture Content (%)	Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)	Passing #200 Sieve (%)	Estimated Angle of Internal Friction (°), Other Tests & Remarks
0	CL	**SANDY LEAN CLAY (CL),** stiff to hard, medium plasticity, brown and tan, with ferrous nodules, moist	P = 1.25										
			P = 4.50										
5			P = 2.50	118.0	1.05	7.1	0	14.4				60.0	(1)
			P = 3.75										
10		10'	P = 2.00					15.5	27	15	12		
	SP SM	**POORLY GRADED SAND WITH SILT (SP-SM),** medium dense, light tan and light gray, with clay pockets, moist	N = 11										
			N = 15										
15			N = 11										
		18'	N = 17										
	CL	**LEAN CLAY WITH SAND (CL),** stiff to hard, medium plasticity, light gray and light tan, with ferrous nodules, moist	P = 2.00	121.3	1.90	12.6	16.5	14.1	32	16	16	73.1	(3)
20		- with silt pockets at 23'											
25			P = 3.00										
30		30'	P = 4.50										
		Boring terminated at 30'											

Field Strength Data: ● BLOW COUNT ● 20 40 60 80; ▲ C_u (tsf) ▲ 1.0 2.0 3.0 4.0; ■ SS (tsf) ■ 1.0 2.0 3.0 4.0; ◆ Torvane (psf) ◆ 200 400 600 800

Natural Moisture Content and Atterberg Limits: Plastic Limit — Moisture Content — Liquid Limit; 20 40 60 80

Water Level Est.: ▽ Measured: ▼ Perched: ▼

Water Observations: GW was not encountered during drilling nor 24 hours after the completion of drilling.

Sample Key: ☒ SPT ⧄ Shelby Tube ⧈ Disturbed ⧈ No Recovery

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psf)
C_u - Undrained Cohesion (tsf)
SS - Shear Strength (P/2, tsf)

Notes:
(1) Sample failed along diagonal shear planes. (3) Sample bulged at failure.

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LOG OF BORING NO. B-7

PROJECT: Pavement and Storm Sewer Ravensway Subdivision Drainage Improvement, UPIN # 19103MF14601, Harris County, Texas

PROJECT NO.: 22-S-148 BORING TYPE: Auger (0'-15')

DATE 03/14//22

SURFACE ELEVATION +133' above MSL

LOCATION

Northing, Y (Feet): 13911551.844
Easting, X (Feet): 3037212.133

See Figure 2

DEPTH (ft.)	SAMPLES	USC	WATER LEVEL	MATERIAL DESCRIPTION	FIELD STRENGTH DATA	DRY DENSITY (pcf)	SHEAR STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	MOISTURE CONTENT (%)	ATTERBERG LIMITS(%) LIQUID LIMIT (LL)	PLASTIC LIMIT (PL)	PLASTICITY INDEX (PI)	PASSING #200 SIEVE (%)	ESTIMATED ANGLE OF INTERNAL FRICTION (°), OTHER TESTS & REMARKS
0		CL		**LEAN CLAY WITH SAND (CL),** stiff to very stiff, medium plasticity, light tan and light gray, with ferrous nodules, moist	P = 2.50	120.1	2.00	7.1	0	14.9	30	15	15	71.7	(2)
					P = 4.50										
5					P = 3.00										
					P = 3.00	109.5	1.05	15.0	6	18.4	32	16	16		(3)
				10'	P = 2.00										
10		SM		**SILTY SAND (SM),** medium dense, no plasticity, llight gray, moist	N = 15										
					N = 16										
15				15'	N = 16					9.2				21.1	Non Plastic
				Boring terminated at 15'											

Natural Moisture Content and Atterberg Limits: Plastic Limit, Moisture Content, Liquid Limit (20, 40, 60, 80)

Water Level Est.: ▽ Measured: ▼ Perched: ▼

Water Observations: GW was not encountered during drilling nor 24 hours after the completion of drilling.

Sample Key: ☒ SPT ⧄ Shelby Tube ⧈ Disturbed ⧈ No Recovery

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psf)
C_u - Undrained Cohesion (tsf)
SS - Shear Strength (P/2, tsf)

Notes:
(2) Sample failed along vertical shear planes. (3) Sample bulged at failure.

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LOG OF BORING NO. B-8

PROJECT: Pavement and Storm Sewer Ravensway Subdivision Drainage Improvement, UPIN # 19103MF14601, Harris County, Texas

PROJECT NO.: 22-S-148 BORING TYPE: Auger (0'-30')

DATE 03/11/22

SURFACE ELEVATION +134' above MSL

LOCATION

Northing, Y (Feet): 13911767.29
Easting, X (Feet): 3036483.451

See Figure 2

MATERIAL DESCRIPTION

Depth (ft.)	USC	Material Description	Field Strength Data	Moisture Content (%)	Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)	Passing #200 Sieve (%)	Estimated Angle of Internal Friction (°), Other Tests & Remarks
0	SC	**CLAYEY SAND (SC),** slight plasticity, brown, with ferrous nodules, moist	P = 4.50	12.4	23	13	10	47.5	
2'	CL	**SANDY LEAN CLAY (CL),** very stiff to hard, medium plasticity, brown, light tan, and light gray, with ferrous nodules, moist	P = 4.50						
5			P = 4.50	9.8	37	18	19		
			P = 2.25						
10'			P = 4.50						
10	SM	**SILTY SAND (SM),** loose to medium dense, no plasticity, light gray and light tan, with clay pockets, moist	N = 24						
			N = 23						
15			N = 22						
			N = 24						
20			N = 23	15.1				49.1	Non Plastic
25			N = 36						
30'			N = 10						
		Boring terminated at 30'							

Field Strength Data: ● BLOW COUNT ● 20 40 60 80; ▲ C_u (tsf) ▲ 1.0 2.0 3.0 4.0; ■ SS (tsf) ■ 1.0 2.0 3.0 4.0; ◆ Torvane (psf) ◆ 200 400 600 800

Natural Moisture Content and Atterberg Limits: Plastic Limit — Moisture Content — Liquid Limit; 20 40 60 80

Dry Density (pcf) | Shear Strength (tsf) | Failure Strain (%) | Confining Pressure (psi)

Water Level Est.: ▽ Measured: ▼ Perched: ▼

Water Observations: GW was not encountered during drilling nor 24 hours after the completion of drilling.

Sample Key: ☒ SPT ☒ Shelby Tube ☒ Disturbed ☒ No Recovery

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psf)
C_u - Undrained Cohesion (tsf)
SS - Shear Strength (P/2, tsf)

Notes:

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LOG OF BORING NO. B-9

PROJECT: Pavement and Storm Sewer Ravensway Subdivision Drainage Improvement, UPIN # 19103MF14601, Harris County, Texas

PROJECT NO.: 22-S-148 BORING TYPE: Auger (0'-15')

DATE 03/11/22

SURFACE ELEVATION +134' above MSL

LOCATION

Northing, Y (Feet): 13912092.183
Easting, X (Feet): 3036885.904

See Figure 2

DEPTH (ft.)	SAMPLES	USC	WATER LEVEL	MATERIAL DESCRIPTION	FIELD STRENGTH DATA	DRY DENSITY (pcf)	SHEAR STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	MOISTURE CONTENT (%)	LIQUID LIMIT (LL)	PLASTIC LIMIT (PL)	PLASTICITY INDEX (PI)	PASSING #200 SIEVE (%)	ESTIMATED ANGLE OF INTERNAL FRICTION (°), OTHER TESTS & REMARKS
0		CL		**LEAN CLAY WITH SAND (CL),** hard, high plasticity, brown, light tan, and light gray, with ferrous nodules, moist	P = 4.50										
					P = 4.50	123.4	4.60	15.0	0	12.0	43	18	25		(1)
5					P = 4.50										
				8'	P = 4.50	116.7	2.65	10.3	6.1	12.4	41	18	23		(2)
		SM		**SILTY SAND (SM),** medium dense to dense, no plasticity, light gray and light tan, with clay pockets, moist	N = 37										
10					N = 25										
					N = 17										
				15'	N = 23					7.5				34.2	Non Plastic
15				Boring terminated at 15'											

Natural Moisture Content and Atterberg Limits (Plastic Limit, Moisture Content, Liquid Limit; 20 40 60 80)

Water Level Est.: Measured: Perched:

Water Observations: GW was not encountered during drilling nor 24 hours after the completion of drilling.

Sample Key: SPT Shelby Tube Disturbed No Recovery

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psf)
C_u - Undrained Cohesion (tsf)
SS - Shear Strength (P/2, tsf)

Notes:
(1) Sample failed along diagonal shear planes. (2) Sample failed along vertical shear planes.

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LOG OF BORING NO. B-10

PROJECT: Pavement and Storm Sewer Ravensway Subdivision Drainage Improvement, UPIN # 19103MF14601, Harris County, Texas

PROJECT NO.: 22-S-148 BORING TYPE: Auger (0'-30')

DATE 03/11/22

SURFACE ELEVATION +133' above MSL

LOCATION

Northing, Y (Feet): 13912114.391
Easting, X (Feet): 3036114.411

See Figure 2

MATERIAL DESCRIPTION

Depth (ft.)	USC	Material Description
0	CL	**LEAN CLAY WITH SAND (CL),** very stiff to hard, medium to high plasticity, brown, light tan, and light gray, with ferrous nodules, moist
12'	SP SM	**POORLY GRADED SAND WITH SILT (SP-SM),** medium dense, no plasticity, light tan and light gray, with clay pockets, moist
30'		Boring terminated at 30'

Samples: SPT, Shelby Tube, Disturbed, No Recovery

Water Level: Est.: ▽ Measured: ▼ Perched: ▼

Water Observations: GW was not encountered during drilling nor 24 hours after the completion of drilling.

Depth (ft.)	Field Strength Data	Blow Count	C_u (tsf)	SS (tsf)	Torvane (psf)	Dry Density (pcf)	Shear Strength (tsf)	Failure Strain (%)	Confining Pressure (psi)	Natural Moisture Content	Moisture Content (%)	Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)	Passing #200 Sieve (%)	Estimated Angle of Internal Friction (°), Other Tests & Remarks
0	N =16															
	P = 4.50															
5	P = 4.50		>>			127.9	5.85	5.9	0		10.7	37	17	20		(1)
	P = 4.50															
10	P = 4.50					114.0	2.25	5.8	7.8		15.8	44	19	25	76.8	(1)
	P = 3.25															
	N = 16															
15	N = 19															
	N = 18															
20	N = 14															
25	N = 19										4.4				9.4	Non Plastic
30	N = 21															

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psf)
C_u - Undrained Cohesion (tsf)
SS - Shear Strength (P/2, tsf)

Notes:
(1) Sample failed along diagonal shear planes.

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LOG OF BORING NO. B-11

PROJECT: Pavement and Storm Sewer Ravensway Subdivision Drainage Improvement, UPIN # 19103MF14601, Harris County, Texas

PROJECT NO.: 22-S-148 BORING TYPE: Auger (0'-15')

DATE 03/14//22

SURFACE ELEVATION +132' above MSL

LOCATION

Northing, Y (Feet): 13912406.473
Easting, X (Feet): 3036220.382

See Figure 2

DEPTH (ft.)	SAMPLES	USC	WATER LEVEL	MATERIAL DESCRIPTION	FIELD STRENGTH DATA	DRY DENSITY (pcf)	SHEAR STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	MOISTURE CONTENT (%)	ATTERBERG LIMITS(%) LIQUID LIMIT (LL)	PLASTIC LIMIT (PL)	PLASTICITY INDEX (PI)	PASSING #200 SIEVE (%)	ESTIMATED ANGLE OF INTERNAL FRICTION (°), OTHER TESTS & REMARKS
0		SC		**CLAYEY SAND (SC),** loose, medium plasticity, tan, brown, and gray, with silt pockets, moist	N = 9										
					N =10										
5					P = 3.75										
					P = 4.25	119.7	1.80	10.1	6.1	14.1	38	18	20	36.5	(3)
				10'	P = 2.25										
10		SP SM		**POORLY GRADED SAND WITH SILT (SP-SM),** medium dense, no plasticity, light tan and light gray, with clay pockets, moist	N = 18										
					N = 17										
				15'	N = 19					6.7				7.3	Non Plastic
15				Boring terminated at 15'											

Natural Moisture Content and Atterberg Limits: Plastic Limit, Moisture Content, Liquid Limit (20, 40, 60, 80)

Water Level Est.: ▽ Measured: ▼ Perched: ▼

Water Observations: GW was not encountered during drilling nor 24 hours after the completion of drilling.

Sample Key: ☒ SPT ☒ Shelby Tube ☒ Disturbed ☒ No Recovery

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psf)
C_u - Undrained Cohesion (tsf)
SS - Shear Strength (P/2, tsf)

Notes:
(3) Sample bulged at failure.

HTS, Inc. Consultants
416 Pickering Street
Houston, Texas 77091

LOG OF BORING NO. B-12

PROJECT: Pavement and Storm Sewer Ravensway Subdivision Drainage Improvement, UPIN # 19103MF14601, Harris County, Texas

PROJECT NO.: 22-S-148 BORING TYPE: Auger (0'-25')

DATE

SURFACE ELEVATION +133' above MSL

LOCATION

Northing, Y (Feet): 13911434.602
Easting, X (Feet): 3038153.548

See Figure 2

MATERIAL DESCRIPTION

DEPTH (ft.)	USC	MATERIAL DESCRIPTION	FIELD STRENGTH DATA	DRY DENSITY (pcf)	SHEAR STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	MOISTURE CONTENT (%)	LIQUID LIMIT (LL)	PLASTIC LIMIT (PL)	PLASTICITY INDEX (PI)	PASSING #200 SIEVE (%)	ESTIMATED ANGLE OF INTERNAL FRICTION (°), OTHER TESTS & REMARKS
0	CL	**SANDY LEAN CLAY (CL),** very stiff to hard, medium to high plasticity, light gray and light tan, with ferrous nodules, moist	P = 2.25										
			P = 4.50					9.5	34	15	19	55.8	
5			P = 4.50	124.7	3.55	4.3	0	10.7	39	18	21	59.8	(4)
			P = 4.50										
			P = 4.50										
10		12'	P = 4.50					10.6	33	14	19	34.8	
	SM	**SILTY SAND (SM),** medium dense to dense, no plasticity, light gray and light tan, with clay pockets, moist	N = 20										
15			N = 20										
			N = 22					7.8				22.6	Non Plastic
20			N = 27										
25		25'	N = 41					6.0				14.4	Non Plastic
		Boring terminated at 25'											

Natural Moisture Content and Atterberg Limits: Plastic Limit, Moisture Content, Liquid Limit (20, 40, 60, 80)

BLOW COUNT (20, 40, 60, 80); C_u (tsf) (1.0, 2.0, 3.0, 4.0); SS (tsf) (1.0, 2.0, 3.0, 4.0); Torvane (psf) (200, 400, 600, 800)

Water Level Est.: ▽ Measured: ▼ Perched: ▼

Water Observations: GW was not encountered during drilling nor 24 hours after the completion of drilling.

Sample Key: ☒ SPT ⧄ Shelby Tube ⧈ Disturbed ⧈ No Recovery

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psf)
C_u - Undrained Cohesion (tsf)
SS - Shear Strength (P/2, tsf)

Notes:
(4) Sample failed along sand fissures.

HTS, Inc. Consultants
416 Pickering Street
Houston, Texas 77091

LOG OF BORING NO. B-13

PROJECT: Pavement and Storm Sewer Ravensway Subdivision Drainage Improvement, UPIN # 19103MF14601, Harris County, Texas

PROJECT NO.: 22-S-148 BORING TYPE: Auger (0'-25')

DATE 03/14//22

SURFACE ELEVATION +130' above MSL

LOCATION

Northing, Y (Feet): 13912284.489
Easting, X (Feet): 3038750.282

See Figure 2

MATERIAL DESCRIPTION

DEPTH (ft.)	USC	MATERIAL DESCRIPTION	FIELD STRENGTH DATA	DRY DENSITY (pcf)	SHEAR STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	MOISTURE CONTENT (%)	LIQUID LIMIT (LL)	PLASTIC LIMIT (PL)	PLASTICITY INDEX (PI)	PASSING #200 SIEVE (%)	ESTIMATED ANGLE OF INTERNAL FRICTION (°), OTHER TESTS & REMARKS
0	CL	**SANDY LEAN CLAY (CL),** very stiff to hard, medium to high plasticity, brown, light tan, and light gray, with ferrous nodules, moist	P = 2.50	112.1	1.75	14.4	0	18.7	47	20	27	60.6	(3)
			P = 4.50										
5			P = 4.50										
			P = 4.50										
10			N = 17										
			N = 22										
		14'	P = 3.00	111.5	1.45	14.8	11.3	17.3	35	17	18	56.6	(3)
15	SP SM	**POORLY GRADED SAND WITH SILT (SP-SM),** loose to medium dense, no plasticity, light tan and light gray, with clay pockets, moist to wet	N = 22										
			N = 13										
20			N = 9										
25		25'	N = 6										
		Boring terminated at 25'											

Natural Moisture Content and Atterberg Limits: Plastic Limit, Moisture Content, Liquid Limit (20, 40, 60, 80)

Water Level Est.: ▽ Measured: ▼ Perched: ▼

Water Observations: GW was encountered at a depth of 22.5' during drilling. 24 hours after the completion of drilling, GW was measured at a depth of 21.5' below existing ground surface.

Sample Key: SPT, Shelby Tube, Disturbed, No Recovery

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psf)
C_u - Undrained Cohesion (tsf)
SS - Shear Strength (P/2, tsf)

Notes:
(3) Sample bulged at failure.

HTS, Inc. Consultants
416 Pickering Street
Houston, Texas 77091

LOG OF BORING NO. B-14

PROJECT: Pavement and Storm Sewer Ravensway Subdivision Drainage Improvement, UPIN # 19103MF14601, Harris County, Texas

PROJECT NO.: 22-S-148 BORING TYPE: Auger (0'-25')

DATE 03/14//22

SURFACE ELEVATION +133' above MSL

LOCATION

Northing, Y (Feet): 13912292.205
Easting, X (Feet): 3037618.422

See Figure 2

MATERIAL DESCRIPTION

DEPTH (ft.)	USC	MATERIAL DESCRIPTION	FIELD STRENGTH DATA	DRY DENSITY (pcf)	SHEAR STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	MOISTURE CONTENT (%)	LIQUID LIMIT (LL)	PLASTIC LIMIT (PL)	PLASTICITY INDEX (PI)	PASSING #200 SIEVE (%)	ESTIMATED ANGLE OF INTERNAL FRICTION (°), OTHER TESTS & REMARKS
0	CL	**SANDY LEAN CLAY (CL),** hard, medium plasticity, brown, light tan, and light gray, with ferrous nodules, moist	P = 4.50										
			P = 4.50										
5			P = 4.50	125.2	4.85	6.1	4.3	10.6				58.6	(1)
			P = 4.50										
10		10'	P = 4.50	120.9	2.30	8.3	7.8	11.7	33	16	17		(1)
	SP SM	**POORLY GRADED SAND WITH SILT (SP-SM),** medium dense, no plasticity, light tan and light gray, with clay pockets, moist	N = 14										
			N = 20										
15			N = 22										
			N = 22										
20			N = 16					4.8				9.8	Non Plastic
25		25'	N = 26										
		Boring terminated at 25'											

Field strength data: ● BLOW COUNT (20 40 60 80); ▲ C_u (tsf) (1.0 2.0 3.0 4.0); ■ SS (tsf) (1.0 2.0 3.0 4.0); ◆ Torvane (psf) (200 400 600 800)

Natural Moisture Content and Atterberg Limits: Plastic Limit — Moisture Content — Liquid Limit (20 40 60 80)

Water Level Est.: ▽ Measured: ▼ Perched: ▼

Water Observations: GW was not encountered during drilling nor 24 hours after the completion of drilling.

Sample Key: ☒ SPT ⧄ Shelby Tube ⧈ Disturbed ⧈ No Recovery

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psf)
C_u - Undrained Cohesion (tsf)
SS - Shear Strength (P/2, tsf)

Notes:
(1) Sample failed along diagonal shear planes.

HTS, Inc. Consultants
416 Pickering Street
Houston, Texas 77091

LOG OF BORING NO. B-15

PROJECT: Pavement and Storm Sewer Ravensway Subdivision Drainage Improvement, UPIN # 19103MF14601, Harris County, Texas

PROJECT NO.: 22-S-148 BORING TYPE: Auger (0'-25')

DATE 03/14//22

SURFACE ELEVATION +129' above MSL

LOCATION

Northing, Y (Feet): 13912876.742
Easting, X (Feet): 3037737.932

See Figure 2

MATERIAL DESCRIPTION

Depth (ft.)	USC	Material Description	Field Strength Data	Moisture Content (%)	Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)	Passing #200 Sieve (%)	Estimated Angle of Internal Friction (°), Other Tests & Remarks
0	CL	**SANDY LEAN CLAY (CL),** soft, high plasticity, brown, moist	P = 0.25	15.1	39	18	21	54.7	
2'	SP SM	**POORLY GRADED SAND WITH SILT (SP-SM),** medium dense to dense, no plasticity, light tan and light gray, with clay pockets, moist	N = 21						
5			N = 20	6.9				5.2	Non Plastic
			N = 22						
10			N = 31						
			N = 33						
14'			N = 21						
15	SM	**SILTY SAND (SM),** medium dense to dense, no plasticity, light tan and light gray, with clay pockets, moist	N = 21	5.8				30.5	Non Plastic
			N = 14						
20			N = 11						
25'			N = 41						
25		Boring terminated at 25'							

Field Strength Data: ● BLOW COUNT ● (20 40 60 80); ▲ C_u (tsf) ▲ (1.0 2.0 3.0 4.0); ■ SS (tsf) ■ (1.0 2.0 3.0 4.0); ◆ Torvane (psf) ◆ (200 400 600 800)

Dry Density (pcf) | Shear Strength (tsf) | Failure Strain (%) | Confining Pressure (psi)

Natural Moisture Content and Atterberg Limits: Plastic Limit — Moisture Content — Liquid Limit (20 40 60 80)

Water Level Est.: ▽ Measured: ▼ Perched: ▼

Water Observations: GW was not encountered during drilling nor 24 hours after the completion of drilling.

Sample Key: ☒ SPT ⧄ Shelby Tube ⧈ Disturbed ⧈ No Recovery

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psf)
C_u - Undrained Cohesion (tsf)
SS - Shear Strength (P/2, tsf)

Notes:

Appendix C
Drainage Impact Analysis

March 11, 2022

Mr. Isaac Muniz, P.E.
Project Manager – Water Resources
LJA Engineering
3600 W. Sam Houston Parkway S Suite 600
Houston, TX 77042

RE: Ravensway Subdivision Improvements Drainage Impact Analysis; UPIN 19103MF14601

Dear Mr. Muniz,

Included with the letter is the Final Drainage Impact Analysis for the Ravensway Subdivision Improvements.

The submittal package includes Gauge's responses to comments from the comments on the previous submittal on February 8, 2022, a PDF of the revised draft report, as well as the supporting model data for the analysis. Model Data includes the InfoWorks ICM models, the HEC-HMS models, and the unsteady-state HEC-RAS models. Through this analysis, Gauge has demonstrated that the proposed Ravensway Subdivision improvements will cause no downstream impacts to Cypress Creek in the 2-year, 10-year, 50-year, or 100-year storm events.

If you have any questions, please feel free to contact me at hgoodpasture@gaugeengineering.com, or at 832.318.8910.

Sincerely,

Heather Goodpasture

Heather Goodpasture, P.E., CFM
Project Manager
Gauge Engineering

Ravensway Subdivision Drainage Improvements Study, Precinct 3

UPIN: 19103MF14601

Submitted By:

Heather Goodpasture, P.E., CFM

Date: March 2022

03/11/2022

STATE OF TEXAS
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Subconsultant to

LJA

Gauge ENGINEERING

Executive Summary

Gauge Engineering, LLC (Gauge), as a sub-consultant to LJA (Prime) was contracted to perform a drainage assessment and develop recommendations for local drainage improvement to the Ravensway Subdivision. The project is titled the Ravensway Subdivision Drainage Improvements-2018, also referred to as UPIN 19103MF14601 (Ravensway Subdivision, PROJECT). Ravensway Subdivision is a Harris County Engineering Department (HCED) project and LJA is the prime consultant. Gauge's services included:

- Existing conditions analysis of the project using 2D modeling to accurately determine the sources of flooding,
- Development of proposed improvement concepts,
- Analysis of the proposed concepts,
- Development and analysis of mitigation measures, and
- Development of an improvement recommendation.

General Project Location

The project study area of concern (see **Exhibit 1**) is 290-ac (0.45-sqmi) within the Cypress Creek Watershed and Harris County Precinct 3. (See **Exhibit 1**). The project area is located between HCFCD channels K100-00-00 (Cypress Creek) and K163-00-00 (See **Exhibit 2**). The location of the subdivision near the confluence of the two channels and the expansive floodplain within the study area indicates a strong likelihood of out of bank channel flooding from K100-00-00 and K163-00-00 during extreme events. The subdivision is reported to experience frequent flooding, which is supported by historical flooded structure records as well as impassable roadways due to high inundation. Flooded structures were reported for the Tax Day Flood (2016) and Hurricane Harvey (2017), with the vast majority of the flooded structure reports occurring during Hurricane Harvey (See **Exhibit 3**).

Existing Conditions Analysis

Gauge performed a drainage analysis using InfoWorks ICM for the 50%, 10%, 2%, and 1% AEP events. The evaluation utilized rain-on-mesh hydrology that applied rainfall directly to the surface of the model. The most current Atlas 14 rainfall was used for this study to ensure consistency with updated Harris County design criteria. The existing conditions modeling was performed with and without consideration of the influence from the K100-00-00 and K163-00-00, allowing for the evaluation of both local intense rainfall events and rainfall events that cause flooding from Cypress Creek.

The existing conditions modeling with the influence of K100-00-00 and K163-00-00 supports the idea that K100-00-00 and K163-00-00 exceed their banks and cause substantial structural flooding in the project area. The existing localized flooding analysis (without influence from K100-00-00 and K163-00-00) indicates that there is also significant inundation that occurs in the streets and low-lying areas in isolated local rainfall events and supports the need for increased localized conveyance capacity. These key issues contribute to the conclusion that the community would benefit significantly from improvements to the existing localized infrastructure.

Drainage Problems

The drainage analysis identified a substantial lack of conveyance capacity and overland flow routes in the system. Combined with low-lying streets and areas within the subdivision, the lack of capacity results in significant flooding throughout the project area. Impassable areas along the roadways during the 2- and 10-year events were identified. In addition, FEMA records indicate 25 Repetitive Loss (RL) properties in the study area.

Local Storm Event (Without Tailwater Influence) Impassable Zones	50% AEP (2-year)	10% AEP (10-year)
Impassable Zones (Local Conveyance Only)	5	20

Flooded Structures for Existing Conditions

	50% AEP (2-year)	10% AEP (10-year)	1% AEP (100-year)
Structures Flooded (With Tailwater Influence)	**2***	**9**	**72**
Flooded from Creek or Drainage Infrastructure	0*	6	68
Flooded due to Private Property Grading	2*	3	4
Structures Flooded (Without Influence)	**2**	**3**	**14**
Flooded from Creek or Drainage Infrastructure	0	0	8
Flooded due to Private Property Grading	2	3	6

* *The 2-Year storm event "with tailwater influence" was not run in the 2D model. Reported flooded structures are from the "without tailwater influence" run.*

Based on the existing conditions modeling, there is significant structural flooding that appears to be caused by creek influence in the project area. A total of 72 structures are predicted to flood in a 100-year storm event with tailwater influence. In localized events without influence from the creek, 4 structures are predicted to flood in the 10-year event, and 14 structures in the 100-year event. The structures that are at risk for flooding are in the lowest lying areas that could benefit from increase storm sewer and inlet capacity. It should be noted that some structures in the 2, 10 and 100-year event appear to flood from due to private property grading issues, and not from inadequate storm sewer capacity. Since these structures flood from localized grading issues, they may not benefit significantly from the proposed storm drain improvements.

Flood Improvement Concepts

Gauge analyzed the project study area with and without the influence of the channel floodplains. Improvements proposed to the local drainage systems focused on increased conveyance and the associated mitigation. The measure of effectiveness for the proposed improvements was the reduction in structural flooding and the reduction of impassable roadways in the 2-year and the 10-year storm events.

Two conveyance improvement concepts were considered:

1. Option 1: Trunkline improvements to Ravensway Subdivision (South of Jarvis Rd.)
2. Option 2: In addition to Option 1, add trunkline improvements along Texas Army Trail Rd. (North of Jarvis Rd.)

To prevent the proposed conveyance improvements from creating an increase in discharge to K100-00-00, a detention basin is proposed. The proposed detention basin is to be located on the northwest side of the project area adjacent to Huffmeister Rd. and is recommended to hold 101 Ac-Ft of volume to mitigate the 100-year storm event. A stage/volume curve for the proposed basin was provided by the prime consultant based on an initial basin layout. The modeled 100-year water surface elevation in the detention basin is 125.3-ft.

Since the proposed detention basin is located partially in the floodplain, a conveyance analysis was performed to determine any potential impacts to Cypress Creek. The conveyance analysis indicated that if the proposed detention

basin is constructed below natural ground, it will lower the southern side of the property that is not currently in the floodplain and add too much conveyance back to Cypress Creek, causing downstream impacts. For this reason, the proposed detention basin top of bank is proposed to be raised to 128.5-ft. This leaves approximately 3.2-ft of freeboard in the detention basin. This excess 3.2-ft of freeboard equates to around 28 ac-ft of excess volume that is available for use by the Cypress Creek Watershed.

Existing flow rates and discharge hydrographs from the project limits to K100-00-00 and K163-00-00 were quantified using the 2D analysis. Overland flow and storm sewer outfall point discharges were aggregated for K100-00-00 and K163-00-00 for the existing conditions to establish a baseline for comparison to the proposed mitigated discharge. This comparison was needed to demonstrate No Adverse Impact to HCFCD channels.

The impact analysis was performed using HEC-HMS and unsteady-state HEC-RAS. The effective drainage areas were subdivided so that the project area was represented by a single drainage area. By adjusting the storage coefficient, R, the flow from the project drainage area was calibrated to match the total existing and proposed discharges calculated from the 2D model. The existing and proposed HEC-HMS drainage areas were input into an unsteady-state HEC-RAS model to evaluate potential downstream water surface elevations.

Through this process, it was determined that the proposed improvements will cause no downstream impacts in the 2-year, 10-year, 50-year, and 100-year storm events.

Proposed Analysis Results

The proposed alternatives results were evaluated by looking at the inundation mapping and modeling output data, including profiles, the number of structures benefitted, and combined discharge into Cypress Creek and K163-00-00. The proposed improvements were evaluated for the 50% AEP, 10% AEP, 2% AEP, and 1% AEP storms without the influence from Cypress Creek.

The results from the analysis show that ponding along Tall Forest Drive and Jarvis Road is significantly reduced in low -lying areas for all localized storm events (i.e. Without Tailwater Influence). The design storm event was the 10-year event, with the goal of removing all impassable street ponding in the 10-year storm event. The results show that in the 2-year event, all impassable areas were removed. In the 10-year event, 19 of 20 impassable areas were removed.

*Flooded Structures for Proposed Conditions **without** Tailwater Influence*

	Existing Flooded Structures	Proposed Flooded Structures	Removed Flooded Structures	Benefited, but not Removed
100-Year Proposed Conditions Flooded Structures (without tailwater influence)	14	8	6	2*
Flooded from Creek or Drainage Infrastructure	8	0		
Flooded due to Private Property Grading	6	8*		

* There are two structures that flood from the street in existing conditions, and from the back of lot in proposed conditions. When the drainage infrastructure improvements are implemented in proposed conditions, these two structures no longer flood from the street, but calculations are showing that they will still flood from the back. These two structures will see reduced flood depth in proposed conditions, and will benefit, but will not be removed.

Flooded Structures for Proposed Conditions with Tailwater Influence

	Existing Flooded Structures	Proposed Flooded Structures	Flooded Structures Removed	Structures Benefited, but Not Removed
100-Year Proposed Conditions Flooded Structures (with tailwater influence)	72	62	10	2*
Flooded from Creek or Drainage Infrastructure	68	56		
Flooded due to Private Property Grading	4	6*		

* There are two structures that flood from the street in existing conditions, and from the back of lot in proposed conditions. When the drainage infrastructure improvements are implemented in proposed conditions, these two structures no longer flood from the street, but calculations are showing that they will still flood from the back. These two structures will see reduced flood depth in proposed conditions, and will benefit, but will not be removed

Benefits to structures were also evaluated in both the localized and the with tailwater storm events. It was determined that the proposed improvements would remove flooding from 6 of 14 flooded structures in the 100-year localized event, and from 10 of 72 structures in the 100-year with tailwater event. In the 10-year localized event, only one structure appears to flood from the street, and the proposed improvements also remove this structure from flooding.

Recommendations

Both the Option 1 and Option 2 improvements involve upsizing the existing trunklines in the project area. To prevent an increase in discharge to Cypress Creek caused by the additional conveyance, 101 ac-ft of stormwater detention is recommended in the 100-year storm event. Both Options 1 and 2 improvements provide significant reduction in inundation along streets and low-lying areas, reducing the number of flooded structures and impassable zones.

It is recommended that the Option 2 improvements be considered for construction within the Ravensway Subdivision and along Texas Army Trail Road. Even though Texas Army Trail Road is located near the channel banks and does experience out-of-bank creek flooding, it also experiences flooding from local conveyance issues that can be mitigated with increased trunkline sizes.

This analysis has shown that the proposed project improvements 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 Atlas 14 100-year storm event.

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7. Proposed Storm Sewer Improvements. Option Improvements are along Jarvis and South of Jarvis, and Option 2 Improvements Include all proposed Improvements North and South of Jarvis.
8. Revised Existing and Proposed Conditions HEC-RAS Cross Sections
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A. Revised Effective Drainage Areas
B. HEC-HMS Flow Comparisons
C. HEC-RAS Flow and Water Surface Elevation Comparisons
D. Preliminary Basin Layout
E. Post-Project Floodway Surcharge Results

1.0 General Project and Contact Information

1.1. Project Name

Ravensway Subdivision Drainage Improvements-2018 (PROJECT)

1.2. UPIN

The project UPIN number is 19103MF14601

1.3. Precinct

The project is located in Harris County Precinct 3

1.4. Project Location Map

See **Figure 1** below and the attached **Exhibit 1—Location Map**

The project area is located along Cypress Creek just upstream of its junction with Little Cypress Creek, and just downstream of Huffmeister Rd. A 2D InfoWorks ICM model was built for the project area to evaluate existing problem areas and potential improvement benefits. An unsteady-state HEC-RAS analysis of Cypress Creek was conducted from Telge Rd to Champion Forest Dr. to evaluate potential impacts due to both changes in floodplain conveyance, and from changes in discharge.

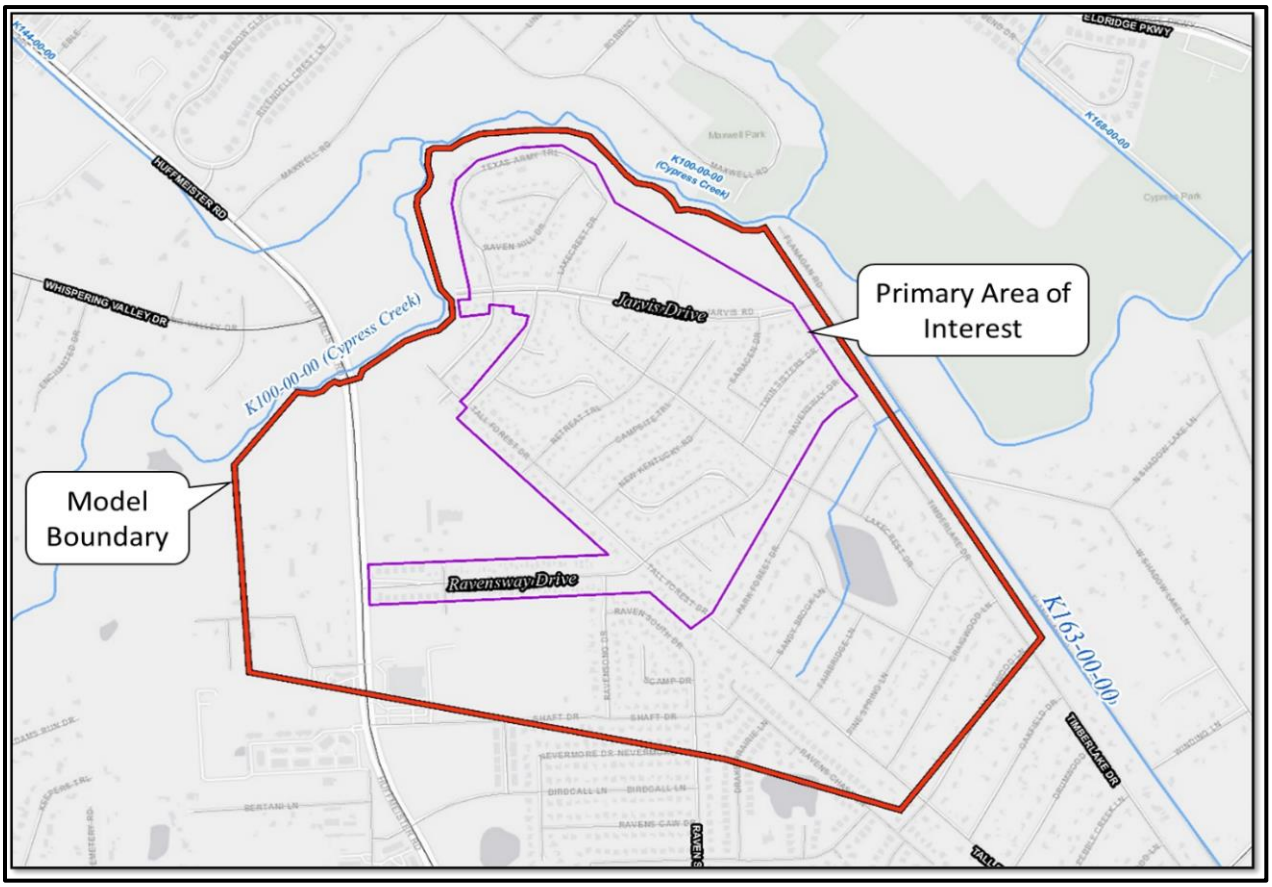


Figure 1. Project Location Map

1.5. Preparer Information:

i. Firm Name: Gauge Engineering, LLC (ENGINEER)

ii. Firm Address: 3200 Wilcrest Drive, Suite 220; Houston, TX 77042

iii. Preparer Name: Heather Goodpasture, P.E., CFM

iv. Preparer Phone Number: 832.318.8800

v. Preparer Email Address: HGoodpasture@GaugeEngineering.com

2.0 Existing Conditions

This section contains an overview of the existing conditions in the project area, including general location and topography, data collected, and the existing conditions analysis methodology and findings.

2.1 General Descriptions and Locations

The project study area of concern, shown on **Exhibit 1**, is 290-ac (0.45-sqmi) within the Cypress Creek Watershed and Harris County Precinct 3. The study area is bound along the northern side by K100-00-00 (Cypress Creek), which converges with K163-00-00 along the eastern side. The study area boundaries were determined based on a previous performed analysis. Additional areas were included when looking at the floodplain in reference to the subdivision.

The project area drains to K100-00-00 and K163-00-00 via underground storm sewer. For this project area, six outfalls drain to K100-00-00 and three outfalls drain to K163-00-00. A review of FEMA's web mapping server indicates the Ravensway Subdivision resides mainly in the unincorporated areas of Harris County, Texas (Community), as shown on map number 48201C0430M (effective data 10/16/2013). It has been determined that there are a significant number of structures located within the Special Flood Hazard Area (100-Year and 500-year Effective Floodplain). See **Exhibits 2** and **3.**

2.2 Summary of Data Collected

Elevations and data for the existing storm sewer system were provided by Costello Inc. in their previous report. Survey was also conducted for the subdivision by Costello.

The team was provided a previous study report for review:

- Ravensway Subdivision Drainage Assessment (UPIN: 19103MF14601)

Timberlake ID provided record drawings for the portion of the development that was not captured by survey. This included the area north of the subdivision, along Texas Army Trail Road.

2.3 Summary of Existing Conditions

This section includes a general summary of the features and historical flood information for the study area.

2.3.1 Historical Flooding

Flooded structures (**Exhibit 3**) were reported for the Memorial Day Flood (2015), Tax Day (2016), and Hurricane Harvey (2017), with the vast majority of the flooded structure reports occurring during Hurricane Harvey.

The expansive K100-00-00 and K163-00-00 floodplains within the study area indicate a strong likelihood of out of bank channel flooding and potential overflow during extreme events. Flood records from Hurricane Harvey indicate a significant number of structures within the regulatory floodplain, indicating that the area is vulnerable to overbank flooding from Cypress Creek. Reports of flooding for the Tax Day event were generally located inside the channel floodplain. No flooded structures were reported during the Memorial Day Flood. However, observed sheet flow patterns resulting from the neighborhood's low-lying areas and roadways indicates a localized drainage issue that is

independent of the channel flooding. The approximate number of flooded structures for the aforementioned historical events are listed below.

- 22 structures reported flooding during the Tax Day Storm (2016)
- 242 structures reported flooding during Hurricane Harvey (2017)

In addition, FEMA records indicate 25 Repetitive Loss (RL) properties in the study area, five of which are classified as Severe Repetitive Loss (SRL).

2.3.2 Terrain Features

The topography (**Exhibit 4**) within the project area varies. Elevations within the majority of the neighborhood are noticeably higher than the adjacent floodplain as well as the overbank on the other side of Cypress Creek. There is a significant drop-off as the area approaches the creek, with an average drop in elevation of around 10-ft. Natural ground elevations for the study area range from approximately 123-135 ft., based on the 2018 LiDAR data. The roadways are low-lying within the neighborhoods which may result in street flooding once the storm sewer capacity has been exceeded. The area is mainly comprised of single family and multi-family housing with some forested open space.

