2023 BASIN HIGHLIGHTS REPORT

Watershed Characterizations of

Greens Bayou Above Tidal (Segment 1016), Halls Bayou (Segment 1006D), and Greens Bayou Tidal (Segment 1006)

Photo courtesy of Greens Bayou Coalition staff and volunteers

Houston-Galveston Area Council

PREPARED IN COOPERATION WITH THE
TEXAS COMMISSION ON ENVIRONMENTAL QUALITY
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Texas Commission on Environmental Quality

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The H-GAC Clean Rivers Program has lost a dear member of its family. **Brian Sims**, Senior Environmental Planner and Clean Rivers Program Laboratory Contract Manager, passed away unexpectedly on April 3, 2023. Brian was well liked and respected by everyone he worked with. He was reserved but had an incredible wit and great sense of humor. He had an unusual set of skills. Not only was Brian a technical expert and excellent writer – he also had an incredible eye for graphic design. His reports were not only technically accurate, but the designs were also beautiful (he was in the final stages of preparing this report). Brian also had a very big heart. He helped so many people, both professionally and personally. Brian managed the Homeowner's Wastewater Assistance Program at H-GAC. He helped dozens of families repair or replace their onsite sewage facilities. They trusted him with sensitive information, and he did a great job shepherding the process to make it as easy as possible. Brian felt a real calling to ensure that all people were treated fairly and felt included. He was a stalwart participant in H-GAC's equity and inclusion group. We are all better people for having known Brian. His coworkers at H-GAC feel lucky to have had the chance to work alongside him over the past 5 years. We will miss him, both professionally and personally, but the work he did and the legacy he left will long remain.

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INTRODUCTION

For the 6.5 million people residing in the Houston- Galveston region, water is essential to their way of life. Water is a vital resource for Houston and plays a critical role in the region's economic, social, and environmental well-being. With over 16,000 miles of streams and shorelines in our region, water is all around us. The region's water passes through our ditches, creeks, streams, bayous, and rivers before feeding into Galveston Bay and ultimately entering the Gulf of Mexico. Water fuels the region's economy, bringing in billions of dollars and providing numerous employment opportunities. With millions more people expected to move into the region in the next few decades, the strain put on these water resources will only continue to increase.

Photo 1: Greens Bayou Above Tidal

The Fiscal Year (FY) 2023 Basin Highlights Report provides detailed watershed characterizations of the stream segments within the Greens Bayou watershed.

This watershed, located within the northern portion of the Houston metropolitan area, includes the following segments:

- Greens Bayou Above Tidal (Segment 1016),
- Halls Bayou (Segment 1006D), and
- Greens Bayou Tidal (Segment 1006_03, 1006_05, 1006F_01 and 1006H_01).

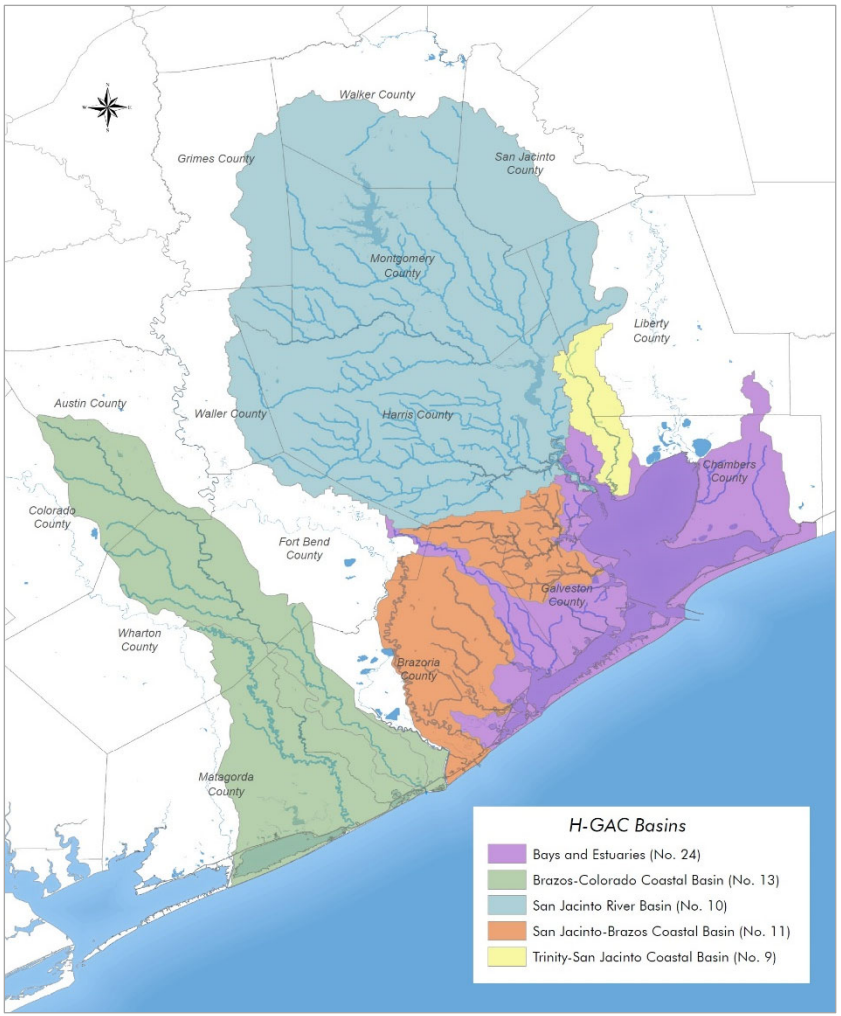
The watershed characterizations identify:
Specific water quality issues,

- Sources of point and nonpoint source pollution,
- Current strategies and plans to reduce pollution within the watershed, and
- Current and potential stakeholders within these watersheds.

H-GAC'S CLEAN RIVERS PROGRAM

The Houston-Galveston Area Council's (H-GAC) Clean River Program is charged with conducting water quality monitoring and assessment to determine the health of water bodies throughout the region. H-GAC's Clean Rivers Program does this through a coordinated effort with local partners and the Texas Commission on Environmental Quality (TCEQ). In addition to analyzing monitoring data, H-GAC assesses factors and activities affecting water quality. Through an extensive public education and outreach program, H-GAC provides information on regional water quality and recommendations on what individuals, industry, and local governments can do to preserve and make improvements to local waterways. Data acquired through the Clean Rivers Program provides support for all watershed-based activities in the region.

H-GAC's Clean Rivers Program uses a coordinated approach to water quality monitoring. H-GAC's extensive water quality monitoring activities cover one river and three coastal basins in all or a portion of 15 counties.



Map 1: River and Coastal Basins in H-GAC's Clean Rivers Program Area

BASINS AND COUNTIES

The four basins included in H-GAC's Clean Rivers Program study area are:

- San Jacinto River Basin
- Brazos-Colorado Coastal Basin
- San Jacinto-Brazos Coastal Basin
- Trinity-San Jacinto Coastal Basin

The Bays and Estuaries are also included.

The counties included in the H-GAC's Clean Rivers Program area are:

- Austin
- Brazoria
- Chambers
- Colorado
- Fort Bend
- Galveston
- Grimes
- Harris
- Liberty
- Matagorda
- Montgomery
- San Jacinto
- Walker
- Waller
- Wharton

MONITORING PARTNERS AND CONTRACTORS

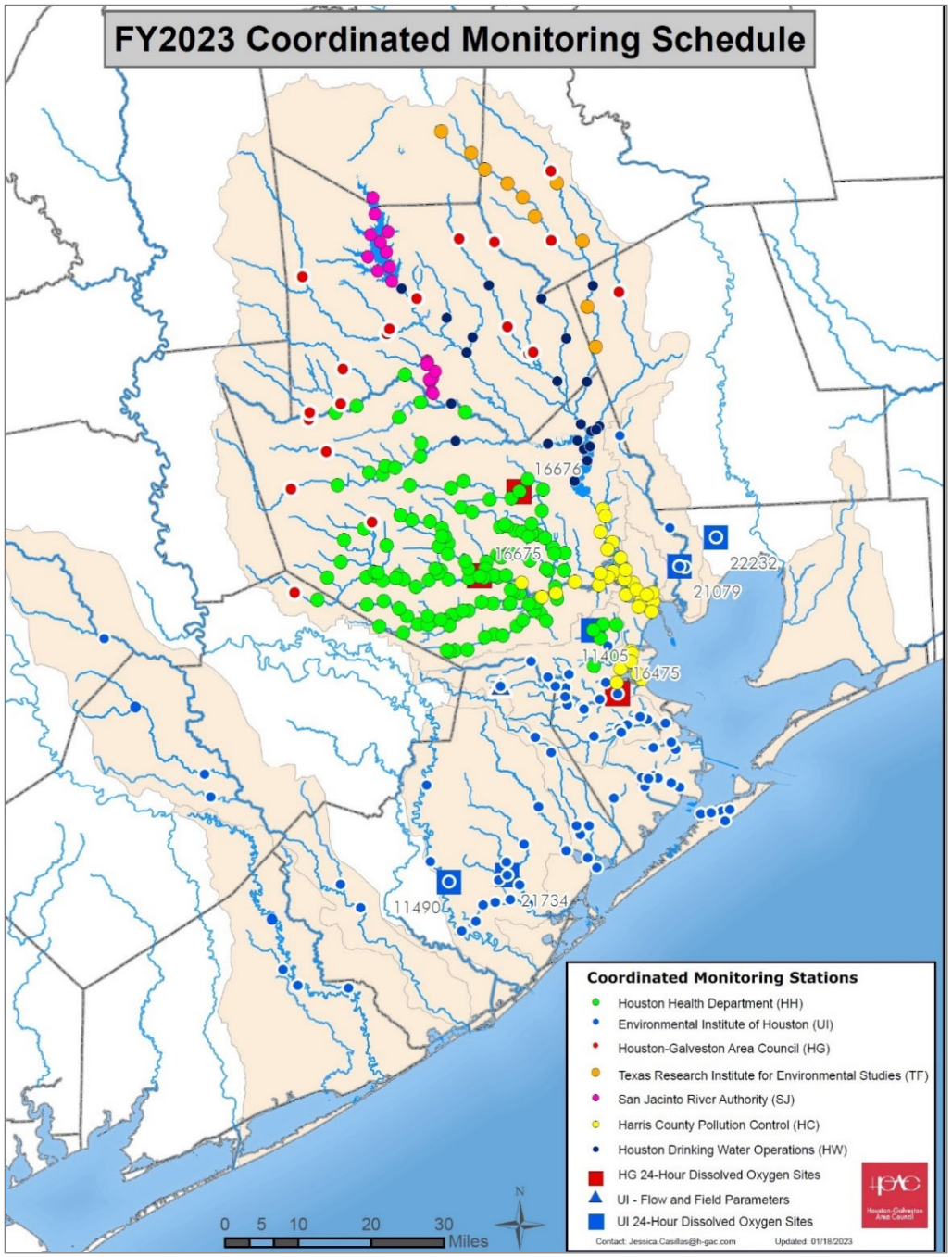
H-GAC's Clean Rivers Program monitoring includes more than 370 coordinated sampling sites and six regional partners.

These partners are:

- City of Houston Health Department
- City of Houston Drinking Water Operations
- Environmental Institute of Houston (EIH) | University of Houston-Clear Lake
- Harris County Pollution Control Services
- San Jacinto River Authority (SJRA) – Lake Conroe Division & The Woodlands Division
- Texas Research Institute for Environmental Studies | Sam Houston State University

Other agencies contributing data used by the Clean Rivers Program include:

- Texas Commission on Environmental Quality
- United States Geological Survey (flow gage data)



Map 2: Clean Rivers Program FY 2023 Coordinated Monitoring Schedule

REGIONAL IMPAIRMENTS AND CONCERNS

BACTERIA

44% of stream miles in our region our impaired due to elevated levels of bacteria

In the Houston-Galveston region, one of the most significant water quality issues faced is elevated levels of bacteria in our local waterways. Bacteria concentrations are measured to ensure a water body is safe for recreation. Enterococci is collected in tidal waterways, while Escherichia coli (E. coli) is collected in freshwater. Both are found in digestive tracts in people and animals and are used as indicators of the presence of sewage and pathogens. High bacterial concentrations may cause gastrointestinal illnesses or skin infections in swimmers or others who come into direct contact with the water.

Sources of bacterial contamination include:

- Wastewater treatment facility (WWTF) releases;
- Sanitary sewer overflows (SSOs);
- Failing on-site sewage facilities (OSSFs); and
- Fecal waste from livestock, pets, feral hogs, and other wildlife.

DISSOLVED OXYGEN

17% of stream miles in our region are impaired for low levels of dissolved oxygen

Dissolved Oxygen (DO levels) are measured to ensure a water body can support aquatic life. As a general rule, higher levels of DO can support more abundant and diverse aquatic species. DO levels fluctuate naturally based on season and time of day; however, human activities can have a negative effect on DO concentrations in water bodies. Sudden or prolonged decreases in DO could result in fish kills.

DO levels can be negatively impacted by many factors, including:

- High concentrations of nutrients that cause algal blooms;
- Sediment from construction sites;
- Overgrazing of livestock;
- Stream channel modification and development; and
- Reduced riparian tree cover.

NUTRIENTS

34% of stream miles in our region exceed state screening levels for nutrients, such as nitrate, ammonia, and phosphorus
20% of stream miles in our region exceed state screening levels for Chlorophyll-a

Nutrients, including phosphorus, nitrate, and ammonia, occur naturally in surface waters. They are an important part of a healthy aquatic ecosystem. However, human activities can contribute excessive nutrients to water bodies. High concentrations of nutrients can result in algal blooms, which can depress DO levels and produce toxins that are harmful to humans and aquatic species.

Sources of nutrient pollution include:

- Sewage treatment plant discharges;
- Stormwater runoff;
- Failing on-site sewage facilities, including septic systems.
- Fertilizer runoff from lawns and agricultural fields; and
- Animal manure.

PCBS AND DIOXINS

68% of tidal streams and bays in our region are impaired for PCBs and Dioxins

PCBs, or polychlorinated biphenyls, and Dioxins are broad groups of synthetic organic compounds developed for industrial purposes or are by-products of industrial processes. PCBs and Dioxins are toxic and carcinogenic.

PCBs and Dioxins are legacy pollutants, meaning they can remain in the environment long after they are introduced. Both accumulate in the fatty tissue of marine life, and humans can be exposed through consumption of contaminated fish and shellfish.

"FROG CHART" REGIONAL WATER QUALITY SUMMARY

The numbers represent the percent of total segment length that is impaired or of concern for each parameter. Cells without numbers (blanks) represent stream segments that are currently meeting state standards but may be improving or degrading for each parameter.

Houston-Galveston Area Council

2023 REGIONAL WATER QUALITY SUMMARY*

DO = Dissolved Oxygen Bact = Bacteria Chl-a = Chlorophyll-a Nutr = Nutrients PCB = PCBs/Dioxins Other = See Key

Basin	Watershed	Segment	DO	Bact	Chl-a	Nutr	PCB	Other**	Frogs
Trinity-San Jacinto Coastal	Cedar Bayou Tidal	0901	14.2	100			85.8		
	Cedar Bayou Above Tidal	0902	82.7	82.7		17.3			
San Jacinto River	Buffalo Bayou Above Tidal	1014	6.3	77.9		69			
	Buffalo Bayou Tidal	1013	34.2	77.8		**47.9**			
	Caney Creek	1010		69.2					
	Cypress Creek	1009		80.3	9.3	**80.3**		10.3	
	East Fork San Jacinto River	1003		94.1					
	Greens Bayou Above Tidal	1016	**6.4**	**95.8**		85.3			
	Houston Ship Channel	1006	**5.3**	**44.7**	**3.4**	**80.2**		22.2	
	Houston Ship Channel Buffalo Bayou Tidal	1007	**16.7**	**70.2**		**85.6**	28.7	0.9	
	Houston Ship Channel/San Jacinto River Tidal	1005				**82.3**	100		
	Lake Conroe	1012							
	Lake Creek	1015	40.1	12.1					
	Lake Houston	1002	**9.8**	**9.8**		9.8			
	Peach Creek	1011		100				15.4	
	San Jacinto River Tidal	1001					47.3		
	Spring Creek	1008	8.2	77.8		**39.2**		2.4	
	West Fork San Jacinto River	1004		53.6	16.6				
	White Oak Bayou Above Tidal	1017	**11.7**	**87**		79.6			
San Jacinto-Brazos Coastal	Armand Bayou Tidal	1113	61.7	**69.6**	**28.6**	17	23.4		
	Bastrop Bayou Tidal	1105	31.4	69.6					
	Chocolate Bayou Above Tidal	1108		100					
	Chocolate Bayou Tidal	1107		**100**	100		100		
	Clear Creek Above Tidal	1102	25	78.8		76.1	48.4	13.1	
	Clear Creek Tidal	1101	**37.4**	**78**		31.8	29.2		
	Dickinson Bayou Above Tidal	1104		54.5					
	Dickinson Bayou Tidal	1103	86.9	100			43.6		
	Old Brazos River Channel Tidal	1111							
	Oyster Creek Above Tidal	1110	96.8	64.5		**37.5**		96.8	
	Oyster Creek Tidal	1109	100	100					

Chart Key

The numbers represent the percent of total segment length that is impaired or of concern for each parameter. Cells without numbers (blanks) represent stream segments that are currently meeting state standards but may be improving or degrading for each parameter.

Severe, multiple water quality impairment(s) or concern(s) exist in a majority of the water body.

Significant, multiple water quality impairment(s) or concerns exist in the water body.

Water quality impairment(s) or concern(s) exist in a substantial portion of the water body.

Water quality impairment(s) or concern(s) exist in the water body.

No significant water quality impairments or concerns exist in the water body.

GETTING BETTER

GETTING WORSE

* Frog Chart analysis differs with the TCEQ Integrated Report 2022 due to an updated period of record (6/1/15 - 12/31/22)

** Other includes parameters such as metals in water, metals in sediment, impaired habitat, impaired benthic macroinvertebrates, impaired fish communities, sediment toxicity, fecal coliform, mercury in fish tissues and fish consumption

\+ This segment was not assessed for routine parameters, but was assessed for fecal coliform in Oyster Waters

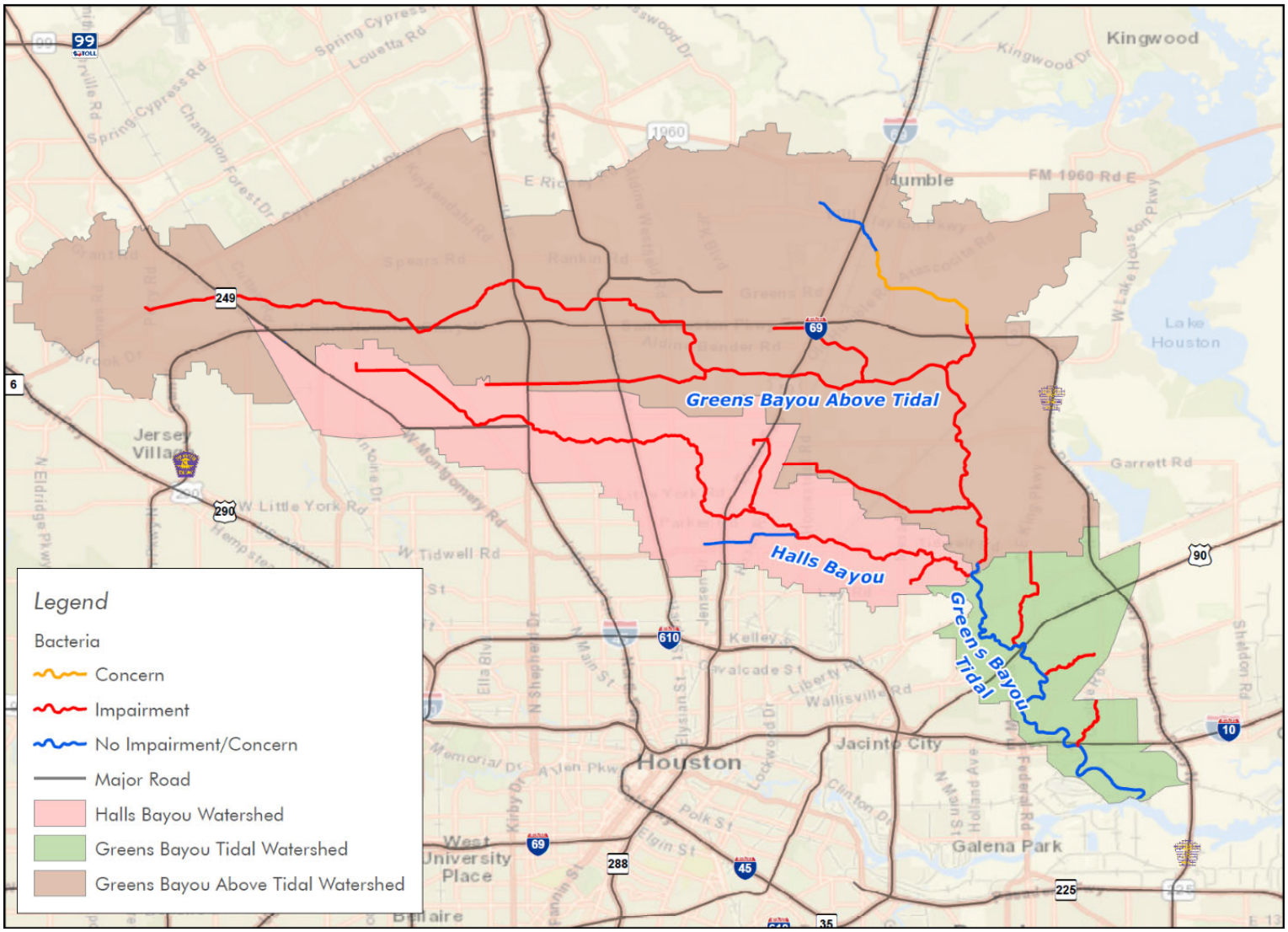
++This segment was not assessed due to insufficient data

DO = Dissolved Oxygen Bact = Bacteria Chl-a = Chlorophyll-a Nutr = Nutrients PCB = PCBs/Dioxins Other = See Key

Basin	Watershed	Segment	DO	Bact	Chl-a	Nutr	PCB	Other**	Frogs
Brazos-Colorado Coastal	Caney Creek Above Tidal	1305	44.6	71.6		**57.7**		13.9	
	Caney Creek Tidal	1304	36.8	61					
	San Bernard River Above Tidal	1302	61.5	68.2		20.9		7.3	
	San Bernard River Tidal	1301		100					
Bays & Estuaries	Barbours Cut	2436				100	100		
	Bastrop Bay / Oyster Lake +	2433							
	Bayport Ship Channel	2438			100	**100**	100	100	
	Black Duck Bay	2428			**100**	100	100		
	Burnett Bay	2430			69.2	100	100		
	Cedar Lakes ++	2442							
	Chocolate Bay	2432	51	86.3		18.8	33		
	Christmas Bay +	2434							
	Clear Lake	2425		4.3	**56.5**	69.6	73.9	45.3	
	Drum Bay +	2435							
	East Bay	2423	**33.9**		**100**		100.0		
	East Matagorda Bay +	2441							
	Lower Galveston Bay	2439			**92.8**	**13.6**	92.8		
	Moses Lake	2431	12.2	**19.7**	52.8		56.8		
	San Jacinto Bay	2427			**100**	100	100		
	Scott Bay	2429				100	100		
	Tabbs Bay	2426				48.3	69.5		
	Texas City Ship Channel	2437			100	100	100		
	Trinity Bay	2422	**29.1**	**29.1**	72.7		88.5		
	Upper Galveston Bay	2421		7.1	96.9	**88.7**	87.9		
	West Bay	2424	9.1	7.4	**10.6**	**5.7**	91.1		
	Gulf of Mexico	2501		26.4					

WATERSHED CHARACTERIZATIONS

The FY 2023 Basin Highlights Report characterizes select water bodies within the Houston-Galveston region. For this report, H-GAC has chosen to characterize the Greens Bayou watershed, including Greens Bayou Above Tidal (Segment 1016), Halls Bayou (Segment 1006D), and Greens Bayou Tidal (Segment 1006_03, 1006_05, 1006F_01 and 1006H_01). These watershed characterizations may be used to help prioritize monitoring efforts and in the development of watershed-based plans [such as Total Maximum Daily Loads (TMDLs) or Watershed Protection Plans (WPPs)] to improve water quality.



Map 3: Greens Bayou watershed, including Greens Bayou Above Tidal, Halls Bayou, and Greens Bayou Tidal

Each watershed characterization will include the following sections:

Table 1: Watershed Characterization Sections

Content	Description
Segment Description	A description of the segment, assessment unit (AU) boundaries, and monitoring sites within each segment.
Hydrologic Characteristics	Streamflow variability, reservoir dynamics, seasonality of flow and typical flow trends.
Land Cover and Natural Characteristics	A description of the land surrounding a segment, including developed lands, agricultural lands, forest/shrubs, barren land, open water, and wetlands.
Description of Water Quality Issues	Identification of the reason why the water body is listed as impaired and when it first appeared on the 303(d) List or why it is in an area of interest. This includes the number of samples, parameters of concern or impairment, assessment results, and the designated state water quality standard for comparison.
Potential Sources of Water Quality Issues	Possible sources of water quality issues identified through land use and land cover, watershed surveys, and communications with stakeholders and staff from local and state agencies.
Potential Stakeholders	Governmental agencies (Federal/State/Local), organizations, companies, or individuals that have a vested interest in the area and who may have a representative serve as a stakeholder.
Recommendations for Improving Water Quality	Proposed next steps based on the potential sources of impairment or concern.
Watershed Projects	Current or future projects within the segment (TMDLs, WPPs, special studies, etc.).
Major Watershed Events	Anticipated or known occurrences that have the potential to either positively or negatively affect water quality.
Community Engagement	Public engagement activities within the watershed.
Images of the Watershed	Photographic images of the watershed (monitoring stations, public access, and recreational activities, etc.).
Maps	Maps of stream segments, assessment units, monitoring stations, land use, soils, water quality impairments/concerns, wastewater treatment facility outfalls, sanitary sewer overflows, on-site sewage facilities, and other areas of interest.

ADDITIONAL INFORMATION

For more information, including a list of acronyms, a glossary of water quality terminology, a technical primer, and information regarding the statistical methodology used for H-GAC's water quality analyses presented in this report, please refer to the appendices.

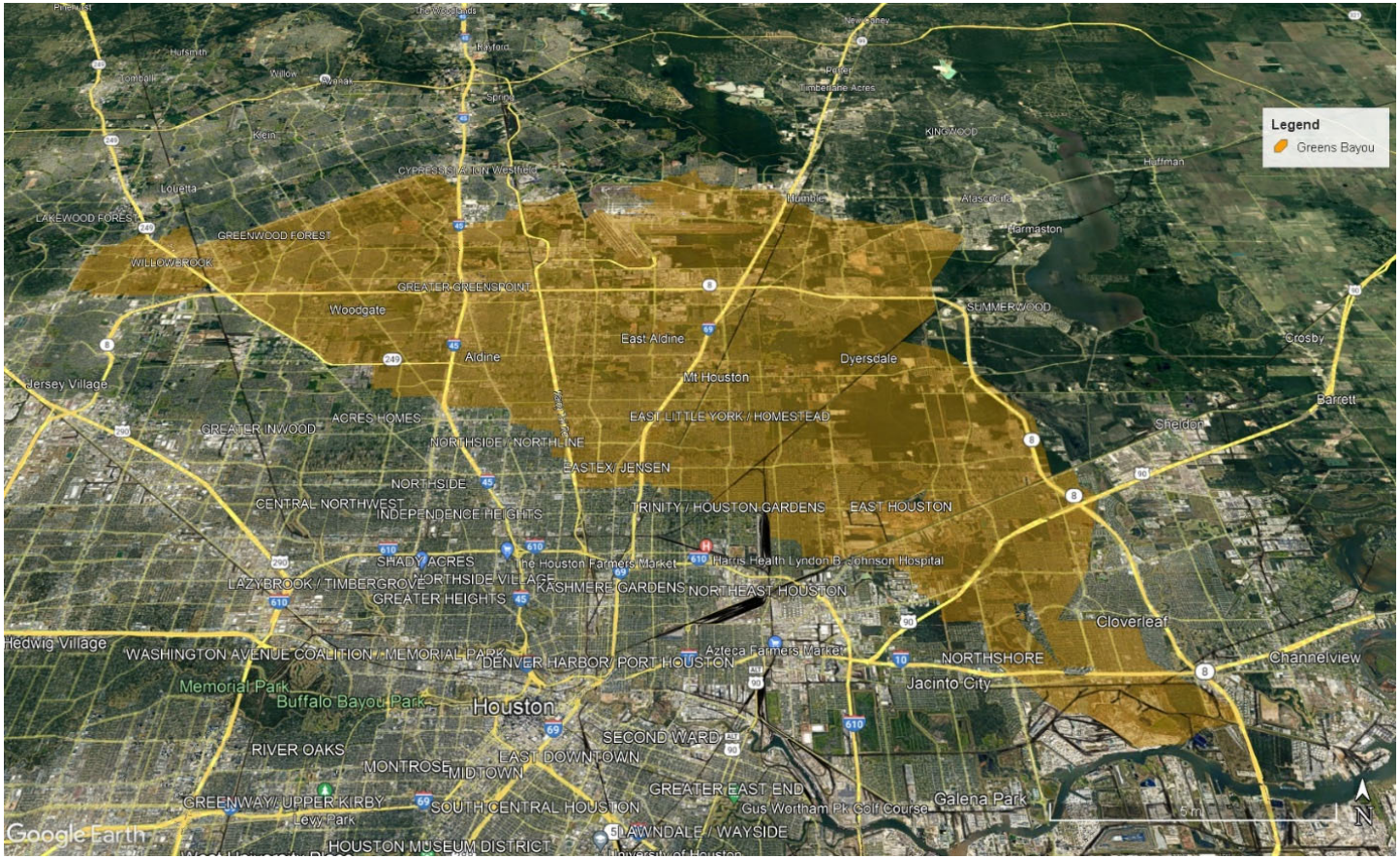
For more information on H-GAC's Clean Rivers Program, please visit: https://www.h-gac.com/clean-rivers-program

THE GREENS BAYOU WATERSHED

The Greens Bayou watershed covers 208 square miles of densely developed area in Harris County. This watershed overlaps portions of the City of Houston, Aldine, Humble, Atascocita, and Cloverleaf.

Much of the watershed area is home to disadvantaged and under-served communities, with over 60% of the population considered to be low-to-moderate income. Demographic breakdowns of each watershed acquired from the Environmental Protection Agency's (EPA) Environmental Justice Screening Tool (EJScreen) are included in the appendices.

Greens Bayou and its tributaries face water quality challenges similar to many Houston area waterways including elevated fecal bacteria impairments. Dissolved oxygen and nutrient concerns impede the waterway's ability to support its designated uses. Flooding issues in the watershed also have a negative impact on water quality and segment hydrology.



Map 4: Greens Bayou Google Earth Imagery

This Watershed Characterization Report addresses the following segments that comprise the Greens Bayou Watershed:

- Greens Bayou Above Tidal (Segment 1016)
- Halls Bayou (1006D)
- Greens Bayou Tidal (1006_03, 1006_05, 1006F_01, and 1006H_01)

SEGMENT 1016 – GREENS BAYOU ABOVE TIDAL

Photo 2: North reach of Greens Bayou Above Tidal (Photo courtesy of Greens Bayou Coalition staff and volunteers)

SEGMENT DESCRIPTION

Greens Bayou Above Tidal (Segment 1016) is approximately 24 miles long. Designated uses for this classified freshwater perennial stream are General Use, Primary Contact Recreation 1 (PCR1), and Limited Aquatic Life Use (ALU). Greens Bayou Above Tidal is in the San Jacinto River Basin (Basin 10).

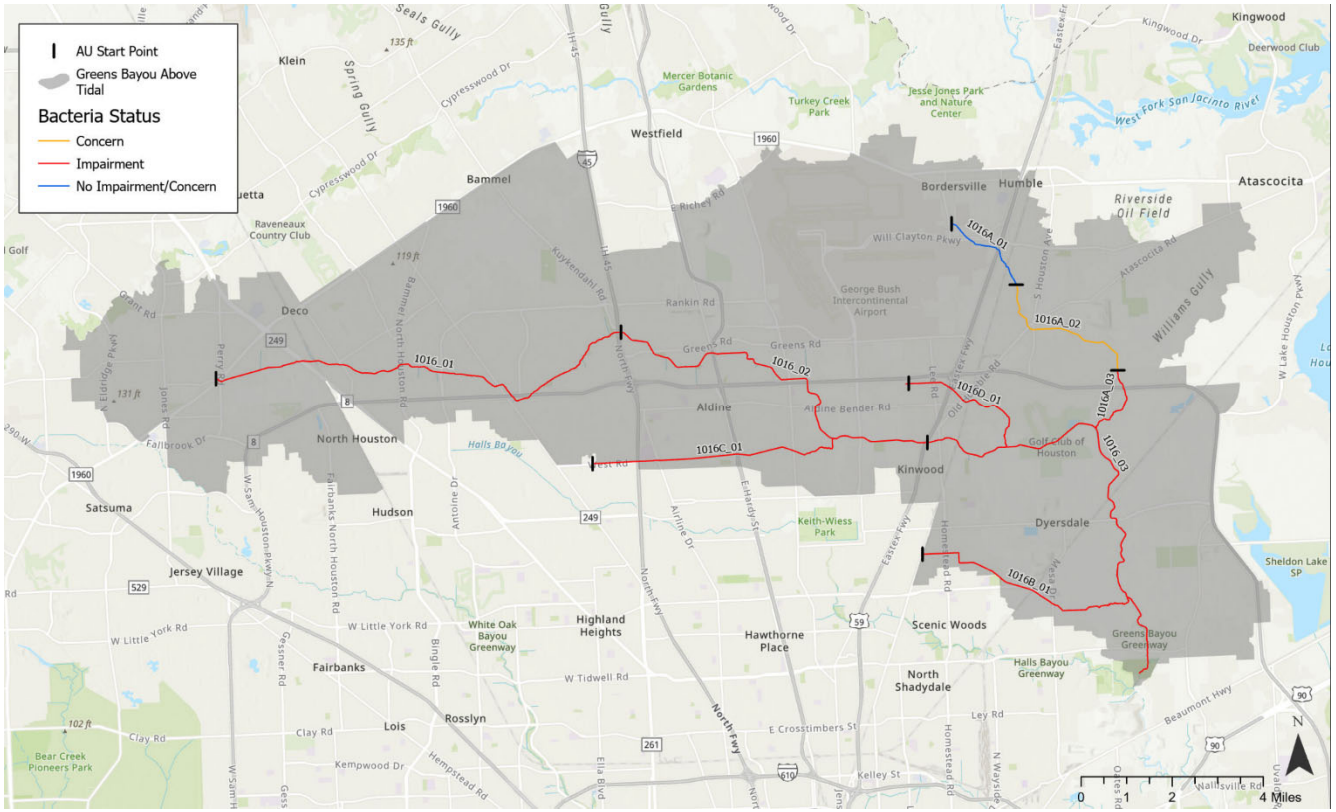
The 143 square mile watershed includes the following segments:

- Segment 1016: Greens Bayou Above Tidal – From a point 0.7 km (0.4 miles) above the confluence of Halls Bayou in Harris County to a point 100 meters (110 yards) above FM 1960 in Harris County

- Segment 1016A: Garners Bayou – From the Greens Bayou confluence to a point 1.5 km (0.93 mi) upstream of Will Clayton Pkwy in Harris County

- Segment 1016B: Unnamed Tributary of Greens Bayou – From the Greens Bayou Above Tidal confluence to Hirsch Road in Harris County

- Segment 1016C: Unnamed Tributary of Greens Bayou – From the Greens Bayou Above Tidal confluence to 1.6 km (0.99 mi) west of IH-45 in Harris County



Map 5: Segment 1016 - Greens Bayou Above Tidal

- Segment 1016D: Unnamed Tributary of Greens Bayou – From the Greens Bayou Above Tidal confluence to 0.19 km (0.12 mi) west of JFK Blvd in Harris County

Greens Bayou Above Tidal (Segment 1016) is comprised of three assessment units, with active monitoring stations in each AU. Garners Bayou (Segment 1016A) has three AUs but routine monitoring is conducted at stations in AU 1016A_02 only. There are no active monitoring stations in AU 1016A_01 or 1016A_03. Three additional unnamed tributaries (1016B, 1016C, and 1016D) are each a single AU. Descriptions of each assessment unit are included in the accompanying table.

Table 2: Assessment Unit Descriptions for Segment 1016 - Greens Bayou Above Tidal

Segment ID	Segment Name	AU ID	AU Description
1016	Greens Bayou Above Tidal	1016_01	Upper segment boundary (FM 1960) to IH 45
		1016_02	IH 45 to US 59
		1016_03	From US 59 to the downstream boundary 0.7 km (0.4 mi) upstream of the Halls Bayou confluence
1016A	Garners Bayou	1016A_01	From 1.5 km north of Atascocita Road to 0.89 km northeast of Will Clayton Parkway
		1016A_02	From the Williams Gully confluence upstream to 1.5km north of Atascocita Road
		1016A_03	From the Greens Bayou confluence to the Williams Gully confluence
1016B	Unnamed Tributary of Greens Bayou	1016B_01	From confluence with Greens Bayou to Hirsch Road in Harris County
1016C	Unnamed Tributary of Greens Bayou	1016C_01	From the confluence with Greens Bayou, east of Aldine Westfield Road, to the Hardy Toll Road in Harris County
1016D	Unnamed Tributary of Greens Bayou	1016D_01	From the confluence with Greens Bayou, west of El Dorado Country Club, upstream to Crosswinds Drive, west of US Hwy 59 in Harris County

The accompanying table provides a description of each active monitoring station in the FY 2023 Coordinated Monitoring Schedule, the submitting and collecting entities, the monitoring type (i.e., routine, biased, etc.), the number of monitoring events per year, and the parameter groups collected. In addition to the professionally-monitored stations shown, there is one volunteer monitoring station in the watershed that is monitored as part of the Texas Stream Team (81696 – Greens Bayou at Knobcrest Dr.).

Table 3: FY 2023 Coordinated Monitoring Schedule[1] for Segment 1016 - Greens Bayou Above Tidal

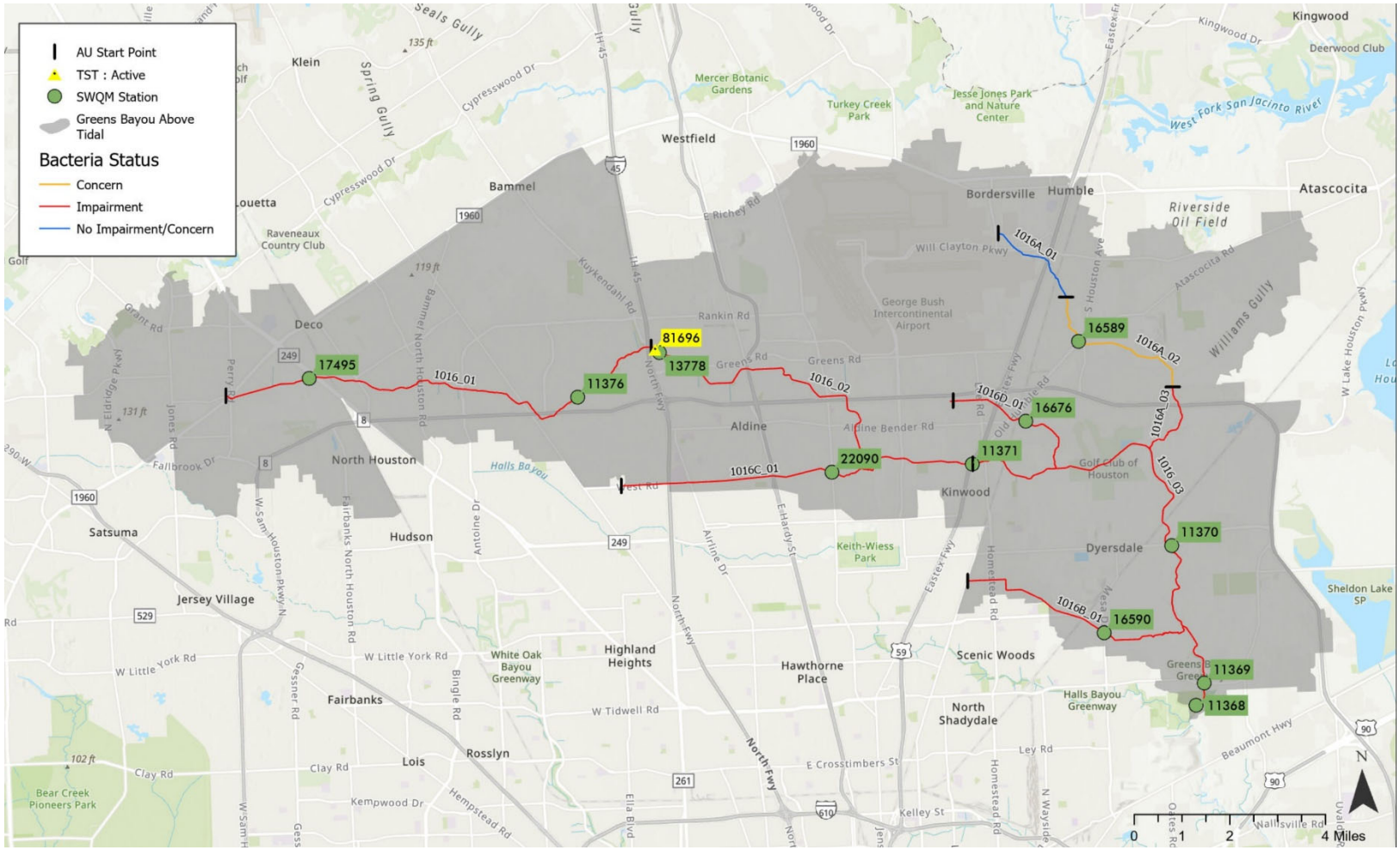
Segment ID	Segment Name	Station ID	Station Description	SE[2]	CE[3]	MT[4]	Number of Monitoring Events Per Year								
							Field	Conv	Bact	Flow	24-Hr DO	Metals Water	Org Water	Metals Sed	Org Sed
1016	Greens Bayou Above Tidal	13778	GREENS BAYOU 184 METERS DOWNSTREAM OF KNOBCREST DRIVE	HG	HH	RT	6	6	6	6	–	–	–	–	–
		11369	GREENS BAYOU AT TIDWELL ROAD IN HARRIS COUNTY	WC	FO	RT	4	4	4	4	–	–	–	–	–
		11368	GREENS BAYOU AT UNNAMED ROAD IN BROCK PARK GOLF COURSE 705 METERS UPSTREAM OF THE CONFLUENCE WITH HALLS BAYOU	HG	HH	RT	6	6	6	–	–	–	–	–	–
		11371	GREENS BAYOU AT US 59 NORTH OF HOUSTON	HG	HH	RT	6	6	6	–	–	–	–	–	–
		11376	GREENS BAYOU AT WEST GREENS PARKWAY	HG	HH	RT	6	6	6	–	–	–	–	–	–
		11370	GREENS BAYOU IMMEDIATELY DOWNSTREAM OF MT HOUSTON PARKWAY	HG	HH	RT	6	6	6	–	–	–	–	–	–
		17495	GREENS BAYOU IMMEDIATELY UPSTREAM OF MILLS ROAD WEST OF HOUSTON	HG	HH	RT	6	6	6	–	–	–	–	–	–
1016A	Garners Bayou	16589	GARNERS BAYOU IMMEDIATELY UPSTREAM OF OLD HUMBLE ROAD AT CONFLUENCE WITH RIENHARDT BAYOU IN NORTHEAST HOUSTON	HG	HH	RT	6	6	6	–	–	–	–	–	–
1016B	Unnamed Tributary of Greens Bayou	16590	UNNAMED TRIBUTARY OF GREENS BAYOU AT MESA DR/E. HOUSTON-DYERSDALE ROAD IN NORTHEAST HOUSTON	HG	HH	RT	6	6	6	–	–	–	–	–	–
1016C	Unnamed Tributary of Greens Bayou	22090	UNNAMED TRIBUTARY OF GREENS BAYOU AT ALDINE WESTFIELD RD	HG	HH	RT	6	6	6	–	–	–	–	–	–
1016D	Unnamed Tributary of Greens Bayou	16676	UNNAMED TRIBUTARY OF GREENS BAYOU AT SMITH RD IN NORTHEAST HOUSTON	HG	HG	BS	–	–	–	4	4	–	–	–	–
				HG	HH	RT	6	6	6	–	–	–	–	–	–

[1] The Coordinated Monitoring Schedule for current and previous fiscal years can be located at cms.lcra.org
[2] Submitting Entity – The entity submitting monitoring data to TCEQ's Surface Water Quality Information System
[3] Collecting Entity – The entity collecting monitoring data

Submitting and Collecting Entities
HG = Houston-Galveston Area Council
WC = Texas Commission on Environmental Quality
FO = Field Operations
HH = Houston Health Department

Monitoring Types
RT = Routine
BS = Biased Season

There have been several changes to monitoring frequencies at station 11369 (Greens Bayou at Tidwell Road) in recent years. From FY 2015 through FY 2019, The Houston Health Department (HH) monitored at station 11369 and collected samples 9 times per year, while TCEQ Region 12 Field Operations (FO) collected samples 4 times per year. Beginning in FY 2020, HH reduced their monitoring frequency to 6 times per year, with TCEQ monitoring remaining unchanged. In FY 2023, HH stopped monitoring station 11369 due to bridge construction that made it difficult to access the site. HH added station 11368 (Greens Bayou at unnamed road in Brock Park Golf Course) as a replacement. TCEQ FO continues to monitor at station 11369.

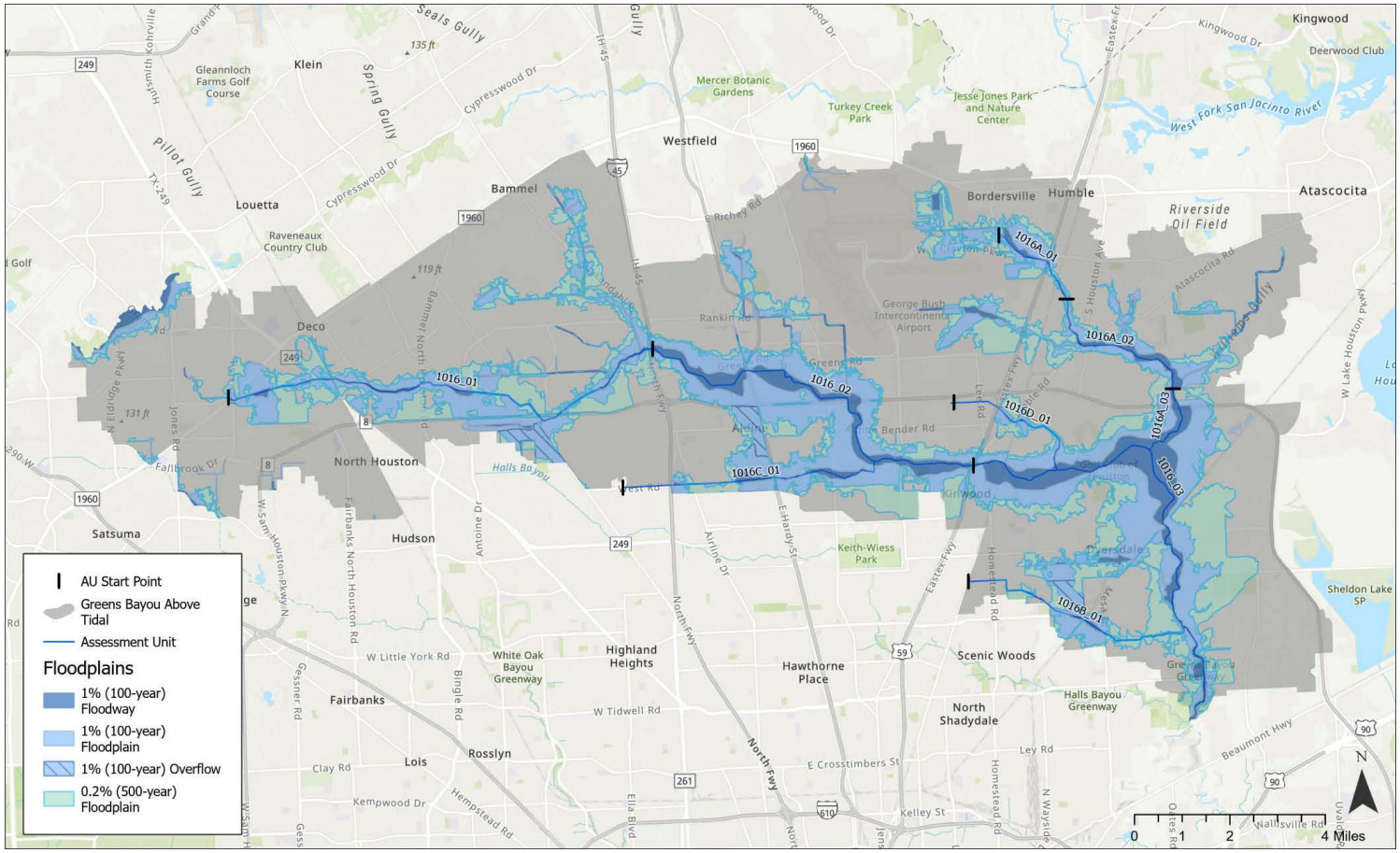


Map 6: FY 2023 Routine Monitoring Stations for Segment 1016 - Greens Bayou Above Tidal

HYDROLOGIC CHARACTERISTICS

Classified segment 1016 and unclassified segments 1016A, 1016B, 1016C, and 1016D are all freshwater streams. All assessment units in these segments have perennial flow with the exception of 1016A_01, which is intermittent with pools.

Greens Bayou begins near the intersection of Jones Road and Mills Road in north central Harris County, approximately 10 miles north of the City of Houston's central business district. NRG's T.H. Wharton Combined Cycle Gas Turbine power plant cooling water discharges provide year-round flow to the headwaters of Greens Bayou. The non-tidal portion of the Greens Bayou watershed flows eastward across northern Harris County from its headwaters near Farm-to-Market 1960 for approximately 23 miles and then turns at its confluence with Garners Bayou and flows southward for 7 miles to the confluence with Halls Bayou. Greens Bayou initially flows west to east through generally flat to rolling land and continues for most of its length through an area of low-lying shallow depressions. Although the area is highly urbanized, Greens Bayou flows through numerous neighborhood parks.



Map 7: Floodplains for Segment 1016 - Greens Bayou Above Tidal

The Greens Bayou watershed is prone to flooding. Significant floodplains, combined with the area's high-density development, results in severe damage to homes and businesses during these frequent flood events. Much of the Houston area's rapid growth and development in the 1970s occurred prior to restrictions on building in the floodplains, which puts numerous areas at risk of flooding.

Numerous projects have been initiated by the Harris County Flood Control District (HCFCD) to address flooding in the Greens Bayou watershed, including channel improvements and the building of stormwater detention basins.

PRECIPITATION

Precipitation is one of the primary factors affecting stream flow in the Greens Bayou Above Tidal watershed. During rainfall events, water runoff from the surrounding land flows into the bayou. This runoff results in a rise in the water level and increased flow, which can lead to flooding in low-lying areas adjacent to the bayou. Seasonal changes, proximity to the coast, and the movement of storm systems largely control the amount and timing of precipitation.

As part of the Harris County Flood Warning System (HCFWS), there are 10 precipitation gages located within the Greens Bayou Above Tidal watershed. There are seven rainfall gages on Greens Bayou Above Tidal, with an additional rain gage located on the North Fork of Greens Bayou at Ella. Two precipitation gages are located on Garners Bayou (Rankin Road and Beltway 8).

Annual rainfall totals for 2022 for Greens Bayou Tidal are shown in the accompanying table.

Table 4: HCFWS Rain Gage Stations in Segment 1016 - Greens Bayou Above Tidal

Rain Gage ID	Site Description	Annual Rainfall (2022)
1670	Greens Bayou at Cutten Road	36.00"
1665	Greens Bayou at Bammel N Houston Road	34.92"
1655	North Fork Greens Bayou at Ella Boulevard	41.04"
1660	Greens Bayou at Knobcrest Drive	38.48"
1645	Greens Bayou at Beltway 8	40.76"
1640	Greens Bayou at US 59	33.96"
1600	Greens Bayou at Mount Houston Parkway	41.84"
1685	Greens Bayou at Tidwell Road	41.20"
1650	Garners Bayou at Rankin Road	38.92"
1630	Garners Bayou at Beltway 8	39.44"

Source: Harris County Flood Warning System (https://www.harriscountyfws.org/)

For the most upstream rain gage (Greens Bayou Above Tidal at Cutten Road, 2022 annual rainfall was 36.00", with the highest rainfall total in August, with rainfall being relatively stable from January – June. Moving east to US59 at Humble, annual rainfall was 33.96". Again, the highest monthly total was recorded in August, but there is much more variability in monthly totals in the January – June time period. At the most eastern and downstream location, Tidwell Road, annual rainfall was 41.20", with the highest rainfall total recorded in November.

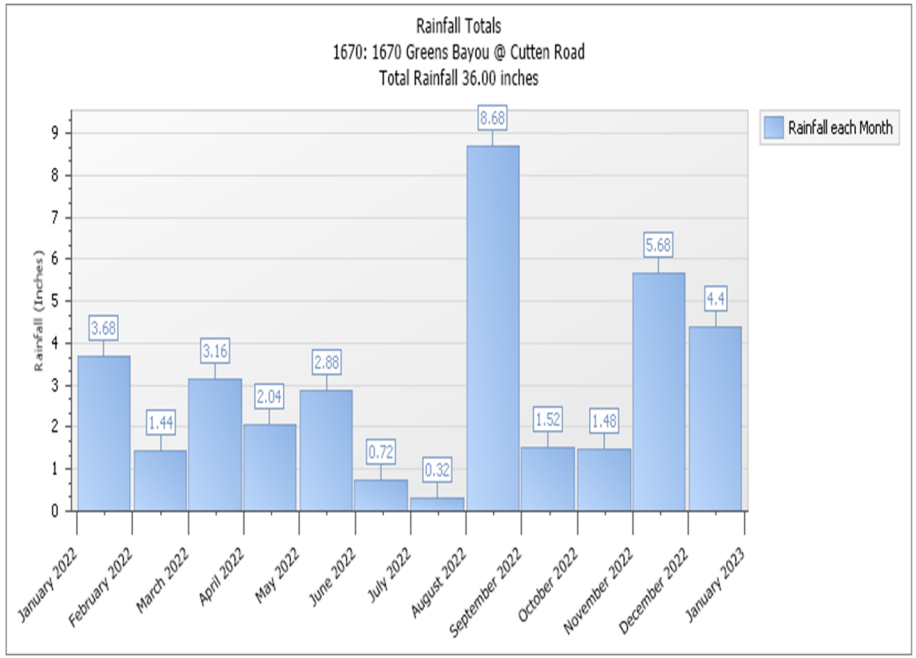


Figure 1: Monthly rainfall at Greens Bayou at Cutten Road, 2022 (Source: HCFWS)

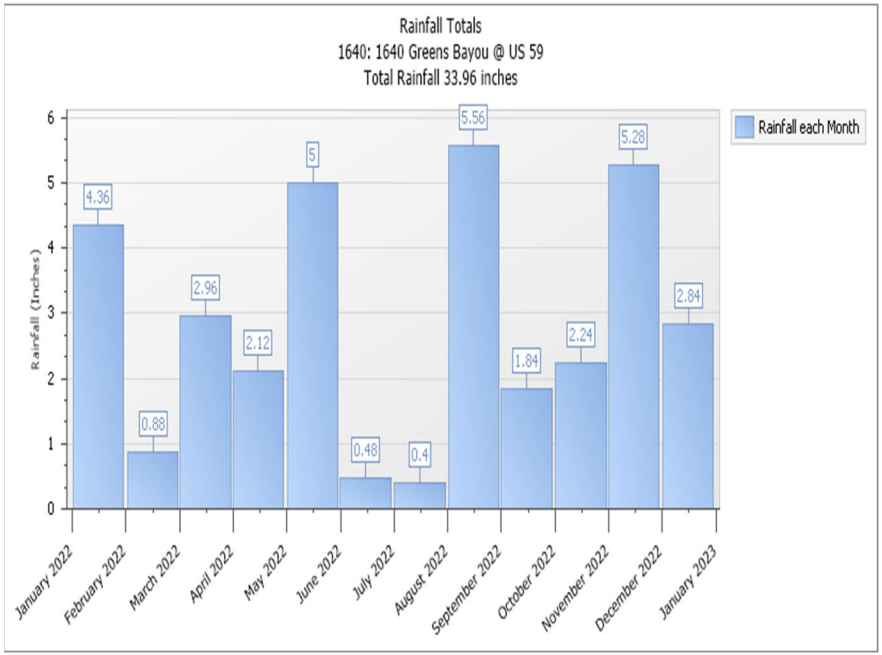


Figure 2: Monthly rainfall at Greens Bayou at US 59, 2022 (Source: HCFWS)

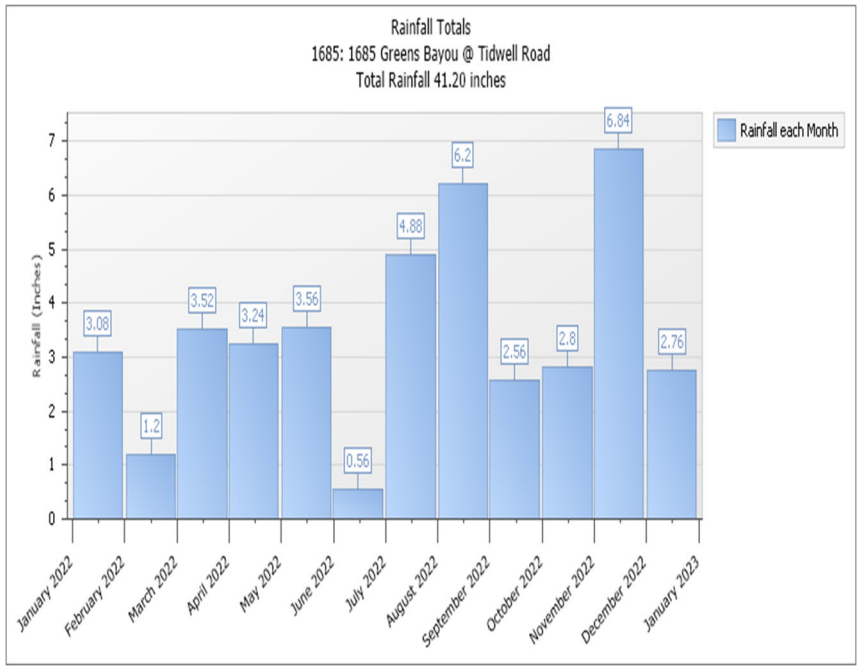


Figure 1: Monthly rainfall at Greens Bayou at Tidwell Road, 2022 (Source: HCFWS)

USGS STREAM FLOW GAGES

There are four U.S. Geological Survey (USGS) stream gages in this watershed. The accompanying table lists these stations from upstream to downstream.

Hydrographs of the gage heights for each USGS station from the period of 01-01-2015 to 12-31-2022 are shown. As you move downstream and further east into the floodplain, numerous flood events are observed in the watershed. These are particularly pronounced at the Garners Bayou near Humble site. There have been frequent flooding events resulting in damage to homes and businesses over the past two decades. This includes devastating flooding of Greens Bayou during Hurricane Harvey.

Table 5: USGS Gage Stations in Segment 1016 - Greens Bayou Above Tidal

USGS Gage Station ID	Site Description
08075780	Greens Bayou at Cutten Road near Houston, TX
08075900	Greens Bayou near Hwy 75 near Houston, TX
08076000	Greens Bayou near Houston, TX (at US 59N)
08076180	Garners Bayou near Humble, TX

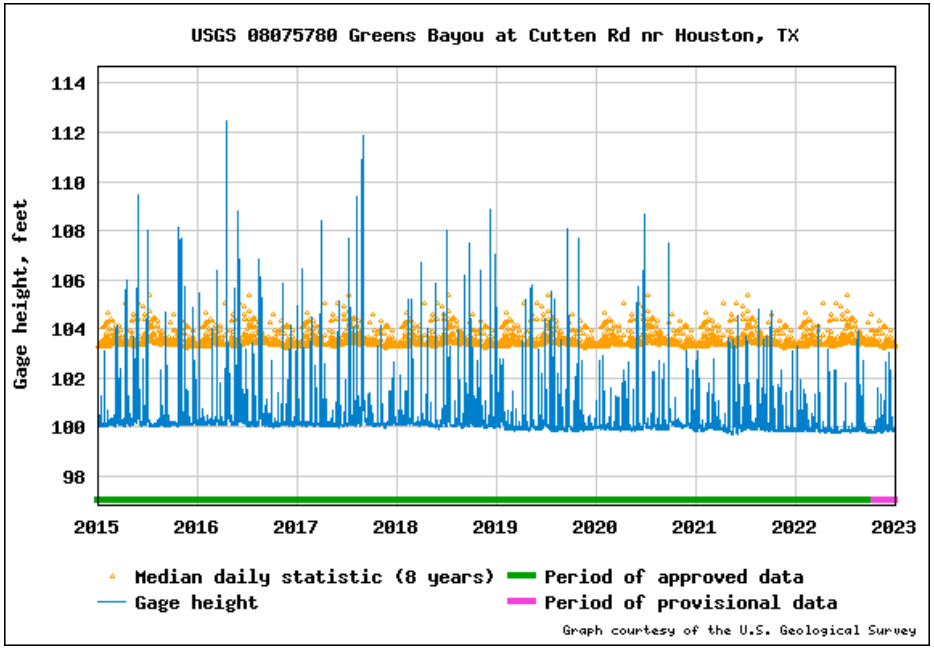


Figure 4: Gage Height at Greens Bayou at Cutten Road (USGS 08075780), 2015-2022

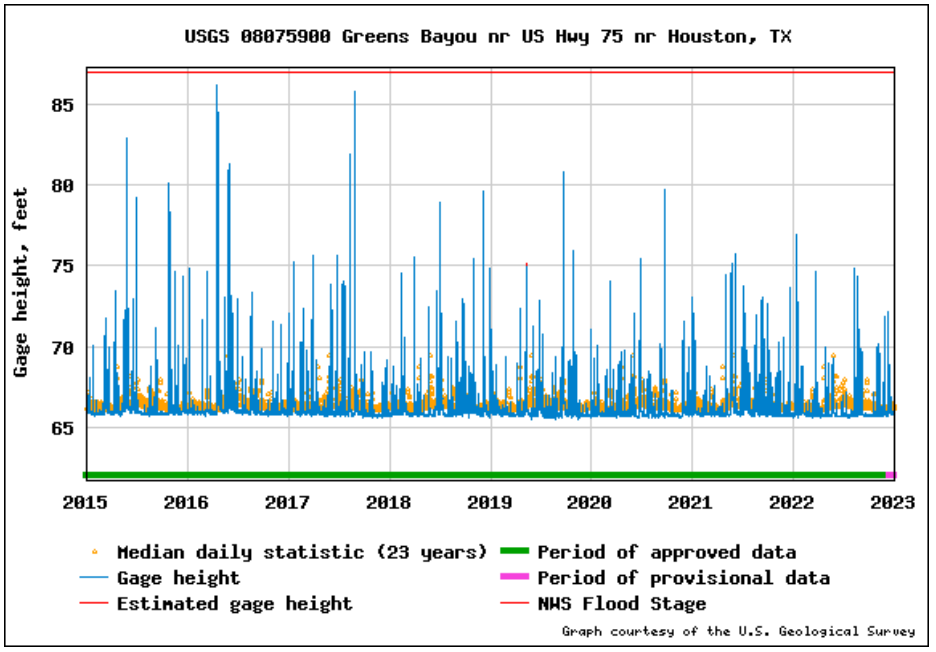


Figure 5: Gage Height at Greens Bayou near US Hwy 75 (USGS 0809500), 2015-2022

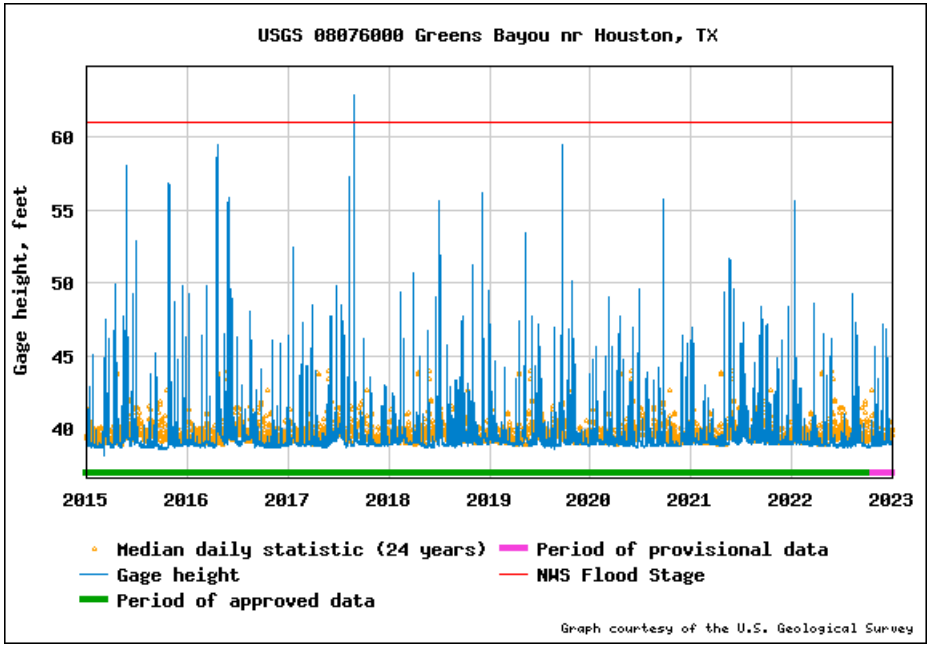


Figure 6: Gage Height at Greens Bayou near Houston (USGS 08076000), 2015-2022

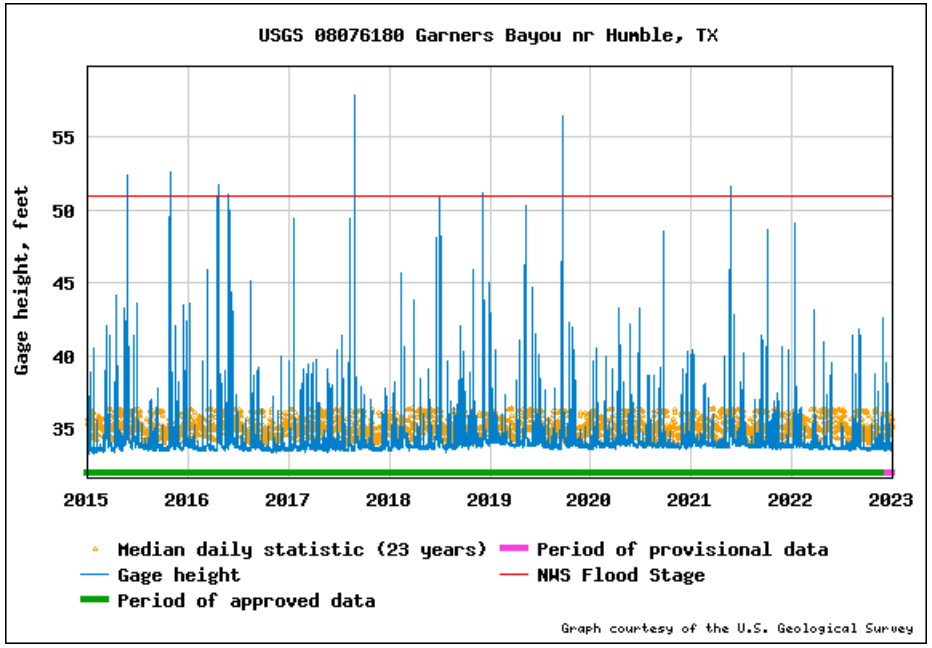
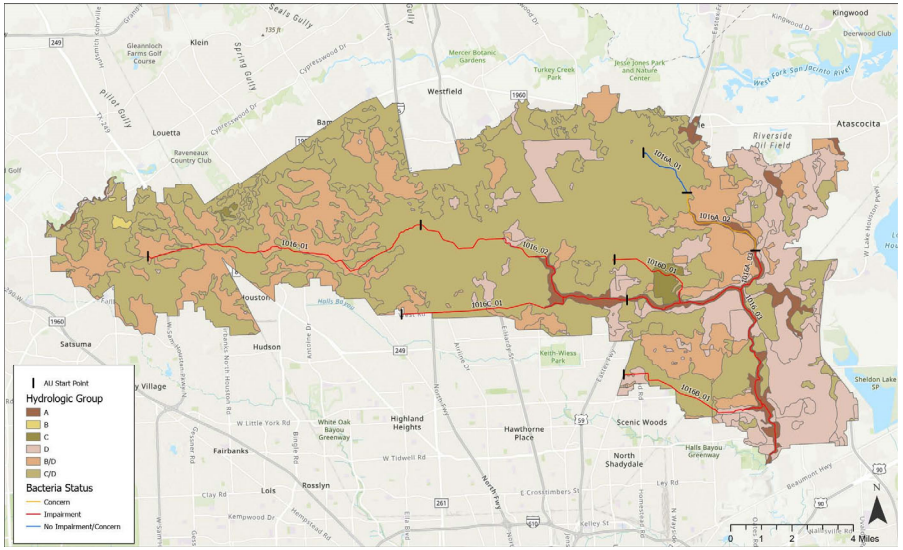


Figure 7: Gage Height at Greens Bayou near Humble (USGS 08076180), 2015-2022

HYDROLOGIC SOIL GROUPS

The most prevalent soil types in the Greens Bayou Above Tidal watershed area are clay loam, sandy loam, and clay soils. The predominant hydrologic soil groups in the segment are C/D (58.92%), B/D (20.36%), and D (16.70%). All three of these soil groups are characterized as having very slow infiltration rates and high runoff potential. This runoff can contribute to nonpoint sources of bacteria and nutrients entering the waterways.



