Targeted Bacteria Monitoring Project

Executive Summary

Houston-Galveston Area Council

Overview

The Houston-Galveston Area Council's (H-GAC) Targeted Bacteria Monitoring Project focuses on the region's most prevalent pollutant – bacteria. The goal is to examine various watersheds with elevated bacteria levels to identify potential sources. A seven-year geometric mean analysis defining the severity of impairment was performed on each assessment unit (AU) within the region. H-GAC ranked waterways using the highest geomean relative to the state standards for contact recreation. Assessment units were selected by 1) highest geomean identified, and 2) accessibility and feasibility of the waterway for field investigations (Figure 1). Twelve AUs were identified for investigation as part of this project, with project funding provided by both the Clean Rivers Program and the TMDL Program (Table 1).

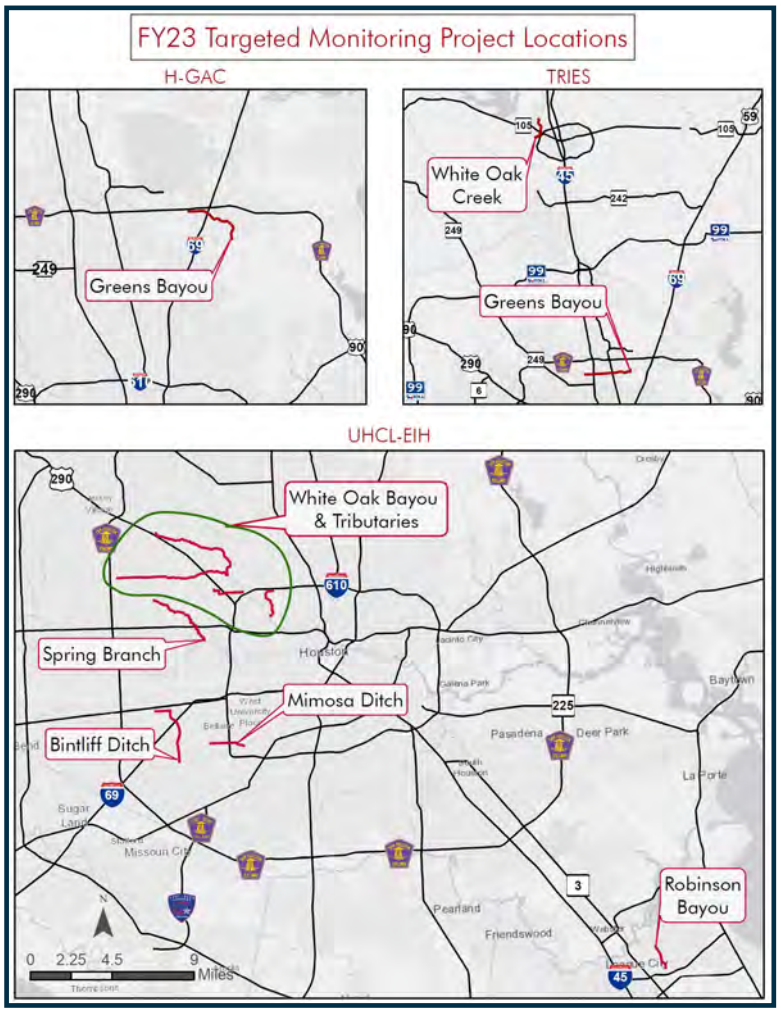

Table 1. Targeted Bacteria Monitoring Assessment Units (AUs)

AU ID	AU Name	Relative Bacteria Geomean	AU Length (miles)	Funding Source for Investigation
1004J_01	White Oak Creek (Conroe)	2981	2.79	TMDL Program
1007T_01	Bintliff Ditch	5969	3.90	Clean Rivers Program
1007U_01	Mimosa Ditch	1457	1.90	Clean Rivers Program
1014O_01	Spring Branch (tributary of Buffalo Bayou)	1206	4.30	Clean Rivers Program
1016C_01	Unnamed Tributary of Greens Bayou	2023	5.64	TMDL Program
1016D_01	Unnamed Tributary of Greens Bayou	1536	3.30	TMDL Program
1017_03	White Oak Bayou Above Tidal	1625	1.63	Clean Rivers Program
1017A_01	Brickhouse Gully	1406	6.43	Clean Rivers Program
1017B_01	Cole Creek	1602	4.08	Clean Rivers Program
1017D_01	Unnamed Tributary of White Oak Bayou	1226	1.84	Clean Rivers Program
1017E_01	Unnamed Tributary of White Oak Bayou	2288	1.93	Clean Rivers Program
1101D_01	Robinson Bayou Tidal/Above Tidal	305 (enterococcus)	1.41	Clean Rivers Program

Methods

H-GAC and its subcontractors, the Environmental Institute of Houston, University of Houston-Clear Lake and the Texas Research Institute for Environmental Studies, Sam Houston State University, first conducted a windshield survey on each watershed. This survey served as a spatial assessment of the watershed and determined where hotspots of high bacteria concentrations existed along the waterway and its tributaries. During the windshield survey the field crew collected bacteria samples at easily accessible locations, such as major road crossings and public access points adjacent to the waterway. Results from the survey aided in prioritizing intensive field investigations along the waterway and tributaries of concern leading into the main segment. Both survey events (windshield survey and field investigation) were only conducted during dry weather following a 72-hour antecedent dry period.

For the field investigation, any outfall categorized as "permitted" or > 12 inches was collected upstream and downstream of the permitted pipe and the difference in results was compared, but samples were not collected directly from the outfall source. Any outfall that was judged to be "unpermitted" in the field was sampled directly at the source. All tributary samples were collected far enough into the flowing water so that mixing was not a factor. In instances where no potential sources were observed for an extended section of the waterway, a single ambient reference sample was taken mid-stream.

Results

A report detailing methods and findings was created for each AU. In total, 108 samples were collected in all windshield surveys, 587 samples collected within the field investigations, and 109 sites were included among the referrals to the proper authorities (Table 2). In addition to referrals for specific outfalls, some referrals include areas where high bacteria levels were found in ambient samples without any flows observed from nearby potential sources. Individual AU reports are included in this document and will be available at https://www.h-gac.com/community-and-environmental-planning-publications/water-resources.

Table 2. Bacteria Sample Results

AU ID	AU Name	Windshield Survey Sample Count	Field Investigation Sample Count	Referral Sites	Funding Source
1004J_01	White Oak Creek (Conroe)	6	74	7	TMDL Program
1007T_01	Bintliff Ditch	12	71	14	Clean Rivers
1007U_01	Mimosa Ditch	7	27	5	Clean Rivers
1014O_01	Spring Branch (tributary of Buffalo Bayou)	9	70	14	Clean Rivers Program
1016C_01	Unnamed Tributary of Greens Bayou	10	40	11	TMDL Program
1016D_01	Unnamed Tributary of Greens Bayou	13	26	5	TMDL Program
1017_03	White Oak Bayou Above Tidal	6	41	9	Clean Rivers
1017A_01	Brickhouse Gully	13	57	16	Clean Rivers
1017B_01	Cole Creek	8	61	12	Clean Rivers
1017D_01	Unnamed Tributary of White Oak Bayou	5	23	4	Clean Rivers Program
1017E_01	Unnamed Tributary of White Oak Bayou	13	27	4	Clean Rivers Program
1101D_01	Robinson Bayou Tidal/Above Tidal	6	70	8	Clean Rivers

Future Work

Next steps include sending the referral sites to the proper authorities to see if any potential sources can be eliminated with repairs or corrective action, and if any of the referral sites resulting from ambient reference samples can have their sources identified. With future funding, some of these AUs may undergo additional field investigations, and H-GAC anticipates continual work with the proper authorities towards corrective action. H-GAC also anticipates future iterations of this project, with a re-analysis of the priority AU list based on more recently obtained ambient monitoring data through the Clean Rivers Program.

Photo credits: Houston-Galveston Area Council and Environmental Institute of Houston, University of Houston-Clear Lake.

Targeted Bacteria Monitoring Project
Field Investigation Final Report
Assessment Unit 1007T _01 Bintliff Ditch

Environmental Institute of Houston

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Segment Description

Bintliff Ditch is a tributary to Brays Bayou and the Segment ID is 1007T (Figure 1). This segment is 6.3 km long, consists of one assessment unit (AU) of concern, AU 1007T _01, and is defined as from the confluence with Brays Bayou upstream 5.8 km to the Fondren Road bridge crossing. There is one current surface water quality monitoring (SWQM) station located on this AU (station ID: 18690). This AU has been selected for targeted monitoring due to a bacteria (*Escherichia coli*) seven-year geometric mean of 5,969.1 MPN/100 mL and has a current impairment category of 4a (H-GAC QAPP, 2022, TCEQ, 2022). The potential sources of bacteria impairments are non-point source pollution, urban runoff, and sanitary sewer overflows (TCEQ, 2022). This AU was monitored previously as part of the FY20-21 Targeted Monitoring Study.

The contributing watershed for this segment is 12 km^2 (Data source: H-GAC, SWRC, 2023). The soil types in the watershed have medium to very slow infiltration rates and the land cover is dominated by 99.99% developed land (Data sources: United States Department of Agriculture Hydrologic Soil Groups from gSSURGO 2016 and National Land Cover Database NLCD 2019). There are not any permitted wastewater outfalls or documented unpermitted on-site sewage facilities (OSSF) within the watershed (Data source: H-GAC). There is one documented permitted OSSF on an unnamed tributary to Bintliff Ditch (Data source: H-GAC).

Background

Clean Rivers Program (CRP) routine monitoring data are analyzed each year as part of the Houston-Galveston Area Council (H-GAC) Basin Summary/Basin Highlights Report process. Bacteria continues to be the most prevalent pollutant in the H-GAC CRP Basins (H-GAC, 2022). The Bacteria Implementation Group (BIG), formed in 2008, oversees the Total Maximum Daily Load (TMDL) Implementation Plan (I-Plan). The BIG requested that H-GAC produce a list of the water bodies with the highest bacteria concentrations in the BIG project area and conduct targeted monitoring to identify potential bacteria sources.

H-GAC, using information from previous Basin Highlights/Summary Reports, BIG annual reports, and previous targeted monitoring efforts, identified and selected waterways for targeted bacteria monitoring to refine our understanding of the spatial distribution of elevated bacterial concentrations contributing to these waterways. Phase 1 of this targeted monitoring project included an intensive desktop review of the most up to date imagery available and compilation of data from field investigations (FI) conducted in 2021. Phase 2 of this targeted monitoring project included a FI of the entire AU conducted during dry conditions where all flowing point and non-point sources were evaluated.

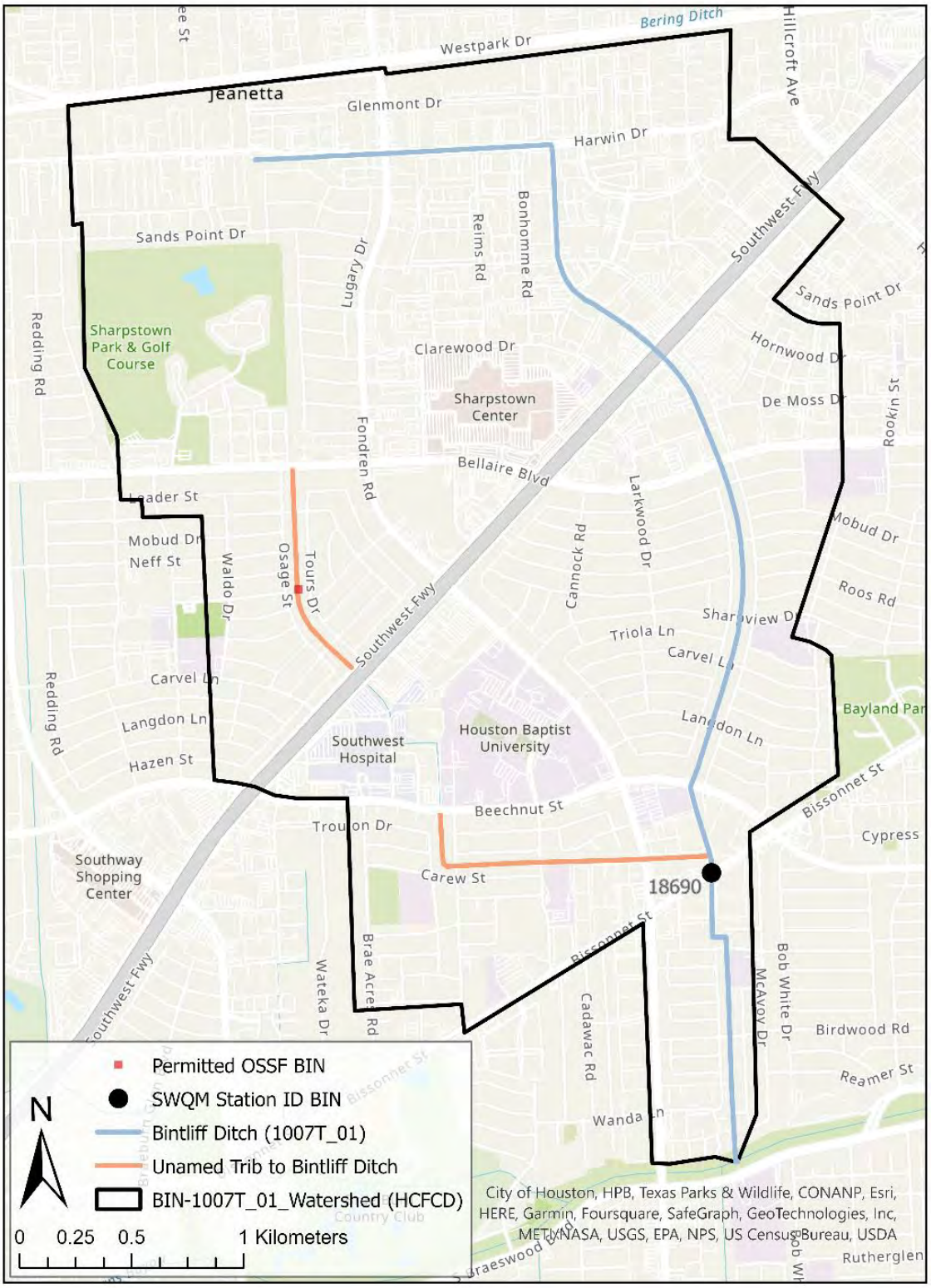

Figure 1: Watershed Map for Bintliff Ditch (Assessment Unit 1007T _01).

Desktop Review

Methods

The intensive desktop review included an evaluation of permitted discharges, outfalls, and potential sources of point and nonpoint source pollution that may contribute to bacteria loading in the AU. Using Google Earth imagery and GIS, the locations of wastewater treatment facilities, permitted on-site sewage facilities (OSSFs), and potential locations of unpermitted OSSFs were identified. If present, other potential sources such as landfills and industrial facilities were also identified. Parks were noted, as these can contribute to bacterial sources through runoff of animal wastes but also provide opportunity for contact recreation. Bridge crossings and other public entry points were identified to provide access into the stream to collect bacteriological samples. The Environmental Institute of Houston conducted this review in 2021 and AU 1007T_01 was reviewed again prior to beginning the 2023 FI.

Results

The results of the desktop review indicated that there is one unnamed tributary that runs into Bintliff Ditch via a concrete canal. The unnamed tributary runs underground under Memorial Hermann Southwest Hospital and resurfaces on the north side of Southwest Freeway. There is one documented permitted OSSF on an unnamed tributary to Bintliff Ditch. This AU runs through a highly commercial area, positioned beside multiple strip malls, residential areas, and apartment complexes potentially introducing bacteria into the water. Publicly accessible entry points into the Bintliff Ditch were identified at Fondren Road and Brays Bayou, Birdwood Road, Grape Street, Bissonnet Street, Beechnut Street, Langdon Lane, Carvel Lane, Sharpview Drive, Neff Street, and Leader Street. Publicly accessible entry points to the unnamed tributary start behind the shopping center at Bissonnet Street and Bintliff Ditch, moving west towards Fondren Road, Bonhomme Road, Braeburn Valley Drive, and finally to Beechnut Street.

Windshield Survey

Methods

Field events must take place during dry weather (after three or more days without significant rainfall in the watershed). This ensures that any flowing water into the segment is not stormwater. Windshield surveys (WS) of the watershed were conducted in 2021 and bacteria sampling was performed at public access points throughout the AU (primarily at bridge crossings). The survey consisted of driving the catchment area to confirm identified pollution sources found during the desktop review and to find any potential sources not identified during that review. Bridge crossings chosen for sampling were spatially distributed to provide a spatial snapshot of bacteria concentrations in the AU and identify sections of the AU where elevated bacteria concentrations were found. Those areas with elevated bacteria levels identified in the

WS monitoring were focused on during the FI of the FY20-21 study. The results from the 2021 sampling events were used to plan the 2023 FI. Therefore, a WS was not completed in 2023.

Assessment Units, sample collection and laboratory methods, and data handling practices for the 2021 study are detailed in Appendix J of the FY 2020-2021 H-GAC Multi-Basin Clean Rivers Program Quality Assurance Project Plan (H-GAC QAPP, 2020). For all WS bacteria monitoring conducted in 2021, field personnel documented the latitude and longitude of sample locations. All bacteria samples were analyzed by a National Environmental Laboratory Accreditation Program (NELAP)-Accredited laboratory.

Results

The WS was conducted on March 9, 2021 (Oakley and Lesher, 2021). At that time, it had been eight days since the last significant rainfall in the watershed. A total of 12 samples were collected on 1007T _01 and one on a contributing tributary. Bacteria results from the ambient water samples collected during the WS ranged from 52–8660 MPN/100 mL.

Field Investigation

Methods

The following methods were conducted for the FI in 2021 and were also used for the 2023 FI. Assessment Units, collection and laboratory methods, and data handling practices for the 2023 FI are detailed in Appendix J of the FY 2022-2023 H-GAC Multi-Basin Clean Rivers Program Quality Assurance Project Plan (H-GAC QAPP, 2022). The FI was a thorough survey where a team of two either walked or paddled the entire assessment unit and sampled dry-weather flow into the segment. Water could be flowing in from a pipe, culvert, natural tributary, or earthen/concrete-lined ditch. Flowing water was categorized into two source types: permitted outfalls or unpermitted outfalls. Permitted outfalls included wastewater facilities and municipal separate storm sewer systems (MS4). Any pipe greater than 12 inches (in.) in diameter was assumed to be permitted by our field crews.

When flowing water was observed from a permitted outfall, two samples were collected. One sample was collected immediately downstream of the outfall where the flowing outfall was mixing with the ambient water. The second sample was taken upstream of the flowing outfall outside of the realm of influence from the outfall to provide the ambient bacteria levels of the assessment unit in that area. The second type of source was an unpermitted outfall, which was any other flowing source of water that was judged not to be permitted in the field, including flowing small (<12 in. diameter) “homemade” pipes and tributaries.

When a flowing unpermitted outfall was observed, the bacteria sample was taken directly from the source. If the source was a flowing pipe, the sample was collected directly from the pipe,

before it entered the segment. If it was an open-top earthen ditch or natural tributary, the sample was collected from far enough into the inflow source that there was no mixing with the receiving water. In some cases, when no flowing permitted or unpermitted outfalls were observed in an extended section of the segment, a single ambient reference sample was taken mid-stream. Left and right bank references are oriented with the observer facing downstream.

For all FIs, the field team recorded location of the flowing outfall (latitude and longitude), the diameter, material, and water depth of the flowing outfall, and documented site conditions by taking photos and other relevant notes. All bacteria samples were collected following procedures listed in Appendix J of the FY 2022-2023 H-GAC Multi-Basin Clean Rivers Program Quality Assurance Project Plan (H-GAC QAPP, 2022) and analyzed by a National Environmental Laboratory Accreditation Program (NELAP)-Accredited laboratory.

2021 Results and Recommendations

The FI of the main stream and tributary was conducted on April 6, 2021 (nine days since last significant rainfall) and a total of 76 bacteria samples were collected. Findings from the 2021 FI indicated that there are many broken concrete and metal pipes throughout the segment and the unnamed tributary was contributing high bacteria levels into the segment. The values of the bacteria samples collected from downstream of permitted outfalls, or directly from unpermitted outfalls are illustrated in Figure 2. A total of eight referral locations with elevated *E. coli* bacteria levels measured during the FI were recommended for further investigation by the proper authorities (Oakley and Lesher 2021). Much of the segment had ambient samples with bacteria levels ≥ 24,200 MPN/100 mL making a complete assessment of this segment impossible. Complete results and recommendations are available in the 2021 report (Oakley and Lesher 2021).

Based upon the results of the 2021 FI, a subsequent FI covering the entire length of the AU and the unnamed tributary was recommended. It was recommended for a 1mL dilution to be conducted for processing 2023 samples due to the number of locations with high bacteria levels greater than the detection limit of > 24,200 MPN/100mL. This allows for a reporting window of < 100 to > 242,000 and can facilitate identifying specific areas of concern in Bintliff Ditch and the unnamed tributary.

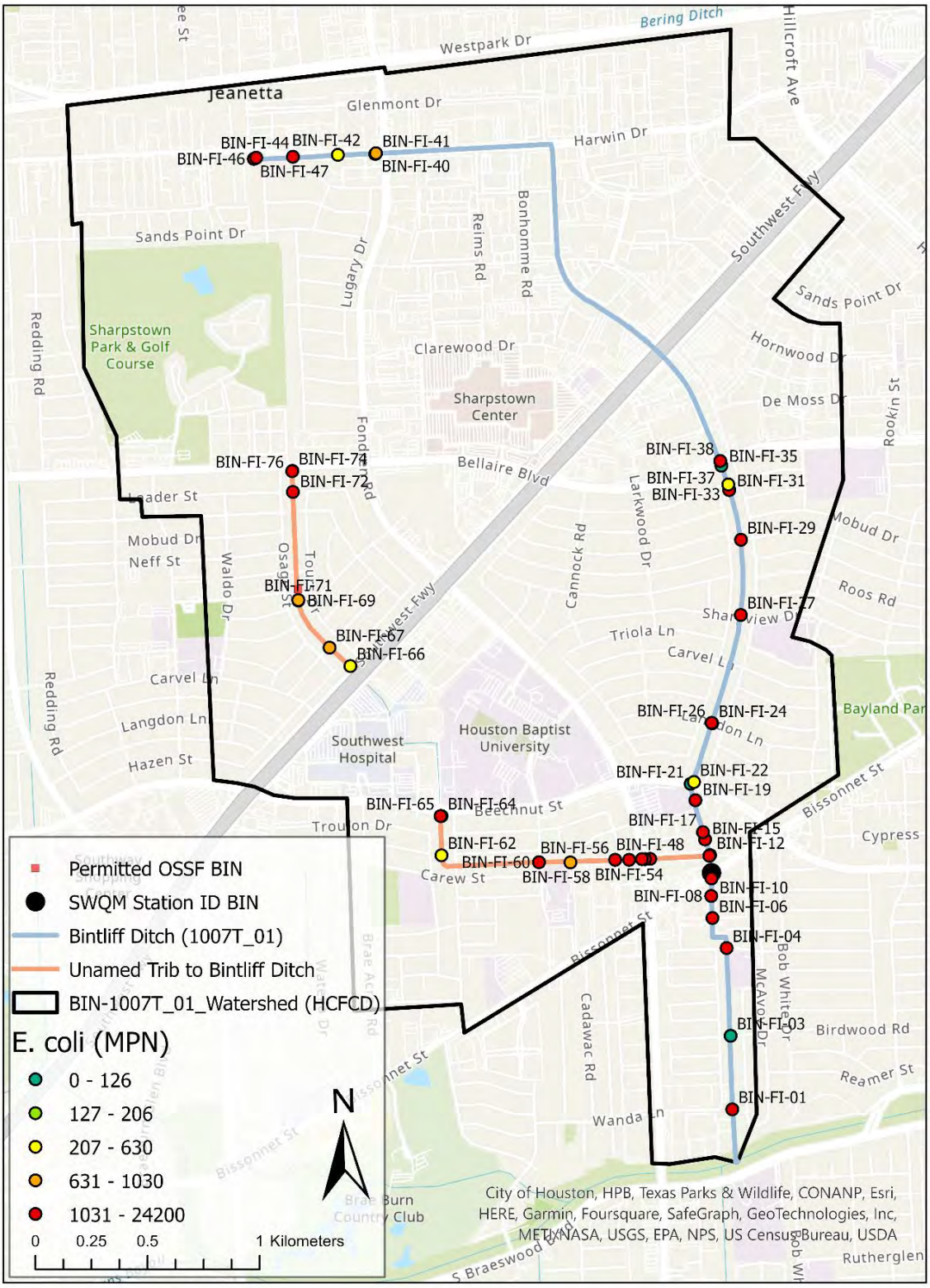

Figure 2: Field investigation bacteria sampling results from 04/06/2021 on Bintliff Ditch (AU 1007T_01).

2023 Results

The 2023 FI was conducted on April 11, 2023 (four days since last significant rainfall) and a total of 71 bacteria samples were collected. The values of the bacteria samples collected from downstream of permitted outfalls, directly from unpermitted outfalls, or as ambient samples are summarized in Table 1 and Figure 3. Based on the data collected, eight locations with elevated *E. coli* bacteria levels measured during the field investigation are recommended for high priority, and three locations for low priority investigation by the proper authorities. High priority sites had the highest potential bacteria loading observed and are recommended to be the areas for local authorities to focus efforts on should there be insufficient resources to address all referral sites. As time and resources allow the low priority and "investigate further" referrals also are recommended for further investigation. These locations are summarized in Table 1 (highlighted in grey) and Figure 4. In addition, three locations were flagged where ambient or upstream samples had elevated bacteria levels with no obvious explanations. Further investigation of these areas by the proper authorities are recommended. Each of these referrals are summarized by site, herein. The referral summaries are listed in order of priority (High, Low, then Investigate Further). Within each priority group, sites are listed from downstream to upstream.

Table 1: Field investigation bacteria results from sampling on 4/11/2023 on Bintliff Ditch (Assessment Unit 1007T_01). Referrals: N = No, Y-H = Yes – High Priority, Y-L = Yes - Low Priority, IF = Investigate Further, DS = Downstream, US = Upstream.

Sample ID	Lat	Long	DS or Direct *E. coli* Sample Results (MPN/100 mL)	US *E. coli* Sample Results (MPN/100 mL)	Difference* DS - US (MPN/100 mL)	Referral	Comments
BIN-FI2-01	29.67662	-95.50523	2,750	NA	NA	N	Ambient sample at confluence with Brays Bayou.
BIN-FI2-02-D	29.67816	-95.50527	740	1,830	-1,090	N	Weep hole mostly submerged - cloudy water coming out - right bank.
BIN-FI2-03-D	29.67870	-95.50526	5,210	1,830	3,380	Y-H	Ambient air smells of effluent. Trickle of water coming out - right bank.
BIN-FI2-04-D	29.68520	-95.50536	1,480	1,460	20	N	Trickle of water coming out - left bank.
BIN-FI2-05-D	29.68565	-95.50597	3,360	3,990	-630	N	Pipe up on concrete covered in vegetation. Distances estimated. Just a trickle coming down into ditch - right bank.
BIN-FI2-06-D	29.68645	-95.50596	4,410	7,540	-3,130	N	Diameter and distance estimated - unable to check water depth in pipe. Slow flow from pipe. - left bank.
BIN-FI2-NS-1	29.68718	-95.50594	NA	NA	NA	N	Not sampled. Slow drip from pipe.
BIN-FI2-NS-2	29.68731	-95.50596	NA	NA	NA	N	Not sampled. Slow drip from pipe.
BIN-FI2-07-D	29.68814	-95.50593	4800	4080	720	N	Lat/long not exact due to bridge interference. D: pooled water, pipe in left bank culvert; U: on other side of bridge. A sheen on water from unknown source.
BIN-FI2-08-D	29.68896	-95.50598	27,600	2,060	25,540	N	Downstream sample collected before confluence with tributary on the right bank.
BIN-FI2-09-D	29.68992	-95.50623	> 242,000	< 100	241,900	Y-H	Pipe rusted out, dripping from concrete - right bank.
BIN-FI2-10-D	29.69096	-95.50656	200	< 100	100	N	Pipe up high on concrete. Weep hole where water is flowing from on vertical concrete. Veg growing from pipe - right bank.
BIN-FI2-NS-3	29.69365	-95.50599	NA	NA	NA	N	Not sampled. Water dripping down concrete. No discernable pipe can be seen or source.

Sample ID	Lat	Long	DS or Direct *E. coli* Sample Results (MPN/100 mL)	US *E. coli* Sample Results (MPN/100 mL)	Difference* DS - US (MPN/100 mL)	Referral	Comments
BIN-FI2-11-D	29.69424	-95.50574	4,040	112,000	-107,960	N	Ambient air smells like chlorine/bleach. Pipe on left bank - significant flow.
BIN-FI2-12-D	29.69424	-95.50571	> 242,000	112,000	130,000	Y-H	Broken concrete pipe, water coming out side. Directly across from sample 11 - shares US sample w/ 11. Sudsy water; water trickling; pipe on right bank.
BIN-FI2-13-D	29.69855	-95.50421	155,000	> 242,000	-87,000	N	A fire hose is tied along concrete with one end in pipe - cannot see end of it - right bank.
BIN-FI2-14-D	29.70170	-95.50407	68,700	> 242,000	-173,300	N	Broken concrete, water going through crack - left bank.
BIN-FI2-15-D	29.70363	-95.50454	155,000	> 242,000	-87,000	IF	Weep hole on right bank – trickle.
BIN-FI2-16-D	29.70465	-95.50488	100	850	-750	N	Pipe on right bank - trickle. Segment goes underground from here.
BIN-FI2-17	29.71761	-95.52035	410	NA	NA	N	Ambient sample on upstream side of where segment re-emerges.
BIN-FI2-18-D	29.71757	-95.52207	520	100	420	Y-L	Lots of aquatic veg in ditch; left bank, US sample was not put on ice until 1535 and delivered to lab until next day, 4/12/23.
BIN-FI2-19-D	29.71757	-95.52342	630	300	330	Y-L	Pipe on left bank – flowing.
BIN-FI2-20-D	29.71758	-95.52382	630	1,340	-710	N	Pipe submerged on right bank.
BIN-FI2-21-D	29.71756	-95.52421	860	1,750	-890	N	Lots of vegetation where water enters from pipe on left bank.
BIN-FI2-22	29.71755	-95.52599	46,100	NA	NA	IF	Ambient sample taken at top of AU.
BIN-T-FI2-01	29.68893	-95.50880	5460	NA	NA	N	Ambient sample taken on DS side of bridge; sheen on water from unknown source.
BIN-T-FI2-02-D	29.68889	-95.50970	5,290	3,130	2,160	Y-H	Right bank - trickle, light brown filamentous algae.
BIN-T-FI2-03-D	29.68887	-95.51032	48,800	5,650	43,150	Y-H	Right bank - Pipe is collapsing; leaking before opening into trib. Same light brown growth.
BIN-T-FI2-04-P	29.68885	-95.51241	> 242,000	NA	NA	Y-H	Water has strong sewage odor; leaking pipe over waterway; leak flowing down left bank.

Sample ID	Lat	Long	DS or Direct *E. coli* Sample Results (MPN/100 mL)	US *E. coli* Sample Results (MPN/100 mL)	Difference* DS - US (MPN/100 mL)	Referral	Comments
BIN-T-FI2-05-D	29.68886	-95.51241	200	1,100	-900	N	Right bank - Leaking around pipe – trickle.
BIN-T-FI2-06-D	29.68887	-95.51390	520	< 100	420	Y-L	Left bank – trickle.
BIN-T-FI2-07-D	29.68928	-95.51830	< 100	< 100	0	N	Right bank – trickle.
BIN-T-FI2-08	29.69085	-95.51828	< 100	NA	NA	N	Left tunnel facing US - tunnels go underground and the main tributary reappears on NW side of Southwest Fwy. Unable to tell which tunnel is connected to main channel.
BIN-T-FI2-09	29.69089	-95.51836	200	NA	NA	N	Blue tint to water. Two tunnels that go underground and the main trib. reappears on NW side of Southwest Fwy. This tunnel is on the right (facing US). Unable to tell which tunnel is connected to main channel.
BIN-T-FI2-10	29.69694	-95.52226	2,470	NA	NA	N	Ambient sample taken on US side of underground tunnel; oil sheen on surface.
BIN-T-FI2-11-D	29.69779	-95.52319	9,090	15,200	-6,110	N	Pipe submerged - took sample within pipe - Right bank.
BIN-T-FI2-12-D	29.69972	-95.52457	> 242,000	1,580	240,420	Y-H	Left bank – trickle.
BIN-T-FI2-13-D	29.69974	-95.52460	> 242,000	1,580	240,420	Y-H	Same US sample as sample 12; pipes immediately adjacent to each other - Left bank.
BIN-T-FI2-14-D	29.70321	-95.52467	4,220	4,730	-510	N	Left bank - broken concrete around pipe.
BIN-T-FI2-15-P	29.70449	-95.52473	< 100	NA	NA	N	Weep hole on right bank – trickle.
BIN-T-FI2-16-D	29.70489	-95.52471	100	5,040	-4,940	N	Pipe on right bank.
BIN-T-FI2-17-D	29.70485	-95.52471	310	5,040	-4,730	IF	Same US sample as 16; pipes directly across from each other; pipe on left bank.

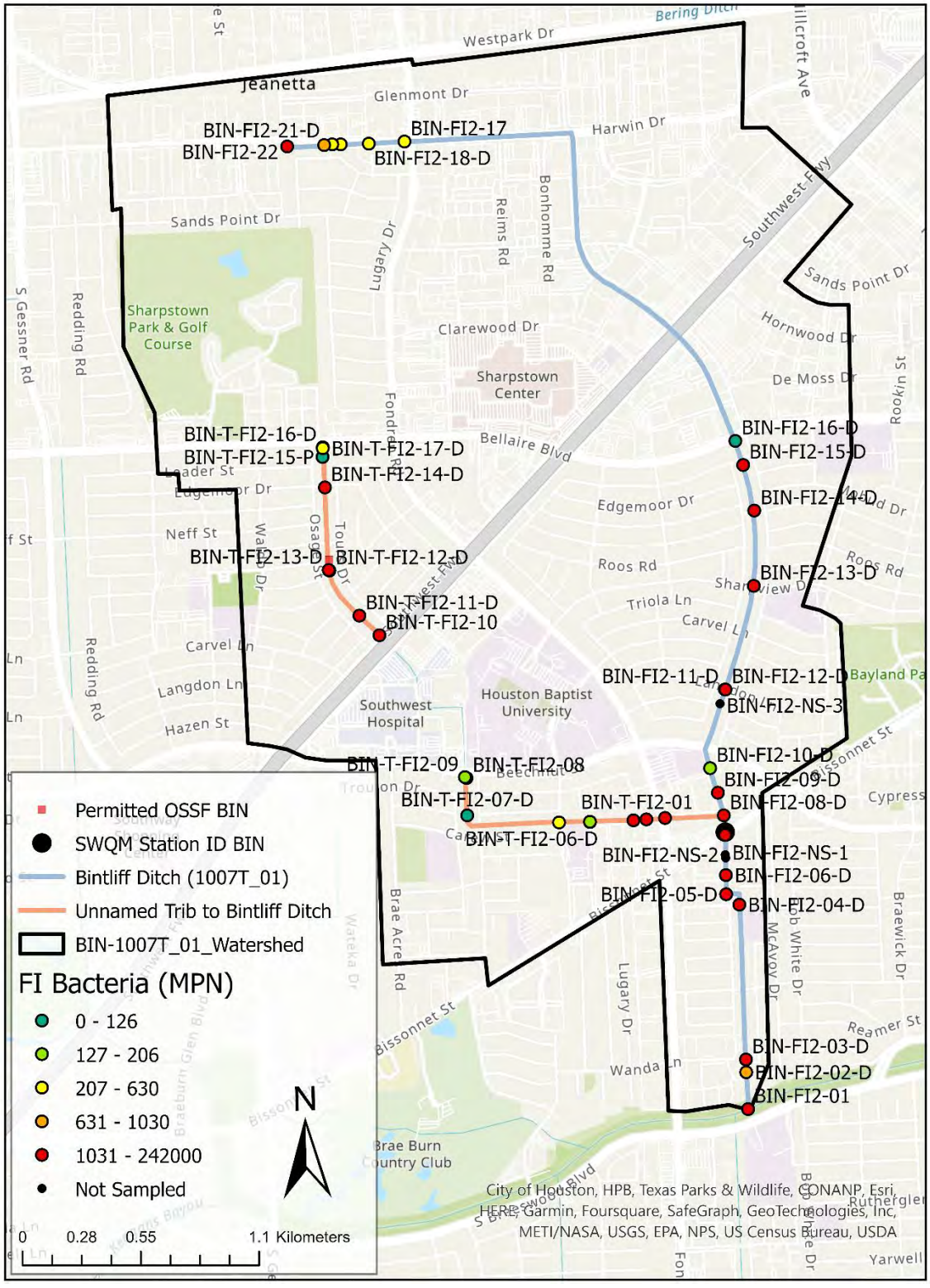

Figure 3: Field investigation bacteria sampling results from 4/11/2023 on Bintliff Ditch (Assessment Unit 1007T_01).

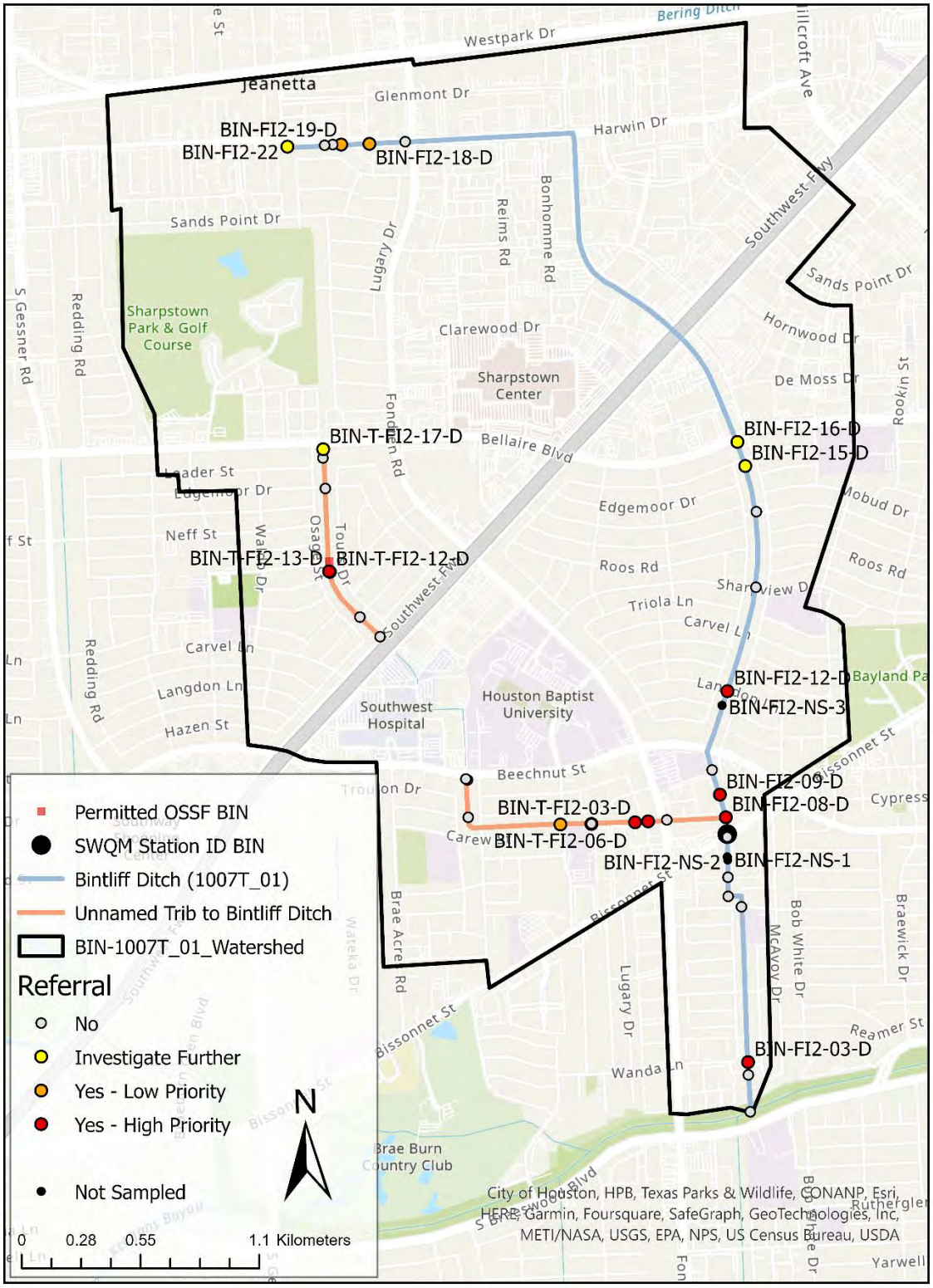

Figure 4: Field investigation sites identified for referral from 4/11/2023 to the proper authorities on Bintliff Ditch (Assessment Unit 1007T_01).

Referral site: BIN-FI2-03-D– High Priority

This is a 35 in. diameter metal pipe located on the right bank of Bintliff Ditch. Water within the pipe was 0.5 in. deep and trickling into the segment. There was a smell of effluent in the ambient air. There are apartments located in the area on the right bank. A sample taken 0.1 m downstream of the pipe had a bacteria value of 5,210 MPN/100 mL. The ambient sample collected upstream of the pipe had a bacteria value of 1,830 MPN/100 mL. This pipe is a high priority referral site for the proper local authority.

Referral site: BIN-FI2-09-D– High Priority

This is an approximately 20 in. diameter metal pipe located on the right bank of Bintliff Ditch. Water within the pipe was 0.1 in. deep and trickling into the segment. The pipe was partially collapsed and rusted through and the concrete around the pipe was broken. There are apartments located in the area on the right bank. A sample just 0.05 m downstream of the pipe had a bacteria value of > 242,000 MPN/100 mL. The ambient sample collected upstream of the pipe had a bacteria value of < 100 MPN/100 mL. This pipe is a high priority referral site for the proper local authority.

Referral site: BIN-FI2-12-D – High Priority

This is a 40 in. diameter concrete pipe located on the right bank of Bintliff Ditch. Water within the pipe was 0.1 in. deep and trickling into the segment through cracks in the cement wall. The cement pipe and the cement around the pipe was collapsed and broken. The field crew noted that the water was “sudsy”. There are single-family homes located in the area on the right bank. A sample just 0.1 m downstream of the pipe had a bacteria value of > 242,000 MPN/100 mL. The ambient sample collected upstream of the pipe had a bacteria value of 112,000 MPN/100 mL. This pipe is a high priority referral site for the proper local authority. Note: there was also a pipe located on the left bank directly across from this pipe which had significant flow and smelled like chlorine but had a much lower downstream bacteria value of 4,040 MPN/100 mL and was not referred.

Referral site: BIN-T-FI2-02-D– High Priority

This is a 25 in. diameter metal pipe located on the right bank of the tributary to Bintliff Ditch. Water within the pipe was 0.125 in. deep and trickling into the segment. The pipe was partially collapsed and rusted through. The substrate that the water was flowing down on the cement was filamentous and light brown in color. There are apartments and commercial buildings located in the area on the right bank. A sample just 0.55 m downstream of the pipe had a bacteria value of 5,290 MPN/100 mL. The ambient sample collected upstream of the pipe had a bacteria value of 3,130 MPN/100 mL. This pipe is a high priority referral site for the proper local authority.

Referral site: BIN-T-FI2-03-D– High Priority

This is a 24 in. diameter metal pipe located on the right bank of the tributary to Bintliff Ditch. Water within the pipe was 0.125 in. deep and trickling into the segment. The pipe was rusted through and leaking behind the cement wall and a filamentous light brown substrate was observed where the water was pouring over the cement. There are apartments and commercial buildings located in the area on the right bank. A sample just 0.5 m downstream of the pipe had a bacteria value of 48,800 MPN/100 mL. The ambient sample collected upstream of the pipe had a bacteria value of 5,650 MPN/100 mL. This pipe is a high priority referral site for the proper local authority.

Referral site: BIN-T-FI2-04-P– High Priority

This is a 12 in. diameter metal pipe that crosses above the tributary to Bintliff Ditch. It was broken/leaking and flowing down the left bank (white circle in photo below). The crew noted a strong sewage odor from the water leaking from the pipe. There are single-family homes located in the area on the left bank and Sugar Grove Elementary School located on the right bank. A sample taken directly from the leaking pipe had a bacteria value of > 242,000 MPN/100 mL. This pipe is a high priority referral site for the proper local authority.

Referral site: BIN-T-FI2-12-D– High Priority

This is a 26 in. diameter cement pipe located on the left bank of the tributary to Bintliff Ditch. Water within the pipe was 0.125 in. deep and trickling into the segment. There are single-family homes located in the area on the left bank. A sample just 0.2 m downstream of the pipe had a bacteria value of > 242,000 MPN/100 mL. The ambient sample collected upstream of the pipe had a bacteria value of 1,580 MPN/100 mL. This pipe is a high priority referral site for the proper local authority. Note: the next referral site (BIN-T-FI2-13-D) is immediately upstream (approximately 1 m) of this pipe on the same bank.

Referral site: BIN-T-FI2-13-D– High Priority

This is a 26 in. diameter cement pipe located on the left bank of the tributary to Bintliff Ditch, approximately 1 m upstream of the last referral site (BIN-T-FI2-12-D). Water within the pipe was 0.125 in. deep and trickling into the segment. There are single-family homes located in the area on the left bank. A sample just 0.2m downstream of the pipe had a bacteria value of > 242,000 MPN/100 mL. The ambient sample collected upstream of the pipe had a bacteria value of 1,580 MPN/100 mL. This pipe is a high priority referral site for the proper local authority.

Referral site: BIN-FI2-18-D– Low Priority

This is a 36 in. diameter metal pipe located on the left bank of Bintliff Ditch. Water within the pipe was 0.25 in. deep and trickling into the segment through significant vegetation. There are commercial buildings located in the area on the left bank. A sample just 0.7 m downstream of the pipe had a bacteria value of 520 MPN/100 mL. The ambient sample collected upstream of the pipe had a bacteria value of 100 MPN/100 mL. This pipe is a low priority referral site for the proper local authority.

Referral site: BIN-FI2-19-D– Low Priority

This is a 21 in. diameter metal pipe located on the left bank of Bintliff Ditch. Water within the pipe was 2 in. deep and flowing into the segment over the cement wall through some vegetation. There are commercial buildings located in the area on the left bank. A sample just 1.3 m downstream of the pipe had a bacteria value of 630 MPN/100 mL. The ambient sample collected upstream of the pipe had a bacteria value of 300 MPN/100 mL. This pipe is a low priority referral site for the proper local authority.

Referral site: BIN-T-FI2-06-D– Low Priority

This is a 42 in. diameter cement pipe located on the left bank of the tributary to Bintliff Ditch. Water within the pipe was 0.5 in. deep and trickling into the segment. There are single-family homes located in the area on the left bank. A sample just 0.2 m downstream of the pipe had a bacteria value of 520 MPN/100 mL. The ambient sample collected upstream of the pipe had a bacteria value of < 100 MPN/100 mL. This pipe is a low priority referral site for the proper local authority.

Referral site: BIN-FI2-15-U – Investigate Further

This was an ambient (upstream) sample taken to accompany a sample taken at a trickling weep hole (BIN-FI2-15-D) on Bintliff Ditch. The ambient sample had a bacteria value of > 242,000 MPN/100 mL. The next upstream ambient sample taken at site BIN-FI2-16-U, just before the segment continues underground, had a bacteria value of 850 MPN/100 mL. While there were no obvious pipes flowing into the segment between these two sample points, there is a source of elevated bacteria. There are some kind of large tanks located along the left bank between these two sites as seen in the map and photo facing upstream from site BIN-FI2-15-U below. Further investigation is recommended by the proper local authority to determine the source of elevated bacteria in this small stretch of the segment.

Referral site: BIN-FI2-22 – Investigate Further

This was an ambient sample taken at the most upstream portion of the Bintliff Ditch segment before it goes underground around Osage St. A sample just downstream of the two cement pipes had a bacteria value of > 46,100 MPN/100 mL. Further investigation is recommended by the proper local authority to determine the source of elevated bacteria underground and upstream of the segment.

Referral site: BIN-T-FI2-16-U – Investigate Further

This was an ambient upstream sample which accompanied samples BIN-T-FI2-16-D and BIN-T-FI2-17-D, taken at the most upstream portion of the tributary to Bintliff Ditch before it goes underground at Bellaire Blvd. The ambient sample taken just in front of the bridge crossing had a bacteria value of 5,040 MPN/100 mL. Further investigation is recommended by the proper local authority to determine the source of elevated bacteria underground and upstream of the segment. There are apartment and single-family homes located upstream of the site as well as a golf course.

List of Acronyms and Abbreviations

AU	Assessment Unit
BIG	Bacteria Implementation Group
BIN	Bintliff Ditch 1007T_01
CRP	Clean Rivers Program
DS	Downstream
E. coli	*Escherichia coli*
FI	Field Investigation
FY	Fiscal Year
GIS	Geographic Information Systems
H-GAC	Houston-Galveston Area Council
IF	Investigate Further
in.	inch
I-Plan	Implementation Plan
km	kilometer
LB	Left Bank
m	meter
mL	milliliter
MPN	Most probable number
N	No
NELAP	National Environmental Laboratory Accreditation Program
NLCD	National Land Cover Database
OSSF	On-Site Sewage Facilities
QAPP	Quality Assurance Project Plan
RB	Right Bank
SWQM	Surface Water Quality Monitoring
SWRC	Stroud Water Research Center
T or trib.	Tributary
TCEQ	Texas Commission on Environmental Quality
TMDL	Total Maximum Daily Load
US	Upstream
WS	Windshield Survey
Y-H	Yes – High Priority
Y-L	Yes-Low Priority

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Targeted Bacteria Monitoring Project
Field Investigation Final Report
Assessment Unit 1007U_01 Mimosa Ditch

Environmental Institute of Houston

August 1, 2023

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Segment Description

Mimosa Ditch is a tributary to Brays Bayou and the Segment ID is 1007U (Figure 1). This segment consists of one assessment unit (AU) of concern, AU 1007U_01, that is 3 km long and is defined as from the Brays Bayou confluence upstream 2.9 km to the Chimney Rock bridge crossing. There is one current surface water quality monitoring (SWQM) station located on this AU (station ID: 18691). This AU has been selected for targeted monitoring due to a bacteria (*Escherichia coli*) seven-year geometric mean of 1,457.4 MPN/100 mL (H-GAC QAPP, 2022) and has a current impairment category of 4a (TCEQ, 2022). The potential sources of bacteria impairments are non-point source pollution, urban runoff, and sanitary sewer overflows (TCEQ, 2022). This AU was monitored previously as part of the FY20-21 Targeted Monitoring Study.

The contributing watershed for this segment is 10 km^2 (Data source: H-GAC, SWRC, 2023). The soil types in the watershed have very slow infiltration rates (Data source: United States Department of Agriculture Hydrologic Soil Groups from gSSURGO 2016), and land cover is dominated by 99.99% developed land (Data source: National Land Cover Database NLCD 2019). There is one permitted wastewater outfall in the watershed (Data source: H-GAC). There is also one documented permitted and zero documented unpermitted on-site sewage facilities (OSSF) within the watershed (Data source: H-GAC).

Background

Clean Rivers Program (CRP) routine monitoring data are analyzed each year as part of the Houston-Galveston Area Council (H-GAC) Basin Summary/Basin Highlights Report process. Bacteria continues to be the most prevalent pollutant in the H-GAC CRP Basins (H-GAC, 2022). The Bacteria Implementation Group (BIG), formed in 2008, oversees the Total Maximum Daily Load (TMDL) Implementation Plan (I-Plan). The BIG requested that H-GAC produce a list of the water bodies with the highest bacteria concentrations in the BIG project area and conduct targeted monitoring to identify potential bacteria sources.

H-GAC, using information from previous Basin Highlights/Summary Reports, BIG annual reports, and previous targeted monitoring efforts, identified and selected waterways for targeted bacteria monitoring to refine our understanding of the spatial distribution of elevated bacterial concentrations contributing to these waterways. Phase 1 of this targeted monitoring project included an intensive desktop review of the most up to date imagery available and compilation of data from field investigations (FI) conducted in 2021. Phase 2 of this targeted monitoring project included a FI of the entire AU conducted during dry conditions where all flowing point and non-point sources were evaluated.

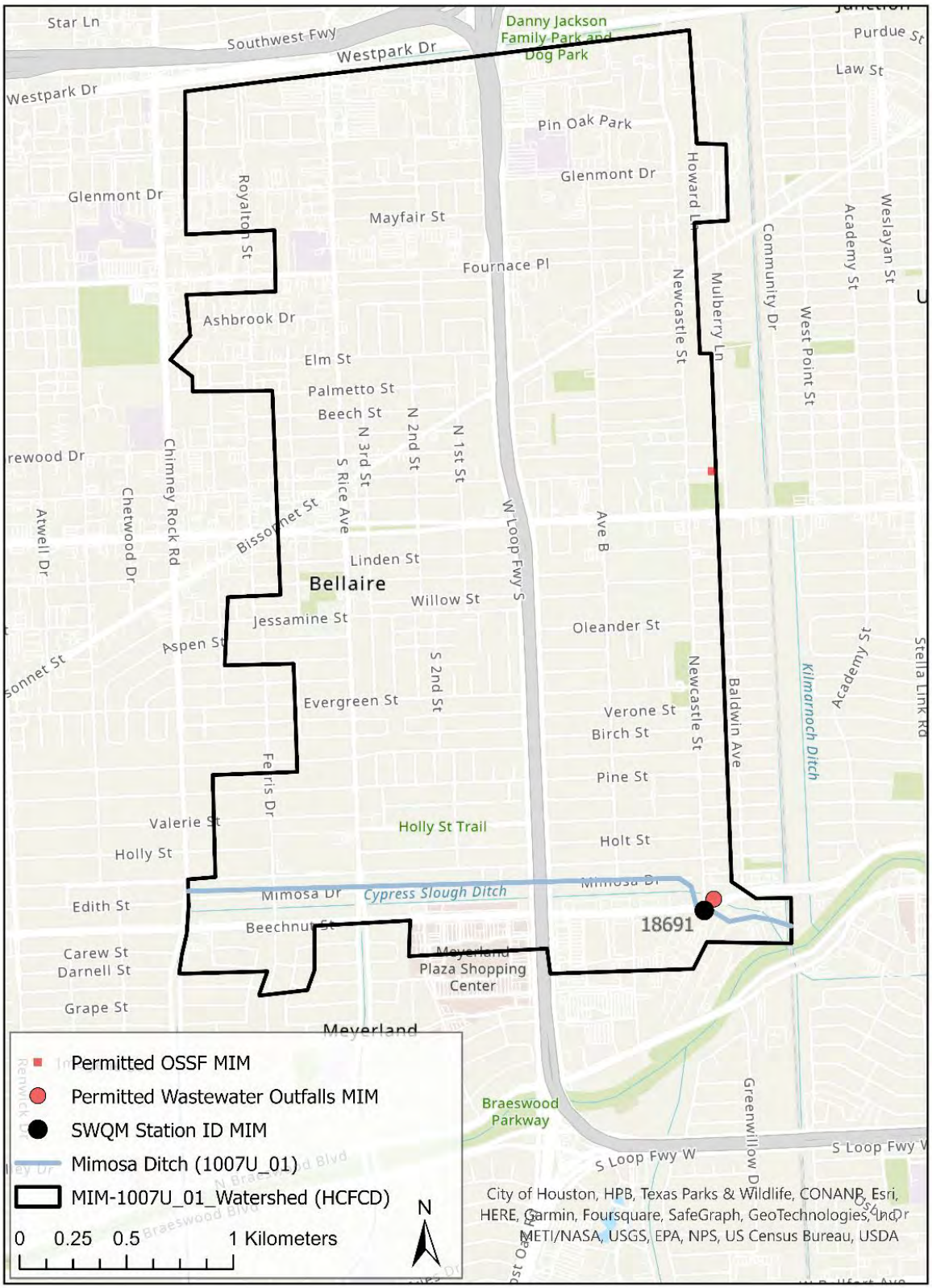

Figure 1: Watershed Map for Mimosa Ditch (Assessment Unit 1007U_01).

Desktop Review

Methods

The intensive desktop review included an evaluation of permitted discharges, outfalls, and potential sources of point and nonpoint source pollution that may contribute to bacteria loading in the AU. Using Google Earth imagery and GIS, the locations of wastewater treatment facilities, permitted on-site sewage facilities (OSSFs), and potential locations of unpermitted OSSFs were identified. If present, other potential sources such as landfills and industrial facilities were also identified. Parks were noted as they can contribute to bacterial sources through runoff of animal wastes but also provide opportunity for contact recreation. Bridge crossings and other public entry points were identified to provide access into the stream to collect bacteriological samples. The Environmental Institute of Houston conducted this review in 2021 and AU 1007U_01 was reviewed again prior to beginning the 2023 FI.

Results

The results of the desktop review indicated that there is one permitted OSSF and one permitted wastewater discharge on the segment. The segment is surrounded by wastewater treatment plants, commercial businesses, and a residential neighborhood. Publicly accessible entry points into the stream were identified at the confluence of Mimosa Ditch and Brays Bayou on South Braeswood Boulevard, Beechnut Street and Newcastle Street, West Loop South, South Rice Avenue, Ferris Drive, and finally at Chimney Rock Road.

Windshield Survey

Methods

Field events must take place during dry weather (after three or more days without significant rainfall in the watershed). This ensures that any flowing water into the segment is not stormwater. Windshield surveys (WS) of the watershed were conducted in 2021 and bacteria sampling was performed at public access points throughout the AU (primarily at bridge crossings). The survey consisted of driving the catchment area to confirm identified pollution sources found during the desktop review and to find any potential sources not identified during that review. Bridge crossings chosen for sampling were spatially distributed to provide a spatial snapshot of bacteria concentrations in the AU and identify sections of the AU where elevated bacteria concentrations were found. Those areas with elevated bacteria levels identified in the WS monitoring were focused on during the FI of the FY20-21 study. The results from the 2021 sampling events were used to plan the 2023 FI. Therefore, a WS was not completed in 2023.

Assessment Units, sample collection and laboratory methods, and data handling practices for the 2021 study are detailed in Appendix J of the FY 2020-2021 H-GAC Multi-Basin Clean Rivers

Program Quality Assurance Project Plan (H-GAC QAPP, 2020). For all WS bacteria monitoring conducted in 2021, field personnel documented the latitude and longitude of sample locations. All bacteria samples were analyzed by a National Environmental Laboratory Accreditation Program (NELAP)-Accredited laboratory.

Results

The WS and ground-truthing was conducted on March 9, 2021. At that time, it had been eight days since the last significant rainfall in the watershed. A total of seven samples were collected on AU 1007U_01 during the WS. Bacteria results from the ambient water samples collected during the WS ranged from < 10 to 399 MPN/100ML.