2.3.3 Existing Infrastructure

The existing drainage infrastructure can be seen in **Exhibit 5**. The following are key drainage features for the project area:

1. The study area is within the Cypress Creek Watershed. It is west of the confluence of K100-00-00 and K163-00-00 and is inside the 100-yr and 500-yr floodplain.
2. There are nine outfall locations in this study area. Six of the outfalls drain north into K100-00-00 while the other three drain to the east into K163-00-00
3. The existing underground storm sewer system is mainly 24" RCP. Along Ravensway Drive, Tall Forest Road and Jarvis Road the storm sewer system varies between 36" and 48" RCP.
4. The existing storm sewer does not adequately contain the 2-year event, resulting in street flooding
5. A portion of the project area is located within the regulatory floodplain for Cypress Creek (K100-00-00) and K163-00-00. The floodplain significantly influences flooding at the north and east ends of the project area and increase the number of at-risk structures.

2.3.4 Previous Studies and Existing Models

Gauge was provided an engineering study report for the Ravensway Subdivision. Below is a summary of the report.

Ravensway Final Study Report: Subdivision Drainage Assessment-Prepared in July 2019 by Costello Inc. This study analyzes localized flooding as well as regional flooding. Improvements are proposed to local conveyance issues such as providing a parallel storm sewer as well as a proposed detention basin. The proposed improvements cost was estimate at approximately $7M.

HEC-RAS and HEC-HMS Models for Cypress Creek (K100-00-00) were obtained from the HCFCD M3 site (www.m3models.org) as the most current effective models. In addition, the HEC-RAS and HEC-HMS models for K163-00-00 were obtained from LJA. The most up to date model outlines channel improvements for K163-00-00 that are currently being constructed.

2.4 Existing Conditions Analysis

This section details the existing conditions 2D analysis procedure and findings. The Ravensway Subdivison existing conditions analysis utilized InfoWorks ICM 1D/2D dynamic modeling to capture the subsurface and above ground drainage network as well as the overland flow, including overflow from the bounding HCFCD channels.

2.4.1 Precipitation

The most current Region 1 Atlas 14 rainfall was used for this study to ensure consistency with updated Harris County design criteria. Frequency storms analyzed included the 50% Annual Exceedance Probability (AEP) (2-year), 10% AEP (10-year), 2% AEP (50-year), and 1% AEP (100-year) events. Infiltration losses were accounted for by removing the loss from the rainfall hyetograph using methods consistent with HCFCD criteria, which was calculated using HEC-HMS. The remaining excess precipitation was applied to the 2D mesh in the InfoWorks ICM model.

2.4.2 Model Development

The following process outlines the existing conditions data, parameters, and modeling assumptions.

- Software: Innovyze InfoWorks ICM (Version 2021.5)
- Surface mesh development: 2018 LiDAR
- Rainfall: Atlas 14 2-year (50%), 10-year (10%), 50-year (2%), 100-year (1%), and frequency storm events were simulated. HCFCD Region 1 rainfall depths were used.
- Manning's n-values were applied to the mesh based on the HCFCD recommended values for rain-on grid modeling. These values are shown in **Table 1** and **Figure 2.**
- Storm sewer systems data for elevations and locations of storm sewer trunk lines, manholes, and inlets were provided by Costello within the previously conducted analysis and updated according to recent survey.
- Survey data was applied to the model for the existing storm sewer along Ravensway Drive, Jarvis Road, and bisecting streets. All survey elevations are on the NAVD '88, 2001 adjustment datum.
- All inlets were modeled as using the "2D node" flood type. Due to the rain-on-grid nature of the model, the 2D node flood type was used to ensure that ponding in the subdivision is controlled by the size of the trunkline.
    - This was important to appropriately size the proposed trunklines by allowing as much surface flow to enter the proposed trunklines as possible, rather than being restricted by inlet curves.
    - In existing conditions, a discharge coefficient value of 0.5 was used on the 2D inlet nodes. Inlets with the "2D Node" flood type capture ponding based on the weir equation. A discharge coefficient of 0.5 in ICM equates to a weir coefficient of approximately 2.8 as typically used in the United States. In proposed conditions, a higher coefficient was used to capture as much surface ponding as possible and ensure that ponding is being controlled by the trunkline. Modeling the inlets using the weir equation was considered an appropriate assumption for the project scope. It was also observed that the existing conditions ponding in the Ravensway subdivision is mostly controlled by the trunkline size rather than the inlet capacity.
    - Sizing of the laterals and the inlets was performed by the design team. Gauge coordinated with the design to on inlet and lateral sizing.
- The existing conditions InfoWorks ICM model was run with both a "With Tailwater Influence" scenario, and a "Without Tailwater Influence" scenario. The "With Tailwater" scenarios were developed by applying stage hydrographs from Cypress Creek for each storm event to 2D boundary lines that were drawn along the edge of the 2D mesh.
- In the "With Tailwater Influence" scenario, Cypress Creek variable tailwater elevations were applied for the 10-year (10%), 50-year (2%), 100-year (1%) frequency storm events. These stage hydrographs were determined using the unsteady-state HEC-RAS model developed as part of this study.
- In the "Without Tailwater Influence" scenario, a constant tailwater elevation was using for each storm event based on the elevation that Cypress Creek would be at the time of the local peak.
    - The local peak flow for project area was determined to occur at time 16:15. For the 100-year and the 50-year storm events, the Cypress Creek water surface elevation at time 16:15 was used and was

determined based on the stage hydrographs that were developed for the "With Tailwater Influence" scenario, which were taken from the unsteady-state HEC-RAS model developed as part of this study.

- Since the top of pipe elevations in existing and proposed conditions were determined to be higher than the 10-year Cypress Creek water surface elevation at time 16:15, a constant top of pipe tailwater was applied for the 10-year event in both existing and proposed conditions.
- A constant top of pipe tailwater was also applied for the 2-year storm event.

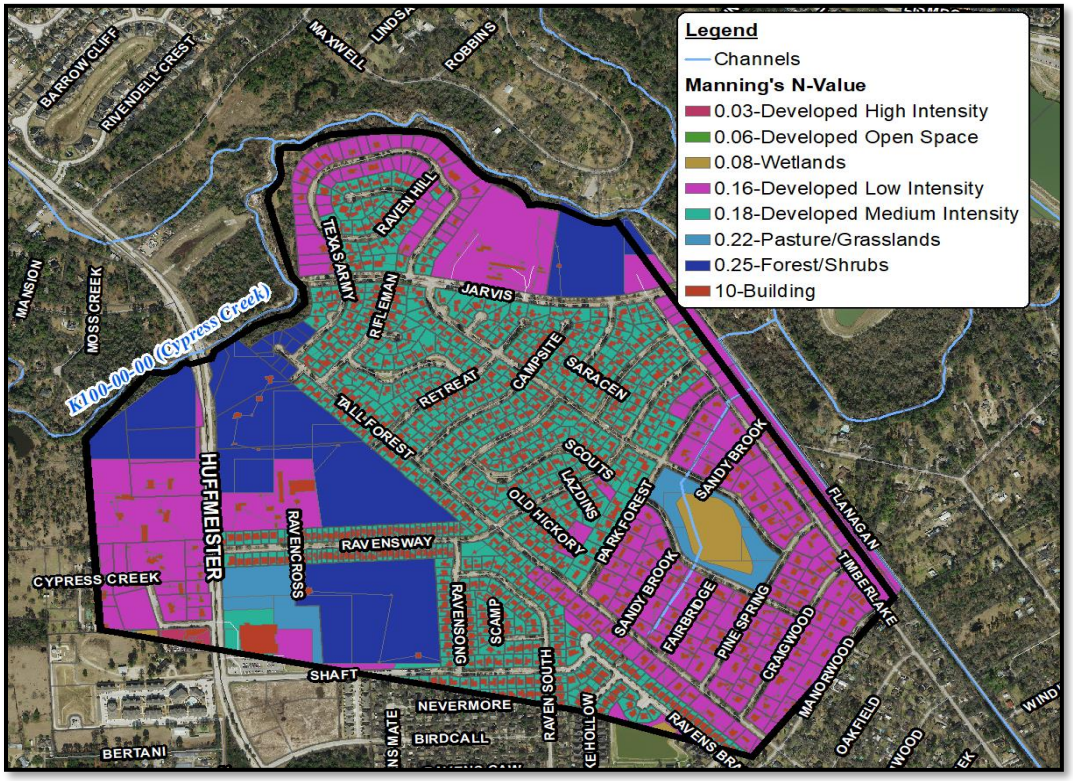


Figure 2. Land Classification for the Project Area

Table 1. Manning's N-Values used for the Rain-on-grid analysis

Land Classification	HGAC Code	Recommended Manning's n- Value for Rain On Grid (Precipitation Assigned)
Open Water	1	0.02
Developed High Intensity	2	0.03
Developed Med Intensity	3	0.18
Developed Low Intensity	4	0.16
Developed Open Space	5	0.06
Barren Lands	6	0.04
Forest/Shrubs	7	0.25
Pasture/Grasslands	8	0.22
Cultivated Crops	9	0.17
Wetlands	10	0.08
Building	21*	10
Pavement	22*	0.02

**Supplemental Code*

- Validation: Hurricane Harvey was simulated, and results were assessed against documented flooded structures.
    - As mentioned earlier, the Cypress Creek floodplain is modeled by applying creek elevations to 2D boundary lines that run along the edge of the model boundary. For the statistical storm events, the cross sections in the HEC-RAS unsteady state model were used to assign the stage hydrographs at each 2D boundary line. However, Hurricane Harvey was not run in the unsteady-state model. To assign Hurricane Harvey tailwaters to the ICM model, gauge data was used to get stage hydrograph data at each 2D boundary line along the edge of the mesh. The orange polygon in **Figure 3** shows the extent of the model boundary along Cypress Creek with respect to the Gauge locations, illustrating that the model boundary is between gauge locations. To assign Hurricane Harvey water surface elevations to the model boundary, water surface elevations were calculated by interpolating between the two gauge locations using the slope of the 500-year water surface elevation profile.
    - Tailwater elevation from Cypress Creek was taken from HCFCD Gauge number 1170. The observed gauge data was adjusted down for the extent of the project area based on the slope of the 500-year HGL. **Figure 3** shows the 500-year FEMA Cypress Creek water surface elevations in comparison to the calculated Harvey water surface elevations. At each gauge location, the difference between the Hurricane Harvey elevation and the FEMA 500-year elevation was calculated. Next, the difference between the FEMA 500-year elevation and Hurricane Harvey was interpolated at each HEC-RAS river station. Then, at each river station, the calculated difference was added to the FEMA 500-year WSE to develop the estimate Hurricane Harvey WSE.
- A downstream impact analysis was performed using a combination of InfoWorks ICM, HEC-HMS, and an unsteady-state HEC-RAS model. See **Section 4.2** for additional information.

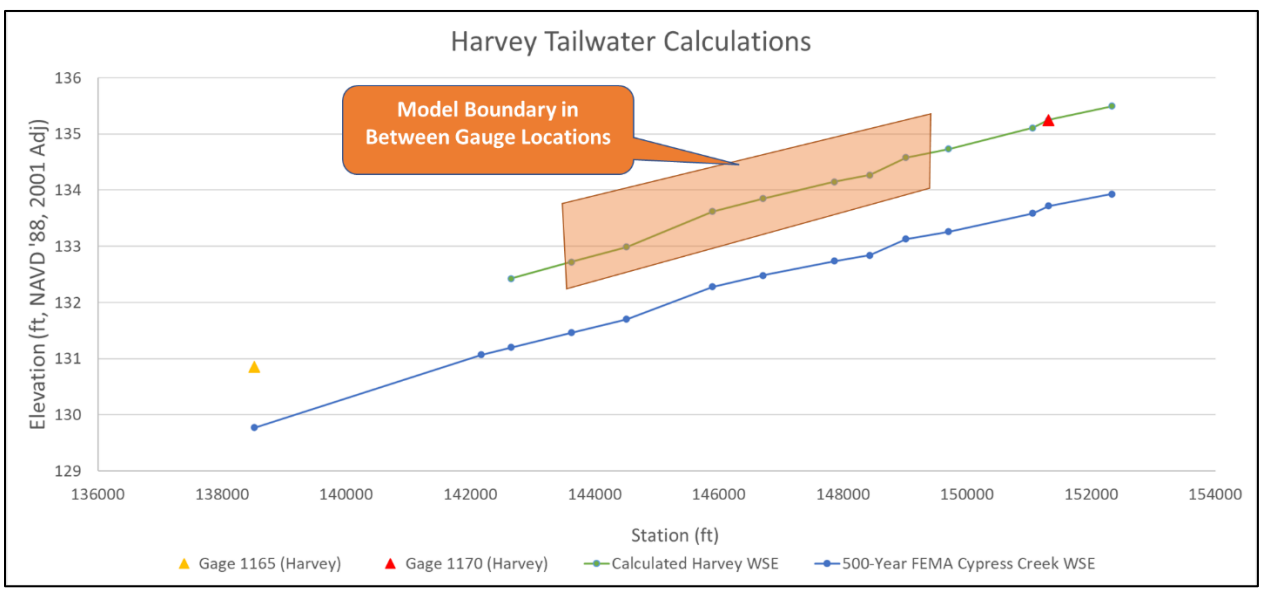


Figure 3. *Calculated Hurricane Harvey WSE vs. FEMA 500-year WSE*

Datum Considerations:

The 2018 LiDAR is on the NAVD '88 vertical datum. The Cypress Creek effective HEC-RAS model is on the is NAVD '88, 2001 adjustment vertical datum, which is approximately 0.96-ft higher than the LiDAR datum, according to survey. In the development of the unsteady-state HEC-RAS model, new cross sections were updated from the

2018 LiDAR and adjusted up by 0.96-ft to be consistent with the vertical datum of the effective model. In the InfoWorks ICM the LiDAR ground model was also adjusted up 0.960ft to be consistent with the vertical datum of the effective model, and with the datum of the design.

All water surface elevations, detention basin, and pipe elevations mentioned in this report are on the NAVD '88, 2001 adjustment vertical datum.

2.5 Existing Conditions 2D Modeling Results

This section discusses the existing conditions modeling results.

- With Tailwater Influence-
  - The InfoWorks ICM model indicates that K100-00-00 and K163-00-00 exceed their banks and flow through the subdivision, causing substantial flooding.
  - Significant structural flooding in the 10-year and 100-year storm events. See **Figure 4** and **Exhibits 6** and **7** for the 10-year and 100-year inundation with the influence of tailwater.
- Without Tailwater Influence-
  - Significant inundation in streets and low-lying areas
  - Inadequate storm sewer conveyance
  - Minimal structural flooding specifically in the 100-yr storm event. See **Figure 5** and **Exhibits 8-10** for the 10-year and 100-year inundation without the influence of tailwater.

The study focused on localized flooding in order to develop improvement concepts. Improvement concepts developed for this study do not address out of bank channel flooding but are intended to provide relief for the community during the short duration high intensity storms where Cypress Creek does not overtop but localized flooding still occurs.

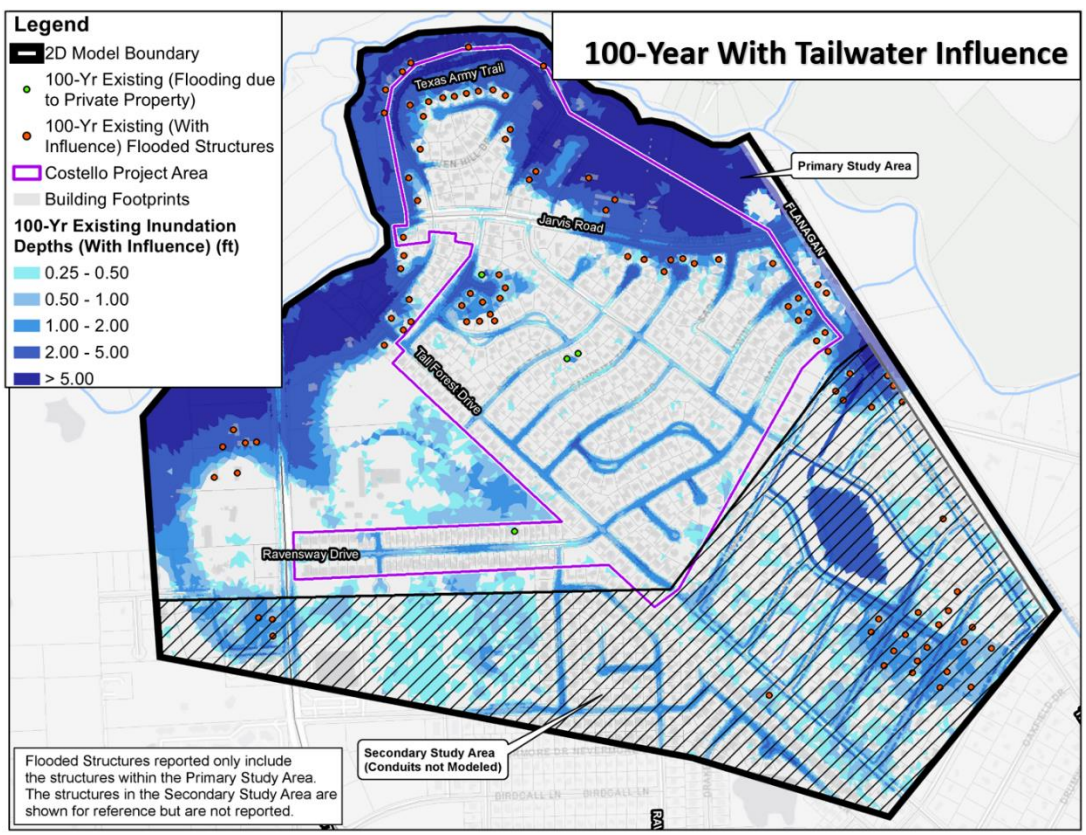


Figure 4. *100-Year Atlas 14 Inundation with tailwater influence.*

2.5.1 Historical Flood Comparison

Hurricane Harvey was run in the existing conditions model and compared to the historical flooding record to identify the correlation between predicted and actual flooding. The structures predicted to be inundation for Hurricane Harvey strongly align with those structures that reported flooding during the historical event. This comparison represented model validation. Rainfall data from Hurricane Harvey was applied to the 2D mesh. The results are shown in **Exhibit 11** and demonstrate that the majority of the structures that reported flooding were confirmed by the model.

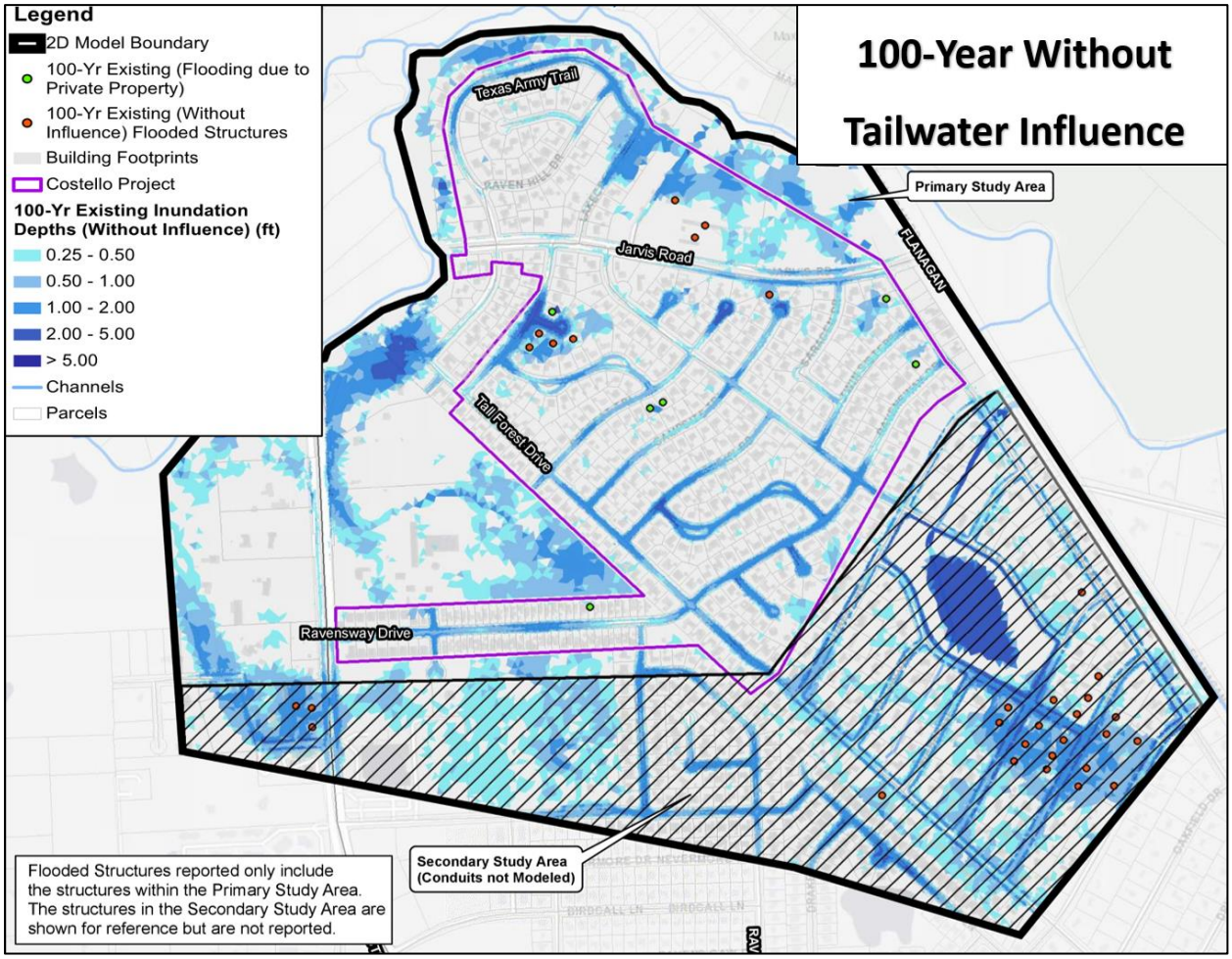


Figure 5. *100-Year Atlas 14 Inundation without tailwater influence.*

3.0 Identification of Problems

This section contains a brief discussion of the drainage problems and damages identified in the project area.

3.1. Damage Caused by Flooding

A detailed analysis was performed for existing conditions which is outlined in **Section 2** of this report. The existing conditions identified a lack of conveyance capacity and overland flow routes in the system for the localized rainfall events. Low-lying streets create several impassable zones for the 2-year and 10-year events and some structural flooding in the 100-year event.

3.2. Structures Flooded

Based on the existing conditions modeling, there are a significant number of structures at risk from flooding from the localized event as well as the K100-00-00 and K163-00-00 channel floodplains. **Table 2** shows the approximate number of existing flooded structures in the 2-year, 10-year, and 100-year storm events with and without tailwater influence.

Table 2. *Flooded Structures for Existing Conditions*

	50% AEP (2-year)	10% AEP (10-year)	1% AEP (100-year)
Structures Flooded (With Tailwater Influence)	**2***	**10**	**72**
Flooded from Creek or Drainage Infrastructure	0*	7	68
Flooded due to Private Property Grading	2*	3	4
Structures Flooded (Without Influence)	**2**	**4**	**14**
Flooded from Creek or Drainage Infrastructure	0	1	8
Flooded due to Private Property Grading	2	3	6

* *The 2-Year storm event "with tailwater influence" was not run in the 2D model. Reported flooded structures are from the "without tailwater influence" run.*

This study explores both the channel overbank flooding and the localized flooding; however, the primary focus is on the development of conveyance solutions and associated mitigation for localized flooding.

Flooded structures were also evaluated as a method for determining potential local conveyance improvement locations for the 100-year event**.** In the "without tailwater influence" runs, fourteen (14) flooded structures were identified in the 100-year event. Note that of the 14 identified flooded structures, six (6) were determined to have a local flooding source due to water ponding on private property, preventing water from draining. The flooding that impacts these structures likely will not be influenced by the proposed improvements and instead requires regrading on private property towards the roadway. The remaining 8 structures were targeted for improvement.

Exhibits summarizing the existing conditions analysis, including potentially flooded structures identified through the analysis and are included in **Exhibits 8-10**.

3.4. Issues with Access

In addition to historical data, the existing conditions model reported impassable roadway flooding along Tall Forest Drive, Ravensway Drive, and certain bisecting streets during Hurricane Harvey. The existing 2-, 10-, and 100-year storm event also demonstrated impassable roadways with depths up to approximately 3.1 feet in certain areas of the subdivision.

Impassable roadway zones were determined for the 2 and 10-year existing storm event. Inundation above 1 foot was determined to be impassable. **Figure 6** and **Exhibits 12** and **13** show the impassable areas for the 2-year and 10-year storm events.

- In the 2-year event there are 6 impassable zones.
- In the 10-year event there are 20 impassable zones.

3.5. Other Contributing Factors

Due to the frequent out of bank flooding for the project area, the analysis was performed both with and without the influence of the channel floodplains**.** The existing conditions modeling without the influence of the channel floodplains focuses on localized flooding. This existing localized flooding analysis supports an overall need for increased localized

conveyance capacity due to significant inundation in the streets and low-lying areas within the subdivision. The localized flooding analysis did not demonstrate a significant structural flooding issue. The majority of the structural flooding in this area appears to be strongly linked to out of bank channel flooding. For this reason, the design has focused on creating passable roadway conditions during a local 10-year storm event.

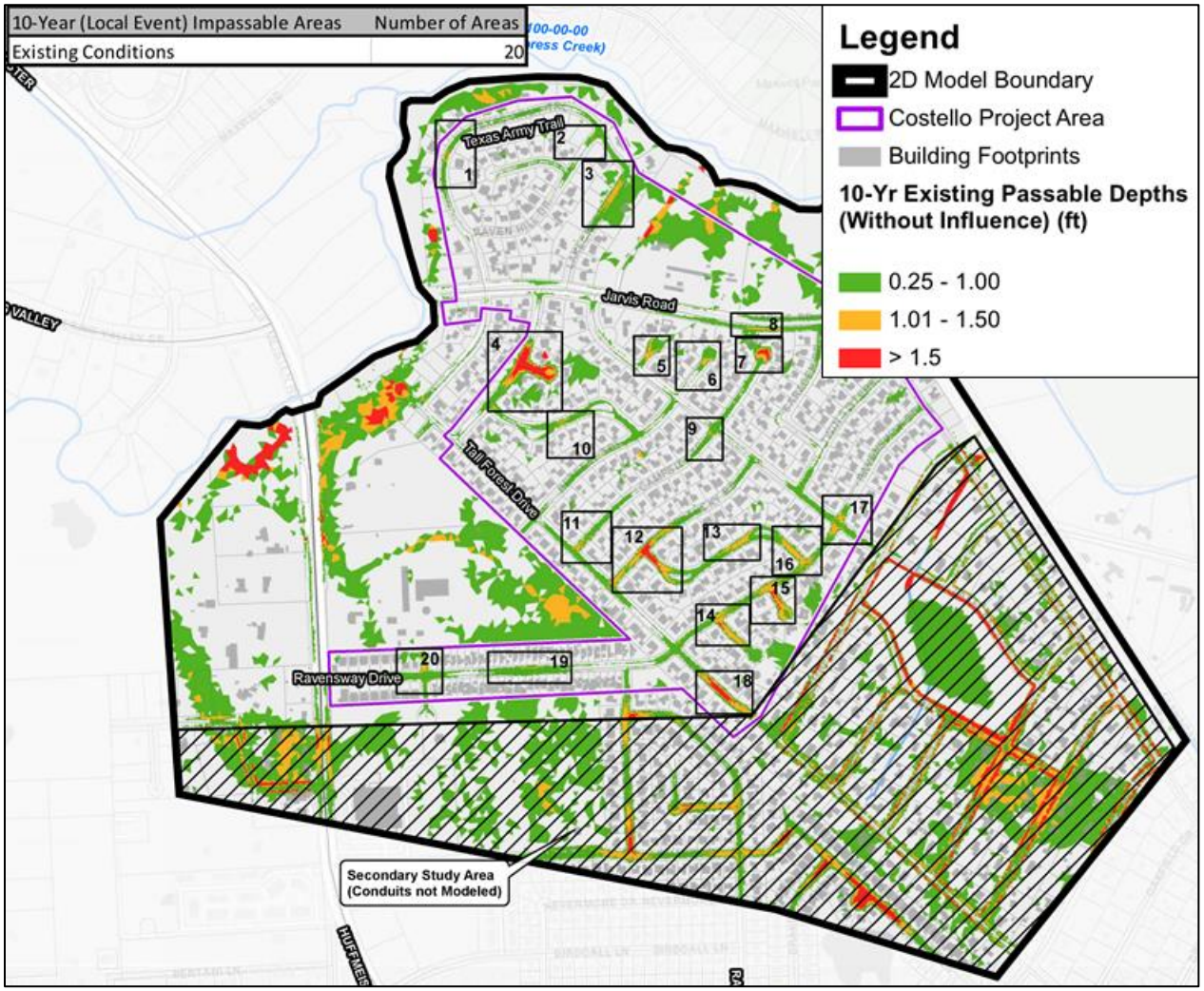


Figure 6. *Impassable roadways for the 10-year Atlas 14 Storm Event*

4.0. Proposed Improvements

This section contains a detailed discussion of the proposed drainage improvements and their associated benefits and costs. As part of the proposed conditions analysis, two (2) improvement options were identified and evaluated.

4.1. Proposed Improvement Approach

Improvements proposed to the local drainage systems focused on increased conveyance and the associated mitigation at a preferred detention location. Two conveyance improvement options were considered. See **Figure 7** for a layout of the proposed improvements.

- Option 1: Trunkline improvements to Ravensway Subdivision along Jarvis Rd., and south of Jarvis Rd.
- Option 2: Trunkline Improvements to Texas Army Trail Road (in addition to the improvements within Ravensway Subdivision)

Both conveyance improvements involve upsizing the existing trunklines in the project area and increasing discharge to Cypress Creek. Option 1 is the primary recommendation. Option 2 is intended as an optional add-on to Option 1. See **Exhibit 14** for a layout of the proposed improvements.

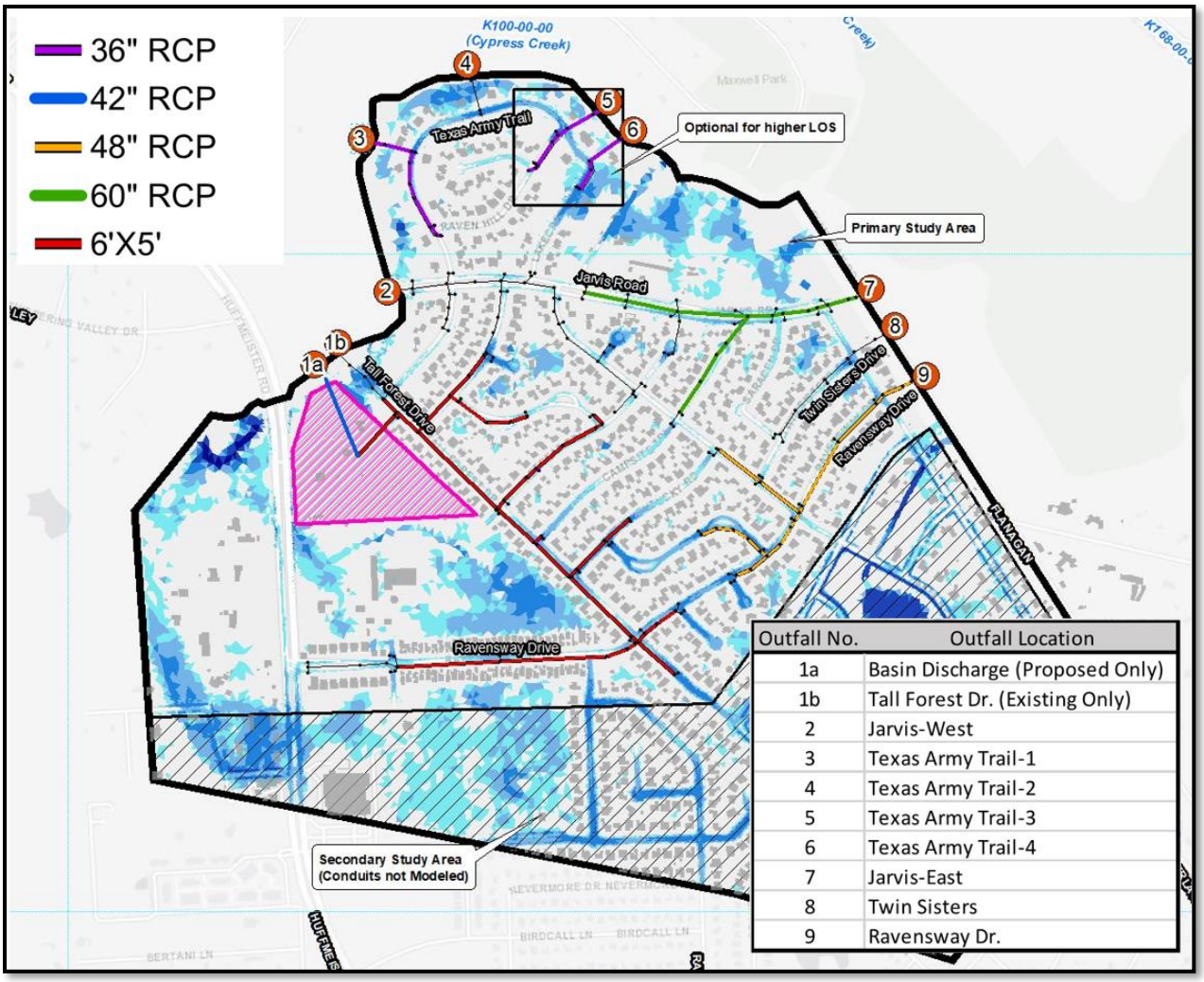


Figure 7. *Proposed Storm Sewer Improvements. Option 1 Improvements are along Jarvis and South of Jarvis, and Option 2 Improvements Include all proposed Improvements North and South of Jarvis.*

4.1.1 Option 1 Improvements

The Option 1 scenario consisted of modeling the following improvements.

- Install 6'X5' RCB's along the southwest portion of Ravensway Drive, Tall Forest Drive and bisecting streets to capture overland sheet flow
- Install 60" RCP's along the eastern portion of Jarvis to capture overland sheet flow
- Install 48" RCP's along the northeastern segment of Ravensway Drive to capture overland sheet flow
- Proposed Detention located west of the project on HCFCD owned site.

4.1.2 Option 2 Improvements

Option 2 builds upon Option 1 and includes improvements within the Ravensway Subdivision along with the proposed detention. Provided in the following is an outline of those improvements.

- All of the Option 1 improvements listed in Section 4.1.1
- Proposed 36" RCP along Texas Army Trail Road

4.1.3 Detention and No Adverse Impact

To prevent the proposed conveyance improvements from creating an increase in discharge to K100-00-00, a 9.5-acre detention basin location is proposed to be utilized to reduce peak flows from the project area back to pre-project conditions. The proposed stormwater detention basin site is located west of Tall Forest Drive and north of Ravensway Dr. and will occupy HCAD Parcels 0410650000097 and 0410650000088. These two parcels were previously purchased by HCFCD using federal funds through FEMA. Since the parcels were purchased using federal funds, the use of the sites for the purpose of detention must be approved by FEMA and the Texas Division of Emergency Management (TDEM). This process has been initiated, but approval is still to be determined.

The detention basin is proposed to have the following features. Elevations are on the NAVD '88, 2001 adjustment vertical datum

- Approximately 101 Ac-ft of storage available for the 100-year storm event.
- A top of bank elevation of 128.5-ft
- A 42" RCP outfall pipe with a downstream flowline set at elevation 108.75-ft with a backflow preventor.
    - A duckbill backflow preventer is proposed to be installed in the pipe within the outfall manhole structure and placed within extreme event overland flow weir for ease of maintenance access. The proposed outfall is designed per HCFCD standard PCPM guidelines. The intent will be for the backflow preventer to be maintained by HCFCD.
- A 65-ft long emergency overflow weir set at elevation 126.3, 1-ft above the 100-year water surface elevation. The emergency overflow weir has been sized to accommodate the 500-year storm event discharge draining towards the detention basin, assuming the outfall pipe is blocked.

Existing and proposed discharge hydrographs from the project area were quantified using the 2D analysis. The detention basin site was modeled in the unsteady InfoWorks ICM model. See **Section 4.2** for more on methodology. The total hydrograph from the overland sheet flow leaving the neighborhood and flowing into the creek was summed with each of the outfall hydrographs to develop one total hydrograph leaving the project area under existing and proposed conditions for each storm event modeled. This comparison was needed to demonstrate No Adverse Impact to HCFCD channels. A secondary site east of L100-00-00 near K500-01-00 was evaluated as a potential detention location but was not recommended due to its location deep in the floodplain and inefficiency to function as an off-line basin for the purposes of mitigating the subdivision improvements.

4.2. Impact Analysis Methodology

The impact analysis was performed using a combination of InfoWorks ICM (version 2021.5), HEC-HMS (version 3.4), and HEC-RAS (version 6.1).

4.2.1 HEC-HMS Model

The HEC-HMS model used is thought to be most current version of the HEC-HMS model developed for the Cypress Creek watershed and was provided by HCFCD. The HEC-HMS model provided was then updated to include Atlas 14 rainfall for each of the storm events.

The project area lies within the effective K100N2 drainage area and a portion of the K100O2 drainage area. These two effective drainage areas were subdivided based on the extents of the project area. See **Appendix A** for an exhibit showing the extents of the effective and the subdivided drainage areas. The time of concentration was calculated for the subdivided drainage area using the HCFCD TC&R Excel Template provided with the effective model download. See **Table 3** for calculations. The storage coefficient, "R" was adjusted until the total project area flow matched the total flow coming from the InfoWorks ICM model in existing and proposed conditions.

Table 3. *TC & R Calculations*

SUB AREA	Area (mi2)	L (mi)	Lca (mi)	S (ft/mi)	So (ft/mi)	UDTOT	DCI	DCC	DPP	Tc	Tc+R	R	ADET	UDDET (%)	DLU-DET	DLU (min)	Tc(adj) (hr)
K100N2 (Effective)	2.67	3.22	1.60	2.2	50	60	0	30	0	4.92	12.53	7.61	0.057	2.15	57.85	60.00	4.92
K100N2_2 (Project Area)	0.52	0.73	0.87	19.0	39	50	0	30	0	0.62	2.05	1.43	0	0.00	50	50	0.62

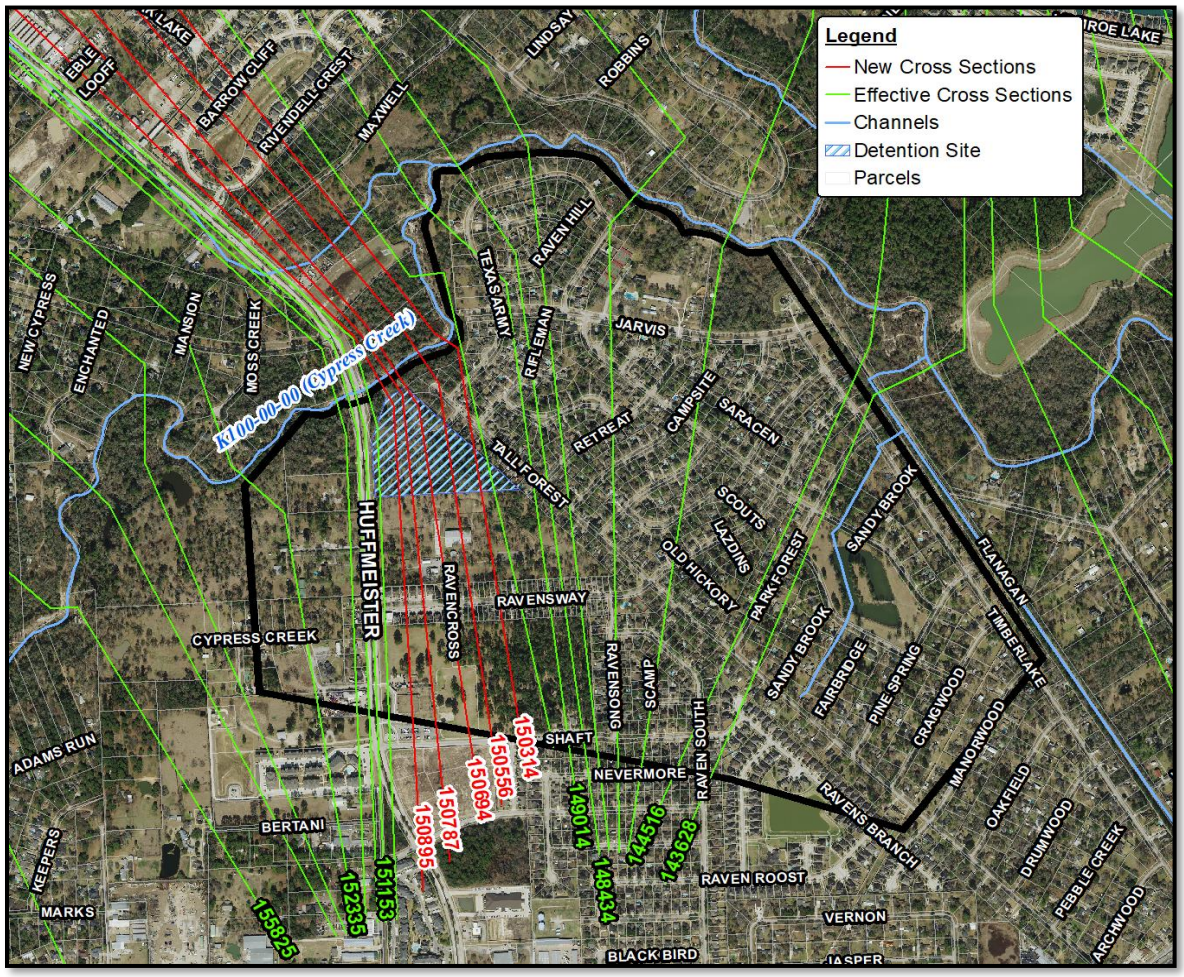


Figure 8. *Revised Existing and Proposed Conditions HEC-RAS Cross Sections*

4.2.2 Unsteady-State HEC-RAS Model

Using the effective cross sections, an unsteady-state HEC-RAS model was built to encompass the effective reaches, K100000_1445_R (Telge Rd. to Junction with Little Cypress Creek), K1000000_1221_R (Junction with Little Cypress

Creek to Jones Rd.), K1000000_1118_R (Jones Rd. to Cutten Rd.), and K1000000_0965_R (Cutten Rd. to Champion Forest Dr.). The unsteady-state HEC-RAS model was run in version 6.1, and hydrographs were applied to the model from the updated HEC-HMS model. For all storm events, a normal depth boundary condition was applied using the slope of the effective water surface elevation. A sensitivity analysis was performed to ensure that the downstream tailwater condition did not influence water surface elevations in the project area. Five cross sections were added in the vicinity of the project area detention basin and were updated based on the 2018 LiDAR. The terrain in these cross sections were adjusted based on the datum conversion to ensure they were on the same datum as the effective model. Manning's n-values for the added sections were applied to be consistent with existing conditions landuse and with the n-values used in the effective model. The effective cross sections, 151314, 151214, 151153, 151057, and 149704 were also updated based on the 2018 LiDAR. See **Figure 8** for the additional cross sections added.

