



DOWNTOWN DRAINAGE PLANNING STUDY

City of Fulshear, TX

February, 2019



ARKK Engineers, LLC

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May 23, 2019

Mr. Brant Gary
Assistant City Manager
City of Fulshear
30603 FM 1093 West
PO BOX 273
Fulshear, Texas 77441

Re: **Downtown Drainage Planning Study**
ARKK Job No. 18-034

Dear Mr. Gary:

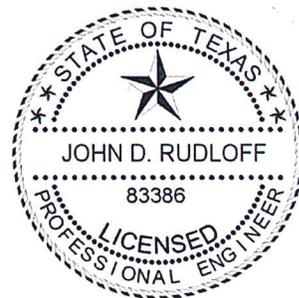
ARKK Engineers, LLC (ARKK) is pleased to present two (2) draft hard copies and one (1) electronic copy of the report for the above referenced project for your review and comment. The report contains a summary of the recommendations for improving drainage in the City's Downtown area. We greatly appreciate your input and assistance during the project.

Please feel free to contact us if additional information is needed. We greatly appreciate the opportunity to work for the City of Fulshear.

Sincerely,
ARKK ENGINEERS, LLC

A handwritten signature in blue ink, appearing to read "John D. Rudloff".

John D. Rudloff, P.E.
Senior Project Manager / Principal



5/23/19

CITY OF FULSHEAR

DOWNTOWN DRAINAGE PLANNING STUDY

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I. INTRODUCTION

ARKK Engineers, LLC (ARKK) is pleased to submit this drainage study detailing the findings of our field investigation and evaluation of the drainage system in the Downtown Fulshear area. This report is based on information gathered from our site visits to the project areas, and on previous drainage reports. This report summarizes the various aspects of the study and includes recommendations and cost estimates for the recommended drainage improvements.

II. BACKGROUND

ARKK Engineers LLC (ARKK) was authorized by the City of Fulshear to prepare a study on drainage within the Downtown area. This report presents an evaluation of the existing drainage system and future recommended drainage systems in the Downtown area. The Downtown area of the City of Fulshear is generally located between Wallis Street on the west, Syms Street on the east, FM 1093 on the south, and 5th Street on the north. The area is a mixture of commercial and residential development. The commercial areas are primarily on the lots adjacent to FM 359 and FM 1093.

As part of the investigative efforts, and to aid with the preparation of this report, ARKK performed the following tasks:

- Reviewed previous drainage reports previously prepared for the study area and surroundings.
- Reviewed LIDAR-based topographical mapping of the study area.
- Performed site visits.
- Observed the drainage patterns during several recent rainfall events.
- Developed recommendations for drainage system improvements.
- Prepared preliminary construction cost estimates for the recommended drainage improvements.
- Prepared a report summarizing the engineering study, with exhibit drawings showing the location of the recommended improvements.

III. FIELD INVESTIGATION

The Field Investigation efforts involved performing site visits to obtain information on the existing drainage system layout and drainage patterns for the City of Fulshear Downtown area. The site visits included a general observation of the ditches, culverts, manholes, and inlets that could be accessed and located in the field. The flow direction in the ditches and culvert sizes at the roadway and driveway crossing were determined. Notes were taken on existing surface features that could potentially have an impact on the drainage system.

The Downtown area sits upon a ridge line (or topographical “high point”), and drains away from the Downtown area to the lower-elevation areas to the west and east of the Downtown area. The Downtown area drains to both the east and west directions via natural drainage paths to “bottomland” areas. The bottomland areas have elevations approximately 15-20 feet lower than the Downtown area. The “low” bottomland area located west of Downtown drains via Fulshear Creek Tributary Number 2. The low bottomland area located east of Downtown drains via an unnamed tributary that flows to Fulshear Lake. The Downtown area itself is generally drained by shallow ditches and culverts that lead to these tributaries. There are several areas in which the roadside ditches have been enclosed, with storm pipe added in place of the ditch. Both of the primary outfalls (Fulshear Creek Tributary Number 2 and the unnamed Fulshear Lake tributary) flow south under FM 1093 to Fulshear Creek, and then on to the Brazos River.

West Side Outfall Description

The west side of Downtown does not have a well-defined drainage pathway for storm water to flow from Wallis Street directly to Fulshear Creek Tributary 2. The storm water on the west side of Downtown flows southward along the Wallis Street roadside ditches, and then continues south of 1st St via a drainage ditch to the old railroad right-of-way; and from there continues west to Fulshear Creek Tributary 2. Along FM 359 between 5th Street and 3rd Street, the ditch has been enclosed with a 24” storm pipe installed. The storm water from the 24” pipe crosses FM 359 at a junction box in Dozier’s parking lot in 2-18” RCP’s (reinforced concrete pipe storm sewer) north of 3rd Street.

East side Outfall Description

The east side of Downtown drains to Fulshear Lake via the previously mentioned unnamed tributary. Wilson Street represents a “grade break” (or drainage basin divide) on the east side of Downtown.

West of Wilson Street: The area west of Wilson Street and north of 2nd Street flows to the roadside ditch along FM 359, and then to a drainage ditch that splits the vacant tract of land between 3rd Street and 4th Street. The ditch collects the water from FM 359 and also collects flow from the two 18” culverts from the west, then flows east to a 24” storm sewer that runs from Wilson Street to Syms Street. Then, the storm water crosses under Syms Street through a 30” culvert.

East of Wilson Street: The area east of Wilson Street and north of 2nd Street flows through the culvert crossing under Syms between 3rd Street and 4th Street, down the roadside ditches of 4th and 5th Streets, to natural drainage swales leading to the unnamed Fulshear Lake tributary. It appears that this storm pipe is located under existing building structures. The area south of 2nd Street flows south to FM 1039, then east to the Fulshear Lake tributary crossing. The Fulshear Lake tributary is a low area that passes thru the tract of land bounded by Higgins Drive to the north, FM 1093 to the south, Houston Street and Syms Street to the west, and Katy-Fulshear Road to the east.

Field Observations: ARKK personnel visited the study area during rainfall events to observe the drainage conditions and to verify the flow directions of the ditches. These rainfall events were moderate, having approximately 2”-3” of rainfall in 2 hours. The drainage system generally worked well under these rainfall conditions.

West Side: Water was observed backing up in the ditches along FM 359 north of 3rd Street and along 5th Street west of FM 359. There was quite a bit of ponding around La Balance Café and the City Fire Department. The ditches along Wallis Street were also full during these rainfall events.

East Side: East of Wilson Street, the land falls in elevation relatively fast toward the east, and no standing water was seen. The ponding noticed along FM 359 and 5th Street is caused by a lack of capacity in an enclosed ditch on the west side of FM 359, lack of capacity in the two 18” pipes crossing FM 359, and lack of capacity in the 24” pipe from Wilson Street to Syms Street. This system does not currently meet the local standard of 2-year storm capacity for the drainage area that is actually flowing to it. It appears that the area along FM 359 will continue to experience nuisance ponding until additional drainage capacity is installed to convey the storm water flowing to this location.

Floodplain Information: The Downtown area and the tributary streams on each side of Downtown are situated outside of the mapped 100-year flood plain (reference: FEMA Firm Panel 48157C0085L April 2, 2014). The Downtown area is approximately 15' to 20' in elevation above the tributaries. Structures in the Downtown area are not at a significant risk from flood waters backing up in the Brazos River or the tributaries. During extreme event rainfalls, it is anticipated that the water will rise along FM 359 until the water gets high enough to sheet flow to the west overtopping Wallis Street and east overtopping Wilson Street and sheet flowing to either of the two tributaries. Local area storm sewer systems are not typically built to convey the 100-year storm. The larger event storms are typically conveyed by overland flow (sheet flow) and channelized flow. In areas in which the outfall streams are unstudied, and therefore do not have a published flood elevation, it is common for buildings to be built with a finished floor elevation of at least 1' above the center of the adjacent roadway. This allows the storm water to drain by overland flow before flooding a structure.