Map 8: Hydrologic Soil Groups for Segment 1016 - Greens Bayou Above Tidal

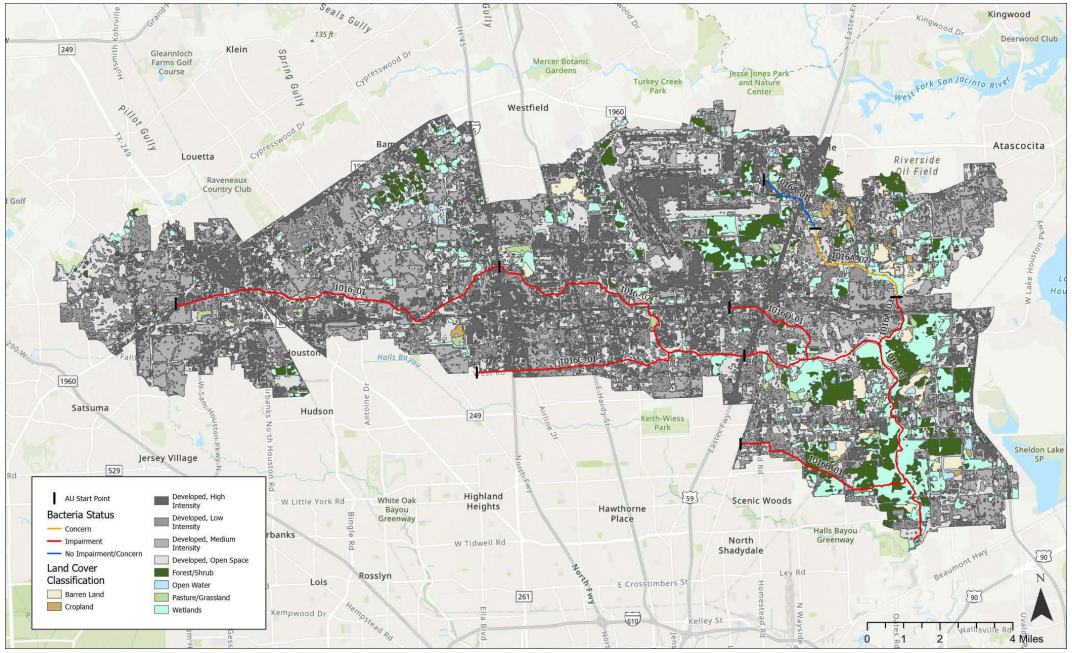
Table 6: Hydrologic Soil Groups by Area in the Segment 1016 - Greens Bayou Above Tidal

Hydrologic Soil Group	Soil Texture Class	Typical Soil Composition	Infiltration Rate	Runoff Potential	Area Square Miles	Area %
A	Sand	<10% clay, >90% sand or gravel	High	Low	5.08	3.19%
B	Sandy loam, Loamy sand	10 – 20% clay, 50 – 90% sand	Moderate	Moderately Low	0.21	0.13%
C	Clay loam. Silty clay loam, Sandy clay loam, Loam, Silty loam, Silt	20 – 40% clay, <50% sand	Slow	Moderately High	1.10	0.69%
D	Clay, Silty clay, Sandy clay	>40% clay, <50% sand	Very Slow	High	26.60	16.70%
A/D	Sand	<10% clay, >90% sand or gravel	Very Slow (High if drained)	High (Low if drained)	–	–
B/D	Sandy loam, Loamy sand	10 – 20% clay, 50 – 90% sand	Very Slow (Moderate if drained)	High (Moderate if drained)	32.42	20.36%
C/D	Clay loam, Silty clay loam, Sandy clay loam, Loam, Silty loam, Silt	20 – 40% clay, <50% sand	Very Slow (Slow if drained)	High	93.83	58.92%
				TOTAL	159.23	100.00%

LAND COVER AND NATURAL CHARACTERISTICS

The Greens Bayou Above Tidal watershed is heavily developed, with 81.82% of the land area classified as one of the four developed classes (Open Space, Low Intensity, Medium Intensity, and High Intensity). Residential and mixed commercial developments are the dominant uses.

Beltway 8 runs through the middle of the watershed with large, high intensity developments and business districts found adjacent to, and at the intersections with, I-45, U.S. Highway 59 and Texas Highway 249. Development has continued to expand along the U.S. Hwy 59 and Beltway 8 corridors in recent years where high intensity residential development has replaced single family homes. Bush Intercontinental Airport is located in the north central section of the watershed. The easternmost portion of the watershed is mostly



Map 9: Land Cover for Segment 1016 - Greens Bayou Above Tidal (2020)

Combined pasture/grassland and cropland is less than 2% of the watershed area, with 6% of the land area being covered with forests/shrubs.

Table 7: Land Cover for Segment 1016 - Greens Bayou Above Tidal (2020)

Land Cover Class Name	Area Square Miles	Area %
Barren Land	2.84	1.78%
Cropland	0.66	0.41%
Developed, High Intensity	21.51	13.51%
Developed, Low Intensity	31.24	19.62%
Developed, Medium Intensity	42.84	26.90%
Developed, Open Space	34.69	21.79%
Forest/Shrub	9.68	6.08%
Open Water	1.08	0.68%
Pasture/Grassland	1.15	0.72%
Wetlands	13.55	8.51%
TOTAL	159.23	100.00%

DESCRIPTION OF WATER QUALITY ISSUES

WATER QUALITY STANDARDS AND NUTRIENT SCREENING CRITERIA

Segment 1016 (Greens Bayou Above Tidal) and three unnamed tributaries (1016B, 1016C, and 1016D) have a limited aquatic life use designation. Garners Bayou (1016A_03) has a high aquatic life use designation while 1016A_01 and 1016A_02 have limited ALUs. All segments within the watershed are designated as primary contact recreation 1. The accompanying table describes the water quality standards for each segment and parameter.

Table 8: Designated Uses and Numeric Criteria[1] for Segment 1016 - Greens Bayou Above Tidal

Segment ID	Segment Name	DESIGNATED USES				CRITERIA								NUTRIENT SCREENING LEVELS			
		Recreation[2]	Aquatic Life Use[3]	Domestic Water Supply	Other Uses	Chloride (mg/L)	Sulfate (mg/L)	Total Dissolved Solids (mg/L)	Dissolved Oxygen Grab Minimum (mg/L)	Dissolved Oxygen Grab Screening Level (mg/L)	pH Range (SU)	Temperature (°F)	Indicator Bacteria[4] Geometric Mean (MPN/100 mL)	Total Phosphorus (mg/L)	Nitrate-Nitrogen (mg/L)	Ammonia-Nitrogen (mg/L)	Chlorophyll-*a* (µg/L)
1016	Greens Bayou Above Tidal	PCR1[2]	Limited	–	–	150	150	1,000	2.0	3.0	6.5–9.0	92	126	0.69	1.95	0.33	14.1
1016A_01 & 1016A_02	Garners Bayou	PCR1	Limited	–	–	–	–	–	2.0	3.0	–	–	126	0.69	1.95	0.33	14.1
1016A_03	Garners Bayou	PCR1	High	–	–	–	–	–	3.0	5.0	–	–	126	0.69	1.95	0.33	14.1
1016B	Unnamed Tributary of Greens Bayou	PCR1	Limited	–	–	–	–	–	2.0	3.0	–	–	126	0.69	1.95	0.33	14.1
1016C	Unnamed Tributary of Greens Bayou	PCR1	Limited	–	–	–	–	–	2.0	3.0	–	–	126	0.69	1.95	0.33	14.1
1016D	Unnamed Tributary of Greens Bayou	PCR1	Limited	–	–	–	–	–	2.0	3.0	–	–	126	0.69	1.95	0.33	14.1

[1] Source: 2022 *Texas Surface Water Quality Standards* (https://www.tceq.texas.gov/waterquality/standards/2022-texas-surface-water-quality-standards)

[2] PCR1 = Primary Contact Recreation 1

[3] Aquatic Life Use is categorized as either Exceptional, High, Intermediate, Limited, or Minimal.

[4] The indicator bacteria for freshwater is *E. coli*. The indicator bacteria for saltwater is Enterococci.

SUMMARY OF 2022 ASSESSMENT RESULTS

The accompanying table shows assessment results from the 2022 Texas Integrated Report. The IR describes the status of the water body based on historical data and the extent to which it attains the Texas Surface Water Quality Standards. The seven-year assessment period for the 2022 IR was 12/1/13 – 11/30/20.

Table 9: Integrated Level of Support for Assessment Units in Segment 1016 - Greens Bayou Above Tidal (2022 Integrated Report)

Designated Use	Method	Parameter	Integrated Level of Support							
			Greens Bayou Above Tidal			Garners Bayou		Unnamed Tributary	Unnamed Tributary	Unnamed Tributary
			1016_01	1016_02	1016_03	1016A_02	1016A_03	1016B_01	1016C_01	1016D_01
Aquatic Life Use	Dissolved Oxygen Grab Minimum	Dissolved Oxygen Grab	FS	FS	FS	FS	FS	FS	FS	NS
	Dissolved Oxygen Grab Screening Level	Dissolved Oxygen Grab	NC	NC	NC	NC	NC	NC	NC	CS
General Use	Dissolved Solids	Total Dissolved Solids	FS	FS	FS	–	–	–	–	–
		Sulfate	FS	FS	FS	–	–	–	–	–
		Chloride	FS	FS	FS	–	–	–	–	–
	High pH	pH	FS	FS	FS	–	–	–	–	–
	Low pH	pH	FS	FS	FS	–	–	–	–	–
	Nutrient Screening Levels	Total Phosphorus	CS	CS	CS	CS	CS	NC	CS	CS
		Nitrate	CS	CS	CS	CS	CS	NC	CS	NC
		Ammonia	NC	CS	NC	NC	NC	NC	CS	CS
		Chlorophyll-a	FS	–	NC	–	–	–	–	–
	Water Temperature	Water Temperature	FS	FS	NC	–	–	–	–	–
Recreation Use	Bacteria Geomean	*E. coli*	NS	NS	NS	CN	NS	NS	NS	NS

Integrated Level of Support

FS	= Fully Supporting	NC	= No Concern
NS	= Non-Supporting	CN	= Use Concern
		CS	= Screening Level Concern

DISSOLVED OXYGEN IMPAIREMENTS AND CONCERNS

A Dissolved Oxygen concern is present for 1016D_01. In this segment, 15.1% of the samples assessed for the 2022 IR were below the water quality standard established for this segment's designated aquatic life use. All other segments and assessment units in the watershed are supporting their designated use.

Table 10: Comparison of 2022 IR Dissolved Oxygen Data (2013-2022) and H-GAC Analysis of Water Quality Data (2015-2022)

AU ID	Parameter	Level of Support	Category	Samples Exceeding Standard (2022 IR) 12/1/13 – 11/30/20	H-GAC Trend Analysis 1/1/15 – 5/31/22
1016D_01	Dissolved Oxygen Grab Minimum	NS	5c	8/53 (15.1%)	Stable
1016D_01	Dissolved Oxygen Grab Screening Level	CS		21/53 (39.6)	Stable

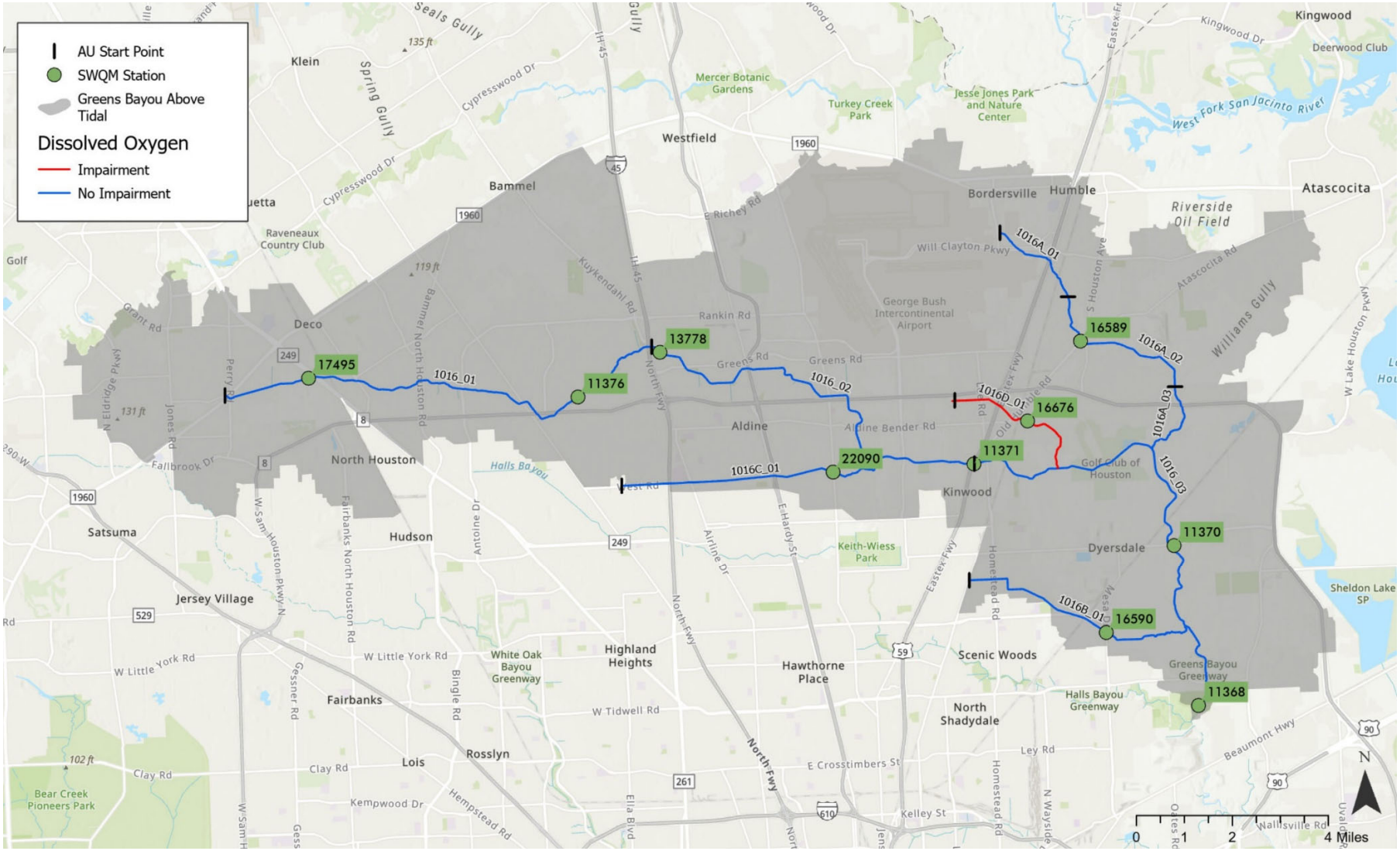
Category

5c = Additional data and information will be collected or evaluated before a management strategy is selected.

Integrated Level of Support

FS	= Fully Supporting
NS	= Non-Supporting

NC	= No Concern
CN	= Use Concern
CS	= Screening Level Concern



Map 10: Dissolved Oxygen Impairments and Concerns for Segment 1016 - Greens Bayou Above Tidal (2022 IR)

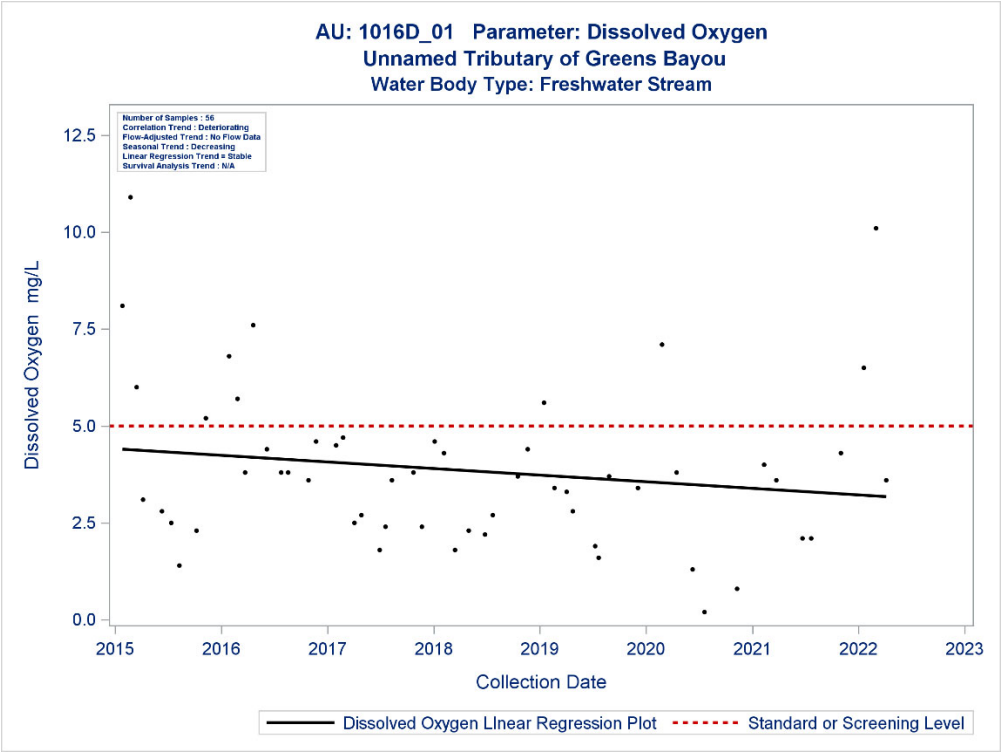


Figure 8: Seven-Year Dissolved Oxygen trend for AU 1016D_01 (Unnamed Tributary of Greens Bayou Above Tidal), 2015-2022

AU 1016D_01 has a deteriorating trend for DO. Over the last seven years, individual results were rarely measured above the standard of 5.0 mg/L. Additionally, the DO concentrations over time have decreased in mg/L as well.

NUTRIENT CONCERNS

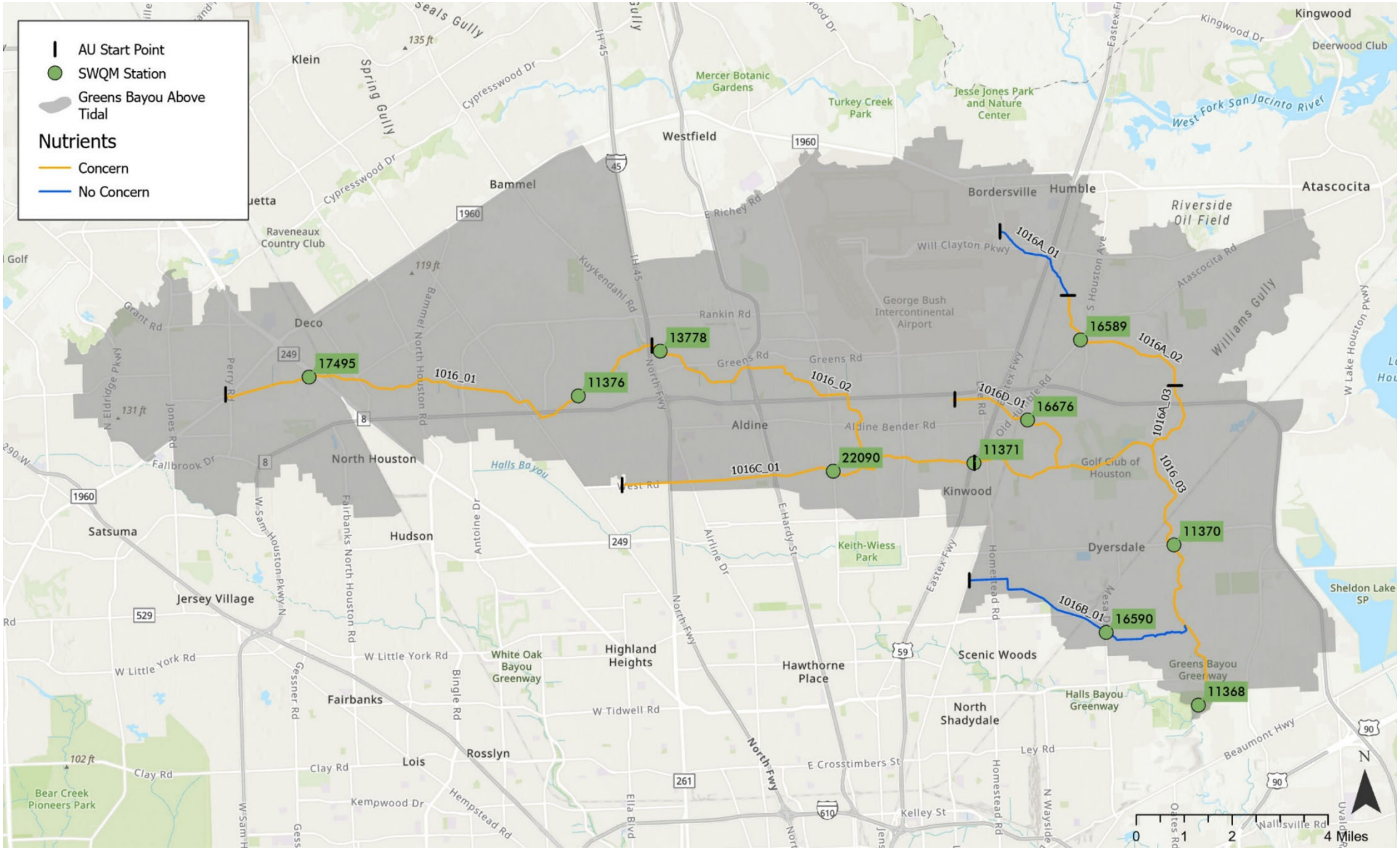
Screening level concerns for nutrients are found throughout the watershed. Concerns for Total Phosphorus screening levels are identified in seven of the eight assessed AUs. For Nitrate, six of eight assessed AUs have screening level concerns, with no concerns identified for 1016B and 1016D. For Ammonia, screening level concerns are found in 1016_02, 1016C_01, and 1016D_01. Excluding AU 1016A_01 (which was not assessed), AU 1016B_01 is the only assessment unit in the watershed without a nutrient screening level concern. However, Nitrate is deteriorating over time. Between 2015 and 2019, there were several results <0.04 mg/L but after 2019, all results were >0.04 mg/L.

Table 11: Comparison of 2022 IR Nutrient Data (2013-2020) and H-GAC Analysis of Water Quality Data (2015-2022)

Parameter	AU ID	Level of Support	2022 Integrated Report (12/01/13 – 11/30/20)		H-GAC Trend Analysis 1/1/15 – 5/31/22
			# Exceedances/ #Assessed	Percentage	
Total Phosphorus	1016_01	CS	94/110	85.4%	Stable
	1016_02	CS	93/110	84.5%	Stable
	1016_03	CS	95/129	73.6%	Stable
	1016A_02	CS	46/55	83.6%	Stable
	1016A_03	CS	49/55	89.1%	Stable
	1016B_01	NC	0/55	0%	Stable
	1016C_01	CS	25/55	45.4%	Stable
	1016D_01	CS	25/55	45.4%	Stable
Nitrate	1016_01	CS	97/110	81.2%	Stable
	1016_02	CS	95/110	86.4%	Stable
	1016_03	CS	109/131	83.2%	Stable
	1016A_02	CS	44/55	80%	Stable
	1016A_03	CS	50/55	90.9%	Stable
	1016B_01	NC	0/55	0%	Deteriorating
	1016C_01	CS	27/55	49.1%	Stable
	1016D_01	NC	0/55	0%	Stable
Ammonia	1016_01	NC	3/110	2.7%	Stable
	1016_02	CS	35/110	31.8%	Stable
	1016_03	NC	3/129	2.3%	Stable
	1016A_02	NC	1/55	1.8%	Stable
	1016A_03	NC	13/55	23.6%	Deteriorating
	1016B_01	NC	0/55	0%	Stable
	1016C_01	CS	15/55	27.3%	Deteriorating
	1016D_01	CS	53/55	96.4%	Improving

Integrated Level of Support

NC	= No Concern
CS	= Screening Level Concern



Map 11: Nutrient Concerns for Segment 1016 - Greens Bayou Above Tidal (2022 IR)

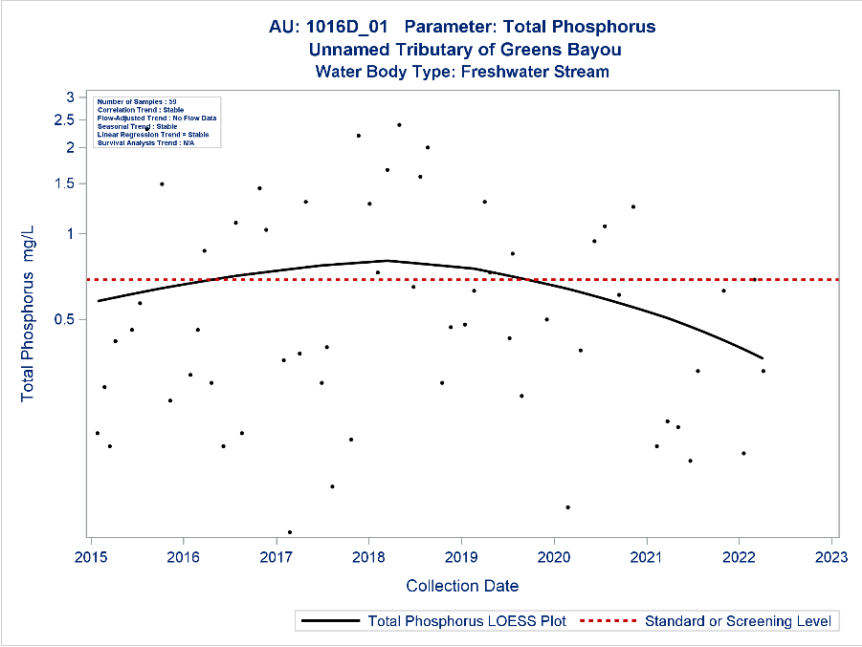


Figure 9: Seven-Year Total Phosphorus trend for AU 1016D_01(Unnamed Tributary of Greens Bayou), 2015-2022

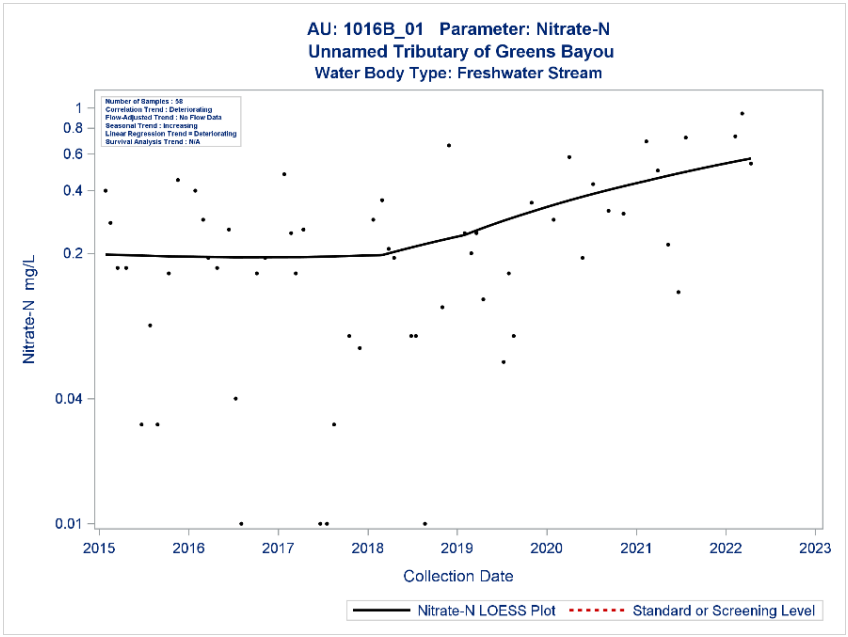


Figure 10: Seven-Year Nitrate-Nitrogen trend for AU 1016B_01(Unnamed Tributary of Greens Bayou), 2015-2022

On 1016D_01 the trend for Total Phosphorus is identified as stable but following an all-time high in 2018, results have been steadily decreasing so that all results since 2021 were below the screening level for Total Phosphorus. However, both 1016B_01 and 1016A_03 have a deteriorating trend for nutrients.

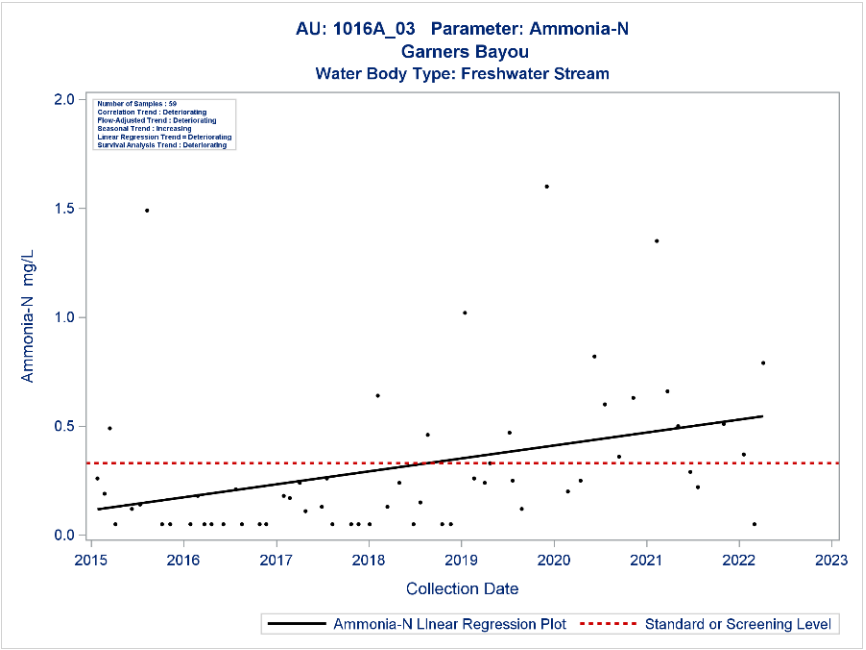
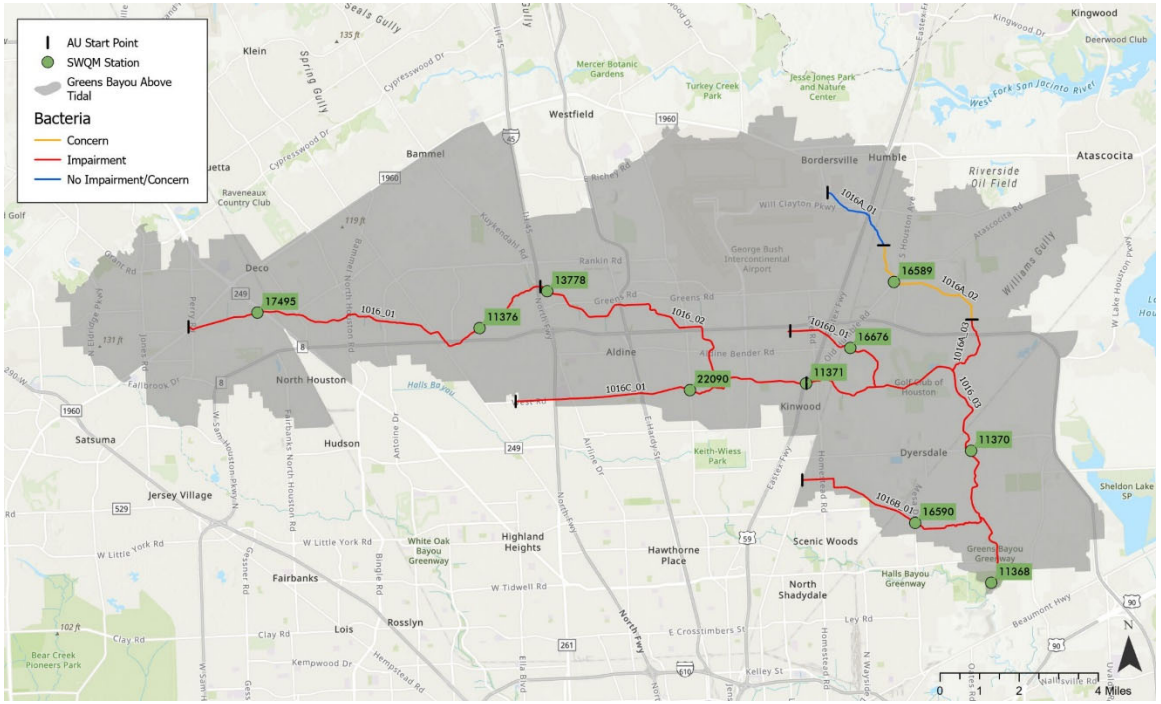


Figure 11: Seven-Year Ammonia-Nitrogen trend for AU 1016A_03(Garners Bayou), 2015-2022

BACTERIA IMPAIRMENTS AND CONCERNS

Bacteria impairments and concerns are present in all eight of the AUs assessed for the 2022 IR. Seven of those AUs fail to support their
designated primary contact recreation use, with one having a use concern.

In segments 1016C and 1016D, the *E. coli* geometric means are 1,707.96 and 1,509.99 MPN/100 mL, both of which are more than ten times the standard of 126 MPN/100 mL for PCR1.



Map 12: Bacteria Impairments and Concerns for Segment 1016 - Greens Bayou Above Tidal (2022 IR)

Table 12: Comparison of 2022 IR Bacteria Data (2013-2020) and H-GAC Analysis of Water Quality Data (2015-2022)

Parameter	AU ID	Level of Support	Category	Geometric Mean (MPN/100mL) 2022 Integrated Report (12/01/13 – 11/30/20)	H-GAC Trend Analysis 1/1/15 – 5/31/22
E. coli Geometric Mean	1016_01	NS	4a	284.82	Deteriorating
	1016_02	NS	4a	583.76	Stable
	1016_03	NS	4a	414.43	Deteriorating
	1016A_02	CN	–	144.51	Stable
	1016A_03	NS	4a	423.1	Deteriorating
	1016B_01	NS	4a	171.36	Stable
	1016C_01	NS	4a	1,707.96	Deteriorating
	1016D_01	NS	4a	1,509.99	Stable

Category

4a = A state-developed TMDL has been approved by EPA or a TMDL has been established by EPA for any water-pollutant combination.

Integrated Level of Support

FS	= Fully Supporting	NC	= No Concern
NS	= Non-Supporting	CN	= Use Concern
		CS	= Screening Level Concern

Table 13: Comparison of 2022 IR Bacteria Data (2013-2020) and H-GAC Analysis of Water Quality Data (2015-2022)

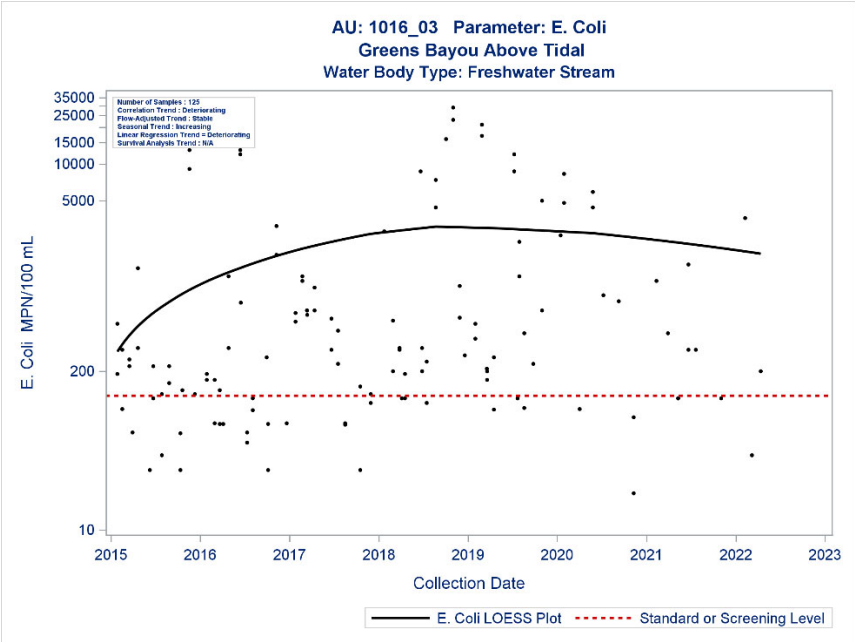


Figure 12: Seven-Year E. coli trend for AU 1016_03 (Greens Bayou Above Tidal), 2015-2022

The three *E. coli* graphs found on this page are examples of deteriorating trends within the Greens Bayou Above Tidal watershed.

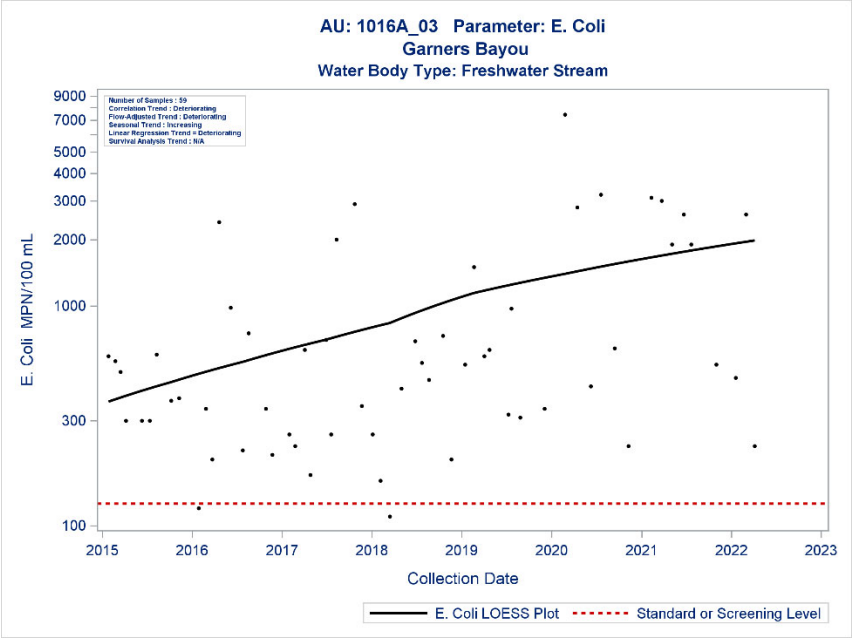


Figure 13: Seven-Year E. coli trend for AU 1016A_03 (Garners Bayou), 2015-2022

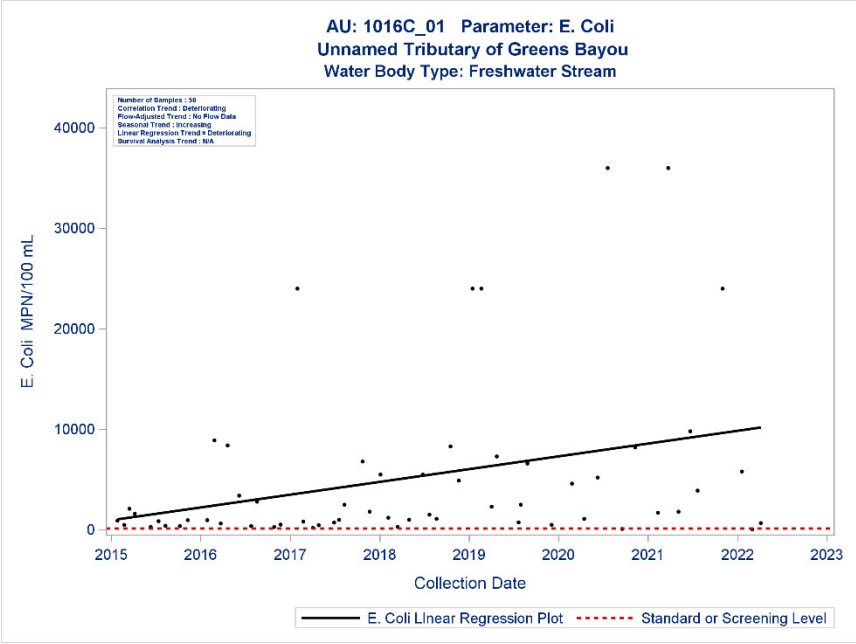


Figure 14: Seven-Year E. coli trend for AU 1016C_01 (Unnamed Tributary of Greens Bayou), 2015-2022

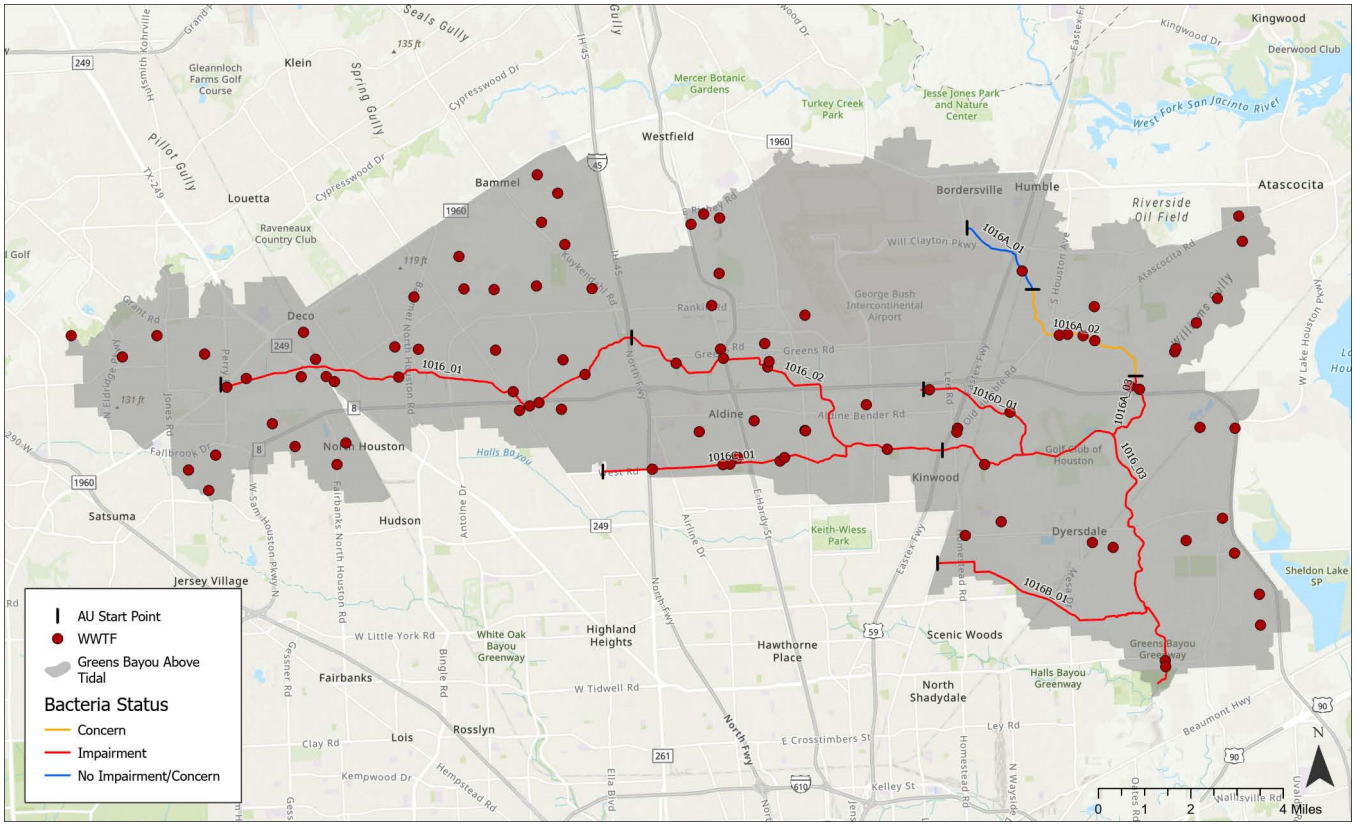
POTENTIAL SOURCES OF WATER QUALITY ISSUES

Potential sources of fecal indicator bacteria and nutrients in the Greens Bayou Above Tidal watershed include both point and nonpoint sources. These sources include wastewater treatment facility outfalls, sanitary sewer overflows, failing on-site sewage facilities, stormwater runoff, and animal waste.

PERMITTED EFFLUENT DISCHARGES

There are 95 permitted outfalls in Segment 1016. Of these outfalls, 58 are classified as domestic sewage with a discharge of <1 million gallons per day (MGD). The remaining 37 permittees have a discharge of ≥1 MGD. As discussed in the 2022 *Water Quality Management Plan Update*, smaller wastewater treatment facilities (those with flows of <1 MGD) throughout the Houston-Galveston region tend to have the highest rate of bacteria geometric mean exceedances (1.5% in 2021) when compared to other size categories.

Permitted outfalls are shown in the accompanying map. A list of permits in the watershed is included in the Appendix.

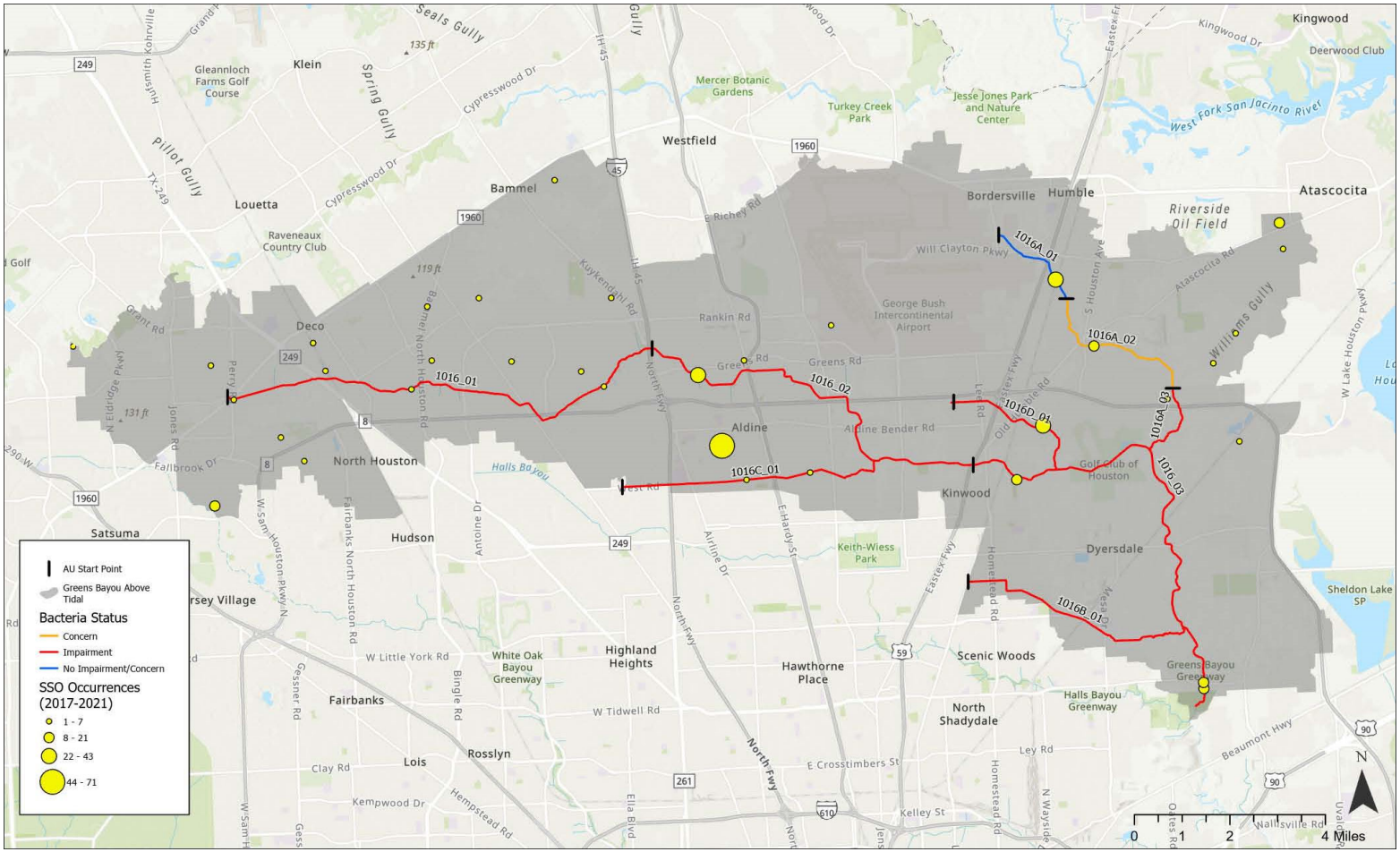


Map 13: Permitted Effluent Discharges for Segment 1016 - Greens Bayou Above Tidal (2022)

SANITARY SEWER OVERFLOWS

For the period of 2017 – 2021, 35 permittees reported a total of 321 sanitary sewer overflows in the Greens Bayou Above Tidal watershed. The total reported volume of these discharges was 370,582 gallons. While this number and volume of SSOs may not necessarily cause chronically high bacteria levels within this waterway, each discrete event may cause acute conditions that could affect public health.

Sources of sanitary sewer overflows include aging wastewater infrastructure, mechanical failure, inflow and infiltration, and improper disposal of fats, oils, and grease. Flooding issues within the Greens Bayou watershed contribute to the frequency, volume, and duration of SSOs.

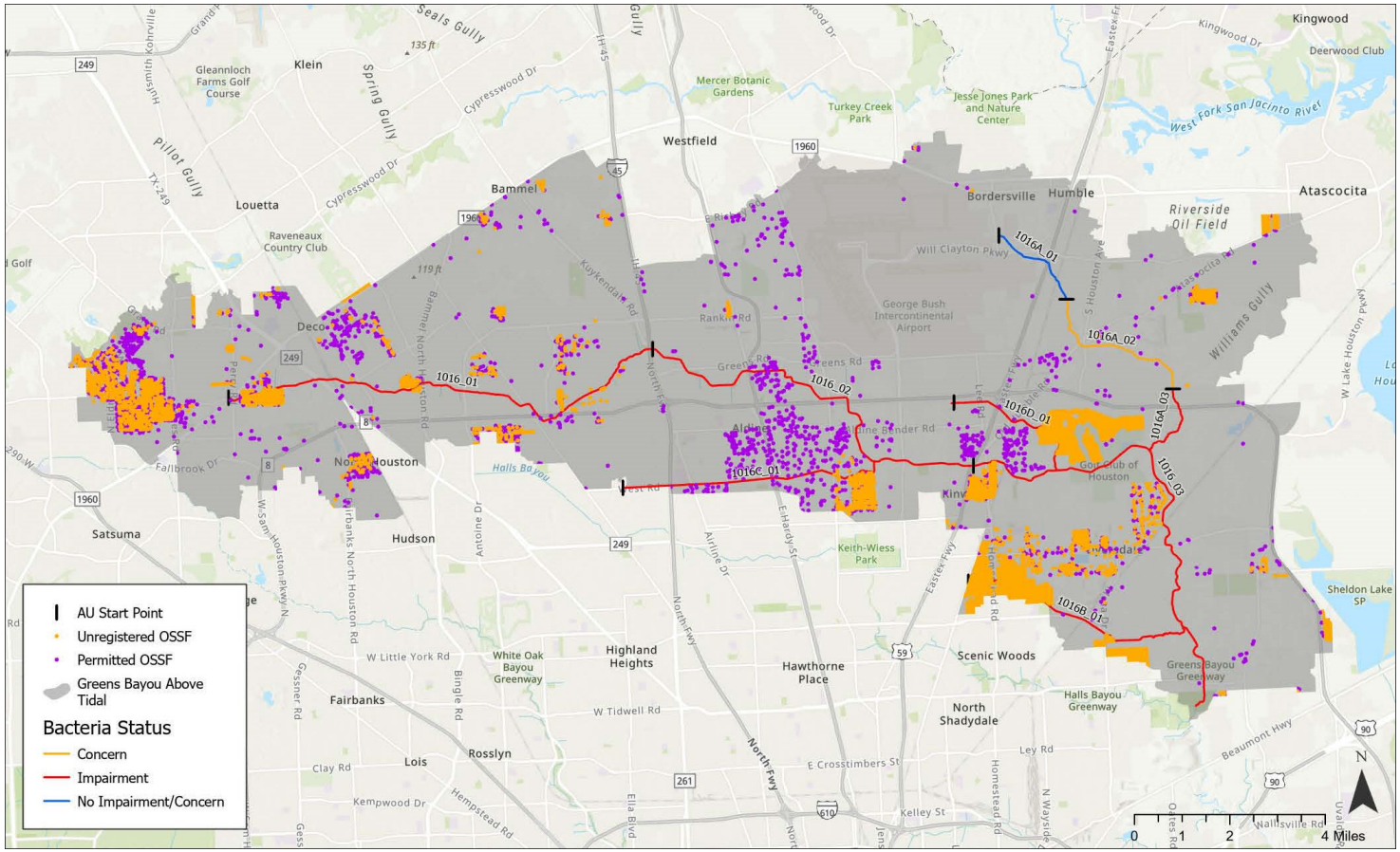


Map 14: Sanitary Sewer Overflows for Segment 1016 - Greens Bayou Above Tidal (2017-2021)

ON-SITE SEWAGE FACILITIES

Although the majority of the watershed is serviced by residential sewer collection systems and wastewater treatment facilities, there are areas within the watershed where on-site sewage facilities are utilized. Within the Greens Bayou Above Tidal watershed, there are 2,984 permitted OSSFs, with an estimated 8,211 unpermitted OSSFs.

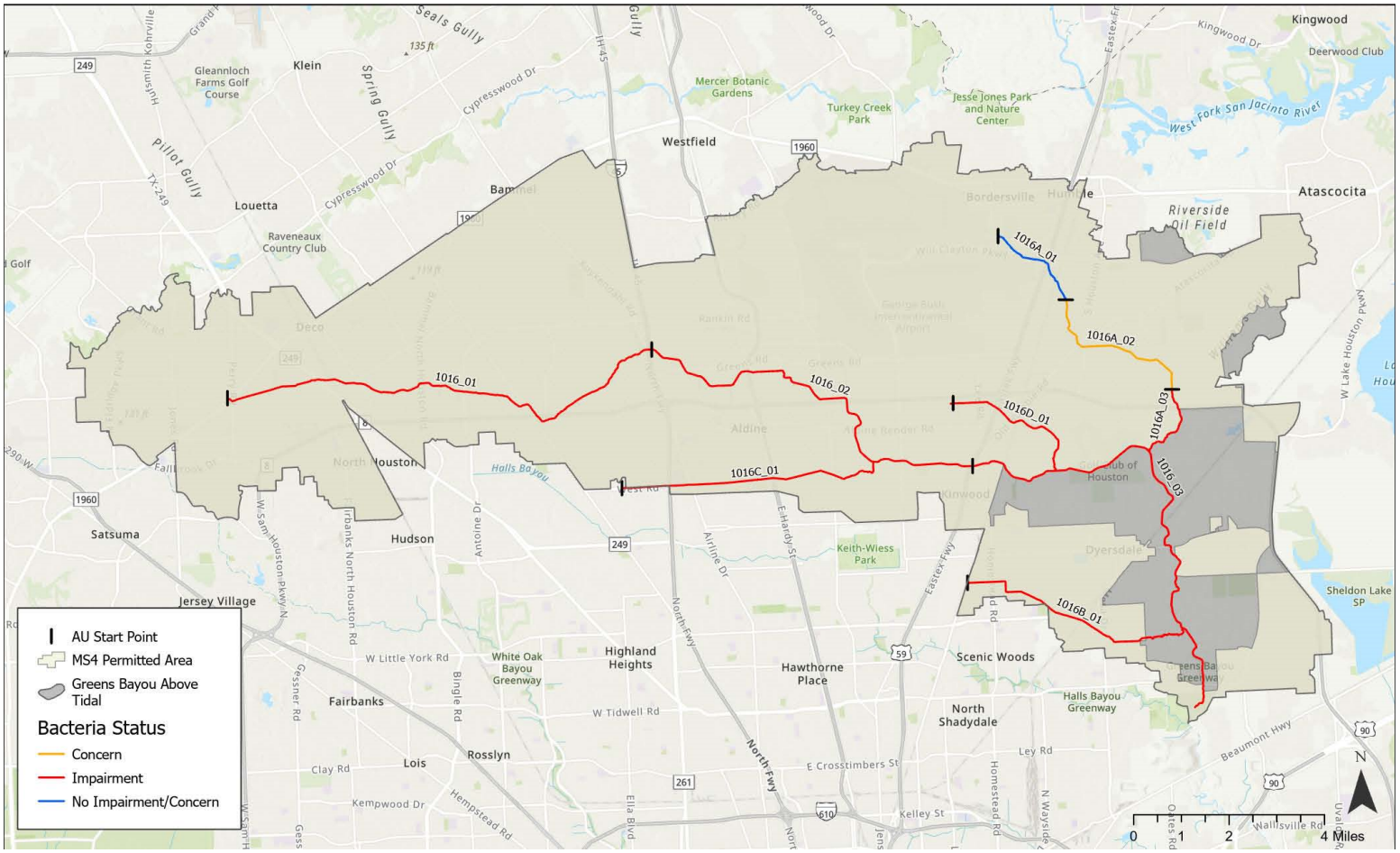
Please note that many of the OSSFs within the unincorporated portion of Harris County were permitted by the county between 1978 –1992. Historical permit records from that time frame are not available electronically in the current OSSF database, so many of those systems show up as unpermitted. H-GAC is currently in the process of digitizing and converting those historical records so that this data can be available electronically for use by both H-GAC and Harris County. Once these permit records are converted, maps, and counts of permitted and unpermitted systems can be revised to reflect actual on-the-ground conditions.



Map 15: On-Site Sewage Facilities for Segment 1016 – Greens Bayou Above Tidal

URBAN RUNOFF/STORM SEWERS

Urban runoff can contribute to nutrient and bacteria contamination of waterways. The large land area within the floodplain, the amount of development with impervious land cover within the watershed, and the slow-draining soils all exacerbate this problem. The Above Tidal portion of the Greens Bayou watershed is covered by stormwater permits. The City of Houston, Harris County, and the Harris County Flood Control District hold Phase I stormwater permits with the Texas Commission on Environmental Quality, providing 100% coverage. Additionally, smaller local governmental entities hold Phase II stormwater permits within the watershed. The state's stormwater permitting program covers both phases, describing the minimum requirements each entity must meet to ensure water quality protection and address identified impairments. To search for more information on a general permit (including stormwater), please visit TCEQ's Water Quality General Permits Search tool.



Map 16: MS4 Permitted Areas for Segment 1016 - Greens Bayou Above Tidal

POTENTIAL STAKEHOLDERS

Potential stakeholders in the watershed include:

- City of Houston
- City of Humble
- Harris County Flood Control District (HCFCD)
- Harris County Precinct 1
- Harris County Precinct 2
- Harris County Precinct 3
- Houston Parks Board
- Houston Parks and Recreation Department
- Houston Public Works Department
- National Parks Service
- Texas Parks and Wildlife
- Bacteria Implementation Group
- United States Geological Survey
- US Army Corps of Engineers (USACE) Galveston District
- East Aldine Management District
- Special Districts (Municipal Utility Districts, Water Control & Improvement Districts, etc.)
- Bush Intercontinental Airport
- Texas A&M Forest Service
- Greens Bayou Coalition
- North Houston Association
- Bayou Preservation Association
- Galveston Bay Estuary Program
- Galveston Bay Foundation
- The Nature Conservancy

RECOMMENDATIONS FOR IMPROVING WATER QUALITY

- Development of a watershed protection plan to address bacteria impairments and concerns
- Address bacteria and nutrient concerns through stakeholder involvement and best management practices
- Continue collecting water quality data and expand monitoring efforts to support actions associated with the development of a Watershed Protection Plan
- Continue to work with the BIG to implement the I-Plan recommendations for bacteria reduction
- Continue to analyze Discharge Monitoring Report data and present results to TCEQ, wastewater permittees, local governments/utility districts, and
- stakeholders through updates to the Regional Water Quality Management Plan
- Continue to analyze sanitary sewer overflow data from regulated dischargers and present results to TCEQ, wastewater permittees, local governments/utility districts, and stakeholders through updates to the Regional Water Quality Management Plan
- Improve compliance and enforcement of existing stormwater quality permits and improve stormwater controls in new developments
- Expand use of low impact development and green infrastructure practices
- Consult stakeholders to identify illegal dumping sites and improve signage and/or cameras, if needed
- Pursue new local partners to collect additional data to help better isolate problem areas
- Expand volunteer monitoring with Texas Stream Team in areas without professional monitoring
- Support programs to assist homeowners with the repair or replacement of failing on-site sewage facilities
- Support programs to assist homeowners with on-site sewage facilities to connect to centralized sewer collection systems (where practical)
- Support public education programs to inform business and homeowners on appropriate disposal of fats, oil, grease, and wipes
- Support programs to educate homeowners on proper management of pet wastes

WATERSHED PROJECTS

- **Implementation Plan for One Hundred and Three Total Maximum Daily Loads for Bacteria in the Houston-Galveston Region**
  A TMDL for Greens Bayou was approved by the Bacteria Implementation Group on October 16, 2012, and by TCEQ on January 20, 2013. It has been revised multiple times, with the latest revision (Addendum 4) occurring on June 5, 2018.

- **Targeted Monitoring in Selected Assessment Units**
  In FY2021 H-GAC's Clean Rivers Program conducted a Targeted Monitoring Project that focused on ten watersheds that were divided into four highly urbanized areas, four suburban areas, and two rural areas. As part of this project, bacteria samples were collected to identify potential sources of pollution and contaminated dry-weather flows were referred to the appropriate, responsible local jurisdiction for further investigation and repair/remediation. One of the segments investigated during this project was 1016D_01 – Unnamed Tributary of Greens Bayou. Results of the FY2021 Targeted Monitoring Project can be found here.

  In FY2022-2023, H-GAC's Clean Rivers Program, using information from previous Basin Highlights/Summary Reports, BIG annual reports, and previous targeted monitoring efforts, will address selected waterways to refine our spatial understanding of where extremely high bacterial concentrations are found in these waterways. The project will be fully documented to continue demonstrating the value of a prioritized watershed and targeted monitoring approach. Two AUs to be monitored as part of this project are located in the Greens Bayou Above Tidal segment. These AUs are 1016C_01 Unnamed Tributary of Greens Bayou and 1016D_01 Unnamed Tributary of Greens Bayou

- **24-Hour Dissolved Oxygen Monitoring**
  Beginning in FY 2023, 24-Hour Dissolved Oxygen is being monitored on a quarterly basis at Station ID 16676 – Unnamed Tributary of Greens Bayou at Smith Road. The goal is to complete at least 10 monitoring events so that TCEQ can determine whether the water body is fully supporting its designated use.

- **Greens Bayou Watershed Protection Plan Development**
  In 2022, the Houston-Galveston Area Council was awarded $397,831.50 through the United States Environmental Protection Agency's (EPA) Clean Water Act 319(h) grant program administered locally by the TCEQ to facilitate stakeholders in the development of a voluntary, community-led watershed protection plan to address bacteria impairments and concerns for low dissolved oxygen and high nutrient concentrations. Work will begin in the fall of 2023 and is expected to continue for a duration of three years. The project will engage stakeholders to develop a WPP to address listed impairments, concerns, and stakeholder-identified water quality priorities in the waterways of the Greens Bayou watershed. The WPP will be developed to conform to the EPA's 9-element watershed-based plan standard and will utilize existing data for technical analysis. H-GAC will update existing water quality analyses with additional ambient data acquired from 28 stations monitored by the Clean Rivers Program and sanitary sewer overflow and discharge monitoring reports data from the TCEQ. Further, H-GAC will develop modeling analyses using the Spatially Explicit Load Enrichment Calculation Tool (SELECT) and load duration curves (LDCs) to assess causes and sources of pollution and establish reduction targets for compliance. Refinement will utilize stakeholder review and update of data sources as needed. The modeling will inform stakeholder decisions by indicating the potential causes, extent, and required reductions associated with water quality issues.

MAJOR WATERSHED EVENTS

- **Flooding Events in Greens Bayou**
  There have been frequent and numerous flooding events in the Greens Bayou watershed. This is due to the significant size of the floodplains alongside high- density development and impervious surfaces. As much of this areas development occurred prior to restrictions on building in the floodplains, these events typically result in severe damages to homes and businesses. Tropical Storm Allison in 2001 and Hurricane Harvey in 2017 resulted in devastating flood levels throughout the watershed. Numerous other flooding events have affected the Greens Bayou watershed.

- **Harris County Flood Control District Flood Control Projects**
  The HCFCD has numerous flood control projects in the Greens Bayou Above Tidal watershed. These include completed projects, projects under construction, and projects still in the planning/feasibility study stage.

  - Greens Bayou Federal Flood Risk Management Project
  - Cutten Stormwater Detention Basin Improvements
  - Greens Bayou Mid-Reach Channel Conveyance Improvements
  - Smith Road Channel Diversion Project
  - Aldine Westfield Stormwater Detention Basin
  - Lauder Stormwater Detention Basin
  - Tributaries P138-01-00 & P138-01-01 Channel Conveyance Improvements and Feasibility Analysis
  - Flood Risk Reduction near P130-05-00 and P130-05-01 Feasibility Study and Preliminary Engineering
  - Glen Forest Stormwater Detention Basin
  - Kuykendahl Stormwater Detention Basin
  - P190-00-00 Sediment Removal and Pipe Replacement
  - Drainage Improvements in the Greenwood Forest Subdivision
  - Partnership Project with Trail of the Lakes Municipal Utility District for Tributary P130-02-00 Channel Repairs
  - Feasibility Study of Tributary P125-00-00 and Sub-Watershed
  - Winfield Stormwater Detention Basin
  - Greens Bayou Wetlands Mitigation Bank

- **Home Buyout Program**
  Home buyouts are used by the HCFCD to reduce flood damage in areas that are within the floodplain where structural projects such as stormwater detention basins or channelization to reduce flooding would not be cost-effective or beneficial. Through this program, properties that have frequently been inundated through flood events have been purchased at fair-market value. These flood-prone structures are then removed.