Flows in the HEC-RAS model were input based on **Table 4.**

Table 4. *Unsteady-State Model Boundary Conditions*

HEC-RAS River Station	HEC-HMS Element	Type of Boundary Condition
159764	K1000000_1604_J	Inflow Hydrograph
158469	K100N2_1 (Effective portion of Subdivded K100N2)	Uniform Lateral Inflow Hydrograph
149704	K100N2_2 (Project Area)	Uniform Lateral Inflow Hydrograph
145901	L1000000_0013_J (Little Cypress Creek)	Lateral Inflow Hydrograph
143628	K100O1 + K100O2	Uniform Lateral Inflow Hydrograph
123212	K142000_0018_J	Lateral Inflow Hydrograph
122086	K100P	Uniform Lateral Inflow Hydrograph
112513	K140A	Lateral Inflow Hydrograph
108501	K100Q	Uniform Lateral Inflow Hydrograph
97287	K133A	Lateral Inflow Hydrograph
96543	Normal Depth	

Table 5. *Detention Basin Elevation-Volume Curve*

Elevation (ft)*	Volume (Ac-Ft)
110	0
112	5
114	15
116	28
118	42
120	57
122	73
124	90
126	107
128	125
128.5	129

4.2.3 InfoWorks ICM - Detention Basin

The detention basin was modeled in InfoWorks ICM using a storage node with a storage curve, a storage area polygon, and an inline bank around the polygon to capture the overland sheet flow. In proposed conditions, the Tall Forest 6'x5' RCB was routed directly into the basin. The storage curve for the detention basin is represented in **Table 5**. A 42" RCP outfall pipe with an downstream elevation of 108.75-ft is used, and a backflow preventer is placed on the outfall pipe to prevent Cypress Creek waters from backing into the detention basin.

4.2.4 Impact Analysis Process

To determine whether the proposed improvements will cause downstream impacts, the following process was followed.

- Using the "Without Tailwater Influence" scenarios, a 2D results line was drawn on the edge of the InfoWorks ICM mesh in both existing and proposed conditions to measure the total overland sheet flow leaving the project area and flowing into Cypress Creek.
- Using the "Without Tailwater Influence" scenarios, the discharge hydrographs from each outfall were summed together.
- The summed outfall hydrograph was then added to overland sheetflow hydrograph to obtain one overall hydrograph for flow leaving the project area. This was done for the 2-year, 10-year, 50-year, and 100-year storm events in both existing and proposed conditions.
- The storage coefficient for the HEC-HMS basin for the project area (K100N2_2) was adjusted until the total flow leaving the drainage area matched the total flow leaving the InfoWorks ICM model. This was done for the 2-year, 10-year, 50-year, and 100-year storm events in both existing and proposed conditions.
- The HEC-HMS junction flows were compared to evaluate potential downstream flow increases for all storm events.
- The project area HEC-HMS hydrograph for both the revised existing and proposed conditions was input into the unsteady-state HEC-RAS model as a uniform lateral inflow hydrograph. The HEC-RAS upstream and downstream water surface elevations were compared to ensure no impacts to Cypress Creek.
- In addition to modeling impacts from proposed discharges in the unsteady-state HEC-RAS model, the geometry of the HEC-RAS cross sections in the vicinity of the proposed detention basin were modified to reflect the proposed basin. See **Figure 9** for an example section.
    - Manning's n-values were lowered to 0.05 to reflect a dry detention basin, and the proposed geometry was added using a bottom elevation of 110-ft, a top of bank of 128.5-ft, and 4:1 side slopes. The detention basin area was blocked in the cross sections up to the top of bank elevation of 128.5-ft.
    - In addition to modifying the HEC-RAS cross sections, a storage area was input in the proposed basin area to represent the storage that will be available to the Cypress Creek Watershed. See **Figure 10.** For each storm event, the proposed volume to be used by the proposed improvements was subtracted out of the storage area volume, since that volume will be used by the proposed Ravensway improvements and will not be available to Cypress Creek.
    - See **Section 4.1.3** for more on the proposed basin geometry.

Using this methodology, the unsteady-state HEC-RAS model evaluates impacts from both proposed discharges, and potential impacts to the floodplain due to fill.

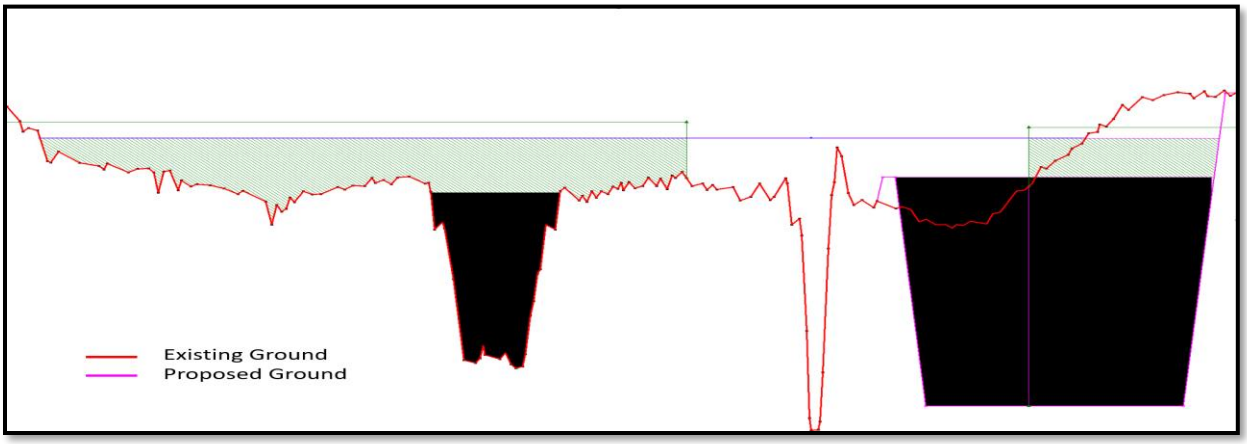


Figure 9. *Example section in the Proposed RAS model*

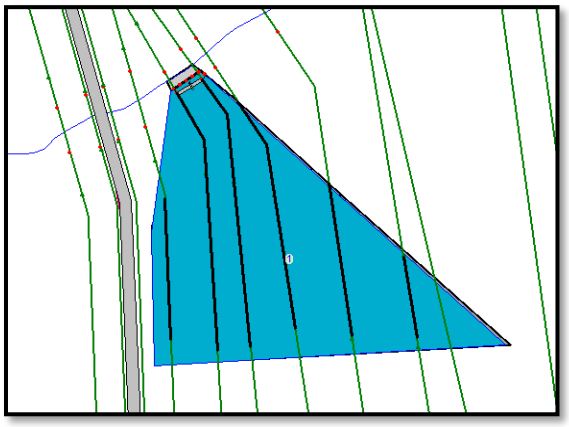


Figure 10. *Storage Area representing the Proposed Basin in the RAS model*

4.3. Proposed Conditions Results

The proposed alternatives results were generally evaluated by looking at the metrics listed below. Each alternative was evaluated for the 2-year, 10-year, 50-year, and 100-year storm events.

- Inundation mapping, specifically the reduction in inundated area for each of the modeled events
- Proposed storm sewer profiles to determine the capacity for various events and an evaluation of the hydraulic grade line to determine containment of the flows
- The number of improved impassable zones for the 2-year and 10-year event specifically.
- The number of structures benefitted and removed in the 100-year event
- Stormwater detention and downstream impacts were evaluated using the process outlined in **Section 4.2.4**.

4.3.1 Proposed Conditions Results Summary

The impassable zones for the 2-and 10-year event were evaluated with the proposed conditions. In the 2-year proposed event all five (6) impassable zones are expected to be made passable, and in the 10-year proposed event 19 of the 20 impassable zones are expected to be made passable. See **Table 6** for the proposed conditions impassable zones. The one remaining impassable area is only impassable by an inch. **Exhibits 15-16** show the impassable proposed

inundation for the 2 and 10-year event respectively. **Tables 7** and **8** show the existing and proposed conditions flooded structures with and without tailwater conditions for the 100-year event. In the proposed 100-year event without tailwater influence, flooding was removed from 6 of the 14 flooded structures. Proposed Inundation for the 2, 10 and 100-year events without tailwater influence, along with structural flooding counts, are shown in **Figure 11** and **Exhibits 17-19**.

Table 6. *Impassable Zones for Proposed Conditions*

	50% AEP (2-year)	10% AEP (10-year)
Impassable Zones (Local Conveyance Only)	0	1

Table 7. *Flooded Structures for Proposed Conditions* ***without*** *Tailwater Influence*

	Existing Flooded Structures	Proposed Flooded Structures	Removed Flooded Structures	Benefited, but not Removed
100-Year Proposed Conditions Flooded Structures (without tailwater influence)	14	8	6	2*
Flooded from Creek or Drainage Infrastructure	8	0		
Flooded due to Private Property Grading	6	8*		

** There are two structures that flood from the street in existing conditions, and from the back of lot in proposed conditions. When the drainage infrastructure improvements are implemented in proposed conditions, these two structures no longer flood from the street, but calculations are showing that they will still flood from the back. These two structures will see reduced flood depth in proposed conditions, and will benefit, but will not be removed.*

Table 8. *Flooded Structures for Proposed Conditions* ***with*** *Tailwater Influence*

	Existing Flooded Structures	Proposed Flooded Structures	Flooded Structures Removed	Structures Benefited, but Not Removed
100-Year Proposed Conditions Flooded Structures (with tailwater influence)	72	62	10	2*
Flooded from Creek or Drainage Infrastructure	68	56		
Flooded due to Private Property Grading	4	6*		

** There are two structures that flood from the street in existing conditions, and from the back of lot in proposed conditions. When the drainage infrastructure improvements are implemented in proposed conditions, these two structures no longer flood from the street, but calculations are showing that they will still flood from the back. These two structures will see reduced flood depth in proposed conditions, and will benefit, but will not be removed*

Exhibits 20 and **21** show the proposed inundation with tailwater influence. As expected, the structures closer to the creek bank that flood from Cypress Creek overbank flooding will not benefit from the proposed improvements should Cypress Creek get out of banks. However, in the low-lying areas south of Jarvis that experience flooding due to inadequate storm sewer capacity, the proposed improvements would provide benefit. In the proposed 100-year event with tailwater influence, flooding was removed from 10 of the 72 flooded structures.

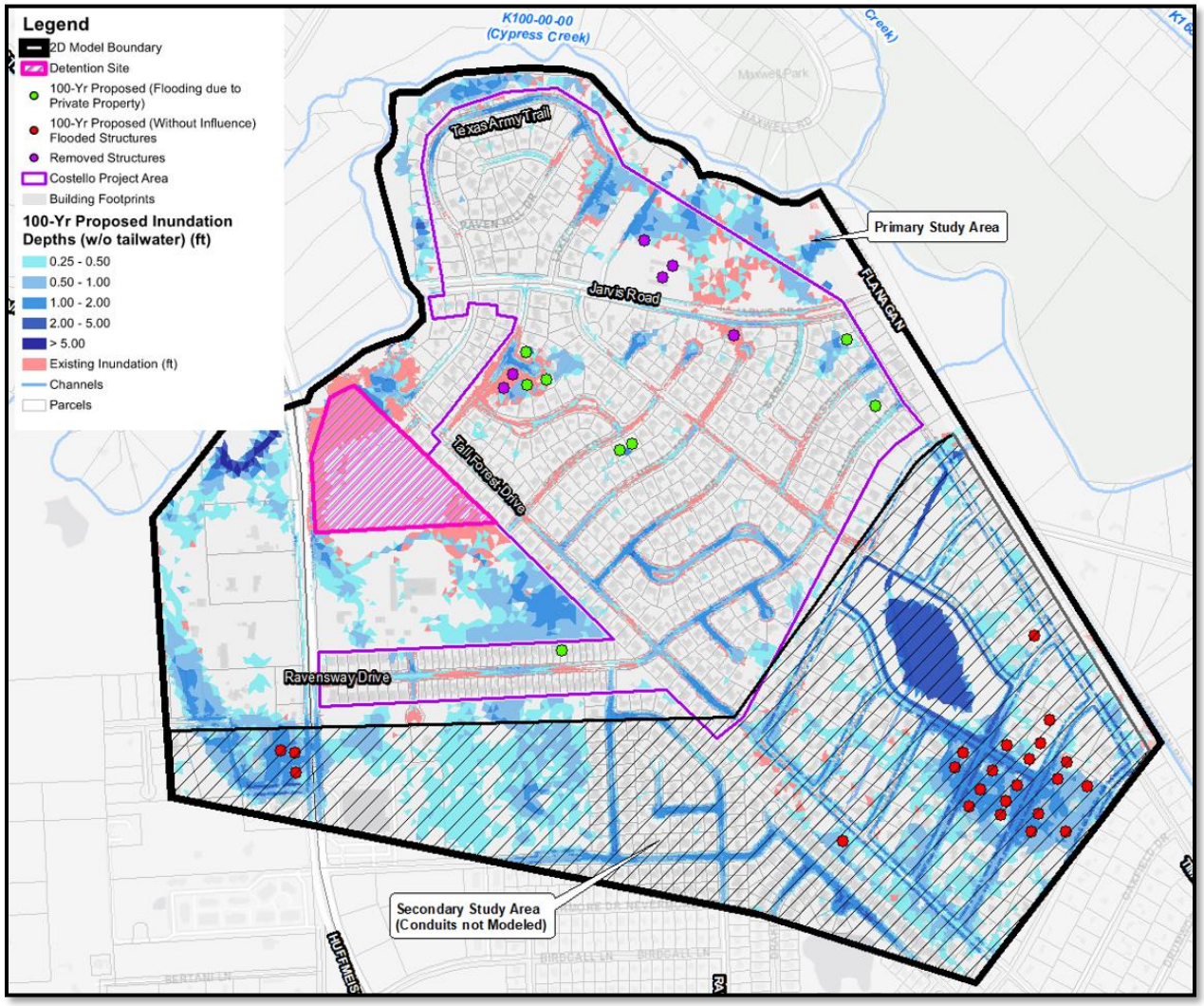


Figure 11. *Proposed 100-Year Inundation Without Tailwater Influence. Blue (Proposed); Pink (Existing)*

4.3.2 Detention Basin Results

The detention basin that was modeled in InfoWorks ICM determined the amount of volume that will be used by the proposed improvements for each storm event. **Table 9** shows the peak water surface elevation and the total volume utilized for the detention basin for each storm event. The results indicate that the detention basin will have approximately 3.2-ft of freeboard in the 100-year storm event, leaving approximately 28 ac-ft of volume available for use by Cypress Creek in the 100-year event for regional detention.

Floodplain Fill Mitigation

Using the average-end-area method, it is estimated that the detention basin berm will account for approximately 1 ac-ft of fill in the floodplain. Since the elevation of Cypress Creek is at or greater than the detention basin berm elevation at the 10-, 50-, and 100-year events, the detention basin volume above the water surface elevation will be available to Cypress Creek in all events except the 2-year event, and therefore does not need to be mitigated for. In the 2-year event, the Cypress Creek water surface elevation is within banks in this location, so having creek volume "cut off" from

the detention basin will not cause any downstream impacts. The detention basin will be able to accommodate any volume required for floodplain fill mitigation.

Table 9. *Water Surface elevations and volumes for the proposed detention basin*

Storm Event	A) Cypress Creek Water Surface	B)Basin Water Surface Elevations (ft)	C) Basin Volume used by Improvements (ac-ft)	D) Basin Volume at Top of Bank (ac-ft)	Basin Volume Available to Creek (ac-ft) (*D minus C*)
2-Year	125.6	113.28	11	129	0
10-Year	128.5	117.57	40		89
50-Year	131.1	123.09	82		47
100-Year	132.1	125.30	101		28

The analysis has shown that if the detention basin top of bank is not raised to an elevation of 128.5, the excavation of the detention basin will cause increased conveyance and cause downstream impacts in Cypress Creek. The following bullet points explain why this happens.

Figure 12. *Proposed Site of Detention Basin*

- The existing basin site is a wooded area with a relatively high n-value. When the site is cleared for the detention basin, water will be stored in a significant portion of the constructed volume. Additional flow above the storage volume will have a significantly lower resistance than it did when the same area was wooded. This increase in conveyance results in small water surface impacts downstream. See **Figure 12** for the existing aerial.

- The construction of the detention basin will require further excavation in land that is already in the floodplain and will also be excavating land that is currently outside of the floodplain. See **Figure 13** for a typical cross section across the basin site. In **Figure 13**, the shaded red area represents area of the cross section that is currently in the floodplain and that will be excavated and cleared when the basin is constructed, thereby contributing to additional conveyance in the floodplain. The shaded yellow area is also area that will be excavated and cleared and is area that is not currently in the floodplain. The shaded yellow region of excavation will add ineffective storage area to the floodplain. The increased conveyance lowers water surface elevations in Cypress Creek in the vicinity of the detention basin but increases flow rates and water surface elevations downstream.
- The detention basin berm is proposed to be raised to 128.5-ft offset this increased conveyance that will be caused by the basin excavation.

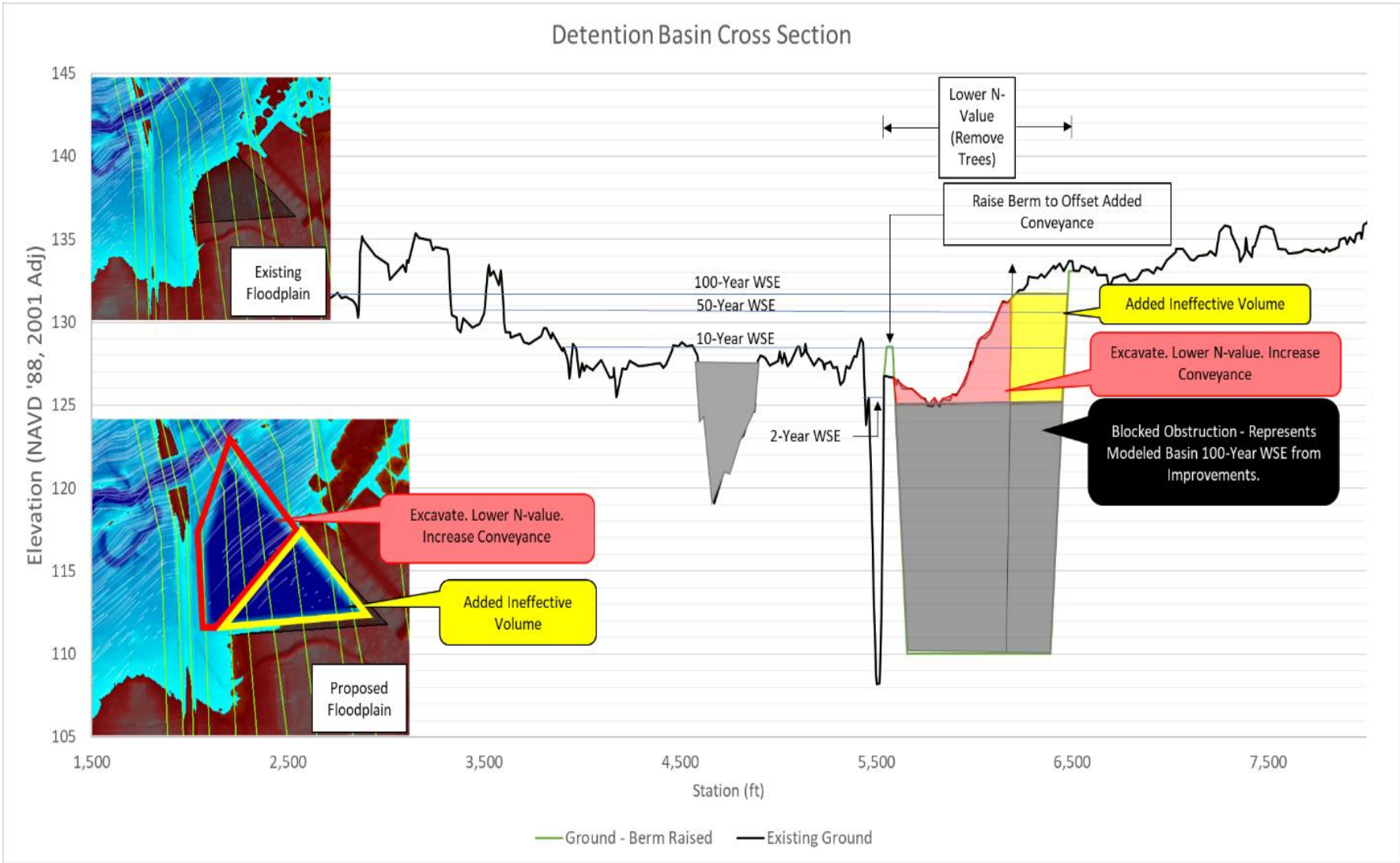


Figure 13. *Detention Basin Cross Section*

Detention Basin Maintenance Berm

A minimum of 30-foot berms have been incorporated into the basin as required by HCFCD criteria for maintenance. With regard to areas where the berms will be built up to an elevation of 128.5, an additional 10-feet has been provided, to allow a maximum transition of 4:1 to the backslope swale. A basin layout is included in **Appendix D**.

4.3.3 Impact Analysis Results

The detention basin not only mitigates the improved discharge for the Tall Forest outfall, but for each event, it also over-mitigates to account for the other outfalls in the project area that are not being detained for. Therefore, the total flow going to K100-00-00 from the project area is less in proposed conditions than in existing conditions.

See **Table 10** for the existing and proposed 100-year discharges for each outfall, and **Figure 14** for the existing and proposed 100-Year hydrographs coming from the Tall Forest outfall location. **Figure 7** shows the outfall locations.

Table 10. *Outfall discharges for Existing and Proposed Conditions*

Outfall Number	Outfall Location	100-Year Existing Flow (cfs)	100-Year Proposed (cfs)	Difference (cfs)
1a/1b	Tall Forest	101	19 *(Basin Discharge)*	-71
2	Jarvis - West	72	67	-12
3	Texas Army Trail - 1	16	58	31
4	Texas Army Trail - 2	20	19	-1
5	Texas Army Trail - 3	22	54	32
6	Texas Army Trail - 4	27	39	24
7	Jarvis - East	98	178	78
8	Twin Sisters	57	55	-5
9	Ravensway Dr.	82	140	64
--	Overland Sheet Flow	435	223	-243
Sum of Peak Discharges (cfs)		**930 cfs**	**851 cfs**	**-79 cfs**

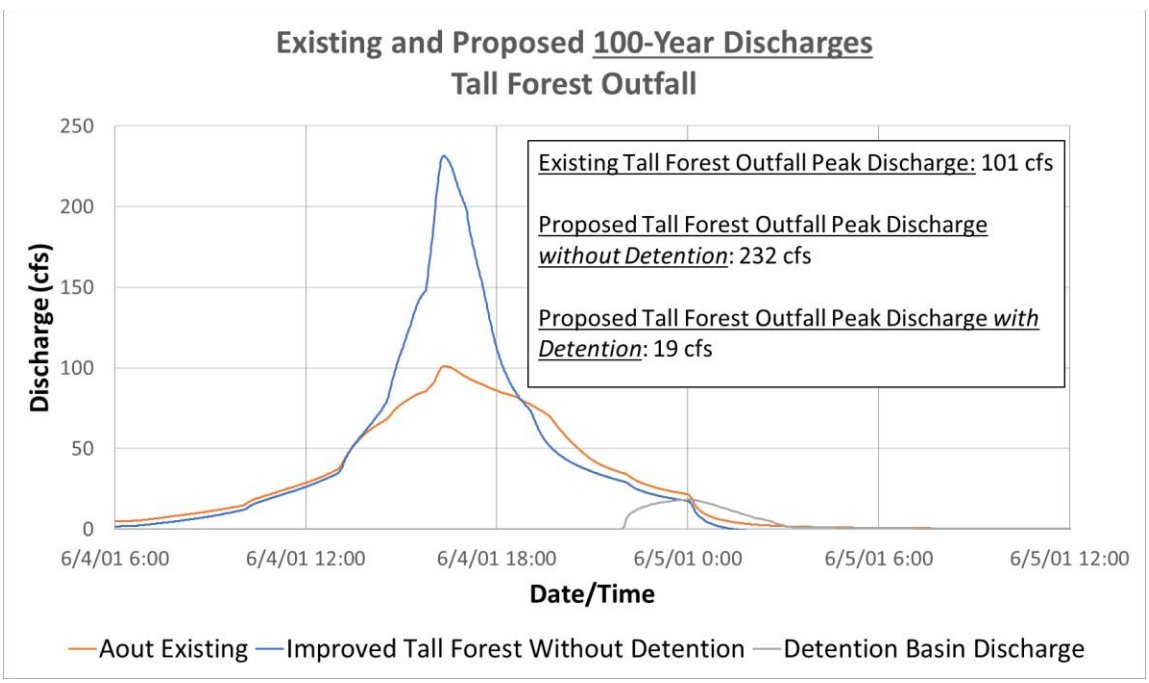


Figure 14. *Hydrograph for Existing and Proposed Conditions*

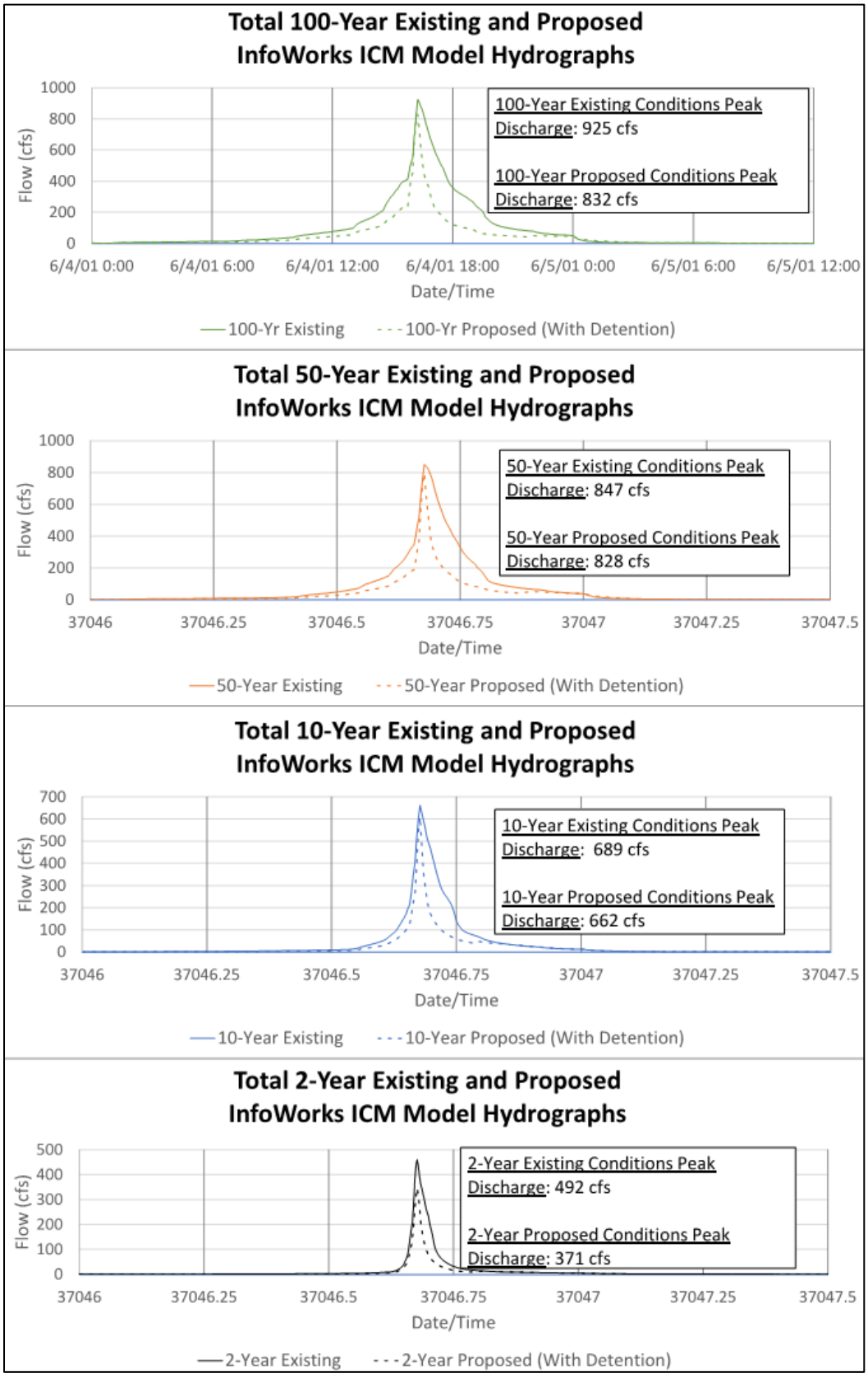


Figure 15. *Existing and Proposed Conditions (With Detention) Hydrographs from the Project Area*

Flows discharged into Cypress Creek were evaluated and compared to existing discharges in order to determine no adverse impacts downstream of the channel. The proposed **101 Ac-Ft** detention basin is designed to help reduce the discharge into the creek in order to maintain existing flows.

The hydrographs from all of the outfalls and from the overland sheet flow approaching the creek were summed together to achieve one project area hydrograph under existing and proposed conditions. **Figure 15** shows the total existing and proposed hydrographs from the InfoWorks ICM model, and **Table 11** shows total existing and proposed project area discharges for each storm event. As mentioned previously, HEC-HMS discharges were calibrated to match the model discharges by adjusting the storage coefficient, R. See **Table 12** for the storage coefficients for each storm event under existing and proposed conditions. The proposed conditions storage coefficients were increased to represent the added volume from the detention basin.

HEC-HMS Results

The existing and proposed conditions resultant hydrographs were evaluated in HEC-HMS to determine whether there are downstream impacts in each respective storm event. A minor flow impact of 1 cfs (0.03% of total flow) was observed in the 2-year event at junction K1000000_1131_J, but this impact does not result in water surface elevation impacts, as is shown by the HEC-RAS comparison in **Appendix C**. **Appendix B** shows the existing and proposed discharges for the junctions downstream of the project site for the 2-year, 10-year, 50-year, and 100-year storm events.

Since HEC-HMS and Unsteady-State HEC-RAS route flows a little differently, the existing and proposed discharges were also input into the Unsteady-State HEC-RAS model to evaluate whether any increases in water surface elevations would occur. The HEC-HMS drainage areas were input into the Unsteady-State HEC-RAS model according to **Table 4.** The next section elaborates on the results of the unsteady-state HEC-RAS analysis. It should be noted that the extent of the HEC-RAS model covers all of the HEC-HMS junctions listed in **Appendix B**.

HEC-RAS Results

The unsteady-state HEC-RAS analysis evaluates potential impacts due to both changes in floodplain conveyance, and from changes in discharge. The results of the unsteady-state HEC-RAS analysis indicate that **the proposed Ravensway Subdivision storm drain improvements and the proposed stormwater detention basin will cause no upstream or downstream impacts in the 2-year, 10-year, 50-year, or 100-year Atlas 14 storm events**. See **Appendix C** for the HEC-RAS water surface elevation and flow comparisons for each storm event.

Table 11. *Total Project Area Discharge for Existing and Proposed Conditions*

Storm Event	Existing Conditions Discharge (cfs)	Proposed Conditions Discharge (cfs)
2 Year Storm Event	492	371
10 Year Storm Event	689	662
50 Year Storm Event	847	828
100 Year Storm Event	925	832

Table 12. *Existing and Proposed HEC-HMS Storage Coefficients*

Storm Event	Existing Conditions Storage Coefficient (R)	Proposed Conditions Storage Coefficient (R)
2 Year Storm Event	0.618	1.050
10 Year Storm Event	0.997	1.074
50 Year Storm Event	1.340	1.396
100 Year Storm Event	1.475	1.807

Impacts to K163-00-00

Two outfalls are proposed to be improved that drain to K163-00-00—Outfalls 7 and 9 in **Table 10**. These two outfalls are located along Jarvis St. and along Ravensway Dr. In all storm events, the peak elevations along K163-00-00 are tied to the Cypress Creek elevations. **See Figure 16**. The section of K163-00-00 where the improved outfalls discharge is so low, it can be considered part of K100-00-00. Even the K100-00-00 2-year storm event completely submerges the outfalls that are proposed to be improved.

In fact, the HCFCD Channel linework shapefile shows the main centerline of K163-0-00 turning to the right to meet up with K100-00-00 south of the outfalls that are proposed to be improved, indicating that the outfalls actually drain to K100-00-00. See **Figure 17** for a topography map showing the low elevations at the outfall locations and the channel linework. **Figure 18** shows the Steady-state normal depth profile of K163-00-00 and highlights the drastic difference between a normal depth tailwater and a tailwater tied to Cypress Creek.

It can be concluded that the increased in proposed discharges at these locations will have no impact on the peak elevations in K163-00-00 at the outfall locations because the water surface elevations in this location are controlled by K100-00-00, and the impact analysis has shown that the improvements will have no impact to K100-00-00.

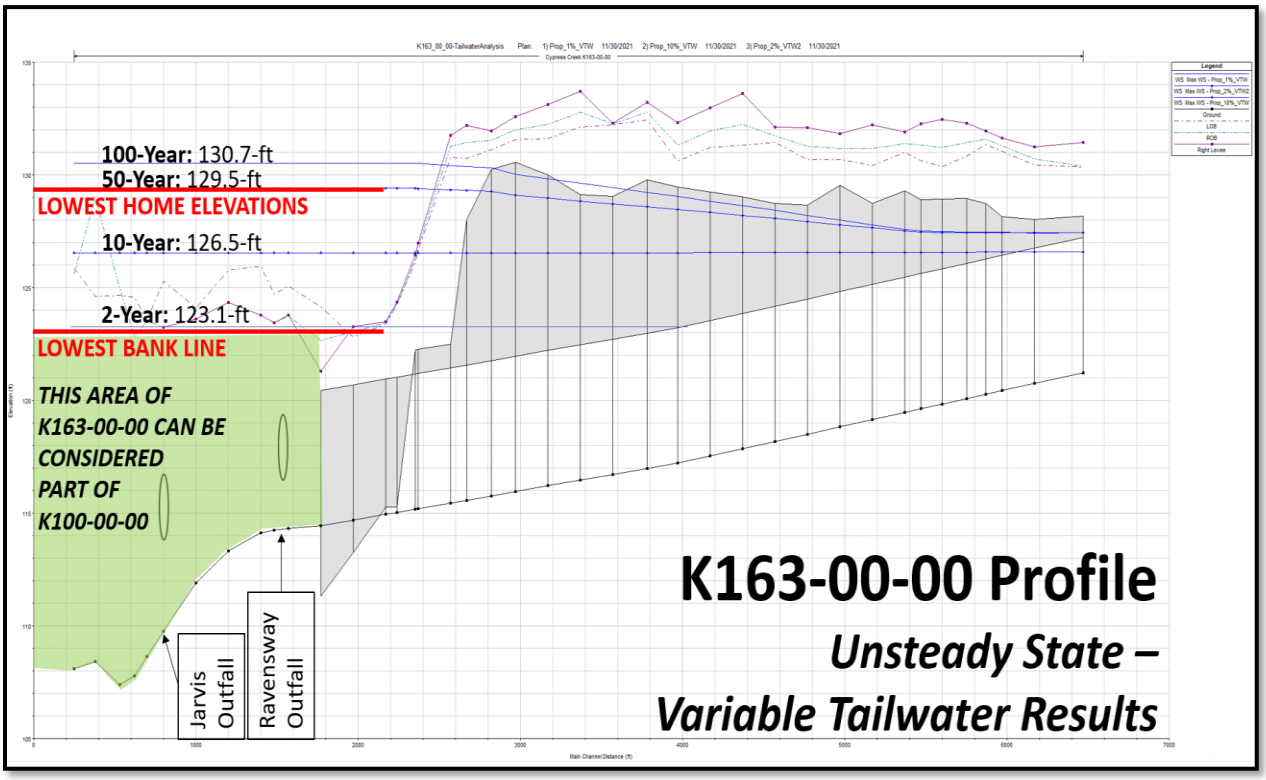


Figure 16. K163-00-00 Peak Water Surface Elevations using an Unsteady-State Variable Tailwater Stage condition

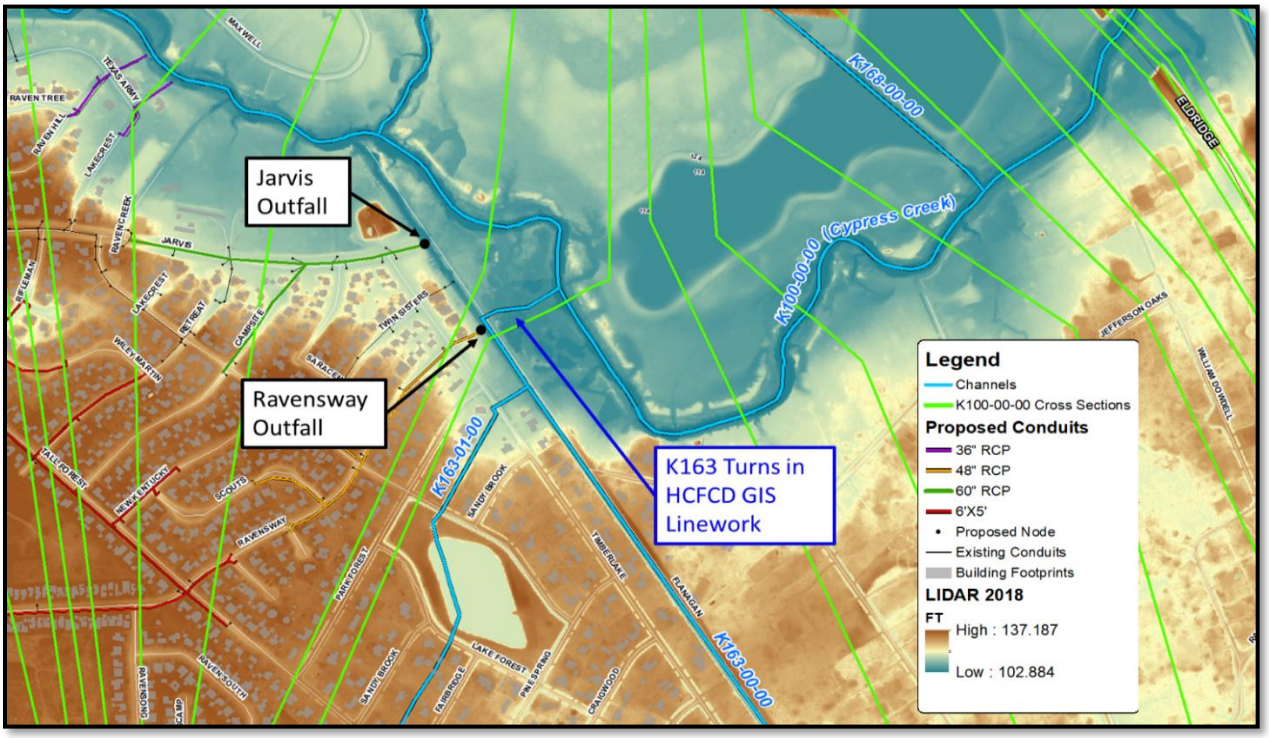


Figure 17. *Topography map of the area*

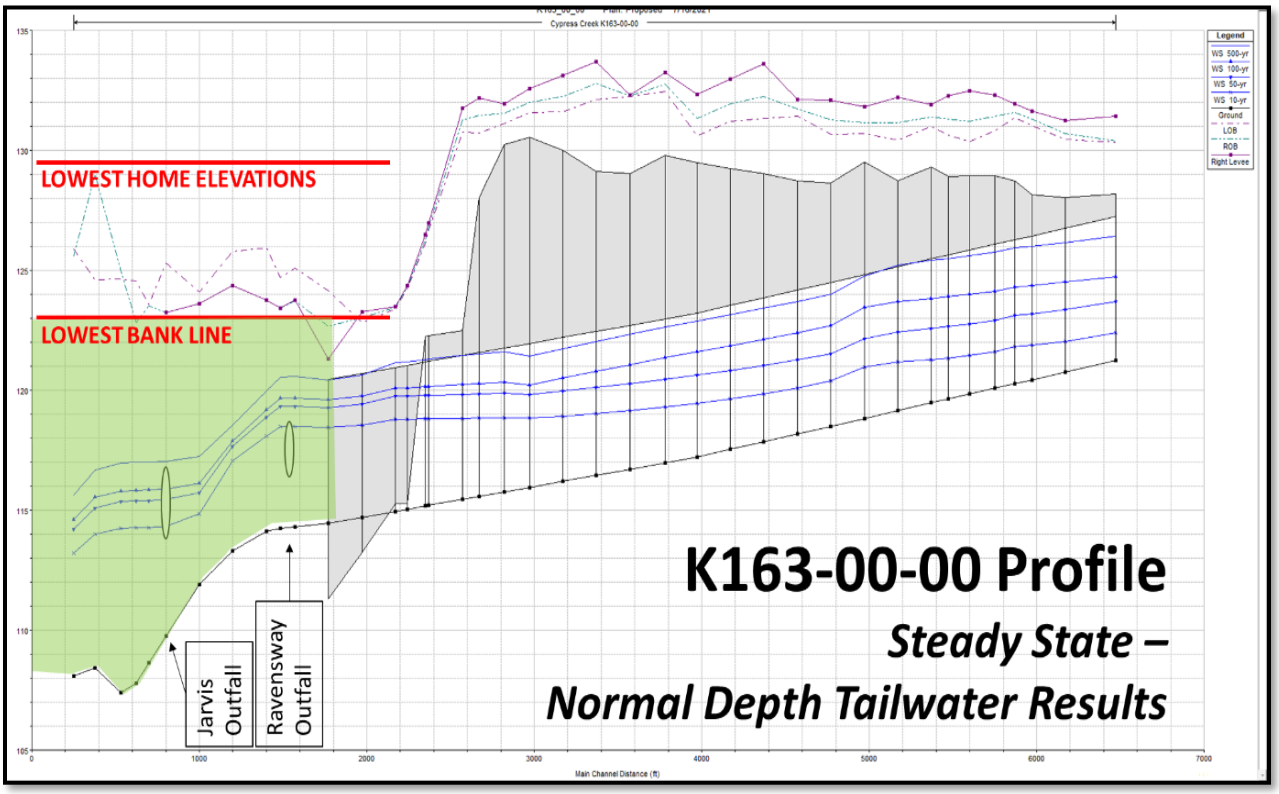


Figure 18. *K163-00-00 Peak Water Surface Elevations using a Steady-State Normal Depth Tailwater Stage condition*

5.0. Floodway Analysis

Since the raised basin berm encroaches upon the Effective Floodway, a floodway analysis is required to show that the surcharges within floodway are not in excess of 1 foot to comply with the FEMA and local floodplain management regulations. Gauge has shown no adverse impact using an unsteady-state model. However, there is not an existing floodway run in the unsteady-state model that we used. For this reason, Gauge has performed the required floodway analysis using the FEMA Effective model. The following steps were taken.

