Texas Water Development Board

VOLUME 2

2023 REGIONAL FLOOD PLAN
REGION 6
SAN JACINTO

January 2023

PREPARED FOR THE **SAN JACINTO REGIONAL FLOOD PLANNING GROUP**

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Appendix 5-4F:
White Oak Bayou CDBG-MIT

MEMORANDUM

HARRIS COUNTY FLOOD CONTROL DISTRICT

9900 Northwest Freeway

Houston. TX 77092

DATE: November 28, 2022

TO: Gary Bezemek, PE
Feasibility Studies Department Manager

FROM: Burton Johnson, PE, CFM
Project Manager, Feasibility Studies Department

RE: Little White Oak Bayou CDBG-MIT Project
Project Background and Certification of No Adverse Impact

The purpose of this memorandum is to provide a general description of the Little White Oak Bayou Sub-Watershed Flood Risk Reduction Plan proposed project and specifically the identified project along Little White Oak Bayou as part of the CDBG-MIT application, and to certify that the proposed CDBG-MIT project will not result in an increase in flood risk or flood levels in the Little White Oak Bayou watershed and areas downstream.

Earlier this year, the Harris County Flood Control District completed development of a large flood risk reduction plan for the Little White Oak Bayou sub-watershed of White Oak Bayou. This study was prepared by Entech Civil Engineers, Inc. under my supervision and direction. The Little White Oak Bayou subwatershed encompasses 22 acres in the lower portion of the larger White Oak Bayou watershed. The subwatershed includes 32 miles of channel and main trunkline lateral systems in a heavily developed and floodprone portion of Harris County.

The recommended plan includes features anticipated to be constructed by TxDOT as part of the North Houston Highway Improvement Project (NHHIP) Segment 2, including the replacement of four highway/road crossings, two detention basins, and the North Canal bypass of Buffalo Bayou (actually part of Segment 3). Additionally, the plan includes channel modifications between Stokes Road and Tidwell Road and between Yale Boulevard and Little York Road, four detention areas totaling 1,600 acre-feet of storage, and improvements to 12 lateral systems. The TxDOT NHHIP lower downstream flowrates and water surface elevations, and as such the lower channel and areas downstream are able to accommodate the increased flowrates resulting from the proposed channel modifications. The primary purpose of the detention storage is to offset the increased flowrates from the proposed improvements to the lateral systems.

During the preparation of the larger sub-watershed study, the study team was asked to extract and identify a stand-alone project that could be put forward as a CDBG-MIT grant. The project identified was a sub-set of the larger sub-watershed plan being formulated at the time, and consisted of channel modifications from Crosstimbers Road to Tidwell Road and approximately 800 acre-feet of detention in the same reach.

While the CDGB-MIT project described above (and described in more detail in the CDBG-MIT application) was part of the larger plan for Little White Oak Bayou, the timing does not afford the luxury of the benefits of the NHHIP features and therefore to prevent downstream impacts it must be self-mitigating. For the larger watershed plan, the purpose of the detention storage is to mitigate impacts from improvements to the lateral system. The CDBG-MIT project does not include the lateral system improvements and therefore the detention is targeted toward the mitigation of the proposed main-stem channel modifications between Crosstimbers Road and Tidwell Road.

Typically, a certification of no adverse impact is included in the report supporting a project. Since the CDBG-MIT project was extracted from the larger sub-watershed study, a stand-alone report was not prepared. In lieu of a traditional report, this memorandum provides the certification of no adverse impact. The proposed channel modifications along with 800 acre-feet of detention storage were modeled using the project models. The results were compared to the baseline condition models to confirm no impact along Little White Oak Bayou are in the receiving channels downstream. The results of this modeling generally showed the proposed project results in a decrease in peak flowrates and water surface elevations for areas upstream, adjacent to, and downstream of the project for events up to and including the 500-year event (using the legacy HCFCD rainfall). There are some cross sections that show a very small increase of no more than 0.20 feet. During the development of the project, we determined that this very small increase was the result of some numerical nuance that could be eliminated by optimizing the detention basin inflow and outflow controls and did not represent an adverse impact downstream. When this project moves forward in the project life cycle, the appropriate features will be further considered and optimized.

Based upon my review of the computed flowrates and water surface elevations associated with the CDBG-MIT project described in this memorandum along with and my understanding of the hydrologic and hydraulic models utilized in the determination of the water surface elevations, I hereby conclude and certify that the proposed CDBG-MIT project will not increase water surface elevations and peak flowrates upstream of, adjacent to, or downstream of the proposed project.

STATE OF TEXAS
BURTON L. JOHNSON
79741
LICENSED
PROFESSIONAL ENGINEER

Burton L Johnson

Mitigation Application

General

Program *

Hurricane Harvey State Mitigation Competition – HUD MID

Applicant *

Harris County Community Services Department (CSD)

County *

Harris

Application Type *

New

FY End Date

2/28/2021

Council of Governments

Houston-Galveston Area Council (HGAC)

Each application must upload a MIT-Local Certifications form signed by an authorized signatory along with other required application documentation. Each applicant for CDBG-MIT funding must certify by signing that both the Application for Federal Assistance Standard Form 424 (SF-424) and the MIT-Local Certifications form provided on the GLO website and described in the application guide were followed in the preparation of any CDBG-MIT program application, and will continue to be followed in the event of funding.

The Application for Federal Assistance Standard Form 424 (SF-424) and the MIT-Local Certifications

Related Contacts

Contact *

Mrsny, Reid

Authorized Representative

Hidalgo, Lina

Grant Administrator

Hickingbottom, Kent

Standard Form 424

Application Title *

White Oak Bayou Partnership Application

Applicant Delinquent on Federal Debt

- [x] No
- [ ] Yes

Construction Application

- [ ] No
- [x] Yes

Construction Pre-Application

- [x] No
- [ ] Yes

Program Not Selected by State for Review

- [x] No
- [ ] Yes

Mitigation Application

Addressed Risk - Select the risk identified in the Action Plan that will be addressed. (select all that apply)

- [x] **Hurricanes/Tropical Storms/Tropical Depressions**
- [ ] **Severe Coastal Flooding**
- [x] **Riverine Flooding**

"The Federal Register, 84 FR 45838 (August 30, 2019) defines mitigation as:
"Activities that increase resilience to disasters and reduce or eliminate the long-term risk of loss of life, injury, damage to and loss of property, and suffering and hardship, by lessening the impact of future disasters."

Applicants must describe in narrative format how their proposed project meets the above definition and clearly identify the methodology used to determine how the described criteria are being met. Include information identifying how the proposed project addresses overall local mitigation needs.

Mitigation presents communities with unique opportunities to examine a wide range of issues including (1) housing quality and availability, (2) road and rail

Hazard, Risk Description - Describe how the risk(s) selected are impacting the proposed project area. Reference where adopted local mitigation efforts are planned or underway where appropriate.

Subdivisions and businesses throughout the White Oak Bayou Watershed in Harris County experience flooding conditions during hurricanes, tropical storms, and even intense rainfall events that overwhelm drainage systems and result in riverine, or out-of-bank, flooding of the local bayous, tributaries, and drainage channels. The risk of flooding is a daily threat to the residents that live in areas with aging and inadequate drainage systems. The project sites identified throughout this application are part of an organized county-wide effort to analyze infrastructure shortfalls, build community resilience, and mitigate future hazards through flood risk reduction projects and strict floodplain management practices. The sites described in this application benefit many residents in some of the most vulnerable and at-risk areas of the County.

The massive and long-term financial commitment is recognized locally, and so a portion of project site costs, most of the sites included in this application, were approved for funding in the 2018 Harris County Flood Control District Bond Program. While some funding was earmarked for these sites, and is currently being used to fund the engineering study and design, the bond funding is not adequate to construct the required improvements. As a result, Harris County and Harris County Flood Control District are in dire need of additional funding to help address these urgent concerns. Income and need were factors when selecting projects for inclusion in the Bond program and the improvements were designed to assist low- and moderate-income persons/communities. Earmarked funding can be found in the Harris County FY 2020 Mid-Year Review and Capital Improvements Program (CIP), adopted in September 2019, along with subdivisions and mapped sites. Additionally, measures needed to address subdivision drainage were included in the Harris County Hazard Mitigation Plan.

See the attached narrative for additional information.

Hazard Mitigation Actions - Describe how the proposed project will mitigate against the identified risks. Reference where adopted local mitigation efforts are being enhanced where appropriate.

The Greater Houston area has experienced multiple major flooding events in recent years including the Memorial Day Flood (2015), the Tax Day Flood (2016) and Hurricane Harvey (2017). These events have amounted to 84 deaths and over $125.5 billion in damages. Because of the devastation and the need to identify measures to mitigation the impacts of major storm events, Harris County studied nearly 100 previously flooded subdivisions and found drainage solutions to mitigate risk to life and safety during future storm events.

This Flood and Drainage Activity improves drainage at neighborhood and regional levels by making improvements to subdivisions (Barwood, Kolbe Road area, and Tower Oaks Meadows) within the White Oak Bayou Watershed and to the E132-00-00 and Little White Oak Bayou channels. The proposed improvements include adding or upgrading storm sewer systems, adding curb and gutter systems, and increasing storage capacity with new detention basins and enlarging channels. The increased capacity across multiple project sites ultimately places less burden on the watershed, or service area. The cumulative benefits of multiple project sites ultimately mitigate property, life, and economic loss in future flooding events.

Harris County and Harris County Flood Control District have adopted the most stringent floodplain regulations in the United States by incorporating robust infrastructure regulations that ensure development follows standards that minimize the likelihood of future flooding. Copies of the Harris County floodplain regulations, infrastructure regulations, and HCFCD Policies, Criteria, and Procedures Manual with proof of adoption by Commissioners Court can be found in the supporting documentation for this application.

Due to space limitations, details for this section can be found in the narrative attached in documents.

Local Adopted Plans - To meet the local plan requirement, applicants follow specific procedures identified in the CDBG-MIT Application Guide

Is the proposed project included in one or more locally adopted plans?

Yes

Provide the title of the adopted plan being referenced.

Harris County Multi-Hazard Mitigation Action Plan

Provide the page number(s) in the adopted plan(s) where the proposed project is identified.

11-1 through 11-38, 21-5

Provide the date (Month, Year) the plan(s) was/ were adopted:

5/19/2020

Added Resiliency Measures

Applicants must explain if prior capital improvement projects, short or long-range planning efforts, community engagement or educational outreach, the implementation of enhanced building codes or code enforcement, or other related work has been completed which enhances hazard mitigation and/or resiliency throughout the applicable community or service area of the applicant(s).

If no previous efforts have been made, this must be stated in the application. If a joint project is being submitted by multiple entities that crosses jurisdictional or service area boundaries, each jurisdiction or entity should provide examples of previous hazard mitigation or resiliency efforts that have been completed within their particular jurisdiction or service area. Source documents, such as signed memorandum, must be attached to the application which prove such efforts have been implemented.

Does the proposed project enhance mitigation efforts that are already completed or underway?

Yes

If Yes, then provide a brief description.

Public meetings were held for all subdivision sites in this application during project development to gain public input and comments. Discussion for E132-00-00 was included with Barwood and Tower Oaks Meadows. The study reports and meeting information have been attached. Harris County and the Flood Control District have also taken measures through the most stringent floodplain regulations in the United States and by incorporating robust infrastructure regulations to ensure that development is built to standards that will minimize the likelihood of future flooding. Copies of the above documents and their adoption by Commissioners Court can be found in the supporting documentation for this application. Also, Harris County and the Flood Control District have included funding for the study and design of the projects in their capital program. A copy of the Capital Improvements Program (CIP) has also been attached.

Please see the attached narrative for additional information.

Select the type(s) of prior or current local efforts undertaken that, combined with the proposed project, will provide enhanced hazard mitigation:

- [ ] **Prior capital improvement project(s)**
- [x] **Current capital improvement project(s)**
- [x] **Short-range planning efforts**
- [x] **Long-range planning efforts**
- [x] **Community engagement**
- [x] **Educational outreach**
- [x] **Implementation of enhanced building codes**
- [x] **Code enforcement**

- [ ] **Other related work which enhances hazard mitigation and/or resiliency through the proposed project.**

Other Hazard Mitigation Work

Mitigation Application Project

Acknowledging that mitigation needs may span a variety of services and facilities, for purposes of Mitigation funding only, the definition of project is expanded to include a discrete and well-defined beneficiary population and subsequent geographic location consisting of all eligible activities required to complete and provide specific successful mitigation benefit to the identified population.

For purposes of Mitigation application and implementation, the Project provided represents the overall Mitigation need being met.

There may be more than one Activity included in a Project. For instance, a successful Mitigation Project may require a drainage facilities activity, a street improvements activity, and a water facilities activity.

Program

Hurricane Harvey State Mitigation Competition – HUD MID

Subrecipient Application/Contract

White Oak Bayou Partnership Application

Project Title

White Oak Bayou Partnership Drainage Improvements

Project Summary

The White Oak Bayou Watershed has experienced multiple major flooding events in recent years including the Memorial Day Flood (2015), the Tax Day Flood (2016) and Hurricane Harvey (2017). These events have amounted to 84 deaths and over $125.5 billion in damages. Because of the devastation and the need to identify measures to mitigation the impacts of major storm events, Harris County studied nearly 100 previously flooded subdivisions and Harris County Flood Control District identified regional solutions, finding drainage alternatives to mitigate risk to life and safety during future storm events.

This Flood and Drainage Activity improves drainage at neighborhood and regional levels by making improvements to subdivisions (Barwood, Kolbe Road area, and Tower Oaks Meadows) within the White Oak Bayou Watershed and to the E132-00-00 and Little White Oak Bayou channels. The proposed improvements include adding or upgrading storm sewer systems, adding curb and gutter systems, and increasing storage capacity with new detention basins and enlarging channels. The increased capacity across multiple project sites ultimately places less burden on the watershed, or service area. The cumulative benefits of multiple project sites ultimately mitigate property, life, and economic loss in future flooding events.

Mitigation Application Project

All of the state's mitigation activities under this grant will meet a national objective for either (1) benefiting low- to moderate-income persons (LMI), or (2) urgent need mitigation (UNM). At least 50 percent of CDBG-MIT funds will be used to support activities that benefit LMI person, and all programs and projects will have an LMI priority. For CDBG-MIT activities, HUD approval will be required to rely on the national objective criteria for elimination of slum and blighting conditions, because this national objective generally is not appropriate in the context of mitigation activities.

As indicated in the State Mitigation Action Plan:

Does the proposed project principally benefit Low- and Moderate-Income Persons or Mitigation Urgent Need?

Low-and Moderate-Income Persons

Low- and Moderate-Income Persons

- [x] **LMI Area Benefit**
- [ ] **LMI Housing Activity**
- [ ] **LMI Limited Clientele**

Provide the proposed beneficiary data:

Total Beneficiaries

439025

LMI Beneficiaries

235750

% LMI Beneficiaries

53.70

Applicants must follow the procurement process guidelines set forth in 2 CFR §200.318-§200.326 for grant administration, environmental, and engineering services if using CDBG-MIT funds to pay third-party vendors for those services. These rules and regulations also apply to procurement of construction services. For better detail regarding procurement methods and requirements, refer to: https://recovery.texas.gov/local-government/resources/procurement-contracting/index.html

Have you procured a third-party administrator to administer the proposed project?

No

Have you procured a third-party environmental service provider for the proposed project?

Yes

Company Name

Various (by site) - Procured with local funds and not requesting reimbursement.

Contact

Email

Phone

Have you procured a third-party engineer for the proposed project?

Yes

Mitigation Application Project

What is the current status of the project?

In Progress

Provide a brief narrative regarding how CDBG-MIT funding is to be used. Demonstrate that all HUD CDBG environmental requirements have been met to date. Applicants should be advised that all HUD CDBG environmenal requirements must be met before reimbursement can be considered.

More information at https://www.hudexchange.info/resource/167/environmental-review-procedures-24-cfr-58
(https://www.hudexchange.info/resource/167/environmental-review-procedures-24-cfr-58)

Funding requested in this application will be utilized to improve drainage at regional and neighborhood levels by constructing drainage infrastructure that meets the most stringent infrastructure and floodplain regulations in the nation. The activities consist of a wide variety of solutions, but generally consist of either upgrading and improving storm sewer systems, adding curb and gutter, or adding a or increasing the capacity of detention basins. The incremental benefit of each project site begins to cumulatively place less burden on the watershed service area. In future flooding events, this improved capacity mitigates deaths and property damage caused by flooding.

Harris County is committed to meeting all HUD CDBG environmental requirements and performing environmental reviews in compliance with 24 CFR 58, and other federal guidelines. In preparation for this application and in meeting environmental requirements, the applicants have performed Phase I Environmental Site Assessments on some sites included in this application, and has performed high level reviews of all sites. The findings from those reviews are indicated below and further detail can be found in the documents section.

Will the proposed project site have any negative impact(s) or effect(s) on the environment per HUD environmental regulations as described?

More information at https://www.hudexchange.info/programs/environmental-review (https://www.hudexchange.info/programs/environmental-review)

No

Is the proposed project site likely to require a historical resources/archaeological assessment?

More information at https://www.hudexchange.info/environmental-review/historic-preservation (https://www.hudexchange.info/environmental-review/historic-preservation)

No

Is the proposed project site listed on the National Register of Historic Places?

More information at https://www.nps.gov/subjects/nationalregister/index.htm (https://www.nps.gov/subjects/nationalregister/index.htm)

No

Is the proposed project site in a designated ood hazard area or a designated wetland?

FEMA Firmette located here: https://msc.fema.gov/portal/search (https://msc.fema.gov/portal/search?)

Yes

Is the applicant participating in the National Flood Insurance Program?

More information at https://www.hudexchange.info/programs/environmental-review/flood-insurance (https://www.hudexchange.info/programs/environmental-review/flood-insurance)

Yes

Is the project in compliance with Executive Order 11990?

More information at https://www.hudexchange.info/environmental-review/wetlands-protection (https://www.hudexchange.info/environmental-review/wetlands-protection)

Yes

Is the project in a designated Regulatory Floodway?

More information at https://www.hudexchange.info/environmental-review/floodplain-management (https://www.hudexchange.info/environmental-review/floodplain-management)

Unknown

Is the proposed project site located in a known critical habitat for endangered species?

More information at https://www.hudexchange.info/environmental-review/endangered-species (https://www.hudexchange.info/environmental-review/endangered-species)

Yes

Is the proposed project site a known hazardous site?

More information at https://www.hudexchange.info/environmental-review/site-contamination (https://www.hudexchange.info/environmental-review/site-contamination)

No

Is the proposed project site located on federal lands or at a federal installation?

No

What level of environmental review is likely needed for the proposed project site?

More information at HUD Exchange (https://www.hudexchange.info/resource/785/summary-table-of-levels-of-environmental-review-and-documentation-required-in-err)

Categorical Exclusion

Provide any additional detail or information relevant to Environmental Review

For some sites, Phase I Environmental Site Assessments were completed. For others, desktop reviews were performed to evaluate the potential impacts. Findings from those reviews are summarized in the documents section of this application. Answers to the above questions could change upon further review. All State and Federal policies and guidelines will be followed in addressing any of the above noted issues.

Mitigation Application Project

Identify activities already achieved to further fair housing, and those activities to be undertaken if an award is made by CDBG-MIT and when that activity will be complete. Upload any backup documentation to support your efforts.

Name	Activity 1
Comment Planned	Publishing the contact information, at the local, state and federal levels, for repor ting a Fair Housing complaint—achieved March 1 2020

Name	Activity 2
Comment Planned	Designating a Fair Housing Month – will achieve April 1, 2021 and have achieved April 1, 2020

Name	Activity 3
Comment Planned	Develop an anti-NIMBYism plan – achieved Nov. 12, 2018

Name	Activity 4
Comment Planned	Developed an AFH/Fair Housing Plan and submitted to HUD – achieved Jan 31, 2019

The Project Level Budget represents summary data compiled as each Activity and Site are defined. Applicants are expected to present a thorough budget at the site level that includes all elements required for an eligible and successful project. Construction or public facilities budgetary information must be provided by a professional engineer or architect licensed to practice in the state of Texas using the **MIT-Budget Justification of Retail Costs (formerly Table 2)** form available the GLO website at: https://recovery.texas.gov/files/resources/mitigation/mit-budget-justification-of-retail-costs.xlsx

Original sealed construction and public facilities budgetary information must be uploaded as supporting

Minimum Total Amount Requested

$0.00

Maximum Total Amount Requested

$1,000,000,000.00

Maximum # of Activities per Project

20 Activities

Total Estimated/Original Project Budget

$100,000,000.00

Budget Activities

Program Budget Code	Flood control and drainage Improvements
Planned/Requested Amount	100,000,000.00
Total Other Funds	$17,207,261.05
Activity Total	$117,207,261.05

Project Site

Project Sites & Locations

Program

Hurricane Harvey State Mitigation Competition – HUD MID

Site Number

S-003175

Site Title *

Barwood Subdivision Drainage Improvements

Site Description

The Barwood subdivision, constructed in the 1970s, consists of 200+ acres of residential parcels and is located southwest of the intersection of N Eldridge Parkway and Cypress North Houston Road. The existing drainage system consists of curb and gutter roadways with Type B and BB inlets that drain to an underground storm sewer system. The storm sewer outfalls into either the Harris County Flood Control District (HCFCD) channel E132-00-00 to the east or the HCFCD channel E133-00-00 to the west. Approximately 70 acres drain west to HCFCD channel E133-00-00 through a single outfall. The remaining 130 acres drain east to the HCFCD channel E132-00-00 through seven (7) outfalls. The existing system is considered partially non-conforming with current infrastructure regulations primarily due to small inlets (Type B), non-existent detention, and lack of extreme event sheetflow paths.

Historic heavy rain events and recent extreme rain events such as Hurricane Harvey and Houston Tax Day Flood caused widespread flooding throughout the Barwood subdivision. During the Tax Day Flood, some homes saw up to 12 inches of water, and during Hurricane Harvey some residents reported up to 30 inches. The neighborhood is very flat topographically and is bordered by two major drainage ditches to the east and west draining south to White Oak Bayou. The high tail water conditions in E132-00-00 and E133-00-00 during extreme rainfall events exacerbate the flooding conditions internal to the Barwood Subdivision.

During Hurricane Harvey, 131 homes reported flooding with an average depth of 4.21 inches. During the 2016 Tax Day event, 31 homes reported flooding with an average depth of 2.65 inches. There are 32 FEMA repetitive loss claims in the Barwood Subdivision, spread throughout the area.

Street Address

Campos and Chetman

Street Limits on Street

From Street

To Street

Zip Code

77065

City

Houston

County

Harris

State

TX

Latitude

29.94261

Longitude

-95.61223

Scope of Work

The proposed Barwood flood and drainage activity project includes the addition of storm sewer along North Eldridge Parkway to increase capacity of the existing system as well as the strategic replacement of storm sewer within the subdivision. The construction of extreme event overflows along the HCFCD channel E132-00-00 are included in the improvements as well. These improvements conform to current infrastructure regulations and provide a greater level of protection during severe flooding. The proposed improvements create downstream adverse impact, but the E132-00-00 Mitigation project addresses these needs and must be constructed in advance of the Barwood flood and drainage activity.

The proposed improvements result in a significant benefit to mitigating flooding in the subdivision by reducing the 100-year, or 1% AEP, water surface elevations by 6 to 24 inches. The reduction in ponding depth mitigates future flood damages for 131 homes.

As previously indicated, applicants must follow the procurement process guidelines set forth in 2 CFR §200.318-§200.326 for procurement of construction services. For better detail regarding procurement methods and requirements, refer to:
https://recovery.texas.gov/local-government/resources/procurement-contracting/index.html

Have you procured construction services for the proposed project?

No

Construction completion method to be used

Competitve Sealed Bid/Contract

Will acquisition of real property or any activity requiring compliance with URA be required?

No

Applicants must follow 2 CFR 200 rules and regulations in the procurement of construction services. For better detail regarding procurement methods and requirements, refer to 2 (

Districts and Elected Officials

Cong. Rep

McCaul, Michael

State Rep

Oliverson, Tom

State Senator

Bettencourt, Paul

Cong. Rep District #

10

State Rep District #

130

State Senator Dist#

7

Site Budget

Specify Site Budget Information

Total Requested Grant Funds

$4,232,492.55

Total Other Funds

$903,375.00

Total Grant & Other Funds

$5,135,867.55

Amount Requested	$18,067.50
Site Budget Code	CDBG-MIT Environmental
Other Funds	
Site Budget Total	$18,067.50
Name	Barwood Subdivision Drainage Improvements - CDBG-MIT Environmental
Created On	9/23/2020 11:27 AM
Budget Line Item	Flood control and drainage Improvements - - GLO17-11274-P

Amount Requested	$239,575.05
Site Budget Code	CDBG-MIT Admin
Other Funds	
Site Budget Total	$239,575.05
Name	Barwood Subdivision Drainage Improvements - CDBG-MIT Admin
Created On	9/23/2020 11:31 AM
Budget Line Item	Flood control and drainage Improvements - - GLO17-11274-P

Amount Requested	$361,350.00
Site Budget Code	CDBG-MIT Engineering
Other Funds	$903,375.00
Site Budget Total	$1,264,725.00
Name	Barwood Subdivision Drainage Improvements - CDBG-MIT Engineering
Created On	9/23/2020 10:57 AM
Budget Line Item	Flood control and drainage Improvements - - GLO17-11274-P

Amount Requested	$3,613,500.00
Site Budget Code	CDBG-MIT Construction
Other Funds	
Site Budget Total	$3,613,500.00
Name	Barwood Subdivision Drainage Improvements - CDBG-MIT Construction
Created On	9/23/2020 10:54 AM
Budget Line Item	Flood control and drainage Improvements - - GLO17-11274-P

Site Metrics

Name	Linear Feet of Public Improvement
Comment Planned	Storm Sewer Upgrades (LF) - 5,180 Storm Sewer New (LF) - 1,300 Manholes (EA) - 4
Numeric Resp Planned	6480

Name	Number of public improvements
Comment Planned	Storm Sewer Upgrades (LF) 5180 Storm Sewer New (LF) 1300 Manholes (Ea) 4
Numeric Resp Planned	3

Project Site

Project Sites & Locations

Program

Hurricane Harvey State Mitigation Competition – HUD MID

Site Number

S-003176

Site Title *

Tower Oaks Meadows Subdivision Drainage Improvements

Site Description

The Tower Oaks Meadows subdivision was developed throughout the 1970s and consists of 150+ acres of residential parcels. Tower Oaks Meadows is located immediately south of Barwood and is drained via roadside ditches and driveway culverts which drain to an existing storm sewer trunk line along the back of lots between Dakar and Aste Streets. The storm sewer outfalls into the HCFCD channel E132-00-00 to the east while the remainder of the ditches outfall to the HCFCD channel E133-00-00 to the west. Approximately 30 acres drain west to HCFCD channel E133-00-00 through two outfalls. The remaining 120 acres drain east to the HCFCD channel E132-00-00 through four (4) outfalls. Although current regulations allow roadside ditches, the existing drainage system is considered non-conforming due to ditch geometry, culvert sizing, a lack of detention, and no consideration for extreme event overflows. The high tail water conditions in E132-00-00 and E133-00-00 during extreme rainfall events exacerbate the flooding conditions internal to the Tower Oaks Meadows Subdivision.

Multiple single-family residential homes flooded during the April 2016 (Tax Day) and August 2017 (Hurricane Harvey) storm events. Approximately 91 structures flooded during Hurricane Harvey with Flooding depths that ranged from 6 inches to 12 inches. During the April 2016 (Tax Day) storm event approximately 97 structures flooded. There are 21 FEMA repetitive or severe repetitive loss properties within Tower Oaks Meadows.

Street Address

Maxim Drive and Honey Grove Lane

Street Limits on Street

From Street

To Street

Zip Code

77065

City

Houston

County

Harris

State

TX

Latitude

29.93801

Longitude

-95.61301

Scope of Work

The proposed Tower Oaks Meadows flood and drainage activity includes a portion of full conversion from asphalt pavement and roadside ditches to curb and gutter with underground storm sewer and the sections that remain roadside ditch will have a storm sewer installed below the current flow line. Roadside ditches will be re-graded to provide positive drainage toward the storm sewers. The roadway profiles will be designed to provide a cascading effect and provide capacity to convey extreme event runoff toward HCFCD Unit E132-00-00. The construction of extreme event overflows along the HCFCD channel E132-00-00 are included in the improvements as well. The proposed improvements create downstream adverse impact, but the E132-00-00 Mitigation project addresses these needs and must be constructed in advance of the Tower Oaks Meadows flood and drainage activity.

Additional information about the details and benefits of the project can be found in the narrative attached in Documents.

As previously indicated, applicants must follow the procurement process guidelines set forth in 2 CFR §200.318-§200.326 for procurement of construction services. For better detail regarding procurement methods and requirements, refer to:
https://recovery.texas.gov/local-government/resources/procurement-contracting/index.html

Have you procured construction services for the proposed project?

No

Construction completion method to be used

Competitve Sealed Bid/Contract

Will acquisition of real property or any activity requiring compliance with URA be required?

No

Applicants must follow 2 CFR 200 rules and regulations in the procurement of construction services. For better detail regarding procurement methods and requirements, refer to

Districts and Elected Officials

Cong. Rep

McCaul, Michael

State Rep

Oliverson, Tom

State Senator

Bettencourt, Paul

Cong. Rep District #

10

State Rep District #

130

State Senator Dist#

7

Site Budget

Specify Site Budget Information

Total Requested Grant Funds

$8,314,234.40

Total Other Funds

$1,277,693.33

Total Grant & Other Funds

$9,591,927.73

Amount Requested	$35,491.48
Site Budget Code	CDBG-MIT Environmental
Other Funds	
Site Budget Total	$35,491.48
Name	Tower Oaks Meadows Subdivision Drainage Improvements - CDBG-MIT Environmental
Created On	9/23/2020 11:37 AM
Budget Line Item	Flood control and drainage Improvements - - GLO17-11274-P

Amount Requested	$470,617.04
Site Budget Code	CDBG-MIT Admin
Other Funds	
Site Budget Total	$470,617.04
Name	Tower Oaks Meadows Subdivision Drainage Improvements - CDBG-MIT Admin
Created On	9/23/2020 11:39 AM
Budget Line Item	Flood control and drainage Improvements - - GLO17-11274-P

Amount Requested	$709,829.63
Site Budget Code	CDBG-MIT Engineering
Other Funds	$1,277,693.33
Site Budget Total	$1,987,522.96
Name	Tower Oaks Meadows Subdivision Drainage Improvements - CDBG-MIT Engineering
Created On	9/23/2020 11:37 AM
Budget Line Item	Flood control and drainage Improvements - - GLO17-11274-P

Amount Requested	$7,098,296.25
Site Budget Code	CDBG-MIT Construction
Other Funds	
Site Budget Total	$7,098,296.25
Name	Tower Oaks Meadows Subdivision Drainage Improvements - CDBG-MIT Construction
Created On	9/23/2020 11:33 AM
Budget Line Item	Flood control and drainage Improvements - - GLO17-11274-P

Site Metrics

Name	Linear Feet of Public Improvement
Comment Planned	Storm Sewer New (LF) - 13,123 Excavate and Regrade Ditches (LF) - 19,200 Road Reconstruction (LF) - 9,600
Numeric Resp Planned	41923

Name	Number of public improvements
Comment Planned	New Storm Sewer (LF) 13123 Excavate and Regrade Ditches (LF) 19200 Road Reconstruction (LF) 9600
Numeric Resp Planned	3

Project Site

Project Sites & Locations

Program

Hurricane Harvey State Mitigation Competition – HUD MID

Site Number

S-003177

Site Title *

E132-00-00 Mitigation Project

Site Description

The HCFCD channel E132-00-00 is a tributary of White Oak Bayou and serves as the main storm water conveyance structure for approximately 1,400 acres of dense residential development. This project site includes a section of HCFCD channel E132-00-00 from Wortham Landing Drive to Lieder Drive, which serves approximately 670 acres of the 1,400 total drainage area acreage. The project area was developed from the 1950s to the 1970s and nearly all existing drainage systems, in comparison to current regulations, are considered non-conforming. The current channel geometry provides less than a 25-year level of service for the drainage area, which results in high tail water conditions during extreme or long duration rainfall events.

The channel's insufficient capacity, combined with the lack of detention in the surrounding developments contribute to an increase in water surface elevations throughout the project areas, which increase the risk of flooding in the Bernadine Estates, Barwood, Tower Oaks, and Tower Oaks Meadows subdivisions. The high tail water conditions in HCFCD channel E132-00-00 contributed to the flooding of over 200 residential structures throughout the drainage area.

Street Address

Iberia Drive and Dakar Drive

Street Limits on Street

From Street

To Street

Zip Code

77065

City

Houston

County

Harris

State

TX

Latitude

29.95475

Longitude

-95.60275

Scope of Work

The proposed E132-00-00 flood and drainage activity includes enclosing a portion of the upstream channel, modifying the width of the remaining channe
and acquiring right-of-way (ROW) for additional detention storage volume or channel widening. The enclosed portion is anticipated to consist of four 9'x
Reinforced Concrete Boxes (RCBs) from Advance Drive to Foxburo Dr. A conceptual detention basin providing approximately 21 acre-feet of detention storage has been identified immediately south of Foxburo Street and east of HCFCD Unit E132-00-00.

The goal is to increase the storage and conveyance capacity in the E132-00-00 channel for all adjacent sites to reach full mitigation potential. The conformance of this channel to current floodplain regulations and HCFCD policies, criteria, and design standards will result in not only direct benefit to th
Barwood, Tower Oaks Meadows, and Bernadine Estates neighborhoods, but also mitigate future flood damages for the sub-regional area.

As previously indicated, applicants must follow the procurement process guidelines set forth in 2 CFR §200.318-§200.326 for procurement of construction services. For better detail regarding procurement methods and requirements, refer to:
https://recovery.texas.gov/local-government/resources/procurement-contracting/index.html

Have you procured construction services for the proposed project?

No

Construction completion method to be used

Competitve Sealed Bid/Contract

Will acquisition of real property or any activity requiring compliance with URA be required?

Yes

Estimated Number of Parcels

18

If yes, has acquisition been completed, in progress, or will need to be acquired?

Still Needed

If yes, provide a brief narrative describing the acquisition activities required.

Acquisition will be required for the detention pond.

Applicants must follow 2 CFR 200 rules and regulations in the procurement of construction services. For better detail regarding procurement methods and requirements, refer to 2 C

Districts and Elected Officials

Cong. Rep

McCaul, Michael

State Rep

Oliverson, Tom

State Senator

Bettencourt, Paul

Cong. Rep District #

10

State Rep District #

130

State Senator Dist#

7

Site Budget

Specify Site Budget Information

Total Requested Grant Funds

$16,429,224.08

Total Other Funds

$1,710,288.00

Total Grant & Other Funds

$18,139,512.08

Amount Requested	$47,508.00
Site Budget Code	CDBG-MIT Environmental
Other Funds	
Site Budget Total	$47,508.00
Name	E132-00-00 Mitigation Project - CDBG-MIT Environmental
Created On	9/23/2020 11:47 AM
Budget Line Item	Flood control and drainage Improvements - - GLO17-11274-P

Amount Requested	$929,956.08
Site Budget Code	CDBG-MIT Admin
Other Funds	
Site Budget Total	$929,956.08
Name	E132-00-00 Mitigation Project - CDBG-MIT Admin
Created On	9/23/2020 11:47 AM
Budget Line Item	Flood control and drainage Improvements - - GLO17-11274-P

Amount Requested	$950,160.00
Site Budget Code	CDBG-MIT Engineering
Other Funds	$1,710,288.00
Site Budget Total	$2,660,448.00
Name	E132-00-00 Mitigation Project - CDBG-MIT Engineering
Created On	9/23/2020 11:46 AM
Budget Line Item	Flood control and drainage Improvements - - GLO17-11274-P

Amount Requested	$5,000,000.00
Site Budget Code	CDBG-MIT Acquisition
Other Funds	
Site Budget Total	$5,000,000.00
Name	E132-00-00 Mitigation Project - CDBG-MIT Acquisition
Created On	9/23/2020 11:48 AM
Budget Line Item	Flood control and drainage Improvements - - GLO17-11274-P

Amount Requested	$9,501,600.00
Site Budget Code	CDBG-MIT Construction
Other Funds	
Site Budget Total	$9,501,600.00
Name	E132-00-00 Mitigation Project - CDBG-MIT Construction
Created On	9/23/2020 11:42 AM
Budget Line Item	Flood control and drainage Improvements - - GLO17-11274-P

Site Metrics

Name	Linear Feet of Public Improvement
Comment Planned	Storm sewer improvements (LF) - 5,600 Detention Pond (Ac-Ft) - 17
Numeric Resp Planned	5600

Name	Number of public improvements
Comment Planned	Storm sewer improvements (LF) - 5,600 Detention Pond (Ac-Ft) - 17
Numeric Resp Planned	2

Project Site

Project Sites & Locations

Program

Hurricane Harvey State Mitigation Competition – HUD MID

Site Number

S-003179

Site Title *

Kolbe Road & Related Infrastructure Drainage Improvements

Site Description

The Kolbe Road project area was developed throughout the 1970s and consists of approximately 80 acres of large lot residential parcels drained using a system of roadside ditches which drain north to the Cypress North Houston Road storm sewer. Although current regulations allow roadside ditches, the current system is considered non-conforming due to poor lot grading, lack of detention, and no consideration for extreme event flow paths. All these factors combined lead to shallow, but widespread and long duration inundation throughout the project area.

The recorded damages from Hurricane Harvey showed that 38 homes experienced structural flooding during Hurricane Harvey with flooding depths from 2 to 12 inches above finished floor elevations. Only two structures within the study area were reported in the Tax Day storm event. Additionally, there are two FEMA repetitive flood loss properties.

Street Address

South Kolbe Drive and South Kolbe Circle

Street Limits on Street

From Street

To Street

Zip Code

77429

City

Cypress

County

Harris

State

TX

Latitude

29.94051

Longitude

-95.64223

Scope of Work

The flood and drainage activity for Kolbe Road include the addition of storm sewers under the existing roadside ditches throughout the project site. The storm sewer redirects a portion of drainage area from Cypress North Houston to now drain to HCFCD channel E133-01-00. The change in flows require detention to mitigate any adverse impact, so ROW acquisition is included in the project requirements. All improvements conform with current infrastructure and floodplain regulations.

The increased drainage capacity, along with the detention component, mitigates the risk of damage to buildings during extreme storm events by reducing ponding depths up to 7 inches. The reduced ponding depths potentially alleviating the structural flooding concerns of at least the 38 previously flooded homes.

As previously indicated, applicants must follow the procurement process guidelines set forth in 2 CFR §200.318-§200.326 for procurement of construction services. For better detail regarding procurement methods and requirements, refer to: https://recovery.texas.gov/local-government/resources/procurement-contracting/index.html

Have you procured construction services for the proposed project?

No

Construction completion method to be used

Competitve Sealed Bid/Contract

Will acquisition of real property or any activity requiring compliance with URA be required?

Yes

Estimated Number of Parcels

3

If yes, has acquisition been completed, in progress, or will need to be acquired?

In Progress

If yes, provide a brief narrative describing the acquisition activities required.

Acquisition is required for the 38.4 acre foot detention pond, a 30 foot drainage easement, and for dedication of ROW associated with the private streets.

Applicants must follow 2 CFR 200 rules and regulations in the procurement of construction services. For better detail regarding procurement methods and requirements, refer to 2 (

Districts and Elected Officials

Cong. Rep

Fletcher, Lizzie

State Rep

Oliverson, Tom

State Senator

Bettencourt, Paul

Cong. Rep District #

7

State Rep District #

130

State Senator Dist#

7

Site Budget

Specify Site Budget Information

Total Requested Grant Funds

$5,698,832.08

Total Other Funds

$622,483.00

Total Grant & Other Funds

$6,321,315.08

Amount Requested	$18,218.36
Site Budget Code	CDBG-MIT Environmental
Other Funds	
Site Budget Total	$18,218.36
Name	Kolbe Road & Related Infrastructure Drainage Improvements - CDBG-MIT Environmental
Created On	9/23/2020 11:59 AM
Budget Line Item	Flood control and drainage Improvements - - GLO17-11274-P

Amount Requested	$322,575.40
Site Budget Code	CDBG-MIT Admin
Other Funds	
Site Budget Total	$322,575.40
Name	Kolbe Road & Related Infrastructure Drainage Improvements - CDBG-MIT Admin
Created On	9/23/2020 12:00 PM
Budget Line Item	Flood control and drainage Improvements - - GLO17-11274-P

Amount Requested	$364,367.12
Site Budget Code	CDBG-MIT Engineering
Other Funds	$622,483.00
Site Budget Total	$986,850.12
Name	Kolbe Road & Related Infrastructure Drainage Improvements - CDBG-MIT Engineering
Created On	9/23/2020 11:58 AM
Budget Line Item	Flood control and drainage Improvements - - GLO17-11274-P

Amount Requested	$1,350,000.00
Site Budget Code	CDBG-MIT Acquisition
Other Funds	
Site Budget Total	$1,350,000.00
Name	Kolbe Road & Related Infrastructure Drainage Improvements - CDBG-MIT Acquisition
Created On	9/23/2020 12:00 PM
Budget Line Item	Flood control and drainage Improvements - - GLO17-11274-P

Amount Requested	$3,643,671.20
Site Budget Code	CDBG-MIT Construction
Other Funds	
Site Budget Total	$3,643,671.20
Name	Kolbe Road & Related Infrastructure Drainage Improvements - CDBG-MIT Construction
Created On	9/23/2020 11:57 AM
Budget Line Item	Flood control and drainage Improvements - - GLO17-11274-P

Site Metrics

Name	Linear Feet of Public Improvement
Comment Planned	Storm Sewer Upgrades (LF) - 9,910 Detention (CY) - 62,000
Numeric Resp Planned	9910

Name	Number of public improvements
Comment Planned	Storm Sewer Upgrades (LF) 9910 Detention (cy) 62000
Numeric Resp Planned	2

Project Site

Project Sites & Locations

Program

Hurricane Harvey State Mitigation Competition – HUD MID

Site Number

S-003321

Site Title *

Little White Oak Bayou

Site Description

Little White Oak Bayou has a total of length of about 14 miles, from its headwaters in North Houston to its confluence with White Oak Bayou near downto Houston. The Little White Oak Bayou subwatershed is part of the larger White Oak Bayou watershed. The lower ¼ of the channel is downstream of Interstate 610. This portion of the channel is natural and larger, and there is minimal flood history along this portion of the channel. However, upstream c Interstate 610, the channel has been rectified. Much of the channel, with the exception of the most upstream reach, was concrete lined in the late 1970's. The watershed is fully urbanized, with most development occurring before 1960.   In the 1940's, Little White Oak Bayou was extended upstream beyond North Shepherd.

Little White Oak Bayou upstream of Interstate 610 has a long history of flooding. This is due to (1) the overall lack of capacity of the channel and (2) restrictions from a long culvert underneath Interstate 610. The impact of this restricted culvert is felt upstream to Crosstimbers.
Between 1978 and 1980, HCFCD completed the following projects:

- Channel Improvements – IH-45 to Riggs Road (1978)
- Channel Improvement – Riggs Road to Victoria Drive (1979)
- Channel Improvements – Victoria Drive to Yale Blvd (1980)

All of these projects included concrete lining of the channel, and the channels were designed to accommodate 100-year flowrates using the hydrologic methodology available at that time.

In the early 1980's, HCFCD continued the preliminary engineering and design of channel improvement projects extending upstream of Yale Blvd. Howev at the same time HCFCD was completing its first countywide floodplain study using hydrologic and hydraulic computer models. This new study showed t the older methods underpredicted flood flows and did not adequately account for the impact of channel improvements on flood flows downstream.

See attached narrative for more detail.

Street Address

359 Spell Street

Street Limits on Street

From Street

Tidwell Road

To Street

Crosstimbers Street

Zip Code

77002

City

Houston

County

Harris

State

TX

Latitude

29.83642

Longitude

-95.39424

Scope of Work

The proposed project involves channel widening 8.700 feet of Little White Oak Bayou (HCFCD Unit No. E101-00-00) from Tidwell Road (upstream) to Crosstimbers Street (downstream) along with two detention basins and additional in-line storage. The existing channel is concrete lined with a top-width of approximately 50 feet. The existing right-of-way is between 75 to 80 feet, although there are some areas with additional existing right-of-way through the corridor. The proposed channel will be grass lined with a geomorphologic low flow channel. The full channel, including the low flow and high flow areas, will have a top width of 270 (although it may be wider where right-of-way allows). The detention basins will provide an additional 800 acre-feet of storage during a 500-year event. There are six bridge crossings in the project reach – Leago, Werner, Oxford Footbridge, Victoria, Distribution Center and Whiney. These will be modified as necessary to accommodate the project.

As previously indicated, applicants must follow the procurement process guidelines set forth in 2 CFR §200.318-§200.326 for procurement of construction services. For better detail regarding procurement methods and requirements, refer to:
https://recovery.texas.gov/local-government/resources/procurement-contracting/index.html

Have you procured construction services for the proposed project?

No

Construction completion method to be used

Competitve Sealed Bid/Contract

Will acquisition of real property or any activity requiring compliance with URA be required?

Yes

Estimated Number of Parcels

If yes, has acquisition been completed, in progress, or will need to be acquired?

Still Needed

If yes, provide a brief narrative describing the acquisition activities required.

Applicants must follow 2 CFR 200 rules and regulations in the procurement of construction services. For better detail regarding procurement methods and requirements, refer to 2 C

Districts and Elected Officials

Cong. Rep

Jackson Lee, Sheila

State Rep

Johnson, Jarvis

State Senator

Whitmire, John

Cong. Rep District #

18

State Rep District #

139

State Senator Dist#

15

Site Budget

Specify Site Budget Information

Total Requested Grant Funds

$65,325,216.89

Total Other Funds

$12,693,421.72

Total Grant & Other Funds

$78,018,638.61

Amount Requested	$2,350,111.61
Site Budget Code	CDBG-MIT Admin
Other Funds	
Site Budget Total	$2,350,111.61
Name	Little White Oak Bayou - CDBG-MIT Admin
Created On	9/30/2020 7:21 AM
Budget Line Item	Flood control and drainage Improvements - - GLO17-11274-P

Amount Requested	$26,475,105.28
Site Budget Code	CDBG-MIT Construction
Other Funds	$12,693,421.72
Site Budget Total	$39,168,527.00
Name	Little White Oak Bayou - CDBG-MIT Construction
Created On	9/30/2020 7:20 AM
Budget Line Item	Flood control and drainage Improvements - - GLO17-11274-P

Amount Requested	$36,500,000.00
Site Budget Code	CDBG-MIT Acquisition
Other Funds	
Site Budget Total	$36,500,000.00
Name	Little White Oak Bayou - CDBG-MIT Acquisition
Created On	9/30/2020 7:21 AM
Budget Line Item	Flood control and drainage Improvements - - GLO17-11274-P

Site Metrics

Name	Linear Feet of Public Improvement
Comment Planned	Channel widening - 8,700 linear feet
Numeric Resp Planned	8700

Name	Number of public improvements
Comment Planned	(1) Channel Conveyance Improvements along Little White Oak Bayou and (2) Stormwater Detention Basins
Numeric Resp Planned	3

Mitigation Application Project

The schedule requested here is the Project Level Schedule. Identify the time needed to complete every activity and ensure a full and eligible project. Activity Level schedules must be uploaded separately.

Project Phase	Start Date	Length (months)	End Date (calculated)	Phase Status
Start-Up Documentation	9/14/2018	38	11/13/2021	Not Executing
Procurement of Engineer/Architect Services Professional Services	6/10/2020	15	9/10/2021	Not Executing
Broad Environmental Review	6/11/2020	19	1/10/2022	Not Executing
Acquisition	10/28/2020	40	2/27/2024	Not Executing
Engineering Design	5/18/2021	21	2/17/2023	Not Executing
Bid Advertisement	12/14/2022	16	4/14/2024	Not Executing
Contract Award	2/3/2023	15	5/3/2024	Not Executing
Construction NTP	4/5/2023	15	7/5/2024	Not Executing
Construction	4/10/2023	37	5/10/2026	Not Executing
Submit As-Builts/COCC/FWCR	11/4/2024	21	8/4/2026	Not Executing
Contract Closeout	12/4/2024	21	9/4/2026	Not Executing
Construction Activity Completion	4/10/2026	1	5/10/2026	Not Executing

CDBG MIT Application Development Environmental Narrative Form

Date: 7/29/2020

Project Name: Kolbe Road and Related infrastructure

Application #: Application 4

Reviewer: Courtney Blechle

1. Status of Environmental (Has Not Started, In Progress, Completed): Has not started.
2. Provide a brief narrative regarding how CDBG-MIT funding is to be used. Demonstrate that all HUD CDBG environmental requirements have been met/addressed. CDBG- MIT funding would be used to upgrade the existing drainage system due to past structural flooding in the area. A high-level environmental review was performed for this application, further studies would be conducted before construction to ensure HUD CDBG environmental requirements have been met and in accordance with 24 CRF Part 58.
3. Will the proposed project have any negative impact(s) or effect(s) on the environment per HUD environmental regulations as described? Potential for negative impacts or effects.
    a. If yes, or the applicant believes an issue may exist, provide a brief narrative explaining the issue: Due to the possibility of Eastern Spotted Skunk habitat, wetlands and a current ongoing archaeological investigation on site, further environmental studies would be conducted for this proposed project site before work is performed.
4. Is the proposed project site likely to require a historical resources/archaeological assessment? Yes
    a. If yes, or the applicant believes a historical resources/archaeological assessment may be needed, provide a brief narrative explaining the issue: According to the Texas Historical Commission, the southwest quadrant of the proposed site is currently undergoing an archaeological investigation. No historic resources are located on the proposed project site.
5. Is the proposed project site listed on the National Register of Historic Places? No
    a. If yes, provide a brief narrative explaining how the historic site will be impacted: N/A
6. Is the proposed project site in a designated flood hazard area or a designated wetland? The proposed project site is not located within a designated flood hazard area. According to the National Wetland Inventory, there is the potential for several wetlands on site, mostly within the undeveloped area on the west. There is potential for wetlands located in drainage ditches, before construction begins a wetland delineation would be conducted to determine if wetlands exist in the area. Impacts to wetlands would be avoided and minimized as possible. Permitting efforts would be done in accordance with USACE protocols.
7. Is the applicant participating in the National Flood Insurance Program? Yes
8. Is the project in a designated Regulatory Floodway? No
    a. If yes, please explain. N/A
9. Is the proposed project site located in a known critical habitat for endangered species? Yes
    a. If yes, please explain. According to the National Diversity Database, habitat could be present for the Eastern Spotted Skunk, *Spilogale putorius,* last observed in 1980.

Because of development in the area, habitat for the Eastern Spotted Skunk is unlikely. A habitat survey would be performed before any work is done in the area.

10. Is the proposed project site a known hazardous site? No
    a. If yes, please explain. N/A
11. Is the proposed project site located on federal lands or at a federal installation? No
    a. If yes, provide a brief narrative detailing why federal land or a federal installation is required for the proposed project. N/A
12. What level of environmental review is likely needed for the proposed project site (EA, CE, EIS)? CE
13. Provide a brief narrative to include any additional detail or information relevant to Environmental Review. Sources: Texas Parks and Wildlife National Diversity Database, U.S. Fish and Wildlife Service, National Wetland Inventory, Texas Historical Commission, and Texas Commission on Environmental Quality.

CDBG MIT Application Development Environmental Narrative Form

Date: 7/28/2020

Project Name: Barwood

Application #: Application 4

Reviewer: Courtney Blechle

1. Status of Environmental (Has Not Started, In Progress, Completed): Has not started.
2. Provide a brief narrative regarding how CDBG-MIT funding is to be used. Demonstrate that all HUD CDBG environmental requirements have been met/addressed. CDBG- MIT funding would be used to upgrade the existing drainage system due to past structural flooding in the area. A high-level environmental review was performed for this application, further studies would be conducted before construction to ensure HUD CDBG environmental requirements have been met and in accordance with 24 CRF Part 58.
3. Will the proposed project have any negative impact(s) or effect(s) on the environment per HUD environmental regulations as described? Potential for negative impact or effect.
    a. If yes, or the applicant believes an issue may exist, provide a brief narrative explaining the issue: Potential habitat is located within the proposed project site for the Eastern Spotted Skunk and the Southern Crawfish Frog, before any work is done a habitat survey would be conducted.
4. Is the proposed project site likely to require a historical resources/archaeological assessment? No known historic resources or archaeological sites are located within the proposed project site.
    a. If yes, or the applicant believes a historical resources/archaeological assessment may be needed, provide a brief narrative explaining the issue: N/A
5. Is the proposed project site listed on the National Register of Historic Places? No
    a. If yes, provide a brief narrative explaining how the historic site will be impacted: N/A
6. Is the proposed project site in a designated flood hazard area or a designated wetland? The project site is not located within a designated flood hazard area. There is potential for wetlands located in drainage ditches, before construction begins a wetland delineation would be conducted to determine if wetlands exist in the area. Impacts to wetlands would be avoided and minimized as possible. Permitting efforts would be done in accordance with USACE protocols.
7. Is the applicant participating in the National Flood Insurance Program? Yes
8. Is the project in a designated Regulatory Floodway? No
    a. If yes, please explain. N/A
9. Is the proposed project site located in a known critical habitat for endangered species? Yes
    a. If yes, please explain. According to TPWD National Diversity Database, potential habitat exists within the area for the Eastern Spotted Skunk, *Spilogale putorius,* and Southern Crawfish Frog, *Lithobates areolatus,* before work is performed a habitat survey would be conducted.
10. Is the proposed project site a known hazardous site? No known hazardous materials or sites are located on the proposed project site.
    a. If yes, please explain. N/A

11. Is the proposed project site located on federal lands or at a federal installation? No
    a. If yes, provide a brief narrative detailing why federal land or a federal installation is required for the proposed project. N/A
12. What level of environmental review is likely needed for the proposed project site (EA, CE, EIS)?CE
13. Provide a brief narrative to include any additional detail or information relevant to Environmental Review. Sources: Texas Parks and Wildlife National Diversity Database, U.S. Fish and Wildlife Service, National Wetland Inventory, Texas Historical Commission, and Texas Commission on Environmental Quality.

CDBG MIT Application Development Environmental Narrative Form

Date: 7/29/2020

Project Name: Tower Oaks Meadows

Application #: 4

Reviewer: Courtney Blechle

1. Status of Environmental (Has Not Started, In Progress, Completed): Has not started.
2. Provide a brief narrative regarding how CDBG-MIT funding is to be used. Demonstrate that all HUD CDBG environmental requirements have been met/addressed. CDBG- MIT funding would be used to upgrade the existing drainage system due to past structural flooding in the area. A high-level environmental review was performed for this application, further studies would be conducted before construction to ensure HUD CDBG environmental requirements have been met and in accordance with 24 CRF Part 58.
3. Will the proposed project have any negative impact(s) or effect(s) on the environment per HUD environmental regulations as described? Potential for negative impacts or effects.
    a. If yes, or the applicant believes an issue may exist, provide a brief narrative explaining the issue: Potential habitat is located within the proposed project site for the Eastern Spotted Skunk and the Southern Crawfish Frog, before any work is done a habitat survey would be conducted.
4. Is the proposed project site likely to require a historical resources/archaeological assessment? No
    a. If yes, or the applicant believes a historical resources/archaeological assessment may be needed, provide a brief narrative explaining the issue: N/A
5. Is the proposed project site listed on the National Register of Historic Places? No
    a. If yes, provide a brief narrative explaining how the historic site will be impacted: N/A
6. Is the proposed project site in a designated flood hazard area or a designated wetland? The project site is not located within a designated flood hazard area. There is potential for wetlands located in drainage ditches, before construction begins a wetland delineation would be conducted to determine if wetlands exist in the area. Impacts to wetlands would be avoided and minimized as possible. Permitting efforts would be done in accordance with USACE protocols.
7. Is the applicant participating in the National Flood Insurance Program? Yes
8. Is the project in a designated Regulatory Floodway? No
    a. If yes, please explain. N/A
9. Is the proposed project site located in a known critical habitat for endangered species? Yes
    a. If yes, please explain. According to TPWD National Diversity Database, potential habitat exists within the area for the Eastern Spotted Skunk, *Spilogale putorius,* and Southern Crawfish Frog, *Lithobates areolatus,* before work is performed a habitat survey would be conducted.
10. Is the proposed project site a known hazardous site? No
    a. If yes, please explain. N/A
11. Is the proposed project site located on federal lands or at a federal installation? No

a. If yes, provide a brief narrative detailing why federal land or a federal installation is required for the proposed project. N/A

12. What level of environmental review is likely needed for the proposed project site (EA, CE, EIS)? CE
13. Provide a brief narrative to include any additional detail or information relevant to Environmental Review. Sources: Texas Parks and Wildlife National Diversity Database, U.S. Fish and Wildlife Service, National Wetland Inventory, Texas Historical Commission, and Texas Commission on Environmental Quality.

Innovative approaches
Practical results
Outstanding service

BENEFIT-COST ANALYSIS

WHITE OAK BAYOU WATERSHED MITIGATION PROJECT

Prepared for:

Harris County

October 2020

Prepared by:

FREESE AND NICHOLS, INC.
4055 International Plaza, Suite 200
Fort Worth, Texas 76109
817-735-7300

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APPENDICES

EXECUTIVE SUMMARY

The benefit-cost analysis performed for White Oak Bayou Watershed Mitigation Project included quantification of the following types of benefits:

- Building damages (avoided costs)
- Content damages (avoided costs)
- Residential displacement (avoided costs)
- Non-residential displacement (avoided costs)
- Mental health treatment (avoided costs)
- Worker productivity (avoided costs)
- Ecosystem services (added benefit of conversion of developed land)

Net present value benefits were calculated using a 7% discount rate. *Table ES-1* summarizes benefits on an annual basis and at present value.

Table ES-1 – Summary of Project Benefits

Expected Benefits	Annual Benefit	Present Value Benefit
Structures + Contents	$1,596,613	$22,034,445
Displacement, Residential	$124,458	$1,717,620
Displacement, Non-residential	$5,279	$72,858
Social (Mental Health & Productivity)	$2,281,641	$31,488,345
Environmental (Ecosystem services of converted land)	$690,548	$9,530,078
Total Expected Benefits (all categories)	**$4,698,539**	**$64,843,345**

Social benefits represent the expected benefits of reducing mental health impacts associated with experiencing a disaster such as flooding. These benefits include avoided costs of:

- Health treatment for mental stress and anxiety of impacted residents
- Productivity losses by impacted residents who work full-time due to impacts on mental health

Social benefits of the White Oak Bayou Watershed Mitigation Project are shown in *Table ES-2*.

Table ES-2 – Summary of Social Benefits

Category	Number of Persons	Benefit per Person	Present Value Social Benefits
Number of Persons Directly Benefitted by Mitigation of Residential Structural Flooding	3,531	$ 2,443	$8,626,233
Number of Full-time Workers Directly Benefitted by Mitigation of Residential Structural Flooding	2,617	$ 8,736	$22,862,112
Total Social Benefit			**$31,488,345**

Environmental benefits based on the FEMA Toolkit represent the value of ecosystem services provided by enhancement of a parcel's land use to a use type which provides a higher level of natural environmental benefits. The White Oak Bayou Watershed Mitigation Project requires some acquisition and conversion of developed land to undeveloped floodplain. Additionally, a riparian corridor is planned as part of the project. The benefit values for Green Open Space and Riparian land use have been applied to these areas. Environmental benefits of the White Oak Bayou Watershed Mitigation Project are summarized in *Table ES-3*.

Table ES-3 – Summary of Environmental Benefits

Post-Mitigation Land Use	Acres Converted	Benefit per Acre per Year	Annual Benefits	Present Value Benefits
Green Open Space	26	$8,308	$216,008	$2,981,072
Riparian	12	$39,545	$474,540	$6,549,006
Wetlands	0	$6,010	$-	$-
Forests	0	$554	$-	$-
Marine / Estuary	0	$1,799	$-	$-
Total Environmental Benefit	**38**		$690,548	$9,530,078

In addition to environmental benefits, social benefits, and reduced structural damages and displacement costs, the White Oak Bayou Watershed Mitigation Project represents a holistic benefit to its service area, the White Oak Bayou Watershed, by removing structures and land area from the floodplain. *Table ES-4* summarizes the impacts of the mitigation project.

Table ES-4 – Impacts of Mitigation Project

Number of structures benefitted in any event *(estimated losses to structural damage are reduced)*	1,495
Number of structures removed from 10% AEP (10-year) floodplain	76
Number of structures removed from 1% AEP (100-year) floodplain	527
Number of acres removed from 10% AEP (10-year) floodplain	117
Number of acres removed from 1% AEP (100-year) floodplain	258
Number of structures removed from risk* in 10% AEP (10-year) event	7
Number of structures removed from risk* in 1% AEP (100-year) event	461

**Structures "at risk" refer to those for which the modeled water surface elevation is at or above finished floor elevation.*

The Present Value Benefits, as shown in *Table ES-1* and *Table ES-3*, were developed from Annual Benefits using a 7% discount rate as required by the Office of Management and Budget (OMB) Circular No. A-94[1]. (Social benefit unit values are provided as standard Present Value amounts and are discounted using a 7% rate to estimate Annual Benefits.) This discount rate assumes present benefits have much more value than future benefits, which is not necessarily true for flood risk mitigation projects with a 50-year and greater life cycle. A lower discount rate assumes present benefits are only slightly more valuable than future benefits – a more realistic assumption when considering extended life cycle projects that provide the same level of risk reduction from year to year. U.S. Department of Housing and Urban Development (HUD) Notice CPD-16-06, which was created to provide guidance on benefit-cost analyses for Community Development Block Grant Disaster Recovery (CDBG-DR) projects, notes "grantees may additionally calculate benefits and costs using alternate discount rates (no lower than 3%) provided it also includes justification acceptable to HUD based on the nature of the project." For comparison purposes, Present Value Benefits were also determined using a 3% discount rate.

Project costs as estimated for the Community Development Block Grant Mitigation (CDBG-MIT) grant application include estimated costs of design and construction. The benefit-cost ratio was determined as the ratio of the present value of Total Expected Benefits to Total Project Cost. *Table ES-5* presents the project cost, along with the estimated benefits and benefit-cost ratio resulting from use of both the 7% and 3% discount rates. It is important to note that the White Oak Bayou Watershed Mitigation Project

[1] *Circular A-94*, Office of Management and Budget, last revised October 29, 1992.

will provide many community benefits for which an economic value could not be quantified as part of this analysis. Additional unquantified benefits are discussed further in the section on **Qualitative Benefits**.

Table ES-5 – Benefit-Cost Ratio

	7% Discount Rate	3% Discount Rate
Present Value Total Benefits	$64,843,345	$93,674,568
Present Value Total Cost	$117,207,261	$117,207,261
Benefit-Cost Ratio	0.55	0.80

1.0 METHODOLOGY

1.1 BENEFIT-COST ANALYSIS REQUIREMENTS FOR CDBG-MIT PROJECTS

Although a benefit-cost ratio (BCR) is not a factor in the competition score as set forth by the Texas General Land Office (GLO), applicants are required to demonstrate that the benefits of any Covered Project outweigh its costs. As described in the Federal Register,[2] this requirement may be met in either of two ways:

1. Benefit-cost ratio developed during a benefit-cost analysis (BCA) is greater than 1.0.
    a. Calculations should be prepared in accordance with OMB Circular A-94[3].
    b. BCA methodology should follow FEMA standardized methodologies unless
        1) A BCA for the project has already been completed or is in progress under guidelines of other Federal agencies, or
        2) The BCA addresses a non-correctable flaw in the FEMA methodology, or
        3) A new approach is proposed that is unavailable using the FEMA Toolkit.
2. Alternately, projects may have a benefit-cost ratio of less than 1.0 under these conditions:
    a. A BCA is still completed following the methodologies described above.
    b. The project "serves low- and moderate- income persons or other persons that are less able to mitigate risks or respond to and recover from disaster."
    c. A qualitative description is provided for "benefits that cannot be quantified but sufficiently demonstrate unique and concrete benefits of the Covered Project for low- and moderate- income persons or other persons that are less able to mitigate risks, or respond to and recover from disasters."

