

FINAL ENGINEERING REPORT

Wastewater Treatment Plant Flood Resiliency Study

CITY OF WEST UNIVERSITY PLACE

IDS Project No. 2348-001-03

October 2020



Kameron H. Pugh
10/1/2020



TABLE OF CONTENTS

TABLE OF CONTENTSi

I. PURPOSE1

II. BACKGROUND1

III. LOCATION.....2

IV. EXISTING CONDITIONS2

V. REGULATORY ANALYSIS2

VI. REVIEW OF HISTORICAL FLOOD DATA.....3

VII. SUMMARY OF CRITICAL FACILITIES AND CRITICAL ELEVATIONS4

VIII. RECOMMENDATIONS.....5

TABLES/EXHIBITS

- (A) EXISTING WASTEWATER TREATMENT PLANT SITE LOCATION**
- (B) FEMA FLOODPLAIN DOCUMENTATION**
 - 1) FLOODPLAIN MAP FOR SITE
 - 2) FIS PROFILE OF BRAYS BAYOU NEAR SITE
- (C) SURVEY OF WASTEWATER TREATMENT PLANT SITE**
- (D) JURISDICTIONAL REGULATORY AGENCY CRITERIA**
 - 1) TCEQ RELEVANT FLOODPLAIN CRITERIA
 - 2) CITY OF HOUSTON RELEVANT FLOODPLAIN CRITERIA
 - 3) HARRIS COUNTY RELEVANT FLOODPLAIN CRITERIA
- (E) HCFCD HIGH WATER MARKS DATA**
- (F) TABLE OF CRITICAL FACILITIES AND ELEVATIONS**
- (G) PHOTOGRAPHS OF WWTP EQUIPMENT**

I. PURPOSE

The purpose of this report is to identify critical facilities at the City of West University Place (City) Wastewater Treatment Plant (WWTP) that should be protected from future flood events and to identify critical flood event water surface elevations. The report was prepared by IDS Engineering Group (IDS) and contains written descriptions of facilities, levels of protection, and the criteria that defines the basis of the recommendations.

II. BACKGROUND

The City has an existing WWTP that is located in the floodway of Brays Bayou (Exhibit B-1). Critical equipment should be protected from the floodway to avoid interruption of plant operations and potential repair costs.

IDS has visited the WWTP site and has reviewed the following documentation related to the project:

1. Construction plans titled “West University Place Plans for Construction of 2 MGD Sewage Treatment Plant” and dated October 1980.
2. Survey documents of the site completed by Weisser Engineering Company dated July 27, 2018 (Exhibit C).
3. Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRM) dated June 18, 2007 to identify the 100-year and 500-year flood plain locations (Exhibit B-1).
4. FEMA FIS Study to identify the 100-year and 500-year water surface elevations at the site (Exhibit B-2).
5. Information provided by the City and Harris County Flood Control District (HCFCD) showing approximate high-water mark elevations from the Hurricane Harvey flood event and other historical rainfall events.
6. City of West University Place, Wastewater Treatment Plant Master Plan dated August 2019 prepared by Kimley-Horn and Associates, Inc.
7. Regulatory agency criteria on elevations of equipment and facilities within the floodway including criteria issued by:
 - a. Texas Commission on Environmental Quality (TCEQ)
 - b. City of Houston (COH)
 - c. Harris County

All elevations included in this report are based on an average height above sea level and are based on the North American Vertical Datum of 1988 (NAVD 88), 2001 adjustment. This datum was adopted after Tropical Storm Alison and all current FEMA FIRMs are based on this.

Future FEMA FIRMs will use the GEOID12B vertical datum. Therefore, IDS has field verified the future datum change. Future reference to GEOID12B can be made by adding approximately 0.13-feet to the NAVD 88, 2001 Adjusted elevations.

III. LOCATION

The WWTP site is located within the City limits of the COH at 2801 North Braeswood Boulevard, Houston, Texas 77025. Exhibit A shows the location of the existing WWTP site.

IV. EXISTING CONDITIONS

The WWTP site is located within the floodway of Brays Bayou, Zone AE as defined by the FEMA FIRM – Panel 48201C0860L (Exhibit B-1). The existing 100-year and 500-year floodplain elevations at the WWTP site are 48.08-feet and 50.85-feet respectively, and the ground elevations of the site range approximately from 45.3-feet to 48.7-feet based on the above referenced topographical survey. The buildings and equipment on the site range in elevation from 48.15 to 62'. These elevations place the mechanical and electrical equipment above the 100 year but below the 500-year floodplain elevations. Additional details are presented in section VII of this report.

V. REGULATORY ANALYSIS

In 2019 the National Oceanic and Atmospheric Administration (NOAA) issued new rainfall data nationwide. The Texas release was termed Atlas 14, based on the issuance of this new rainfall data and recognized flooding outside mapped floodplains during Hurricane Harvey, HCFCD is in the process of conducting new flood studies on the major channels within Harris County. This program, MAAPNext, includes Brays Bayou and is anticipated to be complete in 2021. Upon completion of this program, Harris County, HCFCD, and the City of Houston are anticipated to adopt the data (floodplain/flood elevation data) developed from MAAPNext. The agencies plan to utilize this data to manage development within the floodplain in the interim, prior to the official release of the updated FEMA FIRM and FIS. The date at which FEMA will adopt new maps is unknown but is not expected until 2023 at the earliest.

The Atlas 14 data shows that more intense storms are more likely to occur over the region than those predicted from previous models. It is anticipated that once the new FIRMs are completed and adopted, the future 100-year floodplain will increase to approximately the elevation of the current 500-year floodplain for a large portion of the greater Houston area. Both the City of Houston and Harris County adopted new regulations to protect critical facilities from flooding based on this assumption and to ensure that new development does not impact future 100-year. It is anticipated but not guaranteed that these regulations will be updated again once FEMA adopts the new maps.

Based on conversations with HCFCD, protecting to the current 500-year elevation for Brays Bayou may be overly conservative. HCFCD anticipates that the new 100-year floodplain will not increase all the way to the current 500-year level but will be between the current 100-year and 500-year floodplain elevations. The exact increase is unknown at this time, but it possible that the level to which critical facilities at the WWTP site will need to be raised to be in compliance with local regulations could actually decrease after 2023.

The specific regulations that currently apply to this facility are as follows:

1. TCEQ rules for wastewater treatment facilities included in TCEQ 217.35 require protection from the current 100-year floodplain for all open process tanks and electrical units (Exhibit D-1). The TCEQ analysis must be based on the FEMA study in effect at the time plans are submitted to the TCEQ. This is less stringent than the requirements adopted by the CoH and Harris County as described below.
2. City of Houston adopted Ordinance No. 2018-258, an ordinance amending Chapter 19 of the Code of Ordinances, Houston, Texas, relating to floodplains (Exhibit D-2). The criteria states that for critical facilities located in an area that is subject to a 0.2 percent or greater chance of flooding in any given year (X Shaded Zone), all additions, new construction, and substantial improvements shall have the lowest floor elevated or floodproofed to at least three feet above the elevation that is subject to a 0.2 percent or greater chance of flooding. Prior to this ordinance, the COH requirement was for facilities to be located one foot above the 500-year floodplain elevation.
3. Harris County Regulations for Floodplain Management adopted July 9, 2019 require critical facilities within the 100-year floodplain to be located a minimum of 3 feet above the 500-year flood plain elevations (Exhibit D-3). This requirement was adopted in response to Hurricane Harvey and the Atlas 14 rainfall data. Prior to these requirements, Harris County required critical infrastructure to be elevated 3 feet above the 100-year floodplain elevation.

Based on the best available information at this time, and to be in compliance with local jurisdictional requirements, we advise that any WWTP equipment which is modified or replaced as part of the Wastewater Treatment Plant Master Plan be raised to a minimum of three feet above the current 500-year water surface elevation. This will be in compliance with the current rules adopted by the COH and Harris County and should provide adequate protection from the future 100-year flood plain. It should be noted that the required elevations for critical infrastructure as listed could change once the updated FIRMs are published, and the COH and Harris County regulations are modified based on those future maps.