IV. **REVIEW OF EXISTING DATA**

ARKK Engineers obtained and reviewed the City of Fulshear Comprehensive Plan and the following drainage reports:

- Impact Analysis for the Katy Fulshear Watershed (Dodson April 2012)
- Fulbrook on Fulshear Creek North Master Drainage Plan (Costello, Inc. September 2013)
- Fulbrook on Fulshear Creek South Master Drainage Plan Update (Costello, Inc. June 2014)
- Drainage Impact Analysis for the Westpark Expansion Phase II within the Outfall 2 / Fulshear Lake Watershed (Costello, Inc. December 2015)
- Westpark Expansion Phase 2 Hydraulic Impact Report (Klotz Associates, Inc. February 2016)

Costello Inc. Studies: The Costello, Inc. study modeled Fulshear Creek from the Brazos River to Pool Hill Road, Fulshear Creek Tributary 2 from Fulshear Creek to FM 359, and the Fulshear Lake System from Fulshear Creek to Huggins Drive. The reports and models show that Fulbrook on Fulshear Creek Subdivision and the FM 1093 Expansion drain to the Fulshear Creek Tributary 2 and Fulshear Lake do not require detention, since they are located in the lower end of

Bessie's Creek (Fulshear Creek) watershed. The hydrologic models reflected that the Downtown area would be fully developed, and therefore redevelopment within the Downtown area should not require stormwater detention. Outside of the developed Downtown area, the large tracts of undeveloped land in the Fulshear Creek Tributary 2 and Fulshear Lake drainage area will need to evaluate the need detention on a case by case basis to reduce the drainage impact on the existing developments south of FM 1093.

FM 1093 Expansion Drainage Studies and Plans: The plans for the FM 1093 expansion through the existing Downtown area show the proposed westbound lanes to be generally located where the current lanes of FM 1093 are east of FM 359 and Front Street west of FM 359. The proposed improvements include storm drainage improvements along the north side of the westbound lanes. East of FM 359, the proposed drainage area taken in by the FM 1093 expansion drainage system includes all the area between FM 359 and Syms Street south of 3rd Street (Drainage Area Maps for the FM 1093 expansion from the Drainage Impact Analysis prepared by Klotz Associates are included for reference as **Figure 1** and **Figure 2**). The proposed storm sewer improvements are along the north side of the FM 1093 expansion, and a 30" storm sewer pipe is proposed between Wilson Street and Syms Street. Between Syms Street and the unnamed Fulshear Lake tributary is proposed a 5'x3' storm sewer box culvert for about 1/3 of the distance, and a 6'x3' box culvert the remainder of the way to the Fulshear Lake tributary crossing.

On the west side of FM 359, the drainage area for the proposed FM 1093 expansion storm sewer along the north side of the FM 1093 only includes the area south of 1st Street. The proposed drainage area shown on the plans does not take in all of the areas that are actually draining in this direction via the roadside ditches along Wallis Street and Harris Street. The proposed storm sewer improvements along the north side of the FM 1093 expansion west of FM 359 is a 30" storm sewer pipe from the Wallis Street ditch outfall for 300 feet, and then a 4'x3' box culvert to Fulshear Creek Tributary Number 2. It appears that only about 30 cubic feet per second (cfs) of stormwater runoff was designed to drain to FM 1093 from the Downtown area west of FM 359. The proposed system along the FM 1093 expansion does not have capacity to convey the 2-year storm flow from the entire upstream drainage basin that would flow to this outfall. Therefore, recommended improvements to the drainage system in the Downtown area west of FM 359 include a plan to route storm water flow to the west to drain directly to Fulshear Creek Tributary Number 2. Presently, there does not appear to be any right-of-way or natural drainage swales that could be utilized to convey the storm water to the Fulshear Creek Tributary 2. Two

locations were evaluated for establishing drainage paths to convey the storm water on the northwest side of Downtown directly to Fulshear Creek Tributary 2. The first route is just north of 5th Street. The property across Wallis Street from the City Fire Department appears to be owned by Fort Bend County Emergency Services #4. A drainage easement across this property gets about halfway to the Fulshear Creek Tributary Number 2. Therefore, additional easements would be needed to complete the drainage improvements to the tributary (See **Exhibit 2** – Proposed Drainage Area Map). Fort Bend Central Appraisal District (FBCAD) data shows that the land between the Fort Bend County Emergency Services #4 and Fulshear Creek Tributary Number 2 is owned by Carol Ann McCann. If a drainage easement is obtained from the Fort Bend County Emergency Services #4 and from Ms. McCann, a drainage ditch and storm sewer pipe could be installed to provide relief to the nuisance ponding along 5th Street and the west side of FM 359. The second route would be along the proposed collector street just north of Downtown. In reviewing the Major Thoroughfare Plan in the Comprehensive Plan, there is shown a proposed east-west collector street just north of 5th Street from Bois D’Arc Lane to Pool Hill Road. Drainage for the west side of Downtown could be addressed within this future roadway right-of-way. The location of this collector street is only conceptual for planning purposes. The exact location of the proposed future roadway right-of-way has not been established. While this drainage route may be a viable option in the future, it does not provide an avenue for relief of the current nuisance ponding along 5th Street and the west side of FM 359 until the location of the proposed right-of-way is established and acquired.

V. DOWNTOWN DRAINAGE AREA AND STORM RUNOFF

ARKK utilized the site visits and LIDAR-based topographic data (See **Exhibit 5** – Elevation Contour Map) to map the drainage basin areas in the Downtown area. Once the areas were mapped, the storm water runoff was calculated for the 2-year storm and the 100-year storm events. The existing drainage area map (**Exhibit 1**) shows the flow direction of the roadside ditches and the areas contributing to the storm water runoff. The rainfall runoff was calculated using the Rational Method. The Rational Method is a method for calculating the peak runoff for a drainage system using the following equation:

$$Q = (C)(i)(A)$$

Where: C = runoff coefficient (dimensionless)

A = Basin area (acres)

I = rainfall intensity (inches per hour)

The runoff coefficient “C” values in the rational method formula will vary based on the land use. These values typically range from 0.15 to 0.90. The more dense and impervious cover of the development, the higher the C value. For the mixed use Downtown area, 0.70 was used for the C Factor.

The rainfall intensity calculation is based on the following equation. The rainfall intensity is calculated as follows:

$$I = b/(d + TC)^e$$

Where b, d, and e are coefficients dependent on the rainfall event and geographical location. The b, d, and e coefficients used for this study are those same factors used by TXDOT for Fort Bend County.

Time of concentration was calculated from the following formula, which is based upon the City of Houston standard design method:

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

Where: T_C = time of concentration (minutes)
A = Basin area (acres)

The existing drainage area map (see **Exhibit 1** – Existing Drainage Area Map) was prepared based on what was observed in the field during the rainfall events. Drainage areas A and B drain south to FM 1093. Drainage areas C, D, and E drain east to the unnamed Fulshear Lake tributary. The existing drainage area map shows that approximately 20 acres on the west side of FM 359 currently drains across FM 359 in the two 18” storm sewers just north of 3rd Street (Drainage Area C1 on **Exhibit 1**). This flow is combined with approximately 21.5 acres on the east side FM 359 and flows across the 2 acre tract on the east side of FM 359 between 3rd Street and 4th Street in a natural swale ditch to Wilson Street. Fort Bend Central Appraisal District (FBCAD) data shows this 2 acre tract to be owned by MBB and TBJ Investment LLC. This natural swale ditch is in a low-lying area that appears to have historically been collecting the storm water from this area, and then drains to the unnamed Fulshear Lake Tributary. Between Wilson Street and Syms Street, this natural swale ditch has been enclosed within a 24” storm sewer pipe. The natural swale ditch and 24” RCP storm sewer do not appear to be in an

easement. This 24” storm sewer pipe from Wilson Street to Syms Street appears to be routed underneath an existing building structure. This 24” storm sewer from Wilson Street to Syms Street discharges into the western roadside ditch of Syms Street. The storm water crosses Syms Street in a 30” storm sewer pipe into a natural swale that flows to the unnamed Fulshear Lake tributary. FBCAD data shows that the land east of Syms Street containing the natural swale is owned by Huggins Ranch LTD.