Field Investigation

Methods

The following methods were conducted for the FI in 2021 and were also used for the 2023 FI. Assessment Units, collection and laboratory methods, and data handling practices for the 2023 FI are detailed in Appendix J of the FY 2022-2023 H-GAC Multi-Basin Clean Rivers Program Quality Assurance Project Plan (H-GAC QAPP, 2022). The FI was a thorough survey where a team of two either walked or paddled the entire assessment unit and sampled dry-weather flow into the segment. Water could be flowing in from a pipe, culvert, natural tributary, or earthen/concrete-lined ditch. Flowing water was categorized into two source types: permitted outfalls or unpermitted outfalls. Permitted outfalls included wastewater facilities and municipal separate storm sewer systems (MS4). Any pipe greater than 12 inches (in.) in diameter was assumed to be permitted by our field crews.

When flowing water was observed from a permitted outfall, two samples were collected. One sample was collected immediately downstream of the outfall where the flowing outfall was mixing with the ambient water. The second sample was taken upstream of the flowing outfall outside of the realm of influence from the outfall to provide the ambient bacteria levels of the assessment unit in that area. The second type of source was an unpermitted outfall, which was any other flowing source of water that was judged to not be permitted in the field, including flowing small (<12 in. diameter) “homemade” pipes and tributaries.

When a flowing unpermitted outfall was observed, the bacteria sample was taken directly from the source. If the source was a flowing pipe, the sample was collected directly from the pipe, before it entered the segment. If it was an open-top earthen ditch or natural tributary, the sample was collected from far enough into the inflow source that there was no mixing with the receiving water. In some cases, when no flowing permitted or unpermitted outfalls were observed in an extended section of the segment, a single ambient reference sample was taken mid-stream. Left and right bank references are oriented with the observer facing downstream.

For all FI monitoring the field team recorded location of the flowing outfall (latitude and longitude), the diameter, material, and water depth of the flowing outfall, and documented site conditions by taking photos and other relevant notes. All bacteria samples were collected following procedures listed in Appendix J of the FY 2022-2023 H-GAC Multi-Basin Clean Rivers Program Quality Assurance Project Plan (H-GAC QAPP, 2022) and analyzed by a National Environmental Laboratory Accreditation Program (NELAP)-Accredited laboratory.

2021 Results and Recommendations

The 2021 FI was conducted on March 12, 2021 (11 days since last significant rainfall) and a total of 26 bacteria samples were collected. The values of the bacteria samples collected from downstream of permitted outfalls, or directly from unpermitted outfalls are illustrated in Figure 2. A total of four referral locations with elevated *E. coli* bacteria levels measured during the FI in 2021 were recommended for further investigation by the proper authorities. Complete results and recommendations are available in the 2021 report (Oakley and Lesher 2021).

A leaking metal pipe was present within the wastewater treatment facility property downstream of Beechnut Street (referral site: MIM-FI-01). A sample was collected where the leaking/spraying water was entering the segment and a bacteria value of 169 MPN/100ML was recorded. The ambient sample collected just upstream of the bridge outside of the influence of the leaking pipe had a bacteria value of 108 MPN/100 mL (MIM-FI-02) indicating that the leaking pipe may be a source of elevated bacteria. Water from an additional metal pipe downstream of the permitted wastewater treatment facility outfall between Newcastle St. and Beechnut St. was sampled in 2021 (Referral site: MIM-FI-05). The sample collected in the mixing zone, just downstream of the outfall, had a bacteria value of 683 MPN/100 mL, and the ambient sample collected just upstream of the outfall (mid channel) had a bacteria value of 119 MPN/100 mL indicating that the outfall is likely a source of elevated bacteria. Another metal pipe discharging water in the segment is believed to be the permitted wastewater treatment facility outfall between Newcastle St. and Beechnut St. (Referral site: MIM-FI-07). The sample collected in the mixing zone, just downstream of the outfall had a bacteria value of 313 MPN/100 mL, and the ambient sample collected just upstream of the outfall (mid channel) had a bacteria value of 160 MPN/100 mL indicating that the outfall is most likely a source of elevated bacteria. It is important to note that the field crew made a remark on the field datasheet that they did not observe any aquatic vegetation, fish, or invertebrates in the downstream of the permitted wastewater treatment facility outfall, but that all of those things were observed upstream of it. Chlorine levels were not tested. Based on these results, a second FI on this segment was recommended to be sampled in 2023.

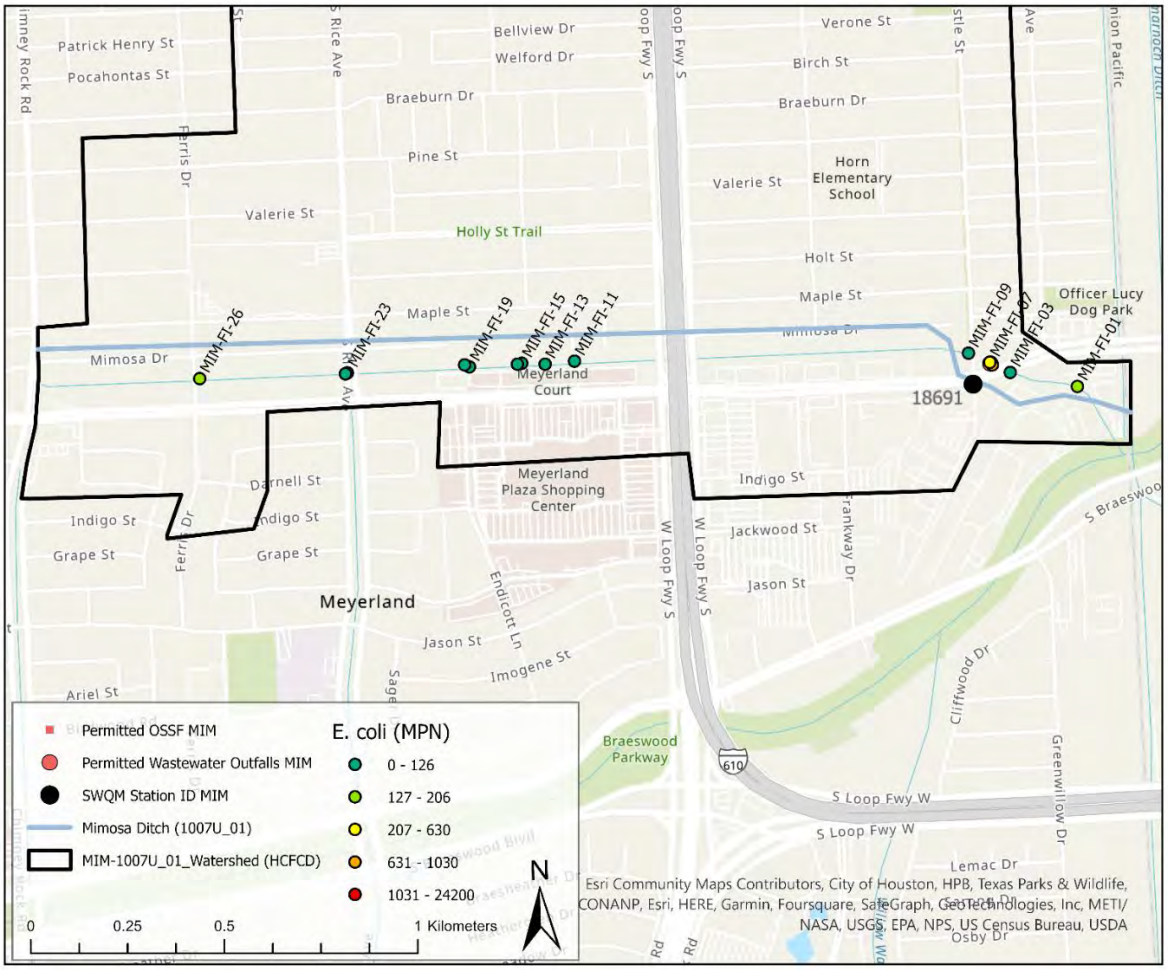

Figure 2: Field investigation results from 03/12/2021 on Mimosa Ditch (AU 1007U_01).

2023 Results

The 2023 FI was conducted on April 4, 2023 (17 days since last significant rainfall) and a total of 27 bacteria samples were collected. The values of the bacteria samples collected from downstream of permitted outfalls, directly from unpermitted outfalls, or as ambient samples are summarized in Table 1 and Figure 3. Based on the data collected, four locations with elevated *E. coli* bacteria levels measured during the field investigation are recommended for high priority, and one location for low priority investigation by the proper authorities. High priority sites had the highest potential bacteria loading observed and are recommended to be the areas for local authorities to focus efforts on should there be insufficient resources to address all referral sites. As time and resources allow the low priority and "investigate further" referrals also are recommended for further investigation. These locations are summarized in Table 1 and Figure 4. Each of these referrals are summarized by site, herein. Each of these referral summaries are listed in order of priority (High, Low, then Investigate Further). Within each priority group, sites are listed from downstream to upstream.

Table 1: Field investigation bacteria results from sampling on 04/04/2023 on Mimosa Ditch (Assessment Unit 1007U_01). Referrals: N = No, Y-H = Yes – High Priority, Y-L = Yes-Low Priority, IF = Investigate Further, US = Upstream, DS = Downstream.

Sample ID	Lat	Long	DS or Direct *E. coli* Sample Results (MPN/100 mL)	US *E. coli* Sample Results (MPN/100 mL)	Difference* DS - US (MPN/100 mL)	Referral	Comments
MIM-FI2-01	29.68757	-95.44731	100	NA	NA	N	Ambient sample US of confluence with Brays Bayou.
MIM-FI2-02-D	29.68904	-95.44832	< 100	< 100	0	N	The pipe that goes over waterway is leaking. Pipe measurements are estimated.
MIM-FI2-NS-1	29.68920	-95.44870	NA	NA	NA	N	Not sampled. Evidence of pipe on left bank discharging recently but water not reaching ditch.
MIM-FI2-NS-2	29.68919	-95.44878	NA	NA	NA	N	Not sampled. Weep hole. Evidence of possible leak (wet concrete) but no flow on left bank.
MIM-FI2-03-D	29.68941	-95.45010	< 100	< 100	0	N	Right bank.
MIM-FI2-04-D	29.68959	-95.45056	1,690	100	1,590	Y-H	Left bank downstream of permitted wastewater discharge.
MIM-FI2-05-D	29.68965	-95.45067	< 100	100	0	N	Heavy flow creating large mixing zone on left bank. Wastewater discharge.
MIM-FI2-06-D	29.68987	-95.45118	200	100	100	N	Left bank; Large square concrete pipe adjacent to another concrete pipe, this one is furthest DS. Sheen on outflowing water.
MIM-FI2-07-D	29.68989	-95.45123	100	100	0	N	Left bank; Large square concrete pipe adjacent to another concrete pipe, this one is further US. Upstream sample same as previous MIM-FI2-06-U. Sheen on outflowing water.
MIM-FI2-08	29.68996	-95.45837	100	NA	NA	N	Large square concrete outflow that goes underground/under the freeway seems to divert to the right. No light visible to confirm.
MIM-FI2-09	29.68989	-95.45840	200	NA	NA	N	Right bank culvert is main stem of Mimosa Ditch but does flow through an underground tunnel.
MIM-FI2-10	29.68990	-95.45979	< 100	NA	NA	N	Ambient sample upstream of bridge.
MIM-FI2-11-D	29.68990	-95.46250	970	100	870	Y-H	Right bank; lots of algae growing on wet concrete on wall and all along section of segment.
MIM-FI2-12-D	29.68993	-95.46312	< 100	100	0	N	Vegetation growing in and around pipe on left bank.
MIM-FI2-13-D	29.68989	-95.46452	410	200	210	Y-L	Vegetation growing in and around pipe right bank.

Sample ID	Lat	Long	DS or Direct *E. coli* Sample Results (MPN/100 mL)	US *E. coli* Sample Results (MPN/100 mL)	Difference* DS - US (MPN/100 mL)	Referral	Comments
MIM-FI2-NS-4	29.68986	-95.46741	NA	NA	NA	N	Not sampled. Cracked concrete with some flow.
MIM-FI2-14-D	29.68991	-95.46774	9,330	630	8,700	Y-H	Two large square culverts left bank under the bridge, pretty good flow.
MIM-FI2-NS-3	29.68990	-95.46950	NA	NA	NA	N	Not sampled. Cracked concrete with some flow.
MIM-FI2-15-D	29.68982	-95.47025	3,730	NA	NA	N	Ambient sample.
MIM-FI2-16-D	29.68984	-95.47175	2,990	1,200	1,790	Y-H	Two large square culverts on left bank just DS of the bridge.
MIM-FI2-17	29.68975	-95.47202	< 100	NA	NA	N	Waterway is dry upstream of flowing pipe. Only flowing water to source stream is from pipe at this point. Water is very cloudy and milky. Verified that waterway is dry to top of AU from here.

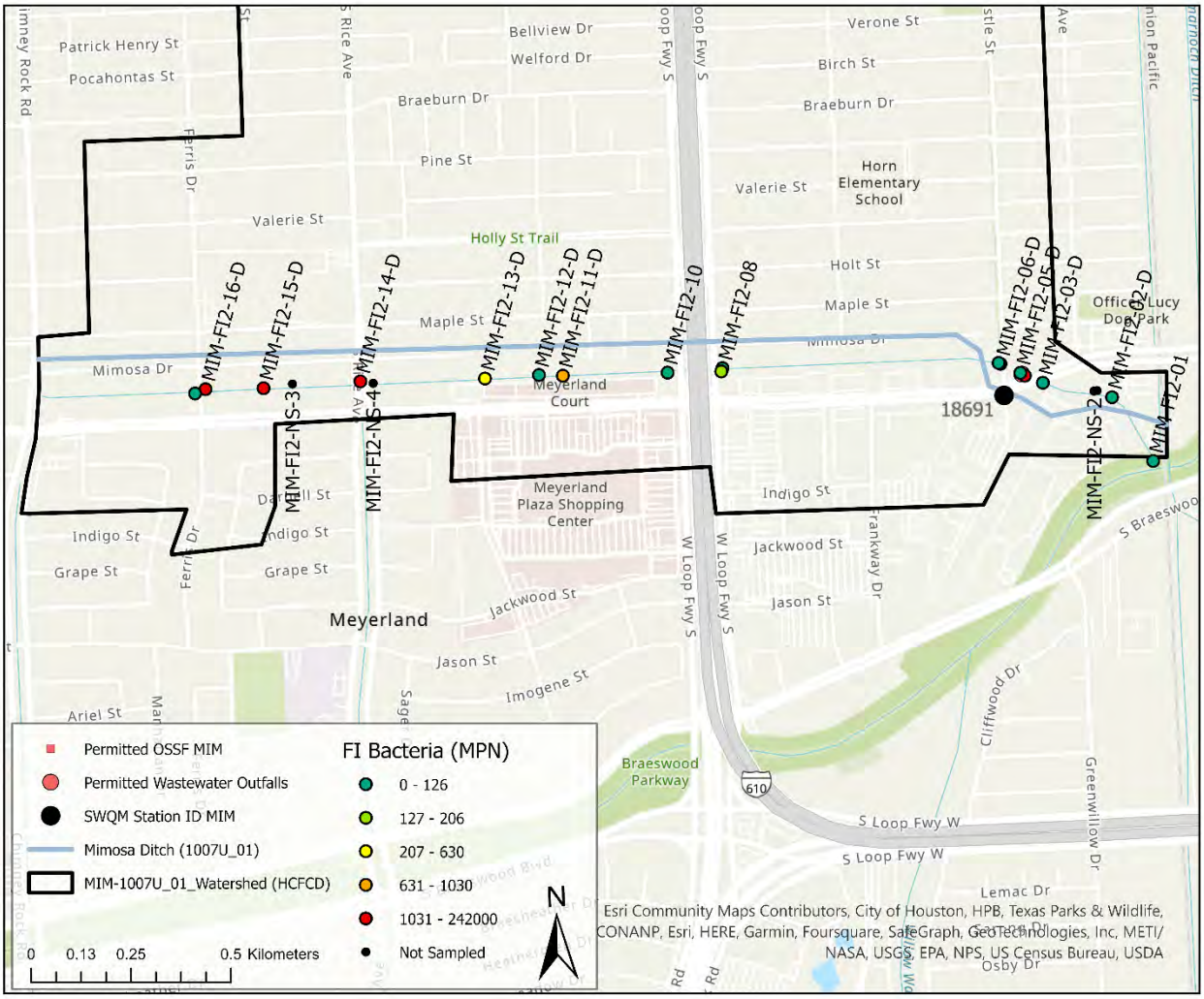

Figure 3: Field investigation bacteria sampling results from 4/4/2023 on Mimosa Ditch (Assessment Unit 1007U_01).

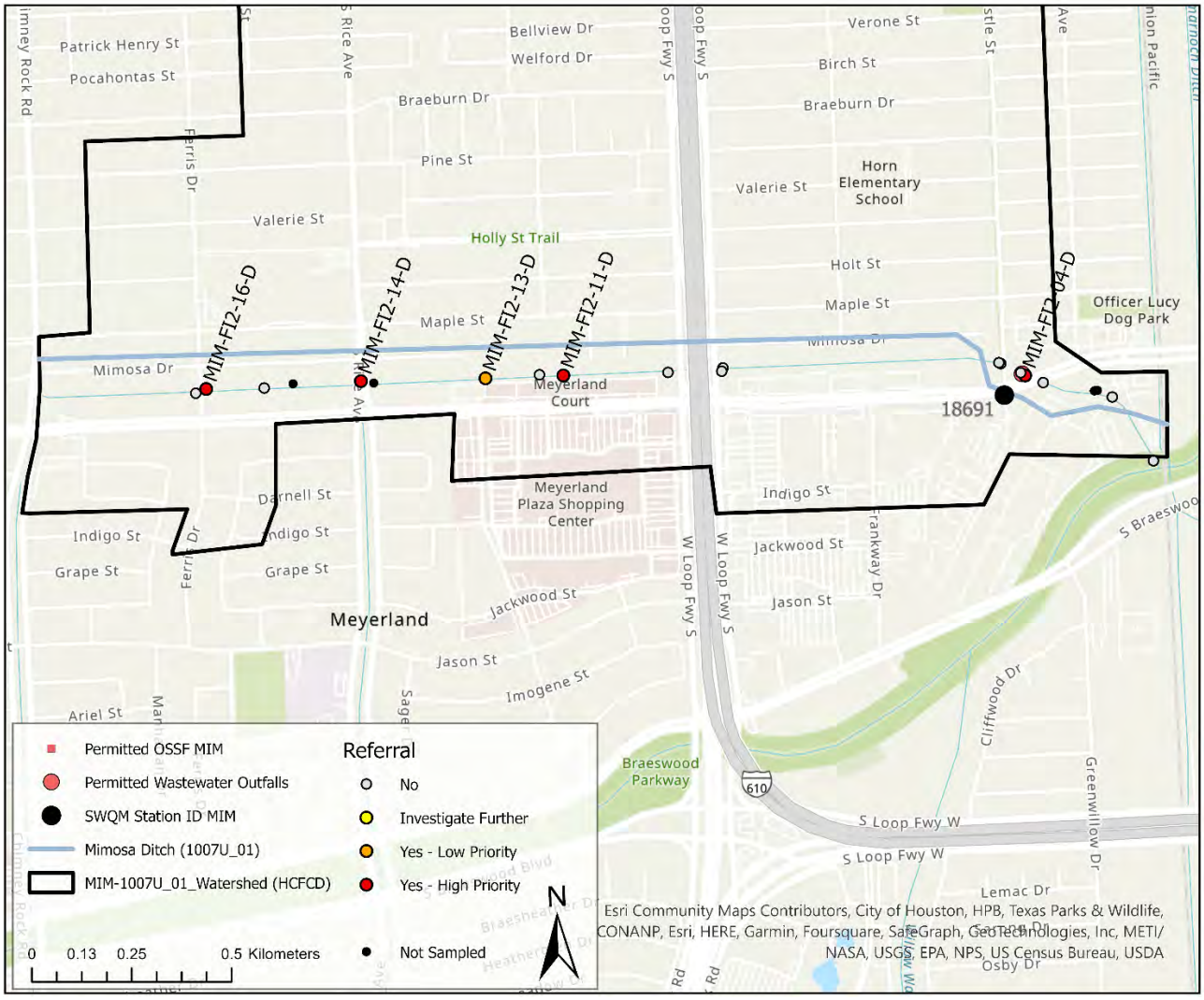

Figure 4: Field investigation sites sampled on 4/4/23 and identified for referral to the proper authorities on Mimosa Ditch (Assessment Unit 1007U_01).

Referral site: MIM-FI2-04-D – High Priority

This is a 78 in. diameter metal pipe located on the left bank of Mimosa Ditch. Water within the pipe was 1.0 in. deep and flowing down algae-coated concrete before entering the segment. There is a permitted wastewater treatment discharge located in the area on the left bank. A sample taken 0.2 m downstream of the pipe had a bacteria value of 1,690 MPN/100 mL. The ambient sample collected upstream of the pipe had a bacteria value of 100 MPN/100 mL. This pipe is a high priority referral site for the proper local authority.

Referral site: MIM-FI2-11-D – High Priority

This is a 4 in. diameter PVC pipe located on the right bank of Mimosa Ditch. Water within the pipe was 0.25 in. deep and flowing down algae-coated concrete before entering the segment. There are multiple restaurants and a shopping plaza located in the area on the right bank. A sample taken 1.0 m downstream of the pipe had a bacteria value of 970 MPN/100 mL. The ambient sample collected upstream of the pipe had a bacteria value of 100 MPN/100 mL. This pipe is a high priority referral site for the proper local authority.

Referral site: MIM-FI2-14-D – High Priority

This is a 98 in. wide, square concrete culvert located under the bridge of S. Rice Avenue on the left bank of Mimosa Ditch. Water within the culvert was 0.25 in. deep and flowing into the segment. The area is mostly residential around this site, but there is a high school undergoing construction about 200 m north of the bridge on S. Rice Avenue. A sample taken 0.6 m downstream of the culvert had a bacteria value of 9,330 MPN/100 mL. The ambient sample collected upstream of the culvert had a bacteria value of 630 MPN/100 mL. This culvert is a high priority referral site for the proper local authority.

Referral site: MIM-FI2-16-D – High Priority

This is a 72 in. diameter square cement culvert located on the left bank of Mimosa Ditch. Water within the culvert was 0.13 in. deep and flowing into the AU. The culvert that was flowing at the time of sampling was the most upstream of the two culverts at this location. A sample taken 0.1 m downstream of the culvert had a bacteria value of 2,990 MPN/100 mL. The ambient sample collected upstream of the culvert had a bacteria value of 1,200 MPN/100 mL. This culvert is a high priority referral site for the proper local authority.

Referral site: MIM-FI2-13-D– Low Priority

This is a 36 in. diameter metal pipe located on the right bank of Mimosa Ditch. Water within the pipe was 6.0 in. deep and flowing down the vertical concrete bank and into the segment. There was vegetation growing and trash around the pipe at the time of sampling. There are several restaurants and a shopping plaza located in the area on the right bank. A sample 1.25 m downstream of the pipe had a bacteria value of 410 MPN/100 mL. The ambient sample collected upstream of the pipe had a bacteria value of 200 MPN/100 mL. This pipe is a low priority referral site for the proper local authority.

List of Acronyms and Abbreviations

AU	Assessment Unit
BIG	Bacteria Implementation Group
CRP	Clean Rivers Program
DS	Downstream
E. coli	*Escherichia coli*
FI	Field Investigation
FY	Fiscal Year
GIS	Geographic Information Systems
H-GAC	Houston-Galveston Area Council
IF	Investigate Further
in.	inch
I-Plan	Implementation Plan
km	kilometer
LB	Left Bank
m	meter
MIM	Mimosa Ditch 1007U_01
mL	milliliter
MPN	Most probable number
N	No
NELAP	National Environmental Laboratory Accreditation Program
NLCD	National Land Cover Database
OSSF	On-Site Sewage Facilities
QAPP	Quality Assurance Project Plan
RB	Right Bank
SWQM	Surface Water Quality Monitoring
SWRC	Stroud Water Research Center
T or trib.	Tributary
TCEQ	Texas Commission on Environmental Quality
TMDL	Total Maximum Daily Load
US	Upstream
WS	Windshield Survey
Y-H	Yes – High Priority
Y-L	Yes-Low Priority

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Targeted Bacteria Monitoring Project

Field Investigation Final Report

Assessment Unit 1014O_01

Spring Branch (Tributary of Buffalo Bayou)

Environmental Institute of Houston

August 1, 2023

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Segment Description

Segment 1014O is a freshwater, perennial stream referred to as Spring Branch (Figure 1) and is a tributary of Buffalo Bayou. This segment consists of one assessment unit (AU) of concern, AU 1014O_01. This AU is 6.9 km and is defined as spanning from Buffalo Bayou Above Tidal confluence to 1.4 km (0.87 mi) upstream of Long Point Road in Harris County. There is one current (station ID: 16592) and two historic (station IDs: 16591, 11192) surface water quality monitoring (SWQM) stations located on this AU. This AU has been selected for targeted monitoring due to a bacteria (*Escherichia coli*) seven-year geometric mean of 1,206.2 MPN/100 mL (H-GAC QAPP, 2022). The AU was listed for exceedances of bacteria in the water (Recreation use) and has a current impairment category of 4a (TCEQ, 2022). The potential sources of bacteria are non-point source pollution, urban runoff, and sanitary sewer overflows (TCEQ, 2022).

The contributing watershed for this AU is 29 km^2 (Data source: HGAC and SWRC, 2023). The predominant soil group in the watershed is medium/very slow infiltration coverage and the land cover in the watershed is dominated by 99.95% developed land (Data source: Data source: United States Department of Agriculture Hydrologic Soil Groups from gSSURGO 2016 and National Land Cover Database NLCD 2019). There are no permitted wastewater outfalls in the watershed or documented unpermitted on-site sewage facilities (OSSF), but there are seven documented permitted OSSFs within the watershed (Data source: H-GAC).

Background

Clean Rivers Program (CRP) routine monitoring data are analyzed each year as part of the Houston-Galveston Area Council (H-GAC) Basin Summary/Basin Highlights Report process. Bacteria continues to be the most prevalent pollutant in the H-GAC CRP Basins (H-GAC, 2022). The Bacteria Implementation Group (BIG), formed in 2008, oversees the Total Maximum Daily Load (TMDL) Implementation Plan (I-Plan). The BIG requested that H-GAC produce a list of the water bodies with the highest bacteria concentrations in the BIG project area and conduct targeted monitoring to identify potential bacteria sources.

H-GAC, using information from previous Basin Highlights/Summary Reports, BIG annual reports, and previous targeted monitoring efforts, have identified and selected waterways for targeted bacteria monitoring to refine our understanding of the spatial distribution of elevated bacterial concentrations contributing to these waterways. Phase 1 of this targeted monitoring project included an intensive desktop review and a windshield survey (WS) of each AU catchment area, and sampling of the AU from primary road crossings. Phase 2 of this targeted monitoring project included a field investigation (FI) of the entire AU where all flowing point and non-point sources were evaluated.

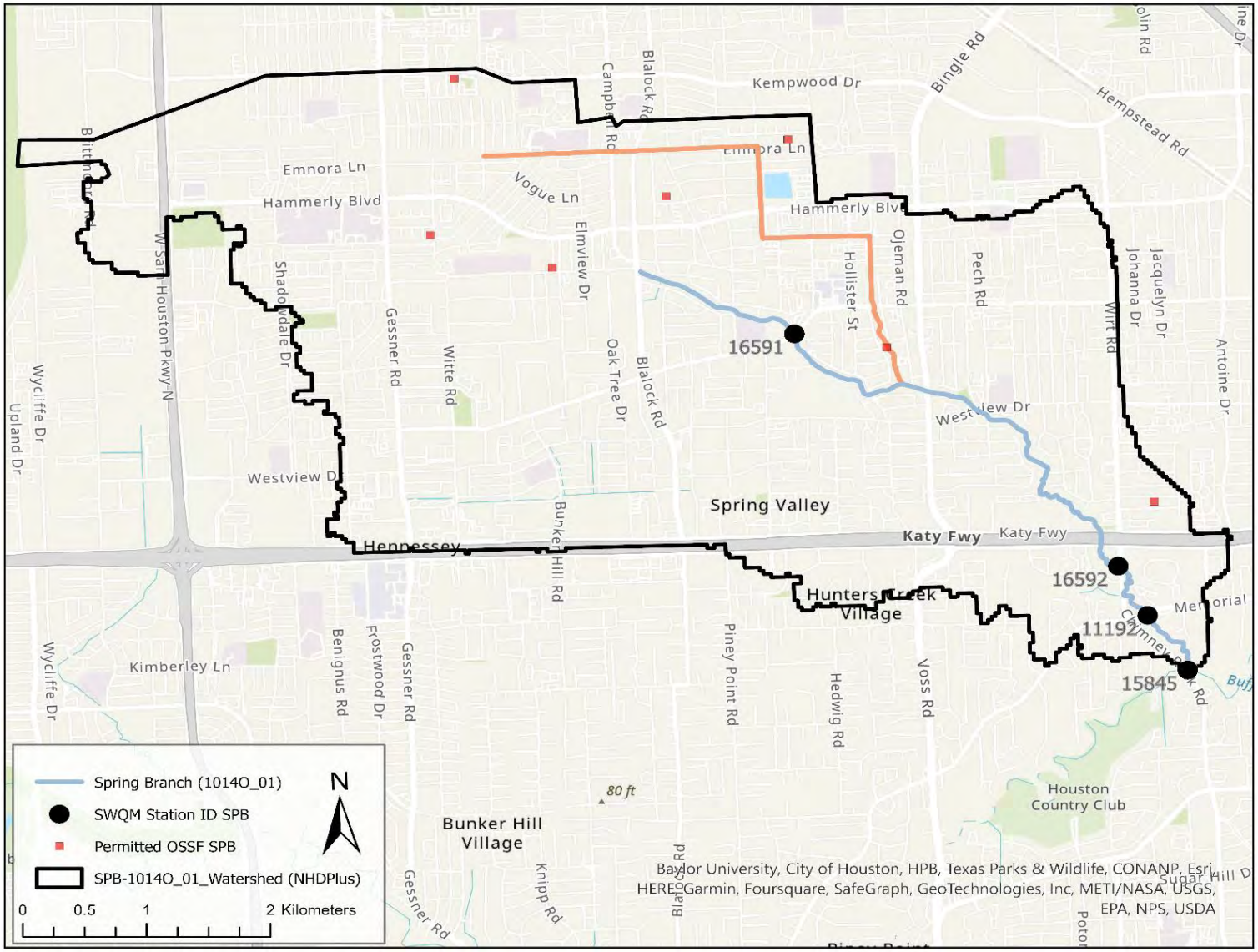


Figure 1 Watershed Map for Assessment Unit 1014O_01, Spring Branch (Tributary of Buffalo Bayou).

Desktop Review

Methods

The intensive desktop review included an evaluation of permitted discharges, outfalls, and potential sources of point source and nonpoint source pollution that may contribute to bacteria loading in the AU. Using Google Earth imagery and GIS, the locations of wastewater treatment facilities, permitted OSSFs, and potential locations of unpermitted OSSFs were identified. Other potential sources such as landfills and industrial facilities, were also identified. Parks were noted, as these can contribute to bacterial sources through runoff of animal wastes but also provide opportunity for contact recreation. Bridge crossings and other entry points were identified to provide access into the stream to collect bacteriological samples.

Results

The results of the desktop review indicated that the AU lies within a mix of mostly suburban and some urban environments. It spans through many residential neighborhoods and schools/parks with some businesses and manufacturing facilities. From our desktop review there were some potential sources identified, such as a recycling facility that borders Spring Branch near Long Point Rd, a permitted OSSF on the east side of Spring Branch near the Katy freeway, and the Moritz Pech Family Park that has a drainage spillway leading directly into the AU. Publicly accessible entry points into the stream were identified at Memorial Dr., Chimney Rock Rd., I-10 Frontage Rd., Burkhart Rd., Pech Rd., Bingle Rd., Bracher St., Ruland Rd., Longpoint Rd., and Campbell Rd.

Windshield Survey

Methods

Field events must take place during dry weather (after 3 or more days without significant rainfall in the watershed). This ensures that any flowing water into the AU is not stormwater. Windshield surveys of the watershed were conducted, and bacteria sampling was performed at public access points throughout the AU (primarily at bridge crossings). The survey consisted of driving the catchment area to confirm identified pollution sources found during the desktop review and to find any potential sources not identified during that review. Bridge crossings chosen for sampling were spatially distributed to provide a spatial snapshot of bacteria concentrations in the AU and identify sections of the AU where elevated bacteria concentrations were found. Those areas with elevated bacteria levels identified in the WS monitoring were focused on during the FI in Phase 2.

Assessment Units, collection and laboratory methods, and data handling practices are detailed in Appendix J of the FY 2022-2023 H-GAC Multi-Basin Clean Rivers Program Quality Assurance

Project Plan (H-GAC QAPP, 2022). For the WS, field personnel documented the latitude and longitude of sample locations. All bacteria samples were collected following procedures listed in Appendix J of the FY 2022-2023 H-GAC Multi-Basin Clean Rivers Program Quality Assurance Project Plan (H-GAC QAPP, 2022) and analyzed by a National Environmental Laboratory Accreditation Program (NELAP)-Accredited laboratory.

Results and Recommendations

The WS was conducted on March 14, 2023. At that time, it had been 12 days since the last significant rainfall in the watershed. A total of nine samples were collected on AU 1014O_01 and two on contributing tributaries during the WS (Table 1 and Figure 2).

Table 1. Windshield survey bacteria results from sampling on 03/14/2023 on Spring Branch (AU 1014O_01). Samples were taken at bridge crossings and other publicly accessible points. US = Upstream, DS = Downstream. LB = Left Bank, RB = Right Bank.

Sample ID	Latitude	Longitude	*E. coli* Sample Results (MPN/100 mL)	Comments
SPB-WS-01	29.77774	-95.48256	3,180	On DS LB pipe leak
SPB-WS-02	29.78357	-95.48636	>242,000	Sampled from bridge; steep banks and encampment under bridge
SPB-WS-03	29.78947	-95.49078	<100	
SPB-WS-04	29.79404	-95.49557	520	Good access; Poison ivy; Evidence of fishing; Site becomes concrete lined
SPB-WS-05	29.79612	-95.50024	310	HCFCD gauge site; need step ladder
SPB-WS-06	29.79606	-95.50515	<100	On US RB is best access
SPB-WS-07	29.79871	-95.50999	200	
SPB-WS-08	29.80091	-95.51128	24,800	Stairs to water DS RB; encampment under bridge; Sampled just DS of 2 outfalls, one on RB white w/odor
SPB-WS-09	29.80293	-95.51622	<100	Can hear water flow in tunnel, LB culvert majority of flow
SPB-T1-WS-01	29.80025	-95.50388	410	Trickling flow
SPB-T1-WS-02	29.80866	-95.50672	<100	US RB pooled water, turbid greyish

Based upon the results of the WS and ground-truthing, a FI covering the entire length of the AU and the unnamed tributary was recommended. Based on the results of the WS, we expected to identify potential point or non-point sources of elevated bacteria near the following portions of the AU:

1) SPB-WS-02 was collected on the downstream side of the Interstate 10 Frontage Road and had a bacteria level of > 242,000 MPN/100 mL. The notes indicate that there was an encampment under the bridge upstream of where the sample was collected. This could be a potential source, as the sample collected approximately 0.6 miles upstream had a result of <

100 MPN/100 mL and that stretch of the stream is surrounded by single-home residences and a large church compound. The one sample collected downstream of this site also had a high level of bacteria (3,180 MPN/100 mL).

2) SPB-WS-04 was collected at Pech Road and had a higher result than the samples collected just upstream and downstream. The right bank is bordered by single-family residences and the left bank has some newly constructed business built close to the stream.

3) SPB-WS-08 was collected at Long Point Road and had a bacteria result of 24,800 MPN/100 mL despite the upstream sample, which was approximately 0.35 miles upstream, resulting in < 100 MPN/100 mL.

4) SPB-T1-WS-01 was collected from a tributary nestled between a single-family residence neighborhood off Bracher Street and a multi-family residence off Ojeman Road. This sample had a bacteria level of 410 MPN/100 mL and may be a potential source of bacteria.

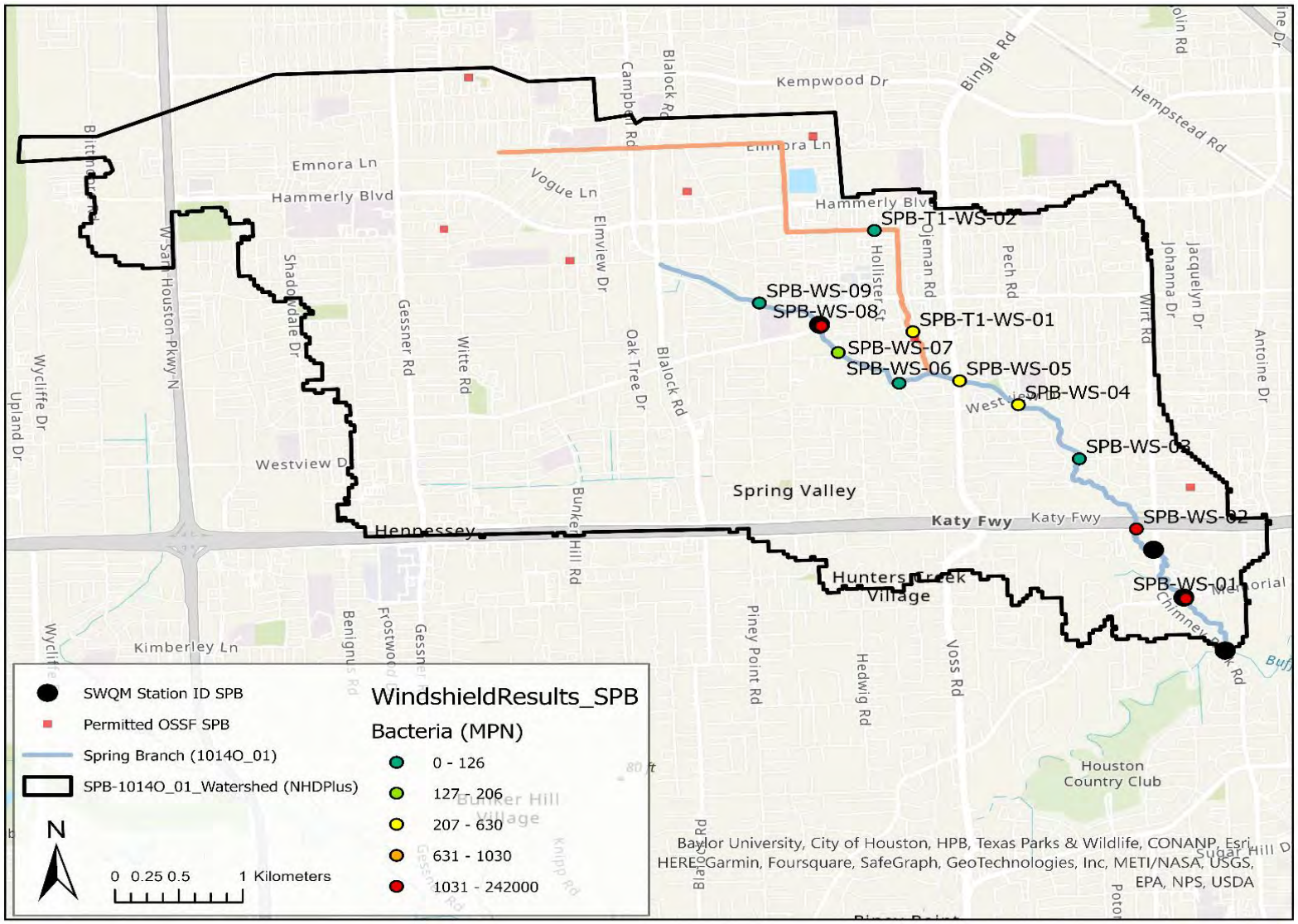


Figure 2 Windshield survey/ground truthing bacteria results from sampling on 03/14/2023 on Spring Branch (Tributary of Buffalo Bayou) (AU 1014O_01). Samples were taken at bridge crossings and other easily accessible points.

Field Investigation

Methods

The FI was a thorough survey where a team of two either walked or paddled the entire assessment unit and sampled any water observed flowing into the stream. Water could be flowing in from a pipe, culvert, natural tributary, or earthen ditch. Flowing water was categorized into two source types: permitted outfalls or unpermitted outfalls. Permitted outfalls included wastewater facilities and municipal separate storm sewer systems (MS4). Any pipe greater than 12 inch (in.) in diameter was assumed to be permitted by our field crews.

When flowing water was observed from a permitted outfall, two samples were collected. One sample was collected immediately downstream of the outfall where the flowing outfall was mixing with the ambient water. The second sample was taken upstream of the flowing outfall outside of the realm of influence from the outfall to provide the ambient bacteria levels of the assessment unit in that area. The second type of source was an unpermitted outfall, which was any other flowing source of water that was judged to not be permitted in the field, including flowing small (<12 in. diameter) “homemade” pipes and tributaries.

When a flowing unpermitted outfall was observed, the bacteria sample was taken directly from the source. If the source was a flowing pipe, the sample was collected directly from the pipe, before it entered the AU. If it was an open-top earthen ditch or natural tributary, the sample was collected from far enough into the inflow source that there was no mixing with the receiving water. In some cases, when no flowing permitted or unpermitted outfalls were observed in an extended section of the AU, a single ambient reference sample was taken mid-stream. Left and right bank references are oriented with the observer facing downstream.

Assessment Units, sample collection and laboratory methods, and data handling practices are detailed in Appendix J of the FY 2022-2023 H-GAC Multi-Basin Clean Rivers Program Quality Assurance Project Plan (H-GAC QAPP, 2022). For all field investigations the field team recorded location of the flowing outfall (latitude and longitude), the diameter, material, and water depth of the flowing outfall, and documented site conditions by taking photos and other relevant notes. All bacteria samples were analyzed by a National Environmental Laboratory Accreditation Program (NELAP)-Accredited laboratory.

Results

The FI was conducted on May 3rd, 2023 (five days since last significant rainfall) and a total of 70 bacteria samples were collected. The values of the bacteria samples collected from downstream of permitted outfalls, directly from unpermitted outfalls, or as ambient samples are summarized in Table 2 and Figure 3. Based on the data collected, three locations with elevated *E. coli* bacteria levels measured during the FI are recommended for high priority and

two locations for low priority investigation by the proper authorities. High priority sites had the highest potential bacteria loading observed and are recommended to be the areas for local authorities to focus efforts on should there be insufficient resources to address all referral sites. As time and resources allow the low priority and “investigate further” referrals also are recommended for further investigation. These locations are summarized in Table 2 (highlighted in grey) and Figure 4. In addition, nine locations were flagged where ambient or upstream samples had elevated bacteria levels with no obvious explanations. Further investigation of these areas by the proper authorities are recommended. Each of these referrals are summarized by site, herein. The referral summaries are listed in order of priority (High, Low, then Investigate Further). Within each priority group, sites are listed from downstream to upstream.

Table 2: Field investigation bacteria results from sampling on 5/03/2023 on Spring Branch (Assessment Unit 1014O_01). Referrals (gray rows): N = No, Y-H = Yes – High Priority, Y-L = Yes-Low Priority, IF = Investigate Further, US = Upstream, DS = Downstream. LB = Left Bank, RB = Right Bank.

Sample ID	Lat	Long	DS or Direct *E. coli* Sample Results (MPN/100 mL)	US *E. coli* Sample Results (MPN/100 mL)	Difference * DS - US (MPN/100 mL)	Referral	Comments
SPB-FI1-01	29.77387	-95.47906	100	NA	NA	N	Ambient sample taken from tributary to Spring Branch in the mixing zone; Left bank.
SPB-FI1-02	29.77398	-95.47927	980	NA	NA	IF	Ambient sample taken upstream of estimated mixing zone. Bottom of SPB segment.
SPB-FI1-03	29.77664	-95.48180	410	NA	NA	N	Ambient sample.
SPB-FI1-04-D	29.77674	-95.48190	100	630	-530	N	Water flowing down from left bank from unknown source.
SPB-FI1-05-D	29.77796	-95.48293	740	410	330	Y-L	Pipe located at small waterfall where water is mixing; RB.
SPB-FI1-06-P	29.77809	-95.48262	< 100	NA	NA	N	LB: leaking pipe over waterway; took sample directly from pipe.
SPB-FI1-07	29.77930	-95.48409	1460	NA	NA	IF	Ambient sample taken on LB of tributary.
SPB-FI1-08-D	29.77946	-95.48443	< 100	8,390	-8,290	IF	US sample taken first; RB; DS of bridge where bats are; beavers swimming; pipe dripping.
SPB-FI1-09	29.77935	-95.48492	630	NA	NA	IF	Ambient sample of tributary Briar Branch at Chimney Rock bridge US; RB (include in future FI).
SPB-FI1-10-D	29.78096	-95.48409	200	860	-660	N	LB: Slow trickle-down bank US of left pipe.
SPB-FI1-11	29.78203	-95.48595	410	NA	NA	IF	Ambient sample taken at RB at small tributary.
SPB-FI1-12	29.78265	-95.48650	630	NA	NA	N	Ambient sample taken.
SPB-FI1-13-D	29.78347	-95.48649	1,340	740	600	Y-L	Pipe measurements estimated; on left bank.
SPB-FI1-14-D	29.78532	-95.48670	310	200	110	N	LB: Bottom of pipe rusted out, just trickling; in a large, pooled area.
SPB-FI1-15-D	29.78559	-95.48687	1,210	100	1,110	Y-H	Extremely large pipe on LB; substantial flow coming from pipe; coordinates may not be exact due to tree cover.
SPB-FI1-16-D	29.78789	-95.49136	100	200	-100	N	Smells like sewage; RB.

Sample ID	Lat	Long	DS or Direct *E. coli* Sample Results (MPN/100 mL)	US *E. coli* Sample Results (MPN/100 mL)	Difference * DS - US (MPN/100 mL)	Referral	Comments
SPB-FI1-17-D	29.78815	-95.49140	410	310	100	N	Almost stagnant pool under pipe with oily sheen on surface; RB; unable to tell where connected took DS sample from pool.
SPB-FI1-18-D	29.79264	-95.49229	100	4570	-4,470	N	Took sample directly from tributary; Took US directly from main AU; LB.
SPB-FI1-19-D	29.79383	-95.49542	43,500	77,000	-33,500	N	Material of pipe; Outside is metal, opening lining is plastic, and body is concrete; RB.
SPB-FI1-20-D	29.79412	-95.49556	> 242,000	17,800	224,200	Y-H	Submerged pipe: LB. Took sample in pipe. Bats under bridge US of samples.
SPB-FI1-21-D	29.79485	-95.49672	< 100	< 100	0	N	LB rusted out pipe; Water not flowing out of pipe but flow on concrete below. US of bridge with bats.
SPB-FI1-22-D	29.79596	-95.49923	< 100	< 100	0	N	Several weep holes on both banks; Same US sample as 23; Flowing & 1 rusted out; Metal pipe. No water in pipe but wet concrete below; LB.
SPB-FI1-23-D	29.79600	-95.49933	1,340	< 100	1,240	Y-H	Water started flowing while at site out of metal pipe on RB. Smells of effluent.
SPB-FI1-24-D	29.79615	-95.50028	300	< 100	200	N	LB - pipe dripping down concrete before mixing in stream.
SPB-FI1-25	29.79684	-95.50263	630	NA	NA	N	Ambient sample of trib. on LB.
SPB-FI1-26	29.79680	-95.50258	< 100	NA	NA	N	Ambient sample US of trib.
SPB-FI1-27-D	29.79604	-95.50526	< 100	< 100	0	N	RB; trickling, wet pipe DS of this one on other side of bridge - no flow.
SPB-FI1-28-D	29.79730	-95.50732	< 100	< 100	0	N	RB; Sheet flow from pipe to bank.
SPB-FI1-29-D	29.79755	-95.50771	100	<100	0	N	Submerged pipe on LB; unable to tell if flowing. ~20m US of this pipe, another on RB, wet, no flow.
SPB-FI1-30-D	29.79830	-95.50944	100	< 100	0	N	RB - 2 metal pipes: US one flowing, DS one wet but no flow; sheet flow to stream.
SPB-FI1-31-D	29.79841	-95.50958	< 100	100	0	N	RB; Sheet flow to stream.
SPB-FI1-32-D	29.79875	-95.51005	200	< 100	100	N	LB; Sheet flow on concrete before reaching stream; flow ~15m US coming from broken concrete on LB.

Sample ID	Lat	Long	DS or Direct *E. coli* Sample Results (MPN/100 mL)	US *E. coli* Sample Results (MPN/100 mL)	Difference * DS - US (MPN/100 mL)	Referral	Comments
SPB-FI1-33-D	29.80094	-95.51128	100	< 100	0	N	RB; white growth in pipe extending to stream.
SPB-FI1-34-D	29.80097	-95.51133	< 100	< 100	0	N	LB; several weep holes flowing and encampment under bridge.
SPB-FI1-35	29.80127	-95.51156	750	NA	NA	N	Ambient sample taken just US of bridge.
SPB-FI1-36	29.80298	-95.51620	410	NA	NA	IF	Ambient sample; LB pipe can hear flow. Top of segment - goes underground.
SPB-FI1-37	29.80298	-95.51623	750	NA	NA	IF	Ambient sample; RB pipe. Top of segment - continues underground.
SPB-FI1-NS-01	29.77800	-95.48283	NA	NA	NA	N	Stagnant pool in front of pipe; not sampled; LB; Water is cloudy.
SPB-FI1-NS-02	29.78177	-95.48527	NA	NA	NA	N	Metal pipe not sampled along RB; wet inside but not flowing.
SPB-FI1-NS-03	29.78573	-95.48776	NA	NA	NA	N	Unsampled pipe along RB; metal; one drip per minute.
SPB-FI1-NS-04	29.79570	-95.49784	NA	NA	NA	N	Not sampled. Metal pipe LB - no flow, water inside, wet concrete with orange growth; wet concrete DS of this pipe too.
SPB-FI1-NS-04	29.79664	-95.50166	NA	NA	NA	N	Unsampled metal pipe on LB, wet, no flow. 2nd metal pipe ~15m US of this one. Wet concrete. No water in pipe – LB.
SPB-FI1-NS-06	29.80229	-95.51276	NA	NA	NA	N	Not sampled; Metal pipe on LB, wet but not flowing.
SPB-T1-FI1-01	29.79770	-95.50301	34,500	NA	NA	IF	Ambient sample.
SPB-T1-FI1-02	29.80035	-95.50394	310	NA	NA	N	Ambient sample.
SPB-T1-FI1-03	29.80309	-95.50474	< 100	NA	NA	N	Ambient sample; LB and RB pipes both wet but no flow, encampment on LB.
SPB-T1-FI1-04	29.80442	-95.50488	< 100	NA	NA	N	Ambient sample. At this location there is dry trib. on RB.
SPB-T1-FI1-05-D	29.80867	-95.50492	100	100	0	N	LB; rusted out pipe. Two pipes; Sample taken from US pipe.
SPB-T1-FI1-06	29.80871	-95.50645	510	NA	NA	N	Ambient sample.
SPB-T1-FI1-07-D	29.80871	-95.50670	520	860	-340	IF	Submerged pipe on LB. Unable to tell if flowing. Trib. continues, sample from WS was < 100MPN.

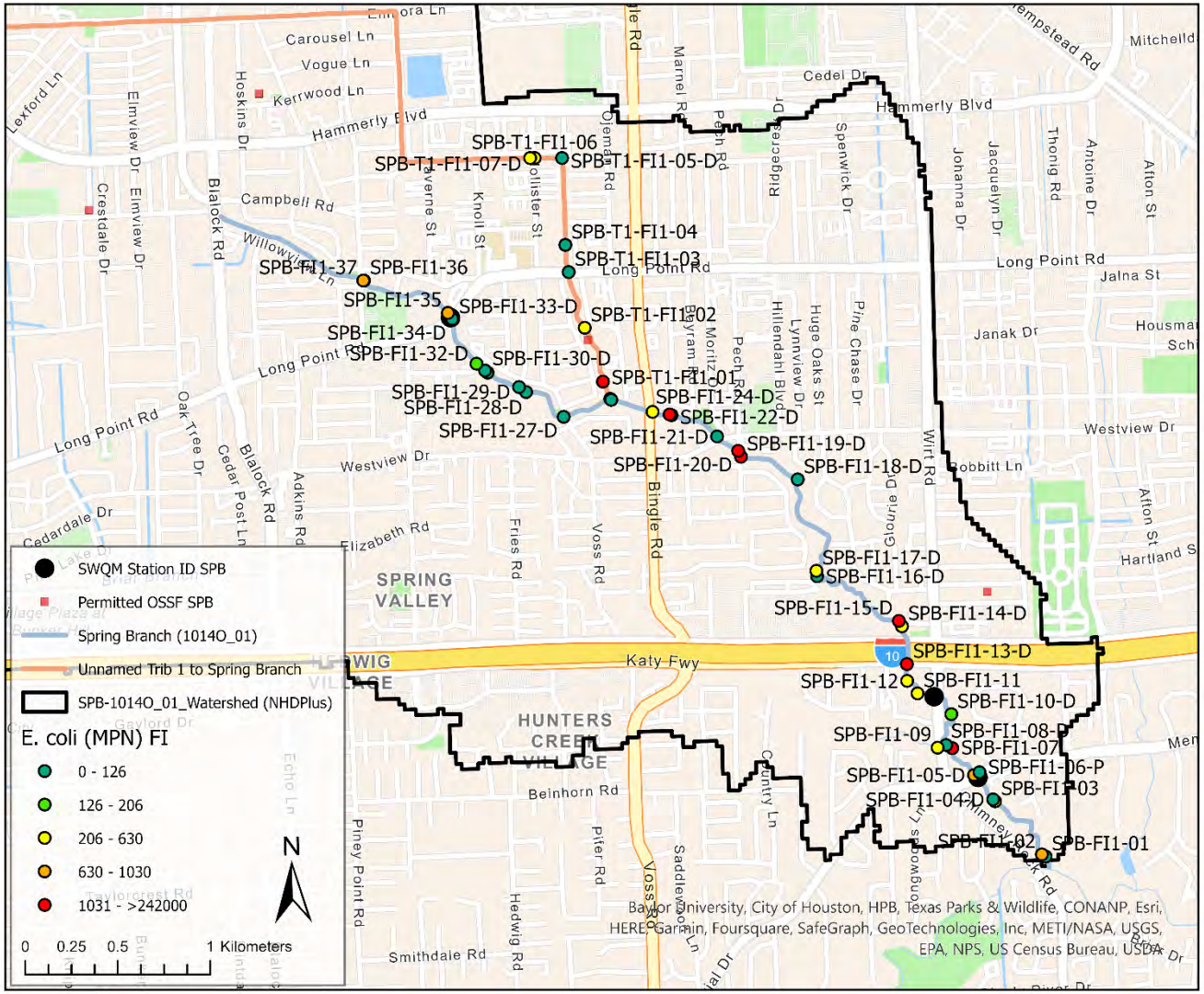


Figure 3: Field investigation bacteria sampling Results from 5/03/2023 on Spring Branch (Assessment Unit 1014O_01).

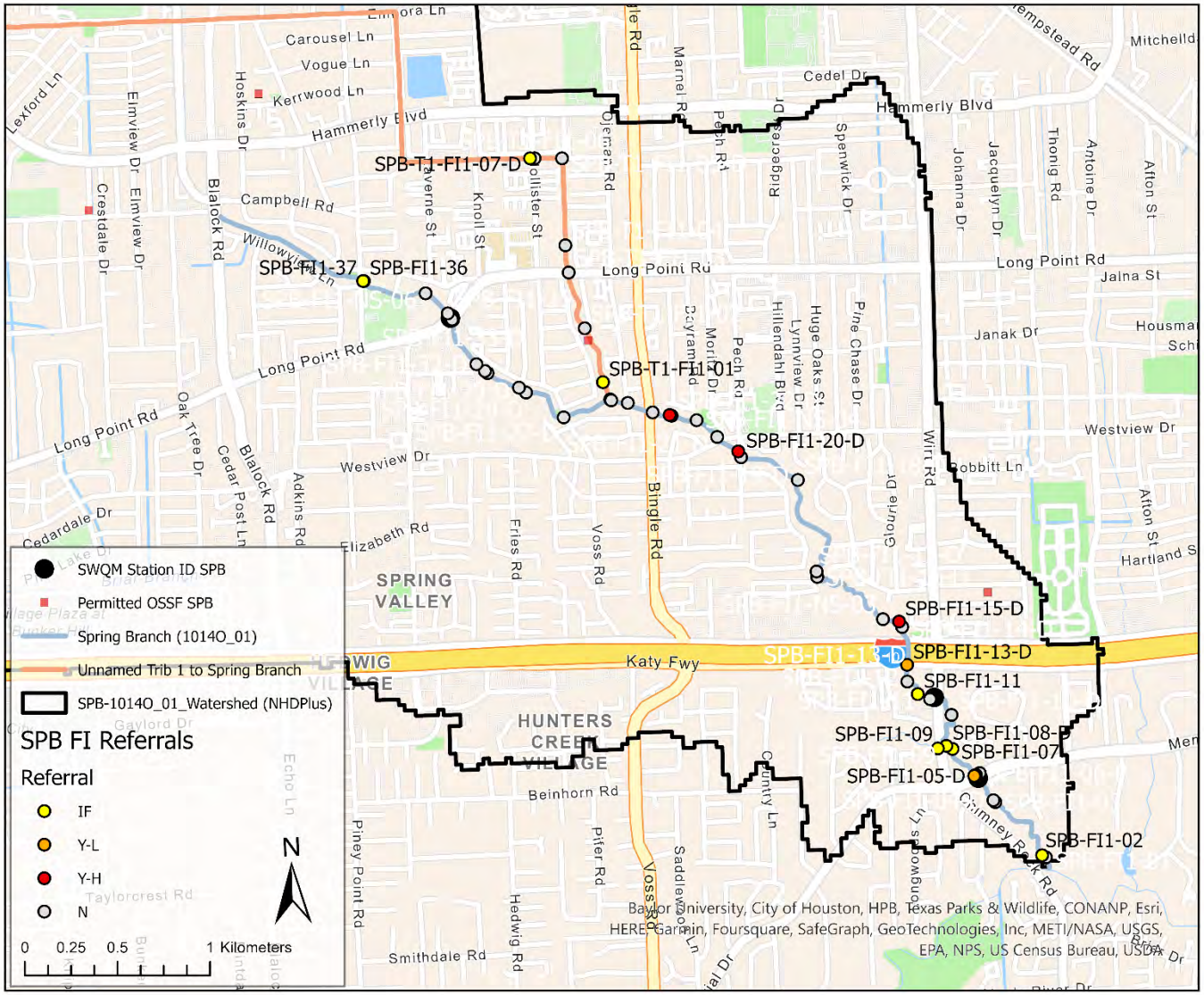


Figure 4: Field investigation sites identified for referral to the proper authorities on Spring Branch (Assessment Unit 1014O_01).

