Executive Summary

Overview

The Houston-Galveston Area Council's (H-GAC) Targeted Monitoring Project focuses on the region's most prevalent pollutant – bacteria. The goal is to examine ten watersheds in various land cover types to identify bacteria sources (Table 1). 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, 2) land cover type, and 3) accessibility and feasibility of the waterway for field investigations (Figure 1).

Table 1. Targeted Monitoring Assessment Units

Predominant Land Cover Type	AU ID	AU Name	Relative Bacteria Geomean	AU Length (miles)
Urban	1007T_01	Bintliff Ditch	24.46	3.9
Urban	1017E_01	Unnamed tributary of White Oak Bayou	17.22	1.92
Urban	1007U_01	Mimosa Ditch	15.37	1.9
Urban	1016D_01	Unnamed Tributary of Greens Bayou	15.11	4.49
Suburban	1004J_01	White Oak Creek	26.39	2.96
Suburban	1103G_01	Unnamed Tributary of Gum Bayou	15.26	3.29
Suburban	2432A_02	Mustang Bayou	11.68	5.08
Suburban	1101D_01	Robinson Bayou (tributary of Clear Creek)	6.62	2.7
Rural	1104_01	Dickinson Bayou Above Tidal	14.11	3.43
Rural	1103E_01	Cedar Creek (tributary of Dickinson Bayou)	1.96	1.31

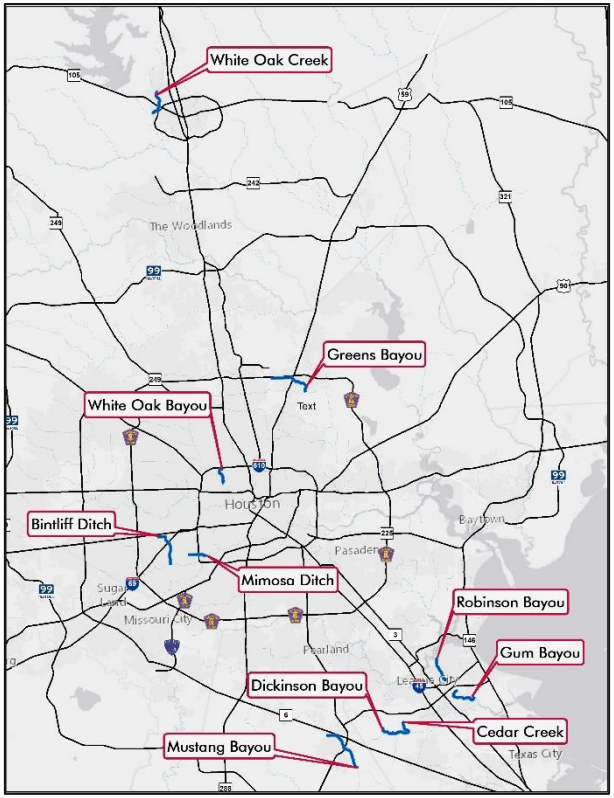


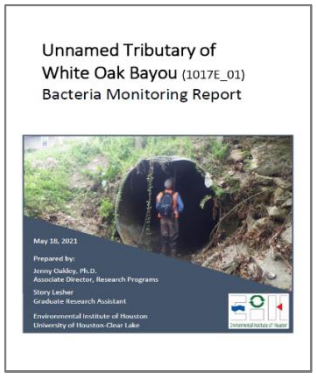
Figure 1. Prioritized AU Locations

Methods

H-GAC and its subcontractor, the Environmental Institute of Houston, University of Houston-Clear Lake 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 concerning tributaries leading into the main segment. Both survey events (windshield survey and field investigation) were only conducted during dry weather and strategically at certain outfalls or incoming tributaries. Any outfall categorized as "permitted" or > 12 inches in diameter was sampled twice; a sample was collected upstream and downstream of the permitted pipe but not at the outfall source. Any outfall that was assumed to be "unpermitted" or < 12 inches in diameter was sampled directly at the source. All tributary samples were collected far enough into the flowing water so that mixing was not a factor.

Results

A report for approach and findings were created for each watershed. In total, 92 samples were collected in all windshield surveys, 343 samples collected within the field investigations, and 52 sites were described for referral to the proper authorities (Table 2). Two watersheds are recommended for additional field investigations as some high bacteria concentrations had no sources identified and could not be explained. Individual assessment unit reports are found at https://h-gac.com/community-and-environmental-planning-publications/water-resources.



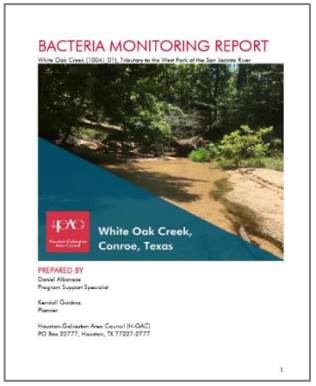


Table 2. Bacteria Sample Results

AU ID	AU Name	Windshield Survey Sample Count	Field Investigation Sample Count	Referral Sites
1007T_01	Bintliff Ditch	13	76	8
1017E_01	Unnamed tributary of White Oak Bayou	13	26	3*
1007U_01	Mimosa Ditch	7	26	4
1016D_01	Unnamed Tributary of Greens Bayou	11	47	5
1004J_01	White Oak Creek	9	29	3*
1103G_01	Unnamed Tributary of Gum Bayou	8	22	4
2432A_02	Mustang Bayou	16	39	10
1101D_01	Robinson Bayou (tributary of Clear Creek)	10	53	9
1104_01	Dickinson Bayou Above Tidal	4	13	5
1103E_01	Cedar Creek (tributary of Dickinson Bayou)	1	12	1

*Additional sites may be referred once sources can be identified in future field investigations.