The analysis presented here meets these requirements as follows:

- In accordance with OMB Circular A-94, a 7% discount rate was used when determining equivalent present values of expected annual benefits and vice versa.

[2] Allocations, Common Application, Waivers, and Alternative Requirements for Community Development Block Grant Mitigation Grantees, 84 FR 169 (August 30, 2019).
[3] *Circular A-94*, Office of Management and Budget, last revised October 29, 1992.

- The quantitative benefit-cost analysis (BCA) was based on benefit quantification methods and assumptions used in FEMA tools such as the FEMA BCA Toolkit version 6.0[4] (hereafter "FEMA Toolkit") and HAZUS (Hazards U.S. planning-level damage and loss estimating tool). These tools were not used directly, but the methods and assumptions in the FEMA Toolkit and HAZUS were applied using a combination of geospatial and tabular analysis tools to more efficiently:
  - Assess thousands of potentially impacted structures.
  - Utilize spatially variable modeled water surface elevation data.
  - Incorporate detailed information at an individual structure level.
- As indicated by the beneficiary population analysis detailed in the **LMI Evaluation Attachment**, over 51% of the project beneficiaries of are low- to moderate-income persons.
- The **Qualitative Benefits** section of this report discusses benefits of the Covered Project that could not be quantified.

1.2 QUANTITATIVE BENEFIT CATEGORIES

The benefit-cost analysis included quantification of the following types of benefits:

- Building damages (avoided costs)
- Content damages (avoided costs)
- Residential displacement (avoided costs)
- Non-residential displacement (avoided costs)
- Mental health treatment (avoided costs)
- Worker productivity (avoided costs)
- Ecosystem services (added benefit of conversion of developed land)

1.3 INPUT DATA

A separate analysis was performed to estimate the number of residents and residential units per structure, as well as the number of residents who are full-time workers. The primary datasets used in the BCA are summarized in *Table 1-1.*

[4] *Benefit Cost Toolkit Version 6.0.* FEMA. October 2019. Available at https://www.fema.gov/media-library/assets/documents/179903.

Table 1-1 – Input Datasets to Benefit-Cost Analysis

Dataset	Source	Description
Harris County Structure Inventory	Harris County Flood Control District	attributes of individual structures in the study area, including use, size, and look-up codes for various reference tables
Right-of-Way Acquisition	Harris County Flood Control District	parcels and impacted structures to be bought out as part of project
Capital Costs	Harris County Flood Control District; Harris County	project capital costs
Existing and Proposed Water Surface Elevations	Harris County Flood Control District; Harris County	Estimated water surface elevations based on hydraulic modeling of conditions before and after project implementation
American Community Survey Data[5]	U.S. Census Bureau	2018 ACS 5-year data related to population, average household size, number of full-time workers, median household income, and other variables
Census Geographic Areas	U.S. Census Bureau	boundaries of 2010 Census tracts and block groups

The Harris County Flood Control District maintains a detailed structure inventory of all structures in Harris County. This inventory includes data on the number of housing units in each structure, square footage, building style, finished floor elevation, and numerous other attributes. The qualitative structure attributes in the inventory were used to determine the appropriate depth-damage functions and content-to-structure value ratios, and the finished floor elevation is the basis for determining damage and displacement costs based on depth of flooding above finished floor.

Data from the 2018 American Community Survey (ACS) 5-year[5] data tables was used in various parts of the BCA; the variables used are listed below. The following sections describe the use of this data in more detail.

- Subject Table S1903 –Median Income in the Past 12 Months
- Detail Table B01003 – Total Population
- Data Profile Table DP04 – Selected Housing Characteristics
- Detail Table B23027 – Full-Time, Year-Round Work Status in the Past 12 Months by Age for Population 16+ Years

[5] U.S. Census Bureau. American Community Survey, 2014-2018. Detailed Tables, Subject Tables, and Data Profile Tables; generated by Freese & Nichols, Inc. using the U.S. Census Bureau Application Programming Interface.

Table 1-2 lists the various standard values and lookup tables referenced in the calculations.

Table 1-2 – Sources of Standard Values and Reference Tables

Name	Purpose	Source
Discount Rate	calculate discount factors for converting between annual and present value equivalent costs/benefits	OMB Circular A-94
Demolition Threshold	threshold above which building is assumed to be fully lost and contents maximally lost	FEMA BCA Toolkit v6.0
Useful Life	project lifetime used in discounting	
Depth-Days Curve	table of days displaced for depth flooded	
Disruption Cost Factor	one-time cost per square foot for non-residential structures	
Monthly Cost Factor	recurring cost per square foot per month for non-residential structures	
Hotel per Diem Cost	daily cost per household, up to 5 people, for lodging	
Meal per Diem Cost	daily cost per person of eating out, less average cost of eating at home	
Mental Stress and Anxiety Unit Cost	cost of mental stress and anxiety per resident	
Productivity Loss Unit Cost	productivity loss per full-time worker	
Land Use Conversion Unit Benefit	value of ecosystem services ($/acre/year) provided by land use conversion	
Replacement Cost Models	building replacement values ($/sq. ft.)	Hazus Technical Manual[6]
Depth-Damage Functions	tables of percent damage for depth flooded given the building type	USACE New Orleans District[7]
SFR Content-to-Structure Value Ratios	ratio for single-family residences for 1 story, 2 stories, or mobile home	USACE New Orleans District[7]
Other Content-to-Structure Value Ratios	ratio for structures other than single-family residences	USACE New Orleans District[7]

1.4 CALCULATION OF EXPECTED ANNUAL BENEFITS

For benefit categories based on avoided losses, impacts are assessed for multiple storm recurrence intervals, and an Expected Annual Loss value is estimated from the estimated value of damages caused by each storm and the associated probability of such a storm in a single year. This annualized value is

[6] Hazus-MH MR3 Technical Manual. FEMA.
[7] *Final Report: Depth-Damage Relationships for Structures, Contents, and Vehicles and Content-to-Structure Value Ratios (CSVR) in Support of the Donaldsonville to the Gulf, Louisiana, Feasibility Study*. U.S. Army Corps of Engineers, New Orleans District. New Orleans, Louisiana. 2006.

estimated as the area under the Damage vs Probability curve using the trapezoidal area method. This method is described in a FEMA guidance document for flood risk assessments[8]. *Equation 1* demonstrates how this method is applied if impacts are modeled for 10-, 25-, 50-, 100-, and 500-year storms.

$$\begin{aligned} Expected\ Annual\ Loss = & \left(\frac{1}{500} * Loss_{500yr}\right) \\ & + \left(\frac{1}{100} - \frac{1}{500}\right)\left(Loss_{100yr} + Loss_{500yr}\right) \\ & + \left(\frac{1}{50} - \frac{1}{100}\right)\left(Loss_{50yr} + Loss_{100yr}\right) \\ & + \left(\frac{1}{25} - \frac{1}{50}\right)\left(Loss_{25yr} + Loss_{50yr}\right) \\ & + (\frac{1}{10} - \frac{1}{25})(Loss_{10yr} + Loss_{25yr}) \end{aligned}$$

Equation 1

Loss values are not extrapolated to storm events with recurrence intervals smaller or larger than the events simulated in a hydraulic model. The Expected Annual Benefit (EAB) is the difference in Expected Annual Loss under existing and post-mitigation conditions (*Equation 2*).

$$Expected\ Annual\ Benefit = (Expected\ Annual\ Loss)_{Existing} - (Expected\ Annual\ Loss)_{Post-mitigation}$$

Equation 2

1.5 PRESENT VALUE ANALYSIS

Benefits in all categories except Social Benefits were determined on an annualized basis as described in the previous section or using standard annual benefit values. (Social benefit unit values are provided as standard Present Value amounts and are not discounted.) The present value of the Expected Annual Benefits (EAB) was then determined using the standard economic equivalence factor. Equivalence factors were determined using an annual discount rate of 7% as specified in OMB Circular A-94 and an assumed project useful life of 50 years. Alternate factors were also determined using a lower discount rate of 3%. Equivalence factors for converting between annual and present values are shown in *Equation 3* and *Equation 4*. The 50-year life was based on a table of project lifetimes within the FEMA Toolkit (*Table 1-3*).

$$Capital\ Recovery\ Factor\ (\frac{A}{P}) = \frac{Annual\ Value}{Present\ Value} = \frac{i(1+i)^n}{(1+i)^n - 1}$$

Equation 3

$$Uniform\ Series\ Present\ Worth\ Factor\ \left(\frac{P}{A}\right) = \frac{Present\ Value}{Annual\ Value} = \frac{(1+i)^n - 1}{i(1+i)^n}$$

Equation 4

[8] "Guidance for Flood Risk Analysis and Mapping: Flood Risk Assessments." p. 18. FEMA. February 2018.

Table 1-3 – Standard Values for Project Useful Life in FEMA BCA Toolkit v6.0

Flood Hazard Mitigation Project Type	Useful Life (years)
Acquisition / Relocation	
Acquisition / Relocation	100
Building Elevation	
Residential Building	30
Non-Residential Building	25
Public Building	50
Historic Buildings	50
Mitigation Reconstruction	
Mitigation Reconstruction	50
Infrastructure Projects	
Major Infrastructure (dams, levees)	50
Concrete infrastructure, flood walls, roads, bridges, major drainage system	50
Culverts (concrete, PVC, CMP, HDPE, etc.) with end treatment	30
Culverts without end treatment	10
Major pump stations, substations, wastewater systems, or equipment such as generators	50
Minor pump stations, substations, wastewater systems, or equipment such as generators	5

Present Value Benefits were then compared to Total Project Cost to determine the Benefit-Cost Ratio (BCR) as shown in *Equation 5*.

$$BCR = \frac{(Expected\ Annual\ Benefits * \ Uniform\ Series\ Present\ Worth\ Factor) + Present\ Worth\ Social\ Benefits}{Project\ Capital\ Cost}$$ ***Equation 5***

In the FEMA Toolkit, project useful life is specified for each structure individually, allowing a different factor to be applied to structures subject to buyouts, for which the useful life is assumed to be 100 years. However, for simplicity in the preliminary BCAs, a single equivalence factor based on a 50-year life was applied across the entire project. In other words, although the project does include acquisition and demolition of some structures, the shorter useful life of the primary project infrastructure has been used to apply a consistent present worth conversion factor to all components. This simplification causes a slight underestimation of benefits, but the difference is negligible.

2.0 QUANTITATIVE BENEFITS

2.1 BENEFITS BASED ON DEPTH OF FLOODING

A traditional BCA for flood mitigation projects assesses the difference in probable damages to a structure and its contents under existing (baseline) conditions and post-mitigation (proposed) conditions. Baseline and proposed impacts to a structure and its contents are assessed for multiple storm recurrence intervals based on the depth to which the structure is inundated in each scenario. Flooding depth for each structure is calculated as the difference in modeled water surface elevation (WSE) and finished floor elevation (FFE) as provided in the structure inventory. For structures with missing FFE data, FFE was estimated at 6 inches above ground elevation, using the same ground elevation data as was used in development of the structure inventory[9].

Depth-related benefit categories include traditional structural benefits as well as others that can be related to the depth of flooding in a given storm frequency:

- Building Damages – Depth related to % of value lost.
- Content Damages – Depth related to % of value lost.
- Displacement Costs – Depth related to number of days displaced.
- Loss of Income / Loss of Function – Depth related to number of days rent payment income or commercial function is lost.

The following sections explain how these categories were assessed in the BCA.

2.1.1 Building and Content Damages

The FEMA Toolkit requires structural damages to be calculated based on a Building Replacement Value (BRV), not the appraised value or market value. The Unit BRV (cost per square foot) has a default value of $100/sf in the FEMA Toolkit. This default value was replaced with a value specific to each structure's attributes as described in the Hazus Technical Manual[10]. Hazus unit BRVs depend on building type and number of stories. Residential unit BRVs are further broken down by construction class (economy, average, custom, or luxury). Using Hazus methodology[11], a weighted composite building replacement value was assigned to single-family residential structures in the project service area based on the ratio of

[9] Bare Earth LiDAR, HGAC 2008 Datum Adjusted. Houston-Galveston Area Council. 2008.
[10] Hazus-MH MR3 Technical Manual. FEMA.
[11] Hazus-MH MR3 Technical Manual. FEMA. "Section 14.2.1 – Full Building Replacement Costs."

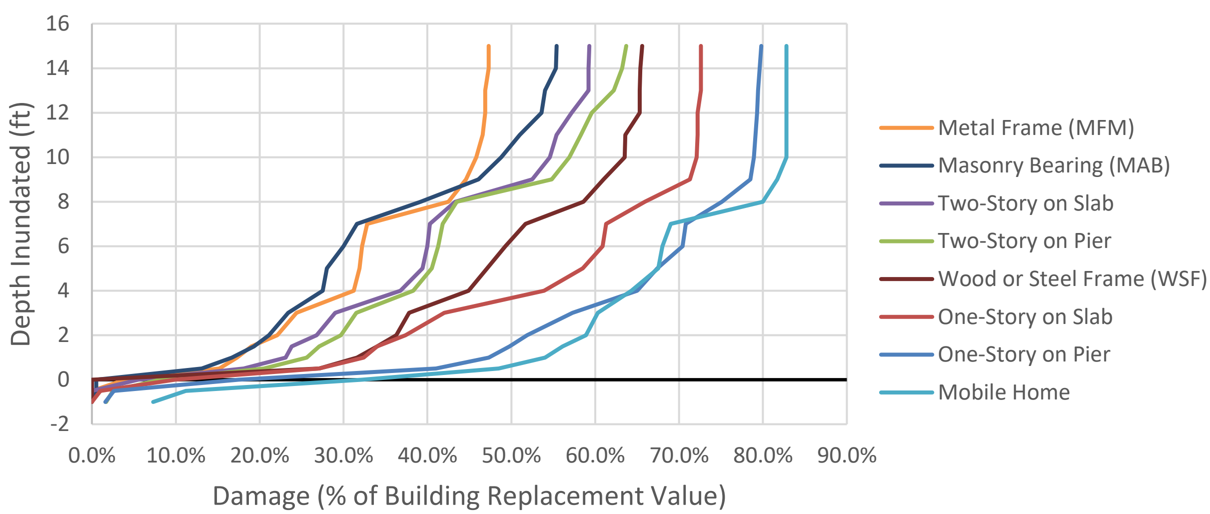
median household income in each census tract to median income across Texas (median household income determined from 2018 ACS 5-year data Subject Table S1903). Finally, the Total Building Replacement Value of a structure is calculated by multiplying the Unit BRV by the building size (*Equation 6*). This approach allowed for the use of local data to appropriately reflect structure values in the project service area.

$$Total\ BRV = Unit\ BRV\ (\$/sf) * Area\ (sf)$$ **Equation 6**

Values documented in the Hazus Technical Manual are based on standard cost-estimation models published in *Means Square Foot Costs*[12] and were reported in 2006 dollars. For this analysis, these values were scaled up using the RSMeans Historical Cost Indices from 2006 to 2020 to be consistent with project cost estimates. Building replacement values can be found in **Appendix A**.

Once depth of flooding is determined for a structure under a given scenario, the percent of the Total BRV that is lost to damage is determined from a depth-damage function (DDF). The DDFs used in this BCA were developed by the USACE New Orleans District[13] and are illustrated in *Figure 1*. It should be noted that some structures are expected to experience damage even when WSE is below FFE by up to 2 feet, depending on structure type.

Figure 1 – Depth-Damage Functions



[12] R.S. Means, 2005.
[13] Final Report: Depth-Damage Relationships for Structures, Contents, and Vehicles and Content-to-Structure Value Ratios (CSVR) in Support of the Donaldsonville to the Gulf, Louisiana, Feasibility Study. U.S. Army Corps of Engineers, New Orleans District. New Orleans, Louisiana. 2006.

The percent damage estimated from the DDFs is also applied to the value of the contents in the structures. The total value of contents in each structure was estimated from content-to-structure value ratios developed by the USACE New Orleans District[13], which specify a percentage of the building value depending on the building type.

A demolition threshold was set to 50%, which is the default value in the FEMA Toolkit. If percent damage based on depth and the depth-damage curve exceeded this threshold, the structure is expected to be substantially damaged and is assumed to need replacement rather than repair. In this case, the value of Expected Structure Damage is the Total BRV. Additionally, the value of Expected Content Losses is assumed to be maximized at this point (not a total loss, but the maximum value on the depth-damage curve).

Total benefits of avoided structure and content losses are summarized in the **Executive Summary**.

2.1.2 Displacement Costs (Residential)

Residential displacement losses represent the cost to residents of being out of their home after a flood event. The cost of residential displacement under baseline and proposed conditions for each modeled event was calculated using the method and standard values (shown in *Table 2-1*) in the FEMA Toolkit:

- Temporary lodging for each displaced household (assumes up to 5 household members per hotel room)
- Increase in meal cost (above average cost of eating at home) for each displaced resident

Expected annual benefits depend on a relationship between number of days displaced for depth of inundation. Using the relationship in the FEMA Toolkit, 45 days of displacement were assumed for each foot of flooding above FFE. No displacement was assumed if WSE did not exceed FFE. Total benefits of avoided residential displacement costs are summarized in the **Executive Summary**.

Table 2-1 – Residential Displacement Unit Costs

Meals per diem per capita	Cost of eating at home	Hotel per diem per family, up to 5 people	Meal cost / person / day
$55	$7	$94	$48

2.1.3 Displacement Costs (Non-Residential)

The costs of non-residential displacement, as defined by FEMA, include:

- One-time cost of relocating business equipment
- Monthly rental costs of new space

The same relationship between depth flooded and days displaced was used for non-residential displacement as for residential displacement. Cost factors provided in the FEMA Toolkit as $/sq. ft. values were used to estimate both the monthly and one-time cost components of non-residential displacement (*Table 2-2*). Total benefits of avoided non-residential displacement costs are summarized in the **Executive Summary**.

Table 2-2 – Non-residential Displacement Cost Factors

Occupancy Class	Disruption Cost Factor ($/sf)	Rental Cost Factor ($/sf)
Retail Trade	1.09	1.16
Wholesale Trade	0.95	0.48
Personal and Repair Services	0.95	1.36
Technical Business	0.95	1.36
Banks	0.95	1.7
Hospital	1.36	1.36
Medical Office/Clinic	1.36	1.36
Entertainment and Recreation	0	1.7
Theaters	0	1.7
Heavy	0	0.2
Light	0.95	0.27
Food/Drugs/Chemicals	0.95	0.27
Metals/Mineral Processing	0.95	0.2
High Technology	0.95	0.34
Construction	0.95	0.14
Agriculture	0.73	0.73
Religious/Nonprofit/Membership Organization	0.68	0.68
Government, General Services	0.95	1.36
Government, Emergency Response	0.95	1.36
Schools/Libraries	0.95	1.02
College/Universities	0.95	1.36

2.1.4 Loss of Income / Loss of Function

Loss of Income represents the loss of monthly rental income to owners of rental properties. Because additional monthly rental costs were considered as a displacement cost to non-residential tenants, property owner income losses were excluded from this BCA to avoid double-counting benefits.

Loss of Function represents the lost revenue due to inability to operate a business for some amount of time after a flood event. This avoided cost benefit category requires knowledge of the operating budget of the business for each individual non-residential structure in a project service area. As the majority of flood mitigation benefits in the project service area are to residential structures, this category was not assessed.

2.2 ANCILLARY BENEFITS

In addition to the benefit categories that represent avoided costs based on reduction in flooding depth, social and environmental benefits of the project were also quantified.

2.2.1 Avoided Social Costs

Social benefits based on the FEMA Toolkit represent the expected benefits of reducing mental health impacts associated with experiencing a disaster such as flooding. These benefits include avoided costs of:

- Health treatment for mental stress and anxiety of impacted residents
- Productivity losses by impacted residents who work full-time due to impacts on mental health

The calculation of social benefits replicated the method used in the FEMA Toolkit, which applies a present value benefit amount per impacted person to estimate the avoided costs of mental health treatment and of lost productivity *(Table 2-3)*. These values are based on studied prevalence, severity, and course of mental effects following a disaster[14]. It should be noted that because these values are present value benefits, they are not dependent on the annual expected probability of a storm event or the level of flooding anticipated from a given event. Instead, these benefits represent the positive impact of a mitigation project reducing flooding in a resident's home, which may include an existing condition of minor flooding compared to a post-mitigation condition of no flooding. Even when traditional benefit

[14] *Final Sustainability Benefits Methodology Report.* FEMA. Task order HSFEHQ-11-J-1408. August 2012.

estimates might indicate a very small value of saved structural and content damages, the positive impact on residents of not having to do any repairs instead of a few repairs is significant.

Table 2-3 – Unit Values for Social Benefits as Avoided Costs of Mental Health Impacts

Category	Benefit per Person (Present Value)	Unit
Treatment for mental stress and anxiety	$2,443	Resident of home benefitted by project
Lost productivity	$8,736	Resident of home benefitted by project who works full-time

The present value benefits per person for treatment of mental stress and anxiety were applied to all residents of structures which experienced a reduced modeled WSE after project implementation, regardless of event frequency. The **Population Estimate Attachment** describes how ACS Table B01003 (Total Population Estimates) and ACS Data Profile DP04 (Selected Housing Characteristics) were used to allocate numbers of residents to each structure in the watershed. The number of full-time workers in each Census tract (B23027_001E) was compared to the total tract population (B01003_001E) to estimate the number of full-time workers living in each structure. Costs of lost productivity were based on the estimated number of full-time workers residing in each structure. Estimated social benefits are summarized in the **Executive Summary**.

2.2.2 Environmental Benefits

Environmental benefits based on the FEMA Toolkit represent the value of ecosystem services provided by enhancement of a parcel's land use to a use type which provides a higher level of natural environmental benefits. Unlike other benefit categories based on avoided costs, environmental benefits represent an added service. *Table 2-4* indicates the value of each land use type (assuming existing condition is developed land).

Table 2-4 – Unit Benefit Values for Conversion of Developed Land to Land Use of Higher Ecosystem Value

Documented Benefit/acre/year[15]				
Green Open Space	Riparian	Wetlands	Forests	Marine /Estuary
$8,308	$39,545	$6,010	$554	$1,799

[15] Help Section of B/C Analysis Toolkit v6.0, as of 01/28/2020.

Expected environmental benefits are summarized in the **Executive Summary**.

2.3 SPECIAL CONSIDERATIONS

Certain mitigation activities occurring in areas that ultimately outfall to the main channel of the project service area are included in the White Oak Bayou Covered Project. Detailed hydraulic modeling has not yet been performed for all of these activities, so data on the exact depth of inundation at each structure location under multiple storm event scenarios is not available. In these cases, expected damages to structures and contents, and subsequently expected benefits, were estimated based on the following:

1. Professional estimates of the existing and proposed project conditions:
    a. Number of inundated structures in existing conditions, and average flooding depth for these structures
    b. Number of inundated structures in proposed conditions, and average flooding depth for these structures. This structure count is equal to the number of inundated structures in existing conditions less the number of structures from which the floodplain will be removed.
    c. Average loss per structure in existing conditions, based on the average flooding depth, average structure size, and average market value. A generic damage curve for single-story residential structures was applied to all structures.
    d. Average loss per structure in proposed conditions, based on the average flooding depth, average structure size, and average market value. A generic damage curve for single-story residential structures was applied to all structures.
2. For each event return period for which professional estimates were available, expected losses in the existing condition were calculated as Number of Inundated Structures (Existing) x Average Loss Per Structure (Existing).

3. For each event return period assessed in Step 2, expected losses in the proposed condition were calculated as Number of Inundated Structures (Proposed) x Average Loss Per Structure (Proposed).
4. Expected annual benefits for each activity were calculated as described in **Section 1.4** by considering the expected frequency of each event and calculating benefits for each event as Total Expected Losses (Existing) less Total Expected Losses (Proposed).

Social benefits were assumed to apply to the residents of all benefitted structures in these areas which are anticipated to experience a reduction in water surface elevation. Avoided costs of displacement and environmental benefits were not considered for these activities.

3.0 QUALITATIVE BENEFITS

As described in the Federal Register,[16] as long as a quantitative BCA has been completed, projects may have a benefit-cost ratio of less than 1.0 when the project provides concrete benefits to "low- and moderate- income persons or other persons that are less able to mitigate risks or respond to and recover from disaster," including benefits that cannot be quantified. Qualitative benefits of this project are discussed below.

3.1 BENEFICIARIES VULNERABLE TO FLOOD RISK

This application has demonstrated that 53.7% of the beneficiaries of White Oak Bayou Watershed Mitigation Project are low- to moderate-income persons. Additionally, many of the residents of the project service area may be considered particularly vulnerable to disasters. 33.9% of the households in the project service area are considered to be housing cost-burdened, and 16.0% are severely housing cost-burdened[17]. These households spend 30+% and 50+% of their monthly income on housing-related costs, respectively. This cost burden may make it particularly hard for these households to recover from disaster, as they are less likely to have additional funds available for repairs, hotel stays, and lost wages during and after a flood. Additionally, 23.4% of the households in the project service area have no

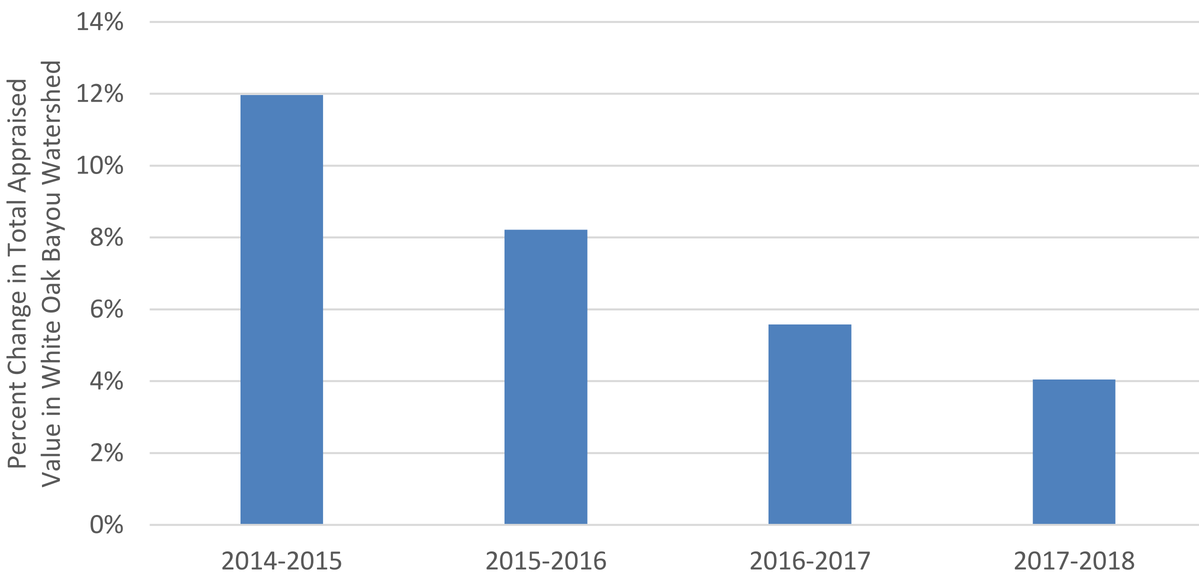
[16] Allocations, Common Application, Waivers, and Alternative Requirements for Community Development Block Grant Mitigation Grantees, 84 FR 169 (August 30, 2019).
[17] Estimates derived from data in tables B25070 (Gross Rent as a Percentage of Household Income in the Past 12 Months) and B25091 (Mortgage Status by Selected Monthly Owner Costs as a Percentage of Household Income in the Past 12 Months). U.S. Census Bureau. American Community Survey, 2014-2018.

computer and/or no internet subscription[18]. Lack of reliable internet access may reduce residents' ability to benefit from early warning systems in case of flooding events, making them more vulnerable.

3.2 BENEFIT OF REDUCING FLOOD IMPACTS TO PROPERTY VALUES

A review of parcel appraisal values from the Harris County Appraisal District suggests that the annual rate of growth in property values generally slowed from 2014 to 2018 in the White Oak Bayou Watershed (*Figure 2*). This trend could be caused or influenced by floods in 2015, 2016, and 2017, but the degree to which local flooding impacted the value growth rates cannot be ascertained. General economic conditions in Harris County following Hurricane Harvey, as well as other external economic factors, could also contribute to changes in property values. Although the exact impact of local flooding on property values cannot be quantified, flood risk mitigation projects are likely to have a positive impact on the residents of flood-prone areas, as falling property values can have a negative effect on the financial flexibility of housing cost-burdened homeowners and even renters. Finally, the White Oak Bayou Watershed Mitigation Project will remove 258 acres from the 100-year floodplain, providing a potential positive impact to property values.

Figure 2 – Year-to-Year Percent Change in Total Appraised Value of Property in White Oak Bayou Watershed



[18] Estimate derived from data in table B28003 (Presence of a Computer and Type of Internet Subscription in Household). U.S. Census Bureau. American Community Survey, 2014-2018.

3.3 TRANSPORTATION BENEFITS

Street closures due to flooding in the White Oak Bayou Watershed during Hurricane Harvey likely impacted a large number of commuters, including those who do not live in the watershed. Frequently, residential streets are inundated and may become impassable without the water level reaching a point of causing any damage to homes. In these scenarios, no quantitative benefits are counted in the BCA as there is no structural damage or displacement of residents. However, the street flooding poses an inconvenience and in some cases a safety risk, as it can inhibit evacuations, potentially trapping residents in homes that may lose power or keeping them from accessing groceries or medical supplies. The White Oak Bayou Watershed Mitigation Project will provide some reduction in street inundation as a benefit to residents in the service area.

In Harris County, over 50,000 workers 16 years and older use a bus or trolley bus as means of transportation to work. Of workers living within the watershed, 2.3% (5,198 workers) use a bus to commute to work[19]. Data from the Metropolitan Transit Authority of Harris County (Metro) indicates that 29 bus routes through the watershed were closed for up to 4 or more days during and after Hurricane Harvey, with 3 of these routes being closed for 15 or more days. No methods were found that could be used to quantify the productivity losses of workers impacted by road closures. Additionally, all Metro bus routes passing through the project service area also extend across multiple floodplains in Harris County. It was determined that even if a substantial section of a route is removed from the floodplain as a result of the White Oak Bayou Watershed Mitigation Project, inundation elsewhere could still cause route closure. Because of this, assigning quantitative economic benefits to reduced flooding along bus routes that could be attributed only to this project was not considered to be a valid approach. However, the White Oak Bayou Watershed Mitigation Project is important to reducing the overall flooding along major commuter routes, providing significant benefit to residents of the project service area as well as workers traveling to and through the area.

4.0 SUMMARY

The approach to benefit-cost analysis documented here was based on FEMA BCA methodologies and considered various categories of benefits afforded by the White Oak Bayou Watershed Mitigation Project. However, as discussed in **Section 2.1.1**, the use of structural damages in a benefit-cost ratio, while valid,

[19] Estimate derived from data in table B08301 (Means of Transportation to Work). U.S. Census Bureau. American Community Survey, 2014-2018.

means that a project in a lower income service area that provides flood mitigation benefits to the same number of homes as a project in a higher-income area may have a lower calculated benefit-cost ratio due to the lower replacement values of homes in the service area. As a result, the low- and moderate-income populations that the CDBG-MIT funding seeks to serve may be underserved by funding sources which rely primarily on traditional benefit-cost analysis methods. Considering this, it is important to recognize that quantitative BCRs should not be used alone when evaluating the effectiveness of a mitigation project, and in fact, comparing BCRs between projects may actually work against the goal of serving of CDBG-MIT funding to serve LMI and other vulnerable populations.

APPENDIX A
BUILDING REPLACEMENT VALUES

Table A-1
Single-Family Residential Building Replacement Values (2020 dollars, assuming no basements)

Income Ratio (r) Number of Stories	r < 0.5	0.5 <= r < 0.85	0.85 <= r < 1.25	1.25 <= r < 2.0	r >= 2.0
1	$97.28	$107.21	$145.17	$169.60	$206.28
2	$103.51	$110.89	$141.45	$166.65	$196.43
3	$103.51	$112.50	$147.76	$172.67	$202.32
split	$95.14	$102.70	$132.88	$155.34	$184.21

Table A-2
Multi-Family Residential Building Replacement Values (2020 dollars)

Number of Units	Unit Building Replacement Value ($/sf)
2	$117.00
3-4	$128.00
5-9	$228.00
10-19	$203.00
20-49	$200.00
50+	$195.00

Table A-3
Non-Residential Building Replacement Values (2020 dollars)

Occupancy Class	Occupancy Sub-Class	Unit Building Replacement Value ($/sf)
Manufactured Housing	Manufactured Housing	$52.76
Retail Trade	Dept Store, 1 st	$121.96
Wholesale Trade	Warehouse, medium	$112.10
Personal and Repair Services	Garage, Repair	$151.05
Prof./ Tech./Business Services	Office, medium	$196.93
Banks	Bank	$282.68
Hospital	Hospital, medium	$331.04
Medical Office/Clinic	Med. Office, medium	$242.32
Entertainment & Recreation	Restaurant	$251.66
Theaters	Movie Theatre	$180.14
Parking	Parking garage	$64.53
Heavy	Factory, small	$130.29
Light	Warehouse, medium	$112.10
Food/Drugs/Chemicals	College Laboratory	$214.11
Metals/Minerals Processing	College Laboratory	$214.11
High Technology	College Laboratory	$214.11
Construction	Warehouse, medium	$112.10
Agriculture	Warehouse, medium	$112.10
Church	Church	$204.52
General Services	Town Hall, small	$158.34
Emergency Response	Police Station	$245.87
Schools/Libraries	High School	$170.19
Colleges/Universities	College Classroom	$213.61

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BENEFIT-COST ANALYSIS

WHITE OAK BAYOU WATERSHED MITIGATION PROJECT

Prepared for:

Harris County

October 2020

Prepared by:

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The benefit-cost analysis performed for White Oak Bayou Watershed Mitigation Project included quantification of the following types of benefits:

- Building damages (avoided costs)
- Content damages (avoided costs)
- Residential displacement (avoided costs)
- Non-residential displacement (avoided costs)
- Mental health treatment (avoided costs)
- Worker productivity (avoided costs)
- Ecosystem services (added benefit of conversion of developed land)

Net present value benefits were calculated using a 7% discount rate. *Table ES-1* summarizes benefits on an annual basis and at present value.

Table ES-1 – Summary of Project Benefits

Expected Benefits	Annual Benefit	Present Value Benefit
Structures + Contents	$1,647,690	$22,739,349
Displacement, Residential	$124,458	$1,717,620
Displacement, Non-residential	$5,279	$72,858
Social (Mental Health & Productivity)	$2,341,772	$32,318,205
Environmental (Ecosystem services of converted land)	$690,548	$9,530,078
Total Expected Benefits (all categories)	**$4,809,748**	**$66,378,109**

Social benefits represent the expected benefits of reducing mental health impacts associated with experiencing a disaster such as flooding. These benefits include avoided costs of:

- Health treatment for mental stress and anxiety of impacted residents
- Productivity losses by impacted residents who work full-time due to impacts on mental health

Social benefits of the White Oak Bayou Watershed Mitigation Project are shown in *Table ES-2*.

Table ES-2 – Summary of Social Benefits

Category	Number of Persons	Benefit per Person	Present Value Social Benefits
Number of Persons Directly Benefitted by Mitigation of Residential Structural Flooding	3,634	$ 2,443	$8,878,297
Number of Full-time Workers Directly Benefitted by Mitigation of Residential Structural Flooding	2,683	$ 8,736	$23,439,908
Total Social Benefit			**$32,318,205**

Environmental benefits based on the FEMA Toolkit represent the value of ecosystem services provided by enhancement of a parcel's land use to a use type which provides a higher level of natural environmental benefits. The White Oak Bayou Watershed Mitigation Project requires some acquisition and conversion of developed land to undeveloped floodplain. Additionally, a riparian corridor is planned as part of the project. The benefit value for Green Open Space has been applied to these areas. Environmental benefits of the White Oak Bayou Watershed Mitigation Project are summarized in *Table ES-3*.

Table ES-3 – Summary of Environmental Benefits

Post-Mitigation Land Use	Acres Converted	Benefit per Acre per Year	Annual Benefits	Present Value Benefits
Green Open Space	26	$8,308	$216,008	$2,981,072
Riparian	12	$39,545	$474,540	$6,549,006
Wetlands	0	$6,010	$-	$-
Forests	0	$554	$-	$-
Marine / Estuary	0	$1,799	$-	$-
Total Environmental Benefit	**38**		$690,548	$9,530,078

In addition to environmental benefits, social benefits, and reduced structural damages and displacement costs, the White Oak Bayou Watershed Mitigation Project represents a holistic benefit to its service area, the White Oak Bayou Watershed, by removing structures and land area from the floodplain. *Table ES-4* summarizes the impacts of the mitigation project.

Table ES-4 – Impacts of Mitigation Project

Number of structures benefitted in any event *(estimated losses to structural damage are reduced)*	1,586
Number of structures removed from 10% AEP (10-year) floodplain	76
Number of structures removed from 1% AEP (100-year) floodplain	527
Number of acres removed from 10% AEP (10-year) floodplain	117
Number of acres removed from 1% AEP (100-year) floodplain	258
Number of structures removed from risk* in 10% AEP (10-year) event	7
Number of structures removed from risk* in 1% AEP (100-year) event	475

**Structures "at risk" refer to those for which the modeled water surface elevation is at or above finished floor elevation.*

Project costs as estimated for the CDBG-MIT grant application include estimated costs of design and construction. The benefit-cost ratio was determined as the ratio of the present value of Total Expect Benefits to Total Project Cost; this ratio is presented in *Table ES-5*. It is important to note that the White Oak Bayou Watershed Mitigation Project will provide many community benefits for which an economic value could not be quantified as part of this analysis. Additional unquantified benefits are discussed further in the section on **Qualitative Benefits**.

Table ES-5 – Benefit-Cost Ratio

Present Value Total Benefits	$66,378,109
Present Value Total Cost	$121,281,560
Benefit-Cost Ratio	0.55

1.0 METHODOLOGY

1.1 BENEFIT-COST ANALYSIS REQUIREMENTS FOR CDBG-MIT PROJECTS

Although a benefit-cost ratio (BCR) is not a factor in the competition score as set forth by the Texas General Land Office (GLO), applicants are required to demonstrate that the benefits of any Covered Project outweigh its costs. As described in the Federal Register,[1] this requirement may be met in either of two ways:

1. Benefit-cost ratio developed during a benefit-cost analysis (BCA) is greater than 1.0.
    a. Calculations should be prepared in accordance with OMB Circular A-94[2].
    b. BCA methodology should follow FEMA standardized methodologies unless
        1) A BCA for the project has already been completed or is in progress under guidelines of other Federal agencies, or
        2) The BCA addresses a non-correctable flaw in the FEMA methodology, or
        3) A new approach is proposed that is unavailable using the FEMA Toolkit.
2. Alternately, projects may have a benefit-cost ratio of less than 1.0 under these conditions:
    a. A BCA is still completed following the methodologies described above.
    b. The project "serves low- and moderate- income persons or other persons that are less able to mitigate risks or respond to and recover from disaster."
    c. A qualitative description is provided for "benefits that cannot be quantified but sufficiently demonstrate unique and concrete benefits of the Covered Project for low- and moderate- income persons or other persons that are less able to mitigate risks, or respond to and recover from disasters."

The analysis presented here meets these requirements as follows:

- In accordance with OMB Circular A-94, a 7% discount rate was used when determining equivalent present values of expected annual benefits and vice versa.

[1] Allocations, Common Application, Waivers, and Alternative Requirements for Community Development Block Grant Mitigation Grantees, 84 FR 169 (August 30, 2019).
[2] *Circular A-94*, Office of Management and Budget, last revised October 29, 1992.

- The quantitative benefit-cost analysis (BCA) was based on benefit quantification methods and assumptions used in FEMA tools such as the FEMA BCA Toolkit version 6.0[3] (hereafter "FEMA Toolkit") and HAZUS (Hazards U.S. planning-level damage and loss estimating tool). These tools were not used directly, but the methods and assumptions in the FEMA Toolkit and HAZUS were applied using a combination of geospatial and tabular analysis tools to more efficiently:
    - Assess thousands of potentially impacted structures.
    - Utilize spatially variable modeled water surface elevation data.
    - Incorporate detailed information at an individual structure level.
- As indicated by the beneficiary population analysis detailed in the **LMI Evaluation Attachment**, over 51% of the project beneficiaries of are low- to moderate-income persons.
- The **Qualitative Benefits** section of this report discusses benefits of the Covered Project that could not be quantified.

1.2 QUANTITATIVE BENEFIT CATEGORIES

The benefit-cost analysis included quantification of the following types of benefits:

- Building damages (avoided costs)
- Content damages (avoided costs)
- Residential displacement (avoided costs)
- Non-residential displacement (avoided costs)
- Mental health treatment (avoided costs)
- Worker productivity (avoided costs)
- Ecosystem services (added benefit of conversion of developed land)

1.3 INPUT DATA

A separate analysis was performed to estimate the number of residents and residential units per structure, as well as the number of residents who are full-time workers. The primary datasets used in the BCA are summarized in *Table 1-1.*

[3] *Benefit Cost Toolkit Version 6.0.* FEMA. October 2019. Available at https://www.fema.gov/media-library/assets/documents/179903.

Table 1-1 – Input Datasets to Benefit-Cost Analysis

Dataset	Source	Description
Harris County Structure Inventory	Harris County Flood Control District	attributes of individual structures in the study area, including use, size, and look-up codes for various reference tables
Right-of-Way Acquisition	Harris County Flood Control District	parcels and impacted structures to be bought out as part of project
Capital Costs	Harris County Flood Control District; Harris County	project capital costs
Existing and Proposed Water Surface Elevations	Harris County Flood Control District; Harris County	Estimated water surface elevations based on hydraulic modeling of conditions before and after project implementation
American Community Survey Data[4]	U.S. Census Bureau	2018 ACS 5-year data related to population, average household size, number of full-time workers, median household income, and other variables
Census Geographic Areas	U.S. Census Bureau	boundaries of 2010 Census tracts and block groups

HCFCD maintains a detailed structure inventory of all structures in Harris County. This inventory includes data on the number of housing units in each structure, square footage, building style, finished floor elevation, and numerous other attributes. The qualitative structure attributes in the inventory were used to determine the appropriate depth-damage functions and content-to-structure value ratios, and the finished floor elevation is the basis for determining damage and displacement costs based on depth of flooding above finished floor.

Data from the 2018 American Community Survey (ACS) 5-year[4] data tables was used in various parts of the BCA; the variables used are listed below. The following sections describe the use of this data in more detail.

- Subject Table S1903 –Median Income in the Past 12 Months
- Detail Table B01003 – Total Population
- Data Profile Table DP04 – Selected Housing Characteristics
- Detail Table B23027 – Full-Time, Year-Round Work Status in the Past 12 Months by Age for Population 16+ Years

[4] U.S. Census Bureau. American Community Survey, 2014-2018. Detailed Tables, Subject Tables, and Data Profile Tables; generated by Freese & Nichols, Inc. using the U.S. Census Bureau Application Programming Interface.

Table 1-2 lists the various standard values and lookup tables referenced in the calculations.

Table 1-2 – Sources of Standard Values and Reference Tables

Name	Purpose	Source
Discount Rate	calculate discount factors for converting between annual and present value equivalent costs/benefits	OMB Circular A-94
Demolition Threshold	threshold above which building is assumed to be fully lost and contents maximally lost	FEMA BCA Toolkit v6.0
Useful Life	project lifetime used in discounting	
Depth-Days Curve	table of days displaced for depth flooded	
Disruption Cost Factor	one-time cost per square foot for non-residential structures	
Monthly Cost Factor	recurring cost per square foot per month for non-residential structures	
Hotel per Diem Cost	daily cost per household, up to 5 people, for lodging	
Meal per Diem Cost	daily cost per person of eating out, less average cost of eating at home	
Mental Stress and Anxiety Unit Cost	cost of mental stress and anxiety per resident	
Productivity Loss Unit Cost	productivity loss per full-time worker	
Land Use Conversion Unit Benefit	value of ecosystem services ($/acre/year) provided by land use conversion	
Replacement Cost Models	building replacement values ($/sq. ft.)	Hazus Technical Manual[5]
Depth-Damage Functions	tables of percent damage for depth flooded given the building type	USACE New Orleans District[6]
SFR Content-to-Structure Value Ratios	ratio for single-family residences for 1 story, 2 stories, or mobile home	USACE New Orleans District[6]
Other Content-to-Structure Value Ratios	ratio for structures other than single-family residences	USACE New Orleans District[6]

1.4 CALCULATION OF EXPECTED ANNUAL BENEFITS

For benefit categories based on avoided losses, impacts are assessed for multiple storm recurrence intervals, and an Expected Annual Loss value is estimated from the estimated value of damages caused by each storm and the associated probability of such a storm in a single year. This annualized value is

[5] Hazus-MH MR3 Technical Manual. FEMA.

[6] *Final Report: Depth-Damage Relationships for Structures, Contents, and Vehicles and Content-to-Structure Value Ratios (CSVR) in Support of the Donaldsonville to the Gulf, Louisiana, Feasibility Study*. U.S. Army Corps of Engineers, New Orleans District. New Orleans, Louisiana. 2006.

estimated as the area under the Damage vs Probability curve using the trapezoidal area method. This method is described in a FEMA guidance document for flood risk assessments[7]. *Equation 1* demonstrates how this method is applied if impacts are modeled for 10-, 25-, 50-, 100-, and 500-year storms.

$$\begin{aligned} Expected\ Annual\ Loss = &\left(\frac{1}{500} * Loss_{500yr}\right) \\ &+\left(\frac{1}{100}-\frac{1}{500}\right)\left(Loss_{100yr}+Loss_{500yr}\right) \\ &+\left(\frac{1}{50}-\frac{1}{100}\right)\left(Loss_{50yr}+Loss_{100yr}\right) \\ &+\left(\frac{1}{25}-\frac{1}{50}\right)\left(Loss_{25yr}+Loss_{50yr}\right) \\ &+(\frac{1}{10}-\frac{1}{25})(Loss_{10yr}+Loss_{25yr}) \end{aligned}$$

Equation 1

Loss values are not extrapolated to storm events with recurrence intervals smaller or larger than the events simulated in a hydraulic model. The Expected Annual Benefit (EAB) is the difference in Expected Annual Loss under existing and post-mitigation conditions *Equation 2*.

$$Expected\ Annual\ Benefit = (Expected\ Annual\ Loss)_{Existing} - (Expected\ Annual\ Loss)_{Post-mitigation}$$

Equation 2

1.5 PRESENT VALUE ANALYSIS

Benefits in most categories were determined on an annualized basis as described in the previous section. The present value of the Expected Annual Benefits (EAB) was then determined using the standard economic equivalence factor. Equivalence factors were determined using an annual discount rate of 7% as specified in OMB Circular A-94 and an assumed project useful life of 50 years. Equivalence factors for converting between annual and present values are shown in *Equation 3* and *Equation 4*. The 50-year life was based on a table of project lifetimes within the FEMA Toolkit (*Table 1-3*).

$$Annual\ Value\ =\ Present\ Value * \frac{i(1+i)^n}{(1+i)^n-1}$$

Equation 3

$$Present\ Value\ =\ Annual\ Value * \frac{(1+i)^n-1}{i(1+i)^n}$$

Equation 4

[7] "Guidance for Flood Risk Analysis and Mapping: Flood Risk Assessments." p. 18. FEMA. February 2018.

Table 1-3 – Standard Values for Project Useful Life in FEMA BCA Toolkit v6.0

Flood Hazard Mitigation Project Type	Useful Life (years)
Acquisition / Relocation	
Acquisition / Relocation	100
Building Elevation	
Residential Building	30
Non-Residential Building	25
Public Building	50
Historic Buildings	50
Mitigation Reconstruction	
Mitigation Reconstruction	50
Infrastructure Projects	
Major Infrastructure (dams, levees)	50
Concrete infrastructure, flood walls, roads, bridges, major drainage system	50
Culverts (concrete, PVC, CMP, HDPE, etc.) with end treatment	30
Culverts without end treatment	10
Major pump stations, substations, wastewater systems, or equipment such as generators	50
Minor pump stations, substations, wastewater systems, or equipment such as generators	5

Present Value Benefits were then compared to Total Project Cost to determine the Benefit-Cost Ratio (BCR) as shown in *Equation 5*.

$$BCR = ((Project\ Capital\ Cost) * (A/P\ Discount\ Factor) + Annual\ Maintenance\ Costs)/(Expected\ Annual\ Benefits)$$

Equation 5

In the FEMA Toolkit, project useful life is specified for each structure individually, allowing a different factor to be applied to structures subject to buyouts, for which the useful life is assumed to be 100 years. However, for simplicity in the preliminary BCAs, a single discount factor based on a 50-year life was applied across the entire project. In other words, although the project does include acquisition and demolition of some structures, the shorter useful life of the primary project infrastructure has been used to apply a consistent present worth conversion factor to all components. This simplification causes a slight underestimation of benefits, but the difference is negligible.

2.0 QUANTITATIVE BENEFITS

2.1 BENEFITS BASED ON DEPTH OF FLOODING

A traditional BCA for flood mitigation projects assesses the difference in probable damages to a structure and its contents under existing (baseline) conditions and post-mitigation (proposed) conditions. Baseline and proposed impacts to a structure and its contents are assessed for multiple storm recurrence intervals based on the depth to which the structure is inundated in each scenario. Flooding depth for each structure is calculated as the difference in modeled water surface elevation (WSE) and finished floor elevation (FFE) as provided in the structure inventory. For structures with missing FFE data, FFE was estimated at 6 inches above ground elevation, using the same ground elevation data as was used in development of the structure inventory[8].

Depth-related benefit categories include traditional structural benefits as well as others that can be related to the depth of flooding in a given storm frequency:

- Building Damages – Depth related to % of value lost.
- Content Damages – Depth related to % of value lost.
- Displacement Costs – Depth related to number of days displaced.
- Loss of Income / Loss of Function – Depth related to number of days rent payment income or commercial function is lost.

The following sections explain how these categories were assessed in the BCA.

2.1.1 Building and Content Damages

The FEMA Toolkit requires structural damages to be calculated based on a Building Replacement Value (BRV), not the appraised value or market value. The Unit BRV (cost per square foot) has a default value of $100/sf in the FEMA Toolkit. This default value was replaced with a value specific to each structure's attributes as described in the Hazus Technical Manual[9]. Hazus unit BRVs depend on building type and number of stories. Residential unit BRVs are further broken down by construction class (economy, average, custom, or luxury). Using Hazus methodology[10], a weighted composite building replacement value was assigned to single-family residential structures in the project service area based on the ratio of median household income in each census tract to median income across Texas (median household income determined from 2018 ACS 5-year data from Subject Table S1903). Finally, the Total Building Replacement Value of a structure is calculated by multiplying the Unit BRV by the building size *Equation 6*. This

[8] Bare Earth LiDAR, HGAC 2008 Datum Adjusted. Houston-Galveston Area Council. 2008.
[9] Hazus-MH MR3 Technical Manual. FEMA.
[10] Hazus-MH MR3 Technical Manual. FEMA. "Section 14.2.1 – Full Building Replacement Costs."

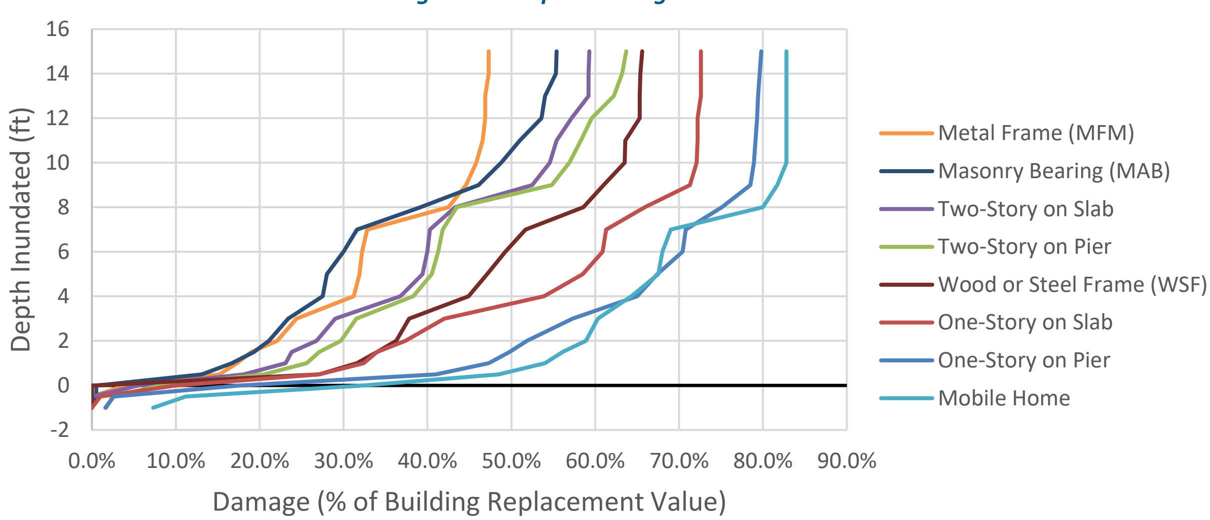
approach allowed for the use of local data to appropriately reflect structure values in the project service area.

$$Total\ BRV = Unit\ BRV\ (\$/sf) * Area\ (sf) \quad \text{Equation 6}$$

Values documented in the Hazus Technical Manual are based on standard cost-estimation models published in *Means Square Foot Costs*[11] and were reported in 2006 dollars. For this analysis, these values were scaled up using the RSMeans Historical Cost Indices from 2006 to 2020 to be consistent with project cost estimates. Building replacement values can be found in **Appendix A**.

Once depth of flooding is determined for a structure under a given scenario, the percent of the Total BRV that is lost to damage is determined from a depth-damage function (DDF). The DDFs used in this BCA were developed by the USACE New Orleans District[12] and are illustrated in *Figure 1*. It should be noted that some structures are expected to experience damage even when WSE is below FFE by up to 2 feet, depending on structure type.

Figure 1 – Depth-Damage Functions



The percent damage estimated from the DDFs is also applied to the value of the contents in the structures. The total value of contents in each structure was estimated from content-to-structure value ratios

[11] R.S. Means, 2005.
[12] Final Report: Depth-Damage Relationships for Structures, Contents, and Vehicles and Content-to-Structure Value Ratios (CSVR) in Support of the Donaldsonville to the Gulf, Louisiana, Feasibility Study. U.S. Army Corps of Engineers, New Orleans District. New Orleans, Louisiana. 2006.

developed by the USACE New Orleans District[12], which specify a percentage of the building value depending on the building type.

A demolition threshold was set to 50%, which is the default value in the FEMA Toolkit. If percent damage based on depth and the depth-damage curve exceeded this threshold, the structure is expected to be substantially damaged and is assumed to need replacement rather than repair. In this case, the value of Expected Structure Damage is the Total BRV. Additionally, the value of Expected Content Losses is assumed to be maximized at this point (not a total loss, but the maximum value on the depth-damage curve).

Total benefits of avoided structure and content losses are summarized in the **Executive Summary**.

2.1.2 Displacement Costs (Residential)

Residential displacement losses represent the cost to residents of being out of their home after a flood event. The cost of residential displacement under baseline and proposed conditions for each modeled event was calculated using the method and standard values (shown in *Table 2-1*) in the FEMA Toolkit:

- Temporary lodging for each displaced household (assumes up to 5 household members per hotel room)
- Increase in meal cost (above average cost of eating at home) for each displaced resident

Expected annual benefits depend on a relationship between number of days displaced for depth of inundation. Using the relationship in the FEMA Toolkit, 45 days of displacement were assumed for each foot of flooding above FFE. No displacement was assumed if WSE did not exceed FFE. Total benefits of avoided residential displacement costs are summarized in the **Executive Summary**.

Table 2-1 – Residential Displacement Unit Costs

Meals per diem per capita	Cost of eating at home	Hotel per diem per family, up to 5 people	Meal cost / person / day
$55	$7	$94	$48

2.1.3 Displacement Costs (Non-Residential)

The costs of non-residential displacement, as defined by FEMA, include:

- One-time cost of relocating business equipment

- Monthly rental costs of new space

The same relationship between depth flooded and days displaced was used for non-residential displacement as for residential displacement. Cost factors provided in the FEMA Toolkit as $/sq. ft. values were used to estimate both the monthly and one-time cost components of non-residential displacement (*Table 2-2*). Total benefits of avoided non-residential displacement costs are summarized in the **Executive Summary**.

Table 2-2 – Non-residential Displacement Cost Factors

Occupancy Class	Disruption Cost Factor ($/sf)	Rental Cost Factor ($/sf)
Retail Trade	1.09	1.16
Wholesale Trade	0.95	0.48
Personal and Repair Services	0.95	1.36
Technical Business	0.95	1.36
Banks	0.95	1.7
Hospital	1.36	1.36
Medical Office/Clinic	1.36	1.36
Entertainment and Recreation	0	1.7
Theaters	0	1.7
Heavy	0	0.2
Light	0.95	0.27
Food/Drugs/Chemicals	0.95	0.27
Metals/Mineral Processing	0.95	0.2
High Technology	0.95	0.34
Construction	0.95	0.14
Agriculture	0.73	0.73
Religious/Nonprofit/Membership Organization	0.68	0.68
Government, General Services	0.95	1.36
Government, Emergency Response	0.95	1.36
Schools/Libraries	0.95	1.02
College/Universities	0.95	1.36

2.1.4 Loss of Income / Loss of Function

Loss of Income represents the loss of monthly rental income to owners of rental properties. Because additional monthly rental costs were considered as a displacement cost to non-residential tenants, property owner income losses were excluded from this BCA to avoid double-counting benefits.

Loss of Function represents the lost revenue due to inability to operate a business for some amount of time after a flood event. This avoided cost benefit category requires knowledge of the operating budget of the business for each individual non-residential structure in a project service area. As the majority of flood mitigation benefits in the project service area are to residential structures, this category was not assessed.

2.2 ANCILLARY BENEFITS

In addition to the benefit categories that represent avoided costs based on reduction in flooding depth, social and environmental benefits of the project were also quantified.

2.2.1 Avoided Social Costs

Social benefits based on the FEMA Toolkit represent the expected benefits of reducing mental health impacts associated with experiencing a disaster such as flooding. These benefits include avoided costs of:

- Health treatment for mental stress and anxiety of impacted residents
- Productivity losses by impacted residents who work full-time due to impacts on mental health

The calculation of social benefits replicated the method used in the FEMA Toolkit, which applies a present value benefit amount per impacted person to estimate the avoided costs of mental health treatment and of lost productivity *(Table 2-3)*. These values are based on studied prevalence, severity, and course of mental effects following a disaster[13]. It should be noted that because these values are present value benefits, they are not dependent on the annual expected probability of a storm event or the level of flooding anticipated from a given event. Instead, these benefits represent the positive impact of a mitigation project reducing flooding in a resident's home, which may include an existing condition of minor flooding compared to a post-mitigation condition of no flooding. Even when traditional benefit

[13] *Final Sustainability Benefits Methodology Report.* FEMA. Task order HSFEHQ-11-J-1408. August 2012.

estimates might indicate a very small value of saved structural and content damages, the positive impact on residents of not having to do any repairs instead of a few repairs is significant.

Table 2-3 – Unit Values for Social Benefits as Avoided Costs of Mental Health Impacts

Category	Benefit per Person (Present Value)	Unit
Treatment for mental stress and anxiety	$2,443	Resident of home benefitted by project
Lost productivity	$8,736	Resident of home benefitted by project who works full-time

The present value benefits per person for treatment of mental stress and anxiety were applied to all residents of structures which experienced a reduced modeled WSE after project implementation, regardless of event frequency. The **Population Estimate Attachment** describes how ACS Table B01003 (Total Population Estimates) and ACS Data Profile DP04 (Selected Housing Characteristics) were used to allocate numbers of residents to each structure in the watershed. The number of full-time workers in each Census tract (B23027_001E) was compared to the total tract population (B01003_001E) to estimate the number of full-time workers living in each structure. Costs of lost productivity were based on the estimated number of full-time workers residing in each structure. Estimated social benefits are summarized in the **Executive Summary**.

2.2.2 Environmental Benefits

Environmental benefits based on the FEMA Toolkit represent the value of ecosystem services provided by enhancement of a parcel's land use to a use type which provides a higher level of natural environmental benefits. Unlike other benefit categories based on avoided costs, environmental benefits represent an added service. *Table 2-4* indicates the value of each land use type (assuming existing condition of is developed land).

Table 2-4 – Unit Benefit Values for Conversion of Developed Land to Land Use of Higher Ecosystem Value

Documented Benefit/acre/year[14]				
Green Open Space	Riparian	Wetlands	Forests	Marine /Estuary
$8,308	$39,545	$6,010	$554	$1,799

[14] Help Section of B/C Analysis Toolkit v6.0, as of 01/28/2020.

Expected environmental benefits are summarized in the **Executive Summary**.

2.3 SPECIAL CONSIDERATIONS

Certain mitigation activities occurring in areas that ultimately outfall to the main channel of the project service area are included in the White Oak Bayou Watershed Mitigation Project. For these activities, benefits were calculated based on [insert HNTB methodology summary here], and social benefits were assumed to apply to the residents of all benefitted structures.

3.0 QUALITATIVE BENEFITS

As described in the Federal Register,[15] as long as a quantitative BCA has been completed, projects may have a benefit-cost ratio of less than 1.0 when the project provides concrete benefits to "low- and moderate- income persons or other persons that are less able to mitigate risks or respond to and recover from disaster," including benefits that cannot be quantified. Qualitative benefits of this project are discussed below.