The 24” storm sewer on the west side of FM 359 from 5th Street to 3rd Street, the dual 18” RCPs under FM 359, and the 24” storm sewer between Wilson Street and Syms Street are significantly undersized to convey the 2-year design storm, given the size of the area that drain to these systems. Recommendations for improvements are discussed in Section VI of this report.

The area of Downtown north of 4th Street and east of Wilson Street flows eastward along 5th Street, 4th Street, and at the 30” storm sewer crossing of Syms north of 3rd Street. Because the land has good fall from west to east, there did not appear to be an issue with drainage in this area.

The area east of FM 359 and south of 3rd Street drains south to FM 1093, then east to the unnamed Fulshear Lake tributary crossing. Because the land has good fall to the south and east, there did not appear to be an issue with drainage in this area.

During the site visits with 2”-3” of rainfall occurring, the roadside ditches along Wallis Street and Harris Street were full, but not far outside their banks, as was occurring along 5th Street. These roadside ditches are shallow, with 18”-24” culverts. Many of the culverts along Harris Street appear to be halfway silted in. The roadside ditches and culverts along Wallis Street appear to have been recently cleaned and regraded. The side slopes of the roadside ditches along Wallis Street are steep even though the ditches are relatively shallow (18”-30”). The right-of-way along Wallis Street appears to be only 35’ to 40’ wide.

The proposed drainage area map (**Exhibit 2**) shows the proposed modifications to the existing drainage system basin boundaries based on establishing a new outfall west of Downtown connecting directly to Fulshear Creek Tributary Number 2 (Drainage Area F), and removing approximately 20 acres to the north (Drainage Area G) to be addressed with the future collector road proposed in the Major Thoroughfare Plan.

VI. PROPOSED DRAINAGE IMPROVEMENTS

ARKK is recommending drainage improvements to address issues the Downtown area. The most pressing issue is drainage on the west side of FM 359 and the need to establish a new outfall west, directly connecting to Fulshear Creek Tributary Number 2. Without a new outfall to the west, only limited drainage improvements can be performed in the area west of FM 359 due to the limitations of the current outfalls and right-of-way. The next most pressing issue is the existing drainage thru the natural swale across the middle of the 2-acre tract of land on the east side of FM 359 between 3rd and 4th Streets, and the 24” storm sewer that was used to fill this swale between Wilson Street and Syms Street (the 24” pipe appears to go under building structures). The third item that should be addressed is the roadside ditches along Harris Street and Wallis Street. For budgeting purposes, we have addressed these as four separate projects. If funds are available some cost savings may be realized by combining the projects into a single project.

A. West Side FM 359 Storm Sewer Improvements

To address the drainage issues on the west side of FM 359, it is proposed to add a new drainage outfall directly to Fulshear Creek Tributary Number 2 and to add storm sewers along 5th Street to provide capacity for the 2-year design storm for the northwest part of Downtown (Drainage Area F). This storm sewer system is designed with the idea that basin G1 will not drain through this area, but rather will be addressed with the drainage associated with the future collector street crossing. The proposed improvements include installing a storm sewer on the north side of 5th Street from FM 359 to Wallis Street, then along the east side of Wallis Street, then west to Fulshear Creek Tributary Number 2. It is proposed that this pipe will outfall into a proposed ditch that drains west to Fulshear Creek Tributary Number 2. Easements will be required from Wallis Street to Fulshear Creek Tributary Number 2. This storm sewer pipe will be sized to convey Drainage Area F (See **Exhibit 2**) which contains the area between FM 359 and Wallis Street from 3rd Street to about 800’ north of 5th Street. The proposed improvements are shown on the Proposed Drainage Improvement Plan (**Exhibit 3**). These improvements consist of a storm sewer trunk main ranging from 36” to 48” reinforced concrete pipe (RCP), 24” leads and inlets (Type A grate inlets an type E area inlets), and an open ditch to Fulshear Creek Tributary Number 2. South of 3rd Street will continue to drain south to the FM 1093 Expansion (Front Street).

B. East Side FM 359 Storm Sewer Improvements

Drainage improvements for the area north of 3rd Street would begin east of FM 359 along 4th Street, and involves rerouting the storm water that flows in the ditch between FM 359 and Wilson St, north of 3rd, to a storm sewer system along 4th Street. This would open the area between 3rd Street and 4th Street for development. The storm water would continue to flow thru the existing low-lying area east of Syms Street to the unnamed Fulshear Lake tributary. This is a natural drainage path that does not appear to be within an easement. It is proposed to add storm sewers along 4th Street to provide capacity for the 2-year design storm for the northeast part of Downtown (Drainage Area D). This storm sewer system is designed with the idea that basin G2 will not drain through this area, but rather will be addressed with the drainage associated with the future collector street crossing. The proposed improvements include installing a storm sewer on the south side of 4th Street from FM 359 to Houston St, then east to the Fulshear Lake tributary. It is proposed to extend storm sewers south along FM 359 and Wilson Street to pick up the drainage that flows across the property east of FM 359 between 4th Street and 3rd Street. It is also proposed to plug the 24” storm sewer at Wilson Street that runs beneath a structure. Plugging the existing 24” storm sewer will prevent storm water from the street right-of-way from draining thru this pipe. Any backyard connections that the residents have made to this pipe would still be operable. Easements may be required from 4th Street/Houston Street to the Fulshear Lake tributary. Storm water has historically flowed through this area but it would be advantageous to the City to obtain an easement for drainage through this area. This storm pipe will be sized for Drainage Area D (See **Exhibit 2**). The proposed improvements are shown on the Proposed Drainage Improvement Plan (**Exhibit 3**). These improvements consist of a storm sewer trunk main ranging from 30” to 42”, 24” leads and inlets, and ditch grading along FM 359. South of 3rd Street will continue to drain south to the FM 1093 expansion.

As observed during the site visits, 4th Street is an asphalt street in poor condition. The cost estimate prepared for these drainage improvements includes repairing the roadway by in-place recycling of the base material and overtopping with a 2” thick hot mix asphalt overlay after the drainage improvements have been performed.

C. West Side FM 359 Ditch Regrading and Culvert Improvements

To address the drainage issues on the west side of FM 359, it is proposed to regrade the roadside ditches along Harris Street and Wallis Street. These ditches are recommended to be modified to flow as shown in the proposed drainage area map (**Exhibit 2**). The areas north of 3rd Street would be modified to flow north to the proposed storm sewer system on 5th Street. Because the right-of-way is narrow on Wallis Street, it is proposed to add a 24” storm sewer pipe with inlets (Type A grate inlets and/or type E area inlets) along Wallis Street from 5th Street to 4th Street. It is proposed to increase the capacity of the culvert crossing at the corner of Wallis Street and 1st Street. A second 24” storm sewer pipe is proposed to be added at the outfall crossing at 1st Street and Wallis Street to provide additional capacity. This water will continue to flow south to the proposed storm sewer system along the north side of the FM 1093 expansion.

D. East Side FM 359 Ditch and Trail Improvements

To address the drainage issues on the east side of FM 359, it is proposed to improve the existing Fulshear Lake Tributary. This improvement consist of clearing and straightening the existing tributary. The proposed channel improvements would convey the 100 year storm between Huggins Drive and FM 1093. It is proposed to construct a ditch in a proposed 100’ drainage easement. The drainage easement would allow for the ditch and maintenance berm on each side of the ditch. Exhibit 4 shows the general location and a typical cross-section of the proposed ditch and trails. The cost include placing a 10’ trail along both side of the ditch.