Future Work

Currently, five of the ten AUs have been sent to the proper authorities for further investigation and remediation. The City of Houston was informed of the four AU field investigation results that were found within their jurisdictional boundary. Additionally, the City of League City was informed of Robinson Bayou (1101D_01). Their Wastewater Pretreatment Group is aware of the results and plan to follow up.

Next steps include referring the remaining sites to the proper authorities and working towards identifying the bacteria sources along the two waterways that could not be identified or explained. With future funding, these AUs will undergo an additional field investigation. H-GAC anticipates continual work with the proper authorities towards corrective action of the project's prioritized AUs. Due to the project's success, H-GAC also anticipates adding AUs to the list of field investigations by re-analyzing 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.

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

Bintliff Ditch (1007T_01)
Bacteria Monitoring Report

June 1, 2021

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Introduction and Methods

Bintliff Ditch (TCEQ assessment unit: 1007T_01) was identified by the Houston-Galveston Area Council (HGAC) as having high 7-year geomean for bacteria (*E. coli*) concentrations during regular ambient monitoring through the Clean Rivers Program. As a result, Bintliff Ditch has undergone a bacteria investigation study where bacteria samples were collected at strategic locations along the entire length of the segment in order to aid in pinpointing potential sources, and then refer those sources for investigation by the proper authorities.

There are two separate field events that have taken place to date. 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 segment are not stormwater. A Windshield Survey (WS) acted both as a reconnaissance survey, and initial spatial assessment of ambient bacteria levels throughout the segment and its tributaries. During the WS, surface grab samples for bacteria were collected from bridge crossings and other public access points along the assessment unit and from the most downstream point publicly accessible on each tributary. The WS helped the field crew understand the ambient bacteria levels in the assessment unit on a spatial scale and prioritize tributaries for the Field Investigation (FI).

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 segment. 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 un-permitted outfalls. Permitted outfalls included waste water facilities and municipal separate storm sewer systems (MS4). Any pipe greater than 12 inches 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 un-permitted outfall, which was any other flowing source of water that was not assumed to be permitted including flowing small (<12 inch diameter) “homemade” pipes and tributaries.

When a flowing un-permitted 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 un-permitted 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.

Assessment Units, collection and laboratory methods, and data handling practices are detailed in the Appendix J to the H-GAC Multi-Basin Clean Rivers Program FY 2020-2021 Quality Assurance Project Plan (QAPP). The field crew carefully documented the 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.

Results

Windshield Survey

The windshield survey was conducted on March 9, 2021; it had been 8 days since the last significant rainfall in the watershed. A total of 13 bacteria samples were collected during the WS, 12 on the Bintliff Ditch assessment unit itself and 1 on a tributary to the ditch (Figure 1). Bacteria results from the ambient water samples collected during the WS ranged from 52–8660 MPN/100ML.

Field Investigation

The FI of the main stream and tributary was conducted on April 6, 2021 (9 days since last significant rainfall) and a total of 76 bacteria samples were collected. The values of the bacteria samples collected from downstream of permitted outfalls, or directly from un-permitted outfalls are illustrated in Figure 2. A total of eight referral locations with elevated *E. coli* bacteria levels measured during the FI are recommended for further investigation by the proper authorities. These locations are summarized in Table 1. Each of these referrals are summarized by site herein. Much of the segment had ambient samples with bacteria levels at or greater than 24,200 MPN/100mL (cells highlighted in yellow in Table 1). A segment-wide investigation by the authorities or a second field investigation on this segment is recommended.