1. The Effective Multiple Profile run was included, using the effective model version, HEC-RAS 3.1.3.
2. The Effective Floodway run was included.
3. Per FEMA standards, a Duplicate Effective Multiple Profile run was included.
4. Per FEMA standards, a Duplicate Effective Floodway run was included.
5. Gauge established a Corrected Effective Multiple Profile run that updated the two effective cross sections bounding the project detention site, Cross Sections 151057 and 149704, with 2018 LiDAR.
6. Gauge established a Corrected Effective Floodway run that used the Corrected Effective geometry, and used the effective model encroachments for the floodway analysis.
7. Gauge established a Pre-Project Multiple Profile run that added additional cross sections in the vicinity of the project detention site using 2018 LiDAR.
8. Gauge established a Pre-Project Floodway run that used the Pre-Project geometry, and placed encroachments on the added cross sections, which were interpolated between the effective encroachments.
9. Gauge established a Post-Project Multiple Profile run that modified the cross section geometry in the vicinity of the project to be reflective of proposed conditions.
10. Gauge established a Post-Project Floodway run that used the Post-Project geometry with the same encroachments as the Pre-Project Floodway run. **The Post-Project Floodway model shows that the surcharges within floodway are not in excess of 1 foot under proposed conditions.**

Since no adverse impact has already been shown in the unsteady model, Gauge did not alter the effective flow data to perform this analysis and did not use this analysis to show no adverse impacts between pre- and post-project conditions. **Section 4.3.3** discusses the Impact Analysis results. Furthermore, since the proposed pond berm will not be cutting of the 100-year floodplain, the encroachments used in the post-project condition did not change from the pre-project condition. **Table 13** shows the effective and post-project cross sections and their respective floodway surcharges. See **Appendix E** for the Floodway Surcharge Results for all of the cross sections in the effective model. The results for the remaining runs listed above are included digitally with the model submittal.

Table 13. *Effective and Post-Project Floodway Surcharges for the Cross Sections in the Proposed Detention Project Area*

Cross Section	Effective 100-Yr WSE (ft)	Effective Floodway Elevation (ft)	Effective Floodway Surcharge (ft)	Post-Project 100-Yr WSE (ft)	Post-Project Floodway Elevation (ft)	Post Project Floodway Surcharge (ft)
151057	131.29	132.06	0.77	131.55	132.28	0.73
150895	--	--	--	131.24	132.08	0.84
150787	--	--	--	131.26	132.09	0.83
150694	--	--	--	131.22	132.04	0.81
150556	--	--	--	131.22	132.01	0.79
150314	--	--	--	131.15	131.96	0.81
149704	130.91	131.68	0.77	131.06	131.87	0.80

6.0. Summary and Recommended Approach

6.1 Option 1 Improvements

The Option 1 scenario consisted of modeling the following improvements (See **Exhibit 22**):

- Install 6'X5' RCB's along the southwest portion of Ravensway Drive, Tall Forest Drive, and bisecting streets to capture overland sheet flow
- Install 60" RCP's along the eastern portion of Jarvis to capture overland sheet flow
- Install 48" RCP's along the northeastern segment of Ravensway Drive to capture overland sheet flow
- Proposed Detention located west of the project on HCFCD owned site (See **Exhibit 22**)

Option 1 provides significant benefit to the Ravensway Subdivision by reducing the number of impassable zones and number of flooded structures for the 2-, 10-, and 100-year storm event; however, some homes along Texas Army Trail Road still may see some overflow.

6.2 Option 2 Improvements

As previously stated, Option 2 builds upon Option 1 and includes improvements within the Ravensway Subdivision along with the proposed detention. Provided in the following is an outline of those improvements (See **Exhibit 23**):

- All of the Option 1 improvements, plus
- Proposed 36" RCP for three outfalls along Texas Army Trail Road

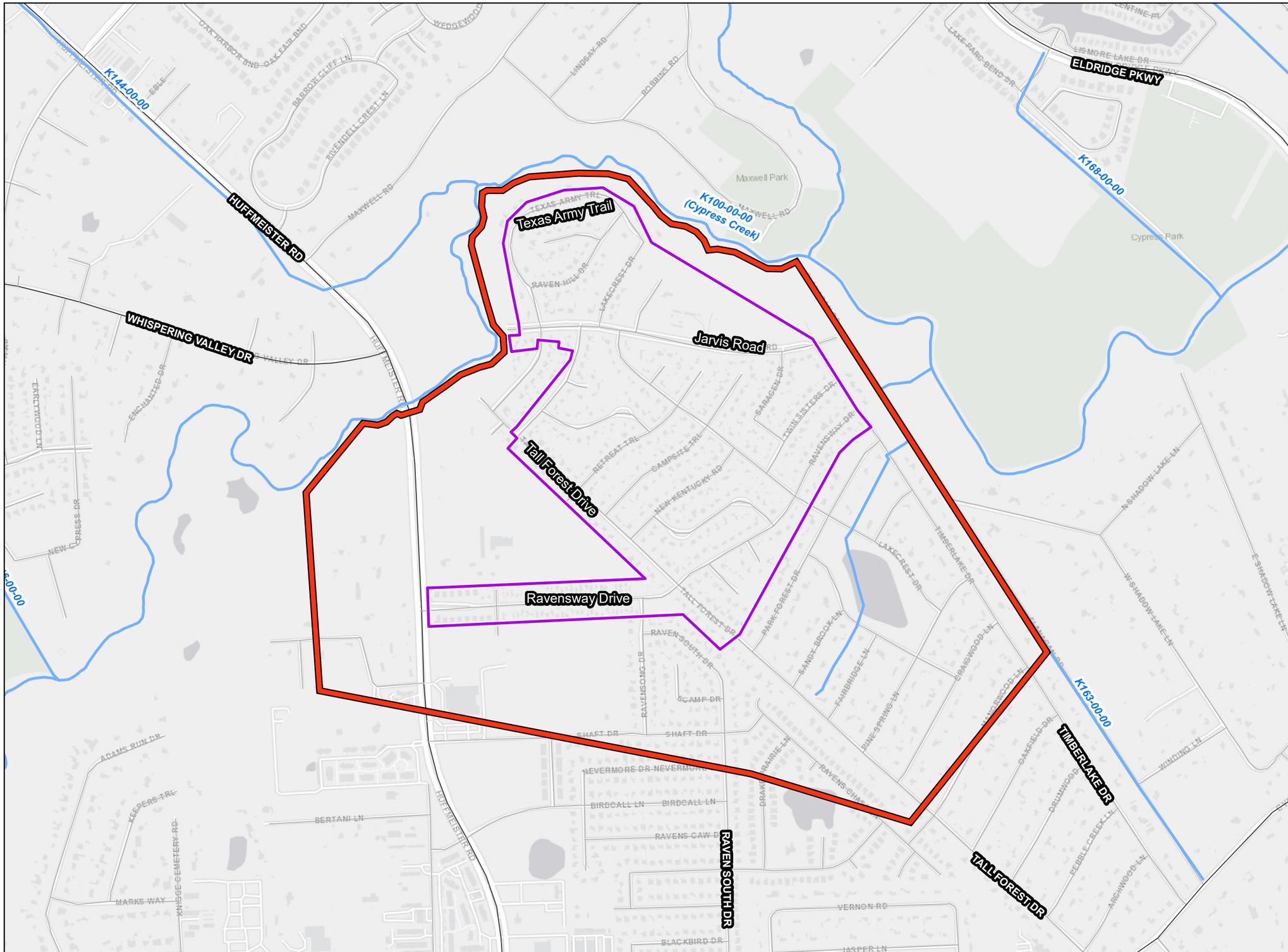
Option 2:

- Reduces all 2-year impassable zones
- Reduces 19 of the 20 10-year impassable zones
- Removes 6 of the 14 100-year flooded structures in a "without tailwater influence" scenario
- Removes 10 of the 72 flooded structures in a "with tailwater influence" scenario

6.3 Recommendations

It is recommended that all improvement concepts be considered for construction within the Ravensway Subdivision and along Texas Army Trail Road. Even though Texas Army Trail Road is located near the channel banks and does experience out-of-bank creek flooding, it also experiences flooding from local conveyance issues that can be mitigated with increased trunkline sizes.

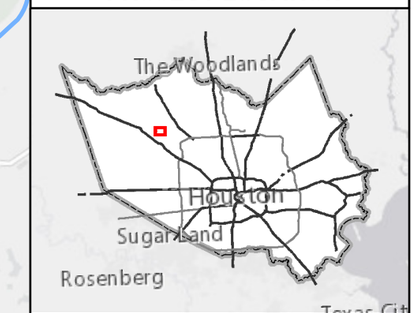
This analysis has shown that the proposed project improvements will cause no adverse impact to flood hazard conditions on the receiving waterways, including downstream properties within the City of Houston, for storm events up to and including the Atlas 14 100-year storm event.



HARRIS COUNTY ENGINEERING DEPARTMENT

RAVENSWAY SUBDIVISIONS DRAINAGE IMPROVEMENTS

EXHIBIT 1
PROJECT LOCATION



Vicinity Map

Legend

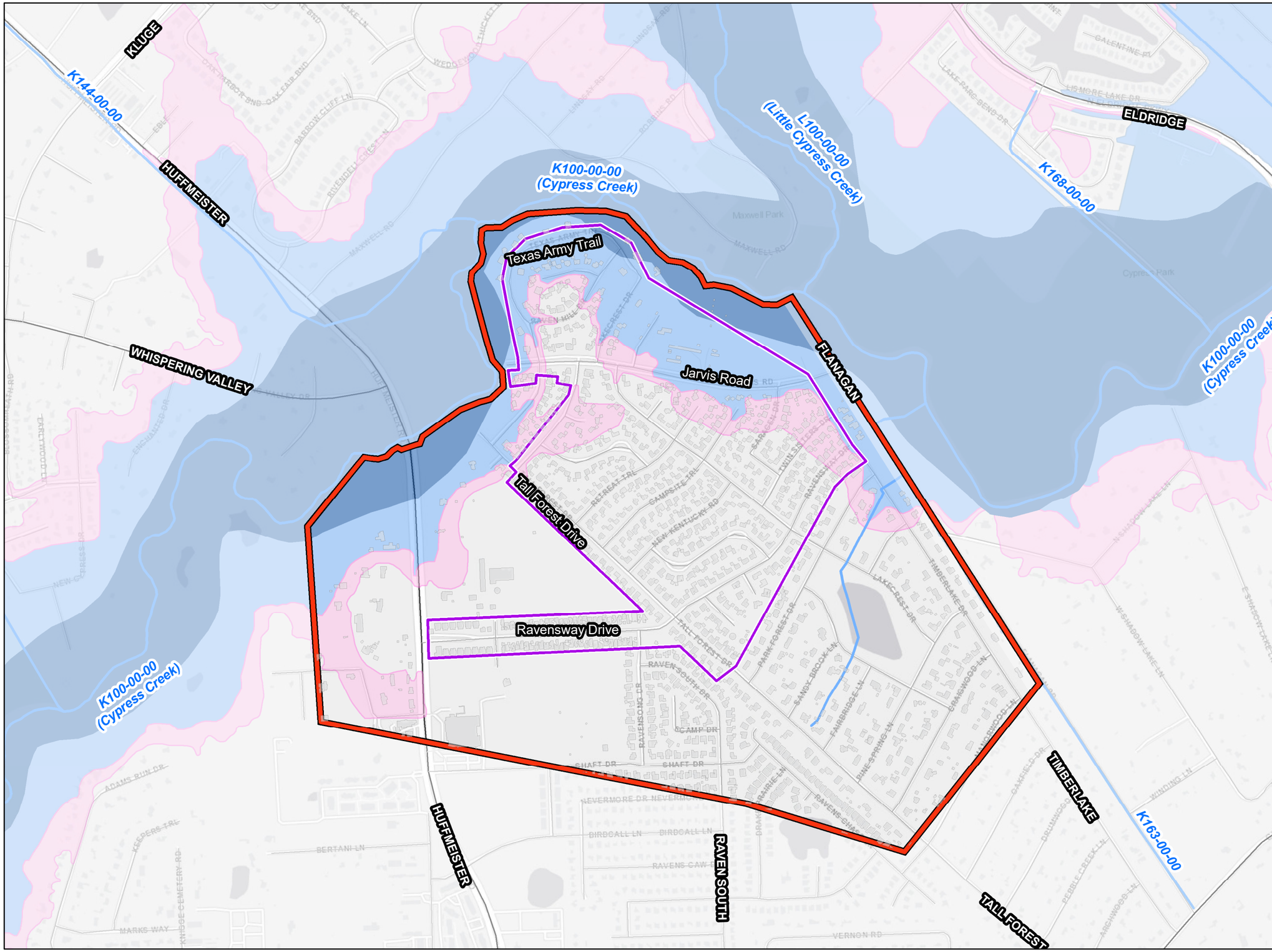
- 2D Model Boundary
- Costello Project Area
- Channels

N

0 400 800

1 inch = 800 feet

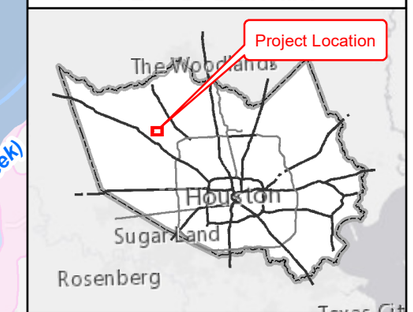
Gauge ENGINEERING



HARRIS COUNTY ENGINEERING DEPARTMENT

RAVENSWAY SUBDIVISIONS DRAINAGE IMPROVEMENTS

EXHIBIT 2
FLOODPLAIN MAP



Vicinity Map

Legend

- 2D Model Boundary
- Costello Project Area
- Building Footprints
- Channels

FEMA Flood Zones

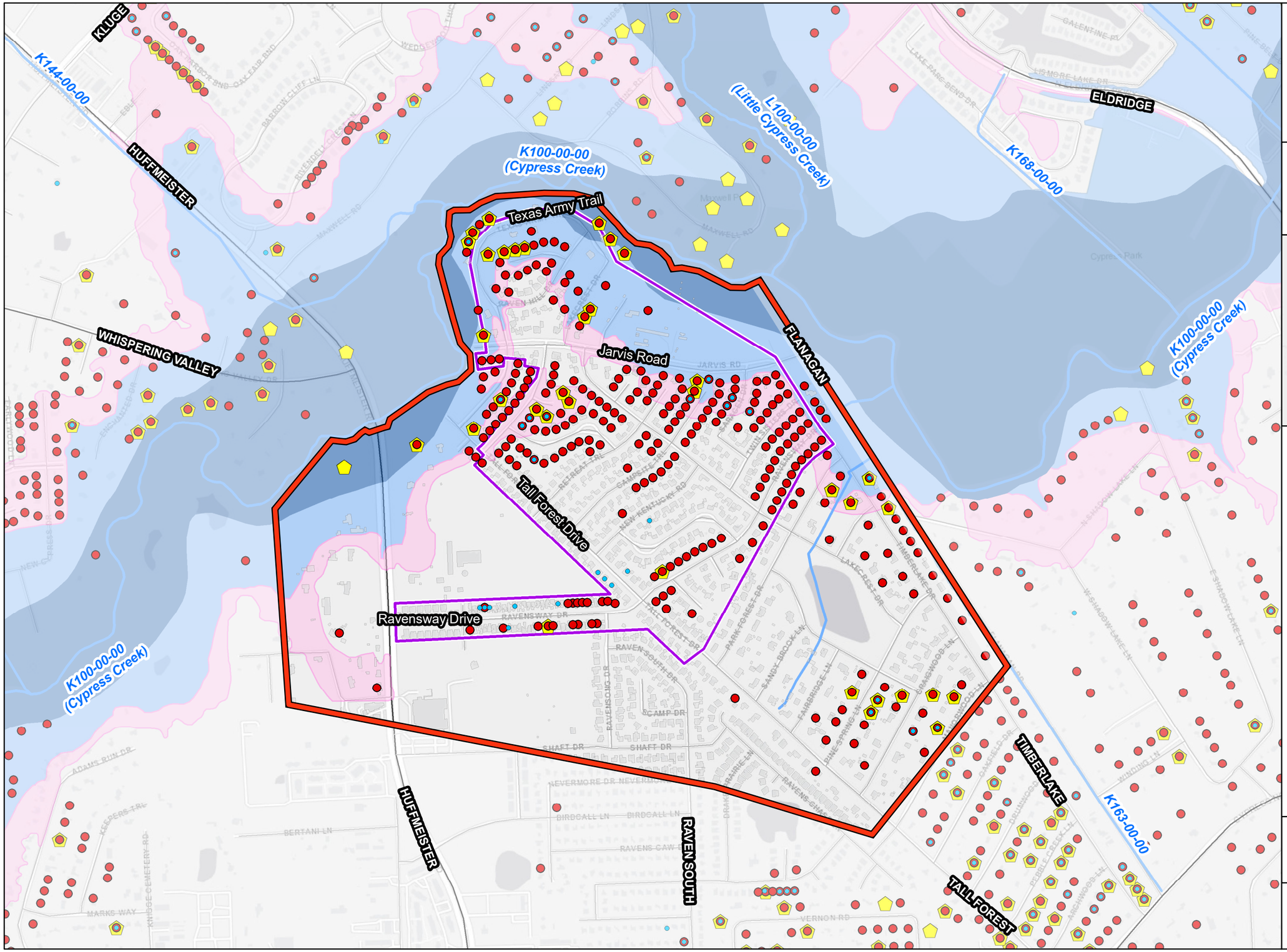
- 1% (100-year) Floodway
- 1% (100-year) Floodplain
- 0.2% (500-year) Floodplain

N

0 400 800

1 inch = 800 feet

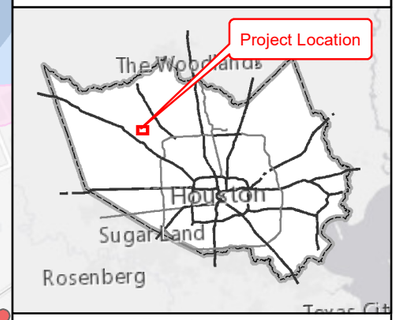
Gauge ENGINEERING



HARRIS COUNTY ENGINEERING DEPARTMENT

RAVENSWAY SUBDIVISIONS DRAINAGE IMPROVEMENTS

EXHIBIT 3
FLOODPLAIN MAP



Vicinity Map

Legend

- 2D Model Boundary
- Costello Project
- Building Footprints
- Channels

Historically Flooded Structures

- Memorial Day 2015
- Tax Day 2016
- Harvey
- FEMA Repetitive Loss

FEMA Flood Zones

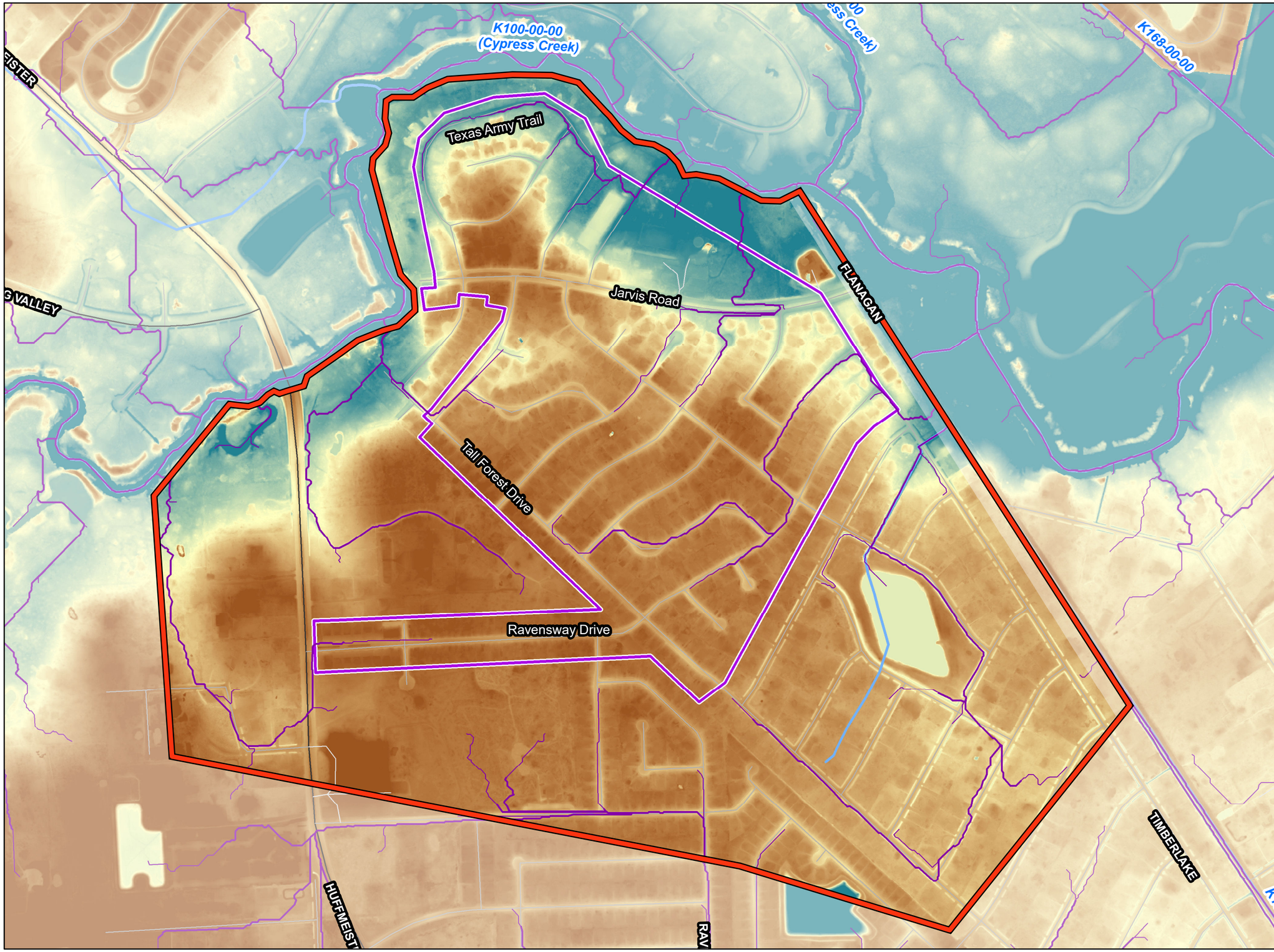
- 1% (100-year) Floodway
- 1% (100-year) Floodplain
- 0.2% (500-year) Floodplain

N

0 400 800

1 inch = 800 feet

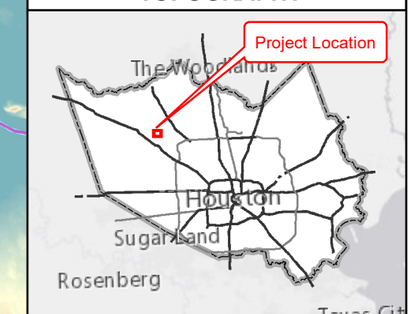
Gauge ENGINEERING



HARRIS COUNTY ENGINEERING DEPARTMENT

RAVENSWAY SUBDIVISIONS DRAINAGE IMPROVEMENTS

EXHIBIT 4
TOPOGRAPHY



Vicinity Map

Legend

- 2D Model Boundary
- Costello Project Area
- Flow Paths - 8ac
- Flow Paths - 4ac
- Channels

2018 LiDAR Elevation Spectrum

Value

High : 135

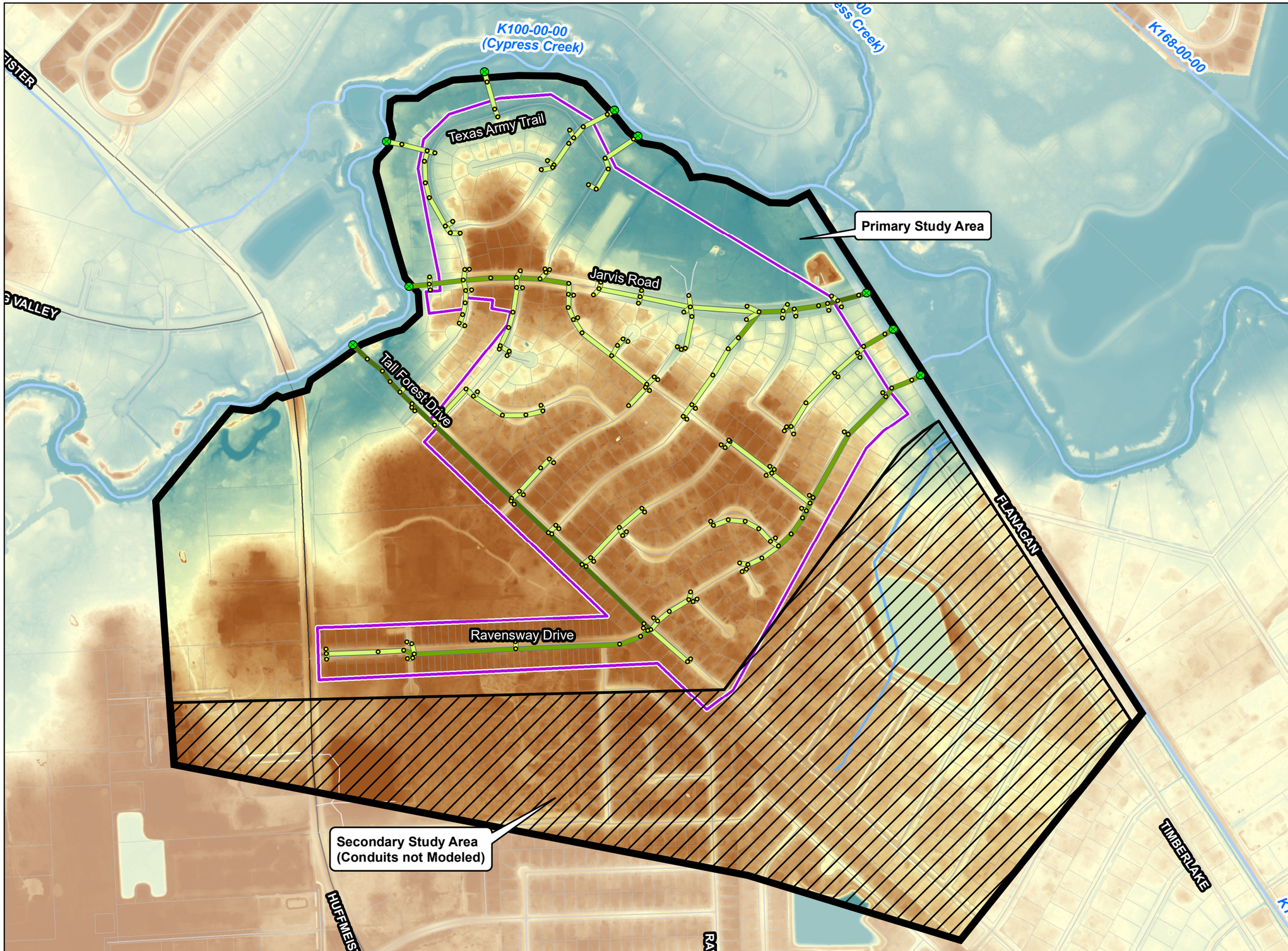
Low : 123

N

0 300 600

1 inch = 600 feet

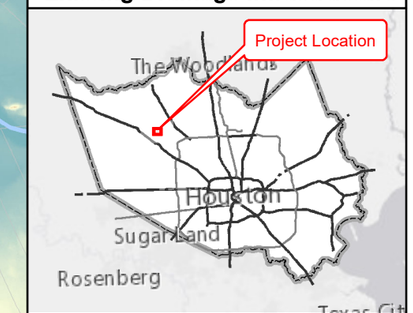
Gauge ENGINEERING



HARRIS COUNTY ENGINEERING DEPARTMENT

RAVENSWAY SUBDIVISIONS DRAINAGE IMPROVEMENTS

EXHIBIT 5
Existing Drainage Infrastructure



Vicinity Map

Legend

- 2D Model Boundary
- Costello Project Area
- Parcels
- Channels
- 24-28"
- 30"-36"
- 36" - 48"
- Manhole/Inlet
- Outfall

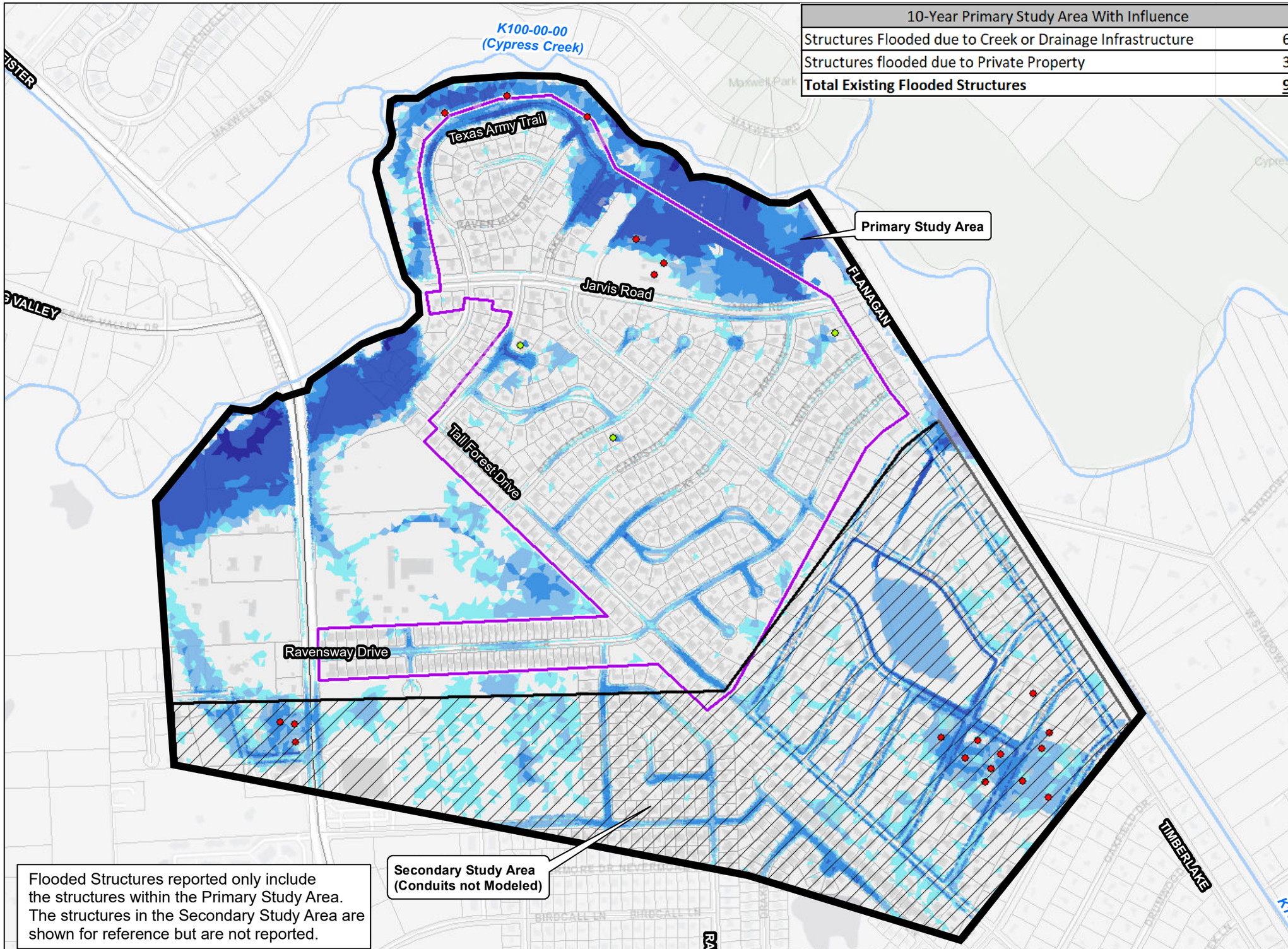
N

0 300 600

1 inch = 600 feet

Gauge ENGINEERING

10-Year Primary Study Area With Influence	
Structures Flooded due to Creek or Drainage Infrastructure	6
Structures flooded due to Private Property	3
Total Existing Flooded Structures	**9**

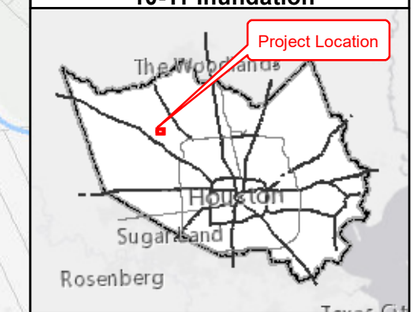


Flooded Structures reported only include the structures within the Primary Study Area. The structures in the Secondary Study Area are shown for reference but are not reported.

HARRIS COUNTY ENGINEERING DEPARTMENT

RAVENSWAY SUBDIVISIONS DRAINAGE IMPROVEMENTS

EXHIBIT 6
Existing (With Influence)
10-Yr Inundation



Vicinity Map

Legend

- 2D Model Boundary
- 10-Yr Existing (Flooding due to Private Property)
- 10-Yr Existing (With Influence) Flooded Structures
- Building Footprints
- Costello Project Area

10-Yr Existing Inundation Depths (With Influence) (ft)

- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- 2.00 - 5.00
- > 5.00
- Channels
- Parcels

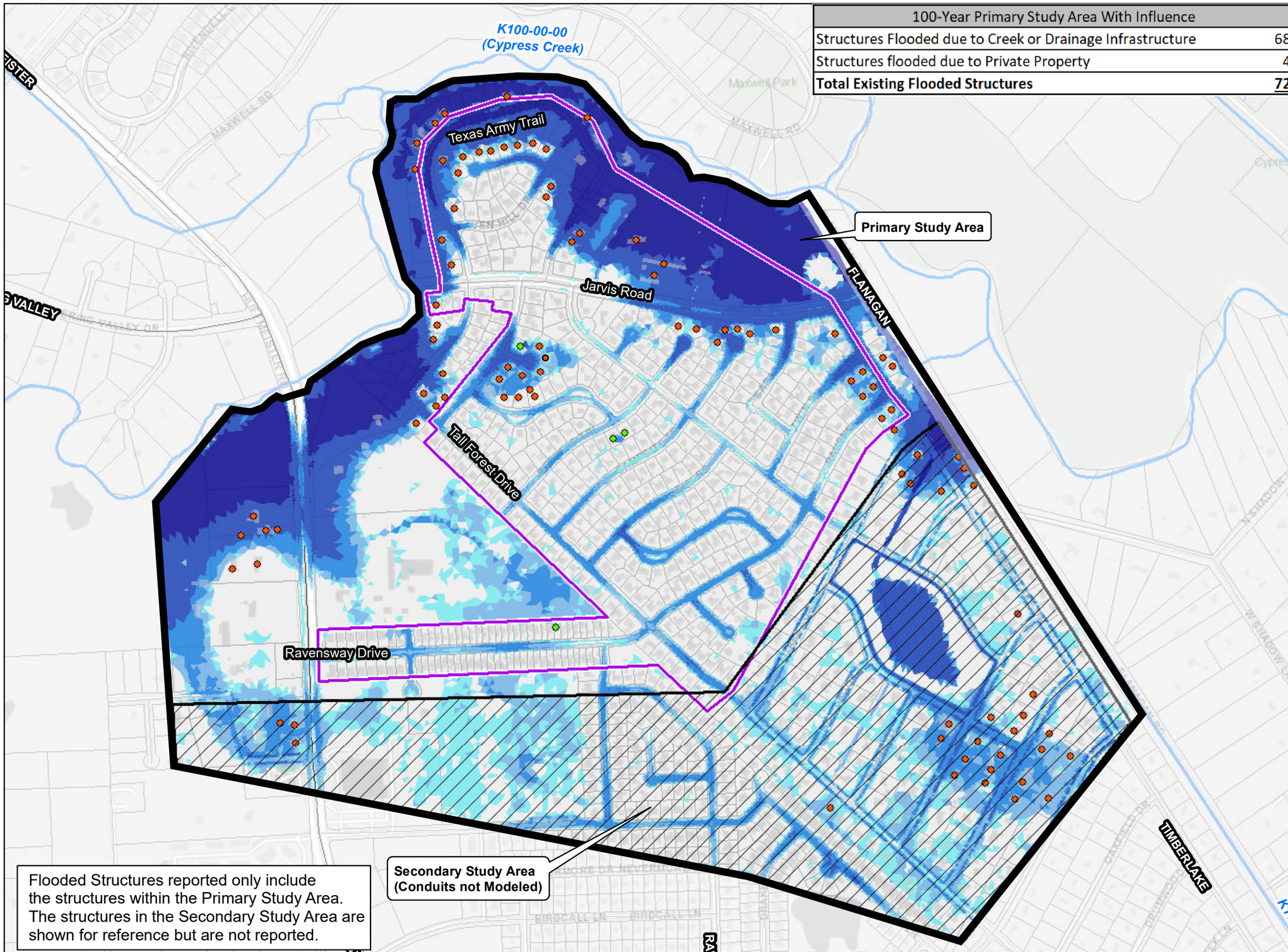
N

0 300 600

1 inch = 600 feet

Gauge ENGINEERING

100-Year Primary Study Area With Influence	
Structures Flooded due to Creek or Drainage Infrastructure	68
Structures flooded due to Private Property	4
Total Existing Flooded Structures	**72**

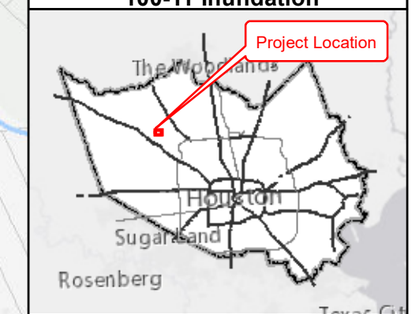


Flooded Structures reported only include the structures within the Primary Study Area. The structures in the Secondary Study Area are shown for reference but are not reported.