VI. REVIEW OF HISTORICAL FLOOD DATA

In September 2017, Harris County Flood Control District made available a summary of highwater marks obtained during numerous flood events over the last 40 years. The data for Brays Bayou is included as Exhibit E. Please keep in mind that this data is approximate as noted in the exhibit and even though the data is from HCFCD they assume no responsibility for its accuracy. Even with this disclaimer, it is the best and most complete data available.

A review of this data shows that Brays Bayou reached a maximum water surface elevation of 47.9-feet at Buffalo Speedway during Hurricane Harvey and 47.2 feet at Kirby during Tropical Storm Alison. All other recorded highwater marks at these locations were lower. These elevations are close to the current 100-year floodplain elevations of 47.1 feet at Buffalo Speedway and 48.4 feet at Kirby.

This approximate flood gauge data reported by HCFCD is similar to information provided by the City, which indicated the water surface at the plant site reached 47.5 feet during Hurricane Harvey. This provides confirmation that the data from HCFCD is fairly accurate.

It is possible that improvements within Brays Bayou may have aided in reducing the flooding impact from Hurricane Harvey within the plant site. The improvements were completed after Tropical Storm Alison, but before Hurricane Harvey, and the flood levels were similar despite much higher recorded rainfall amounts during Harvey than during Alison.

It should be noted that as Brays Bayou becomes inundated during these large storm events, the higher water surface level in the Bayou will cause local storm sewer systems to back up and result in higher water surface elevations in areas upstream. As a result, water can back up in North Brasewood Blvd. to a higher elevation and then flow through the WWTP site to the Bayou.

VII. SUMMARY OF CRITICAL FACILITIES AND CRITICAL ELEVATIONS

IDS looked at each of the components of the WWTP and has identified which components are critical to the operation of the plant and/or should be protected from flood waters due to the expense of repairs, potential damages, and loss of operational capacity of the WWTP facilities. The table below provides a list of WWTP components and if they meet current requirements for flood protection of 3 feet above the current 500-year floodplain elevation – a minimum elevation of 53.85. More detail is shown in Exhibit F, including critical floodplain/high water mark elevations and the recommended elevation to which the equipment is suggested to be elevated. IDS consulted with HCFCD regarding the timing of updated Atlas 14 flood elevations for Brays Bayou. HCFCD anticipates public release of Atlas 14 flood elevations in 2021. At the time of the release of this information, critical elevations will need to be reconfirmed.

Equipment Unit	Elevation (Notes 1 & 2) (ft)	Elevation Subject to Damage from Flooding (ft)	Operation Impacted by Hurricane Harvey Floodwaters	Meets Current Agency Requirements
Electrical Service	49.85-51.80	49.85-51.8	No	No
Bottom of Generator	52.77	52.77	No	No
Blower Equipment	49.58	52.77	No	No
Chemical Feed Equipment Finished Floor Elevation (FF)	46.67	50.6	No	No
Sludge Transfer Pumps	46.67	48.7	No	No
Influent Lift Station Top of Wall	46.67	46.67 (See Note 3)	Yes	No
Electrical Control Building FF	47.31	48.15	No	No
Belt Press FF	61.67	62.0	No	Yes
Dewatering Sludge Pumps FF	46.67	48.0	No	No
NPW Pumps and Screen	48.20	50.7	No	No
Top of WWTP Basin Walls	56.17	56.17	No	Yes

Note:

1. Elevations referenced to NAVD 88, 2001 Adj.
2. This elevation represents the elevation of the equipment pad/bottom of equipment. This is not the elevation of the equipment that is subject to flood damage. However, this elevation of the portion of the equipment that would need to be raised in order to meet current agency criteria.

The electrical and mechanical equipment for the lift station are elevated above this level and were not damaged by Harvey; however, a flood elevation at this level or above will allow water to drain directly into the lift stations causing a significant amount of flood water to have to be pumped through the treatment plant.

While a majority of this equipment would not meet the current regulatory criteria if it was built today, this criteria only requires that any equipment undergoing substantial improvements be protected to three feet above the current 500-year floodplain elevation if it is undergoing the following, “repair, reconstruction, or improvement of a structure, where the cost of said improvement equals or exceeds 50% of the value of the structure either before the improvement is started or, if the structure has been damaged and is being restored, before the damage occurred – is not required to be elevated.” Based on this requirement any project included in the CIP will have to be in compliance with these regulations when constructed but some lower cost interim solutions would be allowed.

VIII. RECOMMENDATIONS

There are three basic ways to protect facilities from flood damage. One is to prevent the flood waters from reaching the facilities by building a berm. The second is by improving drainage to reduce the flood levels. The third is to raise the potentially impacted facilities above the anticipated flood level.

IDS has looked at all of these potential options but has ruled out the first two for the following reasons. In regard to a berm, the existing facility is located within the floodway of Brays Bayou. Building berms within the flood way is a violation of floodplain ordinances because it could result in a higher flood elevation in the Bayou by taking away flood plain storage and by blocking flow within the floodway. As a result, Harris County does not permit berms to be constructed within the floodway.

In regards to lowering the flood level, significant work has been done on Brays Bayou. As discussed in section V, it is anticipated that the increase in 100-year flood elevations in Brays Bayou will not be as significant as it will be for other watersheds in the region when new FIRM maps are completed by FEMA. Significant unknowns regarding what the ultimate flood elevations will be will remain until these new maps are released. Given the increase in rainfall values being used for the new maps, the work already done on Brays Bayou and the size of the watershed, reducing the current flood elevations are not practical and are outside of the scope of this study.

As a result, this report focuses on raising existing equipment that is included in the 2019 Wastewater Treatment Master Plan completed by Kimley-Horn, to meet the current regulations as the primary method of flood resiliency. It also includes recommendations to protect equipment on a temporary basis (until the Master Plan improvements are completed) up to the flood level that was seen in Hurricane Harvey. It should be noted that once the new FEMA maps are adopted and local flood plain regulations are updated based on these new maps, the recommendations in this study will need to be reviewed to confirm that they are still valid.

The following table identifies critical wastewater treatment plant components, the specific master plan projects that will impact these components (if any) and the additional requirements needed to meet the current regulations.

Equipment Unit	Mater Plan Recommendation	Additional Requirements
Electrical Service	Replace in Project P001/P003	Elevate Bottom of New Pad Mounted Transformer, Power Distribution Panel, Automatic Transfer Switch, and Main Circuit Breaker Panel to El. 53.85'
Generator	Not in Current Plan	Not required to be raised if not substantially modified. It is located above the current 500-year flood plain, however; if installed as new today the Generator would need to be Raised by Approximately 1.2 Feet (Min. El. 53.85')
Blowers	Replace in Project P002	Elevate Blowers by Approximately 4.5 Feet (Min. El. 53.85')
Chemical Feed Equipment	Replace in Project P006	Elevate All Mechanical/Electrical Equipment Associated with New Chemical Equipment and Protect Chemical Tanks to El. 53.85'
Sludge Transfer Pumps	Not in Current Plan	If substantially modified would need to elevate Sludge Transfer Pumps by Approximately 7.5 Feet; this is not practical, and these were not damaged during Harvey. The cost to elevate these would exceed the cost to repair them if they were damaged in an event the exceeded Harvey levels.
Influent Lift Station Top of Wall	Replace Screw Pumps with Submersible Pumps in Project P007	Construct New Lift Station Wet Well with Flood Proof Hatches to Protect to El. 53.85'
Electrical Control Building FF	Replace MCC equipment in Project P001/P003	Elevate New Electrical Enclosures by Approximately 6.5 Feet (Min. El. 53.85')
Belt Press FF	Not in Current Plan	No Additional Requirements
Dewatering Sludge Pumps FF	Not in Current Plan	Elevate Pumps by Approximately 7.5 Feet; Optionally Do Not Raise and Forgo Sludge Dewatering in the Event of Pump Failure due to Flooding
Non-Potable Water (NPW) Pumps and Screen	Replace in Project 016	Replace Existing NPW Pumps with Submersible Pumps Installed in the Chlorine Contact Basin
Top of WWTP Basin Walls	Not in Current Plan	No Additional Requirements

In addition to the equipment listed above, all equipment susceptible to impact from forces of floodwater, including buoyant forces, should be anchored. This includes equipment such as the dumpsters collecting solid waste from the influent bar screen and from the sludge dewatering equipment, chemical and sludge holding tanks, etc. All sanitary sewer manhole covers should be sealed with no openings in the lid.