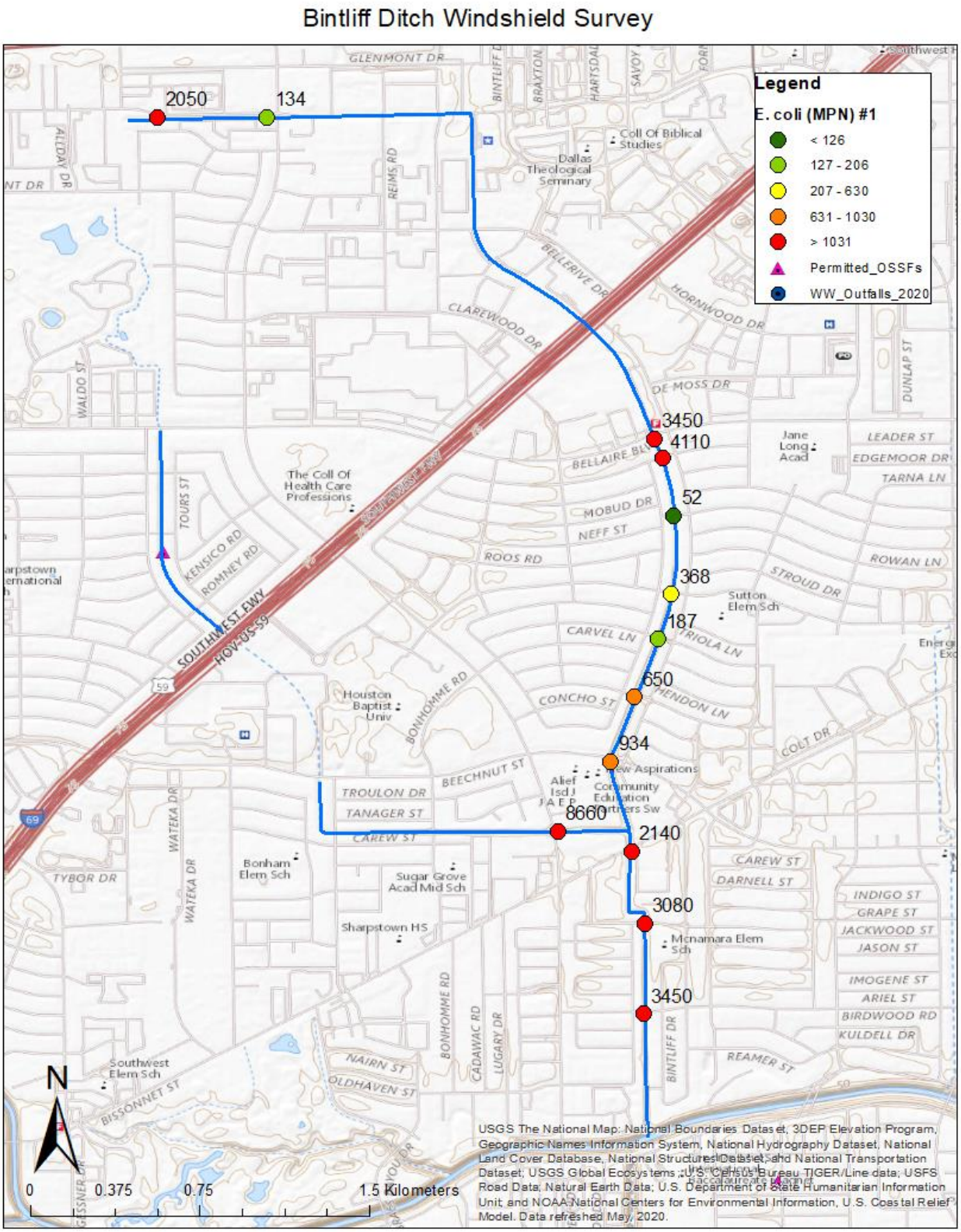

Figure 1. Map of Windshield Survey bacteria results from March 9, 2021.

Figure 2. Map of Field Investigation bacteria results from April 6, 2021. Results displayed are the raw bacteria levels from the samples collected downstream of permitted outfalls, or directly from un-permitted outfalls.

Table 1. *E. coli* bacteria results measured during the field investigation. Rows highlighted in gray are recommended for further investigation by the proper authorities. ID = inner diameter, DS = downstream, US = upstream. NA = Sample was not taken from or in relation to a pipe or outflow.