HARRIS COUNTY ENGINEERING DEPARTMENT

RAVENSWAY SUBDIVISIONS DRAINAGE IMPROVEMENTS

EXHIBIT 7
Existing (With Influence)
100-Yr Inundation



Vicinity Map

Legend

- 2D Model Boundary
- 100-Yr Existing (Flooding due to Private Property)
- 100-Yr Existing (With Influence) Flooded Structures
- Costello Project
- Building Footprints

100-Yr Existing Inundation Depths (With Influence) (ft)

- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- 2.00 - 5.00
- > 5.00
- Channels
- Parcels

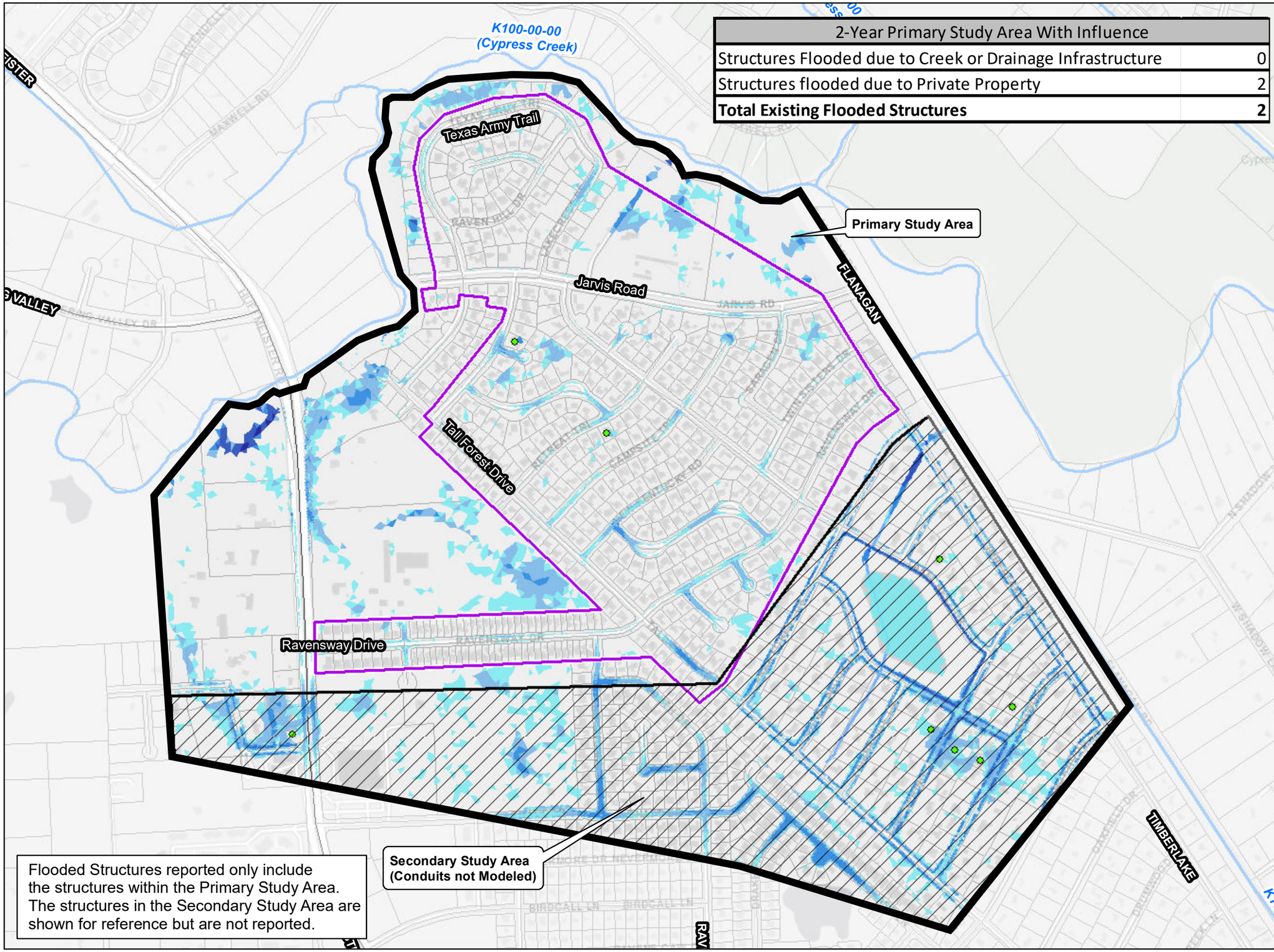
N

0 300 600

1 inch = 600 feet

Gauge ENGINEERING

2-Year Primary Study Area With Influence	
Structures Flooded due to Creek or Drainage Infrastructure	0
Structures flooded due to Private Property	2
Total Existing Flooded Structures	**2**

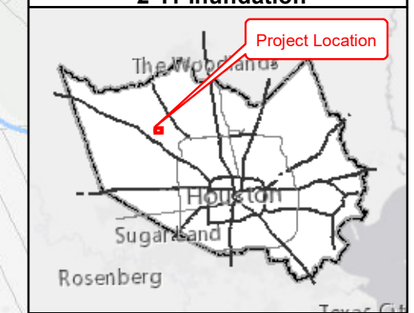


Flooded Structures reported only include the structures within the Primary Study Area. The structures in the Secondary Study Area are shown for reference but are not reported.

HARRIS COUNTY ENGINEERING DEPARTMENT

RAVENSWAY SUBDIVISIONS DRAINAGE IMPROVEMENTS

EXHIBIT 8
Existing (Without Influence) 2-Yr Inundation



Vicinity Map

Legend

- 2D Model Boundary
- 2-Yr Existing Structures (flooded due to Private Property)
- Costello Project Area
- Building Footprints

2-Yr Existing Inundation Depths (Without Influence) (ft)

- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- 2.00 - 5.00
- > 5.00
- Channels
- Parcels

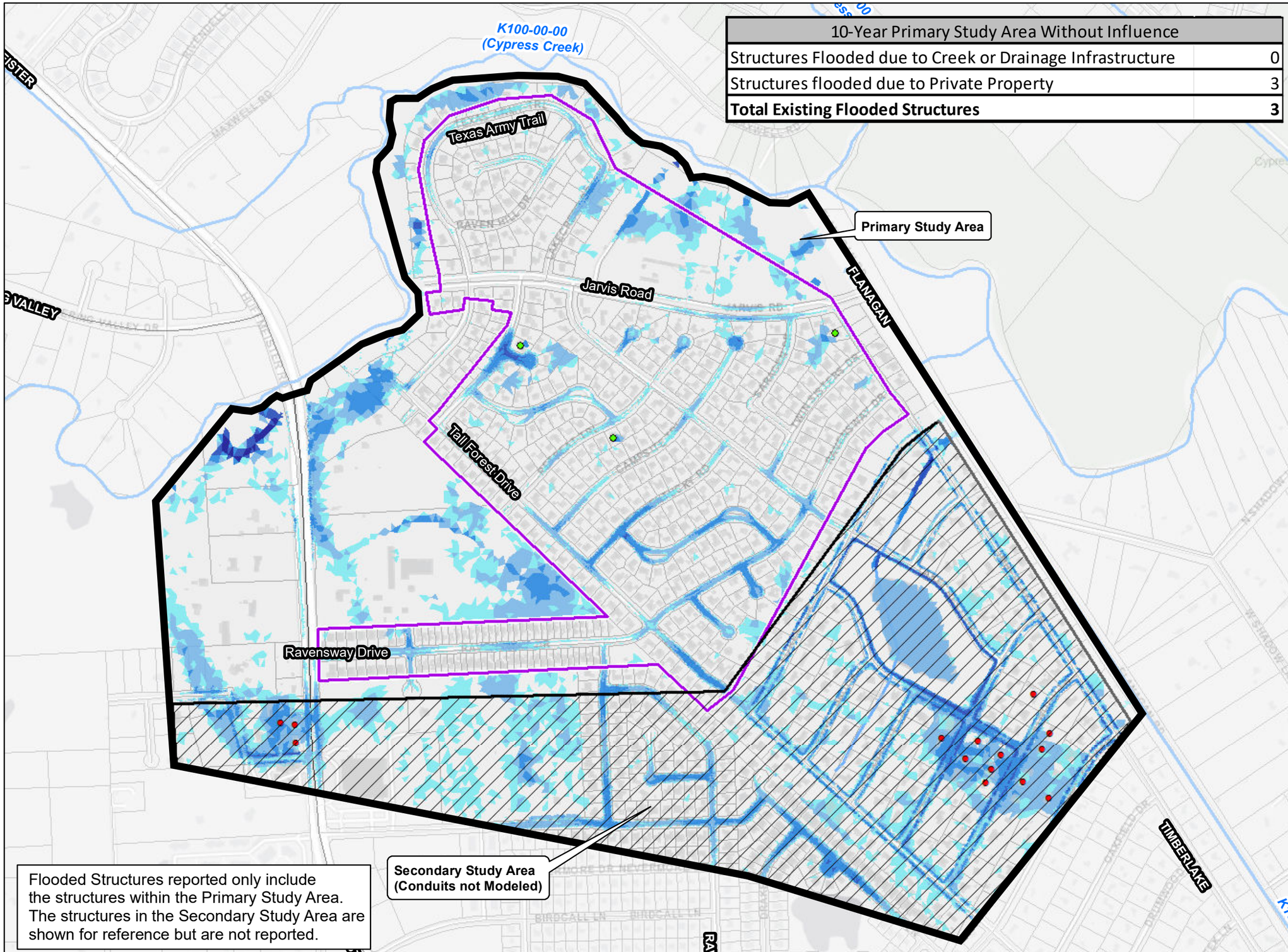
N

0 300 600

1 inch = 600 feet

Gauge ENGINEERING

10-Year Primary Study Area Without Influence	
Structures Flooded due to Creek or Drainage Infrastructure	0
Structures flooded due to Private Property	3
Total Existing Flooded Structures	**3**

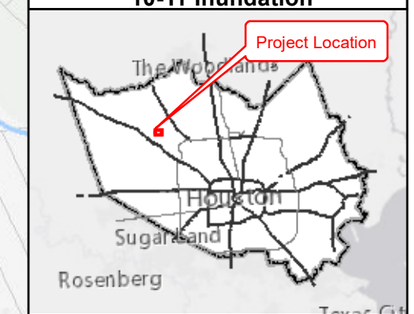


Flooded Structures reported only include the structures within the Primary Study Area. The structures in the Secondary Study Area are shown for reference but are not reported.

HARRIS COUNTY ENGINEERING DEPARTMENT

RAVENSWAY SUBDIVISIONS DRAINAGE IMPROVEMENTS

EXHIBIT 9
Existing (Without Influence) 10-Yr Inundation



Vicinity Map

Legend

- 2D Model Boundary
- 10-Yr Existing (Flooding due to Private Property)
- 10-Yr Existing (Without Influence) Flooded Structures
- Costello Project Area
- Building Footprints

10-Yr Existing Inundation Depths (Without Influence) (ft)

- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- 2.00 - 5.00
- > 5.00
- Channels
- Parcels

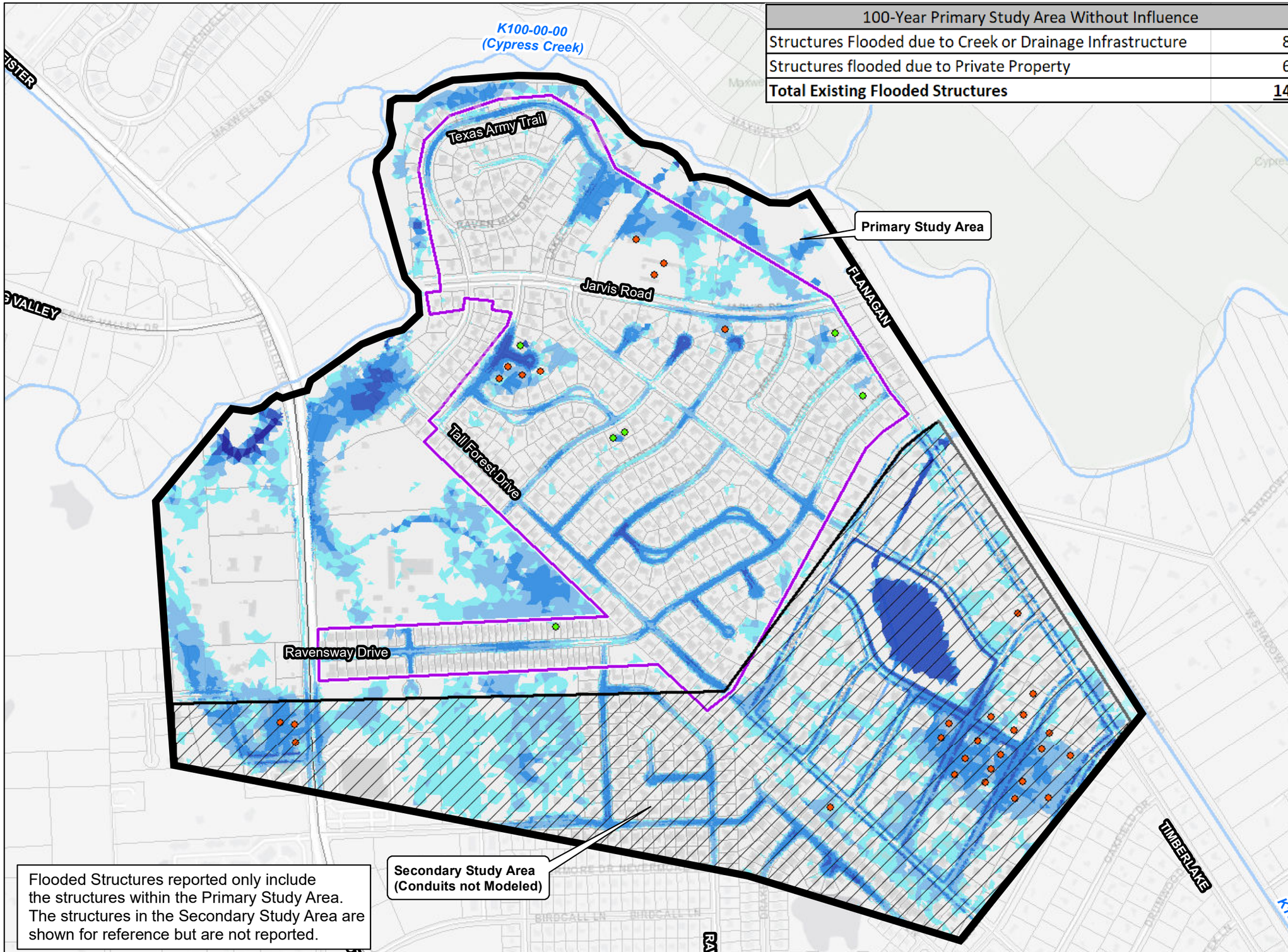
N

0 300 600

1 inch = 600 feet

Gauge ENGINEERING

100-Year Primary Study Area Without Influence	
Structures Flooded due to Creek or Drainage Infrastructure	8
Structures flooded due to Private Property	6
Total Existing Flooded Structures	**14**

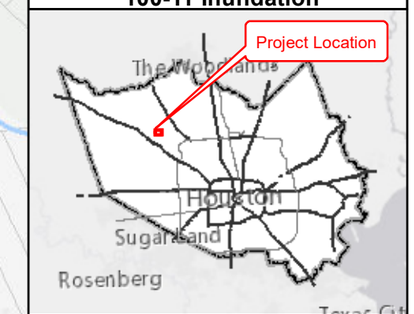


Flooded Structures reported only include the structures within the Primary Study Area. The structures in the Secondary Study Area are shown for reference but are not reported.

HARRIS COUNTY ENGINEERING DEPARTMENT

RAVENSWAY SUBDIVISIONS DRAINAGE IMPROVEMENTS

EXHIBIT 10
Existing (Without Influence) 100-Yr Inundation



Vicinity Map

Legend

- 2D Model Boundary
- 100-Yr Existing (Flooding due to Private Property)
- 100-Yr Existing (Without Influence) Flooded Structures
- Building Footprints
- Costello Project

100-Yr Existing Inundation Depths (Without Influence) (ft)

- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- 2.00 - 5.00
- > 5.00
- Channels
- Parcels

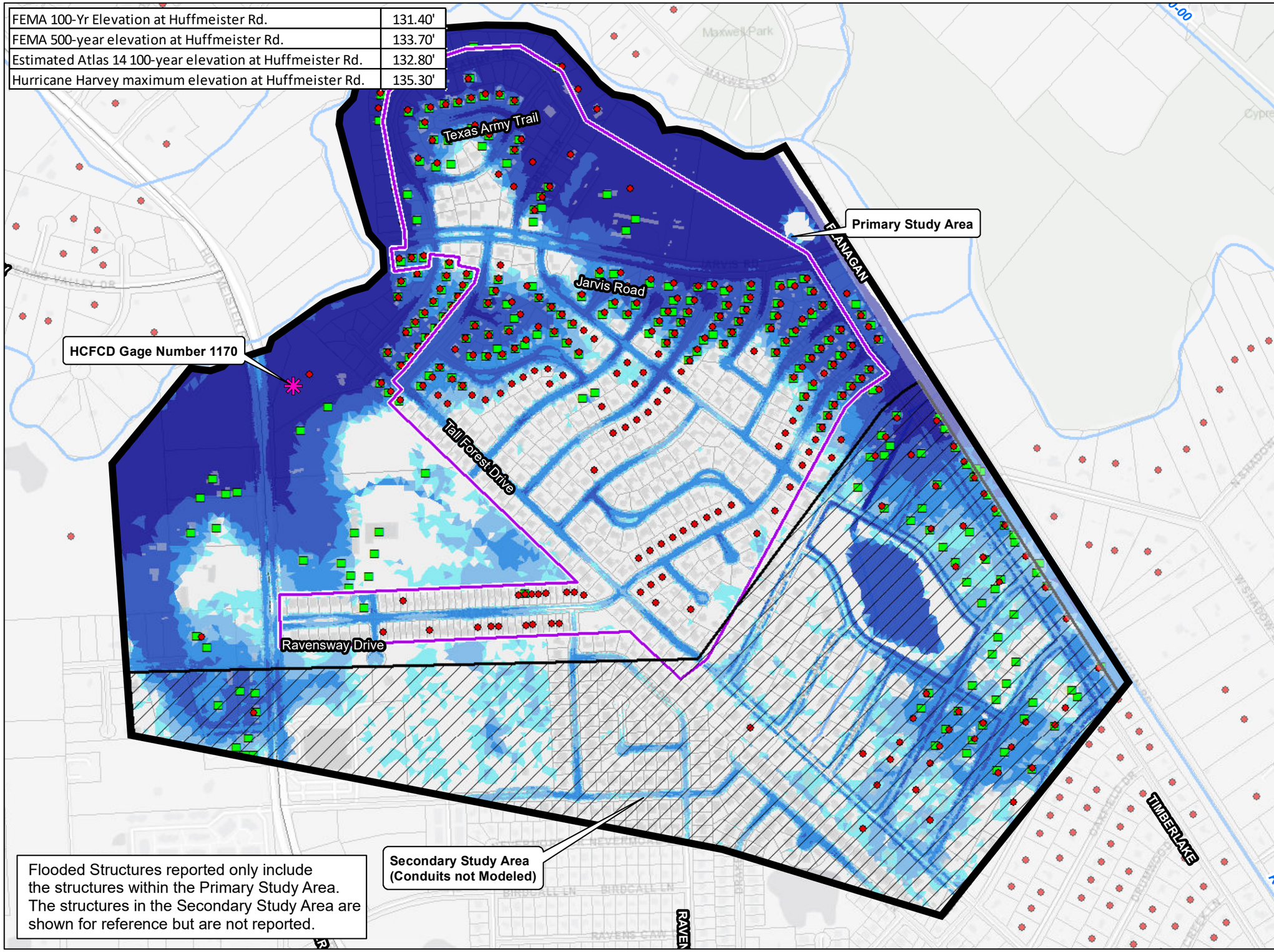
N

0 300 600

1 inch = 600 feet

Gauge ENGINEERING

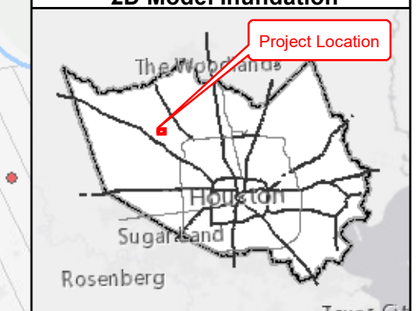
FEMA 100-Yr Elevation at Huffmeister Rd.	131.40'
FEMA 500-year elevation at Huffmeister Rd.	133.70'
Estimated Atlas 14 100-year elevation at Huffmeister Rd.	132.80'
Hurricane Harvey maximum elevation at Huffmeister Rd.	135.30'



HARRIS COUNTY ENGINEERING DEPARTMENT

RAVENSWAY SUBDIVISIONS DRAINAGE IMPROVEMENTS

EXHIBIT 11
Hurricane Harvey
2D Model Inundation



Vicinity Map

Legend

- 2D Model Boundary
- Costello Project Area
- Parcels
- Channels
- Building Footprints
- Harvey Historically Flooded Structures
- Harvey Modeled Flooded Structures

2D Model - Harvey Inundation (ft)

- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- 2.00 - 5.00
- > 5.00

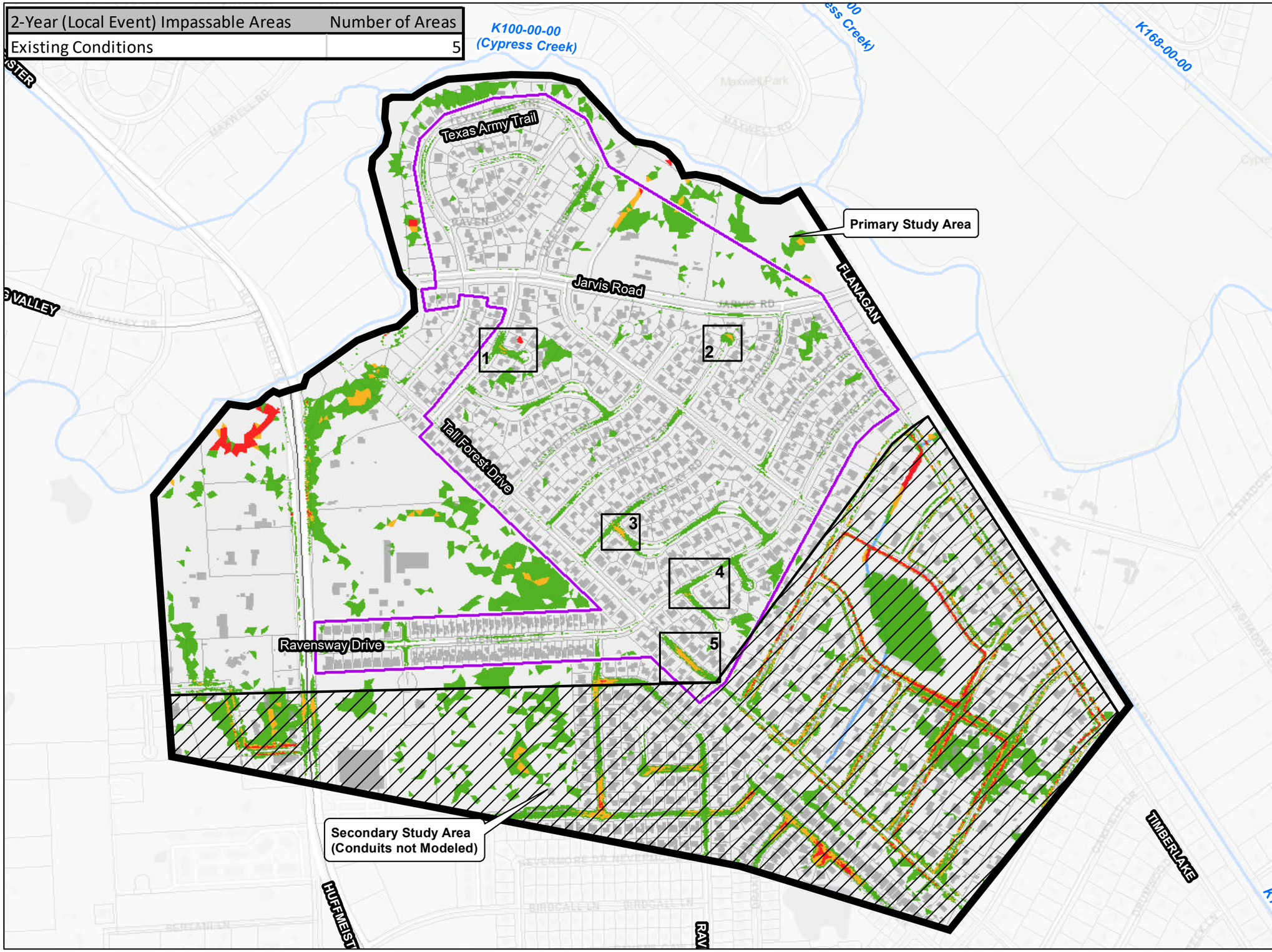
N

0 300 600

1 inch = 576 feet

Gauge ENGINEERING

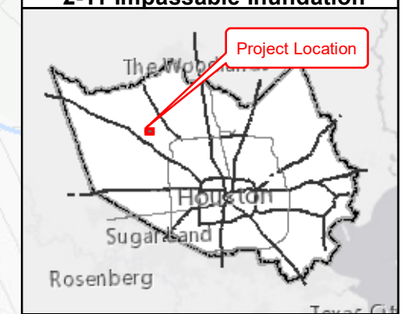
2-Year (Local Event) Impassable Areas	Number of Areas
Existing Conditions	5



HARRIS COUNTY ENGINEERING DEPARTMENT

RAVENSWAY SUBDIVISIONS DRAINAGE IMPROVEMENTS

EXHIBIT 12
Existing (Without Influence) 2-Yr Impassable Inundation



Vicinity Map

Legend

- 2D Model Boundary
- Costello Project
- Building Footprints

2-Yr Existing Passable Depths (Without Influence) (ft)

- 0.25 - 1.00
- 1.01 - 1.50
- > 1.5
- Channels
- Parcels

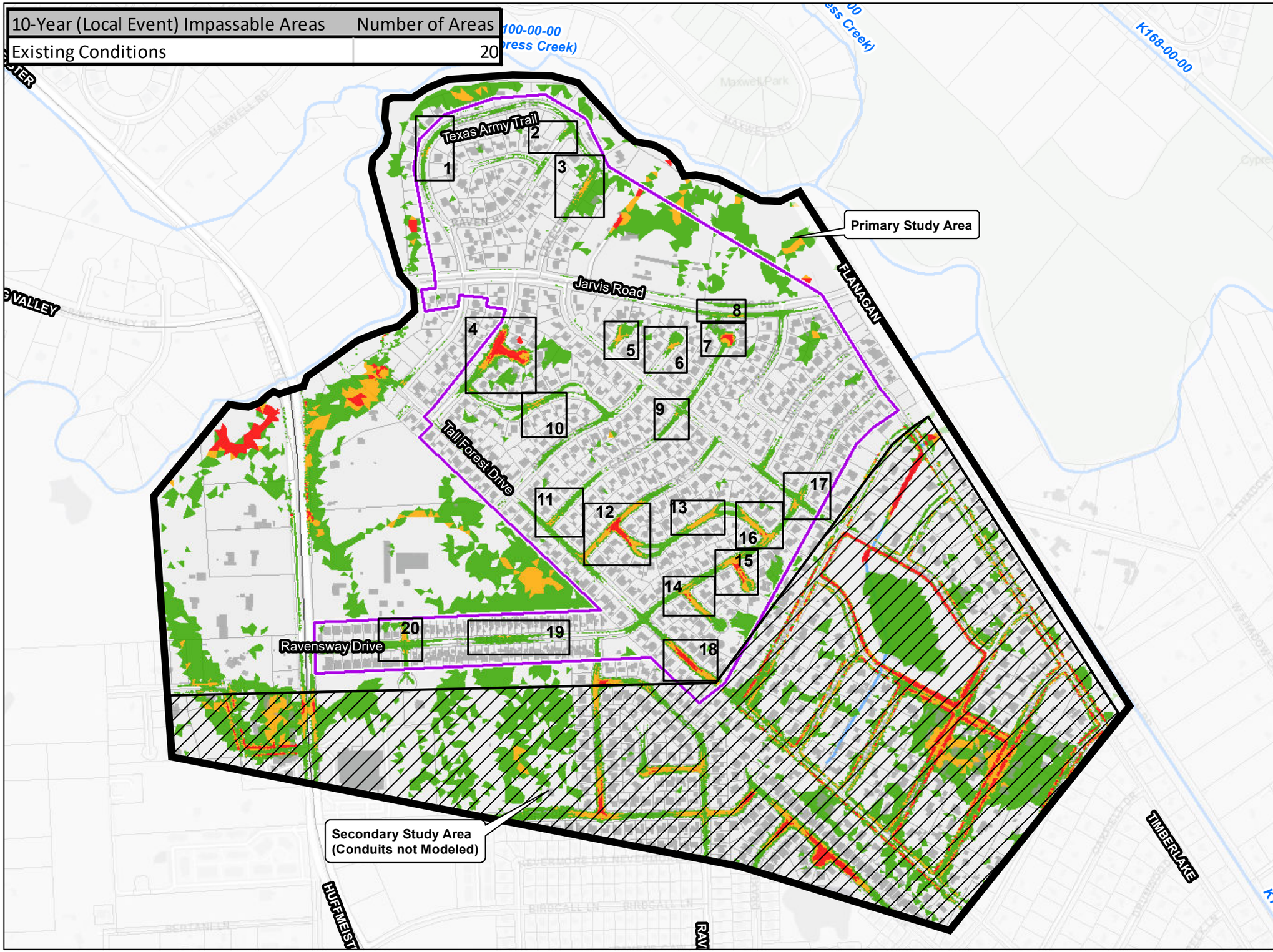
N

0 300 600

1 inch = 600 feet

Gauge ENGINEERING

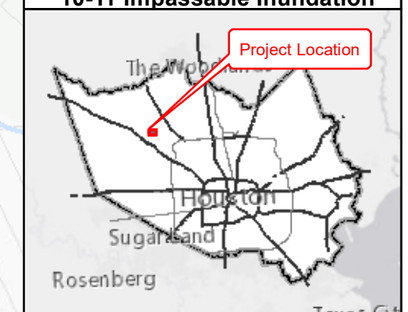
10-Year (Local Event) Impassable Areas	Number of Areas
Existing Conditions	20



HARRIS COUNTY ENGINEERING DEPARTMENT

RAVENSWAY SUBDIVISIONS DRAINAGE IMPROVEMENTS

EXHIBIT 13
Existing (Without Influence)
10-Yr Impassable Inundation



Vicinity Map

Legend

- 2D Model Boundary
- Costello Project
- Building Footprints

10-Yr Existing Passable Depths (Without Influence) (ft)

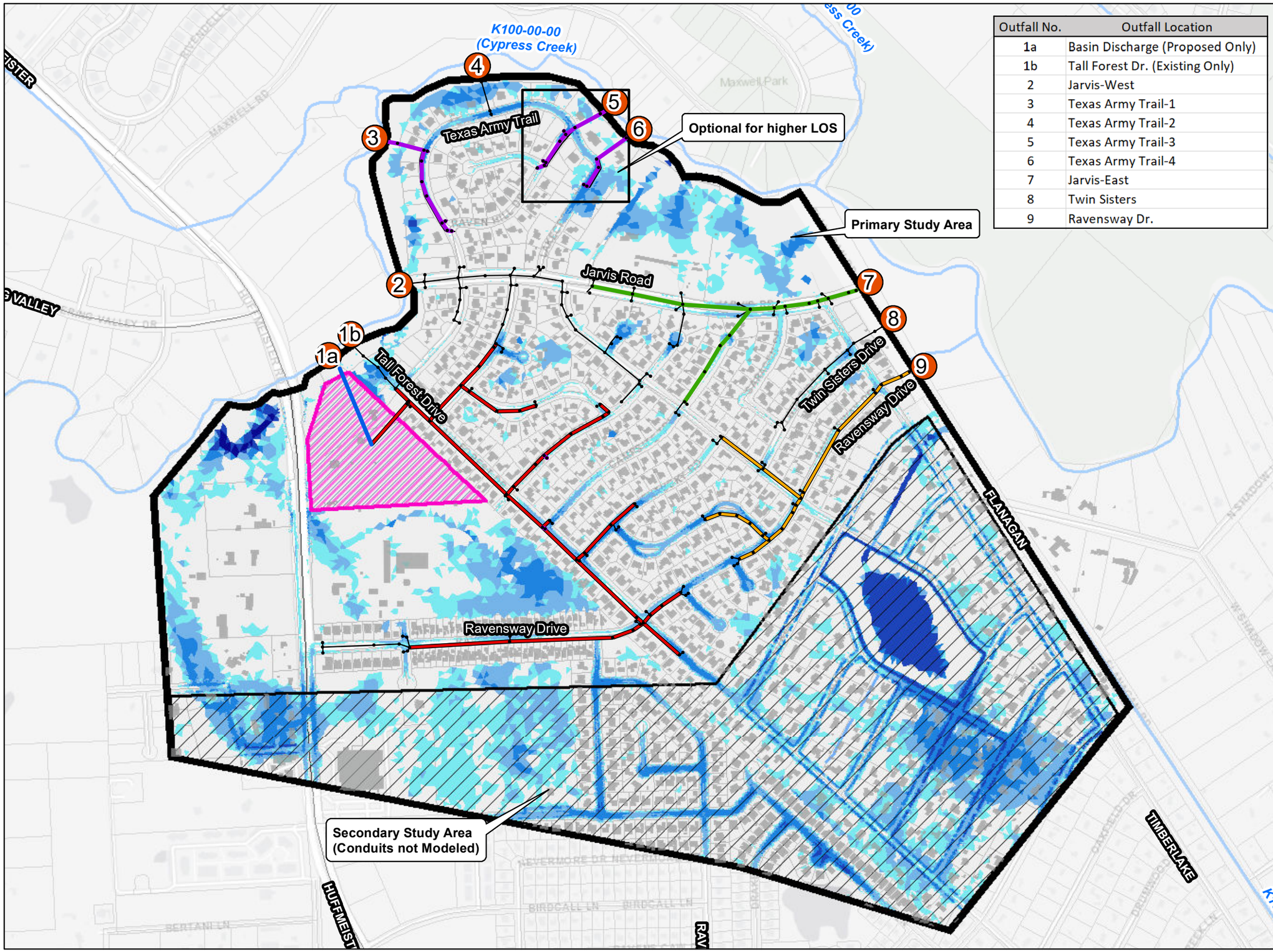
- 0.25 - 1.00
- 1.01 - 1.50
- > 1.5
- Channels
- Parcels

N

0 300 600

1 inch = 600 feet

Gauge ENGINEERING



Outfall No.	Outfall Location
1a	Basin Discharge (Proposed Only)
1b	Tall Forest Dr. (Existing Only)
2	Jarvis-West
3	Texas Army Trail-1
4	Texas Army Trail-2
5	Texas Army Trail-3
6	Texas Army Trail-4
7	Jarvis-East
8	Twin Sisters
9	Ravensway Dr.

HARRIS COUNTY ENGINEERING DEPARTMENT

RAVENSWAY SUBDIVISIONS DRAINAGE IMPROVEMENTS

EXHIBIT 14
Proposed Drainage Infrastructure

Legend

- Proposed Node

Proposed Conduits

condheight

- 36" RCP
- 42" RCP
- 48" RCP
- 60" RCP
- 6'X5'
- Existing Conduits
- Building Footprints
- Detention Site
- 2D Model Boundary

100-Yr Proposed Inundation Depths (w/o tailwater) (ft)

- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- 2.00 - 5.00
- > 5.00
- Channels
- Parcels

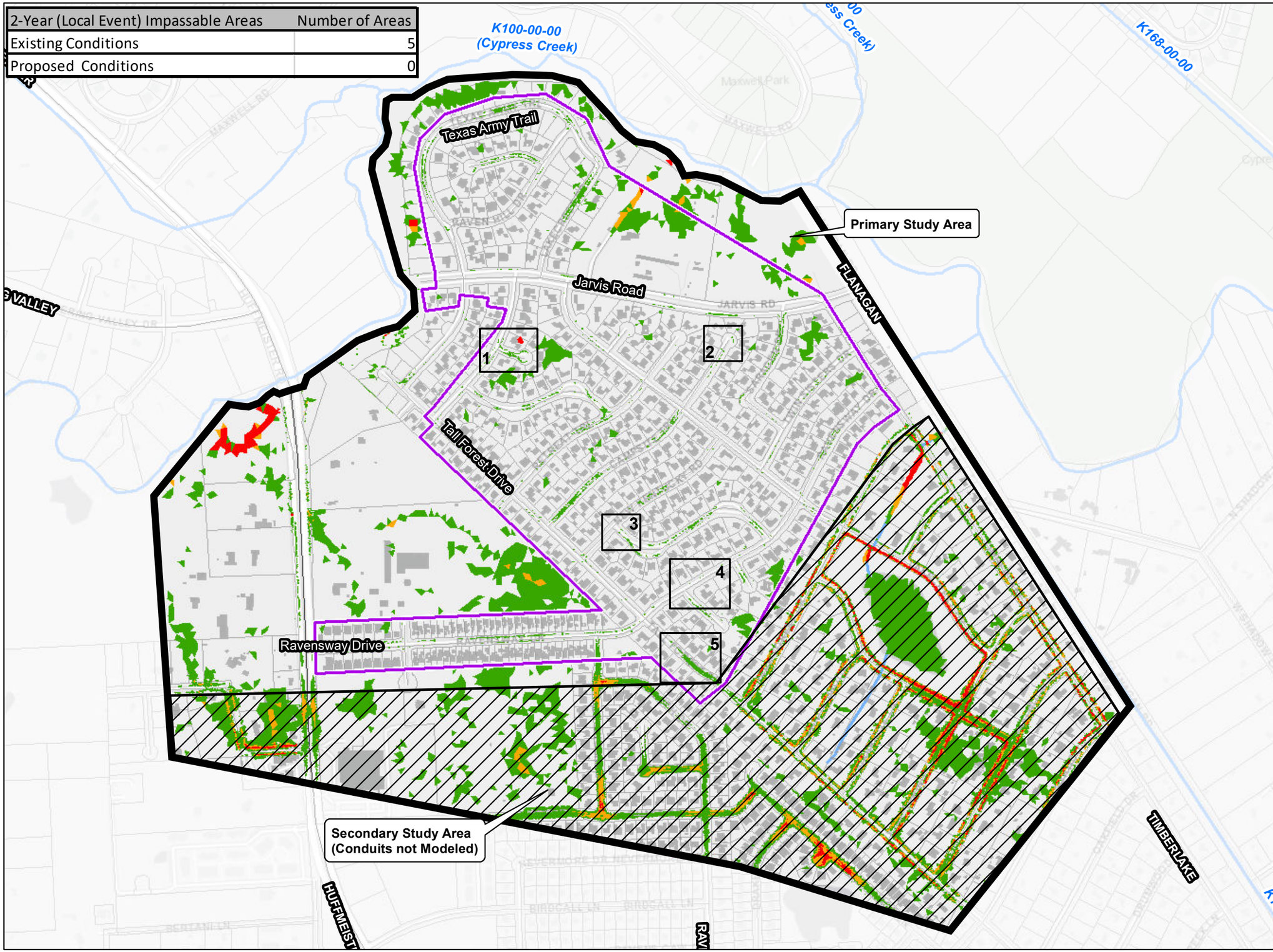
N

0 300 600

1 inch = 600 feet

Gauge ENGINEERING

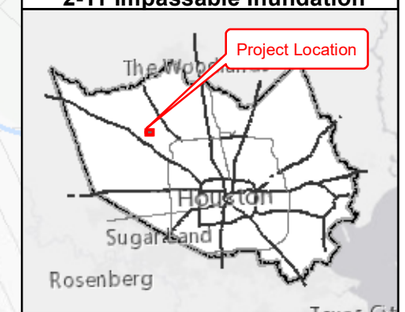
2-Year (Local Event) Impassable Areas	Number of Areas
Existing Conditions	5
Proposed Conditions	0



HARRIS COUNTY ENGINEERING DEPARTMENT

RAVENSWAY SUBDIVISIONS DRAINAGE IMPROVEMENTS

EXHIBIT 15
Proposed (Without Influence) 2-Yr Impassable Inundation



Vicinity Map

Legend

- 2D Model Boundary
- Costello Project Area

2-Yr Proposed Passable Depths (Without Influence) (ft)

- 0.25 - 1.00
- 1.01 - 1.50
- > 1.5
- Building Footprints
- Channels
- Parcels

\# Improved Problem Area

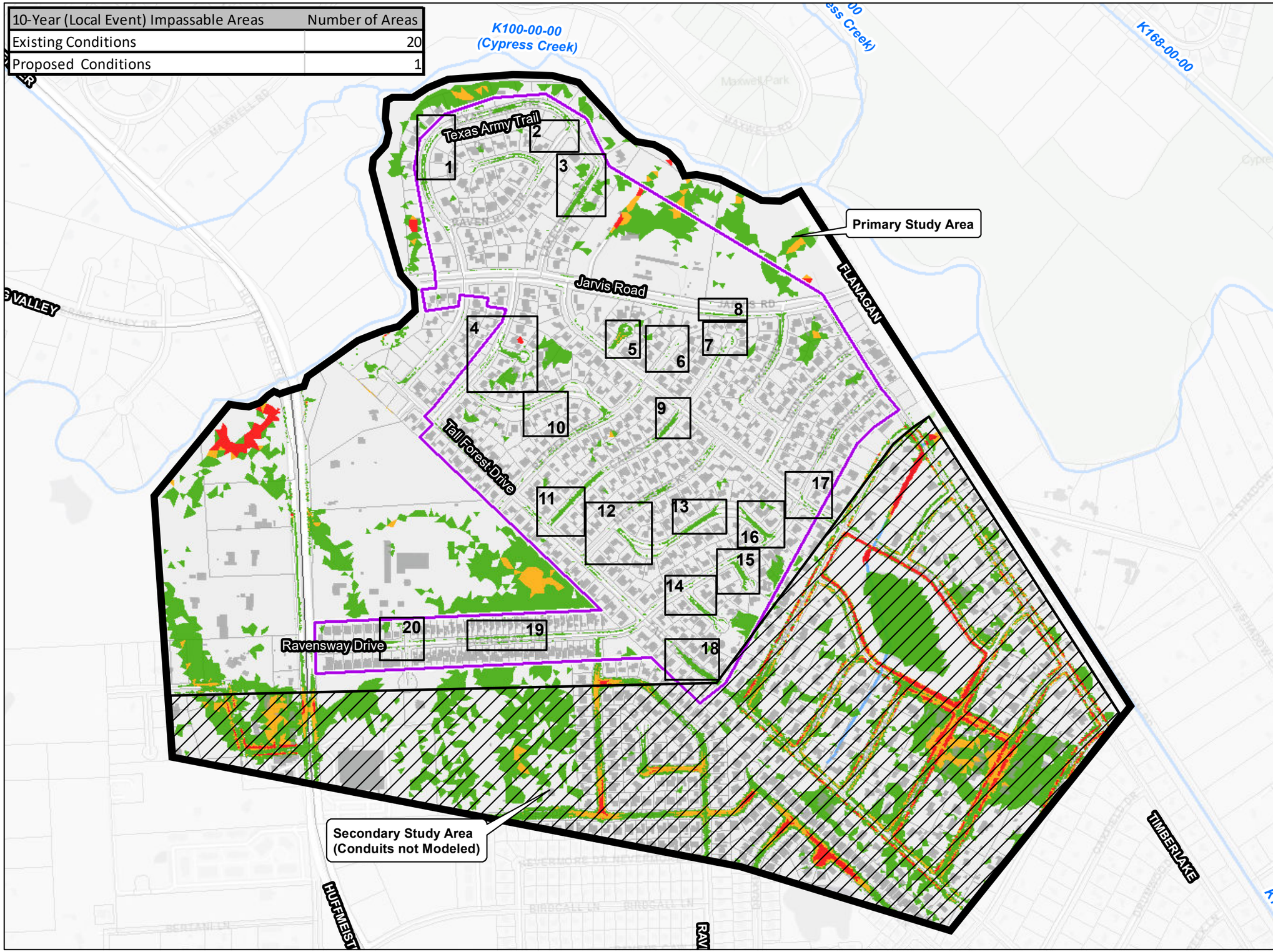
N

0 300 600

1 inch = 600 feet

Gauge ENGINEERING

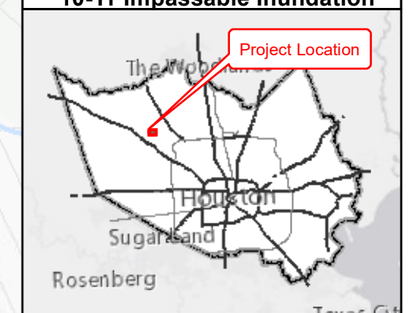
10-Year (Local Event) Impassable Areas	Number of Areas
Existing Conditions	20
Proposed Conditions	1