It is speculated based on historical rainfall events that the 100-year floodplain elevation along Brays Bayou near the site may not increase to the level of current 500-year floodplain elevation when the new flood map data becomes available or when the new FIRMs are adopted. Therefore, the current COH and Harris County design criteria may be more stringent than what will be required when new maps and regulations are published. IDS recommends that for any project currently listed in the Master Plan related to the equipment listed above which are not recommended to be completed immediately, the City consider waiting to proceed with the project until the time at which the new floodplain maps and agency criteria are published.

Based on data from HCFCD and information provided by the City, the equipment in the table above was not damaged by flood waters produced by Hurricane Harvey. Because the equipment was not damaged during the flood of record at the WWTP site, IDS does not recommend separate projects to raise equipment that is not being improved or modified under the Master Plan.

It is important to note that although the influent lift station was not damaged during Hurricane Harvey to our knowledge, the lift station was entirely filled with flood waters from Brays Bayou. This inhibits the ability to convey flow from the City's gravity sanitary sewer system. It also results in the treatment of mostly flood waters conveyed through the lift station as opposed to only treating what is passed through the City's gravity sanitary sewer system. It is recommended that a new wet well with water-tight hatches and submersible pumps be constructed to solve this issue as proposed in the Master Plan Project P007. If the City elect to not proceed with Project P007, a separate project to flood proof the influent lift station is recommended. Interim solutions are also presented below.

Conceptual opinions of probable cost have been prepared for the recommendations listed above. Engineering, surveying, and materials testing fees are excluded from these costs. The cost estimates of the related improvements from the Master Plan have been included for your reference.

- Electrical Service (P001 - Immediate)
 - The Master Plan includes \$606,000 for the replacement of the electrical service equipment and electrical modifications/improvements. We estimate an approximate construction cost of \$200,000 to raise this equipment on a new platform. We met with Kimley-Horn and Associates, Inc. and they confirmed that approximately \$200,000 of the \$606,000 was allocated to raising the equipment, therefore we estimate no additional cost associated with P001 of the Master Plan.

- Blowers (P002 - Immediate)
 - The Master Plan includes \$2,611,000 for Treatment Process Optimization. Approximately \$900,000 was estimated for the replacement of the blowers, piping, associated electrical and appurtenances. We estimate an approximate construction cost of \$480,000 to elevate the blowers. We met with Kimley-Horn and Associates, Inc. and they confirmed that approximately \$180,000 of the \$2,611,000 was allocated to raising the equipment, therefore we estimate an additional cost of \$300,000 associated with P002 of the Master Plan.

- Chemical Feed Equipment (P006 – 5 Year)
 - The Master Plan includes \$473,000 for chlorine conversion/dechlorination improvements. We estimate an approximate construction cost of an additional \$140,000 for flood mitigation for this equipment.

- Lift Station (P007 – 5 Year)
 - The Master Plan includes \$1,217,000 for replacing the Screw Pumps with Submersible Pumps installed in a newly constructed sanitary sewer wet well. We recommend proceeding with this project as planned. However, we estimate the approximate total cost of the project to be \$1,520,000 to achieve flood resiliency for this equipment.

 - In the interim, the walls around the existing lift station should be raised by a minimum of 1.5' to prevent flood waters from entering the lift station during any event up to the current 100-year flood level. Note that to fully comply with current regulations the walls would need to be raised to a level of 53.85 or by about 7 feet. Given the configuration of the site this is not practical. Since the entire lift station is programmed to be replaced, we feel that an interim solution is justified at this location as long as the replacement of the lift station will occur in the near future. This interim work will require the removal and replacement of handrails, modifications to access stairs and some electrical conduits. In addition to raising the walls, a drain should be added near the stairs to help with local drainage in the area. It is estimated that this work will cost about \$50,000 to \$100,000.

- Electrical Control / Office Building (P003 and P011 – Immediate)
 - The Master Plan includes \$1,268,000 for the replacement of the electrical modifications/improvements (P003) and \$1,683,000 for improvements to the Lab/Office Building (P011). We estimate an approximate construction cost of an additional \$580,000 to raise the existing Motor Control Center and electrical controls by adding a second floor to the existing control and office building. This will allow the offices to be moved to the 2nd floor along with the electrical equipment. It is possible to complete this work by installing new columns just outside of the existing building and using these columns to support the second floor. This will keep the existing building from having to support the weight of the structure above it. It will also minimize the impact to operations while the new building is being constructed. By constructing the new building above the existing one, it will minimize

- the need to reroute duct banks and other underground infrastructure to a new building location.
- The costs associated with raising the Motor Control Center and associated equipment assume that the existing electrical conduit and conductors that are connected to the existing electrical equipment can remain in place and continue to be used. It is possible that these underground conduits/conductors may be in poor condition requiring replacement, which would increase the cost of the project. Therefore, additional studies, including field investigations and engineering report, will need to be completed in order to confirm the project scope and costs.
 - In the interim, we recommend that the City keep sandbags, inflatable dams or other similar items on site to protect the existing building from flood events. With Harvey only reaching a few inches above the finished floor elevation of the building these materials placed around the building can provide protection up a Hurricane Harvey level flood at a minimal cost.
 - NPW Pumps and Screens (P016 – 10 Year)
 - The Master Plan Includes \$230,000 for replacement of the existing NPW system. We recommend replacing the existing NPW pumps with submersible pumps rather than skid mounted pumps to protect the NPW from flood damage. We met with Kimley-Horn and Associates, Inc. and they confirmed that the costs included for P016 of the Master Plan were based on the installation of submersible pumps, therefore we estimate no additional cost associated with P016 of the Master Plan.

Based on the construction cost estimates included in the bulleted items above, we estimate a total of \$1,323,000 of construction costs will be required in addition to the costs of the projects described in the Master Plan (P001 – P020) in order to achieve flood resiliency.

EXHIBITS

EXHIBIT A
EXISTING WASTEWATER TREATMENT PLANT SITE LOCATION



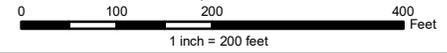
Legend

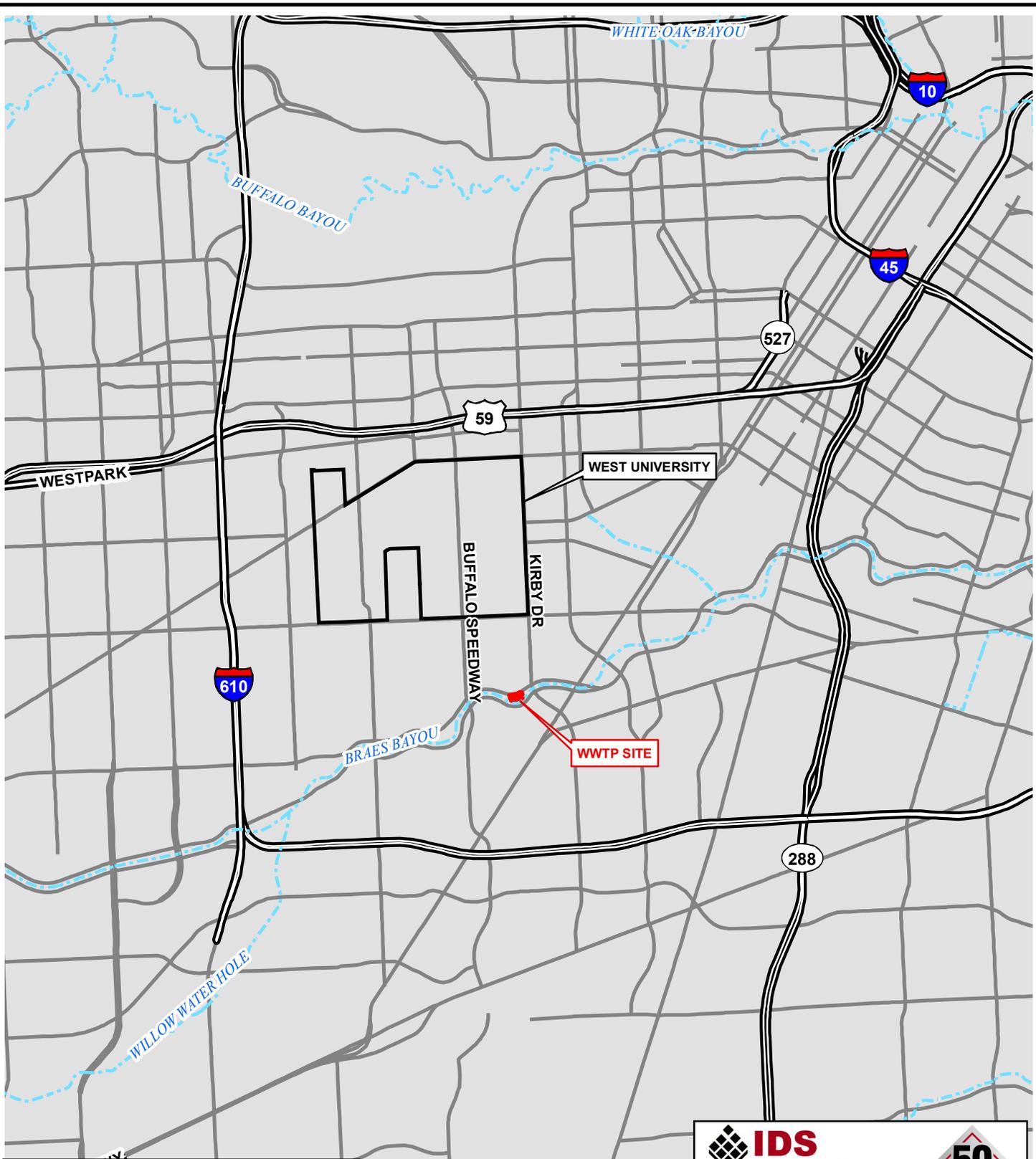
-  Wastewater Facilities
 -  Parcels (HCAD 2019-10)
- *NearMap Aerials (April 2020)