VII. PRELIMINARY COST ESTIMATES

The preliminary Project Cost Estimate for improvements to the **West Side FM 359 Storm Sewer Improvements** is approximately **\$820,700** (see **Table 1** for a breakdown). Costs for land acquisition and easement acquisition are not included in the project cost estimates.

The preliminary Project Cost Estimate for the improvements to the **East Side FM 359 Storm Sewer Improvements** is approximately **\$928,000** (see **Table 2** for a breakdown). Costs for land acquisition and easement acquisition are not included in the project cost estimates.

The preliminary Project Cost Estimate for improvements to the **West Side FM 359 Ditch Improvements** is approximately **\$465,600** (see **Table 3** for a breakdown).

The preliminary Project Cost Estimate for the improvements to the **East Side FM 359 Ditch and Trail Improvements** is approximately **\$1,320,000** (see **Table 4** for a breakdown). Costs for land acquisition and easement acquisition are not included in the project cost estimates.

VIII. RECOMMENDATIONS

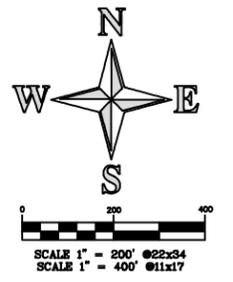
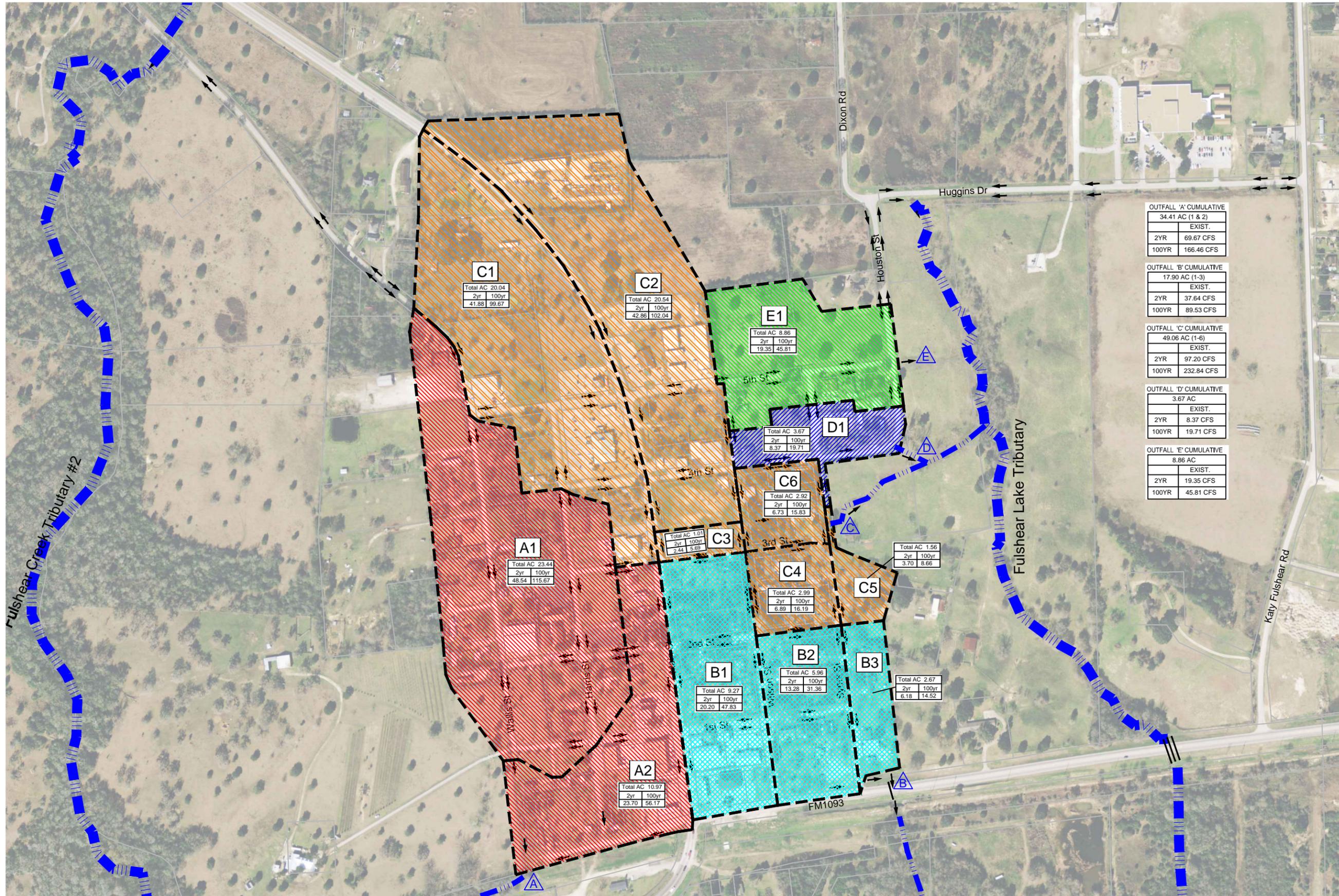
It is recommended that the City proceed with working with the owners of the properties that require an easement for the construction of the west side storm sewer outfall to Fulshear Creek Tributary Number 2 and the east side to Fulshear Lake Tributary.

It is recommended to proceed with design and construction of the above projects based on available funds:

1. West Side FM 359 Storm Sewer Improvements
2. East Side FM 359 Storm Sewer Improvements
3. West Side FM 359 Ditch Improvements (Requires Project 1 above to be complete)
4. East Side FM 359 Ditch and Trail Improvements

If funds are not currently available, the City can utilize these cost estimates to assist with the budget planning process.