3.1 BENEFICIARIES VULNERABLE TO FLOOD RISK

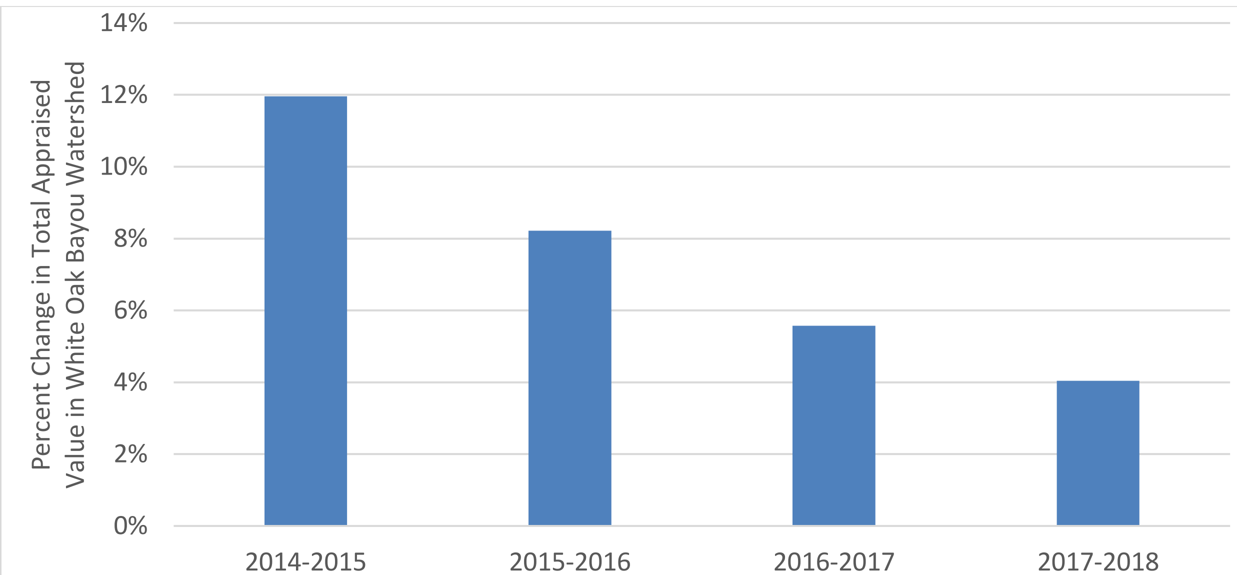
This application has demonstrated that 53.7% of the beneficiaries of White Oak Bayou Watershed Mitigation Project are low- to moderate-income persons. Additionally, many of the residents of the project service area may be considered particularly vulnerable to disasters. 33.9% of the households in the project service area are considered to be housing cost-burdened, and 16.0% are severely housing cost-burdened. These households spend 30+% and 50+% of their monthly income on housing-related costs, respectively. This cost burden may make it particularly hard for these households to recover from disaster, as they are less likely to have additional funds available for repairs, hotel stays, and lost wages during and after a flood. Additionally, 23.4% of the households in the project service area have no computer and/or no internet subscription. Lack of reliable internet access may reduce residents' ability to benefit from early warning systems in case of flooding events, making them more vulnerable.

[15] Allocations, Common Application, Waivers, and Alternative Requirements for Community Development Block Grant Mitigation Grantees, 84 FR 169 (August 30, 2019).

3.2 BENEFIT OF REDUCING FLOOD IMPACTS TO PROPERTY VALUES

A review of parcel appraisal values from the Harris County Appraisal District suggests that the annual rate of growth in property values generally slowed from 2014 to 2018 in the White Oak Bayou Watershed (*Figure 2*). These trends could be caused or influenced by floods in 2015, 2016, and 2017, but the degree to which local flooding impacted the value growth rates cannot be ascertained. General economic conditions in Harris County following Hurricane Harvey, as well as other external economic factors, could also contribute to changes in property values. Although the exact impact of local flooding on property values cannot be quantified, flood risk mitigation projects are likely to have a positive impact on the residents of flood-prone areas, as falling property values can have a negative effect on the financial flexibility of housing cost-burdened homeowners and even renters. Finally, the White Oak Bayou Watershed Mitigation Project will remove 258 acres from the 100-year floodplain, providing a potential positive impact to property values.

Figure 2 - Year-to-Year Percent Change in Total Appraised Value of Property in White Oak Bayou Watershed



3.3 TRANSPORTATION BENEFITS

Street closures due to flooding in the White Oak Bayou Watershed during Hurricane Harvey likely impacted a large number of commuters, including those who do not live in the watershed. Frequently, residential streets are inundated and may become impassable without the water level reaching a point of causing any damage to homes. In these scenarios, no quantitative benefits are counted in the BCA as there is no structural damage or displacement of residents. However, the street flooding poses an inconvenience and in some cases a safety risk, as it can inhibit evacuations, potentially trapping residents in homes that may lose power or keeping them from accessing groceries or medical supplies. The White Oak Bayou Watershed Mitigation Project will provide some reduction in street inundation as a benefit to residents in the service area.

In Harris County, over 50,000 workers 16 years and older use a bus or trolley bus as means of transportation to work. Of workers living within the watershed, 2.3% (5,198 workers) use a bus to commute to work. Data from the Metropolitan Transit Authority of Harris County (Metro) indicates that 29 bus routes through the watershed were closed for up to 5 or more days during and after Hurricane Harvey, with 3 of these routes being closed for 15 or more days. No methods were found that could be used to quantify the productivity losses of workers impacted by road closures. Additionally, all Metro bus routes passing through the project service area also extend across multiple floodplains in Harris County. It was determined that even if a substantial section of a route is removed from the floodplain as a result of the White Oak Bayou Watershed Mitigation Project, inundation elsewhere could still cause route closure. Because of this, assigning quantitative economic benefits to reduced flooding along bus routes that could be attributed only to this project was not considered to be a valid approach. However, the White Oak Bayou Watershed Mitigation Project is important to reducing the overall flooding along major commuter routes, providing significant benefit to residents of the project service area as well as workers traveling to and through the area.

4.0 SUMMARY

The approach to benefit-cost analysis documented here was based on FEMA BCA methodologies and considered various categories of benefits afforded by the White Oak Bayou Watershed Mitigation Project. However, as discussed in Section 2.1.1, the use of structural damages in a benefit-cost ratio, while valid, means that a project in a lower income service area that provides flood mitigation benefits to the same number of homes as a project in a higher-income area may have a lower calculated benefit-cost ratio due to the lower replacement values of homes in the service area. As a result, the low- and moderate-income populations that the CDBG-MIT funding seeks to serve may be underserved by funding sources which rely primarily on traditional benefit-cost analysis methods. Considering this, it is important to recognize that quantitative BCRs should not be used alone when evaluating the effectiveness of a mitigation project, and in fact, comparing BCRs between projects may actually work against the goal of serving of CDBG-MIT funding to serve LMI and other vulnerable populations.

APPENDIX A
BUILDING REPLACEMENT VALUES

Table A-1
Single-Family Residential Building Replacement Values (2020 dollars, assuming no basements)

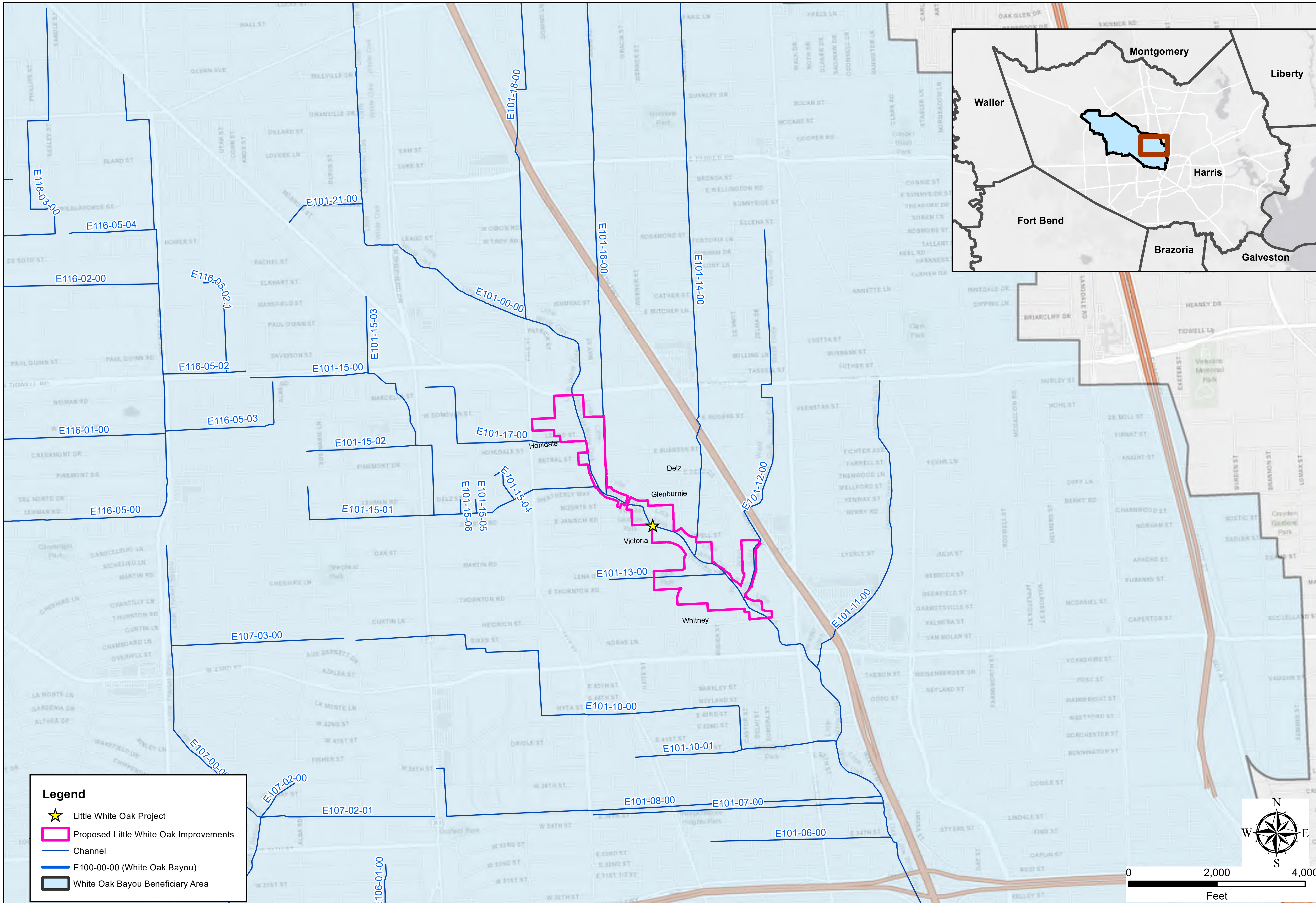
Income Ratio (r) Number of Stories	r < 0.5	0.5 <= r < 0.85	0.85 <= r < 1.25	1.25 <= r < 2.0	r >= 2.0
1	$97.28	$107.21	$145.17	$169.60	$206.28
2	$103.51	$110.89	$141.45	$166.65	$196.43
3	$103.51	$112.50	$147.76	$172.67	$202.32
split	$95.14	$102.70	$132.88	$155.34	$184.21

Table A-2
Multi-Family Residential Building Replacement Values (2020 dollars)

Number of Units	Unit Building Replacement Value ($/sf)
2	$117.00
3-4	$128.00
5-9	$228.00
10-19	$203.00
20-49	$200.00
50+	$195.00

Table A-3
Non-Residential Building Replacement Values (2020 dollars)

Occupancy Class	Occupancy Sub-Class	Unit Building Replacement Value ($/sf)
Manufactured Housing	Manufactured Housing	$52.76
Retail Trade	Dept Store, 1 st	$121.96
Wholesale Trade	Warehouse, medium	$112.10
Personal and Repair Services	Garage, Repair	$151.05
Prof./ Tech./Business Services	Office, medium	$196.93
Banks	Bank	$282.68
Hospital	Hospital, medium	$331.04
Medical Office/Clinic	Med. Office, medium	$242.32
Entertainment & Recreation	Restaurant	$251.66
Theaters	Movie Theatre	$180.14
Parking	Parking garage	$64.53
Heavy	Factory, small	$130.29
Light	Warehouse, medium	$112.10
Food/Drugs/Chemicals	College Laboratory	$214.11
Metals/Minerals Processing	College Laboratory	$214.11
High Technology	College Laboratory	$214.11
Construction	Warehouse, medium	$112.10
Agriculture	Warehouse, medium	$112.10
Church	Church	$204.52
General Services	Town Hall, small	$158.34
Emergency Response	Police Station	$245.87
Schools/Libraries	High School	$170.19
Colleges/Universities	College Classroom	$213.61



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White Oak Bayou Watershed - Project Little White Oak

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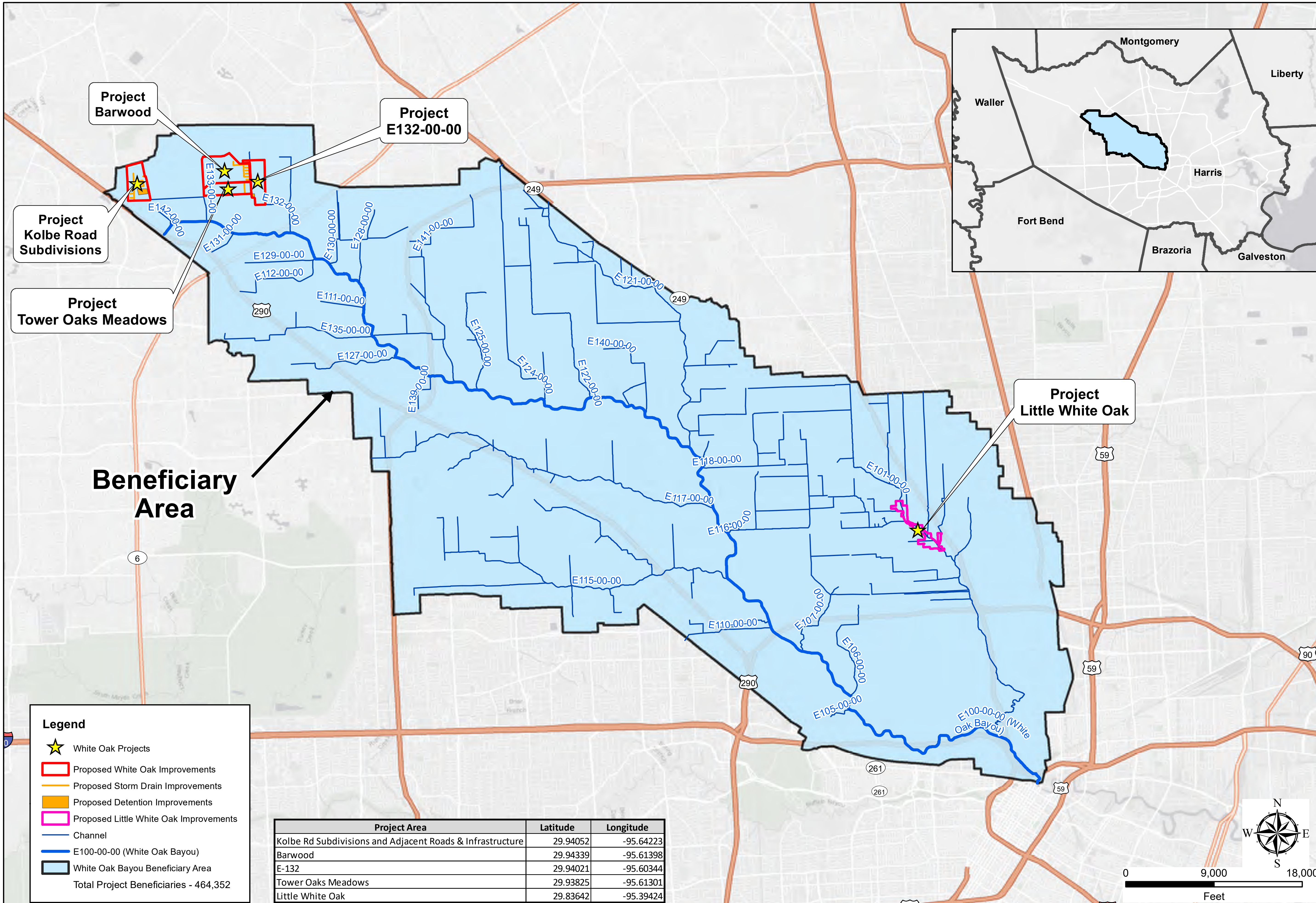

Project Area	Latitude	Longitude
Kolbe Rd Subdivisions and Adjacent Roads & Infrastructure	29.94052	-95.64223
Barwood	29.94339	-95.61398
E-132	29.94021	-95.60344
Tower Oaks Meadows	29.93825	-95.61301
Little White Oak	29.83642	-95.39424

FN PROJECT NO. SCG17357
DATE CREATED 10/20/2020
DATUM & COORDINATE SYSTEM NAD83 State Plane (feet) Texas South Central
FILE NAME White_Oak_Project_Area_Map
PREPARED BY AMJ

White Oak Bayou Watershed - Project Area Map

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EXHIBIT 1

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White Oak Bayou Watershed Beneficiary Area Map

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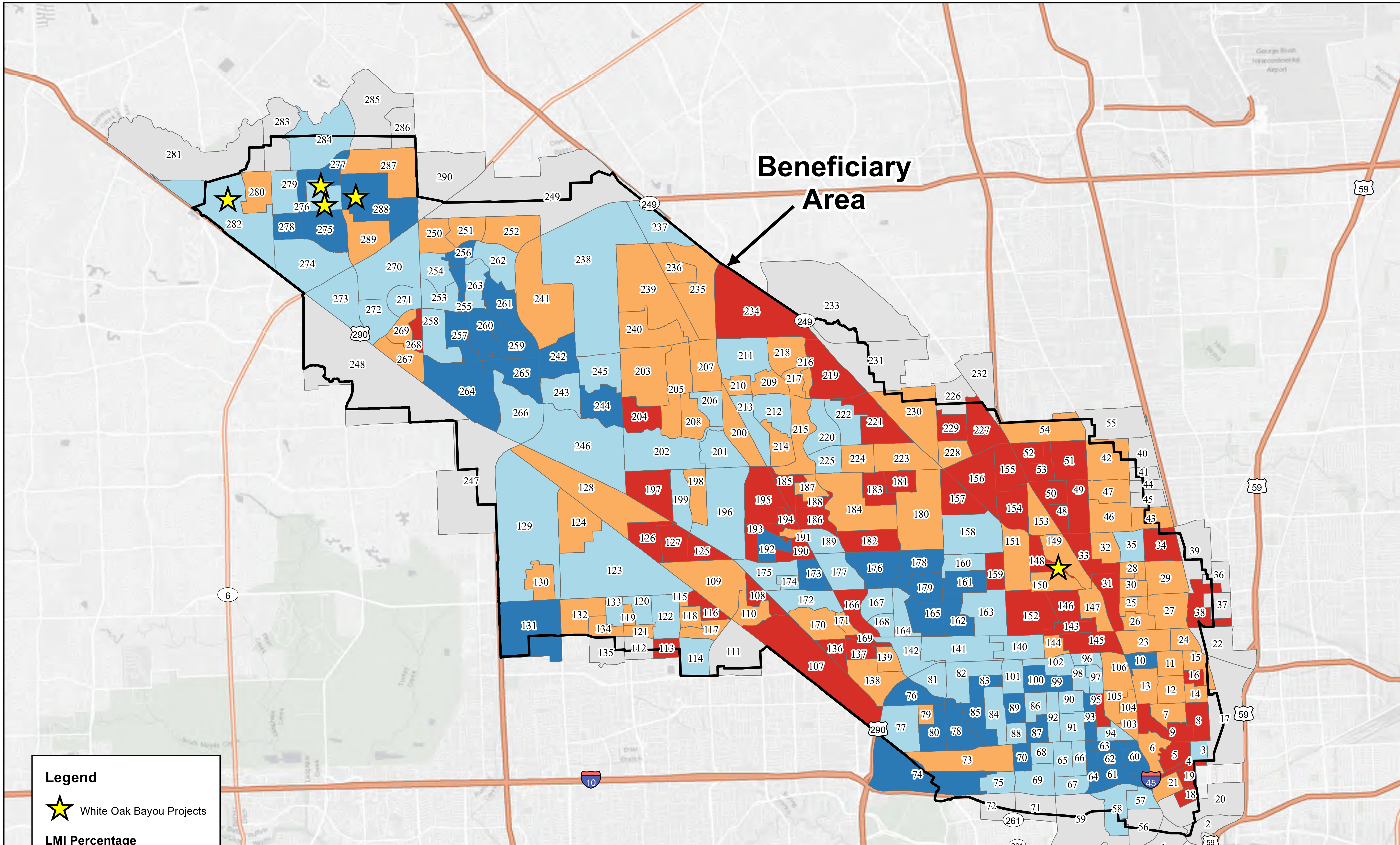

Project Service Area	Number of Block Groups Included in the LMI Calculation	Total Count of LMI Persons	Total Persons with Potential for Being Deemed LMI	Percentage of LMI Persons
White Oak Bayou Watershed in Harris County	258	235,750	439,025	53.7%

FN PROJECT NO.	SCG17357
DATE CREATED	10/5/2020
DATUM & COORDINATE SYSTEM	NAD83 State Plane (feet) Texas South Central
FILE NAME	White_Oak_Project_Area_Map_LMI_1
PREPARED BY	AMJ

EXHIBIT

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White Oak Bayou Watershed Beneficiary Area Table

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CDBG-MIT

FN PROJECT NO.	DATE CREATED	DATUM & COORDINATE SYSTEM	FILE NAME	PREPARED BY
SCG17357	9/28/2020	NAD83 State Plane (feet) Texas South Central	White_Oak_Project_Area_Map_LMI_2	AMJ

FREESE NICHOLS
STUART CONSULTING GROUP

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2
(2 of 2)

Block Group ID	Block Group	# Residents in Block Group of Service Area	# Residents in Block Group	% Residents of Block Group in Service Area	Used for LMI Calculation?	LMI Percentage
1	482011000003	194	1,157	17%	No	23.3%
2	482012101001	129	628	21%	No	0.0%
3	482012104001	1,069	1,134	94%	Yes	45.8%
4	482012104002	201	238	84%	Yes	85.7%
5	482012104003	2,045	2,061	99%	Yes	87.9%
6	482012104004	990	990	100%	Yes	65.0%
7	482012105001	1,853	1,853	100%	Yes	72.6%
8	482012105002	1,794	1,803	100%	Yes	88.6%
9	482012105003	1,820	1,823	100%	Yes	85.1%
10	482012106001	875	875	100%	Yes	11.8%
11	482012106002	1,114	1,114	100%	Yes	56.2%
12	482012106003	2,146	2,146	100%	Yes	52.3%
13	482012106004	1,138	1,138	100%	Yes	62.8%
14	482012107001	825	828	100%	Yes	58.7%
15	482012107002	1,153	1,156	100%	Yes	71.4%
16	482012107003	673	673	100%	Yes	87.1%
17	482012108001	89	1,360	7%	No	86.3%
18	482012123001	1,019	1,019	100%	Yes	79.2%
19	482012123002	950	1,074	88%	Yes	100.0%
20	482012123003	65	364	18%	No	62.5%
21	482012123005	1,169	1,169	100%	Yes	74.5%
22	482012201001	8	1,363	1%	No	75.8%
23	482012202001	1,736	1,736	100%	Yes	62.2%
24	482012202002	873	873	100%	Yes	53.2%
25	482012203001	1,178	1,178	100%	Yes	61.6%
26	482012203002	1,628	1,634	100%	Yes	62.0%
27	482012203003	1,518	1,522	100%	Yes	57.8%
28	482012204001	1,423	1,423	100%	Yes	67.3%
29	482012204002	1,933	1,933	100%	Yes	69.1%
30	482012204003	834	834	100%	Yes	57.0%
31	482012205001	504	504	100%	Yes	78.2%
32	482012205002	1,405	1,405	100%	Yes	65.0%
33	482012205003	1,578	1,697	93%	Yes	97.4%
34	482012206001	2,757	2,814	98%	Yes	75.7%
35	482012206002	1,126	1,126	100%	Yes	37.6%
36	482012207002	138	1,068	13%	No	55.3%
37	482012207003	130	446	29%	No	77.4%
38	482012207004	1,222	1,735	70%	Yes	82.0%
39	482012207005	639	2,396	27%	No	75.3%
40	482012212001	187	2,039	9%	No	70.7%
41	482012212002	343	1,239	28%	No	84.3%
42	482012212003	2,783	3,454	81%	Yes	73.2%
43	482012213001	1,245	2,018	62%	Yes	72.4%
44	482012213002	489	1,263	39%	No	61.1%
45	482012213003	741	1,732	43%	No	65.7%
46	482012213004	2,095	2,095	100%	Yes	68.6%
47	482012213005	2,812	2,812	100%	Yes	71.9%
48	482012214001	815	815	100%	Yes	85.8%
49	482012214002	1,983	1,983	100%	Yes	85.3%
50	482012214003	3,179	3,179	100%	Yes	88.4%
51	482012215001	2,645	2,645	100%	Yes	77.4%
52	482012215002	3,106	3,106	100%	Yes	79.9%
53	482012215003	2,599	2,599	100%	Yes	76.1%
54	482012216003	1,359	1,702	80%	Yes	68.6%
55	482012217002	372	1,644	23%	No	87.9%
56	482015101001	668	1,168	57%	No	34.8%
57	482015101002	1,007	1,020	99%	Yes	30.6%
58	482015102001	1,196	1,746	68%	Yes	38.4%
59	482015102002	183	4,959	4%	No	30.4%
60	482015103001	1,669	1,671	100%	Yes	8.2%
61	482015103002	839	840	100%	Yes	15.7%
62	482015103003	885	910	97%	Yes	14.9%
63	482015103004	1,122	1,129	99%	Yes	11.0%
64	482015103005	493	493	100%	Yes	24.4%
65	482015104001	1,561	1,561	100%	Yes	26.0%
66	482015104002	652	657	99%	Yes	34.4%
67	482015104003	1,661	1,673	99%	Yes	25.4%
68	482015105001	1,263	1,265	100%	Yes	38.4%
69	482015105002	1,073	1,086	99%	Yes	26.0%
70	482015105003	969	974	99%	Yes	14.4%
71	482015106002	1,430	2,593	55%	No	38.9%
72	482015106003	847	2,247	38%	No	20.8%
73	482015109001	2,034	2,036	100%	Yes	54.2%
74	482015109002	2,655	3,708	72%	Yes	20.1%
75	482015109003	1,329	1,331	100%	Yes	44.0%
76	482015110011	1,517	1,517	100%	Yes	16.6%
77	482015110012	1,729	1,729	100%	Yes	28.5%
78	482015110021	1,715	1,715	100%	Yes	11.7%
79	482015110022	1,641	1,641	100%	Yes	56.8%
80	482015110023	905	905	100%	Yes	14.7%
81	482015111001	1,400	1,400	100%	Yes	48.8%
82	482015111002	2,106	2,106	100%	Yes	28.6%
83	482015112001	1,125	1,141	99%	Yes	9.7%
84	482015112002	2,252	2,258	100%	Yes	40.9%
85	482015112003	1,819	1,826	100%	Yes	23.0%
86	482015113011	1,073	1,073	100%	Yes	49.8%
87	482015113012	1,229	1,229	100%	Yes	24.7%
88	482015113013	454	454	100%	Yes	33.6%
89	482015113014	1,215	1,229	99%	Yes	14.2%
90	482015113021	1,016	1,016	100%	Yes	31.7%
91	482015113022	1,556	1,567	99%	Yes	32.0%
92	482015113023	1,278	1,280	100%	Yes	27.1%
93	482015114001	1,503	1,503	100%	Yes	7.2%
94	482015114002	782	782	100%	Yes	26.1%
95	482015114003	905	905	100%	Yes	78.3%
96	482015115001	525	527	100%	Yes	34.0%
97	482015115002	841	847	99%	Yes	29.0%
98	482015115003	936	938	100%	Yes	38.5%
99	482015115004	863	867	99%	Yes	13.5%
100	482015115005	1,406	1,434	98%	Yes	21.5%
101	482015115006	1,854	1,864	99%	Yes	39.0%
102	482015115007	1,523	1,543	99%	Yes	31.9%
103	482015116001	1,188	1,188	100%	Yes	56.9%
104	482015116002	585	585	100%	Yes	64.5%
105	482015116003	937	937	100%	Yes	62.9%
106	482015116004	866	866	100%	Yes	72.5%
107	482015205001	2,516	2,520	100%	Yes	89.5%
108	482015205002	3,622	3,750	97%	Yes	82.5%
109	482015205003	1,466	1,471	100%	Yes	66.2%
110	482015205004	1,557	1,557	100%	Yes	74.4%
111	482015206011	1,010	2,781	36%	No	78.8%
112	482015213001	394	733	54%	No	42.9%
113	482015213002	1,045	1,334	78%	Yes	81.9%
114	482015213003	1,283	1,283	100%	Yes	31.1%
115	482015214001	936	936	100%	Yes	71.7%
116	482015214002	2,973	2,973	100%	Yes	99.1%
117	482015214003	1,701	1,701	100%	Yes	50.6%
118	482015214004	1,345	1,944	69%	Yes	74.7%
119	482015215001	1,111	1,111	100%	Yes	59.8%
120	482015215002	1,037	1,037	100%	Yes	37.5%
121	482015215003	1,713	1,713	100%	Yes	58.3%
122	482015215004	2,175	2,175	100%	Yes	46.3%
123	482015216001	2,480	2,480	100%	Yes	48.4%
124	482015216002	1,014	1,018	100%	Yes	62.5%
125	482015217001	1,280	1,280	100%	Yes	90.2%
126	482015217002	2,384	2,384	100%	Yes	84.9%
127	482015217003	1,836	1,836	100%	Yes	89.3%
128	482015217004	1,367	1,367	100%	Yes	58.2%
129	482015218001	2,993	2,993	100%	Yes	49.4%
130	482015218002	2,549	2,552	100%	Yes	59.1%
131	482015219001	2,329	3,552	66%	Yes	20.9%
132	482015220001	2,090	2,090	100%	Yes	59.6%
133	482015220002	772	772	100%	Yes	47.5%
134	482015220003	1,851	1,851	100%	Yes	73.6%
135	482015221003	19	2,565	1%	No	70.1%
136	482015301001	1,072	1,072	100%	Yes	81.3%
137	482015301002	2,648	2,648	100%	Yes	84.5%
138	482015301003	1,432	1,432	100%	Yes	68.8%
139	482015301004	1,398	1,398	100%	Yes	73.2%
140	482015302001	1,536	1,536	100%	Yes	29.5%
141	482015302002	1,491	1,497	100%	Yes	38.1%
142	482015302003	646	646	100%	Yes	31.6%
143	482015303001	689	691	100%	Yes	79.4%
144	482015303002	682	682	100%	Yes	52.8%
145	482015303003	982	985	100%	Yes	78.1%
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147	482015304002	1,279	1,279	100%	Yes	72.3%
148	482015305001	1,485	1,485	100%	Yes	75.8%
149	482015305002	1,647	1,647	100%	Yes	72.7%
150	482015305003	2,273	2,273	100%	Yes	71.2%
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155	482015307003	1,800	1,800	100%	Yes	87.0%
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157	482015308002	990	993	100%	Yes	81.7%
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160	482015309002	1,855	1,855	100%	Yes	38.6%
161	482015309003	1,399	1,399	100%	Yes	13.0%
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166	482015312001	1,329	1,329	100%	Yes	86.9%
167	482015312002	1,270	1,270	100%	Yes	28.3%
168	482015312003	974	974	100%	Yes	27.5%
169	482015313001	1,982	1,982	100%	Yes	87.0%
170	482015313002	1,571	1,574	100%	Yes	59.4%
171	482015313003	2,719	2,719	100%	Yes	67.6%
172	482015314001	2,150	2,150	100%	Yes	38.4%
173	482015315001	835	835	100%	Yes	21.4%
174	482015315002	802	802	100%	Yes	37.1%
175	482015315003	1,377	1,377	100%	Yes	31.4%
176	482015316001	1,714	1,714	100%	Yes	14.7%
177	482015316002	1,439	1,439	100%	Yes	37.3%
178	482015317001	1,703	1,703	100%	Yes	22.4%
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260	482015517022	1,963	1,963	100%	Yes	5.7%
261	482015517031	3,505	3,505	100%	Yes	20.0%
262	482015517032	3,042	3,042	100%	Yes	35.5%
263	482015517033	1,849	1,849	100%	Yes	32.3%
264	482015518001	2,297	2,297	100%	Yes	11.4%
265	482015518002	1,138	1,138	100%	Yes	10.7%
266	482015518003	950	950	100%	Yes	29.0%
267	482015519001	854	854	100%	Yes	69.4%
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271	482015520012	1,421	1,421	100%	Yes	30.2%
272	482015520013	2,720	2,720	100%	Yes	37.8%
273	482015520021	1,366	1,366	100%	Yes	37.8%
274	482015521011	4,270	4,270	100%	Yes	29.2%
275	482015521021	3,437	3,437	100%	Yes	9.7%
276	482015521022	2,270	2,270	100%	Yes	27.4%
277	482015521023	922	922	100%	Yes	20.3%
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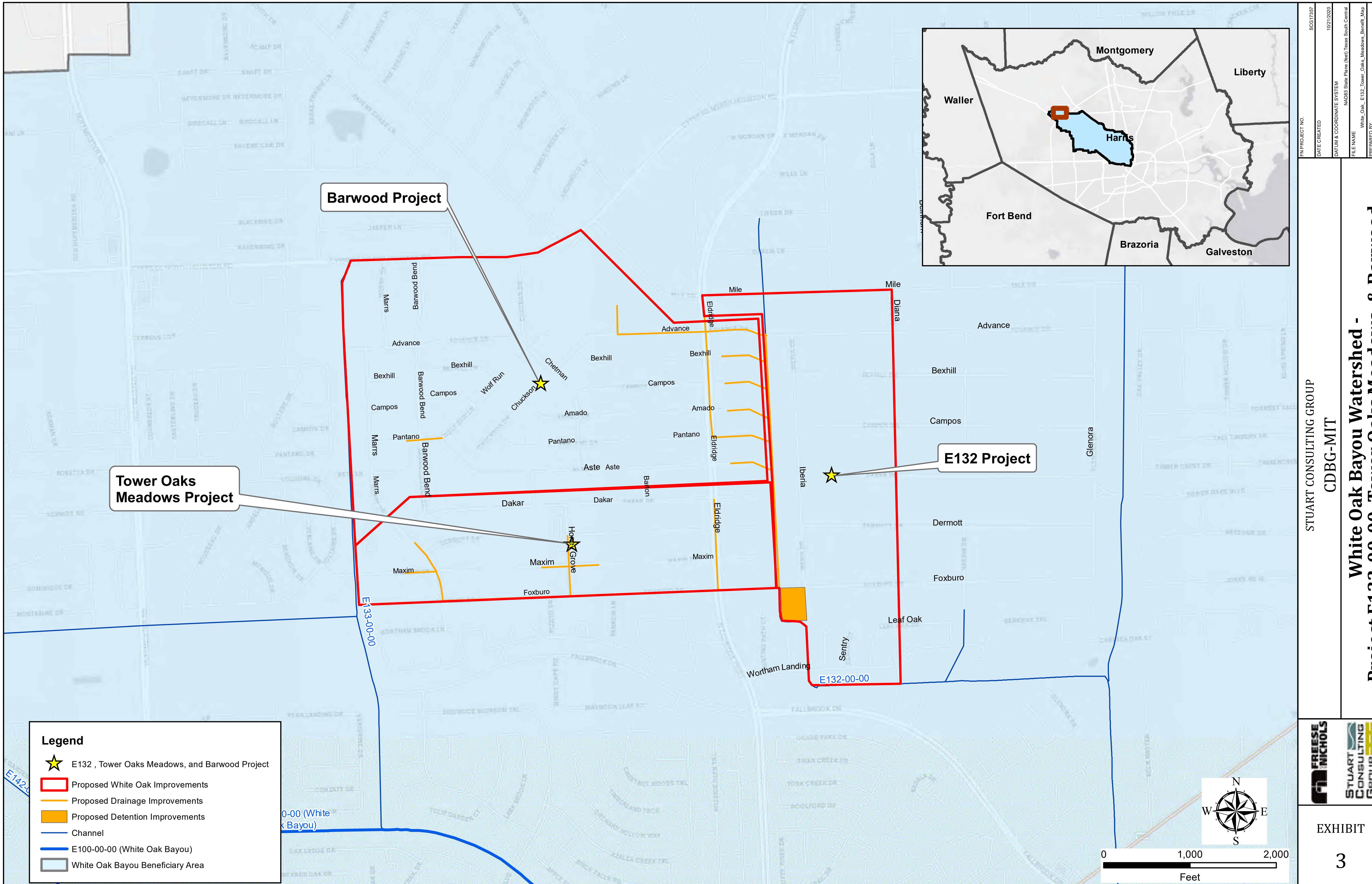

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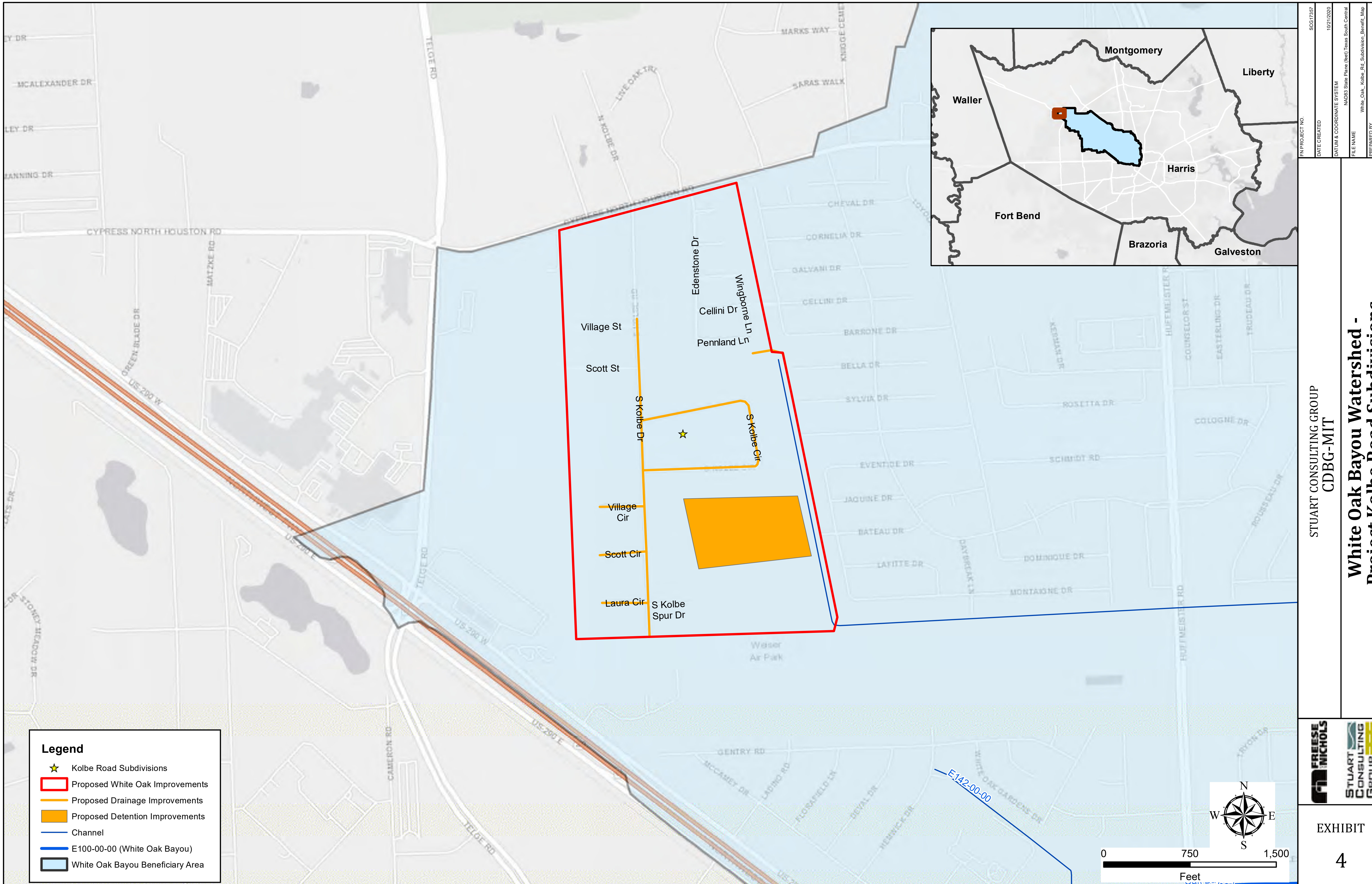

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Barwood Subdivision
Harris County

Drainage Analysis Report

Prepared for:
Harris County Engineering Department

F-14087

STATE OF TEXAS
NAWA RAJ PANTHI
103690
LICENSED
PROFESSIONAL ENGINEER

04/12/2019

Prepared by:

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Ph: 832-767-0090 Fax: 832-767-0141
Engineering Registration No. F-14087

April 2019

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1. General Project and Contact Information

a. Project Name

The study area for this project is the Barwood Subdivision in Harris County, Houston, Texas. The subdivision is located southwest of the intersection of N Eldridge Parkway and Cypress North Houston Road.

b. Precinct

The area is within Harris County Precinct 3.

c. Project Location Map

See Exhibit 1 for the project location map.

d. Preparer Information

This report has been prepared by HT&J, LLC. See Table 1 for all necessary contact information.

Table 1 - Preparer Contact Information

Firm Name:	HT&J, LLC
Firm Address:	10351 Stella Link Road, Houston, TX 77025
Preparer Name:	Nawa R. Panthi, P.E.
Preparer Phone Number:	832-767-0090 ext. 105
Preparer Email Address:	nrp@ht-j.com

2. Existing Conditions Analysis

a. Summary of Drainage Issues/Analysis of Problem

The purpose of this study is to evaluate potential solutions to improve the flooding conditions that occur in the Barwood subdivision during extreme rain events. Historical heavy rain events and recent extreme rain events such as Hurricane Harvey (August 25, 2017) and the Houston Tax Day Flood (April 17, 2016) have caused widespread flooding of homes in the Barwood subdivision. During the Tax Day Flood, some homes saw up to 12 inches of water, and during Hurricane Harvey some residents reported up to 30 inches. With the neighborhood being very flat topographically and bordered by two major drainage ditches, there is a high chance for recurring flooding during heavy rains. The two drainage ditches to the east and west (E132-00-00 and E133-00-00 respectively) drain south to White Oak Bayou. Though E132 and E133 are not detailed studied channels, we anticipate both of these two channels experience backwater effect from White Oak Bayou (E100-00-00) which restricts the local drainage leaving the subdivision.

b. Drainage System – Conditions/Impacts

The existing subdivision drainage system consists of Type B and BB inlets that drain to a reinforced concrete pipe (RCP) storm sewer system. The storm sewer outfalls into either the E132-00-00 or the E133-00-00 channel. The existing storm sewer system to E132 has seven outfalls while E133 has only one. The existing system appears to have decent inlet coverage and pipe sizes; however the rising water level to the east and west overwhelms the existing storm sewer system. Although the effective FEMA floodplain map shows the area outside the 100-year floodplain, HT&J believes this anomaly is a result of a lack of detailed study of the outfall channels.

One of the deficiencies in this system is the lack of usable detention. Nearly every piece of land is put to use for a home or other building in this area, leaving nowhere to detain water during a flood event. Other deficiencies include the fact that some of the inlets are only Type B.

c. Water – Conditions Impacts

HT&J has not been able to determine the location of the water lines to check for impacts that any improvements made to the storm sewer system might have. Lateral connections may be impacted by storm sewer system improvements. Water line impacts can be further determined with an in-depth survey during the final design.

d. Sewer – Conditions Impacts

HT&J has determined that any improvements made to the storm sewer system should not affect any existing sanitary sewer utilities in the area. The existing sanitary sewer lines run along the back property lines in the subdivision, while the storm sewer is located in the streets.

e. Electric – Conditions Impacts

HT&J has not requested any of the dry utilities mapping from AT&T or any other entities to confirm their locations at this time. Utility conflicts need to be verified during the detailed study and design phase. We believe all dry utilities are underground as we didn't notice any overhead electric lines in the area.

f. Gas – Conditions Impacts

HT&J has not requested any of the dry utilities mapping from Centerpoint to confirm their locations at this time. One pipeline easement is visible from Barwood Bend Drive that will be left unaffected.

g. Telecommunications – Conditions Impacts

HT&J has not requested any of the dry utilities mapping to confirm their locations.

h. General Descriptions of Locations

The Barwood subdivision consists of individual family homes with an average lot size of approximately 0.3 acres. The entire subdivision's drainage system is an underground storm sewer system, and all neighborhood streets are two-lane (with the exception of N Eldridge Parkway). See Exhibit 2 for the layout of the existing storm sewer system. The topography of the subdivision generally slopes from west to east, with elevations ranging from 132 to 125 feet. According to our analysis, during extreme rain events such as the 100-year (1% Annual Exceedance Probability (AEP)) storm, Barwood experiences widespread flooding of streets and many homes. Potential areas of concern include the southeast corner of the subdivision, along Aste Lane and Pantano Drive, as these streets lie at a lower elevation than most. This is also where much of the structural damage occurred during Hurricane Harvey and the Tax Day Flood.

In this report, when referring to the 100-year (1% AEP) storm, we are referring to the existing effective rainfall totals from the Harris County Flood Control District (HCFCD). The recently published Atlas 14 rainfall totals were not utilized for this analysis.

i. Other Issues

Some inter-agency coordination may be required for this project as the storm sewer outfalls into HCFCD channels E132-00-00 and E133-00-00.

3. Description of Problems

a. Damage Caused by Flooding

The Barwood subdivision has experienced historical flooding during many storm events over the years. Also, as stated previously, recent extreme storm events have caused flooding in the Barwood Subdivision. During the Tax Day Flood, some homes saw up to 12 inches of water, and during Hurricane Harvey some residents reported up to 30 inches. HT&J does not have information regarding detailed damage to these homes, other than the flooding depths. We were able to analyze the flooding depths at different storm frequencies and understand that any depth above slab elevation has the ability to cause significant damage to a home.

b. Repetitive Loss Analysis

There are 32 FEMA repetitive loss claims in the Barwood Subdivision, spread throughout the area. The entire subdivision is at risk due to the topography and the bordering drainage ditches that appear to back up during large storms. The slab elevations also appear to be even with the adjacent ground, providing no extra freeboard from floodwaters.

c. Structures Flooded

During Hurricane Harvey, 131 homes reported flooding with an average depth of 4.21 inches. During the 2016 Tax Day event, 31 homes reported flooding with an average depth of 2.65 inches. The only structures in the subdivision are residential homes, with exception of the community center. The main cause for flooding from these events is the tailwater condition in channels E132-00-00 and E133-00-00, which is discussed further in Section 4c of this report.

d. Issues with Access

According to our analysis, Barwood experiences significant inhibition of access during extreme rain events due to flooding in the streets. The main access to the subdivision is along N Eldridge Parkway, with secondary access from the west on Barwood Bend Drive. During Hurricane Harvey and the 2016 Tax Day Flood, both of these streets were flooded, limiting access to and from Barwood. Our analysis also shows that during the 100-year (1% AEP) storm event, nearly every street experiences some level of ponding. Areas that are particularly susceptible to street ponding appear to be Barwood Bend Drive, Wolf Run Lane, and Aste Lane. These areas have water ponding in the street in the range of 1.5 to 2 feet, making them impassable to most vehicles and resulting in structural flooding in most cases.

e. Existing Drainage Infrastructure

Drainage areas were delineated to the manhole level for the entire Barwood drainage system using available LiDAR data. All of the drainage areas have the characteristics of a residential neighborhood and catch flow at inlets leading to manholes, then to storm sewer lines. The storm sewer lines are made up of 24-inch to 72-inch RCP, with the outfall pipes protruding into the channels made of corrugated metal pipe (CMP). See Exhibit 2 for the layout of the existing storm sewer system (main lines, excluding inlets). Attachment 1 presents the record drawing of the entire storm sewer system.

During the 2-year storm event, the hydraulic grade line (HGL) is just above the gutter elevation along Aste Lane, Pantano Drive, Amado Drive, Campos Drive, Bexhill Drive, Advance Drive, Wolf Run Lane, and Barwood Bend Drive. The 2-year HGL is below the gutter elevation along the trunkline north of Dakar Drive. The 2-year HGL will be below the gutter elevation for all storm sewer lines with the proposed improvements.

f. Other Contributing Factors

As previously stated, separate from the local drainage system of Barwood, one major cause of flooding is the bordering HCFCD channels (E132-00-00 and E133-00-00). When the water surface backs up in White Oak Bayou downstream, then channels E132 and E133 also back up and have no outlet for drainage. Consequently, this doesn't allow the Barwood system to drain, which leads to increased water surface elevations (WSEL) in the subdivision and structural flooding.

4. Analysis and Proposed Solution

a. Approach

All hydrologic and hydraulic calculations for this analysis were done using the XPSWMM program. An existing model was created in XPSWMM of the Barwood subdivision drainage system using available record drawings, LiDAR data, and aerial imagery. Two known storm events, Hurricane Harvey and the 2016 Tax Day flood were modeled through the existing conditions and the model was calibrated against the known flooding depths in the subdivision. Once the model was calibrated, the 10-, 25-, 50-, 100-, and 500-year storm event existing conditions were modeled to identify the areas in need of drainage improvements. Effective Harris County rainfall data was used, as opposed to the recent release of NOAA Atlas 14 rainfall data, because the HCFCD has not routed the rainfall totals for all time steps yet. However, the effective 500-year (0.2% AEP) rainfall is very similar to the updated Atlas 14 100-year (1% AEP) rainfall. Our analysis is based on the existing 100-year rainfall data. We did not choose to use the existing 500-year rainfall as a comparison to the Atlas 14 100-year rainfall because the localized drainage improvements cannot provide a level of service for that magnitude of storm. A regional approach is necessary to lower the tailwater WSEL in the HCFCD channels in order for local improvements to have a positive benefit during the existing 500-year storm event.

The 500-year (0.2% AEP) evaluation of the existing conditions would result in flooding throughout the subdivision as the conditions are controlled by the downstream tailwater elevation. Due to this, any local improvements would not produce any benefit. In order to achieve benefit, the 500-year (0.2 AEP) event needs to be evaluated with the regional improvements. It would not be possible to accurately determine the impact on the E132 and E133 channels without knowing what changes were to be made. Since the large-scale regional improvements are out of the scope of this analysis, the conditions were evaluated with known tailwater information and effective Harris County rainfall totals. Interdepartmental coordination between HCED and HCFCD is necessary to evaluate the regional improvement options.

We believe XPSWMM is the most appropriate tool for this analysis as it can account for different rainfall, tailwater, and drainage area characteristics, as well as accurately model the storm sewer system and the overland flow on the street surface.

Several scenarios were evaluated for improvements to the drainage system. Each improvement scenario was analyzed through the XPSWMM model for the 10-, 25-, 50-, 100-, and 500-year storm event. However the 100-year storm event was used as the guiding storm event for this analysis. Some of the scenarios analyzed are described below, with further details in Section 4b of this report.

<u>Scenario A</u>: ALL storm sewer pipes in the Barwood drainage system upsized by two line sizes.

<u>Scenario B</u>: Two small detention ponds installed in open spaces within/near the Barwood subdivision.

<u>Scenario C</u>: Twin 4’x8’ box culverts run underground along N Eldridge Parkway from Advance Lane south to Foxburo Drive, outfalling into E132-00-00. Also added twin 4’x8’ box culverts along Barwood Bend Drive from Pantano Drive south and through the water treatment plan to outfall into E133-00-00.

Scenario D: Connected the storm sewer lines along Advance Drive, Bexhill Drive, Campos Drive, Amado Drive, and Pantano Drive with a 48-inch RCP along N Eldridge Parkway. Also installed a detention pond in the vacant lot north of Advance Drive, west of Mile Drive, and connecting it to the storm sewer along Advance Drive. Increased the outfall pipe sizes at all outfalls.

b. Methodology Used for Analysis

All calculations and modelling were performed to the most recent Harris County and Harris County Flood Control District (HCFCD) standards. The HCFCD Hydrology & Hydraulics Guidance Manual dated December 2009, the HCFCD Policy Criteria & Procedure Manual (PCPM) dated October 2018, the Harris County Infrastructure Regulations dated September 2009, and the Harris County Floodplain Management Plan dated 2008 are the governing documents for this study.

The first step in this analysis was determining the individual drainage areas for the system to the manhole-level (e.g. if one manhole has three inlets draining to it, then the drainage areas for all three inlets were included at that manhole). Exhibit 3 presents the existing drainage area map. The drainage area characteristics were determined from the HCFCD H&H Manual, and a percent imperviousness of 40% was applied (Residential – small lot). It was found that an area of approximately 100 acres to the northeast of the subdivision along N Eldridge Parkway will sheet flow through the Barwood subdivision. This was accounted for in our analysis and can be seen in Exhibit 3.

The time of concentration (TC) and storage coefficient (R) were calculated for each subbasin to be used in the Clark's Unit Hydrograph runoff method. Rainfall totals for frequency storms were obtained from the HCFCD H&H Guidance Manual, Table 3 in Section II.2.2. The Barwood Subdivision lies within Hydrologic Region 2 of Harris County, so the values for that region were used. Table 2 below presents the rainfall totals.

Table 2 - Harris County Hydrologic Region 2 Rainfall (inches)

Duration	**Exceedance Probability (Frequency)**						
	50% (2-Year)	**20% (5-Year)**	**10% (10-Year)**	**4% (25-Year)**	**2% (50-Year)**	**1% (100-Year)**	**0.2% (500-Year)**
5 Minutes	0.7	0.8	0.9	1.0	1.1	1.2	1.4
15 Minutes	1.1	1.4	1.5	1.7	1.9	2.1	2.6
30 Minutes	1.5	1.8	2.1	2.4	2.7	3.0	3.8
60 Minutes	2.0	2.5	2.9	3.4	3.8	4.3	5.5
2 Hours	2.3	3.1	3.6	4.3	5.0	5.7	7.6
3 Hours	2.6	3.5	4.1	5.0	5.8	6.7	9.2
6 Hours	3.1	4.3	5.1	6.4	7.6	8.9	12.8
12 Hours	3.7	5.1	6.2	7.8	9.2	10.8	15.5
24 Hours	4.4	6.2	7.6	9.6	11.3	13.2	18.9

Rainfall totals for Hurricane Harvey and the 2016 Tax Day Flood were obtained from the Harris County Flood Warning System (FWS) historical data. The gauge used was Gauge E100_555 White Oak Bayou @ Jones Road. This was the closest gauge within Harris County Region 3 to the study area. The gauge location is shown below in Figure 1.

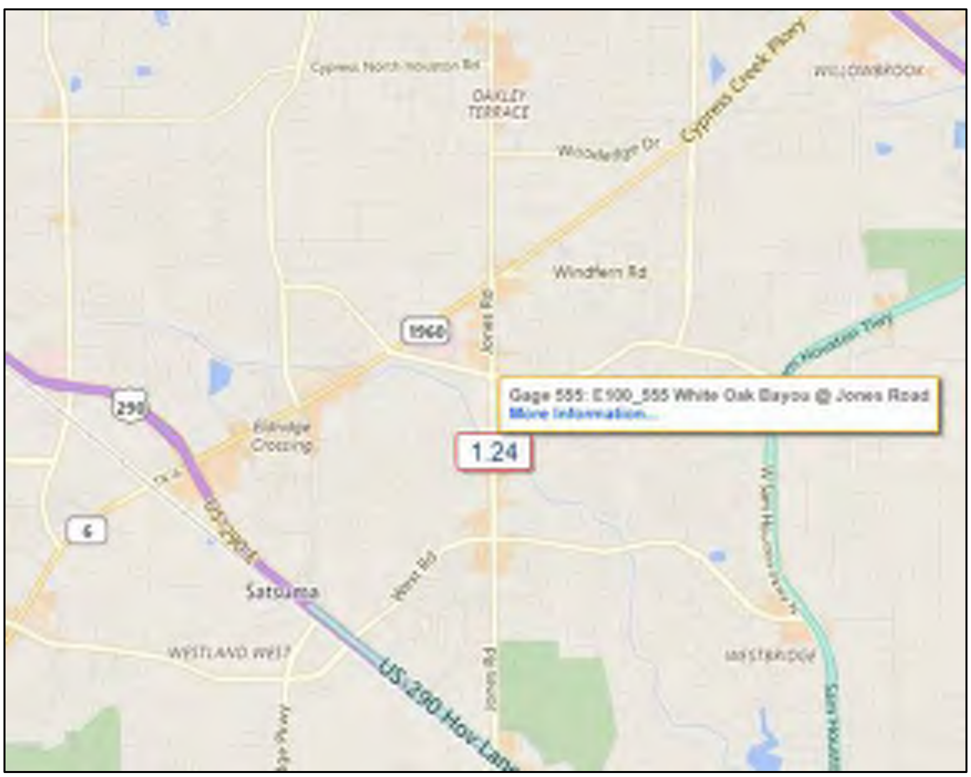


Figure 1 - Rain and Stream Gauge Location

For the two historic storms modeled, Hurricane Harvey and the 2016 Tax Day flood, the tailwater condition in channels E132-00-00 and E133-00-00 was determined via multiple sources of data. The WSEL in White Oak Bayou during these events was obtained from the gauge location above, and the approximate WSEL in channels E132 and E133 was estimated from speaking to residents who lived in the Barwood subdivision during the storm events. Using these queues, the tailwater elevation was calibrated in the model until the flooding results from the model matched the reported flooding during Hurricane Harvey and the 2016 Tax Day flood.

The tailwater elevation for the design storm, the 100-year storm event, was determined using two methods. The first was that the 2016 Tax Day rain event produced a nearly identical 24-hour rainfall total to the 100-year storm (12.8 inches vs. 13.2 inches). Therefore, the tailwater was likely very similar for the two events. The second method was using the known Base Flood Elevation (BFE) downstream of E132-00-00 in White Oak Bayou. Approximately 9,500 feet downstream of Barwood, the BFE in White Oak Bayou is 120 feet, and the channel bottom is at 105 feet. The E132-00-00 channel bottom at Barwood is at approximately 120 feet. Using normal depth techniques, the bed slope was calculated between the two locations and the HGL slope was set approximately 0.1% less than that slope. This produced a WSEL around 129.5 feet. Between this value and the Tax Day flood comparison, this was set at the peak tailwater for the 100-year storm event. See Table 3 for the tailwater conditions for all storms modeled.

Table 3 - Tailwater Conditions

Storm Event	Tailwater Elevation (ft)
Hurricane Harvey	130.5
2016 Tax Day Flood	129.5
500-year	130.5
100-year	129.5
50-year	Top of Outfall Pipes
25-year	Top of Outfall Pipes
10-year	Top of Outfall Pipes

The different proposed scenarios were updated into the model as follows:

Scenario A:

Every pipe in the entire Barwood subdivision drainage system was increased by two pipe sizes, i.e., 12-inches in diameter. This was done to see if the cause of flooding was due to insufficient pipe capacity.

Scenario B:

The two areas where small detention was available are near the southwest corner of the subdivision. Approximately 0.85 acres of area can be used within one area as detention. On the second area, there is already an existing detention pond. So it was determined that the existing pond could be deepened and expanded south to a footprint of 0.96 acres. Assuming a 4H:1V slope on the proposed basins, the first detention pond could provide 3.04 acre-feet of storage and the second could provide 3.79 acre-feet. The top and bottom elevations of the ponds were determined using LiDAR data and the nearest underground storm sewer flowline. See Figure 2 for the location of the proposed detention ponds.

Figure 2 - Proposed Southeast Detention Ponds (Scenario B)

<u>Scenario C</u>:

Twin 4’x8’ box culverts would be installed connected to the storm sewer system along the paths mentioned in Section 4a of this report. This was done to provide two more substantial outfalls to the drainage system and provide underground storage in the large box culverts. See Figure 3 for the layout of the proposed box culverts.

Figure 3 - Proposed Box Culverts (Scenario C)

Scenario D:

For reference, see Exhibit 4 which presents all proposed improvements for Scenario D. In order to equalize the system and allow the flow to spread more evenly across all outfalls, a proposed 48-inch RCP would be installed along N Eldridge Drive, from Advance Drive to Pantano Drive. The vacant lot north of Advance Drive would be converted into a detention pond with a footprint of 6.14 acres, and a proposed volume of approximately 25 acre-feet. This pond would connect to the storm sewer system along Advance Drive with a 48-inch RCP, and the storm sewer lines along Advance Drive would be upsized to match the 48-inches. All outfall lines east of N Eldridge Parkway and west of Barwood Bend Drive would be upsized as well by 12-inches. This would be done to allow water to be released more quickly from the system.

All of the improvements listed in this scenario were modeled separately and showed progressive results; therefore they were combined into one scenario to provide the most benefit.

Exhibit 5 presents the proposed drainage area map for Scenario D.

c. Results of Analysis

The existing drainage system conditions were analyzed using the existing XPSWMM model. Hurricane Harvey, the 2016 Tax Day flood, and the 10-, 25-, 50-, 100-, and 500-year storm events were modeled on the existing conditions. Hurricane Harvey and the 2016 Tax Day flood results were calibrated to best match the reported flooding depths in the Barwood subdivision. Using this calibration, the 10-, 25-, 50-, 100-, and 500-year storm event results were obtained. During the 10-, 25-, and 50-year storm events, flooding was limited mostly to the street, with minimal structural flooding. The worst areas during these events appeared to be the southeast corner of the subdivision along Aste Lane. During the 100- and 500-year storm, there was significantly more structural flooding in the area. Aste Lane, Amado Drive and Advance Lane appeared to be the worst of the flooded areas, with depths of 6 to 18 inches of water in homes during the 100-year event. This is largely due to the tailwater elevation during this storm of 129.5 feet. Many of the homes' slab elevations are below 129.5, setting them up for certain flooding if the tailwater were to reach the 100-year storm level. With nowhere to drain, the water will pond in the streets and rise until the WSEL is equalized, leading to water reaching the structures. During the 500-year storm event, the flooding is understandably similar to the 100-year storm event, but to a higher degree. The 500-year storm event was modeled because it can be considered as similar to the "future" 100-year storm, as the regional rainfall totals are updated in the coming months. However, since the system is controlled by the tailwater in the E132 and E133 channels, there is no reasonable local solution that can provide complete protection to the Barwood subdivision for the 500-year event.

Exhibits 6 through 12 present the existing ponding results for the Barwood Subdivision.

Proposed improvements were applied to the XPSWMM model one at a time to analyze for effectiveness in mitigating flooding in the neighborhood. The 100-year storm event was used as the baseline design storm. The result of each proposed scenario is described below.

<u>Scenario A</u>:

Increasing all pipe sizes led to little to no improvement on the flooding impact in the subdivision. The main issue does not appear to be related to pipe capacity, but rather tailwater flooding. Due to the small positive impact and excessive financial cost of this alternative, analysis of this scenario was discontinued in lieu of more practical and effective options.

<u>Scenario B</u>:

The proposed detention ponds at Barwood Community Park and BF Adams Elementary School do not allow for enough detention volume to make any significant impact on the drainage issues in the area. With maximum volumes of 3.04 acre-feet and 3.79 acre-feet respectively, the cost and impact to the public would not warrant the insignificant impact of these ponds on the drainage system. For reference, Hurricane Harvey created approximately 180 acre-feet of ponding in the Barwood Subdivision alone, while the 2016 Tax Day flood created approximately 95 acre-feet of ponding. A total of 6.83 acre-feet of detention between these two proposed ponds combined does not impact that amount of flooding. Therefore, the analysis of this scenario was discontinued.

Scenario C:

Installing side-by-side 4’x8’ box culverts at the locations presented in Figure 3 does not create a significant impact to the drainage system during the storm events analyzed. This follows the same reasoning as Scenario A – the cause of flooding is not a result of insufficient existing pipe capacity but rather the tailwater level. This line of reasoning, along with the excessive financial cost of this alternative, led to the discontinuation of analyzing this scenario.

Scenario D:

Each of the proposed improvements in Scenario D were modeled individually and produced positive results for the Barwood drainage system. For that reason, they were all included as one complete proposed condition, as none of the improvements impede the other.

The 48-inch proposed RCP down N Eldridge Parkway allows for flow that is ponding on streets with only one outfall to be spread evenly across all five connected outfalls.

The proposed detention pond north of Advance Drive is the largest available piece of land that can be connected to the Barwood drainage system. So for the sake of providing detention, this was deemed as the best option. Approximately 25 acre-feet are detained during the 100-year storm event. The 48-inch outfall and the increased line size along Advance Drive allows for more flow to enter the pond.