 **IDS**
Engineering Group
13430 Northwest Fwy, Ste. 700
Houston, Texas 77040
713.462.3178
TBPE F-002726 | TBPLS 10110700



EXHIBIT A-1
CITY OF WEST UNIVERSITY PLACE
WWTP LOCATION MAP
2801 NORTH BRAESWOOD BLVD
HOUSTON, TEXAS 77025





Legend

- Rivers
- West University City Limits
- Wastewater Facilities

*NearMap Aerials (April 2020)

IDS
Engineering Group
13430 Northwest Fwy, Ste. 700
Houston, Texas 77040
713.462.3178
TBPE F-002726 | TBPLS 10110700

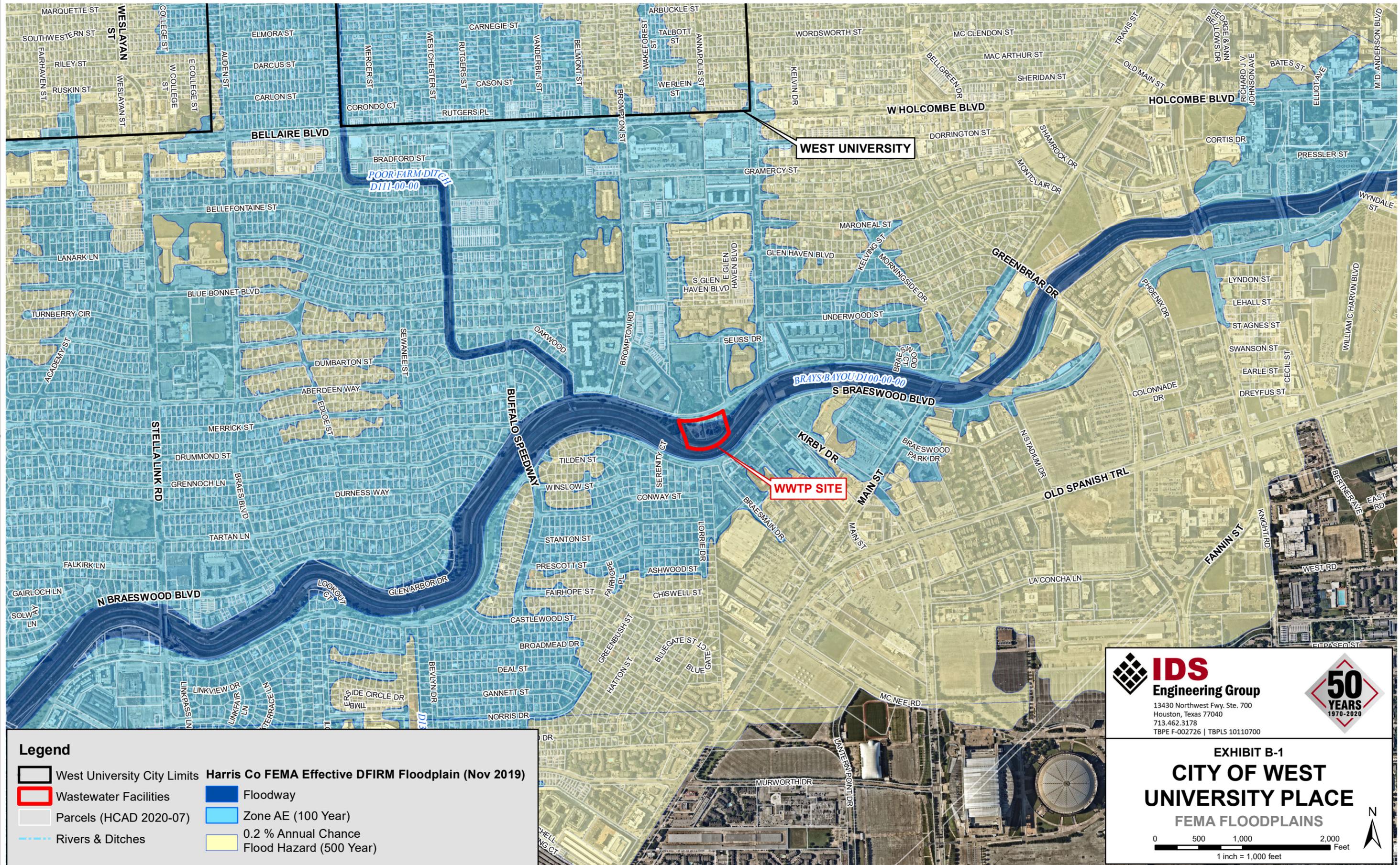
EXHIBIT A-2
CITY OF WEST UNIVERSITY PLACE
WWTP VICINITY MAP

0 3,000 6,000 12,000 Feet
1 inch = 6,000 feet

EXHIBIT B
FEMA FLOODPLAIN DOCUMENTATION

EXHIBIT B-1
FLOODPLAIN MAP FOR SITE

IDS Engineering Group \\houvgisb1\Projects\2300\2348-001-03_Flood Study Exhibits\B-1_Floodplains_11x17.mxd Plotted: 8/5/2020 at 5:12:51 PM by pbond



Legend

West University City Limits	Floodway
Wastewater Facilities	Zone AE (100 Year)
Parcels (HCAD 2020-07)	0.2 % Annual Chance Flood Hazard (500 Year)
Rivers & Ditches	

Harris Co FEMA Effective DFIRM Floodplain (Nov 2019)

IDS Engineering Group
 13430 Northwest Fwy. Ste. 700
 Houston, Texas 77040
 713.462.3178
 TBPE F-002726 | TBPLS 10110700