- **East Aldine Management District Water and Sewer Infrastructure Programs**
  Harris County and the East Aldine Management District has worked to install sewer service in the East Aldine region using grant funding. There have not been any new sewer connections since 2019, as the partners await future funding. Harris County and East Aldine Management District had made 846 connections and abandoned a total of 1,493 systems since 2014. Many of the abandoned OSSFs were failing as evidenced by violations. (SOURCE: 2020 BIG Report).

COMMUNITY ENGAGEMENT

The Bayou Greenways 2020 project is creating a continuous linear park system along Houston's major waterways. In 2019, the Houston Parks Board constructed kayak launch sites on Greens Bayou as part of the project. Launch sites have been completed at Brock Park and Strickland Park, with a launch site under construction at Thomas Bell Foster Park and another in the design phase at W. E. Bill Crowley Park. The Greens Bayou Greenway also includes pedestrian bridges, updated landscaping, and paved and natural walking and biking trails along the bayou.

The Greens Bayou Coalition tries to organize at least one group clean-up or tree planting event each month along the bayou or at a flood control or utility district basin to encourage clean waters, flood mitigation, and quality of life along the bayou. In addition to the benefits of cleaning up trash and debris, these events help train a new generation of environmental stewards. As part of the Greens Bayou Paddle Trail, plans for a kayak launch site at W.E. Bill Crowley Park are being developed.

The 29th annual River, Lakes, Bays 'N Bayous Trash Bash® added a new litter cleanup site on Greens Bayou at W. E. Bill Crowley Park at 5100 Lauder Road. Trash Bash® is typically held the last Saturday in March at multiple locations across the Galveston Bay watershed.

IMAGES OF THE WATERSHED

Photo 3: Monitoring Station 11367 - Greens Bayou at West Greens Parkway (downstream)

Photo 4: Monitoring Station 11370 - Greens Bayou (1016) immediately downstream of Houston Parkway (downstream)

Photo 5: Monitoring Station 17495 - Greens Bayou (1016) immediately upstream of Mills Road west of Houston (downstream)

Photo 6: Monitoring Station 16589 - Greens Bayou (1016) at Old Humble Rd (downstream)

Photo 7: Monitoring Station 16590 - Unnamed tributary of Greens Bayou (1016) at Mesa Dr/E. Houston-Dyersdale Road

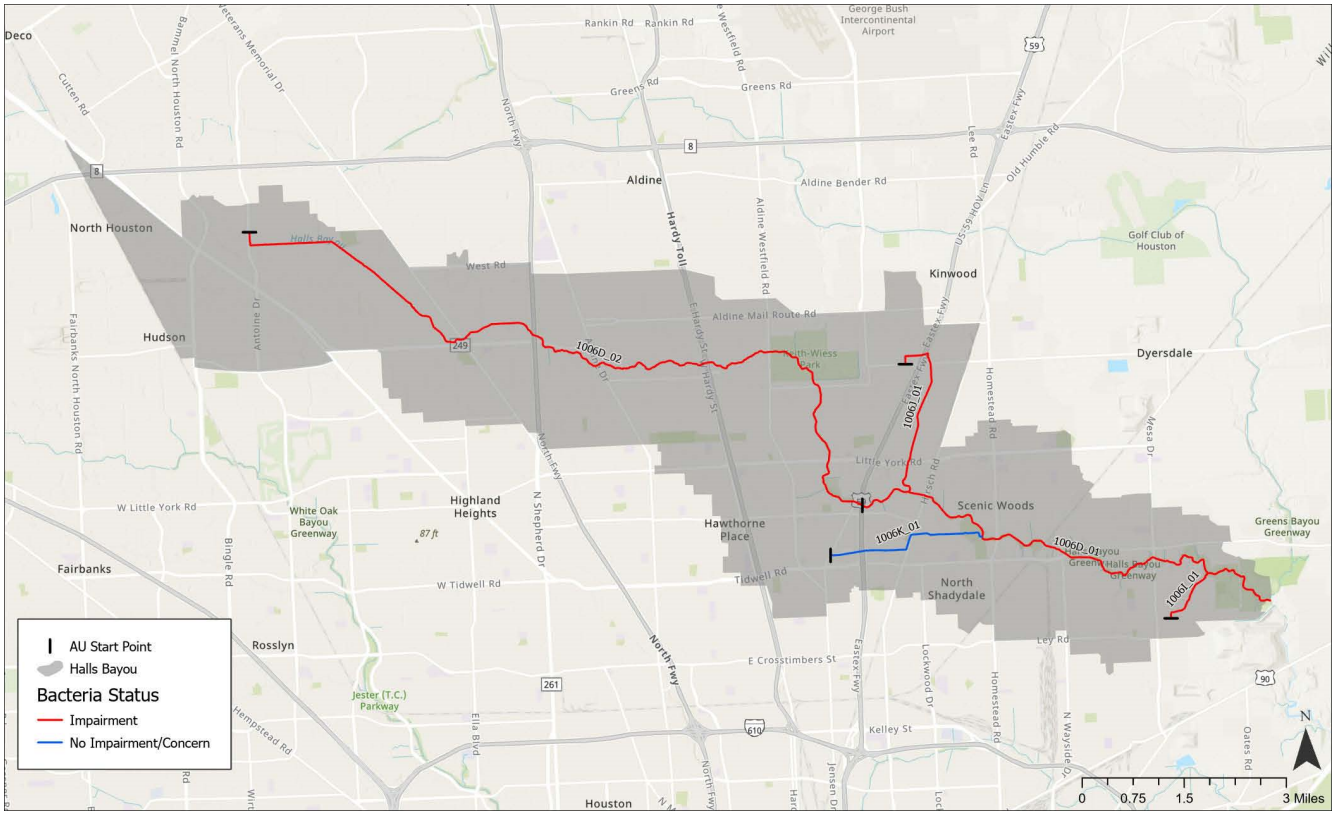
SEGMENT 1006D – HALLS BAYOU

Photo 8: Halls Bayou at Parker Street

SEGMENT DESCRIPTION

Halls Bayou (Segment 1006D) is a tributary of Greens Bayou. This stream segment is approximately 20 miles long, with a drainage area of 46.55 square miles. Designated uses for this unclassified freshwater perennial stream are Primary Contact Recreation 1 (PCR1), with Intermediate Aquatic Life Use (ALU) in AU_01 and Limited ALU for AU_02. This subwatershed of Greens Bayou includes the following segments:

- Segment 1006D: Halls Bayou – From the confluence with Greens Bayou upstream to Frick Road in Harris County
- Segment 1006I: Unnamed Tributary of Halls Bayou – From the confluence with Halls Bayou to a point 0.3 miles upstream of Richland Drive in Harris County
- Segment 1006J: Unnamed Tributary of Halls Bayou – From the confluence of Halls Bayou (east of US 59 and south of Langley Road) to Mount Houston Road in Harris County
- Segment 1006K: Unnamed Tributary of Halls Bayou – From the confluence of Halls Bayou (in Tidwell Park east of Allwood St.) to Jensen west of Hwy 59
- Segment: Kennedy Gully (tributary of Halls Bayou)



Map 17: Segment 1006D - Halls Bayou

Halls Bayou (Segment 1006D) is comprised of two assessment units, with active monitoring stations in each AU. There are three unnamed tributaries of Halls Bayou (1006I, 1006J, 1006K) plus Kennedy Gully which does not currently have a segment ID. Each of the unnamed tributaries are a single assessment unit. Descriptions of each assessment unit are included in the accompanying table.

Table 14: Assessment Unit Descriptions for Segment 1006D_01 - Halls Bayou

Segment ID	Segment Name	AU ID	AU Description
1006D	Halls Bayou	1006D_01	From the Greens Bayou confluence upstream to US 59
		1006D_02	From US 59 upstream to Frick Road
1006I	Unnamed Tributary of Halls Bayou	1006I_01	From the confluence with Halls Bayou to a point 0.3 mi upstream of Richland Drive in Harris County
	Kennedy Gully (Tributary of Halls Bayou missing from TCEQ GIS layer)		From the confluence with Halls Bayou to a point 1.5 mi upstream to Eastover Street in Harris County
1006J	Unnamed Tributary of Halls Bayou	1006J_01	From the confluence with Halls Bayou (east of IH 69 and south of Langley Road) to E. Mount Houston Road in Harris County
1006K	Unnamed Tributary of Halls Bayou	1006K_01	From the Halls Bayou confluence to Jensen Drive in Harris County

The accompanying table provides a description of each active monitoring station in the FY 2023 Coordinated Monitoring Schedule, the submitting and collecting entities, the monitoring type (i.e., routine, biased, etc.), the number of monitoring events per year, and the parameter groups collected.

Table 15: FY 2023 Coordinated Monitoring Schedule[1] for Segment 1006D - Halls Bayou

Segment ID	Segment Name	Station ID	*Station Description*	*SE[2]*	*CE[3]*	*MT[4]*	Number of Monitoring Events Per Year								
							Field	Conv	Bact	Flow	24-Hr DO	Metals Water	Org Water	Metals Sed	Org Sed
1006D	Halls Bayou	17491	HALLS BAYOU AT DEER TRAIL DRIVE IN NORTH HOUSTON	HG	HH	RT	6	6	6	6	–	–	–	–	–
		17490	HALLS BAYOU AT AIRLINE ROAD IN NORTH HOUSTON	HG	HH	RT	6	6	6	–	–	–	–	–	–
		11126	HALLS BAYOU AT JENSEN DRIVE IN HOUSTON	HG	HH	RT	6	6	6	6	–	–	–	–	–
		15863	HALLS BAYOU AT HIRSCH RD IN NORTHEAST HOUSTON	HG	HH	RT	6	6	6	–	–	–	–	–	–
		11127	HALLS BAYOU 87 METERS UPSTREAM OF TIDWELL ROAD IN SETTEGAST	HG	HH	RT	6	6	6	–	–	–	–	–	–
		15862	HALLS BAYOU AT HOMESTEAD ROAD IN NORTHEAST HOUSTON	HG	HH	RT	6	6	6	–	–	–	–	–	–
		15864	HALLS BAYOU AT MESA DR IN NORTHEAST HOUSTON	HG	HH	RT	6	6	6	–	–	–	–	–	–
1006I	Unnamed Tributary of Halls Bayou	16666	UNNAMED TRIBUTARY OF HALLS BAYOU AT TALTON STREET IN NORTHEAST HOUSTON	HG	HH	RT	6	–	6	–	–	–	–	–	–
		16667[5]	UNNAMED TRIBUTARY OF HALLS BAYOU AT WOODLYN ROAD IN NORTH EAST HOUSTON	HG	HH	RT	6	–	6	–	–	–	–	–	–
1006J	Unnamed Tributary of Halls Bayou	16665	UNNAMED TRIBUTARY OF HALLS BAYOU IMMEDIATELY DOWNSTREAM OF LANGLEY ROAD IN NORTH HOUSTON	HG	HH	RT	6	6	6	–	–	–	–	–	–

[1] The Coordinated Monitoring Schedule for current and previous fiscal years can be located at cms.lcra.org

[2] Submitting Entity – The entity submitting monitoring data to TCEQ's Surface Water Quality Information System

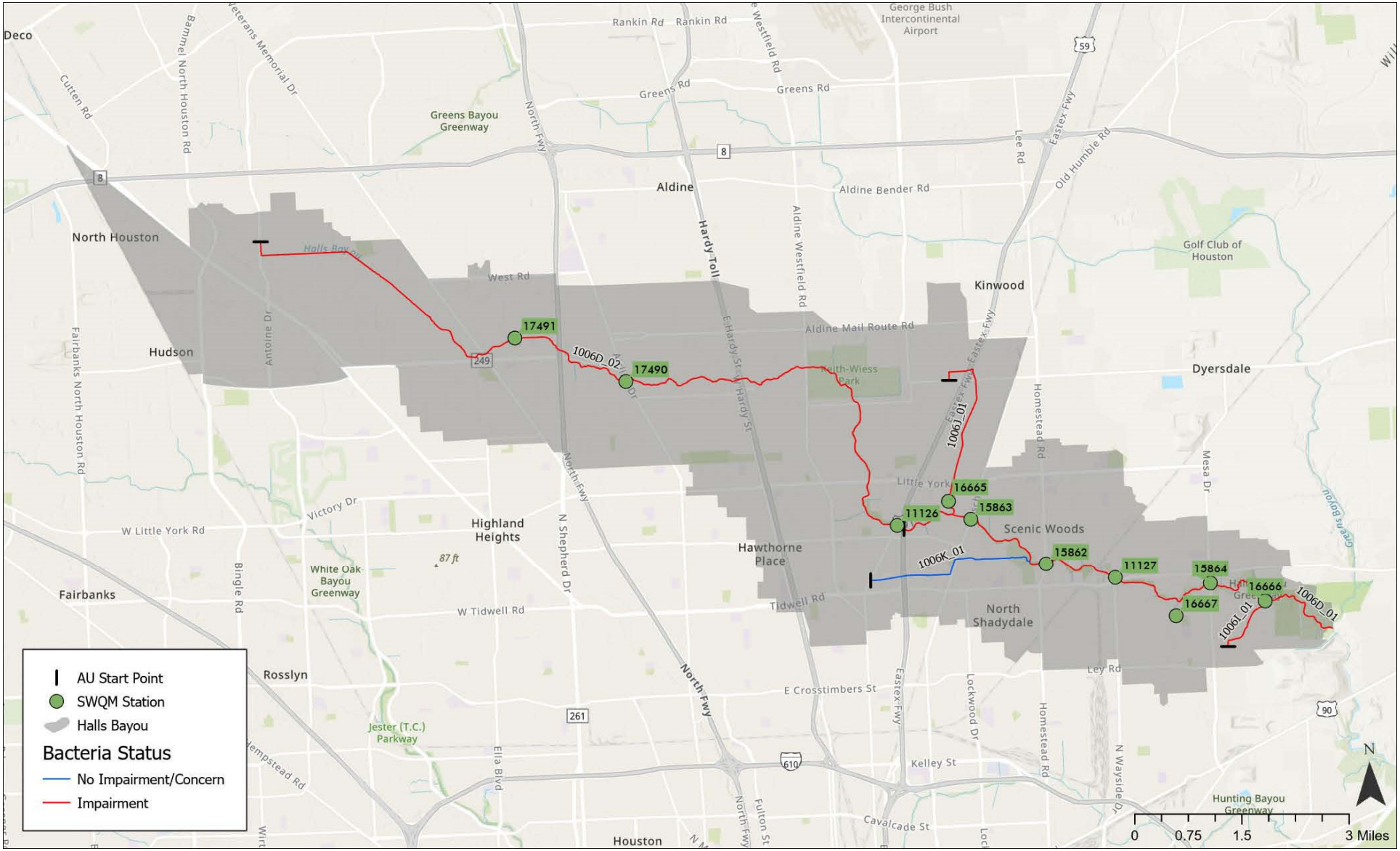
[3] Collecting Entity – The entity collecting monitoring data

[4]Monitoring Type – RT = routine monitoring

[5] Kennedy Gully, a tributary of Halls Bayou, in not identified in TCEQ's GIS layers. Results for site 16667 are currently assigned to AU1006I. A correction will be implemented in the future.

Submitting Entities (SE)and Collecting Entities (CE)
HG = Houston-Galveston Area Council
HH = Houston Health Department

Monitoring Types
RT = Routine



Map 18: FY 2023 Routine Monitoring Stations for Segment 1006D - Halls Bayou

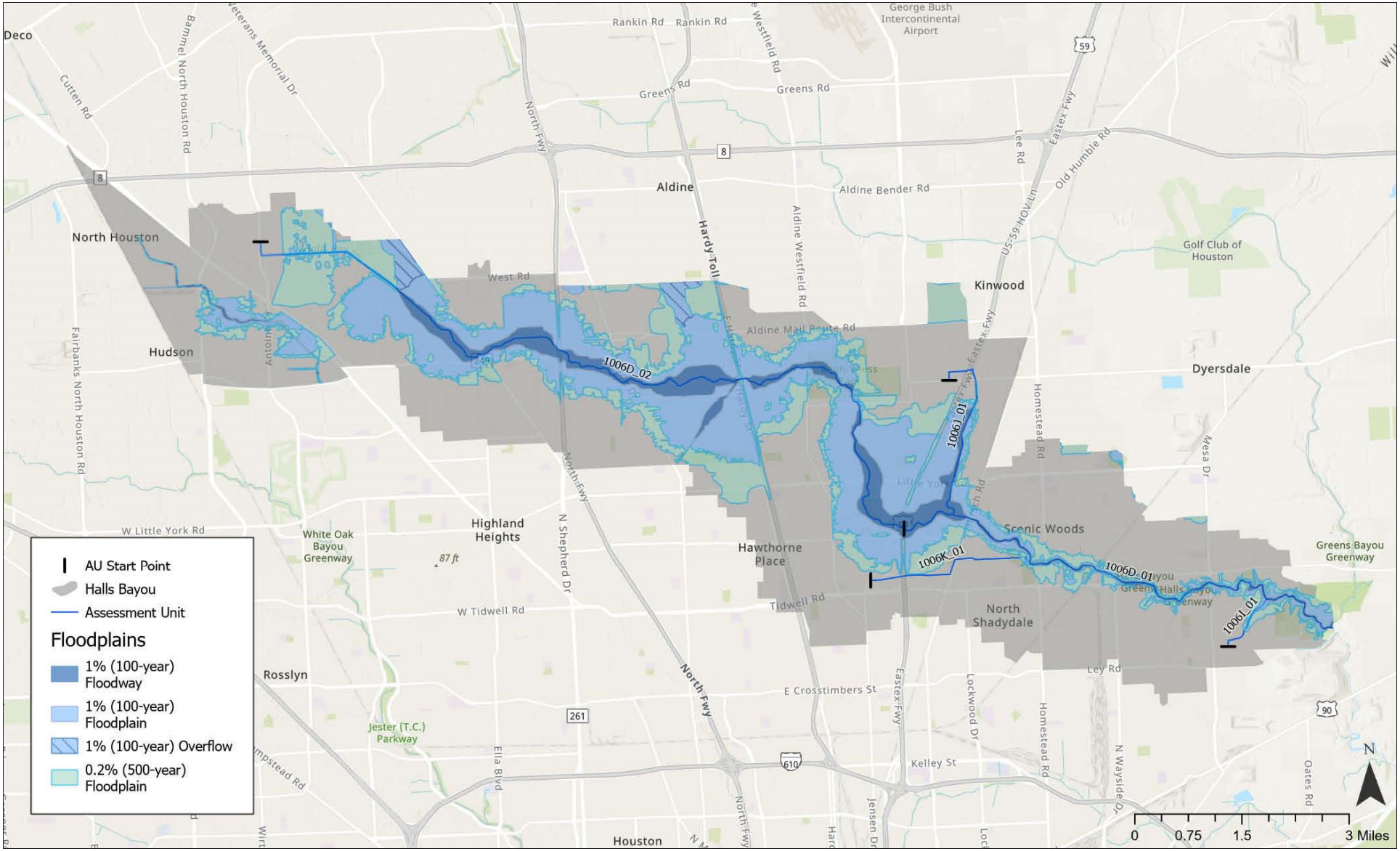
HYDROLOGIC CHARACTERISTICS

Halls Bayou (Segment 1006D) is a freshwater tributary of Greens Bayou Tidal (AU 1006_03). The Halls Bayou watershed is a subwatershed to Greens Bayou. The bayou receives stormwater runoff from the Veterans Memorial Drive area. The stream flows southeastward until its confluence with Greens Bayou at the City of Houston's Brock Park. This slow-moving segment is known for its recreational opportunities, such as fishing and kayaking.

Halls Bayou is influenced by such factors as precipitation and the area's urbanization. It receives industrial discharges and stormwater runoff which can result in elevated levels of pollutants. Halls Bayou has a low-lying elevation and limited channel capacity, making it prone to flooding. Significant floodplains, combined with the area's high-density development, results in severe damage to homes and businesses during these frequent flood events. Much of the Houston area's rapid growth and development in the 1970s occurred prior to restrictions on building in the floodplains, which puts numerous areas at risk of flooding.

Photo 9: Halls Bayou at Snowden Street

The Harris County Flood Control District manages an extensive stormwater conveyance system in the Halls Bayou watershed in order to reduce flood risks. This conveyance system is designed to manage and control the flow of stormwater runoff and functions to prevent or reduce the impact of flooding. This system also improves water quality by capturing and treating runoff before it enters Halls Bayou. The stormwater conveyance system includes a combination of engineered and natural features. Engineered components include stormwater detention basins and channels. Due to this conveyance system, the Halls Bayou watershed includes 37 tributaries that are more than one mile in length.



Map 19: Floodplains for Segment 1006D - Halls Bayou

PRECIPITATION

Precipitation is one of the primary factors affecting stream flow in Halls Bayou. During rainfall events, water runoff from the surrounding land flows into the bayou. This runoff results in a rise in the water level and increased flow, which can lead to flooding in low-lying areas adjacent to the bayou. During periods of dry weather, flow is greatly reduced. Seasonal changes and the movement of storm systems largely control the amount and timing of precipitation.

As part of the Harris County Flood Warning System (HCFWS), there are multiple precipitation gages located within the Halls Bayou watershed. From upstream to downstream, rainfall gages are located at Airline Drive, Jensen Drive, and Tidwell Road. Annual rainfall totals for 2022 for Halls Bayou are shown in the accompanying table.

Table 16: HCFWS Rain Gage Stations in Segment 1006D - Halls Bayou

Rain Gage ID	Site Description	Annual Rainfall (2022)
1690	Halls Bayou at Airline Drive	37.40"
1680	Halls Bayou at Jensen Drive	33.52"
1675	Halls Bayou at Tidwell Road	40.00"

Source: Harris County Flood Warning System (https://www.harriscountyfws.org/)

For the most upstream rain gage (Halls Bayou at Airline Drive), the highest rainfall totals were recorded in January and August. Rainfall peaks in August for the gage station at Jensen Road, coinciding with hurricane season. Precipitation was highest in November for the gage at Tidwell Road, which is closest to the Houston Ship Channel.

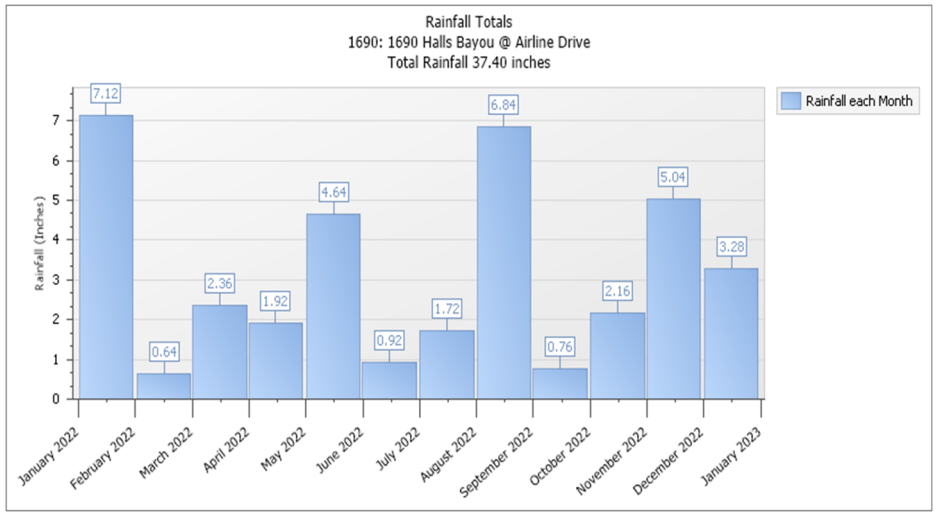


Figure 15: Monthly Rainfall at Halls Bayou at Airline Drive, 2022 (Source: HCFWS)

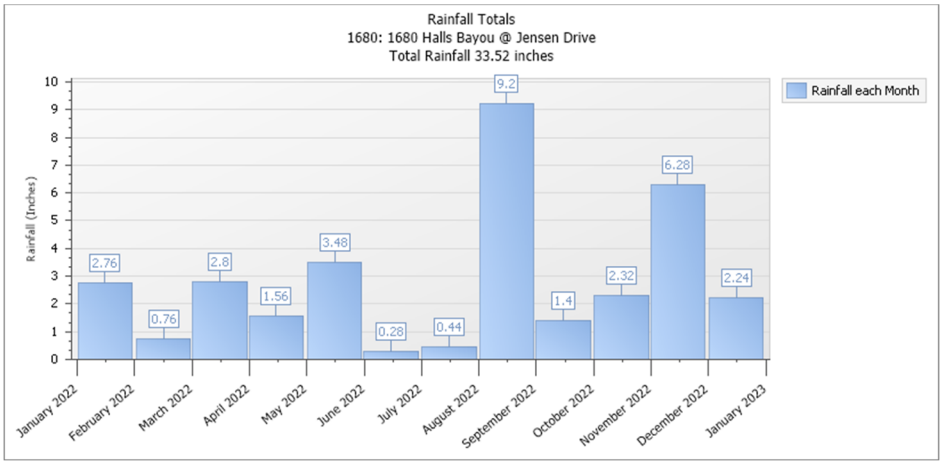


Figure 16: Monthly Rainfall at Halls Bayou at Jensen Drive, 2022 (Source: HCFWS)

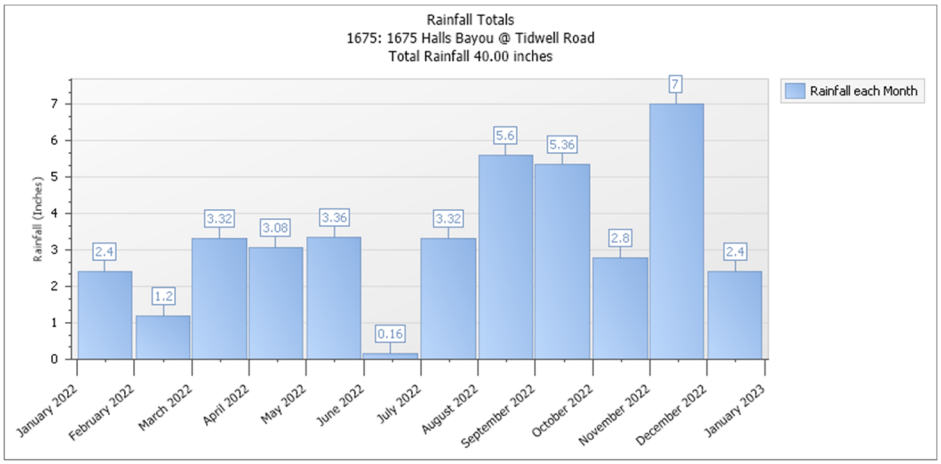


Figure 17: Monthly Rainfall at Halls Bayou at Tidwell Road, 2022 (Source: HCFWS)

USGS FLOW GAGES

There is one USGS stream gage located in the Halls Bayou watershed.

A hydrograph of the gage heights at USGS station 08076500 from the period of 01-01-2015 to 12-31- 2022 is shown. There have been frequent flooding events resulting in damage to homes and businesses over the past two decades. This includes devastating flooding of Greens Bayou during Hurricane Harvey in 2017.

Table 17: USGS Gage Stations in Segment 1006D - Halls Bayou

USGS Gage Station ID	Site Description
08076500	Halls Bayou at Houston, TX

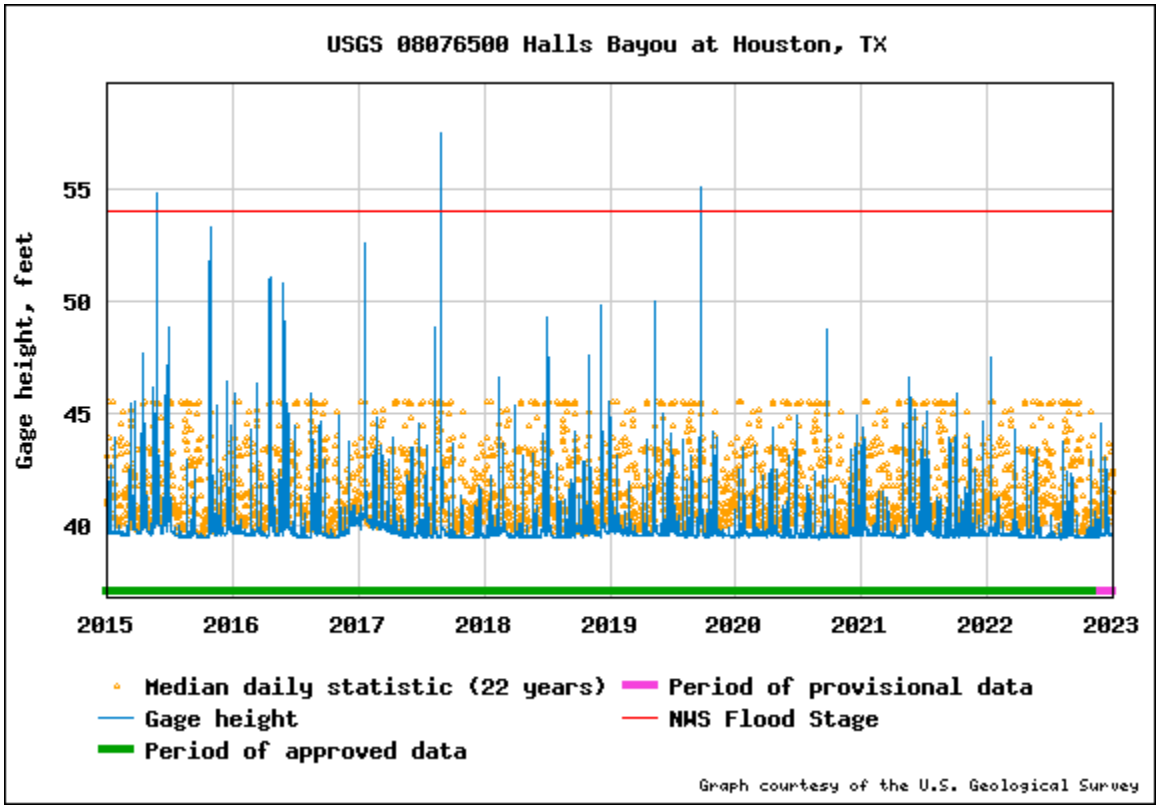
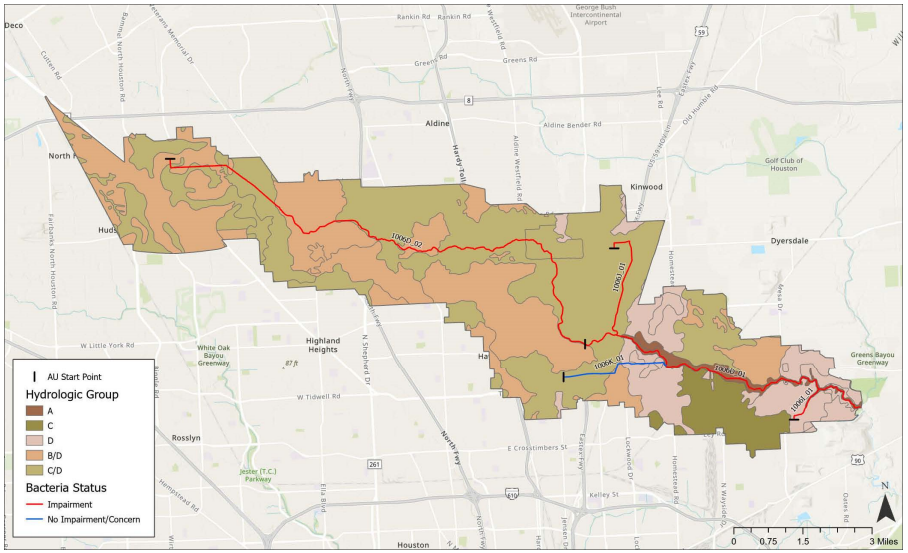


Figure 18: Gage Height at Halls Bayou at Houston, TX (USGS 08076500), 2015-2022

HYDROLOGIC SOIL GROUPS

The most prevalent soil types in the Halls Bayou watershed area are mostly clay loam, sandy loam, and clay soils. The predominant hydrologic soil groups in the segment are C/D (45.41%), B/D (34.68%) and D (12.39%). All three of these soil groups are characterized as having very slow infiltration rates and high runoff potential. This runoff can contribute to nonpoint sources of bacteria and nutrients entering the waterways.



Map 20: Hydrologic Soil Groups for Segment 1006D - Halls Bayou (2021)

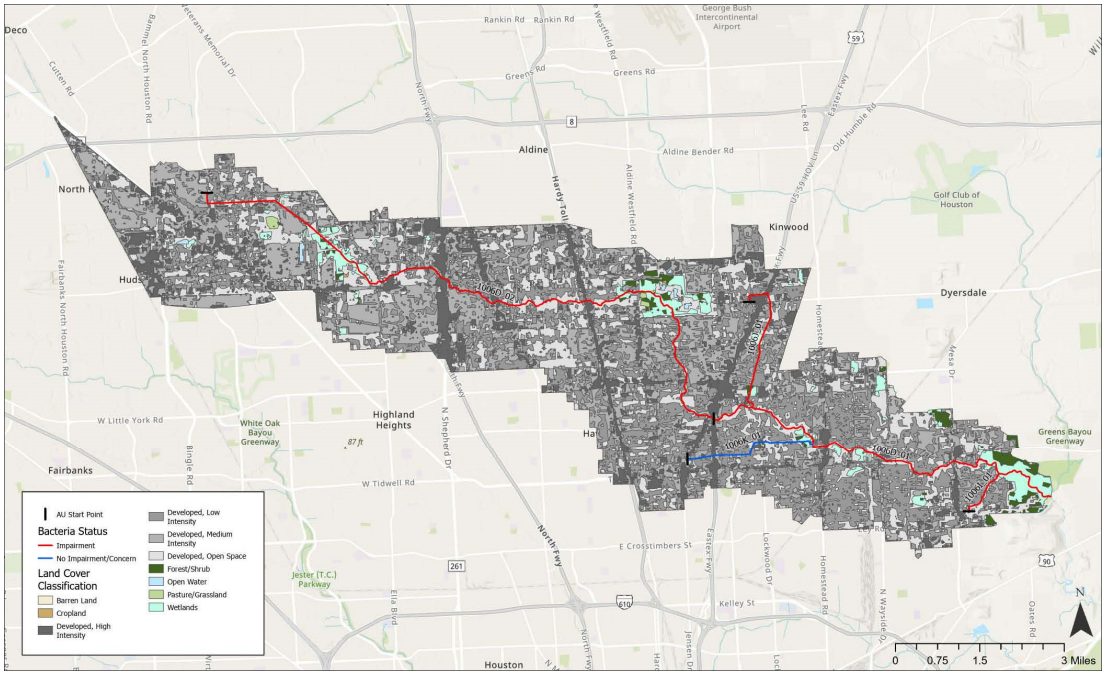
Table 18: Hydrologic Soil Groups by Area in Segment 1006D - Halls Bayou (2021)

Hydrologic Soil Group	Soil Texture Class	Typical Soil Composition	Infiltration Rate	Runoff Potential	Area Square Miles	Area %
A	Sand	<10% clay, >90% sand or gravel	High	Low	0.93	1.99%
B	Sandy loam, Loamy sand	10 – 20% clay, 50 – 90% sand	Moderate	Moderately Low	–	–
C	Clay loam. Silty clay loam, Sandy clay loam, Loam, Silty loam, Silt	20 – 40% clay, <50% sand	Slow	Moderately High	2.57	5.53%
D	Clay, Silty clay, Sandy clay	>40% clay, <50% sand	Very Slow	High	5.77	12.39%
A/D	Sand	<10% clay, >90% sand or gravel	Very Slow (High if drained)	High (Low if drained)	–	–
B/D	Sandy loam, Loamy sand	10 – 20% clay, 50 – 90% sand	Very Slow (Moderate if drained)	High (Moderate if drained)	16.14	34.68%
C/D	Clay loam, Silty clay loam, Sandy clay loam, Loam, Silty loam, Silt	20 – 40% clay, <50% sand	Very Slow (Slow if drained)	High	21.14	45.41%
				TOTAL	**46.55**	**100.00%**

LAND COVER AND NATURAL CHARACTERISTICS

The Halls Bayou watershed is heavily developed, with 95.03% of the land area classified as one of the four developed classes (Open Space, Low Intensity, Medium Intensity, and High Intensity). Residential and mixed commercial developments are the dominant uses. Low Intensity Developed (32.95%) and Medium Intensity Developed (29.82%) are the predominant land cover classes.

The Halls Bayou watershed is located in the area between the I-610 Loop North and Beltway 8. Interstate-45, US 59, and the Hardy Toll Road cross this watershed. Proximity to so many major highways has allowed for population growth within this area.



Map 21: Land Cover for Segment 1006D - Halls Bayou (2020)

Table 19: Land Cover for the Segment 1006D - Halls Bayou (2020)

Land Cover Class Name	Area Square Miles	Area %
Barren Land	0.00	0.00%
Cropland	0.01	0.03%
Developed, High Intensity	5.06	10.88%
Developed, Low Intensity	15.34	32.95%
Developed, Medium Intensity	13.88	29.83%
Developed, Open Space	9.95	21.37%
Forest/Shrub	0.55	1.19%
Open Water	0.07	0.15%
Pasture/Grassland	0.07	0.16%
Wetlands	1.61	3.45%
TOTAL	46.55	100.00%

DESCRIPTION OF WATER QUALITY ISSUES

WATER QUALITY STANDARDS AND NUTRIENT SCREENING CRITERIA

Segment 1006D (Halls Bayou) and three unnamed tributaries (1006I, 1006J, and 1006K) all have a Primary Contact Recreation 1 designated use. There is an intermediate aquatic life use designation for 1006D_01, 1006I, and 1006J, with 1006D_02 and 1006K having a limited ALU. When Kennedy Gully is assigned a segment ID, it is expected to have a Primary Contact Recreation 1 designated use and an Intermediate ALU.

The accompanying table describes the water quality standards for each segment and parameter.

Table 20: Designated Uses and Numeric Criteria[1] for Segment 1006D - Halls Bayou and Tributaries

Segment ID	Segment Name	DESIGNATED USES				CRITERIA								NUTRIENT SCREENING LEVELS			
		Recreation	Aquatic Life Use[3]	Domestic Water Supply	Other Uses	Chloride (mg/L)	Sulfate (mg/L)	Total Dissolved Solids (mg/L)	Dissolved Oxygen Grab Minimum (mg/L)	Dissolved Oxygen Grab Screening Level (mg/L)	pH Range (SU)	Temperature (°F)	Indicator Bacteria[4] Geometric Mean (MPN/100 mL)	Total Phosphorus (mg/L)	Nitrate-Nitrogen (mg/L)	Ammonia-Nitrogen (mg/L)	Chlorophyll-a (µg/L)
1006D_01	Halls Bayou	PCR1[2]	Intermediate	–	–	–	–	–	3.0	4.0	–	–	126	0.69	1.95	0.33	–
1006D_02	Halls Bayou	PCR1[2]	Limited	–	–	–	–	–	2.0	3.0	–	–	126	0.69	1.95	0.33	–
1006I	Unnamed Tributary of Halls Bayou	PCR1	Intermediate	–	–	–	–	–	3.0	4.0	–	–	126	0.69	1.95	0.33	–
1006J	Unnamed Tributary of Halls Bayou	PCR1	Intermediate	–	–	–	–	–	3.0	4.0	–	–	126	0.69	1.95	0.33	–
1006K	Unnamed Tributary of Halls Bayou	PCR1	Limited	–	–	–	–	–	2.0	3.0	–	–	126	0.69	1.95	0.33	–

[1] Source: 2022 *Texas Surface Water Quality Standards* (https://www.tceq.texas.gov/waterquality/standards/2022-texas-surface-water-quality-standards)

[2] PCR1 = Primary Contact Recreation 1

[3] Aquatic Life Use is categorized as either Exceptional, High, Intermediate, Limited, or Minimal.

[4] The indicator bacteria for freshwater is *E. coli*.

SUMMARY OF 2022 ASSESSMENT RESULTS

The accompanying table shows assessment results from the 2022 Texas Integrated Report. The IR describes the status of the water body based on historical data and the extent to which it attains the Texas Surface Water Quality Standards. The seven-year assessment period for the 2022 IR was 12/1/13 – 11/30/20. It should be noted that segment 1006K_01 and Kennedy Gully were not assessed in the IR.

Table 21: Integrated Level of Support for Assessment Units in Segment 1006D - Halls Bayou (2022 Integrated Report)

Designated Use	Method	Parameter	Integrated Level of Support			
			Halls Bayou		Unnamed Tributary of Halls Bayou	Unnamed Tributary of Halls Bayou
			1006D_01	1006D_02	1006I_01	1006J_01
Aquatic Life Use	Dissolved Oxygen Grab Minimum	Dissolved Oxygen Grab	FS	FS	CN	FS
	Dissolved Oxygen Grab Screening Level	Dissolved Oxygen Grab	NC	NC	CS	CS
General Use	Nutrient Screening Levels	Total Phosphorus	CS	CS	NC	NC
		Nitrate	CS	CS	NC	NC
		Ammonia	NC	NC	NC	NC
Recreation Use	Bacteria Geomean	E.coli	NS	NS	NS	NS

Integrated Level of Support

FS	= Fully Supporting	NC	= No Concern
NS	= Non-Supporting	CN	= Use Concern
		CS	= Screening Level Concern

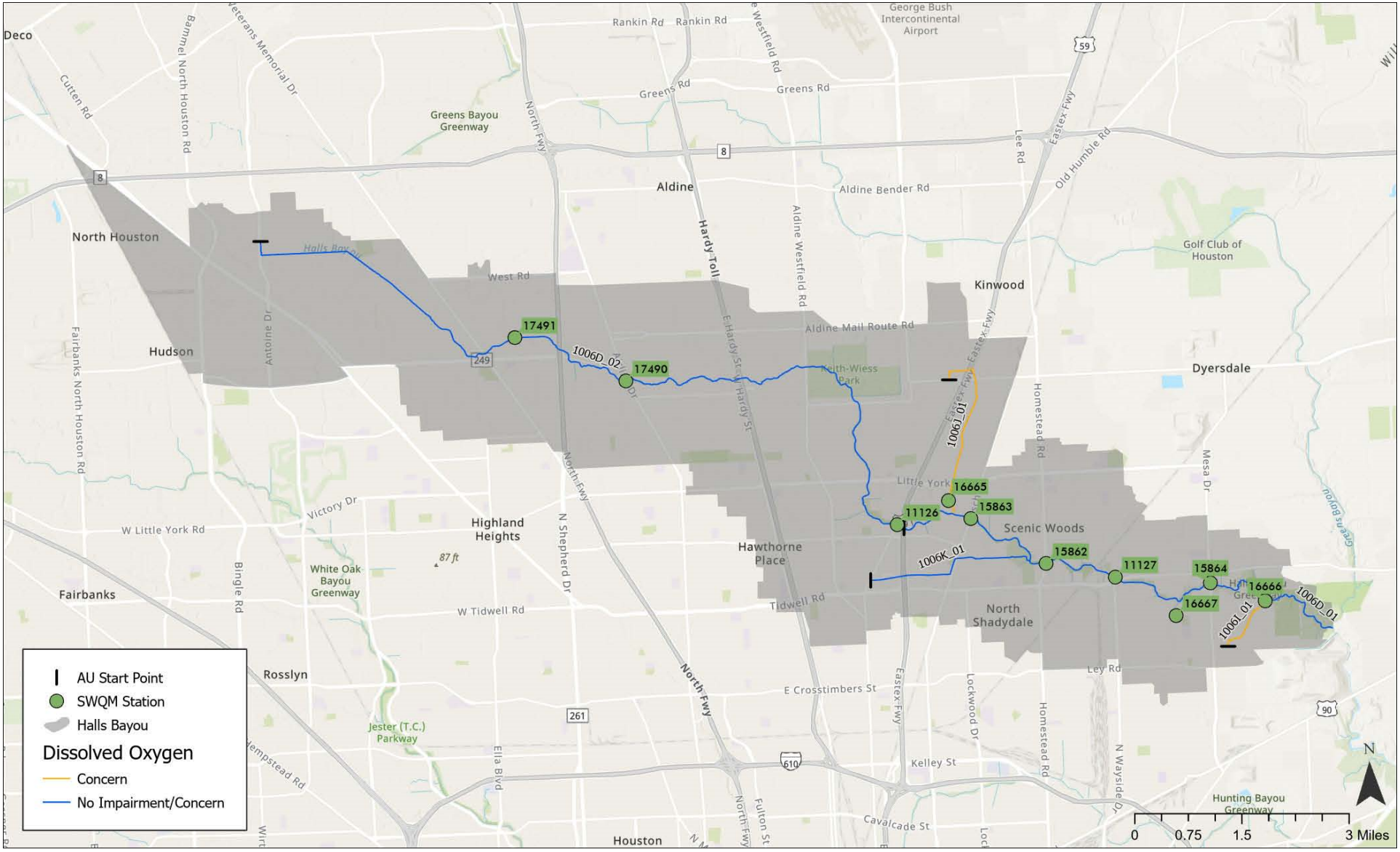
DISSOLVED OXYGEN IMPAIRMENTS AND CONCERNS

Both unnamed tributaries of Halls Bayou are listed in the 2022 IR as having depressed dissolved oxygen. For AU 1006I_01, there is a concern for nonattainment for the DO grab minimum and a screening level concern for DO. There is also a screening level concern in AU 1006J_01, while the DO grab minimum is fully supporting the designated aquatic life use.

Table 22: Comparison of 2022 IR Dissolved Oxygen Data (2013-2020) and H-GAC Analysis of Water Quality Data (2015-2022)

AU ID	Parameter	Level of Support	Category	Samples Exceeding Standard (2022 IR) 12/1/13 – 11/30/20	H-GAC Trend Analysis 1/1/15 – 5/31/22
1006I_01	Dissolved Oxygen Grab Minimum	CN	–	14/110 (12.7%)	Stable
	Dissolved Oxygen Grab Screening Level	CS	–	26/110 (23.6%)	–
1006J_01	Dissolved Oxygen Grab Minimum	FS	–	4/51 (7.8%)	Stable
	Dissolved Oxygen Grab Screening Level	CN	–	12/51 (23.5%)	–

Category	Integrated Level of Support			
5c = Additional data and information will be collected or evaluated before a management strategy is selected.	FS	= Fully Supporting	NC	= No Concern
	NS	= Non-Supporting	CN	= Use Concern
			CS	= Screening Level Concern



Map 22: Dissolved Oxygen Impairments and Concerns for Segment 1006D - Halls Bayou (2022 IR)

The graph below for 1006I_01 shows that the DO levels in this AU have gone below the grab minimum standard frequently, resulting in a concern for its use as well as a concern for the grab screening level. Conversely, 1006J_01 fully supports the grab minimum but still has a concern regarding the screening level. The graph for 1006D_01 shows that while there is no DO concern for Halls Bayou (1006D_01) there is a deteriorating trend present.

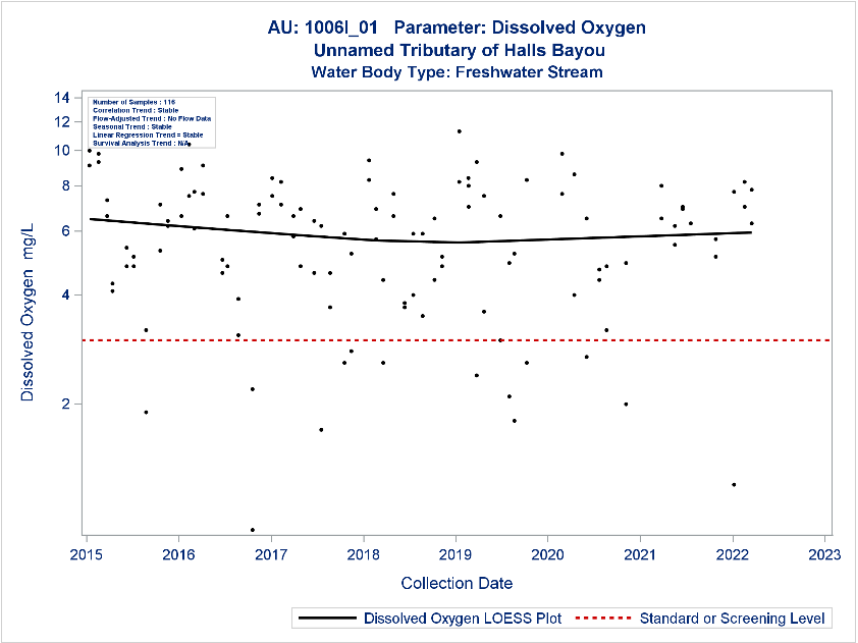


Figure 19: Seven-Year Dissolved Oxygen trend for AU 1006I_01 (Unnamed Tributary of Halls Bayou), 2015-2022

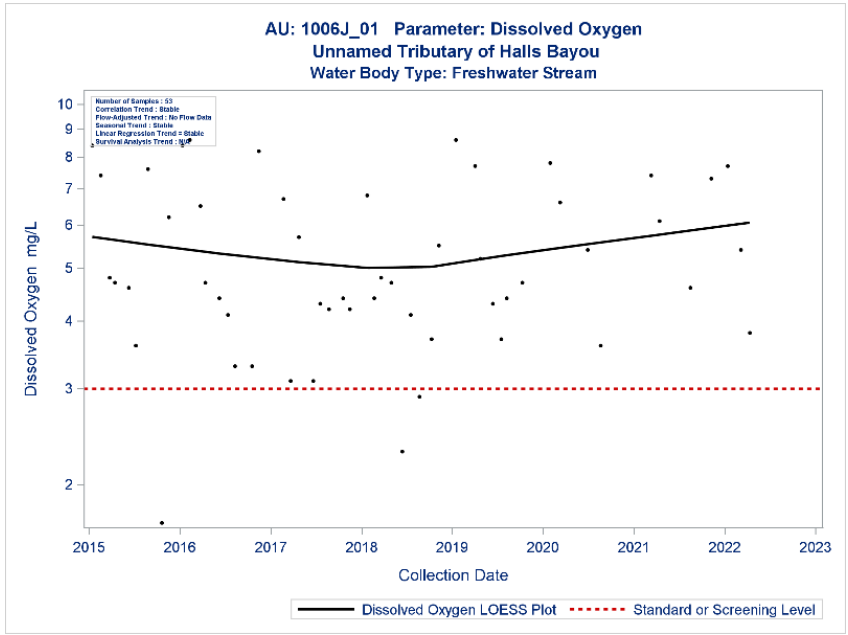


Figure 20: Seven-Year Dissolved Oxygen trend for AU 1006J_01 (Unnamed Tributary of Halls Bayou), 2015-2022

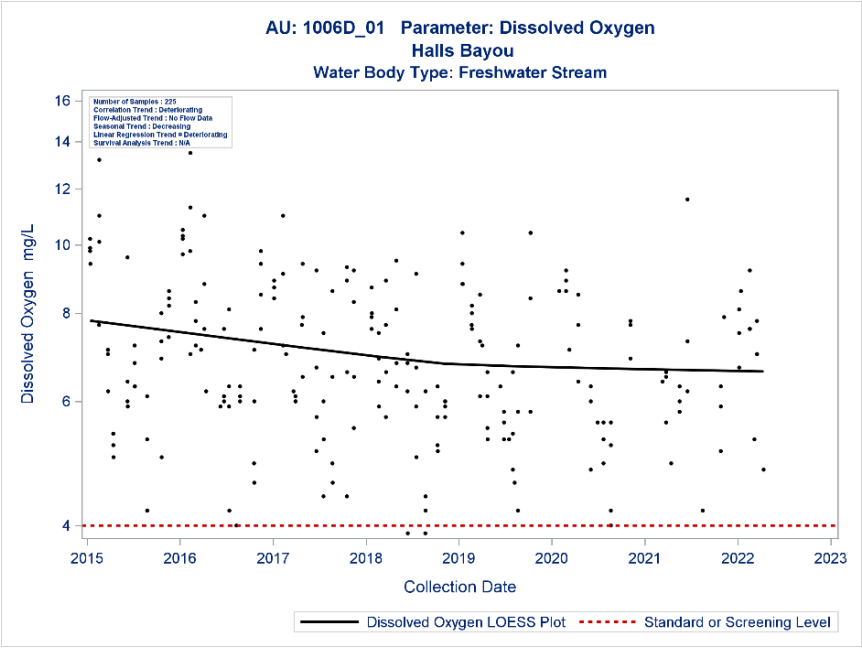


Figure 21: Seven-Year Dissolved Oxygen trend for AU 1006D_01 (Halls Bayou), 2015-2022

NUTRIENT CONCERNS

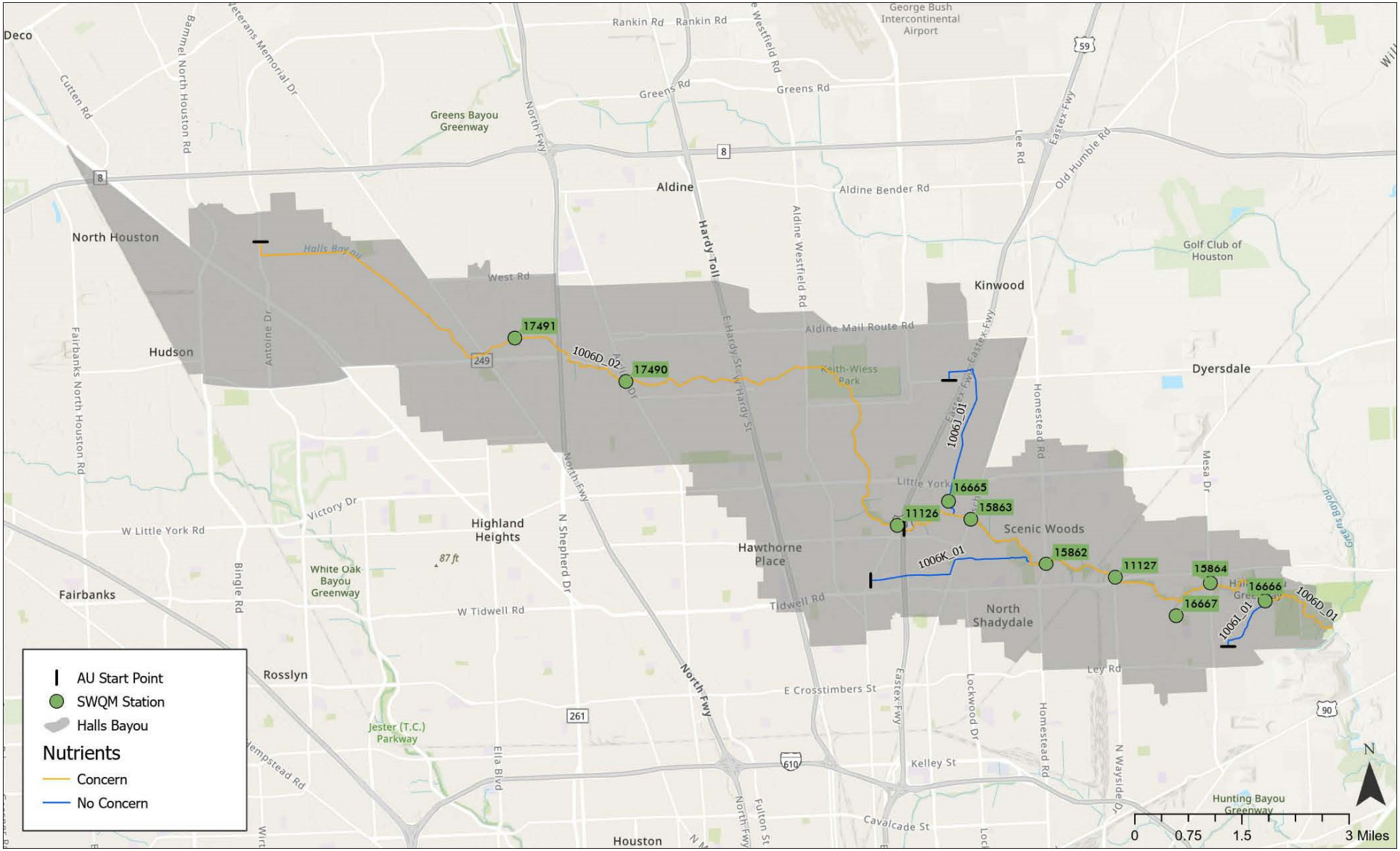
Screening level concerns are indicated for Total Phosphorus and Nitrate in both Halls Bayou AUs (1006D_01 and 1006D_02). For AU 1006D_01, 90.9 % of both Total Phosphorus and Nitrate samples exceeded the screening level criteria. 200 of 220 Total Phosphorus samples exceeded the screening level of 0.69 mg/L and 200 of 220 Nitrate samples exceeded the screening level of 1.95 mg/L. There were no concerns for Ammonia. For AU 1006D_02, 165/178 (92.7%) of Total Phosphorus samples exceeded the 0.69 mg/L screening level. 157/178 (88.2%) of samples exceeded the 1.95 mg/L Nitrate screening level. There were no concerns for Ammonia. There were no nutrient screening level concerns for 1006I or 1006J.

Table 23: Comparison of 2022 IR Nutrient Data (2013-2020) and H-GAC Analysis of Water Quality Data (2015-2022)

Parameter	AU ID	Level of Support	2022 Integrated Report (12/01/13 – 11/30/20)		H-GAC Trend Analysis 1/1/15 – 5/31/22
			# Exceedances/#Assessed	Percentage	
Total Phosphorus	1006D_01	CN	200/220	90.9%	Stable
	1006D_02	CN	165/178	92.7%	Stable
	1006I_01	NC	2/101	2.0%	Stable
	1006J_01	NC	2/54	3.7%	Improving
Nitrate	1006D_01	CN	200/220	90.9%	Stable
	1006D_02	CN	157/178	88.2%	Stable
	1006I_01	NC	0/101	0%	Stable
	1006J_01	NC	0/54	0%	Stable
Ammonia	1006D_01	NC	23/220	10.4%	Stable
	1006D_02	NC	34/178	19.1%	Stable
	1006I_01	NC	10/101	9.9%	Stable
	1006J_01	NC	2/54	3.7%	Improving

Integrated Level of Support

NC	= No Concern
CS	= Screening Level Concern



Map 23: Nutrient Concerns for Segment 1006D - Halls Bayou (2022 IR)

While AU 1006J_01 does not have a nutrient concern, it has improving trends for Ammonia-Nitrogen and Total Phosphorus which are shown in the graphs at right.

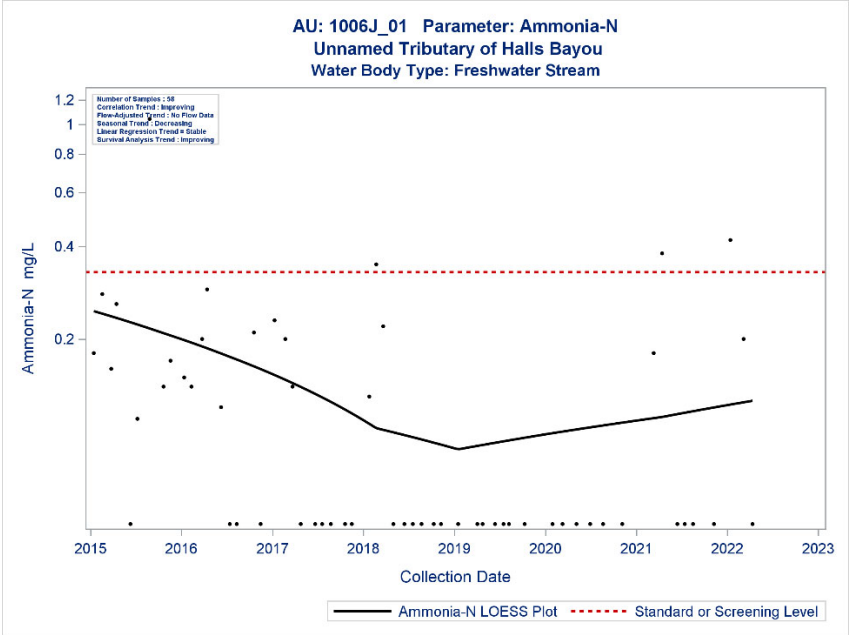


Figure 22: Seven-Year Ammonia-Nitrogen trend for AU 1006J_01 (Unnamed Tributary of Halls Bayou), 2015-2022

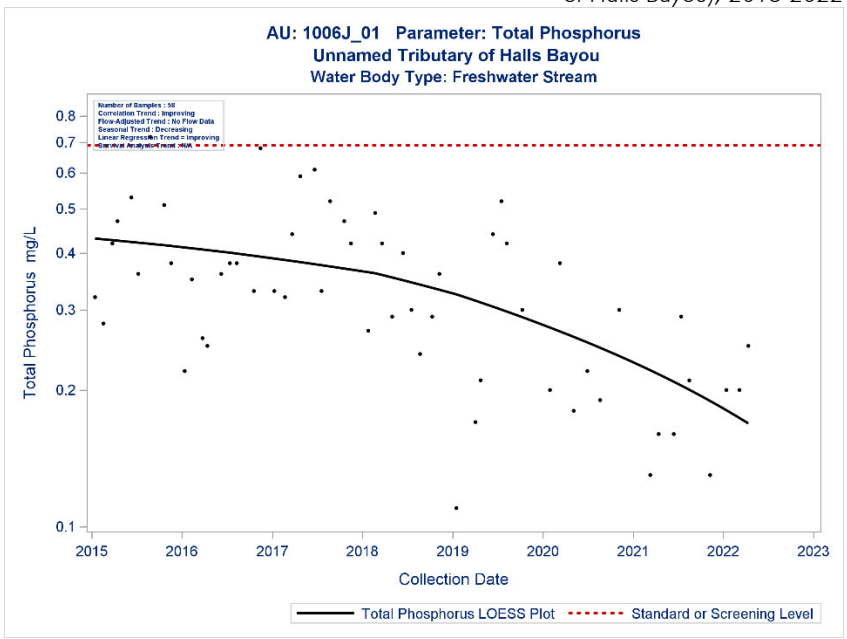


Figure 23: Seven-Year Total Phosphorus trend for AU 1006J_01 (Unnamed Tributary of Halls Bayou), 2015-2022

BACTERIA IMPAIRMENTS AND CONCERNS

The two assessment units of Halls Bayou (AUs 1006D_01 and 1006D_02) and both unnamed tributaries (AUs 1006I_01 and 1006J_01) are listed as impaired for bacteria in water, with *E. coli* geometric means exceeding the PCR1 water quality standard of 126 MPN/100 mL. It should be noted that 1006K_01 was not assessed in the last IR. The geometric mean for AU 1006D_01 was 582.75 MPN/100 mL, while AU 1006D_02 had a geometric mean of 854.78 MPN/100 mL. For the unnamed tributaries, the geometric means were 637.82 MPN/100 mL for 1006I_01 and 975.09 MPN/100 mL for 1006J_01.

Table 24: Comparison of 2022 IR Bacteria Data (2013-2020) and H-GAC Analysis of Water Quality Data (2015-2022)

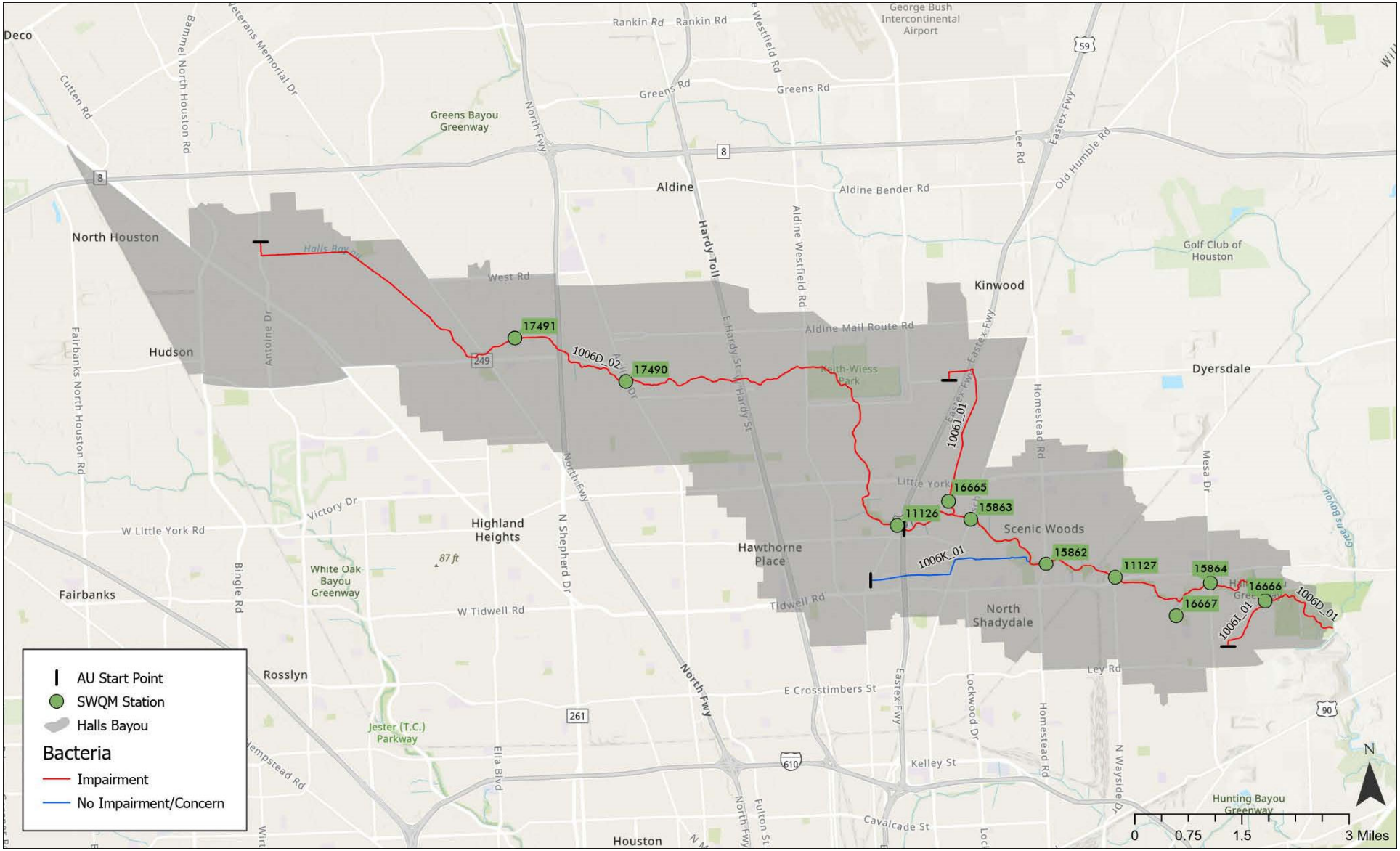
Parameter	AU ID	Level of Support	Category	Geometric Mean (MPN/100mL) 2022 Integrated Report (12/01/13 – 11/30/20)	H-GAC Trend Analysis 1/1/15 – 5/31/22
E. coli Geometric Mean	1006D_01	NS	4a	582.75	Stable
	1006D_02	NS	4a	854.78	Stable
	1006I_01	NS	4a	637.82	Stable
	1006J_01	NS	4a	975.09	Improving

Category

4a = A state-developed TMDL has been approved by EPA or a TMDL has been established by EPA for any water-pollutant combination.