EXHIBITS



OUTFALL 'A' CUMULATIVE	
34.41 AC (1 & 2)	EXIST.
2YR	69.67 CFS
100YR	166.46 CFS

OUTFALL 'B' CUMULATIVE	
17.90 AC (1-3)	EXIST.
2YR	37.64 CFS
100YR	89.53 CFS

OUTFALL 'C' CUMULATIVE	
49.06 AC (1-6)	EXIST.
2YR	97.20 CFS
100YR	232.84 CFS

OUTFALL 'D' CUMULATIVE	
3.67 AC	EXIST.
2YR	8.37 CFS
100YR	19.71 CFS

OUTFALL 'E' CUMULATIVE	
8.86 AC	EXIST.
2YR	19.35 CFS
100YR	45.81 CFS

C1
Total AC 20.04
2yr 100yr
41.86 99.67

C2
Total AC 20.54
2yr 100yr
42.86 102.04

E1
Total AC 8.86
2yr 100yr
19.35 45.81

D1
Total AC 3.67
2yr 100yr
8.37 19.71

C6
Total AC 2.92
2yr 100yr
6.73 15.83

A1
Total AC 23.44
2yr 100yr
48.54 115.67

C3
Total AC 1.21
2yr 100yr
2.44 5.69

C4
Total AC 2.99
2yr 100yr
6.89 16.19

C5
Total AC 1.56
2yr 100yr
3.70 8.66

B1
Total AC 9.27
2yr 100yr
20.20 47.83

B2
Total AC 5.96
2yr 100yr
13.28 31.36

B3
Total AC 2.67
2yr 100yr
6.18 14.52

A2
Total AC 10.97
2yr 100yr
23.70 56.17

**EXHIBIT 1
EXISTING DRAINAGE
AREA MAP**

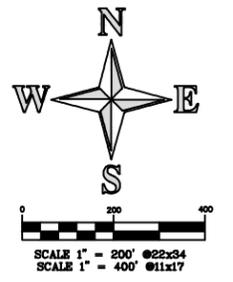
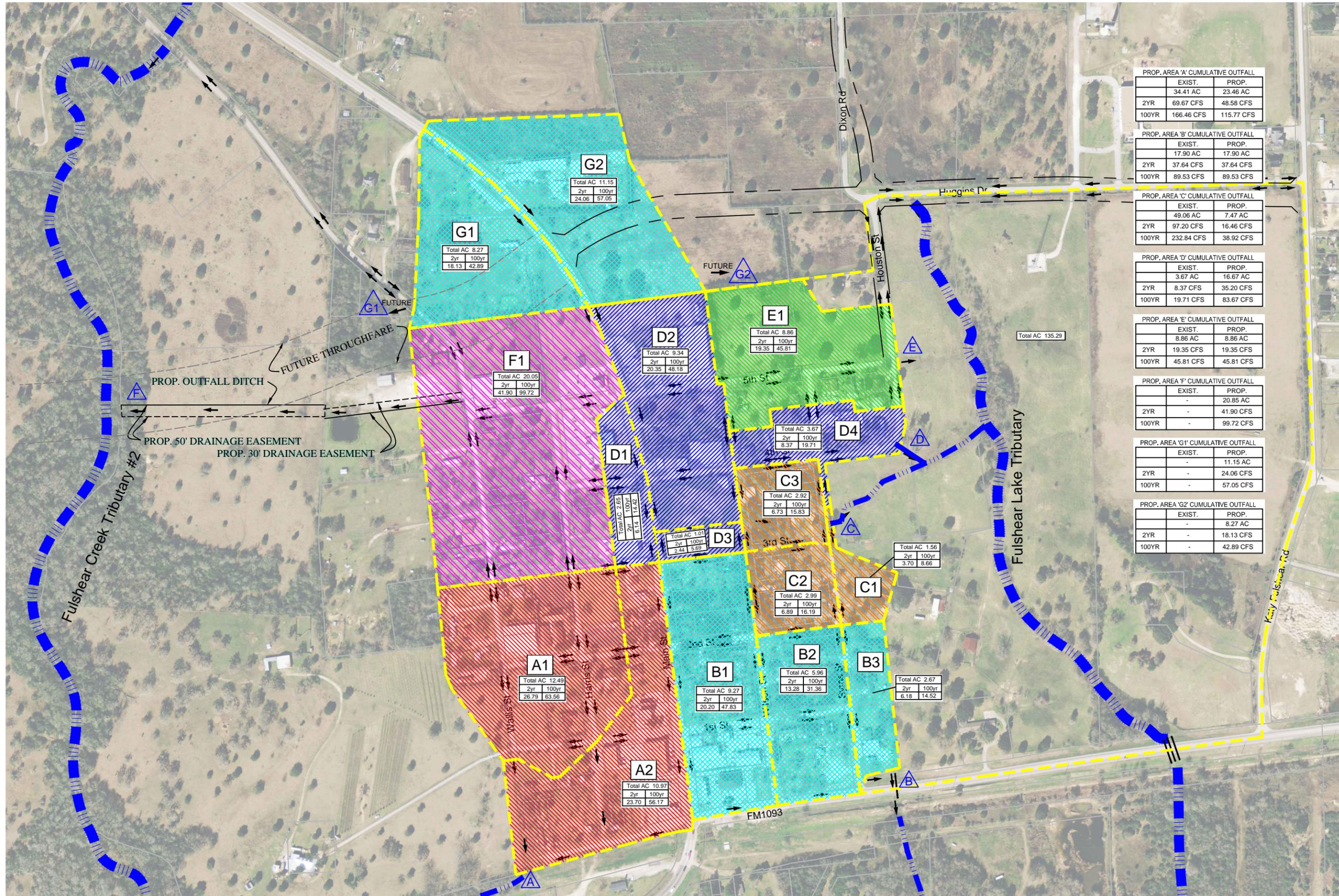
LEGEND

- Drainage Sub-area Boundary
- Overland & Ditch Flow Path
- ||| Natural Drainage Channel
- △ Drainage Outfall

Total AC 19.50
2yr 100yr
25.35 31.69

→ Total 100-year Flow (cfs)
→ Total 2-year Flow (cfs)