HARRIS COUNTY ENGINEERING DEPARTMENT

RAVENSWAY SUBDIVISIONS DRAINAGE IMPROVEMENTS

EXHIBIT 16
Proposed (Without Influence) 10-Yr Impassable Inundation



Vicinity Map

Legend

- 2D Model Boundary
- Costello Project Area
- Building Footprints

10-Yr Proposed Passable Depths (Without Influence) (ft)

- 0.25 - 1.00
- 1.01 - 1.50
- > 1.5
- Channels
- Parcels

Improved Problem Area

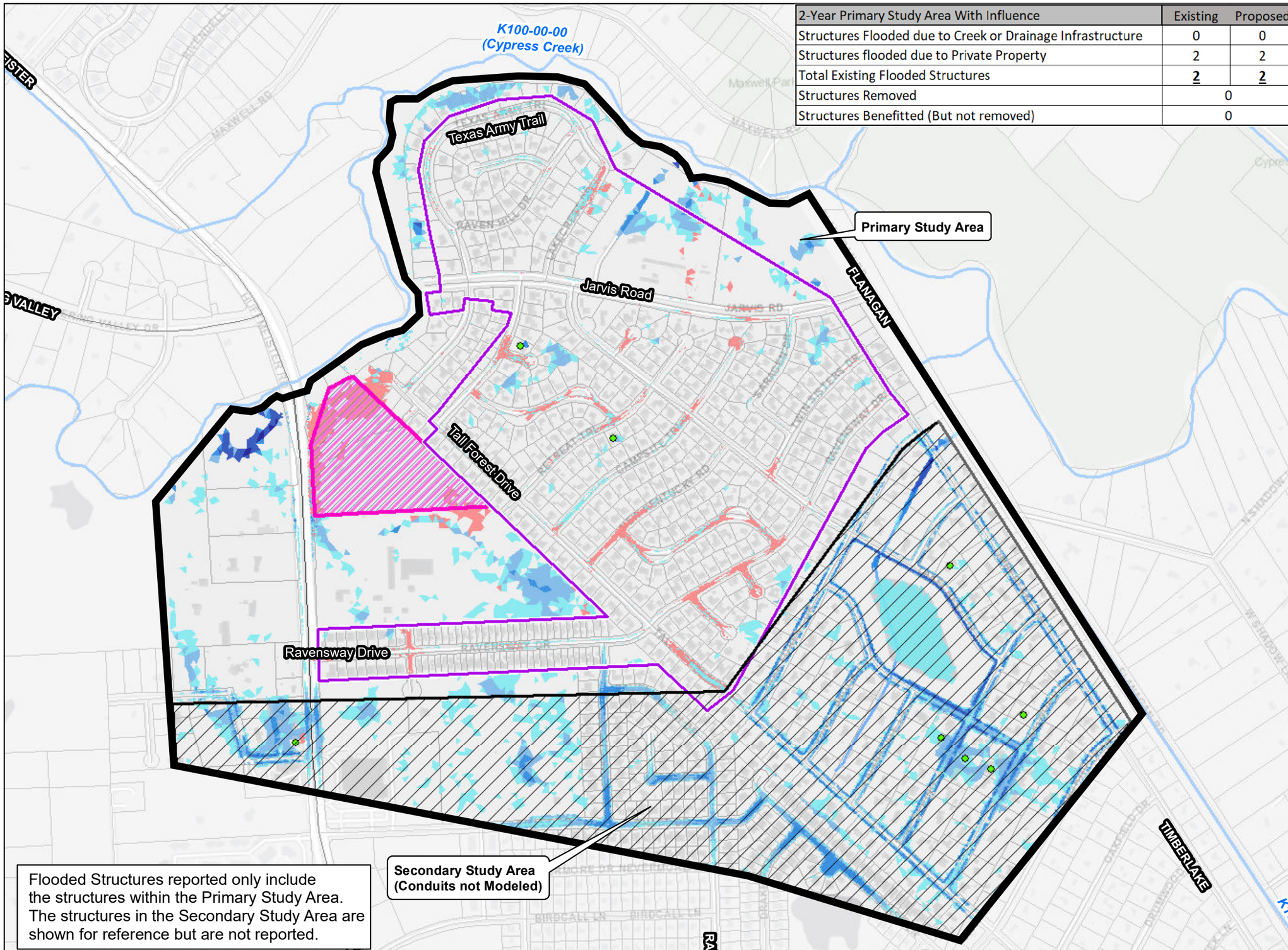
N

0 300 600

1 inch = 600 feet

Gauge ENGINEERING

2-Year Primary Study Area With Influence	Existing	Proposed
Structures Flooded due to Creek or Drainage Infrastructure	0	0
Structures flooded due to Private Property	2	2
Total Existing Flooded Structures	2	2
Structures Removed	0	
Structures Benefitted (But not removed)	0	

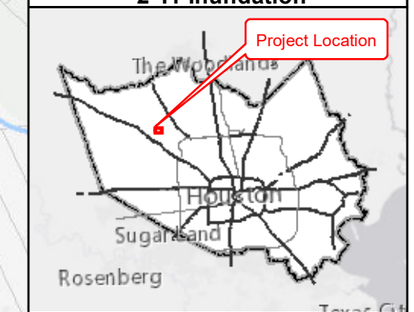


Flooded Structures reported only include the structures within the Primary Study Area. The structures in the Secondary Study Area are shown for reference but are not reported.

HARRIS COUNTY ENGINEERING DEPARTMENT

RAVENSWAY SUBDIVISIONS DRAINAGE IMPROVEMENTS

EXHIBIT 17
Proposed (Without Influence)
2-Yr Inundation



Vicinity Map

Legend

- 2D Model Boundary
- Costello Project
- Detention Site
- 2-Yr Proposed Structures (flooded due to Private Property)
- Building Footprints

2-Yr Proposed Inundation (ft)

- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- 2.00 - 5.00
- > 5.00
- Existing Inundation
- Channels
- Parcels

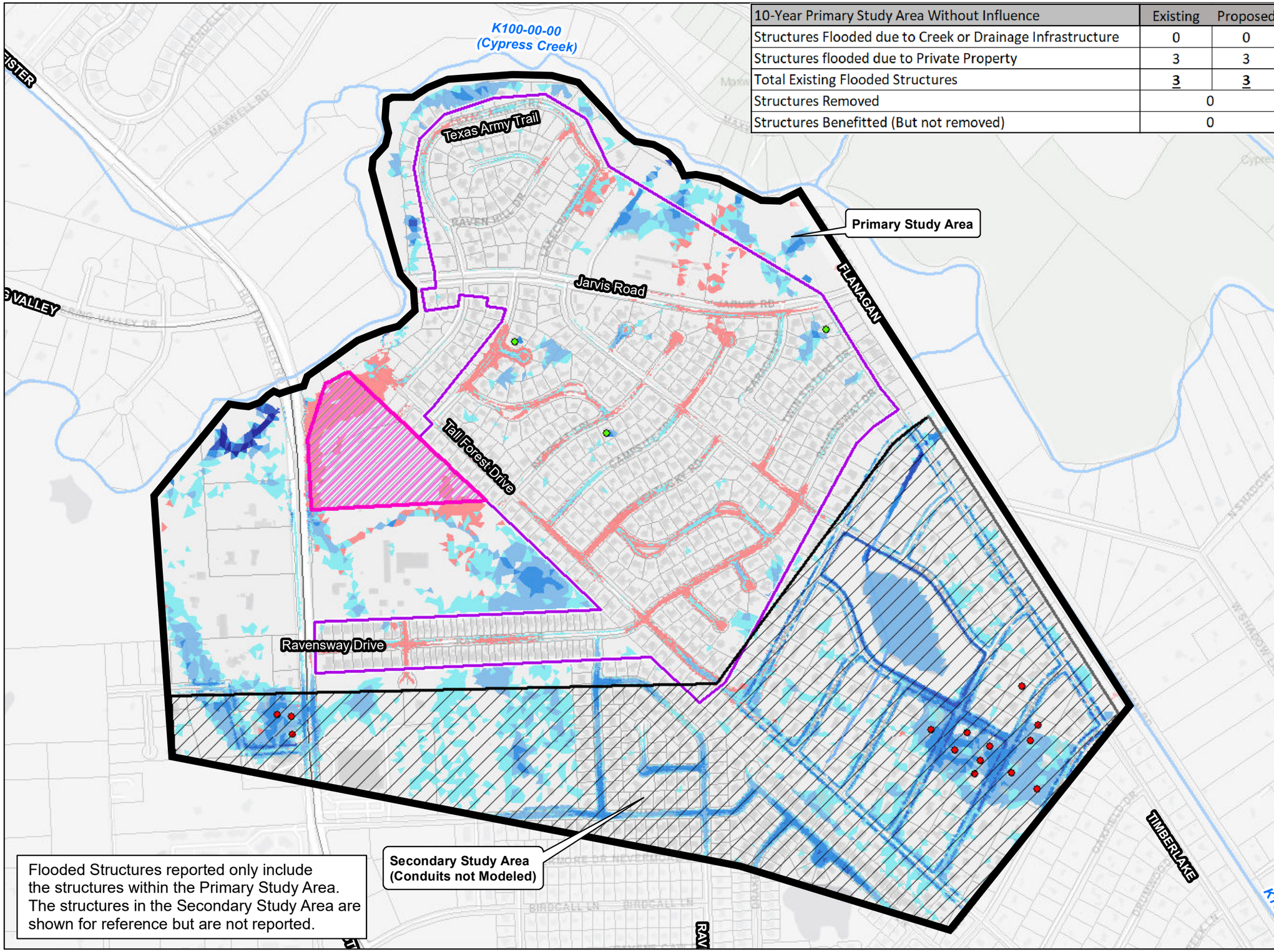
N

0 300 600

1 inch = 600 feet

Gauge ENGINEERING

10-Year Primary Study Area Without Influence	Existing	Proposed
Structures Flooded due to Creek or Drainage Infrastructure	0	0
Structures flooded due to Private Property	3	3
Total Existing Flooded Structures	3	3
Structures Removed	0	
Structures Benefitted (But not removed)	0	

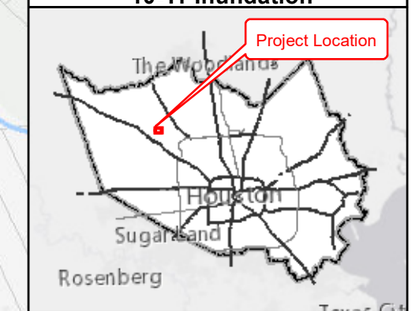


Flooded Structures reported only include the structures within the Primary Study Area. The structures in the Secondary Study Area are shown for reference but are not reported.

HARRIS COUNTY ENGINEERING DEPARTMENT

RAVENSWAY SUBDIVISIONS DRAINAGE IMPROVEMENTS

EXHIBIT 18
Proposed (Without Influence) 10-Yr Inundation



Vicinity Map

Legend

- 2D Model Boundary
- Detention Site
- 10-Yr Proposed (Flooding due to Private Property)
- 10-Yr Proposed (w/o tailwater) Flooded Structures
- Removed Flooded Structures
- Costello Project
- Building Footprints

10-Yr Proposed Inundation Depths (Without Influence) (ft)

- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- 2.00 - 5.00
- > 5.00
- Existing Inundation
- Channels
- Parcels

N

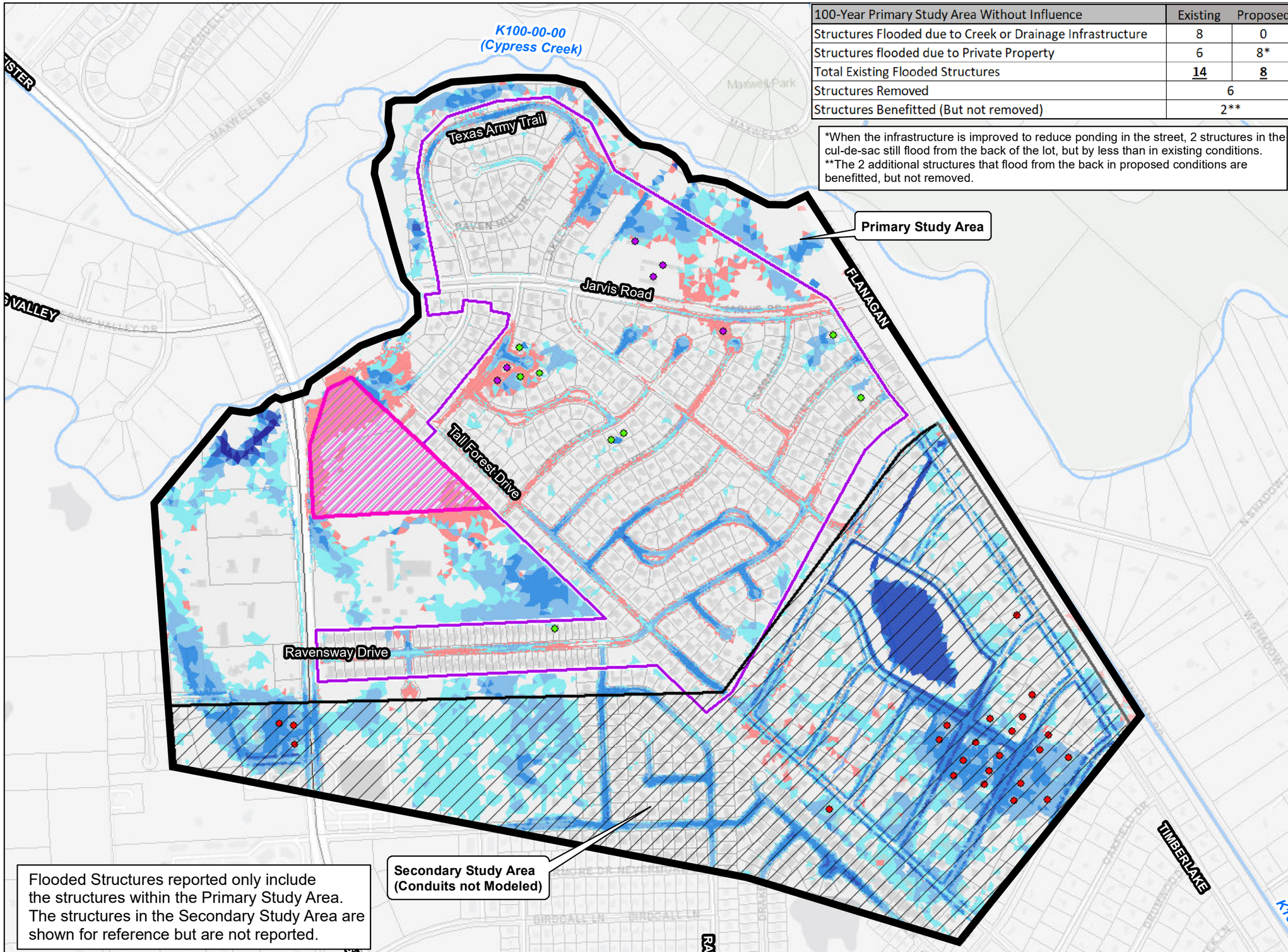
0 300 600

1 inch = 600 feet

Gauge ENGINEERING

100-Year Primary Study Area Without Influence	Existing	Proposed
Structures Flooded due to Creek or Drainage Infrastructure	8	0
Structures flooded due to Private Property	6	8*
Total Existing Flooded Structures	14	8
Structures Removed	6	
Structures Benefitted (But not removed)	2**	

*When the infrastructure is improved to reduce ponding in the street, 2 structures in the cul-de-sac still flood from the back of the lot, but by less than in existing conditions.
**The 2 additional structures that flood from the back in proposed conditions are benefitted, but not removed.

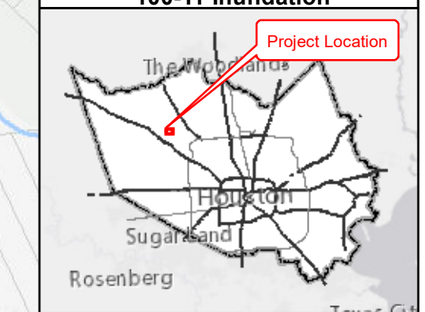


Flooded Structures reported only include the structures within the Primary Study Area. The structures in the Secondary Study Area are shown for reference but are not reported.

HARRIS COUNTY ENGINEERING DEPARTMENT

RAVENSWAY SUBDIVISIONS DRAINAGE IMPROVEMENTS

EXHIBIT 19
Proposed (Without Influence) 100-Yr Inundation



Vicinity Map

Legend

- 2D Model Boundary
- Detention Site
- 100-Yr Proposed (Flooding due to Private Property)
- 100-Yr Proposed (Without Influence) Flooded Structures
- Removed Structures
- Costello Project
- Building Footprints

100-Yr Proposed Inundation Depths (w/o tailwater) (ft)

- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- 2.00 - 5.00
- > 5.00
- Existing Inundation (ft)
- Channels
- Parcels

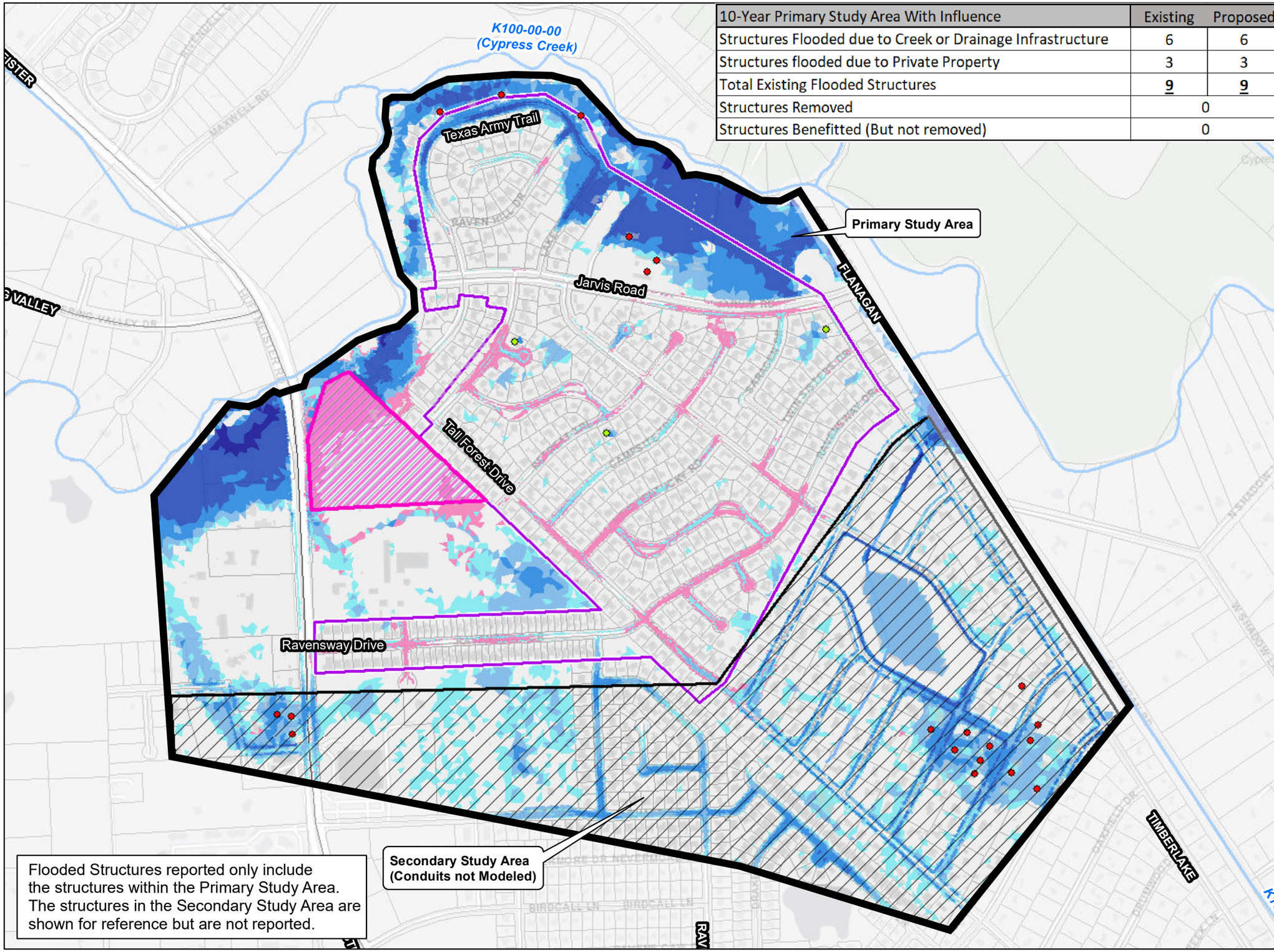
N

0 300 600

1 inch = 600 feet

Gauge ENGINEERING

10-Year Primary Study Area With Influence	Existing	Proposed
Structures Flooded due to Creek or Drainage Infrastructure	6	6
Structures flooded due to Private Property	3	3
Total Existing Flooded Structures	9	9
Structures Removed	0	
Structures Benefitted (But not removed)	0	

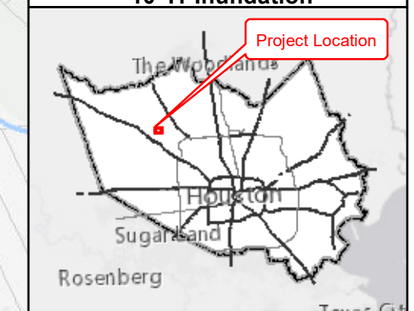


Flooded Structures reported only include the structures within the Primary Study Area. The structures in the Secondary Study Area are shown for reference but are not reported.

HARRIS COUNTY ENGINEERING DEPARTMENT

RAVENSWAY SUBDIVISIONS DRAINAGE IMPROVEMENTS

EXHIBIT 20
Proposed (With Influence)
10-Yr Inundation



Vicinity Map

Legend

- 2D Model Boundary
- 10-Yr Proposed (Flooding due to Private Property)
- 10-Yr Proposed (With Influence) Flooded Structures
- Removed Structures
- Building Footprints
- Detention Site
- Costello Project Area

10-Yr Proposed Inundation Depths (With Influence)

- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- 2.00 - 5.00
- > 5.00
- Existing Inundation
- Channels
- Parcels

N

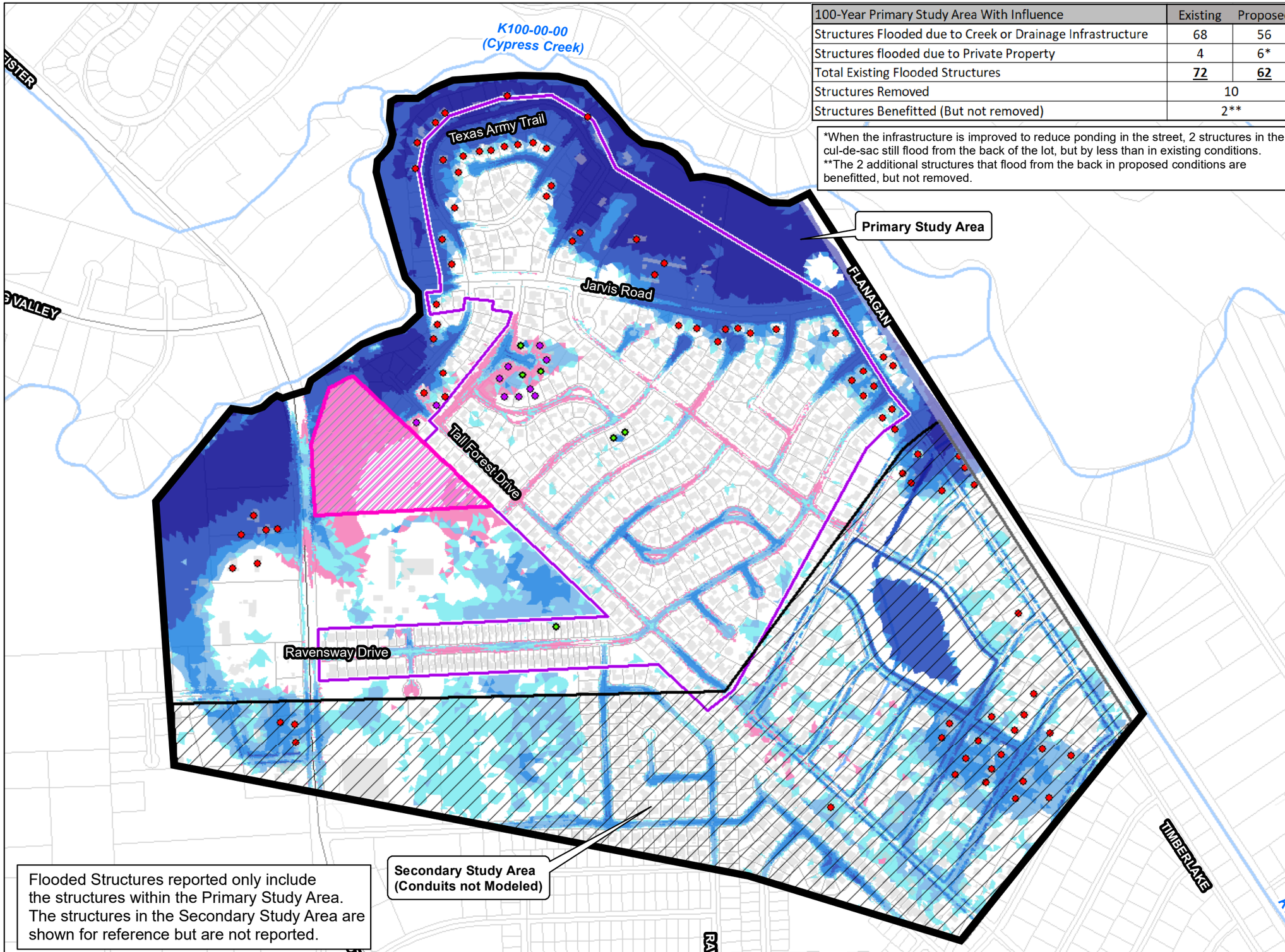
0 300 600

1 inch = 600 feet

Gauge ENGINEERING

100-Year Primary Study Area With Influence	Existing	Proposed
Structures Flooded due to Creek or Drainage Infrastructure	68	56
Structures flooded due to Private Property	4	6*
Total Existing Flooded Structures	72	62
Structures Removed	10	
Structures Benefitted (But not removed)	2**	

*When the infrastructure is improved to reduce ponding in the street, 2 structures in the cul-de-sac still flood from the back of the lot, but by less than in existing conditions.
**The 2 additional structures that flood from the back in proposed conditions are benefitted, but not removed.

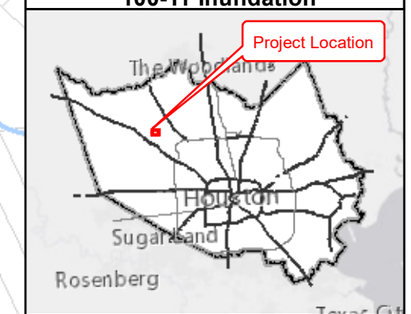


Flooded Structures reported only include the structures within the Primary Study Area. The structures in the Secondary Study Area are shown for reference but are not reported.

HARRIS COUNTY ENGINEERING DEPARTMENT

RAVENSWAY SUBDIVISIONS DRAINAGE IMPROVEMENTS

EXHIBIT 21
Proposed (With Influence)
100-Yr Inundation



Vicinity Map

Legend

- 2D Model Boundary
- Removed Structures
- 100-Yr Proposed (Flooding due to Private Property)
- 100-Yr Proposed (With Influence) Flooded Structures
- Detention Site
- Costello Project
- Building Footprints

100-Yr Proposed Inundation Depths (w/ tailwater) (ft)

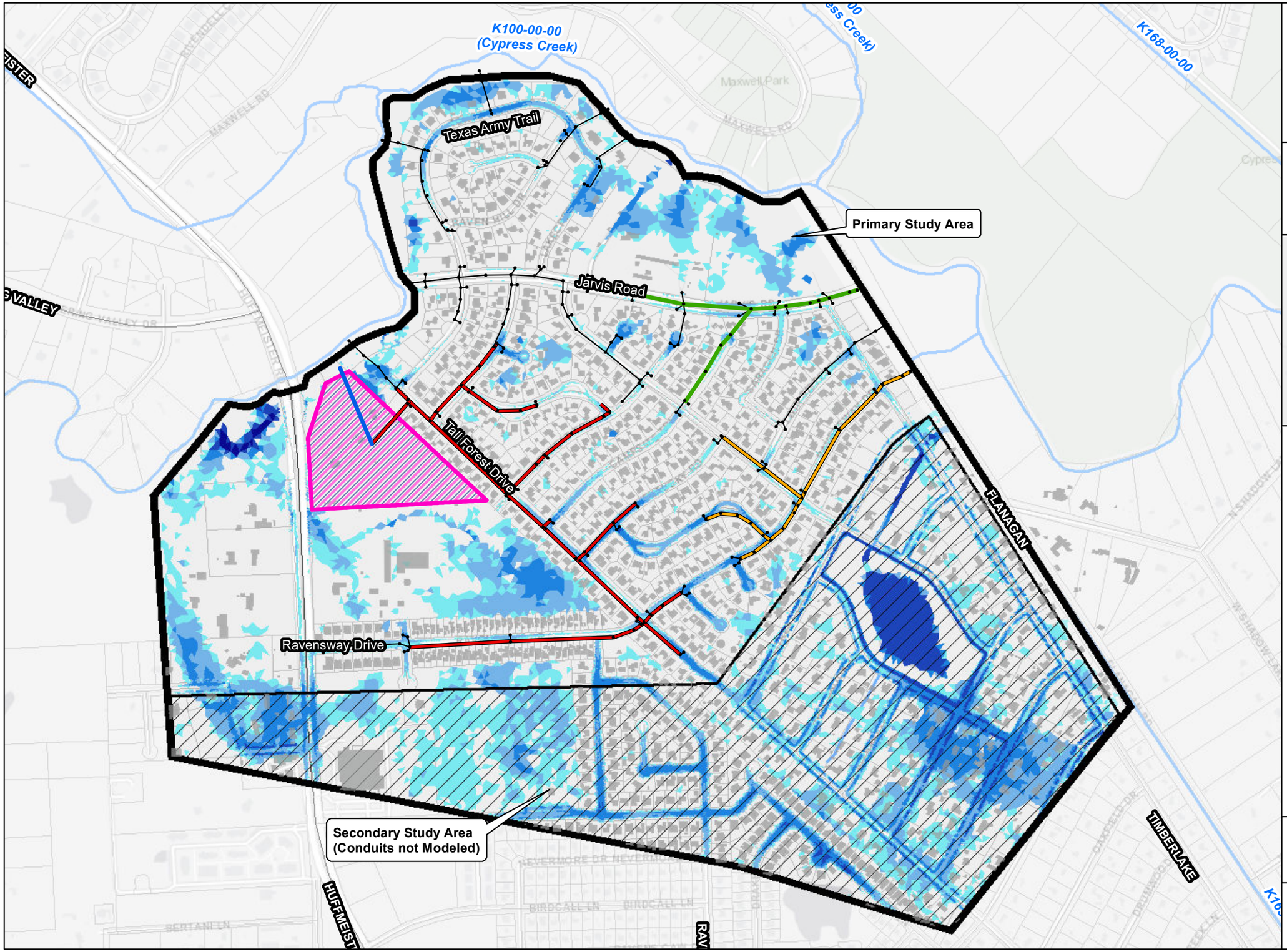
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- 2.00 - 5.00
- > 5.00
- Existing Inundation
- Channels
- Parcels

N

0 300 600

1 inch = 600 feet

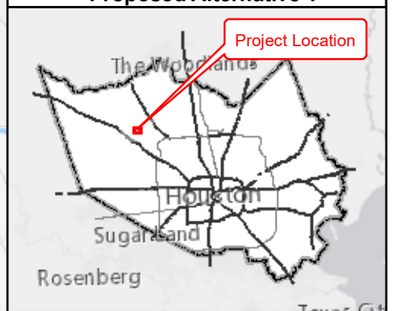
Gauge ENGINEERING



HARRIS COUNTY ENGINEERING DEPARTMENT

RAVENSWAY SUBDIVISIONS DRAINAGE IMPROVEMENTS

EXHIBIT 22
Proposed 100-Yr (Without Influence)
Proposed Alternative 1



Vicinity Map

Legend

- Nodes
- 42" RCP
- 48" RCP
- 60" RCP
- 6'X5'
- Existing Conduits
- Detention Site
- Building Footprints
- 2D Model Boundary

100-Yr Proposed Inundation Depths (w/o tailwater) (ft)

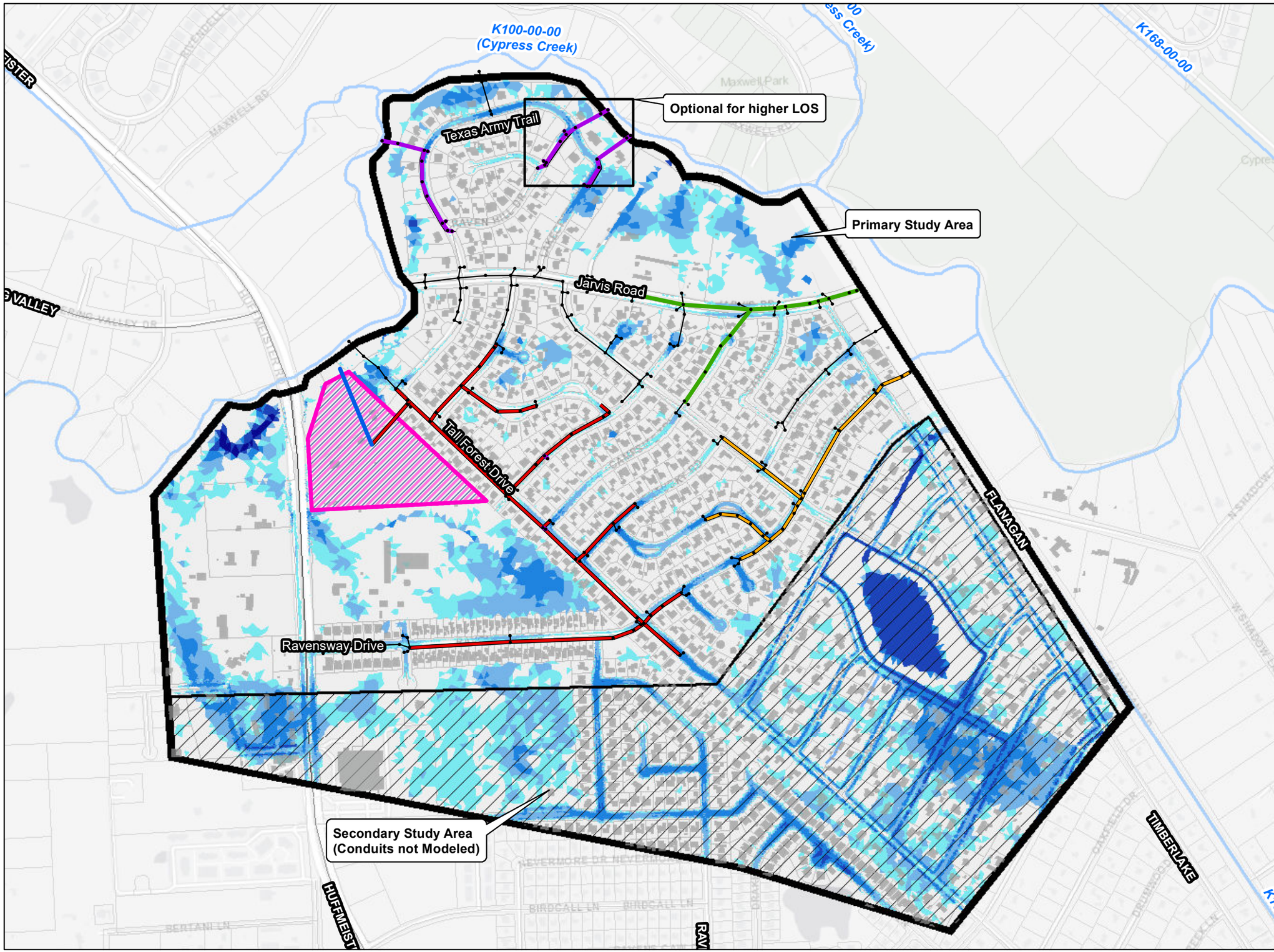
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- 2.00 - 5.00
- > 5.00
- Channels
- Parcels

N

0 300 600

1 inch = 600 feet

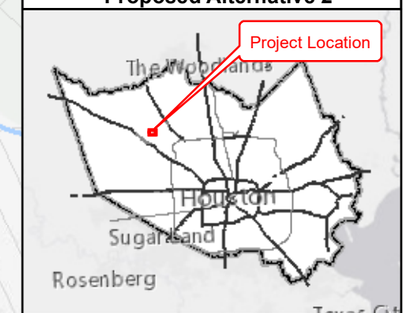
Gauge ENGINEERING



HARRIS COUNTY ENGINEERING DEPARTMENT

RAVENSWAY SUBDIVISIONS DRAINAGE IMPROVEMENTS

EXHIBIT 23
Proposed 100-Yr (Without Influence)
Proposed Alternative 2



Vicinity Map

Legend

- Nodes

Proposed Conduits

condheight

- 36" RCP
- 42" RCP
- 48" RCP
- 60" RCP
- 6'X5'
- Detention Site
- Existing Conduits
- Building Footprints
- 2D Model Boundary

100-Yr Proposed Inundation Depths (w/o tailwater) (ft)

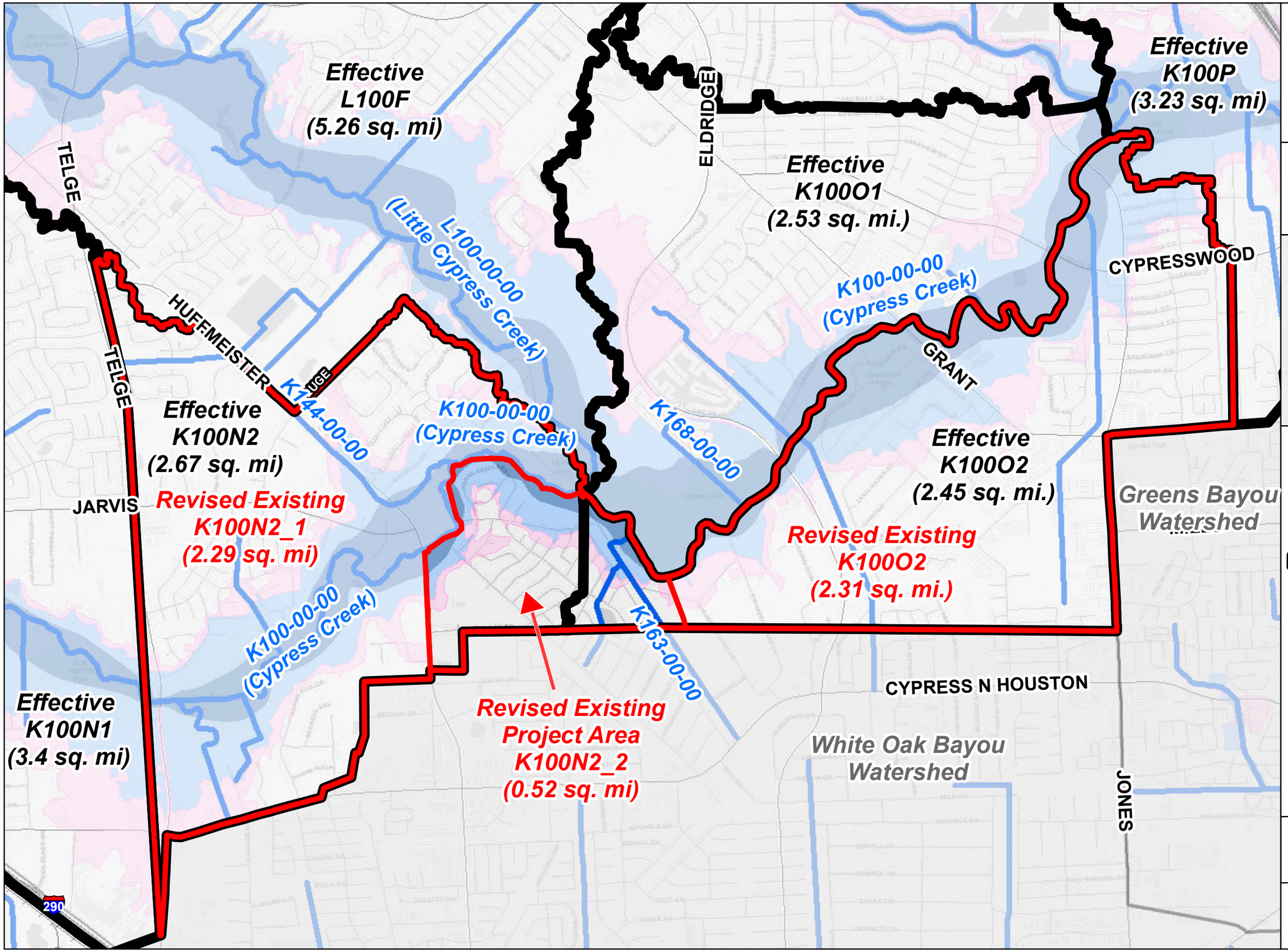
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 2.00
- 2.00 - 5.00
- > 5.00
- Channels
- Parcels