Sample ID	Latitude	Longitude	Material of Outfall	ID of pipe (in)	Water depth in pipe (in)	DS or direct sample *E. coli* (MPN/100mL)	US *E. coli* (MPN/ 100mL)	Difference (DS-US)	Comments
BIN-FI-01	29.67872	-95.50529	Plastic or Plastic Coated	41.00	0.06	24200	24200	0	Barely trickling. Right bank.
BIN-FI-03	29.68168	-95.50527	Metal	12.00	NA	10	NA	NA	Leaking pipe going over (perpendicular) to ditch. Leaking on left bank.
BIN-FI-04	29.68521	-95.50533	Plastic or Plastic Coated	36.00	NA	24200	24200	0	Right bank. Water is leaking from underneath the pipe.
BIN-FI-06	29.68644	-95.50594	Concrete	40.00	0.13	24200	24200	0	Left bank. Veg clogging opening of pipe - water trickling through.
BIN-FI-08	29.68733	-95.50597	Concrete	40.00	0.13	24200	24200	0	Left bank. Large amount of veg growing at opening of pipe - water slowly trickling through.
BIN-FI-10	29.68803	-95.50593	Concrete	40.00	0.13	24200	24200	0	Left bank. Large amount of veg growing out of opening of pipe and in front of. Water trickling through and down crack in cement.
BIN-FI-12	29.68897	-95.50596	Metal	6.00	0.50	1020	NA	NA	Left bank. Pipe once spanned across canal but is now broken and leaking. Collected sample directly from pipe.
BIN-FI-13	29.68895	-95.50600	Concrete	NA	NA	24200	24200	0	Took sample from trib, about 3m upstream of receiving waters. Took sample 14 upstream of trib.
BIN-FI-15	29.68961	-95.50617	Concrete	4.00	0.25	24200	24200	0	Left bank. Large metal outfall broken on bottom and leaking down through concrete to another drain. Foul odor coming from larger pipe.
BIN-FI-17	29.68991	-95.50626	Metal	20.00	NA	24200	24200	0	Right bank. Bottom rusted out - unable to get water depth in pipe.
BIN-FI-19	29.69120	-95.50657	Concrete	NA	NA	24200	24200	0	Left bank. Water flowing out of crack in concrete. Potential busted pipe causing leak.
BIN-FI-21	29.69186	-95.50676	Concrete	40.00	3.00	31	NA	NA	Pipe under bridge. Right bank. Not connected to upstream, blocked off. Flowing downstream and connected downstream.
BIN-FI-22	29.69193	-95.50661	Concrete	30.00	0.03	620	24200	-23580	Dead cat next to outfall. Water flowing downstream. Cut off from upstream. Left Bank. Upstream sample not connected to the 22 and 21 samples.
BIN-FI-24	29.69427	-95.50568	Concrete	40.00	2.00	496	24200	-23704	Large increase in flow during sampling. Left bank. Large broken pipe flowing to smaller pipe.
BIN-FI-26	29.69429	-95.50571	Concrete	40.00	0.03	24200	NA	NA	Broken large pipe flowing into pooled area behind concrete wall. Feces on culvert upstream of site.
BIN-FI-27	29.69860	-95.50422	Concrete	50.00	0.33	24200	24200	0	Pipe broken, flowing out from underneath. Right bank. Flow backed up in pipe due to restrictive flow.
BIN-FI-29	29.70162	-95.50410	Concrete	40.00	0.03	24200	24200	0	Left bank. Large culvert cracked, flowing out of small culvert. Neff St - middle of bridge.
BIN-FI-31	29.70363	-95.50458	Concrete	4.00	0.25	24200	24200	0	Right bank. Small weep hole. More flow than normal.
BIN-FI-33	29.70386	-95.50462	Concrete	22.00	2.00	259	24200	-23941	Water flowing heavily from pipe. Right bank. Weep holes downstream seem to be flowing. Likely flow behind concrete retention wall. Pipe is separated.
BIN-FI-35	29.70462	-95.50491	Concrete	42.00	0.50	24200	24200	0	Water milky upstream, unsure of source. Right bank culvert.
BIN-FI-37	29.70462	-95.50491	Concrete	24.00	0.25	98	NA	NA	Left bank. Lip on retaining wall ponding water. Sample taken from this ponded area. Water is flowing into stream.
BIN-FI-38	29.70482	-95.50495	Concrete	46.00	1.25	24200	24200	0	Left bank under bridge. Good flow, consistent from culvert. 14m under bridge.
BIN-FI-40	29.71758	-95.52042	Concrete	NA	NA	4610	NA	NA	Strong odor. Took sample from one side of the underground tunnel.
BIN-FI-41	29.71761	-95.52039	Concrete	NA	NA	682	NA	NA	Very strong "rotten" stench. Water very milky colored and turbid.
BIN-FI-42	29.71759	-95.52215	Plastic or Plastic Coated	32.00	1.50	241	197	44	Left bank. Barely trickling. Mixing zone is turbid.
BIN-FI-44	29.71757	-95.52422	Metal	25.00	0.50	4110	145	3965	Left bank. Water only trickling out. Veg growing in and around pipe. Sheen on water's surface.
BIN-FI-46	29.71753	-95.52602	Metal	52.00	6.00	15500	NA	NA	Right bank culvert. Round metal. No fish present.
BIN-FI-47	29.71757	-95.52591	Concrete	46.00	12.00	19900	NA	NA	Left bank. Square concrete. Fish present.
BIN-FI-48	29.68889	-95.50873	Concrete	26.00	0.13	24200	24200	0	Right bank. Water barely trickling through veg growing around pipe. Encampment upstream under bridge on RB. Start of trib sampling.
BIN-FI-50	29.68889	-95.50897	Concrete	35.00	0.75	24200	24200	0	Right bank. Strong smell. Encampment on left bank, upstream of pipe.
BIN-FI-52	29.68889	-95.50911	Plastic or Plastic Coated	36.00	0.13	24200	24200	0	Right bank. Trickling.
BIN-FI-54	29.68888	-95.50970	Metal	23.00	0.13	24200	24200	0	Right bank. Strong sewage odor. Water has milky white color to it.
BIN-FI-56	29.68890	-95.51034	Metal	24.00	0.13	24200	3260	20940	Right bank. Strong sewage smell. Water has milky white color to it.
BIN-FI-58	29.68885	-95.51241	Metal	24.00	0.13	906	1620	-714	Right bank.
BIN-FI-60	29.68889	-95.51385	Metal	40.00	0.50	1550	1460	90	Left bank. Algal growth in pipe.
BIN-FI-62	29.68929	-95.51833	Concrete	40.00	0.25	471	10	461	Right bank.
BIN-FI-64	29.69087	-95.51828	Concrete	NA	NA	10	NA	NA	Looking upstream sample taken on right side outfall/square culvert.
BIN-FI-65	29.69091	-95.51834	Concrete	NA	NA	1120	NA	NA	Oil seen downstream and traced back to this as the source. Looking upstream, this culvert is on the left. Very oily on water's surface.
BIN-FI-66	29.69701	-95.52227	Concrete	NA	NA	259	NA	NA	Took reference sample upstream of culvert that runs under a main road.
BIN-FI-67	29.69778	-95.52320	Concrete	35.00	4.00	637	332	305	Right bank. Submerged. Outfall on left bank dribbling, but not enough for a sample.
BIN-FI-69	29.69971	-95.52458	Concrete	24.00	0.13	1730	3080	-1350	Left bank. Trickling.
BIN-FI-71	29.69973	-95.52458	Concrete	24.00	NA	816	24200	-23384	Outfall cement has cracked - water flowing out from crack under pipe. Same up.
BIN-FI-72	29.70408	-95.52468	Earthen over Concrete	NA	NA	24200	24200	0	Observed bubbles coming from mound of sand in center of ditch. Dug down to investigate further and bubbles never stopped.
BIN-FI-74	29.70493	-95.52467	Concrete	42.00	0.50	24200	24200	0	Left bank culvert. Upstream sample taken from underground culvert. Same upstream sample as 76. Could hear water flowing upstream.
BIN-FI-76	29.70492	-95.52469	Concrete	42.00	0.38	24200	24200	0	Right bank culvert. Same upstream sample as sample 74.