Referral site: SPB-FI1-15-D– High Priority

This is a 124 in. diameter concrete pipe located on the left bank of Spring Branch. Water within the pipe was 2 in. deep with a substantial flow into the segment. There are single family homes in the area. A sample taken 0.25 m downstream of the pipe had a bacteria value of 1,210 MPN/100 mL. The ambient sample collected upstream of the pipe had a bacteria value of 100 MPN/100 mL. This pipe is a high priority referral site for the proper local authority.

Referral site: SPB-FI1-20-D– High Priority

This is a 104 in. diameter concrete pipe located on the left bank of Spring Branch. Water within the partially submerged pipe was 22 in. deep. Bats are present under the bridge upstream of where these samples were taken. There are single family homes, commercial businesses, schools, and parks in the area. Due to the pipe being submerged, the downstream sample was taken within the mixing zone in front of the mouth of the pipe and had a bacteria value of > 242,000 MPN/100 mL. The ambient sample collected upstream of the pipe had a bacteria value of 17,800 MPN/100 mL. This pipe is a high priority referral site for the proper local authority.

Referral site: SPB-FI1-23-D– High Priority

This is a 32 in. diameter metal pipe located on the right bank of Spring Branch. Water within the pipe was 0.5 in. deep. While the pipe was not flowing initially, water started flowing out of the pipe while the team was present and it smelled of effluent. There are single-family homes in the area and commercial businesses on the left bank. A sample was taken 1.8 m downstream of the pipe and it had a bacteria value of 1,340 MPN/100 mL. The ambient sample collected upstream of the pipe had a bacteria value of 100 MPN/100 mL. This pipe is a high priority referral site for the proper local authority.

Referral site: SPB-FI1-05-D– Low Priority

This is a 48 in. diameter metal pipe located on the right bank of Spring Branch where a small waterfall mixes with the outflow of the pipe. Water within the pipe was 0.5 in. deep. There are single family homes in the area and a high school on the right bank. A sample 1.5 m downstream of the pipe had a bacteria value of 740 MPN/100 mL. The ambient sample collected upstream of the pipe had a bacteria value of 410 MPN/100 mL. This pipe is a low priority referral site for the proper local authority.

Referral site: SPB-FI1-13-D– Low Priority

This is an approximately 72 in. diameter concrete pipe located on the left bank of Spring Branch. Water within the pipe was estimated to be 0.125 in. The pipe is parallel with Interstate 10 and there are commercial businesses, condos, and single-family homes in the area. Outflow from the pipe runs down approximately 15 m of concrete into cracks before entering the stream. A sample taken downstream of the pipe had a bacteria value of 1,340 MPN/100 mL. The ambient sample collected upstream of the pipe had a bacteria value of 740 MPN/100 mL. This pipe is a low priority referral site for the proper local authority.

Referral site: SPB-FI1-02– Investigate Further

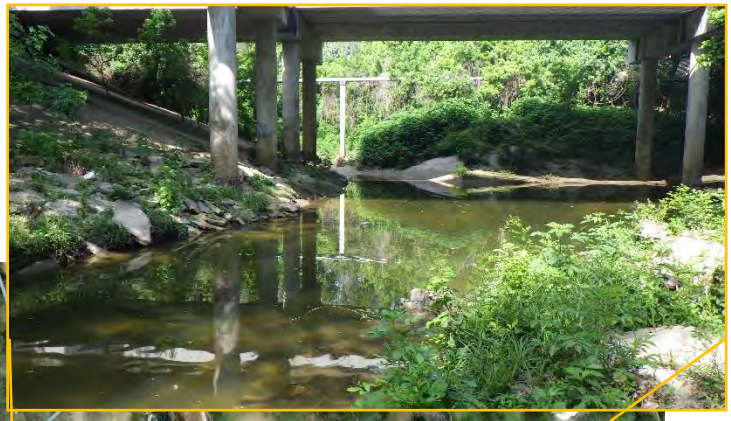
This was an ambient sample taken upstream of the estimated mixing zone of the confluence of Spring Branch and Buffalo Bayou. The ambient sample had a bacteria value of 980 MPN/100 mL while another ambient sample taken approximately 400 m further upstream had a bacteria value of 410 MPN/100 mL. Further investigation is recommended by the proper local authority to determine the source of elevated bacteria in this section of the segment. There are single-family homes and a seminary in the area.

Referral site: SPB-FI1-07– Investigate Further

This was an ambient sample taken from a tributary to Spring Branch on the left bank. The ambient sample had a bacteria value of 1,460 MPN/100 mL. Further investigation is recommended by the proper local authority to determine the source of elevated bacteria in this tributary. There are single-family homes and commercial buildings in the area.

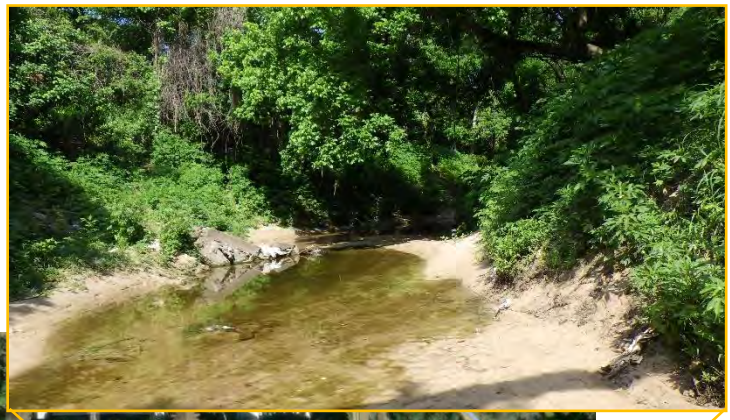
Referral site: SPB-FI1-08-D– Investigate Further

This is a 24 in. metal pipe that was dripping on the left bank of Spring Branch. This sample had a bacteria value of <100 MPN/100 mL but the upstream sample had a bacteria value of 8,390 MPN/100 mL. Bats are present under the bridge upstream of where samples were taken, and a beaver was observed in the water at the site. The next sample taken upstream of this site was SPB-IF1-10D where the upstream sample was 860 MPN/100 mL. There are single-family homes in the area and a high school on the right bank. Further investigation is recommended by the proper local authority to determine the source of elevated bacteria in this section of the segment.



Referral site: SPB-FI1-09– Investigate Further

This was an ambient sample taken from a tributary of Spring Branch (Briar Branch) upstream of the Chimney Rock Bridge. This sample had a bacteria value of 630 MPN/100 mL. A FI or further investigation of this tributary is recommended. There are single-family homes in the area and a high school on the right bank of this tributary.



Referral site: SPB-FI1-11– Investigate Further

This was an ambient sample taken from a small tributary located on the right bank of Spring Branch. This sample had a bacteria value of 410 MPN/100 mL. Further investigation is recommended by the proper local authority to determine the source of elevated bacteria in this tributary. There are apartments on the right bank where it looks like this tributary originates.

Referral site: SPB-FI1-36– Investigate Further

This was a sample taken from the opening of the left bank culvert at the top of the segment that had a bacteria value of 410 MPN/100 mL. The segment goes underground after this point and flow could be heard entering the culvert somewhere further upstream. Further investigation is recommended by the proper local authority to determine the source of elevated bacteria underground and upstream of the segment. There are apartments in the area and a park is located upstream on the right bank.

Referral site: SPB-FI1-37– Investigate Further

This was a sample taken from the opening of the right bank culvert at the top of the segment that had a bacteria value of 750 MPN/100 mL. The segment goes underground after this point. Further investigation is recommended by the proper local authority to determine the source of elevated bacteria underground and upstream of the segment. There are apartments in the area and a park is located upstream on the right bank.

Referral site: SPB-T1-FI1-01– Investigate Further

This was an ambient sample taken from a tributary of Spring Branch that had a bacteria value of 34,500 MPN/100 mL. Another ambient sample taken approximately 300 m further upstream in the tributary had a bacteria value of 310 MPN/100 mL. No evidence of flow entering the stream was observed between the two samples. Further investigation is recommended by the proper local authority to determine the source of elevated bacteria in this section of the tributary. There are apartments and single-family homes located in the area.

Referral site: SPB-T1-FI1-07– Investigate Further

This is a 36 in. diameter rusted out metal pipe located on the left bank of the tributary of Spring Branch. Water within the partially submerged pipe was 5 in. deep and the team was unable to determine if it was flowing into the tributary. There are apartments and commercial buildings located in the area. Due to the pipe being submerged, the downstream sample was taken within the mixing zone in front of the mouth of the pipe and had a bacteria value of 520 MPN/100 mL. The sample collected upstream of the pipe had a bacteria value of 860 MPN/100 mL. A sample from this location during the WS resulted in a bacteria value of < 100 MPN/100 mL and therefore the FI ended at this site. Due to the higher bacteria levels during the FI, further investigation is recommended by the proper local authority to determine the source of elevated bacteria upstream in the tributary.

List of Acronyms and Abbreviations

AU	Assessment Unit
BIG	Bacteria Implementation Group
CRP	Clean Rivers Program
DS	Downstream
E. coli	*Escherichia coli*
FI	Field Investigation
FY	Fiscal Year
GIS	Geographic Information Systems
H-GAC	Houston-Galveston Area Council
IF	Investigate Further
in.	inch
I-Plan	Implementation Plan
km	kilometer
LB	Left Bank
m	meter
mL	milliliter
MPN	Most probable number
N	No
NELAP	National Environmental Laboratory Accreditation Program
NLCD	National Land Cover Database
OSSF	On-Site Sewage Facilities
QAPP	Quality Assurance Project Plan
RB	Right Bank
SPB	Spring Branch (Trib of Buffalo Bayou) 1014O_01
SWQM	Surface Water Quality Monitoring
SWRC	Stroud Water Research Center
T or trib.	Tributary
TCEQ	Texas Commission on Environmental Quality
TMDL	Total Maximum Daily Load
US	Upstream
WS	Windshield Survey
Y-H	Yes – High Priority
Y-L	Yes-Low Priority

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Targeted Bacteria Monitoring Project

Field Investigation Final Report

Assessment Unit 1017_03,
White Oak Bayou Above Tidal

Environmental Institute of Houston

August 1, 2023

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Segment Description

Segment 1017 is White Oak Bayou Above Tidal (Figure 1). This segment contains an assessment unit (AU) of concern, AU 1017_03. This AU is a freshwater, perennial stream that is 2.62 km and is defined as being from the Cole Creek confluence to the Brickhouse Gully confluence in Harris County. There is one current (station ID: 15829) and two historic (station IDs: 11392 and 51830) surface water quality monitoring (SWQM) stations located on this AU. This AU has been selected for targeted monitoring due to a bacteria (*Escherichia coli*) seven-year geometric mean of 1624.8 MPN/100 mL (H-GAC QAPP, 2022). The AU was listed for exceedances of bacteria in the water (Recreation use) and has a current impairment category of 4a (TCEQ, 2022). The potential sources of bacteria are non-point source pollution, urban runoff, and sanitary sewer overflows (TCEQ, 2022).

The contributing watershed for this segment is 4.0 km^2 (Data source: HGAC and SWRC, 2023). The predominant soil group in the watershed is slow infiltration coverage and the land cover in the watershed is dominated by 99.62% developed land (Data source: United States Department of Agriculture Hydrologic Soil Groups from gSSURGO 2016 and National Land Cover Database NLCD 2019). There are no permitted wastewater outfalls in this immediate watershed (Data source: H-GAC), but there is a wastewater outfall at the most downstream portion of Cole Creek, which then flows directly into the most upstream portion of this AU. There are also 3 documented permitted on-site sewage facilities (OSSF) within the watershed, but no documented unpermitted OSSFs (Data source: H-GAC).

Background

Clean Rivers Program (CRP) routine monitoring data are analyzed each year as part of the Houston-Galveston Area Council (H-GAC) Basin Summary/Basin Highlights Report process. Bacteria continues to be the most prevalent pollutant in the H-GAC CRP Basins (H-GAC, 2022). The Bacteria Implementation Group (BIG), formed in 2008, oversees the Total Maximum Daily Load (TMDL) Implementation Plan (I-Plan). The BIG requested that H-GAC produce a list of the water bodies with the highest bacteria concentrations in the BIG project area and conduct targeted monitoring to identify potential bacteria sources.

H-GAC, using information from previous Basin Highlights/Summary Reports, BIG annual reports, and previous targeted monitoring efforts, identified and selected waterways for targeted bacteria monitoring to refine our understanding of the spatial distribution of elevated bacterial concentrations contributing to these waterways. Phase 1 of this targeted monitoring project included an intensive desktop review and a windshield survey (WS) of each AU catchment area, and sampling of the AU from primary road crossings. Phase 2 of this targeted monitoring project included a field investigation (FI) of the entire AU conducted during dry conditions where all flowing point and non-point sources were evaluated.

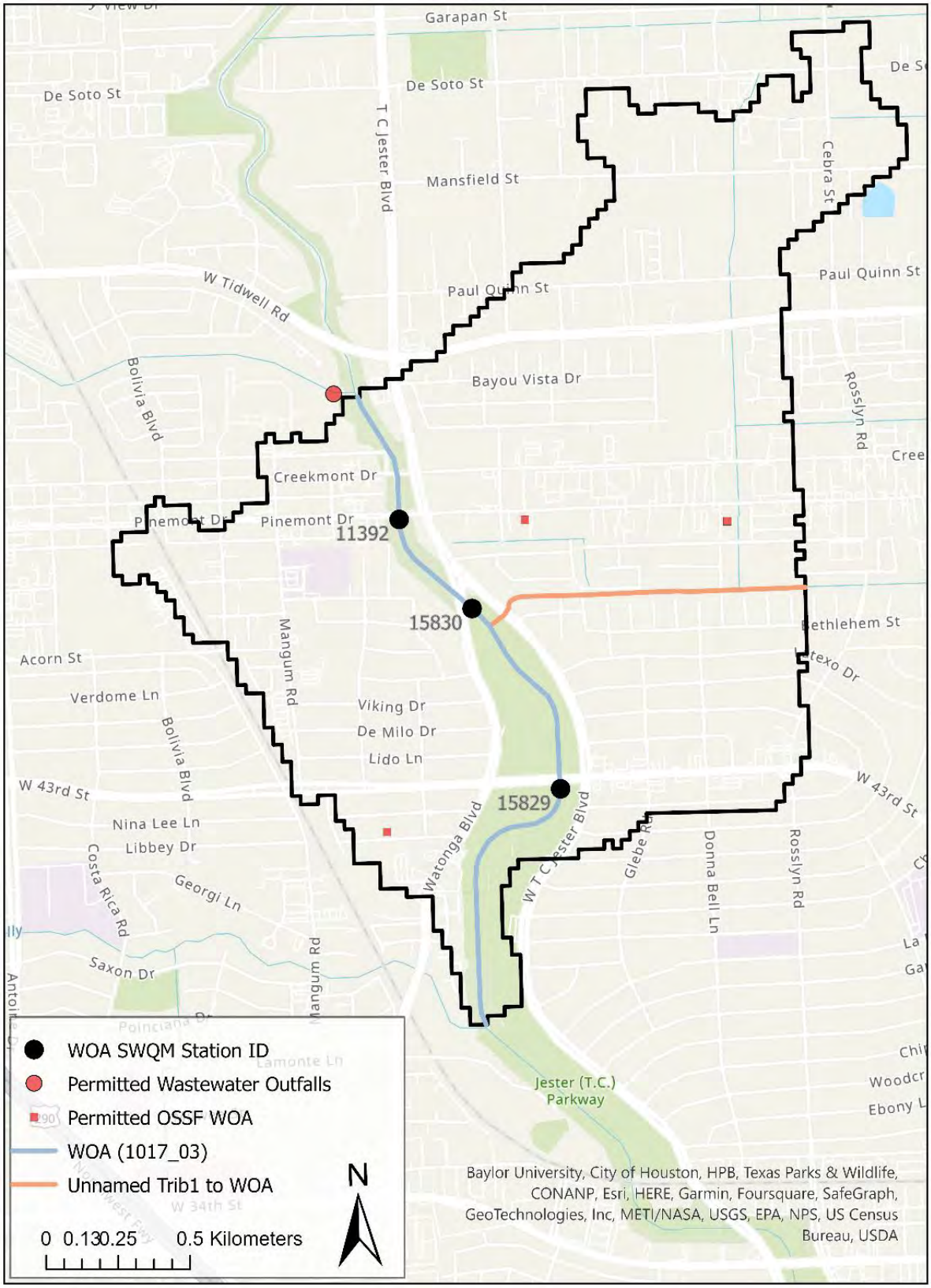


Figure 1 Watershed Map for White Oak Bayou Above Tidal, AU 1017_03.

Desktop Review

Methods

The intensive desktop review included an evaluation of permitted discharges, outfalls, and potential sources of point source and nonpoint source pollution that may contribute to bacteria loading in the AU. Using Google Earth imagery and GIS, the locations of wastewater treatment facilities, permitted OSSFs, and potential locations of unpermitted OSSFs were identified. Other potential sources such as landfills and industrial facilities were also identified. Parks were noted, as these can contribute to bacterial sources through runoff of animal wastes but also provide opportunity for contact recreation. Bridge crossings and other entry points were identified to provide access into the stream to collect bacteriological samples.

Results

The results of the desktop review indicated that this AU is located predominantly in an urban/suburban area with many roads, single-family and multi-family residences, along with some businesses and parking lots within this watershed and bordering the bayou. The majority of this AU is confined within a series of parks that are connected by the White Oak Bayou Greenway Trail and has a walking/biking trail that follows the bayou throughout this entire AU. The following potential sources were identified: TC Jester Dog Park just upstream of the confluence with Brickhouse Gully, Watonga Drive Bridge Bat Colony, and a grouping of manufacturing businesses located near the bayou at Creekmont Drive. Publicly accessible entry points into the stream were identified at the TC Jester Park, near the intersection of Watonga Blvd. and TC Jester Blvd., at Creekmont Dr., and near the confluence of Cole Creek and White Oak Bayou Above Tidal.

Windshield Survey

Methods

Field events must take place during dry weather (after three or more days without significant rainfall in the watershed). This ensures that any flowing water into the AU is not stormwater. Windshield surveys of the watershed were conducted and bacteria sampling was performed at public access points throughout the AU (primarily at bridge crossings). The survey consisted of driving the catchment area to confirm identified pollution sources found during the desktop review and to find any potential sources not identified during that review. Bridge crossings chosen for sampling were spatially distributed to provide a spatial snapshot of bacteria concentrations in the AU and identify sections of the AU where elevated bacteria concentrations were found. Those areas with elevated bacteria levels identified in the WS monitoring were focused on during the FI in Phase 2.

Assessment Units, sample collection and laboratory methods, and data handling practices are detailed in Appendix J of the FY 2022-2023 H-GAC Multi-Basin Clean Rivers Program Quality Assurance Project Plan (H-GAC QAPP, 2022). For all WS monitoring, field personnel documented the latitude and longitude of sample location. All bacteria samples were analyzed by a National Environmental Laboratory Accreditation Program (NELAP)-Accredited laboratory.

Results and Recommendations

The WS was conducted on March 6, 2023. At that time, it had been four days since the last significant rainfall in the watershed. A total of six samples were collected on AU 1017_03 and one on the contributing tributary during the WS (Table 1 and Figure 2).

Table 1. Windshield survey bacteria results from sampling on 03/06/2023 on White Oak Bayou Above Tidal (AU 1017_03). Samples were taken at bridge crossings and other publicly accessible points. US = Upstream, DS = Downstream, LB = Left Bank, RB = Right Bank.

Sample ID	Latitude	Longitude	*E. coli* Sample Results (MPN/100 mL)	Comments
WOA-WS-01	29.82682	-95.45621	309	Smells of effluent.
WOA-WS-02	29.83272	-95.45321	183	
WOA-WS-03	29.83702	-95.45517	292	Possible encampment under pedestrian bridge.
WOA-WS-04	29.83822	-95.45625	185	Two flowing outfalls US on RB. Bats and bat droppings present.
WOA-WS-05	29.84281	-95.45876	262	Very shallow but very swift moving water.
WOA-WS-06	29.84526	-95.46008	288	Smells of effluent. Observed 2 soft-shell turtles US of confluence.
T1WOA-WS-01	29.83771	-95.45505	683	Sample collected from trib to WOA. Bats living under bridge over trib. Smells of guano and observed dropping on bank.

Based upon the results of the WS and ground-truthing, a FI covering the entire length of the AU and the unnamed tributary into White Oak Bayou Above Tidal was recommended. Based on the results of the WS, we expected to identify potential non-point sources or point sources of elevated bacteria near the following portions of the AU:

1) The unnamed tributary that flows into this AU just downstream of the TC Jester Blvd. and Watonga Blvd. intersection where sample T1WOA-WS-01 was taken. Considering the elevated bacteria level (683 MPN/100 mL) found in this tributary and the noticeably lower bacteria level (185 MPN/100 mL) from the sample collected upstream of the confluence with this tributary, this tributary was targeted for a full FI.

2) WOA-WS-01, which was collected near the TC Jester Park approximately 0.13 mi upstream of the confluence with Brickhouse Gully. This sample had an elevated bacteria level (309 MPN/100

mL) compared to the sample collected approximately 0.50 mi upstream at the bridge at 43rd St. (183 MPN/100 mL).

3) WOA-WS-05, which was collected from the upstream side of the bridge at Creekmont Drive. This sample had an elevated bacteria level (262 MPN/100 mL) compared to the sample collected approximately 0.35 mi downstream of the area (185 MPN/100 mL).

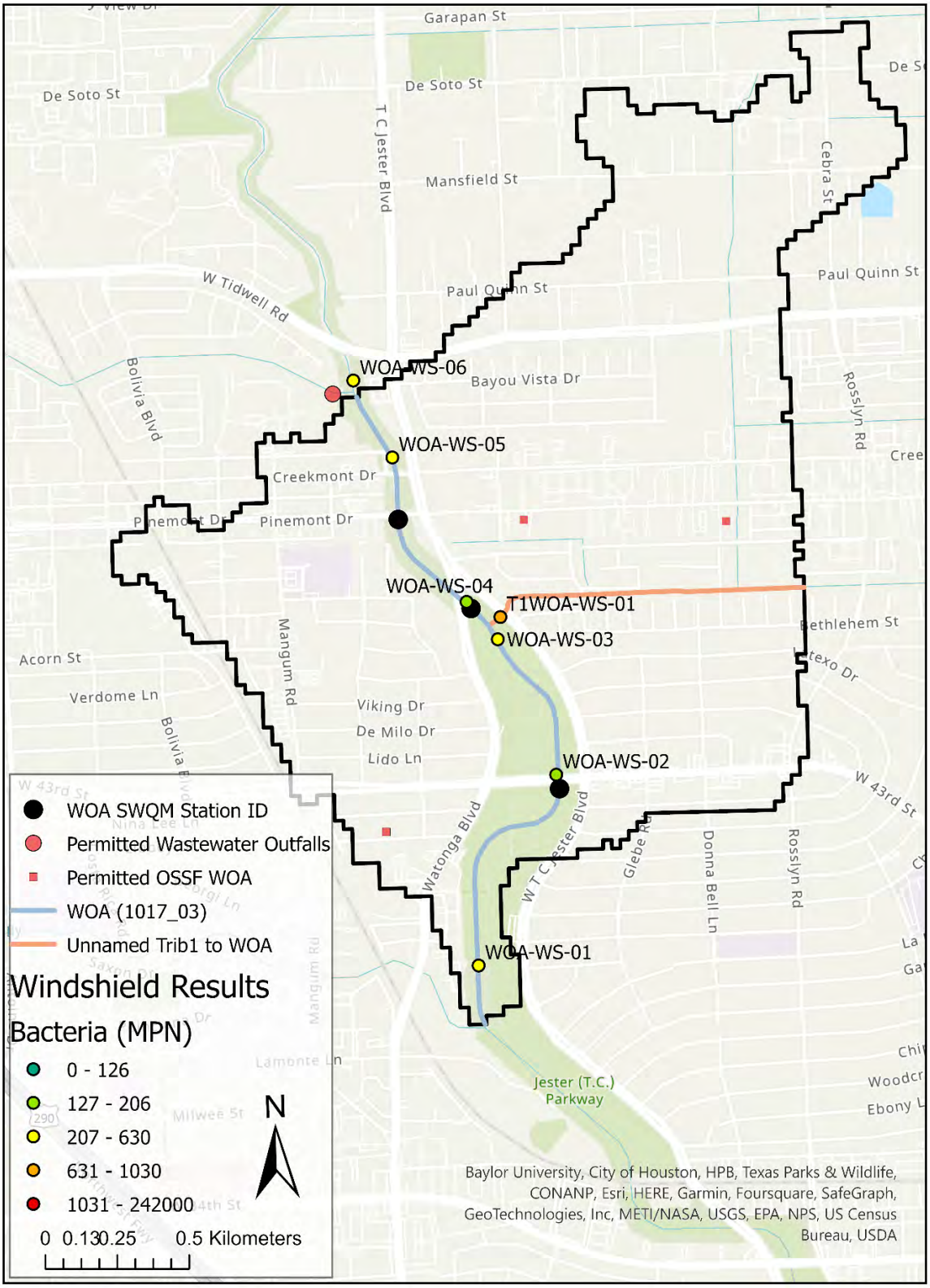


Figure 2. Windshield survey/ground truthing bacteria results from sampling on 03/06/2023 on White Oak Above Tidal (US 1017_03).

Field Investigation

Methods

The FI was a thorough survey where a team of two either walked or paddled the entire assessment unit and sampled any water observed flowing into the stream. Water could be flowing in from a pipe, culvert, natural tributary, or earthen ditch. Flowing water was categorized into two source types: permitted outfalls or unpermitted outfalls. Permitted outfalls included wastewater facilities and municipal separate storm sewer systems (MS4). Any pipe greater than 12 inches (in.) in diameter was assumed to be permitted by our field crews. When flowing water was observed from a permitted outfall, two samples were collected.

One sample was collected immediately downstream of the outfall where the flowing outfall was mixing with the ambient water. The second sample was taken upstream of the flowing outfall outside of the realm of influence from the outfall to provide the ambient bacteria levels of the assessment unit in that area. The second type of source was an unpermitted outfall, which was any other flowing source of water that was judged to not be permitted in the field, including flowing small (<12 in. diameter) “homemade” pipes and tributaries.

When a flowing unpermitted outfall was observed, the bacteria sample was taken directly from the source. If the source was a flowing pipe, the sample was collected directly from the pipe, before it entered the AU. If it was an open-top earthen ditch or natural tributary, the sample was collected from far enough into the inflow source that there was no mixing with the receiving water. In some cases, when no flowing permitted or unpermitted outfalls were observed in an extended section of the AU, a single ambient reference sample was taken mid-stream. Left and right bank references are oriented with the observer facing downstream.

Assessment Units, collection and laboratory methods, and data handling practices are detailed in Appendix J of the FY 2022-2023 H-GAC Multi-Basin Clean Rivers Program Quality Assurance Project Plan (H-GAC QAPP, 2022). For all field investigations the field team recorded location of the flowing outfall (latitude and longitude), the diameter, material, and water depth of the flowing outfall, and documented site conditions by taking photos and other relevant notes. All bacteria samples were collected following procedures listed in Appendix J of the FY 2022-2023 H-GAC Multi-Basin Clean Rivers Program Quality Assurance Project Plan (H-GAC QAPP, 2022) and analyzed by a National Environmental Laboratory Accreditation Program (NELAP)-Accredited laboratory.

Results

The FI was conducted on April 3, 2023 (17 days since last significant rainfall) and a total of 41 bacteria samples were collected on the main AU and a contributing tributary. The values of the bacteria samples collected from downstream of permitted outfalls, directly from unpermitted outfalls, or as ambient samples are summarized in Table 2 and Figure 3. Based on the data

collected, three locations with elevated *E. coli* bacteria levels measured during the FI are recommended for high priority, and three locations for low priority investigation by the proper authorities. High priority sites had the highest potential bacteria loading observed and are recommended to be the areas for local authorities to focus efforts on should there be insufficient resources to address all referral sites. As time and resources allow the low priority and "investigate further" referrals also are recommended for further investigation. These locations are summarized in Table 2 and Figure 4. In addition, three locations were flagged where ambient or upstream samples had elevated bacteria levels with no obvious explanations. Further investigation of these areas by the proper authorities are recommended. Each of these referrals are summarized by site, herein. The referral summaries are listed in order of priority (High, Low, then Investigate Further). Within each priority group, sites are listed from downstream to upstream.

Table 2: Field investigation bacteria results from sampling on 4/3/2023 on White Oak Above Tidal (Assessment Unit 1017_03) and a contributing tributary. Referrals (gray rows): N = No, Y-H = Yes – High Priority, Y-L = Yes-Low Priority, IF = Investigate Further, US = Upstream, DS = Downstream, LB = Left Bank, RB = Right Bank.

Sample ID	Lat	Long	DS or Direct *E. coli* Sample Results (MPN/100 mL)	US *E. coli* Sample Results (MPN/100 mL)	Difference* DS - US (MPN/100 mL)	Referral	Comments
WOA-FI1-01	29.82508	-95.45609	1,610	NA	NA	IF	Ambient sample taken just upstream of confluence with Brickhouse Gully.
WOA-FI1-02	29.82654	-95.45623	200	NA	NA	N	Water coming in from unknown source- possibly from metal panel on concrete banks. Sheen on water.
WOA-FI1-03-D	29.82662	-95.45622	310	410	-100	N	Tributary (concrete-lined ditch on RB) had just a trickle. Did not sample directly from it.
WOA-FI1-04-D	29.82857	-95.45619	750	100	650	Y-H	Metal pipe discharges onto concrete lining. Just a trickle from pipe on LB.
WOA-FI1-05-D	29.83118	-95.45479	310	200	110	Y-L	Decent amount of flow (more than a trickle). Sampled by an open-air concrete lined ditch. RB
WOA-FI1-06-D	29.83261	-95.45316	310	410	-100	N	Decent flow. Effluent odor. LB
WOA-FI1-07-D	29.83551	-95.45370	2,430	300	2,130	Y-H	Water is brownish in color. LB
WOA-FI1-08	29.83746	-95.45541	2,430	NA	NA	IF	Ambient sample taken from tributary upstream of confluence with AU. Bat droppings observed on banks upstream of sample area.
WOA-FI1-09-D	29.83790	-95.45591	410	200	210	Y-L	Right Bank by pipe inaccessible. Collected sample at estimated mixing zone. Water depth in pipe estimated.
WOA-FI1-10-D	29.83837	-95.45646	310	100	210	N	Pipe on inaccessible bank (RB). Pipe measurements estimated. Bat colony living under bridge and bat droppings observed on banks.
WOA-FI1-11-D	29.83853	-95.45673	200	310	-110	N	Large amount of bat droppings on banks. Decent flow from pipe. Pipe is on an inaccessible bank (RB). Pipe measurements estimated.
WOA-FI1-12-D	29.84030	-95.45853	100	410	-310	N	Large amounts of algae directly in front of pipe on LB to water's edge.
WOA-FI1-13-D	29.84199	-95.45860	520	200	320	Y-H	Flow just a trickle and moves through lots of algae. LB

Sample ID	Lat	Long	DS or Direct *E. coli* Sample Results (MPN/100 mL)	US *E. coli* Sample Results (MPN/100 mL)	Difference* DS - US (MPN/100 mL)	Referral	Comments
WOA-FI1-14-D	29.84477	-95.46004	860	630	230	N	At the confluence with Cole Creek (RB). Flowing quickly. Wastewater treatment plant discharge visible into Cole Creek.
WOA-FI1-NS-1	29.83194	-95.45317	NA	NA	NA	N	Not sampled. Cracked left bank. Suspect sheen on water pooled in crack.
WOA-T1-FI1-01	29.83836	-95.45287	100	NA	NA	N	First sample of the tributary of White Oak Bayou above tidal. Ambient sample taken due to lack of samples take beforehand. Gray-black layer on right bank substrate.
WOA-T1-FI1-02-D	29.83838	-95.45197	100	100	0	N	Unable to tell if water is flowing from pipe on RB because of minimal flow and pipe partially submerged.
WOA-T1-FI1-03-D	29.83843	-95.44956	410	< 100	310	Y-L	Water color slightly brown. Bottom of pipe rusted out. RB
WOA-T1-FI1-04-D	29.83844	-95.44731	< 100	< 100	0	N	RB
WOA-T1-FI1-05-D	29.83838	-95.44637	520	< 100	420	IF	Sampled small trib of main tributary. LB
WOA-T1-FI1-06-D	29.83868	-95.44640	100	< 100	0	N	Trickling pipe on LB.
WOA-T1-FI1-07-D	29.84090	-95.44637	< 100	< 100	0	N	2 pipes (1 on each bank and are almost directly across from each other). This sample was from pipe on LB.
WOA-T1-FI1-08-D	29.84091	-95.44643	100	< 100	0	N	Same upstream of WOA-T1-FI1-07-U. 2 pipes on each bank. This sample was from pipe on RB.
WOA-T1-FI1-09-P	29.84096	-95.44632	100	NA	NA	N	Leaking pipe on LB over tributary. The valves above pipe are highly corroded and leaking.
WOA-T1-FI1-10	29.84350	-95.44634	< 100	NA	NA	N	Ambient sample of stem that runs into tributary of WOA. This stem is providing water into tributary while the main tributary is disconnected to the upstream portion by ~8m. Stopped sampling.
WOA-T1-FI1-NS-1	29.83839	-95.45017	NA	NA	NA	N	Not sampled. Plastic pipe on RB just barely dripping.
WOA-T1-FI1-NS-2	29.83832	-95.45391	NA	NA	NA	N	Not sampled. 29.83832, -95.45391 to 29.83835, -95.45204: small fish kill of catfish and sunfish, continued to be scattered while walking upstream. Bass also seen. Once first bridge was reached, no more dead fish were seen. Lots of crawfish claws on substrate.

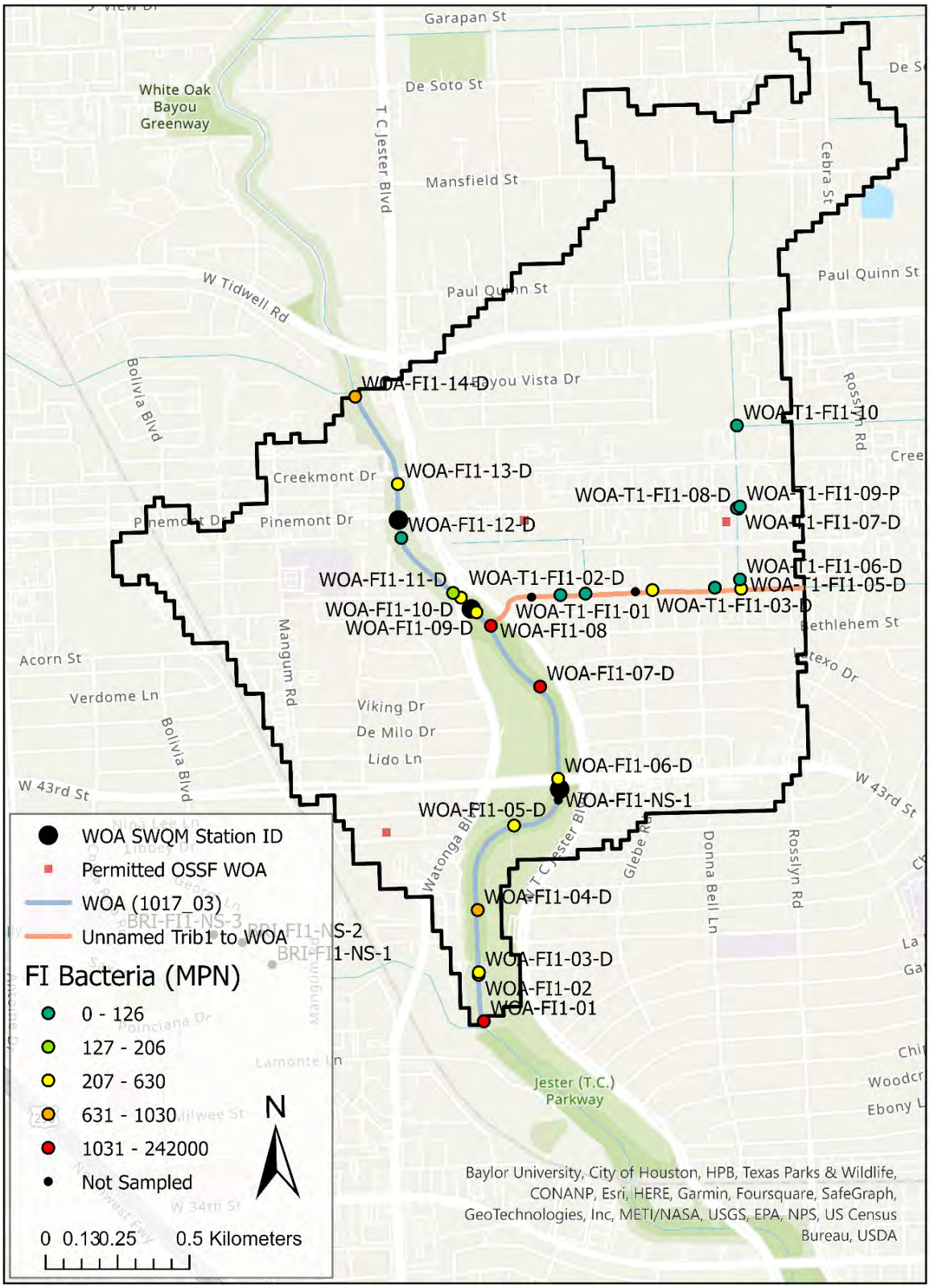


Figure 3: Field investigation bacteria sampling results from 4/3/2023 on White Oak Bayou Above Tidal (Assessment Unit 1017_03).

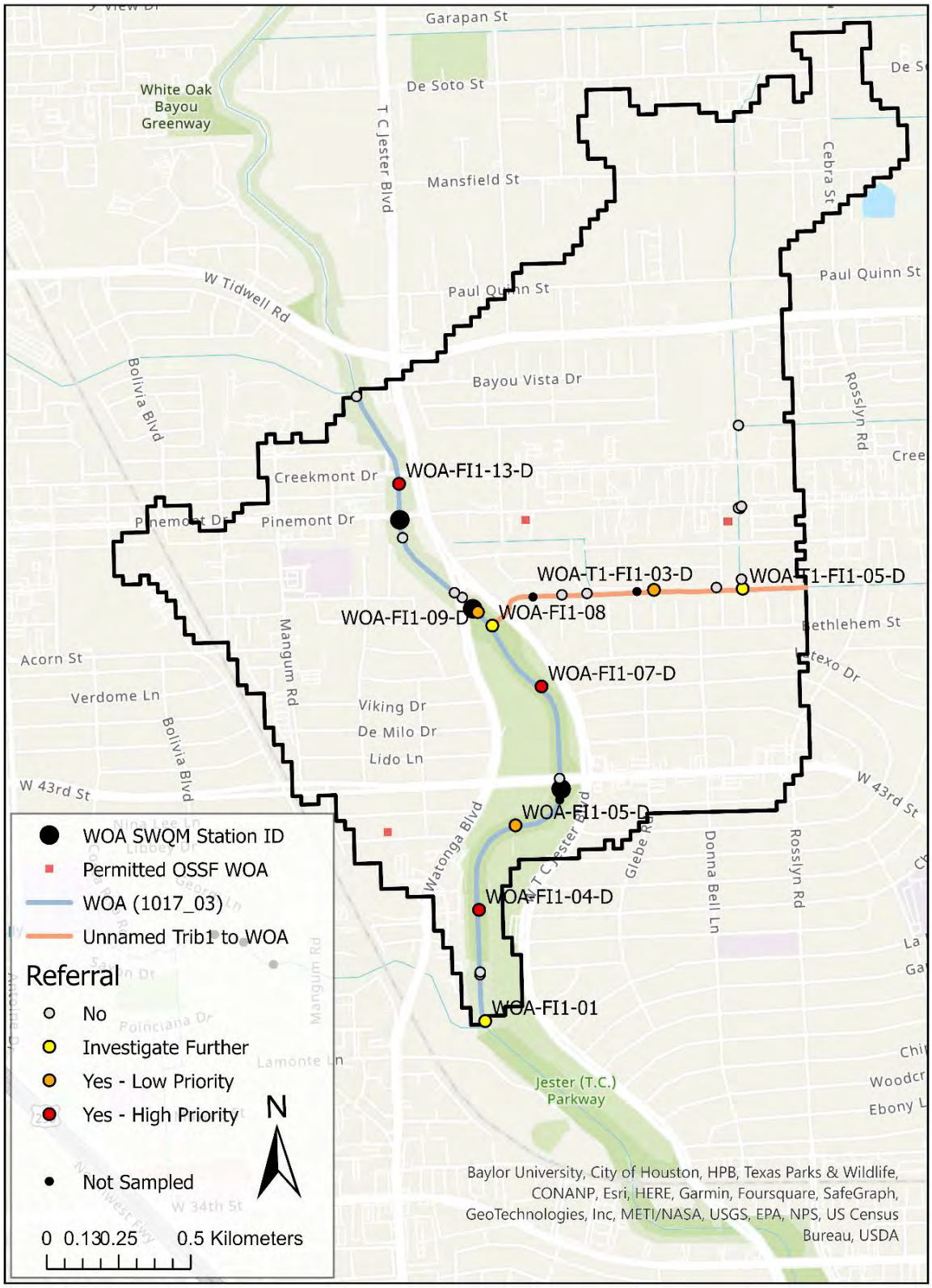


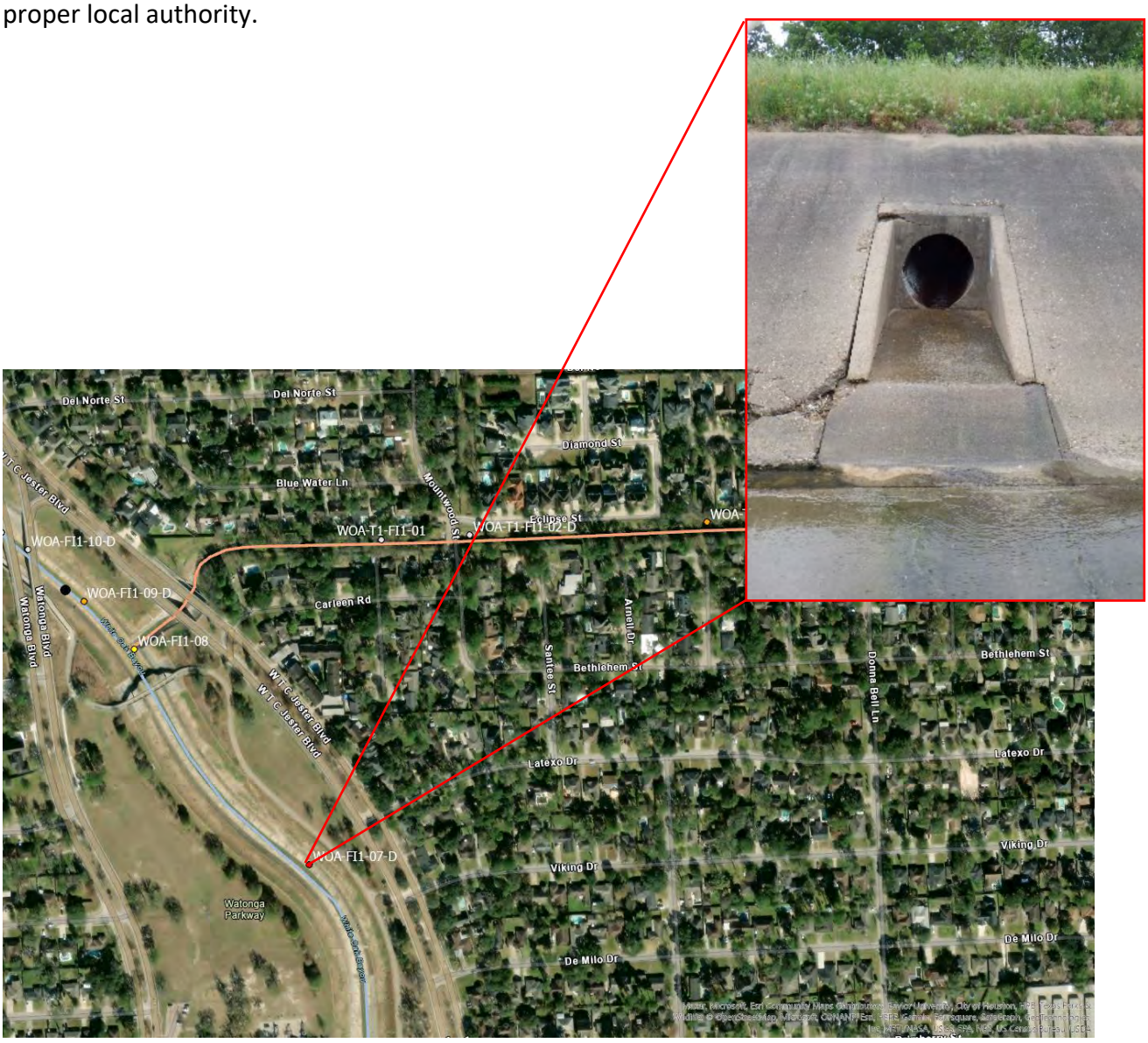
Figure 4: Field investigation sites sampled on 4/3/23 and identified for referral to the proper authorities on White Oak Bayou Above Tidal (Assessment Unit 1017_03).

Referral site: WOA-FI1-04-D – High Priority

This is a 52 in. diameter metal pipe located on the left bank of White Oak Bayou Above Tidal. Water within the pipe was 0.25 in. deep and discharged onto a concrete lining before entering the AU. There is a walking trail that runs parallel with the bayou located on the left bank of this sampling location. Many joggers with dogs were observed utilizing this trail as the field crew was sampling. There is also a park with a public pool located on the left bank of this site, as well as many residential homes located in the adjacent area on the left bank. The area on the right bank is predominantly residential, with many apartment complexes and several schools. A sample taken 5.0 m downstream of the pipe had a bacteria value of 750 MPN/100 mL. The ambient sample collected upstream of the pipe had a bacteria value of 100 MPN/100 mL. This pipe is a high priority referral site for the proper local authority.

Referral site: WOA-FI1-07-D – High Priority

This is a 32 in. diameter metal pipe located on the left bank of White Oak Bayou Above Tidal. Water within the pipe was 0.6 in. deep and lightly flowing onto the concrete lining and bank before entering the segment. The water coming out of the pipe was noted to be brownish in color. There is a walking trail running parallel to the bayou on the left bank. The area on the left bank is predominately a single-family residential area. A sample taken 4.0 m downstream of the pipe had a bacteria value of 2,430 MPN/100 mL. The ambient sample collected upstream of the pipe had a bacteria value of 300 MPN/100 mL. This pipe is a high priority referral site for the proper local authority.



Referral site: WOA-FI1-13-D – High Priority

This is a 66 in. diameter metal pipe located on the left bank of White Oak Bayou Above Tidal. Water within the pipe was 1.0 in. deep and trickling through a large amount of algae before entering the AU. There is a walking trail that runs along the bayou. There are mostly small commercial and industrial properties located near this site. There is also a small lot with a port-o-potty where food trucks frequent on the left bank. A sample taken 15 m downstream of the pipe had a bacteria value of 520 MPN/100 mL. The ambient sample collected upstream of the pipe had a bacteria value of 200 MPN/100 mL. This pipe is a high priority referral site for the proper local authority.

Referral site: WOA-FI1-05-D – Low Priority

This is a concrete-lined, open-air ditch that flows into White Oak Bayou Above Tidal from the right bank. Water within the ditch was flowing onto the concrete-lined right bank before flowing into the AU. The ditch is located between a small dense wooded area and the main AU. A sample collected from the ditch had a bacteria value of 310 MPN/100 mL. The ambient sample collected upstream of the ditch had a bacteria value of 200 MPN/100 mL. This ditch is a low priority referral site for the proper local authority.

Referral site: WOA-FI1-09-D – Low Priority

This is a 60 in. diameter concrete pipe located on the right bank of White Oak Bayou Above Tidal. Water within the pipe was estimated to be 0.25 in. deep and was slowly flowing down cracks in the concrete-lined bank before entering the segment. There are a small number of commercial buildings located in the area on the right bank, but the area is mostly single-residence homes. There is a walking trail along the right bank at this site. The right bank was inaccessible to the field crew at this location so the sample was collected within the estimated mixing zone 20 m downstream of the pipe and had a bacteria value of 410 MPN/100 mL. The ambient sample collected upstream of the pipe had a bacteria value of 200 MPN/100 mL. This pipe is a low priority referral site for the proper local authority.

Referral site: WOA-T1-FI1-03-D – Low Priority

This is a 32 in. diameter metal pipe located on the right bank of Tributary 1 of White Oak Bayou Above Tidal. Water within the pipe was 0.25 in. deep and trickling into the AU. The bottom of the pipe was rusted out and the water color was noted to be slightly brown. The area surrounding the site on both banks includes single-family residences with some small industrial properties located on the other side of the residential neighborhood on the right bank. A sample 0.3 m downstream of the pipe had a bacteria value of 410 MPN/100 mL. The ambient sample collected upstream of the pipe had a bacteria value of < 100 MPN/100 mL. This pipe is a low priority referral site for the proper local authority.

Referral site: WOA-FI1-01 – Investigate Further

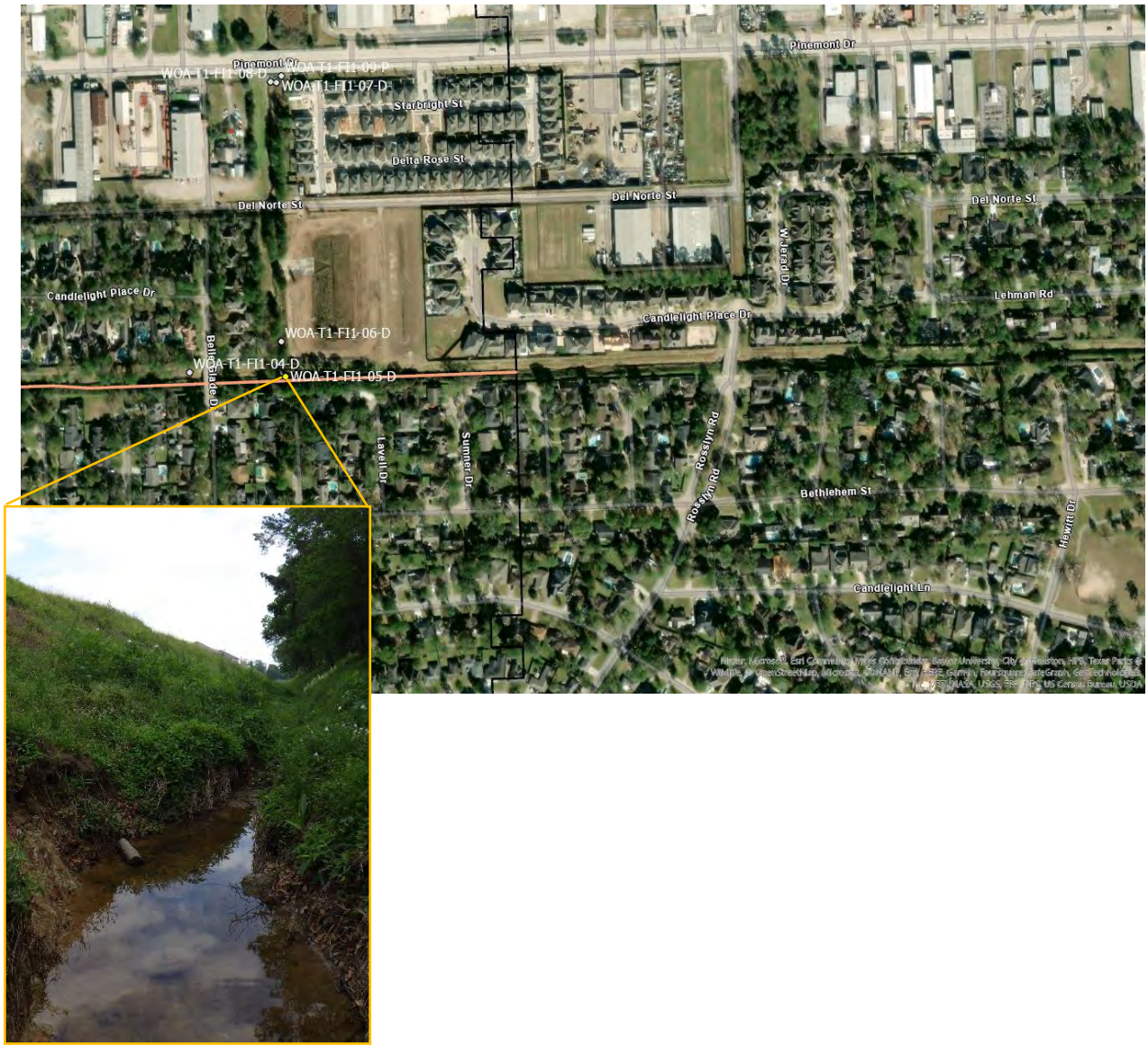
This was an ambient sample taken at the most downstream portion of White Oak Bayou Above Tidal before the confluence with Brickhouse Gully. The ambient sample was taken just upstream of the mixing zone with Brickhouse Gully and had a bacteria value of 1,610 MPN/100 mL. The next sample taken upstream at WOA-FI1-02 had a bacteria value of 200 MPN/100 mL. There were no potential point sources observed between these two samples. Further investigation is recommended by the proper local authority to determine the source of elevated bacteria upstream of the segment. There are apartments and single-family homes located upstream of the site, as well as a small dog park on the left bank.

Referral site: WOA-FI1-08 – Investigate Further

This was an ambient sample taken at the most downstream portion of Tributary 1 of White Oak Bayou Above Tidal before it flows into the main AU. The ambient sample was taken just downstream of the bridge of TC Jester Blvd. that runs over the tributary and had a bacteria value of 2,430 MPN/100 mL. There was a sample collected approximately 286 m upstream of this sample which was 100 MPN/100 mL, but there were no pipes that were observed to be flowing into the tributary in between these samples at the time of sampling. The TC Jester Blvd. bridge did have a colony of bats living under it and there was a large amount of bat droppings on both banks. Further investigation is recommended by the proper local authority to determine the source of elevated bacteria underground and upstream of the segment.

Referral site: WOA-T1-FI1-05-D – Investigate Further

This was an ambient sample taken at the most downstream portion of a small stem of Tributary 1 of White Oak Bayou Above Tidal. The ambient sample collected from the smaller branch of the tributary had a bacteria value of 520 MPN/100 mL and an ambient sample collected on the main stem of Tributary 1 upstream of this confluence was < 100 MPN/100 mL. Further investigation is recommended by the proper local authority to determine the source of elevated bacteria in this section of the tributary. There are single-family homes located upstream of the site on both banks.



List of Acronyms and Abbreviations

AU	Assessment Unit
BIG	Bacteria Implementation Group
CRP	Clean Rivers Program
DS	Downstream
E. coli	*Escherichia coli*
FI	Field Investigation
FY	Fiscal Year
GIS	Geographic Information Systems
H-GAC	Houston-Galveston Area Council
IF	Investigate Further
in.	inch
I-Plan	Implementation Plan
km	kilometer
LB	Left Bank
m	meter
mL	milliliter
MPN	Most probable number
N	No
NELAP	National Environmental Laboratory Accreditation Program
NLCD	National Land Cover Database
OSSF	On-Site Sewage Facilities
QAPP	Quality Assurance Project Plan
RB	Right Bank
SWQM	Surface Water Quality Monitoring
SWRC	Stroud Water Research Center
T or trib.	Tributary
TCEQ	Texas Commission on Environmental Quality
TMDL	Total Maximum Daily Load
US	Upstream
WOA	White Oak Above Tidal 1017_03
WS	Windshield Survey
Y-H	Yes – High Priority
Y-L	Yes-Low Priority

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Targeted Bacteria Monitoring Project
Field Investigation Final Report
Assessment Unit 1017A_01 Brickhouse Gully

Environmental Institute of Houston

August 1, 2023

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Segment Description

Segment 1017A is a freshwater perennial stream referred to as Brickhouse Gully (Figure 1). This segment is 10.33 km long and consists of one assessment unit (AU) of concern, AU 1017A_01, which is defined as spanning from the confluence with White Oak Bayou up to Gessner Road in Harris County. There is one current surface water quality monitoring (SWQM) station located on this AU (station ID: 16594) and five historic stations associated with this AU. This AU has been selected for targeted monitoring due to a bacteria (*Escherichia coli*) seven-year geometric mean of 1,405.4 MPN/100 mL (H-GAC QAPP, 2022). The AU was listed for exceedances of bacteria in the water (Recreation use) and has a current impairment category of 4a (TCEQ, 2022). The potential sources of bacteria impairments and concerns that were reported in the 2022 Integrated Report are non-point source pollution, urban runoff, and sanitary sewer overflows (TCEQ, 2022).

The contributing watershed for this AU is 39 km^2 (Data source: HGAC, SWRC, 2023). The soil groups in the watershed are predominantly medium/very slow infiltration coverage and land cover is predominately developed (98.7%) (Data source: United States Department of Agriculture Hydrologic Soil Groups from gSSURGO 2016 and National Land Cover Database NLCD 2019). There is one permitted wastewater outfall in the watershed (Data source: H-GAC). There are also 49 documented permitted on-site sewage facilities (OSSF) and 16 documented parcels of OSSFs within the watershed (Data source: H-GAC).

Background

Clean Rivers Program (CRP) routine monitoring data are analyzed each year as part of the Houston-Galveston Area Council (H-GAC) Basin Summary/Basin Highlights Report process. Bacteria continues to be the most prevalent pollutant in the H-GAC CRP Basins (H-GAC, 2022). The Bacteria Implementation Group (BIG), formed in 2008, oversees the Total Maximum Daily Load (TMDL) Implementation Plan (I-Plan). The BIG requested that H-GAC produce a list of the water bodies with the highest bacteria concentrations in the BIG project area and conduct targeted monitoring to identify potential bacteria sources.

H-GAC, using information from previous Basin Highlights/Summary Reports, BIG annual reports, and previous targeted monitoring efforts, identified and selected waterways for targeted bacteria monitoring to refine our understanding of the spatial distribution of elevated bacterial concentrations contributing to these waterways. Phase 1 of this targeted monitoring project included an intensive desktop review and a windshield survey (WS) of each AU catchment area, and sampling of the AU from primary road crossings. Phase 2 of this targeted monitoring project included a field investigation (FI) of the entire AU conducted during dry conditions where all flowing point and non-point sources were evaluated.