PROP. AREA 'A' CUMULATIVE OUTFALL

	EXIST.	PROP.
AC	34.41 AC	23.46 AC
2YR	69.67 CFS	48.58 CFS
100YR	166.46 CFS	115.77 CFS

PROP. AREA 'B' CUMULATIVE OUTFALL

	EXIST.	PROP.
AC	17.90 AC	17.90 AC
2YR	37.64 CFS	37.64 CFS
100YR	89.53 CFS	89.53 CFS

PROP. AREA 'C' CUMULATIVE OUTFALL

	EXIST.	PROP.
AC	49.06 AC	7.47 AC
2YR	97.20 CFS	16.46 CFS
100YR	232.84 CFS	38.92 CFS

PROP. AREA 'D' CUMULATIVE OUTFALL

	EXIST.	PROP.
AC	3.67 AC	16.67 AC
2YR	8.37 CFS	35.20 CFS
100YR	19.71 CFS	83.67 CFS

PROP. AREA 'E' CUMULATIVE OUTFALL

	EXIST.	PROP.
AC	8.86 AC	8.86 AC
2YR	19.35 CFS	19.35 CFS
100YR	45.81 CFS	45.81 CFS

PROP. AREA 'F' CUMULATIVE OUTFALL

	EXIST.	PROP.
AC	-	20.85 AC
2YR	-	41.90 CFS
100YR	-	99.72 CFS

PROP. AREA 'G1' CUMULATIVE OUTFALL

	EXIST.	PROP.
AC	-	11.15 AC
2YR	-	24.06 CFS
100YR	-	57.05 CFS

PROP. AREA 'G2' CUMULATIVE OUTFALL

	EXIST.	PROP.
AC	-	8.27 AC
2YR	-	18.13 CFS
100YR	-	42.89 CFS

**EXHIBIT 2
PROPOSED DRAINAGE
AREA MAP**

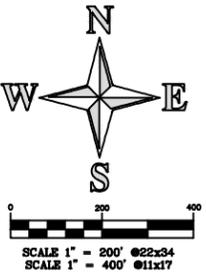
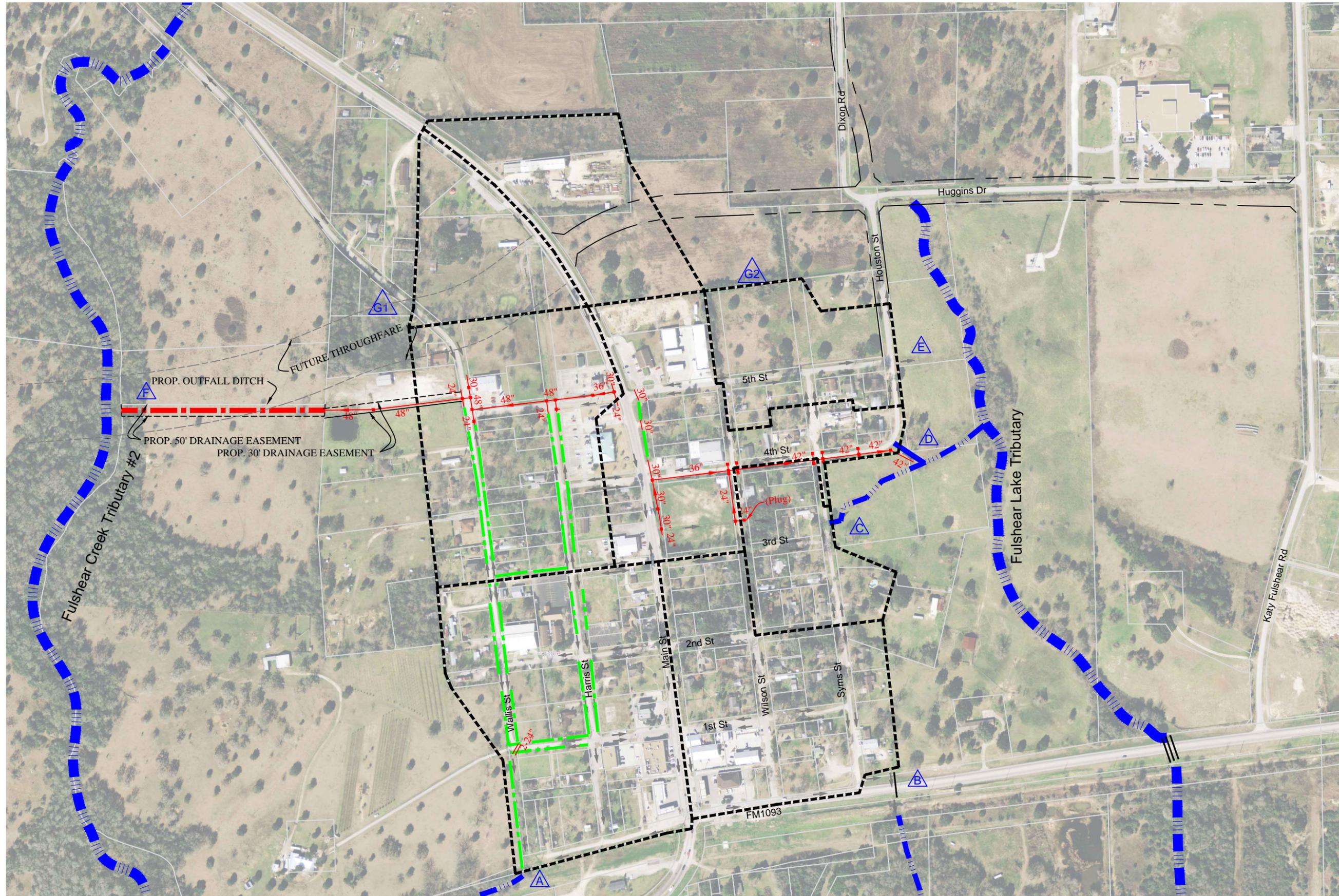
LEGEND

- Drainage Sub-area Boundary
- Overland & Ditch Flow Path
- ||| Natural Drainage Channel
- ▲ Drainage Outfall

Total AC	19.50
2yr	25.35
100yr	31.69

→ Total 100-year Flow (cfs)
→ Total 2-year Flow (cfs)



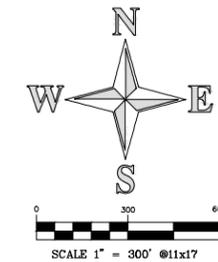


**EXHIBIT 3
PROPOSED DRAINAGE
IMPROVEMENT PLAN**

LEGEND

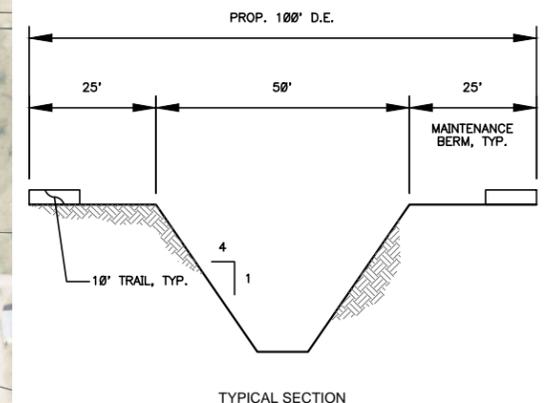
- 36" Proposed Storm Sewers
- Proposed Ditches
- Proposed Ditch Regrading
- Drainage Sub-area Boundary
- Overland & Ditch Flow Path
- Natural Drainage Channel
- Drainage Outfall





LEGEND:

①	36,246 SF	HUGGINS RANCH LTD
②	17,798 SF	HUGGINS RANCH LTD
③	618 SF	HUGGINS RANCH LTD
④	180,323 SF	WOODHAM FAMILY TRUST
⑤	37,095 SF	HUGGINS RANCH LTD
Ⓐ	17,805 SF	HUGGINS RANCH LTD
Ⓑ	2,235 SF	WOODHAM FAMILY TRUST
Ⓒ	21,605 SF	HUGGINS RANCH LTD
Ⓓ	17,667 SF	HUGGINS RANCH LTD



**EXHIBIT 4
PROPOSED DRAINAGE
IMPROVEMENTS &
HUGGINS TRAIL**



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(713) 400-2755 • www.arkkengineers.com • TX PE Firm No. 13872

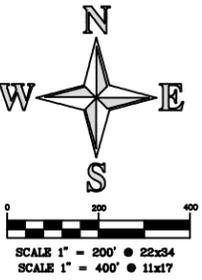
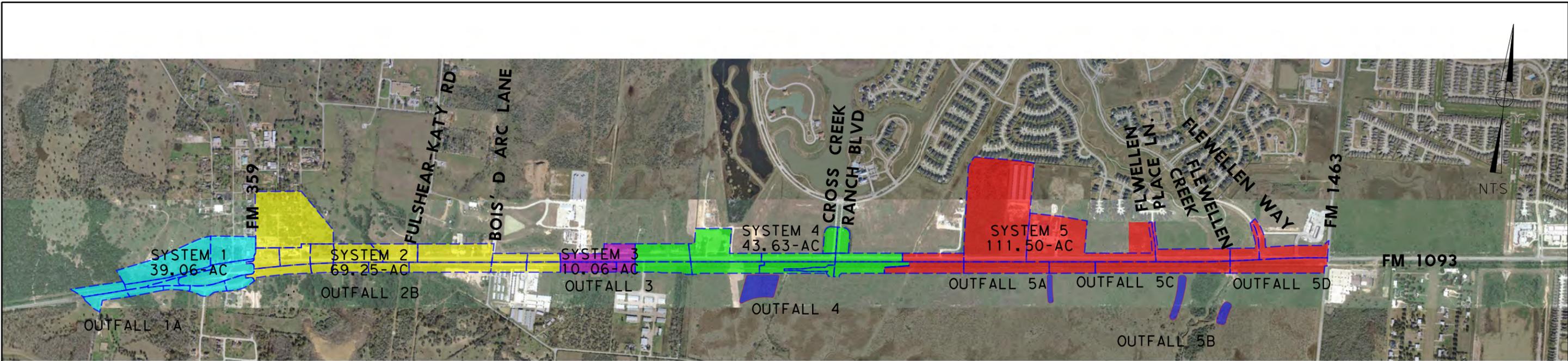