Referral site: BIN-FI-26

This site is located at on the right bank in a residential area. This site is associated with a concrete pipe with a 40-inch diameter. The water depth was only 0.03 inches within the pipe, but the concrete drainage was broken, and water was pooling up before it could exit the outfall. One ambient bacteria sample was collected directly from the pooled water at the base of the broken pipe and it had a bacteria value of 24,200 MPN/100ML. Further investigation is recommended. Photo taken shows broken concrete drainage and pooling.

Referral site: BIN-FI-56

This site is located between a residential area and apartment complexes along the tributary of Bintliff Ditch. This pipe was located on the right bank and was a metal pipe with a diameter of 24-inches. There was 0.13 inches of water in the pipe with a milky hue. A bacteria value of 24,200 MPN/100ML was collected downstream of the pipe. The upstream sample detected 3,260 MPN/100ML, indicating that this pipe is introducing high bacteria levels to the stream. Samplers also noted a strong sewage smell coming from this pipe. Further investigation is suggested. Photo taken shows concrete drainage and milky colored water.

Referral site: BIN-FI-47

This site is located on the very top of the main assessment unit. There are two culverts, and 47 was the culvert on the left bank. The square, concrete culvert was 46-inches tall and there was 12 inches of water. One ambient sample was collected in this location, slightly upstream in the culvert with a bacteria value of 19,900 MPN/100ML. This site is located in a highly commercial area, positioned beside multiple strip malls but no specific bacteria source was identified. Further investigation is recommended. Photo taken facing upstream looking into the culvert as it goes underground.

Referral site: BIN-FI-46

This site is located directly next to site 47, but on the right bank. This round, metal culvert had a diameter of 52 inches and about 6 inches of water flowing in the pipe. The one ambient sample collected at the mouth of this pipe yielded a bacteria value of 15,500 MPN/100ML. Further investigation is recommended. Photo taken shows the sampled pipe facing upstream.

Referral site: BIN-FI-44

This site is located at along the left bank surrounded by vegetation. This concrete outfall had an inner diameter of 25 inches and vegetation growing in it. Water in the pipe was 0.5 inches deep and was only trickling out into the stream. A bacteria value of 4,110 MPN/100ML was collected downstream of the pipe. Upstream, a sample with a value of 145 was collected with a difference of 3,965 MPN/100ML. The outflow was contributing bacteria to the assessed stream and there was a sheen on the water exiting the pipe. Further investigation is suggested. Photo taken facing the left bank shows the concrete outfall.

Referral site: BIN-FI-65

This site is located at along the tributary to Bintliff Ditch. The culvert was located on the right bank in a residential area, just downstream of where the tributary runs belowground under Memorial Hermann Southwest Hospital. One sample was collected from this large concrete culvert. The sample collected had a bacteria value of 1,120 MPN/100ML. The water exiting this culvert had a very oily surface. A specific source for the oil and bacteria was not identified. Photo shows large culvert on the right bank.

Referral site: BIN-FI-12

This site is located just upstream of the confluence of Bintliff Ditch and its tributary, near multiple apartment complexes. This metal pipe has an inner diameter of 6 inches and used to span across the entire channel, but has broken and is leaking into the stream from the side of the left bank. There is approximately 0.5 inches of water flowing out of the pipe. A direct sample was collected from the leaking pipe with a bacteria value of 1,020 MPN/100ML. The correct party should be notified of this leaking pipe and elevated bacteria load. Photo shows the two sides of the pipe that once spanned over the entire stream.

Referral site: BIN-FI-62

This site is located along the tributary of the Bintliff Ditch assessment unit. The outflow pipe on the right bank was made of concrete and had an inner diameter of 40 inches. The water flowing from the pipe had a depth of 0.25 inches. The sample collected from upstream of the outflow had a low *E. coli* bacteria value of 10 MPN/100ML while the downstream value was 471 MPN/100ML. This means the drainage exiting this pipe was adding bacteria to the stream, increasing the detected value by 461 MPN/100ML. Photo taken shows the concrete drainage pipe.