Integrated Level of Support

FS	= Fully Supporting	NC	= No Concern
NS	= Non-Supporting	CN	= Use Concern
		CS	= Screening Level Concern



Map 24: Bacteria Impairments and Concerns for Segment 1006D - Halls Bayou (2022 IR)

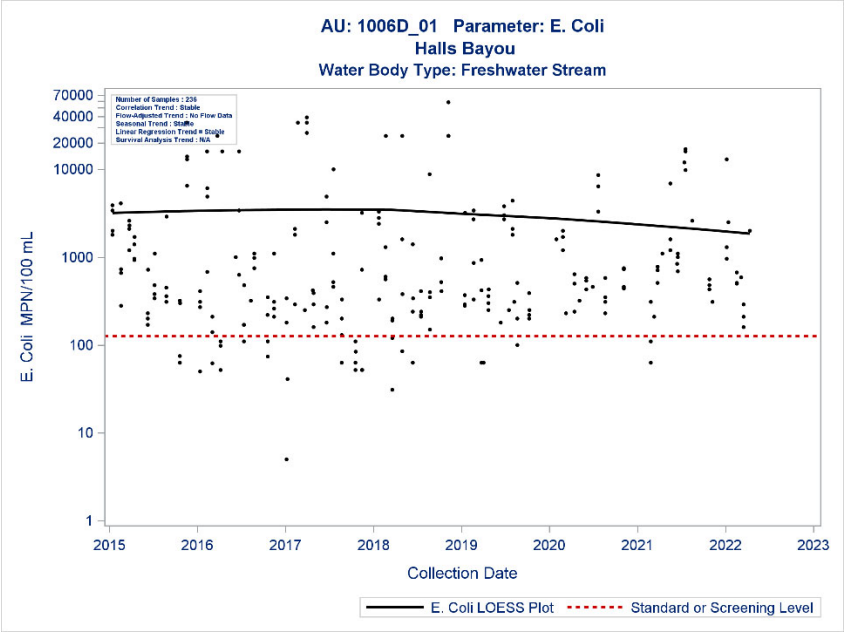


Figure 24: Seven-Year E. coli trend for AU 1006D_01 (Halls Bayou), 2015-2022

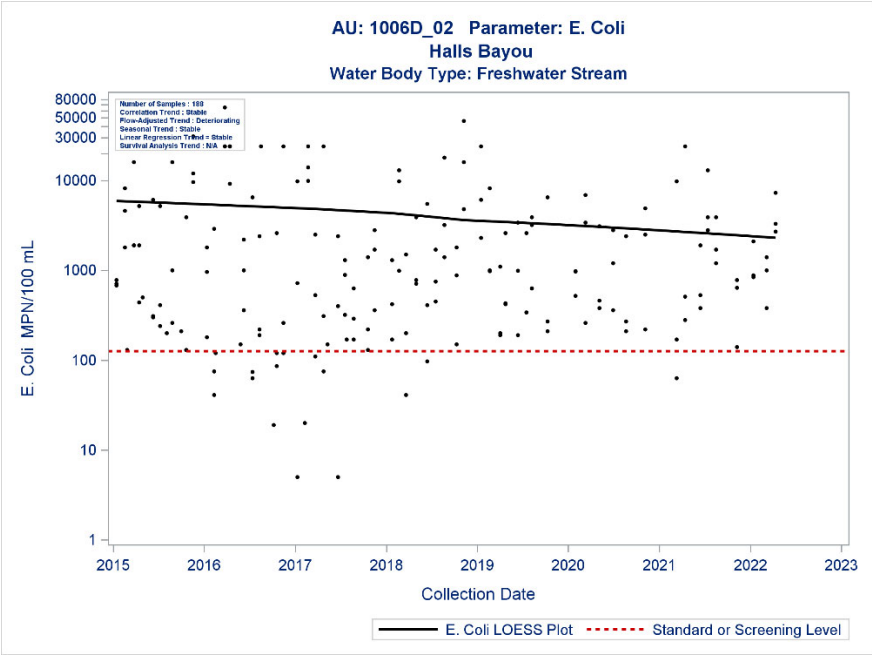


Figure 25: Seven-Year E. coli trend for AU 1006D_02 (Halls Bayou), 2015-2022

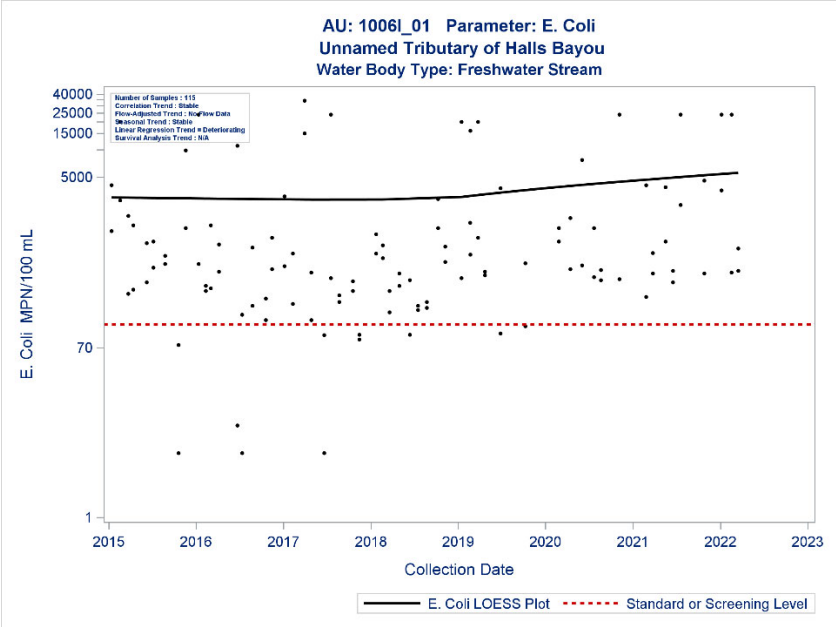


Figure 26: Seven-Year E. coli trend for AU 1006I_01 (Unnamed Tributary of Halls Bayou), 2015-2022

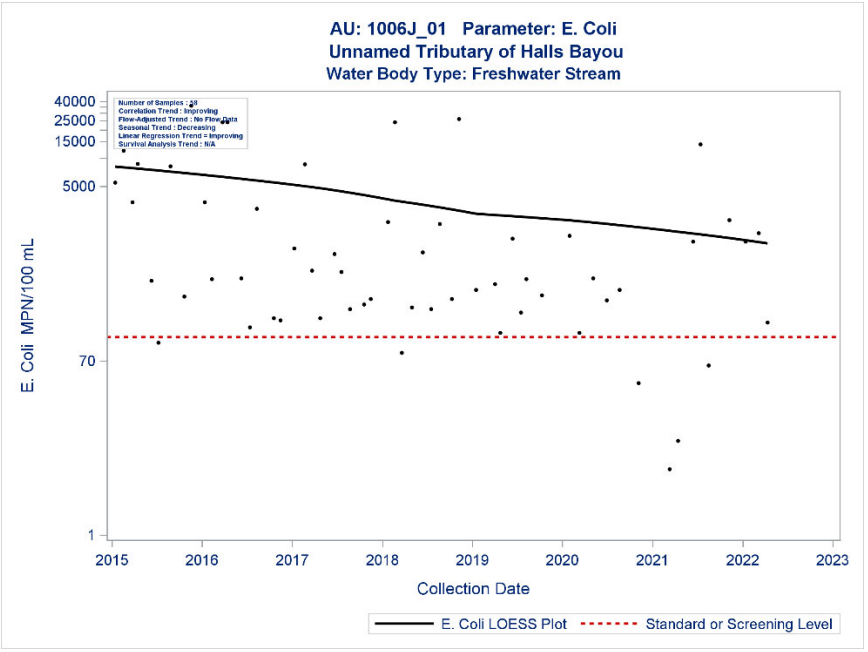


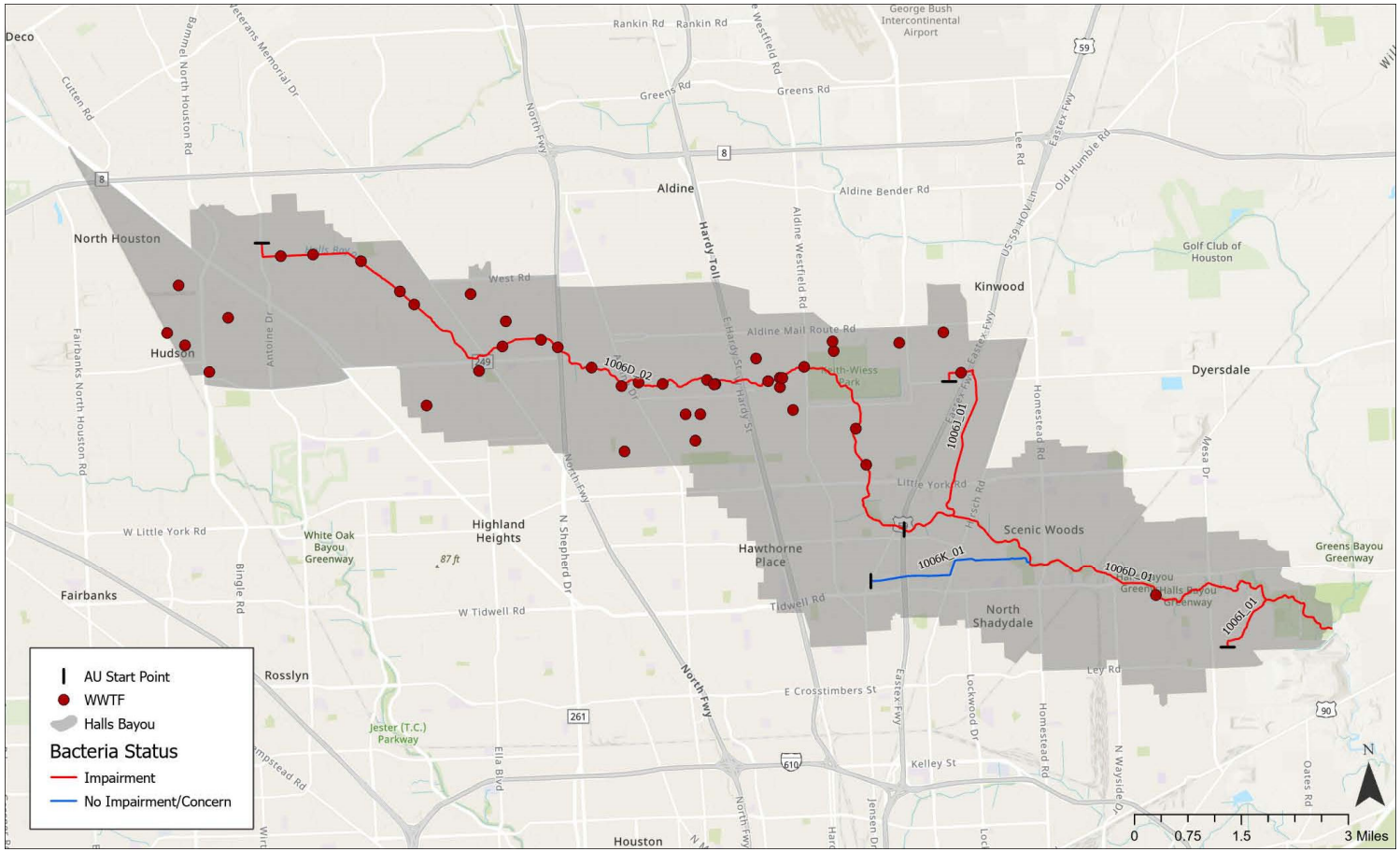
Figure 27: Seven-Year E. coli trend for AU 1006J_01 (Unnamed Tributary of Halls Bayou), 2015-2022

POTENTIAL SOURCES OF WATER QUALITY ISSUES

Potential sources of fecal indicator bacteria and nutrients in the Halls Bayou watershed include both point and nonpoint sources. These sources include wastewater treatment facility outfalls, sanitary sewer overflows, failing on-site sewage facilities, stormwater runoff, and animal waste.

PERMITTED EFFLUENT DISCHARGES

There are 44 permitted outfalls in Segment 1006D. Of these outfalls, 39 are classified as domestic sewage with a discharge of <1 million gallons per day (MGD). The remaining 5 permittees have a discharge of ≥1 MGD. As discussed in the 2022 *Water Quality Management Plan Update*, smaller wastewater treatment facilities (those with flows of <1 MGD) throughout the Houston-Galveston region tend to have the highest rate of bacteria geometric mean exceedances (1.5% in 2021) when compared to other size categories. Permitted effluent outfalls are shown in the accompanying map. A list of permits in the watershed is included in the Appendix.

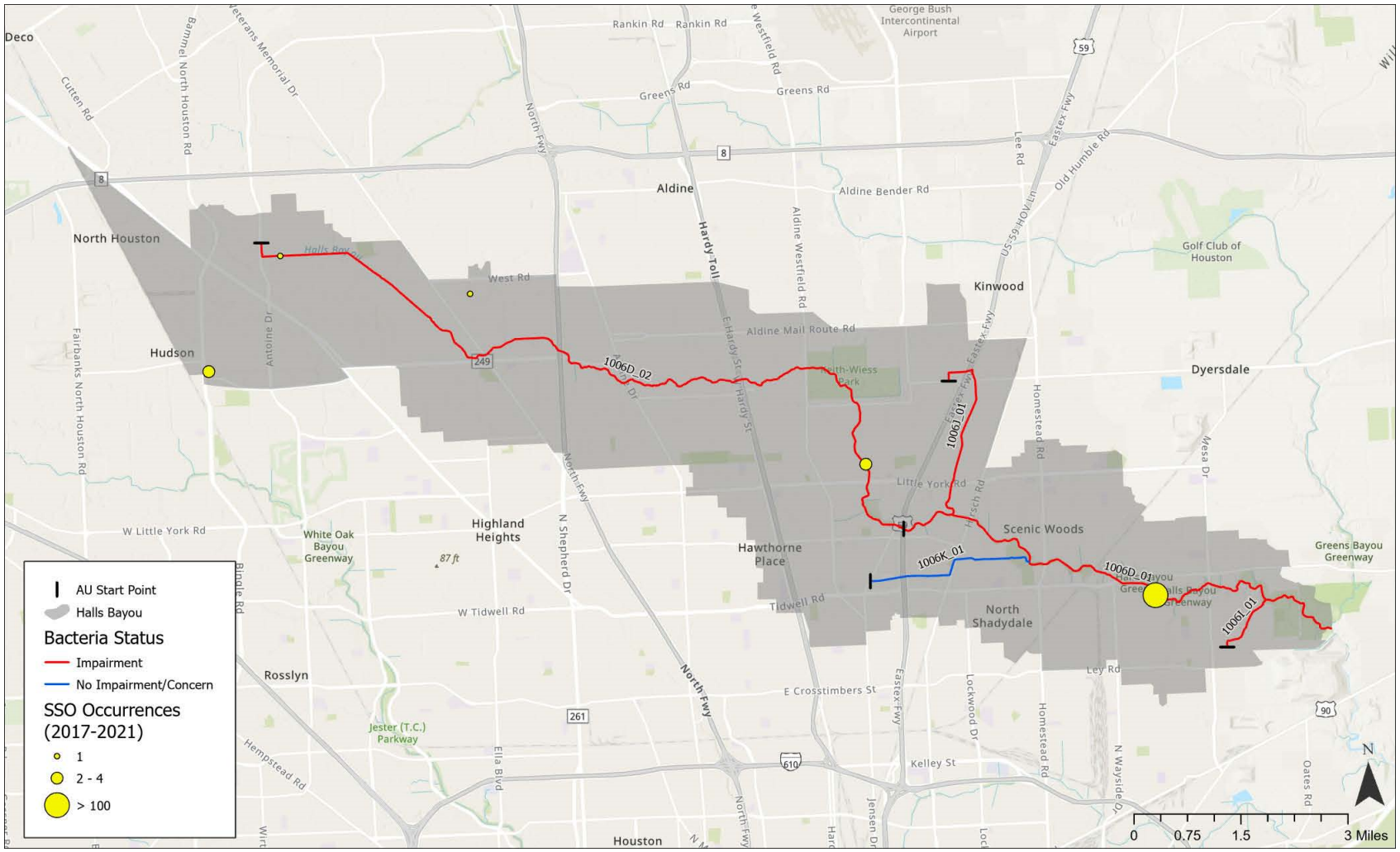


Map 25: Permitted Effluent Discharges for Segment 1006D – Halls Bayou (2022)

SANITARY SEWER OVERFLOWS

For the period of 2017 – 2021, 5 permittees reported a total of 292 sanitary sewer overflows in the Halls Bayou watershed. The total reported volume of these discharges was 280,925 gallons. While this number and volume of SSOs may not necessarily cause chronically high bacteria levels within this waterway, each discrete event may cause acute conditions that could affect public health.

Sources of sanitary sewer overflows include aging wastewater infrastructure, mechanical failure, inflow and infiltration, and improper disposal of fats, oils, and grease. Flooding issues within the Greens Bayou watershed contribute to the frequency, volume, and duration of SSOs.

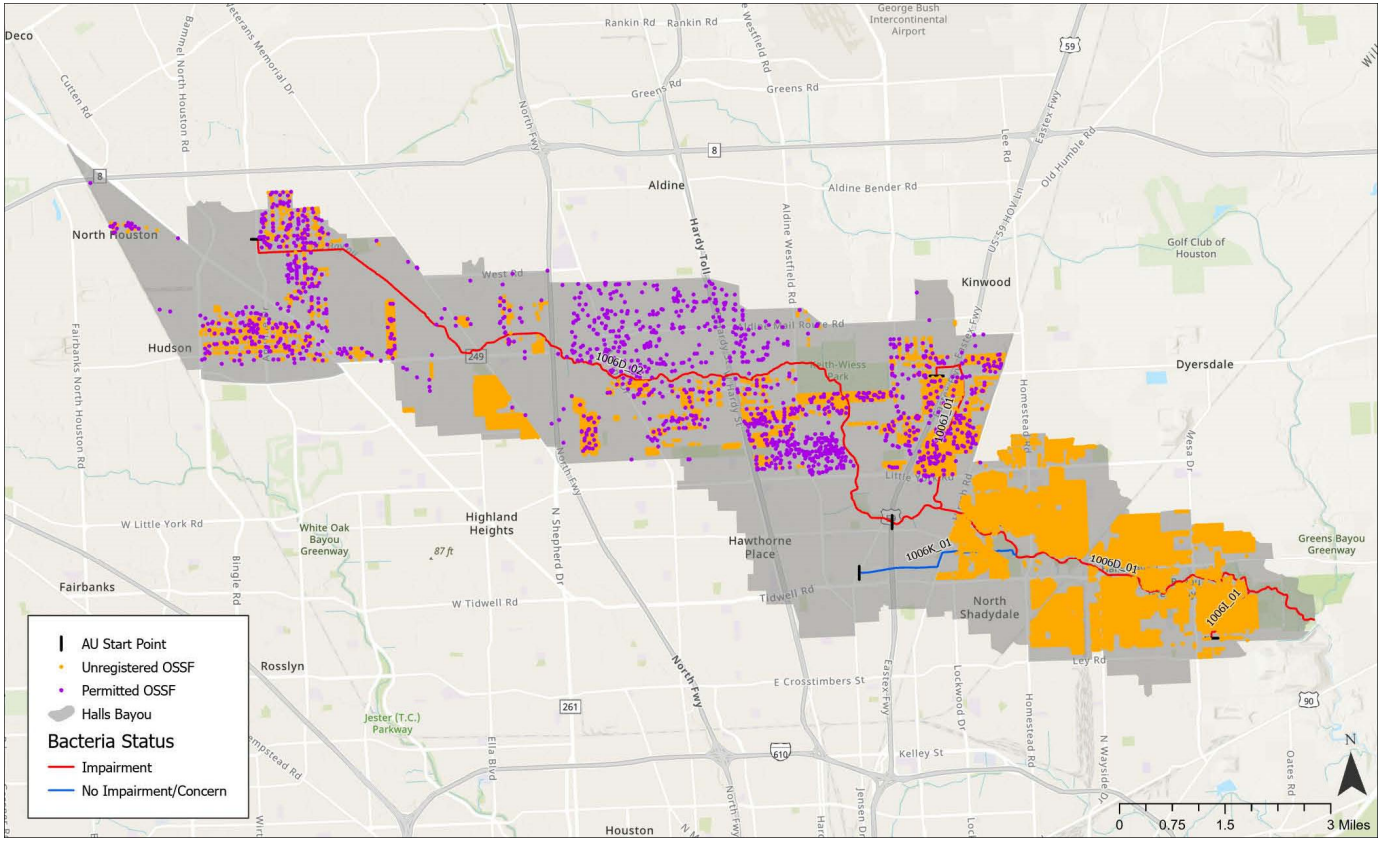


Map 26: Sanitary Sewer Overflows for Segment 1006D - Halls Bayou (2017-2021)

ON-SITE SEWAGE FACILITIES

Although the majority of the watershed is serviced by residential sewer collection systems and wastewater treatment facilities, there are areas within the watershed where on-site sewage facilities are utilized. Within the Halls Bayou watershed, there are 1,757 permitted OSSFs. The estimated number of unpermitted systems is 17,082, although this number is inaccurate due to a lack of digital records for historical permits from the late 1970s to early 1990s. Many of these systems in the eastern portion of the watershed were permitted by Harris County during this time frame.

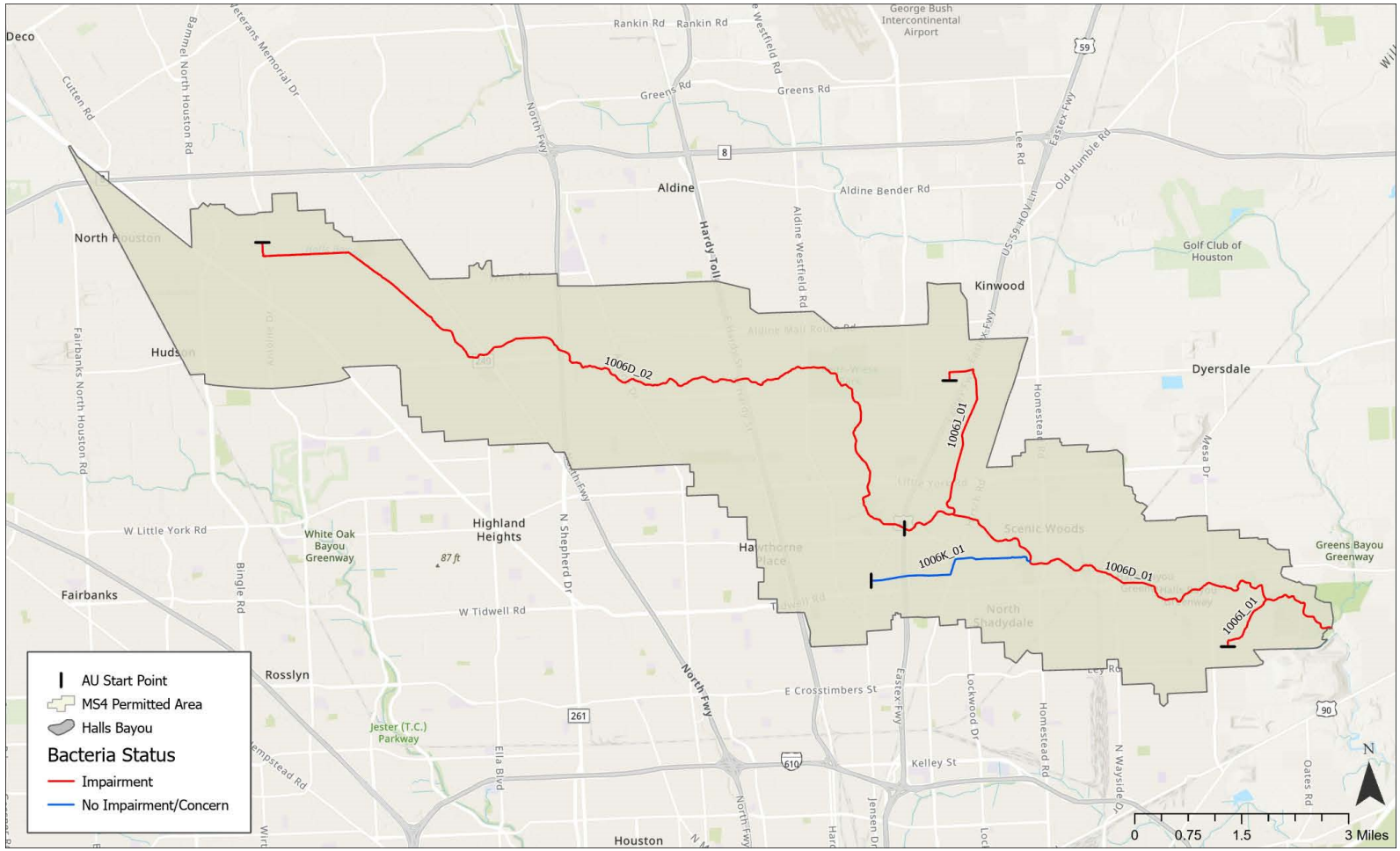
Please note that many of the OSSFs within the unincorporated portion of Harris County were permitted by the county between 1978 –1992. Historical permit records from that time frame are not available electronically in the current OSSF database, so many of those systems show up as unpermitted. H-GAC is currently in the process of digitizing and converting those historical records so that this data can be available electronically for use by both H-GAC and Harris County. Once these permit records are converted, maps, and counts of permitted and unpermitted systems can be revised to reflect actual on-the-ground conditions.



Map 27: On-Site Sewage Facilities for Segment 1006D - Halls Bayou

URBAN RUNOFF/STORM SEWERS

Due to the significant floodplains, the amount of development with impervious land cover within the watershed and the slow-draining soils, urban runoff can contribute to nutrient and bacteria contamination of waterways. The Halls Bayou watershed is covered by stormwater permits. The City of Houston, Harris County, and the Harris County Flood Control District hold Phase I stormwater permits with the Texas Commission on Environmental Quality, providing 100% coverage. Additionally, smaller local governmental entities hold Phase II stormwater permits within the watershed. The state's stormwater permitting program covers both phases, describing the minimum requirements each entity must meet to ensure water quality protection and address identified impairments. To search for more information on a general permit (including stormwater), please visit TCEQ's Water Quality General Permits Search tool.



Map 28: MS4 Permitted Areas for Segment 1006D - Halls Bayou

ILLEGAL DUMPING

Illegal dumping of trash near water bodies can be carried by runoff or wind and end up in streams, which can be detrimental to water quality. Trash in water bodies can lead to habitat destruction, harm to aquatic life, and an increase in turbidity. Additionally, toxins and pollutants can be introduced into the environment, which can have as adverse effect on water quality.

Photo 10: Illegal dumping at the entrance to Brock Park on N Green River Drive

POTENTIAL STAKEHOLDERS

Potential stakeholders in the watershed include:

- City of Houston
- City of Humble
- Harris County Flood Control District (HCFCD)
- Harris County Precinct 1
- Harris County Precinct 2
- Harris County Precinct 3
- Houston Parks Board
- Houston Parks and Recreation Department
- Houston Public Works Department
- National Parks Service
- Texas Parks and Wildlife
- Bacteria Implementation Group
- United States Geological Survey
- US Army Corps of Engineers (USACE) Galveston District
- East Aldine Management District
- Special Districts (Municipal Utility Districts, Water Control & Improvement Districts, etc.)
- Bush Intercontinental Airport
- Texas A&M Forest Service
- Greens Bayou Coalition
- North Houston Association
- Bayou Preservation Association
- Galveston Bay Estuary Program
- Galveston Bay Foundation
- The Nature Conservancy

RECOMMENDATIONS FOR IMPROVING WATER QUALITY

- Development of a watershed protection plan to address bacteria impairments and concerns
- Address bacteria and nutrient concerns through stakeholder involvement and best management practices
- Continue collecting water quality data and expand monitoring efforts to support actions associated with the development of a Watershed Protection Plan
- Continue to work with the BIG to implement the I-Plan recommendations for bacteria reduction
- Continue to analyze Discharge Monitoring Report data and present results to TCEQ, wastewater permittees, local governments/utility districts, and
- stakeholders through updates to the Regional Water Quality Management Plan
- Continue to analyze sanitary sewer overflow data from regulated dischargers and present results to TCEQ, wastewater permittees, local governments/utility districts, and stakeholders through updates to the Regional Water Quality Management Plan
- Improve compliance and enforcement of existing stormwater quality permits and improve stormwater controls in new developments
- Expand use of low impact development and green infrastructure practices
- Consult stakeholders to identify illegal dumping sites and improve signage and/or cameras, if needed
- Pursue new local partners to collect additional data to help better isolate problem areas
- Expand volunteer monitoring with Texas Stream Team in areas without professional monitoring
- Support programs to assist homeowners with the repair or replacement of failing on-site sewage facilities
- Support programs to assist homeowners with on-site sewage facilities to connect to centralized sewer collection systems (where practical)
- Support public education programs to inform business and homeowners on appropriate disposal of fats, oil, grease, and wipes
- Support programs to educate homeowners on proper management of pet wastes

WATERSHED PROJECTS

- **Implementation Plan for One Hundred and Three Total Maximum Daily Loads for Bacteria in the Houston-Galveston Region**
  A TMDL for Greens Bayou was approved by the Bacteria Implementation Group on October 16, 2012, and by TCEQ on January 20, 2013. It has been revised multiple times, with the latest revision but the Bacteria Implementation Group occurring on June 5, 2018 (Addendum 4).

- **Targeted Monitoring in Selected Assessment Units**
  In FY2022-2023, H-GAC's Clean Rivers Program, using information from previous Basin Highlights/Summary Reports, BIG annual reports, and previous targeted monitoring efforts, will address selected waterways to refine our spatial understanding of where extremely high bacterial concentrations are found in these waterways. As part of this project, bacteria samples will be collected to identify potential sources of pollution and contaminated dry-weather flows will be referred to the appropriate responsible local jurisdiction for further investigation and repair/remediation. The project will be fully documented to continue
  demonstrating the value of a prioritized watershed and targeted monitoring approach. The following AU in the Halls Bayou watershed is to be monitored as part of this project: 1006D_02 Halls Bayou

  This Targeted Monitoring Special Study is being conducted under H-GAC's Multi-Basin Clean Rivers Program FY 2022/2023 Quality Assurance Project Plan

- **Greens Bayou Watershed Protection Plan Development**
  In 2022, the Houston-Galveston Area Council was awarded $397,831.50 through the United States Environmental Protection Agency's (EPA) Clean Water Act 319(h) grant program administered locally by the TCEQ to facilitate stakeholders in the development of a voluntary, community-led watershed protection plan to address bacteria impairments and concerns for low dissolved oxygen and high nutrient concentrations

  Work will begin in the fall of 2023 and is expected to continue for a duration of three years. The project will engage stakeholders to develop a WPP to address listed impairments, concerns, and stakeholder-identified water quality priorities in the waterways of the Greens Bayou watershed. The WPP will be developed to conform to the EPA's 9-element watershed-based plan standard and will utilize existing data for technical analysis. H-GAC will update existing water quality analyses with additional ambient data acquired from 28 stations monitored by the Clean Rivers Program and sanitary sewer overflow and discharge monitoring reports data from the TCEQ. Further, H-GAC will develop modeling analyses using the Spatially Explicit Load Enrichment Calculation Tool (SELECT) and load duration curves (LDCs) to assess causes and sources of pollution and establish reduction targets for compliance. Refinement will utilize stakeholder review and update of data sources as needed. The modeling will inform stakeholder decisions by indicating the potential causes, extent, and required reductions associated with water quality issues.

MAJOR WATERSHED EVENTS

- **Flooding Events in Halls Bayou**
  There have been frequent and numerous flooding events in the Halls Bayou watershed. This is due to significant floodplains alongside high-density development and impervious surfaces. As much of this areas development occurred prior to restrictions on building in the floodplains, these events typically result in severe damages to homes and businesses. Tropical Storm Allison in 2001 and Hurricane Harvey in 2017 resulted in devastating flood levels throughout the watershed. Numerous other flooding events have affected the Greens Bayou watershed.

- **Harris County Flood Control District Flood Control Projects**
  The HCFCD has numerous flood control projects in the Halls Bayou watershed. These include completed projects, projects under construction, and projects still in the planning/feasibility study stage.

  - C-01 Helms Stormwater Detention Basins and Channel Conveyance Improvements on Tributary P118-26-00
  - C-23 Tributary P118-08-00 Conveyance Improvements
  - C-24 Tributary P118-09-00 Conveyance Improvements
  - C-25 Halls Bayou Tributary P118-21-00 and related Stormwater Detention
  - C-26 Tributaries P118-25-00 & P118-23-02 Conveyance Improvements
  - C-28 P118-25-00 and P118-25-01 Channel Conveyance Improvements and Related Stormwater Detention
  - C-30 Tributary P118-27-00 Conveyance Improvements
  - C-35 Little York Basin, Hopper Basin, and P118-14-00 Channel Improvements
  - C-41 Main Stem Stormwater Detention Improvements in the Vicinity of Keith Wiess Park and Tributary P118-25-01 Channel Conveyance Improvements and Related Stormwater Detention
  - C-41 Main Stem Flood Risk Reduction in the Vicinity of Hardy West
  - C-41 Main Stem Conveyance Improvements and Related Stormwater Detention
  - C-41 Main Stem Flood Risk Reduction in the Vicinity of I-45 & Halls Bayou
  - CI-006 Brock Park Stormwater Detention Basin

- **Home Buyout Program**
  Home buyouts are used by the HCFCD to reduce flood damage in areas that are within the floodplain where structural projects such as stormwater detention basins or channelization to reduce flooding would not be cost-effective or beneficial. Through this program, properties that have frequently been inundated through flood events have been purchased at fair-market value. These flood-prone structures are then removed.

- **East Aldine Management District Water and Sewer Infrastructure Programs**
  Harris County and the East Aldine Management District has worked to install sewer service in the East Aldine region using grant funding. There have not been any new sewer connections since 2019, as the partners await future funding. Harris County and East Aldine Management District had made 846 connections and abandoned a total of 1,493 systems since 2014. Many of the abandoned OSSFs were failing as evidenced by violations. (SOURCE: 2020 BIG Report).

- **Airline Improvement District Water and Sewer Projects**
  Harris County and the Airline Improvement District continue to install sewer service in the Airline region using grant funding. Harris County and the Airline Improvement District had made 45 connections to new sanitary service in 2021 for a total of 321 since 2017. Fifty OSSFs were abandoned in 2021 for a total of 558 since 2017. Many of the abandoned OSSFs were failing as evidenced by violations.

COMMUNITY ENGAGEMENT

The Bayou Greenways 2020 project is creating a continuous linear park system along Houston's major waterways. In 2019, the Houston Parks Board constructed kayak launch sites on Greens Bayou as part of the project. Launch sites have been completed at Brock Park and Strickland Park, with a launch site under construction at Thomas Bell Foster Park and another in the design phase at W. E. Bill Crowley Park. The Greens Bayou Greenway also includes pedestrian bridges, updated landscaping, and paved and natural walking and biking trails along the bayou.

The Greens Bayou Coalition tries to organize at least one group clean-up or tree planting event each month along the bayou or at a flood control or utility district basin to encourage clean waters, flood mitigation, and quality of life along the bayou. In addition to the benefits of cleaning up trash and debris, these events help train a new generation of environmental stewards.

IMAGES OF THE WATERSHED

Photo 11: Halls Bayou at Homestead Road

Photo 12: Halls Bayou at Snowden Street (FWSD #23 WWTF)

Photo 13: Halls Bayou at Wayside Drive

SEGMENT 1006 – GREENS BAYOU TIDAL

Photo 14: Kayaking on Greens Bayou Tidal (Photo courtesy of Greens Bayou Coalition staff and volunteers)

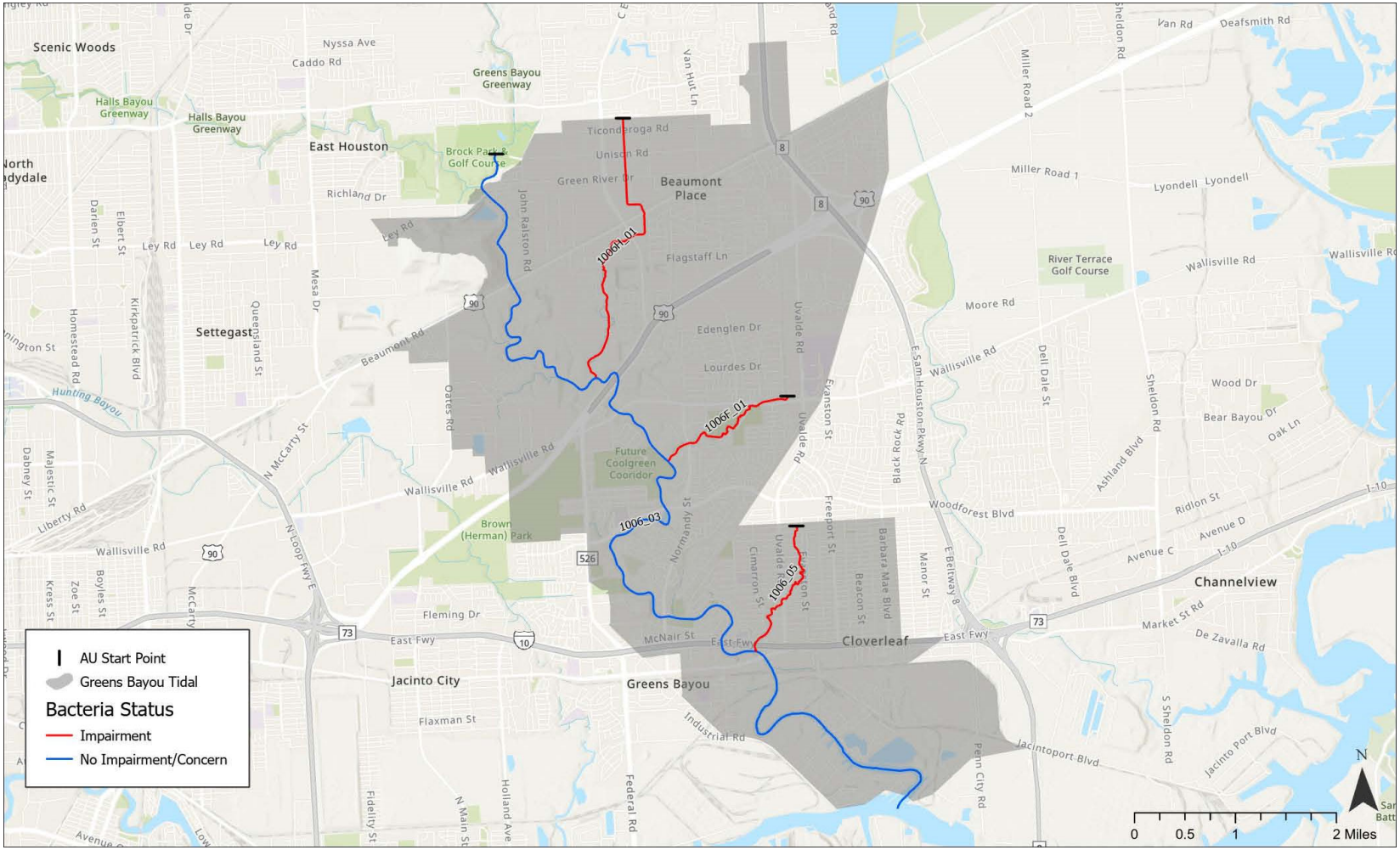
SEGMENT DESCRIPTION

Greens Bayou Tidal is a part of the Houston Ship Channel Tidal segment (Segment 1006). This portion of Greens Bayou is located immediately upstream of the tidal influence from the Houston Ship Channel and Galveston Bay and has an area of 22.54 square miles. Greens Bayou Tidal has a designated Minimal Aquatic Life Use (ALU). The Greens Bayou Tidal watershed includes the following segments:

- Segment 1006: Houston Ship Channel Tidal – From the confluence with the San Jacinto River in Harris County to a point immediately upstream of Greens Bayou in Harris County, including tidal portions of tributaries; Greens Bayou Tidal includes AUs 1006_03 and 1006_05 of the Houston Ship Channel Tidal segment.

- Segment 1006F: Big Gulch Above Tidal – From the confluence with Greens Bayou Tidal to Wallisville Road in Harris County

- Segment 1006H: Spring Gully Above Tidal – From the confluence with Greens Bayou to US 90 in Harris County



Map 29: Segment 1006 - Greens Bayou Tidal

Greens Bayou Tidal is comprised of two assessment units of the Houston Ship Channel Tidal segment (AU 1006_03 and 1006_05). There are six active routine water quality monitoring stations in the Greens Bayou Tidal portion of segment 1006. Two unclassified tributaries (Segment 1006F – Big Gulch Above Tidal and Segment 1006H – Spring Gully Above Tidal) discharge to the tidal portion of Greens Bayou. Each of these tributaries have one assessment unit with a single active monitoring station in each.

Descriptions of each assessment unit are included in the accompanying table.

Table 25: Assessment Unit Descriptions for Segment 1006 - Greens Bayou Tidal

Segment ID	Segment Name	AU ID	AU Description
1006	Houston Ship Channel Tidal (Greens Bayou Tidal)	1006_03	Greens Bayou Tidal - From the Houston Ship Channel confluence to a point 0.7 km (0.4 mi) upstream of the Halls Bayou confluence
		1006_05	Goodyear Creek - From confluence with Greens Bayou Tidal to Granada St. in Harris County
1006F	Big Gulch Above Tidal	1006F_01	From the confluence with Greens Bayou Tidal upstream to a point just upstream of Wallisville Road in Harris County
1006H	Spring Gully Above Tidal	1006H_01	From confluence with Greens Bayou to US 90 in Harris County

The accompanying table provides a description of each active monitoring station in the FY 2023 Coordinated Monitoring Schedule, the submitting and collecting entities, the monitoring type (i.e., routine, biased, etc.), the number of monitoring events per year, and the parameter groups collected.

Table 26: FY 2023 Coordinated Monitoring Schedule[1] for Segment 1006 - Greens Bayou Tidal

Segment ID	Segment Name	Station ID	Station Description	SE[2]	CE[3]	MT[4]	Number of Monitoring Events Per Year								
							Field	Conv	Bact	Flow	24-Hr DO	Metals Water	Org Water	Metals Sed	Org Sed
1006	Greens Bayou Tidal	11279	GREENS BAYOU IMMEDIATELY DOWNSTREAM OF GREEN RIVER ROAD/ LEY ROAD IN HOUSTON	HG	HH	RT	6	6	6	6	–	–	–	–	–
		21008	GREENS BAYOU AT WALLISVILLE ROAD APPROX 150 METERS NORTHEAST OF THE INTERSECTION OF DATTNER ROAD AND WALLISVILLE ROAD IN HOUSTON	HG	HH	RT	6	6	6	–	–	–	–	–	–
		16981	GREENS BAYOU TIDAL AT MOUTH OF ISK BIOSCIENCES DITCH 1.57 KM UPSTREAM OF CONFLUENCE WITH HOUSTON SHIP CHANNEL IN HOUSTON	WC	FO	RT	4	4	4			2		2	
		18363	GREENS BAYOU MID CHANNEL IMMEDIATELY UPSTREAM OF MARKET STREET	WC	FO	RT	4	4	4						
		11271	HOUSTON SHIP CHANNEL AT CONFLUENCE WITH GREENS BAYOU/ CM 152	HG	HC	RT	12	12	12	–	–	–	–	–	–
				WC	FO	RT	4	4	4	–	–	–	–	–	–
		16664	GOODYEAR CREEK TIDAL IMMEDIATELY UPSTREAM OF IH 10 IN EAST HOUSTON	HG	HH	RT	6	6	6	-	–	–	–	–	–
1006 F	Big Gulch Above Tidal	16662	BIG GULCH AT WALLISVILLE ROAD IN EAST HOUSTON	HG	HH	RT	6	–	6	–	–	–	–	–	–
1006 H	Spring Gully Above Tidal	16663	SPRING GULLY AT WEST TERMINUS OF BARNESWORTH DRIVE IN NORTHEAST HOUSTON	HG	HH	RT	6	6	6	–	–	–	–	–	–

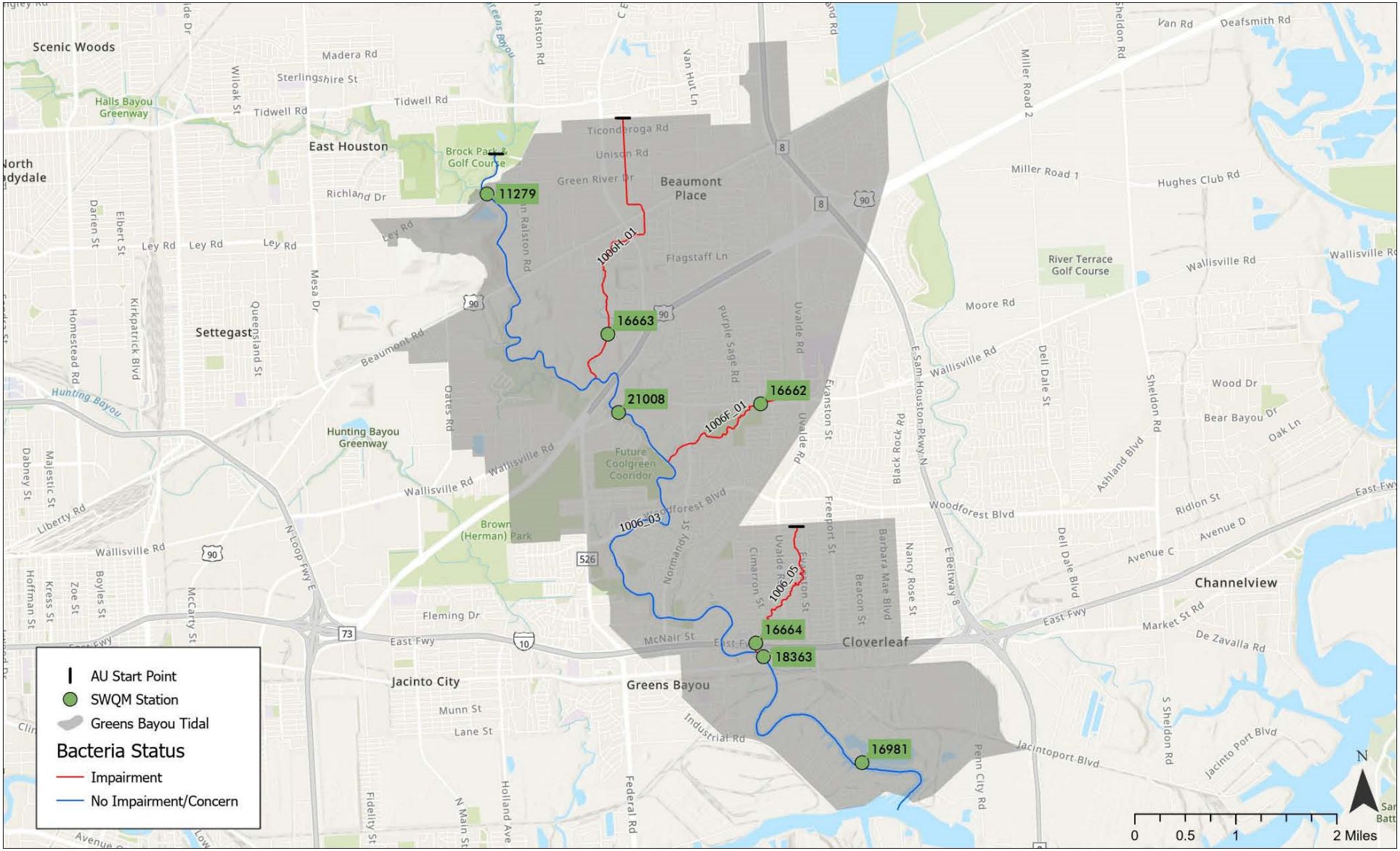
[1] The Coordinated Monitoring Schedule for current and previous fiscal years can be located at cms.lcra.org

[2] Submitting Entity – The entity submitting monitoring data to TCEQ's Surface Water Quality Information System

[3] Collecting Entity – The entity collecting monitoring data

Submitting and Collecting Entities
HG = Houston-Galveston Area Council
HH = Houston Health Department

Monitoring Types
RT = Routine



Map 30: FY 2023 Routine Monitoring Stations for Segment 1006 - Greens Bayou Tidal

HYDROLOGIC CHARACTERISTICS

Greens Bayou Tidal is part of the Houston Ship Channel Tidal segment (1006). Greens Bayou Tidal is comprised of AUs 1006_03 and 1006_05 of the Houston Ship Channel. Greens Bayou Tidal has multiple tributaries, including Goodyear Creek, Jordan Gully, Big Gulch (1006F), Spring Gully (1006H), Halls Bayou (1006D), and an unnamed tributary.

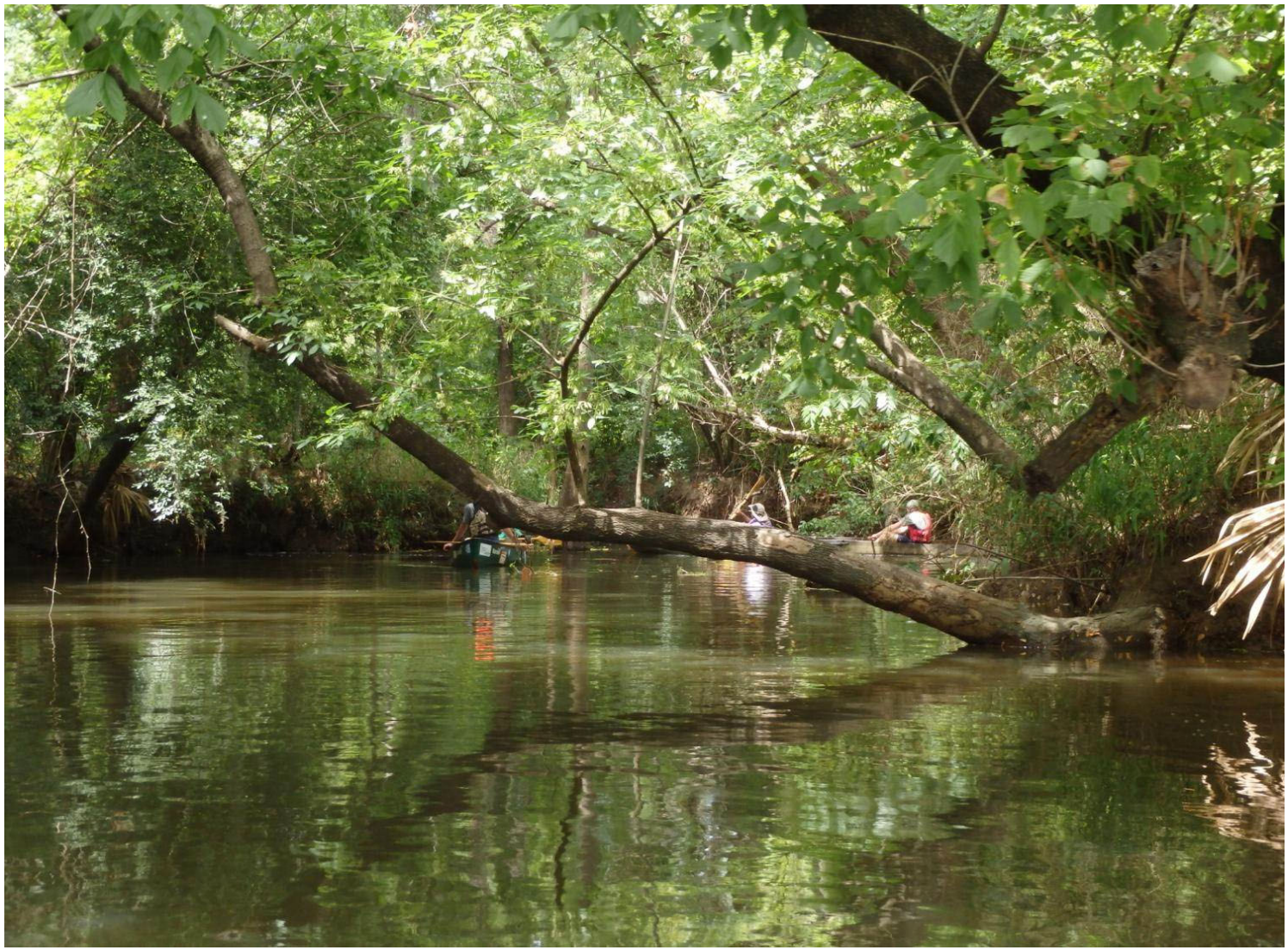
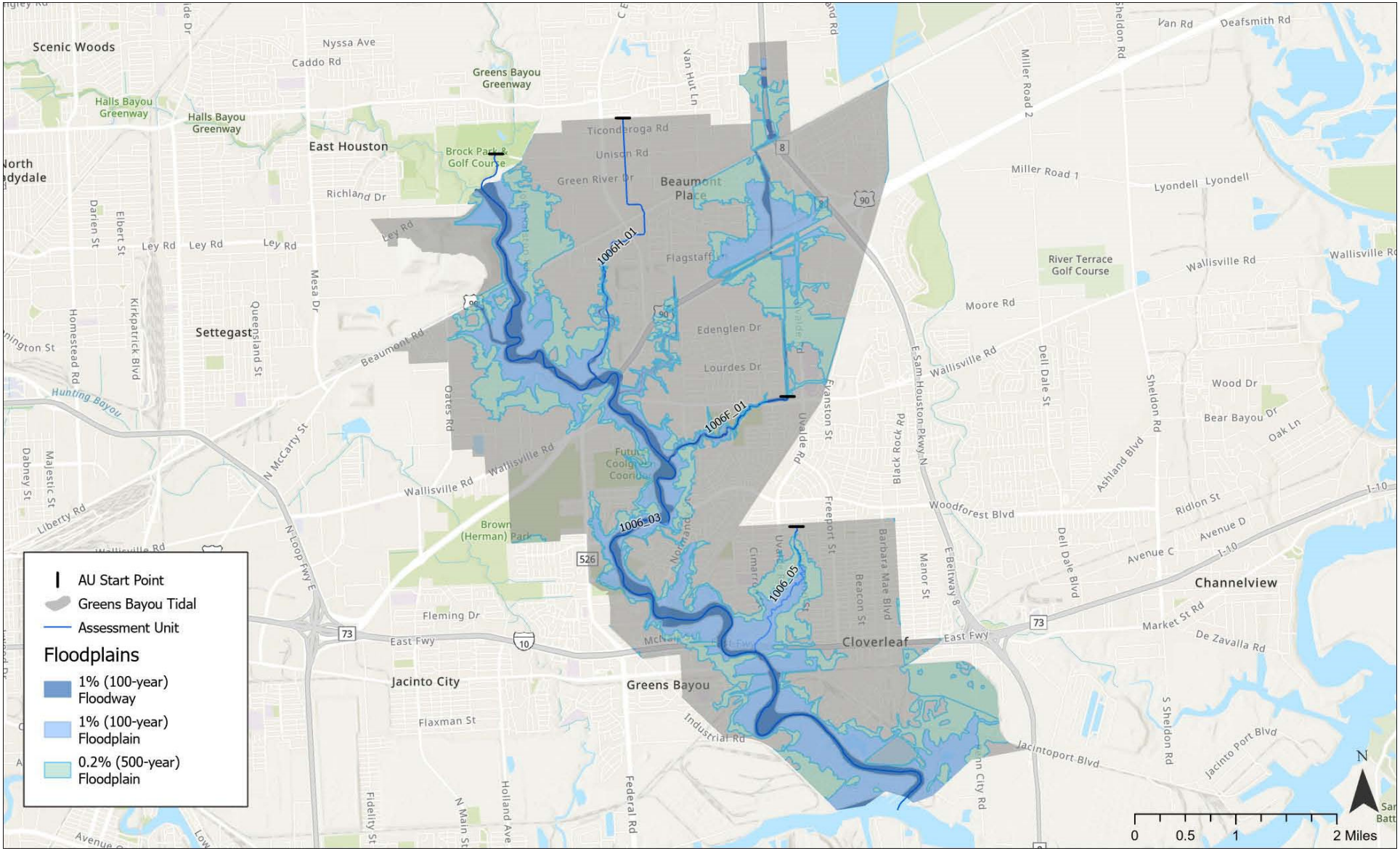


Photo 15: Big Gulch (1006F) Paddle Trail (Photo Courtesy of Greens Bayou Coalition staff and volunteers)

Although much of the watershed is highly developed, there remains large areas between Beltway 8 and I-10 on the east side of Houston that remain undeveloped. The Greens Bayou watershed is prone to flooding. Significant floodplains, combined with the area's high-density development, results in severe damage to homes and businesses during these frequent flood events. Flooding in the lower portion of the Greens Bayou Tidal segment can be influenced by storm surges. Numerous projects have been initiated by the Harris County Flood Control District (HCFCD) to address flooding in the Greens Bayou watershed, including channel improvements and the building of stormwater detention basins.



Map 31: Floodplains for Segment 1006 - Greens Bayou Tidal

PRECIPITATION

Precipitation is one of the primary factors affecting stream flow in Greens Bayou Tidal. During rainfall events, water runoff from the surrounding land flows into the bayou. This runoff results in a rise in the water level and increased flow, which can lead to flooding in low-lying areas adjacent to the bayou. Seasonal changes, proximity to the coast, and the movement of storm systems largely control the amount and timing of precipitation.

As part of the Harris County Flood Warning System (HCFWS), there are two precipitation gages located within the Greens Bayou Tidal watershed. From upstream to downstream, rainfall gages are located at Ley Road and Normandy Street. Annual rainfall totals for 2022 for Greens Bayou Tidal are shown in the accompanying table.

Table 27: HCFWS Rain Gage Stations in Segment 1006 - Greens Bayou Tidal

Rain Gage ID	Site Description	Annual Rainfall (2022)
1690	Halls Bayou at Airline Drive	37.40″
1680	Halls Bayou at Jensen Drive	33.52″
1675	Halls Bayou at Tidwell Road	40.00″

Source: Harris County Flood Warning System (https://www.harriscountyfws.org/)

Annual rainfall totals were 43.96″ at Ley Road and 38.52″ at Normandy Street. The highest monthly rainfall total was recorded in November for both locations.

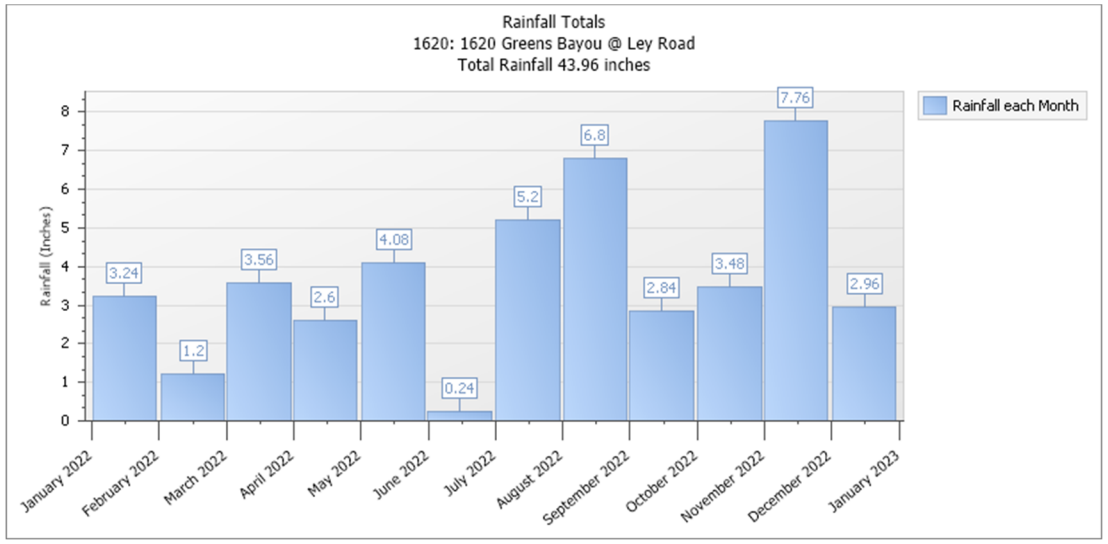


Figure 28: Monthly Rainfall at Greens Bayou Tidal at Ley Road, 2022 (Source: HCFWS)

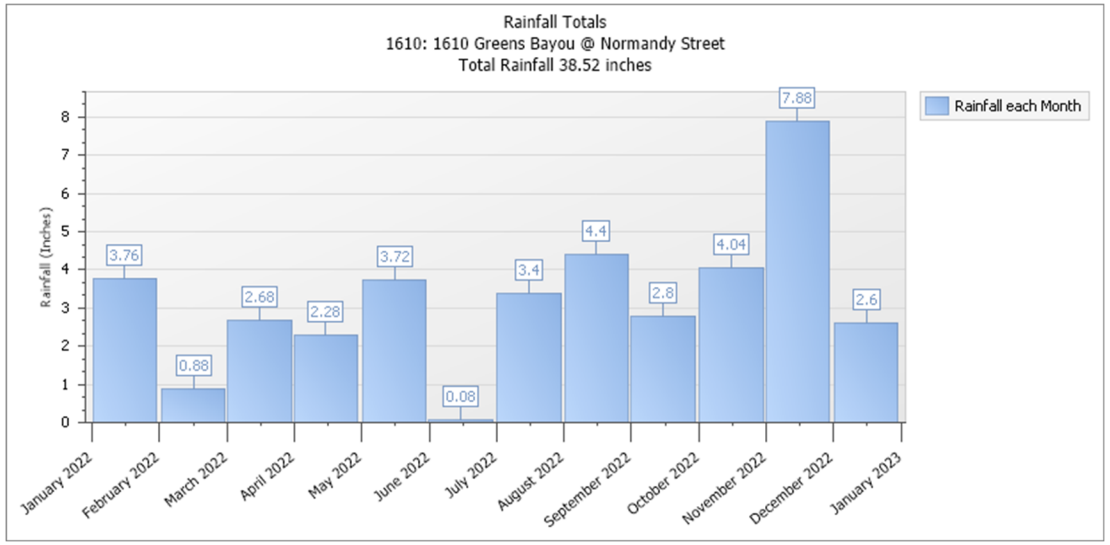


Figure 29: Monthly Rainfall at Greens Bayou at Normandy Street, 2022 (Source: HCFWS)

USGS STREAM FLOW GAGES

There is one USGS stream gage located in the Greens Bayou Tidal watershed. A hydrograph of the gage heights at USGS station 080706700 from the period of 01-01-15 to 12-31-22 is shown. There have been frequent flooding events resulting in damage to homes and businesses over the past two decades. This includes devastating flooding of Greens Bayou during Hurricane Harvey in 2017.

Table 28: USGS Gage Stations in Segment 1006 - Greens Bayou Tidal

USGS Gage Station ID	Site Description
08076700	Greens Bayou at Ley Rd, Houston, TX

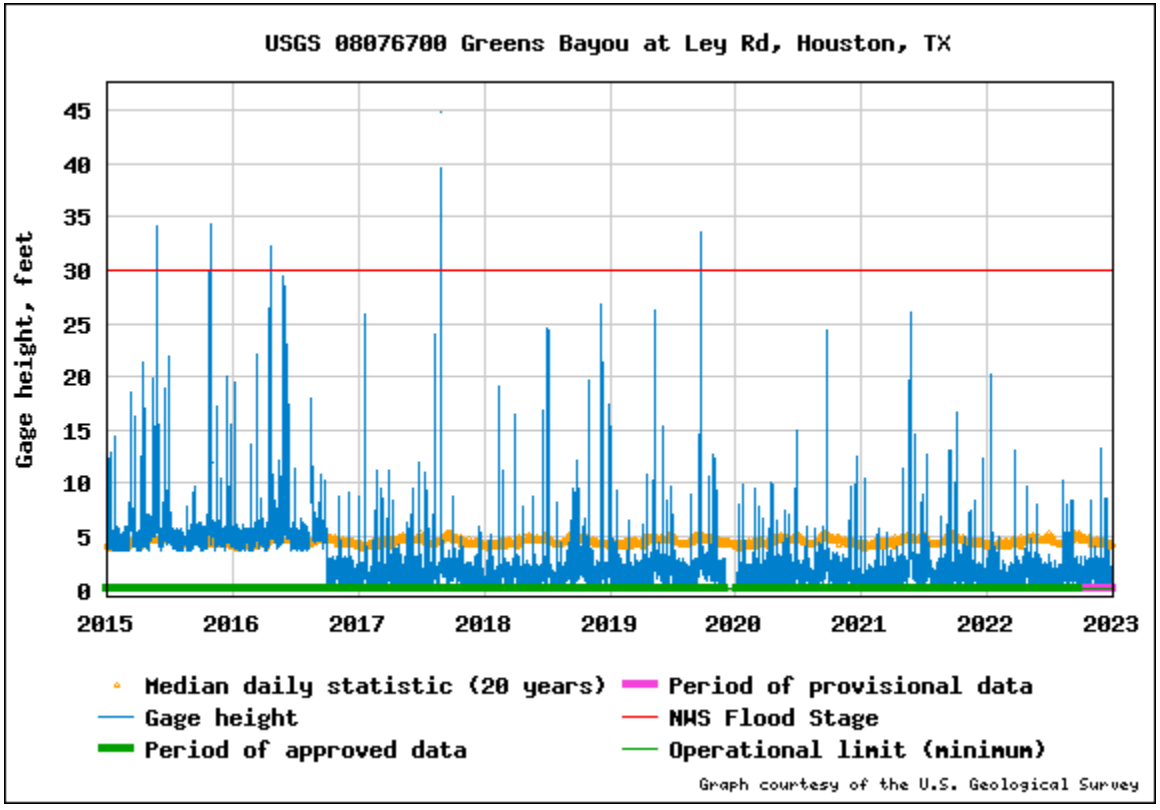
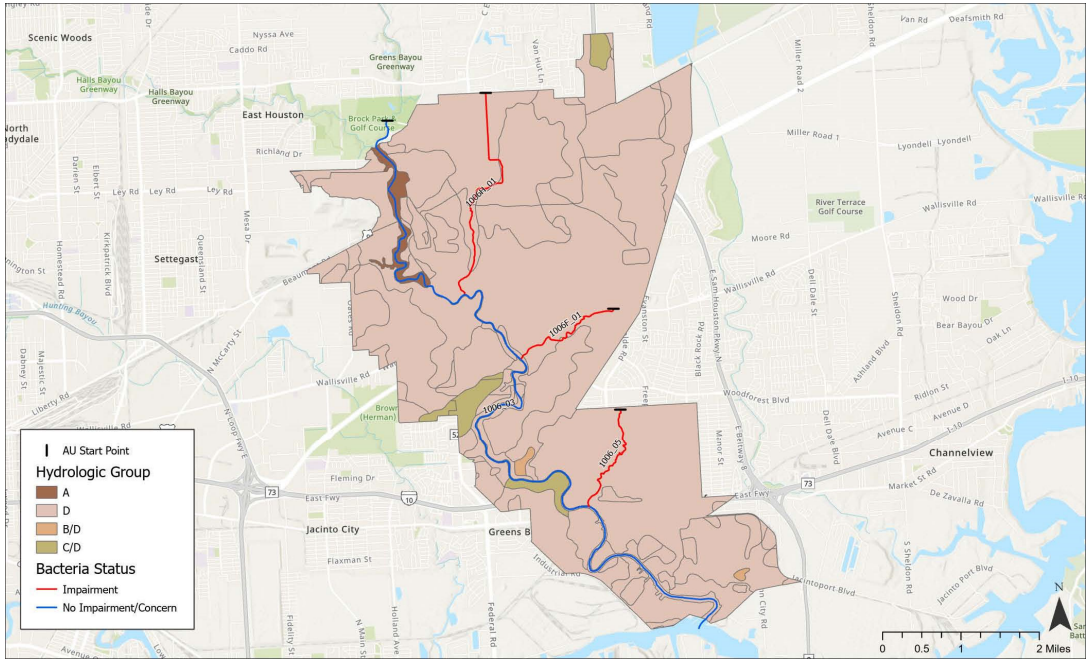


Figure 30: Gage Height at Greens Bayou at Ley Road (USGS 08076700), 2015-2022

HYDROLOGIC SOIL GROUPS

For the Greens Bayou Tidal segment, the soil is almost entirely in the Clay/Silty Clay/Sandy Clay texture class, with 96.29% of the land area being this soil type. This soil class is in hydrologic soil group D, which is characterized by a very slow infiltration rate and high runoff potential. This runoff can contribute to nonpoint sources of bacteria and nutrients entering the waterways. The slow infiltration rate also factors into the high flood potential in this watershed.