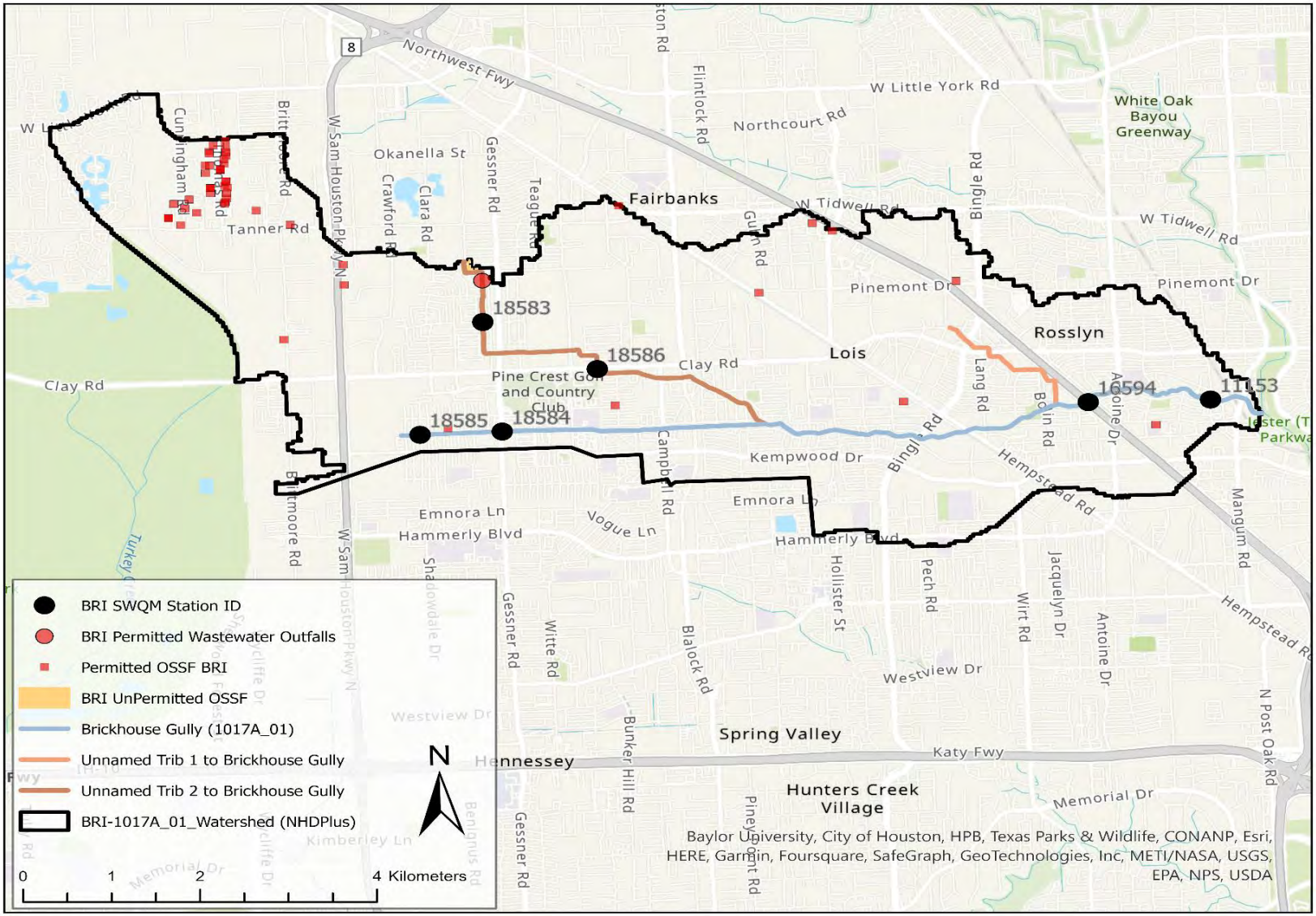


Figure 1: Watershed Map for AU 1017A_01.

Desktop Review

Methods

The intensive desktop review included an evaluation of permitted discharges, outfalls, and potential sources of point source and nonpoint source pollution that may contribute to bacteria loading in the AU. Using Google Earth imagery and GIS, the locations of wastewater treatment facilities, permitted OSSFs, and potential locations of unpermitted OSSFs were identified. Other potential sources such as landfills and industrial facilities were also identified. Parks were noted as these can contribute to bacterial sources through runoff of animal wastes but also provide opportunity for contact recreation. Bridge crossings and other entry points were identified in order to provide access into the stream to collect bacteriological samples.

Results

The results of the desktop review indicated that the watershed lies predominantly within a dense suburban area with some businesses and manufacturing facilities scattered throughout. The results of the review also indicated that there were several permitted and unpermitted OSSFs as well as one permitted wastewater outfall on an upstream portion of a tributary to Brickhouse Gully. Where that permitted wastewater outfall is located is also where the bulk of the unpermitted OSSFs lie, as a result, this tributary was prioritized during the WS, time permitting. The following potential sources were identified:

- a stretch of the AU, approximately 0.75 mi long, that is bordered by many public parks and schoolgrounds situated between Antoine Dr. and Mangum Rd. (Figure 2)
- a city water facility on Kempwood Dr. that is approximately 150 meters from the stream and was not listed under any of the permitted or unpermitted outfalls provided by H-GAC (Figure 3)

Publicly accessible entry points into the stream were identified at stream crossings at Watonga Blvd., Mangum Rd., Antoine Dr., Bolin Rd., Lang Rd., Bingle Rd., Hollister Rd., Peppermill Rd., Campbell Rd., Rosefield Dr., Gessner Rd., and Quincannon Ln. There were also two tributaries of the AU identified during desktop review. Tributary 1 has access to the downstream portion located at the eastern dead end of Underhill St. Tributary 2 has access to the downstream portion closest to the confluence with Brickhouse Gully at Colleen Rd.

Figure 2: Stretch of the AU bordered by many parks and schoolgrounds. Identified during desktop review as a possible source.

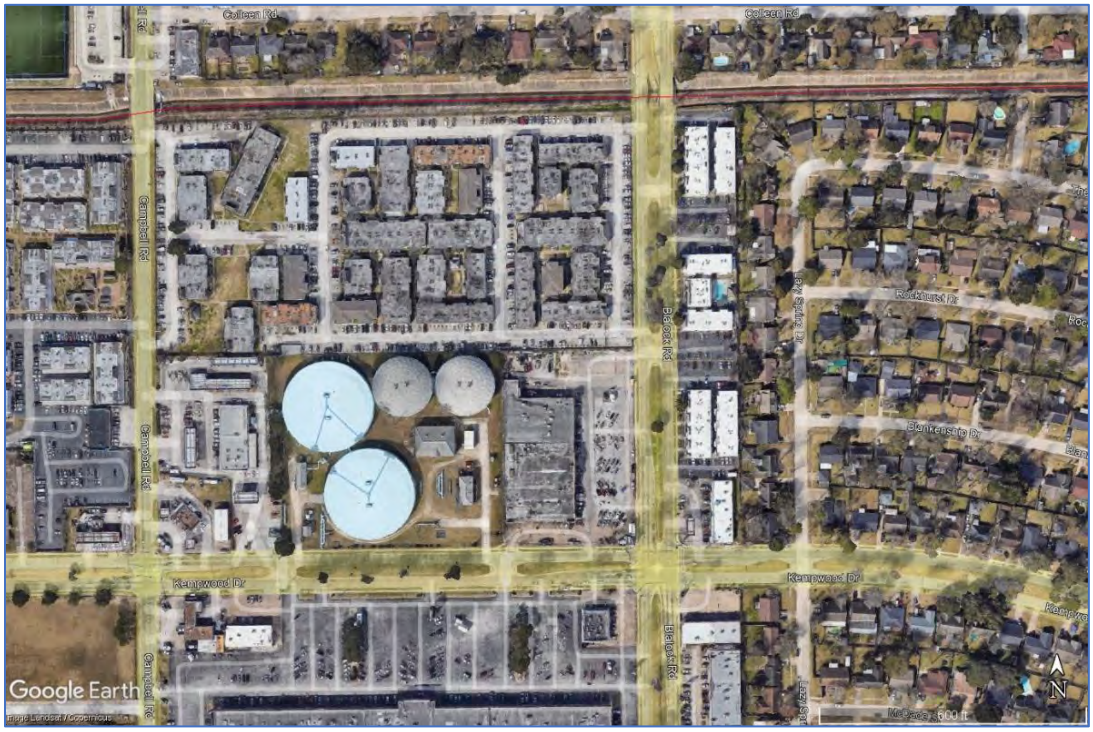


Figure 3: A city water facility near the AU that was not listed under the permitted/unpermitted outfalls provided by H-GAC. Identified during desktop review as a possible source.

Windshield Survey

Methods

Field events must take place during dry weather (after three or more days without significant rainfall in the watershed). This ensures that any flowing water into the AU is not stormwater. Windshield surveys of the watershed were conducted and bacteria sampling was performed at public access points throughout the AU (primarily at bridge crossings). The survey consisted of driving the catchment area to confirm identified pollution sources found during the desktop review and to find any potential sources not identified during that review. Bridge crossings chosen for sampling were spatially distributed to provide a spatial snapshot of bacteria concentrations in the AU and identify sections of the AU where elevated bacteria concentrations were found. Those areas with elevated bacteria levels identified in the WS monitoring were focused on during the FI.

Assessment Units, sample collection and laboratory methods, and data handling practices are detailed in Appendix J of the FY 2022-2023 H-GAC Multi-Basin Clean Rivers Program Quality Assurance Project Plan (H-GAC QAPP, 2022). For all WSs, bacteria monitoring field personnel documented the latitude and longitude of sample location. All bacteria samples were analyzed by a National Environmental Laboratory Accreditation Program (NELAP)-Accredited laboratory.

Results and Recommendations

The WS was conducted on March 9, 2023. At that time, it had been six days since the last significant rainfall in the watershed. A total of 13 samples were collected on AU 1017A_01 and two on contributing tributaries during the WS (Table 1 and Figure 4).

Based upon the results of the WS, FIs covering the length of the AU from its confluence with White Oak Above Tidal to Peppermill Rd. and of the entire unnamed Tributary 1 (confluence with Brickhouse Gully lies between Bolin Rd. and US 290) was recommended. If time and supplies permit, a FI of the entire length of the AU was recommended, but the WS results show the portion upstream of Peppermill Rd. to be of least concern. Based on the results of the WS, we expected to identify potential non-point or point sources of elevated bacteria near the following portions of the AU:

1) BRI-WS-02, which was collected upstream of the bridge at Mangum Rd. This sample had an elevated bacteria result compared to the samples collected upstream and downstream of this area.

2) BRI-WS-06, which was collected on the downstream side of the bridge at Bingle Rd. This sample had a bacteria level that was significantly higher than the samples collected upstream and downstream of this area. The comments written at time of collection also mentioned that

there was a “sewage odor and cloudy water” which may indicate a potential source within the approximately 0.75 mi stretch of the AU from Hollister Rd (which had a bacteria level of < 100 MPN/100 mL) to the bridge at Bingle Rd.

3) T1BRI-WS-01, which was collected from the unnamed tributary 1 (confluence with Brickhouse Gully lies between Bolin Rd. and US 290). This sample had a bacteria level that was significantly higher compared to the sample collected approximately 120 meters upstream.

Table 1. Windshield survey bacteria results from sampling on 03/09/2023 on Brickhouse Gully (AU 1017A_01). Samples were taken at bridge crossings and other publicly accessible points. US = Upstream, DS = Downstream. LB = Left Bank, RB = Right Bank.

Sample ID	Latitude	Longitude	*E. coli* Sample Results (MPN/100 mL)	Comments
BRI-WS-01	29.82685	-95.45857	630	Fishy and bat guano odor; Decomposing cat DS of sample; Lots of trash in and around stream
BRI-WS-02	29.82681	-95.46241	750	Some trash along water's edge
BRI-WS-03	29.82821	-95.47291	520	Trash in stream
BRI-WS-04	29.82608	-95.48160	100	Wastewater effluent odor and cloudy water; Construction at park on LB; Concrete outfall DS of sample point
BRI-WS-05	29.82388	-95.48863	< 100	Small dead fish in water; Several large plastic and metal trash pieces stuck in right DS outfall pipe; Cloudy water; Large trash under bridge
BRI-WS-06	29.82276	-95.49625	> 242,000	Sewage odor and cloudy water; some trash in stream
BRI-WS-07	29.82394	-95.50932	< 100	Cloudy water
BRI-WS-08	29.82500	-95.51673	< 100	Cloudy water; fishy odor in ambient air; fast flow
BRI-WS-09	29.82486	-95.52614	100	Very cloudy water; fast flow; DS of small drop/waterfall; apartment dumpster next to fence on RB
BRI-WS-10	29.82496	-95.53680	< 100	Change in velocity to be much slower; water clarity is very high; shallow
BRI-WS-11	29.82500	-95.54507	< 100	Change from concrete banks to vegetated banks US of bridge; lots of trash and loose concrete slabs under bridge; relatively clear water; leaky water main above RB DS of sample
BRI-WS-12	29.82477	-95.55649	< 100	Lots of aquatic life; banks are heavily vegetated
BRI-WS-13	29.82469	-95.52958	< 100	Very cloudy water like BRI-WS-09
T1BRI-WS-01	29.82661	-95.48034	1,870	Lots of filamentous green algae on trib substrate (concrete); some trash in trib
T2BRI-WS-01	29.82537	-95.51486	410	Clear water; algae coating bottom; very shallow; vertical banks; some trash US; flap gate to large drain pipe US is closed

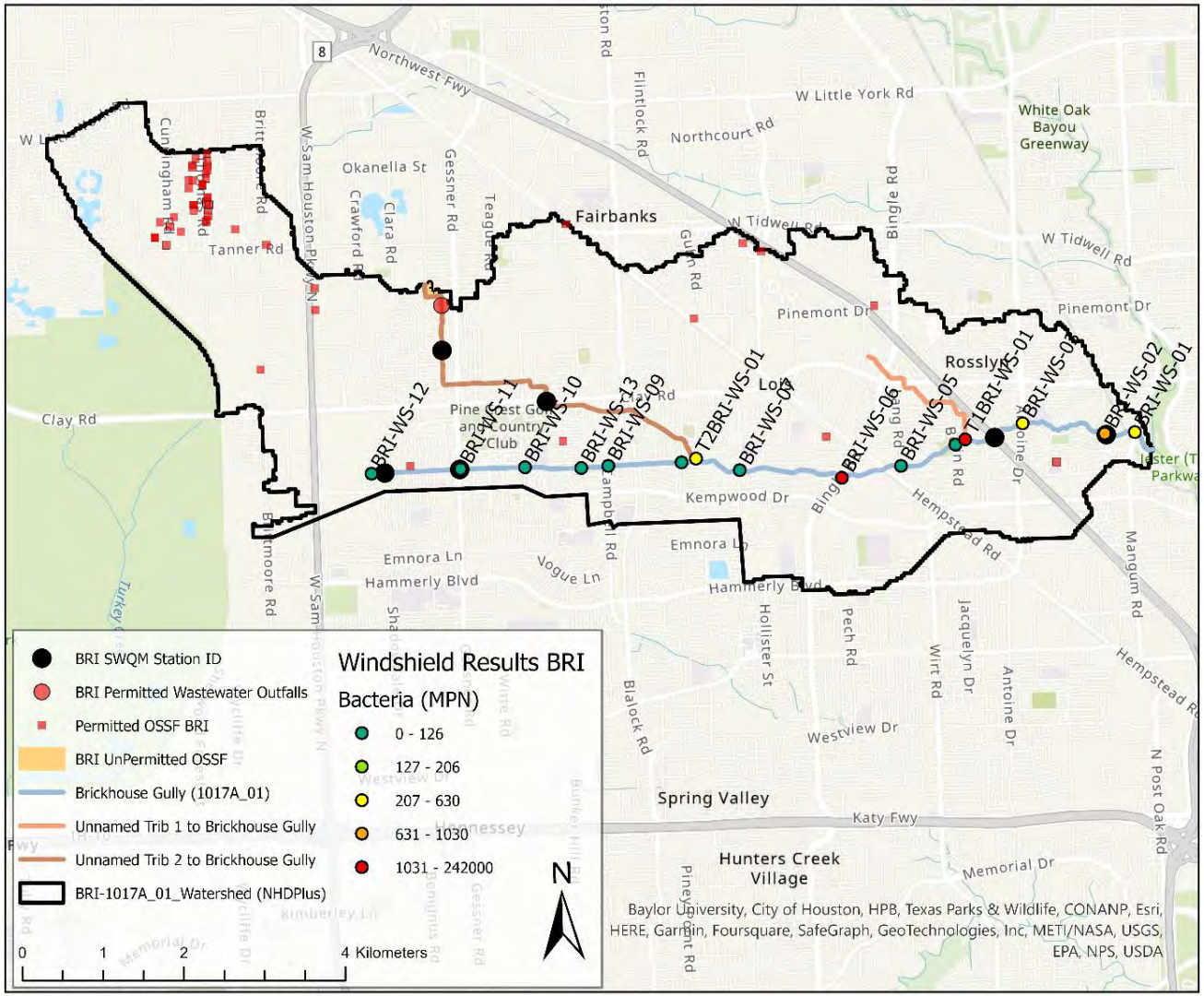


Figure 4: Windshield survey/ground truthing bacteria results from sampling on 03/09/2023 on Brickhouse Gully (AU 1017A_01). Samples were taken at bridge crossings and other easily accessible points.

Field Investigation

Methods

The FI was a thorough survey where a team of two either walked or paddled the entire assessment unit and sampled any water observed flowing into the stream. Water could be flowing in from a pipe, culvert, natural tributary, or earthen ditch. Flowing water was categorized into two source types: permitted outfalls or unpermitted outfalls. Permitted outfalls included wastewater facilities and municipal separate storm sewer systems (MS4). Any pipe greater than 12 inches (in.) in diameter was assumed to be permitted by our field crews.

When flowing water was observed from a permitted outfall, two samples were collected. One sample was collected immediately downstream of the outfall where the flowing outfall was mixing with the ambient water. The second sample was taken upstream of the flowing outfall outside of the realm of influence from the outfall to provide the ambient bacteria levels of the assessment unit in that area. The second type of source was an unpermitted outfall, which was any other flowing source of water that was judged to not be permitted in the field, including flowing small (<12 in. diameter) “homemade” pipes and tributaries.

When a flowing unpermitted outfall was observed, the bacteria sample was taken directly from the source. If the source was a flowing pipe, the sample was collected directly from the pipe, before it entered the AU. If it was an open-top earthen ditch or natural tributary, the sample was collected from far enough into the inflow source that there was no mixing with the receiving water. In some cases, when no flowing permitted or unpermitted outfalls were observed in an extended section of the AU, a single ambient reference sample was taken mid-stream. Left and right bank references are oriented with the observer facing downstream.

Assessment Units, collection and laboratory methods, and data handling practices are detailed in Appendix J of the FY 2022-2023 H-GAC Multi-Basin Clean Rivers Program Quality Assurance Project Plan (H-GAC QAPP, 2022). For all field investigations the field team recorded location of the flowing outfall (latitude and longitude), the diameter, material, and water depth of the flowing outfall, and documented site conditions by taking photos and other relevant notes. All bacteria samples were collected following procedures listed in Appendix J of the FY 2022-2023 H-GAC Multi-Basin Clean Rivers Program Quality Assurance Project Plan (H-GAC QAPP, 2022) and analyzed by a National Environmental Laboratory Accreditation Program (NELAP)-Accredited laboratory.

Results

The FI of the main AU was conducted on April 13, 2023 (eight days since last significant rainfall) and a total of 57 bacteria samples were collected. The FI of unnamed Tributary 1 of Brickhouse Gully was conducted on April 12, 2023 (seven days since last significant rainfall) and a total of 25 bacteria samples were collected. The values of the bacteria samples collected from downstream of

permitted outfalls, directly from unpermitted outfalls, or as ambient samples are summarized in Table 2 and Figure 5. Based on the data collected, eight locations with elevated *E. coli* bacteria levels measured during the field investigation are recommended for high priority, and four locations for low priority investigation by the proper authorities. High priority sites had the highest potential bacteria loading observed and are recommended to be the areas for local authorities to focus efforts on should there be insufficient resources to address all referral sites. As time and resources allow the low priority and "investigate further" referrals also are recommended for further investigation. These locations are summarized in Table 2 and Figure 6. Four locations were flagged where ambient or upstream samples had elevated bacteria levels with no obvious explanations. Further investigation of these areas by the proper authorities is recommended. Each of these referrals are summarized by site, herein. The referral summaries are listed in order of priority (High, Low, then Investigate Further). Within each priority group, sites are listed from downstream to upstream.

Table 2: Field investigation bacteria results from sampling on 4/13/2023 on Brickhouse Gully (Assessment Unit 1017A_01) and from sampling on 4/12/2023 on unnamed tributary 1 of Brickhouse Gully. Referrals (gray rows): N = No, Y-H = Yes – High Priority, Y-L = Yes-Low Priority, IF = Investigate Further, US = Upstream, DS = Downstream. LB = Left Bank, RB = Right Bank.

Sample ID	Lat	Long	DS or Direct *E. coli* Sample Results (MPN/100 mL)	US *E. coli* Sample Results (MPN/100 mL)	Difference* DS - US (MPN/100 mL)	Referral	Comments
BRI-FI1-01	29.82494	-95.45649	5,120	NA	NA	N	Ambient sample collected upstream of confluence with White Oak Bayou.
BRI-FI1-02-D	29.82678	-95.45834	> 242,000	6,370	235,630	Y-H	Pipe on LB is barely trickling.
BRI-FI1-03-P	29.82663	-95.45860	<100	NA	NA	N	Sample taken directly from leaking pipe spanning over channel.
BRI-FI1-04-D	29.82681	-95.45992	4,200	7,590	-3,390	N	Pipe on RB is barely trickling.
BRI-FI1-05-D	29.82669	-95.46206	5,830	9,600	-3,770	N	Right bank. 2 pipes across channel from each other. Same upstream sample used.
BRI-FI1-06-D	29.82668	-95.46210	4,810	9,600	-4,790	N	Left bank. 2 pipes across channel from each other. Same upstream sample used.
BRI-FI1-07-D	29.82673	-95.46230	9,090	8,200	890	Y-L	Barely trickling. Algae in pipe on RB.
BRI-FI1-08-D	29.82697	-95.46279	> 242,000	6,700	235,300	Y-H	Barely trickling pipe on RB.
BRI-FI1-09-D	29.82829	-95.47176	410	27,200	-26,790	N	Pipe on LB.
BRI-FI1-10-P	29.82827	-95.47285	<100	29,100	-29,000	N	Concrete collapsing near opening of pipe on LB.
BRI-FI1-11-D	29.82703	-95.47639	> 242,000	51,700	190,300	Y-H	White cloudiness coming from outfall. Rotting sewage smell. Two pipes across from each other - this pipe is on the right bank.
BRI-FI1-12-D	29.82704	-95.47645	14,700	19,200	-4,500	N	Two pipes across from each other - this pipe is on the left bank.
BRI-FI1-13-D	29.82640	-95.47761	9,870	14,000	-4,130	N	Flap to pipe closed but leaking on LB. Flap gate specifies 48in. Unable to access.
BRI-FI1-14	29.82658	-95.48029	32,600	NA	NA	N	Sample taken directly from tributary.
BRI-FI1-15-D	29.82618	-95.48133	200	9,590	-9,390	N	Pipe on RB.
BRI-FI1-16-D	29.82384	-95.48674	6,630	16,200	-9,570	N	Abundance of algae in pipe on RB.
BRI-FI1-17-D	29.82378	-95.49061	1,480	98,000	-96,520	N	A lot of sand and sediment in outfall on LB.

Sample ID	Lat	Long	DS or Direct *E. coli* Sample Results (MPN/100 mL)	US *E. coli* Sample Results (MPN/100 mL)	Difference* DS - US (MPN/100 mL)	Referral	Comments
BRI-FI1-18-P	29.82358	-95.49079	300	NA	NA	Y-L	Sediment in front of opening. Pipe on RB flowing heavily.
BRI-FI1-19-D	29.82349	-95.49173	19,000	173,000	-154,000	N	Dead opossum ~10m downstream. Pipe on LB.
BRI-FI1-20-D	29.82320	-95.49299	105,000	> 242,000	-137,000	N	Pipe on RB.
BRI-FI1-21-D	29.82307	-95.49345	51,700	> 242,000	-190,300	N	Pipe on LB.
BRI-FI1-22-P	29.82289	-95.49406	520	NA	NA	IF	Ambient sample of tributary.
BRI-FI1-23-D	29.82281	-95.49643	51,700	57,900	-6,200	N	Left bank. Another pipe is across the stream.
BRI-FI1-24-D	29.82281	-95.49647	> 242,000	54,800	187,200	Y-H	Water is cloudy and smells of sewage. Right bank. Unusual white-ish algae is not observed US of this pipe.
BRI-FI1-25-D	29.82357	-95.50217	4,960	22,500	-17,540	N	Right bank
BRI-FI1-26-D	29.82356	-95.50227	8,160	22,800	-14,640	N	Left bank
BRI-FI1-27-D	29.82414	-95.50630	100	410	-310	N	Right bank
BRI-FI1-28-D	29.82417	-95.50632	242,000	200	241,800	Y-H	Left bank
BRI-FI1-29-D	29.82388	-95.50909	1,990	200	1,790	Y-H	Right bank
BRI-FI1-30-D	29.82396	-95.50934	310	630	-320	N	Flap gate closed but leaking out on LB. Bottom of flap gate submerged. Unable to tell water depth inside.
BRI-FI1-31	29.82511	-95.51448	200	NA	NA	N	Ambient sample collected from main stem of AU.
BRI-FI1-32	29.82513	-95.51448	2,530	NA	NA	IF	Ambient sample collected US of confluence with main AU.
BRI-FI1-NS-1	29.82705	-95.46364	NA	NA	NA	NA	Not sampled. Outfall area of pipe wet but not flowing on LB; debris built up around mouth.
BRI-FI1-NS-2	29.82778	-95.46469	NA	NA	NA	NA	Not sampled. Pipe dripping, algae built up around mouth on RB.
BRI-FI1-NS-3	29.82805	-95.46572	NA	NA	NA	NA	Not sampled. Pipe wet, signs of recent flow, not flowing currently.
BRI-FI1-NS-4	29.82509	-95.51471	NA	NA	NA	NA	Not sampled. Flowing weep hole.
BRI-T1-FI1-01	29.82659	-95.48029	100	NA	NA	N	Ambient sample taken just before confluence with Brickhouse Gully.
BRI-T1-FI1-02-D	29.82945	-95.48048	3,450	300	3,150	Y-H	Rusted out pipe up on RB, likely draining to weep hole.

Sample ID	Lat	Long	DS or Direct *E. coli* Sample Results (MPN/100 mL)	US *E. coli* Sample Results (MPN/100 mL)	Difference* DS - US (MPN/100 mL)	Referral	Comments
BRI-T1-FI1-03-D	29.83073	-95.48170	310	310	0	N	Concrete culvert trickling into ditch on LB.
BRI-T1-FI1-04-D	29.83098	-95.48531	100	100	0	N	Pipe on RB.
BRI-T1-FI1-05-D	29.83138	-95.48562	2,990	310	2,680	Y-H	Strong fermented odor. Water discharging is cloudy and brown. Pipe on LB.
BRI-T1-FI1-06-D	29.83455	-95.49071	< 100	310	-210	N	Pipe on LB.
BRI-T1-FI1-07-D	29.83564	-95.49167	200	300	-100	N	Underground submerged metal pipe on RB. Has created a washed-out pool.
BRI-T1-FI1-08-D	29.83659	-95.49268	100	740	-640	N	Observed a small pool of turbid water not near any flowing pipes. Stopped to investigate and saw bubbles come up from center. Took a sample within pool (D) and a sample US of pool (U). Ongoing construction just US on road.
BRI-T1-FI1-09-D	29.83776	-95.49414	< 100	100	0	N	Outfall on LB from reservoir near gated business park.
BRI-T1-FI1-10-D	29.83770	-95.49577	410	100	310	Y-L	Two identical pipes right next to each other on RB. Both are only dripping. Unable to get a sample from each, so sample was collected from the pool the pipes were dripping into.
BRI-T1-FI1-11-D	29.83897	-95.49650	410	100	310	Y-L	Pipe on RB.
BRI-T1-FI1-12-D	29.84124	-95.49653	200	410	-210	N	Dead fish observed at mouth of culvert on RB.
BRI-T1-FI1-13	29.84402	-95.50144	> 242,000	NA	NA	IF	Ambient sample taken on upstream side of bridge.
BRI-T1-FI1-14	29.84599	-95.50655	< 100	NA	NA	IF	Ambient sample taken on upstream side of bridge at Hollister Road.
BRI-T1-FI1-NS-1	29.83094	-95.48211	NA	NA	NA	NA	Not sampled. Small trickle coming out of concrete pipe on LB. Too shallow to sample.

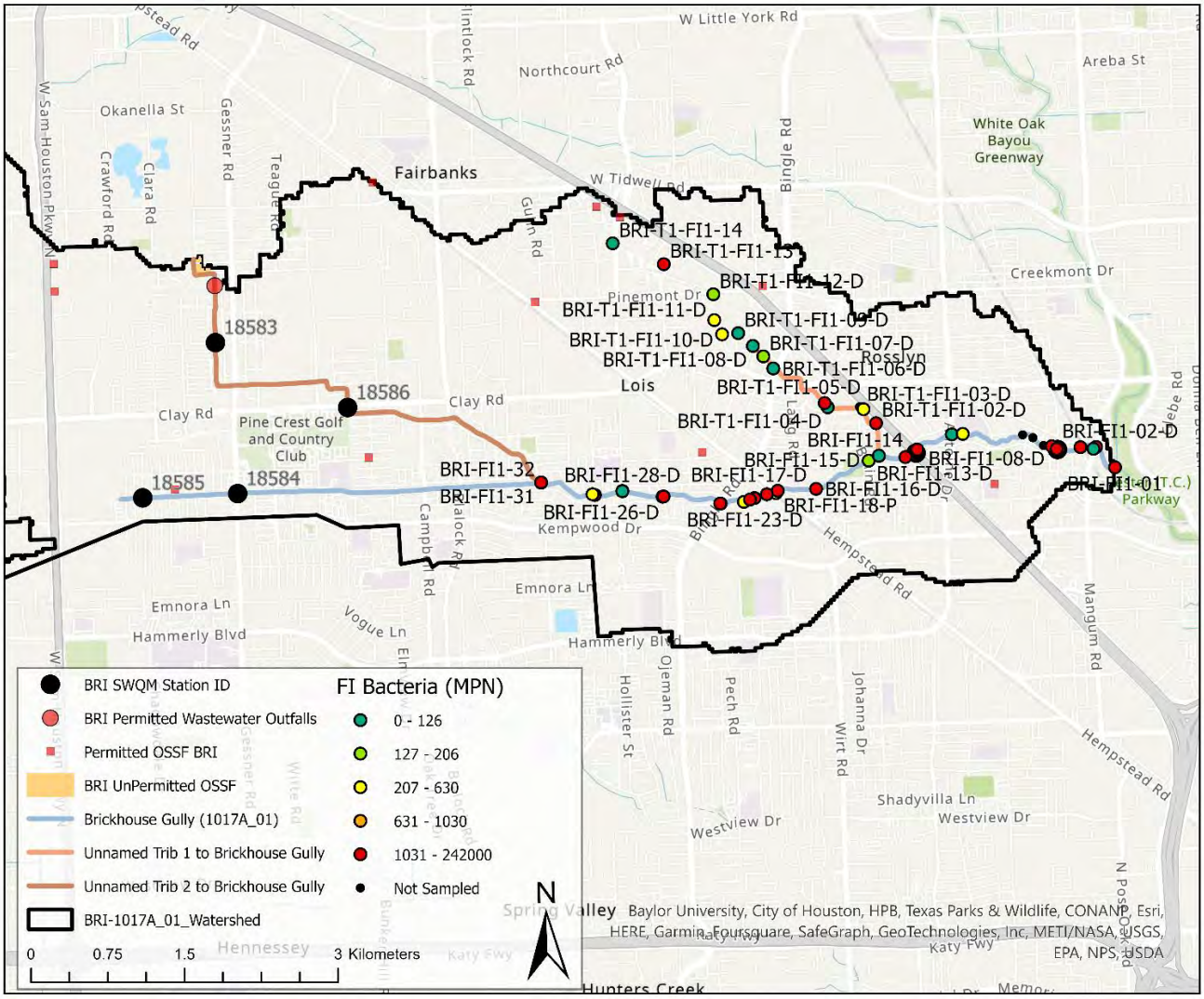


Figure 5: Field investigation bacteria sampling results from 04/12/2023 on unnamed tributary 1 of Brickhouse Gully and from 4/13/2023 on Brickhouse Gully (Assessment Unit 1017A_01).

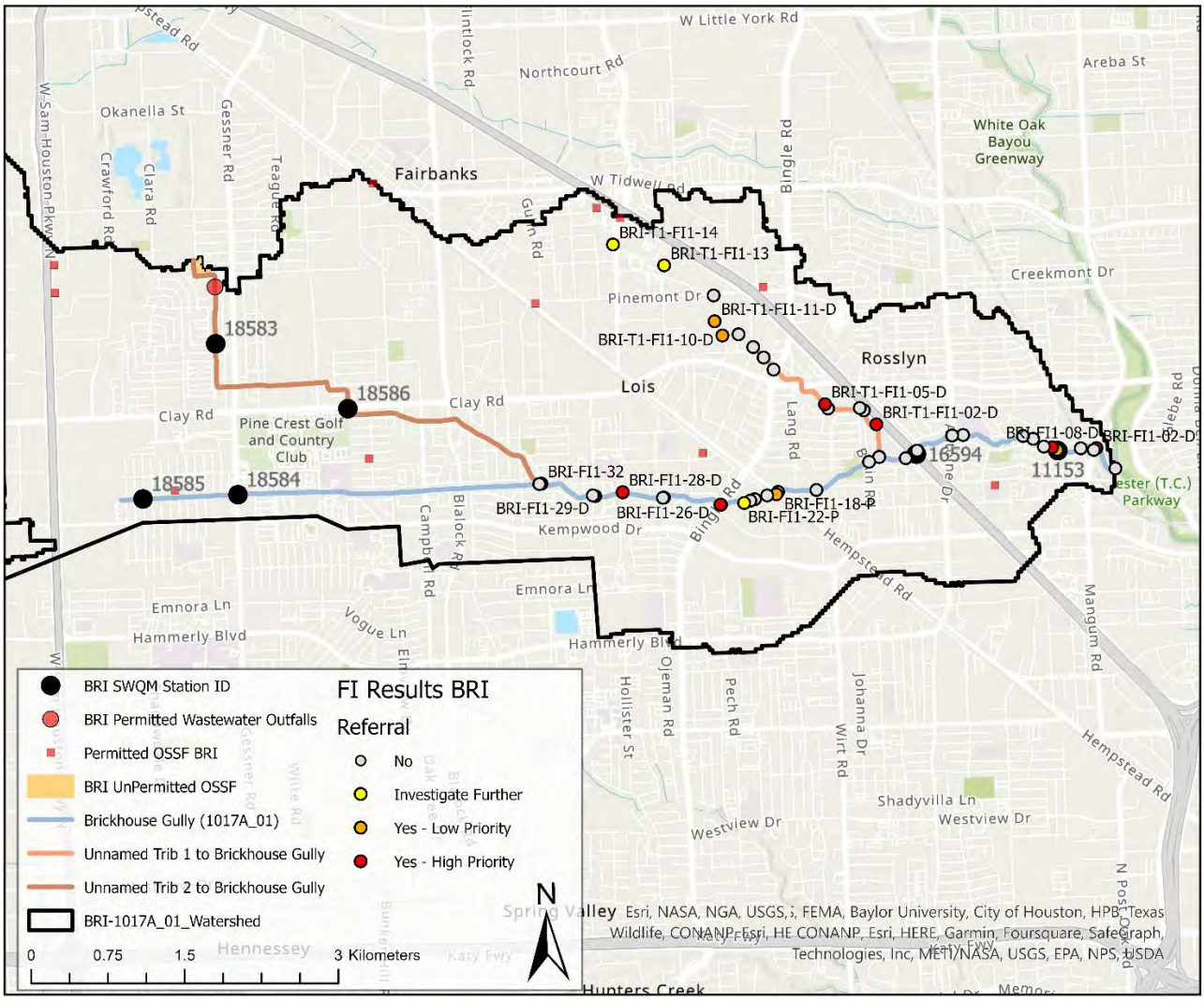


Figure 6: Field investigation sites sampled on 4/12/2023 and 4/13/2023 and identified for referral to the proper authorities on the unnamed tributary 1 of Brickhouse Gully and Brickhouse Gully (Assessment Unit 1017A_01), respectively.

Referral site: BRI-FI1-02-D – High Priority

This is a 36 in. diameter metal pipe located on the left bank of Brickhouse Gully. Water within the pipe was 0.13 in. deep and was barely trickling into the AU. It flowed down the concrete bank where there was a thin layer of algae growing before it entered the channel. There are multiple apartment complexes and a primary school located in the area on the left bank. A sample taken 4 m downstream of the pipe had a bacteria value of > 242,000 MPN/100 mL. The ambient sample collected upstream of the pipe had a bacteria value of 6,370 MPN/100 mL. This pipe is a high priority referral site for the proper local authority.

Referral site: BRI-FI1-08-D – High Priority

This is a 31 in. diameter concrete pipe located on the right bank of Brickhouse Gully. Water within the pipe was 0.06 in. deep and barely trickling into the segment. The bottom of the pipe had a thin layer of algae down to the water's edge and there was a white film on the surface of the water coming out of the pipe. There are apartments and single-family residences located in the area on the right bank, as well as a self-service car wash. A sample taken 0.4 m downstream of the pipe had a bacteria value of > 242,000 MPN/100 mL. The ambient sample collected upstream of the pipe had a bacteria value of 6,700 MPN/100 mL. This pipe is a high priority referral site for the proper local authority.

Referral site: BRI-FI1-11-D – High Priority

This is a 102 in. diameter concrete pipe located on the right bank of Brickhouse Gully. Water within the pipe was 5 in. deep and flowing steadily into the segment. There was a strong smell of sewage in the ambient air. This pipe is located under the bridge of U.S. 290. There are single-family residences located in the area on the right bank. A sample taken 2 m downstream of the pipe had a bacteria value of > 242,000 MPN/100 mL. The ambient sample collected upstream of the pipe had a bacteria value of 51,7000 MPN/100 mL. This pipe is a high priority referral site for the proper local authority.

Referral site: BRI-FI1-24-D – High Priority

This is a 56 in. diameter metal pipe located on the right bank of Brickhouse Gully. Water within the pipe was 2 in. deep and was flowing into the segment. The water was cloudy and there was a smell of effluent in the ambient air. There are single-family homes and commercial buildings in the area. A sample taken 0.6 m downstream of the pipe had a bacteria value of > 242,000 MPN/100 mL. The ambient sample collected upstream of the pipe had a bacteria value of 54,800 MPN/100 mL. This pipe is a high priority referral site for the proper local authority.

Referral site: BRI-FI1-28-D – High Priority

This is a 75 in. diameter concrete pipe located on the left bank of Brickhouse Gully. Water within the pipe was 0.5 in. deep and was flowing into the segment. There are apartments, single-family homes, commercial buildings and an elementary school in the area. A sample taken 15 m downstream of the pipe had a bacteria value of 242,000 MPN/100 mL. The ambient sample collected upstream of the pipe had a bacteria value of 200 MPN/100 mL. This pipe is a high priority referral site for the proper local authority.

Referral site: BRI-FI1-29-D – High Priority

This is a 52 in. diameter concrete pipe located on the right bank of Brickhouse Gully. Water within the pipe was 0.5 in. deep and was flowing into the segment. There are single-family homes in the area. A sample taken 1 m downstream of the pipe had a bacteria value of 1,990 MPN/100 mL. The ambient sample collected upstream of the pipe had a bacteria value of 200 MPN/100 mL. This pipe is a high priority referral site for the proper local authority.

Referral site: BRI-T1-FI1-02-D – High Priority

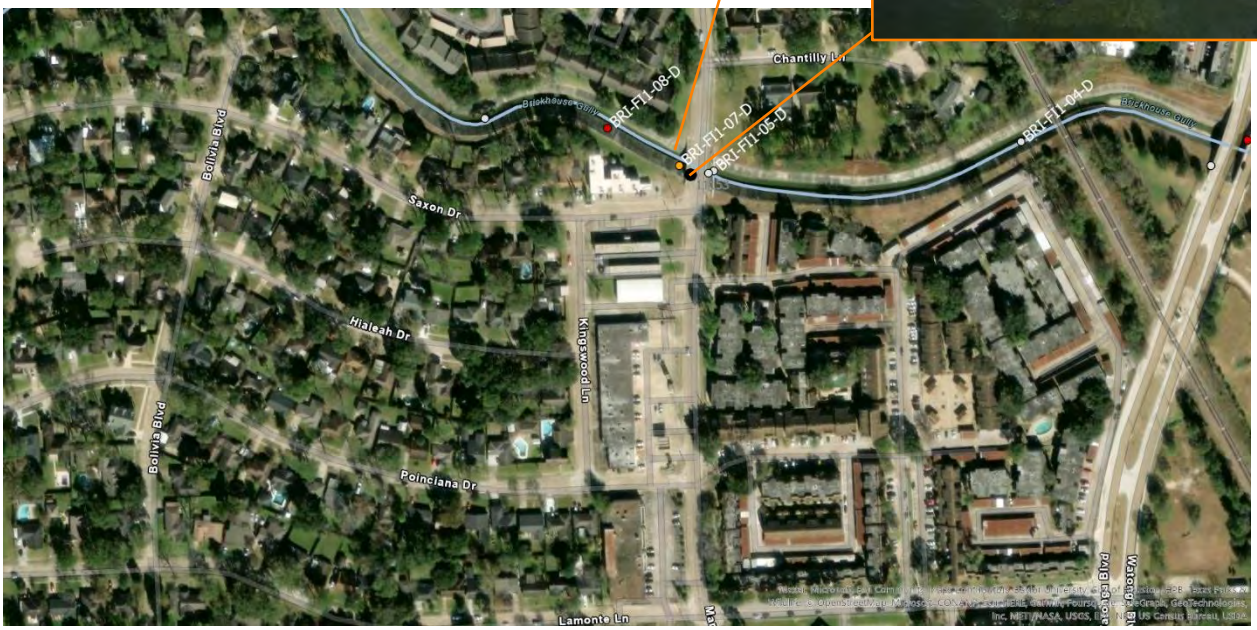
This is a 4.5 in. diameter concrete pipe (weep hole) located on the right bank of the tributary to Brickhouse Gully. Water within the pipe was 0.25 in. deep and trickling into the segment. There was a rusted-out metal pipe higher up on the right bank likely draining water into the source of this weep hole. There are apartments located in the area on the right bank. A sample taken 0.25 m downstream of the pipe had a bacteria value of 3,450 MPN/100 mL. The ambient sample collected upstream of the pipe had a bacteria value of 300 MPN/100 mL. This pipe is a high priority referral site for the proper local authority.

Referral site: BRI-T1-FI1-05-D – High Priority

This is a 40 in. diameter concrete pipe located on the left bank of the tributary to Brickhouse Gully. Water within the pipe was 0.25 in. deep and flowing into the segment. There was a strong fermented odor coming from the pipe and the water that was discharging from the pipe was cloudy and brown. There are commercial buildings in the area on the right bank. A sample taken 0.2 m downstream of the pipe had a bacteria value of 2,990 MPN/100 mL. The ambient sample collected upstream of the pipe had a bacteria value of 310 MPN/100 mL. This pipe is a high priority referral site for the proper local authority.

Referral site: BRI-FI1-07-D – Low Priority

This is a 29 in. diameter concrete pipe located on the right bank of Brickhouse Gully. Water within the pipe was 0.06 in. deep and barely trickling into the segment. Algae was present inside the pipe. There are commercial buildings, single-family homes, and apartments in the area. A sample 1 m downstream of the pipe had a bacteria value of 9,090 MPN/100 mL. The ambient sample collected upstream of the pipe had a bacteria value of 8,200 MPN/100 mL. This pipe is a low priority referral site for the proper local authority.

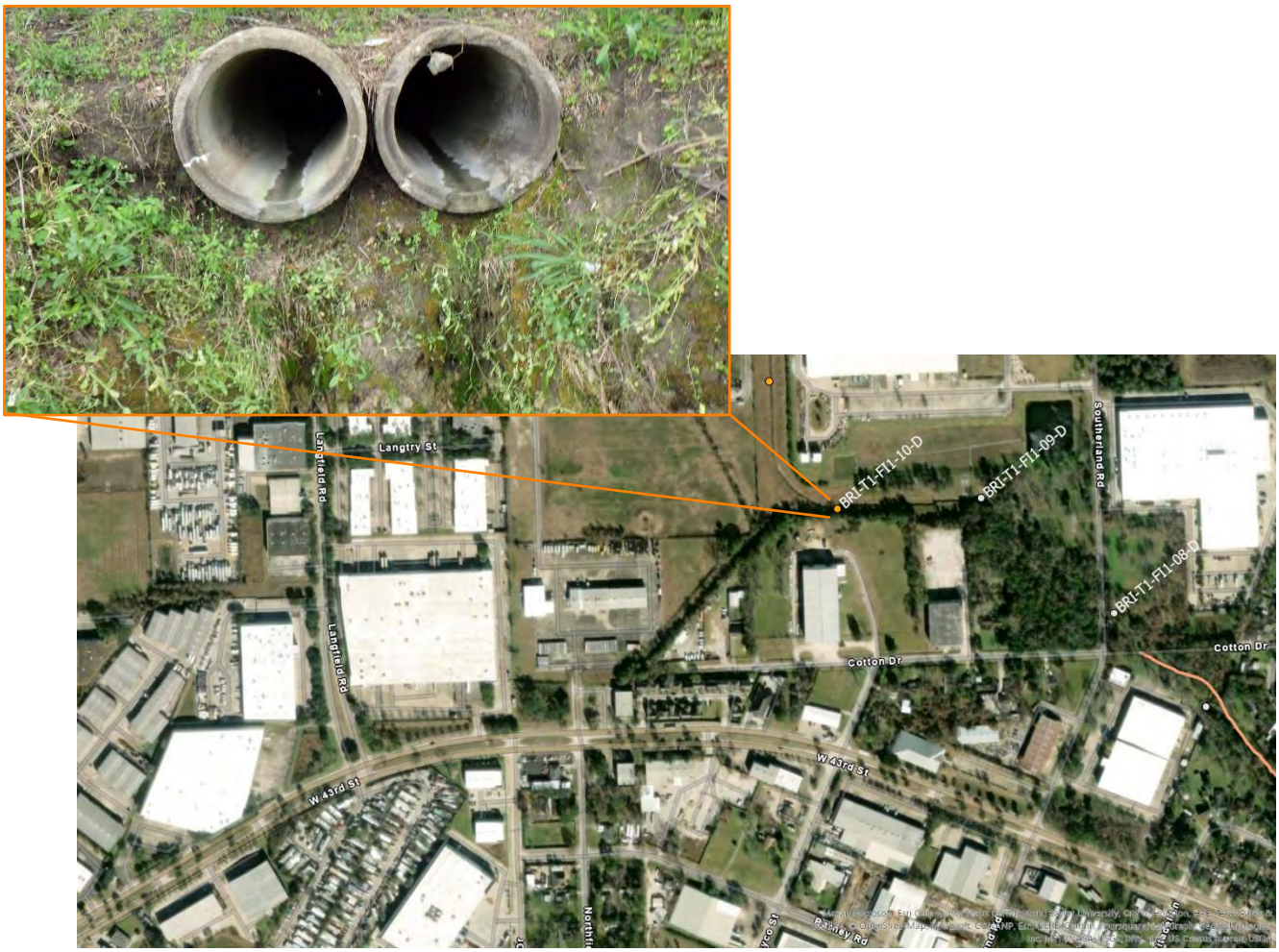


Referral site: BRI-FI1-18-P – Low Priority

This is a 4 in. diameter metal pipe (weep hole) located on the right bank of Brickhouse Gully. Water within the pipe was 1.5 in. deep and was flowing heavily into the segment. Sediment was present in front of the pipe. There are commercial buildings located in the area on the right bank. A sample taken from the pipe had a bacteria value of 300 MPN/100 mL. This pipe is a low priority referral site for the proper local authority.

Referral site: BRI-T1-FI1-10-D – Low Priority

These were two identical 23.5 in. diameter concrete pipes located adjacent to each other on the right bank of the tributary to Brickhouse Gully. Water within the pipes was 0.06 in. deep and both were dripping into the segment. There are commercial buildings located in the area on the right bank. A sample taken from a pool that they were dripping into 1.5 m downstream of the pipes had a bacteria value of 410 MPN/100 mL. The ambient sample collected upstream of the pipes had a bacteria value of < 100 MPN/100 mL. This is a low priority referral site for the proper local authority.



Referral site: BRI-T1-FI1-11-D – Low Priority

This is a 24 in. diameter corrugated plastic pipe located on the right bank of the tributary to Brickhouse Gully. Water within the pipe was 0.25 in. deep and trickling into the segment. There are commercial buildings located in the area on the right bank. A sample 0.2 m downstream of the pipe had a bacteria value of 410 MPN/100 mL. The ambient sample collected upstream of the pipe had a bacteria value of < 100 MPN/100 mL. This pipe is a low priority referral site for the proper local authority.

Referral site: BRI-FI1-22-P – Investigate Further

This was an ambient sample taken from a tributary to Brickhouse Gully on the right bank. The ambient sample had a bacteria value of 520 MPN/100 mL. Further investigation is recommended by the proper local authority to determine the source of elevated bacteria within this tributary. There are commercial buildings surrounding the tributary.

Referral site: BRI-FI1-32 – Investigate Further

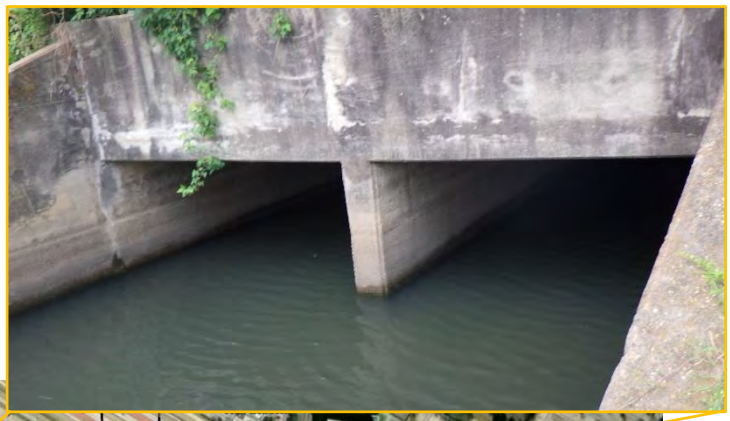
This was an ambient sample collected upstream of the confluence with the main AU. The ambient sample taken had a bacteria value of 2,530 MPN/100 mL. Further investigation is recommended by the proper local authority to determine the source of elevated bacteria upstream of the segment. There are single-family homes and a park located upstream of the site.

Referral site: BRI-T1-FI1-13 – Investigate Further

This was an ambient sample taken upstream of the Langfield Road bridge on the tributary of Brickhouse Gully. The ambient sample taken just in front of the bridge crossing had a bacteria value of > 242,000 MPN/100 mL. The next sample taken was an ambient sample taken upstream of the Hollister Road bridge (BRI-T1-FI1-14). This bacteria value was < 100 MPN/100 mL. Further investigation is recommended by the proper local authority to determine the source of elevated bacteria between these two locations as the field crew was unable to walk this portion due to oncoming thunderstorms. There are apartments and commercial businesses located upstream of the site.

Referral site: BRI-T1-FI1-14 – Investigate Further

This was an ambient sample taken upstream of the Hollister Road bridge on the tributary of Brickhouse Gully. The ambient sample taken just in front of the bridge crossing had a bacteria value of < 100 MPN/100 mL while the sample taken downstream at Langfield Road had a bacteria value of > 242,000 MPN/100 mL. Further investigation is recommended by the proper local authority to determine the source of elevated bacteria between these two locations as the field crew was unable to walk this portion due to oncoming thunderstorms. There are apartments and commercial businesses located between this location and BRI-T1-FI1-13.



List of Acronyms and Abbreviations

AU	Assessment Unit
BIG	Bacteria Implementation Group
BRI	Brickhouse Gully 1017A_01
CRP	Clean Rivers Program
DS	Downstream
E. coli	*Escherichia coli*
FI	Field Investigation
FY	Fiscal Year
GIS	Geographic Information Systems
H-GAC	Houston-Galveston Area Council
IF	Investigate Further
in.	inch
I-Plan	Implementation Plan
km	kilometer
LB	Left Bank
m	meter
mL	milliliter
MPN	Most probable number
N	No
NELAP	National Environmental Laboratory Accreditation Program
NLCD	National Land Cover Database
OSSF	On-Site Sewage Facilities
QAPP	Quality Assurance Project Plan
RB	Right Bank
SWQM	Surface Water Quality Monitoring
SWRC	Stroud Water Research Center
T or trib.	Tributary
TCEQ	Texas Commission on Environmental Quality
TMDL	Total Maximum Daily Load
US	Upstream
WS	Windshield Survey
Y-H	Yes – High Priority
Y-L	Yes-Low Priority

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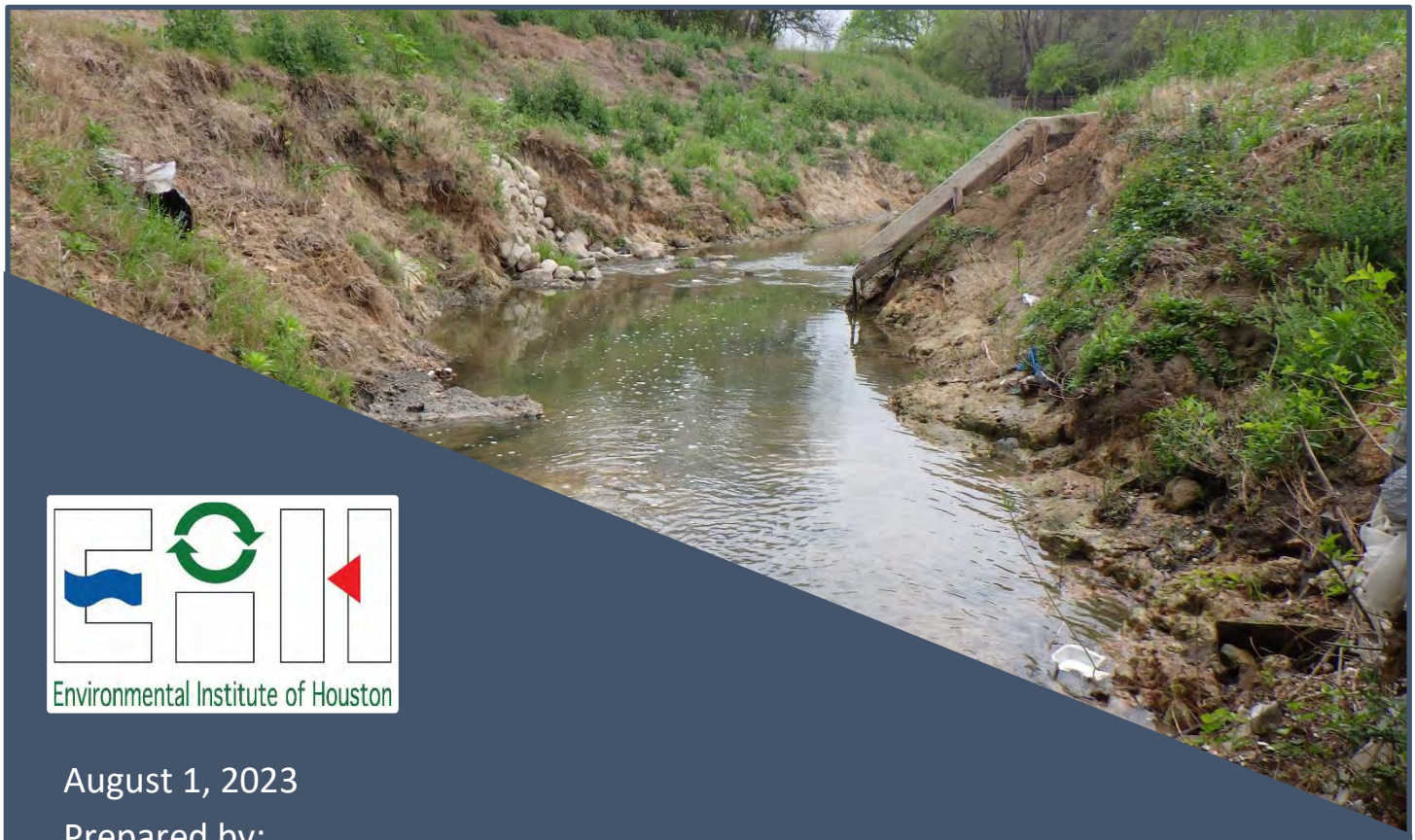
Targeted Bacteria Monitoring Project
Field Investigation Final Report
Assessment Unit 1017B_02, Cole Creek



Environmental Institute of Houston

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Segment Description

Segment 1017B is a freshwater stream called Cole Creek (Figure 1). This segment consists of one assessment unit (AU) of concern. The most downstream AU, 1017B_02, is 6.55 km and is defined as being from Flintlock Street to the confluence with White Oak Bayou in Harris County. There is one current and one historic surface water quality monitoring (SWQM) station located on this AU (station IDs: 16593 and 11154). This AU has been selected for targeted monitoring due to a bacteria (*Escherichia coli*) seven-year geometric mean of 1,601.6 MPN/100 mL (H-GAC QAPP, 2022). The AU was listed for exceedances of bacteria in the water (Recreation use) and has a current impairment category of 4a (TCEQ, 2022). The potential sources of bacteria are non-point source pollution, urban runoff, and sanitary sewer overflows (TCEQ, 2022).

The contributing watershed for this segment is 30 km^2 (Data Source: HGAC, SWRC, 2023). The predominant soil group in the watershed is medium/very slow infiltration coverage and land cover is developed land (96.6%) (Data source: United States Department of Agriculture Hydrologic Soil Groups from gSSURGO 2016 and National Land Cover Database NLCD 2019). There are also 131 documented permitted on-site sewage facilities (OSSFs) and 310 parcels of documented unpermitted OSSFs within the watershed (Data source: H-GAC).

Background

Clean Rivers Program (CRP) routine monitoring data are analyzed each year as part of the Houston-Galveston Area Council (H-GAC) Basin Summary/Basin Highlights Report process. Bacteria continues to be the most prevalent pollutant in the H-GAC CRP Basins (H-GAC, 2022). The Bacteria Implementation Group (BIG), formed in 2008, oversees the Total Maximum Daily Load (TMDL) Implementation Plan (I-Plan). The BIG requested that H-GAC produce a list of the water bodies with the highest bacteria concentrations in the BIG project area and conduct targeted monitoring to identify potential bacteria sources.

H-GAC, using information from previous Basin Highlights/Summary Reports, BIG annual reports, and previous targeted monitoring efforts, identified and selected waterways for targeted bacteria monitoring to refine our understanding of the spatial distribution of elevated bacterial concentrations contributing to these waterways. Phase 1 of this targeted monitoring project included an intensive desktop review and a windshield survey (WS) of each AU catchment area, and sampling of the AU from primary road crossings. Phase 2 of this targeted monitoring project included a field investigation (FI) of the entire AU conducted during dry conditions where all flowing point and non-point sources were evaluated.