Cedar Creek (1103E_01)
Bacteria Monitoring Report

May 18, 2021

Prepared by:

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Introduction and Methods

Cedar Creek (TCEQ assessment unit: 1103E_01) was identified by the Houston-Galveston Area Council (HGAC) as having high 7-year geomean for bacteria (*E. coli*) concentrations during regular ambient monitoring through the Clean Rivers Program. As a result, Cedar Creek has undergone a bacteria investigation study where bacteria samples were collected at strategic locations along the entire length of the segment in order to aid in pinpointing potential sources, and then refer those sources for investigation by the proper authorities.

There are two separate field events that have taken place to date. 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 segment are not stormwater. A Windshield Survey (WS) acted both as a reconnaissance survey, and initial spatial assessment of ambient bacteria levels throughout the segment and its tributaries. During the WS, surface grab samples for bacteria were collected from bridge crossings and other public access points along the assessment unit and from the most downstream point publicly accessible on each tributary. The WS helped the field crew understand the ambient bacteria levels in the assessment unit on a spatial scale and prioritize tributaries for the Field Investigation (FI).

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 segment. 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 un-permitted outfalls. Permitted outfalls included waste water facilities and municipal separate storm sewer systems (MS4). Any pipe greater than 12 inches 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 un-permitted outfall, which was any

other flowing source of water that was not assumed to be permitted including flowing small (<12 inch diameter) "homemade" pipes and tributaries.

When a flowing un-permitted 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 un-permitted 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.

Assessment Units, collection and laboratory methods, and data handling practices are detailed in the Appendix J to the H-GAC Multi-Basin Clean Rivers Program FY 2020-2021 Quality Assurance Project Plan (QAPP). The field crew carefully documented the 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.

Results

Windshield Survey

The windshield survey was conducted on March 5, 2021; it had been 4 days since the last significant rainfall in the watershed. Only one bacteria sample was collected during the WS due to lack of public stream access (Figure 1). The bacteria result from the ambient water sample collected at this location during the WS was 1200 MPN/100mL.

Field Investigation

The FI was conducted on April 7, 2021 (14 days since last significant rainfall) and a total of 12 bacteria samples were collected. The values of the bacteria samples collected from downstream of permitted outfalls, or directly from un-permitted outfalls are illustrated in Figure 2 and Table 1. Only one location with elevated *E. coli* bacteria levels measured during the FI is recommended for further investigation by the proper authorities. This site is not an outfall, but an ambient sample taken at the most upstream site of the assessment unit. This referral location is summarized on page 7.