N

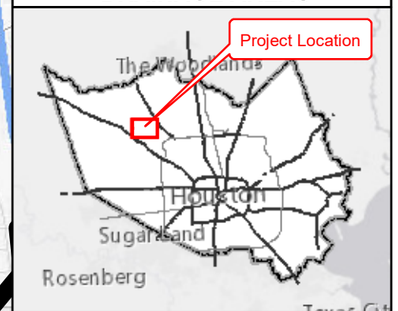
0 300 600

1 inch = 600 feet

Gauge ENGINEERING



RAVENSWAY SUBDIVISIONS
DRAINAGE IMPROVEMENTS
APPENDIX A
REVISED EXISTING
DRAINAGE AREAS



Vicinity Map

Legend

- Channels
- Revised Existing Drainage Areas
- Effective Cypress Creek Drainage Areas

FEMA Flood Zones

- 1% (100-year) Floodway
- 1% (100-year) Floodplain
- 0.2% (500-year) Floodplain

N

0 1,000 2,000

1 inch = 2,000 feet

Gauge ENGINEERING

APPENDIX B

HEC-HMS Downstream Flow Comparisons

2-year event:

HMS Junction	2-Yr Existing Discharge (cfs)	2-Year Proposed Discharge (cfs)	Difference (cfs)
K1000000_1459_J	2,141	2,141	0
K1000000_1445_J	2,971	2,971	0
K1000000_1232_J	3,072	3,072	0
K1000000_1221_J	3,498	3,498	0
K1000000_1131_J	3,661	3,662	1
K1000000_1118_J	4,298	4,270	-28
K1000000_0973_J	4,556	4,542	-14

10-year event:

HMS Junction	10-Yr Existing Discharge (cfs)	10-Year Proposed Discharge (cfs)	Difference (cfs)
K1000000_1459_J	4,146	4,146	0
K1000000_1445_J	7,142	7,142	0
K1000000_1232_J	7,073	7,073	0
K1000000_1221_J	7,221	7,210	-11
K1000000_1131_J	7,882	7,874	-8
K1000000_1118_J	9,472	9,463	-8
K1000000_0973_J	10,084	10,080	-4

50-year event:

HMS Junction	50-Year Existing Discharge (cfs)	50-Year Proposed Discharge (cfs)	Difference (cfs)
K1000000_1459_J	7,139	7,139	0
K1000000_1445_J	14,993	14,993	0
K1000000_1232_J	14,995	14,995	0
K1000000_1221_J	15,255	15,255	0
K1000000_1131_J	15,399	15,399	0
K1000000_1118_J	16,657	16,652	-5
K1000000_0973_J	18,062	18,057	-5

100-year event:

HMS Junction	100-Year Existing Discharge (cfs)	100-Year Proposed Discharge (cfs)	Difference (cfs)
K1000000_1459_J	9,120	9,120	0
K1000000_1445_J	19,945	19,945	0
K1000000_1232_J	19,981	19,981	0
K1000000_1221_J	20,344	20,344	0
K1000000_1131_J	20,582	20,582	0
K1000000_1118_J	20,781	20,781	0
K1000000_0973_J	22,329	22,300	-29

APPENDIX C

HEC-RAS Discharge and Water Surface Elevation Differences

2-Year Storm Event

River Station	Existing Conditions Discharge (cfs)	Proposed Conditions Discharge (cfs)	Difference (cfs)	Existing Conditions Water Surface Elevation (ft)	Proposed Conditions Water Surface Elevation (ft)	Difference (ft)
159764	2026	2026	0	129.2016	129.2036	0.00
158469	2025	2025	0	128.5820	128.5843	0.00
156881	2045	2045	0	127.8063	127.8000	-0.01
155825	2060	2061	0	127.4681	127.4710	0.00
154677	2075	2075	1	127.2057	127.2087	0.00
153727	2087	2087	1	126.8821	126.8853	0.00
152335	2096	2097	1	126.4966	126.5000	0.00
151314	2096	2096	1	126.2566	126.2601	0.00
151214	2097	2097	1	126.2431	126.2466	0.00
151185	*HUFFMEISTER RD.*			*HUFFMEISTER RD.*		
151153	2096	2097	1	125.8051	125.8086	0.00
151057	2096	2097	1	125.7237	125.7272	0.00
150895	2094	2095	1	125.5862	125.5896	0.00
150787	2095	2096	1	125.5912	125.5951	0.00
150694	2096	2097	1	125.5587	125.5612	0.00
150556	2096	2097	1	125.4468	125.4488	0.00
150314	2099	2100	1	125.4370	125.4390	0.00
149704	2090	2091	1	124.9370	124.9389	0.00
149014	2084	2086	2	124.2205	124.2220	0.00
148434	2082	2083	1	124.0192	124.0204	0.00
147865	2085	2086	1	123.8793	123.8804	0.00
146710	2048	2048	0	123.4504	123.4506	0.00
145901	2022	2023	1	123.1278	123.1278	0.00
144516	2938	2938	0	122.4785	122.4786	0.00
143628	2938	2937	0	122.2952	122.2953	0.00
142175	2208	2208	0	122.0366	122.0369	0.00
141381	2213	2213	0	121.8828	121.8831	0.00
140143	2273	2273	0	121.7022	121.7025	0.00
139592	2341	2340	0	121.6215	121.6219	0.00
139166	2688	2687	0	121.4588	121.4593	0.00
138857	2968	2968	0	121.3104	121.3109	0.00
138523	2970	2970	0	121.2257	121.2262	0.00
138420	2971	2971	0	121.2043	121.2048	0.00
138395	*ELDRIDGE PKYY*			*ELDRIDGE PKYY*		
138363	2971	2971	0	121.1638	121.1643	0.00
138264	2972	2972	0	121.1174	121.1180	0.00
137950	2976	2976	0	120.9787	120.9793	0.00
135966	2992	2992	0	120.2417	120.2425	0.00
134226	3005	3005	0	119.5958	119.5967	0.00
134004	3007	3007	0	119.4803	119.4813	0.00
133938	3008	3008	0	119.4650	119.4659	0.00
133891	*GRANT ROAD*			*GRANT ROAD*		
133844	3008	3008	0	119.4010	119.4019	0.00
133720	3009	3009	0	119.3185	119.3195	0.00

APPENDIX C

HEC-RAS Discharge and Water Surface Elevation Differences

2-Year Storm Event

River Station	Existing Conditions Discharge (cfs)	Proposed Conditions Discharge (cfs)	Difference (cfs)	Existing Conditions Water Surface Elevation (ft)	Proposed Conditions Water Surface Elevation (ft)	Difference (ft)
133259	3010	3010	0	119.1824	119.1835	0.00
131653	3019	3019	0	118.7869	118.7881	0.00
130112	3022	3021	0	118.3814	118.3829	0.00
128649	3017	3017	0	117.0497	117.0525	0.00
127383	3007	3007	1	115.6476	115.6515	0.00
127187	3007	3008	1	115.5854	115.5894	0.00
127133	*CYPRESSWOOD CROSSING #3*			*CYPRESSWOOD CROSSING #3*		
127079	3006	3007	1	115.5208	115.5100	-0.01
126877	3006	3007	1	115.4213	115.4100	-0.01
125669	2999	3000	1	114.8799	114.8700	-0.01
124910	2983	2983	1	114.5700	114.5744	0.00
124810	2639	2640	1	114.5320	114.5346	0.00
124751	*JONES ROAD*			*JONES ROAD*		
124694	2637	2637	0	114.2230	114.2256	0.00
124593	2635	2635	1	114.1916	114.1942	0.00
124097	2621	2621	0	114.0603	114.0631	0.00
123437	2598	2599	0	113.8713	113.8743	0.00
123344	2594	2595	0	113.8401	113.8431	0.00
123333.5	*PL1_K100-00-00-S17A*			*PL1_K100-00-00-S17A*		
123316	2592	2593	1	113.8112	113.8141	0.00
123212	2590	2590	0	113.7880	113.7910	0.00
122086	3332	3334	2	113.2538	113.2500	0.00
120997	3359	3361	2	112.8178	112.8206	0.00
120252	3377	3379	2	112.5473	112.5502	0.00
120126	3383	3385	2	112.5132	112.5160	0.00
119576	3403	3405	2	112.4255	112.4283	0.00
118501	3444	3446	2	112.2846	112.2873	0.00
118399	3449	3451	2	112.2917	112.2944	0.00
118237	*SH 249*			*SH 249*		
118064	3449	3450	2	112.2479	112.2506	0.00
117950	3453	3455	2	112.1993	112.2020	0.00
116864	3486	3488	2	111.9678	111.9704	0.00
115085	3543	3545	2	111.6372	111.6397	0.00
113128	3586	3587	2	111.3059	111.3083	0.00
112513	3586	3587	2	111.1602	111.1624	0.00
112191	3956	3958	2	110.9409	110.9431	0.00
111804	3952	3954	2	110.8115	110.8138	0.00
111668	3952	3954	2	110.7982	110.8005	0.00
111533	3952	3953	2	110.7630	110.7652	0.00
111378	3951	3953	2	110.7629	110.7651	0.00
111334.5	*CUTTEN / SCHROEDER*			*CUTTEN / SCHROEDER*		
111284	3951	3953	2	110.3213	110.3235	0.00
111078	3948	3950	2	110.1805	110.1826	0.00
110864	3946	3948	2	110.0978	110.1001	0.00

APPENDIX C

HEC-RAS Discharge and Water Surface Elevation Differences

2-Year Storm Event

River Station	Existing Conditions Discharge (cfs)	Proposed Conditions Discharge (cfs)	Difference (cfs)	Existing Conditions Water Surface Elevation (ft)	Proposed Conditions Water Surface Elevation (ft)	Difference (ft)
109706	3942	3944	1	109.8284	109.8306	0.00
109583	3941	3943	2	109.7897	109.7919	0.00
109428	3942	3943	1	109.7983	109.8005	0.00
109413	*BURLINGTON NORTHERN RR*			*BURLINGTON NORTHERN RR*		
109400	3941	3943	2	109.2729	109.2751	0.00
109300	3941	3943	2	109.2051	109.2073	0.00
108918	3940	3942	1	109.0968	109.0989	0.00
108501	3940	3941	2	109.0255	109.0275	0.00
108274	3948	3950	2	109.0118	109.0138	0.00
108232	*CYPRESSWOOD DRIVE*			*CYPRESSWOOD DRIVE*		
108188	3948	3949	2	108.9756	108.9776	0.00
107974	3954	3956	2	108.9378	108.9398	0.00
107642	3964	3966	2	108.8941	108.8961	0.00
106632	3999	4000	2	108.6167	108.6188	0.00
104790	4069	4071	2	108.1718	108.1739	0.00
103431	4127	4128	2	107.8388	107.8410	0.00
103030	4143	4145	2	107.6493	107.6516	0.00
102901	4150	4152	2	107.6279	107.6301	0.00
102890.5	*PL1_K100-00-00-S13*			*PL1_K100-00-00-S13*		
102875	4150	4152	2	107.5901	107.5924	0.00
102762	4156	4157	2	107.5699	107.5722	0.00
102667	4160	4162	2	107.5442	107.5400	0.00
101787	4200	4202	2	107.1491	107.1512	0.00
100946	4238	4240	2	106.7911	106.7931	0.00
99588	4281	4283	2	106.4516	106.4535	0.00
98945	4313	4315	1	106.2469	106.2488	0.00
98740	4324	4325	2	106.2170	106.2189	0.00
98688	*CHAMPIONS FOREST*			*CHAMPIONS FOREST*		
98634	4324	4325	2	104.4929	104.4948	0.00
98373	4337	4339	2	104.3987	104.4007	0.00
97287	4336	4337	2	104.0744	104.0763	0.00
96543	4671	4672	1	103.7819	103.7838	0.00

APPENDIX C

HEC-RAS Discharge and Water Surface Elevation Differences

10-Year Storm Event

River Station	Existing Conditions Discharge (cfs)	Proposed Conditions Discharge (cfs)	Difference (cfs)	Existing Conditions Water Surface Elevation (ft)	Proposed Conditions Water Surface Elevation (ft)	Difference (ft)
159764	4023	4006	-17	132.4395	132.4116	-0.03
158469	3972	3944	-28	131.7829	131.7533	-0.03
156881	3967	3930	-37	131.1068	131.0779	-0.03
155825	3974	3934	-39	130.7461	130.7196	-0.03
154677	3986	3942	-43	130.4451	130.4217	-0.02
153727	3993	3949	-45	130.0952	130.0762	-0.02
152335	4002	3955	-47	129.8235	129.8085	-0.01
151314	4015	3966	-48	129.6111	129.6002	-0.01
151214	4017	3968	-49	129.5780	129.5679	-0.01
151185	*HUFFMEISTER RD.*			*HUFFMEISTER RD.*		
151153	4017	3967	-50	129.1637	129.1541	-0.01
151057	4016	3965	-51	128.8997	128.8965	0.00
150895	4009	3953	-56	128.5391	128.4812	-0.06
150787	4011	3956	-55	128.5391	128.4916	-0.05
150694	4012	3957	-55	128.4930	128.4408	-0.05
150556	4014	3959	-56	128.4046	128.3645	-0.04
150314	4017	3961	-56	128.3489	128.3096	-0.04
149704	4012	3955	-57	128.1543	128.1143	-0.04
149014	3996	3940	-56	127.5985	127.5613	-0.04
148434	3985	3930	-55	127.3684	127.3344	-0.03
147865	3979	3926	-53	127.1855	127.1544	-0.03
146710	3219	3215	-4	126.7889	126.7854	0.00
145901	3211	3205	-6	126.5329	126.5299	0.00
144516	6726	6721	-5	125.8041	125.8013	0.00
143628	6716	6712	-4	125.5277	125.5250	0.00
142175	3339	3338	-2	125.2742	125.2717	0.00
141381	2670	2670	0	125.2034	125.2008	0.00
140143	2039	2038	-1	125.1550	125.1524	0.00
139592	2163	2162	-1	125.1299	125.1273	0.00
139166	4668	4665	-4	124.9698	124.9673	0.00
138857	6723	6717	-6	124.7516	124.7492	0.00
138523	6722	6717	-5	124.6122	124.6099	0.00
138420	6723	6717	-6	124.5936	124.5913	0.00
138395	*ELDRIDGE PKYY*			*ELDRIDGE PKYY*		
138363	6722	6717	-5	124.5448	124.5426	0.00
138264	6722	6716	-6	124.5109	124.5087	0.00
137950	6721	6717	-5	124.3230	124.3209	0.00
135966	6717	6712	-4	123.4864	123.4846	0.00
134226	6720	6716	-4	122.8014	122.7998	0.00
134004	6720	6717	-3	122.7015	122.6999	0.00
133938	6721	6717	-4	122.6627	122.6611	0.00
133891	*GRANT ROAD*			*GRANT ROAD*		
133844	6721	6717	-4	122.6340	122.6324	0.00
133720	6721	6717	-4	122.5547	122.5531	0.00

APPENDIX C

HEC-RAS Discharge and Water Surface Elevation Differences

10-Year Storm Event

River Station	Existing Conditions Discharge (cfs)	Proposed Conditions Discharge (cfs)	Difference (cfs)	Existing Conditions Water Surface Elevation (ft)	Proposed Conditions Water Surface Elevation (ft)	Difference (ft)
133259	6721	6717	-4	122.4447	122.4431	0.00
131653	6726	6722	-4	122.0311	122.0297	0.00
130112	6727	6723	-4	121.8219	121.8205	0.00
128649	6725	6721	-4	120.9507	120.9479	0.00
127383	6724	6719	-5	119.8679	119.8635	0.00
127187	6724	6719	-5	119.7780	119.7737	0.00
127133	*CYPRESSWOOD CROSSING #3*			*CYPRESSWOOD CROSSING #3*		
127079	6724	6719	-5	119.6892	119.6849	0.00
126877	6724	6719	-5	119.5965	119.5922	0.00
125669	6726	6722	-5	119.0991	119.0944	0.00
124910	6726	6721	-5	118.7929	118.7880	0.00
124810	6726	6720	-5	118.7364	118.7315	0.00
124751	*JONES ROAD*			*JONES ROAD*		
124694	6725	6720	-5	118.3804	118.3755	0.00
124593	6725	6720	-5	118.3669	118.3618	-0.01
124097	6725	6720	-5	118.2548	118.2496	-0.01
123437	6725	6720	-5	117.9490	117.9436	-0.01
123344	6725	6720	-5	117.9011	117.8956	-0.01
123333.5	*PL1_K100-00-00-S17A*			*PL1_K100-00-00-S17A*		
123316	6288	6719	431	117.7516	117.7393	-0.01
123212	5276	5191	-85	117.6957	117.6805	-0.02
122086	6480	6446	-34	117.0616	117.0518	-0.01
120997	6528	6499	-29	116.6621	116.6548	-0.01
120252	6561	6535	-25	116.4792	116.4730	-0.01
120126	6572	6547	-25	116.4148	116.4089	-0.01
119576	6611	6589	-22	116.2861	116.2810	-0.01
118501	6694	6676	-18	116.1030	116.0987	0.00
118399	6704	6686	-18	116.1073	116.1030	0.00
118237	*SH 249*			*SH 249*		
118064	6701	6685	-17	116.0333	116.0293	0.00
117950	6709	6694	-15	115.9644	115.9606	0.00
116864	6776	6764	-12	115.6787	115.6758	0.00
115085	6891	6883	-8	115.1442	115.1426	0.00
113128	6976	6971	-5	114.4634	114.4629	0.00
112513	6972	6968	-4	114.3126	114.3123	0.00
112191	7923	7923	0	114.1794	114.1788	0.00
111804	7920	7919	-1	114.0798	114.0792	0.00
111668	7919	7919	0	114.0758	114.0752	0.00
111533	7916	7917	1	114.0023	114.0017	0.00
111378	7917	7916	-1	113.9939	113.9933	0.00
111334.5	*CUTTEN / SCHROEDER*			*CUTTEN / SCHROEDER*		
111284	7916	7916	0	113.9655	113.9649	0.00
111078	7912	7910	-2	113.8308	113.8302	0.00
110864	7910	7911	0	113.8127	113.8122	0.00

APPENDIX C

HEC-RAS Discharge and Water Surface Elevation Differences

10-Year Storm Event

River Station	Existing Conditions Discharge (cfs)	Proposed Conditions Discharge (cfs)	Difference (cfs)	Existing Conditions Water Surface Elevation (ft)	Proposed Conditions Water Surface Elevation (ft)	Difference (ft)
109706	7908	7907	-1	113.6126	113.6121	0.00
109583	7908	7906	-2	113.5589	113.5584	0.00
109428	7908	7906	-1	113.5555	113.5550	0.00
109413	*BURLINGTON NORTHERN RR*			*BURLINGTON NORTHERN RR*		
109400	7907	7906	-1	113.0366	113.0361	0.00
109300	7907	7906	-1	112.9448	112.9443	0.00
108918	7906	7905	-2	112.7854	112.7849	0.00
108501	7906	7904	-2	112.6543	112.6538	0.00
108274	7925	7923	-2	112.6319	112.6314	0.00
108232	*CYPRESSWOOD DRIVE*			*CYPRESSWOOD DRIVE*		
108188	7925	7923	-2	112.5845	112.5841	0.00
107974	7940	7938	-2	112.5443	112.5438	0.00
107642	7964	7963	-2	112.5182	112.5178	0.00
106632	8048	8046	-2	112.3259	112.3255	0.00
104790	8216	8215	-1	112.0282	112.0279	0.00
103431	8352	8351	-1	111.7846	111.7844	0.00
103030	8391	8390	-1	111.6646	111.6643	0.00
102901	8407	8406	-1	111.6463	111.6461	0.00
102890.5	*PL1_K100-00-00-S13*			*PL1_K100-00-00-S13*		
102875	8407	8406	-1	111.5927	111.5925	0.00
102762	8421	8420	-1	111.5499	111.5498	0.00
102667	8431	8430	-1	111.5275	111.5273	0.00
101787	8526	8525	-1	110.8084	110.8083	0.00
100946	8616	8616	0	110.3373	110.3373	0.00
99588	8717	8716	-1	109.9010	109.9010	0.00
98945	8793	8793	0	109.6262	109.6262	0.00
98740	8819	8818	-1	109.5877	109.5877	0.00
98688	*CHAMPIONS FOREST*			*CHAMPIONS FOREST*		
98634	8818	8817	0	109.4687	109.4687	0.00
98373	8851	8850	0	109.3939	109.3939	0.00
97287	8846	8847	1	109.1200	109.1201	0.00
96543	9682	9682	0	108.8315	108.8315	0.00

APPENDIX C

HEC-RAS Discharge and Water Surface Elevation Differences

50-Year Storm Event

River Station	Existing Conditions Discharge (cfs)	Proposed Conditions Discharge (cfs)	Difference (cfs)	Existing Conditions Water Surface Elevation (ft)	Proposed Conditions Water Surface Elevation (ft)	Difference (ft)
159764	7629	7639	10	135.1207	135.1118	-0.01
158469	7465	7474	9	134.4205	134.4074	-0.01
156881	7479	7485	6	133.7876	133.7687	-0.02
155825	7496	7504	8	133.4135	133.3904	-0.02
154677	7518	7525	7	133.0585	133.0310	-0.03
153727	7539	7544	4	132.6715	132.6380	-0.03
152335	7557	7562	5	132.3652	132.3266	-0.04
151314	7579	7584	5	132.0403	131.9973	-0.04
151214	7583	7587	5	131.9560	131.9121	-0.04
151185	*HUFFMEISTER RD.*			*HUFFMEISTER RD.*		
151153	7577	7580	3	131.8265	131.7841	-0.04
151057	7568	7565	-3	131.5535	131.5045	-0.05
150895	7520	7508	-12	131.0910	131.0576	-0.03
150787	7526	7515	-11	131.0909	131.0626	-0.03
150694	7520	7509	-11	131.0349	131.0127	-0.02
150556	7514	7507	-7	130.9671	130.9643	0.00
150314	7507	7497	-11	130.8974	130.8952	0.00
149704	7477	7466	-11	130.7939	130.7919	0.00
149014	6511	6516	5	130.3374	130.3362	0.00
148434	6304	6288	-16	130.1438	130.1430	0.00
147865	6206	6198	-7	129.9902	129.9893	0.00
146710	6135	6132	-2	129.7102	129.7094	0.00
145901	6094	6091	-3	129.4722	129.4715	0.00
144516	14388	14385	-3	128.8328	128.8321	0.00
143628	14363	14363	0	128.5427	128.5420	0.00
142175	6633	6631	-2	128.2961	128.2953	0.00
141381	4871	4870	-1	128.2580	128.2572	0.00
140143	4952	4951	-2	128.2214	128.2206	0.00
139592	5233	5232	-1	128.1875	128.1867	0.00
139166	10350	10348	-2	127.9928	127.9920	0.00
138857	14321	14319	-2	127.6979	127.6971	0.00
138523	14318	14316	-1	127.4234	127.4226	0.00
138420	14319	14317	-2	127.3879	127.3871	0.00
138395	*ELDRIDGE PKYY*			*ELDRIDGE PKYY*		
138363	14315	14313	-2	127.2921	127.2913	0.00
138264	14315	14314	0	127.2653	127.2645	0.00
137950	14312	14310	-2	126.9957	126.9949	0.00
135966	14297	14295	-2	125.9758	125.9749	0.00
134226	14295	14293	-3	125.2972	125.2962	0.00
134004	14295	14293	-2	125.1936	125.1925	0.00
133938	14295	14293	-3	125.1439	125.1428	0.00
133891	*GRANT ROAD*			*GRANT ROAD*		
133844	14296	14293	-3	125.1329	125.1318	0.00

APPENDIX C

HEC-RAS Discharge and Water Surface Elevation Differences

50-Year Storm Event

River Station	Existing Conditions Discharge (cfs)	Proposed Conditions Discharge (cfs)	Difference (cfs)	Existing Conditions Water Surface Elevation (ft)	Proposed Conditions Water Surface Elevation (ft)	Difference (ft)
133720	14293	14292	-1	125.0454	125.0442	0.00
133259	14293	14290	-3	124.9189	124.9177	0.00
131653	14289	14285	-4	124.3600	124.3588	0.00
130112	14286	14282	-3	124.1105	124.1091	0.00
128649	14287	14284	-3	123.8657	123.8641	0.00
127383	14291	14289	-2	123.4778	123.4761	0.00
127187	14293	14290	-2	123.4143	123.4126	0.00
127133	*CYPRESSWOOD CROSSING #3*			*CYPRESSWOOD CROSSING #3*		
127079	14291	14289	-2	123.3287	123.3269	0.00
126877	14294	14291	-3	123.2588	123.2569	0.00
125669	14301	14298	-3	122.8715	122.8697	0.00
124910	14298	14295	-3	122.5711	122.5693	0.00
124810	14298	14294	-3	122.4401	122.4383	0.00
124751	*JONES ROAD*			*JONES ROAD*		
124694	14296	14293	-3	122.0298	122.0280	0.00
124593	14296	14293	-3	122.0807	122.0788	0.00
124097	14295	14292	-3	121.9868	121.9849	0.00
123437	14294	14291	-3	121.7760	121.7740	0.00
123344	14294	14291	-3	121.7456	121.7436	0.00
123333.5	*PL1_K100-00-00-S17A*			*PL1_K100-00-00-S17A*		
123316	14293	14290	-3	121.6887	121.6868	0.00
123212	14293	14290	-3	121.6489	121.6469	0.00
122086	14560	14557	-4	121.0932	121.0909	0.00
120997	14587	14583	-4	120.7688	120.7664	0.00
120252	14605	14601	-4	120.6016	120.5992	0.00
120126	14611	14607	-4	120.4964	120.4939	0.00
119576	14630	14626	-4	120.2644	120.2619	0.00
118501	14671	14666	-5	119.9594	119.9568	0.00
118399	14675	14671	-5	119.9482	119.9457	0.00
118237	*SH 249*			*SH 249*		
118064	14674	14669	-5	119.7922	119.7896	0.00
117950	14679	14674	-5	119.7589	119.7563	0.00
116864	14711	14706	-5	119.4824	119.4796	0.00
115085	14765	14760	-5	118.7041	118.7007	0.00
113128	14805	14799	-6	117.6119	117.6069	-0.01
112513	12755	12641	-114	117.4270	117.4064	-0.02
112191	14103	14026	-77	117.3389	117.3176	-0.02
111804	14103	14026	-77	117.2728	117.2515	-0.02
111668	14102	14026	-76	117.2740	117.2527	-0.02
111533	14102	14026	-76	117.2162	117.1949	-0.02
111378	14102	14025	-77	117.1812	117.1601	-0.02
111334.5	*CUTTEN / SCHROEDER*			*CUTTEN / SCHROEDER*		
111284	14101	14026	-75	117.1106	117.0902	-0.02

APPENDIX C

HEC-RAS Discharge and Water Surface Elevation Differences

50-Year Storm Event

River Station	Existing Conditions Discharge (cfs)	Proposed Conditions Discharge (cfs)	Difference (cfs)	Existing Conditions Water Surface Elevation (ft)	Proposed Conditions Water Surface Elevation (ft)	Difference (ft)
111078	14100	14025	-75	117.0801	117.0596	-0.02
110864	14100	14025	-76	117.0553	117.0348	-0.02
109706	14096	14022	-74	116.8683	116.8485	-0.02
109583	14096	14020	-75	116.8001	116.7807	-0.02
109428	14095	14020	-75	116.7703	116.7513	-0.02
109413	*BURLINGTON NORTHERN RR*			*BURLINGTON NORTHERN RR*		
109400	14093	14018	-75	116.2324	116.2137	-0.02
109300	14090	14016	-74	116.1103	116.0923	-0.02
108918	14086	14014	-73	115.9694	115.9519	-0.02
108501	14081	14011	-70	115.8613	115.8441	-0.02
108274	14109	14037	-73	115.8181	115.8012	-0.02
108232	*CYPRESSWOOD DRIVE*			*CYPRESSWOOD DRIVE*		
108188	14106	14036	-70	115.7492	115.7327	-0.02
107974	14129	14057	-72	115.7186	115.7027	-0.02
107642	14162	14093	-69	115.6898	115.6739	-0.02
106632	14279	14213	-66	115.5348	115.5195	-0.02
104790	14521	14460	-61	115.2913	115.2767	-0.01
103431	14717	14660	-57	115.0311	115.0168	-0.01
103030	14774	14717	-56	114.9399	114.9256	-0.01
102901	14796	14741	-55	114.9258	114.9116	-0.01
102890.5	*PL1_K100-00-00-S13*			*PL1_K100-00-00-S13*		
102875	14795	14740	-55	114.8676	114.8535	-0.01
102762	14816	14761	-55	114.8348	114.8207	-0.01
102667	14830	14776	-54	114.8220	114.8080	-0.01
101787	14967	14916	-51	114.5307	114.5189	-0.01
100946	15096	15048	-49	114.3006	114.2901	-0.01
99588	15243	15197	-46	114.0789	114.0686	-0.01
98945	15352	15310	-42	113.8844	113.8746	-0.01
98740	15391	15347	-44	113.8409	113.8311	-0.01
98688	*CHAMPIONS FOREST*			*CHAMPIONS FOREST*		
98634	15381	15339	-42	113.6233	113.6145	-0.01
98373	15429	15387	-42	113.5750	113.5663	-0.01
97287	15410	15368	-41	113.3719	113.3638	-0.01
96543	17061	17036	-25	113.1070	113.0990	-0.01

APPENDIX C

HEC-RAS Discharge and Water Surface Elevation Differences

100-Year Storm Event

River Station	Existing Conditions Discharge (cfs)	Proposed Conditions Discharge (cfs)	Difference (cfs)	Existing Conditions Water Surface Elevation (ft)	Proposed Conditions Water Surface Elevation (ft)	Difference (ft)
159764	9742	9749	7	136.1130	136.1069	-0.01
158469	9187	9207	20	135.4277	135.4056	-0.02
156881	9187	9209	22	134.8291	134.7973	-0.03
155825	9174	9199	25	134.4669	134.4279	-0.04
154677	9156	9185	29	134.1164	134.0692	-0.05
153727	9151	9203	52	133.7439	133.6866	-0.06
152335	9191	9224	33	133.4483	133.3815	-0.07
151314	9251	9248	-3	133.0932	133.0199	-0.07
151214	9259	9250	-9	132.9895	132.9151	-0.07
151185	*HUFFMEISTER RD.*			*HUFFMEISTER RD.*		
151153	9259	9235	-23	132.8058	132.7296	-0.08
151057	9476	9206	-269	132.5164	132.4074	-0.11
150895	9390	9112	-277	132.0465	131.9673	-0.08
150787	9396	9119	-278	132.0481	131.9741	-0.07
150694	9397	9099	-298	131.9877	131.9290	-0.06
150556	9398	9087	-311	131.9215	131.8912	-0.03
150314	9399	8047	-1351	131.8461	131.8313	-0.01
149704	7645	7663	19	131.7723	131.7746	0.00
149014	7574	7584	10	131.4794	131.4812	0.00
148434	7527	7537	10	131.3035	131.3052	0.00
147865	7502	7508	6	131.1562	131.1577	0.00
146710	7480	7481	1	130.9083	130.9097	0.00
145901	7452	7457	5	130.7067	130.7079	0.00
144516	18814	18821	7	130.1166	130.1180	0.00
143628	18792	18798	6	129.8215	129.8229	0.00
142175	9240	9244	5	129.5574	129.5588	0.00
141381	7358	7361	3	129.5238	129.5252	0.00
140143	7818	7821	3	129.4848	129.4862	0.00
139592	8187	8190	3	129.4458	129.4472	0.00
139166	14154	14159	5	129.2689	129.2703	0.00
138857	18667	18671	4	128.9575	128.9589	0.00
138523	18663	18667	4	128.6186	128.6200	0.00
138420	18663	18664	1	128.5734	128.5747	0.00
138395	*ELDRIDGE PKYY*			*ELDRIDGE PKYY*		
138363	18658	18660	2	128.4529	128.4543	0.00
138264	18660	18663	3	128.4381	128.4394	0.00
137950	18655	18659	5	128.1474	128.1487	0.00
135966	18633	18640	7	127.1038	127.1051	0.00
134226	18615	18621	6	126.4700	126.4714	0.00
134004	18617	18622	4	126.3754	126.3768	0.00
133938	18614	18623	9	126.3281	126.3295	0.00
133891	*GRANT ROAD*			*GRANT ROAD*		
133844	18617	18623	6	126.3218	126.3232	0.00

APPENDIX C

HEC-RAS Discharge and Water Surface Elevation Differences

100-Year Storm Event

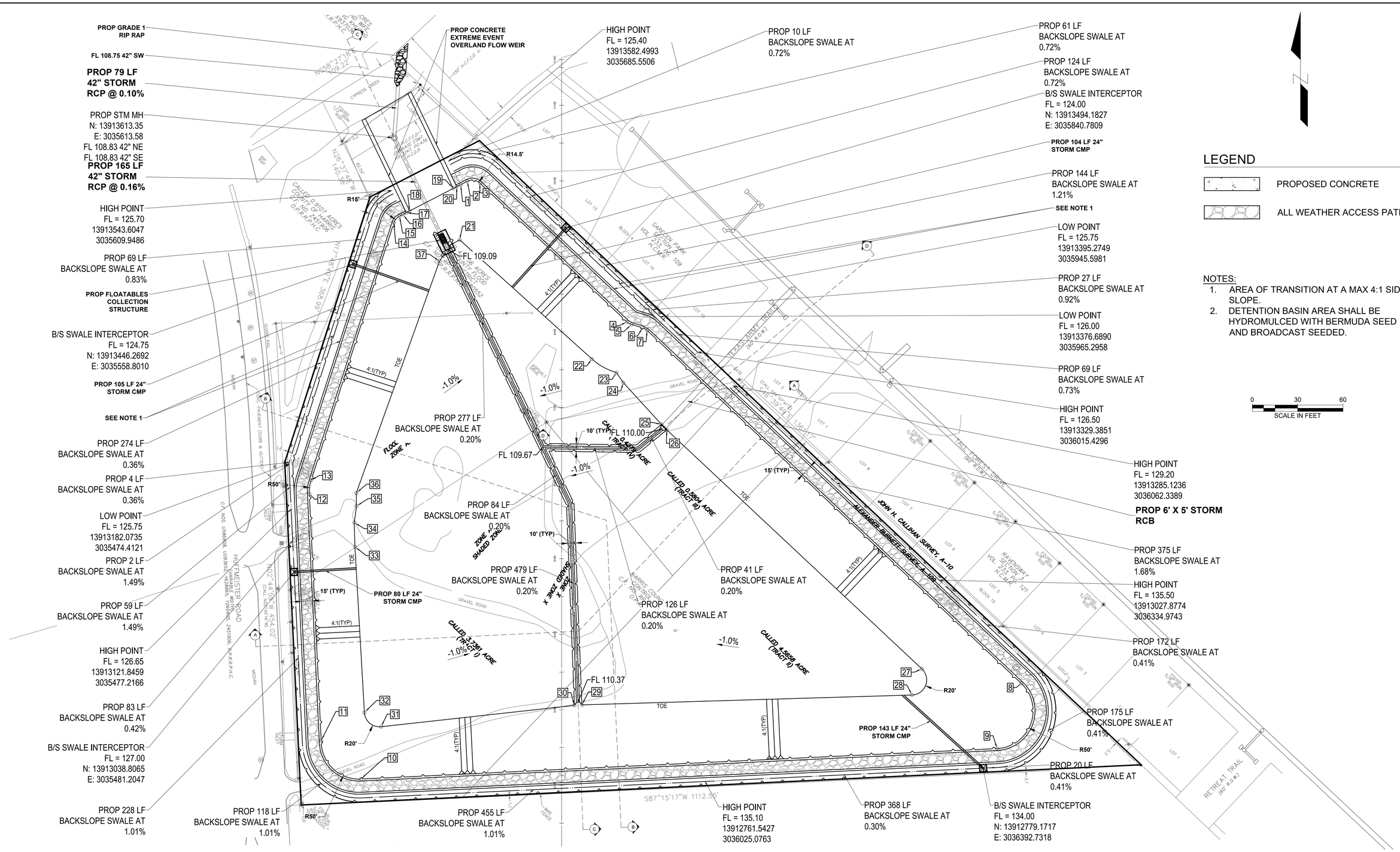
River Station	Existing Conditions Discharge (cfs)	Proposed Conditions Discharge (cfs)	Difference (cfs)	Existing Conditions Water Surface Elevation (ft)	Proposed Conditions Water Surface Elevation (ft)	Difference (ft)
133720	18618	18620	2	126.2423	126.2438	0.00
133259	18615	18620	5	126.1227	126.1241	0.00
131653	18609	18614	5	125.5422	125.5436	0.00
130112	18604	18610	6	125.3042	125.3056	0.00
128649	18609	18615	6	125.1185	125.1200	0.00
127383	18613	18619	5	124.7839	124.7855	0.00
127187	18615	18619	4	124.7251	124.7270	0.00
127133	*CYPRESSWOOD CROSSING #3*			*CYPRESSWOOD CROSSING #3*		
127079	18614	18619	5	124.6508	124.6525	0.00
126877	18615	18621	6	124.5835	124.5852	0.00
125669	18623	18629	6	124.2062	124.2079	0.00
124910	18619	18625	6	123.9900	123.9917	0.00
124810	18617	18622	5	123.8033	123.8049	0.00
124751	*JONES ROAD*			*JONES ROAD*		
124694	18613	18619	6	123.3357	123.3373	0.00
124593	18615	18620	5	123.4220	123.4237	0.00
124097	18614	18619	5	123.3388	123.1400	-0.20
123437	18611	18616	5	123.1413	122.9400	-0.20
123344	18611	18616	5	123.1125	123.1141	0.00
123333.5	*PL1_K100-00-00-S17A*			*PL1_K100-00-00-S17A*		
123316	18610	18616	6	123.0611	122.8600	-0.20
123212	18609	18616	7	123.0277	123.0294	0.00
122086	18959	18966	7	122.5045	122.3000	-0.20
120997	18993	18999	6	122.1918	122.1935	0.00
120252	19017	19023	6	122.0231	121.8200	-0.20
120126	19024	19030	5	121.9173	121.9190	0.00
119576	19049	19056	7	121.6488	121.6504	0.00
118501	19102	19107	5	121.2859	121.2875	0.00
118399	19106	19113	7	121.2638	121.2653	0.00
118237	*SH 249*			*SH 249*		
118064	19104	19110	6	121.0337	120.8600	-0.17
117950	19110	19116	7	121.0115	121.0129	0.00
116864	19152	19159	7	120.7556	120.5800	-0.18
115085	19220	19226	5	120.0201	120.0215	0.00
113128	19269	19276	6	119.1367	119.1383	0.00
112513	19267	19273	6	118.8787	118.8802	0.00
112191	19479	19484	6	118.8146	118.8161	0.00
111804	19476	19482	6	118.7470	118.7486	0.00
111668	19477	19482	5	118.7501	118.7517	0.00
111533	19474	19480	6	118.6934	118.6950	0.00
111378	19475	19480	5	118.6477	118.6493	0.00
111334.5	*CUTTEN / SCHROEDER*			*CUTTEN / SCHROEDER*		
111284	19471	19478	7	118.5381	118.5397	0.00

APPENDIX C

HEC-RAS Discharge and Water Surface Elevation Differences

100-Year Storm Event

River Station	Existing Conditions Discharge (cfs)	Proposed Conditions Discharge (cfs)	Difference (cfs)	Existing Conditions Water Surface Elevation (ft)	Proposed Conditions Water Surface Elevation (ft)	Difference (ft)
111078	19471	19477	6	118.5195	118.5211	0.00
110864	19471	19476	5	118.4911	118.4927	0.00
109706	19467	19472	5	118.2629	118.2645	0.00
109583	19466	19473	6	118.1673	118.1688	0.00
109428	19466	19472	6	118.1107	118.1122	0.00
109413	*BURLINGTON NORTHERN RR*			*BURLINGTON NORTHERN RR*		
109400	19465	19471	6	117.5558	117.5573	0.00
109300	19462	19469	7	117.3844	117.3859	0.00
108918	19461	19468	6	117.2171	117.2185	0.00
108501	17927	19466	1539	117.1020	117.0924	-0.01
108274	17959	17912	-47	117.0722	117.0573	-0.01
108232	*CYPRESSWOOD DRIVE*			*CYPRESSWOOD DRIVE*		
108188	17954	17907	-47	116.9722	116.9577	-0.01
107974	17979	17932	-47	116.9385	116.9239	-0.01
107642	18019	17971	-48	116.9077	116.8931	-0.01
106632	18156	18108	-48	116.7535	116.7401	-0.01
104790	18434	18384	-50	116.5024	116.4915	-0.01
103431	18659	18611	-48	116.2564	116.2461	-0.01
103030	18724	18679	-45	116.1673	116.1571	-0.01
102901	18752	18705	-48	116.1525	116.1423	-0.01
102890.5	*PL1_K100-00-00-S13*			*PL1_K100-00-00-S13*		
102875	18748	18703	-46	116.0866	116.0764	-0.01
102762	18771	18726	-45	116.0518	116.0417	-0.01
102667	18789	18744	-45	116.0388	116.0287	-0.01
101787	18948	18903	-44	115.7808	115.7706	-0.01
100946	19103	19061	-42	115.5738	115.5636	-0.01
99588	19280	19237	-43	115.3698	115.3596	-0.01
98945	19412	19369	-43	115.1864	115.1763	-0.01
98740	19455	19413	-42	115.1378	115.1279	-0.01
98688	*CHAMPIONS FOREST*			*CHAMPIONS FOREST*		
98634	19443	19401	-42	114.9663	114.9559	-0.01
98373	19503	19461	-42	114.9202	114.9098	-0.01
97287	19478	19442	-36	114.7108	114.7006	-0.01
96543	21473	21438	-36	114.4419	114.4317	-0.01



LEGEND

PROPOSED CONCRETE

ALL WEATHER ACCESS PATH

NOTES:

1. AREA OF TRANSITION AT A MAX 4:1 SIDE SLOPE.
2. DETENTION BASIN AREA SHALL BE HYDROMULCED WITH BERMUDA SEED AND BROADCAST SEEDED.