Map 32: Hydrologic Soil Groups for Segment 1016 - Greens Bayou Tidal (2021)

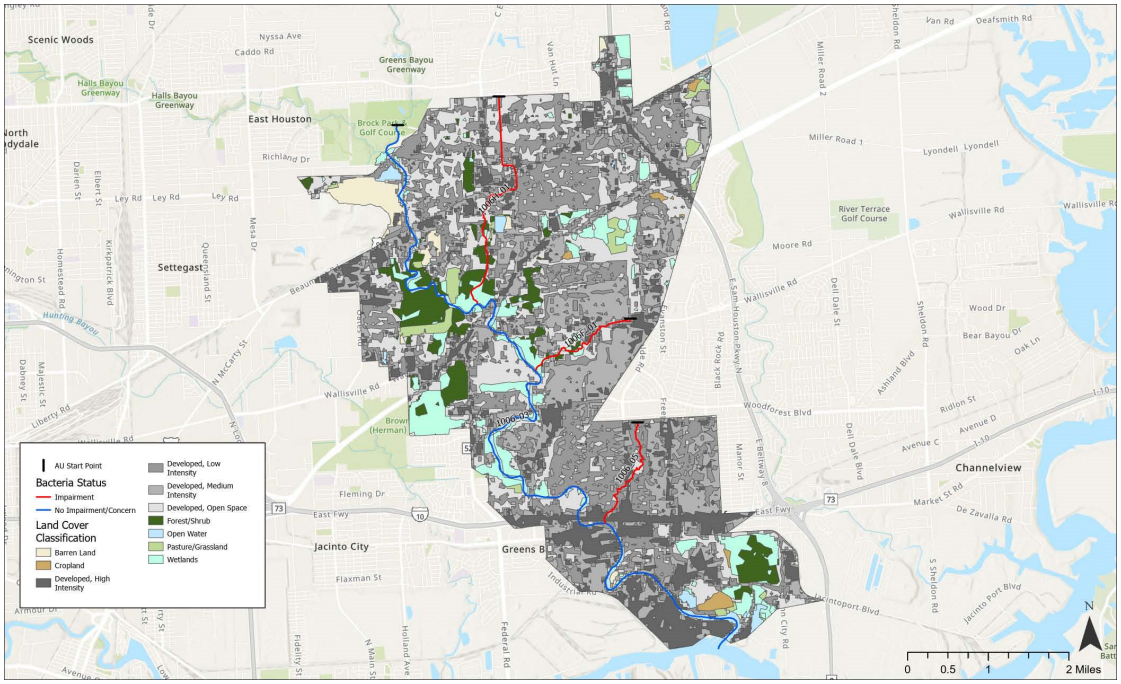
Table 29: Hydrologic Soul Groups by Area in the Segment 1006 - Greens Bayou Tidal (2021)

Hydrologic Soil Group	Soil Texture Class	Typical Soil Composition	Infiltration Rate	Runoff Potential	Area Square Miles	Area %
A	Sand	<10% clay, >90% sand or gravel	High	Low	0.27	1.19%
B	Sandy loam, Loamy sand	10 – 20% clay, 50 – 90% sand	Moderate	Moderately Low	–	–
C	Clay loam. Silty clay loam, Sandy clay loam, Loam, Silty loam, Silt	20 – 40% clay, <50% sand	Slow	Moderately High	–	–
D	Clay, Silty clay, Sandy clay	>40% clay, <50% sand	Very Slow	High	21.71	96.29%
A/D	Sand	<10% clay, >90% sand or gravel	Very Slow (High if drained)	High (Low if drained)	–	–
B/D	Sandy loam, Loamy sand	10 – 20% clay, 50 – 90% sand	Very Slow (Moderate if drained)	High (Moderate if drained)	0.06	0.28%
C/D	Clay loam, Silty clay loam, Sandy clay loam, Loam, Silty loam, Silt	20 – 40% clay, <50% sand	Very Slow (Slow if drained)	High	0.50	2.24%
				TOTAL	**22.54**	**100.00%**

LAND COVER AND NATURAL CHARACTERISTICS

The Greens Bayou Tidal watershed is heavily developed, with 81.66% of the land area classified as one of the four developed classes (Open Space, Low Intensity, Medium Intensity, and High Intensity). This watershed is primarily urban and suburban with areas of commercial, industrial, and residential development.

The two assessment units that comprise Greens Bayou Tidal are part of the Houston Ship Channel segment (1006). The Houston Ship Channel is an important commercial waterway. This area is also a major hub for the oil and gas industry.



Map 33: Land Cover for Segment 1006 - Greens Bayou Tidal (2020)

Table 30: Land Cover for Segment 1006 - Greens Bayou Tidal Watershed (2020)

Land Cover Class Name	Area Square Miles	Area %
Barren Land	0.39	1.74%
Cropland	0.12	0.53%
Developed, High Intensity	2.90	12.87%
Developed, Low Intensity	5.79	25.66%
Developed, Medium Intensity	5.15	22.85%
Developed, Open Space	4.57	20.28%
Forest/Shrub	1.18	5.23%
Open Water	0.46	2.05%
Pasture/Grassland	0.35	1.55%
Wetlands	1.63	7.23%
TOTAL	22.54	100.00%

DESCRIPTION OF WATER QUALITY ISSUES

Greens Bayou Tidal is comprised of assessment units 1006_03 and 1006_05 of the Houston Ship Channel Tidal segment (1006). This segment is tidally influenced and assessed based on the Enterococci geometric mean. Segment 1006 has designated uses of Navigation and Industrial Water Supply. AU 1006_03 is also assessed for toxic substances in sediment, PCBs/Dioxins in fish tissue, dissolved mercury, lead, and nickel in water, and chlorophyll-*a*. AU 1006_05 is assessed PCBs/Dioxins in fish tissue and mercury, lead, and nickel in water. Two tributaries, Big Gulch Above Tidal (1006F) and Spring Gully Above Tidal (1006H) are both freshwater streams with a Primary Contact Recreation 1 designation. Segment 1006F has a Limited ALU and 1006H has an Intermediate ALU. The accompanying table describes the water quality standards for each segment and parameter.

Table 31: Designated Uses and Numeric Criteria1 for Segment 1006 - Greens Bayou Tidal

Segment ID	Segment Name	DESIGNATED USES				CRITERIA								NUTRIENT SCREENING LEVELS			
		Recreation	Aquatic Life Use[3]	Domestic Water Supply	Other Uses	Chloride (mg/L)	Sulfate (mg/L)	Total Dissolved Solids (mg/L)	Dissolved Oxygen Grab Minimum (mg/L)	Dissolved Oxygen Grab Screening Level (mg/L)	pH Range (SU)	Temperature (°F)	Indicator Bacteria[6] Geometric Mean (MPN/100	Total Phosphorus (mg/L)	Nitrate-Nitrogen (mg/L)	Ammonia-Nitrogen (mg/L)	Chlorophyll-*a* (µg/L)
1006	Houston Ship Channel Tidal (Greens Bayou Tidal)	–	–	–	N[4]/IS[5]	–	–	–	2.0	2.0	6.5–9.0	95	168	0.66	1.1	0.46	21
1006F	Big Gulch Above Tidal	PCR1[2]	Limited	–	–	–	–	–	2.0	3.0	–	–	126	0.69	1.95	0.33	–
1006H	Spring Gully Above Tidal	PCR1	Inter-mediate	–	–	–	–	–	3.0	4.0	–	–	126[2]	0.69	1.95	0.33	–

[1] Source: 2022 Texas Surface Water Quality Standards (https://www.tceq.texas.gov/waterquality/standards/2022-texas-surface-water-quality-standards)

[2] PCR1 = Primary Contact Recreation 1

[3] Aquatic Life Use is categorized as either Exceptional, High, Intermediate, Limited, or Minimal.

[4] N = Navigation

[5] IS = Industrial Water Supply

[6] The indicator bacteria for AUs 1006_03 and 1006_05 is Enterococci. The indicator bacteria for 1006F and 1006H is *E. coli*.

SUMMARY OF 2022 ASSESSMENT RESULTS

The accompanying table shows assessment results from the 2022 Texas Integrated Report. The IR describes the status of the water body based on historical data and the extent to which it attains the Texas Surface Water Quality Standards. The seven-year assessment period for the 2022 IR was 12/1/13 – 11/30/20.

Table 32: Integrated Level of Support for Assessment Units in Segment 1006 - Greens Bayou Tidal (2022 Integrated Report)

Designated Use	Method	Parameter	Integrated Level of Support			
			Greens Bayou Tidal		Big Gulch Above Tidal	Spring Gully Above Tidal
			1006_03	1006_05	1006F_01	1006H_01
Aquatic Life Use	Dissolved Oxygen Grab Minimum	Dissolved Oxygen Grab	FS	FS	FS	FS
	Dissolved Oxygen Grab Screening Level	Dissolved Oxygen Grab	NC	NC	NC	NC
	Toxic Substances in Sediment	DDT	CS	–	–	–
		DDD	CS	–	–	–
Fish Consumption Use	Bioaccumulative Toxics in fish tissue	PCBs	CS	CS	–	–
	DSHS No Consumption Advisory	PCBs	NS	NS	–	–
		Dioxins	NS	NS	–	–
	Bioaccumulative Toxics in water	Mercury	FS	FS	–	–
		Dissolved Lead	FS	FS	–	–
		Dissolved Nickel	FS	FS	–	–
General Use	High pH	pH	FS	FS	–	–
	Low pH	pH	FS	FS		
	Nutrient Screening Levels	Total Phosphorus	CS	CS	NC	NC
		Nitrate	CS	CS	NC	NC
		Ammonia	NC	NC	NC	NC
		Chlorophyll-*a*	NC	–	–	–
	Water Temperature	Water Temperature	FS	FS	–	–
	Bacteria Geomean	Enterococci	FS	NS	–	–
		E. coli	–	–	NS	NS

Integrated Level of Support

FS	= Fully Supporting	NC	= No Concern
NS	= Non-Supporting	CN	= Use Concern
		CS	= Screening Level Concern

NUTRIENT CONCERNS

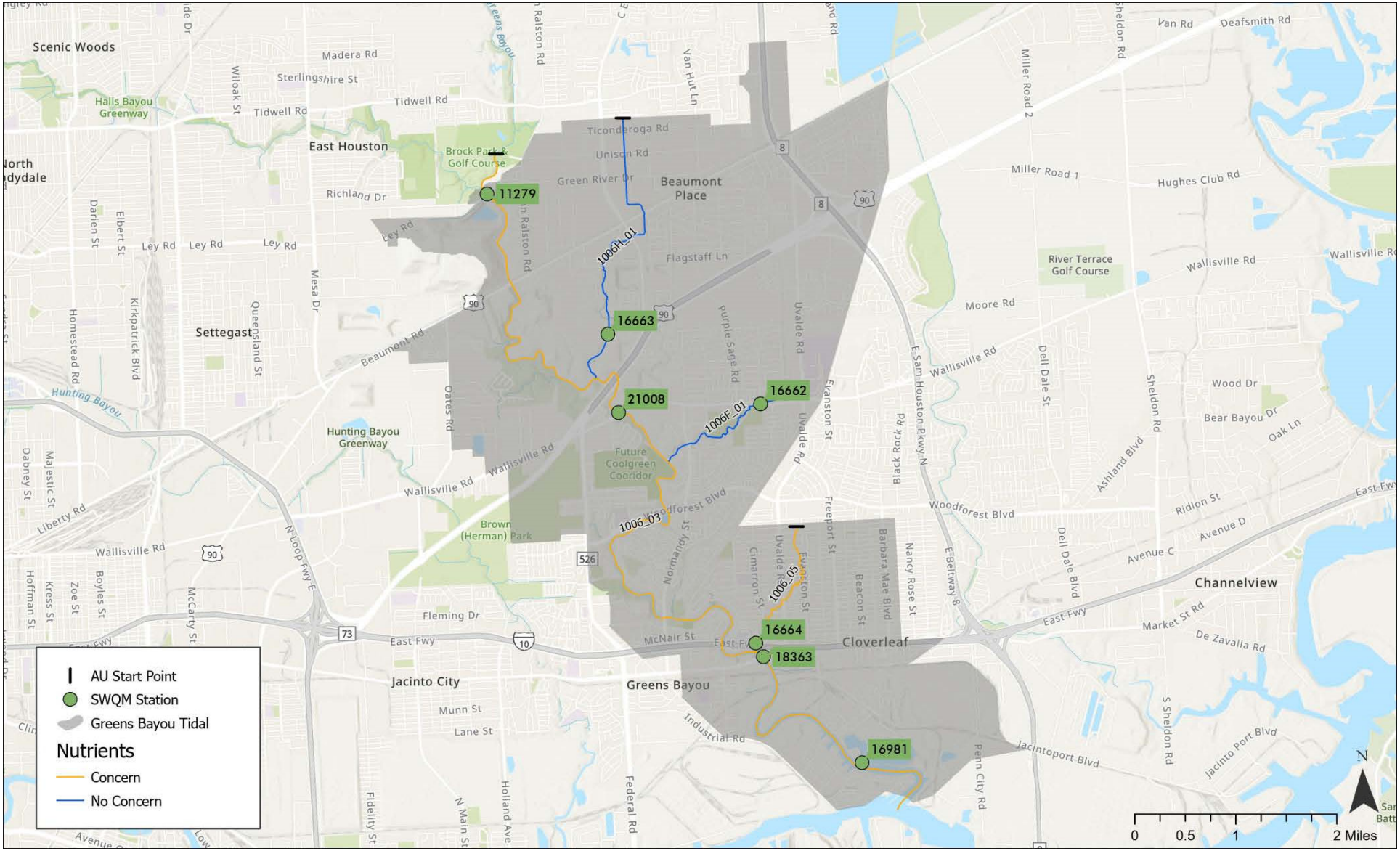
Both assessment units of Greens Bayou Tidal (Segment 1006) have screening level concerns for Total Phosphorus and Nitrate. There are no Ammonia nor Chlorophyll *a* concern in this watershed; however, Ammonia is deteriorating in 1006_03. Trend analysis shows that results for Total Phosphorus and Nitrate are consistently exceeding the nutrient criteria.

Table 33: Comparison of 2022 IR Nutrient Data (2013-2020) and H-GAC Analysis of Water Quality Data (2015-2022)

Parameter	AU ID	Level of Support	2022 Integrated Report (12/01/13 – 11/30/20)		H-GAC Trend Analysis 1/1/15 – 5/31/22
			# Exceedances/ #Assessed	Percentage	
Total Phosphorus	1006_03	CS	101/151	66.9%	Deteriorating
	1006_05	CS	25/55	45.4%	Stable
	1006F_01	NC	1/55	1.85%	Stable
	1006H_01	NC	1/54	1.85%	Stable
Nitrate	1006_03	CS	135/152	88.2%	Stable
	1006_05	CS	38/55	69.1%	Stable
	1006F_01	NC	11/55	20.0%	Stable
	1006H_01	NC	0/54	0%	Improving
Ammonia	1006_03	NC	5/150	0.03%	Deteriorating
	1006_05	NC	0/55	0%	Stable
	1006F_01	NC	2/55	0.04%	Stable
	1006H_01	NC	1/54	1.85%	Stable
Chlorophyll-*a*	1006_03	NC	3/42	7.14%	Stable

Integrated Level of Support

NC	= No Concern
CS	= Screening Level Concern



Map 34: Nutrient Concerns for Segment 1006 - Greens Bayou Tidal

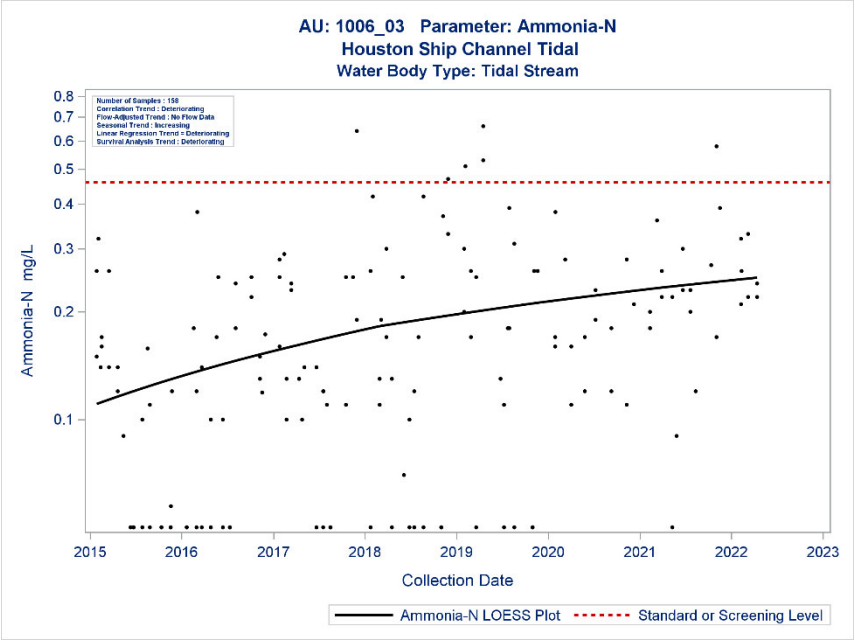


Figure 10: Seven-Year Ammonia-Nitrogen trend for Segment 1006 (Greens Bayou Tidal), 2015-2022

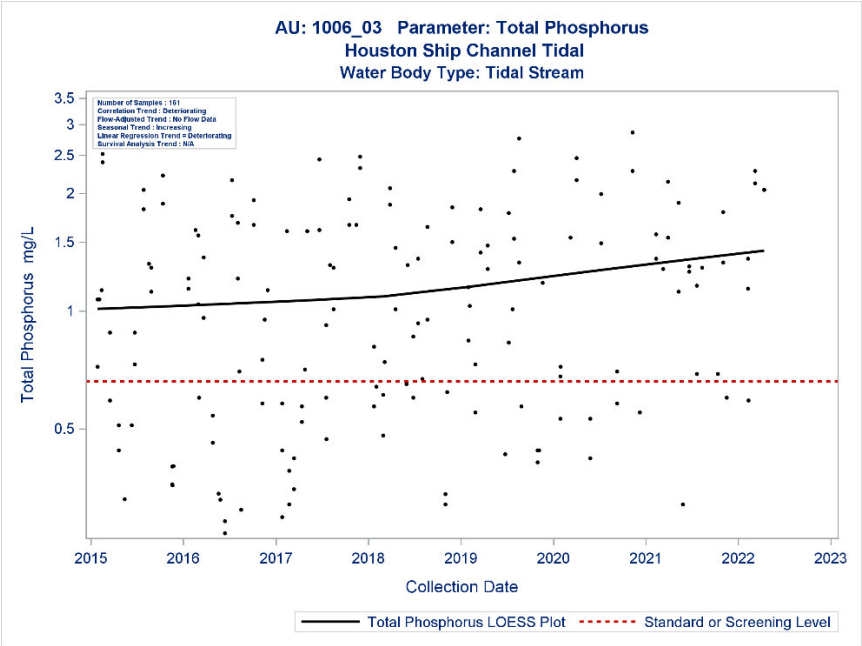


Figure 11: Seven-Year Total Phosphorus trend for Segment 1006 (Greens Bayou Tidal), 2015-2022

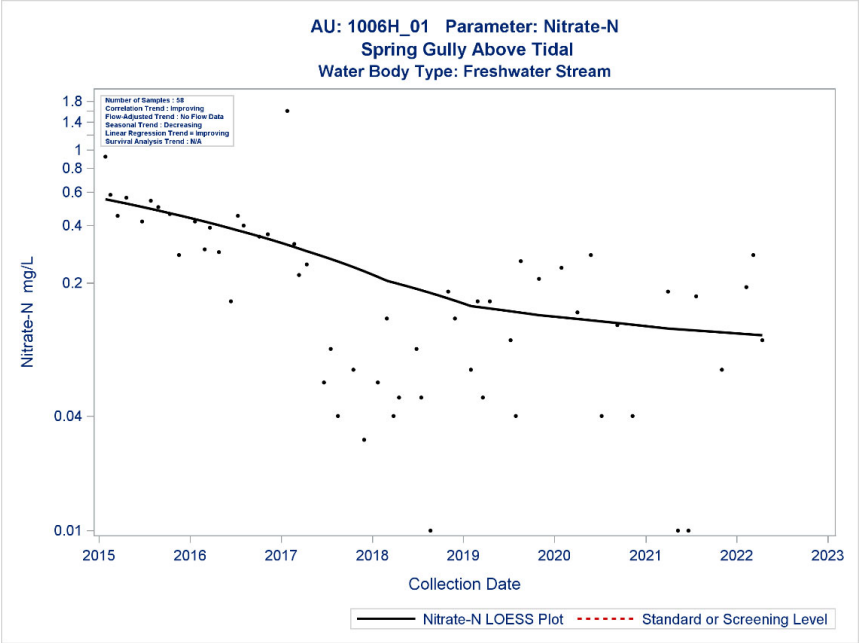


Figure 12: Seven-Year Nitrate-Nitrogen trend for AU 1006H_01 (Spring Gully Above Tidal), 2015-2022

BACTERIA IMPAIRMENTS AND CONCERNS

AU 1006_05 of Greens Bayou Tidal has a bacteria impairment for elevated Enterococci geometric mean. The geometric mean in this AU is 181.3 MPN/100 mL, which exceeds the water quality standard of 168 MPN/100 mL for this segment.

Bacteria impairments are also found in both Big Gulch Above Tidal (1006F) and Spring Gully Above Tidal (1006H). These segments are both freshwater and are assessed based upon the *E. coli* geometric mean. For AU 1006F_01, the geometric mean is 600.73 MPN/100 mL, which exceeds the water quality standard of 126 MPN/100 mL. For AU 1006H_01, the geometric mean is 335.35 MPN/100 mL.

Table 34: Comparison of 2022 IR Bacteria Data (2013-2020) and H-GAC Analysis of Water Quality Data (2015-2022)

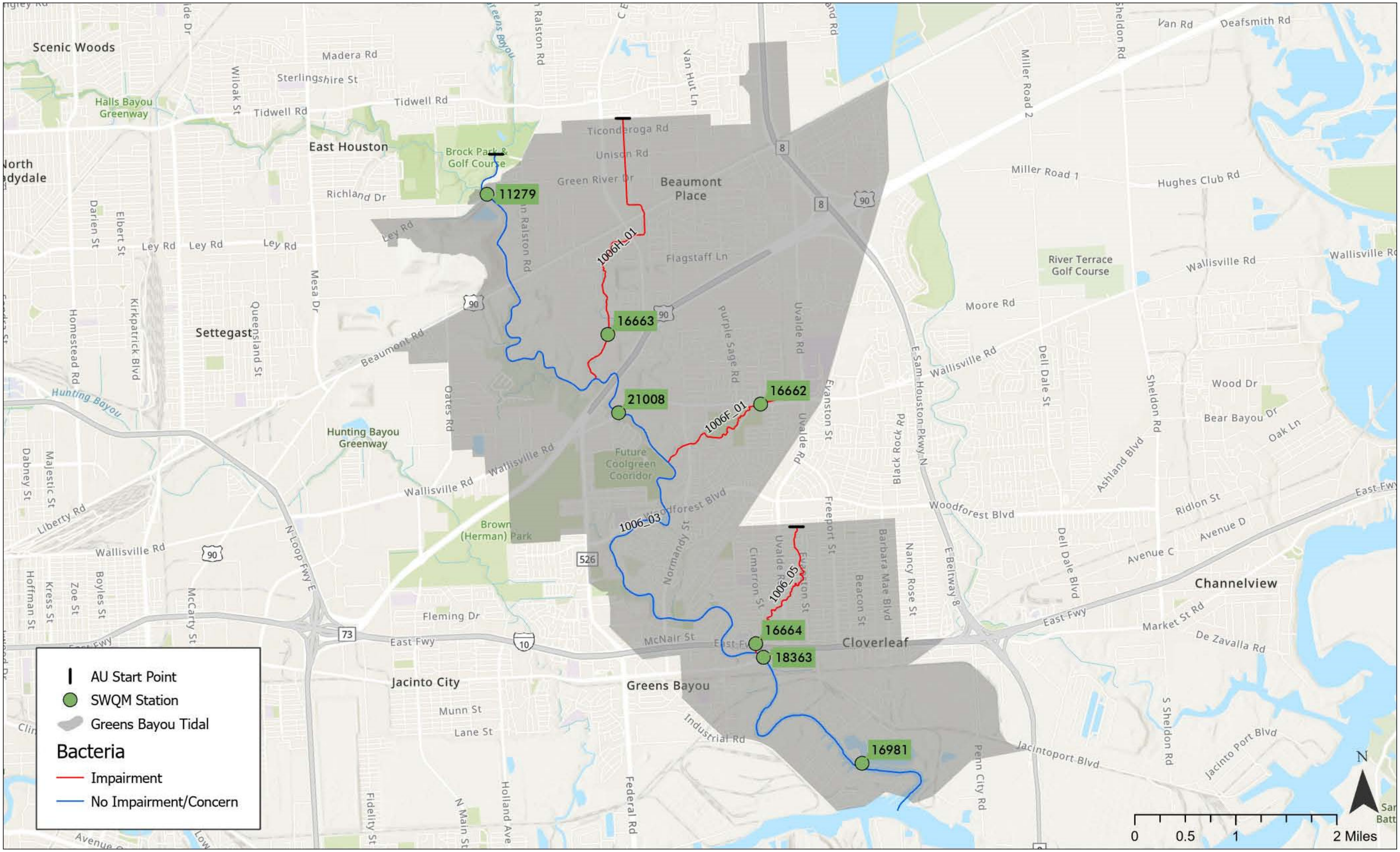
Parameter	AU ID	Level of Support	Category	Geometric Mean (MPN/100mL) Samples Exceeding Standard (2022 IR) 12/1/13 – 11/30/20	H-GAC Trend Analysis 1/1/15 – 5/31/22
Enterococci Geometric Mean	1006_03	FS	–	62.72	Stable
	1006_05	NS	5c	181.3	Stable
E. coli Geometric Mean	1006F_01	NS	4a	600.73	Stable
	1006H_01	NS	4a	335.35	Stable

Category

4a = A state-developed TMDL has been approved by EPA or a TMDL has been established by EPA for any water-pollutant combination.
5c = Additional data and information will be collected or evaluated before a management strategy is selected.

Integrated Level of Support

FS	= Fully Supporting	NC	= No Concern
NS	= Non-Supporting	CN	= Use Concern
		CS	= Screening Level Concern



Map 35: Bacteria Impairments and Concerns for Segment 1006 - Greens Bayou Tidal (2022 IR)

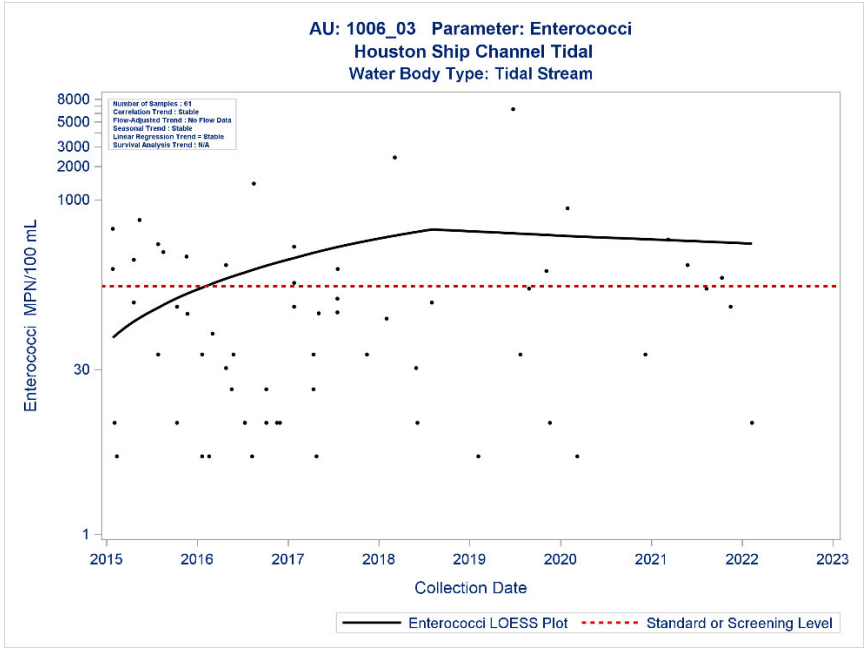


Figure 13: Seven-Year Enterococci trend for AU 1006_03 (Greens Bayou Tidal), 2015-2022

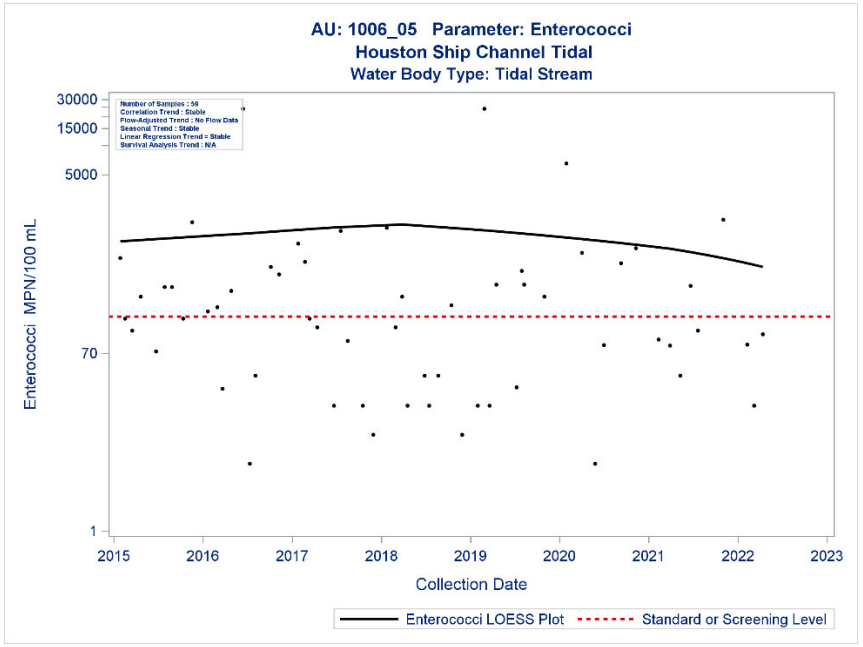


Figure 35: Seven-Year Enterococci trend for AU 1006_05 (Greens Bayou Tidal), 2015-2022

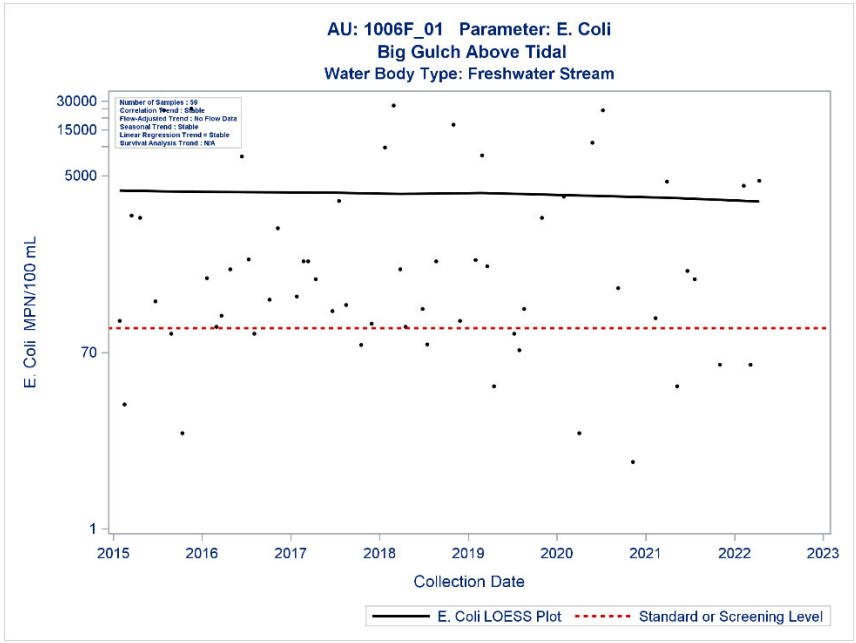


Figure 14: Seven-Year E. coli trend for AU 1006F_01 (Big Gulch Above Tidal), 2015-2022

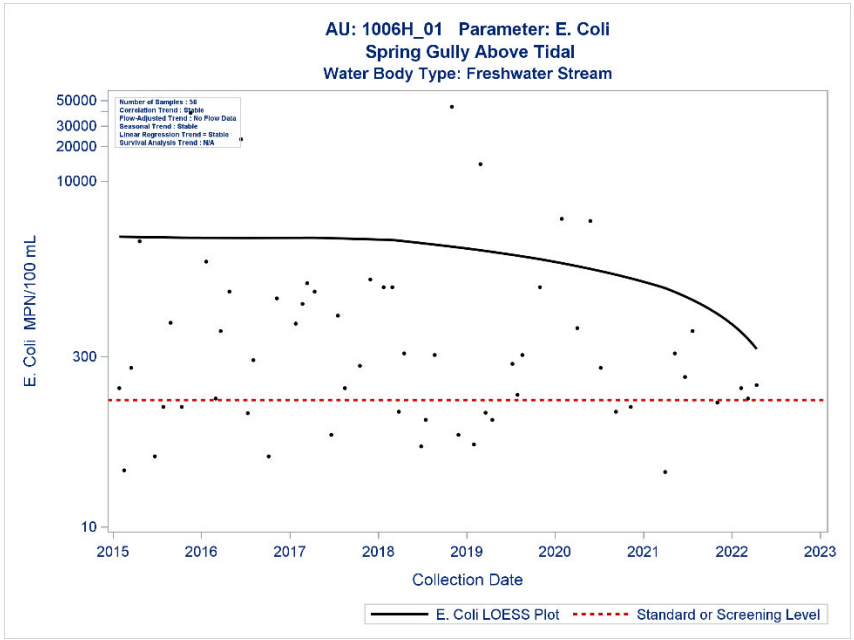


Figure 15: Seven-Year E. coli trend for AU 1006H_01 (Spring Gully Above Tidal), 2015-2022

PCBS AND DIOXIN CONCERNS

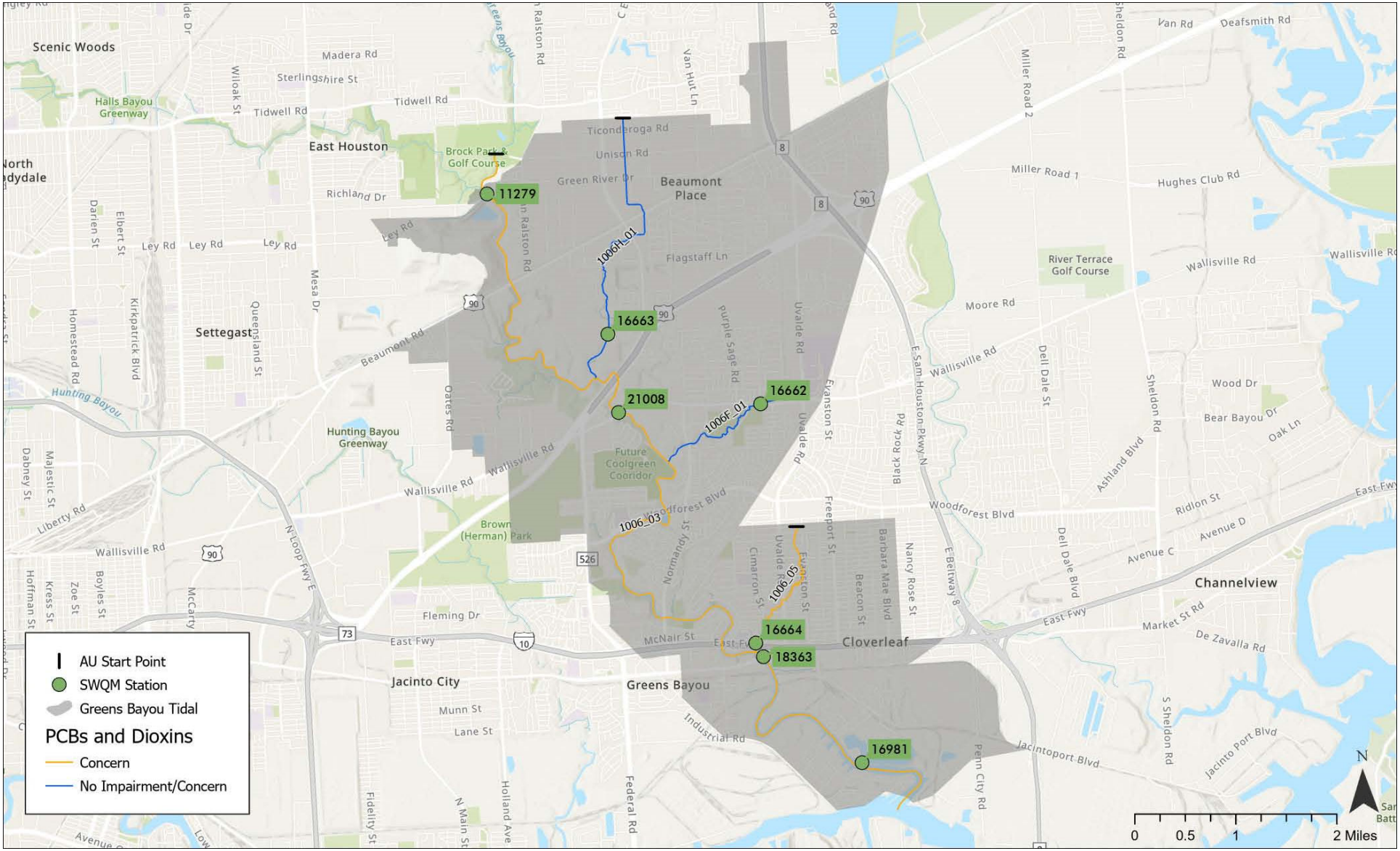
Segments 1006_03 and 1006_05 in this watershed have concerns for polychlorinated biphenyls (PCBs) and Dioxins in fish tissue. While the Texas Department of State Health Services (DSHS) has issued a No Consumption Advisory for the Houston Ship Channel (Segment 1006) based upon PCBs and Dioxin. Fish and Shellfish Advisory 55 (ADV- 55) has been issued as a result of sampling in the Houston Ship Channel. Blue crab and fish samples collected from the Houston Ship Channel indicate the presence of PCBs and Dioxins at concentrations exceeding established health assessment guidelines. Therefore, these same AUs are non-supporting of fish consumption use. A modification to ADV-55 was issued in March 2019 due to the possible presence of volatile organic compounds resulting from the ITC Tank Fire incident in Deer Park. Consumption of blue crab and fish from this water body may pose a threat to human health.

Table 35: 2022 IR PCBs/Dioxin Concerns (2013-2020)

Parameter	AU ID	Level of Support	Category
PCBs in Edible Fish Tissue	1006_03	CS	–
PCBs in Edible Fish Tissue - DSHS No Consumption Advisory		NS	5a
Dioxin in Edible Fish Tissue - DSHS No Consumption Advisory		NS	5a
PCBs in Edible Fish Tissue	1006_05	CS	–
PCBs in Edible Fish Tissue - DSHS No Consumption Advisory		NS	5a
Dioxin in Edible Fish Tissue - DSHS No Consumption Advisory		NS	5a

Category
5a = A TMDL is underway, scheduled, or will be scheduled.

Integrated Level of Support	
NS	= Non-Supporting
CS	= Screening Level Concern



Map 36: PCBs/Dioxin Concerns for Segment 1006 - Greens Bayou Tidal (2022 IR)

TOXIC SUBSTANCES IN SEDIMENT CONCERNS

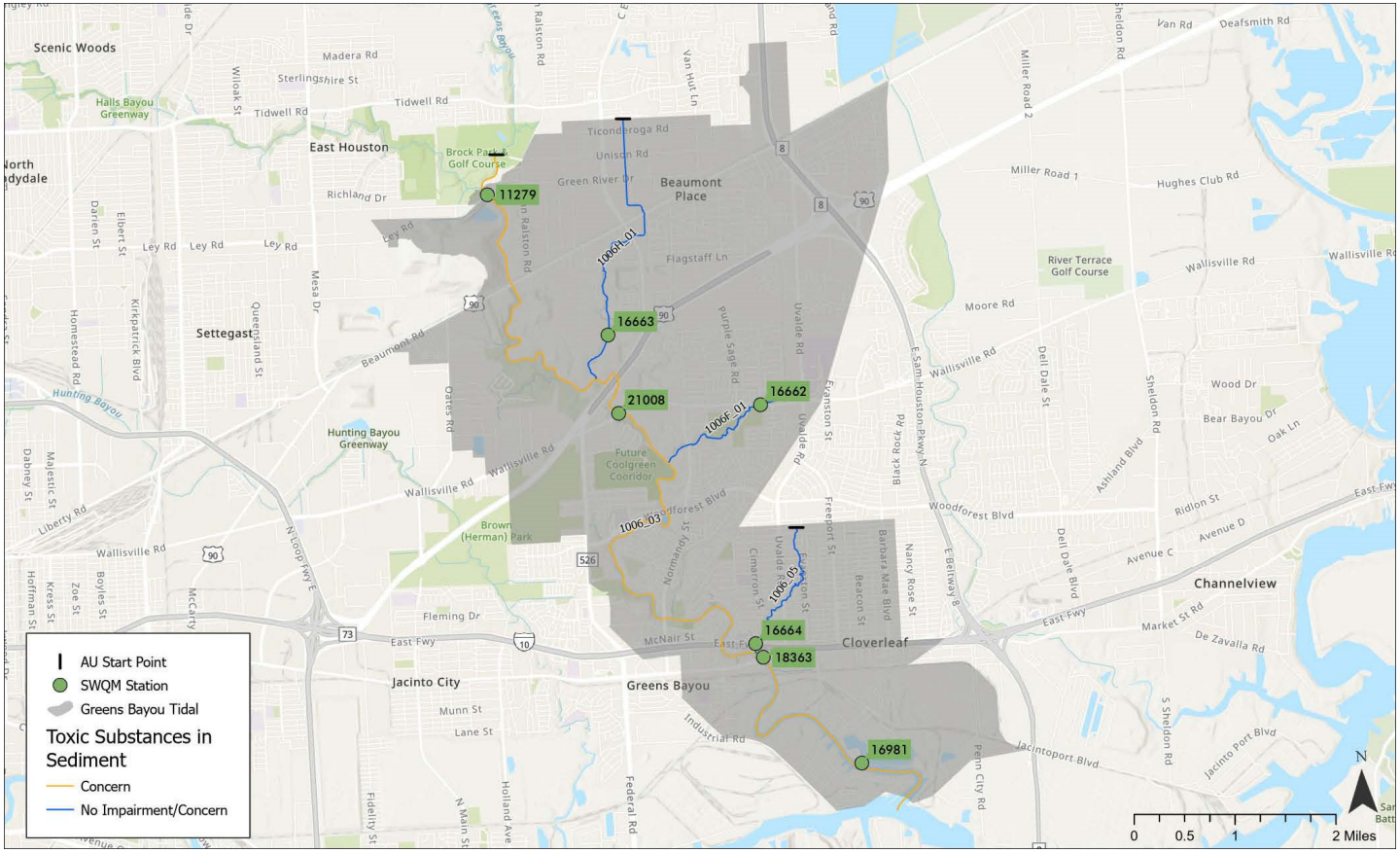
AU 1006_03 is assessed for Toxic Substances in Sediment. A screening level concern for the pesticide DDT was identified for this AU. DDD, a product of the breakdown of DDT, was also identified as a concern in the 2022 IR.

Table 36: 2022 IR Results for Toxic Substances

Parameter	AU ID	Level of Support
DDT (Dichlorodiphenyltrichloroethane)	1006_03	CS
DDD (Dichlorodiphenyldichloroethane)	1006_03	CS

Integrated Level of Support

CS = Screening Level Concern



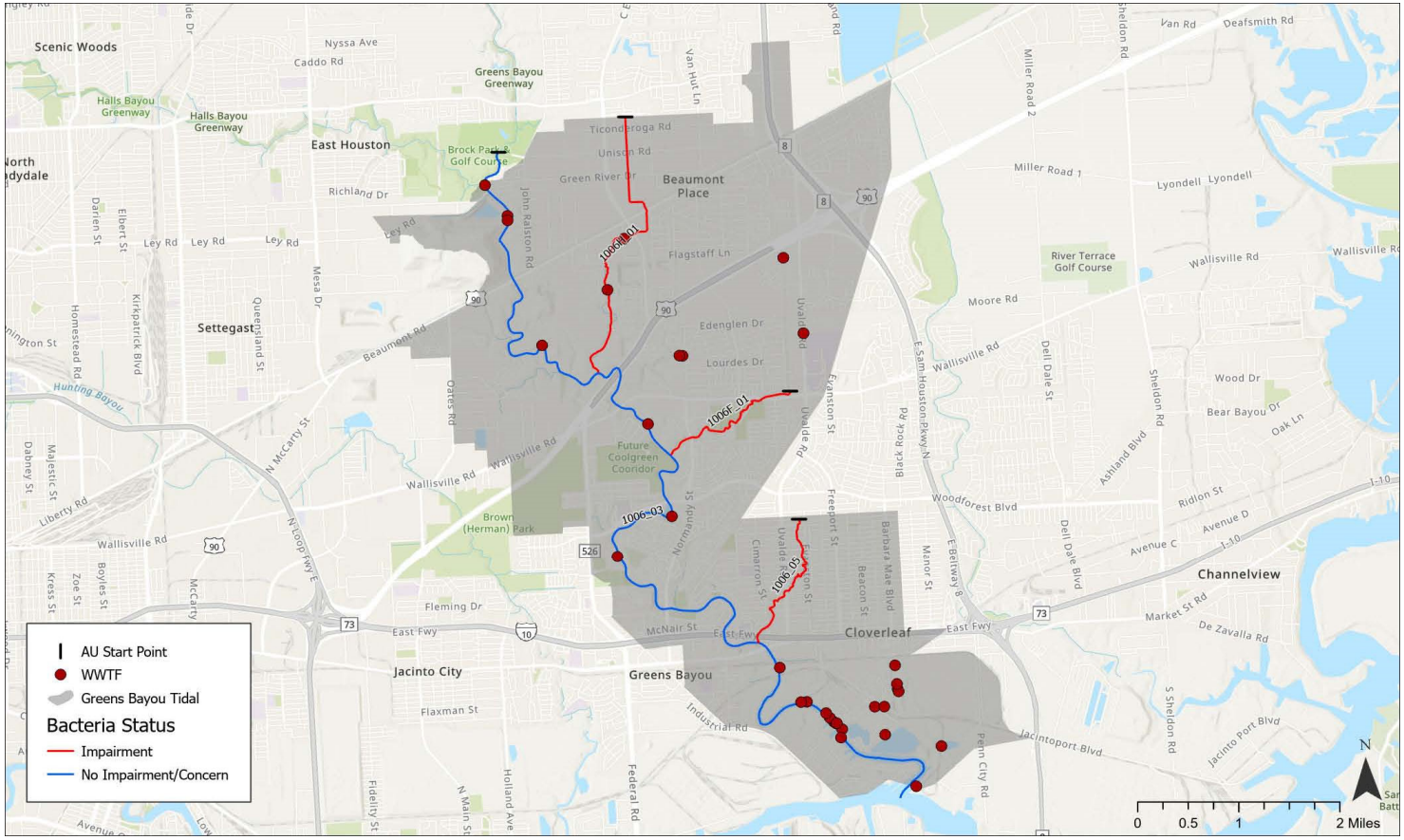
Map 37: Toxic Substances in Sediment Concerns for Segment 1006 - Greens Bayou Tidal

POTENTIAL SOURCES OF WATER QUALITY ISSUES

Potential sources of fecal indicator bacteria and nutrients in the Greens Bayou Tidal watershed include both point and nonpoint sources. These sources include wastewater treatment facility outfalls, industrial discharges, sanitary sewer overflows, failing on-site sewage facilities, stormwater runoff, and animal waste.

PERMITTED EFFLUENT DISCHARGES

There are 35 permitted outfalls in the Greens Bayou Tidal watershed (AUs 1006_03 and 1006_05). Of these outfalls, 6 are classified as domestic sewage with a discharge of <1 million gallons per day (MGD). There are 17 permittees with a discharge of ≥1 MGD. As discussed in the *2022 Water Quality Management Plan Update*, smaller wastewater treatment facilities (those with flows of <1 MGD) throughout the Houston-Galveston region tend to have the highest rate of bacteria geometric mean exceedances (1.5% in 2021) when compared to other size categories. There are also 10 stormwater and 2 groundwater discharge outfalls in the watershed. Permitted outfalls are shown in the accompanying map. A list of permits in the watershed is included in the Appendix.

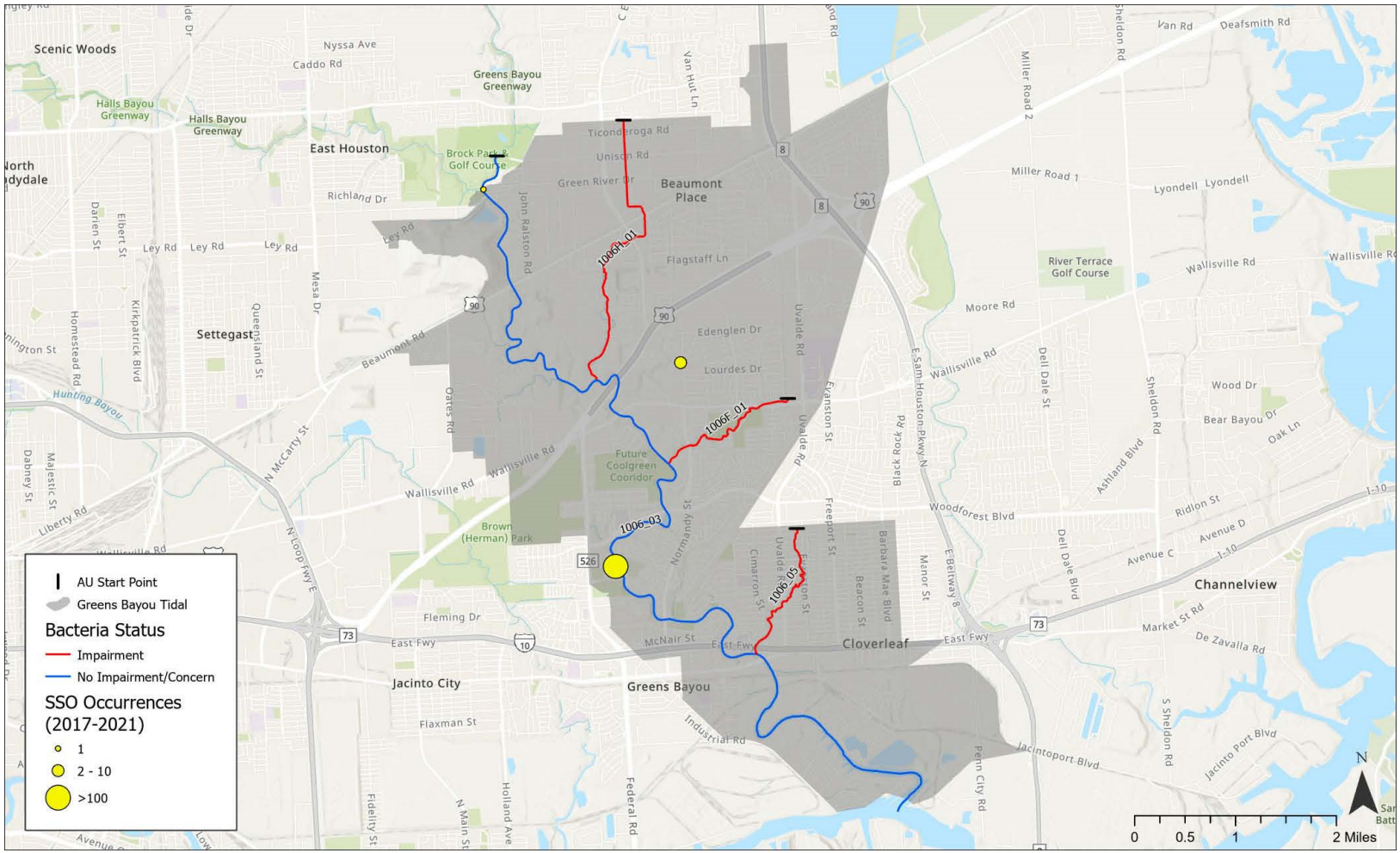


Map 38: Permitted Effluent Discharges for Segment 1006 - Greens Bayou Tidal (2022)

SANITARY SEWER OVERFLOWS

For the period of 2017 – 2021, 3 permittees reported a total of 185 sanitary sewer overflows in the Greens Bayou Tidal watershed. The total reported volume of these discharges was 179,688 gallons. While this number and volume of SSOs may not necessarily cause chronically high bacteria levels within this waterway, each discrete event may cause acute conditions that could affect public health.

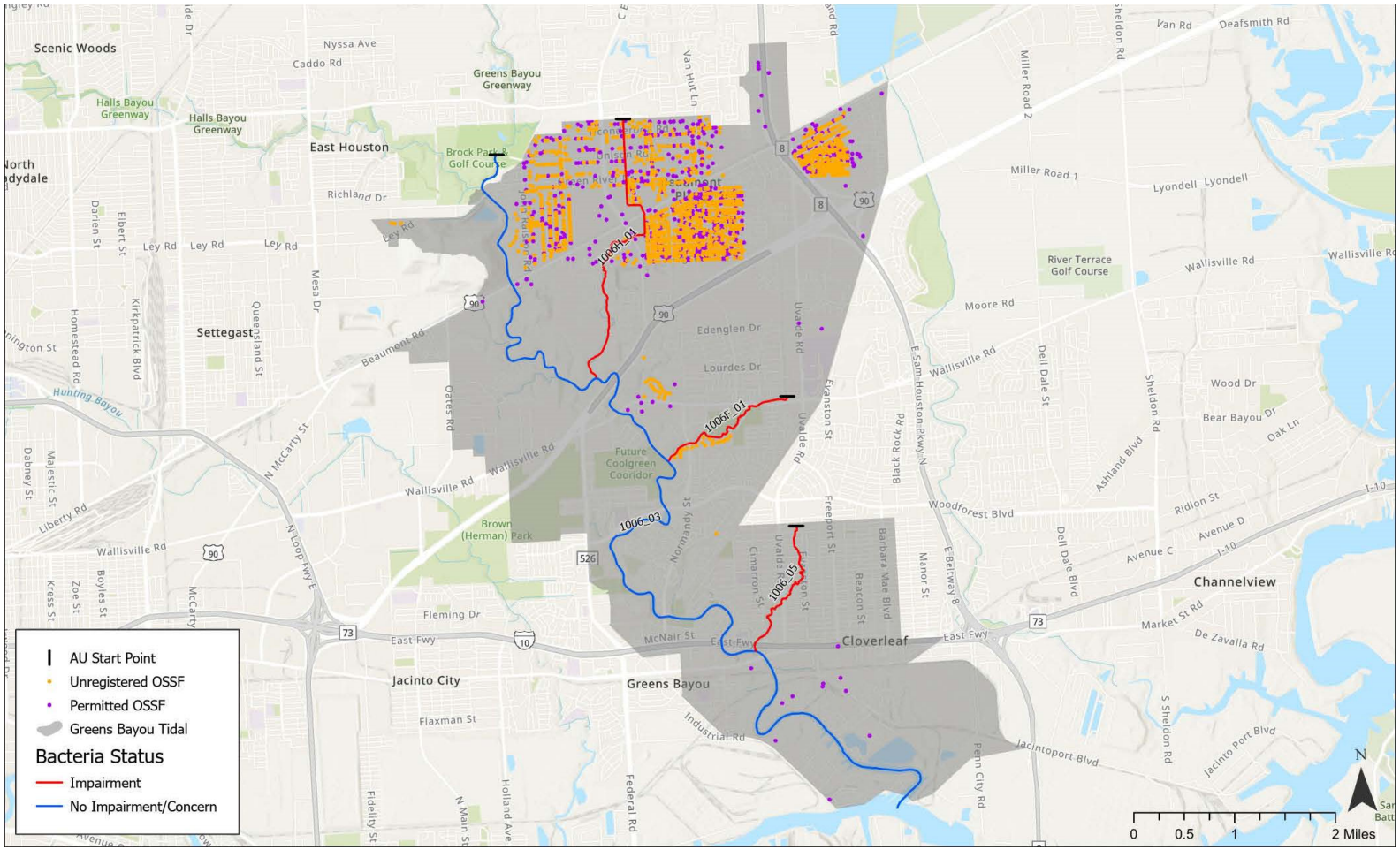
Sources of sanitary sewer overflows include aging wastewater infrastructure, mechanical failure, inflow and infiltration, and improper disposal of fats, oils, and grease. Flooding issues within the Greens Bayou watershed contribute to the frequency, volume, and duration of SSOs.



Map 39: Sanitary Sewer Overflows for Segment 1006 - Greens Bayou Tidal (2017-2021)

ON-SITE SEWAGE FACILITIES

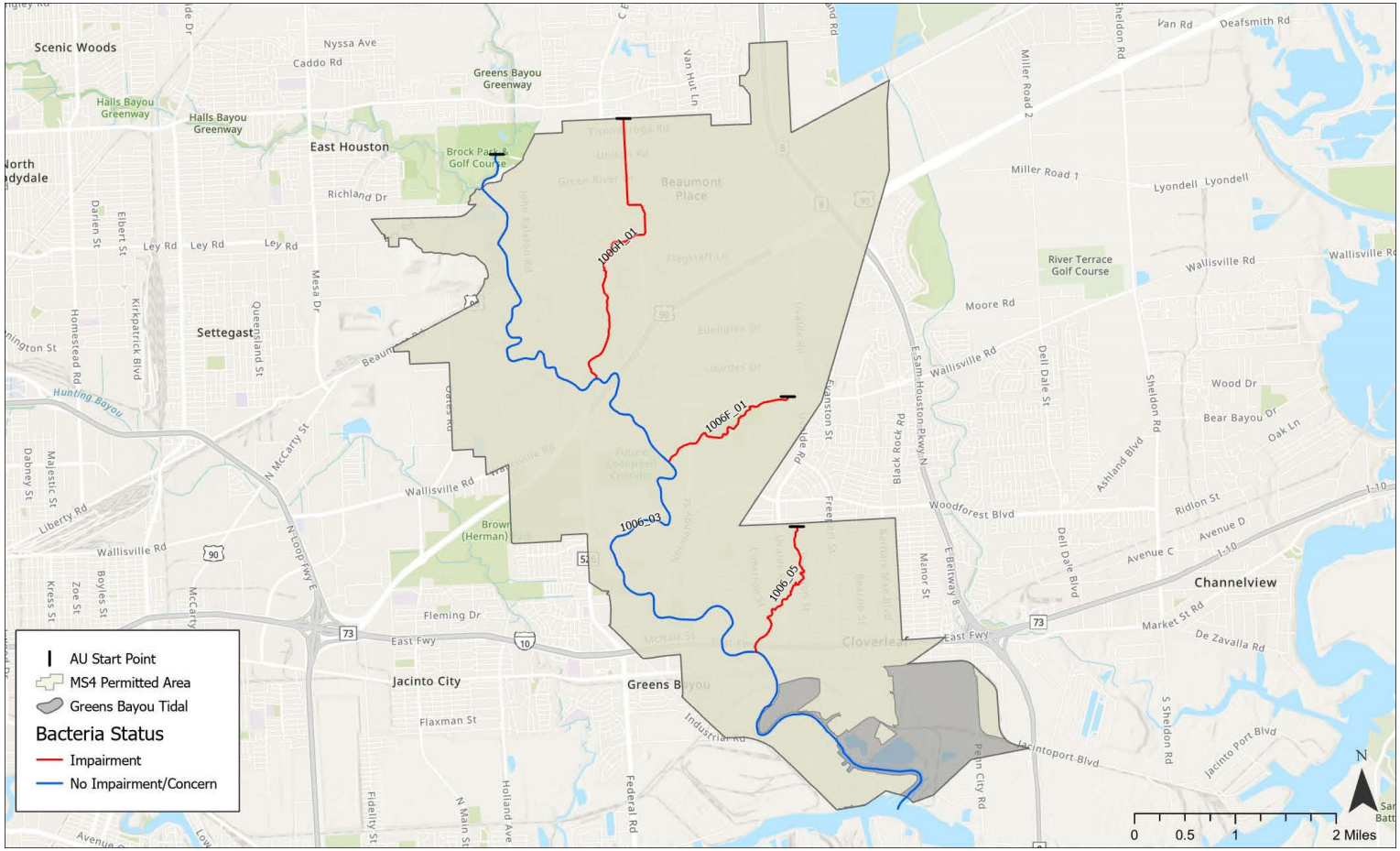
Although the majority of the watershed is serviced by residential sewer collection systems and wastewater treatment facilities, there are areas within the watershed where on-site sewage facilities are utilized. Within the Greens Bayou Tidal watershed, there are 604 permitted OSSFs, with an estimated 1,247 unpermitted OSSFs. Please note that many of the OSSFs within the unincorporated portion of Harris County were permitted by the county between 1978 – 1992. Historical permit records from that time frame are not available electronically in the current OSSF database, so many of those systems show up as unpermitted. H-GAC is currently in the process of digitizing and converting those historical records so that this data can be available electronically for use by both H-GAC and Harris County. Once these permit records are converted, maps, and counts of permitted and unpermitted systems can be revised to reflect actual on-the-ground conditions.



Map 40: On-Site Sewage Facilities for Segment 1006 - Greens Bayou Tidal

URBAN RUNOFF/STORM SEWERS

Due to the significant floodplains, the amount of development with impervious land cover within the watershed and the slow-draining soils, urban runoff can contribute to nutrient and bacteria contamination of waterways. The Tidal portion of the Greens Bayou watershed is covered by stormwater permits. The City of Houston, Harris County, and the Harris County Flood Control District hold Phase I stormwater permits with the Texas Commission on Environmental Quality, providing 100% coverage. Additionally, smaller local governmental entities hold Phase II stormwater permits within the watershed. The state's stormwater permitting program covers both phases, describing the minimum requirements each entity must meet to ensure water quality protection and address identified impairments. To search for more information on a general permit (including stormwater), please visit TCEQ's Water Quality General Permits Search tool.



Map 41: MS4 Permitted Areas for Segment 1006 - Greens Bayou Tidal

POTENTIAL STAKEHOLDERS

Potential stakeholders in the watershed include:

- City of Houston
- City of Humble
- Harris County Flood Control District (HCFCD)
- Harris County Precinct 1
- Harris County Precinct 2
- Harris County Precinct 3
- Houston Parks Board
- Houston Parks and Recreation Department
- Houston Public Works Department
- National Parks Service
- Texas Parks and Wildlife
- Bacteria Implementation Group
- United States Geological Survey
- US Army Corps of Engineers (USACE) Galveston District
- Texas General Land Office
- East Aldine Management District
- Special Districts (Municipal Utility Districts, Water Control & Improvement Districts, etc.)
- Texas A&M Forest Service
- Greens Bayou Coalition
- North Houston Association
- Bayou Preservation Association
- Galveston Bay Estuary Program
- Galveston Bay Foundation
- The Nature Conservancy
- Industrial Facilities
    - Valero Energy Corporation
    - Chevron Phillips Chemical Company
    - Marathon Petroleum Corporation
    - LyondellBasell Industries
    - Huntsman Corporation
    - Waste Management, Inc.
    - Air Liquide
    - Praxair, Inc.

RECOMMENDATIONS FOR IMPROVING WATER QUALITY

- Development of a watershed protection plan to address bacteria impairments and concerns
- Address bacteria and nutrient concerns through stakeholder involvement and best management practices
- Continue collecting water quality data and expand monitoring efforts to support actions associated with the development of a Watershed Protection Plan
- Continue to work with the BIG to implement the I-Plan recommendations for bacteria reduction
- Continue to analyze Discharge Monitoring Report data and present results to TCEQ, wastewater permittees, local governments/utility districts, and
- stakeholders through updates to the Regional Water Quality Management Plan
- Continue to analyze sanitary sewer overflow data from regulated dischargers and present results to TCEQ, wastewater permittees, local governments/utility districts, and stakeholders through updates to the Regional Water Quality Management Plan
- Improve compliance and enforcement of existing stormwater quality permits and improve stormwater controls in new developments
- Expand use of low impact development and green infrastructure practices
- Consult stakeholders to identify illegal dumping sites and improve signage and/or cameras, if needed
- Pursue new local partners to collect additional data to help better isolate problem areas
- Expand volunteer monitoring with Texas Stream Team in areas without professional monitoring
- Support programs to assist homeowners with the repair or replacement of failing on-site sewage facilities
- Support programs to assist homeowners with on-site sewage facilities to connect to centralized sewer collection systems (where practical)
- Support public education programs to inform business and homeowners on appropriate disposal of fats, oil, grease, and wipes
- Support programs to educate homeowners on proper management of pet wastes

WATERSHED PROJECTS

- **Implementation Plan for One Hundred and Three Total Maximum Daily Loads for Bacteria in the Houston-Galveston Region**
  A TMDL for Greens Bayou was approved by the Bacteria Implementation Group on October 16, 2012, and by TCEQ on January 20, 2013. It has been revised multiple times, with the latest revision by the Bacteria Implementation Group occurring on June 5, 2018 (Addendum 4).

- **Greens Bayou Watershed Protection Plan Development**
  In 2022, the Houston-Galveston Area Council was awarded $397,831.50 through the United States Environmental Protection Agency's (EPA) Clean Water Act 319(h) grant program administered locally by the TCEQ to facilitate stakeholders in the development of a voluntary, community-led watershed protection plan to address bacteria impairments and concerns for low dissolved oxygen and high nutrient concentrations

  Work will begin in the fall of 2023 and is expected to continue for a duration of three years. The project will engage stakeholders to develop a WPP to address listed impairments, concerns, and stakeholder-identified water quality priorities in the waterways of the Greens Bayou watershed. The WPP will be developed to conform to the EPA's 9-element watershed-based plan standard and will utilize existing data for technical analysis. H-GAC will update existing water quality analyses with additional ambient data acquired from 28 stations monitored by the Clean Rivers Program and sanitary sewer overflow and discharge monitoring reports data from the TCEQ. Further, H-GAC will develop modeling analyses using the Spatially Explicit Load Enrichment Calculation Tool (SELECT) and load duration curves (LDCs) to assess causes and sources of pollution and establish reduction targets for compliance. Refinement will utilize stakeholder review and update of data sources as needed. The modeling will inform stakeholder decisions by indicating the potential causes, extent, and required reductions associated with water quality issues.

MAJOR WATERSHED EVENTS

- Flooding Events in Greens Bayou
  There have been frequent and numerous flooding events in the Greens Bayou Tidal watershed. This is due to significant floodplains alongside high-density development and impervious surfaces. As much of this areas development occurred prior to restrictions on building in the floodplains, these events typically result in severe damages to homes and businesses. Tropical Storm Allison in 2001 and Hurricane Harvey in 2017 resulted in devastating flood levels throughout the watershed. Numerous other flooding events have affected the Greens Bayou watershed.

- Harris County Flood Control District Flood Control Projects
  The HCFCD has numerous flood control projects in the watershed. These include completed projects, projects under construction, and projects still in the planning/feasibility study stage.

    - Z-03 Flood Risk Reduction Downstream of Lower Greens Bayou Stormwater Detention Basin
    - Z-04 East Houston Medical Center Stormwater Detention Basin
    - F-40 Lower Greens Bayou Regional Detention Embankment

- Home Buyout Program
  Home buyouts are used by the HCFCD to reduce flood damage in areas that are within the floodplain where structural projects such as stormwater detention basins or channelization to reduce flooding would not be cost-effective or beneficial. Through this program, properties that have frequently been inundated through flood events have been purchased at fair-market value. These flood-prone structures are then removed.