EXHIBIT 5
EXISTING ELEVATION
CONTOUR MAP

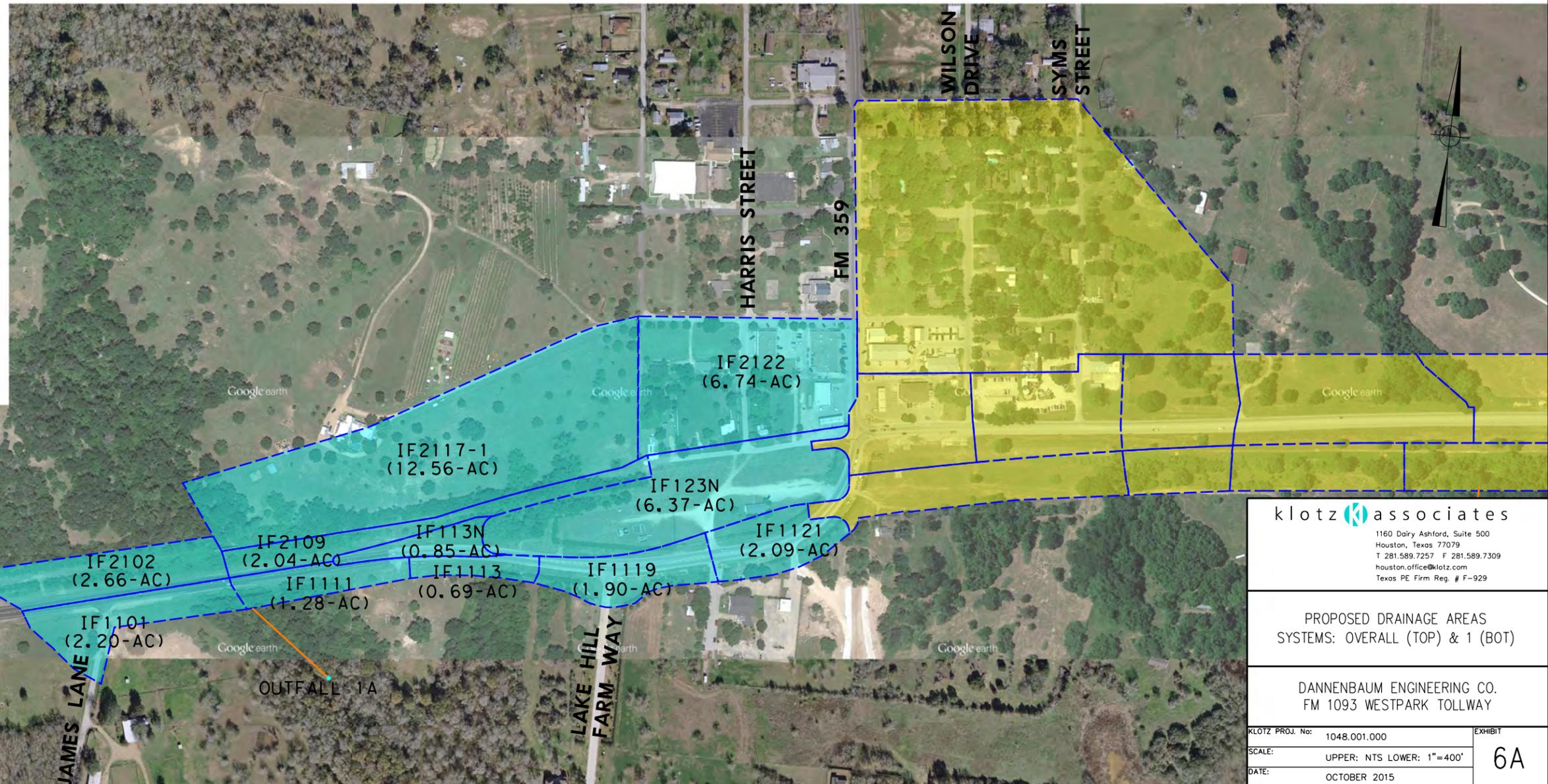


FIGURES



LEGEND
DRAINAGE AREAS (SYSTEM)

- SYSTEM 1
- SYSTEM 2
- SYSTEM 3
- SYSTEM 4
- SYSTEM 5



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PROPOSED DRAINAGE AREAS
 SYSTEMS: OVERALL (TOP) & 1 (BOT)

DANNENBAUM ENGINEERING CO.
 FM 1093 WESTPARK TOLLWAY

KLOTZ PROJ. No: 1048.001.000

SCALE: UPPER: NTS LOWER: 1"=400'

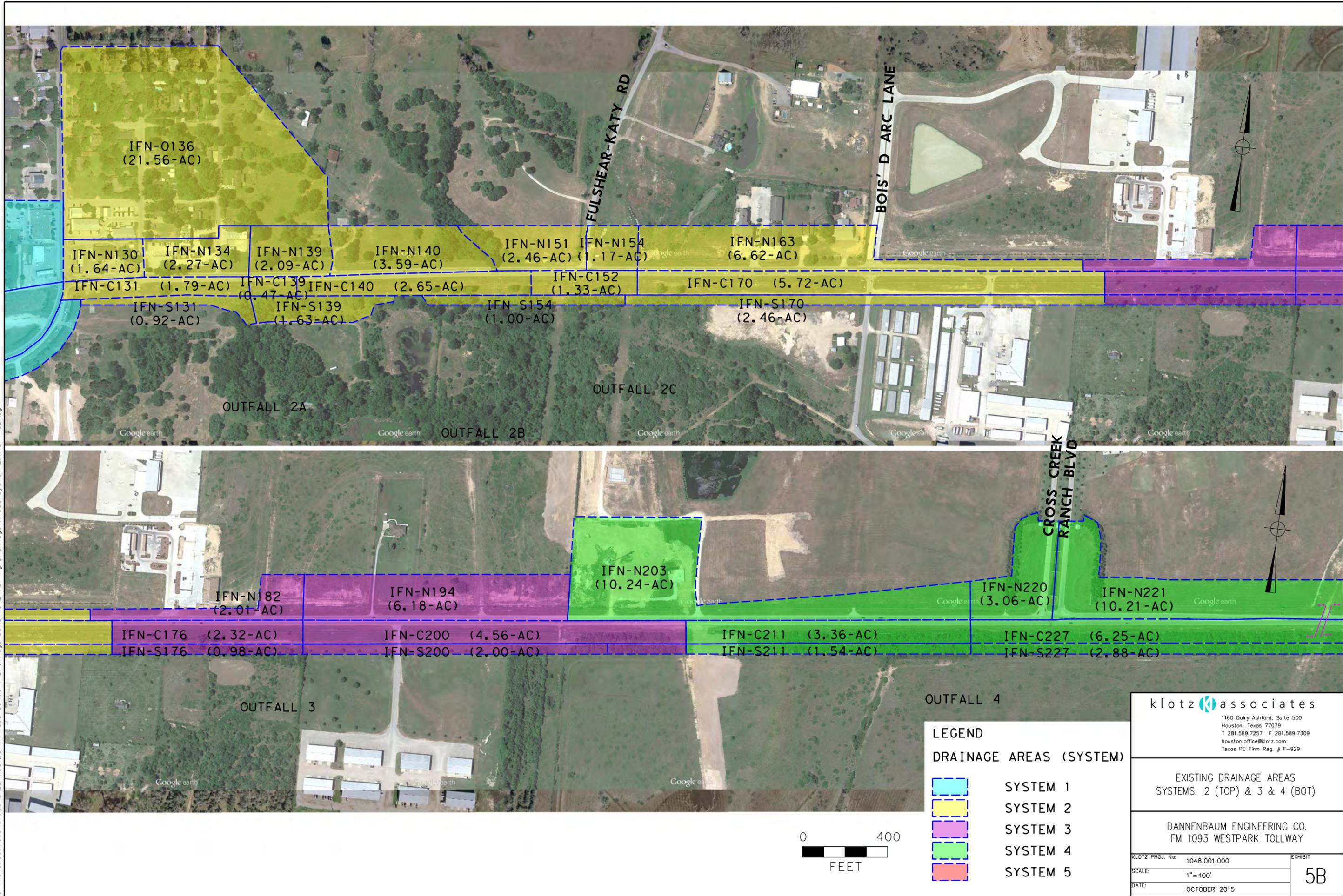
DATE: OCTOBER 2015

EXHIBIT
6A

10/15/2015 4:26:06 PM J:\1048.001.000\07.00 CADD\Westpark Phase 11\06-V Drainage Detail\Proposed Drainage Areas System Exhibit 6A.dgn

FIGURE 1

10/15/2015 5:17:44 PM J:\1048.001\000\07.00 CADD\Westpark Phase 11\06-V Drainage Detail\Existing Drainage Areas System Exhibit 5B.dgn



LEGEND

DRAINAGE AREAS (SYSTEM)

	SYSTEM 1
	SYSTEM 2
	SYSTEM 3
	SYSTEM 4
	SYSTEM 5



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EXISTING DRAINAGE AREAS
 SYSTEMS: 2 (TOP) & 3 & 4 (BOT)