50 YEARS
 1970-2020

EXHIBIT B-1
CITY OF WEST UNIVERSITY PLACE
FEMA FLOODPLAINS

0 500 1,000 2,000 Feet
 1 inch = 1,000 feet

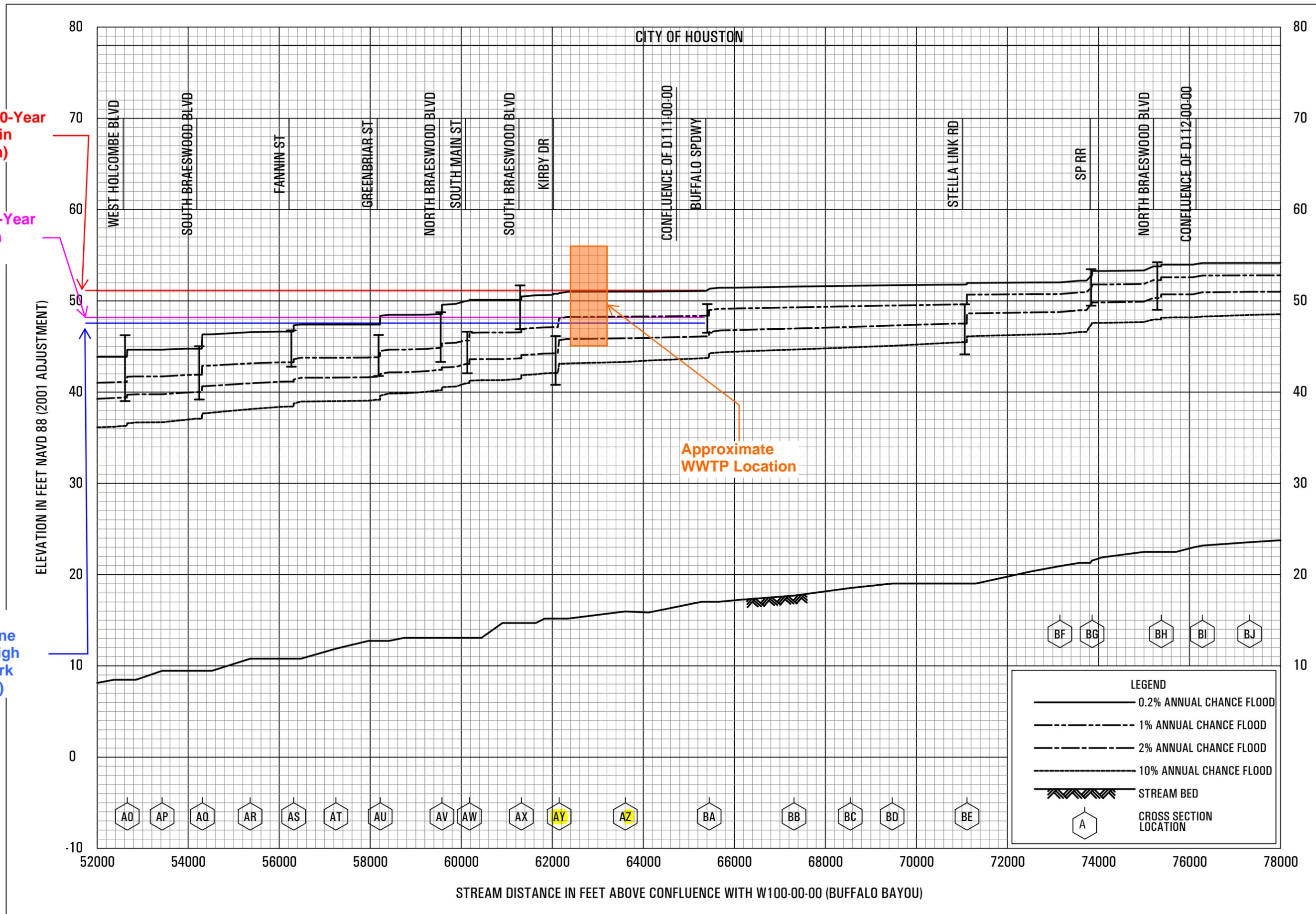
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EXHIBIT B-2
FIS PROFILE OF BRAYS BAYOU NEAR SITE

50.85 (500-Year Floodplain Elevation)

48.08 (100-Year Floodplain Elevation)

47.5 (1Hurricane Harvey High Water Mark Elevation)



FLOOD PROFILES

D100-00-00 (BRAYS BAYOU)

FEDERAL EMERGENCY MANAGEMENT AGENCY
HARRIS COUNTY, TX
AND INCORPORATED AREAS

D03P

Exhibit B-2

EXHIBIT C
EXISTING WASTEWATER TREATMENT PLANT SITE SURVEY

EXHIBIT D
JURISDICTIONAL REGULATORY AGENCY CRITERIA

EXHIBIT D-1
TCEQ RELEVANT FLOODPLAIN CRITERIA

**SUBCHAPTER B: WASTEWATER TREATMENT FACILITY DESIGN
REQUIREMENTS**

**§§217.31 - 217.40
Effective December 4, 2015**

§217.31. Applicability.

This subchapter details the design values that an owner shall use when determining the size of any wastewater treatment facility component. This subchapter applies to the treatment design for a new wastewater treatment facility, the alteration of an existing wastewater treatment facility, the re-rating of an existing wastewater treatment facility, and to an existing wastewater treatment facility that is required to apply for a new permit.

Adopted November 4, 2015

Effective December 4, 2015

§217.32. Organic Loadings and Flows for New Wastewater Treatment Facilities.

(a) The design of a new wastewater treatment facility must be based on the flows and loadings in paragraphs (1) - (3) of this subsection, unless subsection (b) of this section applies.

(1) Design flow.

(A) If the flow is greater than or equal to 1.0 million gallons per day, as determined by multiplying the per capita flow in Table B.1. in paragraph (3) of this subsection by the number of individuals in the service area, then the design flow is the flow calculated from the table.

(B) If the flow is less than 1.0 million gallons per day as determined by multiplying the per capita flow in Table B.1. in paragraph (3) of this subsection by the number of individuals in the service area, then the design flow is determined by multiplying the average annual flow calculated from the table by a factor of at least 1.5.

(C) The design flow must be based on the flow authorized in the wastewater treatment facility's wastewater permit.

(2) Peak flow. When site-specific data is unavailable, the peak flow must be determined by multiplying the design flow by a factor of at least 4.0. If site-specific data or projections are available, the peak flow must be based on the site-specific data.

§217.35. One Hundred-Year Flood Plain Requirements.

(a) If a 100-year flood plain is located within 1,000 feet of the site of a wastewater treatment facility, the 100-year flood plain must be shown on the site plan. A flood plain determination must be based on a superimposition of the 100-year flood elevation on the most accurate available topography and elevation data for the site.

(1) A 100-year flood plain must be based on the Federal Emergency Management Agency (FEMA) Flood Insurance Study in effect at the time the plans and specifications are submitted to the executive director. FEMA maps are prima facie evidence of flood plain locations.

(2) An appropriate flood insurance rate map or Flood Insurance Study profile, adjusted to the site's vertical data, may be used to determine flood elevations.

(3) If a site is adjacent to a FEMA 100-year flood delineation, but has no flood elevation published, a 100-year flood elevation may be determined by overlaying the effective FEMA delineation over a United States Geological Survey Quadrangle Map and interpolating a flood elevation.

(4) If FEMA flood plain information is not available, the engineering report shall include a 100-year flood elevation based on the best information available.

(b) The 100-year flood plain must be shown on the profile drawings.

(1) The FEMA 100-year water surface elevation must be marked on a hydraulic profile of a wastewater treatment facility in accordance with the vertical scale of the drawing.

(2) If a wastewater treatment facility will occupy less than 1,000 feet of shoreline along a flood plain, the profile must show a single line coincident with the elevation of the centerline of any outfall pipe.

(3) If a wastewater treatment facility will occupy 1,000 feet or more of shoreline along a flood plain, the profile must show the water surface elevation at both the upstream and downstream limits of any protective structure for the wastewater treatment facility.

(c) The executive director will not approve a design of a proposed treatment unit within a 100-year flood plain, unless the design provides protection for all open process tanks and electric units from inundation during a 100-year flood event.

EXHIBIT D-2
CITY OF HOUSTON RELEVANT FLOODPLAIN CRITERIA

AN ORDINANCE AMENDING CHAPTER 19 OF THE CODE OF ORDINANCES, HOUSTON, TEXAS, RELATING TO FLOODPLAINS; CONTAINING FINDINGS AND OTHER PROVISIONS RELATING TO THE FOREGOING SUBJECT; PROVIDING FOR SEVERABILITY; AND CONTAINING AN EFFECTIVE DATE.