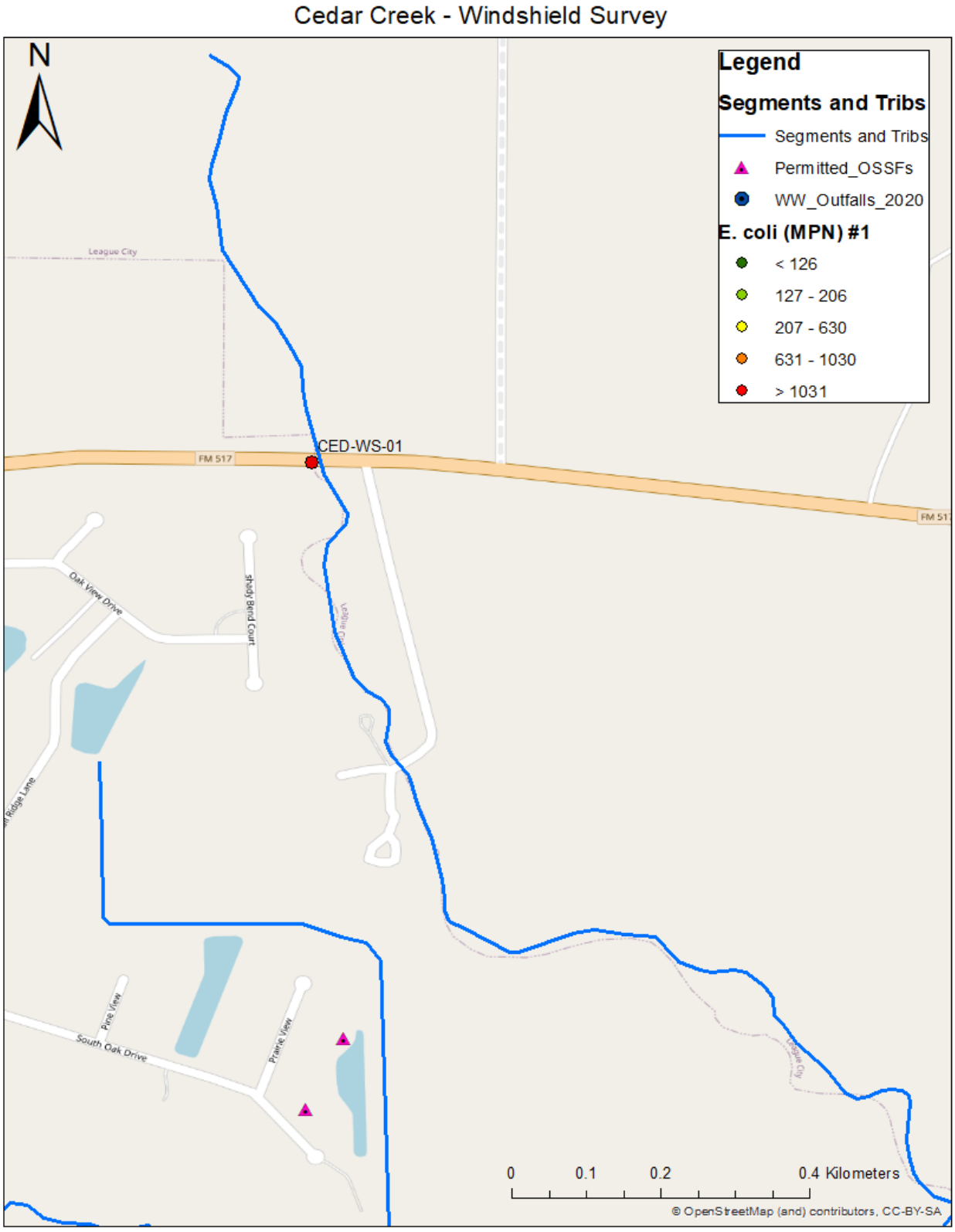

Figure 1. Map of Windshield Survey bacteria results from March 5, 2021.

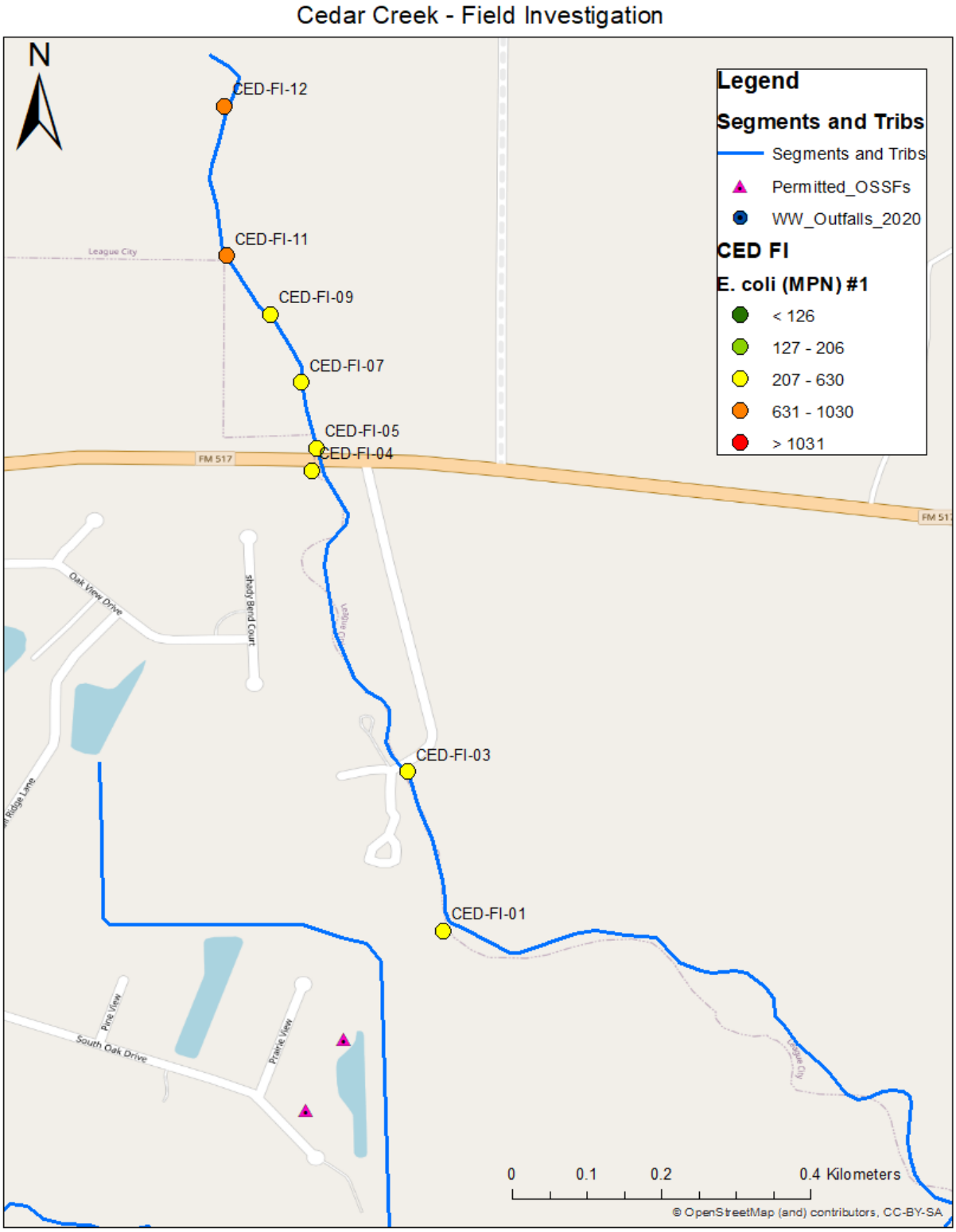

Figure 2. Map of Field Investigation bacteria results from April 7, 2021. The color of the sample location relates to the raw bacteria levels from the samples collected downstream of permitted outfalls, or directly from un-permitted outfalls.