DANNENBAUM ENGINEERING CO.
 FM 1093 WESTPARK TOLLWAY

KLOTZ PROJ. No: 1048.001.000	EXHIBIT 5B
SCALE: 1"=400'	
DATE: OCTOBER 2015	

FIGURE 2

TABLES

Table 1
City of Fulshear

Downtown Drainage Improvements - West Side Storm Sewer System

Project Cost Estimate

February 2019

ITEM	ITEM DESCRIPTION	UNIT	EST. QUAN.	UNIT PRICE	TOTAL
Paving and Drainage Improvements					
1	Remove Existing Driveways	SY	825	\$10.00	\$8,250
2	Removing Existing Roadways	SY	250	\$15.00	\$3,750
3	Asphalt Pavement Repair	SY	250	\$85.00	\$21,250
4	6" reinforced concrete driveway including subgrade	SY	825	\$65.00	\$53,625
5	Remove and dispose of existing inlets/manholes	EA	4	\$500.00	\$2,000
6	Remove and dispose of existing storm sewer	LF	100	\$20.00	\$2,000
7	Water Main offset	EA	1	\$5,000.00	\$5,000
8	San Swr Conflict Box	EA	2	\$5,000.00	\$10,000
9	Junction Manholes/Inlets	EA	14	\$3,500.00	\$49,000
10	24" Storm Sewers	LF	250	\$120.00	\$30,000
11	30" Storm Sewers	LF	125	\$135.00	\$16,875
12	36" Storm Sewers	LF	240	\$150.00	\$36,000
13	48" Storm Sewers	LF	1050	\$215.00	\$225,750
14	24" SET	EA	8	\$2,500.00	\$20,000
15	30" SET	LF	2	\$3,000.00	\$6,000
16	Open Ditch to FCT2	LF	950	\$50.00	\$47,500
17	SWPPP	LS	1	\$7,500.00	\$7,500
18	Trench Safety for Storm Sewer Installation	LF	1665	\$1.50	\$2,498
19	Traffic Control & Regulation	LS	1	\$20,000.00	\$20,000
20	Misc. Project Items	LS	1	\$56,700.00	\$56,700
21	Supplemental Items	LS	1	\$18,720.00	\$18,720
	10% Contingency				\$64,250
Subtotal Paving and Drainage:					\$706,668

Subtotal Construction	\$706,668
Estimated Design & Construction Administration Fees	\$89,500
Estimated Surveying	\$18,500
Estimated Geotechnical	\$6,000
Total Project:	\$820,668

Table 2
City of Fulshear

Downtown Drainage Improvements - East Side Storm Sewer System

Project Cost Estimate

February 2019

ITEM	ITEM DESCRIPTION	UNIT	EST. QUAN.	UNIT PRICE	TOTAL
Paving and Drainage Improvements					
1	Remove Existing Driveways	SY	250	\$10.00	\$2,500
2	Removing Existing Roadways	SY	1450	\$6.00	\$8,700
3	Asphalt Pavement Repair	SY	1450	\$35.00	\$50,750
4	Asphalt Pavement Recycling	SY	2450	\$15.00	\$36,750
5	Cement Slurry for Recycling	Ton	65	\$225.00	\$14,625
6	2" HMAC Surface Course	Ton	295	\$100.00	\$29,500
7	6" reinforced concrete driveway including subgrade	SY	250	\$65.00	\$16,250
8	Remove and dispose of existing inlets/manholes	EA	1	\$500.00	\$500
9	Remove and dispose of existing storm sewer	LF	190	\$20.00	\$3,800
10	Water Main offset	EA	2	\$5,000.00	\$10,000
11	San Swr Conflict Box	EA	4	\$5,000.00	\$20,000
12	Junction Manholes/Inlets	EA	21	\$3,500.00	\$73,500
13	24" Storm Sewers	LF	480	\$120.00	\$57,600
14	30" Storm Sewers	LF	530	\$135.00	\$71,550
15	36" Storm Sewers	LF	330	\$150.00	\$49,500
16	42" Storm Sewers	LF	775	\$185.00	\$143,375
17	24" SET	EA	1	\$2,500.00	\$2,500
18	30" SET	LF	5	\$3,000.00	\$15,000
19	Ditch Regrading	LF	400	\$20.00	\$8,000
20	SWPPP	LS	1	\$7,500.00	\$7,500
21	Trench Safety for Storm Sewer Installation	LF	2115	\$1.50	\$3,173
22	Traffic Control & Regulation	LS	1	\$20,000.00	\$20,000
23	Misc. Project Items	LS	1	\$64,510.00	\$64,510
24	Supplemental Items	LS	1	\$21,290.00	\$21,290
	10% Contingency				\$73,090
Subtotal Paving and Drainage:					\$803,963
Subtotal Construction					\$803,963
Estimated Design & Construction Administration Fees					\$99,500
Estimated Surveying					\$18,050
Estimated Geotechnical					\$6,500
Total Project:					\$928,013

Table 3
City of Fulshear

Downtown Drainage Improvements - West Side Ditch Improvements

Project Cost Estimate

February 2019

ITEM	ITEM DESCRIPTION	UNIT	EST. QUAN.	UNIT PRICE	TOTAL
Paving and Drainage Improvements					
1	Remove Existing Driveways	SY	450	\$10.00	\$4,500
2	Removing Existing Roadways	SY	325	\$15.00	\$4,875
3	Asphalt Pavement Repair	SY	325	\$85.00	\$27,625
4	6" reinforced concrete driveway including subgrade	SY	450	\$65.00	\$29,250
5	Remove and dispose of existing inlets/manholes	EA	4	\$500.00	\$2,000
6	Remove and dispose of existing storm sewer	LF	320	\$20.00	\$6,400
7	Water Main offset	EA	1	\$5,000.00	\$5,000
8	San Swr Conflict Box	EA	1	\$5,000.00	\$5,000
9	Junction Manholes/Inlets	EA	6	\$3,500.00	\$21,000
10	24" Storm Sewers	LF	760	\$120.00	\$91,200
11	Ditch Regrading	LF	5600	\$15.00	\$84,000
12	SWPPP	LS	1	\$7,500.00	\$7,500
13	Trench Safety for Storm Sewer Installation	LF	300	\$1.50	\$450
14	Traffic Control & Regulation	LS	1	\$10,000.00	\$10,000
15	Misc. Project Items	LS	1	\$29,880.00	\$29,880
16	Supplemental Items	LS	1	\$9,870.00	\$9,870
	15% Contingency				\$50,790
Subtotal Paving and Drainage:					\$389,340
Subtotal Construction					\$389,340
Estimated Design & Construction Administration Fees					\$58,500
Estimated Surveying					\$17,750
Total Project:					\$465,590

**Table 4
City of Fulshear**

Downtown Drainage Improvements - East Side Ditch and Trail Improvements

Project Cost Estimate

February 2019

ITEM	ITEM DESCRIPTION	UNIT	EST. QUAN.	UNIT PRICE	TOTAL
Paving and Drainage Improvements					
1	Right of Way Clearing	LS	1	\$50,000.00	\$50,000
2	Ditch Excavation	CY	15000	\$25.00	\$375,000
3	10' Trail both sides of ditch	SY	6000	\$65.00	\$390,000
4	Sodding	SY	15000	\$5.50	\$82,500
5	Hydromulch seeding	AC	6	\$2,500.00	\$15,000
6	SWPPP	LS	1	\$7,500.00	\$7,500
7	Traffic Control & Regulation	LS	1	\$20,000.00	\$20,000
8	Misc. Project Items	LS	1	\$94,000.00	\$94,000
9	Supplemental Items	LS	1	\$31,020.00	\$31,020
	10% Contingency				\$106,510
Subtotal Paving and Drainage:					\$1,171,530
Subtotal Construction					\$1,171,530
Estimated Design & Construction Administration Fees					\$120,000
Estimated Surveying					\$22,600
Estimated Geotechnical					\$6,500
Total Project:					\$1,320,630