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY ENGINEERING DEPARTMENT

HARRIS COUNTY TEXAS 1836

LJA Engineering, Inc.
3600 W Sam Houston Pkwy S, Suite 600
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Phone 713.953.5200 Fax. 713.953.5026
FIRM REGISTRATION No. F-1386
www.LJAengineering.com

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ISAAC MUÑIZ, P.E.
TEXAS P.E. #125839

ISSUED ON:
DEC 18 2021

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018 – UPIN 19103MF14601

SHEET DESCRIPTION: OVERALL POND PLAN

DRAWN BY:

DATE: 12/2/2021

DESIGN BY:

SCALE:

SHEET NO: 121 **163**

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Point Table

Point #	Raw Description	Northing	Easting	Elevation
1	TOP OF BANK	13913551.3765	3035701.5622	128.50
2	TOP OF BANK	13913555.8713	3035710.2989	128.50
3	TOP OF BANK	13913553.5237	3035726.8829	128.50
4	TOP OF BANK	13913369.8181	3035921.5782	128.50
5	TOP OF BANK	13913366.3662	3035927.5441	128.50
6	TOP OF BANK	13913361.9575	3035942.1729	128.50
7	TOP OF BANK	13913358.5056	3035948.1388	128.50
8	TOP OF BANK	13912891.3988	3036443.1892	135.59
9	TOP OF BANK	13912805.0893	3036411.2699	135.31
10	TOP OF BANK	13912764.7242	3035569.4506	130.71
11	TOP OF BANK	13912815.6442	3035516.9513	129.01
12	TOP OF BANK	13913142.3371	3035501.2612	128.50
13	TOP OF BANK	13913160.0297	3035503.6002	128.50
14	TOP OF BANK	13913500.9480	3035613.1301	128.50
15	TOP OF BANK	13913509.6769	3035620.5080	128.50
16	TOP OF BANK	13913512.0464	3035625.1137	128.50
17	TOP OF BANK	13913514.3346	3035629.5614	127.30
18	TOP OF BANK	13913516.6213	3035634.0061	128.15
19	TOP OF BANK	13913546.3639	3035691.8188	128.16
20	TOP OF BANK	13913548.6521	3035696.2666	128.15
21	TOE OF SLOPE	13913478.3230	3035700.0868	110.23
22	TOE OF SLOPE	13913320.6756	3035875.2096	111.61
23	TOE OF SLOPE	13913302.6388	3035907.6364	111.81
24	TOE OF SLOPE	13913289.3037	3035916.7514	111.70
25	TOE OF SLOPE	13913234.0753	3035967.1698	111.01
26	TOE OF SLOPE	13913226.9209	3035974.2152	111.01
27	TOE OF SLOPE	13912910.5625	3036311.6940	115.72
28	TOE OF SLOPE	13912875.9804	3036298.6144	115.75
29	TOE OF SLOPE	13912862.9009	3035861.9156	111.38
30	TOE OF SLOPE	13912862.2030	3035851.9353	111.38
31	TOE OF SLOPE	13912834.0343	3035596.2842	113.93
32	TOE OF SLOPE	13912852.7555	3035574.0850	114.09
33	TOE OF SLOPE	13913072.2290	3035561.5975	113.57
34	TOE OF SLOPE	13913104.2816	3035560.6911	113.26
35	TOE OF SLOPE	13913125.9994	3035563.6989	113.10
36	TOE OF SLOPE	13913143.1390	3035563.2817	113.00
37	TOE OF SLOPE	13913450.1249	3035673.5731	110.23

J:\1994\2102\ACAD\SHEET FILES\60%\122 POND POINTS.dwg

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY
ENGINEERING DEPARTMENT

HARRIS COUNTY 1836 TEXAS

LJA Engineering, Inc.
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TEXAS P.E. #125839

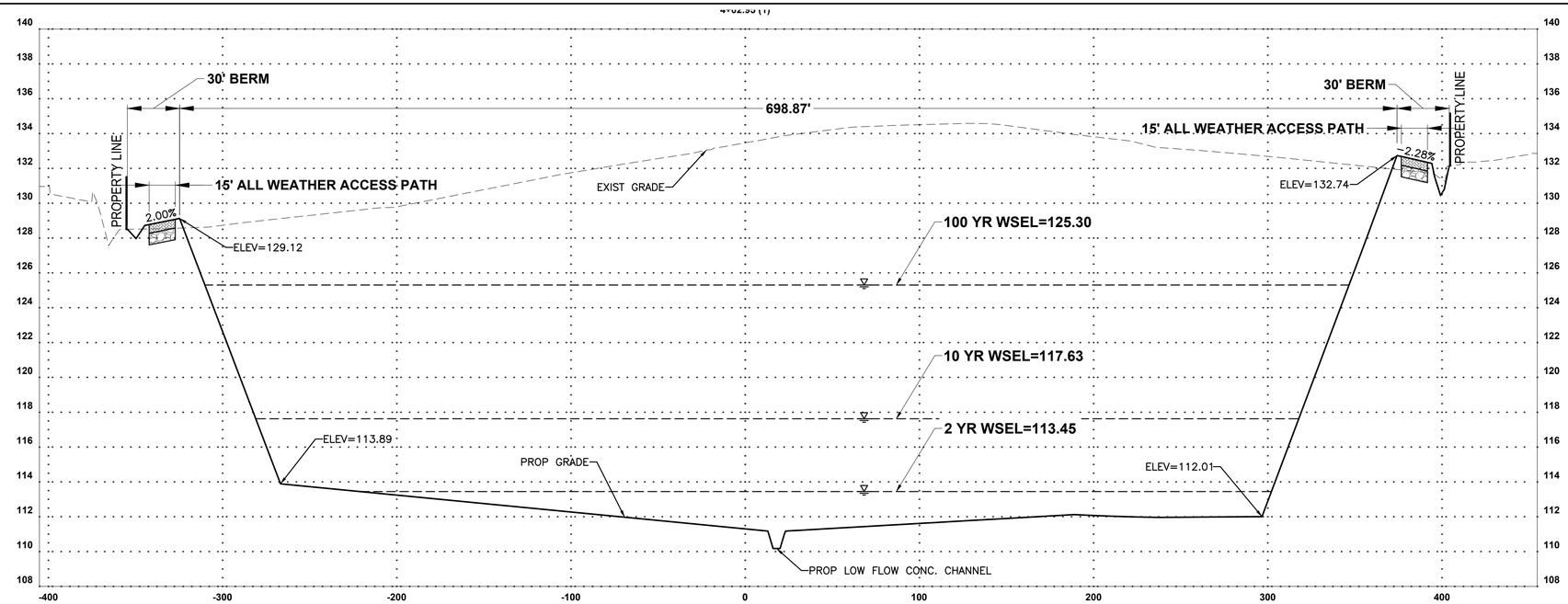
ISSUED ON:
DEC 18 2021

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018 – UPIN 19103MF14601

SHEET DESCRIPTION: POND POINTS

DRAWN BY: | DATE: 12/2/2021

DESIGN BY: | SCALE: | SHEET NO: 122 **163**



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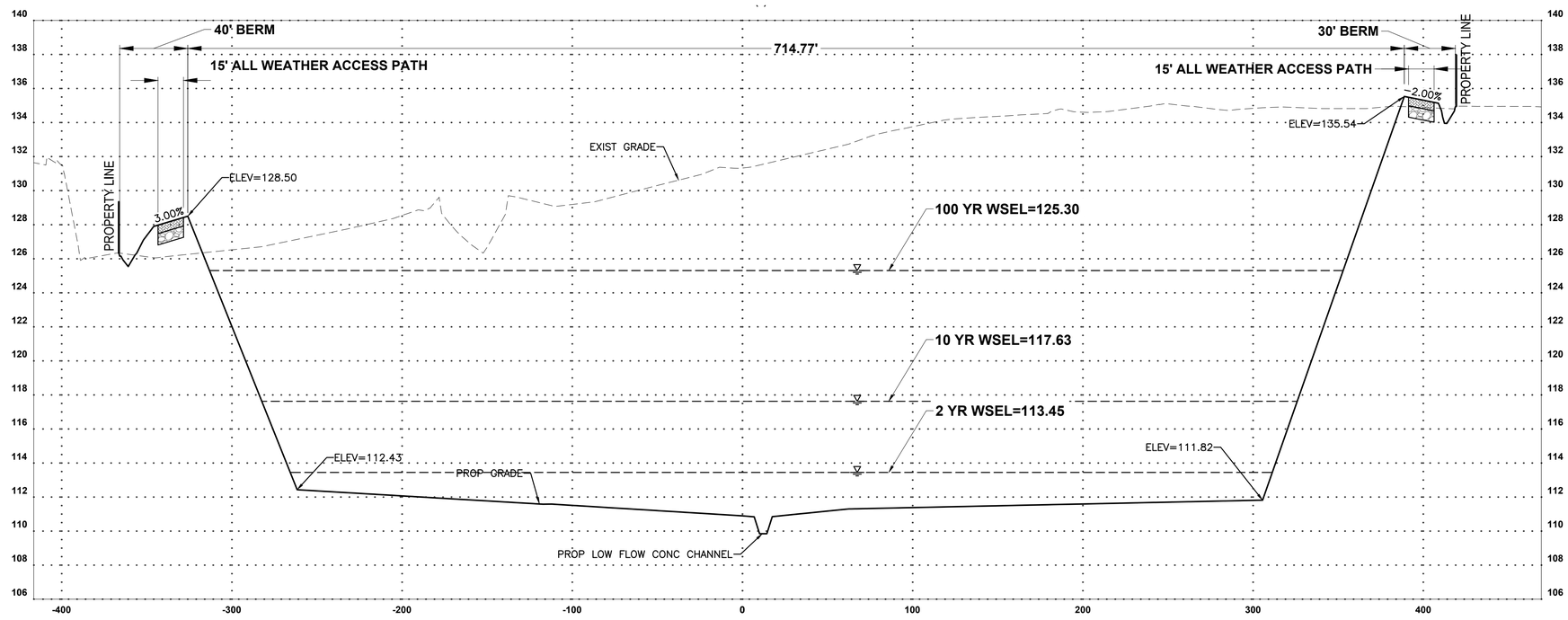

SECTION B–B
1"=40'

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY ENGINEERING DEPARTMENT

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SHEET DESCRIPTION: POND SECTIONS

DRAWN BY:

DATE: 12/2/2021

DESIGN BY:

SCALE:

SHEET NO: 123

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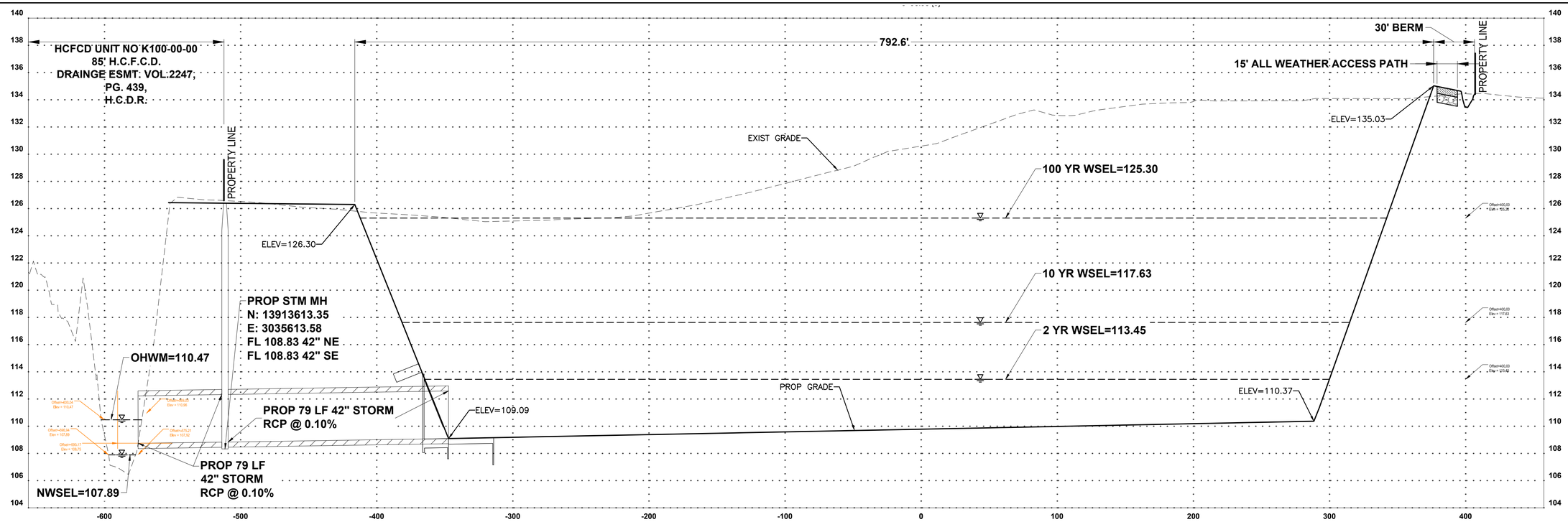

OUTFALL SECTION C-C
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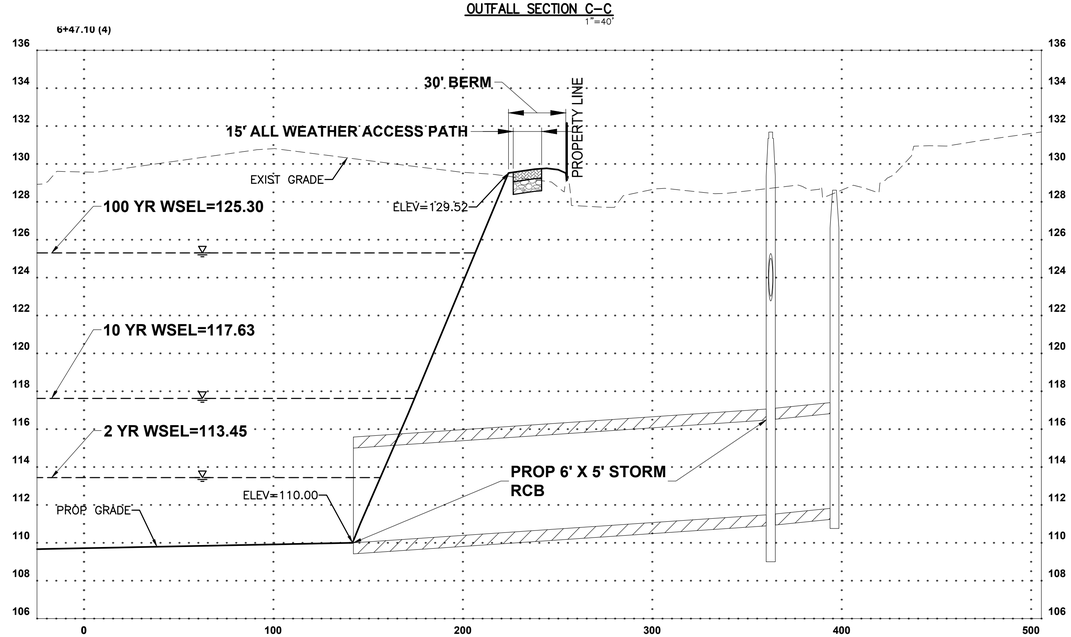

OUTFALL SECTION D-D
1"=40'

NO.	REVISIONS	DATE	NAME

HARRIS COUNTY ENGINEERING DEPARTMENT

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TEXAS P.E. #125839

ISSUED ON:
DEC 18 2021

PROJECT TITLE: RAVENSWAY SUBDIVISION DRAINAGE IMPROVEMENTS – 2018 – UPIN 19103MF14601

SHEET DESCRIPTION: POND OUTFALL SECTIONS

DRAWN BY:
DATE: 12/12/2021
DESIGN BY:
SCALE:
SHEET NO: 124

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APPENDIX E

Post-Project Floodway Surcharge Results

River Station	Post-Project 100-Year WSE (ft)	Post-Project Floodway WSE (ft)	Surcharge (ft)
274030	184.91	185.61	0.69
272601	183.68	184.51	0.83
271395	182.6	183.28	0.68
270356	180.74	181.31	0.56
269458	179.31	180.11	0.8
268288	178.43	179.37	0.94
266491	176.81	177.78	0.97
266161	176.69	177.66	0.97
266065	176.59	177.55	0.96
266035			
266005	176.57	177.52	0.95
265916	176.49	177.35	0.86
265696	176.35	177.17	0.81
264165	175.58	176.38	0.81
262916	175.06	175.94	0.89
262434	174.68	175.57	0.89
260447	173.73	174.56	0.83
259337	172.94	173.87	0.93
257633	172.56	173.52	0.96
256348	172.49	173.47	0.98
255599	172.43	173.39	0.96
254087	172.36	173.31	0.95
252373	172.32	173.27	0.95
251646	172.3	173.24	0.94
251527	172.28	173.22	0.94
251507			
251475	172.28	173.21	0.93
251450	172.26	173.19	0.93
251439 BR U	172.25	173.19	0.93
251439 BR D	172.25	173.18	0.93
251429	172.25	173.18	0.93
251335	172.23	173.16	0.93
250102	171.99	172.93	0.94
249192	171.85	172.81	0.96
248048	171.69	172.68	0.98
247215	171.6	172.59	0.99
245509	171.33	172.33	1
245355	171.31	172.31	1
245276	171.3	172.29	0.99
245265 BR U	171.3	172.29	0.99
245265 BR D	171.3	172.29	0.99
245253	171.29	172.29	0.99
245155	171.28	172.27	0.99
244597	171.22	172.21	0.99
243570	171.07	172.05	0.98
242425	170.85	171.84	0.99

APPENDIX E

Post-Project Floodway Surcharge Results

River Station	Post-Project 100-Year WSE (ft)	Post-Project Floodway WSE (ft)	Surcharge (ft)
240447	170.28	171.26	0.98
240049	170.02	171	0.98
239947	169.93	170.91	0.98
239924			
239899	169.92	170.9	0.98
239803	169.88	170.86	0.98
238992	169.54	170.53	0.99
237222	169.14	170.14	1
236252	168.77	169.73	0.96
234886	168.15	169.04	0.9
234132	167.7	168.58	0.89
233592	167.22	168.17	0.94
232118	166.24	167.03	0.79
230913	165.6	166.45	0.84
229343	164.63	165.52	0.89
228591	164.09	164.84	0.75
226696	163.49	164.38	0.89
225959	163.28	164.22	0.94
224004	163.07	163.97	0.9
222338	162.99	163.86	0.88
222073	162.97	163.85	0.88
221973	162.94	163.8	0.86
221943.5BR U	162.95	163.81	0.86
221943.5BR D	162.94	163.79	0.86
221911	162.92	163.78	0.85
221811	162.92	163.78	0.86
221068	162.82	163.67	0.85
219947	162.66	163.48	0.81
219081	162.42	163.23	0.8
217788	161.69	162.66	0.97
216172	160.86	161.62	0.77
214318	159.47	160.07	0.6
213508	159.12	159.75	0.63
211854	158.49	159.22	0.73
210086	157.56	158.5	0.93
209229	157.22	158.13	0.91
207906	156.61	157.48	0.87
206984	156.16	157.06	0.9
205406	155.6	156.51	0.92
204585	155.42	156.34	0.93
203403	155.01	155.93	0.92
202422	154.62	155.55	0.93
201289	154.21	155.14	0.93
200580	153.96	154.92	0.96
199171	153.48	154.46	0.97
197996	152.72	153.7	0.99

APPENDIX E

Post-Project Floodway Surcharge Results

River Station	Post-Project 100-Year WSE (ft)	Post-Project Floodway WSE (ft)	Surcharge (ft)
196391	151.93	152.7	0.78
195672	151.59	152.29	0.69
194416	151.16	151.75	0.59
194075	150.64	151.29	0.64
193386	150.02	150.66	0.64
191951	148.78	149.25	0.48
190807	147.5	148.01	0.5
190457	147.06	147.58	0.52
190362	146.32	146.97	0.65
190341 BR U	146.11	146.8	0.69
190341 BR D	146.34	146.92	0.59
190317	146.27	146.84	0.57
190211	146.25	146.85	0.6
189564	146.01	146.64	0.63
187983	145.19	145.96	0.77
186937	144.8	145.54	0.73
185713	144.12	144.7	0.58
185488	144.05	144.65	0.6
185278	144.02	144.62	0.6
185251.5BR U	144.01	144.61	0.6
185251.5BR D	143.99	144.6	0.6
185222	143.99	144.59	0.6
185028	143.94	144.5	0.56
184753	143.73	144.27	0.54
183827	142.79	143.45	0.67
182368	142.45	143.21	0.77
181664	142.37	143.16	0.79
181342	142.25	143.08	0.83
'3.6 Proposed Greenh	142.26	143.09	0.83
'3.6 Proposed Greenh	142.26	143.09	0.83
181209	142.19	143.05	0.86
181058	142.14	143	0.86
180551	141.95	142.81	0.86
178635	141.05	141.86	0.81
176773	140.73	141.52	0.79
175264	140.52	141.29	0.77
174850	140.46	141.23	0.76
174737	140.42	141.2	0.77
174726.5BR U	140.42	141.19	0.77
174726.5BR D	140.42	141.2	0.77
174712	140.41	141.19	0.78
174645	140.35	141.14	0.79
174629 BR U	140.33	141.12	0.79
174629 BR D	140.23	141.02	0.79
174614	140.24	141.03	0.79
174515	140.21	141.01	0.8

APPENDIX E

Post-Project Floodway Surcharge Results

River Station	Post-Project 100-Year WSE (ft)	Post-Project Floodway WSE (ft)	Surcharge (ft)
174485 BR U	139.96	140.83	0.87
174485 BR D	140	140.86	0.86
174446	140	140.86	0.86
174414	139.95	140.82	0.87
174305 BR U	139.94	140.81	0.88
174305 BR D	139.89	140.78	0.89
174181	139.88	140.77	0.89
174160	139.84	140.74	0.9
174149 BR U	139.88	140.77	0.89
174149 BR D	139.88	140.77	0.89
174137	139.8	140.71	0.9
173866	139.69	140.57	0.88
173590	139.7	140.59	0.89
172338	139.55	140.45	0.9
170765	139.14	140.04	0.91
170585	139.15	140.07	0.92
170558 BR U	139.15	140.06	0.92
170558 BR D	139.14	140.05	0.91
170526	139.14	140.05	0.91
170401	139.14	140.05	0.91
170004	139.1	140.01	0.92
168614	138.88	139.74	0.87
167592	138.52	139.37	0.84
166998	138.35	139.19	0.83
166479	138.07	138.93	0.85
164989	137.1	137.97	0.86
163957	136.6	137.48	0.88
162447	135.89	136.76	0.87
160778	135.62	136.47	0.85
160351	135.34	136.16	0.82
160245	135.3	136.17	0.87
160197 BR U	135.26	136.13	0.87
160197 BR D	135.16	136.05	0.89
160148	135.18	136.07	0.89
160042	135.17	135.99	0.81
159764	135.08	135.9	0.83
158469	134.42	135.25	0.83
156881	133.69	134.47	0.79
155825	133.33	134.09	0.76
154677	132.92	133.65	0.73
153727	132.46	133.12	0.66
152335	132.05	132.76	0.71
151314	131.84	132.56	0.71
151214	131.81	132.49	0.68
151185 BR U	131.81	132.48	0.67
151185 BR D	131.75	132.4	0.65

APPENDIX E

Post-Project Floodway Surcharge Results

River Station	Post-Project 100-Year WSE (ft)	Post-Project Floodway WSE (ft)	Surcharge (ft)
151153	131.7	132.38	0.68
151057	131.55	132.28	0.73
150895	131.24	132.08	0.84
150787	131.26	132.09	0.83
150694	131.22	132.04	0.81
150556	131.22	132.01	0.79
150314	131.15	131.96	0.81
149704	131.06	131.87	0.8
149014	130.8	131.56	0.76
148434	130.53	131.24	0.71
147865	130.44	131.16	0.72
146710	130.16	130.83	0.66
145901	129.94	130.58	0.64
144516	129.4	129.99	0.59
143628	129.21	129.78	0.56
142175	128.73	129.36	0.62
141381	128.41	129.07	0.65
140143	127.91	128.66	0.75
139592	127.85	128.62	0.77
139166	127.77	128.53	0.76
138857	127.58	128.34	0.77
138523	127.41	128.17	0.75
138420	127.32	128.12	0.8
138395 BR U	127.29	128.1	0.81
138395 BR D	127.25	128.06	0.82
138363	127.24	128.06	0.82
138264	127.19	127.96	0.76
137950	126.91	127.65	0.74
135966	125.99	126.89	0.9
134226	125.36	126.28	0.91
134004	125.26	126.13	0.87
133938	125.17	126.07	0.79
133891 BR U #1	125.19	126.07	0.87
133891 BR U #2	125.26	126.16	0.9
133891 BR D #1	125.12	125.91	0.8
133891 BR D #2	125.19	126.01	0.82
133844	125.14	125.95	0.77
133720	125.03	125.83	0.8
133259	124.94	125.76	0.82
131653	124.36	125.11	0.75
130112	124.04	124.83	0.78
128649	123.83	124.65	0.82
127383	123.41	124.2	0.8
127187	123.35	124.17	0.82
127133 BR U	123.34	124.09	0.75
127133 BR D	123.3	124.03	0.73

APPENDIX E

Post-Project Floodway Surcharge Results

River Station	Post-Project 100-Year WSE (ft)	Post-Project Floodway WSE (ft)	Surcharge (ft)
127079	123.3	124.05	0.75
126877	123.22	123.94	0.72
125669	122.79	123.47	0.68
124910	122.42	123.14	0.72
124810	122.26	123	0.74
124751 BR U	122.21	122.96	0.75
124751 BR D	122.08	122.85	0.77
124694	122.09	122.86	0.77
124593	122.11	122.86	0.75
124097	121.99	122.76	0.77
123437	121.76	122.55	0.79
123344	121.73	122.53	0.8
123333.5BR U	121.77	122.56	0.79
123333.5BR D	121.77	122.56	0.79
123316	121.67	122.47	0.81
123212	121.62	122.41	0.79
122086	121.12	121.95	0.83
120997	120.82	121.72	0.91
120252	120.64	121.55	0.91
120126	120.49	121.39	0.9
119576	120.27	121.2	0.93
118501	120.03	120.7	0.66
118399	120.03	120.74	0.71
118237 BR U	120.02	120.73	0.71
118237 BR D	119.91	120.64	0.72
118064	119.91	120.64	0.73
117950	119.86	120.55	0.68
116864	119.62	120.31	0.69
115085	118.94	119.63	0.69
113128	117.86	118.75	0.89
112513	117.65	118.58	0.94
112191	117.58	118.54	0.96
111804	117.51	118.48	0.97
111668	117.51	118.47	0.95
111533	117.43	118.39	0.95
111378	117.4	118.36	0.96
111334.5BR U	117.36	118.36	1
111334.5BR D	117.29	118.25	0.95
111284	117.3	118.25	0.94
111078	117.27	118.2	0.93
110864	117.23	118.15	0.93
109706	116.99	117.87	0.88
109583	116.92	117.82	0.9
109428	116.89	117.8	0.91
109413 BR U	116.86	117.77	0.91
109413 BR D	116.34	117.25	0.91

APPENDIX E

Post-Project Floodway Surcharge Results

River Station	Post-Project 100-Year WSE (ft)	Post-Project Floodway WSE (ft)	Surcharge (ft)
109400	116.35	117.27	0.92
109300	116.13	117.06	0.93
108918	115.93	116.92	0.99
108501	115.85	116.76	0.92
108274	115.78	116.74	0.96
108232 BR U	115.78	116.73	0.95
108232 BR D	115.73	116.68	0.95
108188	115.73	116.68	0.95
107974	115.67	116.62	0.94
107642	115.62	116.56	0.95
106632	115.41	116.38	0.97
104790	115.17	116.13	0.97
103431	114.81	115.79	0.98
103030	114.67	115.64	0.96
102901	114.65	115.62	0.97
102890.5BR U	114.62	115.58	0.96
102890.5BR D	114.62	115.58	0.96
102875	114.62	115.58	0.96
102762	114.57	115.54	0.97
102667	114.55	115.52	0.97
101787	114.07	115.08	1
100946	113.76	114.74	0.98
99588	113.4	114.35	0.95
98945	113.06	114.05	1
98740	112.99	113.98	1
98688 BR U	112.99	113.98	1
98688 BR D	112.93	113.82	0.89
98634	112.93	113.82	0.89
98373	112.84	113.74	0.89
97287	112.52	113.42	0.9
96543	112.1	112.98	0.88
95525	111.7	112.56	0.86
94445	111.29	112.14	0.86
93663	110.97	111.82	0.85
91723	110.09	110.92	0.83
91077	109.84	110.7	0.85
90869	109.62	110.56	1
90822.5 BR U #1	109.71	110.65	0.94
90822.5 BR U #2	109.54	110.47	0.93
90822.5 BR D #1	109.6	110.65	1.05
90822.5 BR D #2	109.39	110.36	0.97
90765	109.42	110.36	0.98
90551	109.39	110.34	0.95
89785	109.18	110.07	0.89
88708	108.9	109.8	0.9
87603	107.96	108.82	0.87

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Post-Project Floodway Surcharge Results

River Station	Post-Project 100-Year WSE (ft)	Post-Project Floodway WSE (ft)	Surcharge (ft)
86475	107.66	108.52	0.86
85145	107.12	107.96	0.84
83550	106.08	107.07	0.99
82323	105.72	106.7	0.98
80450	105.05	105.98	0.93
78955	104.59	105.52	0.92
78178	104.36	105.28	0.92
76574	104.03	105.02	0.99
75290	103.84	104.83	0.99
73539	103.23	104.21	0.98
71757	102.48	103.46	0.98
71520	102.15	103.12	0.97
71478 BR U	101.89	102.79	0.91
71478 BR D	101.32	102.13	0.81
71432	101.4	102.24	0.84
71179	101.4	102.25	0.85
70967	101.13	101.97	0.84
69993	100.49	101.35	0.86
69040	100.34	101.2	0.87
67953	99.92	100.76	0.84
67762	99.82	100.71	0.89
67655	99.8	100.66	0.86
67644 BR U	99.84	100.67	0.82
67644 BR D	99.82	100.63	0.82
67633	99.69	100.6	0.92
67533	99.56	100.55	0.99
65757	98.98	99.97	0.99
63900	98.55	99.5	0.95
62702	98.24	99.16	0.93
61150	97.28	98	0.72
60282	97.25	98.03	0.78
58980	97.03	97.77	0.74
57388	95.9	96.7	0.8
56074	95.72	96.4	0.68
55399	95.66	96.33	0.67
53569	95.33	95.96	0.63
52461	95.19	95.8	0.61
51407	94.79	95.33	0.54
51161	94.32	95.02	0.7
50993.5 BR U	94.26	94.97	0.71
50993.5 BR D	93.9	94.64	0.74
50807	93.89	94.63	0.74
50514	93.65	94.34	0.68
49972	93.36	94.03	0.67
49009	92.97	93.6	0.63
47721	92.47	93.08	0.61

APPENDIX E

Post-Project Floodway Surcharge Results

River Station	Post-Project 100-Year WSE (ft)	Post-Project Floodway WSE (ft)	Surcharge (ft)
46121	91.84	92.18	0.34
45596	91.69	91.94	0.24
44408	90.95	91.12	0.18
42486	89.83	89.98	0.15
42017	89.5	89.66	0.16
41696	89.38	89.55	0.17
41653.5 BR U	89.34	89.49	0.15
41653.5 BR D	88.65	89.45	0.81
41578	88.65	89.45	0.81
41496	88.65	89.45	0.81
41431 BR U	88.57	88.65	0.08
41431 BR D	88.5	88.65	0.15
41366	88.52	89.38	0.86
41320	88.46	89.32	0.87
41296.5 BR U	88.43	89.29	0.86
41296.5 BR D	88.4	89.26	0.86
41272	88.4	89.27	0.87
41055	88.32	89.2	0.88
40546	88.01	88.89	0.88
39789	87.75	88.62	0.87
38150	86.91	87.79	0.88
37750	86.86	87.75	0.89
37732 BR U	86.93	87.68	0.74
37732 BR D	86.93	87.67	0.74
37714	86.75	87.7	0.95
36814	86.48	87.36	0.88
35492	85.78	86.57	0.79
34622	85.5	86.31	0.81
33472	84.95	85.69	0.74
32385	84.43	84.98	0.55
32215	84.18	84.78	0.59
32175 BR U	84.18	84.56	0.37
32175 BR D	83.84	84.26	0.42
32130	83.79	84.3	0.51
32081	83.81	84.25	0.45
32070 BR U	83.99	84.28	0.29
32070 BR D	83.99	84.28	0.29
32056	83.47	84.14	0.67
31954	83.43	84.11	0.68
31170.63	82.64	83.53	0.89
30887	82.45	83.38	0.92
30107.05	81.79	82.55	0.76
29612.31	81.73	82.56	0.83
29226	81.47	82.35	0.87
28610.95	81.54	82.34	0.8
28109	81.33	82.12	0.79

APPENDIX E

Post-Project Floodway Surcharge Results

River Station	Post-Project 100-Year WSE (ft)	Post-Project Floodway WSE (ft)	Surcharge (ft)
26635	80.32	81.1	0.78
26405	80.21	80.98	0.77
26376 BR U	80.32	80.96	0.63
26376 BR D	80.32	80.91	0.59
26344	80.03	80.91	0.88
26152	79.81	80.69	0.88
25956	79.77	80.63	0.87
24423	79.28	80.15	0.88
23894	78.88	79.78	0.9
23289	78.38	79.31	0.93
22568	78.1	79	0.9
20680	77.48	78.37	0.9
19313	77.05	77.89	0.84
18611	76.69	77.51	0.82
17183	75.95	76.75	0.8
16487	75.75	76.55	0.8
14603	74.74	75.31	0.57
12763	73.96	74.57	0.6
11417	73.62	74.21	0.59
10889	73.29	73.85	0.57
10629	72.89	73.52	0.63
10588.5 BR U	72.89	73.53	0.64
10588.5 BR D	72.73	73.38	0.65
10534	72.68	73.32	0.64
10280	72.75	73.34	0.59
9768	72.64	73.24	0.6
8114	71.99	72.49	0.5
7033	71.58	72	0.42
5279	71.08	71.4	0.32
3988	70.55	70.86	0.32

Appendix D
HCFCD Letter of No Objection

April 6, 2022

Brett Bercher, P.E.
Watershed Management Department
Harris County Flood Control District
Houston, Texas 77092

9900 Northwest Freeway
Houston, TX 77092
346-286-4000

RE: e-Permits Application: 2112090019
Ravensway Subdivision Drainage Improvements
HCFCD Unit No.: K100-00-00
Precinct: 3, Key Map No.: 368 K
Geotechnical Letter of No Objection Imposed

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e-Permit Applicant: Peniamina Lesa
Harris County RRD
13105 Northwest Freeway, Suite 600, Houston, TX 77002
Phone: (385) 625-8104; e-mail: Ben.Lesa@eng.hctx.net

Geotechnical Engineer: Ashique Ahmed, Ph.D., P.E.
Jubair Hossain, Ph.D., P.E. (TX PE License No.: 122131)
HTS, Inc. Consultants

Geotechnical Report No.: 21-S-477 Revision 2, dated March 2, 2022

Project Information:
The Flood Control District has reviewed the Geotechnical Report No. 21-S-477 Revision 2, dated March 2, 2022, submitted by HTS, Inc. Consultants (HTS), pursuant to the HCFCD Policy, Criteria, and Procedure Manual (PCPM). This memo addresses issues regarding geotechnical design criteria applicable to the proposed detention basin associated with above referenced Flood Control Facility.

The project consists of the construction of an approximately 10.5-acre detention basin and installation of RCP and RCB outfall structures for the drainage improvement of Ravensway Subdivision. The proposed basin is located south of the Cypress Creek (HCFCD Unit No. K100-00-00), east of Huffmeister Road, west of the Ravensway residential subdivision, and north of Ravensway Drive. The proposed detention basin will be approximately 15- to 25-foot deep with side slope inclination of 4H:1V.

A total of seven (7), 50-foot deep soil borings were drilled and sampled for this project.

Laboratory testing was carried out for classification testing and developing the design shear strength parameters for the study as well as evaluating the dispersion characteristics of slope soils, and provide recommendations for slope protection/erosion control.

Engineering analyses were carried out to determine the stable slope inclination for the proposed detention basin.

Regulatory and Technical Evaluation:
The subject geotechnical report is revised based on HCFCD's review comments provided previously with two different memos, dated January 7 and February 22, 2022.

HCFCD has completed review of the Geotechnical Report No. 21-S-477 Revision 2, dated March 2, 2022, submitted by HTS. Based on HCFCD's review of the report mentioned above, a number of deficiencies are still observed to be present in this report and some of the comments are not addressed as directed.

Despite the deficiencies cited above, considering the large number of resubmittals over a span of several months, HCFCD decided to impose no objection to the subject Geotechnical Report No. 21-S-477 Revision 2, dated March 2, 2022. This decision is based on relatively conservative design parameters developed for the engineering analysis and known performance level of similar basins within Harris County area. The e-Permits applicant is suggested to note that this is a one-time exception allowed by the District.

Conclusion:
Consequent to the findings of HCFCD's technical review of the geotechnical report, HCFCD imposes no objection to the Geotechnical Report No. 21-S-477 Revision 2, dated March 2, 2022, prepared by HTS, only for this time. If you have any questions regarding the technical evaluation, please contact HCFCD by phone (at 346-286-4000) or by email (preferred).

Mohammad R. Bhuiyan, P.E. (Mohammad.Bhuiyan@hcfcd.hctx.net)
Geotechnical Task Manager
Watershed Management Department
Engineering Division

HARRIS COUNTY FLOOD CONTROL DISTRICT

9900 Northwest Freeway
Houston, Texas 77092
346-286-4000
www.hcfcd.org

March 23, 2022

Mr. David Randolph, P.E.
Harris County Permits Division
10555 Northwest Freeway, Suite 120
Houston, TX 77092
David.Randolph@eng.hctx.net

SENT VIA ELECTRONIC MAIL: NO HARD COPY TO FOLLOW

RE: Project No. 2201180135
Ravensway Subdivision Improvements Drainage Impact Analysis
HCFCD Unit K100-00-00; Key Map 368-K,L; Pct. 3

Dear Mr. Randolph:

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 only. 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"* section.

HCFCD Jurisdiction

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

- 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
Ravensway Subdivision Improvements Drainage Impact Analysis March 11, 2022	Gauge Engineering, LLC 3200 Wilcrest Drive, Suite 220 Houston, TX 77042 TBPE Registration No. F-20017 Heather Goodpasture, P.E. TX P.E. # 126705

Project Summary

This report presents a drainage assessment and develop recommendations for local drainage improvement to the Ravensway Subdivision. The subdivision is reported to experience frequent flooding, which is supported by historical flooded structure records as well as impassable roadways due to high inundation. The project study area of concern is 290-ac within the Cypress Creek Watershed and Harris County. In the existing condition, the project area drains to K100-00-00 and K163-00-00 via underground storm sewer. Improvements proposed to the local drainage systems focused on increased conveyance and the associated mitigation at a preferred detention location. To prevent the proposed conveyance improvements from creating an increase in discharge to K100-00-00, a detention basin is proposed. The proposed detention basin is to be located on the northwest side of the project area adjacent to Huffmeister Rd. and is recommended to hold 101 ac-ft of volume to mitigate the 100-year storm event. Two (2) improvement options were identified and evaluated. It is recommended that the Option 2 improvements be considered for construction within the Ravensway Subdivision and along Texas Army Trail Road.

Detention Summary

Not provided in the report.

Floodplain Related Information

According to FEMA FIRM Panel No. 48201C0430M, effective October 16, 2013, the project area is located partially within the regulatory floodplain and floodway.

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, *"This analysis has shown that the proposed project improvements 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 Atlas 14 100-year storm event. It has also been shown that the Ravensway Subdivision Drainage Improvements project will not increase the effective Base Flood Elevations (BFEs) or change the effective regulatory floodway."*

Hydrologic & Hydraulic Technical Review

HCFCD offers the following:

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 Atlas 14 100-year storm event. The report also includes statements that the project will not increase the effective Base Flood Elevations (BFEs) or change the effective regulatory floodway. 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

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

All work proposed 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 regarding the technical comments, please contact Mr. Wen Zhang, P.E. via email at *Wen.Zhang@hcfcd.hctx.net*. For any other questions, you may contact me at *brett.bercher@hcfcd.hctx.net*.

Sincerely,

Brett K. Bercher, P.E.
Watershed Coordinator

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