Increasing the size of all outfall lines allows for the flow to exit the system more efficiently.

All together, these proposed improvements produce a significant positive impact to the flooding in the Barwood Subdivision, lowering ponding depths by 6 to 24 inches in some streets. This lowers the water enough during the 100-year storm event to remove many homes from the floodplain (approximately 60 homes). Due to the system being controlled by the tailwater in the E132 and E133 channels, it is not reasonably possible to remove all homes from the 100-year floodplain without addressing regional drainage. However, the improvements in Scenario D provide enough relief to the subdivision to protect all properties from flooding for events up to the 25-year storm.

Exhibits 13 and 14 present the ponding conditions during 25- and 100-year storm events with the proposed improvements in Scenario D.

Exhibit 15 presents a comparison of the existing and proposed ponding conditions.

An alternative approach to upsizing the pipes in Scenario D will be to install parallel storm sewer lines alongside the pipes that would be upsized. This would require CCTV inspection of the existing lines to ensure the integrity of the system. Table 4 presents the size of parallel line that would be needed to achieve the same flow area as the proposed increased line sizes.

Table 4 - Parallel Pipe Size Comparison

Original Pipe Size (ft)	Upgraded Pipe Size (ft)	Parallel Pipe Size (ft)
2.0	4.0	3.5
2.0	4.5	4.0
2.5	4.0	3.5
3.0	4.0	3.0
3.5	4.5	3.0
5.0	6.0	3.5

d. Proposed Solutions/Recommended Approach to Improving Drainage

HT&J's ultimate recommendation is for the proposed improvements of Scenario D, described in detail in Section 4b and 4c of this report. Each improvement described in this scenario makes a positive impact individually. HT&J believes that a combination of improvements creates the biggest positive impact to flooding conditions for the Barwood subdivision.

To summarize the proposed Scenario D improvements, they will include:

1. Approximately 1,300 linear feet (LF) of 48-inch new RCP installed along N Eldridge Road, connecting to the intersecting existing lines. Four new manholes would be needed for the intersections.
2. A 25.0 acre-foot detention pond to the north of Advance Drive, connecting to the existing system with approximately 220 LF of 48-inch RCP. One manhole would be added along Advance Drive.
3. Approximately 2,500 LF of 48-inch RCP; 1,600 LF of 54-inch RCP; and 860 LF of 72-inch RCP. Removal of 4,960 LF of existing RCP storm sewer.

These proposed improvements are based on the design rainfall from the Harris County Region 2 rainfall hyetograph for the 100-year storm event. The hyetograph was taken from the effective HEC-HMS model for the White Oak Bayou watershed. Boundary conditions for the analysis are described in Section 4b of this report.

Alternatives to this solution are discussed in this report as Scenarios A through C. Each improvement discussed in Scenario D can also be applied individually for some benefit to the system.

This proposed solution will have some adverse impact to the Barwood subdivision during construction, mainly just the typical nuisance of road construction. One lane of N Eldridge Parkway will need to be closed in order to install the 48-inch RCP from Advance Drive to Pantano Lane. Each cul-de-sac will also be impacted as the outfall lines are removed and replaced with larger sizes. Apart from that, the only offsite impact will be to the vacant lot to the north of Advance

Drive, designated as proposed detention. HT&J has met with IDS Engineering, who is currently handling the drainage analysis of the Bernadine Estates subdivision, to discuss the use of this plot of land as a shared detention site. Further coordination would be required between the design engineer, HCED, and the land owner of the vacant lot.

Exhibit 4 presents all proposed improvements for Scenario D.

Survey Requirement

The design team will need to refine the scope of survey. However, where the changes are proposed, we anticipate a need for a storm sewer survey to cover the flowline, line sizes, top of curb, and other relevant information.

Unresolved Issues

The issue of the tailwater elevations in channels E132-00-00 and E133-00-00 is one that cannot be resolved with local drainage improvements. The remaining issue is that many houses in Barwood lie lower than the 100-year tailwater elevation in these channels, making them targets for future flood risk. The 100-year tailwater elevation is 129.5 feet, and many houses near channel E132-00-00 lie at elevation 127 to 128.5 feet. The only solution to this problem lies in a regional approach that will lower the WSEL in channels E132 and E133, as well as the receiving channel of White Oak Bayou. This will require internal collaboration between HCED and HCFCD to evaluate the practicality and efficacy of potential projects within the watershed.

HT&J also has received contradictory information regarding the water level in the E132 and E133 channels during Hurricane Harvey. Based on estimates from the recorded WSEL in White Oak Bayou and verification from residents during site visits, it was estimated that the WSEL rose above the banks of the channels during the storm. However, during the public meeting it was stated by certain residents that the water level did not overtop the banks, and that the main source of floodwaters was from across Cypress North Houston Road (from the Cypress Creek watershed). The proposed improvements along N Eldridge Parkway and the proposed detention pond will certainly help to mitigate flooding from this source as well, but it does need to be considered a regional problem to be solved with improvements to the Cypress Creek watershed.

As discussed in Section 4b, the diversion of the offsite area of approximately 100 acres coming through N Eldridge Parkway may improve the drainage conditions in the Barwood subdivision. However, further evaluation is necessary to determine the viability of the flow diversion option.

e. Project Cost

A preliminary cost estimate was put together for all proposed solutions. The Harris County Project Scoping and Cost Estimating Development Tool is included as Attachment 2 to this report. Table 5 below presents the preliminary cost estimate for each scenario, including contingencies and engineering costs.

Table 5 - Preliminary Cost Estimate Summary

Proposed Improvement Scenario	Total Cost
A	$14,600,000
B	$600,000
C	$8,200,000
D	$6,900,000

Items were broken down into quantity and units, and TxDOT bid tabs were used for unit costs of each item. Attachment 3 contains the detailed cost breakdown for each scenario.

A percent contingency of 25% was applied to all scenarios. A design cost of 15% (after contingencies) was also assigned to all scenarios.

The land acquisition mentioned in Attachment 3 – Scenario D refers to the vacant lot to be used for detention. The recommended right of way (ROW) rate of $6 per square foot was applied to this property. The parcel is approximately 295,000 square feet, putting the cost of land acquisition at $1,770,000.

A cost estimate was also prepared for the alternative to Scenario D, using parallel pipes in place of full pipe replacement. This is referred to as "Scenario D – Alternative" in Attachment 3.

5. Public Comment

a. Date, Time, and Location of Meeting

The public meeting took place on January 30, 2019 from 6:00pm to 8:00pm CST. The meeting was at Arnold Middle School, located at 11111 Telge Road, Cypress, Texas 77429. The meeting consisted of the subdivision projects for the Barwood, Tower Oaks Meadows, and Bernadine Estates subdivisions. The consulting engineers for each project were HT&J LLC, HDR Engineering, and IDS Engineering, respectively.

b. Input Received

HT&J spoke with many residents during the breakout session portion of the public meeting, answering specific questions and concerns regarding the existing and proposed drainage analysis. Residents were asked to write specific concerns down on the comment cards and submit them to the County. HCED reviewed and compiled these comments and they were sent to all consulting engineers in attendance. HT&J reviewed the comments and found 12 comments that were specific to Barwood subdivision.

Comments from residents of the Barwood subdivision mainly consisted of suggestions for improvements at specific locations, concerns about the impact of improvements on parks and roads, and concerns about why specific areas were not seeing as much benefit as others in the “proposed” conditions flooding results.

The Barwood comment list and responses can be found in Attachment 4 of this report.

c. Responses Provided to Community Input

HT&J has responded to each comment individually as thoroughly as possible. Where a resident suggested a specific improvement, HT&J analyzed the scenario with the XPSWMM model to determine if there was any merit to their suggestion. We also explained how the improvements would affect (or not affect, in some cases) the subdivision, and explained why some issues with flooding within the subdivision are a regional issue, and that local drainage improvements cannot solve all of the flooding problems that residents are experiencing.

SITE PHOTOS

Barwood Subdivision Site Photos

Miscellaneous Subdivision

Barwood Subdivision Site Photos

Barwood Subdivision Site Photos

Barwood Subdivision Site Photos

E132-00-00 Channel

Barwood Subdivision Site Photos

Barwood Subdivision Site Photos

E133-00-00 Channel

Barwood Subdivision Site Photos

Barwood Subdivision Site Photos

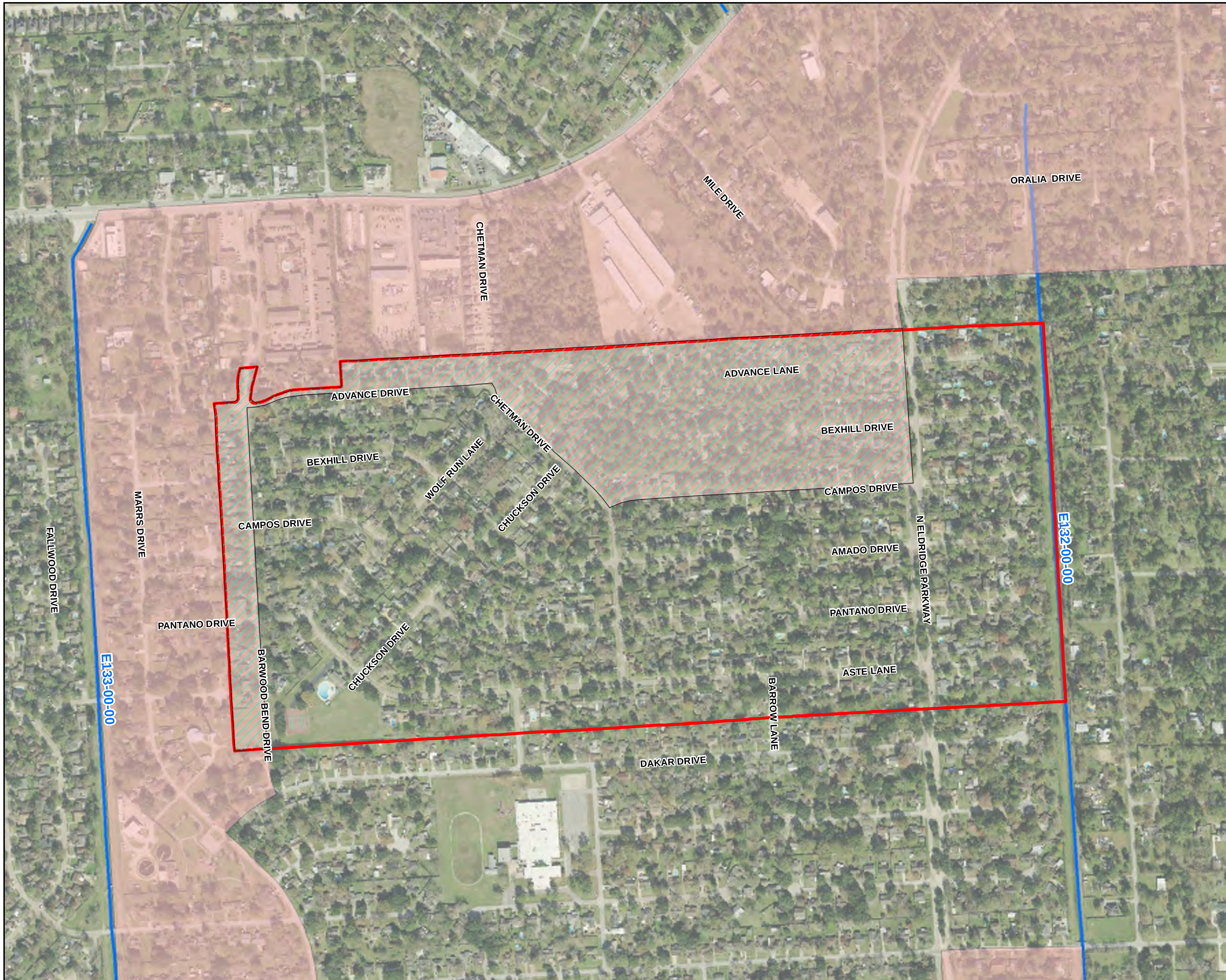
Barwood Subdivision Site Photos

EXHIBITS

Harris County Precinct 3
Barwood Subdivision

EXHIBIT 1
BARWOOD SUBDIVISION
LOCATION

HT&J, LLC
Professional Engineering Services



N

0 250 500 1,000 Feet

Barwood Subdivision Boundary
LMI Area
LMI Area within Barwood

HCFCD Channels

Open Channel

Harris County Precinct 3
Barwood Subdivision

EXHIBIT 1A

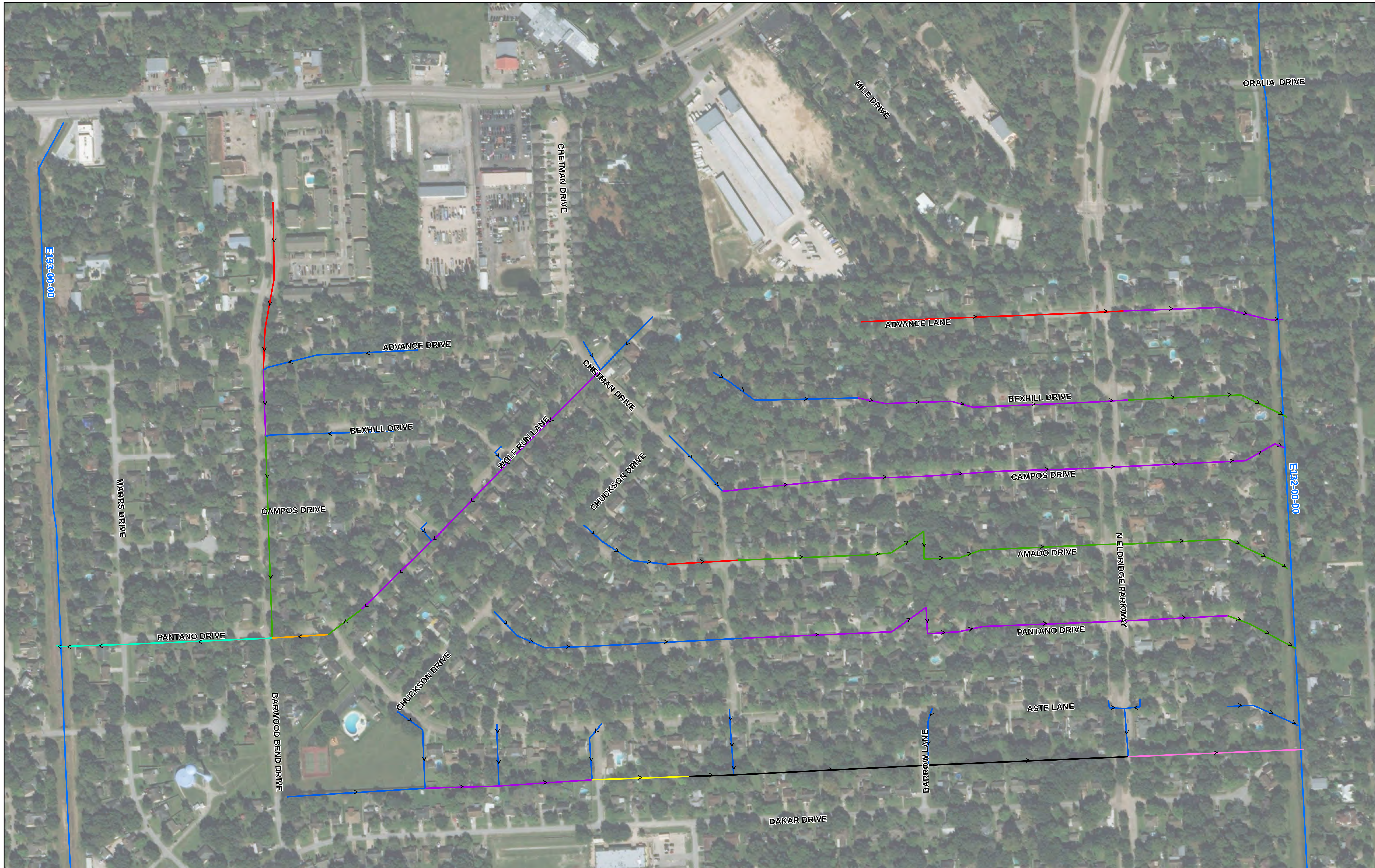
LOW TO MODERATE
INCOME (LMI) AREA

HT&J LLC
Professional Engineering Services

Barwood Subdivision Drainage Analysis

Analysis of Drainage Infrastructure and Recommendation for Improvements to Mitigate Flooding

HARRIS COUNTY
BOND PROGRAM 2018



N

Legend

Existing Storm Sewer

- 24 in.
- 30 in.
- 36 in.
- 42 in.
- 48 in.
- 54 in.
- 60 in.
- 66 in.
- 72 in.

EXHIBIT 2

EXISTING
STORM SEWER SYSTEM

www.hcfcd.org/2018bondprogram

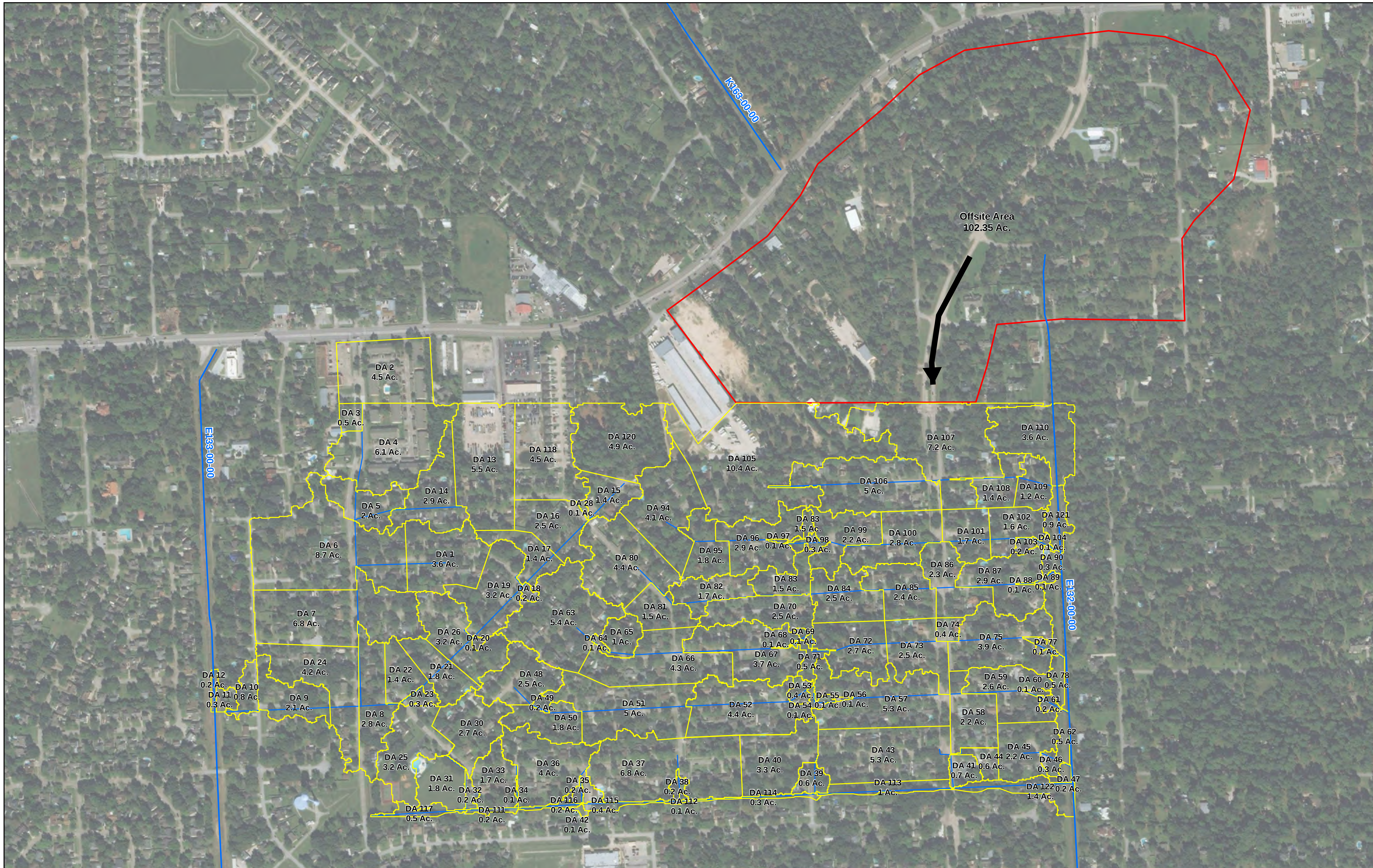
HARRIS COUNTY FLOOD CONTROL DISTRICT

Barwood Subdivision Drainage Analysis

Analysis of Drainage Infrastructure and Recommendation for Improvements to Mitigate Flooding

HARRIS COUNTY

BOND PROGRAM 2018



N

Legend

- Drainage Area
- Offsite Drainage Area from N Eldridge
- Existing Storm Sewer

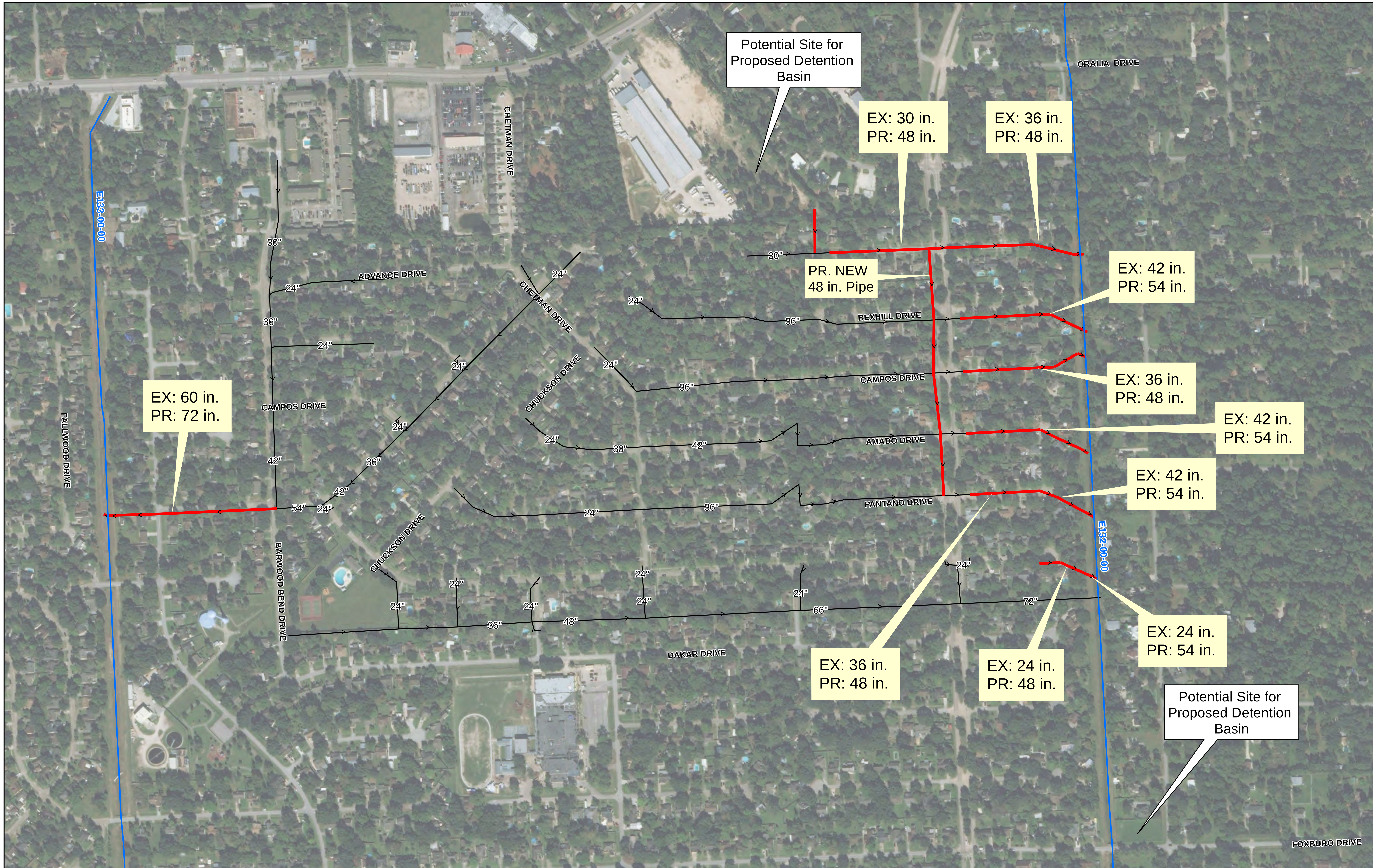
EXHIBIT 3

EXISTING DRAINAGE AREA MAP

Barwood Subdivision Drainage Analysis

Analysis of Drainage Infrastructure and Recommendation for Improvements to Mitigate Flooding

HARRIS COUNTY
BOND PROGRAM 2018



N

Legend

Storm Sewer System
- Existing Pipes
- Pr. Increased Pipe Size

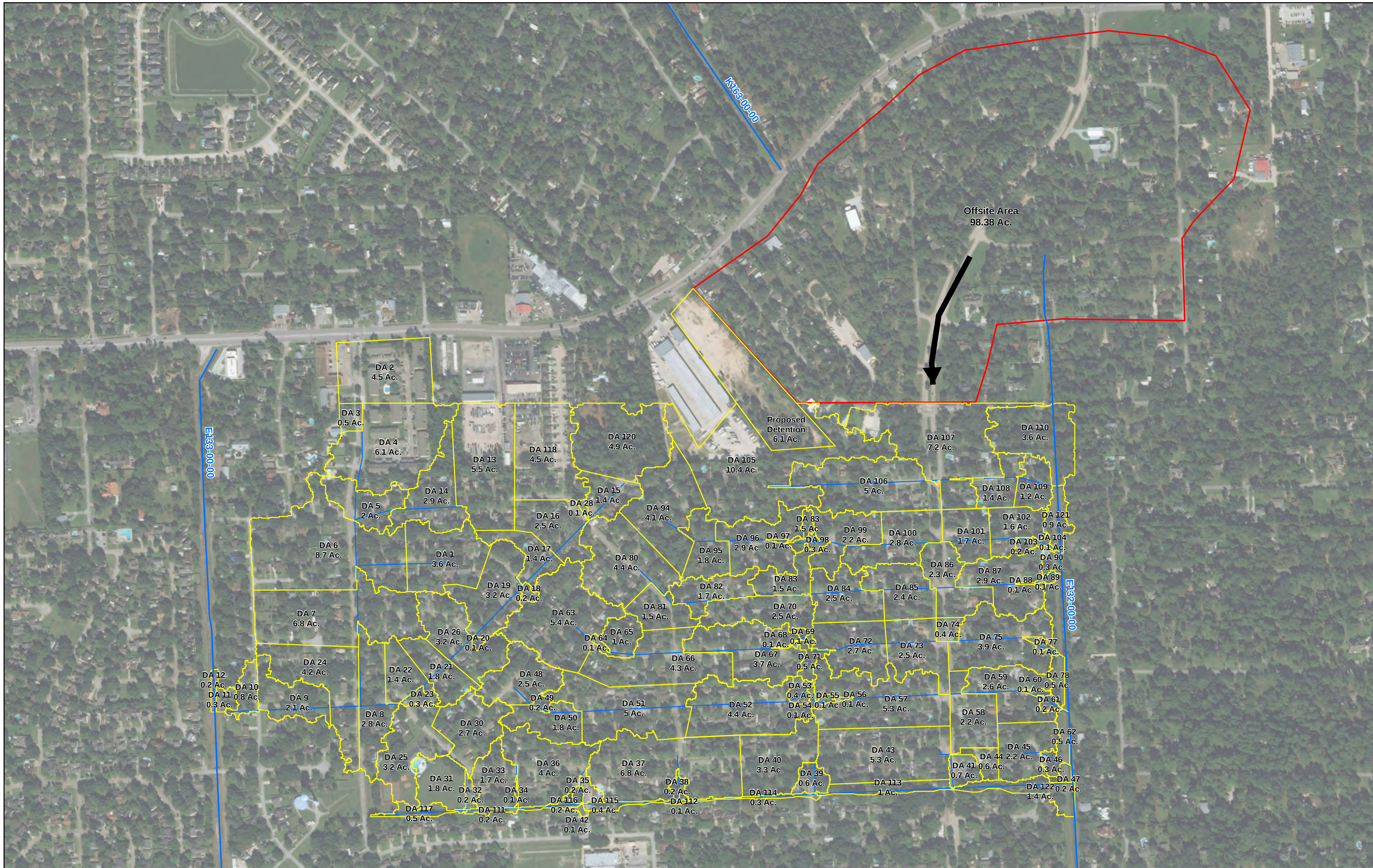
EXHIBIT 4

PROPOSED IMPROVEMENTS (SCENARIO D)

Barwood Subdivision Drainage Analysis

Analysis of Drainage Infrastructure and Recommendation for Improvements to Mitigate Flooding

HARRIS COUNTY
BOND PROGRAM 2018



N

Legend

Drainage Area

Offsite Drainage Area from N Eldridge

Existing Storm Sewer

EXHIBIT 5

PROPOSED DRAINAGE AREA MAP

Barwood Subdivision Drainage Analysis

Analysis of Drainage Infrastructure and Recommendation for Improvements to Mitigate Flooding

HARRIS COUNTY
BOND PROGRAM 2018

Legend

Ponding Depth (feet)

High : 4

Low : 0

EXHIBIT 6

EXISTING
PONDING RESULTS
10-YEAR STORM EVENT

www.hcfcd.org/2018bondprogram

HARRIS COUNTY FLOOD CONTROL DISTRICT

Barwood Subdivision Drainage Analysis

Analysis of Drainage Infrastructure and Recommendation for Improvements to Mitigate Flooding

HARRIS COUNTY
BOND PROGRAM 2018

Legend

Ponding Depth (feet)

High : 4

Low : 0

EXHIBIT 7

EXISTING PONDING RESULTS 25-YEAR STORM EVENT

www.hcfcd.org/2018bondprogram

HARRIS COUNTY FLOOD CONTROL DISTRICT

Barwood Subdivision Drainage Analysis

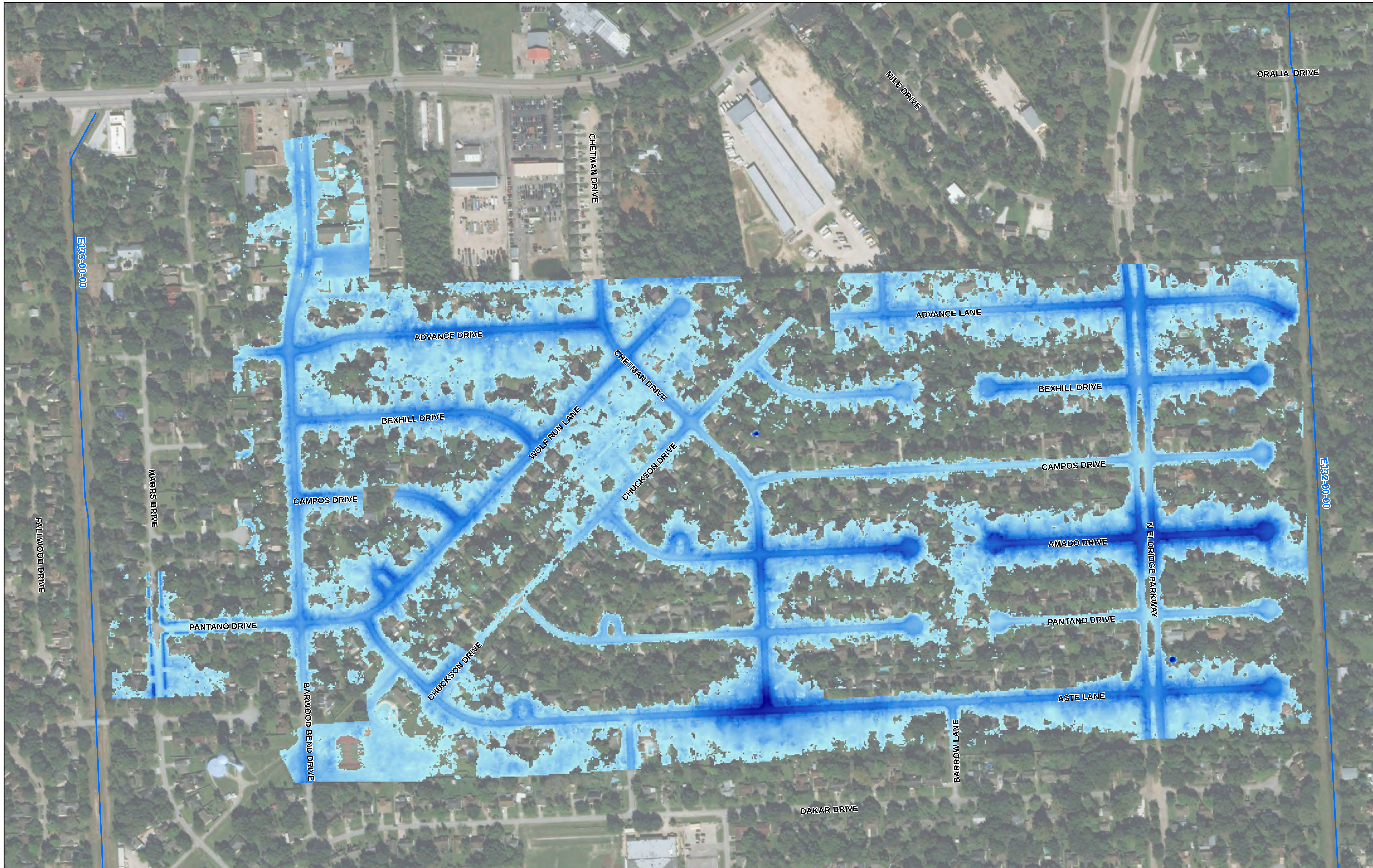
Analysis of Drainage Infrastructure and Recommendation for Improvements to Mitigate Flooding

HARRIS COUNTY
BOND PROGRAM 2018

EXHIBIT 8

EXISTING
PONDING RESULTS
50-YEAR STORM EVENT

www.hcfcd.org/2018bondprogram



N

Legend

Ponding Depth (feet)

High : 4

Low : 0

EXHIBIT 9

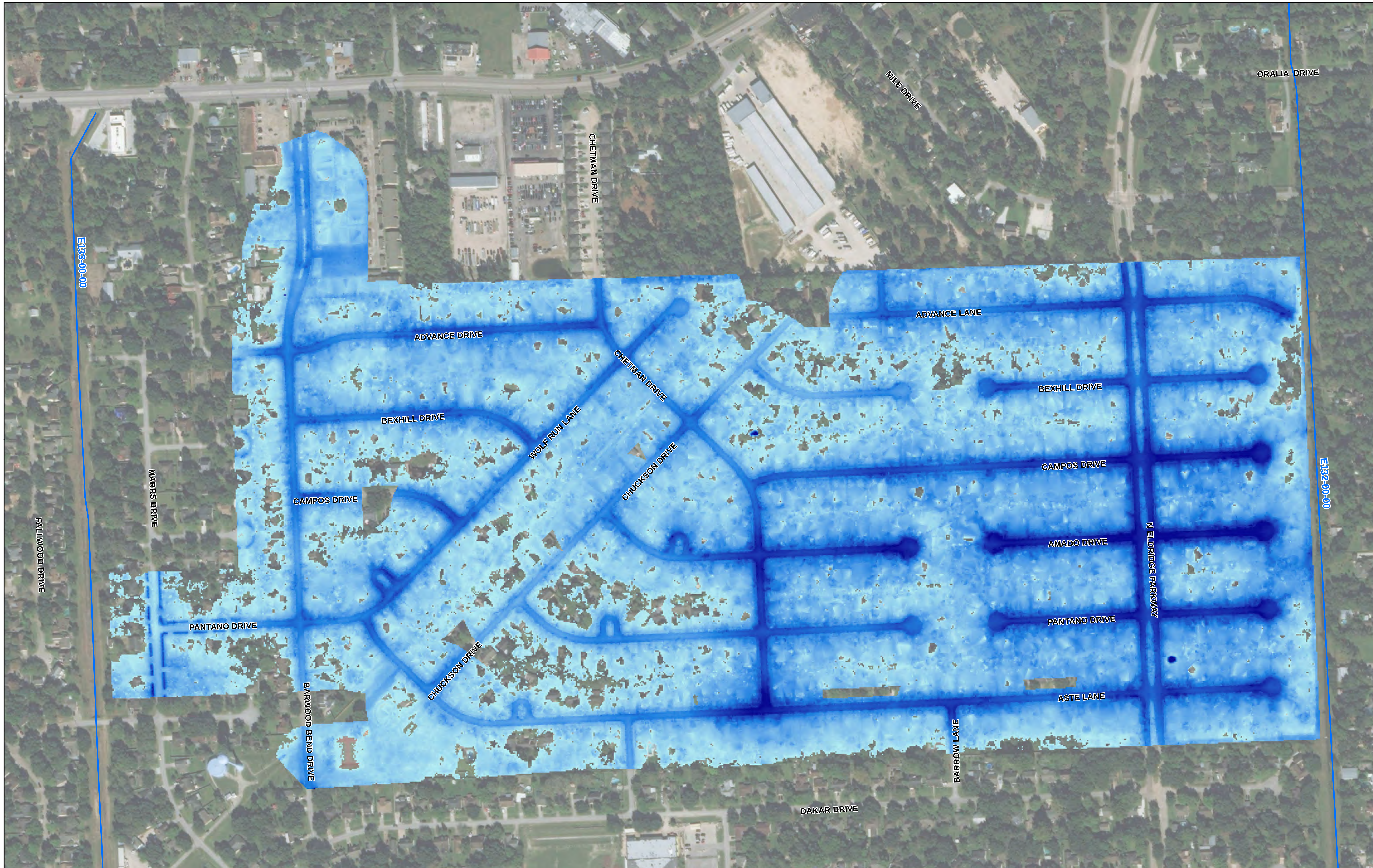
EXISTING
PONDING RESULTS
100-YEAR STORM EVENT

Barwood Subdivision Drainage Analysis

Analysis of Drainage Infrastructure and Recommendation for Improvements to Mitigate Flooding

HARRIS COUNTY

BOND PROGRAM 2018



N

Legend

Ponding Depth (feet)

High : 4

Low : 0

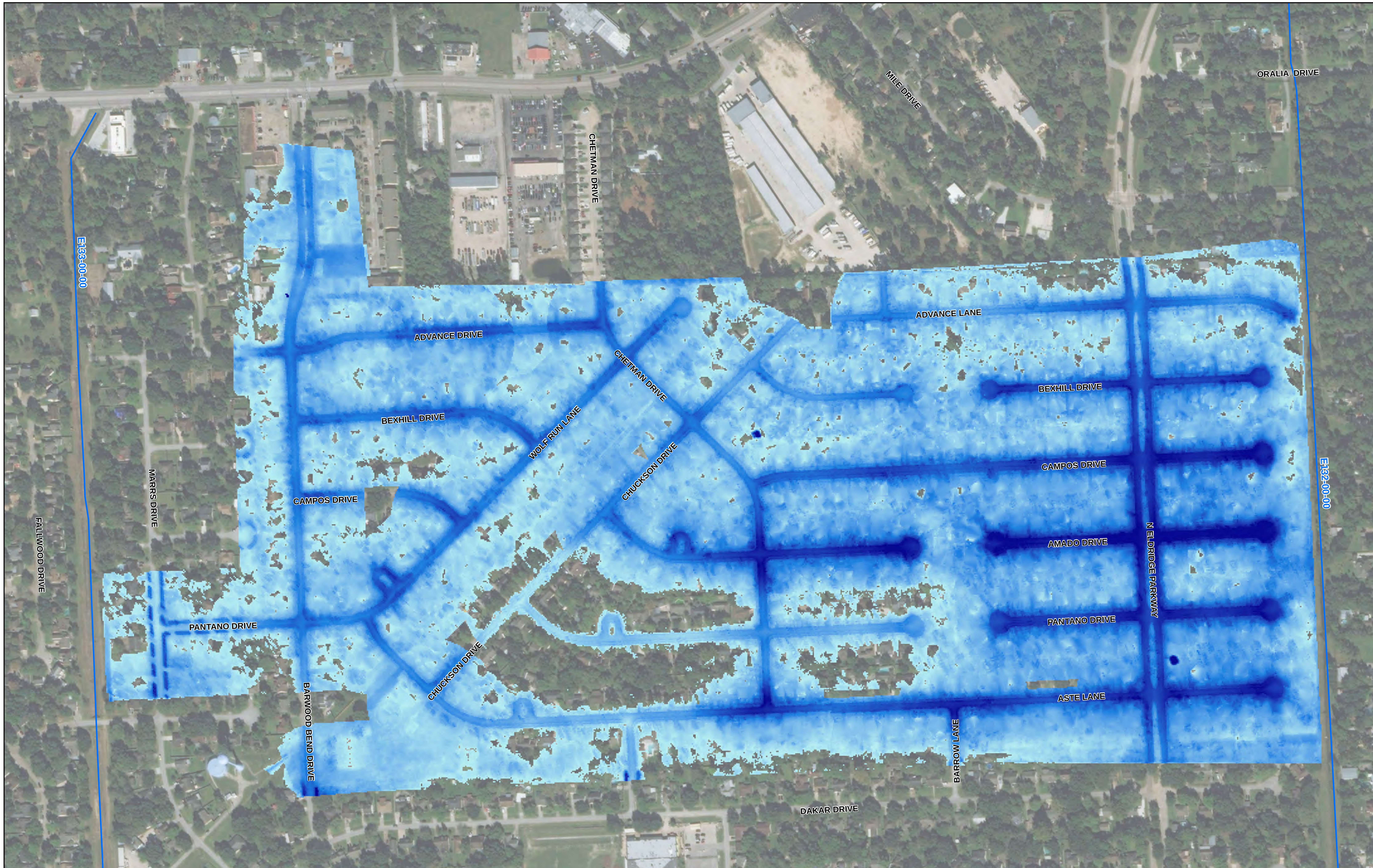
EXHIBIT 10

EXISTING PONDING RESULTS 500-YEAR STORM EVENT

Barwood Subdivision Drainage Analysis

Analysis of Drainage Infrastructure and Recommendation for Improvements to Mitigate Flooding

HARRIS COUNTY
BOND PROGRAM 2018



N

Legend

Ponding Depth (feet)

High : 8

Low : 0

EXHIBIT 11

EXISTING
PONDING RESULTS
HURRICANE HARVEY

August 25-31, 2017

www.hcfcd.org/2018bondprogram

HARRIS COUNTY FLOOD CONTROL DISTRICT

EXHIBIT 12

EXISTING PONDING RESULTS TAX DAY FLOOD

April 16-18, 2016

Barwood Subdivision Drainage Analysis

Analysis of Drainage Infrastructure and Recommendation for Improvements to Mitigate Flooding

HARRIS COUNTY
BOND PROGRAM 2018

N

Legend

Ponding Depth (feet)

High : 4

Low : 0

EXHIBIT 13

PROPOSED
PONDING RESULTS
25-YEAR STORM EVENT

www.hcfcd.org/2018bondprogram

Barwood Subdivision Drainage Analysis

Analysis of Drainage Infrastructure and Recommendation for Improvements to Mitigate Flooding

HARRIS COUNTY

BOND PROGRAM 2018

N

Legend

Ponding Depth (feet)

High : 4

Low : 0

EXHIBIT 14

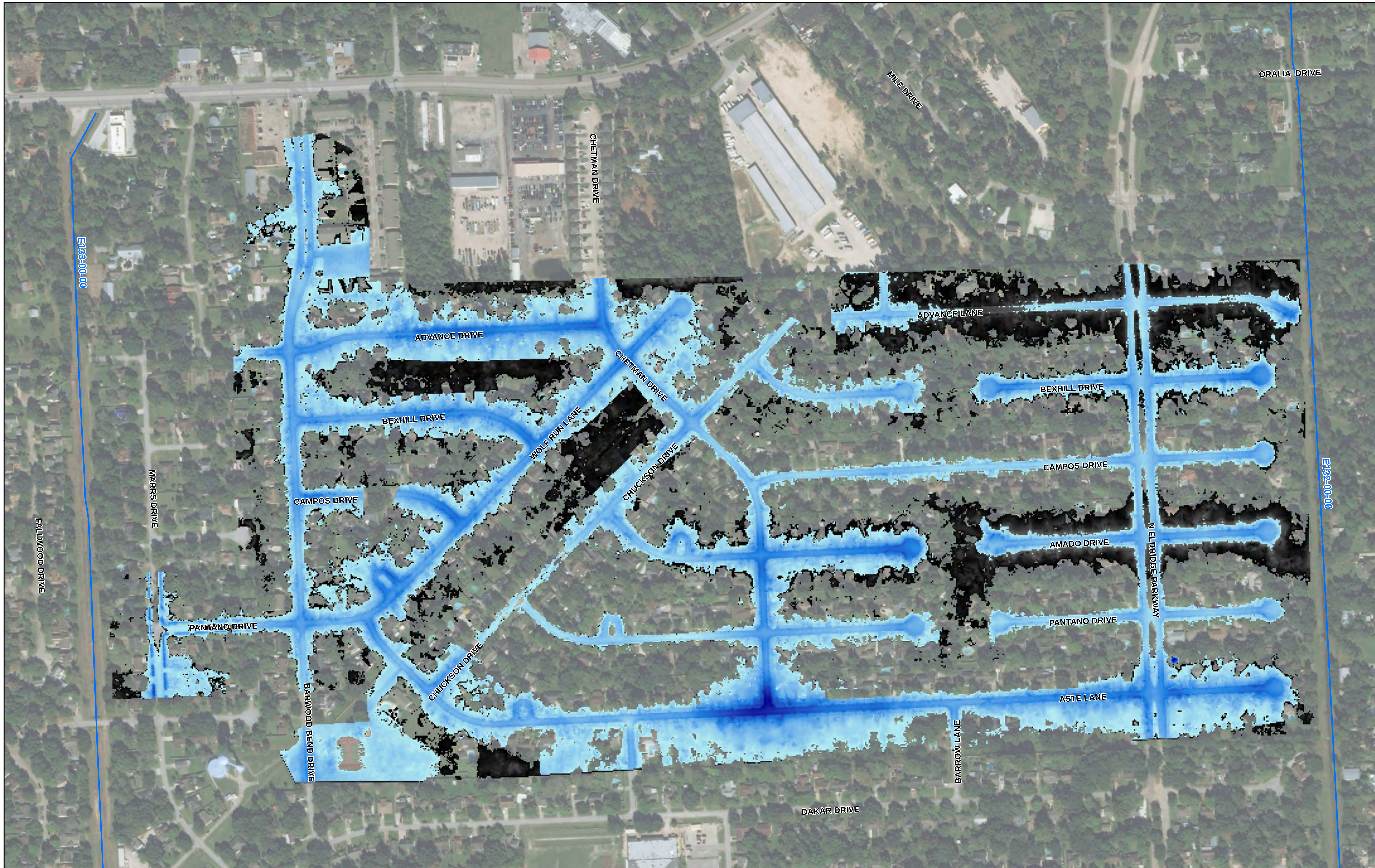
PROPOSED
PONDING RESULTS
100-YEAR STORM EVENT

www.hcfcd.org/2018bondprogram

Barwood Subdivision Drainage Analysis

Analysis of Drainage Infrastructure and Recommendation for Improvements to Mitigate Flooding

HARRIS COUNTY
BOND PROGRAM 2018



N

Legend

Proposed Ponding Depth (feet)

High : 4

Low : 0

Existing Ponding Depth (feet)

High : 4

Low : 0

EXHIBIT 15

PONDING RESULTS COMPARISON
100-YEAR STORM EVENT

www.hcfcd.org/2018bondprogram

HARRIS COUNTY FLOOD CONTROL DISTRICT

ATTACHMENT 1

Barwood Subdivision Drainage Record Drawing


CYPRESS - N. HOUSTON ROAD
KEY MAP
No Scale
BARWOOD
FOXBURO DRIVE
TOWER OAKS MEADOWS
ACREAGE
ADVANCE DRIVE
ADVANCE LANE
BEXHILL DRIVE
CAMPOS DRIVE
AMADOR DRIVE
PANTANO DRIVE
DAKAR DRIVE
DERMOTT DRIVE
FOXBURO DRIVE
IBERIA DRIVE
RESERVE "A" Unrestricted
RESERVE "B" Unrestricted
RESERVE "C" (PARK)
Existing Water Plant
Existing Sewage Treatment Plant
TEXAS-ILLINOIS NATURAL GAS PIPELINE CO. 60' R.O.W. (Vol 2181, Pg 410, H.C.D.R)
NOTES:
1. B.L. indicates - "Building Line"
2. U.E. " - "Utility Easement"
3. G.E. " - "Guy Easement"
4. All side lot lines are either perpendicular or radial to street frontage unless otherwise noted.
5. One-Foot Reserve is dedicated to the public in fee ... etc etc etc (Rules for S/D. - 9-K)
6. This Easement shall be kept clear of Fences, Buildings ... etc (Rules for Land S/D 16-a-2)
Approved: County Engineer Date
Approved: Engineer in Charge 1/25/72 Date
Contractor shall notify Harris County Engineering Department 24 hours in advance of commencing construction.
NOTES:
1. Reinforced concrete pipe storm sewers shall be installed, backfilled and bedded in conformity with Drawings No. 529-S or 530-S, as appropriate.
2. All paving & drainage to conform with Harris County Minimum Specifications E-14-62.
3. All inlet leads to be 24" R.C.P. unless otherwise specified.
4. Standards Adopted by the Utility Coordinating for The Metropolitan Area shall govern all utility Locations with 10' or 16' U.E.s
SEE ATTACHED LETTER
Approved:
ASST. FLOOD CONTROL ENGINEER
1-24-72
DATE
STORM SEWER SYSTEM
APPROVED FOR CITY OF HOUSTON
DEPARTMENT OF PUBLIC WORKS:
Water Design
Paving
Water Quality
Storm Sewer
Sanitary Sewer
Assistant Director
Date
OTHER DEPT'S
4/25/72
B.M. 30d Nail in First Power Pole east of Woodbar Road & South of Drainage Ditch ELEV. 135.36
Revised Jan. 19, 1972
R 10-18-71
COULSON & ASSOCIATES ENGINEERS, INC.
CONSULTING ENGINEERS
2625 LOUISIANA STREET HOUSTON, TEXAS 77006
DRAWN NL
CHK'D RA
APP'D BC
PRELIMINARY PLAT OF
BARWOOD
BEING 199.22 ACRES± OUT OF THE WILLIAM GRAHAM SURVEY, ABSTRACT Nº 308
HARRIS CO., TEXAS.
20 BLOCKS - 580 LOTS
SHEET NO. 1 OF 33 SHEETS
SCALE: 1" = 200'
DATE 9-27-71
P-375
22114
107

ATTACHMENT 2

Harris County Project Scoping and

Cost Estimating Development Tool

HARRIS COUNTY

Project Scoping & Cost Estimating Development Tool

Barwood Subdivision Drainage Analysis

PROJECT NAME

Harris County Precinct 3

PRECINCT

Areas highlighted are to be completed by Consultant

PREPARER INFORMATION		PROJECT INFORMATION	
1. DATE SUBMITTED:	3/20/19	4. PROJECT TYPE:	Drainage Improvement
2. SUBMITTED BY:	Nawa R. Panthi, P.E.	5. PROJECT TITLE:	Barwood Subdivision Drainage Analysis
3. NAME OF FIRM:	HT&J, LLC		

6. ESTIMATED FUNDING (Item 6 to be prepared by Harris County):		
A. CDBG-DR:		** Specify MUD or Other Funding Sources:*
B. OTHER FEDERAL:*		
C. STATE:		
D. COUNTY:		
E. MUD:*		
F. OTHER:*		
ESTIMATED TOTAL:	$ 0.00	

7. NO ACTION ASSESSMENT: Briefly describe the impact of taking no action to repair the damaged facilities.

If no action is taken within the Barwood Subdivision, or regionally to lower the water level in the bordering channels, then the streets and homes will continue to flood during the 10-year (10% AEP) and 50-year (2% AEP) respectively. The receiving storm sewer system will continue to be overwhelmed by rainfall events causing ponding and flooding within the subdivision. The only access to the subdivision will be at risk of being restricted by flooding. Houses with low slab elevations will continue to be at risk of flooding.

DESCRIPTION OF THE NEED(S) ADDRESSED IN THIS DOCUMENT

Provide full and complete answers to each of the following. Descriptions should include the cause of the damage, current condition of the facility, and a detailed description of the project that coincides with the information contained in both Table 1 and 2. All activities must have documented proof of an impact by the floods and storms. CDBG-DR funds must be used for disaster- related expenses in the most impacted and distressed areas.

1. ***Describe the specific flood and storm-related condition that directly caused the damage(s).***

   Floods that caused damage to the subdivision were the "Tax Day Flood" (April 18, 2016) and Hurricane Harvey (August 27, 2017).

2. ***Describe the system that was damaged and how it was damaged.***

   The exisitng storm sewer system was not damaged, however 31 homes were flooded during the Tax Day Flood, and 131 homes were flooded during Hurricane Harvey.

3. ***How does the project support housing?***

   As stated previously, the most recent floods had the water level rise into many homes. This project will lower the potential water surface elevation of less frequent/high intensity storms to reduce flooding of houses.

4. ***Describe the impacts on the community that resulted in direct damage(s).***

   The Tax Day Flood resulted in structural flooding of homes up to 6 inches deep. Hurricane Harvey resulted in structural flooding of homes up to 18 inches deep. Access to the subdivision was severely restriced or blocked in several areas.

5. ***Describe how the proposed activities will address damage(s) of the system affected by the floods and storms.***

   The proposed project will increase the capacity of the system's outfalls, as well as connect several independent lines together to better spread the flow out along the bordering HCFCD channel. The proposed detention will also help contain water coming from offsite to the north.

6. ***List materials submitted as documentation of the flood and storm-related condition.***

7. ***Describe the proposed project.***

   The storm sewer lines along Advance Drive, Bexhill Drive, Campos Drive, Amado Drive, and Pantano Drive would be connected along N Eldridge Parkway with a 48-inch RCP. Also, a detention pond is proposed to be installed at the unused lot north of Advance Drive, west of Miles Drive, and connecting it to the storm sewer along Advance Drive. Lastly, all outfall pipe sizes would be increased in the Barwood system.

PROJECT SUMMARY

The Project Summary consists of 4 parts **for each target area and/or activity**: **(1)** Summarize Problem(s); **(2)** Location and Acquisition; **(3)** Detailed Actions to Address Problems; and **(4)** Disclosure on Non-CDBG-DR Funds.

PART 1 – Summarize the problem(s) to be addressed within the application by Target Area.

The existing storm sewer system becomes overwhelmed by rainfall and begins to pond into the street and residents' homes. The issue lies both in the connectivity of the system, the lack of detention, and the high tailwater conditions in HCFCD channels E132-00-00 and E133-00-00.

PART 2 – Identify the location of each activity/Target Area and any associated acquisition activity.
The spelling and capitalization of the Target Area name(s) listed here must match Table 1 (e.g., "Green Acres" should not appear elsewhere as "green acres subdivision."

Project Title / Target Area:	Barwood Subdivision
Activity:	Flood and Drainage Facilities

On:		**From:**		**To:**	

- OR -

Provide a brief description of the location of the activity / Target Area.

The Barwood Subdivision is located in northwest Harris County. It is west of N Eldridge Pkwy, south of Cypress North Houston Road, north of Dakar Drive, and east of HCFCD channel E133-00-00.

- OR -

Provide physical address if possible.

Latitude:		**Longitude:**	

	Included:	
Please attached project area map (11 x 17)	Yes: ☑	No: ☐
Please attach existing drainage area map (11x17)	Yes: ☑	No: ☐
Please attach proposed drainage area map (11x17)	Yes: ☑	No: ☐
Please attach "Sketch Plans", illustrations or annotated drawings communicating the scope of the recommended improvements	Yes: ☑	No: ☐
Please attach scope of services for final design of the improvements	Yes: ☐	No: ☑
Please attach photographs of problems found, annotated on an area map exhibit or in an appendix	Yes: ☐	No: ☑
	Acquisition Required:	
Will acquisition associated with the project site(s) be required?	Yes: ☑	No: ☐

PART 3 – Identify the action(s) to resolve the problem(s) and their anticipated outcomes. *Include details such as specific materials and quantities.*

The proposed improvements include increasing all storm sewer outfalls to increase their capacity, installing 1,300 LF of 48-inch RCP on N Eldridge to increase system connectivity and share the flow among all outfalls, and adding a 25 acre-foot detention pond connected to Advance Drive storm sewer by 220 LF of 48-inch RCP.

Nawa R. Panthi	Director of Water Resources	(832) 767-0090
Name of Preparer (Printed)	**Position / Title**	**Phone Number**

Signature of Preparer	**Email Address**

PROJECT SCHEDULE

Enter the projected length (in number of months) for each applicable phase / process step below. If a phase is not applicable, enter "0" in the field. *Note: Most projects should be completed in 24 months once the associated contract for the project is executed between the Applicant and the Texas General Land Office.*

PROFESSIONAL PROCUREMENT		Months
ENVIRONMENTAL REVIEW		Months
ACQUISITION		Months
ENGINEERING DESIGN	9	Months
CONSTRUCTION	12	Months
COMPLETE CLOSEOUT		Months
EXTENDED ACTIVITY		Months

ANTICIPATED COMPLETION	

If the proposed project schedule exceeds 24 months, a justification must be provided in the space below.

BENEFICIARY INFORMATION

Does the proposed project serve Low /Moderate Income beneficiaries? Yes: ☑ No: ☐

If answer above is no, provide the following information:

	Included	
Shape file of benefited area	Yes: ☐	No: ☐
Digital Elevation Model for the current condition	Yes: ☐	No: ☐
Digital Elevation Model for the proposed condition(s)	Yes: ☐	No: ☐

TABLE 1 - BUDGET

Project Title/Target Area: Barwood Subdivision

Construction Completion Type: Contract

Activity Description 5. Flood and Drainage Facilities

Probable Construction Cost: $ 4,185,000

Estimated Engineering Cost: $ 895,000

Estimated Acquisition Cost: $ 1,770,000

Total: $ 6,850,000

TABLE 2: BUDGET JUSTIFICATION OF RETAIL COSTS

PROJECT TITLE / TARGET AREA: Barwood Subdivision

Act # Activity Description	Materials / Facilities / Services	$/Unit	Unit	Qty	Construction	Acquisition	TOTAL
5. Flood and Drainage Facilities	** Reinforced Concrete Storm Sewer	$ 254.	LF	6480	$ 1,645,92(		$ 1,645,92
5. Flood and Drainage Facilities	Manholes	$ 4,00			$ 100,000		$ 100,000
5. Flood and Drainage Facilities	Excavation	$ 9.00	CY	4033:	$ 362,997		$ 362,997
4. Street Improvements	Concrete Repaving	$ 70.0	SY	9000	$ 630,000		$ 630,000
5. Flood and Drainage Facilities	Pipe Removal	$ 20.0	LF	4960	$ 99,200		$ 99,200
5. Flood and Drainage Facilities	BB Inlets with Grate	$ 6,00	EA	26	$ 156,000		$ 156,000
5. Flood and Drainage Facilities	25% Contingency	$ 750,	EA	1	$ 750,000		$ 750,000
24a. Acquisition	Land Acquisition for Detention	$ 1,77	EA	1	$ 1,770,00(		$ 1,770,00
				COLUMN TOTALS	$ 5,514,11	$ 0	$ 5,514,11

** - RCP unit price is an average price based on quantities of 48-, 54-, and 72-inch RCP. See Attachment 2, Scenario D of the HT&J report for the full cost breakdown.