* * * * *

WHEREAS, the residents and business owners of the City of Houston have experienced worsening flooding events, the most recent being Hurricane Harvey in 2017, which dropped more than 50 inches of rain in the region, and which was preceded by the 2016 Tax Day Flood and the 2015 Memorial Day Flood; and

WHEREAS, the Mayor and City Council have resolved to make the City more resilient as it rebuilds; and

WHEREAS, the City of Houston is a municipal corporation and home rule city organized under the Constitution and the general and special laws of the State of Texas, and thereby exercises powers granted by the City's Charter and the provisions of Article XI, Section 5 of the Texas Constitution; and

WHEREAS, in the exercise of its lawful authority, the City may enact police power ordinances to promote and protect the health, safety and welfare of the public; and

WHEREAS, the City may implement, in the exercise of its lawful authority, any federal law or rules relating to development in flood hazard areas; and

WHEREAS, a key tool in protecting human life, health, and economic stability, minimize damage to public facilities and utilities is ensuring responsible development in the floodplain areas; and

WHEREAS, the Federal Emergency Management Agency (FEMA) promulgates maps and recommended regulations for development in flood-prone areas; and

WHEREAS, FEMA and Houston Public Works study and identify flood hazard areas within the boundaries of the City of Houston, and such areas may be subject to periodic inundation which may result in loss of life and property, health and safety hazards, disruption of commerce and governmental services, extraordinary public expenditures for flood protection and relief, and impairment of the tax base, all of which adversely affect the public health, safety and general welfare; and

WHEREAS, Houston has seen severe flooding since its founding, thus both historical and recent storms indicate that Houston will continue to see severe flooding events; and

elevated above the highest adjacent grade at least two feet above the depth number specified in feet on the FIRM or at least three feet above the highest adjacent grade where no depth number is specified or, together with utility and sanitary sewerage facilities, be completely floodproofed to or above that level.

(d) All structures to be constructed in whole or in part within these zones shall be designed with adequate drainage paths around structures on slopes to guide floodwaters around and away from those structures.

(e) For critical facilities located in an area that is subject to a 0.2 percent or greater chance of flooding in any given year (X Shaded Zone), all additions, new construction, and substantial improvements shall have the lowest floor elevated or floodproofed to at least three feet above the elevation that is subject to a 0.2 percent or greater chance of flooding.

Sec. 19-34. Additional standards for design and mitigation.

(a) For areas that the city engineer has determined have no conveyance capacity, proposed development shall not, at any time, diminish the storage volume within a Houston special flood hazard area. Applicants shall demonstrate compliance with this requirement by submitting plans that demonstrate one or more of the following:

- (1) Demonstrate that any loss of storage volume will be mitigated on-site, such that there is no net fill;
- (2) Demonstrate that any loss of storage volume will be mitigated off-site in accordance with rules and regulations promulgated by the director pursuant to subsection (f) of section 19-1 of this Code;
- (3) Identify an amount of fill associated with elevated floor construction that, although the amount may be approaching zero, is recognized by the city engineer as sufficiently important to be addressed, but for which mitigation is not required, in accordance with rules and regulations promulgated by the director pursuant to subsection (f) of section 19-1 of this Code; or
- (4) In the 0.2 percent chance floodplain, the amount of fill proposed does not impact or impede the 100 year overland sheet flow in the watershed.

(b) For areas that the city engineer has determined to have conveyance capacity, and for areas for which the city engineer has made no determination of conveyance capacity, development shall not, at any time, either change the conveyance capacity or diminish storage volume of the Houston special flood hazard area; except that, if the applicant submits a Conditional Letter of Map Revision approved by FEMA, the engineering analysis need only demonstrate that the development will not, at any time, diminish storage volume of the Houston special flood hazard area.

EXHIBIT D-3
HARRIS COUNTY RELEVANT FLOODPLAIN CRITERIA

**REGULATIONS OF HARRIS COUNTY, TEXAS
FOR FLOODPLAIN MANAGEMENT**



AS

**ADOPTED 5 JUNE 2007
EFFECTIVE 18 JUNE 2007
AMENDED 8 NOVEMBER 2011
AMENDED 5 DECEMBER 2017
EFFECTIVE 1 JANUARY 2018
AMENDED 9 JULY 2019
EFFECTIVE 9 JULY 2019**

**JOHN R. BLOUNT, P.E.
COUNTY ENGINEER**

**LOYD SMITH, P.E.
ASSISTANT COUNTY ENGINEER**

when measured 10 feet from the edge of the slab or 12 inches above the crown of the adjacent street which ever results in the highest elevation (an exception may be granted on sloping properties where the crown requirement is not achievable).

2. If the structure is other than a single family residence the slab shall have a minimum of 6 inches of exposure to adjacent grade and be at least 12 inches above the crown of the adjacent street (an exception may be granted on sloping properties where the crown requirements cannot be achieved).
3. In cases where a structure is located geographically in the 0.2 percent or 500-year floodplain and the ground is lower than the 0.2 percent or 500-year level but higher than the 1 percent or 100-year level, the finished floor elevation of the lowest habitable floor shall be elevated at or above the 0.2 percent or 500-year level.

SECTION 4.07 - CONDITIONS OF A CLASS "II" PERMIT

A Class "II" Permit will be issued when the County Engineer determines that the development will be made on land that is located in any "A" Zone, below the 1 percent or 100-year

flood elevation in any Zone, in a floodway, or in a “V” Zone and that all other necessary reviews and approvals required by County regulations have been obtained. The following conditions must be met:

- (a) Notwithstanding anything below to the contrary, no development or other encroachment, including fill, is allowed in a floodway which will result in any increase in the base flood elevations within the floodway during discharge of water of a base flood.
- (b) The following conditions must be met for new construction or Substantial Improvement of a structure or repair of a structure with Substantial Damage.
 - 1. The top of the subfloor of the lowest habitable floor must be elevated to twenty-four (24) or more inches above the 0.2 percent or 500-year flood elevation or twelve (12) inches above the level of the crown of the nearest public street, whichever is higher, **except in a floodway where the bottom of the lowest supporting member of the structure shall be elevated thirty-six (36) or more inches above 0.2 percent or 500-year flood elevation.**

6. Water heaters, furnaces, air conditioning systems, electrical distribution panels and any other mechanical or electrical equipment must be elevated to at least twenty-four (24) inches above the 0.2 percent or 500-year flood elevation. Separate electrical circuits shall serve any level below the 0.2 percent or 500-year flood elevation and shall be dropped from above.

7. Basements may be constructed only in nonresidential structures, and only on land which is not in a floodway or "V" Zone, and must, together with attendant utility and sanitary facilities, be designed so that below the base flood elevation the structure is watertight with walls substantially impermeable to the passage of water and with structural components having the capability of resisting hydrostatic and hydrodynamic loads and effects of buoyancy. A registered professional engineer shall certify that the floodproofing methods used in the construction of the basement are adequate to withstand the flood depths, pressures, velocities, impact and uplift forces and other factors associated with the base flood. A record of such certification

indicating the specific elevation to which such structures are floodproofed shall be maintained with the County Engineer.

8. All air ducts, loose pipes, propane tanks and storage tanks located at or below the base flood level shall be firmly anchored to prevent flotation. Tanks and ducts shall be vented to at least twenty-four (24) inches above the 0.2 percent or 500-year flood elevation.
9. No fill may be used to elevate structures in the 1 percent or 100-year floodplain. Structures may be constructed on an open foundation, such as piers, or on continuous foundation walls with properly sized and located openings. All foundations are required to be designed by a registered professional engineer. The Plans shall clearly show compliance with all provisions of these regulations. Fill may be used in coastal surge zones where floodplain fill mitigation is not an issue, however the standard for foundations remain the same.
10. All structures shall be designed to withstand a three second gust basic wind speed of 120