- Houston Parks Board Greens Bayou Watershed Completed Projects
    - Coolgreen Park
        - Reconstruction of dam/drop structures at Coolgreen Park that were damaged by Hurricane Harvey.
        - Riparian Reforestation – completed removal of invasive species and planting of 3,500 native seedlings.

Photo 16: Drop structure repair at Coolgreen Park, before (left) and after (right) (photos courtesy of the Houston Parks Board)

- Strickland Park
  - Riparian Reforestation – completed removal of invasive species and planting of 500 native seedlings.
- Thomas Bell Foster Park
  - Riparian Reforestation – completed planting of 200 native seedlings.
  - Native Landscaping – creation of a native landscape bed.
  - Wetlands – creation of a freshwater wetland.

Photo 17: Native landscaping at Thomas Bell Foster Park (Photo courtesy of the Houston Parks Board)

Photo 18: Freshwater wetlands at Thomas Bell Foster Park (Photo courtesy of the Houston Parks Board)

Photo 19: Riparian reforestation at Thomas Bell Foster Park (Photo courtesy of the Houston Parks Board)

COMMUNITY ENGAGEMENT

The Bayou Greenways 2020 project is creating a continuous linear park system along Houston's major waterways. In 2019, the Houston Parks Board constructed kayak launch sites on Greens Bayou as part of the project. Launch sites have been completed at Brock Park and Strickland Park, with a launch site under construction at Thomas Bell Foster Park and another in the design phase at W. E. Bill Crowley Park. The Greens Bayou Greenway also includes pedestrian bridges, updated landscaping, and paved and natural walking and biking trails along the bayou.

The Houston Parks Board is currently constructing a new 3.6-mi Greens Bayou Greenway segment between Strickland Park and Green Dolphin Steet, between US90 and Business 90, and between Brock Park and Tidwell Road in East Houston. In the process of designing this greenway, the Houston Parks Board acquired 267 acres of land along Green Bayou Tidal for conservation and preservation. This additional land will allow the greenway to be further from the bayou's edge and create a nature-based experience, unlike any other Bayou Greenway. A natural surface trail was designed to minimize the impact on the woodland forest, cypress bog, and tributary crossings.

The Greens Bayou Coalition tries to organize at least one group clean-up or tree planting event each month along the bayou or at a flood control or utility district basin to encourage clean waters, flood mitigation, and quality of life along the bayou. In addition to the benefits of cleaning up trash and debris, these events help train a new generation of environmental stewards.

The Greens Bayou Coalition's Kayaking for Kids program introduces inter-city youth to ecological concepts and environmental stewardship through kayaking trips along Greens Bayou.

The Annual Regatta is a paddling event on the southern portion of Greens Bayou. The Houston Park Board kayak launch sites at Strickland and Thomas Bell Foster Parks allow people to have easy access to the bayou.

IMAGES OF THE WATERSHED

Photo 20: Monitoring Station 11279 Greens Bayou Tidal (1006) immediately downstream of Green River Road/Ley Road (upstream)

Photo 21: Monitoring Station 21008 - Greens Bayou (1006) at Wallisville Road (upstream)

Photo 22: Kayaking on Greens Bayou Tidal (Photo courtesy of Greens Bayou Coalition staff and volunteers)

APPENDICES

APPENDIX A: Acronyms & Abbreviations

APPENDIX B: Glossary of Water Quality Terms

APPENDIX C: Water Quality Parameters

APPENDIX D: Water Quality Technical Primer

APPENDIX E: Statistical Methodology

APPENDIX F: Permitted Wastewater Outfalls

APPENDIX G: EJSCREEN Reports

APPENDIX H: Significant AU Trends

APPENDIX A: ACROMYMS & ABBREVIATIONS

ALU	Aquatic Life Use
AU	Assessment Unit
BIG	Bacteria Implementation Group
BMP	Best Management Practices
CE	Collecting Entity
CFS	Cubic feet per second
CFU	Colony-Forming Unit
CMS	Coordinated Monitoring Schedule
CN	Concern for near nonattainment
CRP	Clean Rivers Program
CS	Concern for screening levels
CWA	Clean Water Act
DMR	Discharge Monitoring Report
DO	Dissolved Oxygen
DSHS	Department of State Health Services
E. coli	*Escherichia coli*
EIH	Environmental Institute of Houston, University of Houston-Clear Lake
EJSCREEN	Environmental Justice Screening and Mapping Tool
EPA	U.S. Environmental Protection Agency
FO	Field Operations
FROG	Fats, rags, oils, and grease
FS	Fully Supporting designated use
FY	Fiscal Year
H-GAC	Houston-Galveston Area Council
HCFCD	Harris County Flood Control District
HH	Houston Health Department
I-Plan	Implementation Plan
IR	Texas Integrated Report for Clean Water Act Sections 305(b) and 303(d)
km	kilometer
L	liter
LDC	Load Duration Curve
LOESS	Locally Weighted Least Squares Plot
LOQ	Limit of Quantitation
mg	milligram
mg/L	milligram per liter
MGD	Millions of Gallons per Day
mi	mile
mg	milligram
mL	milliliter
MPN	Most Probably Number
MS4	Municipal Separate Storm Sewer System
MT	Monitoring Type
NC	No Concern
NCR	Noncontact Recreation
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source Pollution
NS	Nonsupport for designated use
OSSF	On-Site Sewage Facility
PCB	Polychlorinated biphenyl
PCR1	Primary Contact Recreation 1
PCR2	Primary Contact Recreation 2
QAPP	Quality Assurance Project Plan
RUAA	Recreational use attainment analysis
SAS	Statistical Analysis System
SCR1	Secondary Contact Recreation 1
SCR2	Secondary Contact Recreation 2
SE	Submitting Entity
SELECT	Spatially Explicit Load Enrichment Calculation Tool
SEP	Supplemental Environmental Project
SJRA	San Jacinto River Authority
SSO	Sanitary Sewer Overflow
SWQM	Surface Water Quality Monitoring
SWQMIS	Surface Water Quality Monitoring Information System
TCEQ	Texas Commission on Environmental Quality
TDS	Total Dissolved Solids
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TPDES	Texas Pollutant Discharge Elimination System
TRIES	Texas Research Institute for Environmental Studies
TSS	Total Suspended Solids
TSSWCB	Texas State Soil and Water Conservation Board
TSWQS	Texas Surface Water Quality Standards
UAA	Use Attainability Analysis
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
WPP	Watershed Protection Plan
WWTF	Wastewater treatment facility

APPENDIX B: GLOSSARY OF WATER QUALITY TERMS

A

Algae - Plants that lack true roots, stems and leaves.
Algae consist of non-vascular plants that attach to rocks and debris or float freely in the water. Such plants may be green, blue-green, or olive-green and slimy to the touch. They usually have a coarse filamentous structure.

Ambient - The existing water quality in a particular water body (beyond the immediate influence of a discharge pipe).

Ammonia-Nitrogen (NH_3) - Ammonia, naturally occurring in surface and wastewaters, is produced by the breakdown of compounds containing organic nitrogen.

Aquatic Community - An association of interacting populations of aquatic organisms in a given water body or habitat.

Aquatic Life Use (ALU) - A designation assigned to an individual water body segment based upon the potential to support aquatic life.

Assessment Unit (AU) - The smallest geographic areas of a water body that can support a designated or site-specific use.

Attainable Use - A use that can be reasonably achieved by a water body in accordance with its physical, biological, and chemical characteristics whether it is currently meeting that use or not. Guidelines for the determination and review of attainable uses are provided in the standards implementation procedures. The designated use, existing use, or presumed use of a water body may not necessarily be the attainable use.

Assessed Waters - Water bodies for which the State is able to make use-support decisions based on actual information.

B

Basin - Large geographic areas generally containing
one or more watersheds.

Benthos - Aquatic organisms that live on, in, or near the bottom of a water body, including worms, leeches, snails, flatworms, burrowing mayflies and clams.

Best Management Practices (BMPs) - Schedules of activities, maintenance procedures, and other management practices to prevent or reduce the pollution of water to the maximum extent practicable. Best management practices include treatment requirements, operating procedures, and practices
to control plant site runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage.

Bloom - The accelerated growth of algae and/or higher aquatic plants in a body of water. Bloom is often related to pollutants that increase the rate of growth.

C

Channelization - Straightening and deepening streams so water will move faster. A method of flood control that disturbs fish and wildlife habitats and can interfere with a water body's ability to assimilate waste.

Chloride (Cl^-) - One of the major inorganic ions in water and wastewater. Concentrations can be increased by industrial processes. High chloride
concentrations can affect metallic objects and growing plants.

Chlorophyll-*a* - A photosynthetic pigment found in all green plants. The concentration of chlorophyll a is used to estimate phytoplankton biomass (all of the phytoplankton in a given area) in surface water.

Classified - Refers to a water body that is listed and described in Appendix A or Appendix C of the Texas Surface Water Quality Standards.

Coastal Basin - A collection of watersheds adjacent to the coastline that water flows through on its way to the ocean. Typically, coastal basins are between and bound by to

major river basins and a bay or other outlet to the ocean.

Concentration - The amount or mass of a substance present in a given volume or mass of samples.

Conductivity - A measure of the carrying capacity for electrical current, in mhos/cm, of 1 cm^3 of water at 25°C. Dissolved substances in water dissociate into ions with the ability to conduct electrical current. Conductivity is a measure of how salty the water is. Salty water has high conductivity.

Confluence - The flowing together of two or more streams, including where a tributary joins another, usually larger, stream segment.

Contact Recreation - Recreational activities involving a significant risk of ingestion of water; including wading by children, swimming, water skiing, diving, and surfing. See also noncontact recreation.

Contamination - Degradation of water quality due to human activity (as compared to the original or natural conditions).
Conventional Parameters - A list of basic parameters that require laboratory analyses. The parameters frequently include, but are not limited to, solids (TSS and TDS), nutrients (nitrogen and phosphorus compounds), chlorides, and sulfates.

Criteria - Water-quality conditions that are to be met in order to support and protect desired uses.

D

Designated Use - A use that is assigned to specific
water bodies in Appendix A or in Appendix D of the Texas Surface Water Quality Standards. Typical uses that may be designated for specific water bodies include domestic water supply, categories of aquatic- life use, kinds of recreation, and aquifer protection.

Dioxin - A family of polychlorinated chemicals found in waste from the paper bleaching processes and the combustion of chlorinated compounds. It is considered carcinogenic and can disrupt the reproductive and immune systems in humans.

Discharge - The rate of fluid flowing past a given point at a given time.

Dissolved Oxygen (DO) - The oxygen freely available in water. Dissolved oxygen is vital to fish and other aquatic life and for the prevention of odors. Traditionally, the level of dissolved oxygen has been accepted as the single most important indicator of a water body's ability to support desirable aquatic life.

Dissolved Oxygen (DO) Measurements, 24-hour - The measurement of dissolved oxygen over a 24-hour period using deployed, unattended, automated equipment preset to record and store field measurements over one 24-hour period. These measurements are used to assess Aquatic Life Use.

Drought - A time of less-than-normal or less-than-expected rainfall.

E

E. coli - *Escherichia coli*, a member of the total coliform group of bacteria found in feces. It indicates fecal contamination and the possible presence of enteric pathogens (viral, protozoan, and bacterial pathogens of the gastrointestinal route)..

Effluent - Wastewater (treated or untreated) that flows out of a treatment plant or industrial outfall (point source) prior to entering a water body.

Enterococci - A subgroup of fecal streptococcal bacteria (mainly *Streptococcus faecalis* and *Streptococcus faecium*) found in the intestinal tracts and feces of warm-blooded animals. It is used as an indicator of the potential presence of pathogens.

Estuary - Regions of interaction between rivers and near shore ocean waters, where tidal action and river flow create a mixing of fresh and salt water.

Eutrophication - The process by which water becomes enriched with nutrients (particularly phosphorus and nitrogen).

F

Fecal Coliform - A subset of the coliform bacteria
group that is found in the intestinal tracts and feces of warm-blooded animals. Heat-tolerant bacteria from other sources can sometimes be included. It is used as an indicator of the potential presence of pathogens.

Field Parameters - A list of basic tests generally collected in the field using equipment and meters. The list also includes visual observations.

Flood - A relatively high streamflow that overtops the banks of a stream.

Flood Stage - The gage height (or stage) at which overflow of the natural banks of a stream begins to cause damage in the local area from flooding.

Flood Plain - The relatively level area of land bordering a stream channel that is inundated during a flood event.

Fully Supporting (FS) - The water body meets TSWQS or supports its designated uses.

G

Gage Station - A particular site on a stream segment
where systematic observations or hydrologic data are obtained.

Gage Datum - A uniquely selected reference point for each gage site.

Gage Height - The distance (or height) of the stream (or lake) water surface above the gage datum (reference point). Gage height is also called stage, river height, river level, river stage, stream height, stream stage, and water height.

Geographic Information Systems (GIS) - A computerized system for combining, displaying, and analyzing geographic data.

H

Habitat - The area in which an organism lives.

Headwaters - The source and upper part of a stream.

Hydrograph - A graph of the water level or rate of flow of a body of water over time, showing the temporal or seasonal change.

I

Impaired - A designation for an associated use (aquatic life, contact recreation, etc.) where a water quality standard is not attained.

Impairment - A detrimental effect on the integrity of a water body caused by a change in the chemical, physical, or biological quality or condition of a water body that prevents attainment of the designated use.

Implementation Plan (I-Plan) - A formalized written plan developed by stakeholders to address specific concerns (e.g., bacteria) and contain policy recommendations to bring water bodies back into compliance.

Impoundment - A body of water confined by a dam, dike, floodgate, or other barrier.

Indicator Organism - An organism, species or community that indicates the presence of a certain environmental condition or conditions.

Intermittent Stream - A stream that has a period of zero flow for at least one week during most years.

L

Limit of Quantitation (LOQ) - The lowest concentration of a substance that can be accurately measured under specific conditions.

LOESS Plot - a graph that shows the relationship of two variables (measurements or parameter values) made using a technique that calculates the slope
of the plotted line at different time periods (locally weighted least-squares regression), producing a line that usually shows inflections (change points) rather than a straight line that best fits all points. LOESS is not really an acronym but can be thought of as “Local regression.”

M

Macrobenthic Invertebrate - Aquatic bottom-dwelling fauna. Common types are flat worms, leeches, snails, and various insect species.

Monitoring - The process of sampling and analyzing water quality parameters over time.

Municipal Separate Storm Sewer System (MS4) - A conveyance (or system of conveyances) that is owned by a state, city, town, village, or other public entity that discharges to waters of the U.S., is designed to collect or convey stormwater (e.g., storm drains, pipes, ditches), is not a combined sewer, and is not part of a sewage treatment plant or publicly owned treatment works.

N

National Pollutant Discharge Elimination System
(NPDES) - A permit program under Clean Water Act Section 402 that imposes discharge limitations on point sources based upon the effluent limitation capabilities of a control technology or on local water quality standards.

Nekton - The aggregate of actively-swimming aquatic organisms in a body of water able to move independently of water currents.

Nitrate-Nitrogen (NO_3-N) - A compound containing nitrogen that can exist as a dissolved solid in water. Excessive amounts can have harmful effects on humans and animals (>10 mg/L).

Nitrite-Nitrogen (NO_2-N) - An intermediate oxidation state in the nitrification process (ammonia, nitrite, and nitrate).

Noncontact Recreation - Aquatic recreational pursuits not involving a significant risk of water ingestion and limited body contact incidental to shoreline activity; including fishing, and commercial
and recreational boating. See also contact recreation.

Nonpoint Source (NPS) Pollution - A pollution source that is not subject to regulation, that is diffuse and does not have a single point of origin or is not introduced into a receiving stream from a specific outfall. NPS pollution typically results from land runoff, precipitation, atmospheric deposition, drainage, seepage, or hydrologic modification.

Nutrient - Any substance used by living things to promote growth. The term is generally applied to nitrogen and phosphorus in water and wastewater but is also applied to other essential and trace elements.

O

Outfall - A designated point of effluent discharge.

Oyster Waters - Waters producing edible species of clams, oysters, or mussels.

P

Perennial Stream - A stream that has a continuous
flow of surface water throughout the year in at least parts of its catchment area during seasons of normal flow.

Permit - A legally binding document issued by a State or Federal permitting authority to the owner or manager of a point source discharge. The permit document contains a schedule of compliance and specifies monitoring and reporting requirements.

pH - The hydrogen-ion activity of water caused by the breakdown of water molecules and presence of dissolved acids and bases.

Phosphorus - A nutrient that is essential to the growth of organisms. It can be the nutrient that limits the primary productivity of water. In excessive amounts
from wastewater, agricultural drainage, and certain industrial waste it also contributes to the eutrophication (the natural aging progression) of lakes and other water bodies.

Pollution - The alteration of the physical, thermal, chemical, or biological quality of, or the contamination of, any water that renders it harmful, detrimental, or injurious to humans, animal life, vegetation, property, or the public health, safety, or welfare. Pollution may impair the usefulness or the public enjoyment of the water for any lawful or reasonable purpose.

Point Source Pollution - Any source of pollution that is subject to regulation and is permitted. An example of a point source is a permitted wastewater treatment facility effluent discharge.

Polychlorinated Biphenyls (PCBs) - A class of organic compounds used in dielectric fluids in transformers, capacitors, and coolants. PCBs are highly toxic and are associated with endocrine disruption and neural toxicity in humans.

Pool - A small part of a stream reach with little-to-no velocity. Pools commonly contain water deeper than surrounding areas.

Precipitation - Any or all forms of water particles that fall from the atmosphere (such as rain, snow, hail, etc.).

Public Water Supply (PWS) Use - A water body designated to provide water to a public water system.

Q

Quality Assurance Project Plan (QAPP) - A written
document outlining the procedures a monitoring project will use to ensure the data it collects and analyzes meets project requirements.

R

Reach - A continuous part of a stream between two
specified points.

Receiving Waters - Waters that receive treated or untreated wastewaters.

Recreational Use Attainment Analysis (RUAA) - A Use Attainment Analysis that is designed to determine if contact recreation is an appropriate use of a water body.

Reservoir - Any natural or artificial holding area used to store, regulate, or control water.

Riparian - Areas adjacent to streams or rivers with a high density, diversity, and productivity of plant and animal species relative to nearby uplands.

River Basin - A collection of watersheds drained by a major river and its tributaries.

Routine Monitoring - Monitoring that is scheduled in advance without intentionally trying to target a certain environmental condition. Routine monitoring typically consists of field measurements, conventional chemical parameters, bacteria, and flow measurements.

Runoff - The part of precipitation or irrigation water that runs off land into streams and other surface water.

S

Screening Level - Established targets (instream concentrations) for parameters that establish targets that can be directly compared to monitoring data. Screening levels are derived from long-term monitoring data or published levels of concern.

Sediment - Particles and/or clumps of particles of sand, clay, silt, and plant or animal matter carried in water and deposited in reservoirs and slow-moving areas of streams and rivers.

Segment - A water body or portion of a water body that is individually defined and classified in the Texas Surface Water Quality Standards. A segment is intended to have relatively homogeneous chemical, physical, and hydrological characteristics. A segment provides a basic unit for assigning site-specific standards and for applying water quality management programs. Classified segments may include streams, rivers, bays, estuaries, wetlands, lakes, and reservoirs.

Sonde - A multi-parameter water quality monitoring device that calculates and records field parameters.

Specific Conductance - A measure of the ability of a liquid to conduct an electrical current.

Standards - The designation of water bodies for desirable uses and the narrative and numerical criteria deemed necessary to protect those uses.

Stormwater - Rainfall runoff, snow-melt runoff, surface runoff, and drainage.

Stream Mile - A distance of one mile along a line connecting the midpoints of the channel of a stream.

Stream Order - A ranking of the relative sizes of streams within a watershed based on the nature of their tributaries. The smallest unbranched tributary is called first order, the stream receiving the tributary is second order, and so on.

Subwatershed - Any of several drainage areas that flow to a specific location and collectively form a watershed.

Sulfate (SO^{-2}) - An ion derived from rocks and soils containing gypsum, iron sulfides, and other sulfur
compounds. Sulfates are widely distributed in nature.

Surface Water - An open body of water, such as a lake, river, or stream.

Surface Water Quality Monitoring Information System (SWQMIS) - A database that serves as a repository for surface water quality monitoring data for the state of Texas. SWQMIS also provides data validation and reporting tools, a mapping interface, and modules for tracking information about projects and quality assurance documents.

T

Texas Surface Water Quality Standards (TSWQS)
- Standards that establish explicit goals for the water quality of streams, rivers, lakes, and bays throughout the state. The Standards are developed to maintain the quality of surface waters in Texas so that it supports public health and enjoyment and protects aquatic life, consistent with the sustainable economic development of the state. Water quality standards identify appropriate uses for the state's surface waters,
including aquatic life, recreation, and sources of public water supply. The TSWQS are codified in Title 30, Chapter 307 of the Texas Administrative Code.

Tidal - Descriptive of coastal waters subject to the ebb and flow of tides. For purposes of standards applicability, tidal waters are saltwater. Classified tidal waters include all bays and estuaries with a segment number that begins with 24xx, all streams with the word tidal in the segment name, and the Gulf of Mexico.

Total Dissolved Solids (TDS) - The amount of material (inorganic salts and small amounts of organic material) dissolved in water and commonly expressed as a concentration in terms of milligrams per liter.

Total Maximum Daily Load (TMDL) - The total amount of a substance that a water body can assimilate and still meet the Texas Surface Water Quality Standards.

Total Suspended Solids (TSS) - The amount of organic and inorganic suspended particles in water.

Toxic Pollutants - Materials contaminating the environment that cause death, disease, and/or birth defects in organisms that ingest or absorb them.

Tributary - A stream or river that flows into a larger one.

U

Use Attainability Analysis (UAA) - A structured scientific assessment of the factors affecting a water body's attainment of specified uses.

W

Water body - Refers to any mass of water (lake, bay,
river, creek, bayou, etc.).

Water Quality - The chemical, physical, and biological characteristics of water.

Watershed - The area of land from which precipitation drains to a single point. Watersheds are sometimes referred to as drainage basins or drainage areas.

Watershed Protection Plan (WPP) - A voluntary, locally led approach to address state water quality standard impairments along with other water-related concerns.

APPENDIX C: WATER QUALITY PARAMETERS

FIELD PARAMETERS

- Dissolved Oxygen (DO)
- Instantaneous Flow
- pH
- Salinity
- Secchi Transparency
- Specific Conductance (SpCond)
- Temperature

CONVENTIONAL PARAMETERS

- Ammonia-Nitrogen (NH_3-N)
- Chloride (Cl^-)
- Chlorophyll-*a* (Chl-*a*)
- Nitrate-Nitrogen (NO_3-N)
- Nitrite-Nitrogen (NO_2-N)
- Total Phosphorus (TP)
- Sulfate (SO_4^{2-})
- Total Kjeldahl Nitrogen (TKN)
- Total Suspended Solids (TSS)

BACTERIA PARAMETERS

- *Escherichia coli* (*E. coli*)
- Enterococci

ORGANIC PARAMETERS

- Dioxin
- Polychlorinated Biphenyls (PCBs)

Table 37: Water Quality Parameters, Potential Impacts, and Sources

Parameter	Potential Impacts	Potential Causes
Ammonia-Nitrogen (NH_3-N)	Elevated levels of ammonia can injure or kill aquatic life, such as fish and invertebrates. In fish, even low concentrations of ammonia can damage sensitive tissues (such as gills), can deplete natural resistances to bacterial infections, and can hinder reproductive capacities and growth.	Ammonia occurs naturally as a by-product of protein metabolism and decomposition. Ammonia can also enter a water body from runoff of fertilizers, livestock waste, and from discharges of untreated sewage and industrial wastewater.
Chloride (Cl^-)	Although small amounts of chlorides are essential to proper cell function in plants and animals, large concentrations of chlorides can damage aquatic life physiology and hinder reproductive fertility and growth.	Chlorides occur naturally from the weathering and erosion of sedimentary rocks. Agricultural runoff, industrial wastewater, petroleum industrial activities, saltwater intrusions, and effluent from WWTFs are sources of chlorides.
Chlorophyll-a	Chlorophyll-*a* is a photosynthetic pigment found in green plants and is an indicator of the presence of algae in the water. It is used to monitor the trophic status of lakes or the primary productivity of ecosystems.	Elevated levels of nutrients could result in high concentrations of algal biomass.
Dioxin	Dioxin is a family of polychlorinated chemicals. It is carcinogenic and is detrimental to animal and human health.	Dioxin is present in the waste from the paper bleaching process and from the combustion of chlorinated compounds.
Dissolved Oxygen (DO)	The most important component for the survival of aquatic life is oxygen. DO is essentially the amount of oxygen available in water. Low dissolved oxygen will suffocate aquatic species, and a high amount of dissolved oxygen will reduce water odors.	Elevated levels of organic nutrients can cause an overabundance of bacteria and algae, which depletes oxygen from water. Human-caused increases in water temperature will also lower the capacity for water to hold oxygen.
Bacteria *Escherichia coli (E. coli)* Enterococci	*Escherichia coli* and Enterococci are bacterial indicator species for the presence of fecal matter, pathogenic bacteria, and viruses.	Malfunctioning or failing on-site sewage facilities, untreated domestic sewage, improper disposal of grease, and runoff from agricultural and livestock activities can cause an overabundance of bacteria and other pathogens.
Nitrate-Nitrogen (NO_3-N) Nitrite-Nitrogen (NO_2-N)	An abundance of nutrients can increase plant and algal growth. Bacteria use oxygen in the decomposition of plant matter, which can reduce dissolved oxygen. Nitrites are an intermediate form of Nitrogen that can cause brown blood disease in fish by preventing the transfer of oxygen by hemoglobin. Nitrites can also adversely affect human health, especially children under the age of three.	Nutrient sources are usually found in runoff from fertilizers and livestock facilities. They are also present in the effluent of WWTFs.
Polychlorinated Biphenyls (PCBs)	Polychlorinated biphenyls are acutely toxic and can disrupt endocrine and neural processes in aquatic life and humans.	PCBs are found in dielectric fluids used in transformers, capacitors, and coolants.
pH	Aquatic organisms have evolved to live in a specific range of pH. Biological and chemical processes can be altered or affected if the pH drops or rises over certain thresholds. Fish species cannot survive if the pH drops below 4 or rises above 12.	Runoff from mining operations and discharges of industrial wastewater can alter the pH of a water body.

Parameter	Potential Impacts	Potential Causes
Phosphorus Total Phosphate-P	Most phosphorus compounds found in water are phosphates. Orthophosphate is consumed by aquatic plants and organisms and is considered the limiting factor for aquatic plant growth. High or excessive levels of orthophosphate results in higher yield in growth. Excessive plant growth can cause eutrophication, (the natural aging progression of a water body) which will decrease dissolved oxygen levels.	Phosphates occur naturally from the decomposition of organisms. Sources also include the weathering of rock material and runoff from fertilizers.
Salinity	Salinity is the measurement of conductive ions in the water. High levels of sodium sulfate and magnesium sulfate produce a laxative effect in drinking water. High levels of total dissolved solids can cause an unpleasant taste in potable water.	Weathering or erosion of rocks, salt mining, and saltwater intrusions are sources of increased salinity.
Secchi Transparency	Secchi transparency is used to calculate the depth at which natural light can penetrate the water column. It also used as a measurement of eutrophication, the natural aging progression of a water body.	An abundance of algae and plants or excessive levels of TSS will decrease the ability for light to transmit through the water column.
Sulfate (SO_4^{2-})	In the absence of oxygen and with a pH below 8, bacteria will reduce sulfate ions to sulfide ions. Sulfide ions will cause serious and unpleasant odor problems. Sulfates in sediment can also alter soil composition and hinder or prevent growth of native plants.	Sulfate is derived from rocks and soils containing gypsum, iron sulfides, and organic compounds. Sulfur containing fossil fuels, heavy industrial activities, and some fertilizers are also potential sources for sulfates.
Temperature	The types of aquatic life that can survive in a water body are dependent upon the water temperature. Water temperature can affect levels of dissolved oxygen. Water with a high temperature has less capacity to hold oxygen. As the water temperature drops, cold-blooded animals such as fish can become more susceptible to pathogenic stress or shock, which can lead to infections or death.	Releases of water from reservoirs can contribute to drops in temperature. Temperatures will increase with the removal of flora from riparian areas or from the release of heated water from industrial activities.
Total Suspended Solids (TSS)	An increase in the amount of total suspended solids will decrease the ability for light to penetrate through the water column. This can decrease the productivity of aquatic plants. As excessive amounts of TSS settle and become sediment, benthic habitats can be altered or destroyed.	High erosion events, usually coinciding with the removal of riparian floral species and severe flow events will create excess levels of TSS. Unsound agricultural practices can also contribute to soil erosion into waterways.

APPENDIX D: WATER QUALITY TECHNICAL PRIMER

The Water Quality Technical Primer is provided as an overview of general water quality terminology. In combination with the Glossary, the Technical Primer provides background and defines terminologies and methodologies used to acquire, analyze, and report the data that is presented in the Basin Highlights Report.

THE FEDERAL CLEAN WATER ACT

The Clean Water Act establishes the basic structure for regulating pollutant discharges, pollutant loadings in water, and regulating surface water quality standards. The goal of the Clean Water Act is "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters" (33 U.S.C. §1251(a)).
Amendments to The Clean Water Act in 1977:

- Established the basic structure for regulating pollutant discharges into the waters of the United States;
- Gave the US Environmental Protection Agency (EPA) the authority to implement pollution control programs such as setting wastewater standards for industry;
- Maintained existing requirements to set water quality standards for all contaminants in surface waters;
- Made it unlawful for any person to discharge any pollutant from a point source into navigable waters, unless a permit was obtained under its provisions;
- Funded the construction of sewage treatment plants under the construction grants program; and
- Recognized the need for planning to address the critical problems posed by nonpoint source pollution.

POLLUTION

The Texas Administrative Code defines pollution as "the alteration of the physical, thermal, chemical, or biological quantity of, or the contamination of, any water in the state that renders the water harmful, detrimental, or injurious to humans, animal life, vegetation, or property or to public health, safety, or welfare, or impairs the usefulness or the public enjoyment of the water for any lawful or reasonable purpose."

There are two categories of pollution: Point Source and Nonpoint Source Pollution.

Point Source pollution is any source of pollution that is subject to regulation and is permitted. An example of a point source is a permitted wastewater treatment facility effluent discharge.

Nonpoint Source (NPS) pollution is any source that is not subject to regulation, that is diffuse and does not have a single point of origin or is not introduced into a receiving stream from a specific outfall. NPS pollution typically results from land runoff, precipitation, atmospheric deposition, drainage, seepage, or hydrologic modification.

TEXAS SURFACE WATER QUALITY STANDARDS

The Texas Surface Water Quality Standards (TSWQS) establish numerical and narrative goals to maintain the quality of streams, rivers, lakes, and bays throughout the state. Appendix A and Appendix D of the TSWQS establish the geographic boundaries and the appropriate standards for each body of water. The standards are developed to maintain the quality of surface waters. Standards ensure public health and enjoyment, protect aquatic life, and remain consistent with the sustainable economic development of the state. The Texas Commission on Environmental Quality (TCEQ) develops the TSWQS under the authorization of the U.S. Clean Water Act and Texas Water Code. The TSWQS are codified in Title 30, Chapter 307 of the Texas Administrative Code. The standards are approved by the EPA.

The TSWQS are designed to:

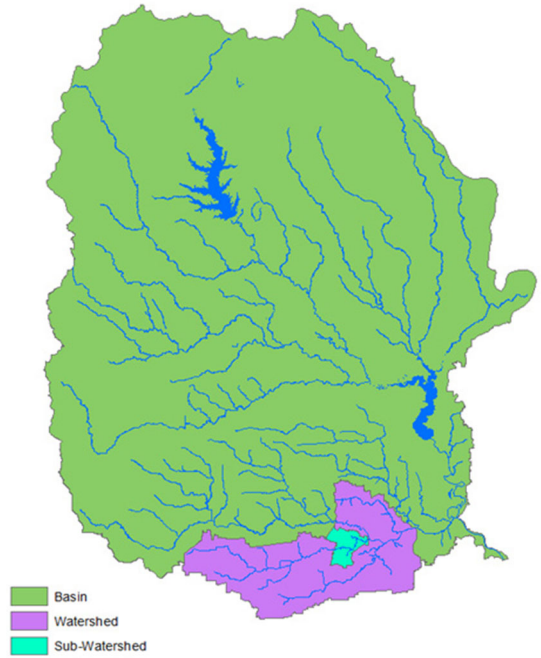
- Designate the uses, or purposes, for which the state's water bodies should be suitable;
- Establish numerical and narrative goals for water quality throughout the state; and
- Provide a basis on which TCEQ regulatory programs can establish reasonable methods to implement and attain the state's goals for water quality.

The criteria adopted and incorporated into the standards are the allowable concentrations of pollutants in State, Territory, and authorized Tribal waters and are developed for the protection of aquatic life and human health. Impairments occur when water quality conditions do not meet the assigned uses or criteria as defined in the TSWQS.

DRAINAGE AREAS — BASINS, WATERSHEDS, AND SUB-WATERSHEDS

A watershed is a defined geographic area that waterways flow through on the way to a common body of water. Basins are larger geographic areas generally containing one or more watersheds. A river basin is a collection of watersheds drained by a major river and tributaries. A coastal basin is a collection of watersheds adjacent to the coastline that water flows through on its way to the ocean. Typically, coastal basins are between and bound by two major river basins and a bay or other outlet to the ocean.

Watersheds can be broken down into even smaller drainage areas, which are referred to as sub-watersheds For example, a sub-watershed could be defined as the drainage area of a small creek, stream, or portion of a stream that is part of the drainage area for a tributary, which is part of a major river drainage basin.

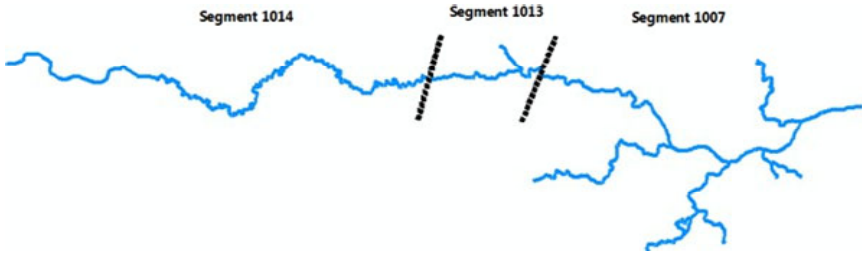


WATER BODIES, SEGMENTS, AND ASSESSMENT UNITS

The term water body is used to refer to any mass of water. A water body can be contained in a lake or a bay, or flow, such as a river, creek, or bayou. The TCEQ divides water bodies in the state into distinct segments that generally represent natural watersheds and are intended to have similar chemical, physical, and hydrological characteristics. Each segment is assigned a four-digit code. The first two digits identify the river basin, and the last two digits identify the segment. Segments can be either classified or unclassified.

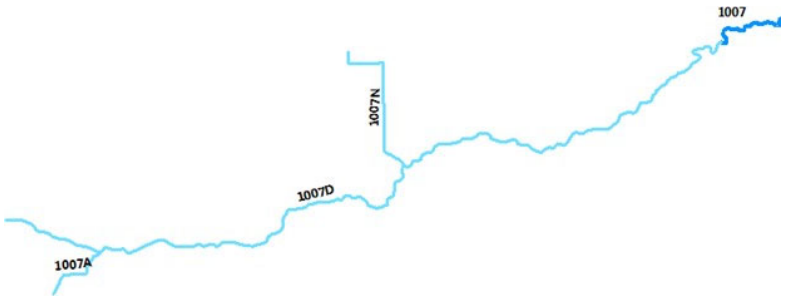
CLASSIFIED SEGMENTS

A classified segment is a water body (or portion of a water body) that is individually defined in the TSWQS. Typically, classified segments are major waterways. Site specific numerical criteria are developed to evaluate the uses and overall water quality of a classified segment. The parameters evaluated include bacteria, nutrients, and dissolved oxygen. Site-specific numerical criteria are developed to evaluate the uses and water quality of classified segments. These uses include aquatic life use and recreational use (discussed later in the primer).



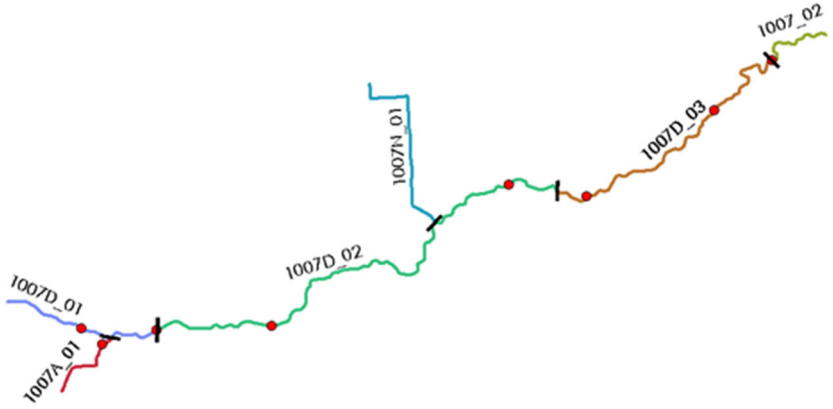
UNCLASSIFIED SEGMENTS

Unclassified segments are often tributaries of classified segments. These segments are usually assessed based on the criteria of the classified segment into which they flow. However, some unclassified segments have been assigned specific water quality standards in the TSWQS. Unclassified segments are assigned the same four-digit code as the classified segment and a letter that is specific to that waterway.



ASSESSMENT UNITS (AUS)

For assessment purposes, each segment is subdivided into hydrologically distinct units, or assessment units (AUs). AUs are the smallest geographic areas of a water body that can support a designated or site-specific use. A segment may have one or multiple AUs, depending on water quality conditions or flow in different sections of the water body. Each AU has the same four or five-digit code as the segment followed by an AU identifier (e.g., _01, _02, etc.). If there are multiple AUs, the assessment units will generally be in sequential order (e.g., 1007D_01, 1007D_02, etc.). Each AU is evaluated separately as part of the assessment.



For example, Sims Bayou Above Tidal is divided into three AUs. The red dots represent monitoring stations. Monitoring stations have been placed on the downstream and upstream ends of each AU in 1007D. Tributary 1007A has one monitoring station close to the confluence with the parent stream 1007D.

WATER QUALITY AND DESIGNATED USES

As defined in the TSWQS, a water body can be assigned specific uses including aquatic life, public water supply, and contact recreation use. Designated uses typically have corresponding numeric criteria listed in the TSWQS. General criteria apply across the entire state, but if sufficient information is available for a specific water body, the site-specific standards may be developed.

AQUATIC LIFE USE

Aquatic life use (ALU) is determined by the amount of Dissolved Oxygen and the abundance and diversity of species. Aquatic life use consists of five categories: minimal, limited, intermediate, high, and exceptional. In Texas, water bodies not specifically listed in Appendix A or D of the TSWQS are presumed to have a high aquatic life use and corresponding Dissolved Oxygen criteria. This use is assessed using 24-hour Dissolved Oxygen data along with nekton and macrobenthic invertebrate community evaluations.

PUBLIC WATER SUPPLY USE

Public water supply (PWS) use includes an evaluation of chloride, sulfates, and total dissolved solids in the water body. Criteria for these parameters are set so that public water supplies are capable of treating and delivering water of acceptable quality.

RECREATIONAL USE

Recreational use refers to how safely a water body can support activities that involve the possibility of ingesting or coming into contact with water. If activities are likely to result in ingestion of water (swimming, diving, tubing, surfing, wading by children), bacteria concentrations need to be lower. The TSWQS protects human health by setting numeric criteria in a water body relative to the types of recreational activity occurring on that water body. Fecal indicator bacteria levels are measured to determine risk. Criteria are expressed as the number of bacteria per 100 milliliters (mL) of water [in terms of colony-forming units (CFU), most probable number (MPN), or other applicable reporting measures]. The presence of fecal indicator bacteria in waters suggests that human and animal wastes may be reaching the assessed waters. In freshwater, the indicator organism is *Escherichia coli* (*E. coli*). Enterococci bacteria are the indicator for tidal water bodies.

There are five categories of recreational use, which are based on the type and frequency of recreation.

- Primary Contact Recreation 1 (PCR1) – Activities that are presumed to involve a significant risk of ingestion of water (e.g., wading by children, swimming, water skiing, diving, tubing, surfing, hand fishing, and the following whitewater activities: kayaking, canoeing, and rafting).

- Primary Contact Recreation 2 (PCR2) – Water recreation activities, such as wading by children, swimming, water skiing, diving, tubing, surfing, hand fishing, and whitewater kayaking, canoeing, and rafting, that involve a significant risk of ingestion of water but that occur less frequently than for PCR1 due to physical characteristics of the water body or limited public access.

- Secondary Contact Recreation 1 (SCR1) – Activities that commonly occur but have limited body contact incidental to shoreline activity (e.g. fishing, canoeing, kayaking, rafting, and motor boating). These activities are presumed to pose a less significant risk of water ingestion than PCR1 or PCR2 but more than secondary contact recreation 2.

- Secondary Contact Recreation 2 (SCR2) – Activities with limited body contact incidental to shoreline activity (e.g. fishing, canoeing, kayaking, rafting, and motor boating) that are presumed to pose a less significant risk of water ingestion than SCR1. These activities occur less frequently than SCR1 due to physical characteristics of the water body or limited public access.

- Noncontact Recreation (NCR) – Activities that do not involve a significant risk of water ingestion, such as those with limited body contact incidental to shoreline activity, including birding, hiking, and biking. NCR use may also be assigned where primary and secondary contact recreation activities should not occur because of unsafe conditions, such as ship and barge traffic.

Primary contact recreation is the presumed recreational use in Texas water bodies unless there is evidence to show that the water body is not used for primary contact recreation. A Recreational Use Attainability Analysis (RUAA) is necessary to change the presumed use of a water body.

WATER QUALITY MONITORING

SURFACE WATER QUALITY MONITORING (SWQM) PROGRAM

TCEQ's Surface Water Quality Monitoring Program evaluates the physical, chemical, and biological characteristics to ensure that it is suitable for general or designated uses. Water quality is monitored and evaluated in relation to human health concerns, ecological conditions, and designated uses. Data collected under the SWQM program is utilized by the TCEQ to provide a basis for effective policies that promote the protection, restoration, and wise use of the state's surface water.

Surface water samples are collected for assessment purposes following the methodologies outlined in TCEQ's *Surface Water Quality Monitoring Procedures Volume 1: Physical and Chemical Monitoring Methods* (TCEQ Publication RG-415) (colloquially referred to as "SWQM Procedures"). The guidelines outlined in the SWQM
Procedures manual document the methods and the quality assurance procedures that must be used to demonstrate that data collected by monitoring personnel across the state are of a known and adequate quality. All data collected by H-GAC and its partners are collected following SWQM procedures.

Water quality data, including data collected under SWQM and the Clean Rivers Program, are stored in the Surface Water Quality Monitoring Information System (SWQMIS). This database is used to enter, manage, track, and report on water quality-related data.

COORDINATED MONITORING SCHEDULE (CMS)

The Coordinated Monitoring Schedule (CMS) is the combined schedule for all surface water quality monitoring in Texas. Monitoring entities within a basin or region meet annually to establish and coordinate monitoring schedules as a way to ensure appropriate coverage, reduce duplication of effort, and better utilize available resources.

The CMS lists:

- Monitoring stations
- Collecting Entities (CE)
- Submitting Entities (SE)
- Monitoring Type (MT)

- Parameters
- Monitoring frequency

The Coordinated Monitoring Schedule is available online at cms.lcra.org

QUALITY ASSURANCE PROJECT PLAN (QAPP)

H-GAC's Clean Rivers Program Quality Assurance Project Plan (QAPP) describes H-GAC's quality assurance policies, management structure, and procedures used to implement the quality assurance requirements for the Clean Rivers Program. These policies and procedures are necessary to verify and validate data collected for the Clean Rivers Program. The QAPP is reviewed and approved by TCEQ to help ensure that all data generated are of known and documented quality, deemed acceptable for their intended use and that the data have been collected and managed in such a way as to guarantee its reliability. Only quality-assured data may be used for water quality assessments or other regulatory purposes. H-GAC's current and previous QAPP documents are available on H-GAC's website at h-gac.com.

MONITORING TYPES

Monitoring activities may be divided into the following categories:

- Routine Monitoring
- Special-Study Monitoring
- Permit-Support Monitoring
- Systematic Monitoring

The type of monitoring conducted by the Clean Rivers Program is usually routine, meaning it is monitoring that is scheduled in advance without intentionally trying to target any certain environmental condition, with samples being collected regardless of the conditions encountered. Routine monitoring, at a minimum, includes field measurements [DO, pH, specific conductance, temperature], conventional chemical parameters (nutrients, chloride, sulfate), bacterial measurements (*E. coli* or enterococci), and flow measurements (if applicable for that water body). Please see Appendix C: Water Quality Parameters for a detailed description of each parameter.

Another monitoring type conducted by the Clean Rivers Program is biased monitoring (monitoring targeted to a season, time, or condition) measurements, such as 24- hour DO. In this procedure a data sonde (a water quality monitoring device that calculates and records field parameters) is deployed to measure DO every 15 minutes for 24 hours. After the deployment period, the data is analyzed, and the 24-hour average and absolute minimum are calculated. The DO average and absolute minimum are used to assign an ALU category to a water body. For example, exceptional aquatic life use has a 24-hour average of 6.0 mg/L and an absolute minimum of 4.0 mg/L.

ASSESSMENT OF WATER QUALITY DATA

The provisions of Sections 305(b) and 303(d) of the Clean Waters Act require the TCEQ to provide the *Texas Integrated Report for Clean Water Act Sections 305(b) and 303(d)* (Integrated Report) to the EPA every two years. The report contains a list of water bodies evaluated, water bodies assessed by basin, impaired water bodies (303(d) List), water bodies of concern, water bodies either newly listed or removed from the 303(d) List, and other supporting information.

For the assessment, TCEQ evaluates data collected during a seven-year period. The time frame is extended to 10 years (if needed) to attain the minimum number of data points needed for the assessment. Each assessed water body is identified as:

- Fully Supporting – At least 10 data points (20 for bacteria) are available for an assessment, and the water body meets TSWQS or supports designated uses
- Of Concern – There are two levels of concern, CN and CS. CN means there is concern for near nonattainment of the TSWQS based on numeric criteria. A concern status of CN indicates that standards are not being met, but there is insufficient data to fully assess the water body. CS means that there is a concern for water quality based on screening levels. Screening levels are used when there is not a defined standard (as with nutrients) and are derived from statistical distributions of statewide water quality monitoring data, with the 85th percentile for each applicable parameter is used as the screening level criteria.
- Impaired – Data indicates that the water body does not meet standards. Impaired water bodies are placed on the 303(d) List.

When a water body is determined to be impaired, several things must happen:

- The water body must be listed on the 303(d) List;
- An evaluation must be undertaken to determine what is preventing the water body from supporting its designated use(s) or if the use(s) are appropriate.
- Steps must be taken to either remedy the problem, collect additional data, or evaluate which uses are appropriate for the water body. These steps may include additional monitoring, development of a Total Maximum Daily Load (TMDL) or Watershed Protection Plan (WPP), or a review of the water quality standards.

After assessment, water bodies are placed into one of five categories (with subcategories). These categories indicate the water quality status of the water body. These categories (as well as subcategories), and their descriptions, are:

1. Attaining all water quality standards and no use is threatened.
2. Attaining some water quality standards and no use is threatened; and insufficient data and information are available to determine if the remaining uses are attained or threatened.
3. Insufficient data and information are available to determine if any water quality standard is attained.
4. Water quality standard is not supported or is threatened for one or more designated uses but does not require the development of a TMDL.
   4a TMDL has been completed and approved by EPA.
   4b Other pollution control requirements are reasonably expected to result in the attainment of the water quality standard in the near future.
   4c Nonsupport of the water quality standard is not caused by a pollutant.
5. The water body does not meet applicable water quality standards or is threatened for one or more designated uses by one or more pollutants.

5a A TMDL is underway, scheduled, or will be scheduled.
5b A review of the water quality standards for the water body will be conducted before a TMDL is scheduled.
5c Additional data and information will be collected before a TMDL is scheduled.

If a previously assessed AU has insufficient data available during the assessment period for the most recent Integrated Report, this results in a carry-forward of the impairment listing from the previous report.

MANAGEMENT MEASURES FOR IMPAIRED WATER BODIES

If sufficient data is available to determine that a water body is impaired and does not meet standards, a management measure can be utilized to address the impairment.

- A Total Maximum Daily Load (TMDL) is a method used to determine the amount (load) of a pollutant an impaired water body can receive daily and still meet water quality standards and designated uses. After a load is calculated for the pollutant sources, an implementation plan (I-Plan) is drafted by the water body's stakeholders outlining management measures to be used to return the target pollutant to the calculated load. An I-Plan's management measures are usually voluntary actions but can, if recommended by stakeholders, include regulatory actions.

- A Watershed Protection Plan (WPP) is a community and stakeholder driven framework that uses a holistic/watershed approach to address potential sources of impaired waterways. The plan is developed with community involvement, and the measures to reduce pollutants are voluntary.

- A Use Attainability Analysis (UAA) determines if the natural characteristics of a water body cannot attain the currently designated uses and/or criteria. Natural characteristics include temperature, pH, DO, diversity of aquatic organisms, amount of streamflow, and physical conditions such as depth. If there is a consensus among stakeholders and resource agencies that a presumed or designated use may not be appropriate for a water body, a UAA may be conducted to determine the most appropriate use(s).

- A Recreational Use Attainment Analysis (RUAA) is used to determines if contact recreation use occurs in a water body. A waterway may have physical characteristics or limited public access that would not warrant a contact recreation use designation.

APPENDIX E: STATISTICAL METHODOLOGY

The identification of long- and short-term trends is important to many stakeholders, and these trends are important components of H-GAC's work, particularly in relation to the evaluation and revision of regional monitoring efforts and priorities. H-GAC staff used several methods of analyses to characterize surface water quality in the H-GAC region. Trend analysis can identify cases where the value of a water quality parameter is changing over time. Statistical tests are performed to distinguish statistically significant trends from random and seasonal variation. While it might seem reasonable to use all the data available for these analyses, as the amount of data increases the likelihood of finding a statistically significant but unimportant trend also increases. To minimize this, H-GAC performed trend analysis on the most recent 7 years (January 1, 2015 – May 31, 2022) of TCEQ-validated data to highlight recent trends in water quality in the region.

All data management and statistical analysis were performed using Statistical Analysis System (SAS). Complete details of data selection, preparation, and analysis can be found in the SAS code, which is available upon request.

DATA SELECTION AND PROCESSING

For analyses in this report, H-GAC staff selected water quality data collected between 1/1/2015 and 5/31/2022 from data downloaded from SWQMIS. All data used for these analyses were collected under a TCEQ-approved QAPP. Qualified data (data added to SWQMIS with qualifier codes that identify quality, sampling, or other problems that may render the data unsuitable) were excluded from the download.

Variables in each dataset were transformed as appropriate, and new variables were created to facilitate analysis and graphical display of results. In some cases, data from two or more STORET (method) codes were combined because the results obtained from each method can be considered equivalent. Any data collected at a depth greater than 0.3 meters, or not collected under a routine ambient monitoring program, were deleted.

Censored data (data reported as < [parameter limit of quantitation (LOQ)] were transformed to a value of one-half the parameter LOQ associated with the data, with some important exceptions. Because nutrient LOQs have been lowered over time, the presence of data censored at many different LOQs in the same dataset poses several problems. If the data for a given parameter are censored at values well above a later, lower LOQ value, trend analysis could suggest a trend where no real water quality trend is present. There is no ideal solution to this problem. Editing the censored data alone would limit, but not eliminate, false trends. In cases where some of the data reflected use of a lower LOQ than the current H-GAC Clean Rivers Program LOQ, values were transformed to one-half of the H-GAC Clean Rivers Program LOQ to minimize the identification of trends caused by changing analytical methods. H-GAC does not believe the impact from this transformation is significant. The impact of this analysis would be most pronounced for parameter trends typically found at concentrations at or near the LOQ in that specific water body.

Table 38: STORET Codes and Parameters for Trend Analysis

STORET Code	Parameter	Units
00061	Instantaneous Flow	cfs
00094	Specific Conductance	µmhos/cm @ 25°C
00010	Temperature	°C
00300	Dissolved Oxygen	mg/L
00078	Secchi Transparency	Meters
00400	pH	SU.
31699	E.coli	MPN/100mL
31701	Enterococci	MPN/100mL
32211 70953	Chlorophyll-a (Spectrophotometric) Chlorophyll-a (Fluorometric)	µg/L
00665	Total Phosphorus	mg/L as P
00610	Ammonia-Nitrogen	mg/L as N
00630 00620	Nitrate+Nitrite* Nitrate	mg/L as N
00625	Total Kjeldahl Nitrogen	mg/L as N
00530	Total Suspended Solids	mg/L
00940	Chloride	mg/L as Cl
00945	Sulfate	mg/L as SO_4

*Nitrate+Nitrite was selected when available, but some labs have reported nitrate rather than Nitrate+Nitrite. These two parameters were considered equivalent for the purpose of analysis.

DATA SELECTION FOR TREND ANALYSIS

H-GAC staff performed segment-level trend analysis on a 7-year data series (if available) from all data in the segment. Trends were also evaluated at the AU level, and graphs showing results from individual stations within each AU were produced for review.

TREND ANALYSIS METHODOLOGY

The first stage of trend analysis looked for temporal patterns for both segments and AUs. To identify these patterns, nonparametric correlation analysis (Kendall's tau-b) of the parameter value with the sample collection date was used to identify correlations that were significant at $p < 0.05$. These potential trends were then evaluated with up to four other methods. Simple linear regression of the natural log of the parameter value on the time variable was performed for all data in the subset selected by H-GAC for trend analysis. Flow-adjusted trends were obtained through correlation of residuals from LOESS (locally weighted least squares) regression in cases where instantaneous flow data were available. If there were no temporal gaps in the time-series (missing years, consistently missing seasons), seasonal Kendall/Sen Slope estimation/Theil regression was run. If more than 15 percent of the data were censored at the analytical LOQ, survival analysis (Tobit analysis in SAS PROC LIFEREG) was performed.

Plots of selected statistically significant trends were produced for segments and AUs in each of the watersheds selected for this report. Each graph includes an inset showing the results of multiple trend analyses. If the trend is described as Increasing or Decreasing the calculated p-value is below the threshold of 0.05 selected by

H-GAC. Trends identified as Stable have a calculated p-value greater than 0.05. When evaluating the results of several trend analyses of a given parameter, H-GAC placed the most weight on the Kendall correlation because nonparametric methods are insensitive to outliers in the time series. However, if Kendall correlation differed from the results of seasonal trend analysis or flow-weighted analysis, the data were further evaluated. If no flow data were available, the flow-adjusted trend appears as Not Calculated (indicating no flow data is available) or Insufficient Data (indicating only one flow value exists and a correlation could not be calculated). If the seasonal Kendall/Sen Slope trend was not calculated due to gaps (missing seasons) in the time series, the seasonal Kendall trend appears as Not Calculated. Survival analysis was only applied in those cases where the amount of censored data could bias the results of the other methods. H-GAC set the threshold at 15 percent or more censored data. If fewer than 15 percent of the data were censored, survival analysis was not performed, and the trend appears as Not Applicable on graphs.

TREND ANALYSIS FOR THE REGIONAL WATER QUALITY SUMMARY ("FROG CHART")

The "Frog Chart" is an index constructed by H-GAC to capture the degree of impairment/concerns for selected parameters (Dissolved Oxygen, bacteria, Chlorophyll-*a*, nutrients, PCBs/Dioxin, and a category for Other impairments) in each segment. H-GAC's assessment of the health of these water bodies is a stream length-weighted summary of the impairments/concerns in each segment and is weighted based upon the percentage of the segment exhibiting the impairment or concern. This index is the basis for assigning a frog count to each segment. Segments are assigned from zero to five frogs, with the higher frog count indicating fewer impairments and concerns and better overall water quality.

In 2015, H-GAC staff compiled a subset of stations in classified segments believed to be most representative of segment water quality by selecting one to three stations that were statistically representative of a given parameter in a given segment. Means and standard deviations of parameter values are calculated for each station, and those stations with means and standard deviations closest to the overall mean and standard deviation for the segment and parameter combination were selected. Preference was given to stations where stream flow was measured, and final selections were reviewed for reasonableness. In most cases, the station, or stations at the most downstream location of the segment was the most statistically representative. Selection relied on SAS procedures PROC MEANS and PROC RANK. The same subset of stations has been used since 2015 to allow consistent comparisons across regional water quality summaries created for different years.

A conservative trend analysis was performed using seven years of recent data (1/1/2015 – 5/31/2022) at the selected representative monitoring stations in the classified portion of each watershed to detect trends at the watershed level for the H-GAC Regional Water Quality Summary ("Frog Chart"). Trends were identified by nonparametric correlation analysis and simple linear regression. Because nonparametric methods are less sensitive to extreme values in the data than parametric techniques like linear regression, trends that were suggested by linear regression analysis alone were not included in the chart.

Trends for the "Frog Chart" analysis were considered statistically significant if the p-value was below 0.05, which is the standard significance level used in most applications.

Some adjustments to the final frog count were made by H-GAC staff based on best professional judgment, in order to capture attributes not fully revealed by the SAS data analysis.

A NOTE ON STATISTICAL SIGNIFICANCE

H-GAC feels that selecting all results with p-values ≤0.10 produces too many real, but unimportant, trends. In part, this is due to the large amount of data collected for our region – the more data one analyzes, the more likely it is that one will find a result – and identify a "trend" – that is statistically different from randomness ("no trend"). For example. 0.0545 rounds to 0.055, which in "arithmetic rounding' becomes 0.06 when expressed as one significant figure.

WATERSHED CHARACTERIZATIONS

H-GAC used SAS to produce tables showing impairments and concerns for each AU, monitoring stations in each AU and segment, and a variety of other summary data to aid in the characterization of water quality issues in each watershed. In most cases, the source of the tabulated information was TCEQ (Integrated Reports and assessment results, the Coordinated Monitoring Schedule, station inventory reports, and AU and segment GIS shapefiles).

APPENDIX F: PERMITTED WASTEWATER OUTFALLS

Table 39: Permitted Effluent Discharges in Segment 1016 - Greens Bayou Above Tidal (2022)

NPDES[1] ID	TCEQ Permit Number	Permittee	Type[2]
TX076651	WQ0011979002	WHITE OAK BEND MUD	D
TX076791	WQ0011986001	TOWER OAK BEND WSC	D
TX138070	WQ0015626001	SOUTH CENTRAL WATER COMPANY	D
TX072893	WQ0011863001	HARRIS COUNTY MUD NO 150	W
TX069582	WQ0011739001	CHAMPS WATER CO	D
TX071382	WQ0011791001	SUNBELT FWSD	W
TX071251	WQ0011794001	HYDRIL USA MANUFACTURING LLC	D
TX078824	WQ0012065001	HARRIS COUNTY MUD 86	D
TX094188	WQ0012070002	ALDINE ISD	D
TX079529	WQ0012127001	HARRIS COUNTY MUD 180	D
TX079821	WQ0012144001	NORTHWEST HARRIS COUNTY MUD NO 21, 22, AND 23	W
TX118095	WQ0004627000	QUALITY PRODUCT FINISHING INC	W
TX092312	WQ0012655001	NORTHWEST HARRIS COUNTY MUD 24	D
TX092711	WQ0012692001	KARBALAI RITA LAURA REDOW	D
TX093475	WQ0012754001	GREENS PARKWAY MUD	D
TX093556	WQ0012765001	UNITED STRUCTURES OF AMERICA INC	D
TX126292	WQ0004690000	US STEEL OILWELL SERVICES LLC	W
TX085413	WQ0012294001	HARRIS COUNTY MUD 200	W
TX083381	WQ0012206001	NORTH GREEN MUD	D
TX083429	WQ0012218001	YES COMPANIES LLC	D
TX083712	WQ0012237001	HARRIS COUNTY MUD NO 189	W
TX083836	WQ0014882001	AMC FACILITIES LP	D
TX006408	WQ0001039000	NRG TEXAS POWER LLC	W
TX077062	WQ0012000001	UA HOLDINGS 1994-5 LP	D
TX063878	WQ0004084000	CSA LIMITED INC	D
TX063878	WQ0004084000	CSA LIMITED INC	W
TX029564	WQ0002611000	HOUSTON FMC-IREIC LLC AND FMC TECHNOLOGIES INC	W
TX119067	WQ0013870001	AQUA TEXAS INC	D
TX132900	WQ0014993001	NK VII PARTNERS LTD	D
TX070769	WQ0013882001	UIC 13 LLC	D
TX082988	WQ0013939001	RIEDEL, ANTHONY JOHN	D
TX075221	WQ0014030001	NORTHWEST HARRIS COUNTY MUD 9	W
TX094935	WQ0013955001	KARBALAI, RITA LAURA REDOW	D
TX034916	WQ0010495078	CITY OF HOUSTON	W
TX055310	WQ0010495100	CITY OF HOUSTON	W
TX020478	WQ0010495101	CITY OF HOUSTON	W
TX103721	WQ0010495122	CITY OF HOUSTON	W
TX113131	WQ0010495126	CITY OF HOUSTON	W
TX084875	WQ0010495133	CITY OF HOUSTON	W
TX101460	WQ0010495148	CITY OF HOUSTON	D
TX025291	WQ0010495150	CITY OF HOUSTON	D
TX109126	WQ0013623001	WEST HARRIS COUNTY MUD 21	D
TX097225	WQ0013564001	HARRIS COUNTY MUD 304	D
TX103705	WQ0013433001	AQUA TEXAS INC	D
TX097071	WQ0013037001	HARRIS CO MUD 278	D
TX127124	WQ0013037002	HARRIS CO MUD 278	W
TX104965	WQ0013483001	HARRIS COUNTY MUD NO 344	W
TX095761	WQ0013559001	HINOJOSA RENE	D
TX088650	WQ0012450001	TRINITY RCT GP LLC	D
TX089281	WQ0012484001	TIMKENSTEEL MATERIAL SERVICES LLC	D
TX090069	WQ0012527001	VAITHI DEVELOPMENT INC	D
TX090506	WQ0012571001	CHAMPS WATER CO	D
TX091651	WQ0012617001	HOUSTON METRO RV PARK INC	D
TX091901	WQ0012631001	HARRIS COUNTY MUD 202	D
TX033189	WQ0011414002	SASSON ELI GRAVRIEL	D
TX058963	WQ0011533001	HARRIS COUNTY MUD NO 109	W
TX053325	WQ0011563001	REID ROAD MUD 1	W
TX020320	WQ0011161001	HUMBLE PARTNERS LP	D
TX131482	WQ0011818003	HARRIS COUNTY MUD NO 148	D
TX031461	WQ0011200001	DOUGLAS UTILITY CO	D
TX027324	WQ0011201001	EMERALD FOREST UD	W
TX025623	WQ0011302001	EL DORADO UTILITY DISTRICT	D
TX131555	WQ0014891001	LOCHINVAR GOLF CLUB	D
TX058424	WQ0010905001	NORTH FOREST MUD	D
TX074021	WQ0011901001	TRAIL OF THE LAKES MUD	W
TX074136	WQ0011904001	HARRIS COUNTY MUD 33	W
TX075132	WQ0011907002	MILLS ROAD MUD	D
TX126756	WQ0014527001	HARRIS COUNTY MUD 412	W
TX125326	WQ0014897001	HOLY TRINITY EPISCOPAL SCHOOL OF GREATER HOUSTON INC	D
TX084093	WQ0015026001	VAM USA LLC	D
TX125661	WQ0014419001	HARRIS COUNTY MUD NO 400	W
TX027707	WQ0010694001	AQUA UTILITIES INC	D
TX124702	WQ0014320001	TIDWELL WASTEWATER UTILITY LLC	D
TX092037	WQ0002761000	WEST ROAD WSC & MCDONALDS CORP	W
TX020800	WQ0011061001	GREENWOOD UTILITY DISTRICT	W
TX090476	WQ0014447001	HARRIS COUNTY MUD NO 191	D
TX082317	WQ0014072001	WEST HARRIS COUNTY MUD 10	W
TX084298	WQ0002453000	SMITH INTERNATIONAL INDUSTRIAL SUBDIVISION WATER SUPPLY AND SEWER	W
TX097047	WQ0012934001	RANKIN ROAD WEST MUD	D
TX074446	WQ0011919002	HARRIS COUNTY MUD NO 49	W
TX137529	WQ0015545001	GSL WELCOME BP 32 LLC	D
TX111767	WQ0011351001	HARRIS COUNTY MUD 11	D
TX033243	WQ0011026002	HARRIS COUNTY WCID NO 109	W
TX126594	WQ0014513001	CHRISTIAN TABERNACLE OF HOUSTON INC	D
TX129666	WQ0014812001	HARRIS COUNTY MUD NO 400	W
TX127957	WQ0014621001	RANKIN PARK MAINTENANCE & UTILITIES CO INC	D
TX103616	WQ0003402000	GSE ENVIRONMENTAL LLC	W
TX127981	WQ0014625001	GENERATION PARK MANAGEMENT DISTRICT	W
TX067539	WQ0014874001	BC HUMBLE ENTERPRISES LLC	D
TX032085	WQ0011158001	CHAMPS WATER CO	D
TX026344	WQ0011238002	HARRIS COUNTY MUD 5	D
TX046868	WQ0011267001	TIMBERLAKE IMPROVEMENT DISTRICT	D
TX034401	WQ0010763002	CITY OF HUMBLE	W
TX140350	WQ0015889001	HARRIS COUNTY MUD NO 422	W
TX141615	WQ0016028001	ALI MOHAMMAD SOLHJOU	D

[1]NPDES = National Pollution Discharge Elimination System

[2]Type = This one-character alphanumeric field contains a code which indicates the discharge type of each permit.
D = Domestic (<1 MGD domestic sewage) W = Wastewater (≥1 MGD domestic sewage or process water including water treatment plant discharge) S = Stormwater

Table 40: Permitted Effluent Discharges in Segment 1006D - Halls Bayou (2022)

NPDES ID	TCEQ Permit Number	Permittee	Type[1]
TX063860	WQ0011673001	WOODLOCH MHP LLC	D
TX132519	WQ0014966001	SAMPOGNA PROPERTIES LP	D
TX071820	WQ0011807001	FOREST HILLS MUD	D
TX078883	WQ0012083001	HOOKS MOBILE HOME PARK LTD	D
TX092908	WQ0012714001	HARRIS COUNTY MUD 119	D
TX084531	WQ0012259001	BAYOU FOREST VILLAGE INC	D
TX084671	WQ0012261001	AKRAM SOLHJOU	D
TX119610	WQ0012261002	SOLHJOU ALI MOHAMMAD	D
TX087785	WQ0012399001	RITA LAURA REDOW KARBALAI	D
TX088102	WQ0012414001	STONETOWN WOODGATE LLC	D
TX124265	WQ0014277001	ALI MOHAMMAD SOLHJOU	D
TX063053	WQ0010495016	CITY OF HOUSTON	W
TX060933	WQ0001899000	PILOT INDUSTRIES OF TEXAS INC	W
TX030988	WQ0010610001	SOUTHERN WATER CORP	D
TX023825	WQ0010679001	HARRIS COUNTY WCID 74	D
TX115797	WQ0013609001	ALDINE ISD	D
TX070611	WQ0010419001	NITSCH & SON UTILITY CO INC	D
TX103071	WQ0013709001	LA CASITA HOLDINGS INC	D
TX122521	WQ0013749001	SULYUKMANOV, NADIJA BALABAN & SULYUKMANOV, ALBERT FARHATOVICH	D
TX095656	WQ0013767001	FATIMA FAMILY VILLAGE INC	D
TX124257	WQ0013770001	SMITH, WILLIAM DONALD	D
TX032093	WQ0010436001	CHAMPS WATER CO	D

NPDES ID	TCEQ Permit Number	Permittee	Type[1]
TX097527	WQ0013084001	ROVING MEADOWS UTILITIES INC	D
TX090492	WQ0012555001	WESTFIELD MOBILE HOME COMMUNITY LTD	D
TX021253	WQ0010236001	SUNBELT FRESH WATER SUPPLY DISTRICT	W
TX066478	WQ0011473001	BLUE BELL MANOR UTILITY CO INC	D
TX123579	WQ0014217001	KARBALAI, RITA LAURA REDOW	D
TX021270	WQ0010812001	SUNBELT FWSD	D
TX090735	WQ0014900001	WILLIAM DONALD SMITH	D
TX094986	WQ0012882001	BAHRAM SOLHJOU	D
TX135364	WQ0014921002	HOA KHUONG BUI AND CHUONG ANH NGUYEN	D
TX021237	WQ0010919001	FALLBROOK UTILITY DISTRICT	W
TX023515	WQ0011154001	MOUNT HOUSTON ROAD MUD	D
TX119431	WQ0014359001	HARRIS COUNTY MUD NO 366	D
TX133001	WQ0015001001	WILLIAM EMMETT HARTZOG JR	D
TX095508	WQ0012918001	HARTZOG LINDA DIANNE	D
TX099171	WQ0012919001	SANJUAN, ESMERALDA	D
TX021261	WQ0010518001	SUNBELT FWSD	D
TX120189	WQ0014144001	BRIXMOR GA MOUNT HOUSTON TX LP	D
TX127949	WQ0014620001	BAHRAM SOLHJOU	D
TX021245	WQ0011231001	SUNBELT FWSD	D
TX032034	WQ0011255001	AQUA UTILITIES INC	D
TX020788	WQ0014538001	HARRIS COUNTY WCID 133	W
TX140171	WQ0015868001	12750 ALDINE WESTFIELD LP	D

[1]NPDES = National Pollution Discharge Elimination System

[2]Type = This one-character alphanumeric field contains a code which indicates the discharge type of each permit.
D = Domestic (<1 MGD domestic sewage) W = Wastewater (≥1 MGD domestic sewage or process water including water treatment plant discharge) S = Stormwater

Table 41: Permitted Effluent Discharges in Segment 1006 - Greens Bayou Tidal (2022)

NPDES ID	TCEQ Permit Number	Permittee	Type[1]
TX007064	WQ0000445000	ARKEMA INC	S
TX007064	WQ0000445000	ARKEMA INC	S
TX007439	WQ0000749000	GB BIOSCIENCES LLC	S
TX007439	WQ0000749000	GB BIOSCIENCES LLC	S
TX007439	WQ0000749000	GB BIOSCIENCES LLC	S
TX007439	WQ0000749000	GB BIOSCIENCES LLC	S
TX007439	WQ0000749000	GB BIOSCIENCES LLC	S
TX068683	WQ0011701001	AQUA TEXAS INC	W
TX075698	WQ0011727001	HARRIS COUNTY MUD NO 8	D
TX007064	WQ0000445000	ARKEMA INC	W
TX007064	WQ0000445000	ARKEMA INC	W
TX005584	WQ0000485000	SASOL CHEMICALS USA LLC	W
TX005584	WQ0000485000	SASOL CHEMICALS USA LLC	W
TX005584	WQ0000485000	SASOL CHEMICALS USA LLC	W
TX005584	WQ0000485000	SASOL CHEMICALS USA LLC	W
TX006386	WQ0001031000	NRG TEXAS POWER LLC	W
TX006386	WQ0001031000	NRG TEXAS POWER LLC	W
TX133141	WQ0004965000	EXPLORER PIPELINE COMPANY	W
TX119326	WQ0004134000	MCCARTY ROAD LANDFILL TX LP	G
TX119326	WQ0004134000	MCCARTY ROAD LANDFILL TX LP	G
TX005584	WQ0000485000	SASOL CHEMICALS USA LLC	W
TX063037	WQ0010495077	CITY OF HOUSTON	W
TX118931	WQ0013581001	CHRISTIAN TABERNACLE OF HOUSTON INC	D
TX105406	WQ0013503001	MAXEY ROAD WSC	D
TX005576	WQ0000662000	REICHHOLD LLC 2	W
TX007439	WQ0000749000	GB BIOSCIENCES LLC	W
TX007064	WQ0000445000	ARKEMA INC	S
TX062952	WQ0010608002	ROYALWOOD MUD	D
TX135062	WQ0015204001	INTERURBAN FOREST LLP	D
TX096679	WQ0012996001	AQUA TEXAS INC	D
TX106542	WQ0003244000	KINDER MORGAN PETCOKE LP	W
TX106542	WQ0003244000	KINDER MORGAN PETCOKE LP	W
TX100935	WQ0003792000	NERRO SUPPLY LLC	W
TX116076	WQ0004884000	BRENNTAG SOUTHWEST INC	S
TX116076	WQ0004884000	BRENNTAG SOUTHWEST INC	S

[1]NPDES = National Pollution Discharge Elimination System

[2]Type = This one-character alphanumeric field contains a code which indicates the discharge type of each permit.
D = Domestic (<1 MGD domestic sewage) W = Wastewater (1 MGD domestic sewage or process water including water treatment plant discharge) S = Stormwater

APPENDIX G: EJSCREEN REPORTS

EJSCREEN Report Segment 1016 – Greens Bayou Above Tidal

EJScreen Report (Version 2.1)

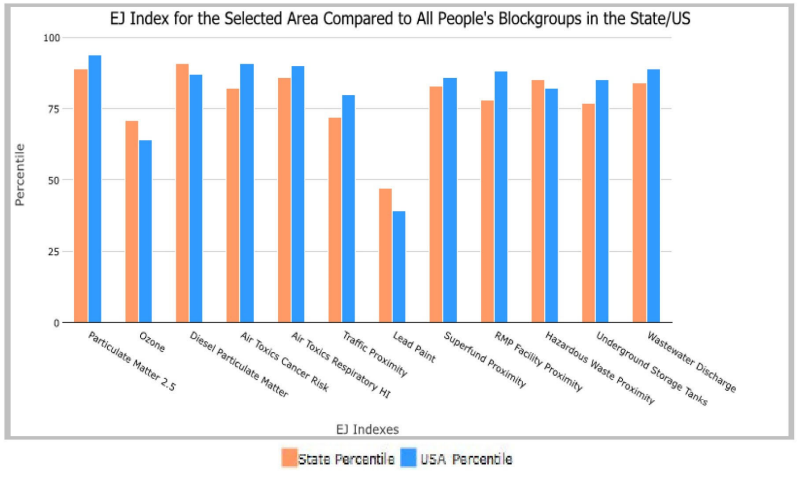
the User Specified Area, TEXAS, EPA Region 6

Approximate Population: 438,888

Input Area (sq. miles): 159.17

(The study area contains 1 blockgroup(s) with zero population.)