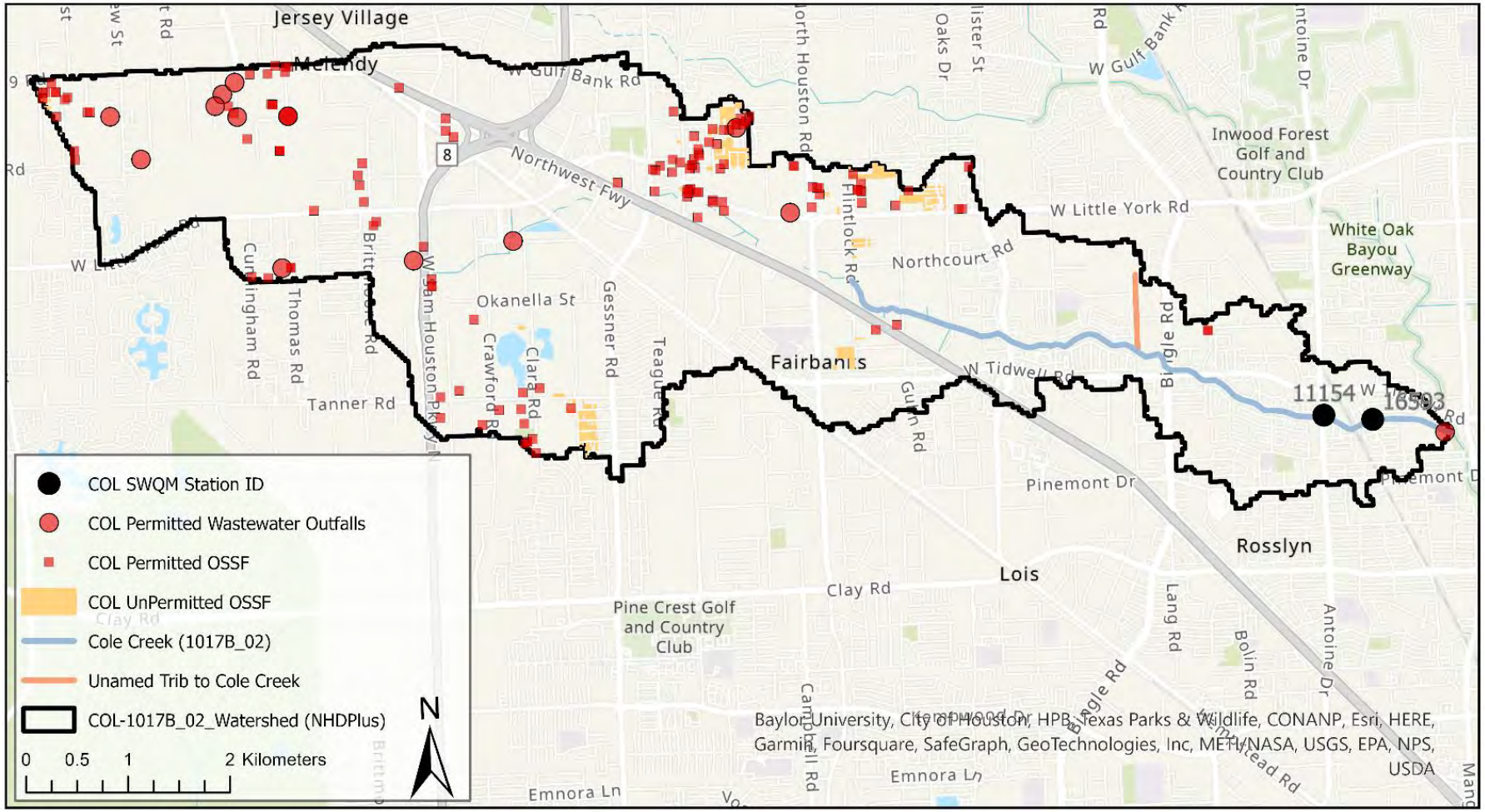


Figure 1 Watershed Map for Cole Creek, Assessment Unit 1017B_02.

Desktop Review

Methods

The intensive desktop review included an evaluation of permitted discharges, outfalls, and potential sources of point source and nonpoint source pollution that may contribute to bacteria loading in the AU. Using Google Earth imagery and GIS, the locations of wastewater treatment facilities, permitted OSSFs, and potential locations of unpermitted OSSFs were identified. Other potential sources such as landfills and industrial facilities, were also identified. Parks were noted, as these can contribute to bacterial sources through runoff of animal wastes but also provide opportunity for contact recreation. Bridge crossings and other entry points were identified in order to provide access into the stream to collect bacteriological samples.

Results

The results of the desktop review indicated that this AU lies within a highly developed urban/suburban area with many potential non-point sources from roads, parking lots, homes, and businesses, as well as many point sources (permitted outfalls, see Figure 1) that may be impacting the water quality of the creek. Publicly accessible entry points into the stream were identified at Bolivia Blvd., Antoine Dr., Tidwell Dr., Bingle Rd., Langfield Rd., and Hollister Rd.

Windshield Survey

Methods

Field events must take place during dry weather (after three or more days without significant rainfall in the watershed). This ensures that any flowing water into the AU is not stormwater. Windshield surveys of the watershed were conducted and bacteria sampling was performed at public access points throughout the AU (primarily at bridge crossings). The survey consisted of driving the catchment area to confirm identified pollution sources found during the desktop review and to find any potential sources not identified during that review. Bridge crossings chosen for sampling were spatially distributed to provide a spatial snapshot of bacteria concentrations in the AU and identify sections of the AU where elevated bacteria concentrations were found. Those areas with elevated bacteria levels identified in the WS monitoring were focused on during the FI in Phase 2.

Assessment Units, sample collection and laboratory methods, and data handling practices are detailed in Appendix J of the FY 2022-2023 H-GAC Multi-Basin Clean Rivers Program Quality Assurance Project Plan (H-GAC QAPP, 2022). For all WS bacteria monitoring, field personnel documented the latitude and longitude of sample locations. All bacteria samples were analyzed by a National Environmental Laboratory Accreditation Program (NELAP)-Accredited laboratory.

Results and Recommendations

The WS was conducted on March 6, 2023. At that time, it had been four days since the last significant rainfall in the watershed. A total of eight samples were collected on AU 1017B_02 and one on a contributing tributary during the WS (Table 1 and Figure 2).

Table 1: Windshield survey bacteria results from sampling on 03/06/2023 on Cole Creek (AU 1017B_02). Samples were taken at bridge crossings and other publicly accessible points. US = Upstream, DS = Downstream. LB = Left Bank, RB = Right Bank.

Sample ID	Latitude	Longitude	*E. coli* Sample Results (MPN/100 mL)	Comments
COL-WS-01	29.84491	-95.46012	155	
COL-WS-02	29.84617	-95.46786	3,260	Slight smell of bat guano.
COL-WS-03	29.84673	-95.47311	933	Encampments present under bridge. Smell of feces in ambient air.
COL-WS-04	29.85037	-95.48577	171	Encampments present under bridge. Smell of feces in ambient air. Discarded used feminine hygiene products on bank.
COL-WS-05	29.85225	-95.48920	171	Encampment in woods on LB.
COL-WS-06	29.85364	-95.50004	512	Possible encampment under bridge.
COL-WS-07	29.85436	-95.50516	2,910	Flocculant in water.
COL-WS-08	29.85691	-95.51580	331	Large encampment under bridge - sampled US of bridge.
T1COL-WS-01	29.85325	-95.49181	31	Sampled from tributary of Cole Creek.

Based upon the results of the WS and ground-truthing, a FI covering the entire length of the AU was recommended. The unnamed tributary that has a confluence with Cole Creek situated between Pine Grove Drive and Bingle Road had a bacteria level of 31 MPN and therefore was not targeted for a FI. Based on the results of the WS, we expected to identify potential non-point sources or point sources of elevated bacteria near the following portions of the AU:

1) COL-WS-02, which was collected from the downstream side of the bridge at Bolivia Blvd. This sample had an elevated bacteria result compared to the samples collected upstream and downstream of this area.

2) COL-WS-03, which was collected from the downstream side of the bridge at Antoine Dr. This sample had an elevated bacteria result compared to the sample collected approximately 0.8 mi upstream of this area.

3) COL-WS-07, which was collected from the upstream side of the bridge at Hollister Rd. This sample had an elevated bacterial level compared to the sample collected approximately 0.65 mi upstream of this area.

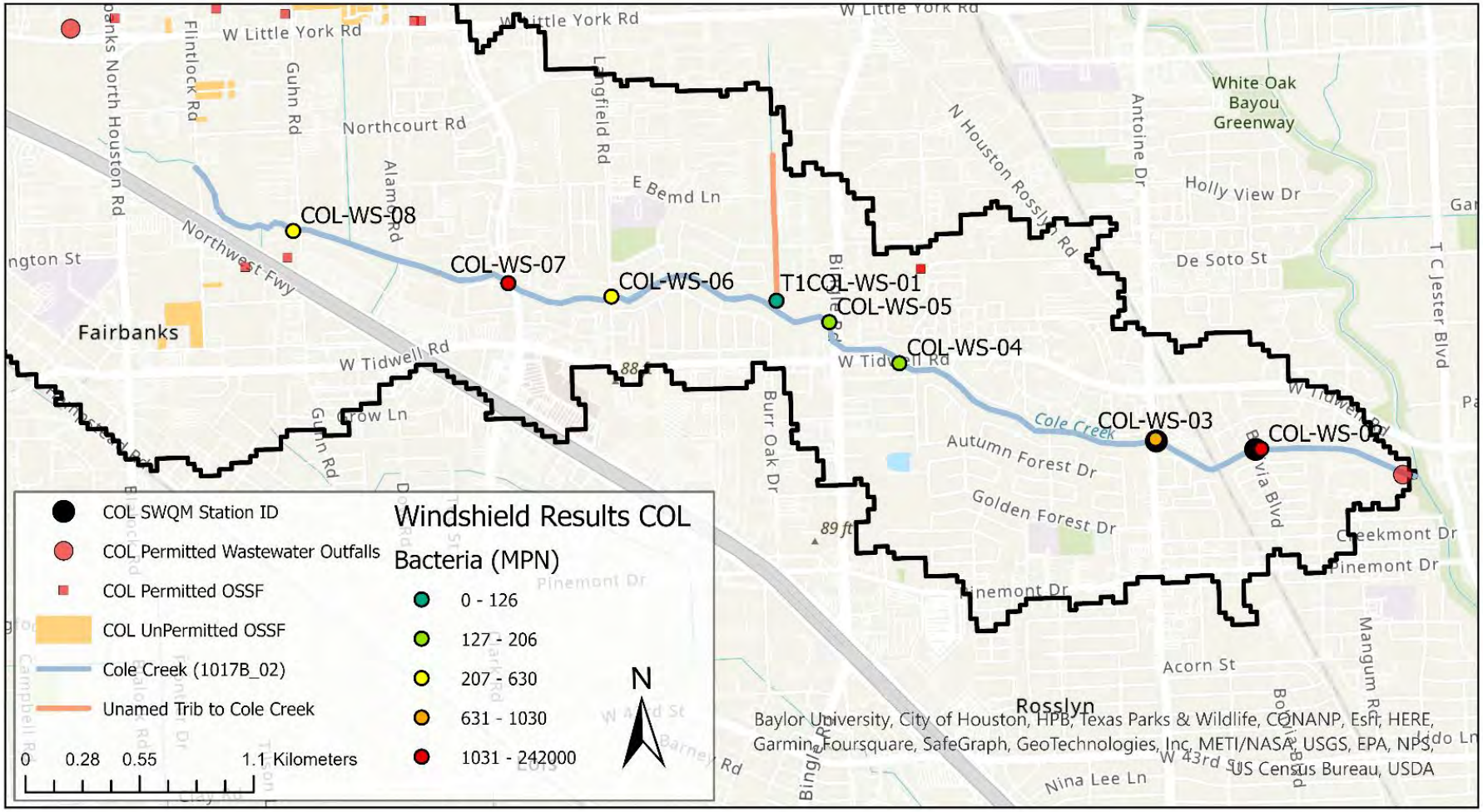


Figure 2: Windshield survey/ground truthing bacteria results from sampling on 03/06/2023 on Cole Creek (AU 1017B_02).

Field Investigation

Methods

The FI was a thorough survey where a team of two either walked or paddled the entire assessment unit and sampled any water observed flowing into the stream. Water could be flowing in from a pipe, culvert, natural tributary, or earthen ditch. Flowing water was categorized into two source types: permitted outfalls or unpermitted outfalls. Permitted outfalls included wastewater facilities and municipal separate storm sewer systems (MS4). Any pipe greater than 12 inches (in.) in diameter was assumed to be permitted by our field crews. When flowing water was observed from a permitted outfall, two samples were collected.

One sample was collected immediately downstream of the outfall where the flowing outfall was mixing with the ambient water. The second sample was taken upstream of the flowing outfall outside of the realm of influence from the outfall to provide the ambient bacteria levels of the assessment unit in that area. The second type of source was an unpermitted outfall, which was any other flowing source of water that was judged to not be permitted in the field, including flowing small (<12 in. diameter) “homemade” pipes and tributaries.

When a flowing unpermitted outfall was observed, the bacteria sample was taken directly from the source. If the source was a flowing pipe, the sample was collected directly from the pipe, before it entered the AU. If it was an open-top earthen ditch or natural tributary, the sample was collected from far enough into the inflow source that there was no mixing with the receiving water. In some cases, when no flowing permitted or unpermitted outfalls were observed in an extended section of the AU, a single ambient reference sample was taken mid-stream. Left and right bank references are oriented with the observer facing downstream.

Assessment Units, collection and laboratory methods, and data handling practices are detailed in Appendix J of the FY 2022-2023 H-GAC Multi-Basin Clean Rivers Program Quality Assurance Project Plan (H-GAC QAPP, 2022). For all field investigations the field team recorded location of the flowing outfall (latitude and longitude), the diameter, material, and water depth of the flowing outfall, and documented site conditions by taking photos and other relevant notes. All bacteria samples were collected following procedures listed in Appendix J of the FY 2022-2023 H-GAC Multi-Basin Clean Rivers Program Quality Assurance Project Plan (H-GAC QAPP, 2022) and analyzed by a National Environmental Laboratory Accreditation Program (NELAP)-Accredited laboratory.

This AU has some changes in depth making it partially boatable and wadeable. The FI for the portion upstream of the bridge at Langfield Rd. was conducted as wadeable while the portion downstream of Langfield Rd. was conducted from kayaks. There was also a safety concern for our field crew as there were encampments encountered at most bridge crossings. Some of these encampments were observed to have multiple residents and at some encampments on-

going illicit activities were observed by our WS field crew. Therefore, the FI field crew was escorted by Harris County Constable Peace Officers.

Results

The FI was conducted on May 24, 2023 (eight days since last significant rainfall) and a total of 61 bacteria samples were collected. The values of the bacteria samples collected from downstream of permitted outfalls, directly from unpermitted outfalls, or as ambient samples are summarized in Table 2 and Figure 3. Based on the data collected, four locations with elevated *E. coli* bacteria levels measured during the FI are recommended for high priority and five locations for low priority investigation by the proper authorities. High priority sites had the highest potential bacteria loading observed and are recommended to be the areas for local authorities to focus efforts on should there be insufficient resources to address all referral sites. As time and resources allow the low priority and “investigate further” referrals also are recommended for further investigation. These locations are summarized in Table 2 and Figure 4. Three locations were flagged where ambient or upstream samples had elevated bacteria levels with no obvious explanations. Further investigation of these areas by the proper authorities is recommended. Each of these referrals are summarized by site, herein. The referral summaries are listed in order of priority (High, Low, then Investigate Further). Within each priority group, sites are listed from downstream to upstream.

Table 2: Field investigation bacteria results from sampling on 5/24/2023 on Cole Creek (Assessment Unit 1017B_02). Referrals (gray rows): N = No, Y-H = Yes – High Priority, Y-L = Yes-Low Priority, IF = Investigate Further, US = Upstream, DS = Downstream. LB = Left Bank, RB = Right Bank.

Sample ID	Lat	Long	DS or Direct *E. coli* Sample Results (MPN/100 mL)	US *E. coli* Sample Results (MPN/100 mL)	Difference* DS - US (MPN/100 mL)	Referral	Comments
COL-FI1-21-D	29.84494	-95.46087	< 100	24,900	-24,800	N	Wastewater outfall on RB just US of confluence with White Oak Bayou. Took US sample ~30m US of outfall to avoid large mixing zone. This is the most DS sample.
COL-FI1-20-D	29.84618	-95.46779	27,200	< 100	27,100	Y-H	Pipe is located on RB, flowing well, and the bottom of the pipe is coated in algae.
COL-FI1-19-D	29.84581	-95.46939	5,860	27,600	-21,740	N	Pipe is trickling and located on LB. There is a large amount of vegetation growing in front of pipe.
COL-FI1-18-D	29.84575	-95.47127	< 100	48,800	-48,700	N	Pipe is dripping and located on RB.
COL-FI1-17-D	29.84618	-95.47206	> 242,000	98,000	144,000	Y-H	RB. Water is trickling, somewhat white, cloudy, and smells of effluent. Pipe is smashed at opening and vegetation is thick around it.
COL-FI1-16-D	29.84673	-95.47327	242,000	242,000	0	N	LB. Pipe directly across from another pipe under bridge. Encampment under bridge. Same US sample.
COL-FI1-15-D	29.84668	-95.47326	173,000	242,000	-69,000	N	RB. Pipe directly across from another pipe under bridge. Encampment under bridge.
COL-FI1-NS-2	29.84658	-95.47467	NA	NA	NA	N	Pipe on RB. Did not sample due to not being able to locate where water flows in as pipe is broken in several places. Could hear flow. Pipe just DS of COL-FI1-14-D.
COL-FI1-14-D	29.84663	-95.47520	155,000	> 242,000	-87,000	N	LB. Flowing steadily.
COL-FI1-13-D	29.84723	-95.47820	< 100	> 242,000	-241,900	IF	LB. water in pipe is cloudy and smells like effluent. Decent flow.
COL-FI1-NS-1	29.84904	-95.48244	NA	NA	NA	IF	Not sampled. Pipe on LB (between samples COL-FI1-12-D and COL-FI1-13-D) dripping once every 30 seconds.
COL-FI1-12-D	29.84995	-95.48375	< 100	3,170	-3,070	IF	LB. Crystal clear water coming out of pipe. Sheen on water in front of pipe. Live apple snails present.
COL-FI1-11-D	29.85010	-95.48491	1,460	1,350	110	N	RB. Decently flowing. Crystal clear water.

Sample ID	Lat	Long	DS or Direct *E. coli* Sample Results (MPN/100 mL)	US *E. coli* Sample Results (MPN/100 mL)	Difference* DS - US (MPN/100 mL)	Referral	Comments
COL-FI1-10-D	29.85018	-95.48518	200	1,200	-1,000	N	LB. Descent flow into creek.
COL-FI1-09-D	29.85109	-95.48705	1,340	1,220	120	N	LB. Trickling. The bridge DS has a large encampment.
COL-FI1-08-D	29.85125	-95.48873	750	1,480	-730	N	This pipe is the most DS pipe of the group of 3 pipes and is located on the RB. Same US sample and coordinates as COL-FI1-06-D.
COL-FI1-07-D	29.85125	-95.48873	4,350	1,480	2,870	Y-L	COL-FI1-07-D is on the LB (second most US). Pipe is submerged- took sample from within. Same US sample and coordinates as COL-FI1-06-D.
COL-FI1-06-D	29.85125	-95.48873	< 100	1,480	-1,380	N	COL-FI1-06-D is the most US pipe of a grouping of 3 pipes. Two are located on the LB and one is on RB. This pipe is on the LB. Coordinates taken DS out from under the bridge.
COL-FI1-05-D	29.85273	-95.49168	410	520	-110	N	Pipe on LB is submerged but could audibly hear it flowing. Sounds like a heavy flow. Took sample from within pipe. Floating animal feces observed.
COL-FI1-04-D	29.85289	-95.49187	750	630	120	IF	Tributary empties into creek on LB. Was not flowing during WS but is currently flowing (trickling).
COL-FI1-03-D	29.85346	-95.49439	410	200	210	N	RB. Pipe on opposite bank but is dry.
COL-FI1-02-D	29.85357	-95.49923	1,100	310	790	Y-L	RB. Trickling.
COL-FI1-01-D	29.85365	-95.49991	1,210	860	350	N	RB. Barely a trickle. Sampling from US to DS in kayak.
COL-FI1-22-D	29.85367	-95.50023	15,500	520	14,980	Y-H	LB. Trickling. Start of walking portion from DS to US. Could kayak.
COL-FI1-23-D	29.85356	-95.50025	630	1,200	-570	N	RB. Heavy flow. Water is clear.
COL-FI1-24-D	29.85363	-95.50098	1,460	1,210	250	N	LB. Steady drip.
COL-FI1-25-D	29.85368	-95.50156	1,080	1,320	-240	N	RB. Trickling.
COL-FI1-26-D	29.85355	-95.50272	740	1,970	-1,230	N	LB. Trickling.
COL-FI1-27-D	29.85351	-95.50322	2,310	2,060	250	N	RB. Dripping.
COL-FI1-28-D	29.85395	-95.50445	2,130	970	1,160	Y-L	Submerged pipe on the RB. Sample taken within pipe.
COL-FI1-29-D	29.85437	-95.50517	8,390	2,460	5930	Y-H	RB. Steady trickle.

Sample ID	Lat	Long	DS or Direct *E. coli* Sample Results (MPN/100 mL)	US *E. coli* Sample Results (MPN/100 mL)	Difference* DS - US (MPN/100 mL)	Referral	Comments
COL-FI1-30-D	29.85453	-95.50523	2,460	1,310	1,150	Y-L	Submerged pipe on the LB. Sample taken within pipe.
COL-FI1-31-D	29.85460	-95.50725	410	310	100	N	Rusted out pipe on the RB. Steady trickle close to the bank.
COL-FI1-32-D	29.85465	-95.50780	< 100	100	0	N	Rusted out metal pipe on the LB.
COL-FI1-33-D	29.85542	-95.51025	200	300	-100	N	Pipe on RB hidden behind vegetation is trickling steadily.
COL-FI1-34-D	29.85550	-95.51059	1,560	520	1,040	Y-L	Submerged pipe on RB. Sample taken within pipe. This is the most US sample.

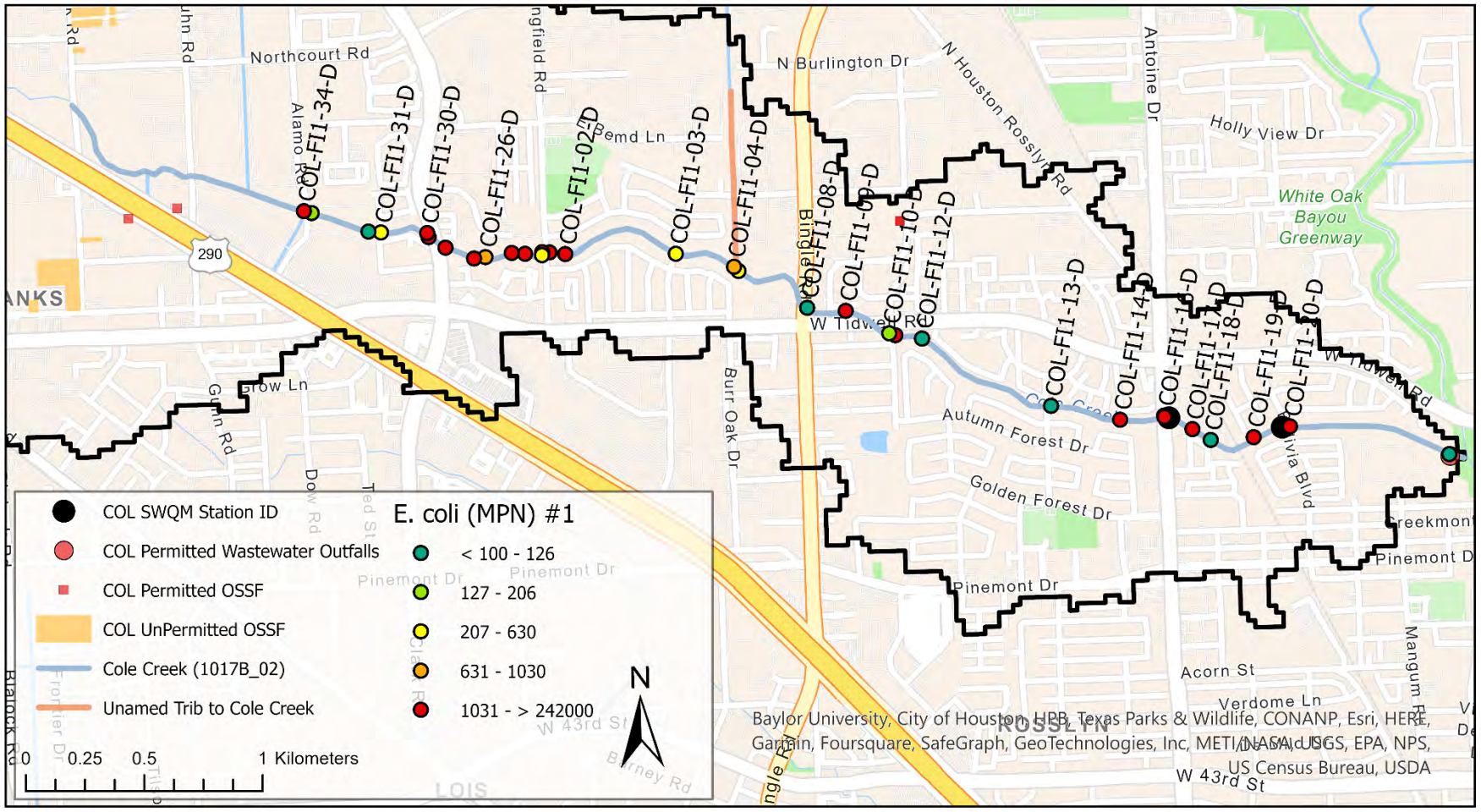


Figure 3: Field investigation bacteria sampling Results from on 5/24/2023 on Cole Creek (Assessment Unit 1017B_02).

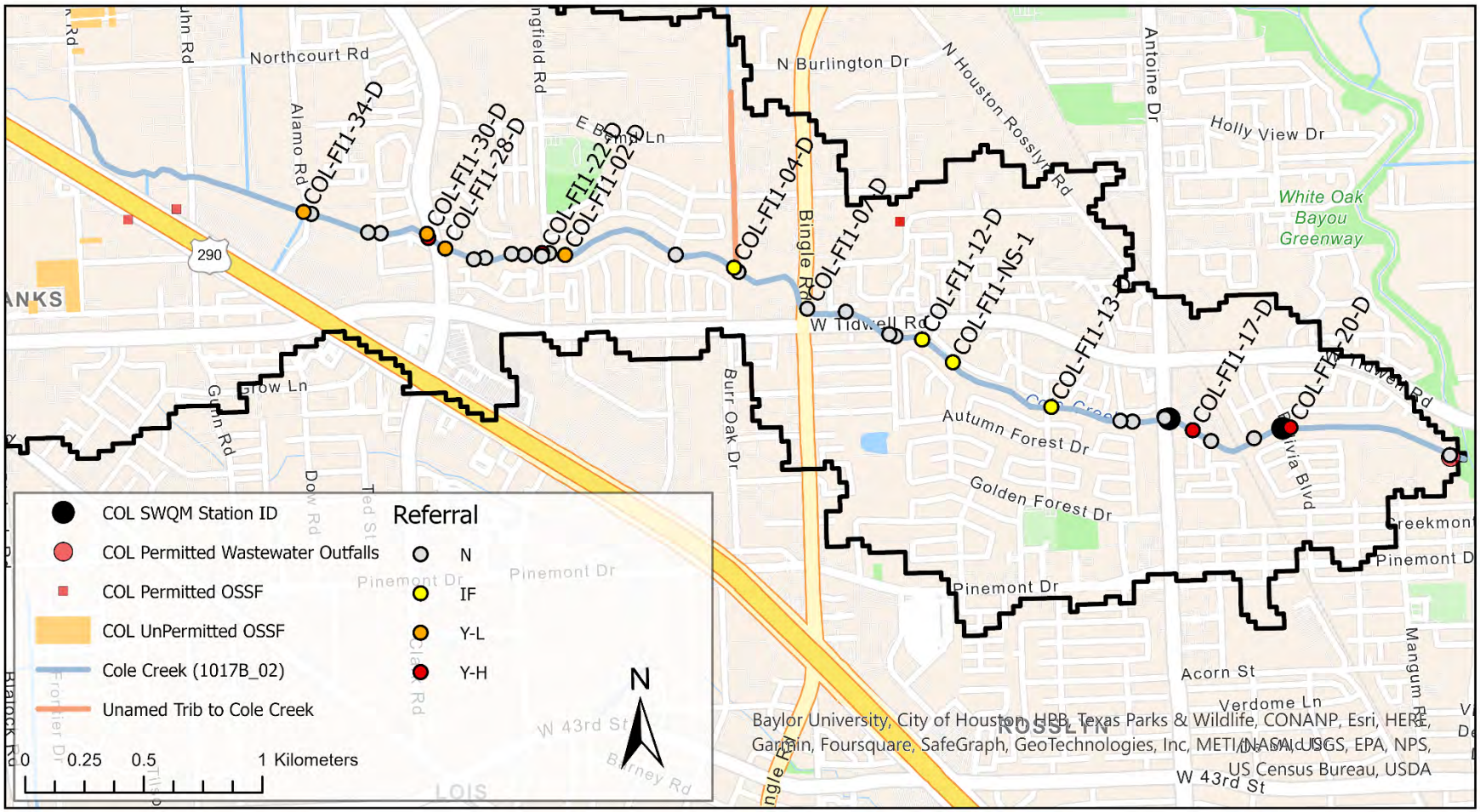


Figure 4: Field investigation sites identified for referral to the proper authorities on Cole Creek (Assessment Unit 1017B_02).

Referral site: COL-FI1-20-D – High Priority

This is a 36 in. diameter metal pipe located on the right bank of Cole Creek. Water within the pipe was 0.5 in. deep and flowing into the segment. The bottom of the pipe is coated in algae. There are single-family homes located in the area on the right bank. A sample taken 0.5 m downstream of the pipe had a bacteria value of 27,200 MPN/100 mL. The ambient sample collected upstream of the pipe had a bacteria value of < 100 MPN/100 mL. This pipe is a high priority referral site for the proper local authority.

Referral site: COL-FI1-17-D – High Priority

This is a 26 in. diameter metal pipe located on the right bank of Cole Creek. Water within the pipe was 0.25 in. deep, somewhat white, cloudy, and trickling into the segment. There was a smell of effluent in the ambient air. The pipe is smashed at the opening and vegetation is growing thick around it. There are apartments located in the area on the right bank. A sample taken 0.3 m downstream of the pipe had a bacteria value of > 242,000 MPN/100 mL. The ambient sample collected upstream of the pipe had a bacteria value of 98,000 MPN/100 mL. This pipe is a high priority referral site for the proper local authority.

Referral site: COL-FI1-22-D – High Priority

This is a 36 in. diameter metal pipe located on the left bank of Cole Creek. Water within the pipe was 0.5 in. deep and trickling into the segment. There are apartments and single-family homes located in the area on the left bank. A sample taken 1 m downstream of the pipe had a bacteria value of 15,500 MPN/100 mL. The ambient sample collected upstream of the pipe had a bacteria value of 520 MPN/100 mL. This pipe is a high priority referral site for the proper local authority.

Referral site: COL-FI1-29-D – High Priority

This is a 24 in. diameter metal pipe located on the right bank of Cole Creek. Water within the pipe was 0.06 in. deep and trickling steadily into the segment. There are apartments located in the area on the right bank. A sample taken 0.7 m downstream of the pipe had a bacteria value of 8,390 MPN/100 mL. The ambient sample collected upstream of the pipe had a bacteria value of 2,460 MPN/100 mL. This pipe is a high priority referral site for the proper local authority.

Referral site: COL-FI1-07-D– Low Priority

This is a 66 in. diameter concrete pipe located on the left bank of Cole Creek. This pipe is the second most upstream pipe at this location. The pipe was partially submerged and water within the pipe was 8.5 in. deep. There are commercial buildings located in the area on the left bank. Due to the pipe being submerged, the downstream sample was taken within the mixing zone in front of the mouth of the pipe and had a bacteria value of 4,350 MPN/100 mL. The ambient sample collected upstream of the pipe had a bacteria value of 1,480 MPN/100 mL. This pipe is a low priority referral site for the proper local authority.

Referral site: COL-FI1-02-D– Low Priority

This is a 28 in. diameter metal pipe located on the right bank of Cole Creek. Water within the pipe was 0.06 in. deep and trickling into the segment. There are commercial buildings, single-family homes, and apartments located in the area on the right bank. A sample taken 1 m downstream of the pipe had a bacteria value of 1,100 MPN/100 mL. The ambient sample collected upstream of the pipe had a bacteria value of 310 MPN/100 mL. This pipe is a low priority referral site for the proper local authority.

Referral site: COL-FI1-28-D– Low Priority

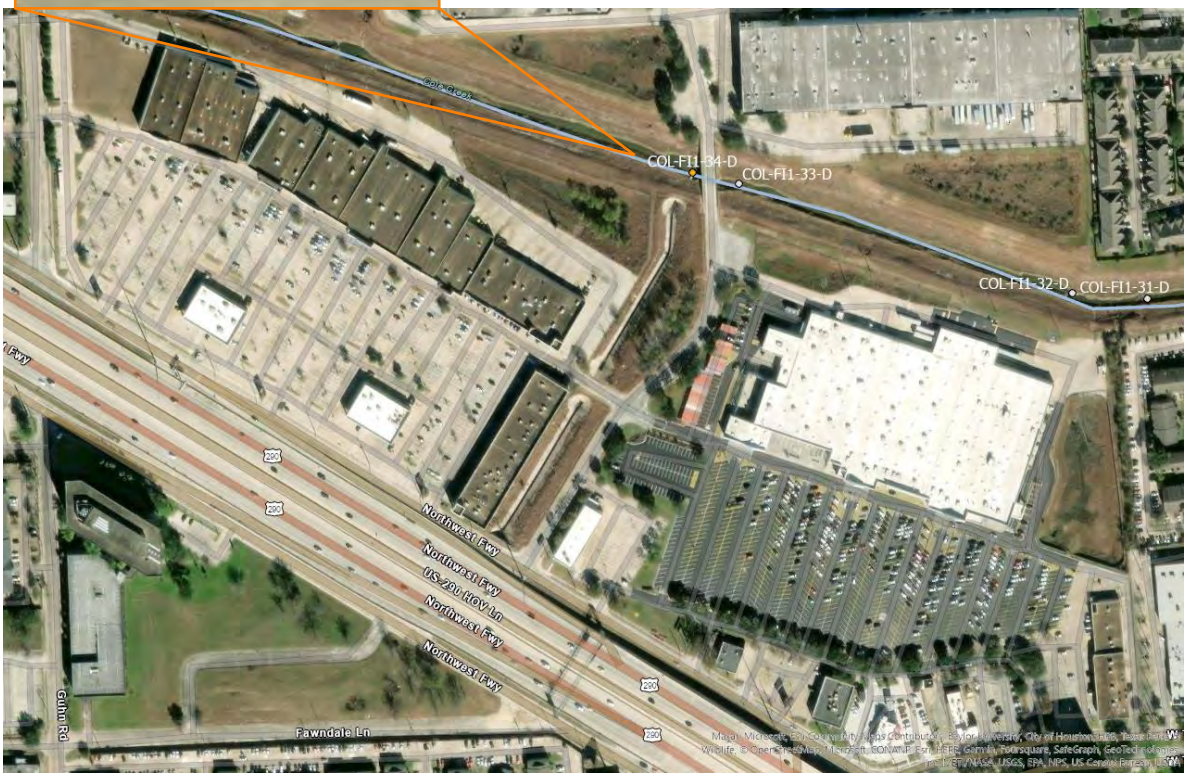
This is a 66 in. diameter metal pipe located on the right bank of Cole Creek. The pipe was partially submerged and water within the pipe was 15 in. deep. There are apartment buildings located in the area on the right bank. Due to the pipe being submerged, the downstream sample was taken within the mixing zone in front of the mouth of the pipe and had a bacteria value of 2,130 MPN/100 mL. The ambient sample collected upstream of the pipe had a bacteria value of 970 MPN/100 mL. This pipe is a low priority referral site for the proper local authority.

Referral site: COL-FI1-30-D– Low Priority

This is a 78 in. diameter metal pipe located on the left bank of Cole Creek. The pipe was partially submerged and water within the pipe was 12 in. deep. There are apartment buildings located in the area on the left bank. Due to the pipe being submerged, the downstream sample was taken within the mixing zone in front of the mouth of the pipe and had a bacteria value of 2,460 MPN/100 mL. The ambient sample collected upstream of the pipe had a bacteria value of 1,310 MPN/100 mL. This pipe is a low priority referral site for the proper local authority.

Referral site: COL-FI1-34-D– Low Priority

This is an 82 in. diameter metal pipe located on the right bank of Cole Creek. The pipe was partially submerged and water within the pipe was 22 in. deep. There are commercial buildings located in the area on the right bank. Due to the pipe being submerged, the downstream sample was taken within the mixing zone in front of the mouth of the pipe and had a bacteria value of 1,560 MPN/100 mL. The ambient sample collected upstream of the pipe had a bacteria value of 520 MPN/100 mL. This pipe is a low priority referral site for the proper local authority.



Referral site: COL-FI1-13-D – Investigate Further

This is a 36 in. diameter metal pipe located on the left bank of Cole Creek. When sampled on May 24, 2023, the water in the pipe was 0.5 in. deep and was flowing into the segment. Although the water in the pipe was cloudy and smelled like effluent, a sample taken 0.3 m downstream of the pipe had a bacteria value of < 100 MPN/100 mL. The ambient sample collected upstream of the pipe had a bacteria value of > 242,000 MPN/100 mL. These results seemed suspicious and the pipe was revisited on June 14, 2023 to take additional samples but the pipe was not discharging into the segment at that time. On the revisit, a sample was taken from a pool below the pipe and from a riffle upstream of the pipe. Both of those samples resulted in bacteria values of < 100 MPN/100 mL. On May 24, 2023, a pipe about 460 m upstream of this pipe on the left bank was observed dripping about once every 30 seconds and was not sampled. The unsampled pipe (COL-FI1-NS-1) could have potentially been the source of the elevated bacteria for this site if it had been flowing heavier prior to the field team observing it only dripping during the time of the FI. Further investigation is recommended by the proper local authority to determine the source of elevated bacteria in this section of the segment. There are apartments and single-family homes located upstream of the site.

Referral site: COL-FI1-12-D – Investigate Further

This is a 38 in. diameter metal pipe located on the left bank of Cole Creek. A sample taken 1 m downstream of the pipe had a bacteria value of < 100 MPN/100 mL. The ambient sample collected upstream of the pipe had a bacteria value of 3,170 MPN/100 mL. The next sample taken about 100 m upstream (COL-FI1-11-D) of this location had a value of 1,460 MPN/100 mL. It was not apparent during the FI where the elevated bacteria were sourced from. Further investigation is recommended by the proper local authority to determine the source of elevated bacteria between the two locations. There are apartments and single-family homes located upstream of the site.

Referral site: COL-FI1-04-D– Investigate Further

This is an earthen tributary of Cole Creek on the left bank. An ambient sample taken within the tributary had a bacteria value of 750 MPN/100 mL and a sample taken upstream of the tributary had a bacteria value of 630 MPN/100 mL. During the WS, the tributary was not flowing but it was trickling during the FI. Further investigation is recommended by the proper local authority to determine the source of elevated bacteria within the tributary. There are single-family homes and commercial buildings located in the area of the tributary.

List of Acronyms and Abbreviations

AU	Assessment Unit
BIG	Bacteria Implementation Group
COL	Cole Creek 1017B_02
CRP	Clean Rivers Program
DS	Downstream
E. coli	*Escherichia coli*
FI	Field Investigation
FY	Fiscal Year
GIS	Geographic Information Systems
H-GAC	Houston-Galveston Area Council
IF	Investigate Further
in.	inch
I-Plan	Implementation Plan
km	kilometer
LB	Left Bank
m	meter
mL	milliliter
MPN	Most probable number
N	No
NELAP	National Environmental Laboratory Accreditation Program
NLCD	National Land Cover Database
OSSF	On-Site Sewage Facilities
QAPP	Quality Assurance Project Plan
RB	Right Bank
SWQM	Surface Water Quality Monitoring
SWRC	Stroud Water Research Center
T or trib.	Tributary
TCEQ	Texas Commission on Environmental Quality
TMDL	Total Maximum Daily Load
US	Upstream
WS	Windshield Survey
Y-H	Yes – High Priority
Y-L	Yes-Low Priority

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Targeted Bacteria Monitoring Project

Field Investigation Final Report

Assessment Unit 1017D_01,
Unnamed Tributary of White Oak Bayou

Environmental Institute of Houston

August 1, 2023

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Segment Description

Segment 1017D is an unnamed tributary of White Oak Bayou (Figure 1). This segment consists of one assessment unit (AU) of concern. AU 1017D_01 is 2.95 km long and is a freshwater, perennial stream spanning from the confluence with White Oak Bayou Above Tidal, near IH-610 and TC Jester, upstream to Mitchelldale St. west of US 290 in Harris County. There is one current (station ID: 22094) and one historic (station ID: 16595) surface water quality monitoring (SWQM) station located on this AU. This AU has been selected for targeted monitoring due to a bacteria (*Escherichia coli*) seven-year geometric mean of 1225.9 MPN/100 mL (H-GAC QAPP, 2022). The AU was listed for exceedances of bacteria in the water (Recreation use) and has a current impairment category of 4a and a 5c impairment for dissolved oxygen (Aquatic Life Use) (TCEQ, 2022). The potential sources of bacteria are non-point source pollution, urban runoff, and sanitary sewer overflows (TCEQ, 2022).

The contributing watershed for this segment is 6 km^2 (SWRC, 2023) (Data source: USGS National Hydrology Dataset (NHD) Plus V2). The soil groups in the watershed range from very slow to slow infiltration rates, while land cover is predominately developed (98.35%) (Data source: United States Department of Agriculture Hydrologic Soil Groups from gSSURGO 2016 and National Land Cover Database NLCD 2019). There are no permitted wastewater outfalls in the watershed and there are also no documented permitted or unpermitted on-site sewage facilities (OSSF) within the watershed (Data source: H-GAC).

Background

Clean Rivers Program (CRP) routine monitoring data are analyzed each year as part of the Houston-Galveston Area Council (H-GAC) Basin Summary/Basin Highlights Report process. Bacteria continues to be the most prevalent pollutant in the H-GAC CRP Basins (H-GAC, 2022). The Bacteria Implementation Group (BIG), formed in 2008, oversees the Total Maximum Daily Load (TMDL) Implementation Plan (I-Plan). The BIG requested that H-GAC produce a list of the water bodies with the highest bacteria concentrations in the BIG project area and conduct targeted monitoring to identify potential bacteria sources.

H-GAC, using information from previous Basin Highlights/Summary Reports, BIG annual reports, and previous targeted monitoring efforts, identified and selected waterways for targeted bacteria monitoring to refine our understanding of the spatial distribution of elevated bacterial concentrations contributing to these waterways. Phase 1 of this targeted monitoring project included an intensive desktop review and a windshield survey (WS) of each AU catchment area, and sampling of the AU from primary road crossings. Phase 2 of this targeted monitoring project included a field investigation (FI) of the entire AU conducted during dry conditions where all flowing point and non-point sources were evaluated.

Figure 1 Watershed Map for AU 1017D_01.

Desktop Review

Methods

The intensive desktop review included an evaluation of permitted discharges, outfalls, and potential sources of point source and nonpoint source pollution that may contribute to bacteria loading in the AU. Using Google Earth imagery and GIS, the locations of wastewater treatment facilities, permitted OSSFs, and potential locations of unpermitted OSSFs were identified (if present). Other potential sources such as landfills and industrial facilities were also identified. Parks were noted as these can contribute to bacterial sources through runoff of animal wastes but also provide opportunity for contact recreation. Bridge crossings and other entry points were identified to provide access into the stream to collect bacteriological samples.

Results

The results of the desktop review indicated that the segment is highly urbanized with a mix of concrete banks and vegetated banks. Many businesses, manufacturers, parking lots, roads, and major freeways surround this AU as well as a small stretch of neighborhoods that border the tributary. The following potential sources were identified:

- newly constructed apartments on Dacoma St. near US 290 that border the unnamed tributary (Figure 2)
- a small (0.45 acre) farm that may have runoff into the AU (Figure 3)

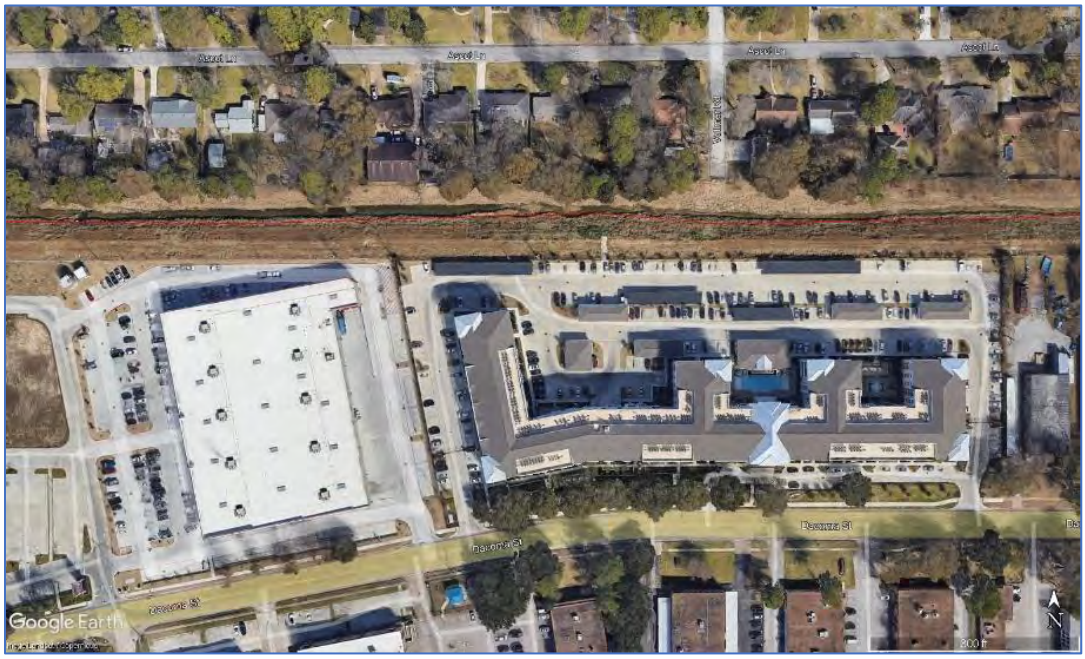


Figure 2. Possible source identified during desktop review.

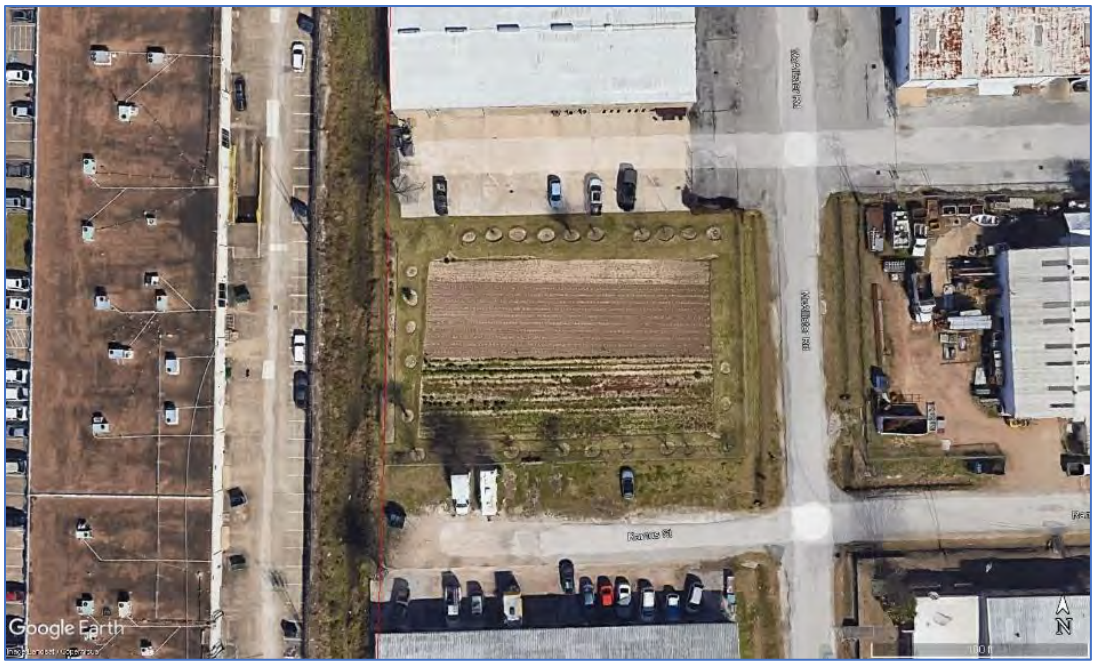


Figure 3. Possible source identified during desktop review.

Publicly accessible entry points into the stream were identified at the bridge at TC Jester Blvd., the dead end of Vollmer Rd. that abuts the tributary, where the AU intersects with the Northwest Fwy. on the upstream side, and the bridge over the tributary at Karbach St. The stream runs dry after it intersects with McAllister Rd.

Windshield Survey

Methods

All field events must take place during dry weather (after three or more days without significant rainfall in the watershed). This ensures that any flowing water into the AU is not stormwater. Windshield surveys of the watershed were conducted, and bacteria sampling was performed at public access points throughout the AU (primarily at bridge crossings). The survey consisted of driving the catchment area to confirm identified pollution sources found during the desktop review and to find any potential sources not identified during that review. Bridge crossings chosen for sampling were spatially distributed to provide a spatial snapshot of bacteria concentrations in the AU and identify sections of the AU where elevated bacteria concentrations were found.

Assessment Units, collection and laboratory methods, and data handling practices are detailed in Appendix J of the FY 2022-2023 H-GAC Multi-Basin Clean Rivers Program Quality Assurance Project Plan (H-GAC QAPP, 2022). For all WS bacteria monitoring, field personnel documented

the latitude and longitude of sample location. All bacteria samples were analyzed by a National Environmental Laboratory Accreditation Program (NELAP)-Accredited laboratory.

Results and Recommendations

The WS was conducted on March 14, 2023. At that time, it had been 12 days since the last significant rainfall in the watershed. A total of five samples were collected on AU 1017D_01 during the WS (Table 1 and Figure 4). While the AU continues past UWO-WS-05 at McAllister Rd., there was no surface water observed upstream of this point. While AU 1017D_01 is 2.95 km long, the distance of the wetted stream for the WS was 2.1 km. Based upon the results of the WS, no sections of the AU were identified for focus during future FIs. A detailed FI throughout the entire assessment unit was still conducted.

Table 1: Windshield survey bacteria results from sampling on 03/14/2023 on Unnamed Tributary of White Oak Bayou (AU 1017D_01). Samples were taken at bridge crossings and other publicly accessible points. US = Upstream, DS = Downstream, RB = Right Bank, LB = Left Bank.

Sample ID	Latitude	Longitude	*E. coli* Sample Results (MPN/100 mL)	Comments
UWO-WS-01	29.81062	-95.44406	<100	Best access DS RB, will need step ladder to access most DS stretch
UWO-WS-02	29.81062	-95.45016	<100	Steep, but looks like it will be nice to walk the stream
UWO-WS-03	29.81061	-95.45798	<100	US LB best access; seems stagnant, very shallow
UWO-WS-04	29.80983	-95.46139	<100	
UWO-WS-05	29.80978	-95.46352	<100	Top of segment with water

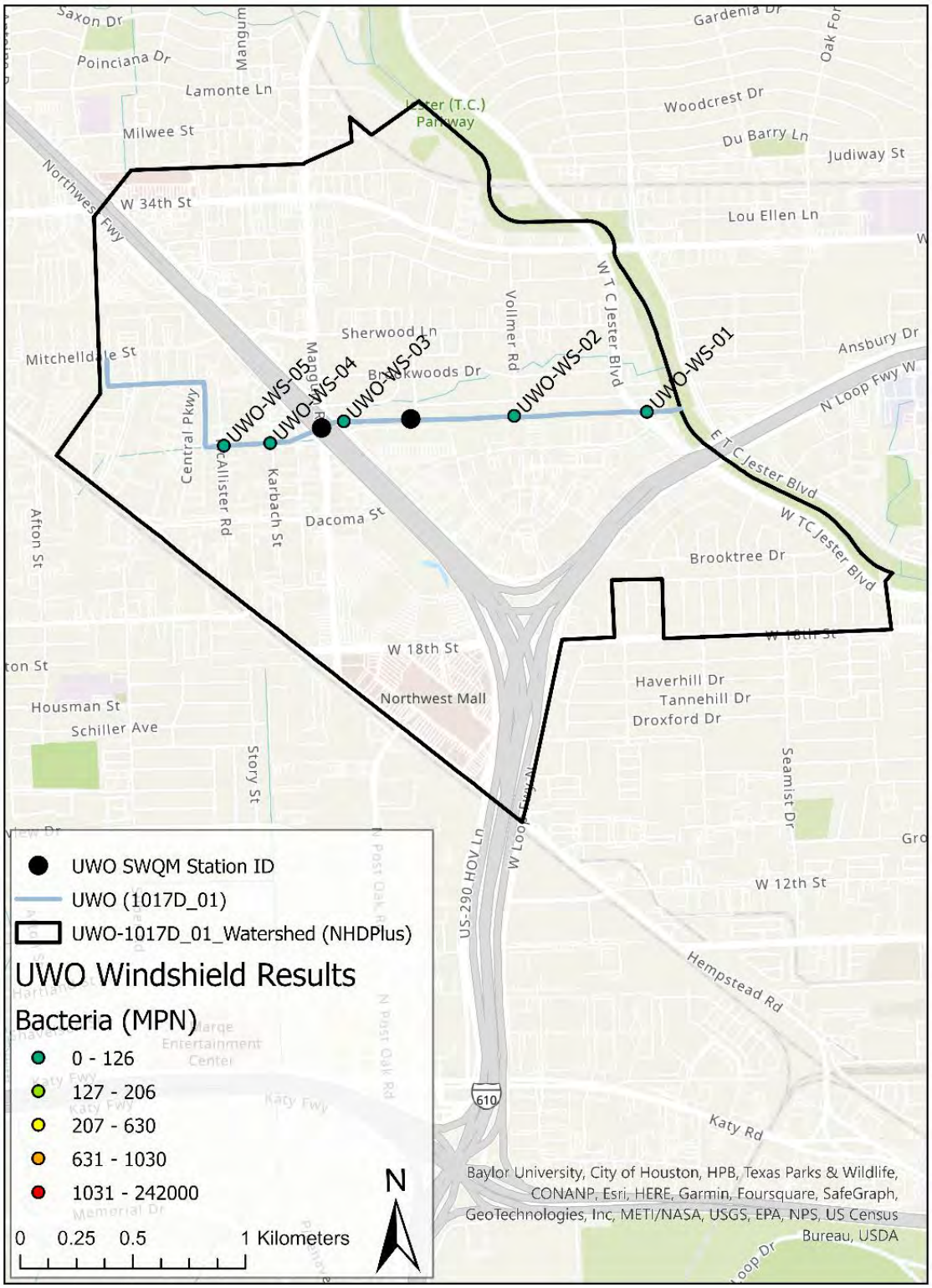


Figure 4 Windshield survey/ground truthing bacteria results from sampling on 03/14/2023 on Unnamed Tributary of White Oak Bayou (AU 1017D_01). Samples were taken at bridge crossings and other easily accessible points.

Field Investigation

Methods

The FI was a thorough survey where a team of two either walked or paddled the entire assessment unit and sampled any water observed flowing into the stream. Water could be flowing in from a pipe, culvert, natural tributary, or earthen ditch. Flowing water was categorized into two source types: permitted outfalls or unpermitted outfalls. Permitted outfalls included wastewater facilities and municipal separate storm sewer systems (MS4). Any pipe greater than 12 inches (in.) in diameter was assumed to be permitted by our field crews.

When flowing water was observed from a permitted outfall, two samples were collected. One sample was collected immediately downstream of the outfall where the flowing outfall was mixing with the ambient water. The second sample was taken upstream of the flowing outfall outside of the realm of influence from the outfall to provide the ambient bacteria levels of the assessment unit in that area. The second type of source was an unpermitted outfall, which was any other flowing source of water that was judged to not be permitted in the field, including flowing small (<12 in. diameter) “homemade” pipes and tributaries.

When a flowing unpermitted outfall was observed, the bacteria sample was taken directly from the source. If the source was a flowing pipe, the sample was collected directly from the pipe, before it entered the AU. If it was an open-top earthen ditch or natural tributary, the sample was collected from far enough into the inflow source that there was no mixing with the receiving water. In some cases, when no flowing permitted or unpermitted outfalls were observed in an extended section of the AU, a single ambient reference sample was taken mid-stream. Left and right bank references are oriented with the observer facing downstream.

Assessment Units, collection and laboratory methods, and data handling practices are detailed in Appendix J of the FY 2022-2023 H-GAC Multi-Basin Clean Rivers Program Quality Assurance Project Plan (H-GAC QAPP, 2022). For all field investigations the field team recorded location of the flowing outfall (latitude and longitude), the diameter, material, and water depth of the flowing outfall, and documented site conditions by taking photos and other relevant notes. All bacteria samples were collected following procedures listed in Appendix J of the FY 2022-2023 H-GAC Multi-Basin Clean Rivers Program Quality Assurance Project Plan (H-GAC QAPP, 2022) and analyzed by a National Environmental Laboratory Accreditation Program (NELAP)-Accredited laboratory.

Results

The FI was conducted on March 31, 2023 (14 days since last significant rainfall) and a total of 23 bacteria samples were collected. The values of the bacteria samples collected from downstream of permitted outfalls, directly from unpermitted outfalls, or as ambient samples

are summarized in Table 2 and Figure 5. Based on the data collected, two locations with elevated *E. coli* bacteria levels measured during the field investigation are recommended for high priority, and one location for low priority investigation by the proper authorities. These locations are summarized in Table 2 (highlighted in grey) and Figure 6. In addition, one location was flagged for further investigation where the upstream sample had elevated bacteria levels with no obvious explanations. High priority sites had the highest potential bacteria loading observed and are recommended to be the areas for local authorities to focus efforts on should there be insufficient resources to address all referral sites. As time and resources allow the low priority and "investigate further" referrals also are recommended for further investigation. Each of these referral summaries are listed in order of priority (High, Low, then Investigate Further). Within each priority group, sites are listed from downstream to upstream.

Table 2: Field investigation bacteria results from sampling on 3/31/2023 on Unnamed Tributary of While Oak Bayou (Assessment Unit 1017D_01). Referrals: N = No, Y-H = Yes – High Priority, Y-L = Yes-Low Priority, IF = Investigate Further, US = Upstream, DS = Downstream, RB = Right Bank, LB = Left Bank.