EXHIBIT E
HCFC HIGH WATER MARKS DATA

SUMMARY SHEET - HCFCD HIGH WATER MARKS

9/13/2017

BRAYS BAYOU D100-00-00 Page 1 of 2

ROAD NAME	STAGE GAGE	BRIDGE BM ELEV	78 TO '01 ADJUST	10.0%	2.0%	1.0%	0.2%	STORM EVENTS														HARVEY 8/27/17						
								7/30/54	6/18/73	8/31/81	ALICIA 8/18/83	CHANTAL 9/19/83	8/1/89	3/4/92	10/18/94	FRANCES 9/11/98	ALLISON 6/9/01	11/17/03	IKE 9/13/08	4/28/09	1/9/12		5/26/15	4/18/16	1/18/17			
75 TH		20.35	-0.5	14.4	17.1	18.3	21.5				13.4	12.7			11.9	13.6	16.5	8.8	16.8	N/A	10.1	12.4	11.9	8.1	16.1			
LAWNDALE	410	21.97	-0.6	18.1	20.7	21.9	24.7				16.7	17.0	13.9		17.6	17.9	22.8	14.9	17.0	9.2	15.6	18.4	18.0	13.4	20.7			
IH 45 (IN BOUND)		31.49	-0.6	21.7	24.4	25.6	28.3		20.1					20.8				21.7	20.7	27.6	20.0	21.6	N/A	18.4	21.6	18.5	16.9	25.5
TELEPHONE RD		25.65	-0.6	23.4	26.0	27.3	30.2	22.4	21.7	20.2	18.7				22.1	21.8	27.8	15.7	22.9	14.8	19.9	22.2	21.0	18.2	25.0			
WAYSIDE		32.17	-0.6	24.9	27.8	29.2	32.0		23.5						23.0	16.8	20.4 ¹				14.2	21.0	23.3	22.5	18.2	26.9		
OLD SPANISH TRAIL (OST)		28.47	-0.7	25.4	28.3	29.9	32.8								26.3		27.8	16.6	25.0	15.7	20.9	23.8	22.5	16.3	27.3			
MARTIN LUTHER KING		36.47	-0.8	29.7	32.4	33.7	36.1				24.9	26.8			26.0	29.5	32.8	26.6	29.9	20.9	26.2	29.3	26.4	18.2	32.3			
CALHOUN		33.41	-0.8	30.3	32.8	34.0	36.5	31.9	29.2	29.0					29.5	30.1	32.8	27.8	30.7	22.0	28.2	28.9	28.8	26.2	33.7			
SCOTT		37.92	-1.0	31.6	34.4	35.7	37.9								31.3	32.3	32.4	29.7	31.5	24.0	29.4	32.1	30.5	28.4	35.2			
ARDMORE		37.36	-1.1	32.8	35.4	36.6	38.9								33.9		38.0	31.9	32.8	25.8	31.2	34.3	29.1 ¹	30.6	37.4			
SH 288		51.01	-1.2	33.6	36.4	37.8	40.1				30.4				34.8	35.2	39.3	33.9	33.6	26.7	33.0	35.2	34.2	31.7	39.2			
ALMEDA RD		41.10	-1.2	34.4	37.6	39.1	41.9		35.1	34.5					36.2	34.7	37.5	33.9	35.0	27.1	33.7	37.0	36.0	32.3	40.4			
D109 @ MACGREGOR	400	39.11	-1.2	34.9	38.2	39.9	43.0												34.0	N/A	36.1	38.0	37.4	35.3	41.5			
HOLCOMBE BLVD		43.31	-1.2	36.3	39.4	41.1	43.9		37.4	37.3	33.8	38.4			38.2	36.7	40.3	36.7	37.2	30.7	36.5	38.2	37.7	34.9	41.7			
S. BRAESWOOD BLVD.		43.68	-1.2	37.1	40.0	41.9	44.8								39.4		42.9	38.0	38.7	32.0	37.3	39.9	38.2	36.4	42.0			
FANNIN		45.81	-1.3	38.4	41.2	43.3	46.6			38.9	34.7				41.0	38.5	44.0	37.8	39.4	34.0	37.9	40.1	39.5	37.5	43.5			
GREENBRIAR		45.11	-1.3	39.2	41.7	43.8	47.4								40.7		42.2	39.9	39.4	35.0	38.7	41.3	40.4		44.4			
N. BRAESWOOD BLVD.		47.58	-1.4	40.2	42.4	44.9	48.6								41.7		44.5	46.5	40.8	N/A	40.6	42.2	41.0		45.7			
SOUTH MAIN	420	46.53	-1.4	41.0	43.1	45.7	50.0		41.2	41.5	37.4	42.4	38.8		42.2	39.6	42.9	40.6	41.3	36.5	40.5	42.9	42.1		45.7			
S. BRAESWOOD		49.74	-1.3	41.4	43.7	46.6	50.1								42.7		44.3	42.0	41.9	36.3	39.9	43.1	42.4	40.5	45.9			
KIRBY		44.30	-1.3	42.1	44.3	47.1	50.7		41.6	42.5					42.7	40.6	47.2	42.1	41.8	37.4	41.6	43.9	43.0		46.3			
BUFFALO SPEEDWAY		49.48	-1.3	43.7	46.1	48.4	51.1		42.8		40.9				44.4	43.1	47.4	43.7	43.3	39.3	43.7	45.5	44.1	42.7	47.9			
STELLA LINK	430	49.55	-1.7	45.5	47.5	49.6	51.8		45.1	46.1	42.7			45.0	46.0	44.3	48.4	46.4	45.9	43.0	45.7	48.3	47.1	45.7	49.7			
SPRR		53.36	-1.7	47.2	49.5	51.3	52.6								47.8	46.3	49.4	47.1	46.5	44.0	47.2	49.1	47.7	46.8	50.7			

NOTE: BRIDGE AND HIGH WATER ELEVATIONS ARE ON 1988 NAVD; 2001 ADJ

NOTE: D109 @ MacGregor added as a HWM location in summer of 2005

¹ = Suspect elevation, low confidence in field

Exceedance probability elevations are from the June 9th, 2006 TSARP Flood Insurance Study.
High water marks are approximate. HCFCD assumes no responsibility for their accuracy.

EXHIBIT F
TABLE OF CRITICAL FACILITIES AND ELEVATIONS

**CITY OF WEST UNIVERSITY PLACE
WASTEWATER TREATMENT PLANT FLOOD MITIGATION STUDY
EXHIBIT F - TABLE OF CRITICAL FACILITIES AND ELEVATIONS**

Equipment Unit	Elevation (2) (ft)	Elevation Subject to Damage from Flooding (ft)	(6/2007) 100-Year Floodplain Elevation (ft)	(6/2007) 500-Year Floodplain Elevation (ft)	500-Year Floodplain Elevation Plus 3-Foot (ft)	Hurricane Harvey High Water Elevation (ft)	Recommended Equipment Minimum Elevation (ft)
Electrical Service	49.85 - 51.8	49.85 - 51.8	48.08	50.85	53.85	47.5	53.85
Bottom of Generator/Top of Fuel Tank	52.77	52.77	48.08	50.85	53.85	47.5	53.85
Blower Equipment	49.58	50.4	48.08	50.85	53.85	47.5	53.85
Chemical Feed Equipment	46.67	50.6	48.08	50.85	53.85	47.5	53.85
Sludge Transfer Pumps	46.67	48.7	48.08	50.85	53.85	47.5	53.85
Influent Lift Station Top of Wall	46.67	46.67	48.08	50.85	53.85	47.5	53.85
Electrical Control Building	47.31	48.15	48.08	50.85	53.85	47.5	53.85
Belt Press	61.67	62.0	48.08	50.85	53.85	47.5	No Change
Dewatering Sludge Pumps	46.67	48.0	48.08	50.85	53.85	47.5	53.85
NPW Pumps and Screens	48.20	50.70	48.08	50.85	53.85	47.5	53.85
Top of WWTP Basin Walls	56.17	56.17	48.08	50.85	53.85	47.5	No Change

Note:

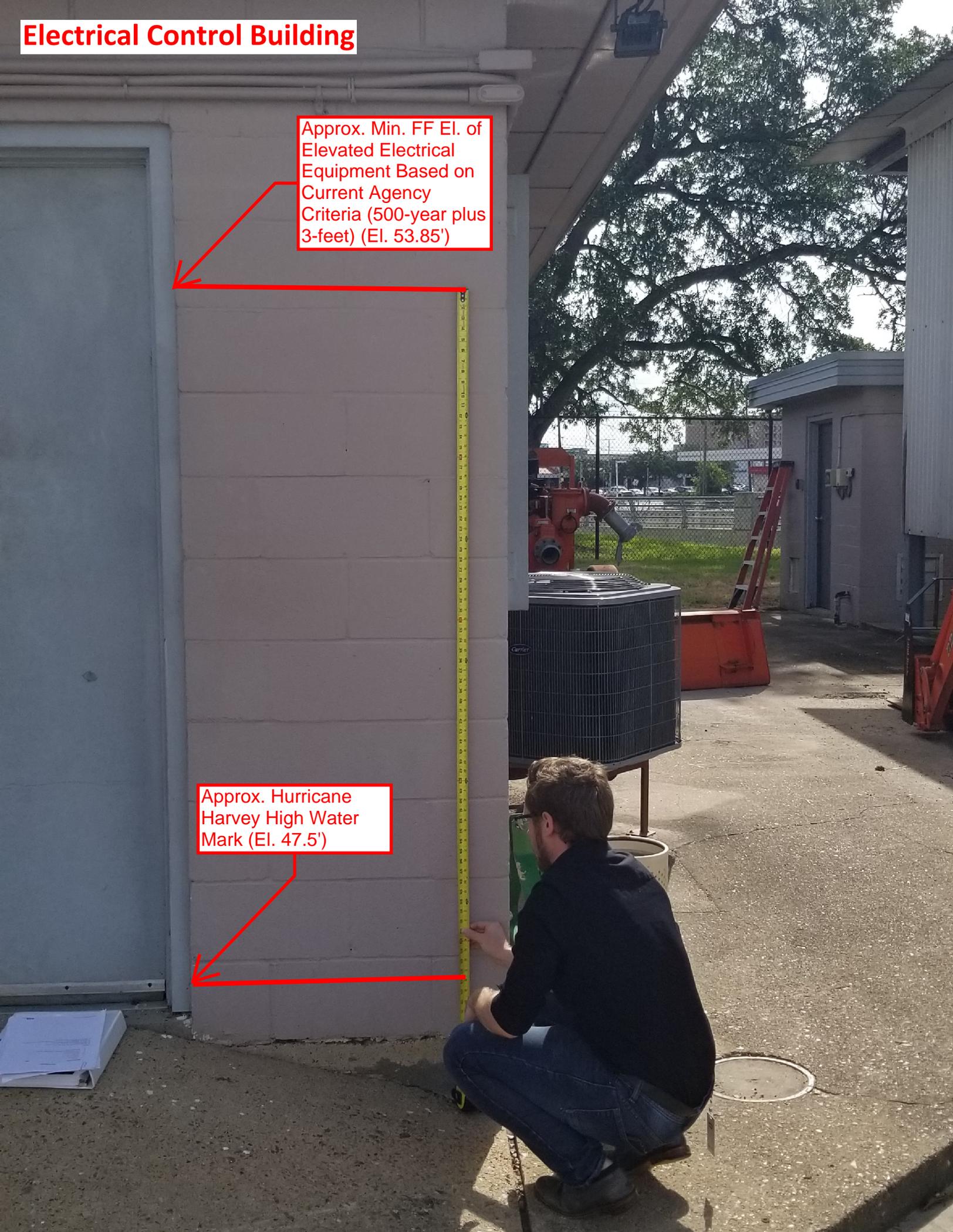
1. Elevations referenced to NAVD 88, 2001 Adj.
2. This elevation represents the elevation of the equipment pad/bottom of equipment. This is not the elevation of the equipment that is subject to flood damage. However, this elevation of the portion of the equipment that would need to be raised in order to meet current agency criteria.
3. This equipment is not proposed to be improved/modified in the Master Plan and was not impacted by Hurricane Harvey flood waters (according to the City of West University Place operations staff). The equipment is not required by regulatory agencies to be raised at this time, so mitigation of this equipment is optional.

EXHIBIT G
PHOTOGRAPHS OF WWTP EQUIPMENT

Electrical Control Building

Approx. Min. FF El. of Elevated Electrical Equipment Based on Current Agency Criteria (500-year plus 3-feet) (El. 53.85')

Approx. Hurricane Harvey High Water Mark (El. 47.5')



Motor Control Center



Electrical Control Panel



***Measuring tape was used for elevation in referenced to the slab elevation**

Emergency Generator



***Measuring tape was used for elevation in referenced to the slab elevation**

Electrical Distribution Panels

DANGER
HIGH
VOLTAGE
KEEP OUT

DANGER
HIGH
VOLTAGE
KEEP OUT



***Measuring tape was used for elevation in referenced to the slab elevation**

Main Circuit Breaker Panel and Automatic Transfer Switch



*Measuring tape was used for elevation in referenced to the slab elevation

Blowers

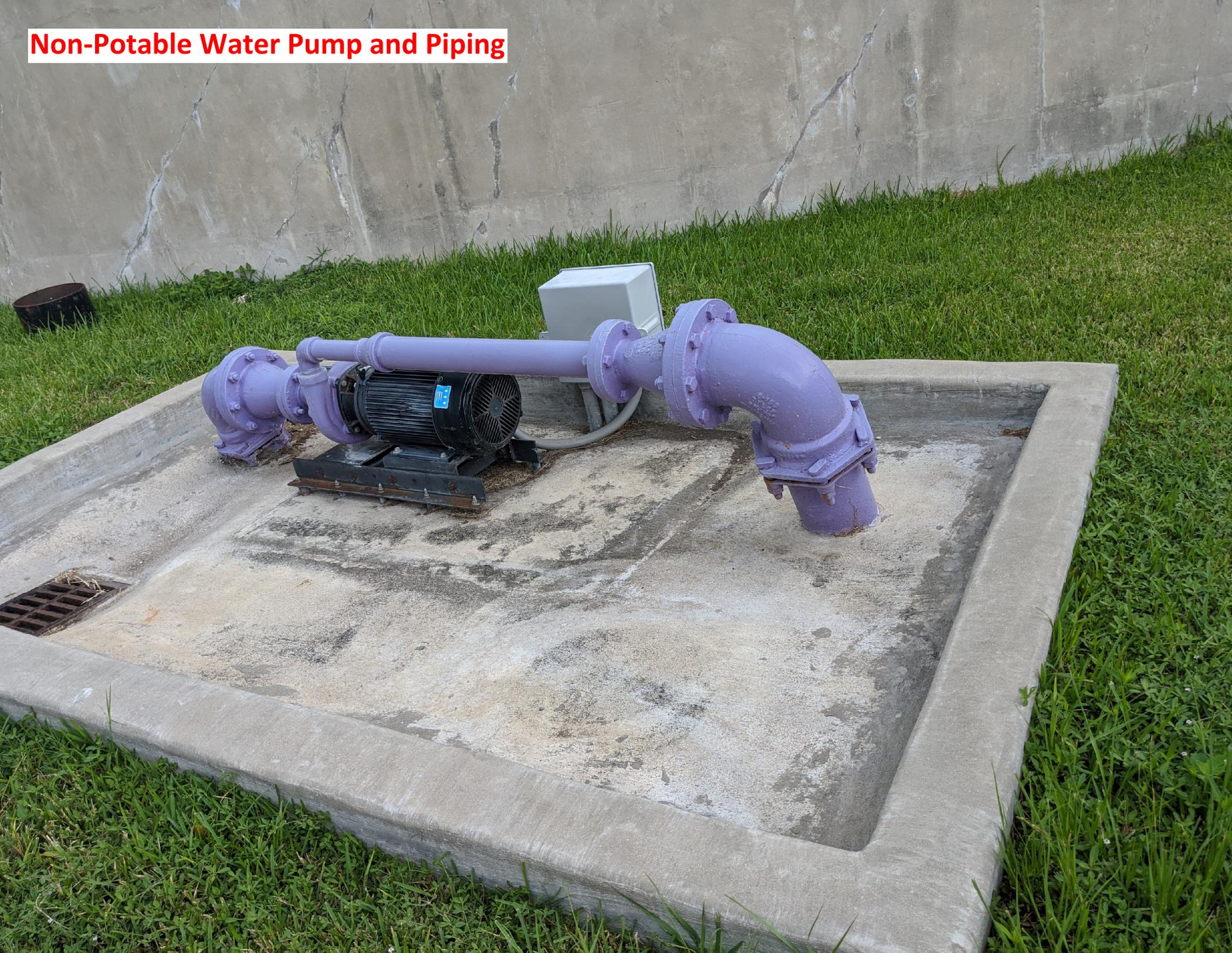


Chemical Feed Equipment



*Measuring tape was used for elevation in referenced to the slab elevation

Non-Potable Water Pump and Piping



Non-Potable Water Pumps and Local Control Panels



Influent Lift Station and Screw Pumps



Lift Station Electrical Equipment



Sludge Dewatering Transfer Pumps and Electrical Panel



Sludge Dewatering Transfer Pumps