Selected Variables	State Percentile	USA Percentile
Environmental Justice Indexes		
EJ Index for Particulate Matter 2.5	89	94
EJ Index for Ozone	71	64
EJ Index for Diesel Particulate Matter*	91	87
EJ Index for Air Toxics Cancer Risk*	82	91
EJ Index for Air Toxics Respiratory HI*	86	90
EJ Index for Traffic Proximity	72	80
EJ Index for Lead Paint	47	39
EJ Index for Superfund Proximity	83	86
EJ Index for RMP Facility Proximity	78	88
EJ Index for Hazardous Waste Proximity	85	82
EJ Index for Underground Storage Tanks	77	85
EJ Index for Wastewater Discharge	84	89



This report shows the values for environmental and demographic indicators and EJSCREEN indexes. It shows environmental and demographic raw data (e.g., the estimated concentration of ozone in the air), and also shows what percentile each raw data value represents. These percentiles provide perspective on how the selected block group or buffer area compares to the entire state, EPA region, or nation. For example, if a given location is at the 95th percentile nationwide, this means that only 5 percent of the US population has a higher block group value than the average person in the location being analyzed. The years for which the data are available, and the methods used, vary across these indicators. Important caveats and uncertainties apply to this screening-level information, so it is essential to understand the limitations on appropriate interpretations and applications of these indicators. Please see EJSCREEN documentation for discussion of these issues before using reports.

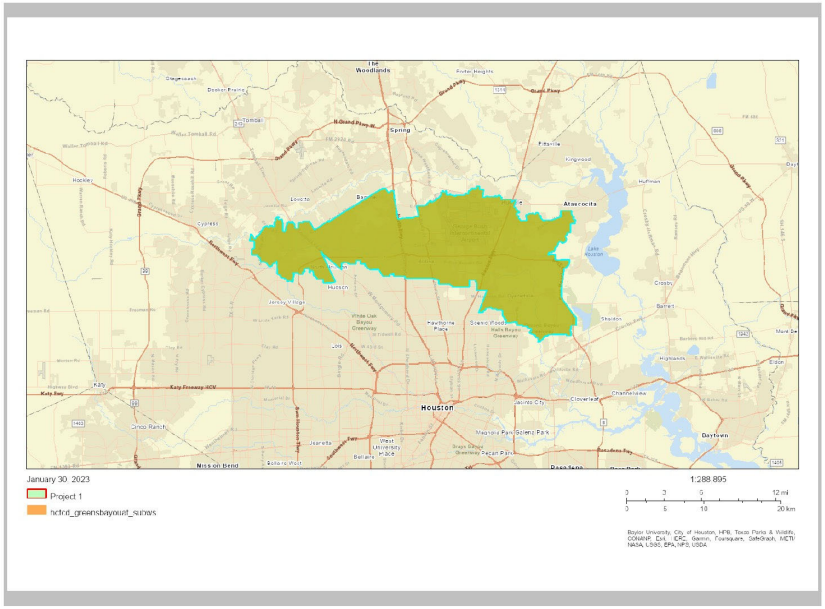
EJScreen Report (Version 2.1)

the User Specified Area, TEXAS, EPA Region 6

Approximate Population: 438,888

Input Area (sq. miles): 159.17

(The study area contains 1 blockgroup(s) with zero population.)



Sites reporting to EPA	
Superfund NPL	1
Hazardous Waste Treatment, Storage, and Disposal Facilities (TSDF)	19

EPA United States Environmental Protection Agency

EJScreen Report (Version 2.1)

the User Specified Area, TEXAS, EPA Region 6

Approximate Population: 438,888

Input Area (sq. miles): 159.17

(The study area contains 1 blockgroup(s) with zero population.)

Selected Variables	Value	State Avg.	%ile in State	USA Avg.	%ile in USA
Pollution and Sources					
Particulate Matter 2.5 (µg/m³)	10.5	9.5	88	8.67	89
Ozone (ppb)	39	40	41	42.5	26
Diesel Particulate Matter* (µg/m³)	0.338	0.211	89	0.294	60-70th
Air Toxics Cancer Risk* (lifetime risk per million)	35	31	89	28	90-95th
Air Toxics Respiratory HI*	0.42	0.35	95	0.36	80-90th
Traffic Proximity (daily traffic count/distance to road)	540	570	72	760	68
Lead Paint (% Pre-1960 Housing)	0.034	0.14	43	0.27	22
Superfund Proximity (site count/km distance)	0.14	0.084	85	0.13	76
RMP Facility Proximity (facility count/km distance)	1.2	0.94	74	0.77	78
Hazardous Waste Proximity (facility count/km distance)	1.2	0.72	81	2.2	59
Underground Storage Tanks (count/km²)	2.9	2.3	70	3.9	66
Wastewater Discharge (toxicity-weighted concentration/m distance)	0.013	0.38	78	12	71
Socioeconomic Indicators					
Demographic Index	66%	46%	75	35%	87
People of Color	86%	59%	75	40%	87
Low Income	45%	33%	67	30%	75
Unemployment Rate	6%	5%	66	5%	65
Limited English Speaking Households	15%	7%	81	5%	89
Less Than High School Education	23%	16%	71	12%	84
Under Age 5	8%	7%	68	6%	76
Over Age 64	8%	13%	31	16%	19

*Diesel particular matter, air toxics cancer risk, and air toxics respiratory hazard index are from the EPA's Air Toxics Data Update, which is the Agency's ongoing, comprehensive evaluation of air toxics in the United States. This effort aims to prioritize air toxics, emission sources, and locations of interest for further study. It is important to remember that the air toxics data presented here provide broad estimates of health risks over geographic areas of the country, not definitive risks to specific individuals or locations. Cancer risks and hazard indices from the Air Toxics Data Update are reported to one significant figure and any additional significant figures here are due to rounding. More information on the Air Toxics Data Update can be found at: https://www.epa.gov/haps/air-toxics-data-update.

For additional information, see: www.epa.gov/environmentaljustice

EJScreen is a screening tool for pre-decisional use only. It can help identify areas that may warrant additional consideration, analysis, or outreach. It does not provide a basis for decision-making, but it may help identify potential areas of EJ concern. Users should keep in mind that screening tools are subject to substantial uncertainty in their demographic and environmental data, particularly when looking at small geographic areas. Important caveats and uncertainties apply to this screening-level information, so it is essential to understand the limitations on appropriate interpretations and applications of these indicators. Please see EJScreen documentation for discussion of these issues before using reports. This screening tool does not provide data on every environmental impact and demographic factor that may be relevant to a particular location. EJScreen outputs should be supplemented with additional information and local knowledge before taking any action to address potential EJ concerns.

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EJSCREEN ACS Summary Report

Location: User-specified polygonal location
Ring (buffer): 0-miles radius
Description:

Summary of ACS Estimates	2016 - 2020
Population	438,888
Population Density (per sq. mile)	2,750
People of Color Population	378,203
% People of Color Population	86%
Households	139,172
Housing Units	150,383
Housing Units Built Before 1950	2,118
Per Capita Income	23,050
Land Area (sq. miles) (Source: SF1)	159.58
% Land Area	99%
Water Area (sq. miles) (Source: SF1)	0.85
% Water Area	1%

	2016 - 2020 ACS Estimates	Percent	MOE (±)
Population by Race			
Total	438,888	100%	2,114
Population Reporting One Race	402,961	92%	7,023
White	206,681	47%	1,384
Black	130,834	30%	1,957
American Indian	1,503	0%	355
Asian	25,276	6%	1,439
Pacific Islander	721	0%	240
Some Other Race	37,947	9%	1,648
Population Reporting Two or More Races	35,927	8%	1,767
Total Hispanic Population	214,615	49%	1,918
Total Non-Hispanic Population	224,273		
White Alone	60,685	14%	1,123
Black Alone	127,930	29%	1,942
American Indian Alone	333	0%	162
Non-Hispanic Asian Alone	25,220	6%	1,439
Pacific Islander Alone	616	0%	240
Other Race Alone	1,467	0%	604
Two or More Races Alone	8,022	2%	908
Population by Sex			
Male	219,469	50%	1,437
Female	219,419	50%	1,254
Population by Age			
Age 0-4	35,811	8%	734
Age 0-17	130,613	30%	749
Age 18+	308,275	70%	1,212
Age 65+	35,550	8%	481

Data Note: Detail may not sum to totals due to rounding. Hispanic population can be of any race.
N/A means not available. Source: U.S. Census Bureau, American Community Survey (ACS) 2016 - 2020 .

EJSCREEN ACS Summary Report

Location: User-specified polygonal location
Ring (buffer): 0-miles radius
Description:

	2016 - 2020 ACS Estimates	Percent	MOE (±)
Population 25+ by Educational Attainment			
Total	264,017	100%	1,828
Less than 9th Grade	34,257	13%	651
9th - 12th Grade, No Diploma	26,749	10%	440
High School Graduate	75,077	28%	931
Some College, No Degree	56,847	22%	637
Associate Degree	20,353	8%	427
Bachelor's Degree or more	50,734	19%	710
Population Age 5+ Years by Ability to Speak English			
Total	403,077	100%	2,017
Speak only English	208,088	52%	1,910
Non-English at Home[1+2+3+4]	194,988	48%	1,490
[1]Speak English "very well"	96,323	24%	1,138
[2]Speak English "well"	43,066	11%	1,075
[3]Speak English "not well"	30,933	8%	714
[4]Speak English "not at all"	24,667	6%	578
[3+4]Speak English "less than well"	55,600	14%	731
[2+3+4]Speak English "less than very well"	98,665	24%	1,078
Linguistically Isolated Households*			
Total	20,327	100%	318
Speak Spanish	18,248	90%	318
Speak Other Indo-European Languages	447	2%	134
Speak Asian-Pacific Island Languages	1,388	7%	140
Speak Other Languages	244	1%	153
Households by Household Income			
Household Income Base	139,172	100%	493
< $15,000	14,626	11%	436
$15,000 - $25,000	15,243	11%	350
$25,000 - $50,000	36,219	26%	440
$50,000 - $75,000	26,376	19%	515
$75,000 +	46,708	34%	505
Occupied Housing Units by Tenure			
Total	139,172	100%	493
Owner Occupied	71,878	52%	495
Renter Occupied	67,294	48%	451
Employed Population Age 16+ Years			
Total	322,670	100%	1,837
In Labor Force	217,612	67%	1,445
Civilian Unemployed in Labor Force	13,155	4%	300
Not In Labor Force	105,059	33%	1,914

Data Note: Detail may not sum to totals due to rounding. Hispanic population can be of any race.
N/A means not available. Source: U.S. Census Bureau, American Community Survey (ACS)
*Households in which no one 14 and over speaks English "very well" or speaks English only.

EJSCREEN ACS Summary Report

Location: User-specified polygonal location
Ring (buffer): 0-miles radius
Description:

	2016 - 2020 ACS Estimates	Percent	MOE (±)
Population by Language Spoken at Home*			
Total (persons age 5 and above)	403,603	100%	2,017
English	208,062	52%	1,453
Spanish	167,348	41%	1,547
French, Haitian, or Cajun	1,936	0%	288
German or other West Germanic	603	0%	244
Russian, Polish, or Other Slavic	668	0%	308
Other Indo-European	5,262	1%	402
Korean	269	0%	94
Chinese (including Mandarin, Cantonese)	1,914	0%	658
Vietnamese	9,922	2%	1,356
Tagalog (including Filipino)	2,120	1%	464
Other Asian and Pacific Island	2,613	1%	359
Arabic	1,076	0%	401
Other and Unspecified	1,813	0%	421
Total Non-English	195,541	48%	2,486

Data Note: Detail may not sum to totals due to rounding. Hispanic population can be of any race.
N/A means not available. **Source:** U.S. Census Bureau, American Community Survey (ACS) 2016 - 2020.
*Population by Language Spoken at Home is available at the census tract summary level and up.

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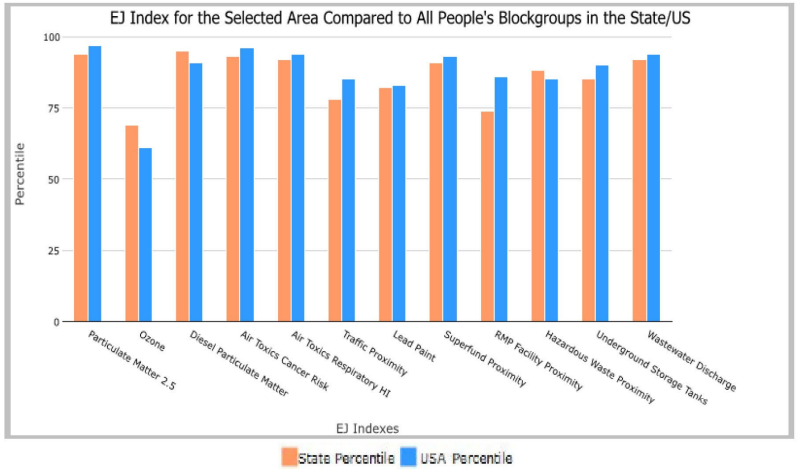
EJScreen Report (Version 2.1)

the User Specified Area, TEXAS, EPA Region 6

Approximate Population: 173,048

Input Area (sq. miles): 46.51

Selected Variables	State Percentile	USA Percentile
Environmental Justice Indexes		
EJ Index for Particulate Matter 2.5	94	97
EJ Index for Ozone	69	61
EJ Index for Diesel Particulate Matter*	95	91
EJ Index for Air Toxics Cancer Risk*	93	96
EJ Index for Air Toxics Respiratory HI*	92	94
EJ Index for Traffic Proximity	78	85
EJ Index for Lead Paint	82	83
EJ Index for Superfund Proximity	91	93
EJ Index for RMP Facility Proximity	74	86
EJ Index for Hazardous Waste Proximity	88	85
EJ Index for Underground Storage Tanks	85	90
EJ Index for Wastewater Discharge	92	94



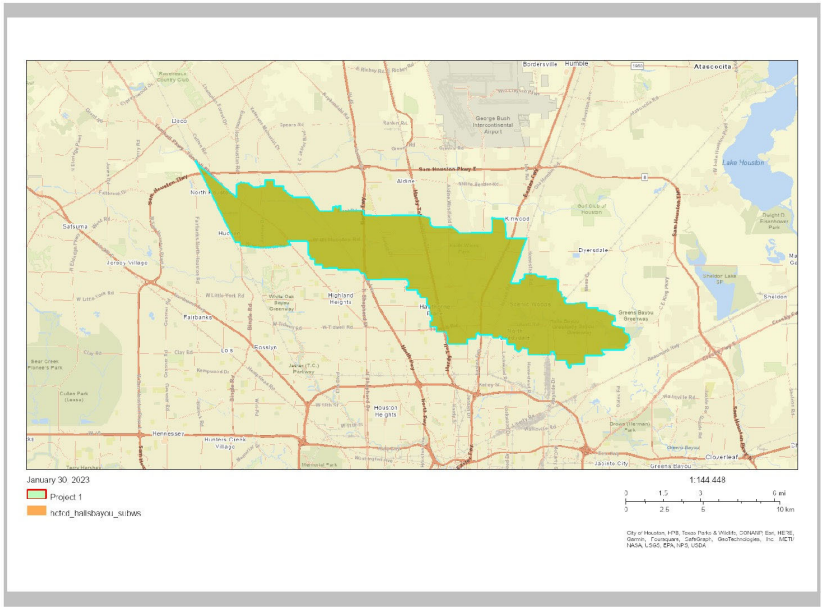
This report shows the values for environmental and demographic indicators and EJSCREEN indexes. It shows environmental and demographic raw data (e.g., the estimated concentration of ozone in the air), and also shows what percentile each raw data value represents. These percentiles provide perspective on how the selected block group or buffer area compares to the entire state, EPA region, or nation. For example, if a given location is at the 95th percentile nationwide, this means that only 5 percent of the US population has a higher block group value than the average person in the location being analyzed. The years for which the data are available, and the methods used, vary across these indicators. Important caveats and uncertainties apply to this screening-level information, so it is essential to understand the limitations on appropriate interpretations and applications of these indicators. Please see EJSCREEN documentation for discussion of these issues before using reports.

EJScreen Report (Version 2.1)

the User Specified Area, TEXAS, EPA Region 6

Approximate Population: 173,048

Input Area (sq. miles): 46.51



Sites reporting to EPA	
Superfund NPL	0
Hazardous Waste Treatment, Storage, and Disposal Facilities (TSDF)	4

EPA United States Environmental Protection Agency

EJScreen Report (Version 2.1)

the User Specified Area, TEXAS, EPA Region 6

Approximate Population: 173,048

Input Area (sq. miles): 46.51

Selected Variables	Value	State Avg.	%ile in State	USA Avg.	%ile in USA
Pollution and Sources					
Particulate Matter 2.5 ($\mu g/m^3$)	10.5	9.5	93	8.67	90
Ozone (ppb)	38	40	34	42.5	21
Diesel Particulate Matter* ($\mu g/m^3$)	0.35	0.211	90	0.294	70-80th
Air Toxics Cancer Risk* (lifetime risk per million)	38	31	92	28	90-95th
Air Toxics Respiratory HI*	0.41	0.35	95	0.36	80-90th
Traffic Proximity (daily traffic count/distance to road)	620	570	76	760	71
Lead Paint (% Pre-1960 Housing)	0.25	0.14	73	0.27	52
Superfund Proximity (site count/km distance)	0.12	0.084	81	0.13	72
RMP Facility Proximity (facility count/km distance)	0.77	0.94	61	0.77	69
Hazardous Waste Proximity (facility count/km distance)	1.2	0.72	81	2.2	59
Underground Storage Tanks (count/km^2)	3.5	2.3	75	3.9	70
Wastewater Discharge (toxicity-weighted concentration/m distance)	0.072	0.38	91	12	83
Socioeconomic Indicators					
Demographic Index	76%	46%	87	35%	93
People of Color	95%	59%	87	40%	92
Low Income	57%	33%	80	30%	86
Unemployment Rate	7%	5%	72	5%	71
Limited English Speaking Households	32%	7%	94	5%	96
Less Than High School Education	41%	16%	90	12%	96
Under Age 5	8%	7%	66	6%	75
Over Age 64	10%	13%	39	16%	26

*Diesel particular matter, air toxics cancer risk, and air toxics respiratory hazard index are from the EPA's Air Toxics Data Update, which is the Agency's ongoing, comprehensive evaluation of air toxics in the United States. This effort aims to prioritize air toxics, emission sources, and locations of interest for further study. It is important to remember that the air toxics data presented here provide broad estimates of health risks over geographic areas of the country, not definitive risks to specific individuals or locations. Cancer risks and hazard indices from the Air Toxics Data Update are reported to one significant figure and any additional significant figures here are due to rounding. More information on the Air Toxics Data Update can be found at: https://www.epa.gov/haps/air-toxics-data-update.

For additional information, see: www.epa.gov/environmentaljustice

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EJSCREEN ACS Summary Report

Location: User-specified polygonal location
Ring (buffer): 0-miles radius
Description:

Summary of ACS Estimates	2016 - 2020
Population	173,048
Population Density (per sq. mile)	3,732
People of Color Population	164,474
% People of Color Population	95%
Households	50,510
Housing Units	54,668
Housing Units Built Before 1950	4,401
Per Capita Income	15,829
Land Area (sq. miles) (Source: SF1)	46.37
% Land Area	100%
Water Area (sq. miles) (Source: SF1)	0.09
% Water Area	0%

	2016 - 2020 ACS Estimates	Percent	MOE (±)
Population by Race			
Total	173,048	100%	1,952
Population Reporting One Race	164,503	95%	5,188
White	99,705	58%	1,044
Black	40,186	23%	1,418
American Indian	1,105	1%	256
Asian	6,104	4%	1,130
Pacific Islander	0	0%	20
Some Other Race	17,403	10%	1,320
Population Reporting Two or More Races	8,545	5%	1,767
Total Hispanic Population	117,657	68%	1,918
Total Non-Hispanic Population	55,391		
White Alone	8,574	5%	462
Black Alone	39,847	23%	1,433
American Indian Alone	269	0%	133
Non-Hispanic Asian Alone	6,031	3%	1,130
Pacific Islander Alone	0	0%	20
Other Race Alone	72	0%	80
Two or More Races Alone	598	0%	200
Population by Sex			
Male	84,906	49%	1,437
Female	88,142	51%	998
Population by Age			
Age 0-4	13,839	8%	357
Age 0-17	52,863	31%	727
Age 18+	120,185	69%	805
Age 65+	16,982	10%	453

Data Note: Detail may not sum to totals due to rounding. Hispanic population can be of any race.
N/A means not available. Source: U.S. Census Bureau, American Community Survey (ACS) 2016 - 2020 .

EJSCREEN ACS Summary Report

Location: User-specified polygonal location
Ring (buffer): 0-miles radius
Description:

	2016 - 2020 ACS Estimates	Percent	MOE (±)
Population 25+ by Educational Attainment			
Total	103,130	100%	1,116
Less than 9th Grade	22,960	22%	651
9th - 12th Grade, No Diploma	18,932	18%	493
High School Graduate	32,263	31%	553
Some College, No Degree	16,843	16%	410
Associate Degree	4,625	4%	338
Bachelor's Degree or more	7,508	7%	280
Population Age 5+ Years by Ability to Speak English			
Total	159,209	100%	1,867
Speak only English	56,494	35%	1,105
Non-English at Home[1+2+3+4]	102,715	65%	1,170
[1]Speak English "very well"	32,484	20%	706
[2]Speak English "well"	32,077	20%	651
[3]Speak English "not well"	17,294	11%	537
[4]Speak English "not at all"	20,860	13%	500
[3+4]Speak English "less than well"	38,154	24%	659
[2+3+4]Speak English "less than very well"	70,231	44%	841
Linguistically Isolated Households*			
Total	16,272	100%	277
Speak Spanish	15,640	96%	277
Speak Other Indo-European Languages	75	0%	66
Speak Asian-Pacific Island Languages	549	3%	83
Speak Other Languages	8	0%	20
Households by Household Income			
Household Income Base	50,510	100%	470
< $15,000	8,180	16%	436
$15,000 - $25,000	6,959	14%	168
$25,000 - $50,000	15,656	31%	344
$50,000 - $75,000	8,342	17%	405
$75,000 +	11,372	23%	351
Occupied Housing Units by Tenure			
Total	50,510	100%	470
Owner Occupied	32,021	63%	350
Renter Occupied	18,489	37%	451
Employed Population Age 16+ Years			
Total	126,766	100%	1,480
In Labor Force	75,558	60%	880
Civilian Unemployed in Labor Force	5,373	4%	254
Not In Labor Force	51,208	40%	1,025

Data Note: Detail may not sum to totals due to rounding. Hispanic population can be of any race.
N/A means not available. Source: U.S. Census Bureau, American Community Survey (ACS)
*Households in which no one 14 and over speaks English "very well" or speaks English only.

EJSCREEN ACS Summary Report

Location: User-specified polygonal location
Ring (buffer): 0-miles radius
Description:

	2016 - 2020 ACS Estimates	Percent	MOE (±)
Population by Language Spoken at Home*			
Total (persons age 5 and above)	154,338	100%	1,772
English	54,651	35%	1,261
Spanish	93,975	61%	1,521
French, Haitian, or Cajun	276	0%	141
German or other West Germanic	64	0%	66
Russian, Polish, or Other Slavic	0	0%	20
Other Indo-European	645	0%	265
Korean	9	0%	20
Chinese (including Mandarin, Cantonese)	266	0%	121
Vietnamese	3,087	2%	1,083
Tagalog (including Filipino)	179	0%	66
Other Asian and Pacific Island	599	0%	248
Arabic	49	0%	65
Other and Unspecified	538	0%	421
Total Non-English	99,687	65%	2,016

Data Note: Detail may not sum to totals due to rounding. Hispanic population can be of any race.
N/A means not available. **Source:** U.S. Census Bureau, American Community Survey (ACS) 2016 - 2020.
*Population by Language Spoken at Home is available at the census tract summary level and up.

January 30, 2023 3/3

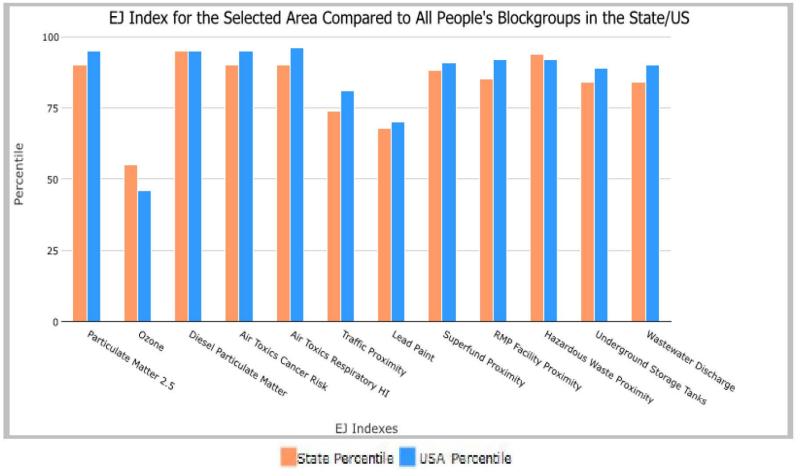
EJScreen Report (Version 2.1)

the User Specified Area, TEXAS, EPA Region 6

Approximate Population: 59,887

Input Area (sq. miles): 22.56

Selected Variables	State Percentile	USA Percentile
Environmental Justice Indexes		
EJ Index for Particulate Matter 2.5	90	95
EJ Index for Ozone	55	46
EJ Index for Diesel Particulate Matter*	95	95
EJ Index for Air Toxics Cancer Risk*	90	95
EJ Index for Air Toxics Respiratory HI*	90	96
EJ Index for Traffic Proximity	74	81
EJ Index for Lead Paint	68	70
EJ Index for Superfund Proximity	88	91
EJ Index for RMP Facility Proximity	85	92
EJ Index for Hazardous Waste Proximity	94	92
EJ Index for Underground Storage Tanks	84	89
EJ Index for Wastewater Discharge	84	90



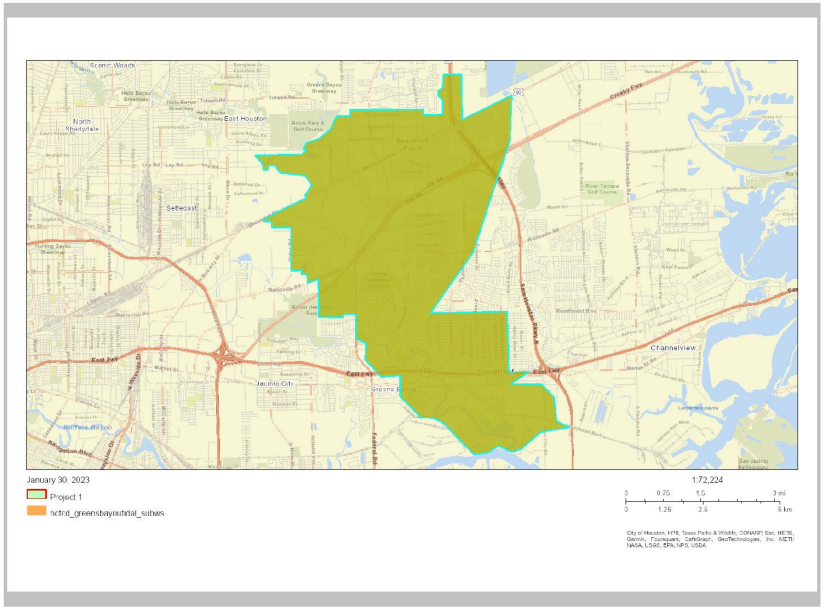
This report shows the values for environmental and demographic indicators and EJSCREEN indexes. It shows environmental and demographic raw data (e.g., the estimated concentration of ozone in the air), and also shows what percentile each raw data value represents. These percentiles provide perspective on how the selected block group or buffer area compares to the entire state, EPA region, or nation. For example, if a given location is at the 95th percentile nationwide, this means that only 5 percent of the US population has a higher block group value than the average person in the location being analyzed. The years for which the data are available, and the methods used, vary across these indicators. Important caveats and uncertainties apply to this screening-level information, so it is essential to understand the limitations on appropriate interpretations and applications of these indicators. Please see EJSCREEN documentation for discussion of these issues before using reports.

EJScreen Report (Version 2.1)

the User Specified Area, TEXAS, EPA Region 6

Approximate Population: 59,887

Input Area (sq. miles): 22.56



Sites reporting to EPA	
Superfund NPL	0
Hazardous Waste Treatment, Storage, and Disposal Facilities (TSDF)	9

EPA United States Environmental Protection Agency

EJScreen Report (Version 2.1)

the User Specified Area, TEXAS, EPA Region 6

Approximate Population: 59,887

Input Area (sq. miles): 22.56

Selected Variables	Value	State Avg.	%ile in State	USA Avg.	%ile in USA
Pollution and Sources					
Particulate Matter 2.5 ($\mu g/m^3$)	10.4	9.5	87	8.67	89
Ozone (ppb)	36.2	40	27	42.5	15
Diesel Particulate Matter* ($\mu g/m^3$)	0.541	0.211	98	0.294	80-90th
Air Toxics Cancer Risk* (lifetime risk per million)	49	31	97	28	95-100th
Air Toxics Respiratory HI*	0.64	0.35	99	0.36	95-100th
Traffic Proximity (daily traffic count/distance to road)	470	570	69	760	65
Lead Paint (% Pre-1960 Housing)	0.15	0.14	64	0.27	41
Superfund Proximity (site count/km distance)	0.11	0.084	80	0.13	71
RMP Facility Proximity (facility count/km distance)	2.2	0.94	88	0.77	91
Hazardous Waste Proximity (facility count/km distance)	3.1	0.72	95	2.2	79
Underground Storage Tanks (count/km^2)	4.1	2.3	80	3.9	73
Wastewater Discharge (toxicity-weighted concentration/m distance)	0.059	0.38	90	12	81
Socioeconomic Indicators					
Demographic Index	69%	46%	79	35%	89
People of Color	91%	59%	81	40%	90
Low Income	47%	33%	70	30%	77
Unemployment Rate	7%	5%	74	5%	73
Limited English Speaking Households	18%	7%	85	5%	92
Less Than High School Education	32%	16%	82	12%	92
Under Age 5	7%	7%	62	6%	71
Over Age 64	8%	13%	28	16%	17

*Diesel particular matter, air toxics cancer risk, and air toxics respiratory hazard index are from the EPA's Air Toxics Data Update, which is the Agency's ongoing, comprehensive evaluation of air toxics in the United States. This effort aims to prioritize air toxics, emission sources, and locations of interest for further study. It is important to remember that the air toxics data presented here provide broad estimates of health risks over geographic areas of the country, not definitive risks to specific individuals or locations. Cancer risks and hazard indices from the Air Toxics Data Update are reported to one significant figure and any additional significant figures here are due to rounding. More information on the Air Toxics Data Update can be found at: https://www.epa.gov/haps/air-toxics-data-update.

For additional information, see: www.epa.gov/environmentaljustice

EJScreen is a screening tool for pre-decisional use only. It can help identify areas that may warrant additional consideration, analysis, or outreach. It does not provide a basis for decision-making, but it may help identify potential areas of EJ concern. Users should keep in mind that screening tools are subject to substantial uncertainty in their demographic and environmental data, particularly when looking at small geographic areas. Important caveats and uncertainties apply to this screening-level information, so it is essential to understand the limitations on appropriate interpretations and applications of these indicators. Please see EJScreen documentation for discussion of these issues before using reports. This screening tool does not provide data on every environmental impact and demographic factor that may be relevant to a particular location. EJScreen outputs should be supplemented with additional information and local knowledge before taking any action to address potential EJ concerns.

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EJSCREEN ACS Summary Report

Location: User-specified polygonal location
Ring (buffer): 0-miles radius
Description:

Summary of ACS Estimates	2016 - 2020
Population	59,887
Population Density (per sq. mile)	2,897
People of Color Population	54,721
% People of Color Population	91%
Households	17,964
Housing Units	20,101
Housing Units Built Before 1950	754
Per Capita Income	19,648
Land Area (sq. miles) (Source: SF1)	20.67
% Land Area	97%
Water Area (sq. miles) (Source: SF1)	0.67
% Water Area	3%

	2016 - 2020 ACS Estimates	Percent	MOE (±)
Population by Race			
Total	59,887	100%	1,557
Population Reporting One Race	50,280	84%	2,567
White	35,268	59%	746
Black	10,194	17%	642
American Indian	568	1%	380
Asian	1,069	2%	304
Pacific Islander	0	0%	14
Some Other Race	3,181	5%	481
Population Reporting Two or More Races	9,607	16%	1,608
Total Hispanic Population	43,299	72%	1,591
Total Non-Hispanic Population	16,588		
White Alone	5,166	9%	469
Black Alone	9,901	17%	644
American Indian Alone	216	0%	288
Non-Hispanic Asian Alone	1,069	2%	304
Pacific Islander Alone	0	0%	14
Other Race Alone	55	0%	70
Two or More Races Alone	181	0%	93
Population by Sex			
Male	31,690	53%	1,176
Female	28,197	47%	666
Population by Age			
Age 0-4	4,441	7%	275
Age 0-17	17,789	30%	440
Age 18+	42,098	70%	840
Age 65+	4,503	8%	197

Data Note: Detail may not sum to totals due to rounding. Hispanic population can be of any race.
N/A means not available. **Source:** U.S. Census Bureau, American Community Survey (ACS) 2016 - 2020 .

EJSCREEN ACS Summary Report

Location: User-specified polygonal location
Ring (buffer): 0-miles radius
Description:

	2016 - 2020 ACS Estimates	Percent	MOE (±)
Population 25+ by Educational Attainment			
Total	35,363	100%	1,021
Less than 9th Grade	6,852	19%	283
9th - 12th Grade, No Diploma	4,412	12%	182
High School Graduate	10,796	31%	637
Some College, No Degree	7,081	20%	412
Associate Degree	2,607	7%	372
Bachelor's Degree or more	3,615	10%	214
Population Age 5+ Years by Ability to Speak English			
Total	55,446	100%	1,410
Speak only English	19,765	36%	1,077
Non-English at Home[1+2+3+4]	35,682	64%	764
[1]Speak English "very well"	20,272	37%	663
[2]Speak English "well"	5,307	10%	326
[3]Speak English "not well"	6,652	12%	319
[4]Speak English "not at all"	3,450	6%	260
[3+4]Speak English "less than well"	10,102	18%	333
[2+3+4]Speak English "less than very well"	15,409	28%	391
Linguistically Isolated Households*			
Total	3,232	100%	244
Speak Spanish	3,092	96%	244
Speak Other Indo-European Languages	88	3%	85
Speak Asian-Pacific Island Languages	38	1%	37
Speak Other Languages	14	0%	132
Households by Household Income			
Household Income Base	17,964	100%	410
< $15,000	1,695	9%	136
$15,000 - $25,000	1,886	10%	108
$25,000 - $50,000	5,357	30%	342
$50,000 - $75,000	3,903	22%	227
$75,000 +	5,122	29%	278
Occupied Housing Units by Tenure			
Total	17,964	100%	410
Owner Occupied	9,358	52%	258
Renter Occupied	8,606	48%	330
Employed Population Age 16+ Years			
Total	44,118	100%	1,213
In Labor Force	29,058	66%	1,027
Civilian Unemployed in Labor Force	2,158	5%	141
Not In Labor Force	15,059	34%	326

Data Note: Detail may not sum to totals due to rounding. Hispanic population can be of any race.
N/A means not available. **Source:** U.S. Census Bureau, American Community Survey (ACS)
*Households in which no one 14 and over speaks English "very well" or speaks English only.

EJSCREEN ACS Summary Report

Location: User-specified polygonal location
Ring (buffer): 0-miles radius
Description:

	2016 - 2020 ACS Estimates	Percent	MOE (±)
Population by Language Spoken at Home*			
Total (persons age 5 and above)	51,095	100%	1,490
English	19,654	38%	1,353
Spanish	30,350	59%	1,355
French, Haitian, or Cajun	71	0%	60
German or other West Germanic	0	0%	20
Russian, Polish, or Other Slavic	0	0%	20
Other Indo-European	192	0%	97
Korean	67	0%	70
Chinese (including Mandarin, Cantonese)	121	0%	103
Vietnamese	346	1%	184
Tagalog (including Filipino)	179	0%	72
Other Asian and Pacific Island	85	0%	73
Arabic	17	0%	48
Other and Unspecified	12	0%	20
Total Non-English	31,441	62%	1,976

Data Note: Detail may not sum to totals due to rounding. Hispanic population can be of any race.
N/A means not available. **Source:** U.S. Census Bureau, American Community Survey (ACS) 2016 - 2020.
*Population by Language Spoken at Home is available at the census tract summary level and up.

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APPENDIX H: SIGNIFICANT AU TRENDS

GREENS BAYOU ABOVE TIDAL

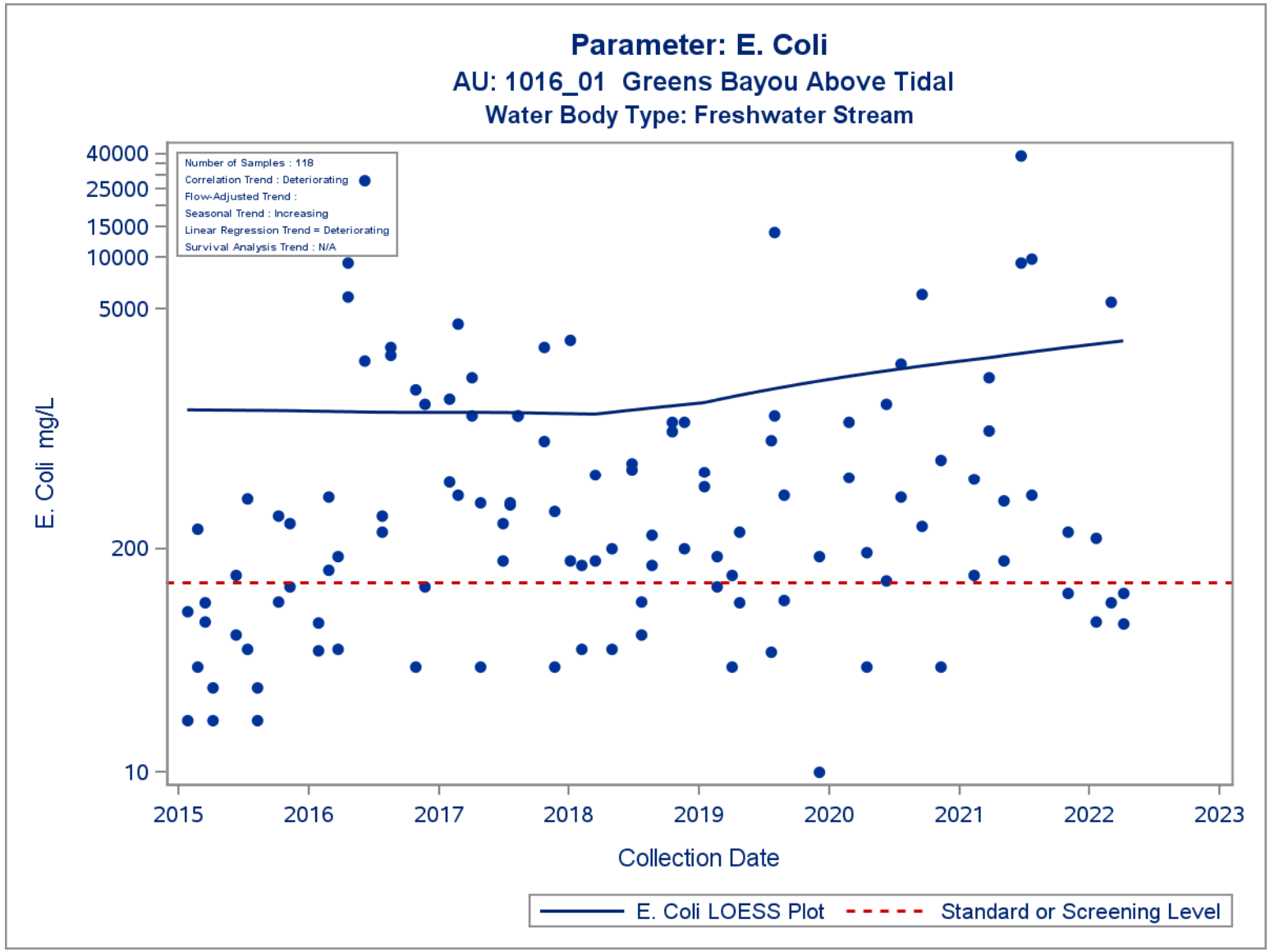
AU 1016_01 Greens Bayou Above Tidal – *E. coli*
AU 1016_01 Greens Bayou Above Tidal – pH
AU 1016_02 Greens Bayou Above Tidal – pH
AU 1016_03 Greens Bayou Above Tidal – Ammonia-N
AU 1016_03 Greens Bayou Above Tidal – *E. coli*
AU 1016_05 Greens Bayou Above Tidal – pH
AU 1016A_03 Garners Bayou – Ammonia-N
AU 1016A_03 Garners Bayou – *E. coli*
AU 1016B_01 Unnamed Tributary of Greens Bayou – Nitrate-N
AU 1016C_01 Unnamed Tributary of Greens Bayou – Ammonia-N
AU 1016C_01 Unnamed Tributary of Greens Bayou – *E. coli*
AU 1016D_01 Unnamed Tributary of Greens Bayou – Ammonia-N

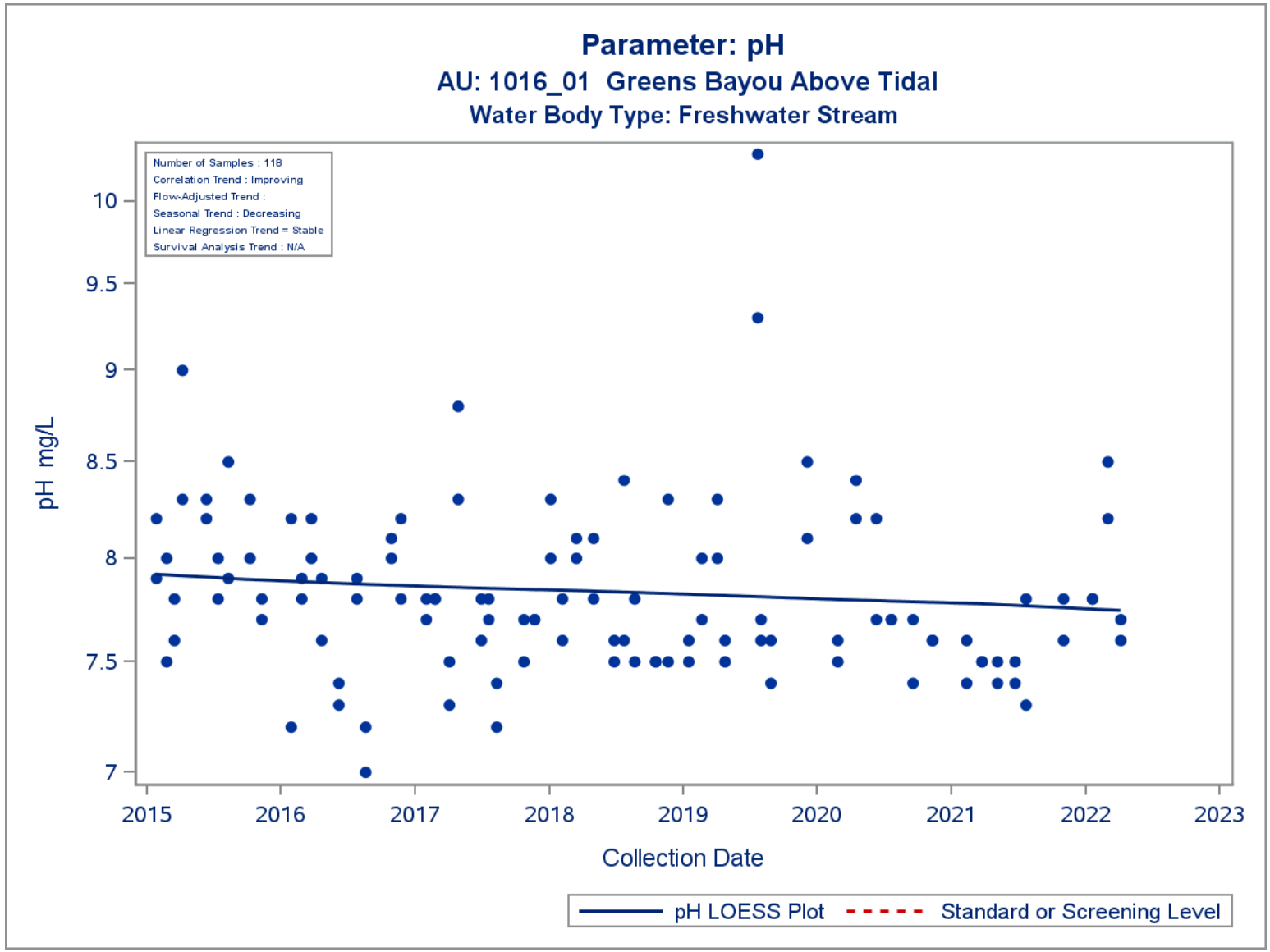
HALLS BAYOU

AU 1006J_01 Unnamed Tributary of Halls Bayou – Ammonia-N
AU 1006J_01 Unnamed Tributary of Halls Bayou – *E. coli*
AU 1006J_01 Unnamed Tributary of Halls Bayou – Total Phosphorus

GREENS BAYOU TIDAL

AU 1006_03 Houston Ship Channel Tidal/Greens Bayou Tidal – Ammonia-N
AU 1006_03 Houston Ship Channel Tidal/Greens Bayou Tidal – Total Phosphorus
AU 1006_03 Houston Ship Channel Tidal/Greens Bayou Tidal – pH
AU 1006_05 Houston Ship Channel Tidal/Greens Bayou Tidal – pH
AU 1006F_01 Big Gulch Above Tidal – Ammonia-N
AU 1006H_01 Spring Gully Above Tidal – Nitrate-N


Parameter: E. Coli
AU: 1016_01 Greens Bayou Above Tidal
Water Body Type: Freshwater Stream
Number of Samples : 118
Correlation Trend : Deteriorating
Flow-Adjusted Trend :
Seasonal Trend : Increasing
Linear Regression Trend = Deteriorating
Survival Analysis Trend : N/A
40000
25000
15000
10000
5000
200
10
E. Coli mg/L
2015
2016
2017
2018
2019
2020
2021
2022
2023
Collection Date
E. Coli LOESS Plot
Standard or Screening Level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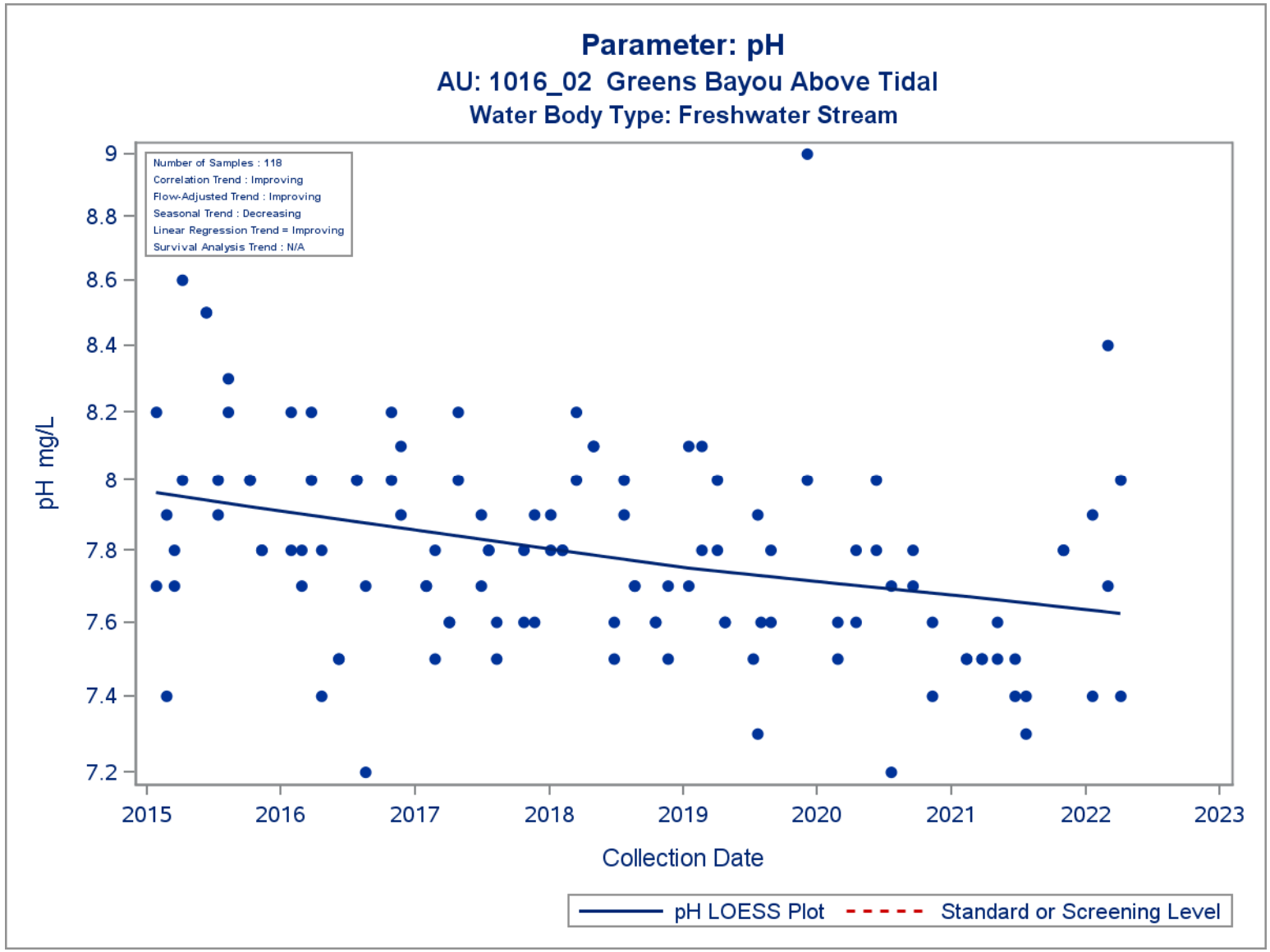
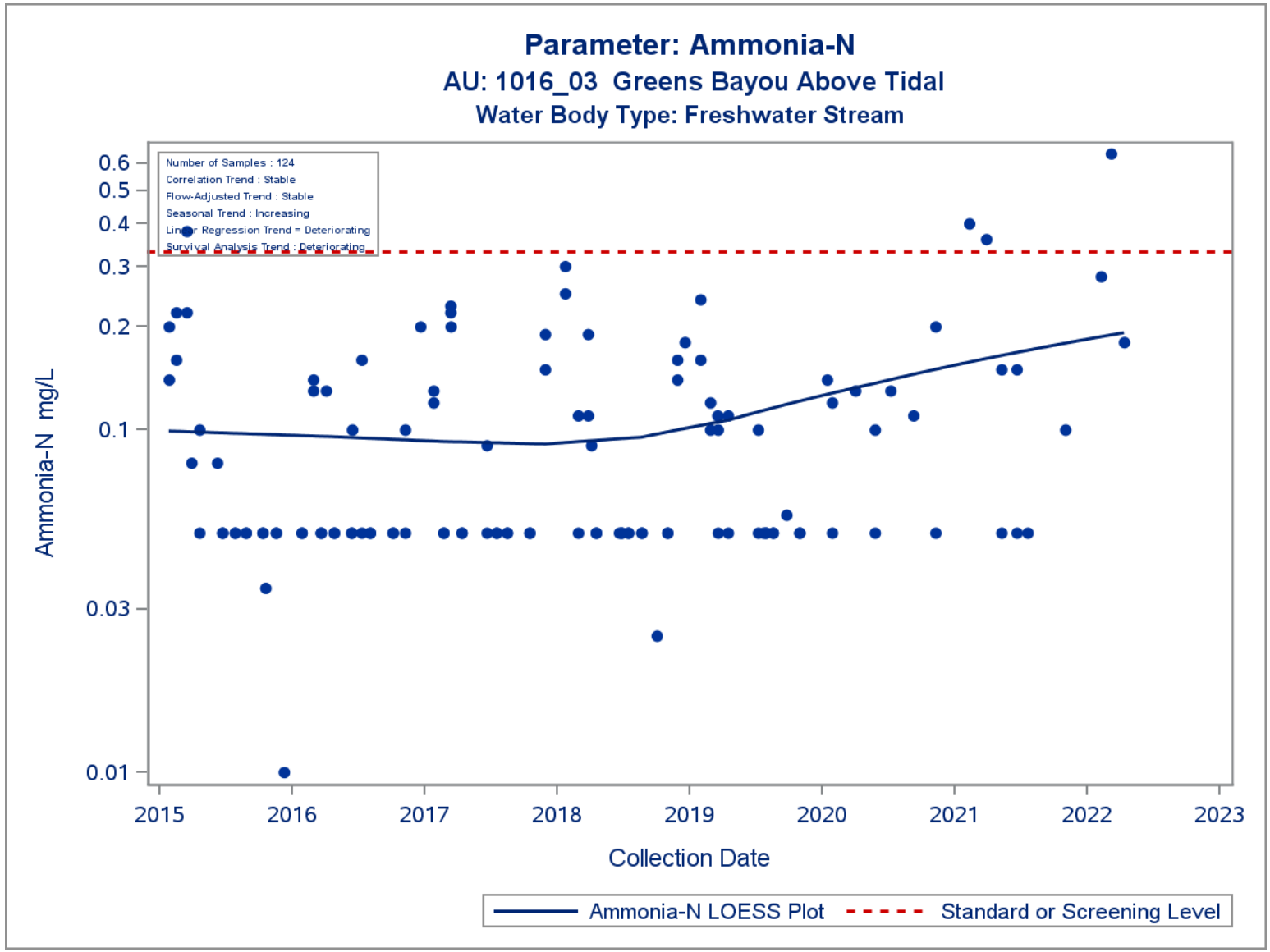
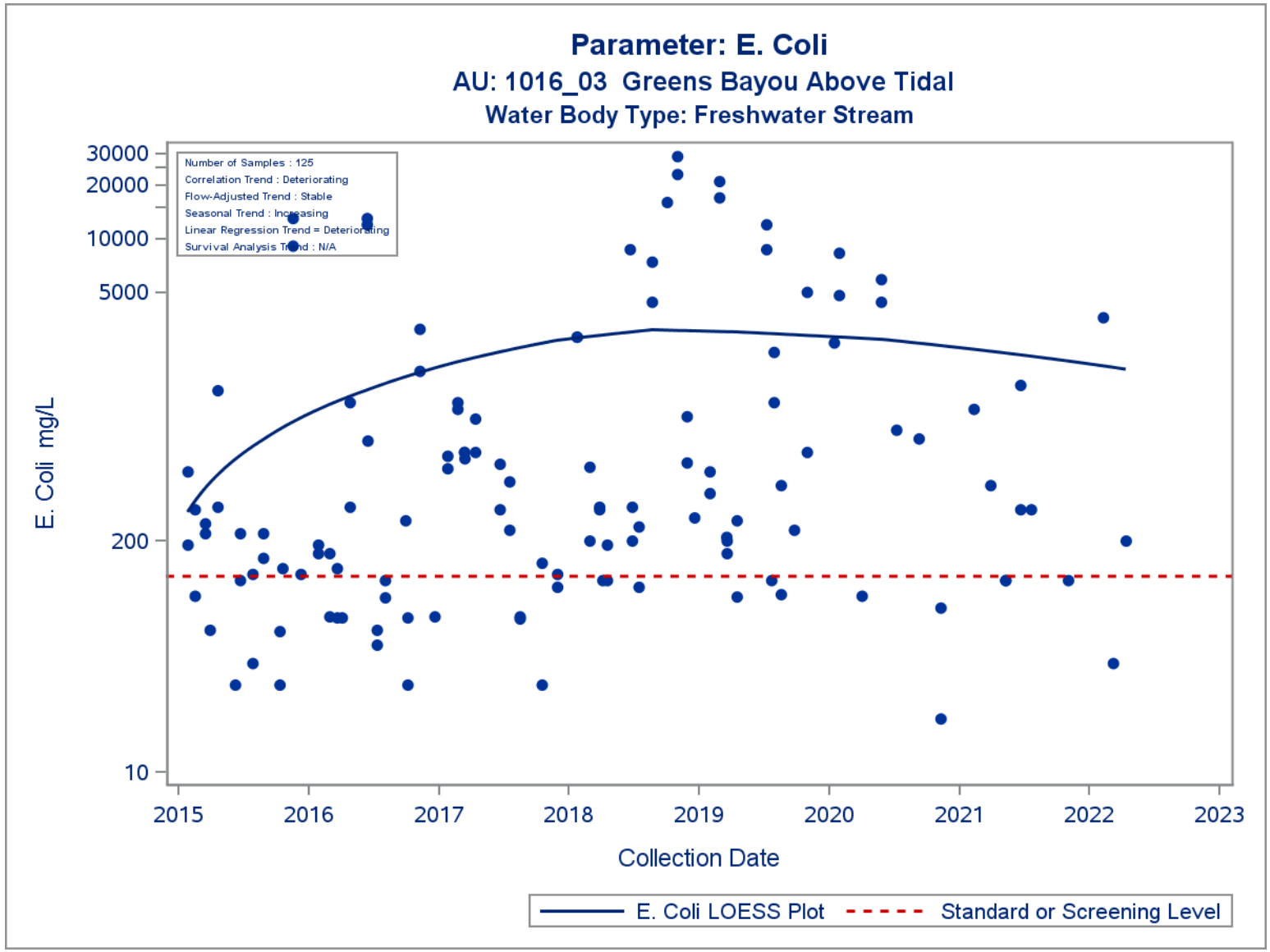
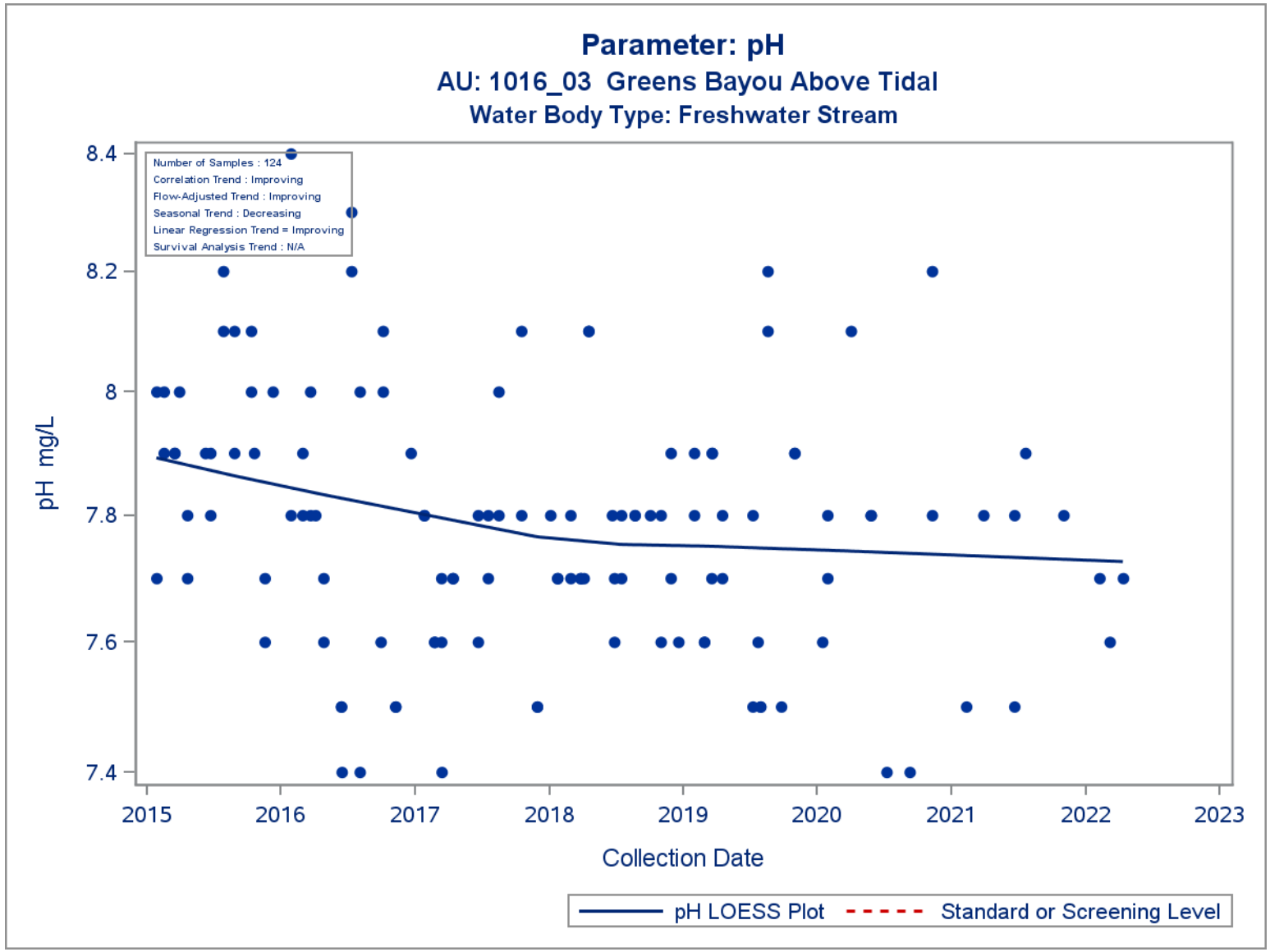
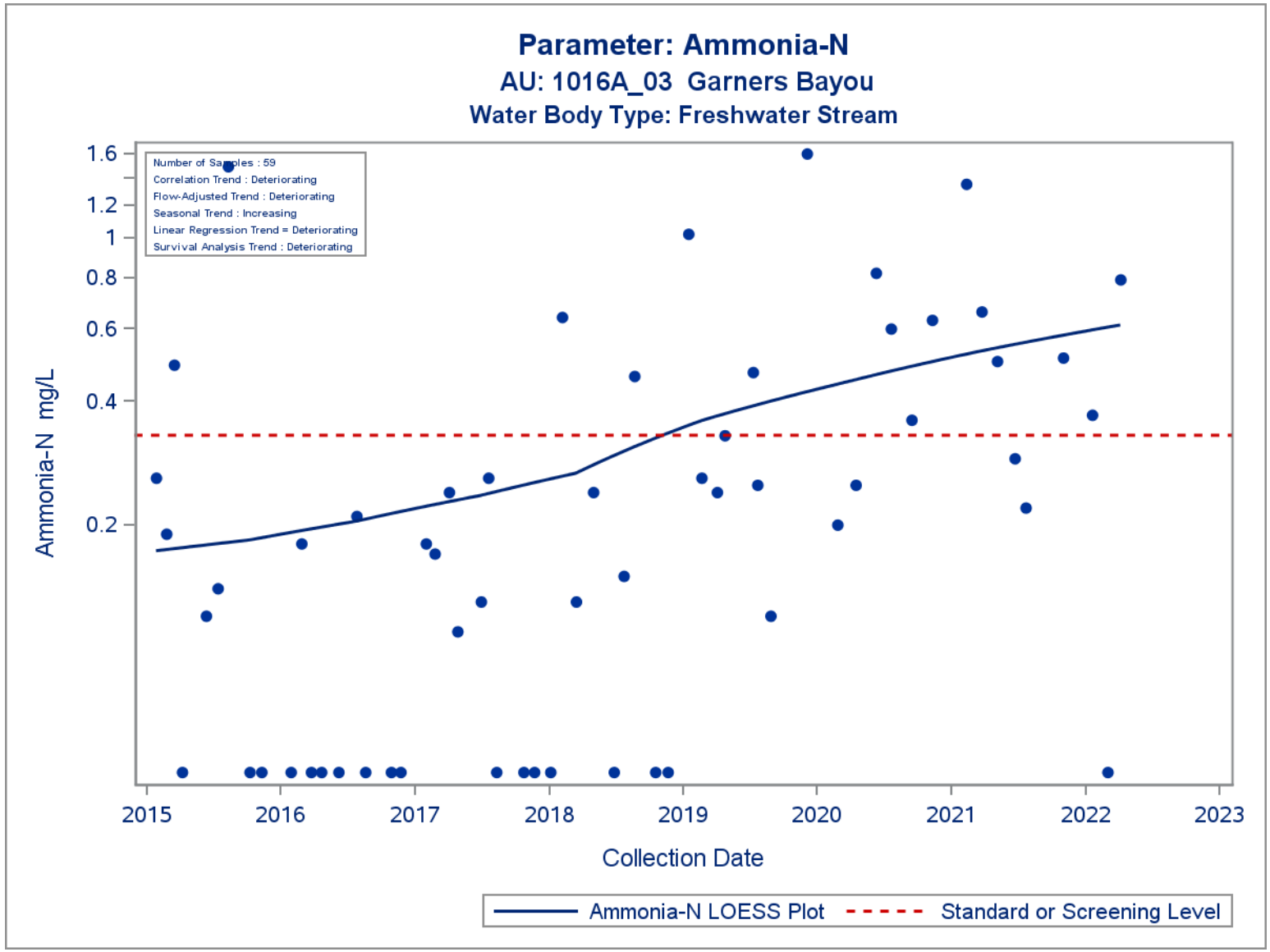
AU: 1016_01 Greens Bayou Above Tidal
Water Body Type: Freshwater Stream
Number of Samples : 118
Correlation Trend : Improving
Flow-Adjusted Trend :
Seasonal Trend : Decreasing
Linear Regression Trend = Stable
Survival Analysis Trend : N/A
pH mg/L
10
9.5
9
8.5
8
7.5
7
2015
2016
2017
2018
2019
2020
2021
2022
2023
Collection Date
pH LOESS Plot
Standard or Screening Level