1. Identify and explain the annual projected operation and maintenance costs associated with the proposed activities.

2. Identify and explain any/all special engineering activities.

Signature of Registered Engineer / Architect Responsible for Budget Justification

Date

Phone Number

(Architect / Engineer Seal)

ATTACHMENT 3

Preliminary Cost Estimates

Item	Quantity	Units	Unit Cost	Total Cost
48-inch RCP	27,000	L.F.	$230.00	$6,210,000.00
54-inch RCP		L.F.	$260.00	$0.00
72-inch RCP		L.F.	$350.00	$0.00
Manhole	50	Ea.	$4,000.00	$200,000.00
Excavation		C.Y.	$9.00	$0.00
Concrete Repaving	36,000	S.Y.	$70.00	$2,520,000.00
Pipe Removal:	27,000	L.F.	$20.00	$540,000.00
24-inch		L.F.		
30-inch		L.F.		
36-inch		L.F.		
42-inch		L.F.		
60-inch		L.F.		
48-inch Flap Gate		Ea.	$5,000.00	$0.00
54-inch Flap Gate		Ea.	$6,000.00	$0.00
72-inch Flap Gate		Ea.	$7,500.00	$0.00
Replace B Inlet with BB Inlet w/ Grate	128	Ea.	$5,000.00	$640,000.00
Replace BB Inlet Plates with Grates		Ea.	$300.00	$0.00
			Construction Cost:	**$10,110,000.00**
			Contingency (25%):	**$2,527,500.00**
			Subtotal:	**$12,637,500.00**
			Design Cost Percentage:	**15.00**
			Design Cost:	**$1,895,625.00**
			TOTAL:	**$14,533,125.00**
			TOTAL (Rounded):	**$14,600,000**

Item	Quantity	Units	Unit Cost	Total Cost
48-inch RCP	1,000	L.F.	$230.00	$230,000.00
54-inch RCP		L.F.	$260.00	$0.00
72-inch RCP		L.F.	$350.00	$0.00
Manhole	4	Ea.	$4,000.00	$16,000.00
Excavation	11,049	C.Y.	$9.00	$99,441.45
Concrete Repaving	300	S.Y.	$70.00	$21,000.00
Pipe Removal:		L.F.	$20.00	$0.00
24-inch		L.F.		
30-inch		L.F.		
36-inch		L.F.		
42-inch		L.F.		
60-inch		L.F.		
48-inch Flap Gate		Ea.	$5,000.00	$0.00
54-inch Flap Gate		Ea.	$6,000.00	$0.00
72-inch Flap Gate		Ea.	$7,500.00	$0.00
Replace B Inlet with BB Inlet w/ Grate		Ea.	$5,000.00	$0.00
Replace BB Inlet Plates with Grates		Ea.	$300.00	$0.00
			Construction Cost:	**$366,441.45**
			Contingency (25%):	**$91,610.36**
			Subtotal:	**$458,051.81**
			Design Cost Percentage:	**15.00**
			Design Cost:	**$68,707.77**
			TOTAL:	**$526,759.58**
			TOTAL (Rounded):	**$600,000**

Item	Quantity	Units	Unit Cost	Total Cost
48-inch RCP		L.F.	$230.00	$0.00
54-inch RCP		L.F.	$260.00	$0.00
72-inch RCP		L.F.	$350.00	$0.00
8' x 4' Box	10,400	L.F.	$435.00	$4,524,000.00
Manhole		Ea.	$4,000.00	$0.00
Junction Box	10	Ea.	$20,000.00	$200,000.00
Excavation		C.Y.	$9.00	$0.00
Concrete Repaving	14,000	S.Y.	$70.00	$980,000.00
Pipe Removal:		L.F.	$20.00	$0.00
24-inch		L.F.		
30-inch		L.F.		
36-inch		L.F.		
42-inch		L.F.		
60-inch		L.F.		
48-inch Flap Gate		Ea.	$5,000.00	$0.00
54-inch Flap Gate		Ea.	$6,000.00	$0.00
72-inch Flap Gate		Ea.	$7,500.00	$0.00
Replace B Inlet with BB Inlet w/ Grate		Ea.	$5,000.00	$0.00
Replace BB Inlet Plates with Grates		Ea.	$300.00	$0.00
			Construction Cost:	**$5,704,000.00**
			Contingency (25%):	**$1,426,000.00**
			Subtotal:	**$7,130,000.00**
			Design Cost Percentage:	**15.00**
			Design Cost:	**$1,069,500.00**
			TOTAL:	**$8,199,500.00**
			TOTAL (Rounded):	**$8,200,000**

Item	Quantity	Units	Unit Cost	Total Cost
48-inch RCP	4,020	L.F.	$230.00	$924,600.00
54-inch RCP	1,600	L.F.	$260.00	$416,000.00
72-inch RCP	860	L.F.	$350.00	$301,000.00
Manhole	25	Ea.	$4,000.00	$100,000.00
Excavation	40,333	C.Y.	$9.00	$362,997.00
Concrete Repaving	9,000	S.Y.	$70.00	$630,000.00
Pipe Removal:	4,960	L.F.	$20.00	$99,200.00
24-inch	290	L.F.		
30-inch	625	L.F.		
36-inch	1,610	L.F.		
42-inch	1,575	L.F.		
60-inch	860	L.F.		
Replace B Inlet with BB Inlet w/ Grate	26	Ea.	$5,000.00	$130,000.00
Replace BB Inlet Plates with Grates	102	Ea.	$300.00	$30,600.00
Land Acquisition		Lump Sum	$1,770,000.00	$1,770,000.00
			Construction Cost:	**$4,764,397.00**
			Contingency (25%):	**$1,191,099.25**
			Subtotal:	**$5,955,496.25**
			Design Cost Percentage:	**15.00**
			Design Cost:	**$893,324.44**
			TOTAL:	**$6,848,820.69**
			TOTAL (Rounded):	**$6,900,000**

Item	Quantity	Units	Unit Cost	Total Cost
36-inch RCP	2,850	L.F.	$140.00	$399,000.00
42-inch RCP	2,150	L.F.	$170.00	$365,500.00
48-inch RCP	1500	L.F.	$230.00	$345,000.00
Manhole	25	Ea.	$4,000.00	$100,000.00
Excavation	40,333	C.Y.	$9.00	$362,997.00
Concrete Repaving	9,000	S.Y.	$70.00	$630,000.00
Pipe Removal:		L.F.	$20.00	$0.00
24-inch		L.F.		
30-inch		L.F.		
36-inch		L.F.		
42-inch		L.F.		
60-inch		L.F.		
Replace B Inlet with BB Inlet w/ Grate	26	Ea.	$5,000.00	$130,000.00
Replace BB Inlet Plates with Grates	102	Ea.	$300.00	$30,600.00
CCTV Inspection		Lump Sum	$20,000.00	$20,000.00
Land Acquisition		Lump Sum	$1,770,000.00	$1,770,000.00
			Construction Cost:	**$4,153,097.00**
			Contingency (25%):	**$1,038,274.25**
			Subtotal:	**$5,191,371.25**
			Design Cost Percentage:	**15.00**
			Design Cost:	**$778,705.69**
			TOTAL:	**$5,970,076.94**
			TOTAL (Rounded):	**$6,000,000**

ATTACHMENT 4

Public Comments and Responses

Comment	Response
No Question- Point of note check with Tx Water Dev. Board for projections in the area. Streets have been raised over the years causing the flooding.	HT&J has reviewed the available record drawings and LiDAR elevation data, and there does not appear to be any decrease in relative elevation change between the gutter and building elevations from the 1970's to now. As a result, the data shows that the roads do not appear to have been raised. However, the available record drawings used are from the 1970's and are difficult to interpret in certain areas. They also use a different elevation datum, which is why relative elevation change was used to compare old with current elevations.
During both, Harvey and Tax Day flooding the water came up to about 1/2" below the edge of the foundation but NOT into the house front(South). At the back of the house there was about 1/4" of water that see page through the bottom of the 2"x4" supporting (flat) stud, but did not contact of welted the insulation. However, my neighbors at the east side and south side had over 8 to 12 inches of water inside. Suggest that in addition to the cleaning and expanding the current main ditches and planned detention ponds for the subdivision to consider the deepening of the existing detention pond located between Wortham Sub Division and Fallbrook Street.	The Fallbrook Street detention pond is out of the scope of the Barwood Subdivision project; however, this comment will have been noted by HCED for consideration in future projects.
Looking at Barwood Flood map at the end of Amado Dr. cul-de-sac there is a drainage pipe that make a Z. To me it looks like this would cause a major bottle neck for drainage. Can this be strengthened to allow better flow?	Yes, that would likely help. However, the physical constraints of the site do not allow for the pipe to pass straight through.
Recommend running another drainage line from Advance Drive across Barwood Bend Dr. (into Tower Oaks Meadows) to the drainage ditch on the Western edge of (E133 Channel) of Barwood and Tower Oaks Meadows; also possibly another retention pond in that area or at near HCFWSD #61 office.	This proposed outlet on Advance Drive was analyzed by HT&J, and it was found to not produce any significant benefit to the subdivision. HT&J has also reviewed all unused land in the area and did not find any spaces significantly large enough in the area mentioned in this comment.
What is being done to reduce the potential flood level at the corner of Aste Lane and Chetman. Based on what the maps show. That area shows no improvement in regards to the water level.	This corner is a low-lying area in the subdivision, and it is currently draining into a 66" to 72" storm sewer pipe that drains to the E132 channel. Therefore, there is no opportunity to increase the storm sewer pipe size, as it does not provide any benefits. To help this area, a regional drainage approach is necessary to lower the tailwater in the HCFCD channels. A regional approach will require internal collaboration between HCED and HCFCD to evaluate the practicality and efficacy of potential projects within the watershed.

Comment	Response
After the Tax Day Flood, I had flooding. In 34 years in my house (11710 Wolf Run Lane) I never had flooding. After the flood, HC came and replaced the drainage sewer in the middle of our cul-de-sac. They said it was collapsed. So they replaced it with a larger pipe; however all the connected 24" pipes remain. So water may enter move quickly, but it slows down and backs up once it those 24" pipes. I was also told by the engineer working that day that they were grading the steel surface to run toward the intersection (Chetman & Wolf Run Ln). This where the sewers are located. I told him that was where it begins to flood first and that would aggravate the receding of water. More importantly to my personal situation is the grading caused the water to now flow to my curve of the cul-de-sac. Anytime it rains now, the water collects on my side and reaches the top of the curb more quickly which in time brings it up my labre toward my house. Even a heavy rain leaves several feet of rain sitting int the gutter. It does not flow away. It sits and dries after several days. This is for flooding on my side of the street.	HT&J looked into increasing the storm sewer line size along Wolf Run Lane so that every pipe was at least a 36-inch diameter. This provided little-to-no benefit to the Wolf Run Lane cul-de-sac or downstream areas. Also, according to the LiDAR data available to HT&J, the street grading in the area mentioned in the comment is as designed, with water running from the middle of the cul-de-sac to the curbs, then running downhill to the inlets at the intersection of Wolf Run Lane and Chetman Drive.
Intersection of Wolf Run and Chetman floods a lot, but cul-de-sac still floods bad after Tax Day and "Harvey". Pipe grading and repairs in cul-de-sac, not much improvement for Wolf Run. The connection of new pipe with old was not a good solution.	See response to comment 18 by Susan Keene, HT&J believes that response addresses this comment as well.
Hopefully all is underground. So we don't have a ditch in our yard.	All existing and proposed storm sewer in the Barwood subdivision is underground.
1. Creation of spillway at Advance Drive at ditch #132. 2. Angle the 5' trunk lines on the cul-de-sac to 30°. 3. Move water from Eldridge down past Barwood to White Oak Bayou. By increasing underground capacity. 4. Replace curb drainage on Eldridge. 5. On the Aste cul-de-sac, replace the 24" pipe to 48" underground to ditch/canal #132.	2.This change will be done in the final design, as that outfall is proposed to be replaced anyway. 3. This solution would require regional improvements, and is not within the scope of this preliminary drainage analysis. Our proposed local improvements, however, do include additional storm sewer along N Eldridge, as do the improvements proposed for the Tower Oaks subdivision. 4. This is one of the proposed improvements already discussed by HT&J. 5. This is one of the proposed improvements already discussed by HT&J.

Comment	Response
Root cause is large amount of water. I saw the overflow from Cypress Creek flowing down (south) over its banks. Water flowing cause a large amount of water that our drainage can not handle. The larger draining will help. I do think that drainage on both sides of Eldridge would also help. What is uncertain is where this water will go if it has somewhere to go. The detention ponds proposed is potentially a plus to help missions of gallons of water would help. Thanks for taking time out to come out and show us what's going and hope to hear from you guys soon.	The larger outfalls, drainage along N Eldridge, and proposed detention pond will provide benefit to the neighborhood from this excess of water. The overflow from Cypress Creek coming across Cypress North Houston Road is a regional issue that has been discussed with HCED. A regional approach will require internal collaboration between HCED and HCFCD to evaluate the practicality and efficacy of potential projects within the watershed.
are detention ponds dug within the subdivision(s)? or the park at Marrs & Dakar.. We don't want it! -- Love the park as is.	No ponds are proposed within the subdivision, only on adjacent empty lots. The park will remain untouched.

Tower Oaks Meadows Subdivision Drainage Improvements

Harris County Engineering Department

Study Report

Harris County Precinct 3

May 2, 2019

Contents

Attachments

Scoping and Cost Estimating Template
Photographs
Cost Estimate

General Project & Contact Information

Project Name

Tower Oaks Meadows Subdivision Drainage Improvements

Harris County Precinct 3

Project Location Map

See Exhibit 1

Preparer Information

Firm Name:	HDR Engineering, Inc.
Firm Address:	4828 Loop Central Drive Suite 800 Houston, TX 77081
Preparer Name:	Jeremy Blevins, PE, CFM
Preparer Phone:	713.576.3513
Preparer Email:	jeremy.blevins@hdrinc.com

Existing Conditions Analysis

Summary of Drainage Issues/Analysis of Problem

The Tower Oaks Meadows Subdivision conveys runoff via roadside ditches, which drain to an existing storm sewer trunk line along the back of lots between Dakar and Aste Streets. The existing roadside ditches are insufficient to convey stormwater to the existing trunkline. The general topography of the subdivision drains toward the southeast; however, the existing roadside ditches were designed to drain northward against the existing topography of the subdivision. Additionally, there is no extreme event stormwater outlet for areas bounded by Eldridge Parkway on the east. Because of this, during Hurricane Harvey and the April 2016 floods, a significant number of homes were flooded within the Tower Oaks Meadows subdivision.

Drainage System – Conditions/Impacts

The western portion of the Tower Oaks Meadows Subdivision was designed to drain westward to HCFCD Unit E133-00-00 via roadside ditch drainage. The eastern portion of the subdivision drains eastward to HCFCD Unit E132-00-00 just east of North Eldridge Parkway. The roadside ditch drainage system does not have the capacity or slope to satisfy current Harris County drainage criteria. Significant ponding occurs along Honey Grove Street, Foxburo Drive, and Dakar Drive during a 2-year storm event. The existing roadside ditches are insufficient to convey the stormwater, causing a long drain time.

The entire Tower Oaks Meadows subdivision lies outside the 1% annual chance (100-year) and 0.2% annual chance (500-year) floodplain of White Oak Bayou. It is important to note that HCFCD Units E132-00-00 and E133-00-00 are not FEMA studied streams; however, the floodplain delineation indicates that these streams are affected by backwater from White Oak Bayou during the 1% annual chance (100-year) and 0.2% annual chance (500-year) storm events.

An existing storm sewer trunkline is located along the back of lots along Dakar and Aste Streets. This storm sewer trunkline provides drainage for the Tower Oaks Meadows subdivision as well as the Barwood subdivision north of Tower Oaks Meadows. This storm sewer trunkline is significantly undersized, and the existing roadside ditches within Tower Oaks Meadows are not sufficient to adequately convey stormwater to the storm sewer trunkline.

Recent improvements within the subdivision include re-grading roadside ditches throughout the subdivision, construction of emergency overflow swales, and upgrades to outfall pipes. Those improvements were part of the Phase 2 construction project completed by Harris County Engineering Department.

A 1D/2D coupled XP-SWMM hydraulic model was built to simulate the 2-year and 100-year storm events in the Tower Oaks Meadows subdivision. The results of that analysis indicate that significant street ponding and minimal structural flooding is expected during a 2-year storm event. The results of the analysis also indicate that significant structural flooding is expected during a 100-year storm event.

Water System – Conditions/Impacts

The Tower Oaks Meadows subdivision is served by Harris County Fresh Water Supply District #61. The FWSD engineer is Lockwood, Andrews, and Newnam, Incorporated (LAN). Record drawings of the existing potable water system were provided by LAN. The existing water system is located within Harris County right-of-way along multiple roadways within the project area, and those existing systems may be impacted by the construction of storm sewer improvements within Harris County right-of-way.

Sewer – Conditions/Impacts

The Tower Oaks Meadows subdivision is served by Harris County Fresh Water Supply District #61. The FWSD engineer is Lockwood, Andrews, and Newnam, Incorporated (LAN). Record drawings of the existing sanitary sewer system were provided by LAN. The sanitary sewer system is located along the back of lots within an existing utility easement. There are several locations where those sanitary sewers cross Harris County right-of-way, and those locations may be impacted by the construction of storm sewer improvements within Harris County right-of-way. An existing wastewater treatment plant is located west of Marrs Drive, north of Maxim Drive, and east of HCFCD Unit E133-00-00.

Electric – Conditions/Impacts

The Tower Oaks Meadows subdivision is served by Centerpoint Energy. An existing overhead power line is located along the back of lots between Dakar Drive and Aste Lane and along HCFCD Unit E132-00-00. It is not anticipated that electrical service will be impacted by construction of the proposed storm sewer improvements.

Gas – Conditions/Impacts

The Tower Oaks Meadows subdivision is served by Centerpoint Energy. Gas lines within the neighborhood are located along the back of lot lines within existing utility easements. It is not anticipated that gas service will be impacted by construction of the proposed storm sewer improvements.

Telecommunications – Conditions/Impacts

The Tower Oaks Meadows subdivision is served by Comcast and AT&T telecommunications. Existing utilities are located along the back of lots between Dakar Street and Aste Street and located throughout the neighborhood within Harris County right-of-way. It is likely that those facilities located within Harris County right-of-way will be impacted by the proposed storm sewer construction.

Other Issues

Real Estate Acquisition

It is likely necessary that property will need to be acquired for a stormwater detention basin. In order to mitigate the adverse impacts caused by the proposed storm sewer improvements, approximately 20.6 acre-feet of detention storage is required. A property of 5.8 acres will be necessary to provide sufficient detention storage to offset potential adverse impacts associated with the proposed storm sewer improvements.

Probable Permits

A permit from Harris County will be required to complete the storm sewer improvements within Harris County right-of-way. It will also be necessary to obtain a letter of no objection from Harris County Flood Control District for a drainage analysis and work within Harris County right-of-way. Should the outfall channels of HCFCD Unit E132-00-00 be deemed as jurisdictional wetlands, it may be necessary to obtain a Nationwide Permit for work in Waters of the U.S.

Driveways

Many driveways along the proposed storm sewer alignment will be impacted by the proposed construction. Driveways will be replaced based on Harris County driveway details. Mailboxes along the storm sewer alignment will also be impacted.

Description of Problem(s)

Damage Caused by Flooding

Multiple single-family residential homes have been flooded during the April 2016 (Tax Day) and August 2017 (Hurricane Harvey) storm events. Approximately 91 structures within Tower Oaks Meadows were flooded as a result of Hurricane Harvey. Flooding depths ranged from 6 inches to 12 inches in those homes. Approximately 97 structures within Tower Oaks Meadows were flooded as a result of the April 2016 storm event.

Repetitive Loss Analysis

There are approximately 21 FEMA repetitive or severe repetitive loss properties within Tower Oaks Meadows. The flooding associated with these occurrences is due to undersized drainage infrastructure and significant rainfall.

Structures Flooded

Approximately 91 structures within Tower Oaks Meadows were flooded as a result of Hurricane Harvey. Flooding depths ranged from 6 inches to 12 inches in those homes. Many of the structures finished floor elevations are less than or equal to the elevation of the roadway crown and roadside ditch drainage does not provide extreme event sheet flow toward either HCFCD Units E132-00-00 or E133-00-00, allowing sheet flow towards the homes instead.

Issues with Access

It can be assumed based on the number of structures flooded within the subdivision that access and mobility are limited during a significant storm event (greater than a 2-year storm event).

Existing Drainage Infrastructure

The Tower Oaks Meadows subdivision is drained via roadside ditch drainage with driveway culverts located at each driveway. Those driveway culverts and roadside ditches are insufficient to convey runoff from a 2-year storm event or greater. The subdivision was designed to drain northward to an existing storm sewer trunkline along Dakar Drive; however, the natural topography of the project area slopes southeastward toward HCFCD Unit E132-00-00.

Analysis & Proposed Solution

Approach

Based on input from Harris County Engineering Department, the proposed improvements to the project area include storm sewer improvements and construction of a stormwater detention basin. The location of the proposed storm sewer trunkline is locate along Foxburo Drive which is the southernmost street within the project area. Due to the topography of the subdivision, stormwater naturally drains to this area. Storm sewers are also recommended along North Eldridge Parkway, Honey Grove Street, and Marrs Street. It is also proposed that the roadside ditches be re-constructed to properly drain to those proposed storm sewers.

Methodology Used for Analysis

Rainfall data for the 2-year and 100-year storm event was obtained using Atlas 14 prepared by the National Oceanic and Atmospheric Administration (NOAA), shown below in Table 1.

Table 1 - NOAA Atlas 14 Rainfall Data

Duration	Rainfall Depth (inches)	
	2-Year	100-Year
5 minutes	0.576	1.22
10 minutes	0.914	1.95
15 minutes	1.16	2.42
30 minutes	1.65	3.38
60 minutes	2.19	4.63
2 hours	2.73	6.68
3 hours	3.06	8.21
6 hours	3.65	10.9
12 hours	4.26	13.6
24 hours	4.94	16.5

Drainage areas were delineated based on construction drawings of minor ditch re-grading and extreme event overflow swales, which were prepared by Harris County Engineering Department. Runoff hydrographs were computed for the 2-year and 100-year storm events using the HEC-HMS software program. Those hydrographs were inserted into a 1D/2D coupled XP-SWMM model built using 2008 LIDAR topographic data obtained from Houston-Galveston Area Council. The existing conditions model was modified to include the proposed storm sewer improvements. Those storm sewers were sized based on the 2-year storm event (NOAA Atlas 14).

Proposed Solutions/Recommended Approach to Improving Drainage

Because the natural topography of the Tower Oaks Meadows subdivision drains to the southeast, it is proposed to construct a trunkline storm sewer along Foxburo Street. Storm sewers are also proposed along Marrs Street, Honey Grove Street, and North Eldridge Parkway. The storms sewers range in size from 30” RCP to dual 9’x4’ RCBs. These recommendations will look to tie into the existing drainage system and will be further evaluated in the design stage with detailed topographic survey and other services.

The scope of the project will include construction of storm sewer ranging from 30” RCP to 48” RCP along Marrs Street from Dermott Street to Foxburo Street. A 30” RCP will also be stubbed out along Maxim Drive. The scope of the project also includes construction of storm sewer ranging from 30” RCP to 42” RCP along Honey Grove Street from Dermott Street to Foxburo Street. A 30” RCP will be stubbed out along Maxim Drive just south of Adam Elementary. Additionally, the project will include the construction of storm sewer ranging from 42” RCP to 60” RCP along North Eldridge Parkway from Dakar Street to Foxburo Street. The proposed storm sewer trunkline along Foxburo Street will include storm sewer ranging in size from 48” RCP to dual 9’x4’ RCBs. Roadside ditches will be re-graded to provide positive drainage toward the storm sewers. The affected streets will be re-constructed from crowned asphalt roadways to curb and gutter concrete roadways. The roadway profiles will be designed to provide a cascading effect to provide capacity to convey extreme event runoff toward HCFCD Unit E132-00-00.

In order to mitigate the potential adverse impacts caused by the proposed storm sewer improvements, stormwater detention is necessary. Approximately 20.6 acre-feet of detention storage will be required to offset increases in peak discharge rates at the outfall to HCFCD Unit E132-00-00. A site has been identified immediately south of Foxburo Street and east of HCFCD Unit E132-00-00 that would provide sufficient detention storage with the allowable outfall depth. Based on the results of this analysis, it is expected that these improvements will remove the risk of structural flooding to approximately 37 existing structures.

Alternatives to this solution include re-grading roadside ditches and further upgrading existing outfalls. Construction drawings were completed by Harris County in January 2018, and construction is slated to begin in early 2019. Further improving ditches and outfalls beyond the current Harris County project being constructed will not provide significant benefit to the subdivisions. Therefore, this alternative was not selected as the recommended alternative.

A second alternative includes improving the trunkline along Dakar and Aste Streets and re-grading roadside ditches to convey stormwater toward that storm sewer trunkline. Constructability will prove to be an issue, as the existing trunkline is located in an existing 60' drainage easement. Additionally, the existing location of that trunkline does not allow for extreme event drainage due to the natural topography of the subdivision draining toward the southeast. Therefore, this alternative was not selected as the recommended alternative.

Project Cost

Design

Based on data provided by Harris County Engineering Department, it is estimated that the detailed design will be approximately 15% of construction cost, which is a total of $1,087,022.

Acquisition

Property acquisition will be required for a proposed detention basin that provides approximately 20.6 acre-feet of detention storage. A property was identified for the detention basin which includes 5.8 acres of land. Based on data provided by Harris County Engineering Department, the total real estate acquisition cost is approximately $1.52 million, which includes real estate acquisition, closing costs, relocation assistance, and demolition.

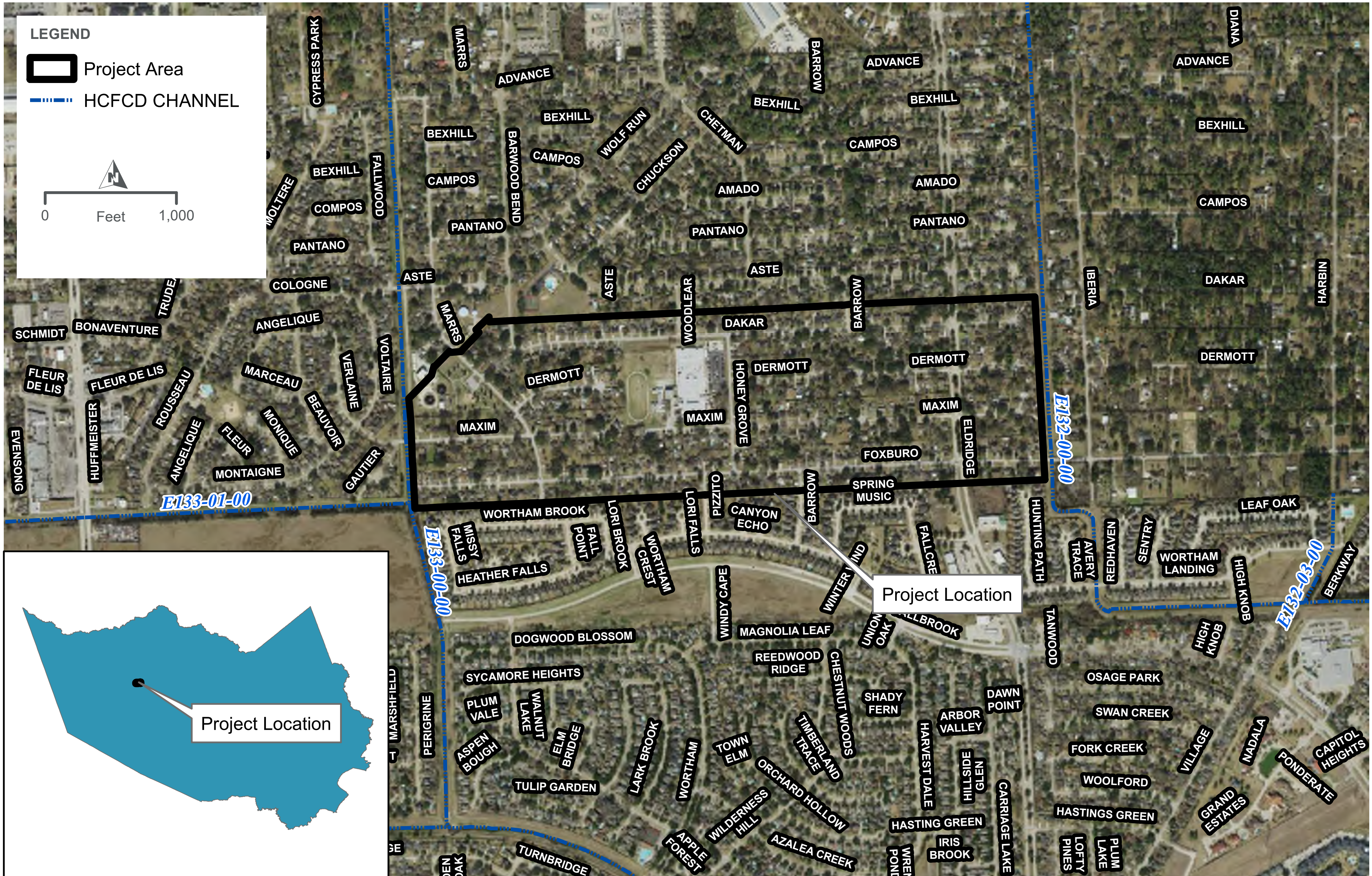
Construction

The preliminary opinion of construction cost is approximately $7.2 million. A summary of the estimated construction cost is shown below.

Description	Cost
Storm Sewer	$5.2 million
Roadway Paving	$1.2 million
Detention Basin	$0.74 million
Contingency (20%)	$1.4 million
Total	**$8.7 million**

Public Comment

A community engagement meeting was held on January 30, 2018 from 6 pm to 9 pm at Arnold Middle School located at 11111 Telge Road, Cypress, TX 77429. Public comments were received, and responses have been provided by HDR. The comments log is provided as an attachment to this document.



TOWER OAKS MEADOWS SUBDIVISION DRAINAGE IMPROVEMENTS

PROJECT LOCATION MAP

EXHIBIT 1

PATH: C:\WORKSPACE\TOWEROAKSMEADOWS\GIS\EXHIBIT1.MXD - USER: JBLEVINS - DATE: 12/14/2018

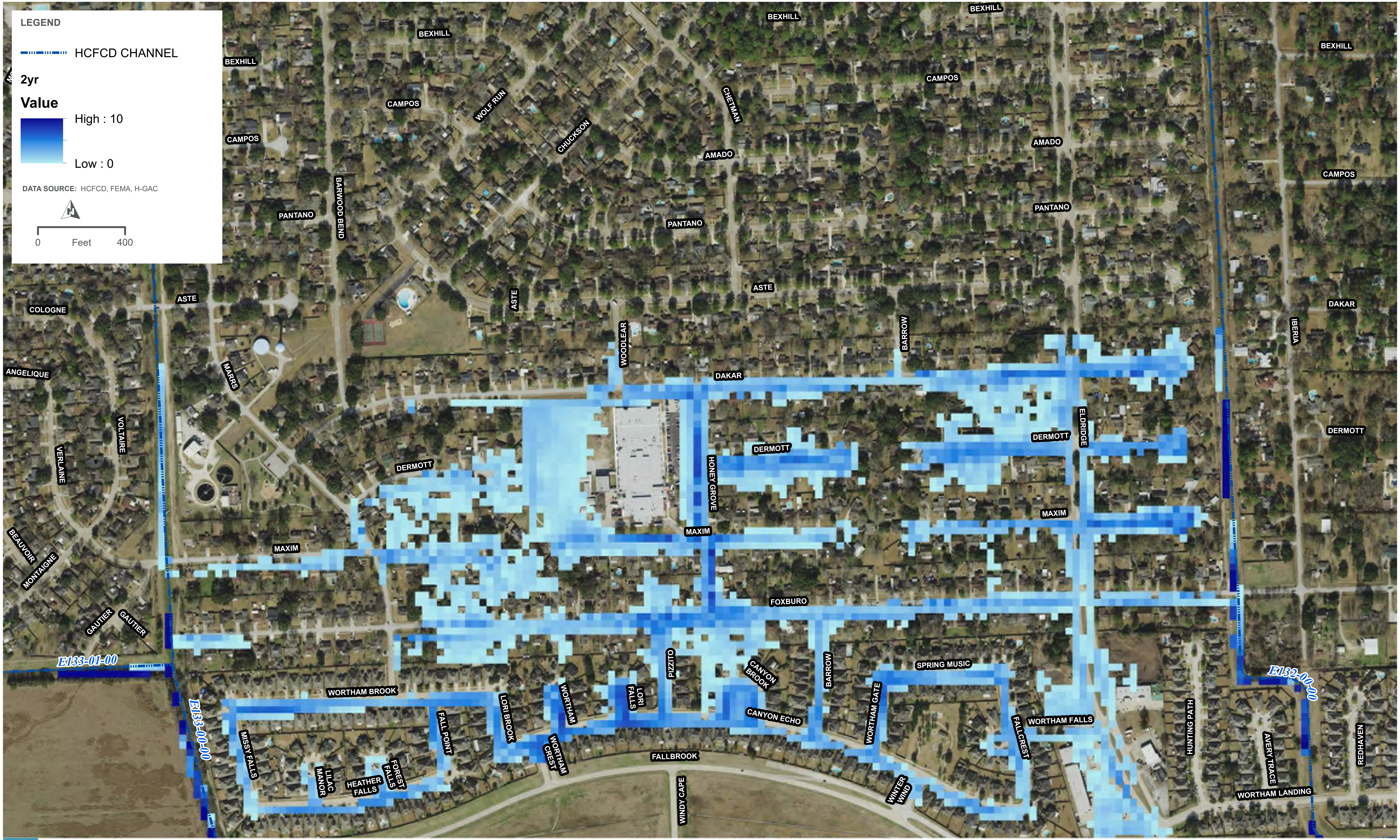
HDR

TOWER OAKS MEADOWS SUBDIVISION DRAINAGE IMPROVEMENTS

EXISTING & PROPOSED DRAINAGE AREA MAP

EXHIBIT 2

PATH: C:\WORKSPACE\TOWEROAKSMEADOWS\GIS\WORKMAP.MXD - USER: JBLEVINS - DATE: 12/14/2018

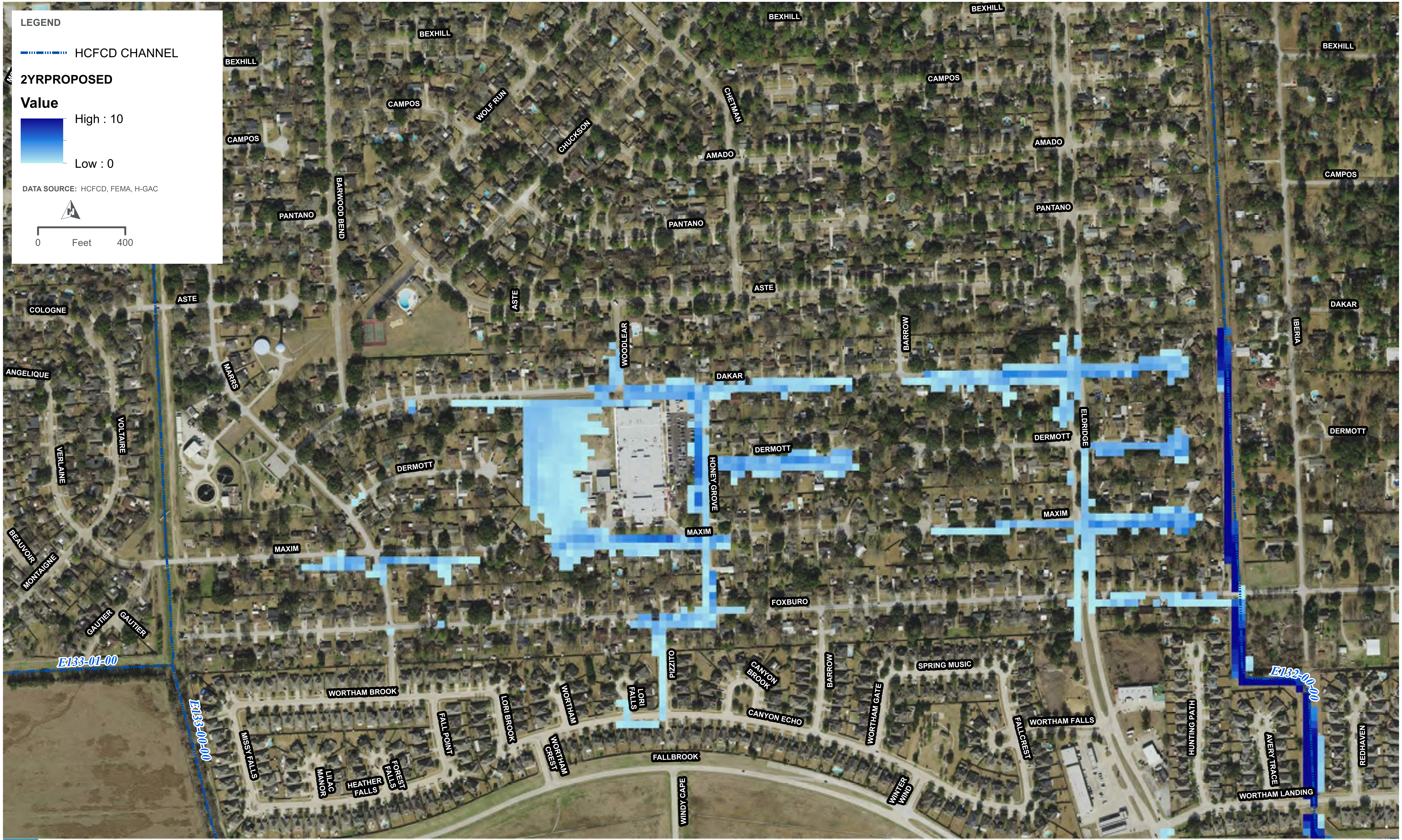


TOWER OAKS MEADOWS SUBDIVISION DRAINAGE IMPROVEMENTS

EXISTING 2-YEAR INUNDATION MAP

EXHIBIT 3

PATH: C:\WORKSPACE\TOWEROAKSMEADOWS\GIS\WORKMAP.MXD - USER: JBLEVINS - DATE: 12/14/2018



TOWER OAKS MEADOWS SUBDIVISION DRAINAGE IMPROVEMENTS

PROPOSED 2-YEAR INUNDATION MAP

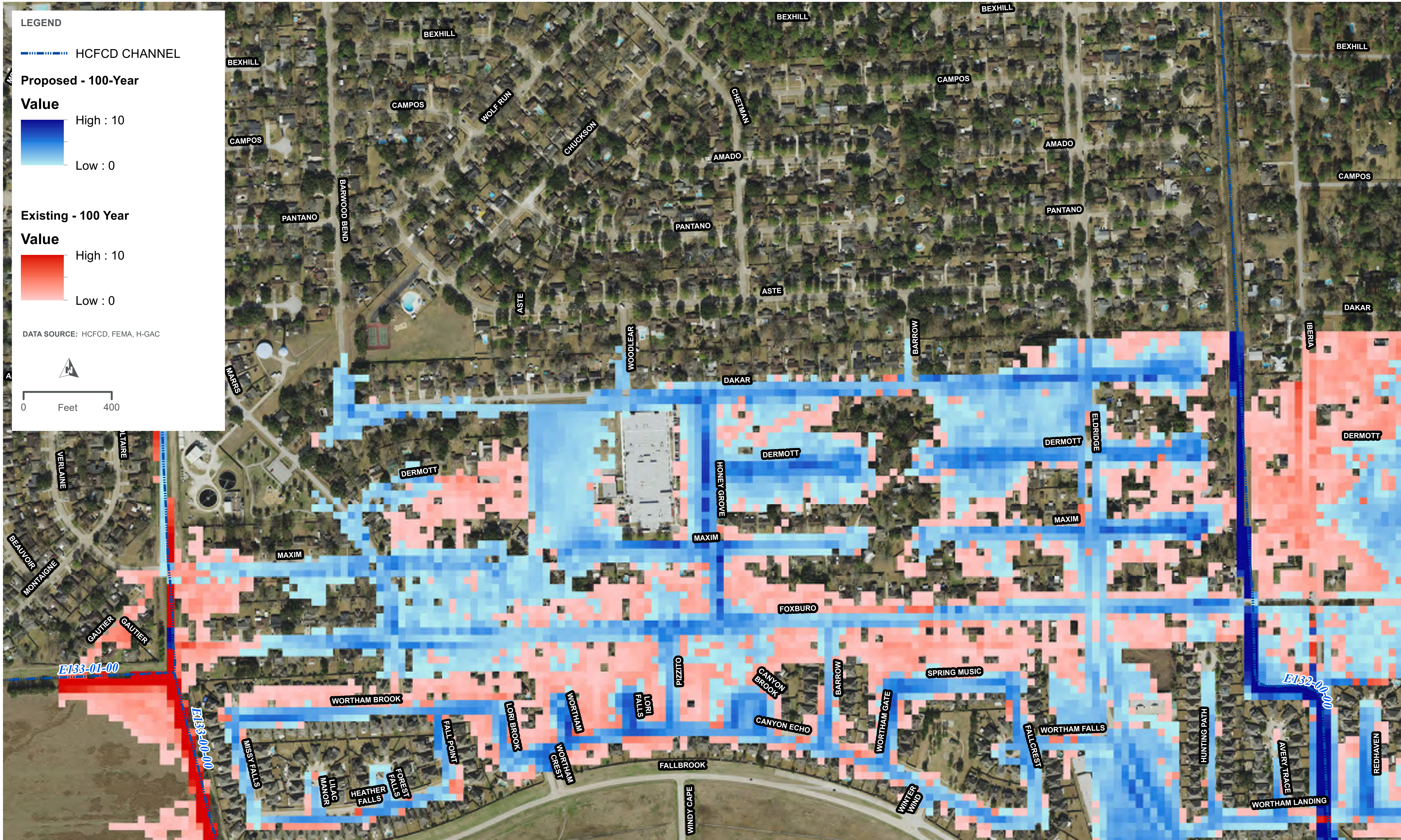
EXHIBIT 4

PATH: C:\WORKSPACE\TOWEROAKSMEADOWS\GIS\WORKMAP.MXD - USER: JBLEVINS - DATE: 12/14/2018

TOWER OAKS MEADOWS SUBDIVISION DRAINAGE IMPROVEMENTS

EXISTING 100-YEAR INUNDATION MAP

EXHIBIT 5



TOWER OAKS MEADOWS SUBDIVISION DRAINAGE IMPROVEMENTS

PROPOSED 100-YEAR INUNDATION MAP

EXHIBIT 6

PATH: C:\WORKSPACE\TOWEROAKSMEADOWS\GIS\WORKMAP.MXD - USER: JBLEVINS - DATE: 4/8/2019

TOWER OAKS MEADOWS SUBDIVISION DRAINAGE IMPROVEMENTS

PHOTOGRAPH LOG

EXHIBIT 7

PATH: C:\WORKSPACE\TOWEROAKSMEADOWS\GIS\WORKMAP.MXD - USER: JBLEVINS - DATE: 12/14/2018

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IMG_1303

HARRIS COUNTY

Project Scoping & Cost Estimating Development Tool

Tower Oaks Meadows Subdivision Drainage Improvements

PROJECT NAME

3

PRECINCT

Areas highlighted are to be completed by Consultant

PREPARER INFORMATION		PROJECT INFORMATION	
1. DATE SUBMITTED:	12/14/18	4. PROJECT TYPE:	Drainage Improvement
2. SUBMITTED BY:	Jeremy Blevins, PE, CFM	5. PROJECT TITLE:	Tower Oaks Meadows Subdivision Drainage Improvements
3. NAME OF FIRM:	HDR Engineering, Inc.		

6. ESTIMATED FUNDING (Item 6 to be prepared by Harris County):		
A. CDBG-DR:		* Specify MUD or Other Funding Sources:
B. OTHER FEDERAL:*		
C. STATE:		
D. COUNTY:		
E. MUD:*		
F. OTHER:*		
ESTIMATED TOTAL:	$ 0.00	

7. NO ACTION ASSESSMENT: Briefly describe the impact of taking no action to repair the damaged facilities.

Structural flooding will continue to occur during storm events of 10-year return period or greater. Approximately 97 structures were flooded as a result of the April 2016 flood, and approximately 91 structures were flooded as a result of Hurricane Harvey. Of those, 21 of the structures have been identified as repetitive or severe repetitive loss properties by FEMA.

DESCRIPTION OF THE NEED(S) ADDRESSED IN THIS DOCUMENT

Provide full and complete answers to each of the following. Descriptions should include the cause of the damage, current condition of the facility, and a detailed description of the project that coincides with the information contained in both Table 1 and 2. All activities must have documented proof of an impact by the floods and storms. CDBG-DR funds must be used for disaster- related expenses in the most impacted and distressed areas.

1. Describe the specific flood and storm-related condition that directly caused the damage(s).

The existing drainage system does not have sufficient capacity to convey storm events greater than a 2-year storm event, which causes a risk for structural flooding.

2. Describe the system that was damaged and how it was damaged.

Approximately 97 structures were flooded as a result of the April 2016 flood, and approximately 91 structures were flooded as a result of Hurricane Harvey. Of those, 21 of the structures have been identified as repetitive or severe repetitive loss properties by FEMA. Those structures were inundated to a depth ranging from 6 inches to 12 inches during Hurricane Harvey.

3. How does the project support housing?

This project reduces the risk of structural flooding within the Tower Oaks Meadows Subdivision.

4. Describe the impacts on the community that resulted in direct damage(s).

Approximately 97 structures were flooded as a result of the April 2016 flood, and approximately 91 structures were flooded as a result of Hurricane Harvey. Of those, 21 of the structures have been identified as repetitive or severe repetitive loss properties by FEMA. Those structures were inundated to a depth ranging from 6 inches to 12 inches during Hurricane Harvey.

5. Describe how the proposed activities will address damage(s) of the system affected by the floods and storms.

This project will involve the construction of storm sewer improvements which will reduce the risk of structural flooding within the Tower Oaks Meadows subdivision.

6. List materials submitted as documentation of the flood and storm-related condition.

7. Describe the proposed project.

The scope of the project will include construction of storm sewer ranging from 30” RCP to 48” RCP along Marrs Street from Dermott Street to Foxburo Street. A 30” RCP will also be stubbed out along Maxim Street. The scope of the project also includes construction of storm sewer ranging from 30” RCP to 42” RCP along Honey Grove Street from Dermott Street to Foxburo Street. A 30” RCP will be stubbed out along Maxim Street just south of Adam Elementary. Additionally, the project

PROJECT SUMMARY

The Project Summary consists of 4 parts **for each target area and/or activity**: **(1)** Summarize Problem(s); **(2)** Location and Acquisition; **(3)** Detailed Actions to Address Problems; and **(4)** Disclosure on Non-CDBG-DR Funds.

PART 1 – Summarize the problem(s) to be addressed within the application by Target Area.

The Tower Oaks Meadows Subdivision is drained by roadside ditches, which drain to an existing storm sewer trunk line along the back of lots along Dakar and Aste Streets. The existing roadside ditches are poorly graded with slope insufficient to convey storm water to the existing trunkline. The general topography of the subdivision drains toward the southeast; however, the existing roadside ditches were designed to drain northward against the existing topography of the subdivision. Additionally, there is not an extreme event stormwater outlet for areas bounded Eldridge Parkway on the east. Because of this, during Hurricane Harvey and the April 2016 floods, a significant number of homes were flooded within the Tower Oaks Meadows subdivision.

PART 2 – Identify the location of each activity/Target Area and any associated acquisition activity.

The spelling and capitalization of the Target Area name(s) listed here must match Table 1 (e.g., "Green Acres" should not appear elsewhere as "green acres subdivision."

Project Title / Target Area:	Tower Oaks Meadows Subdivision Drainage Improvements
Activity:	Flood and Drainage Facilities

On:		**From:**		**To:**	

- OR -

Provide a brief description of the location of the activity / Target Area.

The Tower Oaks Meadows Subdivision is roughly bounded by HCFCD Channel E132-00-00 on the east, Fallbrook Drive on the south, HCFCD Channel E133-00-00 on the west, and Dakar Drive on the north.

- OR -

Provide physical address if possible.

Latitude:	29°56'16.14"N	**Longitude:**	95°36'53.69"W

	Included:	
Please attached project area map (11 x 17)	Yes: ☑	No: ☐
Please attach existing drainage area map (11x17)	Yes: ☑	No: ☐
Please attach proposed drainage area map (11x17)	Yes: ☑	No: ☐
Please attach "Sketch Plans", illustrations or annotated drawings communicating the scope of the recommended improvements	Yes: ☑	No: ☐
Please attach scope of services for final design of the improvements	Yes: ☑	No: ☐
Please attach photographs of problems found, annotated on an area map exhibit or in an appendix	Yes: ☑	No: ☐
	Acquisition Required:	
Will acquisition associated with the project site(s) be required?	Yes: ☑	No: ☐

PART 3 – Identify the action(s) to resolve the problem(s) and their anticipated outcomes. *Include details such as specific materials and quantities.*

The scope of the project will include construction of storm sewer ranging from 30" RCP to 48" RCP along Marrs Street from Dermott Street to Foxburo Street. A 30" RCP will also be stubbed out along Maxim Street. The scope of the project also includes construction of storm sewer ranging from 30" RCP to 42" RCP along Honey Grove Street from Dermott Street to Foxburo Street. A 30" RCP will be stubbed out along Maxim Street just south of Adam Elementary. Additionally, the project will include the construction of storm sewer ranging from 42" RCP to 60" RCP along North Eldridge Parkway from Dakar Street to Foxburo Street. The proposed storm sewer trunkline along Foxburo Street will include storm sewer ranging in size from 48" RCP to dual 9'x4' RCBs. Roadside ditches will be re-graded to provide positive drainage toward the storm sewers. The affected streets will be re-constructed from crowned asphalt roadways to curb and gutter concrete roadways. The roadway profiles will be designed to provide a cascading effect to provide capacity to convey extreme event runoff toward HCFCD Unit E132-00-00.

Jeremy Blevins, PE, CFM	Sr. Water Resources Project Manager	(713) 576-3513
Name of Preparer (Printed)	**Position / Title**	**Phone Number**

	jeremy.blevins@hdrinc.com
Signature of Preparer	**Email Address**

PROJECT SCHEDULE

Enter the projected length (in number of months) for each applicable phase / process step below. If a phase is not applicable, enter "0" in the field. *Note: Most projects should be completed in 24 months once the associated contract for the project is executed between the Applicant and the Texas General Land Office.*

PROFESSIONAL PROCUREMENT		Months
ENVIRONMENTAL REVIEW		Months
ACQUISITION		Months
ENGINEERING DESIGN	9	Months
CONSTRUCTION	15	Months
COMPLETE CLOSEOUT		Months
EXTENDED ACTIVITY		Months

ANTICIPATED COMPLETION	

If the proposed project schedule exceeds 24 months, a justification must be provided in the space below.

BENEFICIARY INFORMATION

Does the proposed project serve Low /Moderate Income beneficiaries?	Yes: ✔	No: ☐

If answer above is no, provide the following information:

	Included	
Shape file of benefited area	Yes: ✔	No: ☐
Digital Elevation Model for the current condition	Yes: ✔	No: ☐
Digital Elevation Model for the proposed condition(s)	Yes: ✔	No: ☐

TABLE 1 - BUDGET

Project Title/Target Area:	Tower Oaks Meadows Subdivision Drainage Improvements
Construction Completion Type:	Contract
Activity Description	5. Flood and Drainage Facilities
Probable Construction Cost:	$ 8,696,177
Estimated Engineering Cost:	$ 1,087,022
Estimated Acquisition Cost:	$ 1,515,888
Total:	$ 11,299,087

TABLE 2: BUDGET JUSTIFICATION OF RETAIL COSTS

PROJECT TITLE / TARGET AREA: Tower Oaks Meadows Subdivision Drainage Improvements

Act # Activity Description	Materials / Facilities / Services	$/Unit	Unit	Qty	Construction	Acquisition	TOTAL
					$ 0		$ 0
					$ 0		$ 0
					$ 0		$ 0
					$ 0		$ 0
					$ 0		$ 0
					$ 0		$ 0
					$ 0		$ 0
					$ 0		$ 0
See enclosed cost estimate.				COLUMN TOTALS	$ 0	$ 0	$ 0

1. Identify and explain the annual projected operation and maintenance costs associated with the proposed activities.

2. Identify and explain any/all special engineering activities.

None

Signature of Registered Engineer / Architect Responsible for Budget Justification

5/2/19
Date

(713) 576-3513
Phone Number

(Architect / Engineer Seal)

Paving					
Item	Item Description	Unit of Measure	Unit Price	Quantity	Item Cost
222101	Remove & Dispose of Existing pavement & Curb	SY	$ 6.00	13,872	$ 83,230.00
222102	Remove & Dispose of Existing driveways	SY	$ 5.00	880	$ 4,400.00
275103	8" Reinforced Concrete Pavement	SY	$ 55.00	10,883	$ 598,565.00
275105	10" Reinforced Concrete Pavement	SY	$ 65.00	2,989	$ 194,263.33
233601	Lime Stabilized Subgrade	SY	$ 4.00	13,872	$ 55,486.67
277101	6" Concrete Curb	LF	$ 4.00	9,604	$ 38,416.00
275401	6" Concrete for Driveways	SF	$ 8.00	880	$ 7,040.00
292201	Sodding	SY	$ 5.00	10671	$ 53,355.00
	Subtotal				$ 1,034,756.00
	Ancillary Items		10%		$ 103,475.60
	General Items		10%		$ 103,475.60
	Paving Total				$ 1,241,707.20

Storm Sewer					
Item	Item Description	Unit of Measure	Unit Price	Quantity	Item Cost
222103	Remove Storm Sewer Pipe (All Types)	LF	$ 20.00	792	$ 15,840.00
222105	Remove Inlets (All Types)	EA	$ 370.00	5	$ 1,850.00
222106	Remove Manholes (All Types, All Depths)	EA	$ 390.00	2	$ 780.00
263301	Curb Inlets (All Types)	EA	$ 2,910.00	24	$ 69,840.00
208201	Manholes (For 42" Diam Pipe & Smaller)	EA	$ 3,470.00	10	$ 34,700.00
208202	Manholes (For 48" to 72" Diam Pipe)	EA	$ 6,340.00	6	$ 38,040.00
208203	Manholes (for 78" Diam Pipe and Larger)	EA	$ 16,500.00	3	$ 49,500.00
263102	30-Inch RCP	LF	$ 150.00	1256	$ 188,400.00
263104	42-Inch RCP	LF	$ 215.00	7036	$ 1,512,740.00
263105	48-Inch RCP	LF	$ 250.00	852	$ 213,000.00
263107	60-Inch RCP	LF	$ 350.00	400	$ 140,000.00
263125	4x4 RCB	LF	$ 280.00	472	$ 132,160.00
263127	5x4 RCB	LF	$ 320.00	779	$ 249,280.00
263130	9x4 RCB	LF	$ 650.00	1460	$ 949,000.00
263137	8x5 RCB	LF	$ 660.00	868	$ 572,880.00
226001	Trench Safety System	LF	$ 2.00	13123	$ 26,246.00
231502	Excavate & Re-grade Roadside Ditches	LF	$ 10.00	19200	$ 192,000.00
	Subtotal				$ 4,386,256.00
	Ancillary Items		10%		$ 438,625.60
	General Items		10%		$ 438,625.60
	Storm Sewer Total				$ 5,263,507.20

Detention Basin					
Item	Item Description	Unit of Measure	Unit Price	Quantity	Item Cost
500001	Detention Pond (Dry)	AC-FT	$ 30,000.00	20.6	$ 618,000.00
	Subtotal				$ 618,000.00
	Ancillary Items		10%		$ 61,800.00
	General Items		10%		$ 61,800.00
	Detention Basin Total				$ 741,600.00

Total Construction Cost	**$ 7,246,814.40**
Contingency (20%)	**$ 1,449,362.88**
Engineering Design (15% of Total Construction Cost)	**$ 1,087,022.16**
Real Estate Acquisition	**$ 1,515,888.00**
Project Total	**$ 11,299,087.44**

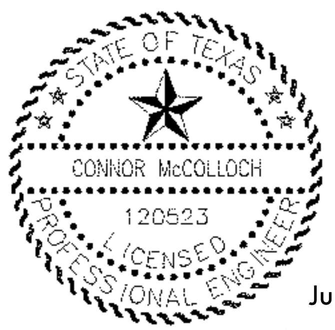
Comment	Response
Double Deep Dual Ditch with water reservoirs on the E132-00-00 channel improvement project. Drainage work would be connected to the 15'x15'x85' tank reservoirs. Rolling fluidity like a roller coaster with initial motion to continue flow. Please see the attached sketch.	Storm sewers are proposed along Eldridge Parkway to provide storm water conveyance to the proposed trunk line along Foxburo Drive. The proposed trunk line along Foxburo will outfall to HCFCD Channel E132-00-00.
If homeowners would dig a hole on both sides of their culvert the culverts would drain much better. I have for 42 years. The county should not have to do this. Please let me know when the ditch will be dug out again so I can take up my sprinkler system. If not ok. Thank you for everything you are doing.	Maintenance of roadside ditches is generally left up to individual homeowners. However, Foxburo Drive is proposed to be a curb and gutter street with no roadside ditches, which will reduce the maintenance needs along Foxburo Drive.
Where are surface water goes into the underground pipe at Dakar & Honey Grove we have a grated cover on the pipe that catches limbs and twigs then leaves and other debris to form a perfect dam. See attached photos showing water level before and after removal of debris.	Acknowledged. We will work with Precinct staff to develop a better solution to reduce debris blockage while maintaining safety to prevent children from entering the pipe.
I have requested several times for the drainage/ culvert needs to be dug-out from the cul-de-sac along the south side of Adams Elementary School on Maxim Drive. To date no one has come out to dig out the drainage/culvert for the residents along the above mentioned section of Maxim Drive. Your with this now, another request will be greatly appreciated. Respectfully, Shirley Johnson- Home Owner	Acknowledged. We will work with Precinct staff to develop a better solution to reduce debris blockage while maintaining safety to prevent children from entering the pipe.
Curbs & gutters on Foxburo Great!	Acknowledged

Comment	Response
After cleaning and deepening our ditches the water seems to be draining a different direction. Water traveling on Marrs to the corner of Dakar Dr. is no longer going through the pipe under Marrs to the other side to continue to Maxim and into 133. It seems to be going around the corner and traveling Dakar to Barwood Bend.	Acknowledged. During design phase, we will verify existing and proposed drainage patterns and design slopes of the ditches appropriately.
Foxboro and Maxim are Wortham's retention pond. Homes in Wortham are built well above grade. Stand at intersection of Marrs and Foxboro and look into Wortham.	Acknowledged.
New projects show that our street will still be able to flood even after the drainage. More information needs to be done to try to rectify this. Our street shows to be low. Design channel from White Oak Bayou to Cypress North Houston (E1320000)	The models are an approximation of expected flooding within the subdivision. Additionally, the models do not take into account the finished floor elevation of the structure in comparison to the elevation of the natural ground surrounding the structure.
Concerned that E1320000 needs to be wider and deeper going into White Oak Bayou from Cypress N. Houston.	Acknowledged. During final design phase, we will study the existing channel and if it would be beneficial to alter the channel construction. -HCED
E1320000 Channel be deeper and wider to White Oak Bayou from Cypress N. Houston. Look for all possible retention areas along that channel E1320000.	Acknowledged. During final design phase, we will study the existing channel and if it would be beneficial to alter the channel construction. -HCED
Informative! E1320000 channel to be deeper and wider all the way to White Oak Bayou from Cypress N. Houston. Look for all possible retention areas that are along that channel.	Acknowledged. During final design phase, we will study the existing channel and if it would be beneficial to alter the channel construction. -HCED
Informative! E1320000 channel to be deeper and wider all the way to White Oak Bayou from Cypress N. Houston. Look for all possible retention areas that are along that channel.	Acknowledged. During final design phase, we will study the existing channel and if it would be beneficial to alter the channel construction. -HCED

KOLBE ROAD & RELATED INFRASTRUCTURE DRAINAGE IMPROVEMENTS

7/10/2019

Planning Phase Subdivision Drainage Improvements
Harris County Bond Program 2018
Precinct 3
UPIN 19103MF16601



July 10, 2019

Prepared for:

Prepared by:

Table of Contents

List of Exhibits

Appendices

I. General Project and Contact Information

Project Name

Kolbe Road and Related Infrastructure Drainage Improvements

Precinct

Harris County Precinct 3

Project Location Map

Exhibit 1 shows the project vicinity map.

Preparer Information

This report was prepared by and under the supervision of

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II. Existing Conditions Analysis

Summary of Drainage Issues/Analysis of Problem

Kolbe Road is drained via roadside ditches which outfall into the Cypress North Houston Road storm sewer. Kolbe Circle is the high point along Kolbe Road with the topography draining away to the north and south. Drainage issues in the study area are primarily caused by the flat topography and consequently, the reduced natural drainage capacity and insufficient drainage capacity of the existing road side ditches. To provide positive drainage, the ditches must be graded with side slopes less than the recommended 3H:1V. The unwanted result is side slope failures and loss of conveyance capacity within the drainage system. Additionally, roadside ditches along private streets Laura Circle, Scott Circle and Village Circle have not been maintained and in some locations have been filled with sediment build up. During Hurricane Harvey, the area along Kolbe Road experienced widespread ponding with a significant number of flooded homes.

The Cypress Chase subdivision, which is adjacent to the study area, is drained via curb and gutter storm sewer systems which outfall into a detention pond at the south end of the neighborhood and ultimately outfall into HCFCD Unit E133-01-00. The Cypress Chase detention pond was designed to handle the flow from the subdivision with a swale constructed around the pond to drain any offsite flows from Kolbe away and into HCFCD Unit E133-01-00. During the field reconnaissance, failure of the embankment around the detention pond was observed along the western edge suggesting that offsite flow from Kolbe Road could enter the detention pond. Rock rip-rap was observed along the location of the failure to protect against erosion. The embankment failure can also be identified utilizing 2018 LiDAR data for the area. This offsite flow enters the pond result in the operational failure of the outlet structure for the pond as it was not designed to drain offsite flows. During extreme storm events, the pond is inundated with significant flow over the overflow spillway. Historical imagery from October 2017 shows erosion issues around the spillway. During the field reconnaissance, repair of the erosion was observed.

Drainage System – Conditions/Impacts

The study area covers approximately 134.5 acres including 24.8 acres of the Cypress Chase Subdivision system in its northeastern part and 109.7 acres along Kolbe Rd. Of the 109.7 acres, topography shows 9.1 acres drains into HCFCD Unit E133-01-00 and the remaining 100.6 acres drains north via Kolbe Road roadside ditches into the Cypress North Houston storm sewer system. The Cypress North Houston storm sewer system drains north along North Kolbe Road and outfalls into Cypress Creek, HCFCD Unit K100-00-00. The drainage areas are shown on **Exhibit 2**.

Historical imagery shows individual units built in the late 1970's along Kolbe Road. The roadside ditches along Kolbe Road were recently regraded by Harris County (2018). There are four private streets located off South Kolbe Drive identified as Laura Circle, Scott Circle, Village Circle and South Kolbe Spur Drive. These streets are not included within Harris County's road log and are not maintained by Harris County.

The capacity of the roadside ditches was analyzed utilizing a 2D hydraulic model (PCSWMM Version 7.1). The system was modeled using the 24-hour 1% exceedance probability storm event rainfall from NOAA Atlas 14 point precipitation values. The analysis shows that the existing drainage system is undersized resulting in widespread ponding throughout the study area.

The Cypress Chase subdivision was constructed in 2006-2008. The Cypress Chase detention pond is constructed at the south end of the subdivision and drains into HCFCD Unit E133-01-00 channel. The streets in the area are sloped south and drain out of the subdivision into the detention pond via an extreme event concrete swale. The 2D hydraulic analysis for the Cypress Chase subdivision shows the roadway has capacity to convey the overland flow to the detention pond.

The study area is located outside but adjacent to the southern limits of the 500-year floodplain of Cypress Creek, HCFCD Unit K100-00-00. The Cypress Creek floodplain is shown on **Exhibit 2**.

Water – Conditions/Impacts

The study area is located within the North Harris County Regional Water Authority District 1. No record drawings detailing water lines is available. The study area is outside of the current existing service area and is not included within the proposed additions as of October 2018. During the field reconnaissance, no water line features were observed; therefore it is assumed that the homes along Kolbe Road are served by well water with no water lines within the Harris County ROW. Real estate listings for homes within the study area seem to confirm this. This will need to be confirmed during design, therefore for the preliminary scope of this study, we assume minor and insignificant impacts from the proposed alternative.

Cypress Chase subdivision is served by Harris County MUD District 69 with water lines located within the roadway ROW. The proposed alternatives will have minor and insignificant impacts to the existing water lines.

Sewer – Conditions/Impacts

The study area along Kolbe Road and South Kolbe Circle is located within North Harris County Regional Water Authority District 1. No record drawings detailing sanitary sewer lines was available. The homes utilize septic tanks for collection of wastewater. Real estate listings for homes within the study area seem to confirm this. This will need to be confirmed during design, therefore for the preliminary scope of this study, we assume minor and insignificant impacts from the proposed alternative.

Cypress Chase subdivision is served by Harris County MUD District 69 with sanitary sewer lines located within the roadway ROW. The proposed alternatives will have minor and insignificant impacts to the existing sanitary sewer lines.

Electric – Conditions/Impacts

The neighborhood is served by overhead powerlines. These powerlines are located along the ROW and could cause potential complications for construction of the underground sewer system. Further investigation is required during the study, design and construction phase of the proposed alternatives to address this potential conflict.

Gas – Conditions/Impacts

The subdivision is not served by a natural gas service network. Therefore, the proposed alternatives have minor and insignificant conflicts with the existing natural gas infrastructure.

Telecommunications – Conditions/Impacts

Record drawings for Cypress North Houston Road shows Comcast underground cables along the South Kolbe Road right of way. The proposed alternatives may have impacts to the existing underground cables. This will need to be accounted for during the study and design phase.

General descriptions of locations

The project is located in Harris County Precinct 3 and is generally bounded by Cypress North Houston Road on the north, HCFCD Unit E133-01-00 to the east, Weiser Airfield to the south and Cypress Fairbanks ISD buildings to the west. Historical imagery shows individual units built in the late 1970's along Kolbe Road. The Cypress Chase subdivision was constructed in 2006-2008. The Cypress Chase detention pond is constructed at the south end of the subdivision. The northwest corner of the study area contains the Klein Memorial Park cemetery. There are four private streets located off South Kolbe Drive identified as Laura Circle, Scott Circle, Village Circle and South Kolbe Spur Drive. These streets are not included within Harris County's road log and are not maintained by Harris County.

A field reconnaissance was performed on February 11, 2019. Photos from the visit are provided in **Appendix A**.

Other Issues

Construction of the proposed drainage improvements will require ROW acquisition for a stormwater detention basin and a drainage easement for the storm sewer outfall.

III. Description of Problem

Damage caused by flooding

According to Harris County dataset, 38 buildings along South Kolbe Rd and 8 homes within the Cypress Chase subdivision experienced structural flooding during Hurricane Harvey. Flooding depths ranged from 2 to 12 inches. Only 2 structures within the study area were reported in the Tax Day storm event (April 2016 storm event). Additionally, there are two FEMA repetitive flood loss properties. The number of flooded structures in each of the inventories are summarized in **Table 1.**

Repetitive loss analysis (structures flooded multiple times)

Two homes in the study area are listed as FEMA repetitive flood loss properties. The flooding associated with these properties is due to undersized drainage infrastructure and the flat topography within the study area.