Sample ID	Lat	Long	DS or Direct *E. coli* Sample Results (MPN/100 mL)	US *E. coli* Sample Results (MPN/100 mL)	Difference* DS - US (MPN/100 mL)	Referral	Comments
UWO-FI1-01-D	29.81073	-95.44265	100	< 100	0	N	Under water pipes flow into White Oak Bayou.
UWO-FI1-02-P	29.81065	-95.44395	200	NA	NA	N	Taken directly from trickling weep hole in concrete-lined segment on left bank.
UWO-FI1-03-P	29.81065	-95.44405	410	NA	NA	N	Taken directly from trickling weep hole in concrete-lined segment on right bank.
UWO-FI1-04-D	29.81062	-95.44415	< 100	3,320	-3,220	IF	Used tampon and feminine pad at sample site on right bank.
UWO-FI1-05	29.81063	-95.44657	< 100	NA	NA	N	Ambient sample.
UWO-FI1-06-D	29.81061	-95.45042	< 100	< 100	0	N	Right bank.
UWO-FI1-07-D	29.81063	-95.45300	3,990	< 100	3,890	Y-H	Pipe on right bank pours into pool.
UWO-FI1-NS-1	29.81056	-95.45352	NA	NA	NA	N	Not sampled. Slow drip from pipe.
UWO-FI1-NS-2	29.81058	-95.45445	NA	NA	NA	N	Not sampled. Pool below pipe. Not currently flowing.
UWO-FI1-NS-3	29.81057	-95.45517	NA	NA	NA	N	Not sampled. Slow drip from pipe.
UWO-FI1-NS-4	29.81058	-95.45654	NA	NA	NA	N	Not sampled. Rainbow sheen on water surface. A potential source is a trash bag in water.
UWO-FI1-08-D	29.81058	-95.45686	< 100	< 100	0	N	Pipe in stream underwater. Unsure if it is leaking but took samples. Pipe just upstream of this pipe on right bank. Moist inside but no flow.
UWO-FI1-NS-5	29.81034	-95.45776	NA	NA	NA	N	Not sampled. Leaking valve on bank, not flowing into segment that we can see.
UWO-FI1-09	29.81058	-95.45810	< 100	NA	NA	N	Three sections of square culverts. Same latitude and longitude used. This one is on the right bank and heads southeast.
UWO-FI1-10	29.81058	-95.45810	< 100	NA	NA	N	Three sections of square culverts. Same latitude and longitude used. This one is the middle culvert.

Sample ID	Lat	Long	DS or Direct *E. coli* Sample Results (MPN/100 mL)	US *E. coli* Sample Results (MPN/100 mL)	Difference* DS - US (MPN/100 mL)	Referral	Comments
UWO-FI1-11	29.81058	-95.45810	< 100	< 100	NA	N	Three sections of square culverts. Same latitude and longitude used. This culvert is on the left bank. The water is pooled in this area.
UWO-FI1-12-D	29.80988	-95.46031	520	< 100	420	Y-H	US sample taken upstream of 290 where segment resurfaces after. DS sample taken from pipe on LB (2nd to last pipe) ~15m DS of upstream sample coordinates. Pipe on RB (across from pipe we sampled) has barely a trickle not sampled.
UWO-FI1-NS-6	29.80984	-95.46042	NA	NA	NA	N	Not sampled. Pipe is metal and rusty. Goes underground in center of segment and comes out from right bank.
UWO-FI1-13-P	29.80988	-95.45959	< 100	NA	NA	N	Pipe pouring in underground and using a stormwater drain into underground tunnel of tributary. Sample taken ~64m from where tributary resurfaces from underground. Latitude and longitude are estimates (under bridge).
UWO-FI1-14-D	29.80980	-95.46139	410	100	310	Y-L	Pipe is submerged and we are unable to tell if it is leaking but the concrete bank around it is collapsed and there is a deep pool under it.
UWO-FI1-15	29.80977	-95.46404	< 100	NA	NA	N	Ambient sample. White film on substrate. Small pool amidst very narrow and shallow section of tributary. Possible chemical (grease?) smell to sample. Flow is just a trickle.
UWO-FI1-16	29.80979	-95.46436	< 100	NA	NA	N	Top of wetted segment. Pipe seems to be main source of flow as it is completely dry upstream of here (after it turns 90 degrees to north) pipe comes from underground to west.

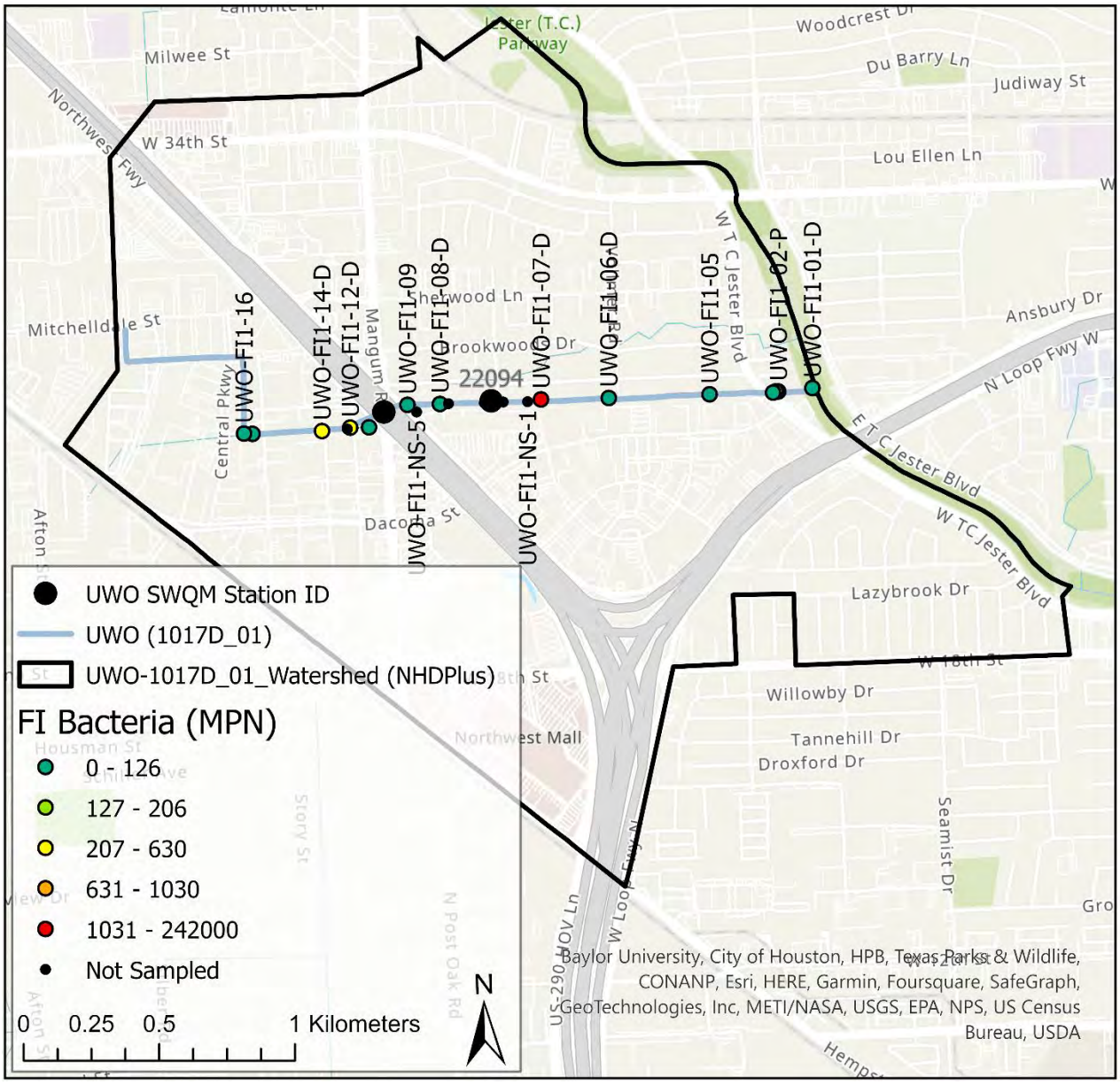


Figure 5: Field investigation bacteria sampling Results from 3/31/2023 on Unnamed Tributary of White Oak Bayou (Assessment Unit 1017D_01).

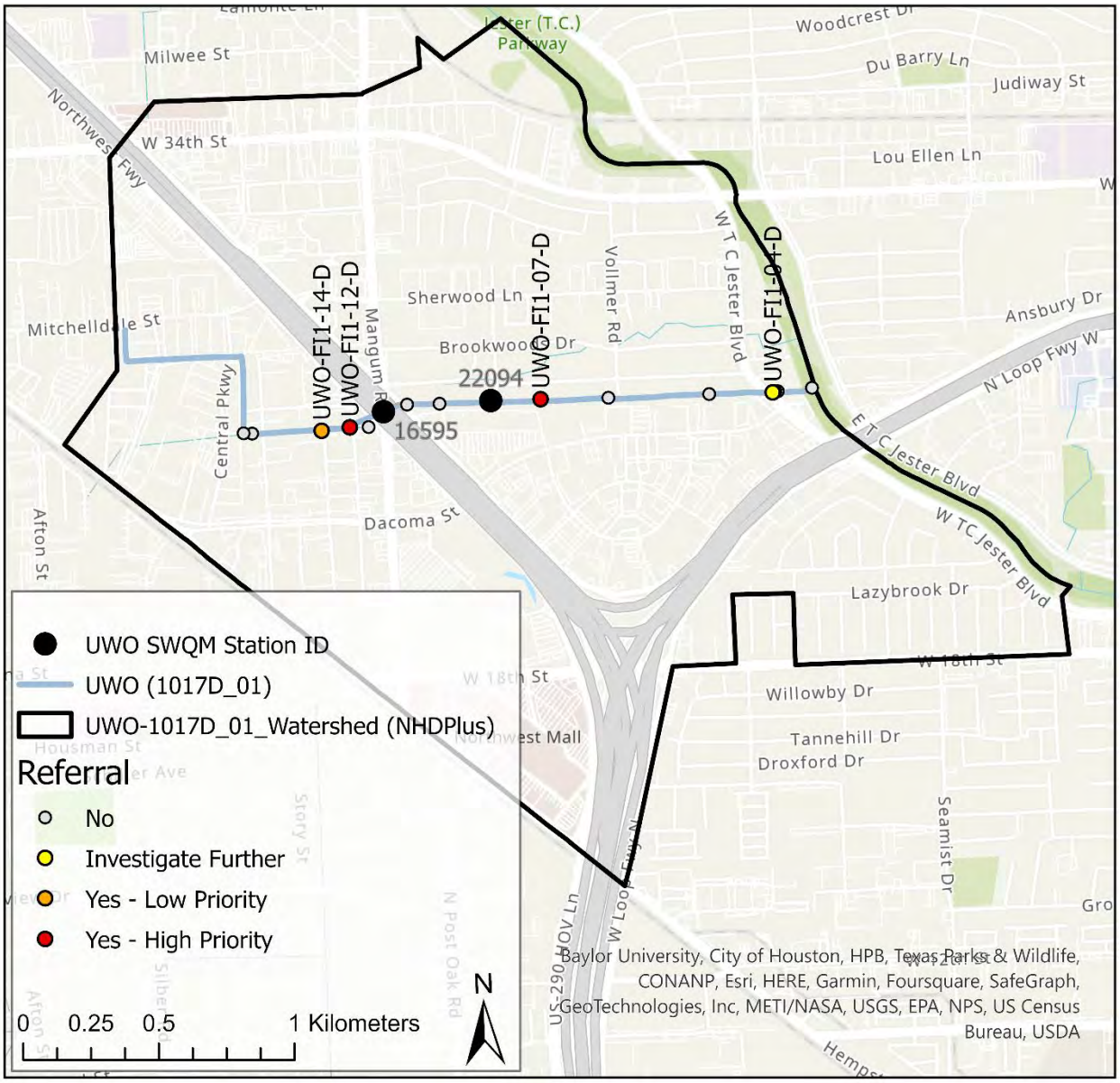


Figure 6: Field investigation sites sampled on 3/31/2023 and identified for referral to the proper authorities on Unnamed Tributary of White Oak Bayou (Assessment Unit 1017D_01).

Referral site: UWO-FI1-07-D– High Priority

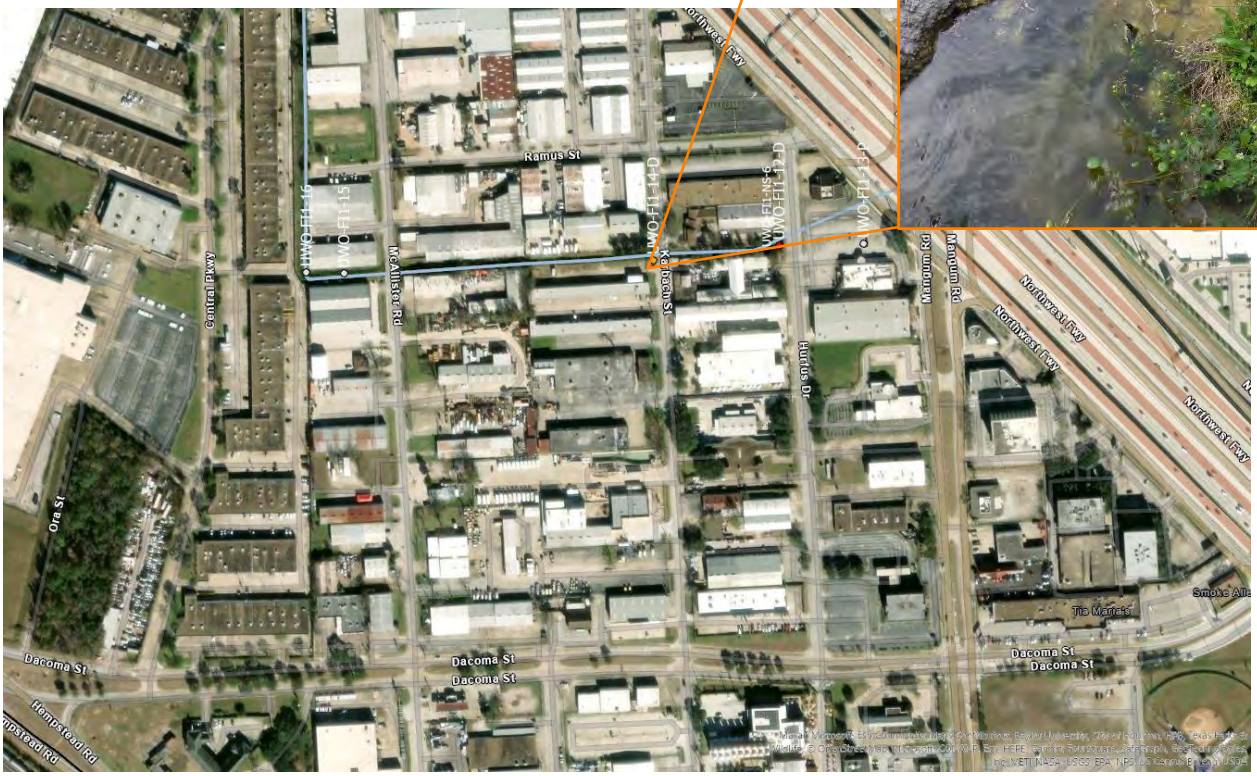
This is a 48 in. diameter metal pipe located on the right bank of the Unnamed Tributary to White Oak Bayou. Water within the pipe was 0.33 in. deep and flowing into a pooled area of the segment. There are commercial buildings located in the area on the right bank. A sample taken 0.3 m downstream of the pipe had a bacteria value of 3,990 MPN/100 mL. The ambient sample collected upstream of the pipe had a bacteria value of < 100 MPN/100 mL. This pipe is a high priority referral site for the proper local authority.

Referral site: UWO-FI1-12-D– High Priority

This is a 54 in. diameter cement pipe located on the left bank approximately 15 m downstream of the upstream side of the bridge on the Unnamed Tributary to White Oak Bayou. Water within the pipe was 0.6 in. deep and flowing into the segment. There was a pipe across from the sampled pipe that was barely trickling and not sampled. There are commercial buildings located in the area on the left bank. A sample taken 0.1 m downstream of the pipe had a bacteria value of 520 MPN/100 mL. The ambient sample collected upstream of the pipe had a bacteria value of < 100 MPN/100 mL. This pipe is a high priority referral site for the proper local authority.

Referral site: UWO-FI1-14-D– Low Priority

This is a 12 in. diameter cement pipe located on the right bank of the Unnamed Tributary to White Oak Bayou. The pipe is completely submerged and the field crew was unable to tell if it was flowing, but the cement bank around it was collapsed and there is a pool under it. There are commercial buildings located in the area on the right bank. A sample taken 1 m downstream of the pipe had a bacteria value of 410 MPN/100 mL. The ambient sample collected upstream of the pipe had a bacteria value of 100 MPN/100 mL. This pipe is a low priority referral site for the proper local authority.



Referral site: UWO-FI1-04-U – Investigate Further

This was an ambient upstream sample taken on the Unnamed Tributary of White Oak Bayou for reference with the sample UWO FI1-04-D taken at a pipe on the right bank near the TC Jester bridge crossing. The ambient sample taken just downstream of the bridge crossing had a bacteria value of 3,320 MPN/100 mL. Another ambient sample was taken approximately 235 m further upstream and had a bacteria value of < 100 MPN/100 mL. No potential point sources were observed within this reach. Further investigation is recommended by the proper local authority to determine the source of elevated bacteria in this section of the segment. There are single-family homes located on the left bank and commercial building located on the right bank in this section of the segment.

List of Acronyms and Abbreviations

AU	Assessment Unit
BIG	Bacteria Implementation Group
CRP	Clean Rivers Program
DS	Downstream
E. coli	*Escherichia coli*
FI	Field Investigation
FY	Fiscal Year
GIS	Geographic Information Systems
H-GAC	Houston-Galveston Area Council
IF	Investigate Further
in.	inch
I-Plan	Implementation Plan
km	kilometer
LB	Left Bank
m	meter
mL	milliliter
MPN	Most probable number
N	No
NELAP	National Environmental Laboratory Accreditation Program
NLCD	National Land Cover Database
OSSF	On-Site Sewage Facilities
QAPP	Quality Assurance Project Plan
RB	Right Bank
SWQM	Surface Water Quality Monitoring
SWRC	Stroud Water Research Center
T or trib.	Tributary
TCEQ	Texas Commission on Environmental Quality
TMDL	Total Maximum Daily Load
US	Upstream
UWO	Unnamed Tributary of White Oak Bayou 2 1017D_01
WS	Windshield Survey
Y-H	Yes – High Priority
Y-L	Yes-Low Priority

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Targeted Bacteria Monitoring Project

Field Investigation Final Report
Assessment Unit 1017E_01,
Unnamed Tributary of White Oak Bayou

Environmental Institute of Houston

August 1, 2023

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Segment Description

Segment 1017E is an unnamed tributary of White Oak Bayou (Figure 1). This segment consists of one assessment unit (AU) of concern, AU 1017E_01, that is 3.1 km long and is defined as from the confluence with White Oak Bayou Above Tidal, near West 11th Street, upstream to West 27th Street south of Loop 610 West in Harris County. There is one current (station ID: 16596) and one historic (station ID: 11151) surface water quality monitoring (SWQM) station located on this AU. This AU was selected for targeted monitoring due to a bacteria (*Escherichia coli*) seven-year geometric mean of 2,288 MPN/100 mL (H-GAC QAPP, 2022) and has a current impairment category of 4a (TCEQ, 2022). The potential sources of bacteria are non-point source pollution, urban runoff, and sanitary sewer overflows (TCEQ, 2022). This AU was previously monitored as part of the FY20-21 Targeted Monitoring Study.

The contributing watershed for this segment is 3 km^2 (Data source: HGAC, SWRC, 2023). The soil types in the area have slow to very slow infiltration rates (Data source: United States Department of Agriculture Hydrologic Soil Groups from gSSURGO 2016) and land cover in the watershed is dominated by 99.9 % developed land (Data source: National Land Cover Database NLCD 2019). There are no permitted wastewater outfalls in the watershed (Data source: H-GAC). There are also no documented permitted or unpermitted on-site sewage facilities (OSSF) on the segment (Data source: H-GAC).

Background

Clean Rivers Program (CRP) routine monitoring data are analyzed each year as part of the Houston-Galveston Area Council (H-GAC) Basin Summary/Basin Highlights Report process. Bacteria continues to be the most prevalent pollutant in the H-GAC CRP Basins (H-GAC, 2022). The Bacteria Implementation Group (BIG), formed in 2008, oversees the Total Maximum Daily Load (TMDL) Implementation Plan (I-Plan). The BIG requested that H-GAC produce a list of the water bodies with the highest bacteria concentrations in the BIG project area and conduct targeted monitoring to identify potential bacteria sources.

H-GAC, using information from previous Basin Highlights/Summary Reports, BIG annual reports, and previous targeted monitoring efforts, identified and selected waterways for targeted bacteria monitoring to refine our understanding of the spatial distribution of elevated bacterial concentrations contributing to these waterways. Phase 1 of this targeted monitoring project included an intensive desktop review of the most up to date imagery available and compilation of data from field investigations (FI) conducted in 2021. Phase 2 of this targeted monitoring project included a FI of the entire AU conducted during dry conditions where all flowing point and non-point sources were evaluated.

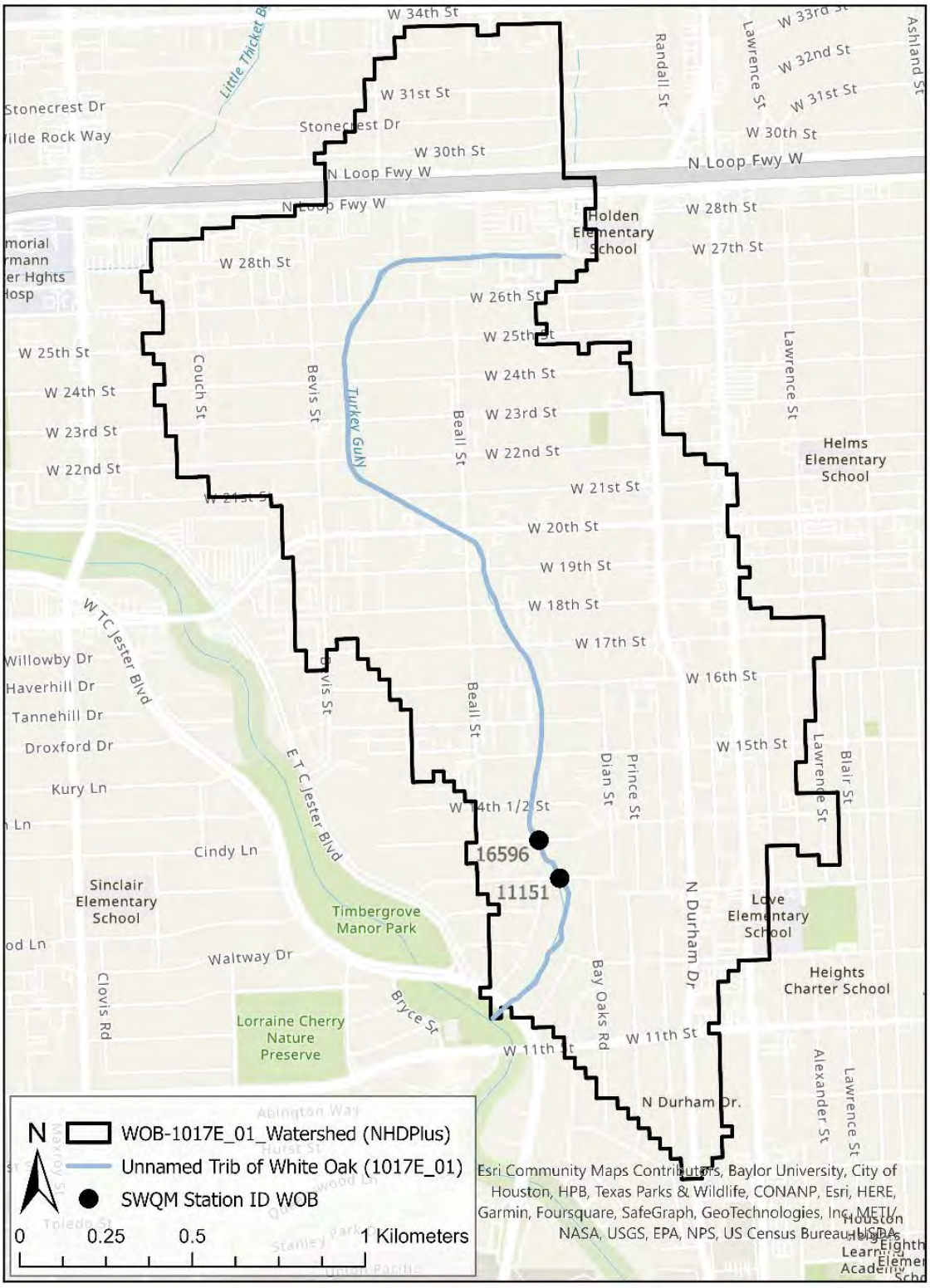

Figure 1: Watershed Map for Unnamed Tributary of White Oak Bayou, Assessment Unit 1017E_01.

Desktop Review

Methods

The intensive desktop review included an evaluation of permitted discharges, outfalls, and potential sources of point and nonpoint source pollution that may contribute to bacteria loading in the AU. Using Google Earth imagery and GIS, the locations of wastewater treatment facilities, permitted on-site sewage facilities (OSSFs), and potential locations of unpermitted OSSFs were identified. If present, other potential sources such as landfills and industrial facilities were also identified. Parks were noted, as these can contribute to bacterial sources through runoff of animal wastes but also provide opportunity for contact recreation. Bridge crossings and other public entry points were identified to provide access into the stream to collect bacteriological samples. The Environmental Institute of Houston conducted this review in 2021 and AU 1017E_01 was reviewed prior to beginning the 2023 FI.

Results

The results of the desktop review indicated that this unnamed tributary of White Oak Bayou runs between residential areas and commercial businesses. Potential sources of bacteria were identified during the FI in 2021 from an outfall from a broken concrete apron leading from a metal pipe, a permitted leaking metal pipe, and a concrete pipe that was discharging cloudy and sudsy water (Oakley and Lesher, 2021). Publicly accessible entry points into the stream

Windshield Survey

Methods

All field events must take place during dry weather (after three or more days without significant rainfall in the watershed). This ensures that any flowing water into the segment is not stormwater. Windshield surveys (WS) of the watershed were conducted in 2021 and bacteria sampling was performed at public access points throughout the AU (primarily at bridge crossings). The survey consisted of driving the catchment area to confirm identified pollution sources found during the desktop review and to find any potential sources not identified during that review. Bridge crossings chosen for sampling were spatially distributed to provide a spatial snapshot of bacteria concentrations in the AU and identify sections of the AU where elevated bacteria concentrations were found. Those areas with elevated bacteria levels identified in the WS monitoring were focused on during the FI of the FY20-21 study. The results from the 2021 sampling events were used to plan the 2023 FI. Therefore, a WS was not completed in 2023.

Assessment units, sample collection and laboratory methods, and data handling practices for the 2021 study are provided in Appendix J of the FY 2020-2021 H-GAC Multi-Basin Clean Rivers Program Quality Assurance Project Plan (H-GAC QAPP, 2020). For all WS bacteria monitoring

conducted in 2021, field personnel documented the latitude and longitude of sample locations. All bacteria samples were analyzed by a National Environmental Laboratory Accreditation Program (NELAP)-Accredited laboratory.

Results

The WS was conducted on March 10, 2021. At that time, it had been four days since the last significant rainfall in the watershed. A total of 13 bacteria samples were collected during the WS. Bacteria results from the ambient water samples collected during the WS ranged from 10-1990 MPN/100 mL.

Field Investigation

Methods

The following methods were conducted for the FI in 2021 and for the FI in 2023. Assessment Units, collection and laboratory methods, and data handling practices for the 2023 FI are detailed in Appendix J of the FY 2022-2023 H-GAC Multi-Basin Clean Rivers Program Quality Assurance Project Plan (H-GAC QAPP, 2022). The FI was a thorough survey where a team of two either walked or paddled the entire assessment unit and sampled dry-weather flow into the segment. Water could be flowing in from a pipe, culvert, natural tributary, or earthen/concrete-lined ditch. Flowing water was categorized into two source types: permitted outfalls or unpermitted outfalls. Permitted outfalls included wastewater facilities and municipal separate storm sewer systems (MS4). Any pipe greater than 12 inches (in.) in diameter was assumed to be permitted by our field crews.

When flowing water was observed from a permitted outfall, two samples were collected. One sample was collected immediately downstream of the outfall where the flowing outfall was mixing with the ambient water. The second sample was taken upstream of the flowing outfall outside of the realm of influence from the outfall to provide the ambient bacteria levels of the assessment unit in that area. The second type of source was an unpermitted outfall, which was any other flowing source of water that was judged to not be permitted in the field, including flowing small (<12 in. diameter) “homemade” pipes and tributaries.

When a flowing unpermitted outfall was observed, the bacteria sample was taken directly from the source. If the source was a flowing pipe, the sample was collected directly from the pipe, before it entered the segment. If it was an open-top earthen ditch or natural tributary, the sample was collected from far enough into the inflow source that there was no mixing with the receiving water. In certain cases, when no flowing permitted or unpermitted outfalls were observed in an extended section of the segment, a single ambient reference sample was taken mid-stream. Left and right bank references are oriented with the observer facing downstream.

For all FIs the field team recorded location of the flowing outfall (latitude and longitude), the diameter, material, and water depth of the flowing outfall, and documented site conditions by taking photos and other relevant notes. All bacteria samples were collected following procedures listed in Appendix J of the FY 2022-2023 H-GAC Multi-Basin Clean Rivers Program Quality Assurance Project Plan (H-GAC QAPP, 2022) and analyzed by a National Environmental Laboratory Accreditation Program (NELAP)-Accredited laboratory.

2021 Results and Recommendations

The 2021 FI was conducted on March 22, 2021 (five days since last significant rainfall) and a total of 26 bacteria samples were collected. The values of the bacteria samples collected from downstream of permitted outfalls, or directly from unpermitted outfalls are illustrated in Figure 2. Based on the data collected, three outfall locations with elevated *E. coli* bacteria levels measured during the FI were recommended for further investigation. Complete results and recommendations are available in the 2021 report (Oakley and Lesher, 2021).

Based upon the results of the 2021 FI, a second FI in 2023 covering the entire length of the AU was recommended. It was expected that if the previously reported referral sites were not successfully addressed, potential point or non-point sources of elevated bacteria would be identified near the following portions of the AU:

1. Site WOB-FI-01 was located where the main assessment unit intersects with W 14½ Street, between Beall Street and Dian Street. This metal pipe is located on the left bank. Just one sample was taken here from the broken concrete apron leading from the pipe with a bacteria value of 4,350 MPN/100 mL. This site, WOB-FI-01, was located just downstream of site WOB-FI-02, which also indicated bacteria loading.
2. Site WOB-FI-02 was a sealed, permitted metal pipe that runs about the main assessment unit of this tributary of White Oak Bayou. It is just upstream of site WOB-FI-01. Connected to the main pipe is a holding pump that was broken and leaking water into the stream along the left bank. One direct sample was taken here from the leaking pipe with a bacteria value of 3,870 MPN/100 mL. It appeared that this permitted pipe needs repair and has been leaking high bacteria water into the stream.
3. Site WOB-FI-15 was located under the road at the intersection of W 20th Street and Beall Street. It is downstream of a car dealership and many townhouses. The pipe located under the street is concrete. The sample taken just downstream of the outfall pipe was 1,620 MPN/100 mL. The ambient sample taken upstream of the outfall had a relatively low bacteria value (109 MPN/100 mL) indicating that this outfall is likely a source contributing to the elevated *E. coli* levels in this assessment unit. When initially passing this pipe, there was no water observed, but it began to flow while the team was sampling another area. The water coming from the pipe was sudsy and cloudy.

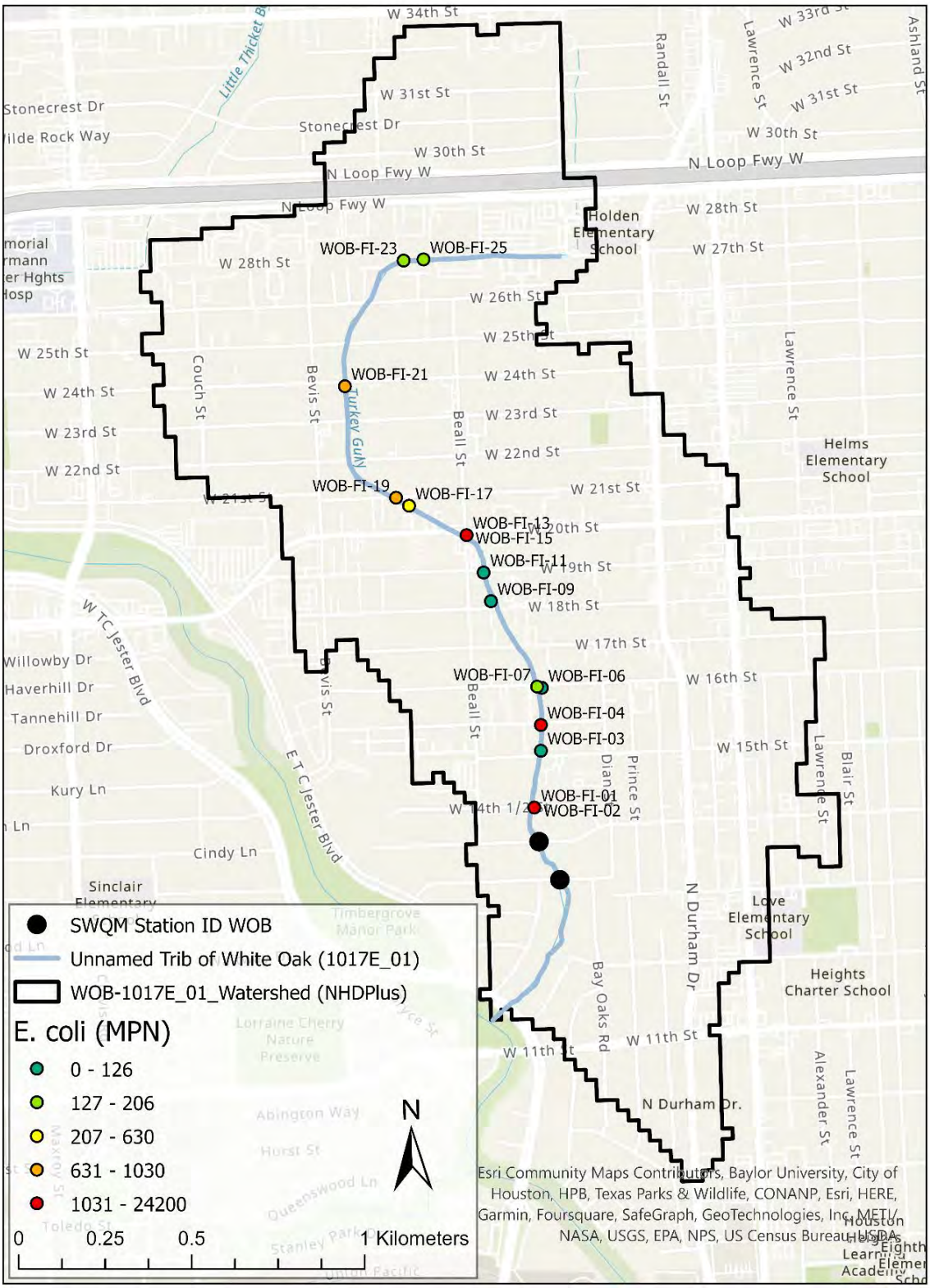

Figure 2: Field investigation bacteria sampling Results from 03/22/2021 on Unnamed Tributary of White Oak Bayou (AU 1017E_01).

2023 Field Investigation Results

The 2023 FI was conducted on March 30, 2023 (13 days since last significant rainfall) and a total of 27 bacteria samples were collected. The values of the bacteria samples collected from downstream of permitted outfalls, directly from unpermitted outfalls, or as ambient samples are summarized in Table 1 and Figure 3. Based on the data collected, two locations with elevated *E. coli* bacteria levels measured during the FI are recommended for high priority investigation by the proper authorities. High priority sites had the highest potential bacteria loading observed and are recommended to be the areas for local authorities to focus efforts on should there be insufficient resources to address all referral sites. As time and resources allow the low priority and "investigate further" referrals also are recommended for further investigation. These locations are summarized in Table 1 and Figure 4. In addition, two locations were flagged where ambient or upstream samples had elevated bacteria levels with no obvious explanations. Further investigation of these areas by the proper authorities are recommended. Each of these referrals are summarized by site, herein. The referral summaries are listed in order of priority (High, Low, then Investigate Further). Within each priority group, sites are listed from downstream to upstream.

Table 1: Field investigation bacteria results from sampling on 03/30/2023 on Unnamed Tributary of White Oak Bayou (AU 1017E_01). Referrals (gray rows): N = No, Y-H = Yes – High Priority, Y-L = Yes-Low Priority, IF = Investigate Further, US = Upstream, DS = Downstream. LB = Left Bank, RB = Right Bank.

Sample ID	Lat	Long	DS or Direct *E. coli* Sample Results (MPN/100 mL)	US *E. coli* Sample Results (MPN/100 mL)	Difference* DS - US (MPN/100 mL)	Referral	Comments
WOB-FI2-01	29.79100	-95.41759	300	NA	NA	N	Ambient sample taken just upstream of confluence.
WOB-FI2-02	29.79152	-95.41685	860	NA	NA	N	Ambient sample from where water goes under road.
WOB-FI2-03	29.79377	-95.41531	5,200	NA	NA	Y-H	Substrate is black with a white film. Sample from mixing zone of submerged pipe. Could not tell if it was flowing. Pooled in front of pipe. LB.
WOB-FI2-04-D	29.79548	-95.41610	630	850	-220	N	Submerged pipe on LB.
WOB-FI2-05-D	29.79790	-95.41599	410	1,480	-1,070	N	Water coming out of pipe on LB appears sudsy. Evidence people go into pipe (graffiti).
WOB-FI2-06-D	29.79862	-95.41595	310	1,210	-900	N	Trickle coming out of pipe on LB.
WOB-FI2-07-D	29.79956	-95.41592	< 100	1,600	-1,500	N	Sheen on water downstream of culvert on LB.
WOB-FI2-08	29.80142	-95.41703	41,000	NA	NA	N	Big pool that was cloudy/milky. Potential source unknown. Ambient sample. Snapping turtle present.
WOB-FI2-09	29.80362	-95.41795	173,000	NA	NA	Y-H	Ambient sample of where segment goes underground.
WOB-FI2-10	29.80381	-95.41857	100	NA	NA	N	Ambient sample between 2 tunnels.
WOB-FI2-11	29.80416	-95.41933	100	NA	NA	N	Ambient sample where water resurfaces. oyster shells
WOB-FI2-12	29.80464	-95.42014	750	NA	NA	N	Ambient sample taken downstream of bridge. Choked with elephant ear, alligator weed, and arrowhead.
WOB-FI2-13	29.80570	-95.42143	630	NA	NA	N	Ambient sample taken DS of construction on bank.
WOB-FI2-14	29.80879	-95.42142	6,130	NA	NA	IF	Ambient sample taken upstream of bridge.
WOB-FI2-15	29.80970	-95.42075	310	NA	NA	N	Sample taken downstream of bridge.
WOB-FI2-16-D	29.81024	-95.42041	100	980	-880	N	Submerged pipe on RB. No visible flow.
WOB-FI2-17-D	29.81088	-95.41992	1,350	11,800	-10,450	IF	Submerged culvert on right bank.
WOB-FI2-18-D	29.81091	-95.41962	630	520	110	N	Trickling out of pipe on LB.
WOB-FI2-19-D	29.81091	-95.41907	< 100	200	-100	N	Dripping out of pipe on LB. Upstream sample taken was almost at top of AU.

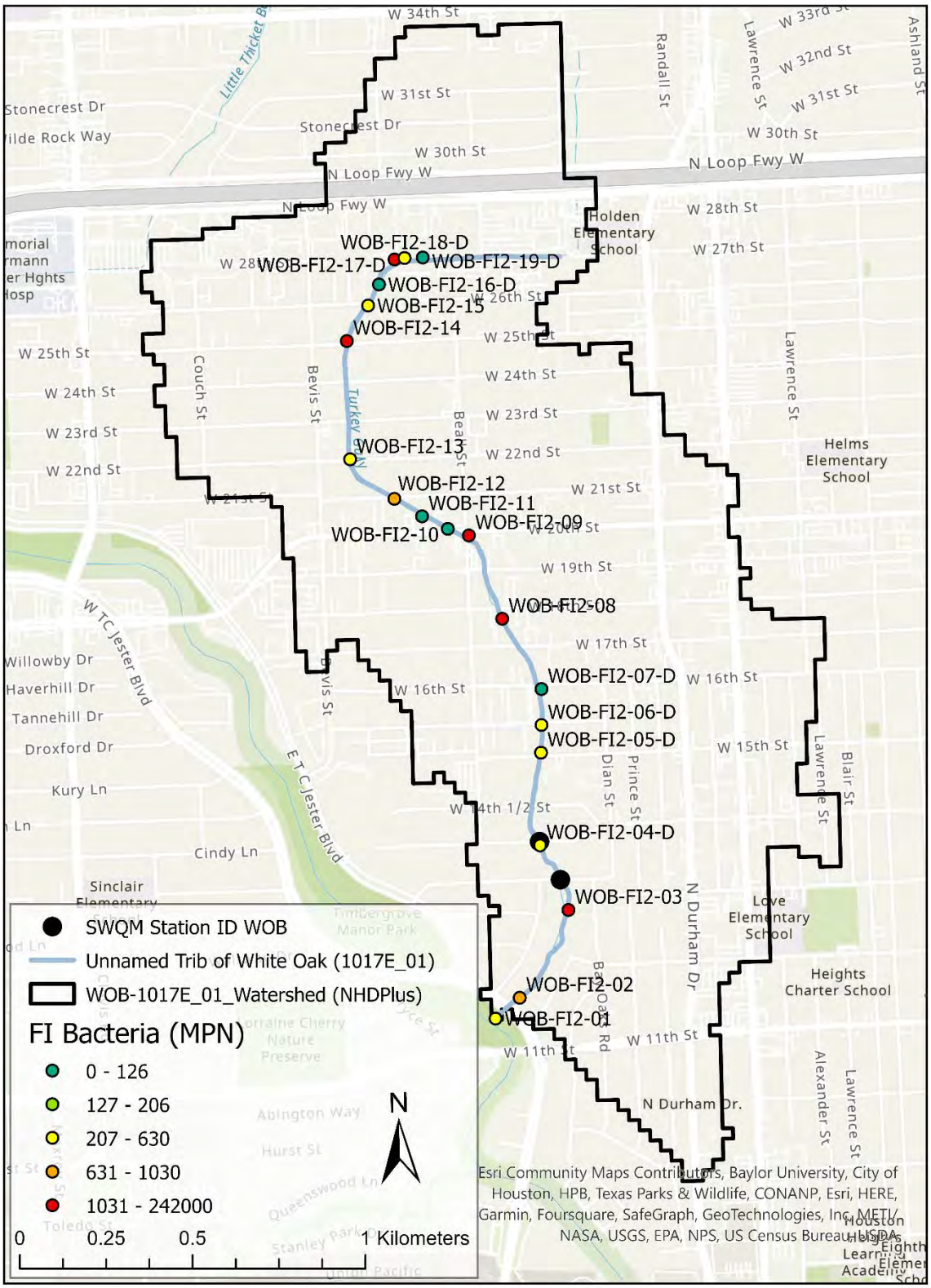

Figure 3: Field investigation bacteria sampling Results from 03/30/2023 on the Unnamed Tributary of White Oak Bayou (Assessment Unit 1017E_01).

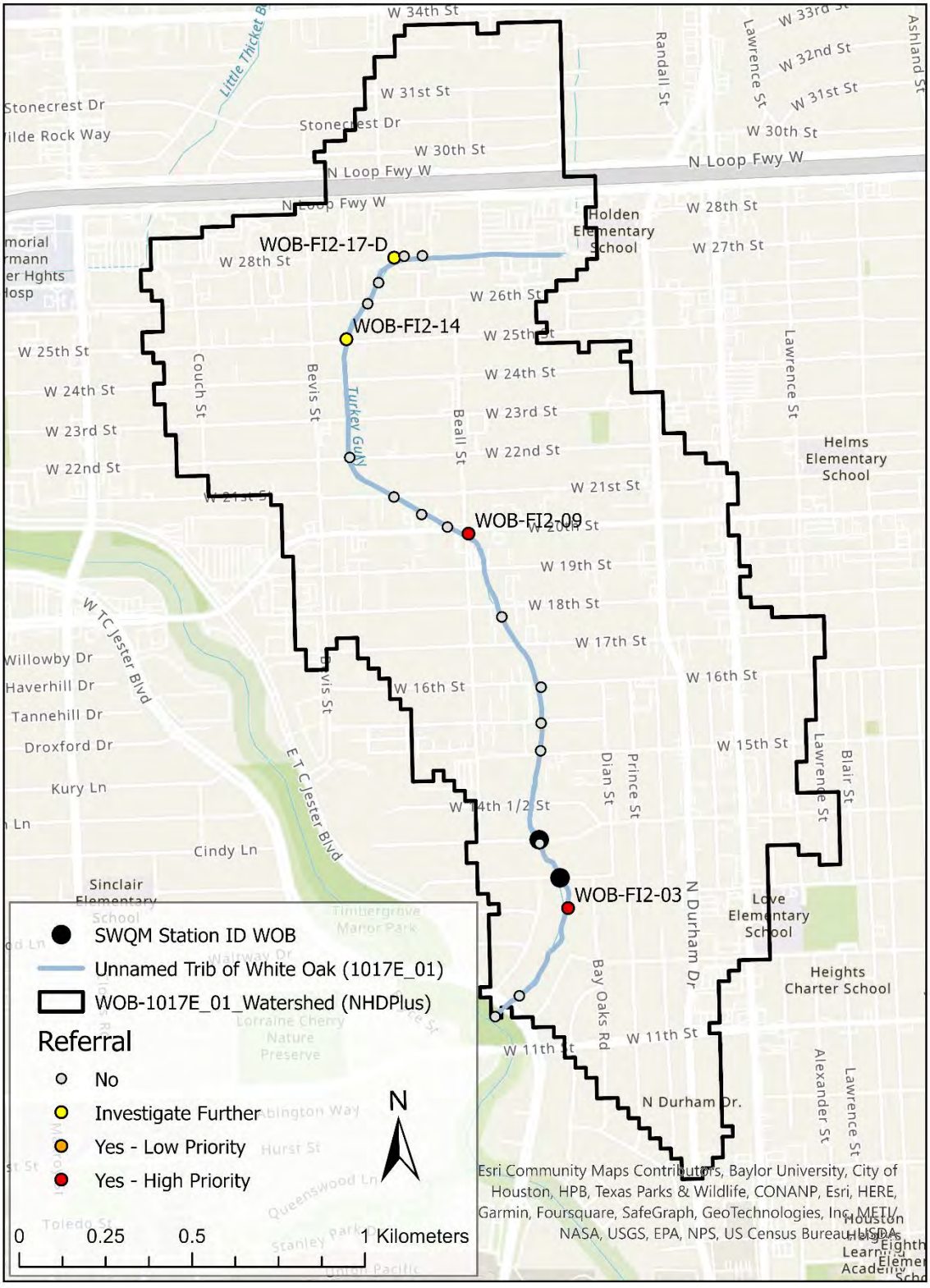

Figure 4: Field investigation sites sampled on 03/30/2023 and identified for referral to the proper authorities on the Unnamed Tributary of White Oak Bayou (Assessment Unit 1017E_01).

Referral site: WOB-FI2-03 – High Priority

This is a 51 in. diameter concrete pipe that was partially submerged on the left bank of the Unnamed Tributary of White Oak Bayou. Water within the pipe was 36 in. deep and the field crew was unable to tell if it was flowing into the segment due to it being submerged. The area in front of the pipe was a stagnant pool and the substrate appeared to be black in color with a white film on top. When disturbed, the substrate gave off an anoxic odor. Due to the pipe being submerged, the downstream sample was taken within the mixing zone in front of the mouth of the pipe and had a bacteria value of 5,200 MPN/100 mL. An ambient sample was not collected directly upstream of this pool, but the next ambient sample collected approximately 200 m upstream of the pipe had a bacteria value of 850 MPN/100 mL. This pipe is a high priority referral site for the proper local authority.

Referral site: WOB-FI2-09 – High Priority

This is where the Unnamed Tributary of White Oak Bayou goes underground. An ambient sample was collected just downstream of this bridge and had a bacteria value of 173,000 MPN/100 mL. The next ambient sample collected approximately 460 m upstream had a bacteria value of 100 MPN/100 mL. There were no pipes between these two ambient samples that were observed to be flowing into the AU at the time of sampling. This portion of the AU runs through a mix of restaurants, clubs, and residences. This section of the AU is a high priority referral site for the proper local authority.

Referral site: WOB-FI2-14 – Investigate Further

This was an ambient sample taken just upstream of the bridge of W 25th St. on the Unnamed Tributary of White Oak Bayou. This ambient sample had a bacteria value of 6,130 MPN/100 mL. The next ambient sample was collected 115 m upstream and had a bacteria value of 310 MPN/100 mL. No pipes were observed to be flowing between these two sampling locations during the time of sampling. Further investigation is recommended by the proper local authority to determine the source of elevated bacteria in this section of the AU. There are apartment and single-family homes located upstream of the site.

Referral site: WOB-FI2-17-U – Investigate Further

This portion between two pipes had suspect levels of bacteria. The ambient sample taken just upstream of this pipe had a bacteria value of 11,800 MPN/100 mL yet the sample collected downstream of the next pipe (18-D), which was only 30 m upstream, had a bacteria value of 630 MPN/100 mL. There were no pipes that were observed to be flowing into the AU between pipes 17-D and 18-D at the time of sampling. Further investigation is recommended by the proper local authority to determine the source of elevated bacteria in this section of the AU. There are apartments and single-family homes located upstream of the site, as well as commercial properties.

List of Acronyms and Abbreviations

AU	Assessment Unit
BIG	Bacteria Implementation Group
CRP	Clean Rivers Program
DS	Downstream
E. coli	*Escherichia coli*
FI	Field Investigation
FY	Fiscal Year
GIS	Geographic Information Systems
H-GAC	Houston-Galveston Area Council
IF	Investigate Further
in.	inch
I-Plan	Implementation Plan
km	kilometer
LB	Left Bank
m	meter
mL	milliliter
MPN	Most probable number
N	No
NELAP	National Environmental Laboratory Accreditation Program
NLCD	National Land Cover Database
OSSF	On-Site Sewage Facilities
QAPP	Quality Assurance Project Plan
RB	Right Bank
SWQM	Surface Water Quality Monitoring
SWRC	Stroud Water Research Center
T or trib.	Tributary
TCEQ	Texas Commission on Environmental Quality
TMDL	Total Maximum Daily Load
US	Upstream
WOB	Unnamed Tributary of White Oak Bayou 1017E_01
WS	Windshield Survey
Y-H	Yes – High Priority
Y-L	Yes-Low Priority

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Targeted Bacteria Monitoring Project

Field Investigation Final Report

Assessment Unit 1101D_01, Robinson Bayou

Environmental Institute of Houston

August 1, 2023

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Segment Description

Robinson Bayou is Segment 1101D, is 4.34 km long, and is defined as from the confluence with Clear Creek to 0.53 km upstream of Webster Street in Galveston County (Figure 1). Two assessment units (AU) are included on the segment: AU 1101D_01 is the non-tidal portion of Robinson Bayou, while AU 1101D_02 is the tidal portion. Abilene Street delineates the location where Robinson Bayou becomes tidally influenced. There are three current and historic surface water quality monitoring (SWQM) stations located on this segment: one is located on AU 1101D_01 (station ID: 16486) while two stations are located on AU 1101D_02 (station IDs: 16475 and 16572). The AU 1101D_01 has been selected for targeted monitoring due to a bacteria (*Escherichia coli*) seven-year geometric mean of 305.4 MPN/100 mL (H-GAC QAPP, 2022). The AU is listed for exceedances of bacteria in the water (Recreation Use) with an impairment category of 4a and a 5c impairment for dissolved oxygen (Aquatic Life Use) (TCEQ, 2022). The potential sources of bacteria impairments are non-point source pollution, unspecified domestic waste, and urban stormwater (TCEQ, 2022). This AU was monitored previously as part of the FY20-21 Targeted Monitoring Study.

The contributing watershed for this segment is 6 km^2 (Data source: H-GAC, SWRC, 2023). The soil types in the watershed have medium to very slow infiltration rates (Data source: United States Department of Agriculture Hydrologic Soil Groups from gSSURGO 2016), while the land cover is predominately developed (78.95%) (Data source: National Land Cover Database NLCD 2019). There are not any permitted wastewater outfalls in the watershed (Data source: H-GAC). There are 683 documented permitted and 41 documented unpermitted on-site sewage facilities (OSSF) within the watershed (Data source: H-GAC).

Background

Clean Rivers Program (CRP) routine monitoring data are analyzed each year as part of the Houston-Galveston Area Council (H-GAC) Basin Summary/Basin Highlights Report process. Bacteria continues to be the most prevalent pollutant in the H-GAC CRP Basins (H-GAC, 2022). The Bacteria Implementation Group (BIG), formed in 2008, oversees the Total Maximum Daily Load (TMDL) Implementation Plan (I-Plan). The BIG requested that H-GAC produce a list of the water bodies with the highest bacteria concentrations in the BIG project area and conduct targeted monitoring to identify potential bacteria sources.

H-GAC, using information from previous Basin Highlights/Summary Reports, BIG annual reports, and previous targeted monitoring efforts, identified and selected waterways for targeted bacteria monitoring to refine our understanding of the spatial distribution of elevated bacterial concentrations contributing to these waterways. Phase 1 of this targeted monitoring project included an intensive desktop review of the most up to date imagery available and compilation of data from field investigations (FI) conducted in 2021. Phase 2 of this targeted monitoring

project included a FI of the entire AU conducted during dry conditions where all flowing point and non-point sources were evaluated.

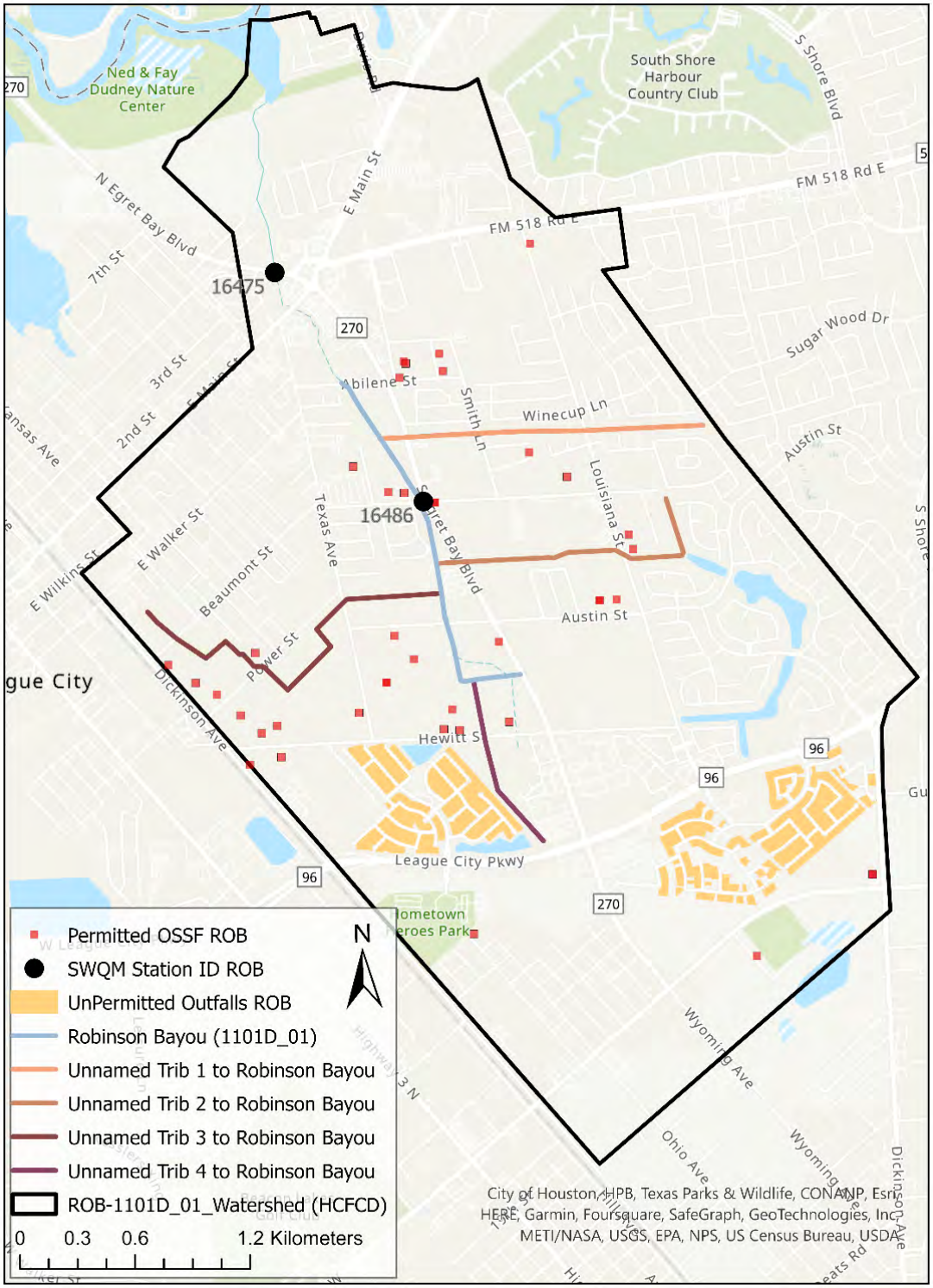

Figure 1: Watershed Map for Robinson Bayou (Assessment Unit 1101D_01).

Desktop Review

Methods

The intensive desktop review included an evaluation of permitted discharges, outfalls, and potential sources of point and nonpoint source pollution that may contribute to bacteria loading in the AU. Using Google Earth imagery and GIS, the locations of wastewater treatment facilities, permitted on-site sewage facilities (OSSFs), and potential locations of unpermitted OSSFs were identified. If present, other potential sources such as landfills and industrial facilities were also identified. Parks were noted as these can contribute to bacterial sources through runoff of animal wastes but also provide opportunity for contact recreation. Bridge crossings and other public entry points were identified to provide access into the stream to collect bacteriological samples. The Environmental Institute of Houston conducted this review in 2021 and AU 1101D_01 was reviewed again prior to beginning the 2023 FI.