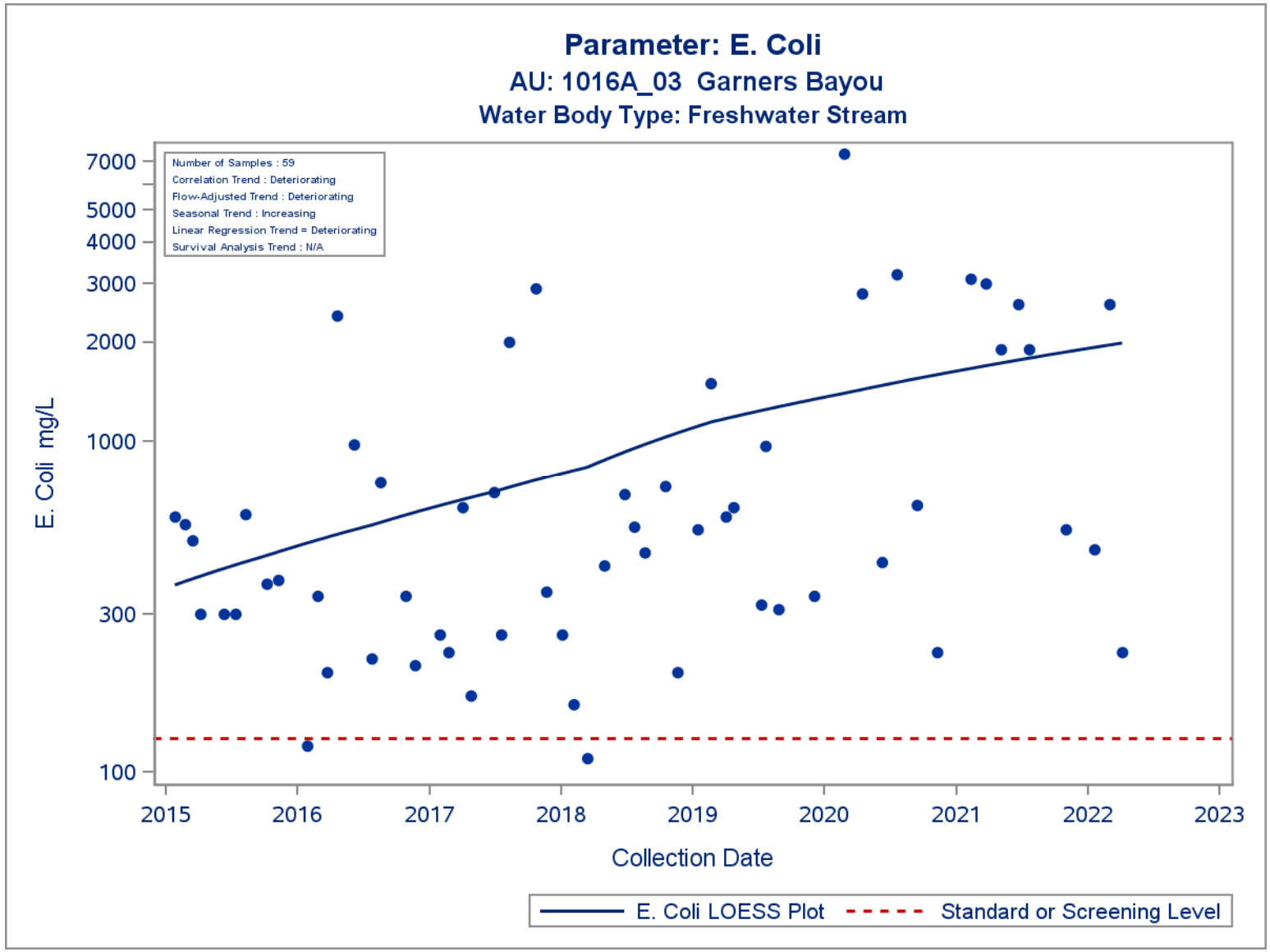

Parameter: pH
AU: 1016_02 Greens Bayou Above Tidal
Water Body Type: Freshwater Stream
Number of Samples : 118
Correlation Trend : Improving
Flow-Adjusted Trend : Improving
Seasonal Trend : Decreasing
Linear Regression Trend = Improving
Survival Analysis Trend : N/A
pH mg/L
9
8.8
8.6
8.4
8.2
8
7.8
7.6
7.4
7.2
2015
2016
2017
2018
2019
2020
2021
2022
2023
Collection Date
pH LOESS Plot
Standard or Screening Level

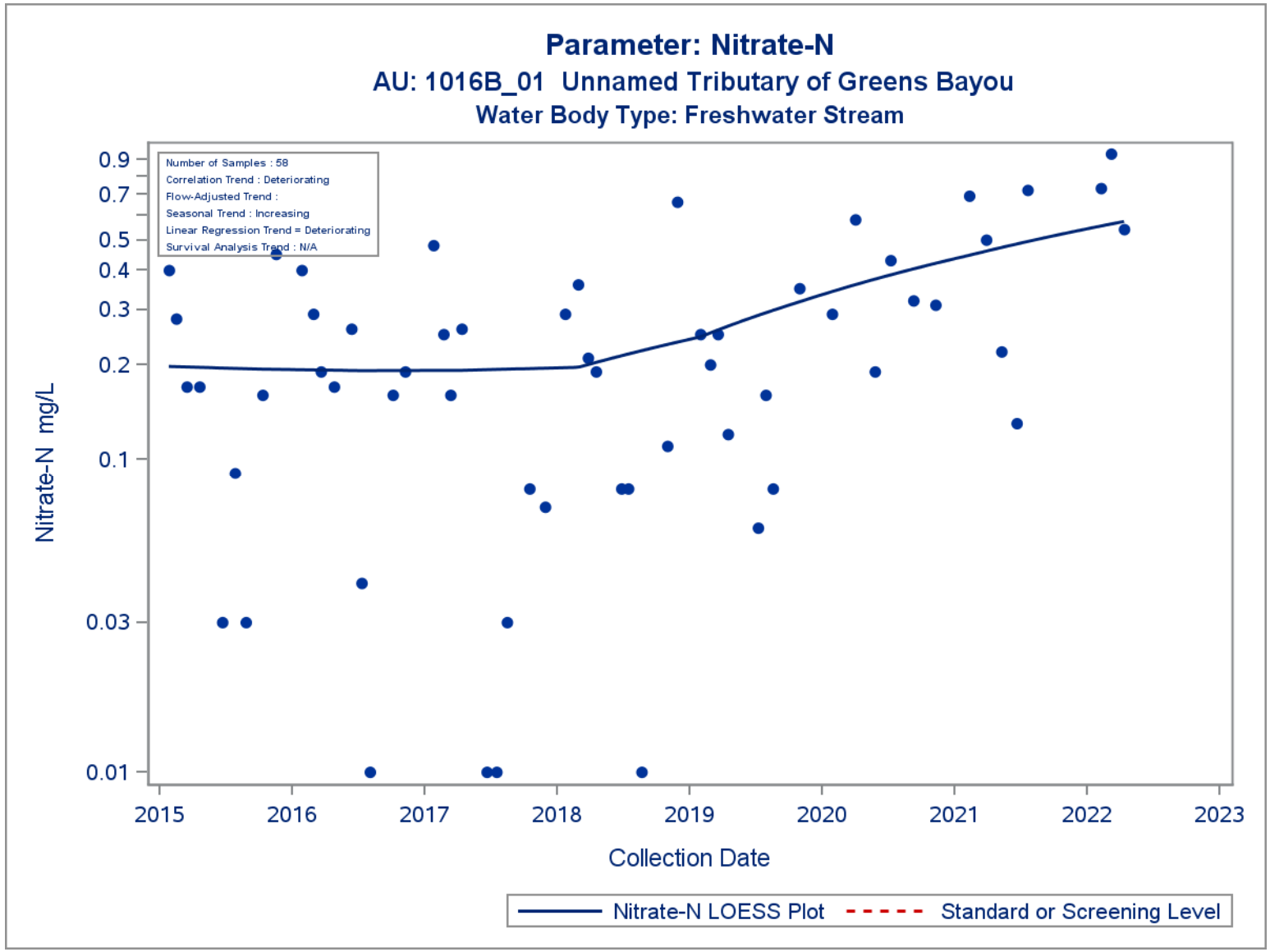

Parameter: Ammonia-N
AU: 1016_03 Greens Bayou Above Tidal
Water Body Type: Freshwater Stream
Number of Samples : 124
Correlation Trend : Stable
Flow-Adjusted Trend : Stable
Seasonal Trend : Increasing
Linear Regression Trend = Deteriorating
Survival Analysis Trend : Deteriorating
Ammonia-N mg/L
0.6
0.5
0.4
0.3
0.2
0.1
0.03
0.01
2015
2016
2017
2018
2019
2020
2021
2022
2023
Collection Date
Ammonia-N LOESS Plot
Standard or Screening Level

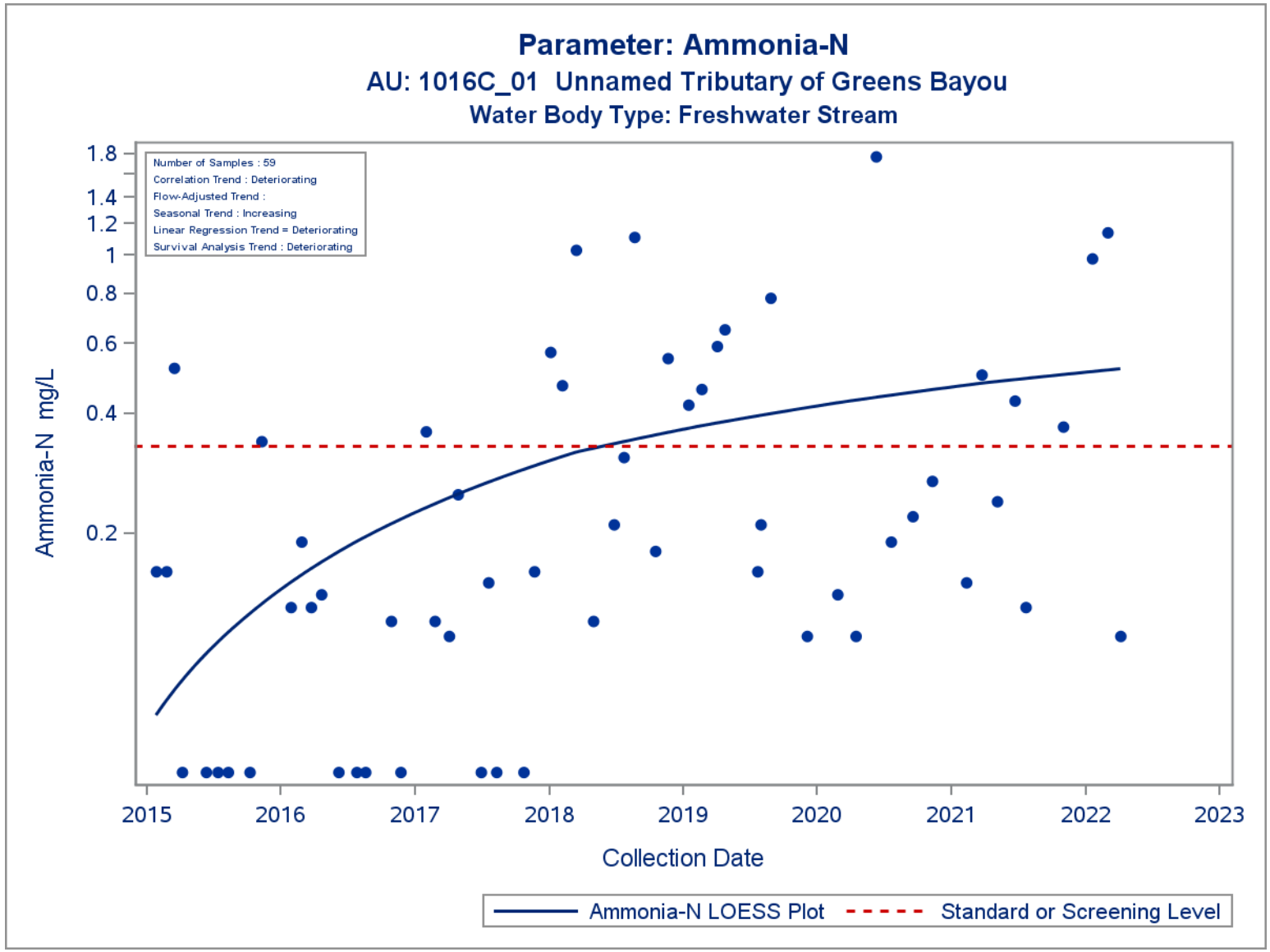

Parameter: E. Coli
AU: 1016_03 Greens Bayou Above Tidal
Water Body Type: Freshwater Stream
Number of Samples : 125
Correlation Trend : Deteriorating
Flow-Adjusted Trend : Stable
Seasonal Trend : Increasing
Linear Regression Trend = Deteriorating
Survival Analysis Trend : N/A
E. Coli mg/L
30000
20000
10000
5000
200
10
2015
2016
2017
2018
2019
2020
2021
2022
2023
Collection Date
E. Coli LOESS Plot
Standard or Screening Level


Parameter: pH
AU: 1016_03 Greens Bayou Above Tidal
Water Body Type: Freshwater Stream
Number of Samples : 124
Correlation Trend : Improving
Flow-Adjusted Trend : Improving
Seasonal Trend : Decreasing
Linear Regression Trend = Improving
Survival Analysis Trend : N/A
pH mg/L
8.4
8.2
8
7.8
7.6
7.4
2015
2016
2017
2018
2019
2020
2021
2022
2023
Collection Date
pH LOESS Plot
Standard or Screening Level


Parameter: Ammonia-N
AU: 1016A_03 Garners Bayou
Water Body Type: Freshwater Stream
Number of Samples : 59
Correlation Trend : Deteriorating
Flow-Adjusted Trend : Deteriorating
Seasonal Trend : Increasing
Linear Regression Trend = Deteriorating
Survival Analysis Trend : Deteriorating
Ammonia-N mg/L
1.6
1.2
1
0.8
0.6
0.4
0.2
2015
2016
2017
2018
2019
2020
2021
2022
2023
Collection Date
Ammonia-N LOESS Plot
Standard or Screening Level


Parameter: E. Coli
AU: 1016A_03 Garners Bayou
Water Body Type: Freshwater Stream
Number of Samples : 59
Correlation Trend : Deteriorating
Flow-Adjusted Trend : Deteriorating
Seasonal Trend : Increasing
Linear Regression Trend = Deteriorating
Survival Analysis Trend : N/A
E. Coli mg/L
7000
5000
4000
3000
2000
1000
300
100
2015
2016
2017
2018
2019
2020
2021
2022
2023
Collection Date
E. Coli LOESS Plot
Standard or Screening Level


Parameter: Nitrate-N
AU: 1016B_01 Unnamed Tributary of Greens Bayou
Water Body Type: Freshwater Stream
Number of Samples : 58
Correlation Trend : Deteriorating
Flow-Adjusted Trend :
Seasonal Trend : Increasing
Linear Regression Trend = Deteriorating
Survival Analysis Trend : N/A
Nitrate-N mg/L
0.9
0.7
0.5
0.4
0.3
0.2
0.1
0.03
0.01
2015
2016
2017
2018
2019
2020
2021
2022
2023
Collection Date
Nitrate-N LOESS Plot
Standard or Screening Level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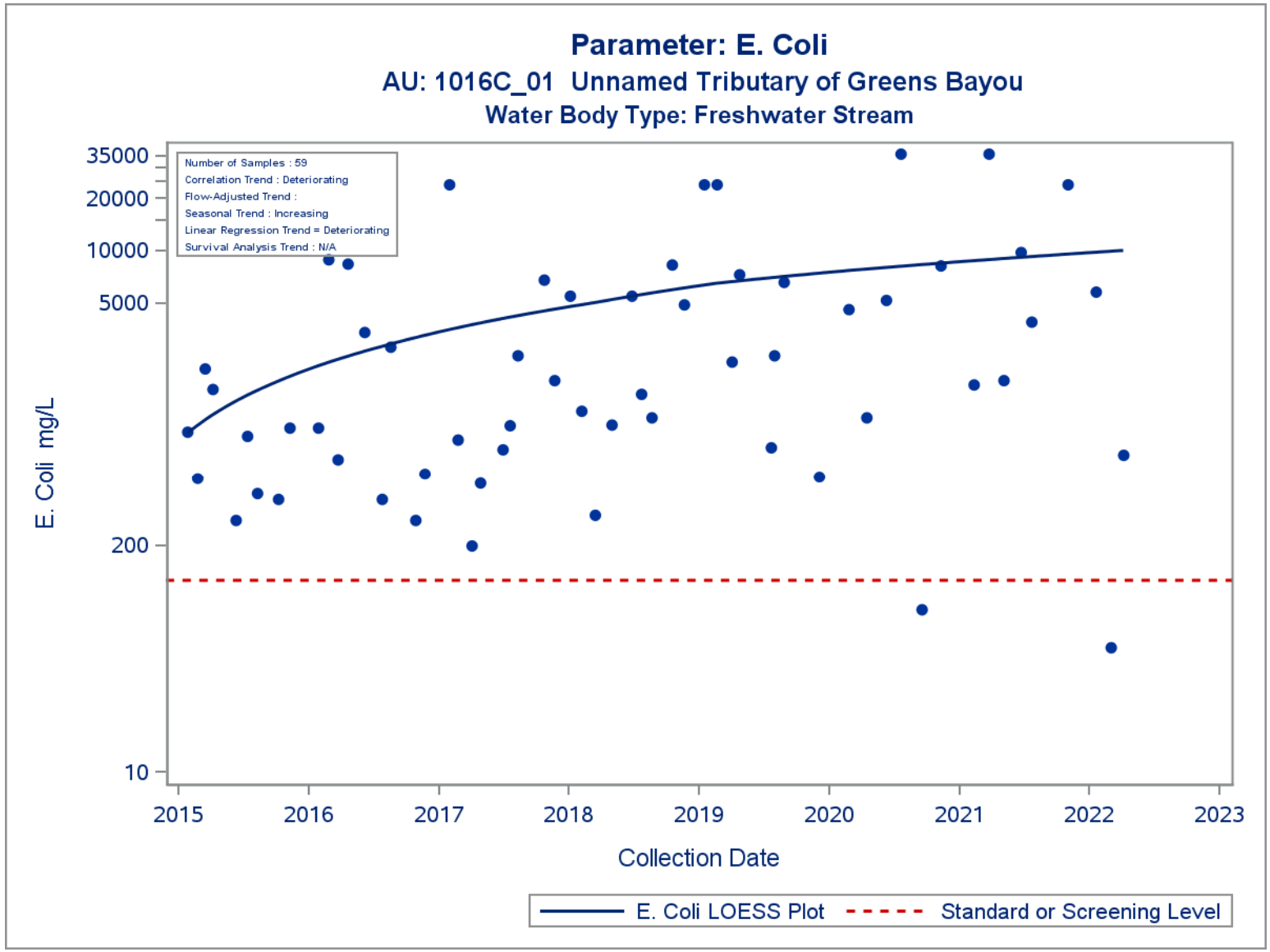
AU: 1016C_01 Unnamed Tributary of Greens Bayou
Water Body Type: Freshwater Stream
Number of Samples : 59
Correlation Trend : Deteriorating
Flow-Adjusted Trend :
Seasonal Trend : Increasing
Linear Regression Trend = Deteriorating
Survival Analysis Trend : Deteriorating
Ammonia-N mg/L
1.8
1.4
1.2
1
0.8
0.6
0.4
0.2
2015
2016
2017
2018
2019
2020
2021
2022
2023
Collection Date
Ammonia-N LOESS Plot
Standard or Screening Level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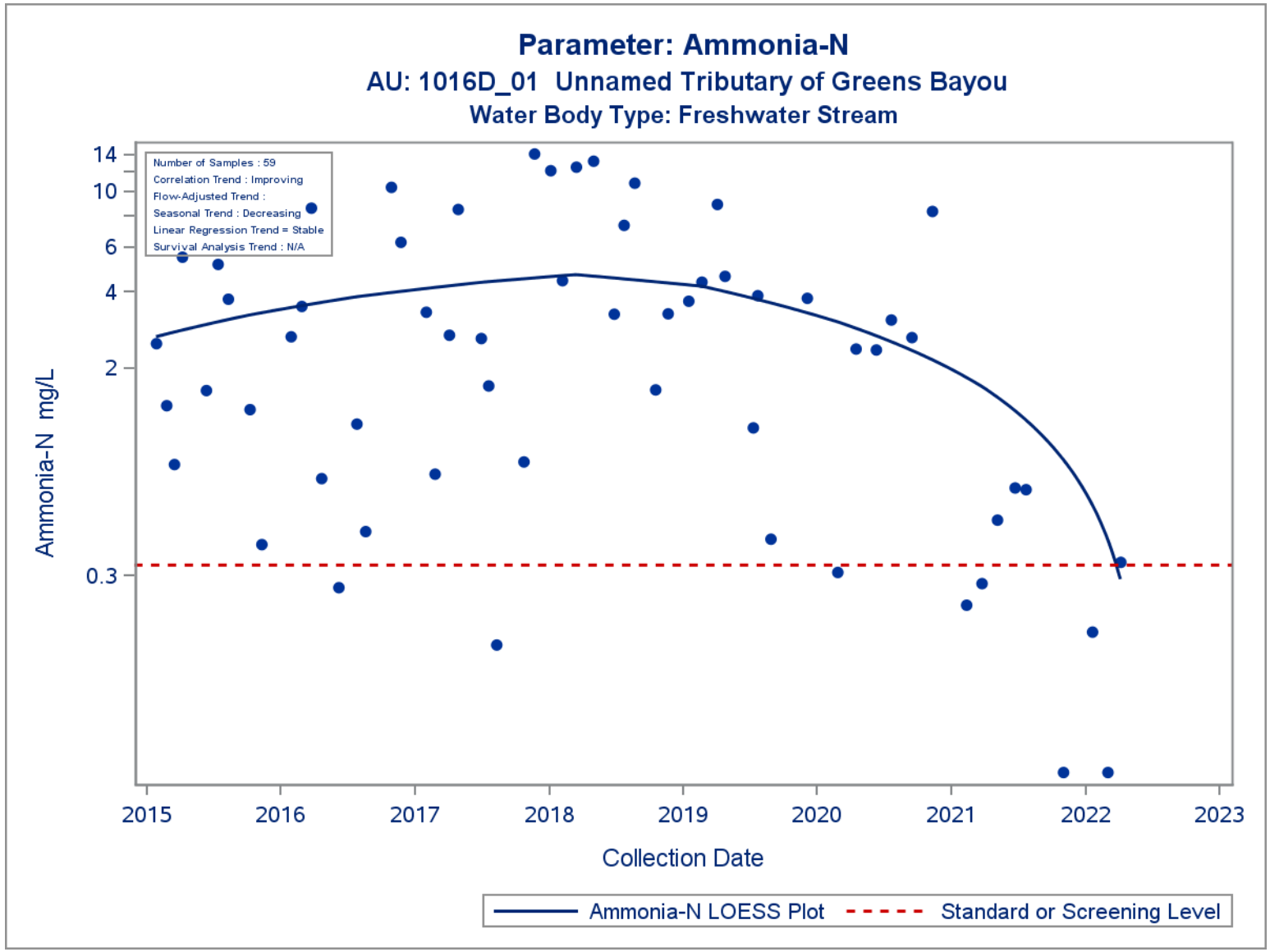
Water Body Type: Freshwater Stream
Number of Samples : 59
Correlation Trend : Deteriorating
Flow-Adjusted Trend :
Seasonal Trend : Increasing
Linear Regression Trend = Deteriorating
Survival Analysis Trend : N/A
35000
20000
10000
5000
200
10
E. Coli mg/L
2015
2016
2017
2018
2019
2020
2021
2022
2023
Collection Date
E. Coli LOESS Plot
Standard or Screening Level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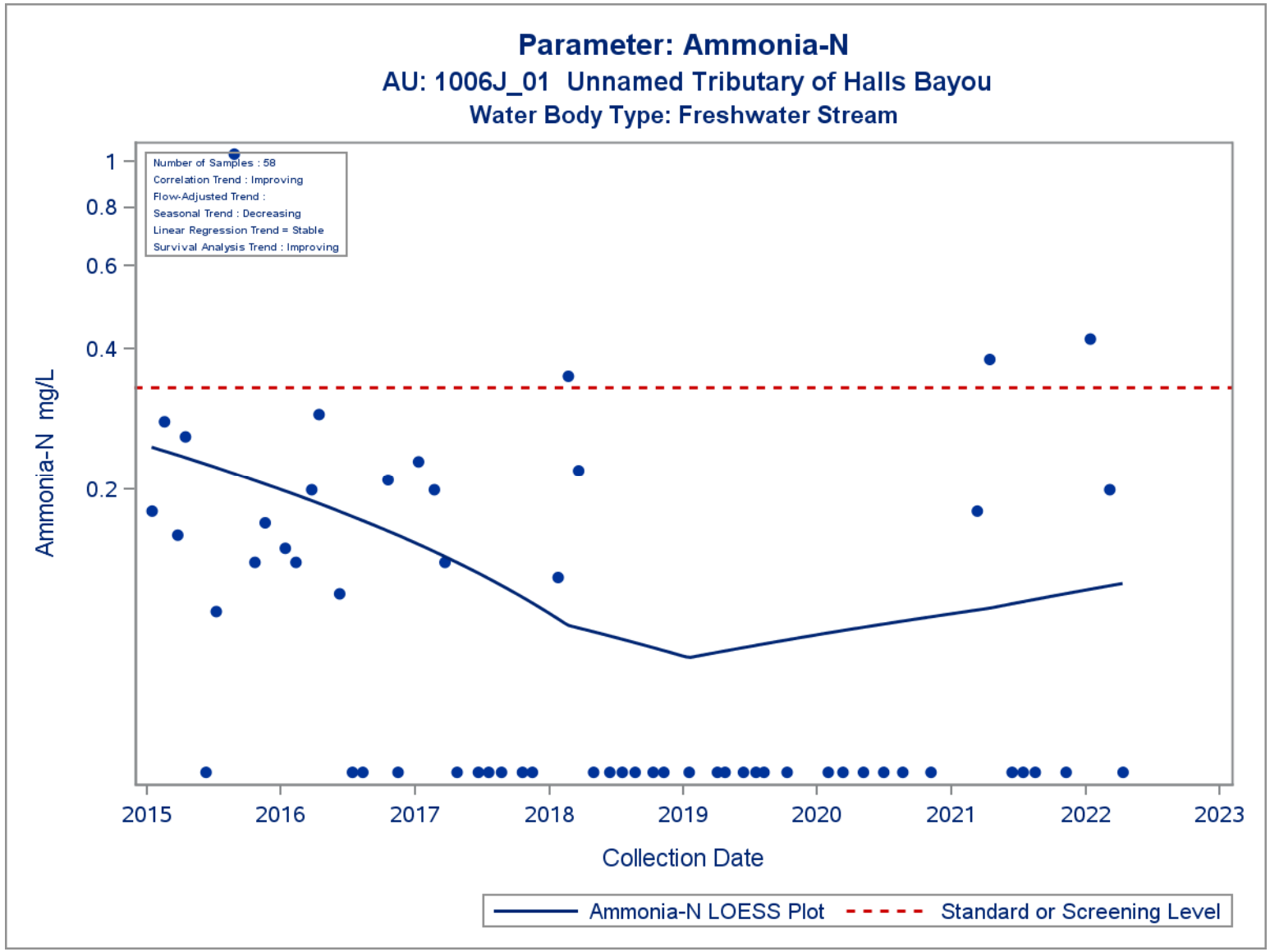
Water Body Type: Freshwater Stream
Number of Samples : 59
Correlation Trend : Improving
Flow-Adjusted Trend :
Seasonal Trend : Decreasing
Linear Regression Trend = Stable
Survival Analysis Trend : N/A
Ammonia-N mg/L
14
10
6
4
2
0.3
2015
2016
2017
2018
2019
2020
2021
2022
2023
Collection Date
Ammonia-N LOESS Plot
Standard or Screening Level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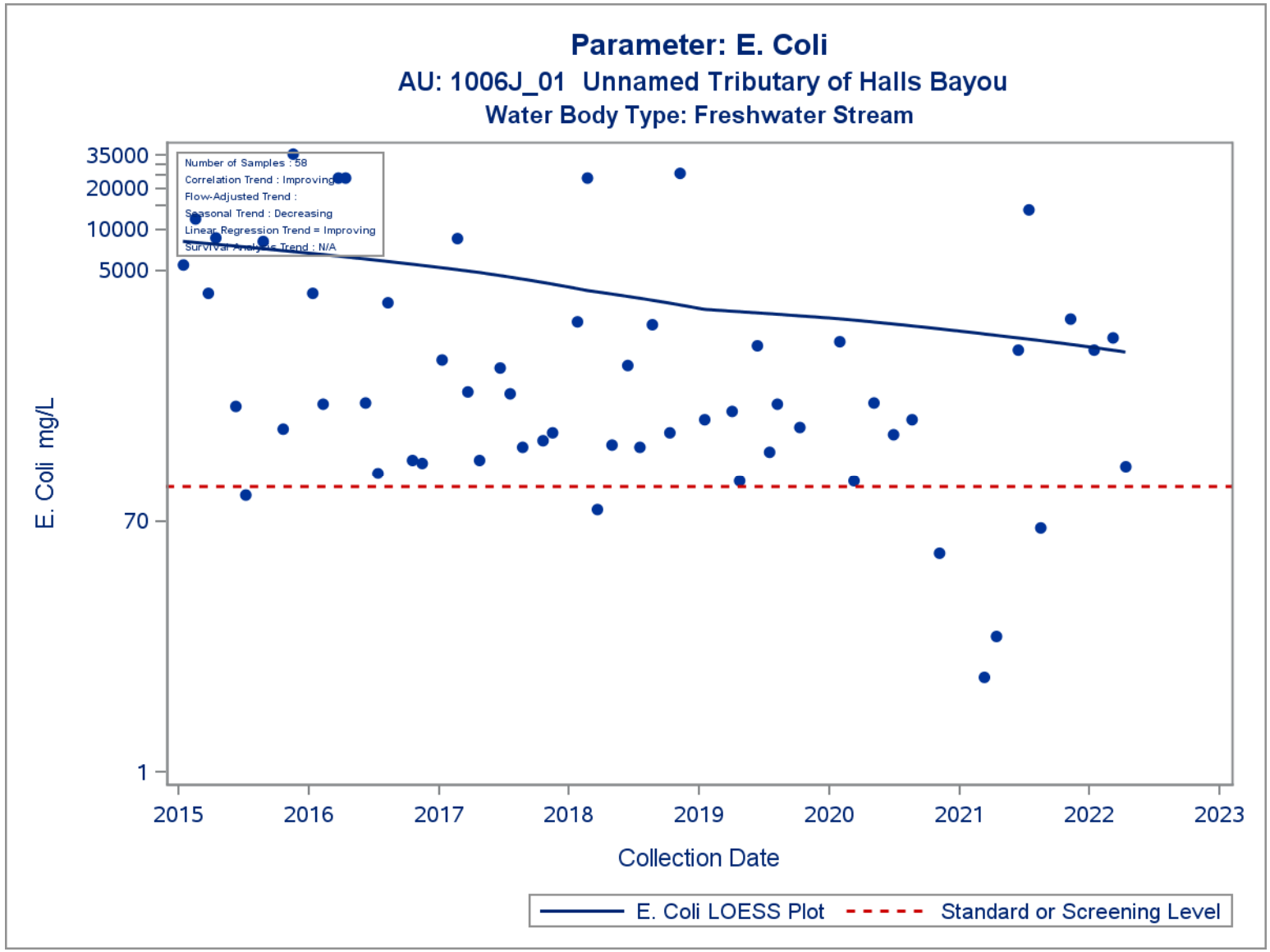
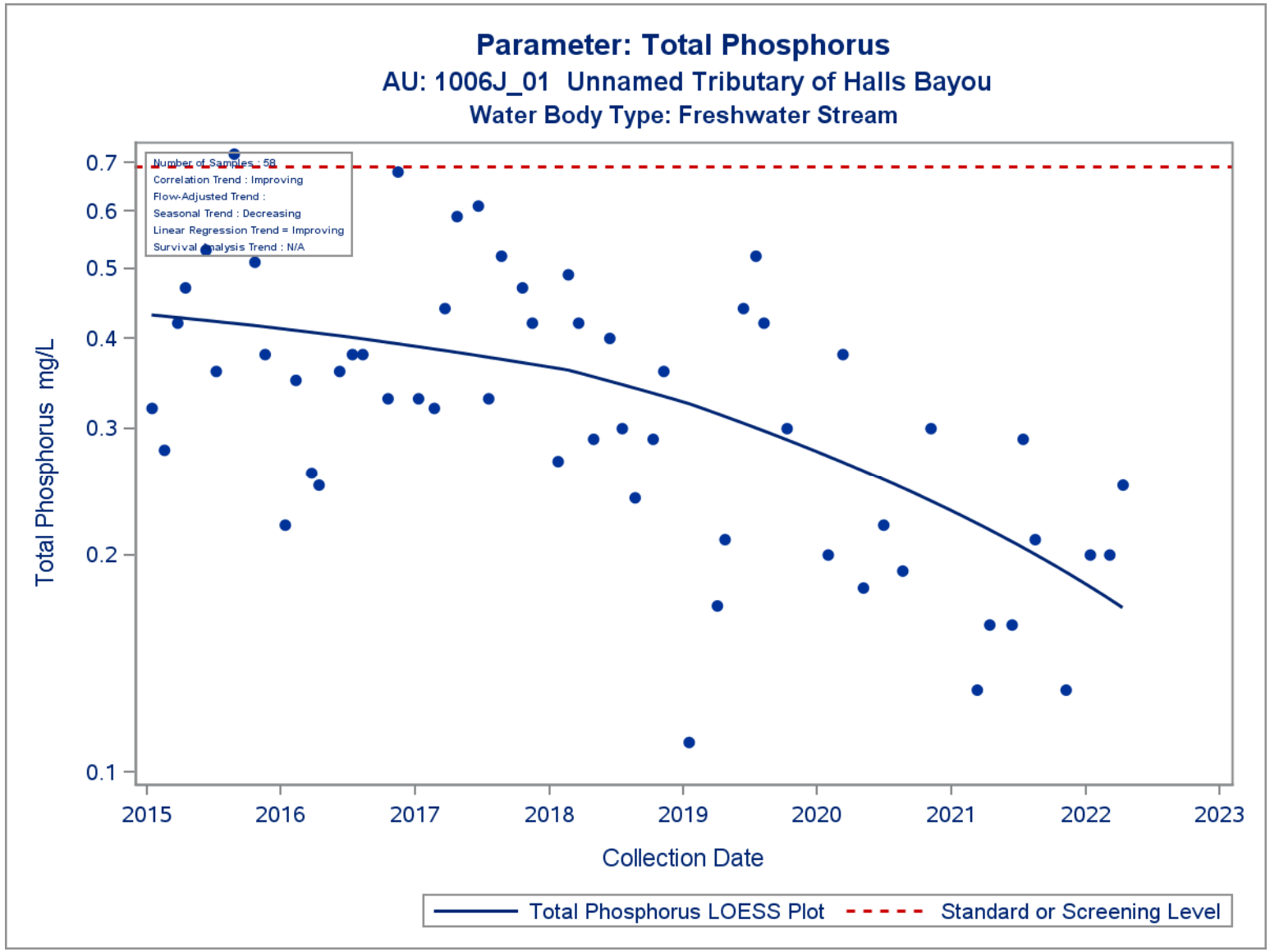
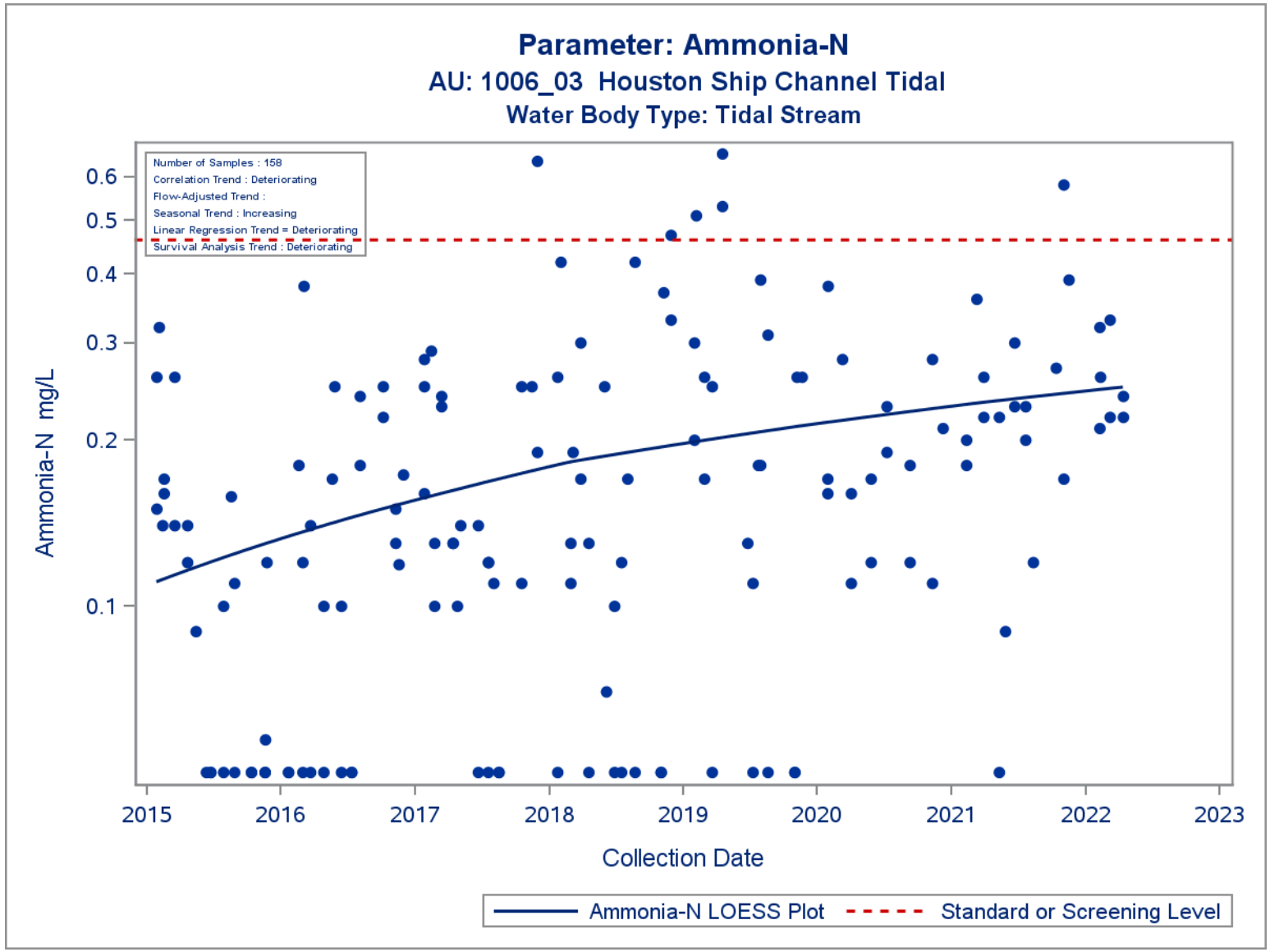
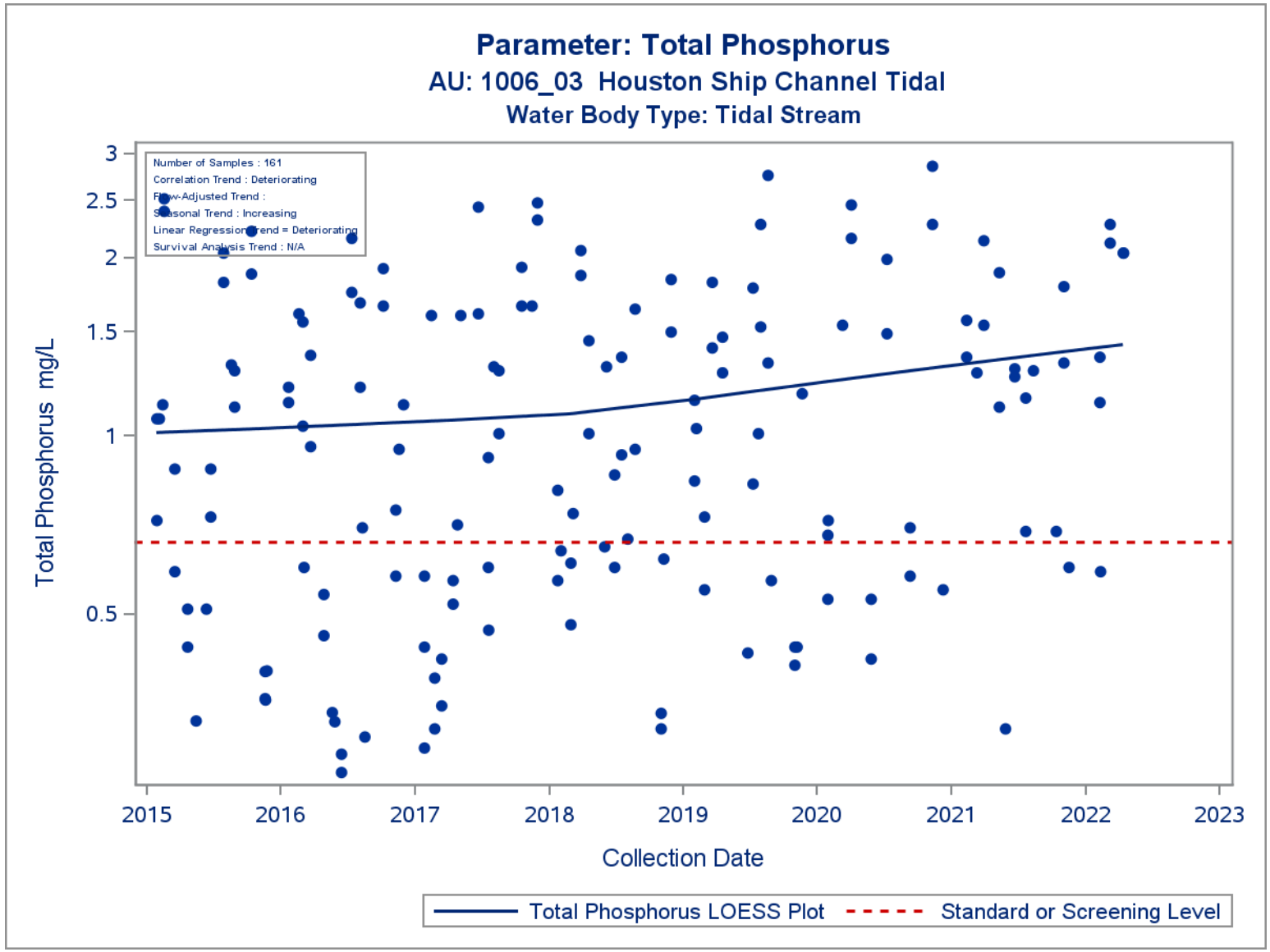
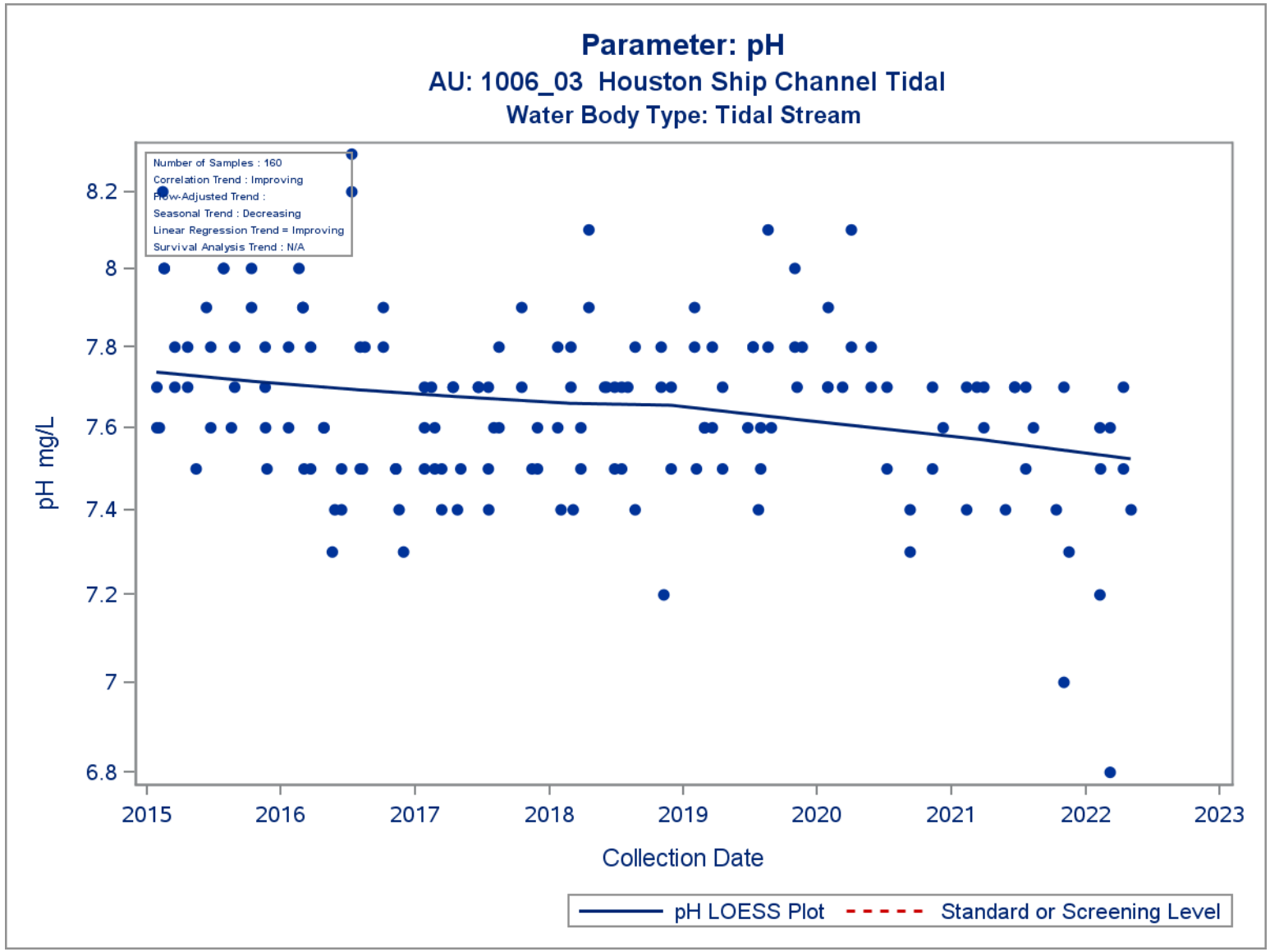
AU: 1006J_01 Unnamed Tributary of Halls Bayou
Water Body Type: Freshwater Stream
Number of Samples : 58
Correlation Trend : Improving
Flow-Adjusted Trend :
Seasonal Trend : Decreasing
Linear Regression Trend = Stable
Survival Analysis Trend : Improving
Ammonia-N mg/L
1
0.8
0.6
0.4
0.2
2015
2016
2017
2018
2019
2020
2021
2022
2023
Collection Date
Ammonia-N LOESS Plot
Standard or Screening Level

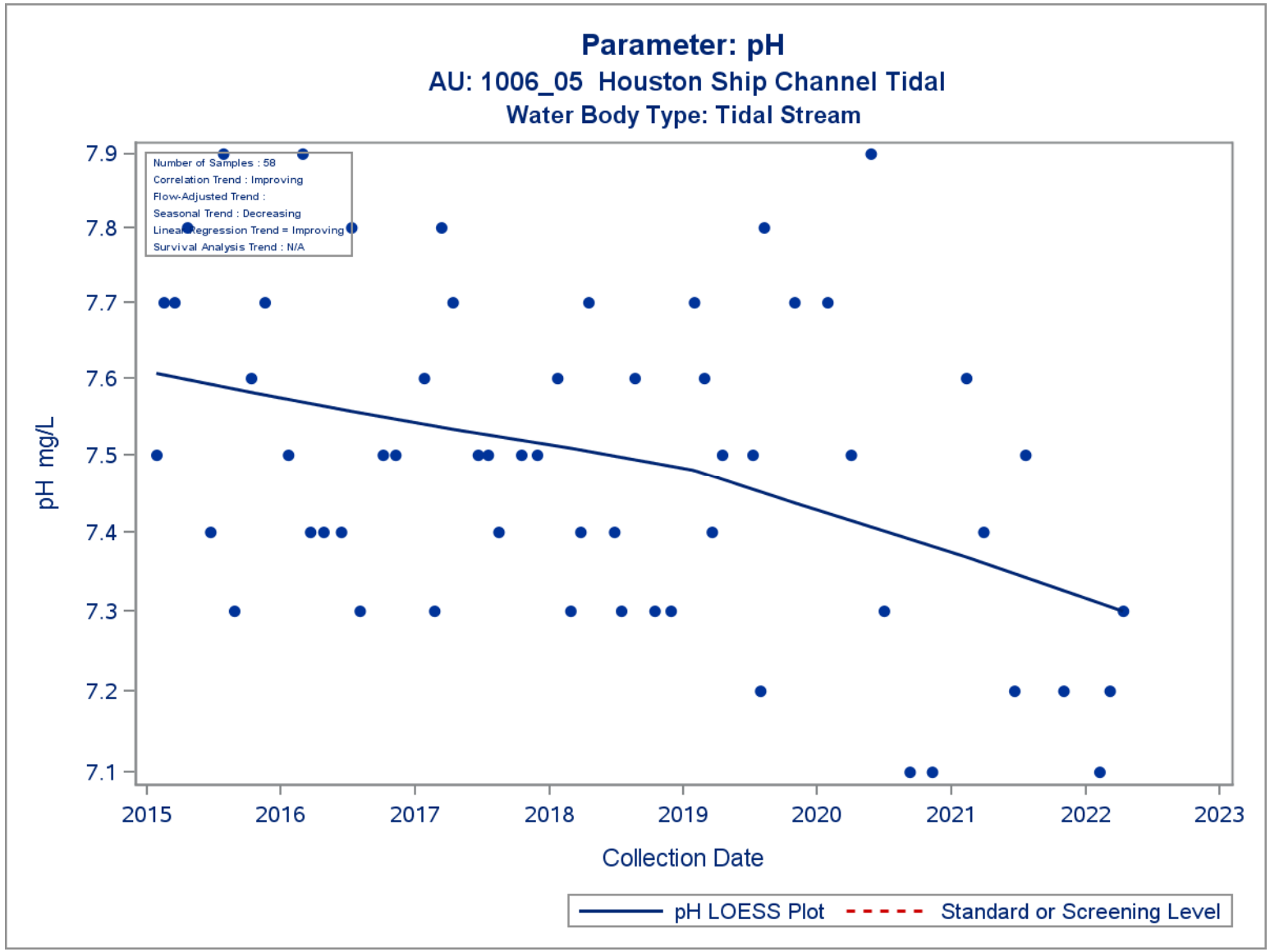

Parameter: E. Coli
AU: 1006J_01 Unnamed Tributary of Halls Bayou
Water Body Type: Freshwater Stream
Number of Samples : 58
Correlation Trend : Improving
Flow-Adjusted Trend :
Seasonal Trend : Decreasing
Linear Regression Trend = Improving
Survival Analysis Trend : N/A
35000
20000
10000
5000
70
1
E. Coli mg/L
2015
2016
2017
2018
2019
2020
2021
2022
2023
Collection Date
E. Coli LOESS Plot
Standard or Screening Level

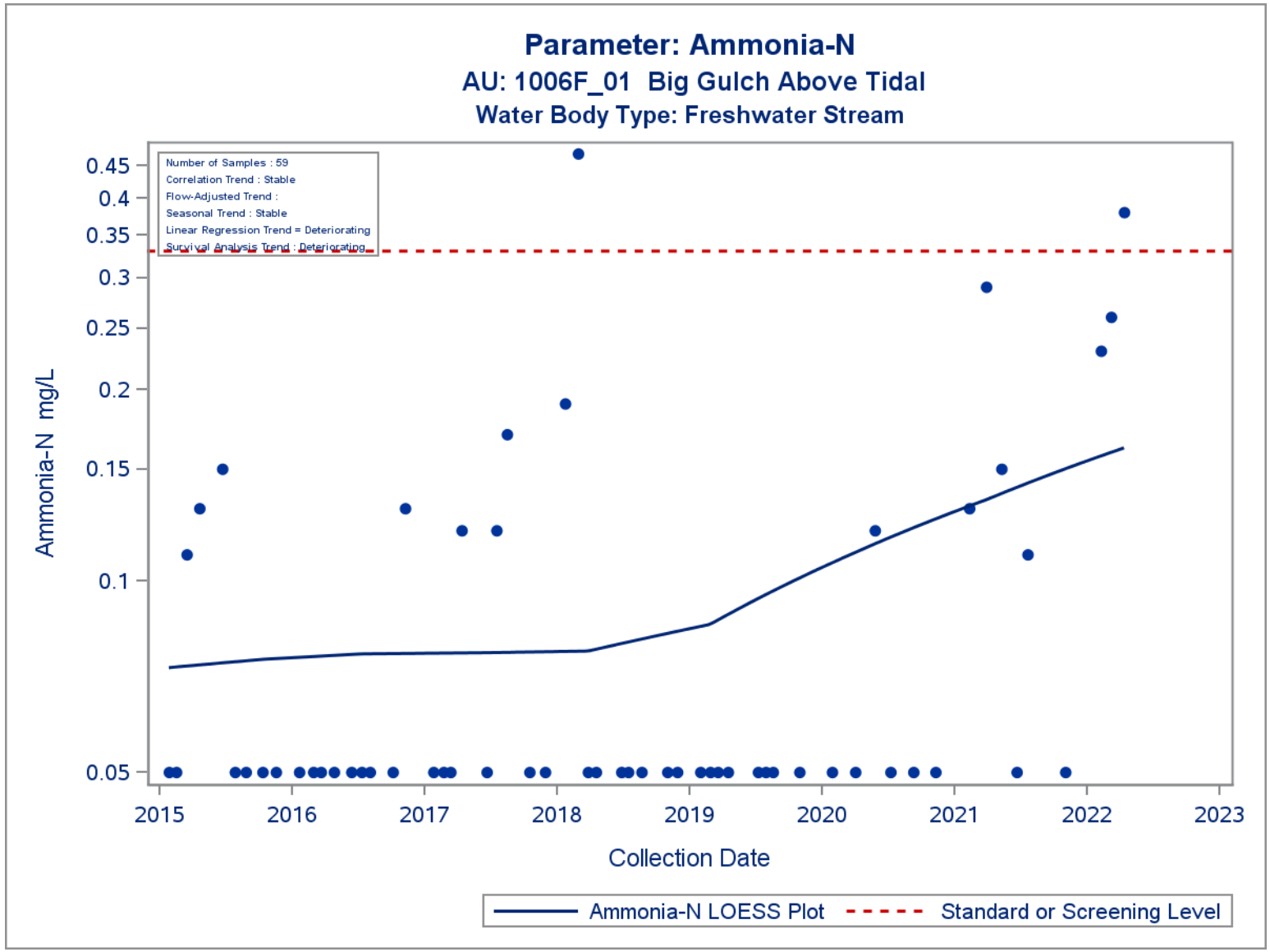

Parameter: Total Phosphorus
AU: 1006J_01 Unnamed Tributary of Halls Bayou
Water Body Type: Freshwater Stream
Number of Samples : 58
Correlation Trend : Improving
Flow-Adjusted Trend :
Seasonal Trend : Decreasing
Linear Regression Trend = Improving
Survival Analysis Trend : N/A
Total Phosphorus mg/L
0.7
0.6
0.5
0.4
0.3
0.2
0.1
2015
2016
2017
2018
2019
2020
2021
2022
2023
Collection Date
Total Phosphorus LOESS Plot
Standard or Screening Level

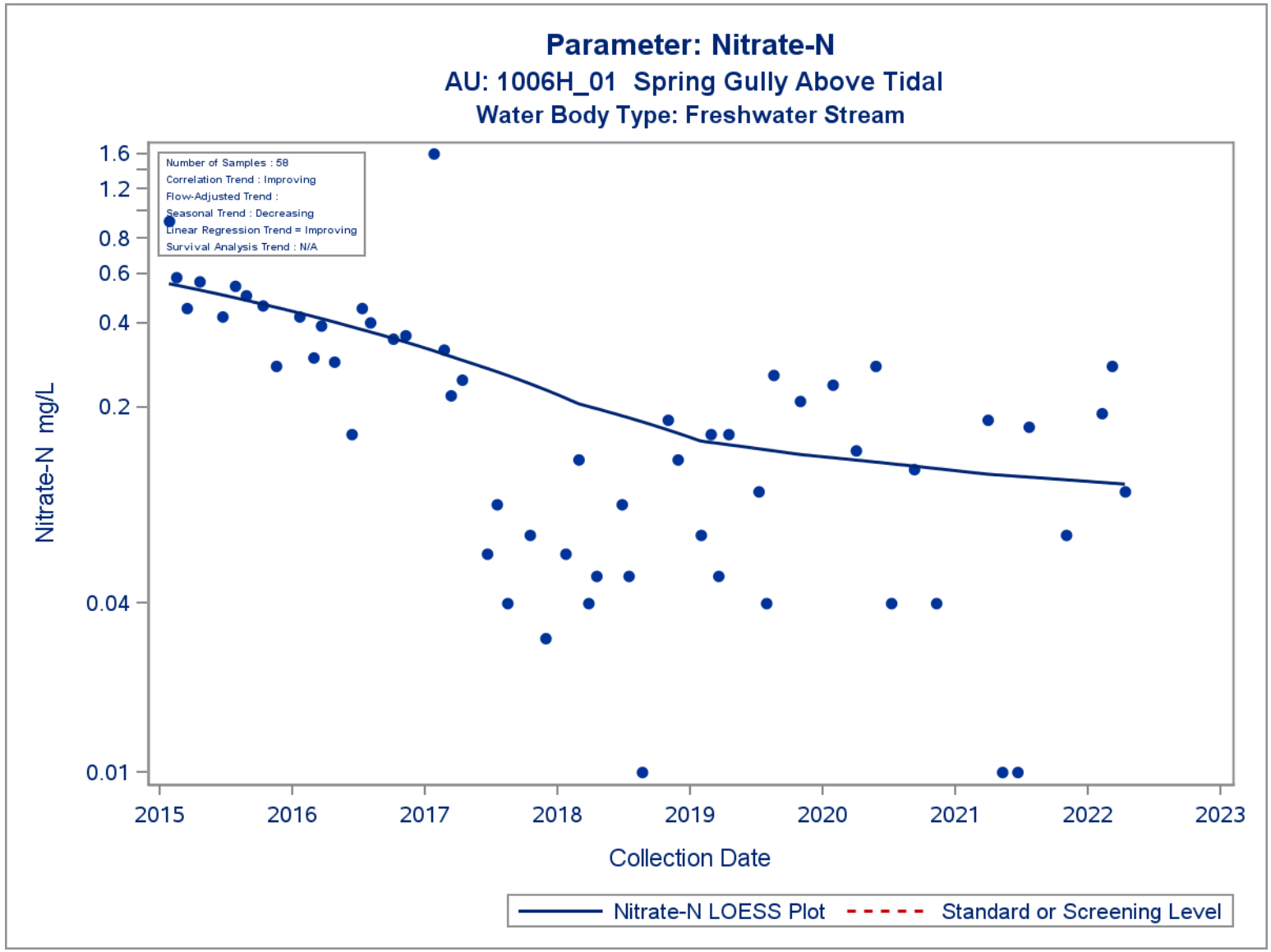

Parameter: Ammonia-N
AU: 1006_03 Houston Ship Channel Tidal
Water Body Type: Tidal Stream
Number of Samples : 158
Correlation Trend : Deteriorating
Flow-Adjusted Trend :
Seasonal Trend : Increasing
Linear Regression Trend = Deteriorating
Survival Analysis Trend : Deteriorating
Ammonia-N mg/L
0.6
0.5
0.4
0.3
0.2
0.1
2015
2016
2017
2018
2019
2020
2021
2022
2023
Collection Date
Ammonia-N LOESS Plot
Standard or Screening Level


Parameter: Total Phosphorus
AU: 1006_03 Houston Ship Channel Tidal
Water Body Type: Tidal Stream
Number of Samples : 161
Correlation Trend : Deteriorating
Flow-Adjusted Trend :
Seasonal Trend : Increasing
Linear Regression Trend = Deteriorating
Survival Analysis Trend : N/A
Total Phosphorus mg/L
3
2.5
2
1.5
1
0.5
2015
2016
2017
2018
2019
2020
2021
2022
2023
Collection Date
Total Phosphorus LOESS Plot
Standard or Screening Level


Parameter: pH
AU: 1006_03 Houston Ship Channel Tidal
Water Body Type: Tidal Stream
Number of Samples : 160
Correlation Trend : Improving
Flow-Adjusted Trend :
Seasonal Trend : Decreasing
Linear Regression Trend = Improving
Survival Analysis Trend : N/A
pH mg/L
8.2
8
7.8
7.6
7.4
7.2
7
6.8
2015
2016
2017
2018
2019
2020
2021
2022
2023
Collection Date
pH LOESS Plot
Standard or Screening Level


Parameter: pH
AU: 1006_05 Houston Ship Channel Tidal
Water Body Type: Tidal Stream
Number of Samples : 58
Correlation Trend : Improving
Flow-Adjusted Trend :
Seasonal Trend : Decreasing
Linear Regression Trend = Improving
Survival Analysis Trend : N/A
pH mg/L
7.9
7.8
7.7
7.6
7.5
7.4
7.3
7.2
7.1
2015
2016
2017
2018
2019
2020
2021
2022
2023
Collection Date
pH LOESS Plot
Standard or Screening Level


Parameter: Ammonia-N
AU: 1006F_01 Big Gulch Above Tidal
Water Body Type: Freshwater Stream
Number of Samples : 59
Correlation Trend : Stable
Flow-Adjusted Trend :
Seasonal Trend : Stable
Linear Regression Trend = Deteriorating
Survival Analysis Trend : Deteriorating
Ammonia-N mg/L
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
2015
2016
2017
2018
2019
2020
2021
2022
2023
Collection Date
Ammonia-N LOESS Plot
Standard or Screening Level


Parameter: Nitrate-N
AU: 1006H_01 Spring Gully Above Tidal
Water Body Type: Freshwater Stream
Number of Samples : 58
Correlation Trend : Improving
Flow-Adjusted Trend :
Seasonal Trend : Decreasing
Linear Regression Trend = Improving
Survival Analysis Trend : N/A
Nitrate-N mg/L
1.6
1.2
0.8
0.6
0.4
0.2
0.04
0.01
2015
2016
2017
2018
2019
2020
2021
2022
2023
Collection Date
Nitrate-N LOESS Plot
Standard or Screening Level