Structures flooded

The number of flooded structures according to Harris County dataset is summarized in **Table 1:**

TABLE 1. SUMMARY OF FLOODED STRUCTURES IN THE STUDY AREA

Flood Event Inventory	Number of Flooded Structures	
	Kolbe Road Subdivision	Cypress Chase Subdivision
Hurricane Harvey	46	8
Tax Day	2	0
FEMA Repetitive Loss	2	0

Issues with access

For the studied study area, no data was available on the issues with access experienced as a result of past flooding events. However, as the hydraulic model results confirm, it is anticipated that the access and mobility could be significantly affected during heavy rainfall events due to ponding depths up to several feet.

Existing drainage infrastructure

The study area covers approximately 134.5 acres including 24.8 acres of the Cypress Chase Subdivision system in its northeastern part and 109.7 acres along Kolbe Rd. Of the 109.7 acres, topography shows 9.1 acres drains into HCFCD Unit E133-01-00 and the remaining 100.6 acres drains north via Kolbe Road roadside ditches into the Cypress North Houston storm sewer system. The Cypress North Houston storm sewer system drains north along North Kolbe Road and outfalls into Cypress Creek, HCFCD Unit K100-00-00. The Bonaire subdivision is located east of the study area. Record construction drawings show that 166.9 acres drains into HCFCD Unit E133-01-00 via a curb and gutter storm sewer system designed to convey the 2-year storm event. The drainage areas are shown on **Exhibit 2**.

The Cypress North Houston Storm Sewer system drains north along North Kolbe Road via an 8' x 6' Reinforced Box Culvert (RBC). The storm sewer ultimately outfalls into Cypress Creek, HCFCD Unit K100-00-00 via 2-96" Corrugated Metal Pipes (CMP). Record drawings associated with drainage improvements implemented in 2011 show that the storm sewer system was sized to convey the City of Houston 3-year storm event.

The northwest corner of the study area contains the Klein Memorial Park cemetery. The cemetery is a natural low-lying area. This area ponds significantly before overland flow can make it to any Harris County drainage systems.

The Cypress Chase subdivision was constructed in 2006-2008. The Cypress Chase detention pond is constructed at the south end of the subdivision and drains into HCFCD Unit E133-01-00 channel on the east via a 30” pipe with a 15” restrictor. The Cypress Chase subdivision storm sewer ranges in size from 24” Reinforced Concrete Pipe (RCP) to a 42” RCP at the outfall into the detention pond.

The Cypress Chase detention pond was designed to handle the flow from the subdivision with a swale constructed around the pond to drain any offsite flows from Kolbe away and into HCFCD Unit E133-01-00. During the field reconnaissance, failure of the embankment around the detention pond was found along the western edge suggesting that offsite flow from Kolbe Road could enter the detention pond. Rock rip-rap was observed along the location of the failure to protect against erosion. The embankment failure can also be identified utilizing 2018 LiDAR data for the area.

Other contributing factors

As previously mentioned, the study area generally consists of flat topography which reduces the natural drainage capacity to the Harris County ROW. Additionally, the roadside ditches run counter to the topography which generally drains south and east towards HCFCD Unit E133-01-00. These issues compound the drainage issues and consequently the flooding within the study area.

IV. Analysis and Proposed Solution

Approach

The Cypress North Houston drainage system is undersized to handle the Atlas 14 100-year storm event. Drainage improvements to Kolbe Road would also require significant improvements to the Cypress North Houston drainage system and the resulting detention volume needed to mitigate impacts to Cypress Creek, HCFCD Unit K100-00-00. Improvements to the Cypress North Houston were therefore found to be too costly for this project. The existing topography around Kolbe Circle and the area south naturally wants to drain into HCFCD Unit E133-01-00; therefore, proposed solutions to reduce ponding depths and duration were based on following the existing topography while minimizing necessary right-of-way acquisitions for drainage easements. Additionally, HCFCD Unit E133-01-00 was found to have capacity to receive the Kolbe Road flow.

Other considerations taken into account in selection of the proposed alternatives were optimal reduction in overland flooding depth, construction feasibility, traffic impacts, minimum cover and economical feasibility.

The drainage improvements included storm sewers sized to convey the Atlas 14 1% exceedance probability (100-year) storm event flows while maintaining ponding within the Harris County right-of-way. Storm sewers were located outside the existing roadway pavement and underneath the existing roadside ditch to minimize impacts to the existing pavement. The flat topography and tailwater within HCFCD Unit E133-01-00 controls the designed size of the storm sewers.

Methodology Used for Analysis

The overland flow paths, ponding and discharges for the study area were determined utilizing a 1D/2D unsteady hydraulic model (PCSWMM Version 7.1). Updated rainfall from NOAA Atlas 14 was applied to the 2D surface as rainfall on grid. The underground storm sewer system for the Cypress Chase Subdivision was not modeled. The system was assumed to be at capacity during an extreme event with the excess runoff draining overland via the streets.

Flow from the Bonaire Subdivision outside of the study area was modeled utilizing runoff hydrographs developed in HEC-HMS Version 3.5 and NOAA Atlas 14 rainfall. The runoff hydrographs were developed based on the Clark Unit Hydrograph. Infiltration losses were estimated using the Green and Ampt method and the loss parameters for the White Oak Bayou watershed. The time of concentration was calculated based on a true velocity-based method and the R-value, identified as the storage coefficient, was calibrated to a rational method peak flow. The City of Houston runoff coefficients were utilized, and rainfall intensities were interpolated from the NOAA Atlas 14 Rainfall data for the rational method calculation. The Bonaire Subdivision was constructed in the 1970's and the drainage system followed the criteria of that time which stipulated the design for a 3-year rainfall without the requirements for greater events or containment of extreme events within the street right-of-way to the outfall. Current 2-year rainfall events are equivalent to 3-year storm events utilized in design in the 1970's; therefore, it is assumed that the storm sewer can drain the 2-year storm event. Additionally, LiDAR data shows no overland flow path that connects the Bonaire Subdivision to HCFCD Unit E133-01-00; therefore, only the 2-year runoff hydrograph from the Bonaire Subdivision was utilized within HCFCD Unit E133-01-00 for this analysis.

Results of Analysis

Using the methodology described above, the inundation for existing conditions resulting from the NOAA Atlas 14 100-year rainfall were simulated. The NOAA Atlas 14 rainfall data for the study area and the hydrology calculations are provided in **Appendix B**. The resulting ponding locations are shown on **Exhibit 3**. Based on these model results, the study area along Kolbe Road experiences some extent of flooding due to poor drainage. The Cypress Chase subdivision was not found to have any significant flooding concerns with the surface system able to effectively drain the surface flow to the existing detention pond. The Cypress Chase subdivision detention pond is inundated with significant flow over the extreme event overflow weir. This is a result of offsite flow the area along Kolbe Road entering the detention pond whose outfall system was not designed to handle these flows.

Proposed Solutions/Recommended Approach to Improving Drainage

Alternative 1

The proposed drainage system layout for Alternative 1 is shown on **Exhibit 4**. Alternative 1 consists of the following improvements:

- The roadside ditches for S Kolbe Circle and Kolbe Road south are replaced with a storm sewer system sized for Atlas 14 100-year event to redirect 66.3 acres of Kolbe Road flow to HCFCD Unit E133-01-00. The sizing of the storm sewers varies from 24" RCP to a 7' x 5' reinforced box culvert at the outfall.
- The existing ditches for the northern section of Kolbe Road (between S Kolbe Circle and Cypress North Houston Road) are maintained to convey the remaining 43.3 acres to the Cypress North Houston drainage system.
- The embankment for Cypress Chase detention pond is repaired.

The drainage improvements result in significantly reduced ponding along Kolbe Road as shown in **Exhibit 5**. The storm sewer profiles are provided in **Appendix C**. Some locations along S Kolbe Circle show ponding reductions from 3 to 9 inches, potentially alleviating the structural flooding concerns at up to 20 homes. At the south end of Kolbe Road, the results show a decrease in ponding of 7 inches. The ponding along the private streets shows minor improvements as the existing drainage system (roadside ditch) is still undersized to convey the flows to Kolbe Road. The ponding on the north western part of the study area which primarily includes the cemetery is not affected adversely by the proposed alternative.

The results of the analysis show that HCFCD Unit E133-01-00 can convey additional flow within the channel banks; however, the redirected drainage area increases the peak flows downstream. The impacts of the proposed drainage improvements on HCFCD Unit E133-01-00 were determined by comparing the existing and proposed hydrograph within HCFCD Unit E133-01-00 downstream of the proposed outfall. Alternative 1 will require 35.5 ac-ft of detention volume to mitigate the increased peak flows. The detention calculation is provided in **Appendix C**.

Alternative 2

The proposed drainage system layout for Alternative 2 is shown on **Exhibit 6**. Alternative 2 extends the storm sewer system along private streets Laura Circle, Scott Circle and Village Circle via 30” RCP’s. This extension results in upsizing of the storm sewers from Alternative 1 as the drainage system is now receiving more flow with the private streets able to drain properly. The proposed drainage improvements result in significant decreases in ponding depths along the private streets from 5 to 7 inches as shown in **Exhibit 7**, potentially alleviating the structural flooding concerns at up to 54 homes. The storm sewer profiles are provided in **Appendix C**. The impacts of the proposed drainage improvements on HCFCD Unit E133-01-00 will require 38.4 ac-ft of detention volume. The detention calculation is provided in **Appendix C**.

Alternative 3

Alternative 3 has the same layout of Alternative 1 but with the upsized pipe sizes of Alternative 2 to enable a future extension into the private streets. The proposed drainage system layout for Alternative 3 is shown on **Exhibit 8**. The proposed drainage improvements result in significant decreases in ponding depths similar to that of Alternative 1 as shown in **Exhibit 9**, potentially alleviating the structural flooding concerns at up to 20 homes. The storm sewer profiles are provided in **Appendix C**. The impacts of the proposed drainage improvements on HCFCD Unit E133-01-00 will require 35.7 ac-ft of detention volume. The detention calculation is provided in **Appendix C**.

Other Alternatives Considered

During the Client Presentation, Harris County asked if a regional detention pond were implemented that lowered the water surface elevation within HCFCD Unit E133-01-00, could the pipe sizes be further reduced. A quick analysis was performed utilizing the Alternative 2 model and changing the tailwater to a top of pipe elevation. The results showed no real benefit to the design of the storm sewer system. A comparison of the outfall pipe hydrograph and the channel hydrograph shown in Figure 1, shows that during the peak of the storm sewer system the water surface elevation within the channel is at an elevation of 129.68 feet. The top of pipe elevation is 129.4 feet; therefore, the design of the storm sewer system is not controlled by the channel. The design of the storm sewer system is limited by the flat topography, minimum cover and available head loss within the drainage system.

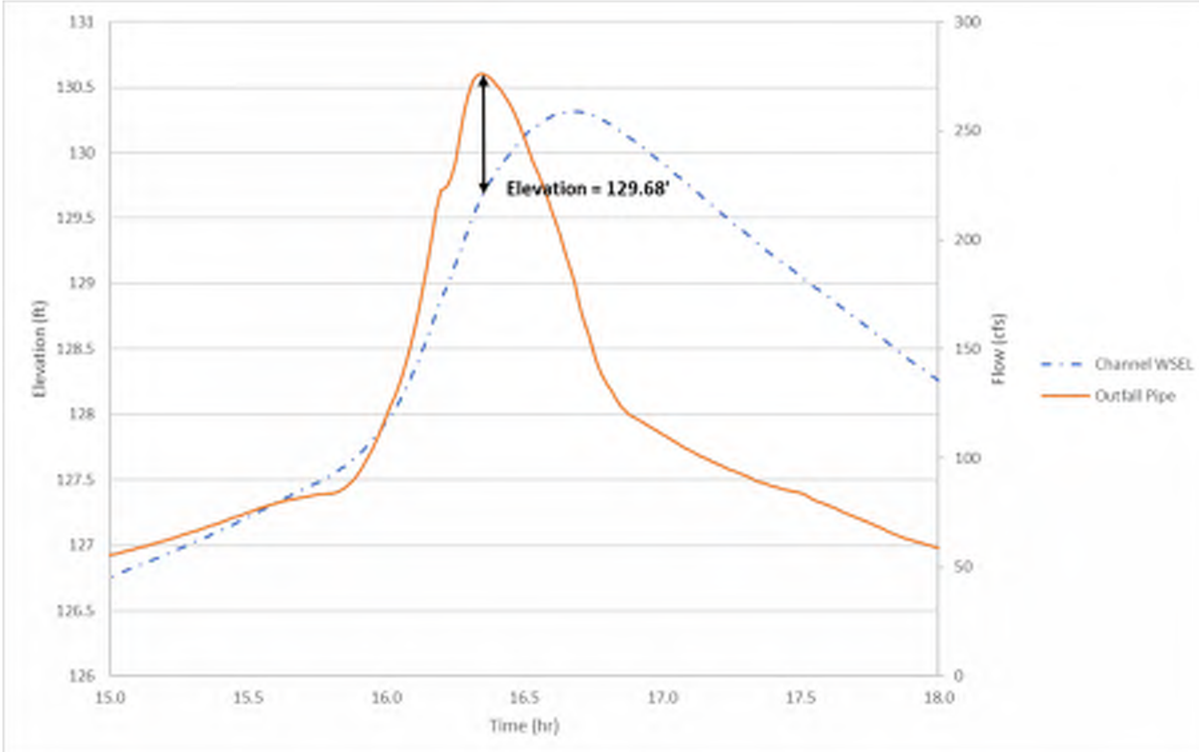

FIGURE 1. HYDROGRAPH COMPARISON OF OUTFALL PIPE AND HCFCD UNIT E133-01-00

Project cost

The preliminary cost estimate including the costs associated with study, design, and construction of the proposed alternatives is presented in **Table 2.** The cost estimates are based upon preliminary quantities for improvements described in this report and presented on **Exhibit 4, Exhibit 6** and **Exhibit 8.** Unit prices were found via recent bid tabulations for Harris County. The details of cost estimates are itemized in **Appendix D.** Data is also provided in the Harris County Project Scoping & Cost Estimating Development Tool found in **Appendix E.**

TABLE 2. SUMMARY OF COST ESTIMATES

Proposed Alternative	Construction Cost	Engineering Fee (20%)	Contingency (30%)	Land Acquisition	Total Cost
Alternative 1	$2.13M	$456K	$684K	$496K	$3.92M
Alternative 2	$2.80M	$561K	$841K	$496K	$4.70M
Alternative 3	$2.58M	$515K	$773K	$496K	$4.36M

V. Public Comment

A community engagement meeting was held to provide information to the community on the proposed drainage improvements and solicit input and comments on the preliminary solution. The following provides details concerning the meeting:

i. Date of Meeting – May 23, 2019
ii. Time of meeting – 6:30 PM – 8:00 PM
iii. Location of meeting
   Cypress Fairbanks ISD Exhibit Center
   11206 Telge Road
   Cypress, TX 77429

From the meeting, the project received one comment. The comment and response log is provided in **Appendix F**.

Kolbe Road and Related Infrastructure Drainage Study

HARRIS COUNTY

BOND PROGRAM 2018

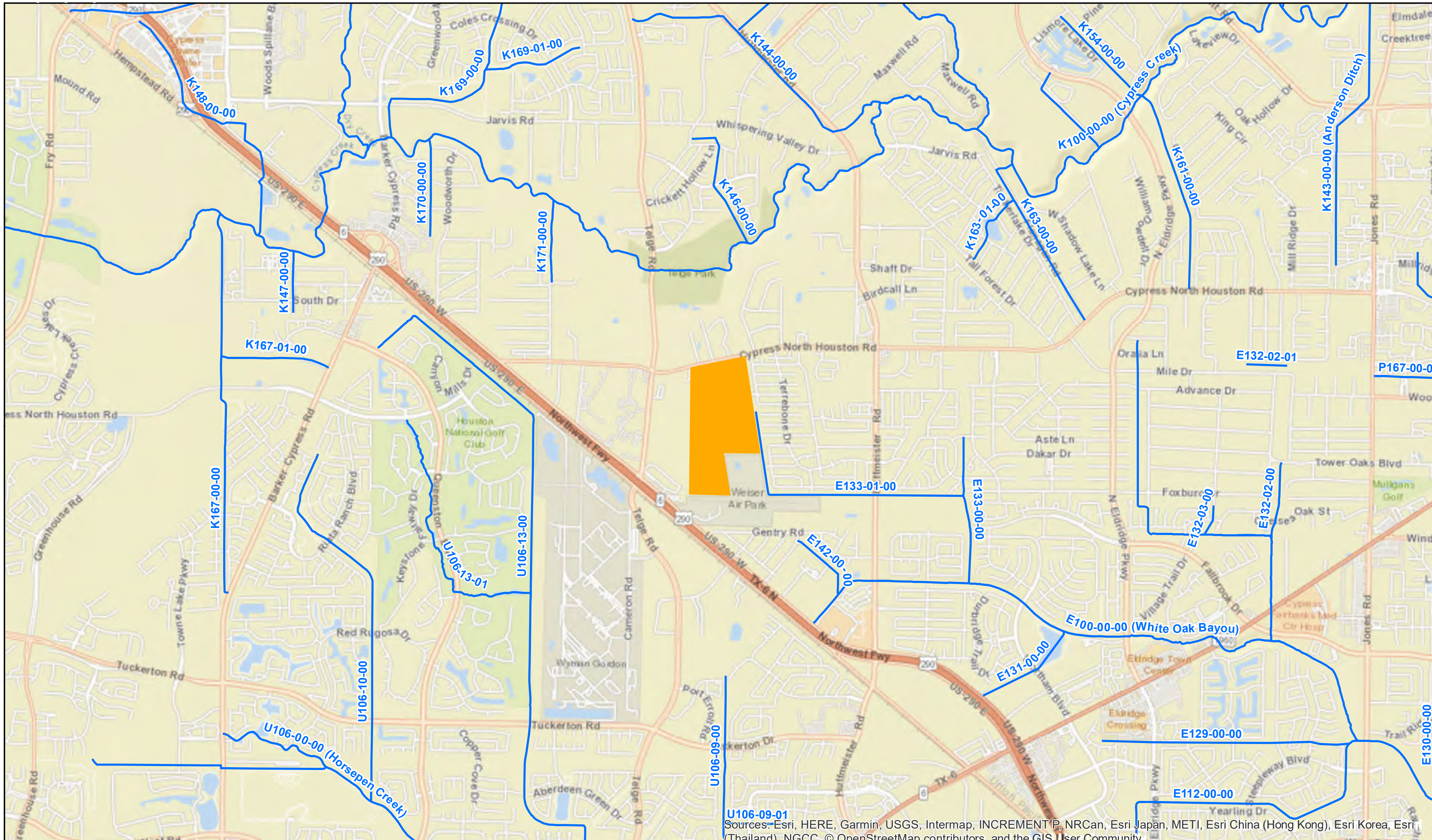

Exhibit 1
Project Vicinity Map

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HARRIS COUNTY FLOOD CONTROL DISTRICT

Kolbe Road and Related Infrastructure Drainage Study

HARRIS COUNTY

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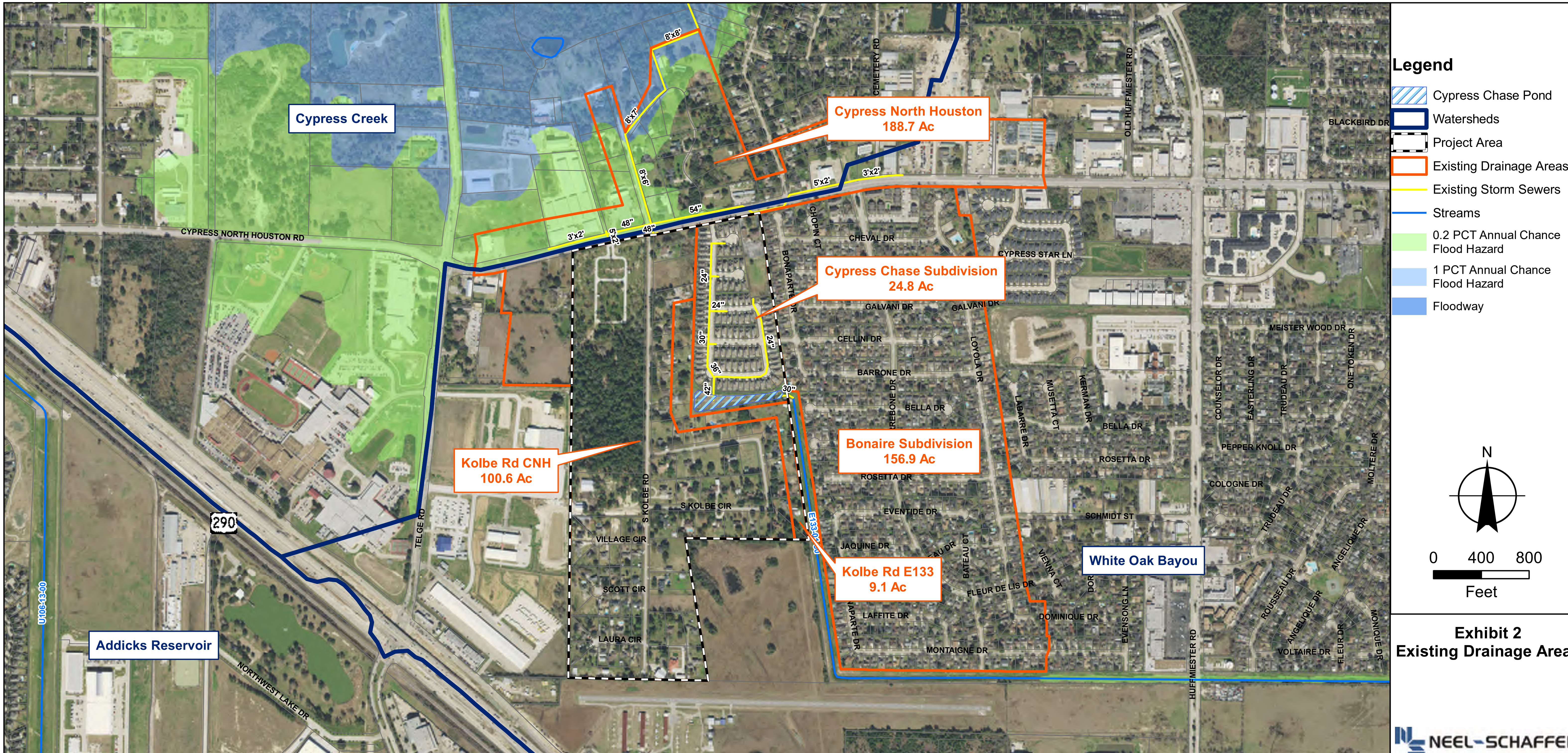

Exhibit 2
Existing Drainage Areas

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HARRIS COUNTY FLOOD CONTROL DISTRICT

Legend

Existing Ponding Depth

- <0.25'
- 0.25' - 0.5'
- 0.5' - 1'
- 1' - 2'
- >2'

N

0 150 300

Feet

Exhibit 3
Atlas 14 100-year
Existing Ponding Map

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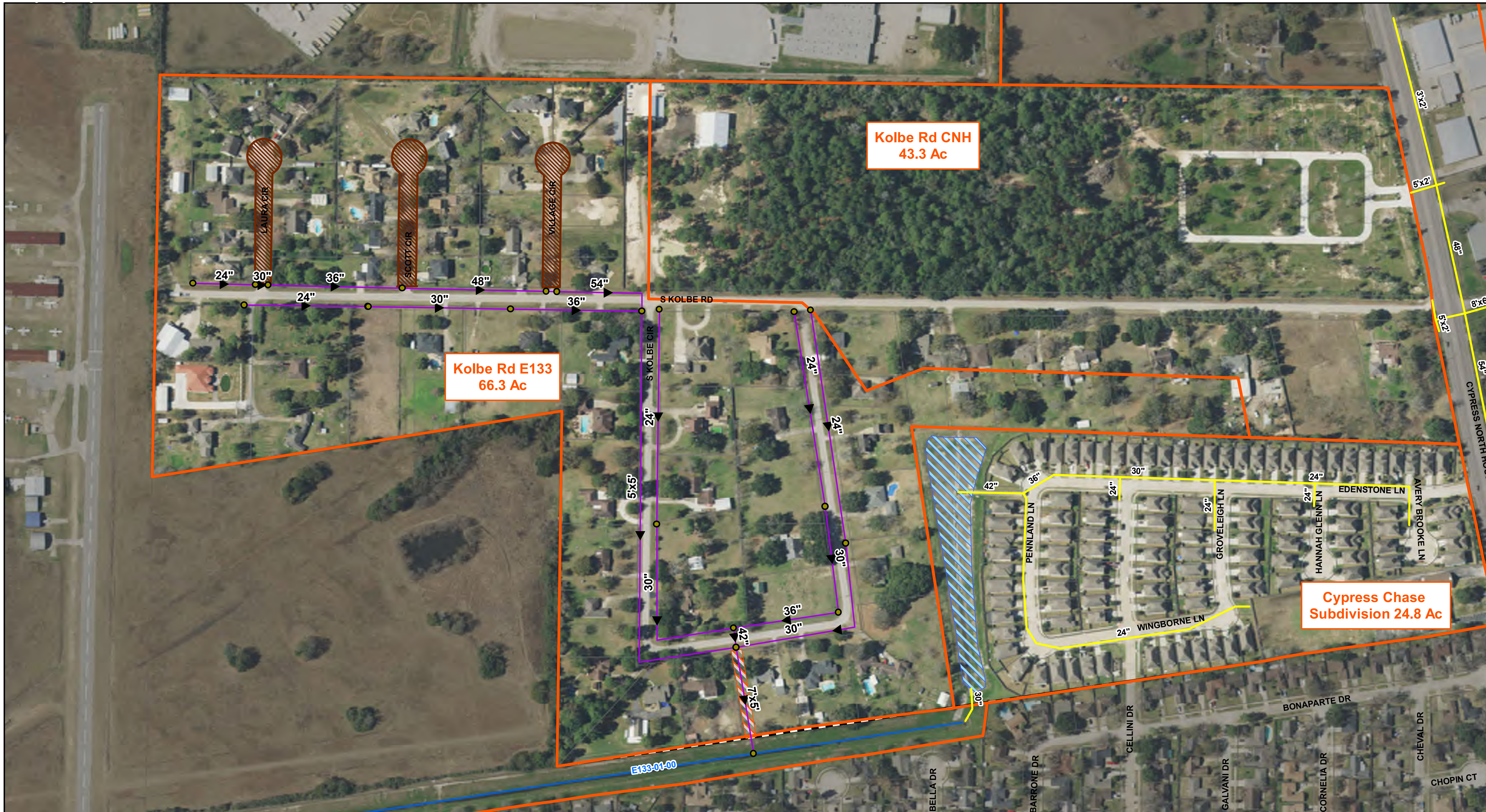

Legend

- Size Change Location
- Proposed Pipes
- Existing Storm Sewers
- Not Public Right of Way
- Cypress Chase Pond
- Proposed Drainage Area
- 30' Drainage Easment

N

0 150 300
Feet

Exhibit 4
Proposed Alternative 1
Storm Sewer
Improvements

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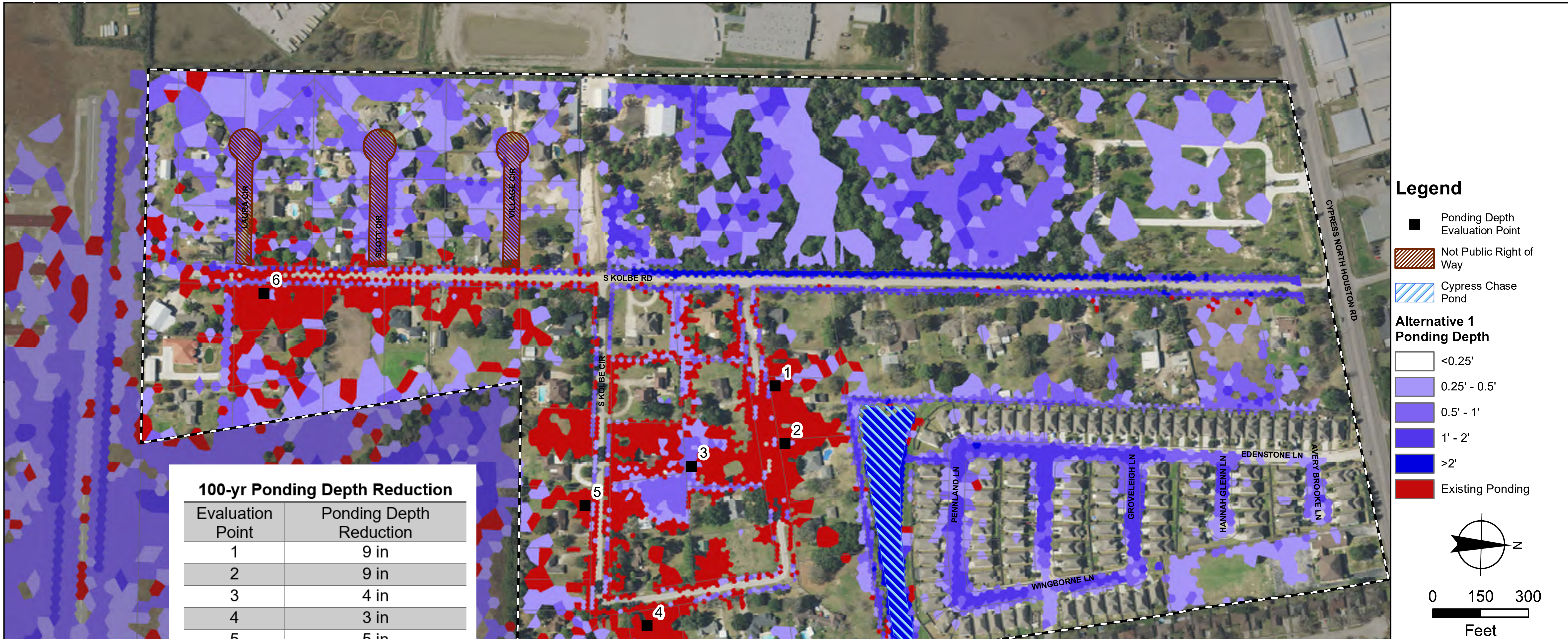
HARRIS COUNTY FLOOD CONTROL DISTRICT



100-yr Ponding Depth Reduction

Evaluation Point	Ponding Depth Reduction
1	9 in
2	9 in
3	4 in
4	3 in
5	5 in
6	7 in

Exhibit 5
Atlas 14 100-year Proposed Alternative 1 Ponding Map

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Kolbe Road and Related Infrastructure Drainage Study

HARRIS COUNTY

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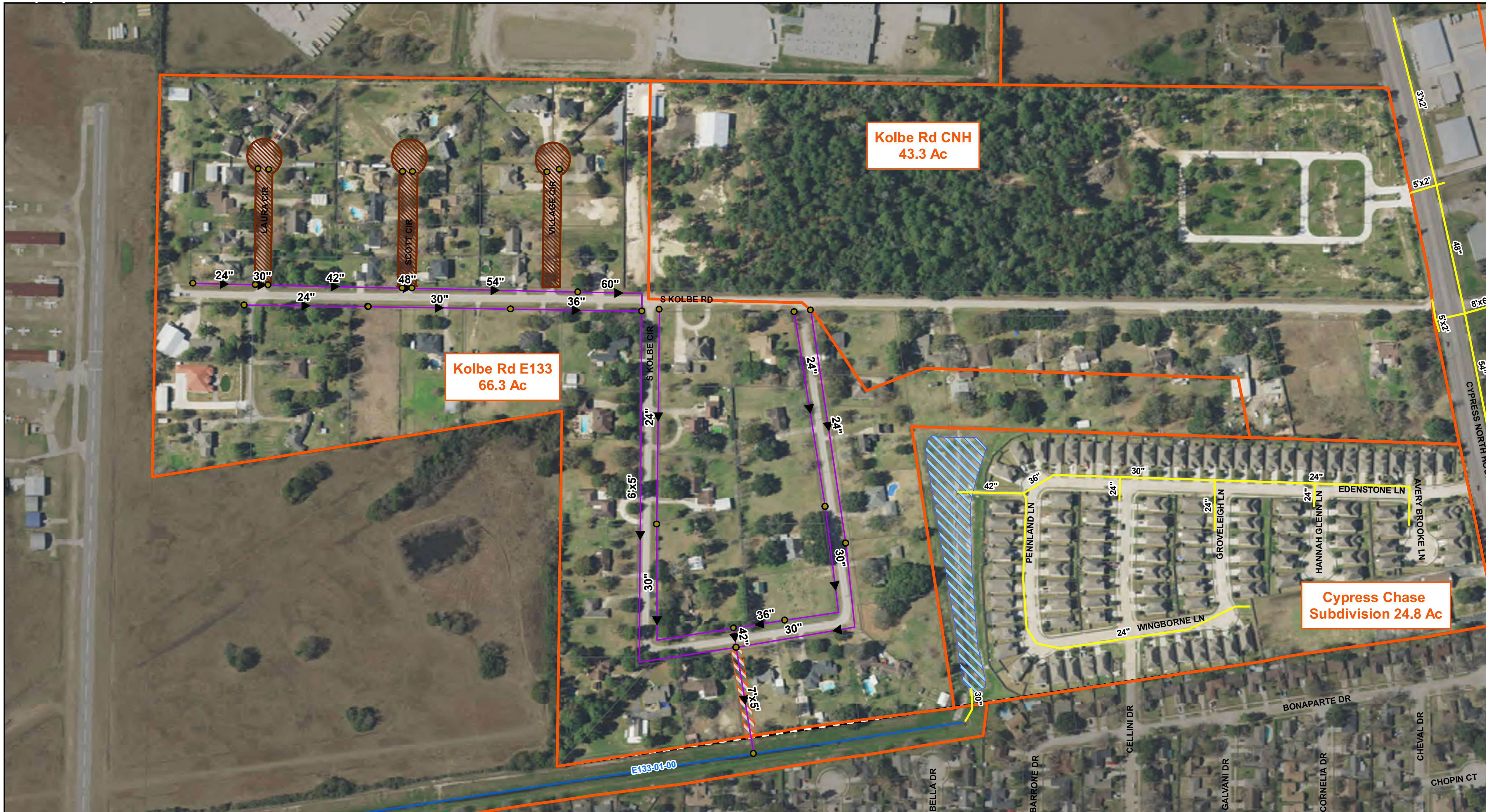

Legend

- Size Change Location
- Proposed Pipes
- Existing Storm Sewers
- Not Public Right of Way
- Cypress Chase Pond
- Proposed Drainage Area
- 30' Drainage Easment

N

0 150 300

Feet

Exhibit 6
Proposed Alternative 2
Storm Sewer
Improvements

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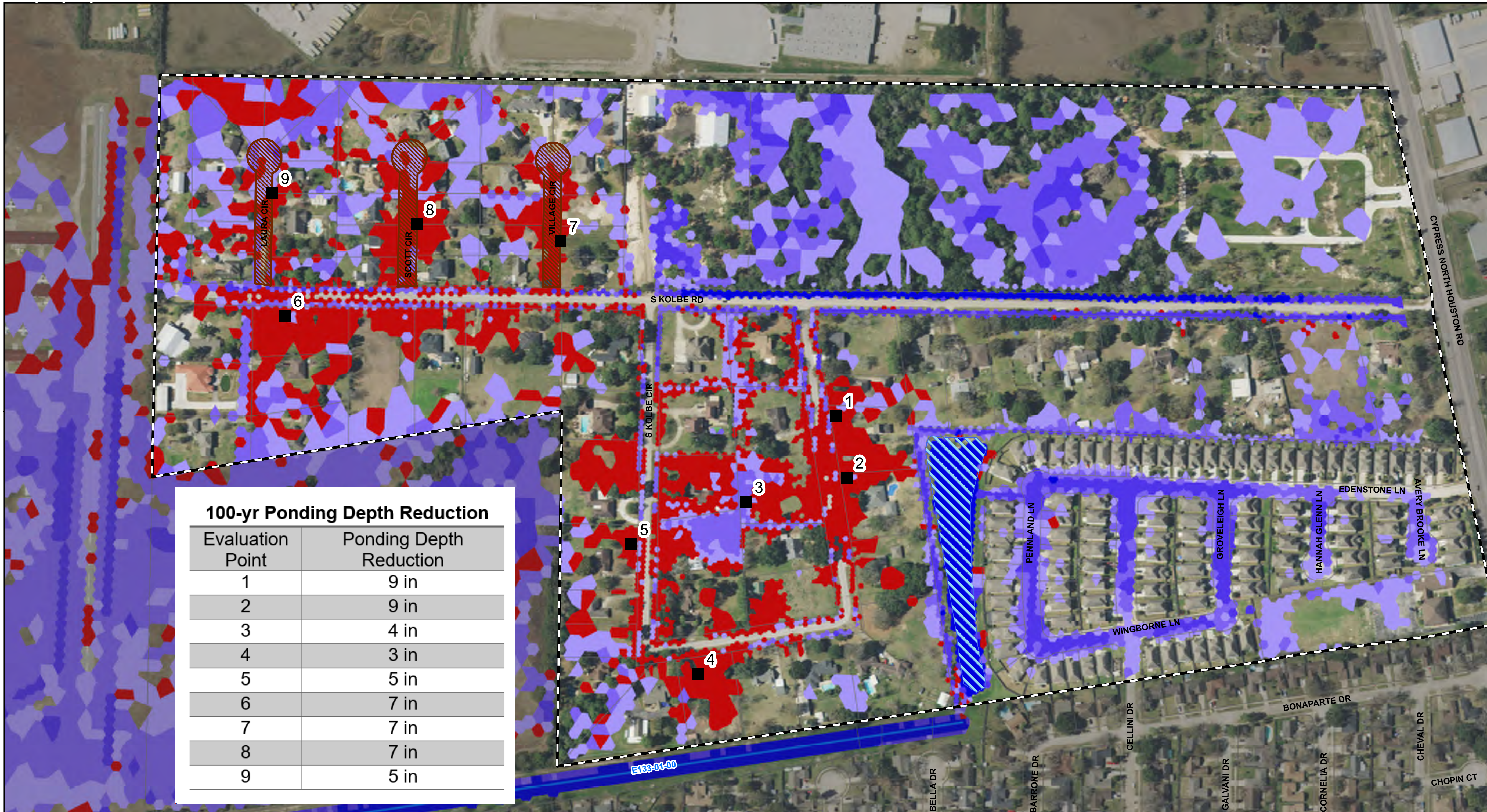

100-yr Ponding Depth Reduction

Evaluation Point	Ponding Depth Reduction
1	9 in
2	9 in
3	4 in
4	3 in
5	5 in
6	7 in
7	7 in
8	7 in
9	5 in

Legend

- Ponding Depth Evaluation Point
- Not Public Right of Way
- Cypress Chase Pond

Alternative 2 Ponding Depth

- <0.25'
- 0.25' - 0.5'
- 0.5' - 1'
- 1' - 2'
- >2'
- Existing Ponding

N

0 150 300
Feet

Exhibit 7
Atlas 14 100-year
Proposed Alternative 2
Ponding Map

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Exhibit 8
Proposed Alternative 3
Storm Sewer
Improvements

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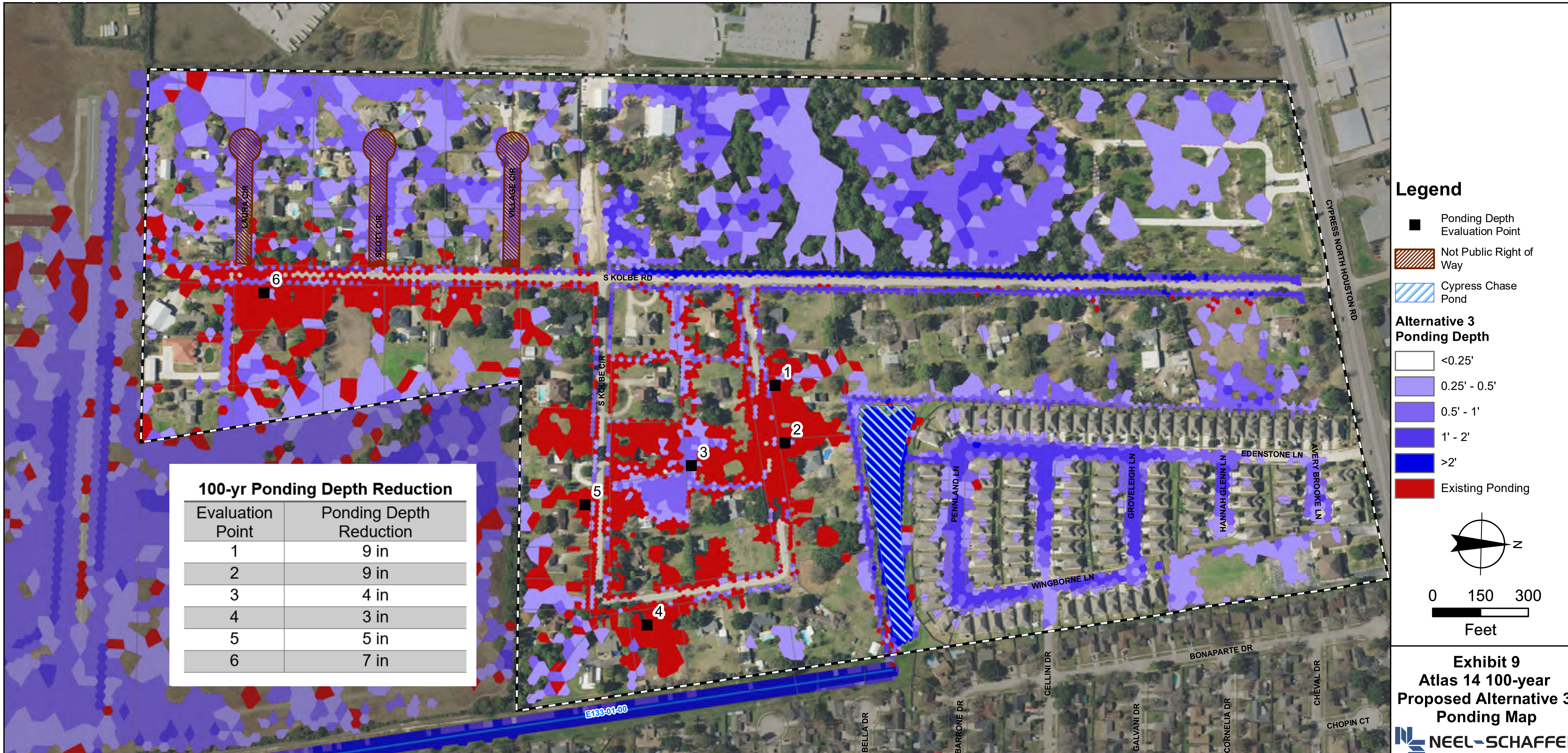
Kolbe Road and Related Infrastructure Drainage Study

HARRIS COUNTY

BOND PROGRAM 2018



100-yr Ponding Depth Reduction

Evaluation Point	Ponding Depth Reduction
1	9 in
2	9 in
3	4 in
4	3 in
5	5 in
6	7 in

Exhibit 9
Atlas 14 100-year Proposed Alternative 3 Ponding Map

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06/18/19

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Kolbe Road and Related Infrastructure Drainage Study

HARRIS COUNTY

BOND PROGRAM 2018

Legend

- Overhead Powerlines
- Not Public Right of Way
- Proposed Drainage Area
- 30' Drainage Easment

N

0 150 300

Feet

Exhibit 10
Potential Utility Conflicts Map

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HARRIS COUNTY ENGINEERING DEPARTMENT

04/24/19

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HARRIS COUNTY FLOOD CONTROL DISTRICT

APPENDIX A: FIELD RECONNAISSANCE

SITE PHOTOGRAPHS DOCUMENTATION FORM	Harris County Subdivision Drainage
Kolbe Road and Related Infrastructure	**UPIN 19103MF16601**

Photo #: 093544	**Photo Date:** 02/11/19
Location: S Kolbe Drive near dead-end	
Description: No ditch on eastside and shallow ditch on westside.	

Photo #: 093751	**Photo Date:** 02/11/19
Location: S Kolbe Drive at dead-end	
Description: No ditch present which drains flow south.	

Photo #: 093918	**Photo Date:** 02/11/19
Location: S Kolbe Drive at Laura Circle	
Description: Shallow ditch on the eastside of roadway with silting of culverts.	

SITE PHOTOGRAPHS DOCUMENTATION FORM	Harris County Subdivision Drainage
Kolbe Road and Related Infrastructure	**UPIN 19103MF16601**

Photo #: 093932	**Photo Date:** 02/11/19
Location: S Kolbe Drive at Laura Circle	
Description: Ditch on west side of roadway. No significant silting present.	

Photo #: 094009	**Photo Date:** 02/11/19
Location: S Kolbe Drive at Laura Circle	
Description: Ditch on west side of roadway with steep backslopes.	

Photo #: 094023	**Photo Date:** 02/11/19
Location: S Kolbe Drive at Laura Circle	
Description: Culvert shows 50% silting on east side of roadway. Photo taken looking south towards dead-end.	

Photo #: 094048	**Photo Date:** 02/11/19
Location: S Kolbe Drive at Laura Circle	
Description: Ditches on the eastside.	

Photo #: 094107	**Photo Date:** 02/11/19
Location: S Kolbe Drive south of Scott Cir	
Description: Ditches on westside with steep backslopes.	

Photo #: 094603	**Photo Date:** 02/11/19
Location: S Kolbe Dr south of S. Kolbe Cir	
Description: Recently regraded ditch on eastside with steep sideslopes.	

SITE PHOTOGRAPHS DOCUMENTATION FORM	Harris County Subdivision Drainage
Kolbe Road and Related Infrastructure	UPIN 19103MF16601

Photo #: 094850	**Photo Date:** 02/11/19
Location: S Kolbe Dr at of S. Kolbe Cir	
Description: Regraded ditch on westside with steep side slopes. Equalizer pipe crosses S Kolbe Drive.	

Photo #: 095324	**Photo Date:** 02/11/19
Location: 11228 S Kolbe Circle	
Description: Offsite area is generally flat with foundations at or below roadway pavement.	

Photo #: 100315	**Photo Date:** 02/11/19
Location: S Kolbe Dr at S. Kolbe Cir	
Description: Looking north at ditches along eastside showing equalizer pipe and steep side slopes.	

Photo #: 100436	**Photo Date:** 02/11/19
Location: S Kolbe Dr at S. Kolbe Cir	
Description: Ditch on westside of roadway with steep side slopes. Side slope failures are visible in the distance associated with the unstable side slopes.	

Photo #: 102317	**Photo Date:** 02/11/19
Location: Cypress Chase Subdivision	
Description: Overland flowpath to detention pond.	

Photo #: 2841	**Photo Date:** 02/11/19
Location: Cypress Chase Subdivision	
Description: Existing swale located between the Cypress Chase subdivision and the residential lots along S Kolbe Drive.	

	**Photo #:** 2842	**Photo Date:** 02/11/19
	Location: Cypress Chase Detention Pond	
	Description: Recently repaired overflow weir. Slope erosion may have been associated with overflow not contained within weir structure.	
	**Photo #:** 2844	**Photo Date:** 02/11/19
	Location: Cypress Chase Detention Pond	
	Description: Detention Pond outfall pipe and outfall pipe from neighborhood east of Cypress Chase.	
	**Photo #:** 2846	**Photo Date:** 02/11/19
	Location: Cypress Chase Detention Pond	
	Description: Overflow weir with erosion at base and recent slope repairs.	

Photo #: 2855	Photo Date: 02/11/19
Location: Cypress Chase Detention Pond	
Description: Existing swale to drain offsite flow around detention pond. Offsite flow from residential area along S Kolbe Drive.	

Photo #: 2856	Photo Date: 02/11/19
Location: Cypress Chase Detention Pond	
Description: Inlet which drains offsite flow in swale.	

Photo #: 2857	Photo Date: 02/11/19
Location: Cypress Chase Detention Pond	
Description: Recently repaired slope at overflow weir.	

Photo #: 2858	**Photo Date:** 02/11/19
Location: HCFCD Unit E133-01-00	
Description: Upper limit of the outfall channel. Outfall from Cypress Chase detention pond and neighborhood east of Cypress Chase.	

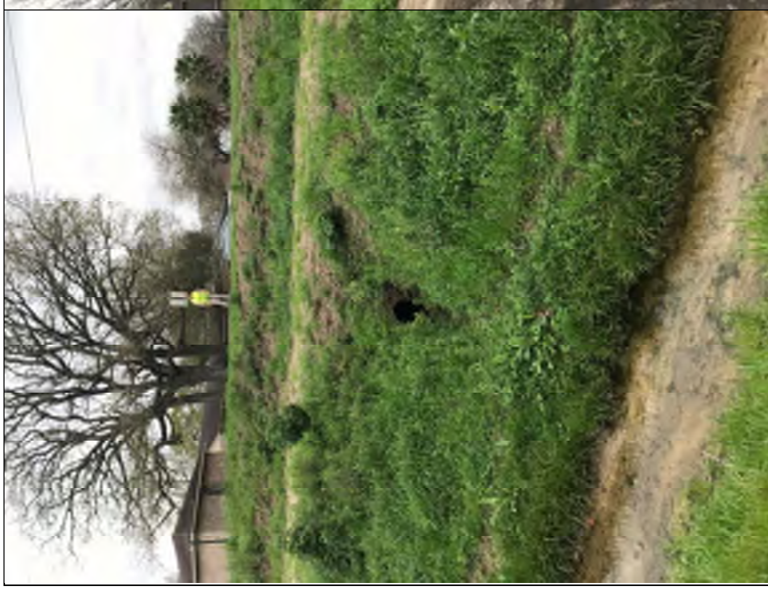

Photo #: 2861	**Photo Date:** 02/11/19
Location: HCFCD Unit E133-01-00	
Description: Outfall pipe draining neighborhood east of channel. No overland flowpath.	

APPENDIX B: NOAA ATLAS 14 RAINFALL DATA AND HYDROLOGY CALCULATIONS

NOAA Atlas 14, Volume 11, Version 2
Location name: Cypress, Texas, USA*
Latitude: 29.9407°, Longitude: -95.6431°
Elevation: 136.9 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sandra Pavlovic, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Orlan Wilhite

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches/hour)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	5.90 (4.48-7.80)	6.90 (5.27-9.02)	8.52 (6.49-11.2)	9.86 (7.40-13.1)	11.7 (8.50-16.1)	13.1 (9.26-18.5)	14.5 (10.0-21.1)	16.1 (10.8-23.9)	18.2 (11.8-28.0)	19.8 (12.5-31.3)
10-min	4.68 (3.54-6.18)	5.47 (4.18-7.16)	6.77 (5.16-8.90)	7.85 (5.89-10.5)	9.34 (6.80-12.8)	10.5 (7.43-14.8)	11.6 (8.02-16.9)	12.8 (8.58-19.0)	14.3 (9.27-22.0)	15.4 (9.74-24.3)
15-min	3.98 (3.01-5.25)	4.62 (3.54-6.06)	5.70 (4.34-7.48)	6.58 (4.94-8.76)	7.78 (5.65-10.7)	8.70 (6.15-12.3)	9.62 (6.64-14.0)	10.6 (7.13-15.8)	12.0 (7.78-18.4)	13.0 (8.24-20.6)
30-min	2.85 (2.16-3.77)	3.30 (2.53-4.33)	4.04 (3.08-5.32)	4.65 (3.49-6.20)	5.47 (3.96-7.48)	6.08 (4.29-8.56)	6.72 (4.63-9.74)	7.44 (5.00-11.1)	8.47 (5.51-13.1)	9.32 (5.90-14.7)
60-min	1.87 (1.42-2.47)	2.19 (1.67-2.86)	2.70 (2.06-3.55)	3.13 (2.35-4.17)	3.71 (2.68-5.07)	4.14 (2.92-5.83)	4.61 (3.18-6.68)	5.16 (3.47-7.69)	5.97 (3.88-9.22)	6.66 (4.22-10.5)
2-hr	1.13 (0.856-1.48)	1.36 (1.03-1.75)	1.73 (1.32-2.25)	2.05 (1.54-2.72)	2.52 (1.84-3.43)	2.90 (2.06-4.07)	3.32 (2.30-4.79)	3.83 (2.58-5.67)	4.60 (3.00-7.07)	5.26 (3.34-8.27)
3-hr	0.818 (0.623-1.07)	1.02 (0.764-1.28)	1.31 (0.997-1.69)	1.58 (1.19-2.09)	1.99 (1.45-2.71)	2.33 (1.66-3.27)	2.72 (1.89-3.92)	3.19 (2.15-4.71)	3.91 (2.55-5.99)	4.53 (2.88-7.10)
6-hr	0.470 (0.360-0.614)	0.607 (0.452-0.750)	0.797 (0.609-1.02)	0.983 (0.746-1.29)	1.27 (0.938-1.73)	1.52 (1.09-2.14)	1.82 (1.27-2.60)	2.17 (1.47-3.18)	2.70 (1.76-4.10)	3.15 (2.01-4.91)
12-hr	0.267 (0.205-0.346)	0.353 (0.262-0.430)	0.470 (0.360-0.601)	0.587 (0.447-0.770)	0.771 (0.572-1.05)	0.935 (0.675-1.31)	1.13 (0.788-1.61)	1.35 (0.917-1.97)	1.69 (1.11-2.56)	1.98 (1.27-3.06)
24-hr	0.152 (0.117-0.197)	0.205 (0.152-0.247)	0.276 (0.213-0.351)	0.349 (0.267-0.455)	0.462 (0.346-0.627)	0.565 (0.411-0.788)	0.685 (0.481-0.971)	0.819 (0.558-1.19)	1.01 (0.668-1.53)	1.18 (0.758-1.82)
2-day	0.086 (0.067-0.111)	0.118 (0.088-0.141)	0.161 (0.124-0.204)	0.205 (0.157-0.266)	0.275 (0.208-0.374)	0.340 (0.250-0.475)	0.414 (0.291-0.583)	0.486 (0.332-0.700)	0.584 (0.386-0.871)	0.660 (0.426-1.01)
3-day	0.063 (0.049-0.080)	0.086 (0.064-0.102)	0.117 (0.091-0.148)	0.149 (0.115-0.193)	0.199 (0.151-0.271)	0.246 (0.181-0.342)	0.297 (0.210-0.418)	0.347 (0.237-0.498)	0.412 (0.273-0.612)	0.461 (0.298-0.704)
4-day	0.050 (0.039-0.065)	0.068 (0.051-0.082)	0.093 (0.072-0.117)	0.118 (0.091-0.152)	0.156 (0.118-0.211)	0.191 (0.141-0.265)	0.230 (0.162-0.322)	0.267 (0.183-0.382)	0.316 (0.210-0.469)	0.353 (0.229-0.538)
7-day	0.033 (0.026-0.043)	0.044 (0.033-0.053)	0.059 (0.046-0.074)	0.073 (0.057-0.094)	0.095 (0.072-0.128)	0.115 (0.085-0.158)	0.136 (0.097-0.191)	0.158 (0.109-0.225)	0.186 (0.124-0.275)	0.208 (0.135-0.316)
10-day	0.026 (0.020-0.033)	0.034 (0.026-0.041)	0.045 (0.035-0.056)	0.055 (0.042-0.070)	0.070 (0.053-0.094)	0.084 (0.062-0.115)	0.099 (0.070-0.137)	0.113 (0.078-0.162)	0.133 (0.089-0.197)	0.149 (0.097-0.226)
20-day	0.017 (0.014-0.022)	0.021 (0.017-0.026)	0.027 (0.021-0.034)	0.033 (0.025-0.042)	0.041 (0.031-0.054)	0.047 (0.035-0.064)	0.054 (0.039-0.075)	0.061 (0.043-0.087)	0.071 (0.048-0.104)	0.079 (0.051-0.119)
30-day	0.014 (0.011-0.017)	0.017 (0.013-0.021)	0.021 (0.017-0.026)	0.025 (0.019-0.032)	0.030 (0.023-0.040)	0.034 (0.025-0.046)	0.039 (0.028-0.054)	0.044 (0.030-0.062)	0.050 (0.034-0.073)	0.055 (0.036-0.082)
45-day	0.012 (0.009-0.014)	0.014 (0.011-0.017)	0.017 (0.013-0.021)	0.020 (0.015-0.025)	0.023 (0.018-0.030)	0.026 (0.019-0.035)	0.029 (0.021-0.040)	0.032 (0.022-0.045)	0.036 (0.024-0.052)	0.039 (0.025-0.058)
60-day	0.010 (0.008-0.013)	0.012 (0.009-0.015)	0.015 (0.012-0.018)	0.017 (0.013-0.021)	0.020 (0.015-0.026)	0.022 (0.016-0.029)	0.024 (0.017-0.033)	0.026 (0.018-0.036)	0.029 (0.019-0.042)	0.031 (0.020-0.046)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

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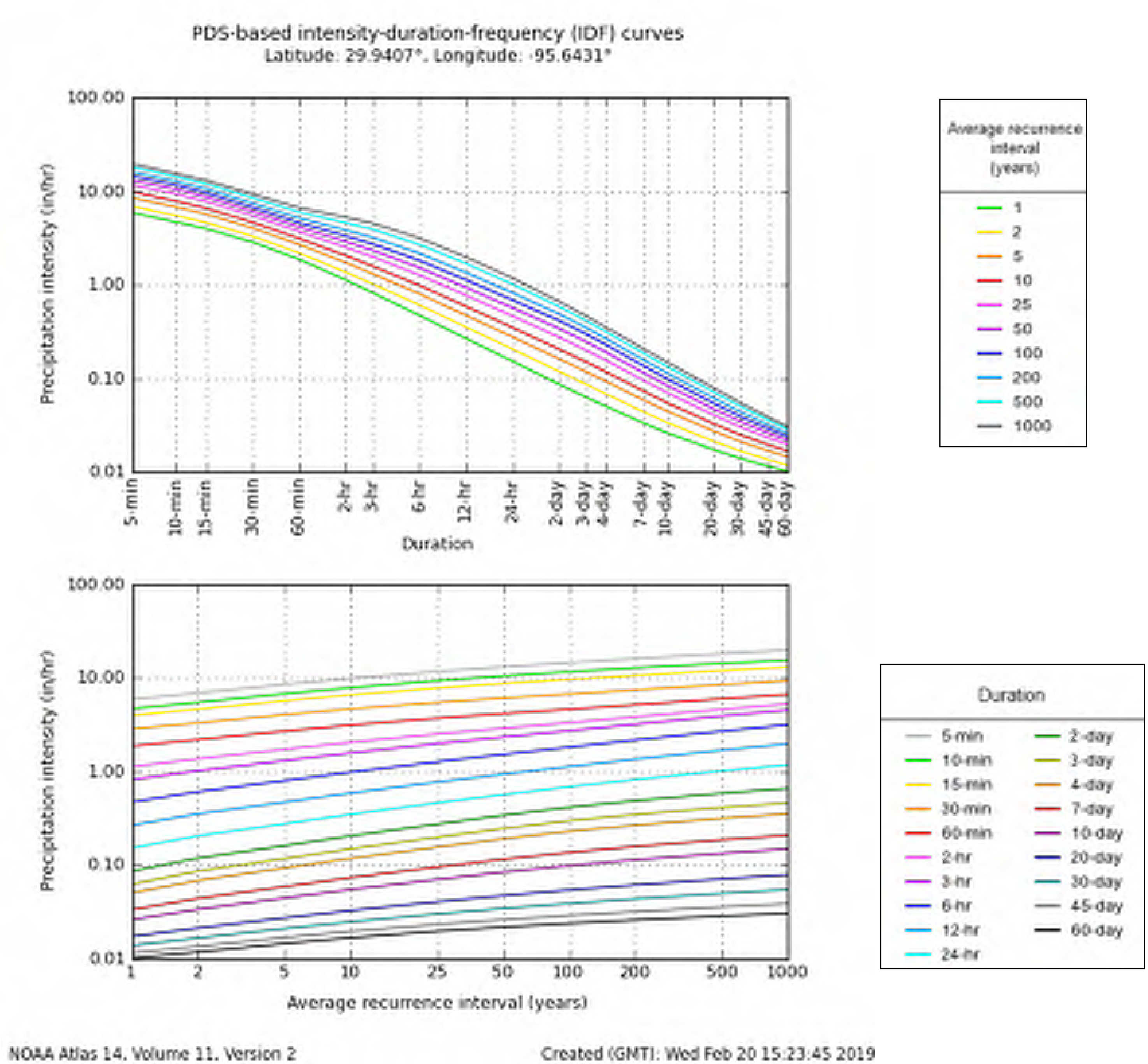
PF graphical



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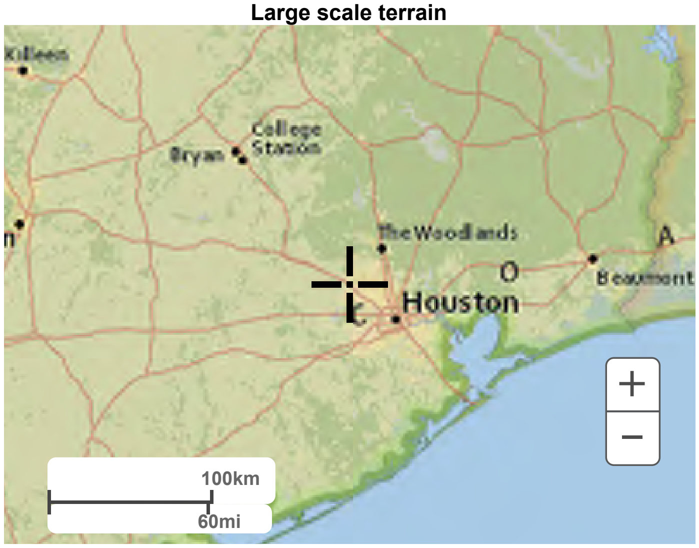
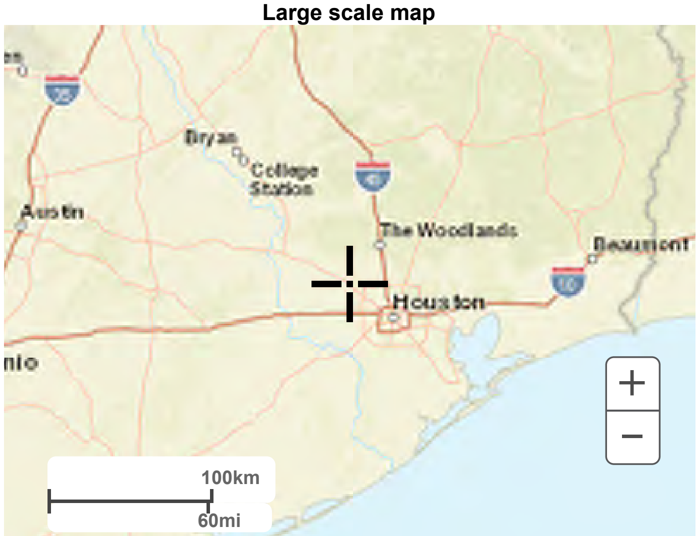
Maps & aerials