Results

The results of the desktop review indicated that four unnamed tributaries run into Robinson Bayou. The course of this AU has been corrected from previous maps reported after the 2021 FI indicated a different route of the water (Oakley, 2021). Robinson Bayou and contributing unnamed tributaries are surrounded by residential neighborhoods, trails, woody areas, schools, and commercial businesses. Publicly accessible entry points into Robinson Bayou were identified at Abilene Street, Webster Street, South 270, Austin Street, and finally Egret Bay Boulevard. An access point to enter the first unnamed tributary of Robinson Bayou was identified just south of Paintbrush Avenue and South Egret Bay Boulevard continuing east in the tributary towards Smith Lane, Louisiana Avenue, and finally at the end of the cul-de-sac of Purple Horse Drive. An access point to enter the second unnamed tributary of Robinson Bayou was identified at 29.508775, -95.069656 on South Egret Bay Boulevard, continuing east in the tributary towards Louisiana Avenue, Astoria Lane, Lombardia Drive, and finally at Milano Lane. The third unnamed tributary can be accessed at Austin Street and Robinson Bayou heading upstream. Following the unnamed tributary west, an access point is on Texas Avenue, Power Street, and at Beaumont Street. The fourth unnamed tributary to Robinson Bayou can be accessed via South Egret Boulevard heading downstream and then at Hewitt Street, and finally at League City Parkway.

Windshield Survey

Methods

Field events must take place during dry weather (after three or more days without significant rainfall in the watershed). This ensures that any flowing water into the segment is not stormwater. Windshield surveys (WS) of the watershed were conducted in 2021 and bacteria sampling was

performed at public access points throughout the AU (primarily at bridge crossings). The survey consisted of driving the catchment area to confirm identified pollution sources found during the desktop review and to find any potential sources not identified during that review. Bridge crossings chosen for sampling were spatially distributed to provide a spatial snapshot of bacteria concentrations in the AU and identify sections of the AU where elevated bacteria concentrations were found. Those areas with elevated bacteria levels identified in the WS monitoring were focused on during the FI of the FY20-21 study. The results from the 2021 sampling events were used to plan the 2023 FI. Therefore, a WS was not completed in 2023.

Assessment Units, sample collection and laboratory methods, and data handling practices for the 2021 study are detailed in Appendix J of the FY 2020-2021 H-GAC Multi-Basin Clean Rivers Program Quality Assurance Project Plan (H-GAC QAPP, 2020). For all WS bacteria monitoring conducted in 2021, field personnel documented the latitude and longitude of sample location. All bacteria samples were analyzed by a National Environmental Laboratory Accreditation Program (NELAP)-Accredited laboratory.

Results

The WS was conducted on February 9, 2021. At that time, it had been four days since the last significant rainfall in the watershed. A total of six samples were collected on AU 1101D_01 and four on contributing tributaries during the WS. Bacteria results from the ambient water samples collected during the WS ranged from 10 to 857 MPN/100ML.

Field Investigation

Methods

The following methods were used for both the FI in 2021 and 2023. Assessment Units, collection and laboratory methods, and data handling practices for the 2023 FI are detailed in Appendix J of the FY 2022-2023 H-GAC Multi-Basin Clean Rivers Program Quality Assurance Project Plan (H-GAC QAPP, 2022). The FI was a thorough survey where a team of two either walked or paddled the entire assessment unit and sampled dry-weather flow into the segment. Water could be flowing in from a pipe, culvert, natural tributary, or earthen/concrete-lined ditch. Flowing water was categorized into two source types: permitted outfalls or unpermitted outfalls. Permitted outfalls included wastewater facilities and municipal separate storm sewer systems (MS4). Any pipe greater than 12 inches (in.) in diameter was assumed to be permitted by our field crews.

When flowing water was observed from a permitted outfall, two samples were collected. One sample was collected immediately downstream of the outfall where the flowing outfall was mixing with the ambient water. The second sample was taken upstream of the flowing outfall outside of the realm of influence from the outfall to provide the ambient bacteria levels of the assessment unit in that area. The second type of source was an unpermitted outfall, which was any other

flowing source of water that was judged to not be permitted in the field, including flowing small (<12 in. diameter) “homemade” pipes and tributaries.

When a flowing unpermitted outfall was observed, the bacteria sample was taken directly from the source. If the source was a flowing pipe, the sample was collected directly from the pipe, before it entered the segment. If it was an open-top earthen ditch or natural tributary, the sample was collected from far enough into the inflow source that there was no mixing with the receiving water. In some cases, when no flowing permitted or unpermitted outfalls were observed in an extended section of the segment, a single ambient reference sample was taken mid-stream. Left and right bank references are oriented with the observer facing downstream.

For all FIs, the field team recorded location of the flowing outfall (latitude and longitude), the diameter, material, and water depth of the flowing outfall, and documented site conditions by taking photos and other relevant notes. All bacteria samples were collected following procedures listed in Appendix J of the FY 2022-2023 H-GAC Multi-Basin Clean Rivers Program Quality Assurance Project Plan (H-GAC QAPP, 2022) and analyzed by a National Environmental Laboratory Accreditation Program (NELAP)-Accredited laboratory.

2021 Results and Recommendations

The results from the WS were used to prioritize the FI in 2021 to focus on the main Robinson Bayou assessment unit and the two tributaries on the eastern side of the Bayou which had the highest ambient bacteria results from the WS (Unnamed Tributary 1: 355 MPN/100 mL and Unnamed Tributary 2: 794 MPN/10 mL). The FI was conducted on March 11, 2021 (6 days since last significant rainfall) and a total of 53 bacteria samples were collected. During the 2021 FI, Robinson Bayou and three unnamed tributaries resulted in multiple culverts and pipes contributing to elevated bacteria levels. The values of the bacteria samples collected from downstream of permitted outfalls, or directly from unpermitted outfalls are illustrated in Figure 2. A total of nine referral locations with elevated *E. coli* bacteria levels measured during the FI in 2021 were recommended for further investigation by the proper authorities. Complete results and recommendations are available in the 2021 report (Oakley, 2021). Based on these results, a second FI on this segment was recommended to be sampled in 2023.

Because no elevated bacteria levels were observed downstream of this AU during the 2021 FI, only the above-tidal portion of this segment was sampled in 2023 (AU 1101D_01). Based upon the results of the 2021 FI, a FI covering the entire length of the AU was recommended. The first unnamed tributary at the northern portion of Robinson Bayou exhibited the highest bacteria levels of all of the unnamed tributaries during the 2021 FI and was recommended for further sampling in 2023. A sample was taken at the confluence of the western most unnamed tributary to Robinson Bayou during the 2021 WS and FI and the bacteria levels were < 126 therefore it was not recommended to be sampled in 2023.

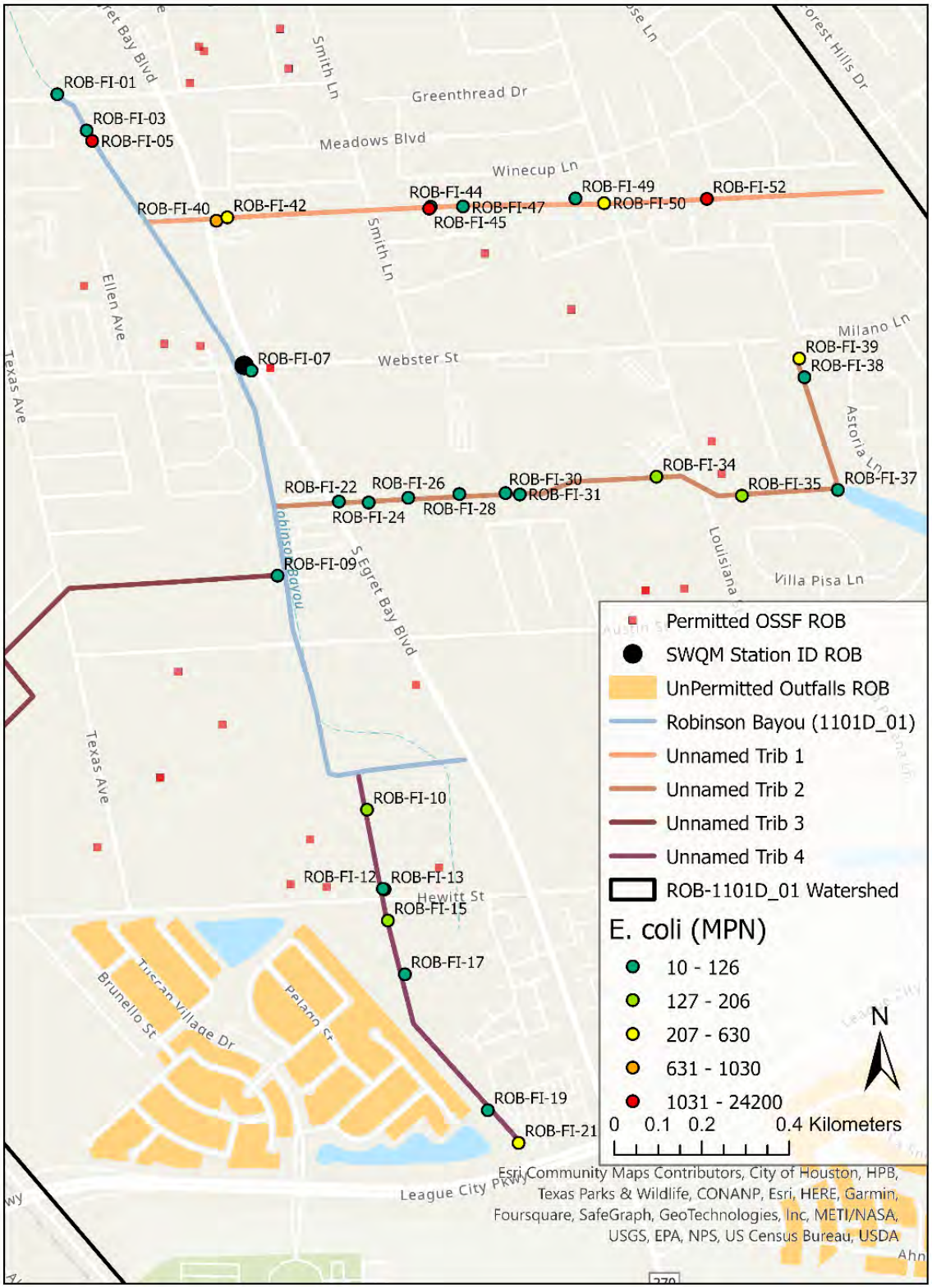

Figure 2: Field investigation bacteria sampling results from 03/11/2021 on Robinson Bayou (AU 1101D_01).

2023 Results

The 2023 FI was conducted on May 2, 2023 (three days since last significant rainfall) and a total of 70 bacteria samples were collected. The values of the bacteria samples collected from downstream of permitted outfalls, directly from unpermitted outfalls, or as ambient samples are summarized in Table 1 and Figure 4. Based on the data collected, four locations with elevated *E. coli* bacteria levels measured during the field investigation are recommended for high priority, and three locations for low priority investigation by the proper authorities. These locations are summarized in Table 1 (highlighted in grey) and Figure 5. In addition, one location was flagged where the ambient sample had elevated bacteria levels with no obvious explanations. High priority sites had the highest potential bacteria loading observed and are recommended to be the areas for local authorities to focus efforts on should there be insufficient resources to address all referral sites. As time and resources allow the low priority and "investigate further" referrals also are recommended for further investigation. Further investigation of these areas by the proper authorities is recommended. Each of these referrals are summarized by site, herein. The referral summaries are listed in order of priority (High, Low, then Investigate Further). Within each priority group, sites are listed from downstream to upstream.

While not related to bacteria, the field crew observed a flow diversion structure that is washing out and causing a bank failure just upstream of Louisiana Ave and the Unnamed Tributary #2 bridge crossing at approximately 29.50854, -95.06004. If the proper authorities are not aware of this infrastructure failure it is recommended that they investigate this further.

Figure 3: Bank collapse at water diversion

Table 1: Field investigation bacteria results from sampling on 5/2/2023 on Robinson Bayou (Assessment Unit 1101D_01). Referrals: N = No, Y-H = Yes – High Priority, Y-L = Yes-Low Priority, IF = Investigate Further, LB = Left Bank, RB= Right Bank, US = Upstream, DS = Downstream.

Sample ID	Lat	Long	DS or Direct *E. coli* Sample Results (MPN/100 mL)	US *E. coli* Sample Results (MPN/100 mL)	Difference* DS - US (MPN/100 mL)	Referral	Comments
ROB-FI2-01	29.51704	-95.07520	100	NA	NA	N	Ambient sample bottom of segment.
ROB-FI2-02-D	29.51643	-95.07486	200	310	-110	N	Submerged pipe on left bank, unable to see flow, but can hear trickle inside pipe.
ROB-FI2-04-D	29.51621	-95.07474	200	200	0	N	Pipe on left bank. Water flowing under, not through.
ROB-FI2-T1-01	29.51454	-95.07339	520	NA	NA	N	Ambient sample at first trib.
ROB-FI2-05-D	29.51345	-95.07271	410	200	210	Y-L	Rusted out pipe, extends into Bayou, submerged. Right bank. Unable to tell if flowing.
ROB-FI2-06-D	29.51190	-95.07152	100	100	0	N	Submerged pipe on left bank. RV Parks on left bank.
ROB-FI2-07-D	29.51023	-95.07102	200	100	100	N	Submerged pipe on left bank. Unable to tell if flowing.
ROB-FI2-T3-01	29.50711	-95.07055	200	NA	NA	N	Ambient sample at Trib. 3.
ROB-FI2-08	29.50711	-95.07049	520	NA	NA	N	Ambient sample up from Trib. 3.
ROB-FI2-09-D	29.50694	-95.07040	310	970	-660	N	Pipe of right bank with vegetation growing on it. Water flows down concrete.
ROB-FI2-10-D	29.50585	-95.07032	850	< 100	750	Y-H	Pipe on left bank trickling - submerged. Pipe on RB across from sample has small trickle. Did not sample right bank.
ROB-FI2-NS-01	29.50376	-95.06980	NA	NA	NA	N	Concrete is wet on cracks. No obvious source.
ROB-FI2-11	29.50309	-95.06839	< 100	NA	NA	N	Ambient sample.
ROB-FI2-12-D	29.50225	-95.06877	510	100	410	Y-H	Pipe on right bank. Water brown. Water bubbling up from substrate. Pipe submerged sediment in pipe appears reddish. Pipe across (left bank) wet but not flowing.
ROB-FI2-NS-02	29.50121	-95.06852	NA	NA	NA	N	Not sampled pipe. Wet at entrance, no flow.
ROB-FI2-13-D	29.50057	-95.06846	100	< 100	0	N	Culvert submerged on left bank.
ROB-FI2-14-D	29.50057	-95.06838	< 100	< 100	0	N	Concrete culvert submerged on right bank. Upstream sample same as 13.
ROB-FI2-15-D	29.49995	-95.06832	100	100	0	N	Submerged pipe of LB. Many apple snails and eggs.

Sample ID	Lat	Long	DS or Direct *E. coli* Sample Results (MPN/100 mL)	US *E. coli* Sample Results (MPN/100 mL)	Difference* DS - US (MPN/100 mL)	Referral	Comments
ROB-FI2-16-D	29.49880	-95.06800	< 100	< 100	0	N	D-Sample is from mixing of 2 culverts on RT Bank, both drain a detention basin behind an apartment building. Ducks in detention basin. Nutria observed just DS of site.
ROB-FI2-17-D	29.49595	-95.06615	< 100	100	0	N	Cement pipe on LB. Egret and whistling ducks at site. Also observed turtles and apple snail eggs. Scum/sheen on water surface where US sample was collected.
ROB-FI2-18-D	29.49532	-95.06549	100	200	-100	N	Sample from DS of cement apron draining 3 pipes that run under TX-96. Top/end of segment.
ROB-FI2-T1-02-D	29.51454	-95.07185	310	200	110	Y-L	Cement pipe right bank 3m from US of bridge. Trickle.
ROB-FI2-T1-03-D	29.51458	-95.07156	300	410	-110	N	RB Pipe. Field off LB with goats observed US of this sample and DS of Smith Ln.
ROB-FI2-T1-NS-03	29.51459	-95.06968	NA	NA	NA	N	Pipe not sampled - wet inside but no flow.
ROB-FI2-T1-NS-04	29.51462	-95.06831	NA	NA	NA	N	Pipe on right & left bank 3m from downstream side of bridge, both moist.
ROB-FI2-T1-NS-02	29.51462	-95.06806	NA	NA	NA	N	Unsampled pipe 1 meter from upstream. Very slow drip.
ROB-FI2-T1-04-D	29.51467	-95.06675	310	300	10	N	Submerged pipe on left bank. Pipe on opposite bank, moist, not flowing.
ROB-FI2-T1-05-D	29.51465	-95.06599	< 100	100	0	N	Left bank pipe.
ROB-FI2-T1-NS-01	29.51469	-95.06489	NA	NA	NA	N	On RB, not sampled. Standing water in pipe. Not flowing.
ROB-FI2-T1-06-D	29.51464	-95.06425	100	100	0	N	Left bank pipe.
ROB-FI2-T1-07-D	29.51462	-95.06268	< 100	200	-100	N	DS sample taken from 2m downstream side of bridge and US sample taken US of bridge. Square cement pipes submerged. Right bank pipe 72 in., Left bank pipe 46 in.
ROB-FI2-T1-08-D	29.51461	-95.06233	200	200	0	N	Submerged cement pipe RB. 8m from US side of bridge.
ROB-FI2-T1-09	29.51464	-95.06023	< 100	NA	NA	N	Smells of effluent. Square concrete pipe; Right bank. Last source of water upstream.
ROB-FI2-T2-01	29.50862	-95.07045	200	NA	NA	N	Ambient.
ROB-FI2-T2-NS-01	29.50862	-95.07027	NA	NA	NA	N	Not sampled. 2 pipes across from each other - corrugated plastic - wet, not flowing.

Sample ID	Lat	Long	DS or Direct *E. coli* Sample Results (MPN/100 mL)	US *E. coli* Sample Results (MPN/100 mL)	Difference* DS - US (MPN/100 mL)	Referral	Comments
ROB-FI2-T2-NS-02	29.50866	-95.06903	NA	NA	NA	N	Moist pipe on RB, corrugated plastic. Dog walker on LB near bridge.
ROB-FI2-T2-02-D	29.50865	-95.06898	410	100	310	Y-H	LB - water in pipe, dripping.
ROB-FI2-T2-03-D	29.50864	-95.06848	200	310	-110	N	LB - water in pipe, dripping.
ROB-FI2-T2-NS-03	29.50865	-95.06754	NA	NA	NA	N	Not sampled - RB - choked with veg. Plastic coated pipe.
ROB-FI2-T2-NS-04	29.50871	-95.06631	NA	NA	NA	N	Not sampled metal pipe, RB, choked with veg.
ROB-FI2-T2-NS-05	29.50870	-95.06592	NA	NA	NA	N	Not sampled pipes, both banks moist, vegetated
ROB-FI2-T2-04-D	29.50873	-95.06521	310	200	110	Y-L	RB - collapsed concrete below metal pipe. DS sample taken from pool in broken concrete.
ROB-FI2-T2-05-D	29.50868	-95.06493	6,700	< 100	6,600	Y-H	Square, LB, good flow.
ROB-FI2-T2-NS-06	29.50890	-95.06364	NA	NA	NA	N	Not sampled, LB, plastic coated pipe, vegetated, moist.
ROB-FI2-T2-06-D	29.50896	-95.06167	100	< 100	0	N	RB. Coordinates are from 20 m from US, RB side of bridge.
ROB-FI2-T2-NS-07	29.50892	-95.06134	NA	NA	NA	N	Not sampled. LB, plastic coated pipe, vegetated, moist. Note for city-diversion washed out US of 07-U.
ROB-FI2-T2-07-D	29.50895	-95.06107	< 100	< 100	0	N	LB culvert. Heavy flow entering culvert. Unable to see source. Coordinates DS of bridge.
ROB-FI2-T2-08-D	29.50895	-95.06107	< 100	< 100	0	N	Center culvert. Can hear flow. Decaying fish US of 07-U, US sample taken US of bridge.
ROB-FI2-T2-09-D	29.50895	-95.06107	< 100	< 100	0	N	RB culvert.
ROB-FI2-T2-10-D	29.50848	-95.05965	100	100	0	N	LB.
ROB-FI2-T2-11	29.50854	-95.05733	< 100	NA	NA	N	Ambient sample. Lake on LB overflowing into trib.
ROB-FI2-T2-12	29.50874	-95.05743	< 100	NA	NA	N	Ambient sample US of lake inflow.
ROB-FI2-T2-13-D	29.50884	-95.05743	100	< 100	0	N	Submerged pipe on LB. Unable to see flow.
ROB-FI2-T2-14-D	29.51086	-95.05809	< 100	970	-870	N	LB; plastic coated pipe. Unsure if it is flowing, submerged.
ROB-FI2-T2-15	29.51126	-95.05821	1,560	NA	NA	IF	Ambient at top of segment. Submerged pipe.

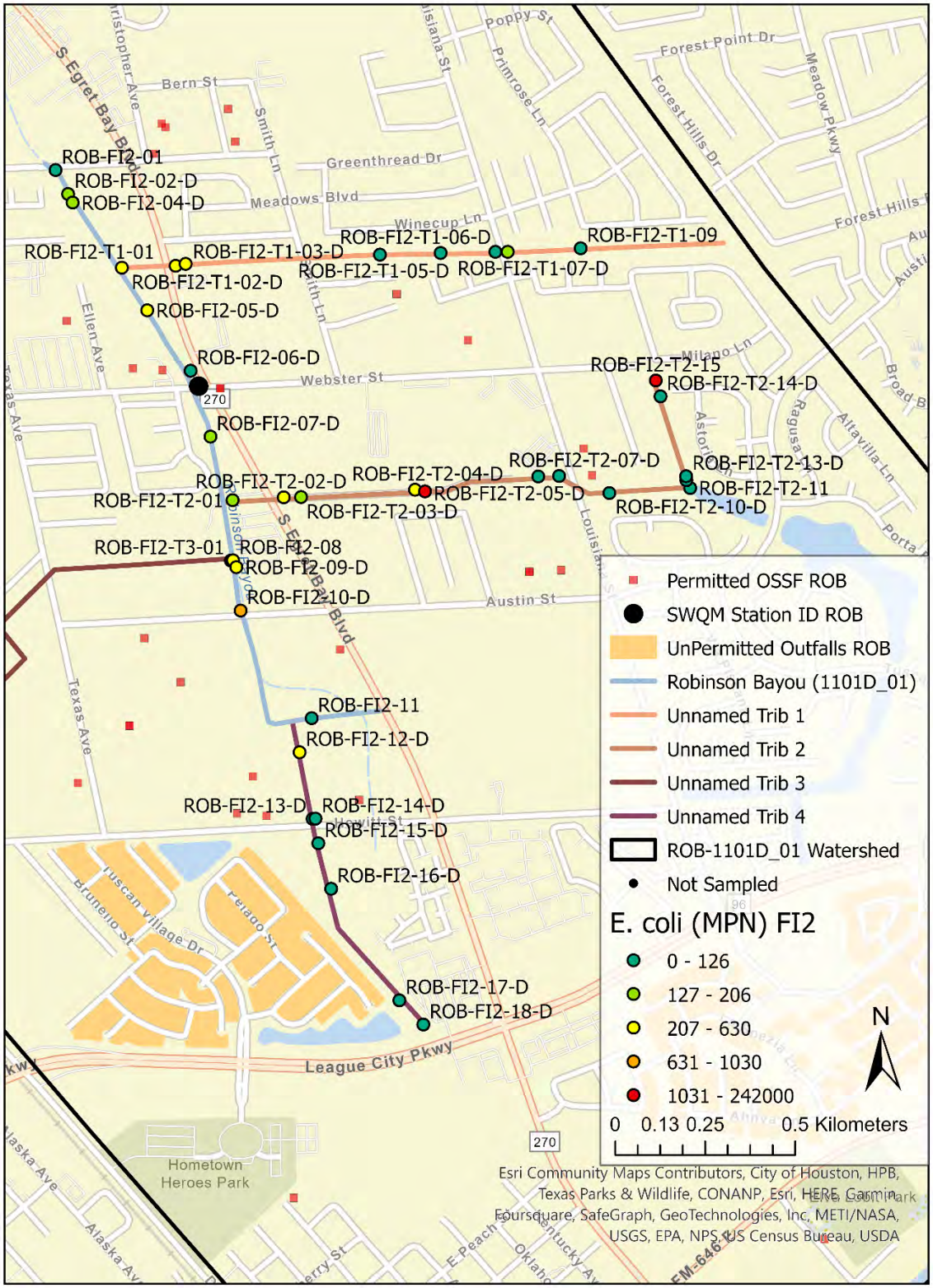

Figure 4: Field investigation bacteria sampling results from 5/2/2023 on Robinson Bayou (Assessment Unit 1101D_01).

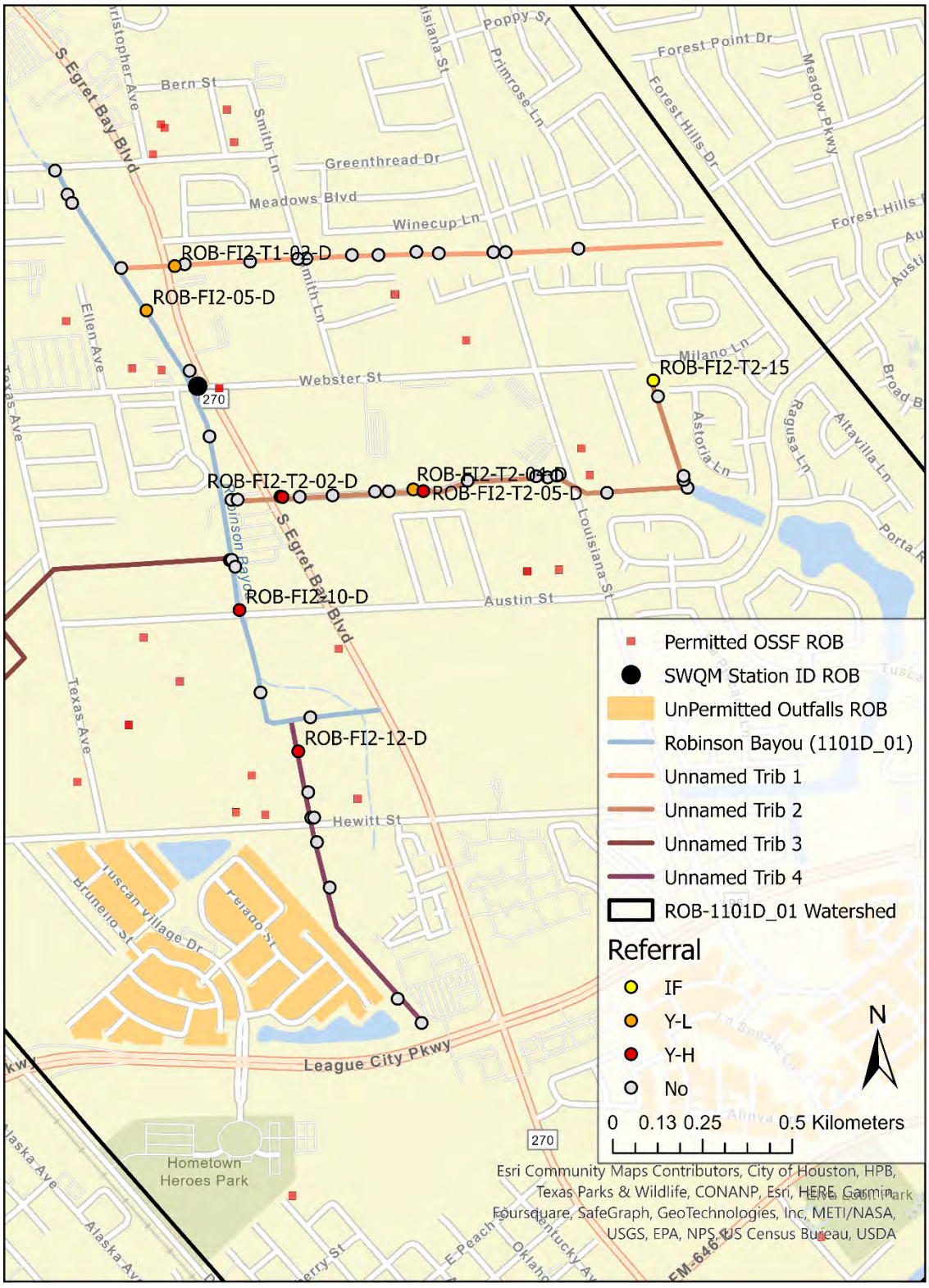

Figure 5: Field investigation sites sampled on 5/2/23 and identified for referral to the proper authorities on Robinson Bayou (Assessment Unit 1101D_01).

Referral site: ROB-FI2-10-D– High Priority

This is a 45 in. diameter metal pipe located on the left bank of Robinson Bayou. Water within the partially submerged pipe was 2 in. deep and trickling into the segment. There was a pipe on the right bank across from the sampled pipe that had a very small trickle but was not sampled. There are large lot single-family homes located in the area on the left bank, several of which have permitted OSSFs. Due to the pipe being submerged, the downstream sample was taken within the mixing zone in front of the mouth of the pipe and had a bacteria value of 850 MPN/100 mL. The ambient sample collected upstream of the pipe had a bacteria value of < 100 MPN/100 mL. This pipe is a high priority referral site for the proper local authority.

Referral site: ROB-FI2-12-D– High Priority

This is a 24 in. diameter metal pipe located on the right bank of Robinson Bayou. Water within the partially submerged pipe was 5 in. deep and flow was observed to be “bubbling” up from the substrate into the segment (white arrow). The substrate in the pipe was reddish in color. There was a pipe across the bayou (left bank) that was moist but not flowing which was not sampled. There are large lot single-family homes located in the area on the right bank. Due to the pipe being submerged, the downstream sample was taken within the mixing zone in front of the mouth of the pipe and had a bacteria value of 510 MPN/100 mL. The ambient sample collected upstream of the pipe had a bacteria value of 100 MPN/100 mL. This pipe is a high priority referral site for the proper local authority.

Referral site: ROB-FI2-T2-02-D– High Priority

This is a 24 in. diameter corrugated plastic coated pipe located on the left bank of Unnamed Tributary #2 to Robinson Bayou. Water within the pipe was 0.25 in. deep and dripping into the segment. There is a condominium complex located in the area on the left bank. A sample taken 0.1 m downstream of the pipe had a bacteria value of 410 MPN/100 mL. The ambient sample collected upstream of the pipe had a bacteria value of 100 MPN/100 mL. This pipe is a high priority referral site for the proper local authority.

Referral site: ROB-FI2-T2-05-D– High Priority

This is an approximately 60 in. diameter square concrete culvert located on the left bank of Unnamed Tributary #2 to Robinson Bayou. Water within the culvert was 0.25 in. deep and steadily flowing into the segment. There are single-family homes located in the area on the left bank. A sample taken 3 m downstream of the culvert had a bacteria value of 6,700 MPN/100 mL. The ambient sample collected upstream of the culvert had a bacteria value of < 100 MPN/100 mL. This is a high priority referral site for the proper local authority.

Referral site: ROB-FI2-05-D– Low Priority

This is a 12 in. diameter rusted metal pipe located on the right bank of Robinson Bayou. Water within the partially submerged pipe was 8.5 in. deep and the field crew was unable to tell if it was flowing into the segment. There is an undeveloped tract of land located in the immediate area on the right bank. A sample taken at the mouth of the submerged pipe had a bacteria value of 410 MPN/100 mL. The ambient sample collected upstream of the pipe had a bacteria value of 200 MPN/100 mL. This pipe is a low priority referral site for the proper local authority.

Referral site: ROB-FI2-T1-02-D– Low Priority

This is a 54 in. diameter cement pipe located under the 270 bridge, approximately 3 m from the upstream side of the bridge on the right bank of the Unnamed Tributary #1 to Robinson Bayou. Water within the pipe was 0.1 in. deep and trickling into the segment. There are single-family homes and a roadway located in the area on the right bank. A sample 0.5 m downstream of the pipe had a bacteria value of 310 MPN/100 mL. The ambient sample collected upstream of the pipe had a bacteria value of 200 MPN/100 mL. This pipe is a low priority referral site for the proper local authority.

Referral site: ROB-FI2-T2-04-D– Low Priority

This is a 28 in. diameter metal pipe located on the right bank of the Unnamed Tributary #2 to Robinson Bayou. The cement apron around the pipe is broken and the sediment underneath is washed out creating a void where the water was flowing into. Water within the pipe was 0.5 in. deep and trickling behind the broken cement wall and then into the segment. League City Intermediate School is in the area on the right bank. A sample was taken where the water that is flowing behind the broken concrete meets the stream, approximately 3.5 m downstream of the pipe outfall and it had a bacteria value of 310 MPN/100 mL. The ambient sample collected upstream of the pipe had a bacteria value of 200 MPN/100 mL. This pipe is a low priority referral site for the proper local authority.

Referral site: ROB-FI2-T2-15 –Investigate Further

This was a single sample taken at the mouth of a partially submerged corrugated plastic-coated pipe at the most upstream portion of the Unnamed Tributary #2 to Robinson Bayou before the pipe goes underground. The ambient sample taken at the pipe had a bacteria value of 1,560 MPN/100 mL. Further investigation is recommended by the proper local authority to determine the source of elevated bacteria underground and upstream of the segment. There are single-family homes located upstream of the site.

List of Acronyms and Abbreviations

AU	Assessment Unit
BIG	Bacteria Implementation Group
CRP	Clean Rivers Program
DS	Downstream
E. coli	*Escherichia coli*
FI	Field Investigation
FY	Fiscal Year
GIS	Geographic Information Systems
H-GAC	Houston-Galveston Area Council
IF	Investigate Further
in.	inch
I-Plan	Implementation Plan
km	kilometer
LB	Left Bank
m	meter
mL	milliliter
MPN	Most probable number
N	No
NELAP	National Environmental Laboratory Accreditation Program
NLCD	National Land Cover Database
OSSF	On-Site Sewage Facilities
QAPP	Quality Assurance Project Plan
RB	Right Bank
ROB	Robinson Bayou 1101D_01
SWQM	Surface Water Quality Monitoring
SWRC	Stroud Water Research Center
T or trib.	Tributary
TCEQ	Texas Commission on Environmental Quality
TMDL	Total Maximum Daily Load
US	Upstream
WS	Windshield Survey
Y-H	Yes – High Priority
Y-L	Yes-Low Priority

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Targeted Bacteria Monitoring Project

Field Investigation Final Report

Segment 1004J_01 White Oak Creek

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Field Investigation Final Report

Segment 1004J_01 White Oak Creek

FIELD INVESTIGATION

METHODS

The field investigation (FI) took place on March 13 and 15 of 2023, 38 and 40 days since significant rainfall within the watershed, respectively. White Oak Creek (WOC) is a tributary of the West Fork of the San Jacinto River and does not have many access points outside of what was sampled during the Ground-truthing/Windshield survey. Its banks are very tall, steep, and heavily wooded or vegetated. This required the field crew to walk in the stream itself starting at the most downstream access point (23_WOC_FS_01) within McDade Estates (Refer to Figure 1). Although White Oak Creek is shallow, the sediment is a very fine sand making it difficult to walk through, and sink holes were often created during the survey. White Oak Creek (1004J_01) until the confluence of the forks was sampled on March 13, 2023. However, we were unable to survey the entirety of the East (1004A_01) and West Forks (1004B_01) on that day. Since neither fork of WOC was assessed in the 2021 survey, the field crew returned on March 15, 2023, for targeted monitoring.

Access to the West Fork of WOC was through the Laurel Ridge neighborhood; field crew walked to the fork until League Line Rd. Access to the East Fork of WOC was at Teas Nursery Rd until White Oak Point Park south of League Line Rd. The West Fork of WOC wound through portions of the Teaswood neighborhood while the East Fork had substantial neighborhood construction underway.

RESULTS

A total of 74 samples were collected at 37 locations (Table 1), all of which consisted of an “upstream” and “downstream” sample location. No direct water samples were collected from outfalls. Most sample locations were from small flowing tributaries, some were suspected to come from outfalls or sources set further back from the banks, and for a few samples piping was entering the assessment unit (AU). To enhance clarity of the sampling efforts, the FI map (Figure 1) displays a singular icon for the upstream and downstream collections, but all locations are listed in the table below.

The 2021 FI was not able to assess the East and West Forks of WOC, and both were included in this FI. The AU was examined by the field crew from FM 2854 in McDade Estates northwards past Highway 105 up to League Line Road where both forks are present. Overall, the bacteria results are lower than the 2021 survey suggesting some incidental mitigation could be occurring, or the change in construction patterns reduced impact on the AU. Based on Google Earth timelapse and FY23 field observations, the neighborhood development south of League Line Rd along the East Fork of WOC was clearing land in 2021. The developments just north of FM 3083, Laurel Ridge and Madison Bend were also being cleared in 2021 but Laurel Ridge was completed by the 2023 survey and Madison Bend appears to be 65% complete. Furthermore, the Panorama Village water treatment facility is housed along League Line Rd and the East Fork of White Oak Creek. This has led to the < 100 MPN/100mL results for sample 23_WOC_FS_37 and could mitigate any impairment further north along the East Fork.

Of the 37 locations, there were seven that reflected a difference of greater than 300 MPN/100mL between upstream and downstream samples. Besides one site along the West Fork of White Oak Creek (23_WOC_FS_30), there were no other significant increases along either fork of White Oak Creek. Sites

with significant bacterial input are highlighted in Table 1 and are listed as referral sites for future mitigation at the end of this report. Based on permitted OSSFs and unregistered OSSF parcels published by Montgomery County (Figure 2) it appears a few sites are associated with unregistered OSSF parcels. Despite this association, those sites did not produce meaningful results and are not listed as referral sites.

Table 1: Field Investigation locations. Upstream and Downstream coordinates and *E. coli* difference reported.

Sample ID	Latitude	Longitude	Material of Outfall	Inner Diameter of Pipe (Inches)	DS or Direct *E. coli* Sample Results (MPN/100 mL)	US *E. coli* Sample Results (MPN/100 mL)	Difference DS – US* (MPN/100 mL)	Comments
23_WOC_FS_01u & 23_WOC_FS_01d	30.321303 & 30.321291	-95.506832 & -95.506883	N/A	N/A	740	310	**430**	Natural outflow in McDade Estates.
23_WOC_FS_02u & 23_WOC_FS_02d	30.321547 & 30.321519	-95.506388 & -95.506399	N/A	N/A	200	630	-430	Natural outfall
23_WOC_FS_03u & 23_WOC_FS_03d	30.321756 & 30.32171	-95.504764 & -95.504828	N/A	N/A	410	520	-110	Small tributary with unknown origin
23_WOC_FS_04u & 23_WOC_FS_04d	30.322294 & 30.322287	-95.504125 & -95.504141	N/A	N/A	100	200	-100	Small tributary with unknown origin
23_WOC_FS_05u & 23_WOC_FS_05d	30.322918 & 30.322862	-95.5037 & -95.503732	N/A	N/A	200	200	0	Small tributary with unknown origin
23_WOC_FS_06u & 23_WOC_FS_06d	30.324905 & 30.324859	-95.503394 & -95.503415	N/A	N/A	630	740	-110	Small tributary with unknown origin
23_WOC_FS_07u & 23_WOC_FS_07d	30.327165 & 30.327151	-95.50162 & -95.501636	2	6	520	300	220	New neighborhood, construction almost complete. Multiple pipes.
23_WOC_FS_08u & 23_WOC_FS_08d	30.328058 & 30.328046	-95.501115 & -95.501123	N/A	N/A	1910	520	**1390**	Left bank; runoff from carwash and other businesses.
23_WOC_FS_09u & 23_WOC_FS_09d	30.328523 & 30.328516	-95.501126 & -95.501129	N/A	N/A	1090	740	**350**	Right bank; runoff feeding into AU.
23_WOC_FS_10u & 23_WOC_FS_10d	30.329675 & 30.329667	-95.501485 & -95.501478	N/A	N/A	630	410	220	Small tributary with unknown origin
23_WOC_FS_11u & 23_WOC_FS_11d	30.330621 & 30.330612	-95.501969 & -95.501961	2	12	970	200	**770**	Pipe on right-bank with dripping water flow.
23_WOC_FS_12u & 23_WOC_FS_12d	30.332485 & 30.332411	-95.50166 & -95.50166	N/A	N/A	100	620	-520	Dual tributary flowing into AU; appear to have same unknown origin.
23_WOC_FS_13u & 23_WOC_FS_13d	30.333302 & 30.333256	-95.501649 & -95.501649	2	6	100	100	0	Multiple PVC outfalls coming from apartment complex on right-bank
23_WOC_FS_14u & 23_WOC_FS_14d	30.335865 & 30.3358	-95.50017 & -95.50018	N/A	N/A	630	410	220	Small outfall with unknown origin
23_WOC_FS_15u & 23_WOC_FS_15d	30.335954 & 30.335917	-95.500201 & -95.50019	1	40	100	310	-210	Water flowing from pipe.

23_WOC_FS_16u & 23_WOC_FS_16d	30.337489 & 30.337443	-95.500548 & -95.500591	N/A	N/A	630	100	**530**	Right bank; small tributary with unknown origin
23_WOC_FS_17u & 23_WOC_FS_17d	30.337999 & 30.337962	-95.500855 & -95.500855	N/A	N/A	200	100	100	Left bank; small tributary with unknown origin
23_WOC_FS_18u & 23_WOC_FS_18d	30.340403 & 30.340366	-95.503395 & -95.503374	1	60	410	100	310	Dam overflow: recreational use of creek observed.
23_WOC_FS_19u & 23_WOC_FS_19d	30.340877 & 30.340831	-95.503915 & -95.503915	N/A	N/A	310	410	-100	Left-bank, small tributary with unknown origin. Under FM3083 bridge crossing.
23_WOC_FS_20u & 23_WOC_FS_20d	30.342905 & 30.342859	-95.505648 & -95.505627	1	40	310	200	110	Concrete outfall
23_WOC_FS_21u & 23_WOC_FS_21d	30.344684 & 30.344628	-95.505902 & -95.505923	2 & 4	6	520	410	110	PVC outfalls from residence
23_WOC_FS_22u & 23_WOC_FS_22d	30.34702 & 30.346974	-95.505031 & -95.505042	1	30	100	200	-100	Water flowing from concrete outfall
23_WOC_FS_23u & 23_WOC_FS_23d	30.350401 & 30.350095	-95.505441 & -95.505495	N/A	N/A	100	510	-410	Small tributary with unknown origin
23_WOC_FS_24u & 23_WOC_FS_24d	30.352255 & 30.352252	-95.507415 & 95.507324	N/A	N/A	410	100	310	Small tributary with unknown origin; left bank
23_WOC_FS_25u & 23_WOC_FS_25d	30.352533 & 30.352536	-95.507571 & -95.507459	2	8	520	100	**420**	Blue water pipe (12 in. dia.) crossing the AU. Water dripping into AU is where samples were collected.
23_WOC_FS_26u & 23_WOC_FS_26d	30.352813 & 30.352767	-95.507787 & -95.507744	N/A	N/A	100	< 100	-50	Right bank; small tributary of unknown origin
23_WOC_FS_27u & 23_WOC_FS_27d	30.35394 & 30.353931	-95.508312 & -95.508452	N/A	N/A	520	410	110	Right bank; small tributary of unknown origin
23_WOC_FS_28u & 23_WOC_FS_28d	30.356705 & 30.356584	-95.509344 & -95.509374	1	N/A	310	200	110	AU crosses over Slick Rock Rd inside Teaswood. Upstream collected north of street, and natural inflow.
23_WOC_FS_29u & 23_WOC_FS_29d	30.357757 & 30.35766	-95.509814 & -95.509803	4	10	100	410	-310	A small tributary running alongside residence from Enchanted Stream Rd.
23_WOC_FS_30u & 23_WOC_FS_30d	30.35908 & 30.359027	-95.511099 & -95.511095	2	2	2110	410	**1700**	Pipe directly from house on left bank; dripping into AU.
23_WOC_FS_31u & 23_WOC_FS_31d	30.359433 & 30.359259	-95.511447 & -95.511357	N/A	N/A	300	100	200	Tributary feeding into WOC. Downstream sample collected 2 feet into tributary.
23_WOC_FS_32u & 23_WOC_FS_32d	30.360311 & 30.360246	-95.512987 & -95.512923	2	3	300	200	100	Pipe in creek. Suspected to be from nearby house.
23_WOC_FS_33u & 23_WOC_FS_33d	30.363352 & 30.36334	-95.514142 & -95.514271	N/A	N/A	200	100	100	Small tributary with unknown origin
23_WOC_FS_34u &	30.354832 &	-95.498092 & -	2	30	100	410	-310	Small tributary with unknown origin

23_WOC_FS_34d	30.354814	95.498242						
23_WOC_FS_35u & 23_WOC_FS_35d	30.358141 & 30.358095	-95.496556 & -95.49662	1 & 1	24 & 36	410	100	310	Construction on same side as the outfalls. Water at .25in flowing into AU.
23_WOC_FS_36u	30.363014	-95.496407	1	40	410	410	0	Construction on same side as the outfalls. Water actively flowing into AU.
23_WOC_FS_37u & 23_WOC_FS_37d	30.366245 & 30.36618	-95.495198 & -95.495219	N/A	N/A	< 100	200	-100	The tributary feeding into the creek south of White Oak Point Park.

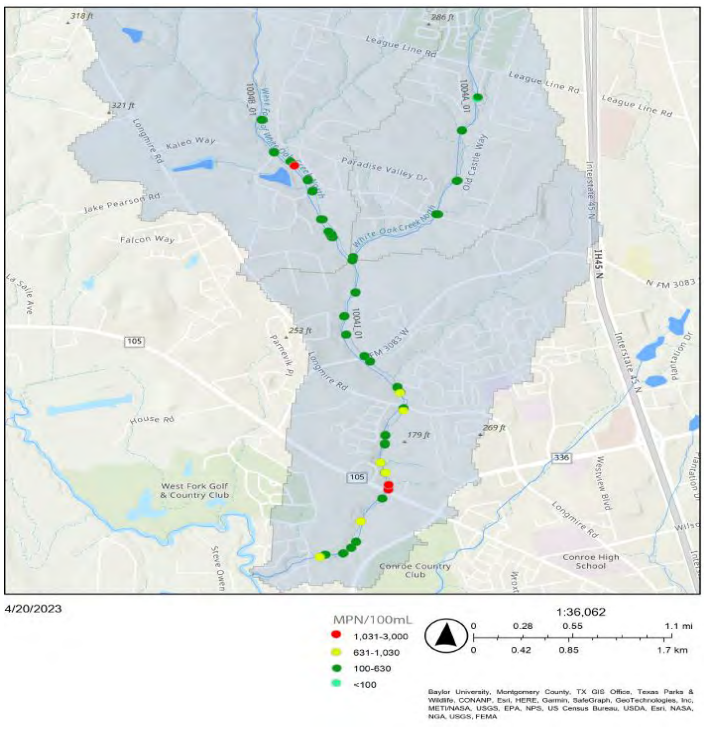
DS = Downstream ID = Inner Diameter NA = Sample not associated with an outfall

* When a sample was taken DS and US, the difference was calculated.

If the Difference is a positive number, it indicates a higher DS than US value and that the source could be contributing *E. coli* to the waterway.

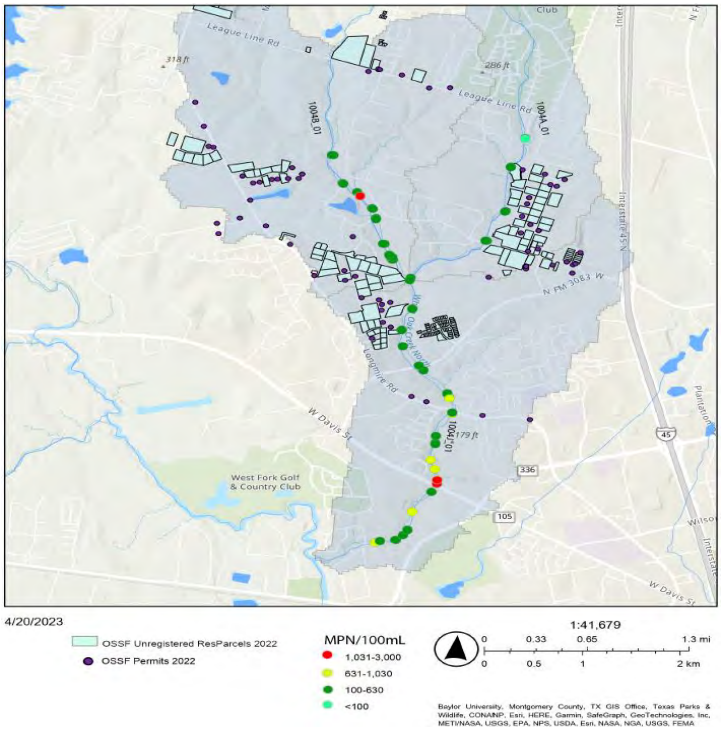
= Recommended for further investigation by the proper authorities

Figure 1: Field Investigation Bacteria Results from 03/13-15/2023 on White Oak Creek (1004J_01, 1004A_01 and 1004B_01)



Map

Figure 2: Field Investigation Bacteria Results on White Oak Creek (1004J_01, 1004A_01 and 1004B_01) with OSSF information.



REFERRALS TO RESPONSIBLE PARTIES

This investigation was able to fully assess the AU along the confluence of the two forks (1004B_01 and 1004A_01). Construction was ongoing along the East Fork of White Oak Creek; however, the only significant increase was from a residence in Teaswood neighborhood along the West Fork of WOC. Samples collected from the FI were able to pinpoint impairments that were not detected during the Windshield Survey. Of the 37 locations, there were 7 that reflected a difference of greater than 300 MPN/100mL between upstream and downstream samples. Given that the FI occurred between 38-40 days since the last significant rainfall these referral sites could have a stronger influence on the bacterial load of the AU during rainy periods. Locations with a significant difference in downstream samples are listed below as referral sites for future mitigation.

REFERRAL SITE: 23_WOC_FS_01

Latitude: 30.321303 Longitude: -95.506832

The first referral site is 23_WOC_FS_01 located in McDade Estates. It presented as a runoff along the left bank (Figure 3). It had noticeable bacteria input into the AU causing it to be listed as a referral site. The upstream sample was 310 MPN/100mL while the downstream sample was 740 MPN/100mL, showing a difference of 430 MPN/100mL.

Figure 3: Referral site 23_WOC_FS_01. Map with star showing referral site location. Subset image of Creekside view; yellow box outlines the runoff into AU.

REFERRAL SITE: 23_WOC_FS_08

Latitude: 30.328046 Longitude: -95.501123

The second referral site is 23_WOC_FS_08 which was runoff associated with the Quick Quack car wash north of Highway 105 (Figure 4) on the left bank of WOC (Figure 5). It had a downstream reading of 1,920 MPN/100mL and upstream reading of 520 MPN/100mL showing a difference of 1,310 MPN/100mL.

Figure 4: Referral site 23_WOC_FS_08, 09 and 11. Map showing proximity to businesses, development, and referral sites.

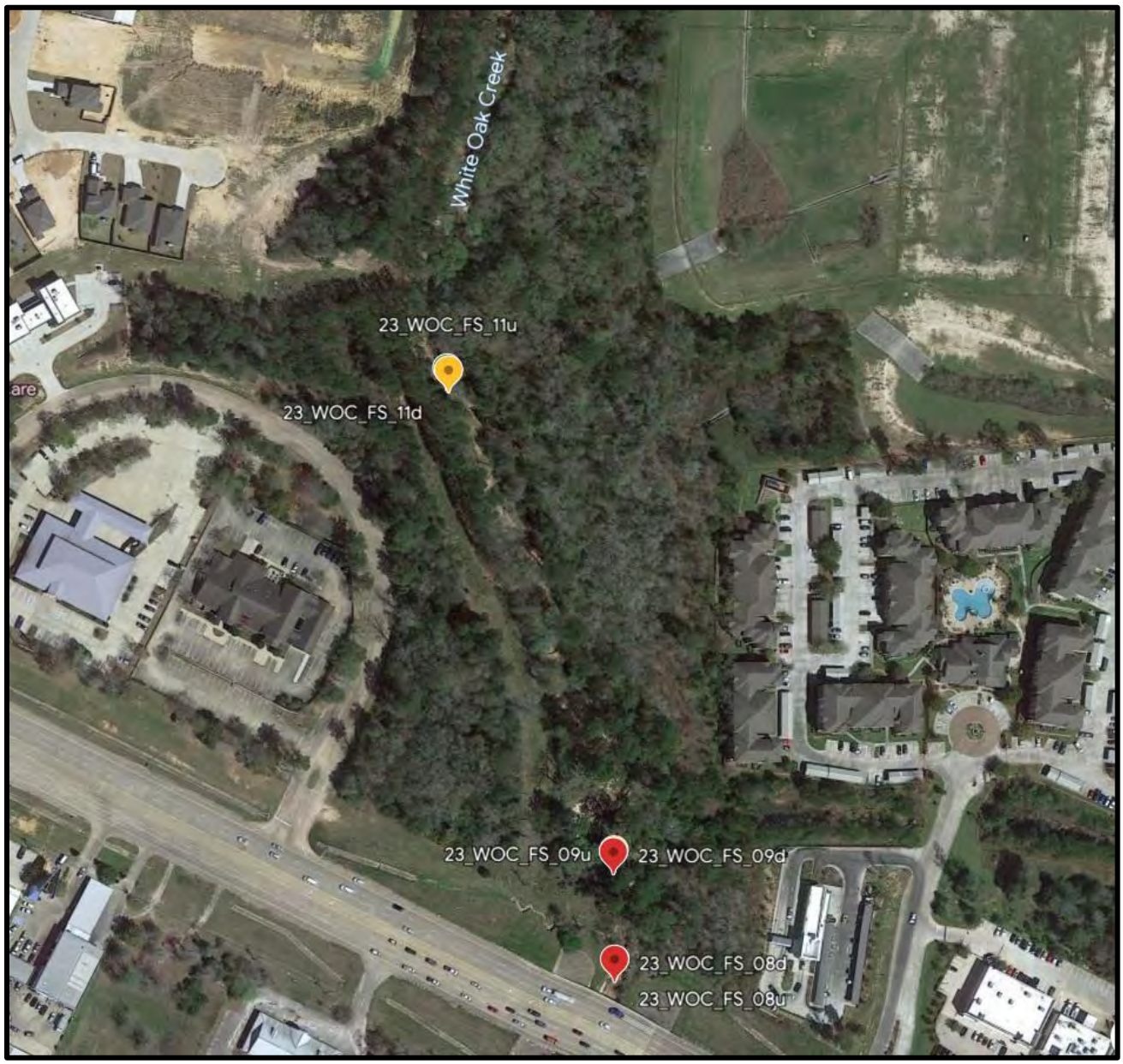


Figure 5: Left-bank runoff and zoomed image.

REFERRAL SITE: 23_WOC_FS_09

Latitude: 30.328523 Longitude: -95.501126

Referral site 23_WOC_FS_09 presented as runoff along the right bank of WOC (Figure 6) upstream of site 08 (Figure 4). The *E. coli* difference readings was 330 MPN/100mL between upstream (740 MPN/100mL) and downstream (1,090 MPN/100mL) samples. Given that both sites 08 and 09 presented as runoff and each were sampled both upstream and downstream of runoff input, it suggests both are contributing higher bacteria loads into the AU.

However, it is important to note that samples collected at the Highway 105 bridge crossing during the windshield survey (downstream of FI locations 07-09) only reported a bacterial load of 310 MPN/100mL.

Figure 6: Referral site 23_WOC_FS_09. Right-bank runoff and zoomed image

REFERRAL SITE: 23_WOC_FS_11

Latitude: 30.330621 Longitude: -95.501969

The referral site, 23_WOC_FS_11, occurred where a single pipe on the right bank had water dripping from it into the AU (Figure 7). The difference of upstream (200 MPN/100mL) and downstream (970 MPN/100mL) samples was 770 MPN/100mL. This sample location was close to other referral sites north of Highway 105 (Figure 4).

Figure 7: Referral site 23_WOC_FS_11. Pipe dripping into AU.

REFERRAL SITE: 23_WOC_FS_16

Latitude: 30.337489 Longitude: -95.500548

The referral site, 23_WOC_FS_016, was a small tributary of unknown origin that showed to influence the *E. coli* levels within the AU by having a difference of 530 MPN/100mL between upstream (100 MPN/100mL) and downstream (630 MPN/100mL) samples. Construction was not visible from the AU during the FI (Figure 8), but the tributary had a significantly cut path (Figure 9) through the sediment suggesting this tributary precedes any construction in the area.

Figures 8 and 9: Referral site 23_WOC_FS_16. Right-bank tributary.

REFERRAL SITE: 23_WOC_FS_25

Latitude: 30.352533 Longitude: -95.507571

The referral site, Site 25, was a blue, 12-inch water pipe crossing the stream. Upon inspection, the field crew noticed it was dripping into the AU (Figures 11 & 12). This referral site was almost 350 meters upstream of the confluence of East and West Forks of White Oak Creek. The pipe crosses the stream south of the cul-de-sac street Walton's Point (Figure 10) in the neighborhood west of the AU. The difference of upstream (100 MPN/100mL) and downstream (520 MPN/100mL) samples at site 25 was 420 MPN/100mL suggesting the dripping water from the pipe is influencing the bacterial levels.

Figures 10, 11, 12: Referral site 23_WOC_FS_25. Map with star demonstrates sample and habitat location. Water transport pipe crossing AU; zoomed image of drippage.

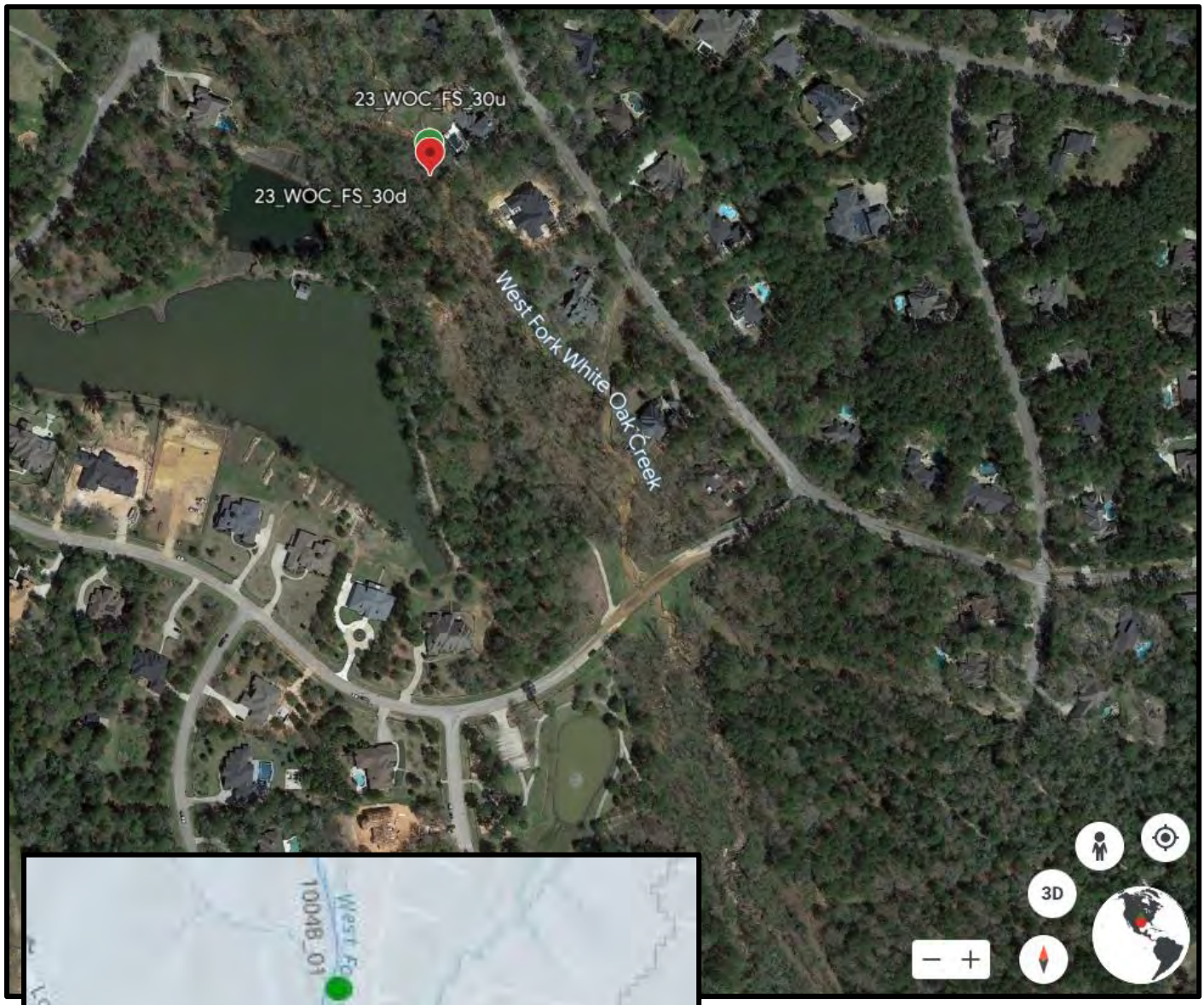
REFERRAL SITE: 23_WOC_FS_30

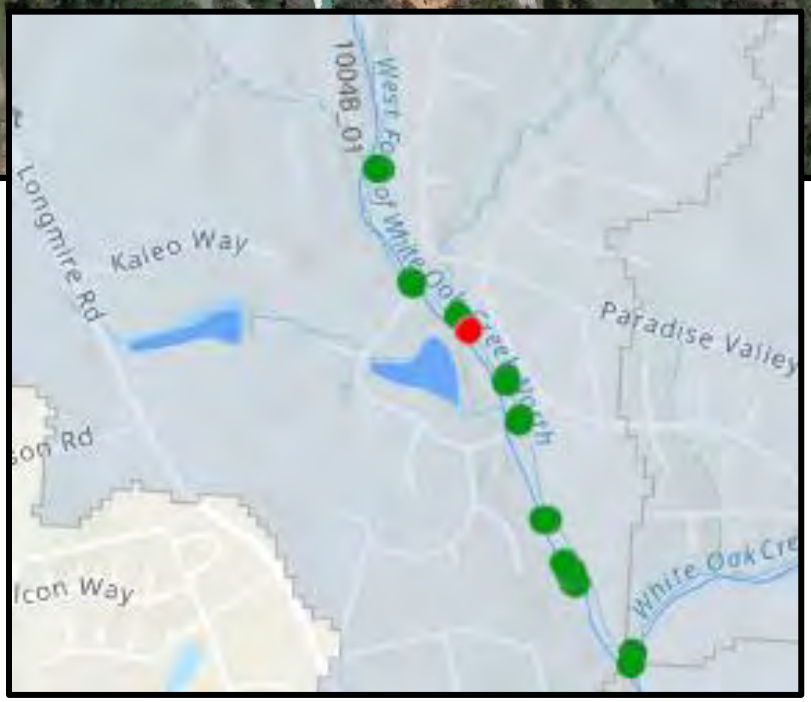
Latitude: 30.35908 Longitude: -95.511099

Site 23_WOC_FS_30 was sampled along the left bank of the West Fork of White Oak Creek in a fully residential area called Teaswood (Figure 13). A residence had a PVC outfall present, extending from under a bulkhead on the creek. Sampling occurred within 1 foot upstream and downstream of the pipe (Figure 14). The upstream sample was 410 MPN/100mL while the downstream sample was 2,110 MPN/100mL. This location was the highest bacteria reading of the whole FI. Retention ponds to the west of White Oak Creek (Figure 15) seemed to have little input on the West Fork of White Oak Creek during the Field Investigation.

Figure 13 and 14: Referral site 23_WOC_FS_30. Google Earth image of site and residence. Field-level picture of pipe from Teaswood residence dripping into AU.

Figure 15: Retention ponds to the west of West Fork White Oak Creek.

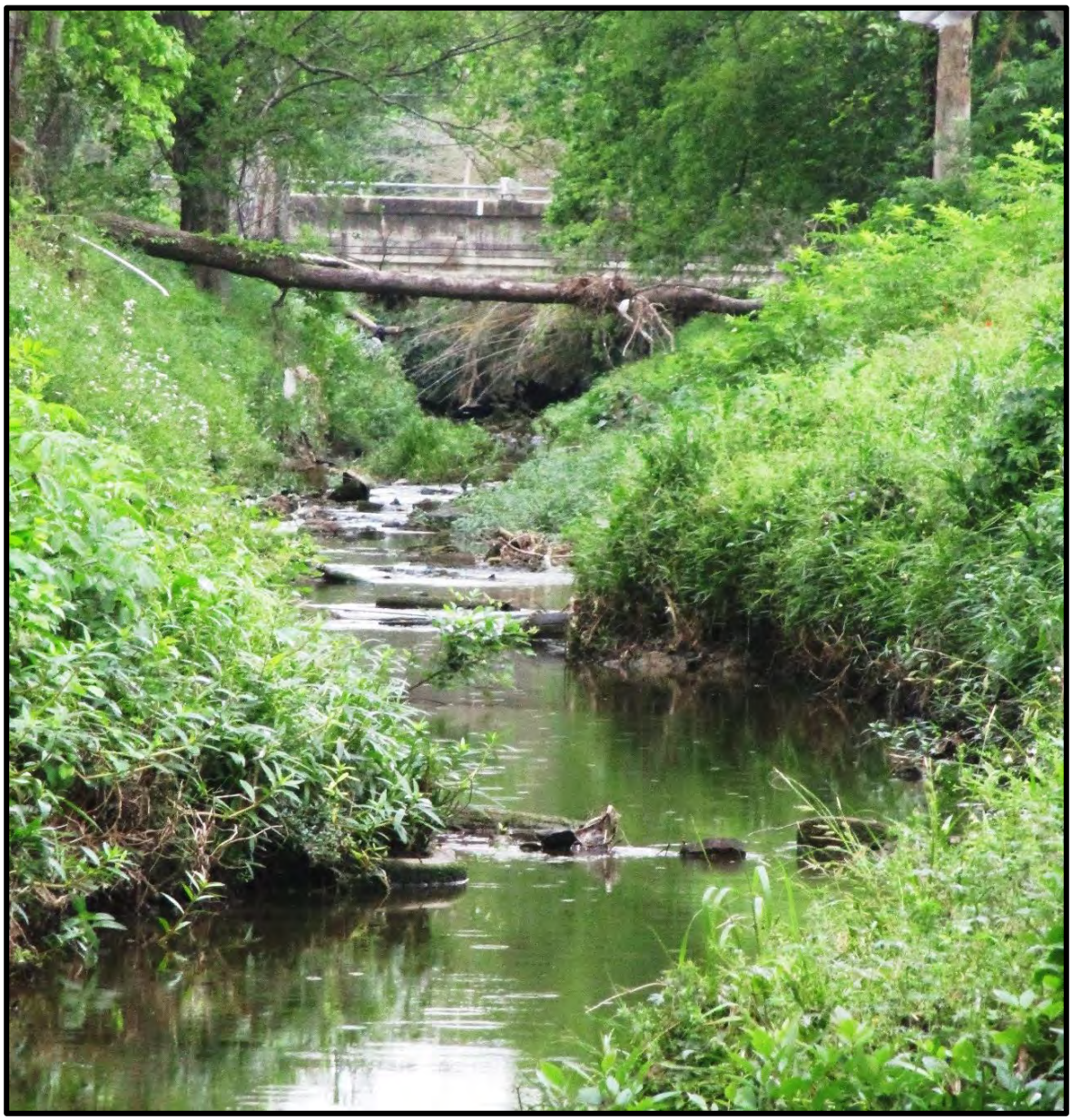




Targeted Bacteria Monitoring Project

Field Investigation Final Report

Segment 1016C_01 Unnamed Tributary of Greens Bayou



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Field Investigation Final Report

Segment 1016C_01 Unnamed Tributary of Greens Bayou

FIELD INVESTIGATION

METHODS

The Field Investigation (FI) took place on March 29, 2023, 12 days after significant rainfall within the watershed. Many roads "dead-end" into the tributary (1016C_01) allowing for multiple points of access. However, during the Windshield Survey (WS) there were sections of the tributary that were inaccessible and the high bacteria readings from that survey highlighted the need for the field crew to examine the portions of 1016C_01 that were not visible from ground-truthing. When referring to the FI map (Figure 1) it will be noticed that the field crew did not sample along the tributary between W Hardy St and Lillija Rd. The primary reason was that during the WS results did not have high *E. coli* levels between those street crossing and there were several other locations that registered significantly high hits. Furthermore, there is a water-treatment plant north of the overflow region that meets the tributary just west of Lilija Rd, and the WS bacterial samples registered around 100 MPN/100mL suggesting the output from the treatment plant negates bacterial loads prior to the overflow region's intersection with 1016C_01 at Hollyvale Rd. Therefore, the field crew focused on portions of the waterway that were not thoroughly assessed during the Windshield Survey.

RESULTS

A total of 40 samples were collected at 20 locations (Table 1), all of which consisted of an "upstream" and "downstream" sample location. No direct water samples were collected from outfalls. All the samples were collected near points where pipes entered the assessment unit (AU), except one (23_UTGB_FS_03) that presented as overflow from a dual-use property (residential and industrial). Of the 20 locations, there were 14 that had *E. coli* levels exceeding 1,500 MPN/100mL and of those, 4 registered elevated levels that were greater than 190,000 MPN/100mL. Sample sites and permitted OSSFs from the 2022 FI are present on Figure 2. Figure 2 also shows that there is overlap with unregistered parcels and permitted OSSFs are present at the most eastern samples sites (i.e.: Sites 1-7).

Table 1: Field Investigation locations. Upstream and Downstream coordinates and *E. coli* difference reported.

Sample ID	Latitude	Longitude	Material of Outfall	DS *E. coli* Sample Results (MPN/100 mL)	US *E. coli* Sample Results (MPN/100 mL)	Difference DS – US* (MPN/100 mL)	Comments
23_UTGB_FS_01u & 23_UTGB_FS_01d	29.916725 & 29.916743	-95.347722 &- 95.347696	2	7,980	2,690	5,290	2 pipes originated from house: no water dripping
23_UTGB_FS_02u & 23_UTGB_FS_02d	29.916609 & 29.916611	-95.348444 & - 95.348461	3	5,560	1,730	3,830	
23_UTGB_FS_03u & 23_UTGB_FS_03d	29.916269 & 29.916271	-95.350072 & - 95.350059	4	5,540	530	5,010	On right-bank; property seemed overly industrial for the area
23_UTGB_FS_04u & 23_UTGB_FS_04d	29.916173 & 29.916165	-95.350724 & - 95.350691	3	6,310	5,560	750	Continuation of same property from site 03, commercial use, salvage yard
23_UTGB_FS_05u & 23_UTGB_FS_05d	29.915772 & 29.91575	-95.351828 & - 95.351801	2	4,350	5,210	-860	On right-bank; steady water flow
23_UTGB_FS_06u & 23_UTGB_FS_06d	29.917231 & 29.917242	-95.355709 & -95.35573	2	2,230	3,010	-780	Right-bank; west of bridge
23_UTGB_FS_07u & 23_UTGB_FS_07d	29.9174206 & 29.917424	-95.356272 & - 95.356327	2	1,220	7,330	-6,110	Right-bank. Outside of potential business. Drip flow from pipe.
23_UTGB_FS_08u & 23_UTGB_FS_08d	29.918033 & 29.91841	-95.361248 & - 95.361293	2	241,960	>242,000	> -40	Right-bank; Numerous animals on property. Smelled of hoofed stock. Heard animals clucking, quacking, braying, and barking.
23_UTGB_FS_09u & 23_UTGB_FS_09d	29.917518 & 29.917514	-95.364562 & - 95.364578	2	520	310	210	Water slowly dripping from pipe
23_UTGB_FS_10u & 23_UTGB_FS_10d	29.917236 & 29.917229	-95.365691 & - 95.365734	3	310	200	110	Right-bank; actively pouring into creek
23_UTGB_FS_11u & 23_UTGB_FS_11d	29.916895 & 29.916917	-95.367849 & - 95.367712	3	520	310	210	4 metal outfalls; upstream sample collected before first pipe and downstream collected after 4th pipe.

23_UTGB_FS_12u & 23_UTGB_FS_12d	29.916603 & 29.916593	-95.369299 & -95.369339	2	< 100	520	420	Sampled at third of 4 pipes on right-bank.
23_UTGB_FS_13u & 23_UTGB_FS_13d	29.916434 & 29.916437	-95.373969 & -95.373995	2	> 242,000	730	242,000	2 drainage outfalls present on right-bank
23_UTGB_FS_14u & 23_UTGB_FS_14d	29.916596 & 29.916526	-95.375595 & -95.375498	3	300	200	100	Outfalls on right and left banks at W Hardy Rd. feeder; sampled downstream of furthest one and upstream of closest one
23_UTGB_FS_15u & 23_UTGB_FS_15d	29.915501 & 29.915498	-95.397725 & -95.397699	3	5,290	2,850	2,440	Outfall on left bank
23_UTGB_FS_16u & 23_UTGB_FS_16d	29.915488 & 29.915481	-95.39852 & -95.398509	3	5,810	3,150	2,660	Outfall on left bank
23_UTGB_FS_17u & 23_UTGB_FS_17d	29.915496 & 29.915485	-95.399273 & -95.399279	3	8,860	16,640	-7,780	
23_UTGB_FS_18u & 23_UTGB_FS_18d	29.91541 & 29.915413	-95.403153 & -95.403142	3	16,640	198,630	-181,990	Outfall on left-bank, unsure of output. Mobile homes on right-bank
23_UTGB_FS_19u & 23_UTGB_FS_19d	29.936443 & 29.936432	-95.393483 & -95.393424	4	200	200	0	Construction is ongoing at site; hoses pumping water because drainage tunnel is being replaced.
23_UTGB_FS_20u & 23_UTGB_FS_20d	29.930528 & 29.930535	-95.930535 & -95.39324	3	410	300	110	Newly installed drainage in fully residential area

DS = Downstream ID = Inner Diameter NA = Sample not associated with an outfall

* When a sample was taken DS and US, the difference was calculated.

If the Difference is a positive number, it indicates a higher DS than US value and that the source could be contributing *E. coli* to the waterway.

= Recommended for further investigation by the proper authorities

Figure 1: Field Investigation Bacteria Results from 03/29/2023 on 1016C_01.

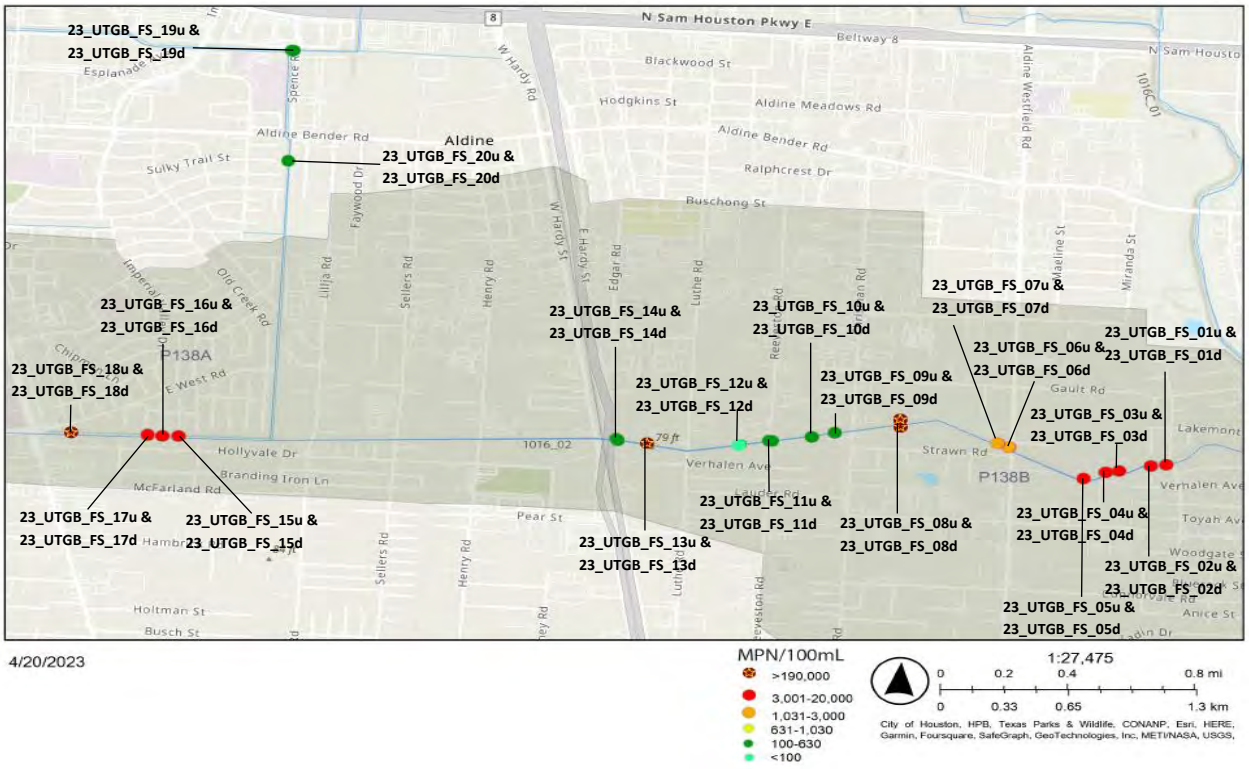
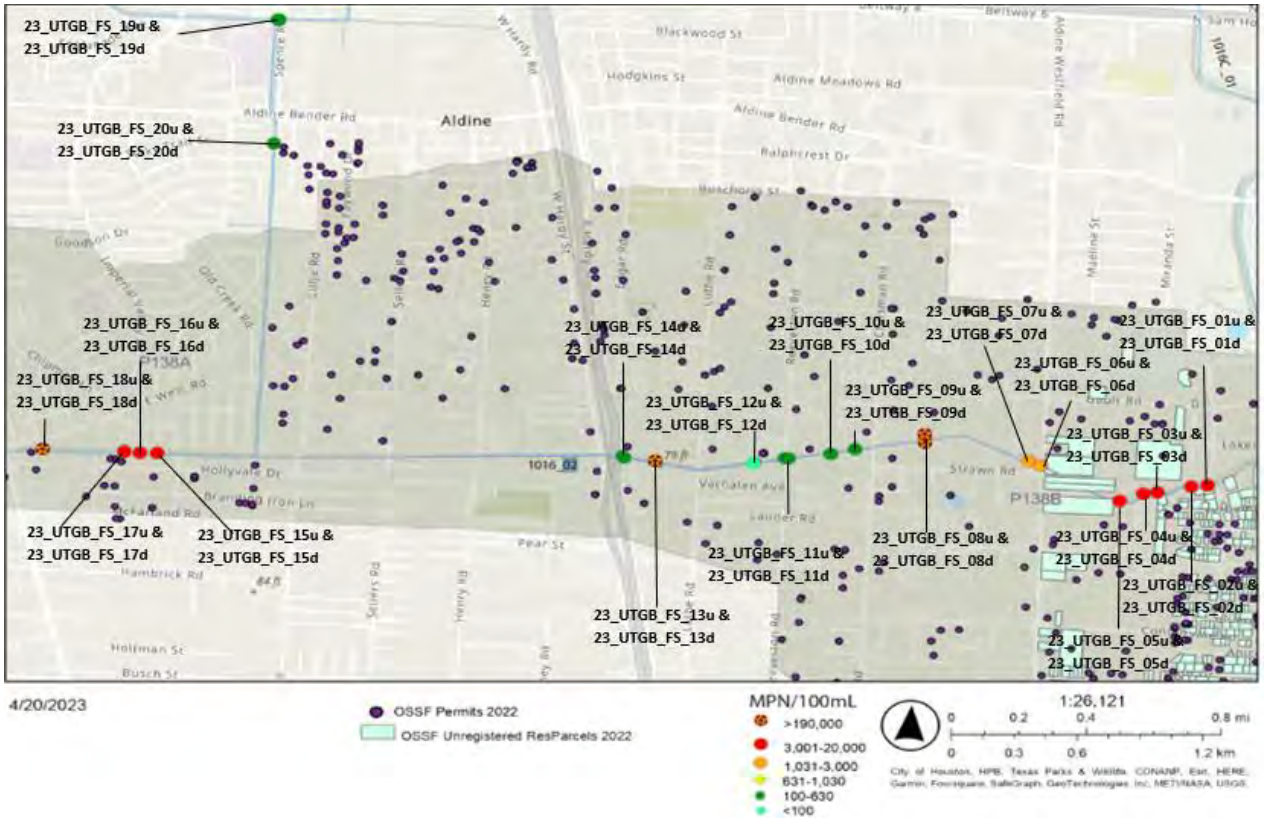


Figure 2: Field Investigation Bacteria Results on 1016C_01 with OSSF information.



REFERRALS TO RESPONSIBLE PARTIES

This investigation was able to fully assess the AU during the Windshield and Field Investigations. The majority of field samples from the 20 locations (14/20) had high levels of bacteria exceeding 1,500 MPN/100mL with several locations reading dangerously high levels of >190,000 MPN/100mL. The exceedingly high readings throughout the AU suggest numerous referral sites. The primary AU regions are the sections before Greens Bayou output but east of Chrisman Rd; then again from Luthe Rd westward until Airline Rd and Interstate 45. Referral sites listed below are within the primary AU region, and results suggest further investigation and mediation is required.

REFERRAL SITE: 23_UTGB_FS_01

Latitude: 29.916725 Longitude: -95.347722

Referral site 23_UTGB_FS_01 was at a pipe that was discharging into the AU. The upstream sample was 2,960 MPN/100mL while the downstream sample was 7,980 MPN/100mL, showing a difference of 5,290 MPN/100mL. Based on aerial maps, it appears there are pools present at the property where the pipe was located.

Figure 3: Referral site 23_UTGB_FS_01. Map showing location of sampling and inset photo of Creekside view.

REFERRAL SITE: 23_UTGB_FS_02

Latitude: 29.916609 Longitude: -95.348444

Referral site 23_UTGB_FS_02 occurred at the neighboring property from site 01, where a pipe was discharging into the AU (Figure 4). The upstream sample was 1,730 MPN/100mL while the downstream sample was 5,560 MPN/100mL, showing a difference of 3,830 MPN/100mL. This property also has a pool present.

Figure 4: Referral site 23_UTGB_FS_02. Map showing location of sampling and inset photo of Creekside view.

REFERRAL SITE: 23_UTGB_FS_03 and 23_UTGB_FS_04

SITE 03 Latitude : 29.916269 Longitude : -95.350072
SITE 04 Latitude : 29.916173 Longitude : -95.350724

Both sites were along the same property; therefore, are grouped together (Figure 7). Referral site 23_UTGB_FS_03 and 23_UTGB_FS_04 were sampled for observed discharge into the AU. Site 03 (Figure 5) had no piping while site 04 (Figure 6) did. For Site 03, the upstream sample was 530 MPN/100mL while the downstream sample was 5,540 MPN/100mL, showing a difference of 5,010 MPN/100mL. For site 04, the upstream sample was 5,560 MPN/100mL while the downstream sample was 6,310 MPN/100mL, showing a difference of 750 MPN/100mL.

Figures 5 & 6: Referral site 23_UTGB_FS_03, right-bank runoff. Site 23_UTGB_FS_04, pipe on right-bank.

Figure 7: Aerial map of sample locations for sites 03 and 04.

REFERRAL SITE: 23_UTGB_FS_08

Latitude: 29.918033 Longitude: -95.361248

At referral site 23_UTGB_FS_08 piping is seen emanating from a residence (Figure 8). Site 08 had numerous animals on the property. A chain link gate and steps on the backside of the property are distinctive. The field crew heard animals clucking, barking, and braying as well as smelled hoofed stock. They were able to confirm poultry, dogs and either horses or donkeys were on the property. The upstream sample was >242,000 MPN/100mL and downstream was 241,960 MPN/100mL, showing a difference of at least-40 MPN/100mL. While the difference was negative, the site is listed for referral because the previous sampling location (23_UTGB_FS_07) only registered at 7,330 MPN/100mL at the upstream collection point and 1,220 MPN/100mL downstream; demonstrating that there is some significant bacterial output happening between these locations. There could have been some unobserved output from the animals at site 08 or there could be more pollutants between sites 08 and 07.

Based on aerial maps (Figure 8) there could be output coming from Coastal Tank & Testing that was not observed. Additionally, between sites 07 and 08 the field crew observed a dry pipe along the left-bank that seemed to have no output, but was noted for reference: 29.917669, -95.357111.

Figure 8: Referral site 23_UTGB_FS_08 with inset photo of dripping pipe into the AU.

REFERRAL SITE: 23_UTGB_FS_13

Latitude: 29.916434 Longitude: -95.373969

Referral site 23_UTGB_FS_13 was a flowing pipe emanating from a property (Figure 10). This site had two drainage pipes present that were both flowing into the AU (Figure 9). Samples were taken upstream of the nearest pipe and downstream of the farthest pipe. The upstream sample was 730 MPN/100mL and downstream was >242,000 MPN/100mL, showing a difference exceeding 242,000 MPN/100mL. Aerial maps show commercial use of properties (Figure 11).

Figures 9 and 10: Referral site 23_UTGB_FS_13, yellow boxes highlighting the output pipes. Zoomed in photos of pipe.

Figures 11: Referral site 23_UTGB_FS_13. Numerous businesses present just upstream of sample site.

REFERRAL SITE: 23_UTGB_FS_15

Latitude: 29.915498 Longitude: -95.397699

Referral site 23_UTGB_FS_15 is a pipe situated on the left bank of the AU (Figure 12). The upstream sample was 2,850 MPN/100mL and downstream was 5,290 MPN/100mL, showing a difference of 2,440 MPN/100mL. Given that aerial maps indicate there is a development north of the AU, this could be storm sewer systems (Figure 12).

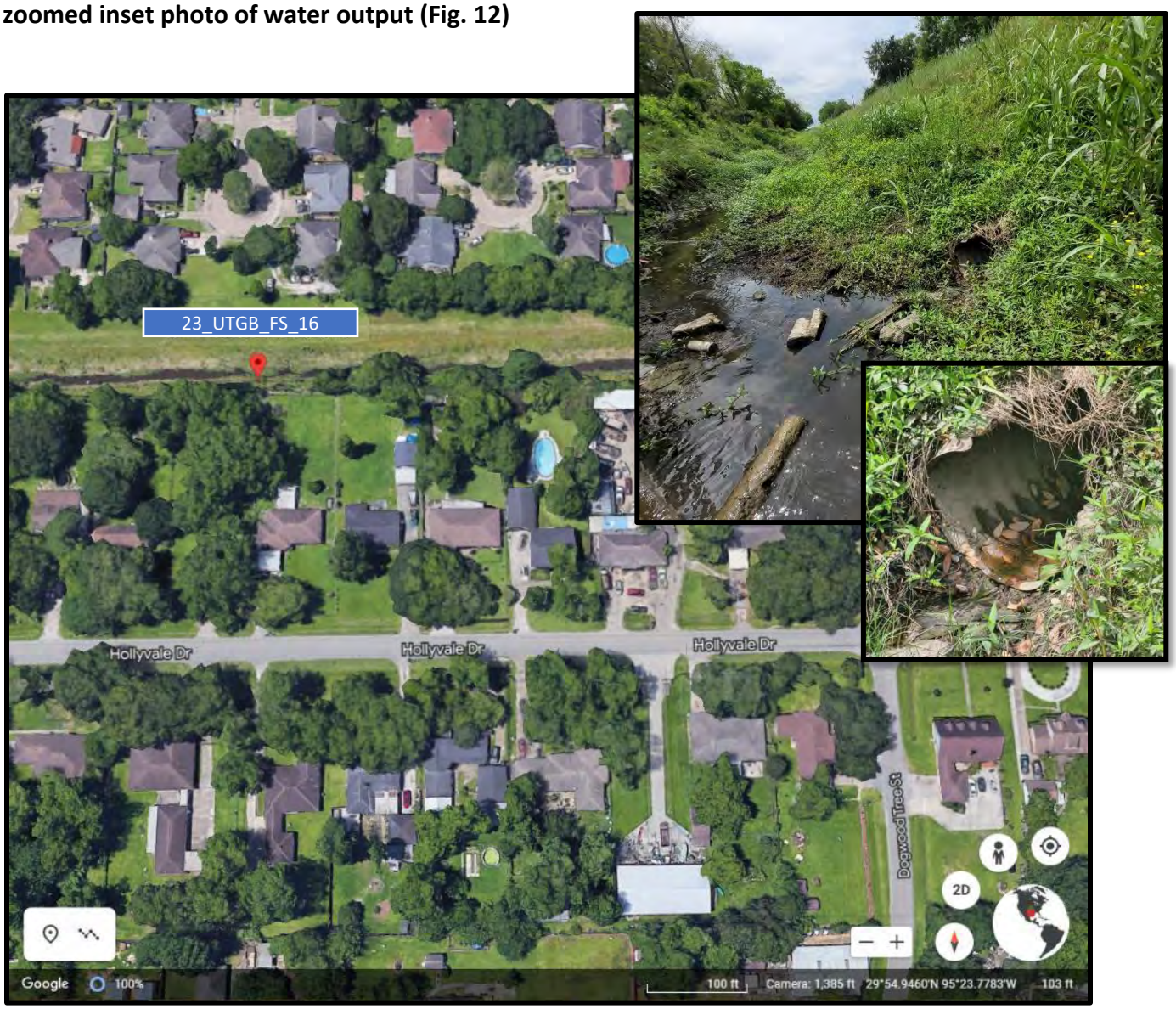
Figure 12: Referral site 23_UTGB_FS_15. Aerial map of sampling site and inset photo of Creekside view.

REFERRAL SITE: 23_UTGB_FS_16

Latitude: 29.915488 Longitude: -95.398520

Referral site 23_UTGB_FS_16 is a pipe situated on the left bank of the AU (Figure 14). The upstream sample was 3,150 MPN/100mL and downstream was 5,810 MPN/100mL, showing a difference of 2,660 MPN/100mL. Given that aerial maps indicate there is a development north of the AU, this could be storm sewer systems (Figure 13).

Figures 13 and 14: Referral site 23_UTGB_FS_16 aerial map (Fig. 11). Pipe on left bank of AU with zoomed inset photo of water output (Fig. 12)



REFERRAL SITE: 23_UTGB_FS_17

Latitude: 29.915496 Longitude: -95.399273

Referral site 23_UTGB_FS_17 is also a pipe on the left-bank in a residential area (Figure 15). The upstream sample was 16,640 MPN/100mL and downstream was 8,860 MPN/100mL, showing a difference of -7,780 MPN/100mL. This site is listed because there was significant input between sites 16 (5,810 MPN/100mL) and 17 (16,640 MPN/100mL) that was not viewed by the field crew. Given that aerial maps indicate there is a development north of the AU, this could be storm sewer systems (Figure 16).

Figures 15 and 16: Referral site 23_UTGB_FS_17. Aerial map (13) and Creekside sample site (14)

REFERRAL SITE: 23_UTGB_FS_18

Latitude: 29.9154100 Longitude: -95.403153

Referral site 23_UTGB_FS_18 is a pipe on the left-bank of the AU (Figure 18). This site is approaching the West Rd and Airline intersections so there is increasing industrial and commercial outputs in the area (Figure 17). The upstream sample was 198,630 MPN/100mL and downstream was 16,640 MPN/100mL, showing a difference of -181,900 MPN/100mL. The lowered *E. coli* is a welcomed reprieve; however, this site is mentioned for referral because of the extremely high *E. coli* measured for the upstream sample (198,630 MPN/100mL). Only one other pipe was noted between site 17 and site 18.

A corroded pipe of the same make and size as those listed in sites 16, 17 and 18 was observed upstream of site 18. Given that it appeared closed, the field crew did not sample there. However, the extremely high *E. coli* load for the upstream sample at site 18 warrants the disclosure of the coordinates for the corroded pipe: 29,915432, -95.402111.

Figures 17 and 18: Referral site 23_UTGB_FS_18. Aerial map of sample site (Figure 17) and Creekside view of sample site (Figure 18).

Targeted Bacteria Monitoring Project

Field Investigation Final Report

Segment 1016D_01 Unnamed Tributary of Greens Bayou

Houston-Galveston Area Council

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Field Investigation Final Report

Segment 1016D_01 Unnamed Tributary of Greens Bayou

METHODS

Targeted monitoring efforts are to enhance the stream for primary contact recreation. According to State Water Quality Standards by the Texas Commission on Environmental Quality, the geometric mean criterion for *E. coli* in this waterway is 126 MPN/100mL and the single sample criterion is 399 MPN/100mL. The first field investigation (FI) took place on April 20, 2023, twelve days after significant rainfall within the watershed. The second FI took place on June 29, 2023, eight days after significant rainfall. The unnamed tributary of Greens Bayou (1016D) has few access points outside of what was sampled during the windshield survey (WS). The banks are very tall, steep, and heavily wooded or vegetated in most places on the main channel.

Due to the excessive walking length of the 1016D assessment unit (AU) and tributaries of interest, the field crew focused sampling efforts on reaches identified during the WS with high bacteria levels. These priority reaches included the 1016D AU between Mesa Drive and Smith Road, plus an upstream tributary crossing McCracken Road. The 1016D AU between Old Humble Road and Highway 59, along with a tributary between Old Humble Road and Beltway 8, were also identified as reaches to investigate as part of the field investigation (Figure 1).

The FI was a thorough survey where a team of two walked the assessment unit and sampled any water observed flowing into the stream. Water could be flowing in from a pipe, culvert, natural tributary, or earthen ditch. Flowing water was categorized into two source types: permitted outfalls or unpermitted outfalls. Permitted outfalls included wastewater facilities and municipal separate storm sewer systems (MS4). Any pipe greater than 12 inches (in.) in diameter was assumed to be permitted by our field crews. When flowing water was observed from a permitted outfall, two samples were collected. One sample was collected immediately downstream of the outfall where the flowing outfall was mixing with the ambient water. The second sample was taken upstream of the flowing outfall outside of the realm of influence from the outfall to provide the ambient bacteria levels of the assessment unit in that area. The second type of source was an unpermitted outfall, which was any other flowing source of water that was judged to not be permitted in the field, including flowing small (<12 in. diameter) “homemade” pipes and tributaries.

Tributaries were sampled directly with a single ambient sample taken upstream of the confluence of the main channel. For investigated reaches where no outfalls or tributaries were identified, yet showed elevated levels of bacteria during the WS, ambient samples were taken by bracketing locations to narrow down where unseen bacteria sources might be present.

Assessment Units, collection, laboratory methods, and data handling practices are detailed in Appendix J of the FY 2022-2023 H-GAC Multi-Basin Clean Rivers Program Quality Assurance Project Plan (H-GAC QAPP, 2022). For all field investigations, the flowing outfall (latitude and longitude) as well as the diameter, material, water depth of the flowing outfall and site conditions were recorded by taking photos and other relevant notes. All bacteria samples were analyzed by Eastex Environmental Laboratory Inc.

RESULTS

Field Investigation 1

For the first FI, 15 samples were collected at 11 locations (Table 1). Outfalls where an "upstream" and "downstream" sample were collected are noted in the Sample ID with a "u" or "d" respectively. No direct water samples were collected from outfalls. To enhance clarity of the sampling efforts, the field survey map (Figure 1) displays a singular icon for the upstream and downstream collections. All locations are listed in Table 1 below.

Figure 1. Field Investigation 1 Bacteria Results from 04/20/2023 on Unnamed Tributary of Greens Bayou (1016D_01)

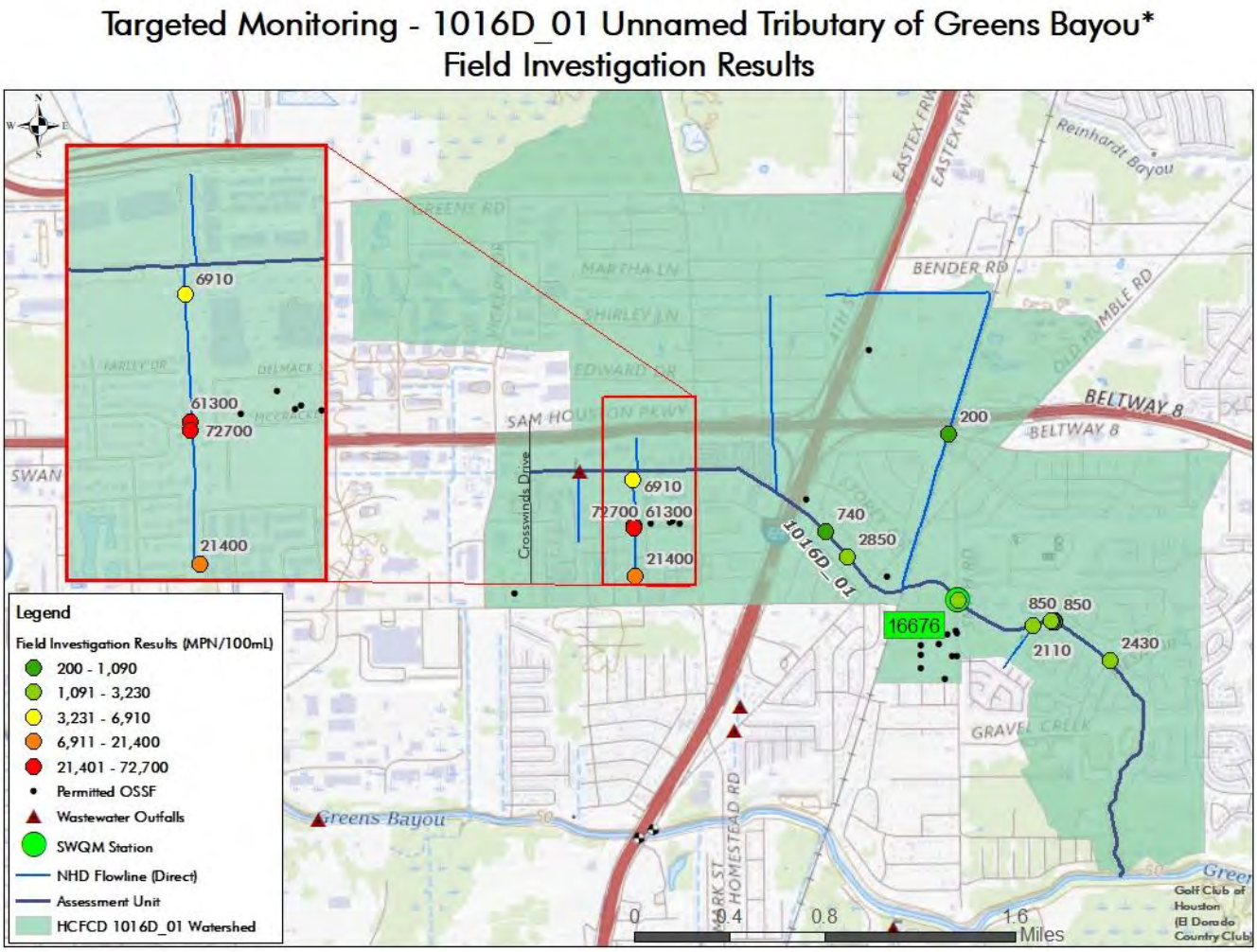


Table 1: Field Investigation 1 locations. Upstream and Downstream coordinates and *E. coli* difference reported.

Sample ID	Latitude	Longitude	Material of Outfall	Inner Diameter of Pipe (Inches)	*DS or direct E. coli* Sample Results (MPN/100 mL)	*US E. coli sample results (MPN/100 mL)*	*Difference (MPN/100mL)*	Comments
1016DF1_01d	29.9297482	-95.28160946	3	36	850	N/A	N/A	Outfall on left bank, just a small trickle discharge.
1016DF1_01u	29.92966215	-95.28162697	N/A	N/A	1,090	N/A	N/A	Taken closer to left bank to avoid upstream discharge.
1016DF1_02d & 1016DF1_02u	29.92969428 & 29.92969843	-95.28176843 & -95.28186203	1	72	850	3,230	2,380	Concrete outfall on left bank. Two openings, downstream one filled in, no flow. Possibly outfall for WWTF. Chlorine strip result between 0.0 and 0.5, pH 6.2
1016DF1_03	29.92946715	-95.28295896	N/A	N/A	2,110	N/A	N/A	Tributary sample taken about 15 ft upstream of confluence
1016DF1_04d & 1016DF1_04u	29.93081733 & 29.93081412	-95.28750823 & -95.28745535	2	35.4	980	2,310	1,330	Clear water flowing from pipe, windshield survey noted it appeared to be from a drinking water main/meter
1016DF1_05	29.93713916	-95.30724806	N/A	N/A	6,910	N/A	N/A	Sample near bottom of McCracken Rd tributary
1016DF1_06d & 1016DF1_06u	29.93474811 & 29.93459752	-95.30722687 & -95.30722481	4	N/A	61,300	72,700	11,400	Sample downstream of culvert under McCracken Rd. Water smells bad like sewer, stronger downstream. Sample upstream of culvert under McCracken Rd. Black pipe from possible septic connection crosses tributary.
1016DF1_07	29.9321009	-95.30712343	4	N/A	21,400	N/A	N/A	Sample downstream of nonflowing outfall near apt. complex near upper reach of walkable part of tributary
1016DF1_08	29.9395968	-95.28809088	4	N/A	200	N/A	N/A	Tributary sample downstream of crossing at railroad and Beltway 8
1016DF1_09	29.92764675	-95.27828443	N/A	N/A	2,430	N/A	N/A	Ambient sample upstream of Mesa Dr.
1016DF1_10	29.93308496	-95.29424371	N/A	N/A	2,850	N/A	N/A	Ambient sample at upstream end of Edmond Park
1016DF1_11	29.93445775	-95.2955503	N/A	N/A	740	N/A	N/A	Ambient sample downstream of Marine Dr. Between this and downstream sample the houses on the waterway had at least 10 dogs, a cow, and a horse in yards adjacent to waterway.

DS = Downstream ID = Inner Diameter NA = Sample not associated with an outfall

* When a sample was taken DS and US, the difference was calculated.

If the Difference is a positive number, it indicates a higher DS than US value and that the source could be contributing *E. coli* to the waterway.

= Recommended for further investigation by the proper authorities

Of the 15 samples, there are 14 that reflected a bacteria level greater than the primary contact recreation single sample criterion of 399 MPN/100 mL. The sample collected at 1016DF1_08 was the only sample below the single sample criterion; it was collected along the tributary between Old Humble Road and Beltway 8. This tributary is not included with the references for further investigation at this point. Although the samples collected on the main channel and two other tributaries were higher than the single sample criterion, significantly in some cases, few locations could be identified for further investigation as they did not result from observed dry weather flows. Areas suggested for further investigation are detailed in the Referrals to Responsible Parties section of the report.

While most of the locations sampled on the main 1016D_01 channel showed higher bacteria results than during the WS, the sample taken at Mesa Drive (1016DF1_09) was lower than the WS result of 24,000 MPN/100mL and was more consistent with the rest of the main channel FI samples. High bacteria levels (2,110 MPN/100mL) were found in a sample taken upstream in a tributary between Mesa Drive and Smith Road and that tributary is recommended for further investigation. The tributary could be the source of the higher bacteria levels at Mesa Dr. during the WS, but that cannot be confirmed with the results from the initial FI.

The highest bacteria result was recorded along an unnamed tributary that runs perpendicular to McCracken Road south of Beltway 8. While all samples from the tributary showed high bacteria levels, the reach between the Haverstock Hills apartment complex and McCracken Road (Samples 1016DF1_06D, 1016DF1_06U and 1016DF1_07) were extremely high (21,400 to 72,700 MPN/100mL). This tributary also had remarkably high bacteria results during the previous targeted monitoring efforts in 2020 and is recommended for further investigation. The sample with the highest bacteria count (1016DF1_06U) is next to a suspicious black plastic pipe going across the channel.

The bacteria results also varied significantly between samples 1016DF1_10 and 1016DF1_11. Although no pipes, outfalls, or flows were identified, those samples are bracketing a section of residential homes with dogs, a cow, and a horse. More information on the locations recommended for further investigation is included in the next section.

Field Investigation 2

Field Investigation 2 was conducted to try and identify sources on a tributary from FI 1 that had high bacteria results (1016DF1_03) and to re-investigate areas from FI 1 that had high results without specific sources identified. During FI 2, 11 samples were collected at 11 locations (Table 2). There were no observed flowing outfalls during this FI, and the tributary investigated was experiencing intermittent flow conditions. To enhance clarity of the sampling efforts, the field investigation map (Figure 2) displays all sampling locations. All locations from FI 2 are listed in Table 2 on page seven.

Figure 2. Field Investigation 2 Bacteria Results from 06/29/2023 on Unnamed Tributary of Greens Bayou (1016D_01)

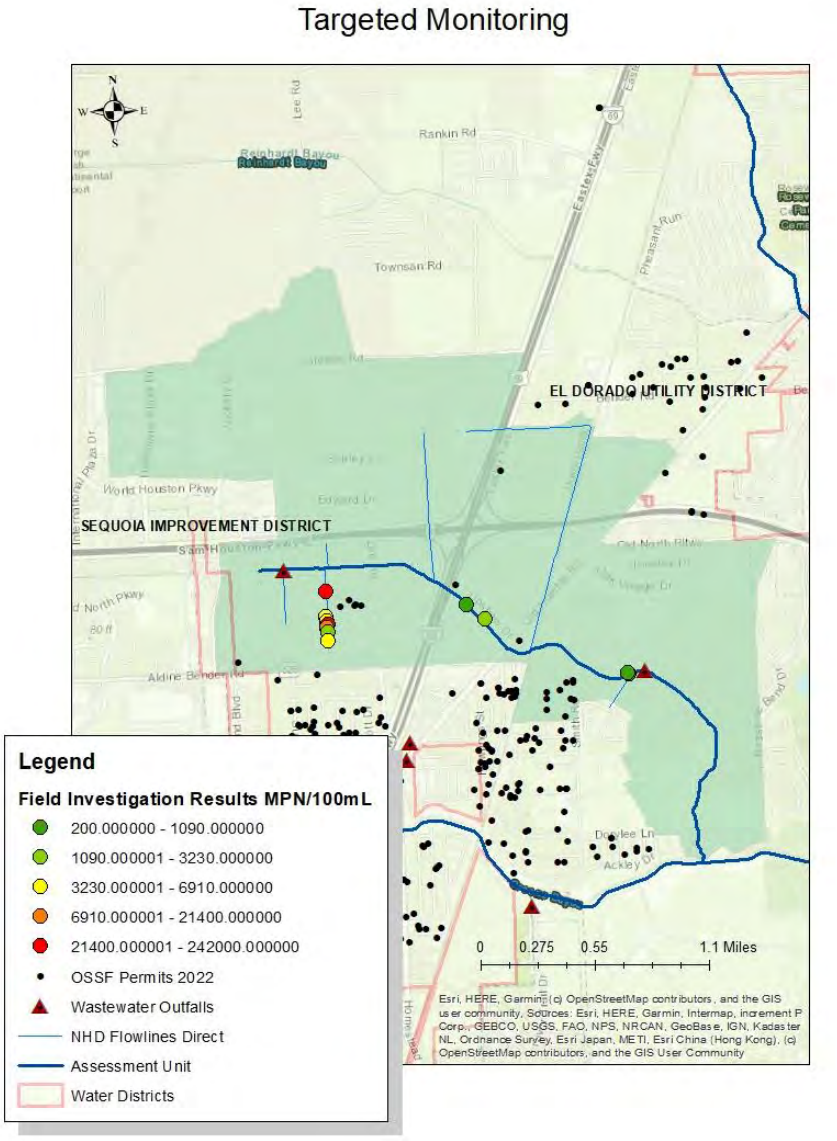


Table 2: Field Investigation 2 locations. Upstream and Downstream coordinates and *E. coli* reported

Sample ID	Latitude	Longitude	Material of Outfall	Inner Diameter of Pipe (Inches)	*E. coli* Sample Results (MPN/100 mL)	Comments
1016D-01-01	29.92954	-95.28303	N/A	N/A	300	Trash and metal scraps present. Small fork in stream leading to tributary. Somewhat clear water. The tributary dried up 30-40 yards upstream.
1016D-01-02	29.92960	-95.28315	N/A	N/A	630	Debris present. Metal present. no flow. Fish and insects present.
1016D-01-03	29.936	-95.30723	N/A	N/A	242,000	Muddy conditions. Muddy water. North of culvert (about 30 yards) on McCracken Road. Intermittent pools going up ditch. Trash and glass present.
1016D-01-04	29.93425	-95.30723	N/A	N/A	4,350	Weeds surround the area and are overgrown. Drier area.
1016D-01-05	29.93394	-95.30719	N/A	N/A	4,370	Weeds overgrown in the area. Drier area of stream.
1016D-01-06	29.93371	-95.30715	N/A	N/A	32,600	Weeds overgrown in the area. Drier area of stream.
1016D-01-07	29.93347	-95.30718	N/A	N/A	17,200	Weeds overgrown. Not as dry. More water along with a lot of green algae.
1016D-01-08	29.93316	-95.30714	N/A	N/A	2,430	Next to storm water outfall. Nothing flowing from outfall.
1016D-01-09	29.93256	-95.30718	N/A	N/A	4,040	
1016D-01-10	29.93374	-95.29452	N/A	N/A	2,560	Sample taken at beginning of residential homes at the end of Edmond Park. Known livestock within community.
1016D-01-11	29.93474	-95.29591	N/A	N/A	200	Ambient sample downstream of Marine Dr. Between this and downstream sample the houses on the waterway had at least 10 dogs, a cow, and a horse in yards adjacent to waterway.

100mOf the 11 samples, there are nine that reflected a bacteria level greater than the primary contact recreation single sample criterion of 399 MPN/100 mL. Samples collected at 1016D-01-01 & 1016D-01-11 were the only samples that meet the single sample criterion. 1016D-01-01 was collected at the entrance of the tributary between Mesa Dr. and Smith Rd. from the first FI. 1016D-01-11 was collected just downstream of Marine Dr., just upstream of where livestock and multiple dogs were noted from the first FI.

The locations targeted and sampled for FI 2 showed consistent bacteria results with the previous FI and WS along the tributary that is perpendicular with McCracken Rd. and south of Beltway 8. Sample 1016D-01-03 was much higher than the WS and the FI result of 242,000 MPN/100mL; the tributary perpendicular with McCracken Rd. had nearly become intermittent. Sampling along this tributary was taken from small stagnant pools. Results continue to be high along the tributary ranging from 2,430 to 242,000 MPN/100mL. High bacteria levels (2,560 MPN/100mL) were also found in a sample taken at the beginning of residential homes on Hamblen Dr. at the end of Edmond Park. This is a significant difference between the sample taken upstream next to Marine Dr. With low bacteria levels (200 MPN/100mL). Livestock such as a Cow and horse were noted as well as many dogs within the neighborhood.

Bacteria results from the tributary between Mesa Dr. And Smith Rd. were not as high as the previous FI. Sample 1016D-01-01 passed primary contact recreation single sample criterion with a result of 300 MPN/100mL. Sample 1016D-01-02 exceeds the primary contact recreation single sample criterion of 399 MPN/100 mL with a result of 630 MPN/100mL.

REFERRALS TO RESPONSIBLE PARTIES

While nearly all the samples collected exceeded the single sample criterion three locations were recommended and investigated based on either high bacteria levels on tributaries or substantial changes in upstream and downstream ambient sample bacteria results that suggest a source that was not located during the initial FI. More details on the three locations are included in the following Referral Site sections.

REFERRAL SITE: Tributary between 1016DF1_06d, _06u, and _07

1016DF1_06d : Latitude : 29.93474811 Longitude : - 95.30722687
1016DF1_06u : Latitude : 29.93459752 Longitude : - 95.30722481
1016DF1_07: Latitude: 29.9321009 Longitude: - 95.30712343

The tributary on the upstream end 1016D_01 that runs perpendicular to McCracken Rd was identified as an area of concern for high bacteria levels during the previous targeted monitoring efforts and was identified during FI 1 as the location with the highest bacteria levels. In particular, the samples collected between the Haverstock Hills Apartments and McCracken Road had *E. coli* levels of 21,400 MPN/100mL, 72,700 MPN/100mL, and 61,300 MPN/100mL. Similar results were found during FI 2, the highest bacteria results between the Haverstock Hills Apartments and McCracken Road had E. coli levels of 242,000 MPN/100mL.

Several observations from FI 1 and FI 2 on the tributary are worth noting. The channel itself is choked with vegetation impeding water flow, so sources of bacteria that flow into the channel may linger for periods of time. A good amount of the vegetation in this reach consisted of elephant ears which could suggest the common presence of nutrients or bacteria sources like sewage. There was also a line of trash down the right bank coming from the northwest corner of the apartment complex. The debris trail looked like it came from a water flow from the complex parking lot, though no flow was present at the time of the FI. Similarly, several broken or questionable pipes were noted in that reach. These included a black pipe crossing the channel just upstream of McCracken Rd and attached to a cleanout pipe, a cleanout pipe with a garbage bag over it, and a broken pipe in the waterway with no identified source.

Figure 1: Referral site 1016DF1_06d. Map with star showing referral site location. Subset image of tributary view.

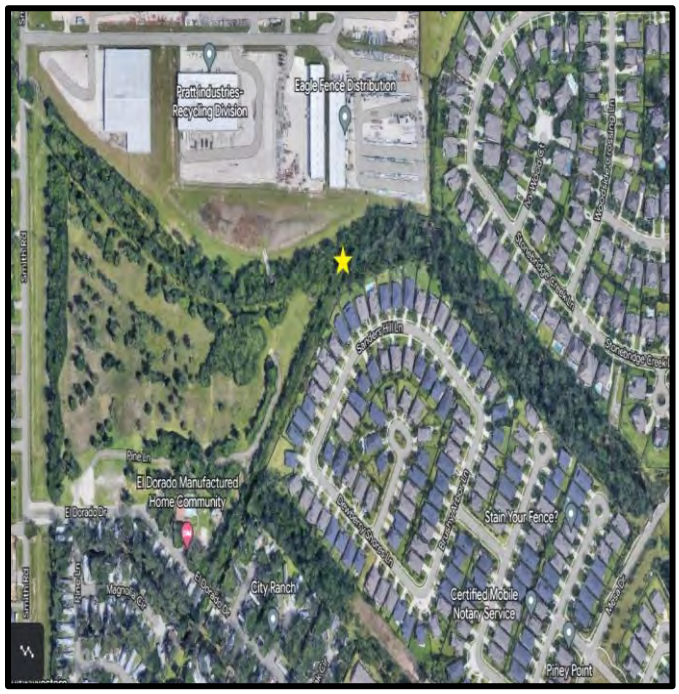
Figure 4: Referral site 1016DF1_06u. Subset image of tributary view

Figure 5: Referral site 1016DF1_07. Map with star showing referral site location. Subset image of tributary view.

REFERRAL SITE: 1016DF1_03

Latitude: 29.92946715 Longitude: -95.28295896
Sample 10106DF1_03 was collected about 15 feet upstream on a tributary on the right bank of 1016D_01. The field crew did not walk this tributary during the FI, but desktop review has the tributary end at the El Dorado Manufactured Home Community next to what is potentially its water treatment system. Dewberry Shores Ln and Sanders Hill Ln in the Piney Point subdivision are also adjacent to the tributary. Further investigation of this tributary was attempted during FI 2, but the channel was experiencing intermittent flow conditions.

Figure 6: Referral site 1016DF1_03. Map showing proximity to two neighborhoods. Subset image of tributary view.



REFERRAL SITE: Residential Area between 1016DF1_10 and _11

Latitude: 29.93308496 Longitude: -95.29424371
As noted in the Results section, overall *E. coli* levels on channel 1016DF1_10 and 1016DF1_11 showed elevated levels of bacteria. Samples between Edmond Park and Marine Drive ranged between 2,850 MPN/100mL to 740 MPN/100mL at the time of the FI. While no dry weather flows were noted during the FI, bracketing samples were taken upstream at the end of Edmond Park and downstream of Marine Dr. Despite the lack of visible dry weather flows, the houses on the waterway had at least 10 dogs, a cow, and a horse in yards adjacent to waterway. Bacteria levels spiked from 740 MPN/100mL (1016DF1_11) upstream of the residential area to 2,850 MPN/100mL downstream of the residential area at the western edge of Edmonds Park.

Figure 7: Referral site 1016DF1_10. Map with star showing referral site location. Subset image of tributary view.

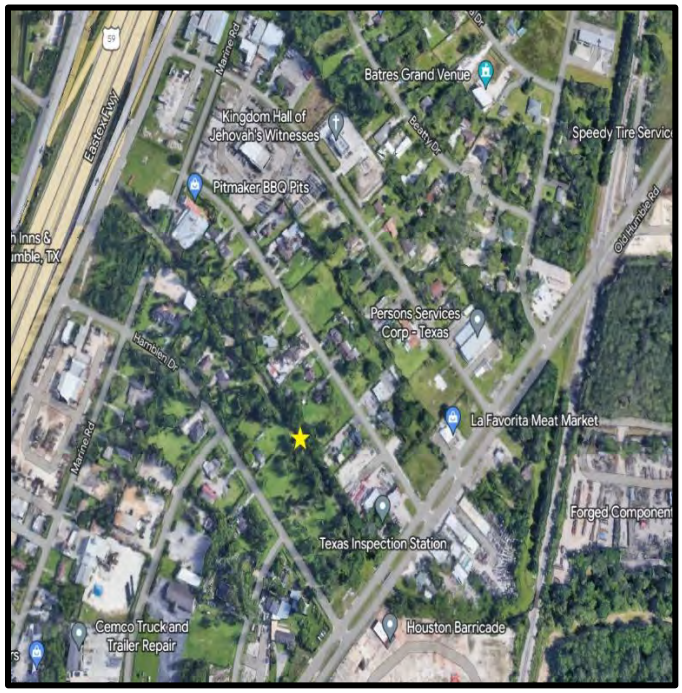


Figure 8: Referral site 1016DF1_11. Map with star showing referral site location. Subset image of tributary view.