Small scale terrain

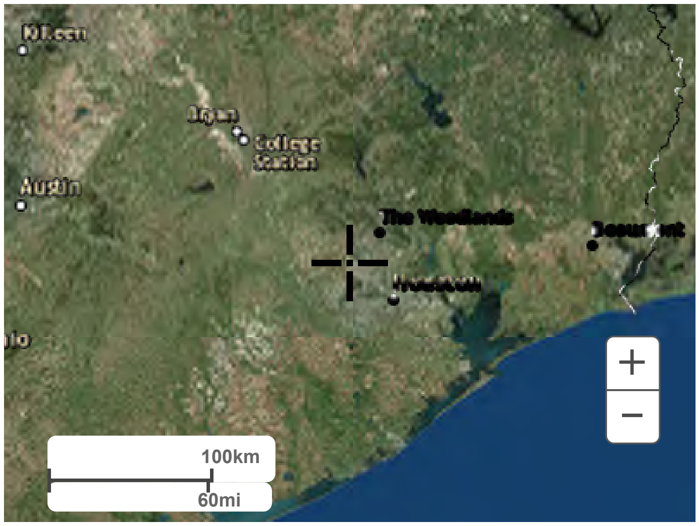
Large scale terrain



Large scale map



Large scale aerial



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National Oceanic and Atmospheric Administration
National Weather Service
National Water Center
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

Disclaimer

NOAA Atlas 14, Volume 11, Version 2
Location name: Cypress, Texas, USA*
Latitude: 29.9405°, Longitude: -95.6432°
Elevation: 137.08 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sandra Pavlovic, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Orlan Wilhite

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.492 (0.373-0.650)	0.575 (0.439-0.752)	0.710 (0.541-0.933)	0.822 (0.617-1.10)	0.976 (0.708-1.34)	1.09 (0.772-1.54)	1.21 (0.836-1.76)	1.34 (0.900-1.99)	1.51 (0.983-2.33)	1.65 (1.04-2.61)
10-min	0.780 (0.590-1.03)	0.912 (0.697-1.19)	1.13 (0.860-1.48)	1.31 (0.982-1.74)	1.56 (1.13-2.14)	1.75 (1.24-2.47)	1.94 (1.34-2.81)	2.13 (1.43-3.17)	2.38 (1.55-3.66)	2.57 (1.62-4.05)
15-min	0.994 (0.753-1.31)	1.16 (0.884-1.52)	1.42 (1.09-1.87)	1.64 (1.23-2.19)	1.95 (1.41-2.67)	2.17 (1.54-3.06)	2.40 (1.66-3.49)	2.65 (1.78-3.95)	2.99 (1.94-4.61)	3.26 (2.06-5.15)
30-min	1.43 (1.08-1.88)	1.65 (1.26-2.17)	2.02 (1.54-2.66)	2.33 (1.75-3.10)	2.74 (1.98-3.74)	3.04 (2.15-4.28)	3.36 (2.32-4.87)	3.72 (2.50-5.54)	4.24 (2.75-6.54)	4.66 (2.95-7.36)
60-min	1.87 (1.42-2.47)	2.19 (1.67-2.86)	2.70 (2.06-3.55)	3.13 (2.35-4.17)	3.71 (2.68-5.07)	4.14 (2.92-5.83)	4.61 (3.18-6.68)	5.16 (3.47-7.69)	5.97 (3.88-9.22)	6.66 (4.22-10.5)
2-hr	2.25 (1.71-2.96)	2.73 (2.07-3.50)	3.45 (2.63-4.50)	4.10 (3.09-5.44)	5.04 (3.67-6.87)	5.79 (4.11-8.13)	6.64 (4.60-9.59)	7.66 (5.16-11.3)	9.20 (6.00-14.1)	10.5 (6.69-16.5)
3-hr	2.46 (1.87-3.22)	3.05 (2.29-3.85)	3.93 (2.99-5.09)	4.74 (3.58-6.27)	5.96 (4.37-8.13)	6.99 (4.98-9.81)	8.18 (5.67-11.8)	9.58 (6.47-14.1)	11.7 (7.67-18.0)	13.6 (8.66-21.3)
6-hr	2.82 (2.15-3.67)	3.63 (2.71-4.49)	4.77 (3.65-6.14)	5.89 (4.47-7.75)	7.61 (5.62-10.4)	9.12 (6.55-12.8)	10.9 (7.59-15.6)	13.0 (8.78-19.0)	16.1 (10.6-24.6)	18.9 (12.0-29.4)
12-hr	3.21 (2.47-4.17)	4.25 (3.15-5.18)	5.66 (4.34-7.24)	7.08 (5.39-9.27)	9.29 (6.89-12.6)	11.3 (8.13-15.7)	13.6 (9.50-19.3)	16.3 (11.1-23.7)	20.3 (13.4-30.8)	23.8 (15.3-36.9)
24-hr	3.65 (2.82-4.72)	4.92 (3.65-5.93)	6.63 (5.11-8.44)	8.37 (6.40-10.9)	11.1 (8.29-15.1)	13.6 (9.86-18.9)	16.4 (11.5-23.3)	19.6 (13.4-28.5)	24.3 (16.0-36.6)	28.3 (18.2-43.6)
2-day	4.14 (3.20-5.32)	5.68 (4.20-6.76)	7.73 (5.97-9.77)	9.84 (7.55-12.8)	13.2 (9.99-18.0)	16.3 (12.0-22.8)	19.9 (14.0-28.0)	23.3 (16.0-33.6)	28.1 (18.5-41.8)	31.7 (20.5-48.6)
3-day	4.51 (3.51-5.79)	6.19 (4.61-7.37)	8.44 (6.54-10.6)	10.7 (8.25-13.9)	14.3 (10.9-19.5)	17.7 (13.0-24.6)	21.4 (15.1-30.1)	25.0 (17.1-35.8)	29.7 (19.6-44.1)	33.2 (21.5-50.7)
4-day	4.84 (3.77-6.20)	6.57 (4.93-7.86)	8.93 (6.93-11.2)	11.3 (8.69-14.6)	14.9 (11.4-20.2)	18.3 (13.5-25.4)	22.0 (15.6-30.9)	25.6 (17.6-36.7)	30.3 (20.1-45.0)	33.9 (22.0-51.7)
7-day	5.61 (4.38-7.16)	7.39 (5.62-8.93)	9.89 (7.72-12.4)	12.3 (9.52-15.8)	16.0 (12.1-21.5)	19.3 (14.2-26.6)	22.9 (16.3-32.0)	26.5 (18.3-37.8)	31.3 (20.8-46.2)	35.0 (22.7-53.1)
10-day	6.26 (4.90-7.97)	8.07 (6.20-9.82)	10.7 (8.36-13.4)	13.1 (10.2-16.9)	16.9 (12.8-22.5)	20.1 (14.8-27.5)	23.6 (16.8-32.9)	27.2 (18.8-38.8)	32.0 (21.4-47.2)	35.7 (23.3-54.1)
20-day	8.28 (6.50-10.5)	10.2 (7.96-12.5)	13.1 (10.3-16.4)	15.7 (12.2-20.0)	19.5 (14.7-25.7)	22.6 (16.7-30.7)	26.0 (18.6-36.0)	29.4 (20.4-41.8)	34.1 (22.9-50.1)	37.8 (24.7-56.9)
30-day	9.97 (7.85-12.6)	12.0 (9.45-14.8)	15.1 (11.9-18.9)	17.8 (13.9-22.7)	21.7 (16.4-28.5)	24.8 (18.3-33.4)	28.0 (20.0-38.7)	31.4 (21.8-44.4)	35.9 (24.1-52.6)	39.4 (25.8-59.2)
45-day	12.4 (9.81-15.7)	14.6 (11.6-18.2)	18.2 (14.4-22.7)	21.1 (16.5-26.8)	25.1 (19.0-32.8)	28.2 (20.8-37.8)	31.3 (22.4-43.1)	34.4 (24.0-48.6)	38.6 (26.0-56.4)	41.8 (27.5-62.5)
60-day	14.7 (11.6-18.4)	17.0 (13.6-21.3)	20.9 (16.7-26.2)	24.1 (18.9-30.5)	28.3 (21.4-36.8)	31.3 (23.1-41.9)	34.3 (24.6-47.1)	37.3 (26.1-52.5)	41.1 (27.8-59.9)	43.9 (28.9-65.6)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

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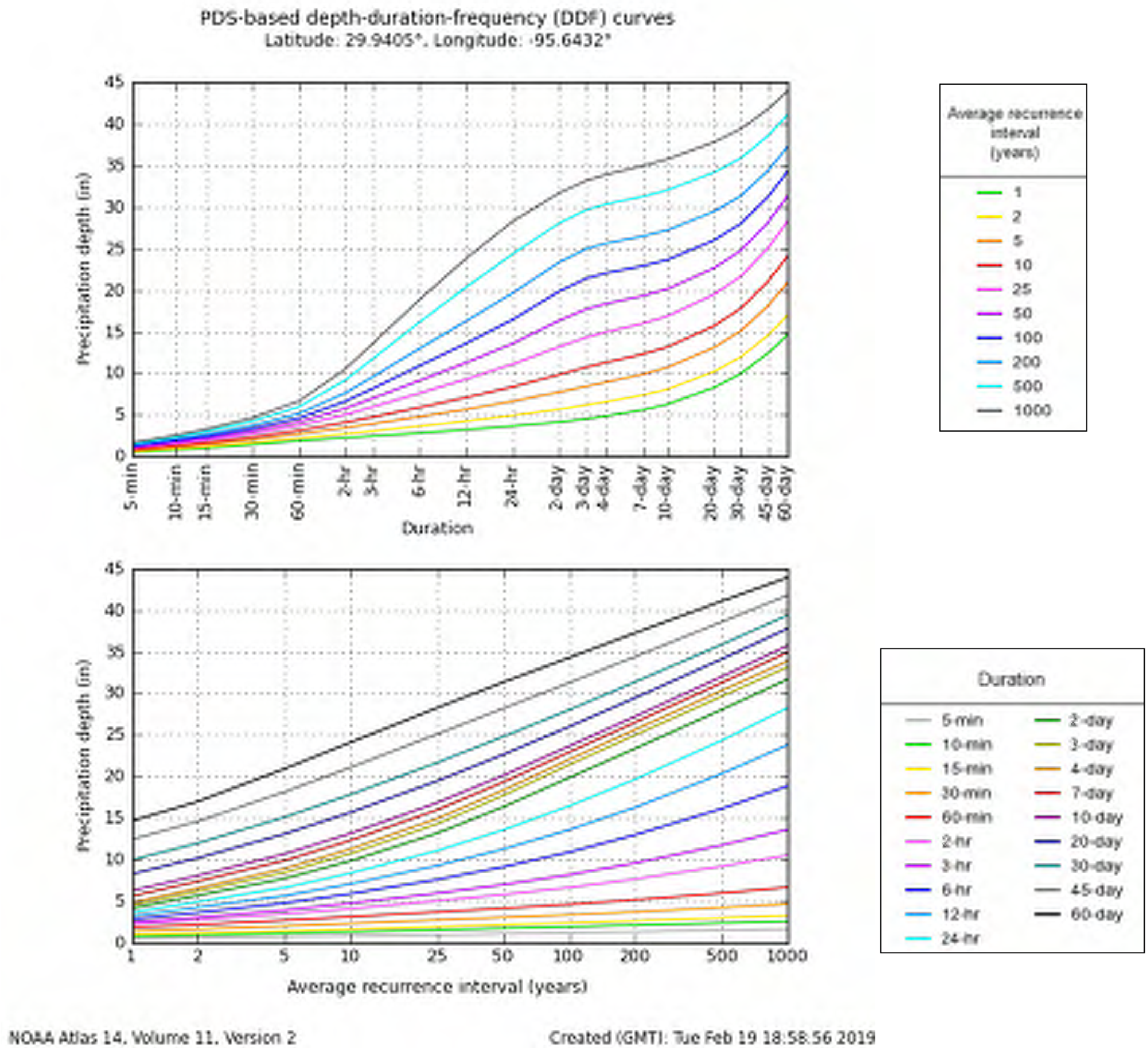
PF graphical



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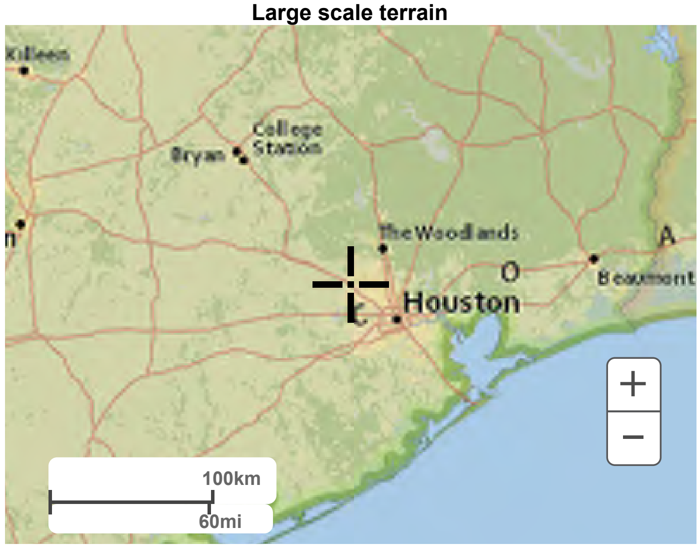
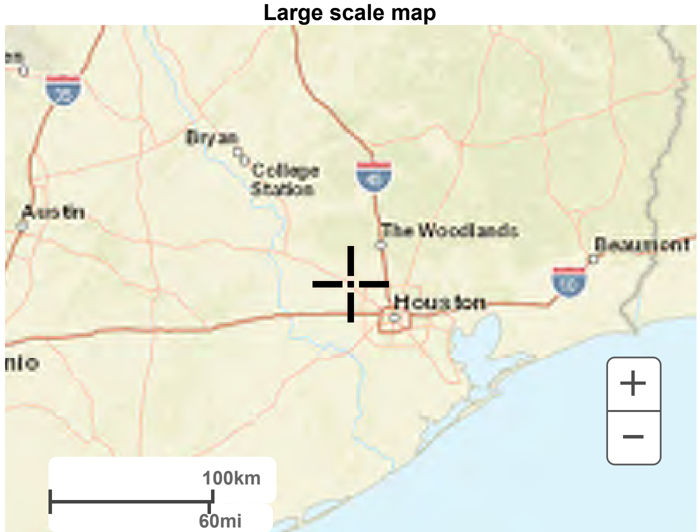
Maps & aerials

Small scale terrain

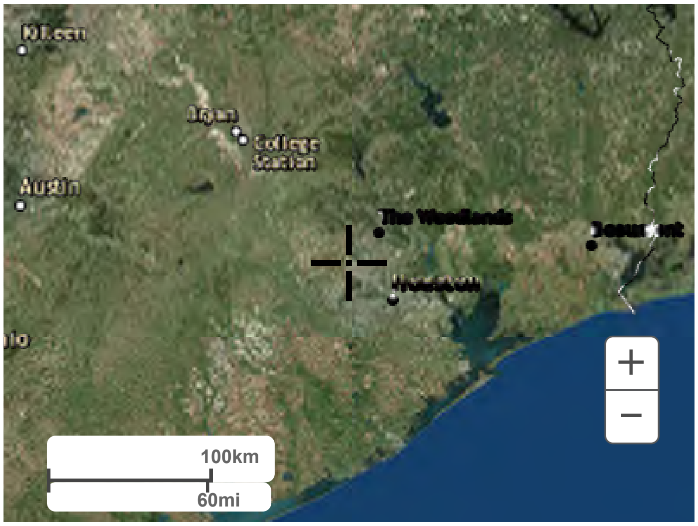
Large scale terrain



Large scale map



Large scale aerial



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National Oceanic and Atmospheric Administration
National Weather Service
National Water Center
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

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OFFSITE AREA PEAK FLOW CALCULATIONS

Project: Kolbe Road and Related Infrastructure Drainage Improvements
Location: Houston, Texas
Date: 4/18/2019

Drainage Subarea ID	Drainage Area (ac)	Time of Concentration									
		Overland Flow (V = 0.5 fps)		Ditch Flow (V=1.0 fps)		Gutter Flow (V=1.0 fps)		Pipe Flow (V=3.0 fps)		Computed Tc	Minimum Tc
		Length (ft)	Tt_o (min)	Length (ft)	Tt_d (min)	Length (ft)	Tt_g (min)	Length (ft)	Tt_p (min)	(min)	(min)
Bonaire	156.85	165	5.50		0.00	305	5.08	3661	20.34	30.92	10.00

Drainage Subarea ID	Drainage Area (acres)	Runoff Coefficients									
		Undeveloped	Residential Rural	Residential Large Lot (>1/4 acre)	Residential Small Lot (<1/4 acre)	Developed Green Areas	Light Industrial	High Density	Transportation	Water	Computed Weighted "C" Value
		C=0.20	C=0.35	C=0.40	C=0.55	C=0.35	C=0.70	C=0.80	C=0.85	C=1.0	
Bonaire	156.85				151.83			5.02			0.56

Drainage Subarea ID	Drainage Area (acres)	Percent Impervious									
		Undeveloped	Residential Rural	Residential Large Lot (>1/4 acre)	Residential Small Lot (<1/4 acre)	Developed Green Areas	Light Industrial	High Density	Transportation	Water	Computed Percent Impervious
		I=0%	I=5%	I=20%	I=40%	I=15%	I=60%	I=85%	I=90%	I=100%	
Bonaire	156.85				151.83			5.02			41.4%

Drainage System ID	Drainage Area (acres)	Peak Flow			
		C-Value (---)	Tc (min)	I_2 (in/hr)	Q_2 (cfs)
Bonaire	156.85	0.56	30.92	3.27	285.8

Atlas 14 2-Yr Precipitation	
Duration (min)	Intensity (in/hr)
10	5.47
15	4.62
30	3.3
60	2.19

APPENDIX C: STORM SEWER PROFILES AND DETENTION ESTIMATES

Kolbe Road and Related Infrastructure Drainage Study

HARRIS COUNTY

BOND PROGRAM 2018

Legend

- Segment 1
- Segment 2
- Segment 3
- Segment 4
- Segment 5
- Segment 6
- Segment 7
- Segment 8
- Segment 9
- Segment 10
- Segment 11
- Segment 12
- Segment 13

N

0 150 300

Feet

Exhibit C1
Proposed Storm Sewer Segments

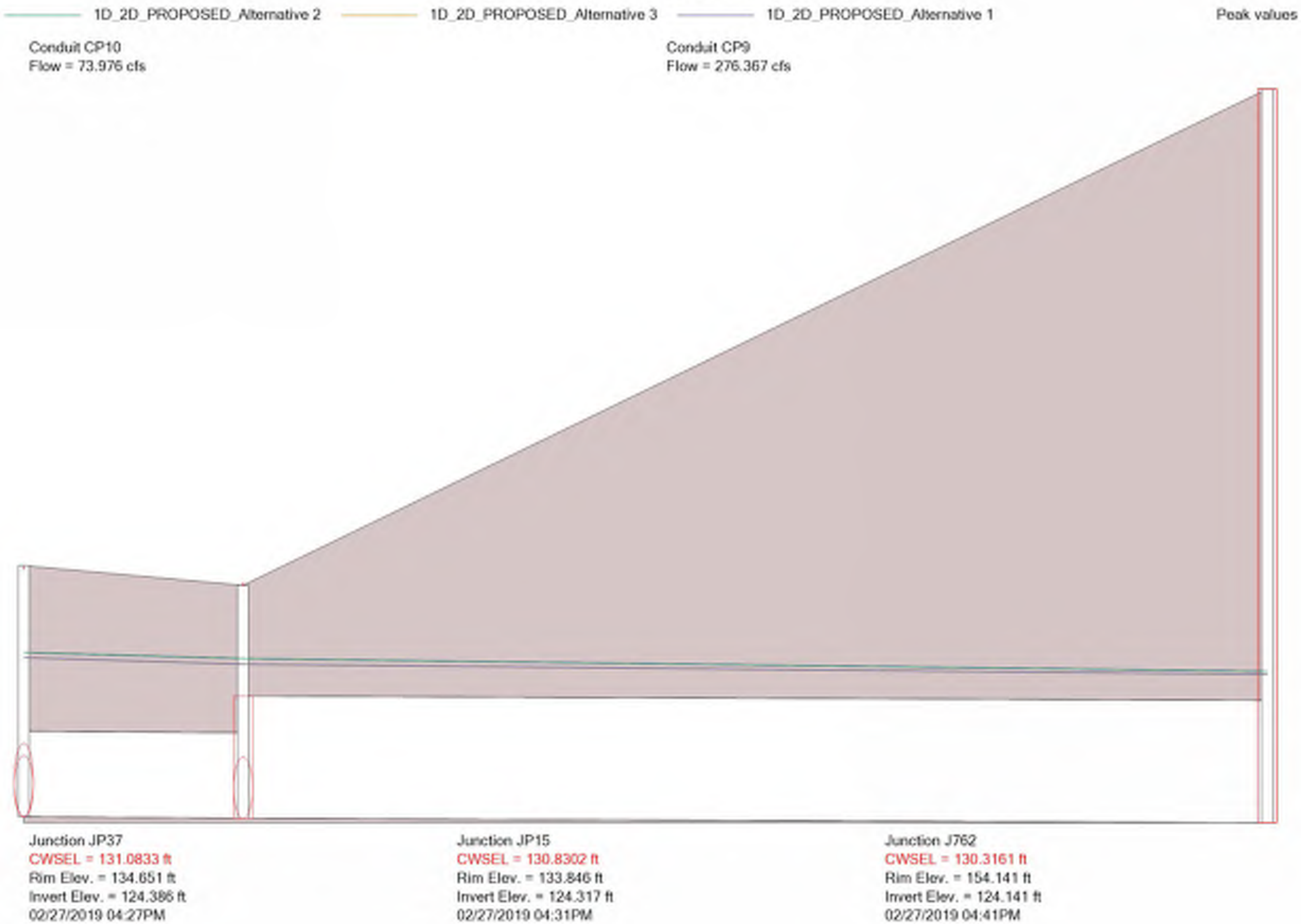
NEEL-SCHAFFER

04/24/19

www.hcfcd.org/2018bondprogram

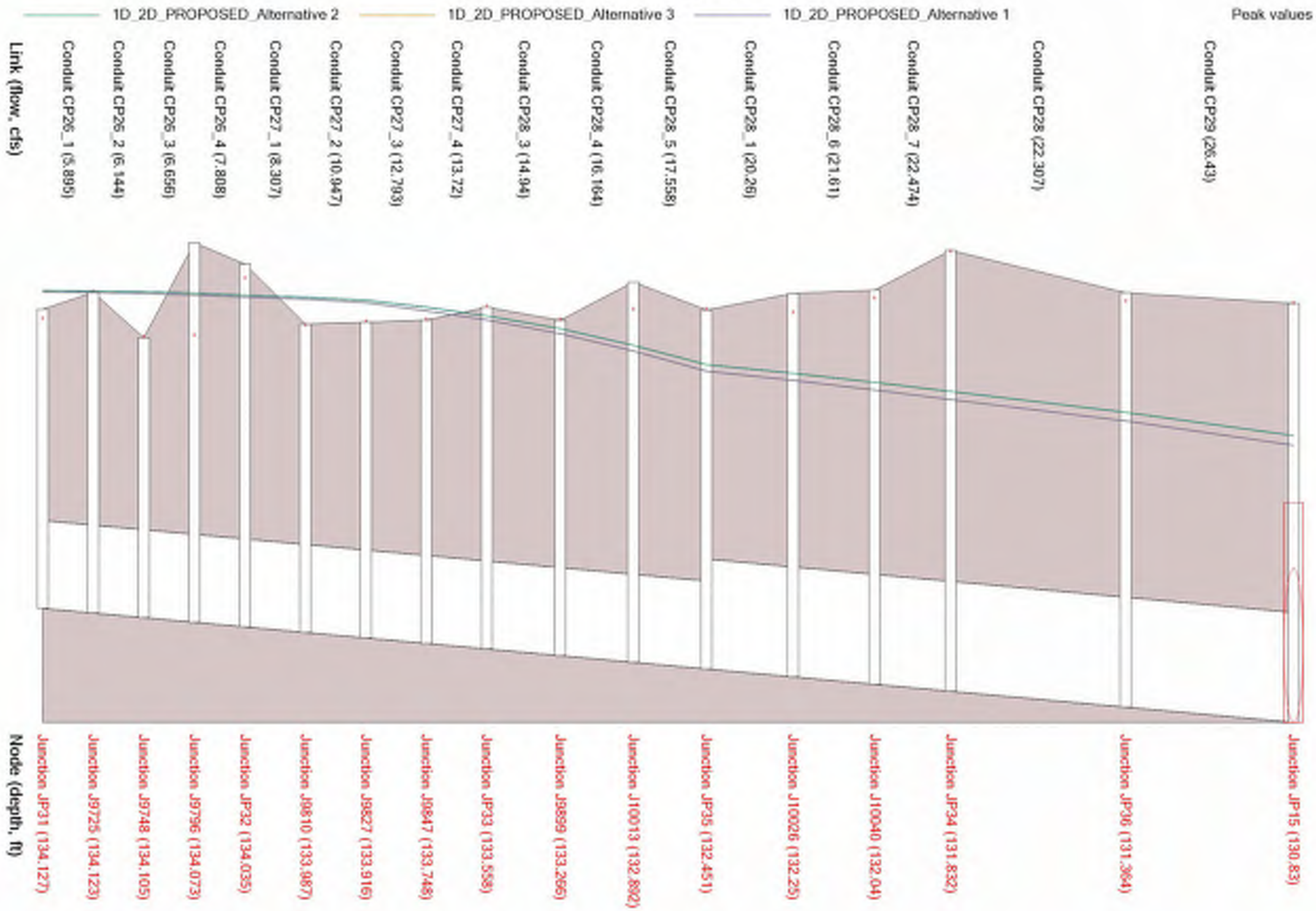
HGL Profile Plot

Segment 1 (Alternatives 1, 2 and 3)



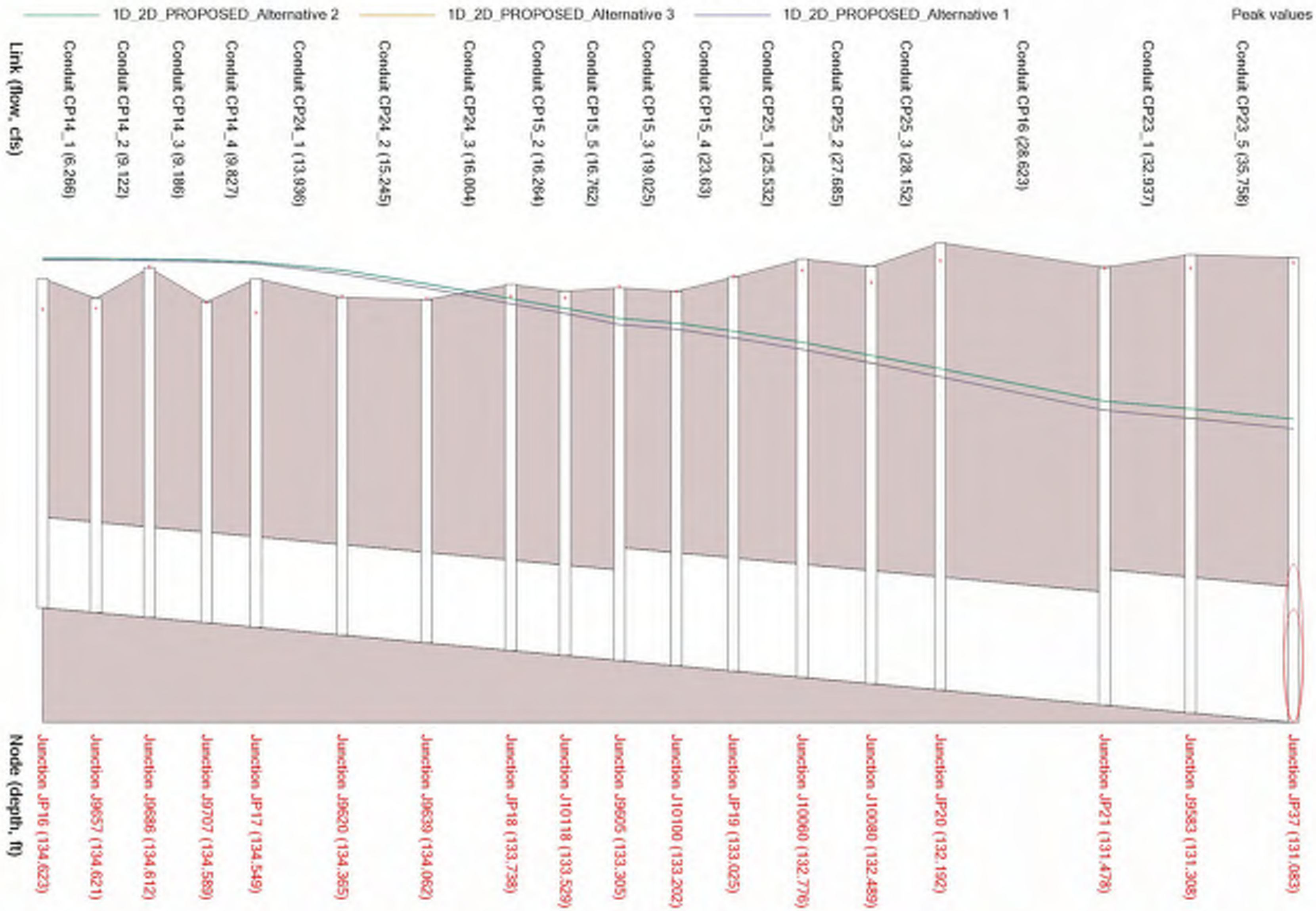
HGL Profile Plot

Segment 2 (Alternatives 1, 2 and 3)



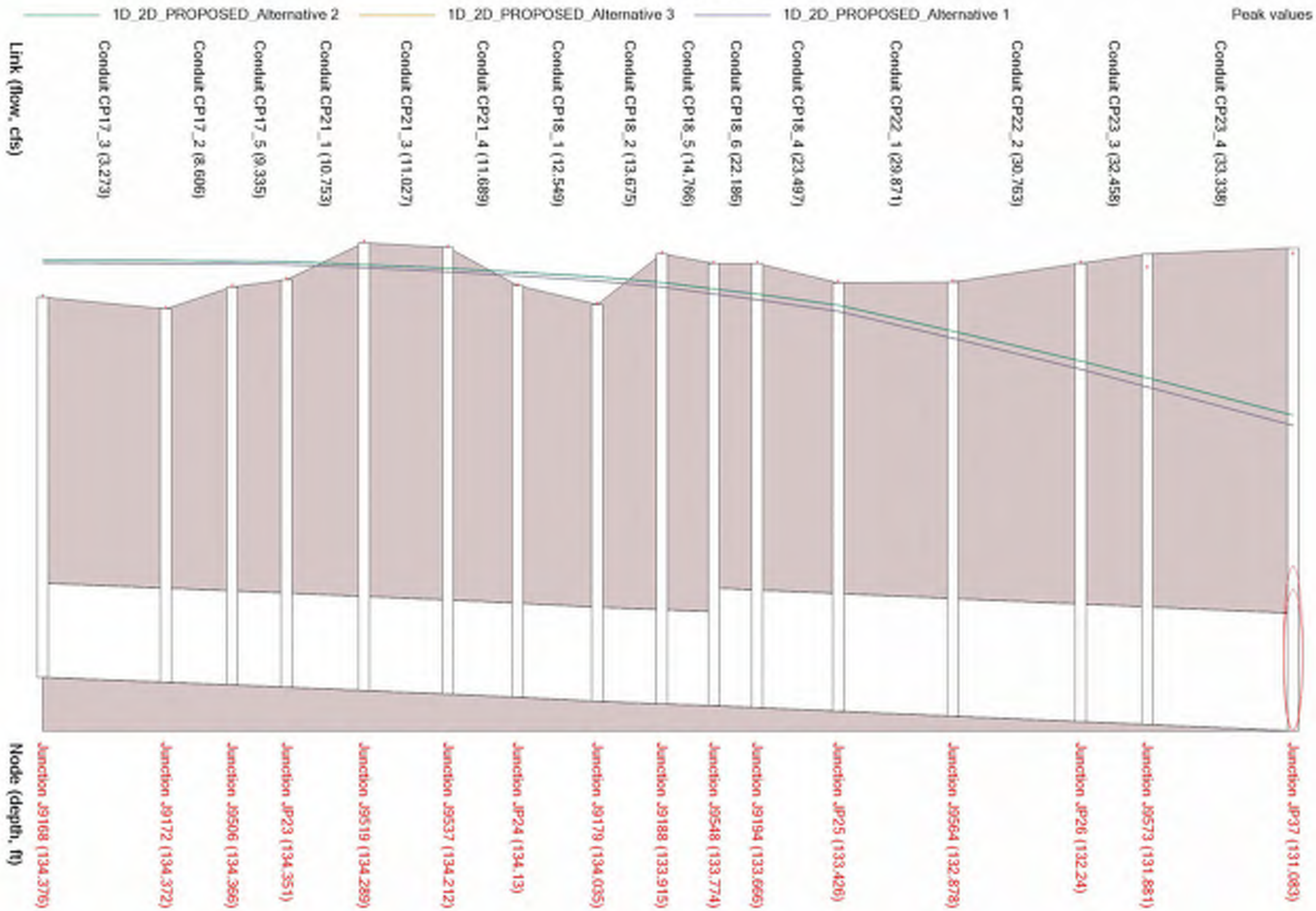
HGL Profile Plot

Segment 3 (Alternatives 1, 2 and 3)



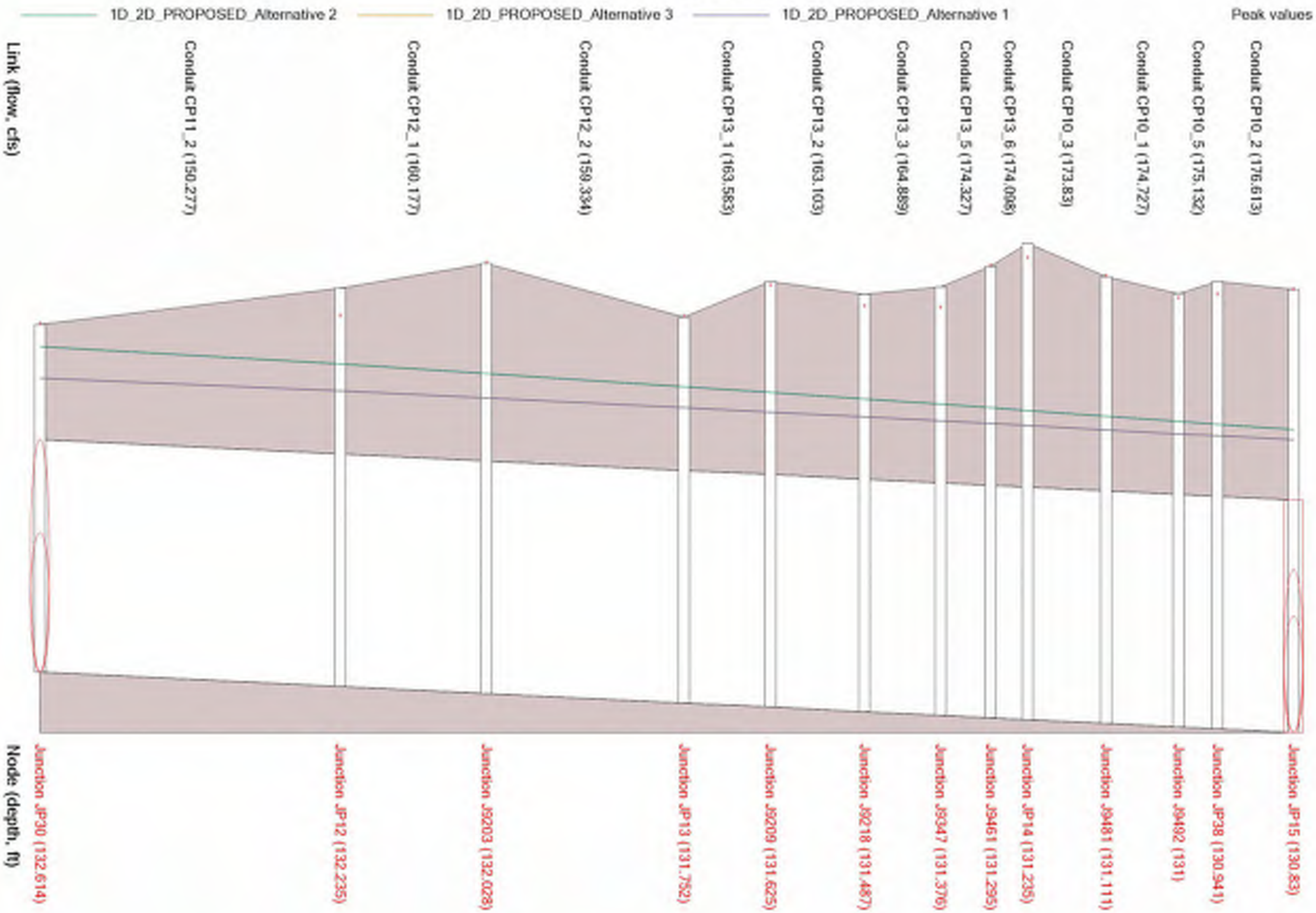
HGL Profile Plot

Segment 4 (Alternatives 1, 2 and 3)



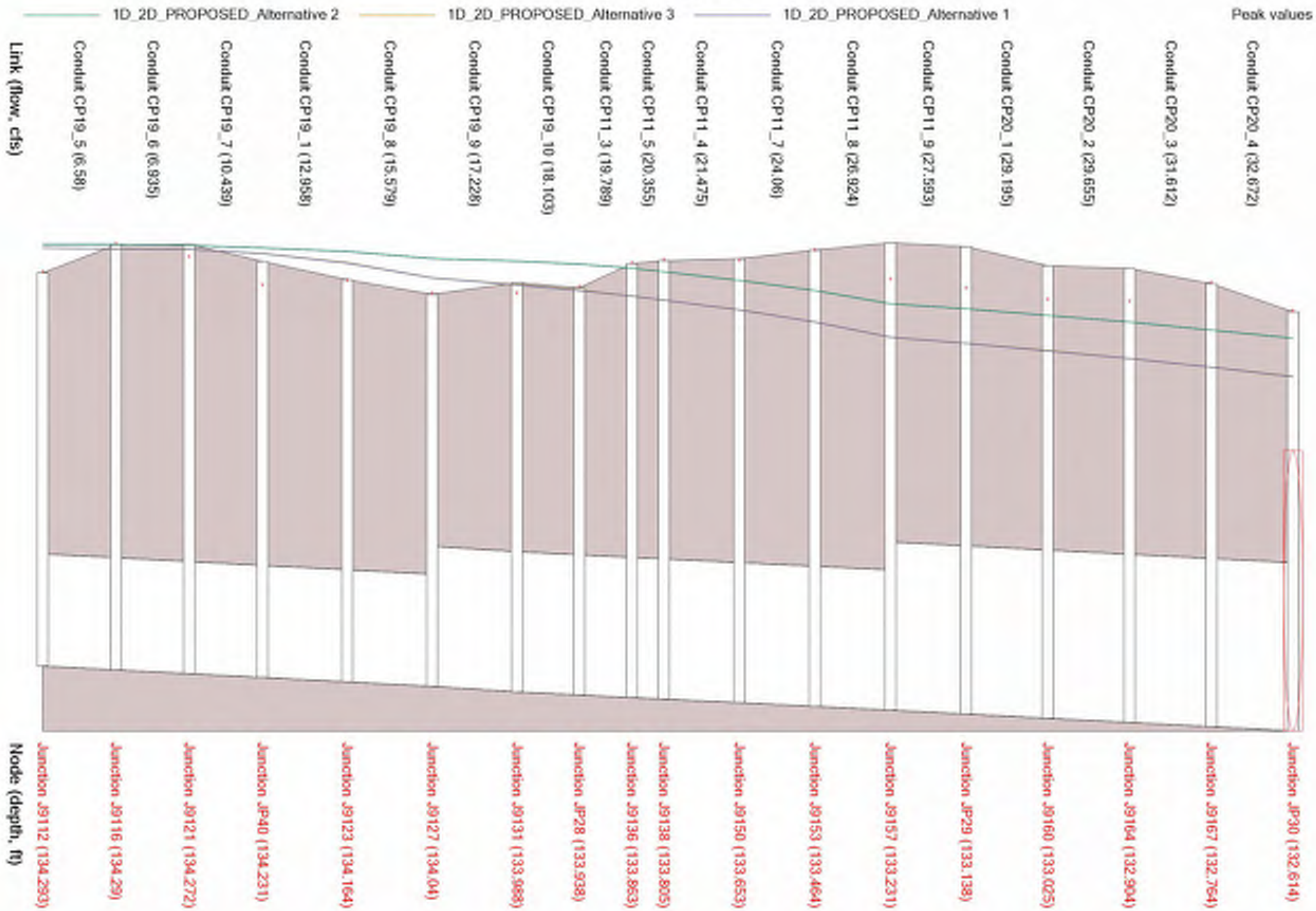
HGL Profile Plot

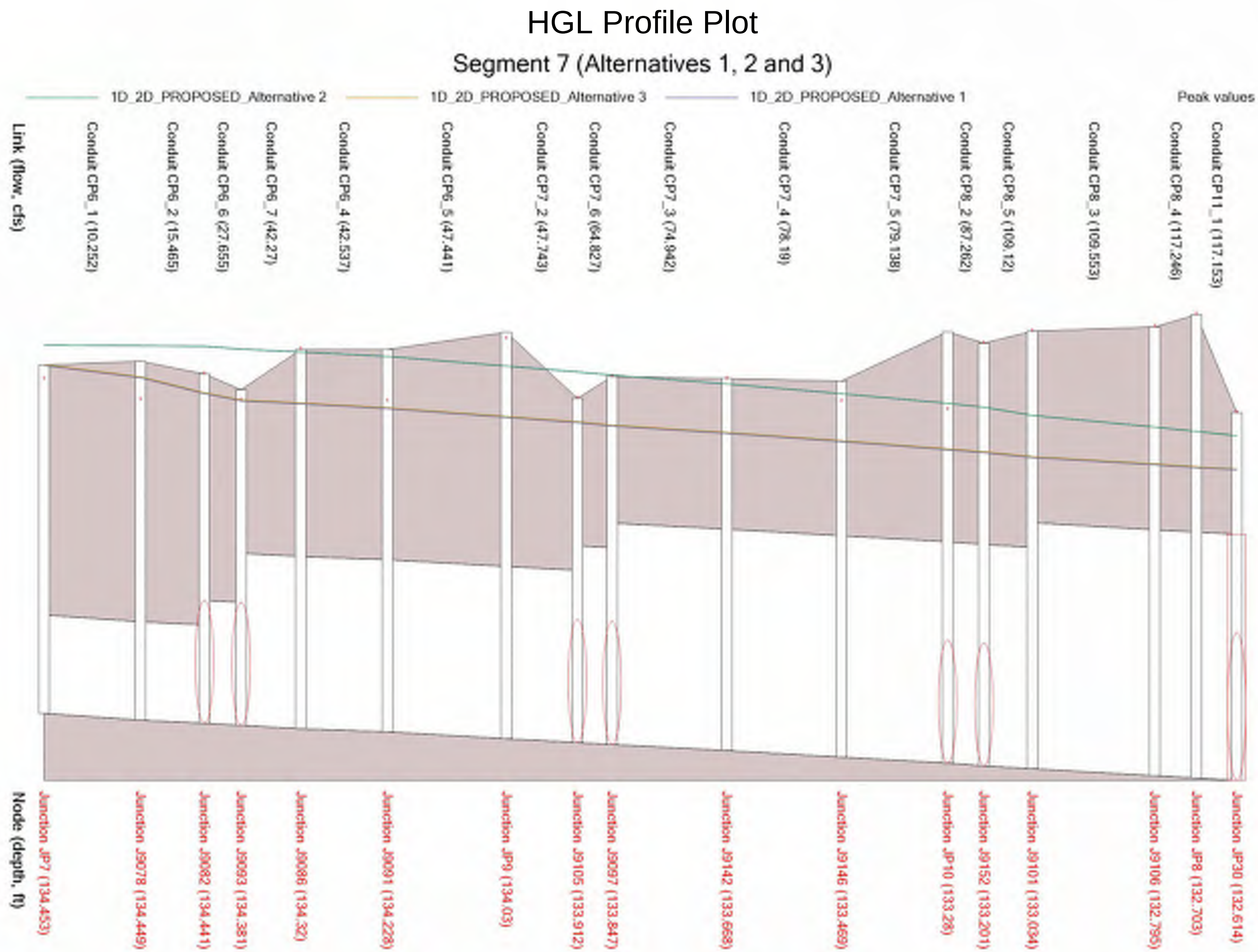
Segment 5 (Alternatives 1, 2 and 3)



HGL Profile Plot

Segment 6 (Alternatives 1, 2 and 3)

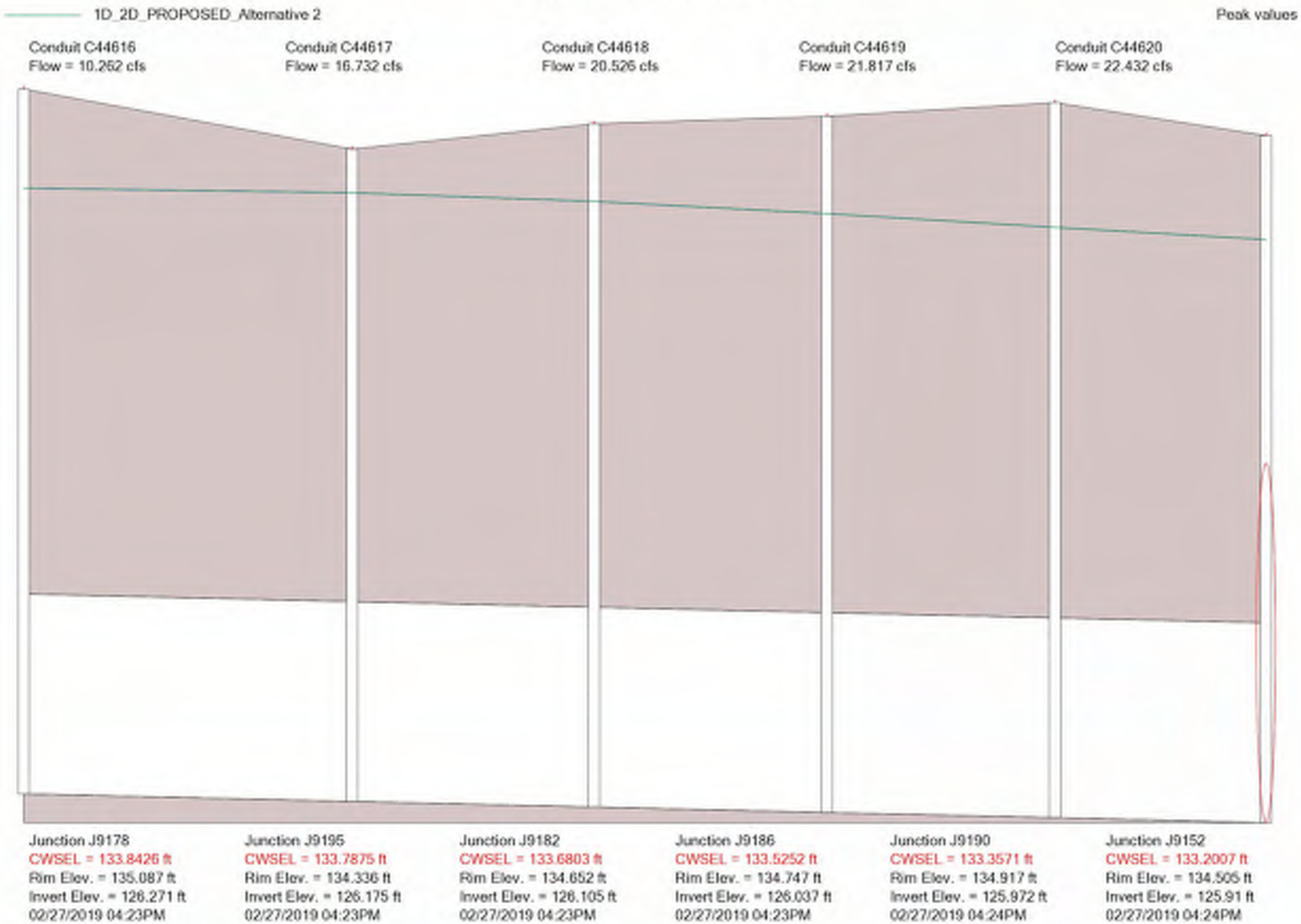




HGL Profile Plot
Segment 7 (Alternatives 1, 2 and 3)
1D_2D_PROPOSED_Alternative 2
1D_2D_PROPOSED_Alternative 3
1D_2D_PROPOSED_Alternative 1
Peak values
Link (flow, cfs)
Conduit CP6_1 (10.252)
Conduit CP6_2 (15.465)
Conduit CP6_6 (27.655)
Conduit CP6_7 (42.27)
Conduit CP6_4 (42.537)
Conduit CP6_5 (47.441)
Conduit CP7_2 (47.743)
Conduit CP7_6 (64.827)
Conduit CP7_3 (74.942)
Conduit CP7_4 (78.19)
Conduit CP7_5 (79.138)
Conduit CP8_2 (87.262)
Conduit CP8_5 (109.12)
Conduit CP8_3 (109.553)
Conduit CP8_4 (117.246)
Conduit CP11_1 (117.153)
Node (depth, ft)
Junction JP7 (134.453)
Junction J9078 (134.449)
Junction J9082 (134.441)
Junction J9093 (134.381)
Junction J9086 (134.32)
Junction J9091 (134.228)
Junction JP9 (134.03)
Junction J9105 (133.912)
Junction J9097 (133.847)
Junction J9142 (133.668)
Junction J9146 (133.469)
Junction JP10 (133.28)
Junction J9152 (133.201)
Junction J9101 (133.034)
Junction J9106 (132.795)
Junction JP8 (132.703)
Junction JP30 (132.614)

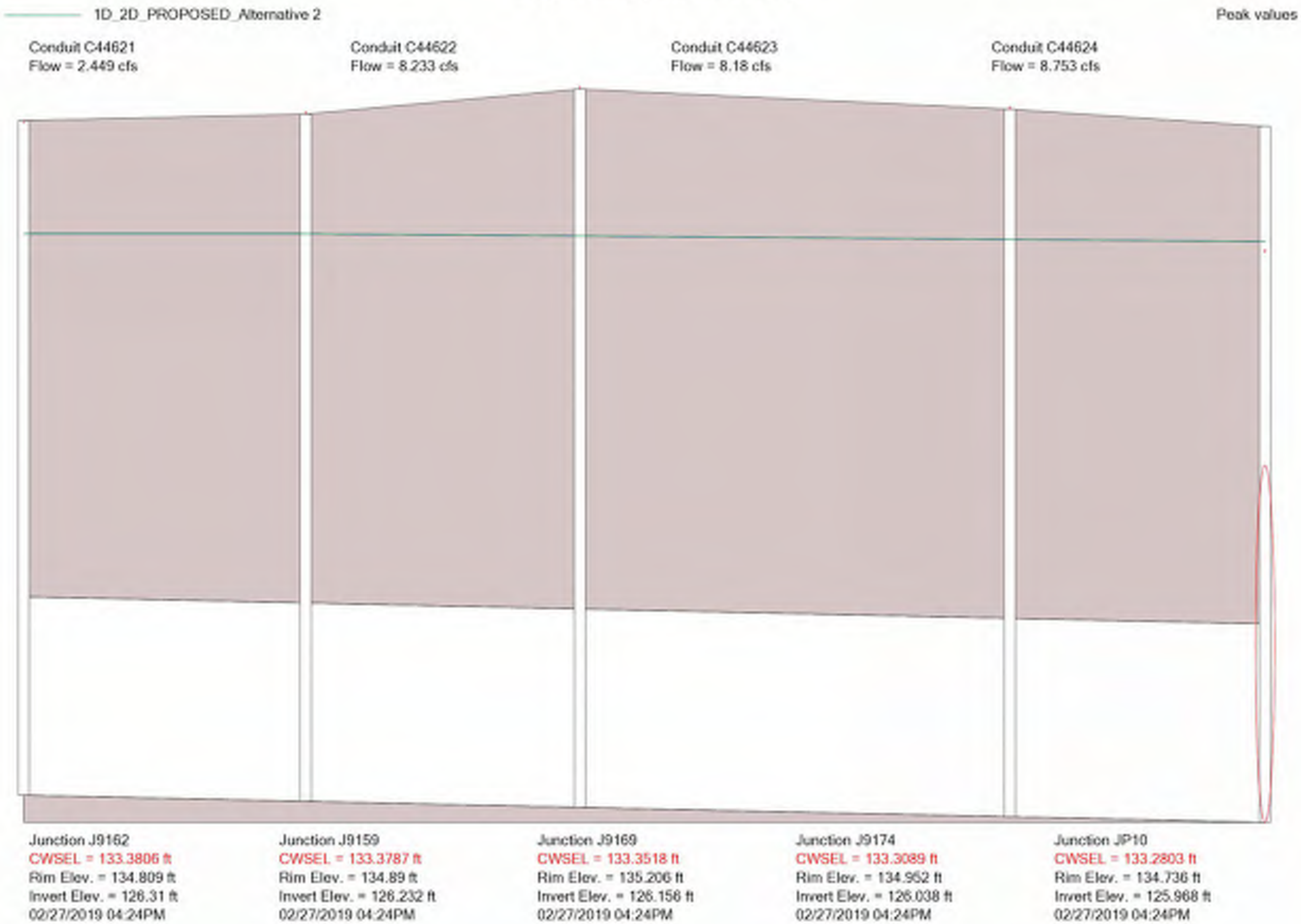
HGL Profile Plot

Segment 8 (Alternative 2)



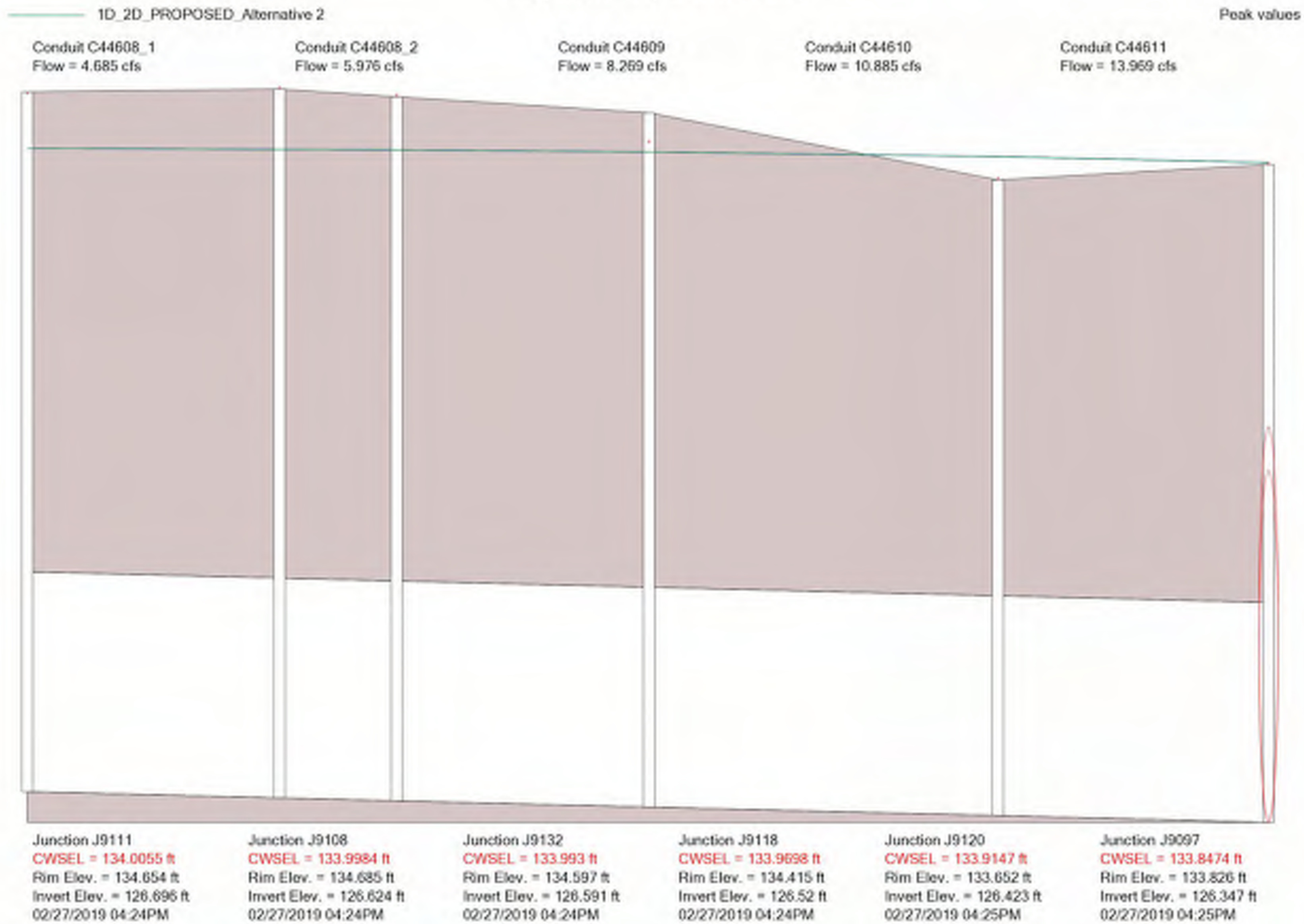
HGL Profile Plot

Segment 9 (Alternative 2)



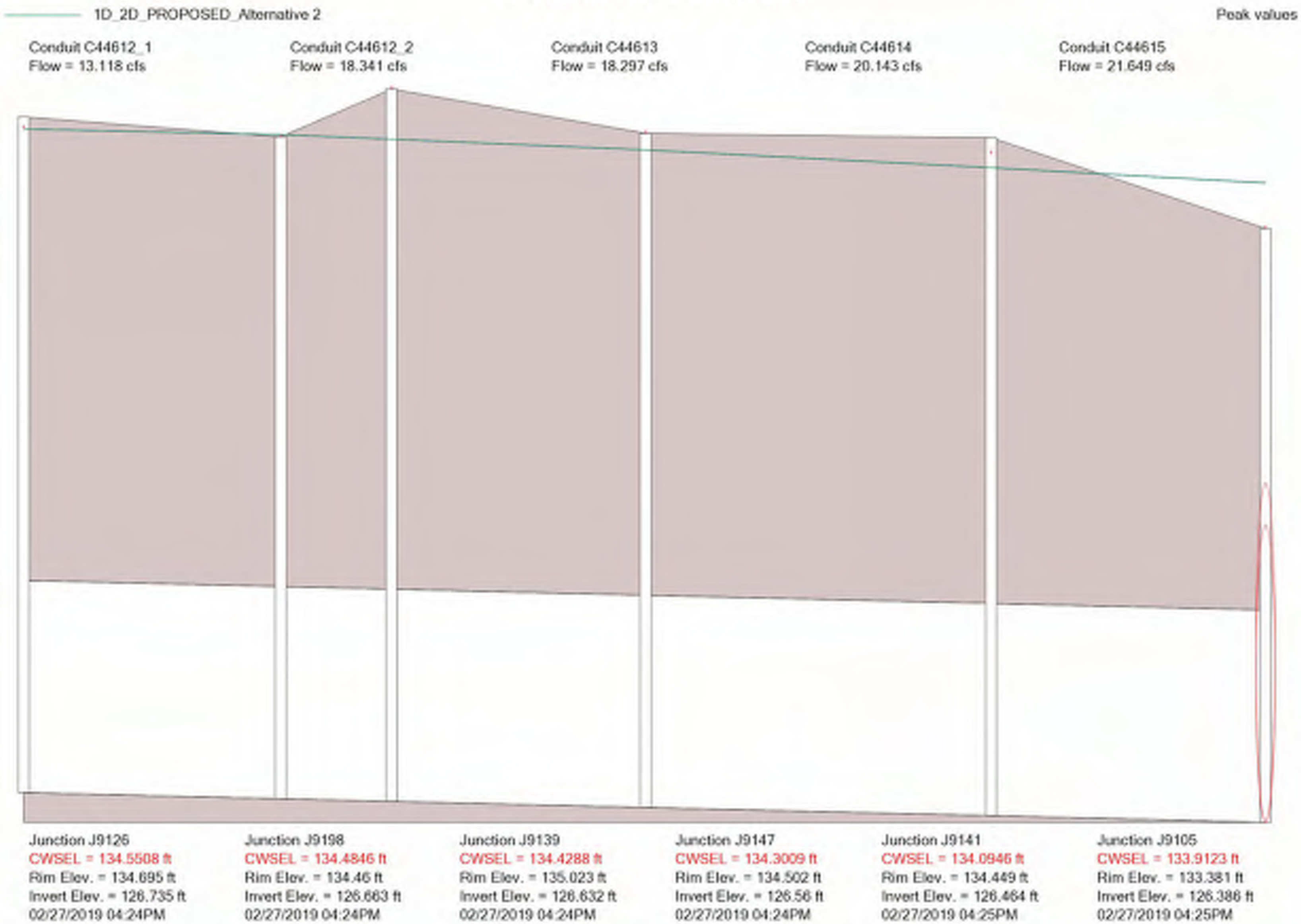
HGL Profile Plot

Segment 10 (Alternative 2)



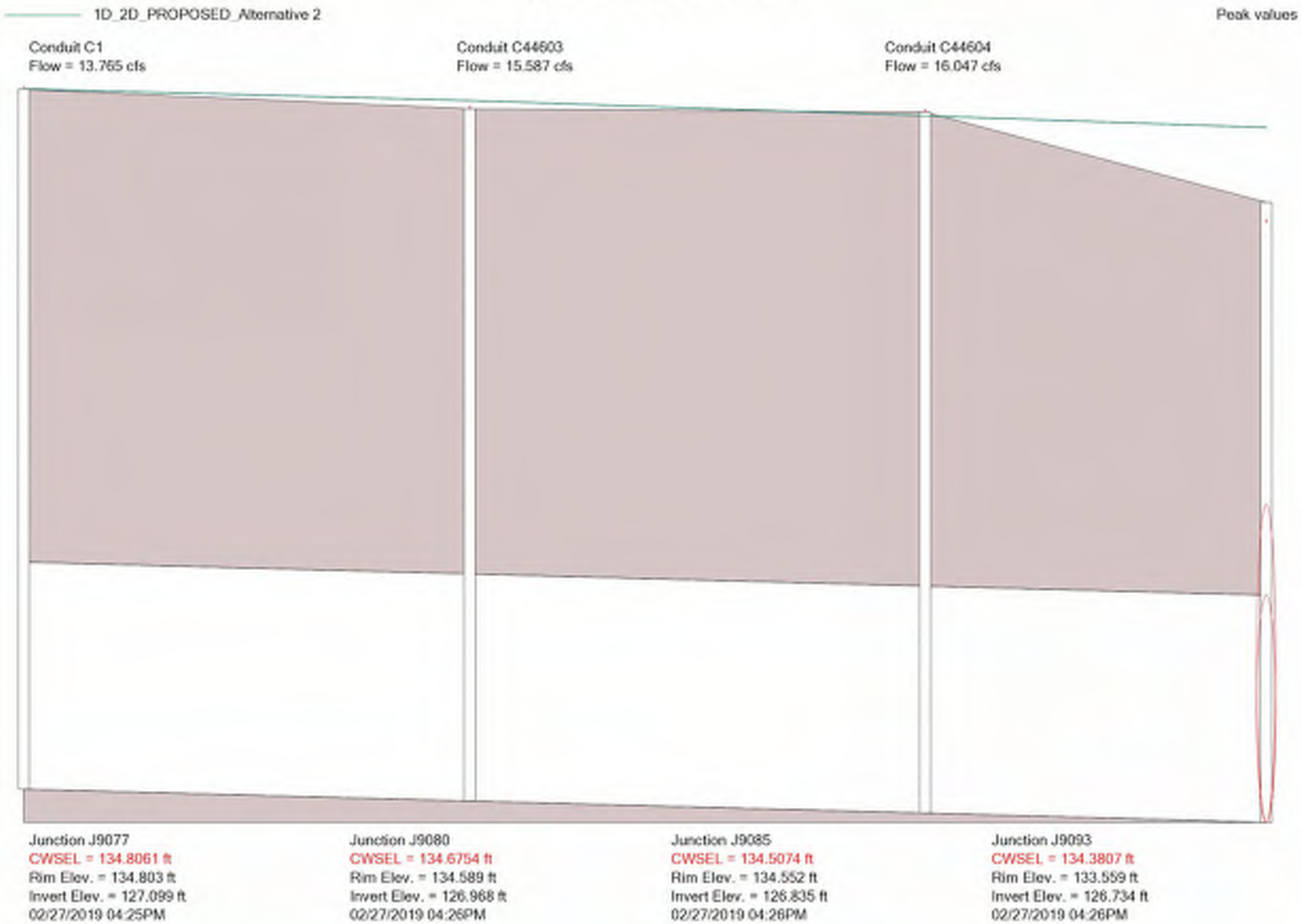
HGL Profile Plot

Segment 11 (Alternative 2)



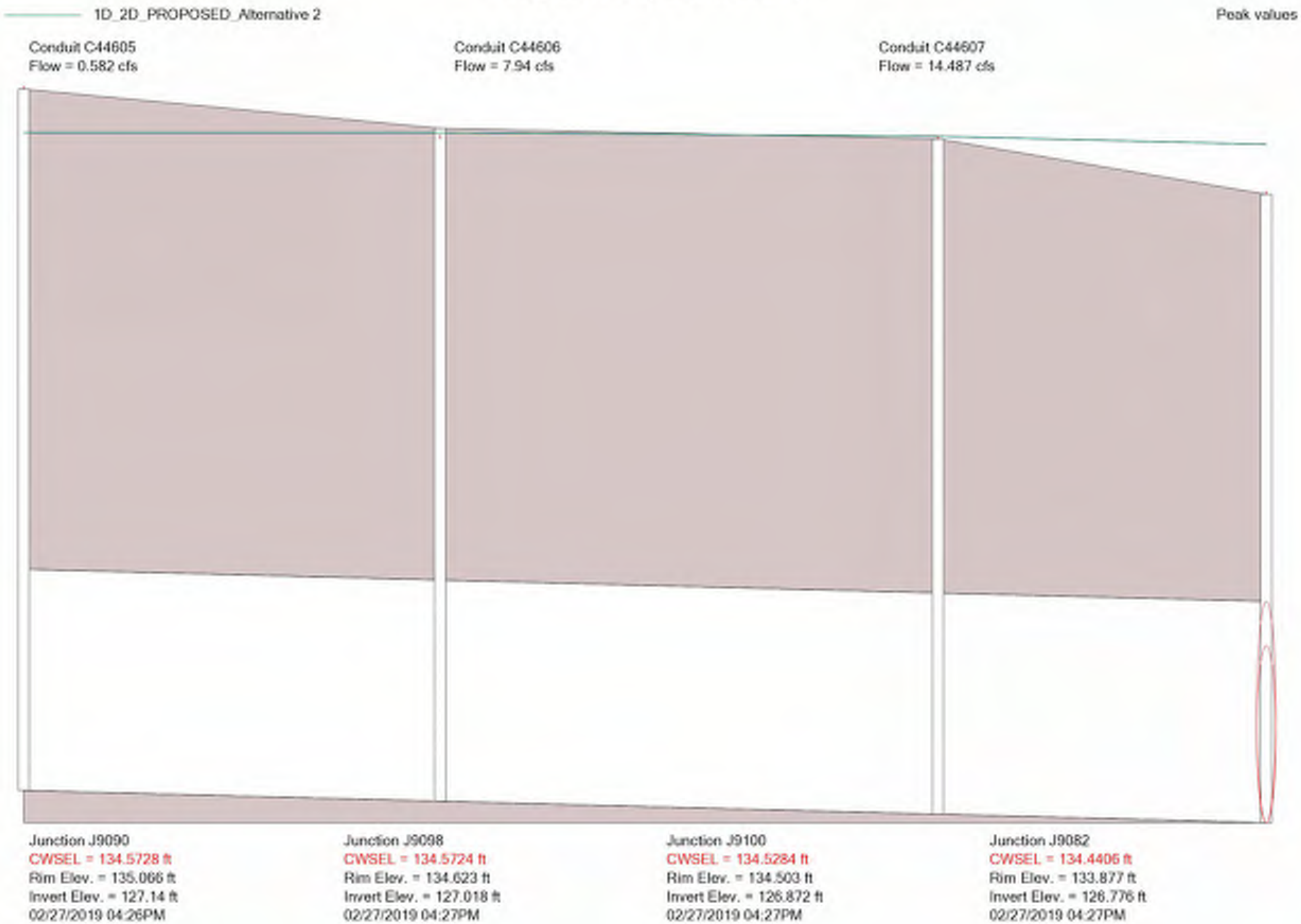
HGL Profile Plot

Segment 12 (Alternative 2)



HGL Profile Plot

Segment 13 (Alternative 2)



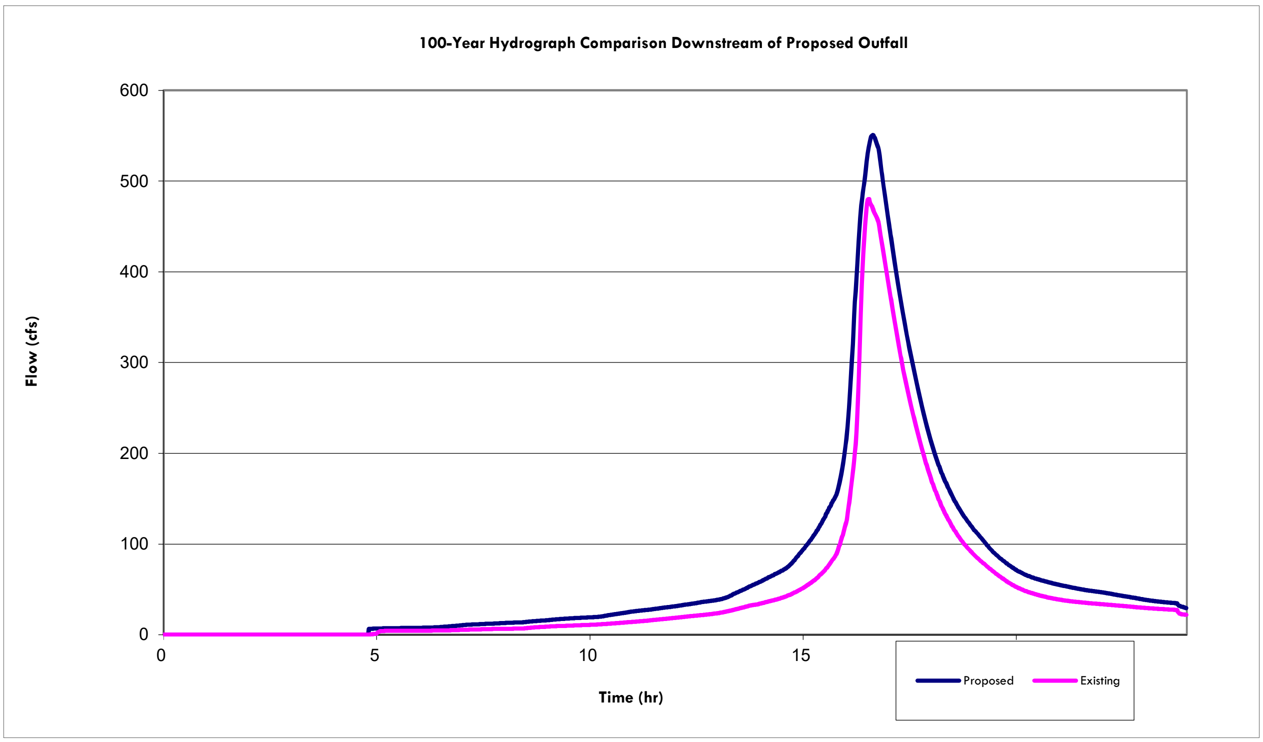
Alternative 1 100-YEAR DETENTION VOLUME CALCULATION

Project Name: Kolbe Road & Related Infrastructure
Location: Houston, Texas
Date: 04/24/19

Computation Parameters:

Design Storm = 100 year
Storm Duration = 24 hours

Calculated	Difference
Existing Peak Flow (cfs)	480.1
Proposed Peak Flow (cfs)	550.7
Flow (cfs)	70.6
Volume (ac-ft)	35.5



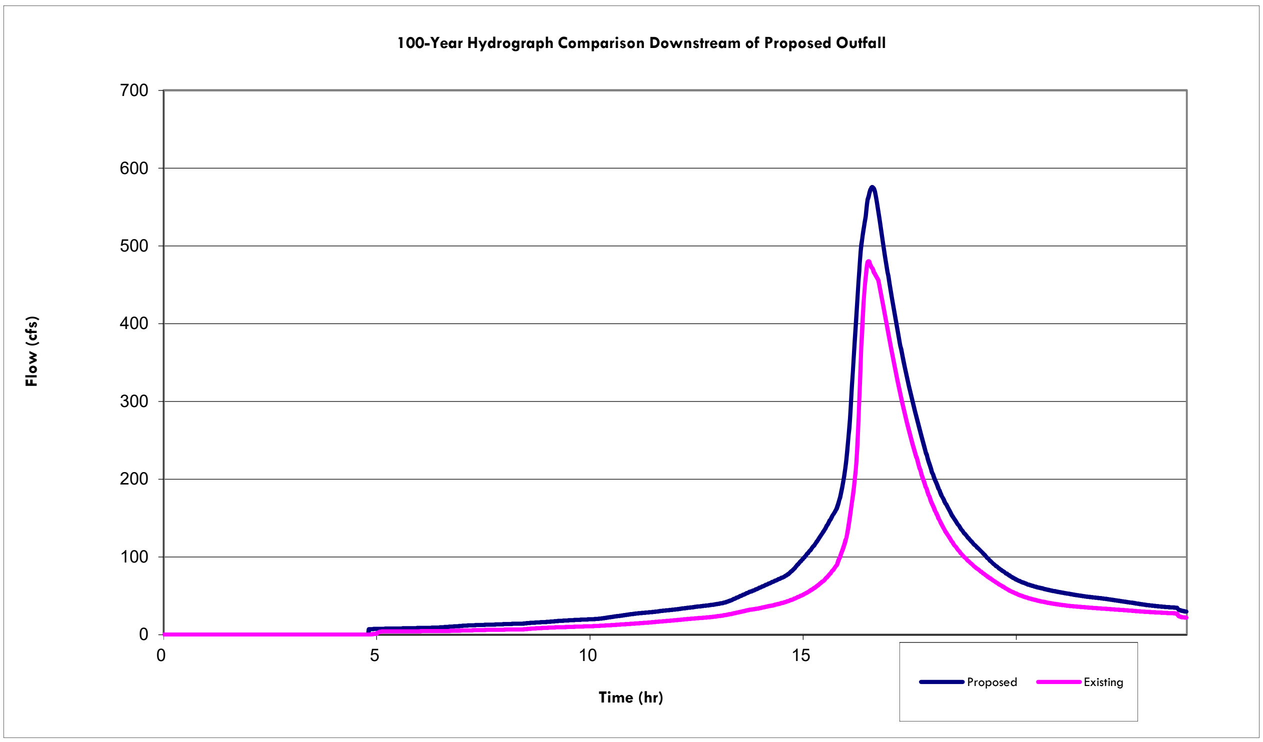
Alternative 2 100-YEAR DETENTION VOLUME CALCULATION

Project Name: Kolbe Road & Related Infrastructure
Location: Houston, Texas
Date: 04/24/19

Computation Parameters:

Design Storm = 100 year
Storm Duration = 24 hours

Calculated	Difference
Existing Peak Flow (cfs)	480.1
Proposed Peak Flow (cfs)	*575.7*
Flow (cfs)	95.5
Volume (ac-ft)	38.4



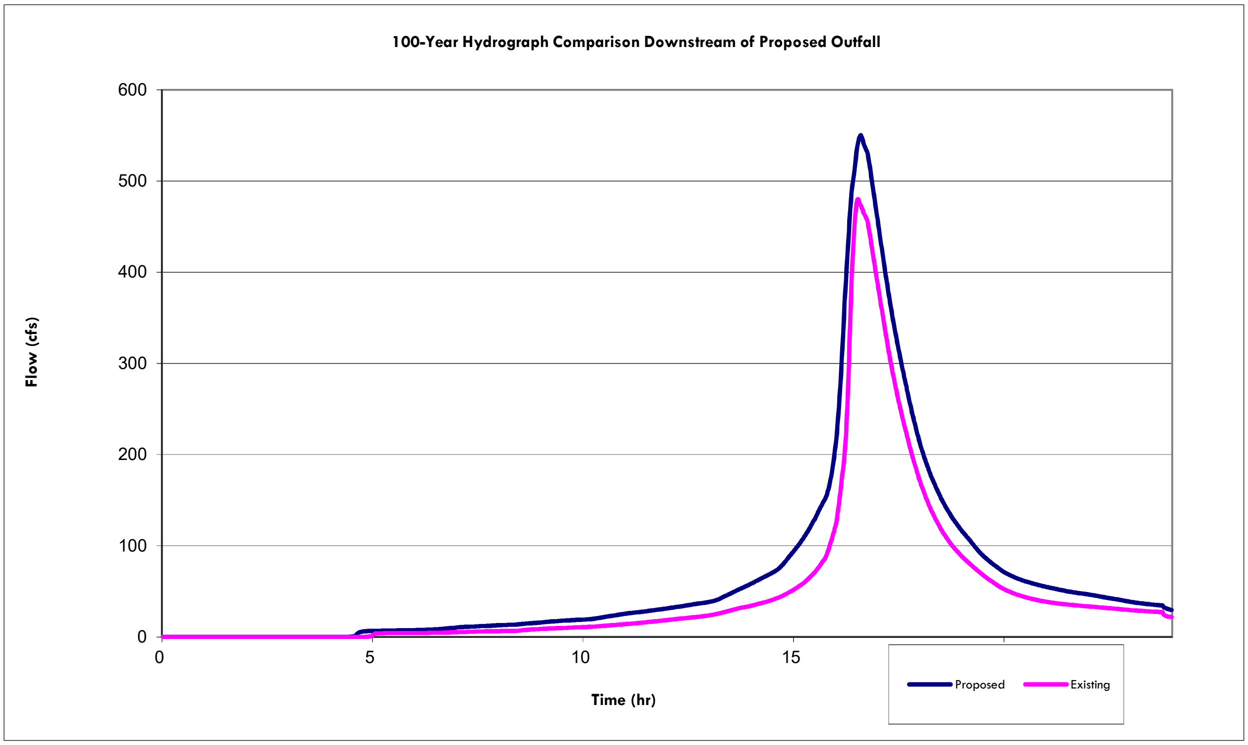
Alternative 3 100-YEAR DETENTION VOLUME CALCULATION

Project Name: Kolbe Road & Related Infrastructure
Location: Houston, Texas
Date: 06/18/19

Computation Parameters:

Design Storm = 100 year
Storm Duration = 24 hours

Calculated	Difference
Existing Peak Flow (cfs)	480.1
Proposed Peak Flow (cfs)	550.3
Flow (cfs)	70.2
Volume (ac-ft)	35.7



APPENDIX D: COST ESTIMATE

Cost Estimate for Proposed Alternative 1				
Item Description	**Unit of Measure**	**Estimated Unit of Quantity**	**Unit Price**	**Cost**
BASE UNIT PRICES - PAVING ITEMS				
Remove and Dispose of Existing Driveways	SY	800	$6	$4,800
Remove and Dispose of Existing Asphalt Pavement	SY	160	$10	$1,600
6" Concrete for Driveways	SF	7920	$13	$102,960
Asphalt Pavement, 4"	SY	180	$52	$9,360
Lime Stabilized Subgrade, 6" Thick	SY	1060	$18	$19,080
Ancillary Paving Items (10%)	LS			$13,780
TOTAL BASE UNIT PRICES - PAVING ITEMS				$151,580
BASE UNIT PRICES - DRAINAGE ITEMS				
Driveway Culvert Removal	LF	600	$20	$12,000
Install 24-Inch Diameter Storm Sewer	LF	2425	$70	$169,750
Install 30-Inch Diameter Storm Sewer	LF	1920	$110	$211,200
Install 36-Inch Diameter Storm Sewer	LF	1080	$120	$129,600
Install 42-Inch Diameter Storm Sewer	LF	55	$140	$7,700
Install 48-Inch Diameter Storm Sewer	LF	455	$165	$75,075
Install 54-Inch Diameter Storm Sewer	LF	300	$220	$66,000
Install 5-Foot by 5-Foot Box Storm Sewer	LF	1305	$320	$417,600
Install 7-Foot by 5-Foot Box Storm Sewer	LF	315	$480	$151,200
Type C Manhole for 42-Inch Diameter and Smaller Sewers	EACH	24	$3,000	$72,000
Type C Manhole for 48-Inch to 72-Inch Diameter Sewers	EACH	6	$4,800	$28,800
Junction Box with Manhole	EACH	5	$10,000	$50,000
Install Type A Grate Inlets	EACH	110	$1,500	$165,000
Detention Pond Excavation	CY	57273	$10	$572,732
TOTAL BASE UNIT PRICES - DRAINAGE ITEMS				$2,128,657
SUBTOTAL CONSTRUCTION				$2,280,237
CONTINGENCY (30% CONSTRUCTION)				$684,071.1
ENGINEERING FEE ESTIMATE (20% CONSTRUCTION)				$456,047.4
LAND ACQUISITION				
30-Foot Drainage Easement	AC	0.2	$80,000	$16,000
ROW Detention Pond	AC	6	$80,000	$480,000
TOTAL LAND ACQUISITION				$496,000
TOTAL				$3,916,356

Cost Estimate for Proposed Alternative 2				
Item Description	**Unit of Measure**	**Estimated Unit of Quantity**	**Unit Price**	**Cost**
BASE UNIT PRICES - PAVING ITEMS				
Remove and Dispose of Existing Driveways	SY	1320	$6	$7,920
Remove and Dispose of Existing Asphalt Pavement	SY	160	$10	$1,600
6" Concrete for Driveways	SF	13068	$13	$169,884
Asphalt Pavement, 4"	SY	180	$52	$9,360
Lime Stabilized Subgrade, 6" Thick	SY	1632	$18	$29,376
Ancillary Paving Items (10%)	LS			$21,814
TOTAL BASE UNIT PRICES - PAVING ITEMS				$239,954
BASE UNIT PRICES - DRAINAGE ITEMS				
Driveway Culvert Removal	LF	970	$20	$19,400
Install 24-Inch Diameter Storm Sewer	LF	2425	$70	$169,750
Install 30-Inch Diameter Storm Sewer	LF	4130	$110	$454,300
Install 36-Inch Diameter Storm Sewer	LF	535	$120	$64,200
Install 42-Inch Diameter Storm Sewer	LF	445	$140	$62,300
Install 48-Inch Diameter Storm Sewer	LF	30	$190	$5,700
Install 54-Inch Diameter Storm Sewer	LF	485	$220	$106,700
Install 60-Inch Diameter Storm Sewer	LF	240	$240	$57,600
Install 6-Foot by 5-Foot Box Storm Sewer	LF	1305	$380	$495,900
Install 7-Foot by 5-Foot Box Storm Sewer	LF	315	$480	$151,200
Type C Manhole for 42-Inch Diameter and Smaller Sewers	EACH	30	$3,000	$90,000
Type C Manhole for 48-Inch to 72-Inch Diameter Sewers	EACH	6	$4,800	$28,800
Junction Box with Manhole	EACH	5	$10,000	$50,000
Install Type A Grate Inlets	EACH	125	$1,500	$187,500
Detention Pond Excavation	CY	61952	$10	$619,519
TOTAL BASE UNIT PRICES - DRAINAGE ITEMS				$2,562,869
SUBTOTAL CONSTRUCTION				$2,802,823
CONTINGENCY (30% CONSTRUCTION)				$840,846.8
ENGINEERING FEE ESTIMATE (20% CONSTRUCTION)				$560,564.5
LAND ACQUISITION				
30-Foot Drainage Easement	AC	0.2	$80,000	$16,000
ROW Detention Pond	AC	6	$80,000	$480,000
TOTAL LAND ACQUISITION				$496,000
TOTAL				$4,700,234

Cost Estimate for Proposed Alternative 3				
Item Description	**Unit of Measure**	**Estimated Unit of Quantity**	**Unit Price**	**Cost**
BASE UNIT PRICES - PAVING ITEMS				
Remove and Dispose of Existing Driveways	SY	1320	$6	$7,920
Remove and Dispose of Existing Asphalt Pavement	SY	160	$10	$1,600
6" Concrete for Driveways	SF	13068	$13	$169,884
Asphalt Pavement, 4"	SY	180	$52	$9,360
Lime Stabilized Subgrade, 6" Thick	SY	1632	$18	$29,376
Ancillary Paving Items (10%)	LS			$21,814
TOTAL BASE UNIT PRICES - PAVING ITEMS				$239,954
BASE UNIT PRICES - DRAINAGE ITEMS				
Driveway Culvert Removal	LF	970	$20	$19,400
Install 24-Inch Diameter Storm Sewer	LF	2425	$70	$169,750
Install 30-Inch Diameter Storm Sewer	LF	2075	$110	$228,250
Install 36-Inch Diameter Storm Sewer	LF	535	$120	$64,200
Install 42-Inch Diameter Storm Sewer	LF	445	$140	$62,300
Install 48-Inch Diameter Storm Sewer	LF	30	$190	$5,700
Install 54-Inch Diameter Storm Sewer	LF	485	$220	$106,700
Install 60-Inch Diameter Storm Sewer	LF	240	$240	$57,600
Install 6-Foot by 5-Foot Box Storm Sewer	LF	1305	$380	$495,900
Install 7-Foot by 5-Foot Box Storm Sewer	LF	315	$480	$151,200
Type C Manhole for 42-Inch Diameter and Smaller Sewers	EACH	30	$3,000	$90,000
Type C Manhole for 48-Inch to 72-Inch Diameter Sewers	EACH	6	$4,800	$28,800
Junction Box with Manhole	EACH	5	$10,000	$50,000
Install Type A Grate Inlets	EACH	125	$1,500	$187,500
Detention Pond Excavation	CY	61952	$10	$619,519
TOTAL BASE UNIT PRICES - DRAINAGE ITEMS				$2,336,819
SUBTOTAL CONSTRUCTION				$2,576,773
CONTINGENCY (30% CONSTRUCTION)				$773,031.8
ENGINEERING FEE ESTIMATE (20% CONSTRUCTION)				$515,354.5
LAND ACQUISITION				
30-Foot Drainage Easement	AC	0.2	$80,000	$16,000
ROW Detention Pond	AC	6	$80,000	$480,000
TOTAL LAND ACQUISITION				$496,000
TOTAL				$4,361,159

APPENDIX E: HARRIS COUNTY PROJECT SCOPING & COST ESTIMATING DEVELOPMENT TOOL

Alternative 1

HARRIS COUNTY

Project Scoping & Cost Estimating Development Tool

KOLBE ROAD & RELATED INFRASTRUCTURE DRAINAGE IMPROVEMENTS

PROJECT NAME

3

PRECINCT

Areas highlighted are to be completed by Consultant

PREPARER INFORMATION		PROJECT INFORMATION	
1. DATE SUBMITTED:	4/25/19	4. PROJECT TYPE:	Drainage Improvements
2. SUBMITTED BY:	Connor McColloch, P.E.	5. PROJECT TITLE:	Kolbe Road and Related Infrastructure
3. NAME OF FIRM:	Neel-Schaffer, Inc.		

6. ESTIMATED FUNDING (Item 6 to be prepared by Harris County):		
A. CDBG-DR:		** Specify MUD or Other Funding Sources:*
B. OTHER FEDERAL:*		
C. STATE:		
D. COUNTY:		
E. MUD:*		
F. OTHER:*		
ESTIMATED TOTAL:	$ 0.00	

7. NO ACTION ASSESSMENT: Briefly describe the impact of taking no action to repair the damaged facilities.

If no action is taken, the buildings flooded during Harvey may experience similar flooding issues as a result of future extreme events.

DESCRIPTION OF THE NEED(S) ADDRESSED IN THIS DOCUMENT

Provide full and complete answers to each of the following. Descriptions should include the cause of the damage, current condition of the facility, and a detailed description of the project that coincides with the information contained in both Table 1 and 2. All activities must have documented proof of an impact by the floods and storms. CDBG-DR funds must be used for disaster- related expenses in the most impacted and distressed areas.

1. ***Describe the specific flood and storm-related condition that directly caused the damage(s).***

   Drainage issues are primarily caused by the flat topography, insufficient drainage capacity of the existing road side ditches, absence of any mitigations for extreme event overland flow paths, maintenance issues with the roadside ditches, and the Cypress Chase detention pond embankment failure.

2. ***Describe the system that was damaged and how it was damaged.***

   According to Harris County, 38 buildings were flooded during Hurricane Harvey.

3. ***How does the project support housing?***

   By providing increased drainage capacity, the risk of damage to buildings during extreme storms is reduced and hence, the project area will be desirable for housing.

4. ***Describe the impacts on the community that resulted in direct damage(s).***

   The community experienced flooding of 38 homes with elevations up to a foot resulting in damages to real and personal property and were without a home for an extended period of time.

5. ***Describe how the proposed activities will address damage(s) of the system affected by the floods and storms.***

   The proposed solutions are intended to mitigate the structural flooding for the project area by redirecting the overland flow into the Harris county maintained channel E133-01-00.

6. ***List materials submitted as documentation of the flood and storm-related condition.***

7. ***Describe the proposed project.***

   Storm sewers were proposed to sized to redirect excess overland flow to HCFCD Unit E133-01-00. The embankment for Cypress Chase detention pond is repaired to increase its mitigation effect during extreme events.

PROJECT SUMMARY

The Project Summary consists of 4 parts **for each target area and/or activity**: **(1)** Summarize Problem(s); **(2)** Location and Acquisition; **(3)** Detailed Actions to Address Problems; and **(4)** Disclosure on Non-CDBG-DR Funds.

PART 1 – Summarize the problem(s) to be addressed within the application by Target Area.

Drainage issues are primarily caused by the flat topography, insufficient drainage capacity of the existing road side ditches, absence of any mitigations for extreme event overland flow paths, maintenance issues with the roadside ditches, and the Cypress Chase detention pond embankment failure.

PART 2 – Identify the location of each activity/Target Area and any associated acquisition activity.
The spelling and capitalization of the Target Area name(s) listed here must match Table 1 (e.g., "Green Acres" should not appear elsewhere as "green acres subdivision."

Project Title / Target Area:	Kolbe Road and Related Infrastructure Drainage Improvements				
Activity:	Flood and Drainage Facilities				
On:		**From:**		**To:**	

- OR -

Provide a brief description of the location of the activity / Target Area.

Kolbe Rd south of Cypress North Houston Rd, S Kolbe Cir.

- OR -

Provide physical address if possible.

Latitude:	29°56'28.01"N	**Longitude:**	95°38'30.82"W

		Included:		
Please attached project area map (11 x 17)	Yes:	☑	No:	☐
Please attach existing drainage area map (11x17)	Yes:	☑	No:	☐
Please attach proposed drainage area map (11x17)	Yes:	☑	No:	☐
Please attach "Sketch Plans", illustrations or annotated drawings communicating the scope of the recommended improvements	Yes:	☑	No:	☐
Please attach scope of services for final design of the improvements	Yes:	☑	No:	☐
Please attach photographs of problems found, annotated on an area map exhibit or in an appendix	Yes:	☑	No:	☐
		Acquisition Required:		
Will acquisition associated with the project site(s) be required?	Yes:	☑	No:	☐

PART 3 – Identify the action(s) to resolve the problem(s) and their anticipated outcomes. *Include details such as specific materials and quantities.*

Replace the existing roadside ditch system with a concrete pipe storm sewer system with a swale on top. The proposed system increases the drainage capacity to meet current standards.

Connor McColloch, PE, CFM	Senior Project Manager	(713) 783-7117
Name of Preparer (Printed)	**Position / Title**	**Phone Number**
Con McColloch		connor.mccolloch@neel-schaffer.com
Signature of Preparer		**Email Address**

PROJECT SCHEDULE

Enter the projected length (in number of months) for each applicable phase / process step below. If a phase is not applicable, enter "0" in the field. *Note: Most projects should be completed in 24 months once the associated contract for the project is executed between the Applicant and the Texas General Land Office.*

PROFESSIONAL PROCUREMENT		Months
ENVIRONMENTAL REVIEW		Months
ACQUISITION		Months
ENGINEERING DESIGN	8	Months
CONSTRUCTION	10	Months
COMPLETE CLOSEOUT		Months
EXTENDED ACTIVITY		Months

ANTICIPATED COMPLETION	

If the proposed project schedule exceeds 24 months, a justification must be provided in the space below.

BENEFICIARY INFORMATION

Does the proposed project serve Low /Moderate Income beneficiaries? Yes: ☐ No: ☑

If answer above is no, provide the following information:

	Included	
Shape file of benefited area	Yes: ☑	No: ☐
Digital Elevation Model for the current condition	Yes: ☑	No: ☐
Digital Elevation Model for the proposed condition(s)	Yes: ☐	No: ☑

TABLE 1 - BUDGET

Project Title/Target Area:	Kolbe Road & Related Infrastructure Drainage Improvements
Construction Completion Type:	Contract
Activity Description	5. Flood and Drainage Facilities
Probable Construction Cost:	$ 2,965,000
Estimated Engineering Cost:	$ 456,000
Estimated Acquisition Cost:	$ 496,000
Total:	$ 3,917,000

TABLE 2: BUDGET JUSTIFICATION OF RETAIL COSTS

PROJECT TITLE / TARGET AREA: Kolbe Road & Related Infrastructure Drainage Improvements/ Paving

Act # Activity Description	Materials / Facilities / Services	$/Unit	Unit	Qty	Construction	Acquisition	TOTAL
4. Street Improvements	Remove and Dispose of Driveways	$ 6.00	SY	800	$ 4,800		$ 4,800
4. Street Improvements	Remove and Dispose of Pavement	$ 10.0	SY	**160**	$ 1,600		$ 1,600
4. Street Improvements	6" Concrete for Driveways	$ 117.	SY	880	$ 102,960		$ 102,960
4. Street Improvements	Asphalt Pavement, 4"	$ 52.0	SY	180	$ 9,360		$ 9,360
4. Street Improvements	Lime Stabilized Subgrade, 6" Thick	$ 18.0	SY	1060	$ 19,080		$ 19,080
4. Street Improvements	Ancillary Paving Items (10%)	$ 13,7		1	$ 13,780		$ 13,780
					$ 0		$ 0
					$ 0		$ 0
				COLUMN TOTALS	$ 151,580	$ 0	$ 151,580

1. Identify and explain the annual projected operation and maintenance costs associated with the proposed activities.

2. Identify and explain any/all special engineering activities.

(Architect / Engineer Seal)

Connor McColloch, PE, CFM

Signature of Registered Engineer / Architect Responsible for Budget Justification

6/4/2019

Date

(713) 783-7117

Phone Number

TABLE 2: BUDGET JUSTIFICATION OF RETAIL COSTS

PROJECT TITLE / TARGET AREA:	Kolbe Road & Related Infrastructure Drainage Improvements/ Drainage Items-Part 1

Act # Activity Description	Materials / Facilities / Services	$/Unit	Unit	Qty	Construction	Acquisition	TOTAL
5. Flood and Drainage Facilities	Driveway Culvert Removal	$ 20.0	LF	600	$ 12,000	$ 0	$ 12,000
5. Flood and Drainage Facilities	24-Inch Diameter Storm Sewer	$ 70.0	LF	**2425**	$ 169,750		$ 169,750
5. Flood and Drainage Facilities	30-Inch Diameter Storm Sewer	$ 110.	LF	1920	$ 211,200	$ 0	$ 211,200
5. Flood and Drainage Facilities	36-Inch Diameter Storm Sewer	$ 120.	LF	1080	$ 129,600		$ 129,600
5. Flood and Drainage Facilities	42-Inch Diameter Storm Sewer	$ 140.	LF	55	$ 7,700		$ 7,700
5. Flood and Drainage Facilities	48-Inch Diameter Storm Sewer	$ 165.	LF	455	$ 75,075		$ 75,075
5. Flood and Drainage Facilities	54-Inch Diameter Storm Sewer	$ 220.	LF	300	$ 66,000		$ 66,000
5. Flood and Drainage Facilities	5-Foot by 5-Foot Box Culvert	$ 320.	LF	1305	$ 417,600		$ 0
				COLUMN TOTALS	$ 671,325	$ 0	$ 671,325

1. Identify and explain the annual projected operation and maintenance costs associated with the proposed activities.

2. Identify and explain any/all special engineering activities.

STATE OF TEXAS
CONNOR McCOLLOCH
120523
LICENSED
PROFESSIONAL ENGINEER

Connor McColloch, PE, CFM

Signature of Registered Engineer / Architect Responsible for Budget Justification

6/4/2019

Date

(713) 783-7117

Phone Number

(Architect / Engineer Seal)

TABLE 2: BUDGET JUSTIFICATION OF RETAIL COSTS

PROJECT TITLE / TARGET AREA:	Kolbe Road & Related Infrastructure Drainage Improvements/ Drainage Items-Part 2

Act # Activity Description	Materials / Facilities / Services	$/Unit	Unit	Qty	Construction	Acquisition	TOTAL
5. Flood and Drainage Facilities	7-Foot by 5-Foot Box Culvert	$ 480.	LF	315	$ 151,200	$ 0	$ 151,200
5. Flood and Drainage Facilities	Type C Manhole for 0 to 42-Inch	$ 3,00	EA	**24**	$ 72,000		$ 72,000
5. Flood and Drainage Facilities	Type C Manhole for 48 to 72-Inch	$ 4,80	EA	6	$ 28,800	$ 0	$ 28,800
5. Flood and Drainage Facilities	Junction Box with Manhole	$ 10,0	EA	5	$ 50,000		$ 50,000
5. Flood and Drainage Facilities	Install Type A Grate Inlets	$ 1,50	EA	110	$ 165,000		$ 165,000
5. Flood and Drainage Facilities	Detention Pond Excavation	$ 10.0	CY	5727:	$ 572,730		$ 572,730
					$ 0		$ 0
					$ 0		$ 0
				COLUMN TOTALS	$ 1,039,73	$ 0	$ 1,039,73

1. Identify and explain the annual projected operation and maintenance costs associated with the proposed activities.

2. Identify and explain any/all special engineering activities.

(Architect / Engineer Seal)

Connor McColloch, PE, CFM

Signature of Registered Engineer / Architect Responsible for Budget Justification

6/4/2019

Date

(713) 783-7117

Phone Number

TABLE 2: BUDGET JUSTIFICATION OF RETAIL COSTS

PROJECT TITLE / TARGET AREA: Kolbe Road & Related Infrastructure Drainage Improvements/ Land Acquisition

Act # Activity Description	Materials / Facilities / Services	$/Unit	Unit	Qty	Construction	Acquisition	TOTAL
24. Acquisition – Easement	30-Foot Drainage Easement				$ 0	$ 16,000	$ 16,000
24a. Acquisition	ROW Detention Pond				$ 0	$ 480,000	$ 480,000
					$ 0	$ 0	$ 0
					$ 0		$ 0
					$ 0		$ 0
					$ 0		$ 0
					$ 0		$ 0
					$ 0		$ 0
				COLUMN TOTALS	$ 0	$ 496,000	$ 496,000

1. Identify and explain the annual projected operation and maintenance costs associated with the proposed activities.

2. Identify and explain any/all special engineering activities.

(Architect / Engineer Seal)

Connor McColloch, PE, CFM

Signature of Registered Engineer / Architect Responsible for Budget Justification

6/4/2019

Date

(713) 783-7117

Phone Number

Alternative 2

HARRIS COUNTY

Project Scoping & Cost Estimating Development Tool

KOLBE ROAD & RELATED INFRASTRUCTURE DRAINAGE IMPROVEMENTS

PROJECT NAME

3

PRECINCT

Areas highlighted are to be completed by Consultant

PREPARER INFORMATION		PROJECT INFORMATION	
1. DATE SUBMITTED:	4/25/19	4. PROJECT TYPE:	Drainage Improvements
2. SUBMITTED BY:	Connor McColloch, P.E.	5. PROJECT TITLE:	Kolbe Road and Related Infrastructure
3. NAME OF FIRM:	Neel-Schaffer, Inc.		

6. ESTIMATED FUNDING (Item 6 to be prepared by Harris County):		
A. CDBG-DR:		* Specify MUD or Other Funding Sources:
B. OTHER FEDERAL:*		
C. STATE:		
D. COUNTY:		
E. MUD:*		
F. OTHER:*		
ESTIMATED TOTAL:	$ 0.00	

7. NO ACTION ASSESSMENT: Briefly describe the impact of taking no action to repair the damaged facilities.

If no action is taken, the buildings flooded during Harvey may experience similar flooding issues as a result of future extreme events.

DESCRIPTION OF THE NEED(S) ADDRESSED IN THIS DOCUMENT

Provide full and complete answers to each of the following. Descriptions should include the cause of the damage, current condition of the facility, and a detailed description of the project that coincides with the information contained in both Table 1 and 2. All activities must have documented proof of an impact by the floods and storms. CDBG-DR funds must be used for disaster- related expenses in the most impacted and distressed areas.

1. ***Describe the specific flood and storm-related condition that directly caused the damage(s).***

   Drainage issues are primarily caused by the flat topography, insufficient drainage capacity of the existing road side ditches, absence of any mitigations for extreme event overland flow paths, maintenance issues with the roadside ditches, and the Cypress Chase detention pond embankment failure.

2. ***Describe the system that was damaged and how it was damaged.***

   According to Harris County, 38 buildings were flooded during Hurricane Harvey.

3. ***How does the project support housing?***

   By providing increased drainage capacity, the risk of damage to buildings during extreme storms is reduced and hence, the project area will be desirable for housing.

4. ***Describe the impacts on the community that resulted in direct damage(s).***

   The community experienced flooding of 38 homes with elevations up to a foot resulting in damages to real and personal property and were without a home for an extended period of time.

5. ***Describe how the proposed activities will address damage(s) of the system affected by the floods and storms.***

   The proposed solutions are intended to mitigate the structural flooding for the project area by redirecting the overland flow into the Harris county maintained channel E133-01-00.

6. ***List materials submitted as documentation of the flood and storm-related condition.***

7. ***Describe the proposed project.***

   Storm sewers were proposed to sized to redirect excess overland flow to HCFCD Unit E133-01-00. The embankment for Cypress Chase detention pond is repaired to increase its mitigation effect during extreme events.

PROJECT SUMMARY

The Project Summary consists of 4 parts **for each target area and/or activity**: **(1)** Summarize Problem(s); **(2)** Location and Acquisition; **(3)** Detailed Actions to Address Problems; and **(4)** Disclosure on Non-CDBG-DR Funds.

PART 1 – Summarize the problem(s) to be addressed within the application by Target Area.

Drainage issues are primarily caused by the flat topography, insufficient drainage capacity of the existing road side ditches, absence of any mitigations for extreme event overland flow paths, maintenance issues with the roadside ditches, and the Cypress Chase detention pond embankment failure.

PART 2 – Identify the location of each activity/Target Area and any associated acquisition activity.

The spelling and capitalization of the Target Area name(s) listed here must match Table 1 (e.g., "Green Acres" should not appear elsewhere as "green acres subdivision."

Project Title / Target Area:	Kolbe Road and Related Infrastructure Drainage Improvements
Activity:	Flood and Drainage Facilities

On:		**From:**		**To:**	

- OR -

Provide a brief description of the location of the activity / Target Area.

Kolbe Rd south of Cypress North Houston Rd, S Kolbe Cir.Laura Circle, Scott Circle and Village Circle

- OR -

Provide physical address if possible.

Latitude:	29°56'28.01"N	**Longitude:**	95°38'30.82"W

	Included:	
Please attached project area map (11 x 17)	Yes: ☑	No: ☐
Please attach existing drainage area map (11x17)	Yes: ☑	No: ☐
Please attach proposed drainage area map (11x17)	Yes: ☑	No: ☐
Please attach "Sketch Plans", illustrations or annotated drawings communicating the scope of the recommended improvements	Yes: ☑	No: ☐
Please attach scope of services for final design of the improvements	Yes: ☑	No: ☐
Please attach photographs of problems found, annotated on an area map exhibit or in an appendix	Yes: ☑	No: ☐
	Acquisition Required:	
Will acquisition associated with the project site(s) be required?	Yes: ☑	No: ☐

PART 3 – Identify the action(s) to resolve the problem(s) and their anticipated outcomes. *Include details such as specific materials and quantities.*

Replace the existing roadside ditch system with a concrete pipe storm sewer system with a swale on top. The proposed system increases the drainage capacity to meet current standards.

Connor McColloch, PE, CFM	Senior Project Manager	(713) 783-7117
Name of Preparer (Printed)	**Position / Title**	**Phone Number**

	connor.mccolloch@neel-schaffer.com
Signature of Preparer	**Email Address**

PROJECT SCHEDULE

Enter the projected length (in number of months) for each applicable phase / process step below. If a phase is not applicable, enter "0" in the field. *Note: Most projects should be completed in 24 months once the associated contract for the project is executed between the Applicant and the Texas General Land Office.*

PROFESSIONAL PROCUREMENT		**Months**
ENVIRONMENTAL REVIEW		**Months**
ACQUISITION		**Months**
ENGINEERING DESIGN	8	**Months**
CONSTRUCTION	10	**Months**
COMPLETE CLOSEOUT		**Months**
EXTENDED ACTIVITY		**Months**

ANTICIPATED COMPLETION	

If the proposed project schedule exceeds 24 months, a justification must be provided in the space below.

BENEFICIARY INFORMATION

Does the proposed project serve Low /Moderate Income beneficiaries? Yes: ☐ No: ☑

If answer above is no, provide the following information:

	Included	
Shape file of benefited area	Yes: ☑	No: ☐
Digital Elevation Model for the current condition	Yes: ☑	No: ☐
Digital Elevation Model for the proposed condition(s)	Yes: ☐	No: ☑

TABLE 1 - BUDGET

Project Title/Target Area:	Kolbe Road & Related Infrastructure Drainage Improvements
Construction Completion Type:	Contract
Activity Description	5. Flood and Drainage Facilities
Probable Construction Cost:	$ 3,644,000
Estimated Engineering Cost:	$ 561,000
Estimated Acquisition Cost:	$496,000
Total:	$ 4,700,000

TABLE 2: BUDGET JUSTIFICATION OF RETAIL COSTS

PROJECT TITLE / TARGET AREA: Kolbe Road & Related Infrastructure Drainage Improvements/ Paving

Act # Activity Description	Materials / Facilities / Services	$/Unit	Unit	Qty	Construction	Acquisition	TOTAL
4. Street Improvements	Remove and Dispose of Driveways	$ 6.00	SY	1320	$ 7,920		$ 7,920
4. Street Improvements	Remove and Dispose of Pavement	$ 10.0	SY	160	$ 1,600		$ 1,600
4. Street Improvements	6" Concrete for Driveways	$ 117.	SY	1452	$ 169,884		$ 169,884
4. Street Improvements	Asphalt Pavement, 4"	$ 52.0	SY	180	$ 9,360		$ 9,360
4. Street Improvements	Lime Stabilized Subgrade, 6" Thick	$ 18.0	SY	1632	$ 29,376		$ 29,376
4. Street Improvements	Ancillary Paving Items (10%)	$ 13,7		1	$ 21,814		$ 21,814
					$ 0		$ 0
					$ 0		$ 0
				COLUMN TOTALS	$ 239,954	$ 0	$ 239,954

1. Identify and explain the annual projected operation and maintenance costs associated with the proposed activities.

2. Identify and explain any/all special engineering activities.

(Architect / Engineer Seal)

Connor McColloch, PE, CFM

Signature of Registered Engineer / Architect Responsible for Budget Justification

6/4/2019

Date

(713) 783-7117

Phone Number

TABLE 2: BUDGET JUSTIFICATION OF RETAIL COSTS

PROJECT TITLE / TARGET AREA: Kolbe Road & Related Infrastructure Drainage Improvements/ Drainage Items-Part 1

Act # Activity Description	Materials / Facilities / Services	$/Unit	Unit	Qty	Construction	Acquisition	TOTAL
5. Flood and Drainage Facilities	Driveway Culvert Removal	$ 20.0	LF	970	$ 19,400	$ 0	$ 19,400
5. Flood and Drainage Facilities	24-Inch Diameter Storm Sewer	$ 70.0	LF	**2425**	$ 169,750		$ 169,750
5. Flood and Drainage Facilities	30-Inch Diameter Storm Sewer	$ 110.	LF	4130	$ 454,300	$ 0	$ 454,300
5. Flood and Drainage Facilities	36-Inch Diameter Storm Sewer	$ 120.	LF	535	$ 64,200		$ 64,200
5. Flood and Drainage Facilities	42-Inch Diameter Storm Sewer	$ 140.	LF	445	$ 62,300		$ 62,300
5. Flood and Drainage Facilities	48-Inch Diameter Storm Sewer	$ 190.	LF	30	$ 5,700		$ 5,700
5. Flood and Drainage Facilities	54-Inch Diameter Storm Sewer	$ 220.	LF	485	$ 106,700		$ 106,700
5. Flood and Drainage Facilities	60-Inch Diameter Storm Sewer	$ 240.	LF	240	$ 57,600		$ 57,600
				COLUMN TOTALS	$ 939,950	$ 0	$ 939,950

1. Identify and explain the annual projected operation and maintenance costs associated with the proposed activities.

2. Identify and explain any/all special engineering activities.

STATE OF TEXAS
CONNOR McCOLLOCH
120523
LICENSED
PROFESSIONAL ENGINEER

Connor McColloch, PE, CFM

Signature of Registered Engineer / Architect Responsible for Budget Justification

6/4/2019

Date

(713) 783-7117

Phone Number

(Architect / Engineer Seal)

TABLE 2: BUDGET JUSTIFICATION OF RETAIL COSTS

PROJECT TITLE / TARGET AREA: Kolbe Road & Related Infrastructure Drainage Improvements/ Drainage Items-Part 2

Act # Activity Description	Materials / Facilities / Services	$/Unit	Unit	Qty	Construction	Acquisition	TOTAL
5. Flood and Drainage Facilities	7-Foot by 5-Foot Box Culvert	$ 480.	LF	315	$ 151,200	$ 0	$ 151,200
5. Flood and Drainage Facilities	Type C Manhole for 0 to 42-Inch	$ 3,00	EA	**30**	$ 90,000		$ 90,000
5. Flood and Drainage Facilities	Type C Manhole for 48 to 72-Inch	$ 4,80	EA	6	$ 28,800	$ 0	$ 28,800
5. Flood and Drainage Facilities	Junction Box with Manhole	$ 10,0	EA	5	$ 50,000		$ 50,000
5. Flood and Drainage Facilities	Install Type A Grate Inlets	$ 1,50	EA	125	$ 187,500		$ 187,500
5. Flood and Drainage Facilities	Detention Pond Excavation	$ 10.0	CY	6195:	$ 619,519		$ 619,519
5. Flood and Drainage Facilities	6-Foot by 5-Foot Box Culvert	$ 380.	LF	1305	$ 495,900		$ 495,900
					$ 0		$ 0
				COLUMN TOTALS	$ 1,622,91	$ 0	$ 1,622,91

1. Identify and explain the annual projected operation and maintenance costs associated with the proposed activities.

2. Identify and explain any/all special engineering activities.

(Architect / Engineer Seal)

Connor McColloch, PE, CFM

Signature of Registered Engineer / Architect Responsible for Budget Justification

6/4/2019

Date

(713) 783-7117

Phone Number

TABLE 2: BUDGET JUSTIFICATION OF RETAIL COSTS

PROJECT TITLE / TARGET AREA: Kolbe Road & Related Infrastructure Drainage Improvements/ Land Acquisition

Act # Activity Description	Materials / Facilities / Services	$/Unit	Unit	Qty	Construction	Acquisition	TOTAL
24. Acquisition – Easement	30-Foot Drainage Easement				$ 0	$ 16,000	$ 16,000
24a. Acquisition	ROW Detention Pond				$ 0	$ 480,000	$ 480,000
					$ 0	$ 0	$ 0
					$ 0		$ 0
					$ 0		$ 0
					$ 0		$ 0
					$ 0		$ 0
					$ 0		$ 0
					COLUMN TOTALS		
					$ 0	$ 496,000	$ 496,000

1. Identify and explain the annual projected operation and maintenance costs associated with the proposed activities.

2. Identify and explain any/all special engineering activities.

STATE OF TEXAS
CONNOR McCOLLOCH
120523
LICENSED
PROFESSIONAL ENGINEER

(Architect / Engineer Seal)

Connor McColloch, PE, CFM

Signature of Registered Engineer / Architect Responsible for Budget Justification

6/4/2019

Date

(713) 783-7117

Phone Number

Alternative 3

HARRIS COUNTY

Project Scoping & Cost Estimating Development Tool

KOLBE ROAD & RELATED INFRASTRUCTURE DRAINAGE IMPROVEMENTS

PROJECT NAME

3

PRECINCT

Areas highlighted are to be completed by Consultant

PREPARER INFORMATION		PROJECT INFORMATION	
1. DATE SUBMITTED:	4/25/19	**4. PROJECT TYPE:**	Drainage Improvements
2. SUBMITTED BY:	Connor McColloch, P.E.	**5. PROJECT TITLE:**	Kolbe Road and Related Infrastructure
3. NAME OF FIRM:	Neel-Schaffer, Inc.		

6. ESTIMATED FUNDING (Item 6 to be prepared by Harris County):		
A. CDBG-DR:		** Specify MUD or Other Funding Sources:*
B. OTHER FEDERAL:*		
C. STATE:		
D. COUNTY:		
E. MUD:*		
F. OTHER:*		
ESTIMATED TOTAL:	$ 0.00	

7. NO ACTION ASSESSMENT: Briefly describe the impact of taking no action to repair the damaged facilities.

If no action is taken, the buildings flooded during Harvey may experience similar flooding issues as a result of future extreme events.

DESCRIPTION OF THE NEED(S) ADDRESSED IN THIS DOCUMENT

Provide full and complete answers to each of the following. Descriptions should include the cause of the damage, current condition of the facility, and a detailed description of the project that coincides with the information contained in both Table 1 and 2. All activities must have documented proof of an impact by the floods and storms. CDBG-DR funds must be used for disaster- related expenses in the most impacted and distressed areas.

1. ***Describe the specific flood and storm-related condition that directly caused the damage(s).***

   Drainage issues are primarily caused by the flat topography, insufficient drainage capacity of the existing road side ditches, absence of any mitigations for extreme event overland flow paths, maintenance issues with the roadside ditches, and the Cypress Chase detention pond embankment failure.

2. ***Describe the system that was damaged and how it was damaged.***

   According to Harris County, 38 buildings were flooded during Hurricane Harvey.

3. ***How does the project support housing?***

   By providing increased drainage capacity, the risk of damage to buildings during extreme storms is reduced and hence, the project area will be desirable for housing.

4. ***Describe the impacts on the community that resulted in direct damage(s).***

   The community experienced flooding of 38 homes with elevations up to a foot resulting in damages to real and personal property and were without a home for an extended period of time.

5. ***Describe how the proposed activities will address damage(s) of the system affected by the floods and storms.***

   The proposed solutions are intended to mitigate the structural flooding for the project area by redirecting the overland flow into the Harris county maintained channel E133-01-00.

6. ***List materials submitted as documentation of the flood and storm-related condition.***

7. ***Describe the proposed project.***

   Storm sewers were proposed to sized to redirect excess overland flow to HCFCD Unit E133-01-00. The embankment for Cypress Chase detention pond is repaired to increase its mitigation effect during extreme events.

PROJECT SUMMARY

The Project Summary consists of 4 parts **for each target area and/or activity**: **(1)** Summarize Problem(s); **(2)** Location and Acquisition; **(3)** Detailed Actions to Address Problems; and **(4)** Disclosure on Non-CDBG-DR Funds.

PART 1 – Summarize the problem(s) to be addressed within the application by Target Area.

Drainage issues are primarily caused by the flat topography, insufficient drainage capacity of the existing road side ditches, absence of any mitigations for extreme event overland flow paths, maintenance issues with the roadside ditches, and the Cypress Chase detention pond embankment failure.

PART 2 – Identify the location of each activity/Target Area and any associated acquisition activity.

The spelling and capitalization of the Target Area name(s) listed here must match Table 1 (e.g., "Green Acres" should not appear elsewhere as "green acres subdivision."

Project Title / Target Area:	Kolbe Road and Related Infrastructure Drainage Improvements				
Activity:	Flood and Drainage Facilities				
On:		**From:**		**To:**	

- OR -

Provide a brief description of the location of the activity / Target Area.

Kolbe Rd south of Cypress North Houston Rd, S Kolbe Cir.

- OR -

Provide physical address if possible.

Latitude:	29°56'28.01"N	**Longitude:**	95°38'30.82"W

	Included:	
Please attached project area map (11 x 17)	Yes: ☑	No: ☐
Please attach existing drainage area map (11x17)	Yes: ☑	No: ☐
Please attach proposed drainage area map (11x17)	Yes: ☑	No: ☐
Please attach "Sketch Plans", illustrations or annotated drawings communicating the scope of the recommended improvements	Yes: ☑	No: ☐
Please attach scope of services for final design of the improvements	Yes: ☑	No: ☐
Please attach photographs of problems found, annotated on an area map exhibit or in an appendix	Yes: ☑	No: ☐
	Acquisition Required:	
Will acquisition associated with the project site(s) be required?	Yes: ☑	No: ☐

PART 3 – Identify the action(s) to resolve the problem(s) and their anticipated outcomes. *Include details such as specific materials and quantities.*

Replace the existing roadside ditch system with a concrete pipe storm sewer system with a swale on top. The proposed system increases the drainage capacity to meet current standards.

Connor McColloch, PE, CFM	Senior Project Manager	(713) 783-7117
Name of Preparer (Printed)	**Position / Title**	**Phone Number**
Con McColloch		connor.mccolloch@neel-schaffer.com
Signature of Preparer		**Email Address**

PROJECT SCHEDULE

Enter the projected length (in number of months) for each applicable phase / process step below. If a phase is not applicable, enter "0" in the field. *Note: Most projects should be completed in 24 months once the associated contract for the project is executed between the Applicant and the Texas General Land Office.*

PROFESSIONAL PROCUREMENT		Months
ENVIRONMENTAL REVIEW		Months
ACQUISITION		Months
ENGINEERING DESIGN	8	Months
CONSTRUCTION	10	Months
COMPLETE CLOSEOUT		Months
EXTENDED ACTIVITY		Months

ANTICIPATED COMPLETION	

If the proposed project schedule exceeds 24 months, a justification must be provided in the space below.

BENEFICIARY INFORMATION

Does the proposed project serve Low /Moderate Income beneficiaries? Yes: ☐ No: ☑

If answer above is no, provide the following information:

	Included	
Shape file of benefited area	Yes: ☑	No: ☐
Digital Elevation Model for the current condition	Yes: ☑	No: ☐
Digital Elevation Model for the proposed condition(s)	Yes: ☐	No: ☑

TABLE 1 - BUDGET

Project Title/Target Area:	Kolbe Road & Related Infrastructure Drainage Improvements
Construction Completion Type:	Contract
Activity Description	5. Flood and Drainage Facilities
Probable Construction Cost:	$ 3,349,805
Estimated Engineering Cost:	$ 515,355
Estimated Acquisition Cost:	$ 496,000
Total:	$ 4,361,160

TABLE 2: BUDGET JUSTIFICATION OF RETAIL COSTS

PROJECT TITLE / TARGET AREA: Kolbe Road & Related Infrastructure Drainage Improvements/ Paving

Act # Activity Description	Materials / Facilities / Services	$/Unit	Unit	Qty	Construction	Acquisition	TOTAL
4. Street Improvements	Remove and Dispose of Driveways	$ 6.00	SY	1320	$ 7,920		$ 7,920
4. Street Improvements	Remove and Dispose of Pavement	$ 10.0	SY	160	$ 1,600		$ 1,600
4. Street Improvements	6" Concrete for Driveways	$ 117.	SY	1452	$ 169,884		$ 169,884
4. Street Improvements	Asphalt Pavement, 4"	$ 52.0	SY	180	$ 9,360		$ 9,360
4. Street Improvements	Lime Stabilized Subgrade, 6" Thick	$ 18.0	SY	1632	$ 29,376		$ 29,376
4. Street Improvements	Ancillary Paving Items (10%)	$ 13,7		1	$ 21,814		$ 21,814
					$ 0		$ 0
					$ 0		$ 0
				COLUMN TOTALS	$ 239,954	$ 0	$ 239,954

1. Identify and explain the annual projected operation and maintenance costs associated with the proposed activities.

2. Identify and explain any/all special engineering activities.

(Architect / Engineer Seal)

Connor McColloch, PE, CFM

Signature of Registered Engineer / Architect Responsible for Budget Justification

6/18/2019

Date

(713) 783-7117

Phone Number

TABLE 2: BUDGET JUSTIFICATION OF RETAIL COSTS

PROJECT TITLE / TARGET AREA:	Kolbe Road & Related Infrastructure Drainage Improvements/ Drainage Items-Part 1

Act # Activity Description	Materials / Facilities / Services	$/Unit	Unit	Qty	Construction	Acquisition	TOTAL
5. Flood and Drainage Facilities	Driveway Culvert Removal	$ 20.0	LF	970	$ 19,400	$ 0	$ 19,400
5. Flood and Drainage Facilities	24-Inch Diameter Storm Sewer	$ 70.0	LF	2425	$ 169,750		$ 169,750
5. Flood and Drainage Facilities	30-Inch Diameter Storm Sewer	$ 110.	LF	2075	$ 228,250	$ 0	$ 228,250
5. Flood and Drainage Facilities	36-Inch Diameter Storm Sewer	$ 120.	LF	535	$ 64,200		$ 64,200
5. Flood and Drainage Facilities	42-Inch Diameter Storm Sewer	$ 140.	LF	445	$ 62,300		$ 62,300
5. Flood and Drainage Facilities	48-Inch Diameter Storm Sewer	$ 190.	LF	30	$ 5,700		$ 5,700
5. Flood and Drainage Facilities	54-Inch Diameter Storm Sewer	$ 220.	LF	485	$ 106,700		$ 106,700
5. Flood and Drainage Facilities	60-Inch Diameter Storm Sewer	$ 240.	LF	240	$ 57,600		$ 57,600
				COLUMN TOTALS	$ 713,900	$ 0	$ 713,900

1. Identify and explain the annual projected operation and maintenance costs associated with the proposed activities.

2. Identify and explain any/all special engineering activities.

STATE OF TEXAS
CONNOR McCOLLOCH
120523
LICENSED
PROFESSIONAL ENGINEER

(Architect / Engineer Seal)

Connor McColloch, PE, CFM

Signature of Registered Engineer / Architect Responsible for Budget Justification

6/18/2019
Date

(713) 783-7117
Phone Number

TABLE 2: BUDGET JUSTIFICATION OF RETAIL COSTS

PROJECT TITLE / TARGET AREA: Kolbe Road & Related Infrastructure Drainage Improvements/ Drainage Items-Part 2

Act # Activity Description	Materials / Facilities / Services	$/Unit	Unit	Qty	Construction	Acquisition	TOTAL
5. Flood and Drainage Facilities	7-Foot by 5-Foot Box Culvert	$ 480.	LF	315	$ 151,200	$ 0	$ 151,200
5. Flood and Drainage Facilities	Type C Manhole for 0 to 42-Inch	$ 3,00	EA	**30**	$ 90,000		$ 90,000
5. Flood and Drainage Facilities	Type C Manhole for 48 to 72-Inch	$ 4,80	EA	6	$ 28,800	$ 0	$ 28,800
5. Flood and Drainage Facilities	Junction Box with Manhole	$ 10,0	EA	5	$ 50,000		$ 50,000
5. Flood and Drainage Facilities	Install Type A Grate Inlets	$ 1,50	EA	125	$ 187,500		$ 187,500
5. Flood and Drainage Facilities	Detention Pond Excavation	$ 10.0	CY	6195:	$ 619,519		$ 619,519
5. Flood and Drainage Facilities	6-Foot by 5-Foot Box Culvert	$ 380.	LF	1305	$ 495,900		$ 495,900
					$ 0		$ 0
				COLUMN TOTALS	$ 1,622,91	$ 0	$ 1,622,91

1. Identify and explain the annual projected operation and maintenance costs associated with the proposed activities.

2. Identify and explain any/all special engineering activities.

(Architect / Engineer Seal)

Connor McColloch, PE, CFM

Signature of Registered Engineer / Architect Responsible for Budget Justification

6/18/2019

Date

(713) 783-7117

Phone Number

TABLE 2: BUDGET JUSTIFICATION OF RETAIL COSTS

PROJECT TITLE / TARGET AREA:	Kolbe Road & Related Infrastructure Drainage Improvements/ Land Acquisition

Act # Activity Description	Materials / Facilities / Services	$/Unit	Unit	Qty	Construction	Acquisition	TOTAL
24. Acquisition – Easement	30-Foot Drainage Easement				$ 0	$ 16,000	$ 16,000
24a. Acquisition	ROW Detention Pond				$ 0	$ 480,000	$ 480,000
					$ 0	$ 0	$ 0
					$ 0		$ 0
					$ 0		$ 0
					$ 0		$ 0
					$ 0		$ 0
					$ 0		$ 0
				COLUMN TOTALS	$ 0	$ 496,000	$ 496,000

1. Identify and explain the annual projected operation and maintenance costs associated with the proposed activities.

2. Identify and explain any/all special engineering activities.

(Architect / Engineer Seal)

Connor McColloch, PE, CFM

Signature of Registered Engineer / Architect Responsible for Budget Justification

6/18/2019

Date

(713) 783-7117

Phone Number

APPENDIX F: PUBLIC COMMENT LOG AND RESPONSE

STONE GATE, STONE GATE AMEND, KOLBE ROAD & RELATED INFRASTRUCTURE - 5-23-2019

First Name	Last Name	Organization Name	Address	City	State	Zip Code	Phone	Email	Input Type	Subject	Comment	Response
Henry	Chavez		11222 S. Kolbe Dr.	Cypress	TX	77429	281-687-8962	henricvs@gmail.com	email	Effects on our small rural neighborhood	Our neighborhood is rural and mostly drained with roadside ditches. How will this project improve the removal of flood waters from our community? Will our community have the same improvements for the draining of excess water? Where can I read what the plans are for this area?	Thank you for your comment. The roadside ditches for the majority of the neighborhood are proposed to be replaced with storm sewers to convey the flow into HCFCD Unit E133-01-00 east of the neighborhood. These storm sewer improvements will reduce the localized ponding associated with the neighborhood drainage. The storm sewer improvements are not intended to address out of bank flooding from Cypress Creek. Harris County Flood Control District has information on proposed improvements to the Cypress Creek watershed on their website. Additionally, the presentation provided at the community engagement meeting can also be found at harris county flood controls website (www.hcfcd.org)