Table 1. *E. coli* bacteria results measured during the field investigation. The most upstream site (highlighted in gray) suggests that the contributing segment upstream of the assessment unit being investigated should be recommended for further investigation by the proper authorities. ID = inner diameter, DS = downstream, US = upstream. NA = Sample was not taken from or in relation to a pipe or outflow.

Sample ID	Latitude	Longitude	Material of Outfall	ID of pipe (in)	Water depth in pipe (in)	DS or direct sample *E. coli* (MPN/100mL)	US *E. coli* (MPN/ 100mL)	Difference (DS-US)	Comments
CED-FI-01	29.43308	-95.13443	Metal	26.00	0.30	373	313	60	Water cloudy around opening of pipe; pipe drains into deep pool. Pipe submerged
CED-FI-03	29.43500	-95.13486	NA	NA	NA	262	NA	NA	Ambient sample on downstream side of bridge. Outfall present, but no current flow.
CED-FI-04	29.43864	-95.13603	NA	NA	NA	373	NA	NA	Ambient sample taken downstream of bridge.
CED-FI-05	29.43891	-95.13596	Plastic or Plastic Coated	36.00	NA	259	462	-203	Submerged pipe, unable to fully tell if flowing.
CED-FI-07	29.43970	-95.13615	NA	NA	NA	327	359	-32	Evidence of cows utilizing stream. Cow feces near water's edge.
CED-FI-09	29.44052	-95.13652	NA	NA	NA	399	557	-158	Evidence of cows utilizing waterway. Ambient sample near their access point.
CED-FI-11	29.44123	-95.13705	NA	NA	NA	905	NA	NA	Ambient water sample taken due to evidence of cows accessing creek here.
CED-FI-12	29.44304	-95.13708	NA	NA	NA	1010	NA	NA	Ambient water sample taken at top of reach for reference sample.

Referral site: CED-FI-12

This site is located at the most upstream point of the Cedar Creek assessment unit, north of FM517**.** There is no pipe or outflow associated with this location, but an ambient sample was collected. This sample had an *E.coli* bacteria value of 1010 MPN/100mL. This indicates that there is likely a bacteria source contributing to the creek upstream of assessment unit 1103E_01. Further investigation upstream of the studied assessment unit by the proper authorities is recommended. Photo taken of the area upstream where the ambient sample was collected.

Dickinson Bayou (1104_01)
Bacteria Monitoring Report

May 18, 2021

Prepared by:

Jenny Oakley, Ph.D.
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Story Lesher
Graduate Research Assistant

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Introduction and Methods

Dickinson Bayou (TCEQ assessment unit: 1104_01) was identified by the Houston-Galveston Area Council (HGAC) as having high 7-year geomean for bacteria (*E. coli*) concentrations during regular ambient monitoring through the Clean Rivers Program. As a result, Dickinson Bayou has undergone a bacteria investigation study where bacteria samples were collected at strategic locations along the entire length of the segment in order to aid in pinpointing potential sources, and then refer those sources for investigation by the proper authorities.

There are two separate field events that have taken place to date. 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 segment are not stormwater. A Windshield Survey (WS) acted both as a reconnaissance survey, and initial spatial assessment of ambient bacteria levels throughout the segment and its tributaries. During the WS, surface grab samples for bacteria were collected from bridge crossings and other public access points along the assessment unit and from the most downstream point publicly accessible on each tributary. The WS helped the field crew understand the ambient bacteria levels in the assessment unit on a spatial scale and prioritize tributaries for the Field Investigation (FI).

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 segment. 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 un-permitted outfalls. Permitted outfalls included waste water facilities and municipal separate storm sewer systems (MS4). Any pipe greater than 12 inches 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 un-permitted outfall, which was any

other flowing source of water that was not assumed to be permitted including flowing small (<12 inch diameter) "homemade" pipes and tributaries.

When a flowing un-permitted 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 un-permitted 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.

Assessment Units, collection and laboratory methods, and data handling practices are detailed in the Appendix J to the H-GAC Multi-Basin Clean Rivers Program FY 2020-2021 Quality Assurance Project Plan (QAPP). The field crew carefully documented the 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.

Results

Windshield Survey

The windshield survey was conducted on March 5, 2021; it had been 4 days since the last significant rainfall in the watershed. A total of 4 bacteria samples were collected during the WS, 1 on Dickinson Bayou and **3** on tributaries to the Bayou (Figure 1). Bacteria results from the ambient water samples collected during the WS ranged from 41 to 435 MPN/100ML.

Field Investigation

The FI was conducted on April 12, 2021 (15 days since last significant rainfall) and a total of 13 bacteria samples were collected. The values of the bacteria samples collected from downstream of permitted outfalls, or directly from un-permitted outfalls are illustrated in Figure 2. A total of five locations with elevated *E. coli* bacteria levels measured during the FI are recommended for further investigation by the proper authorities. These locations are summarized in Table 1 and each of these referrals are summarized by site herein.

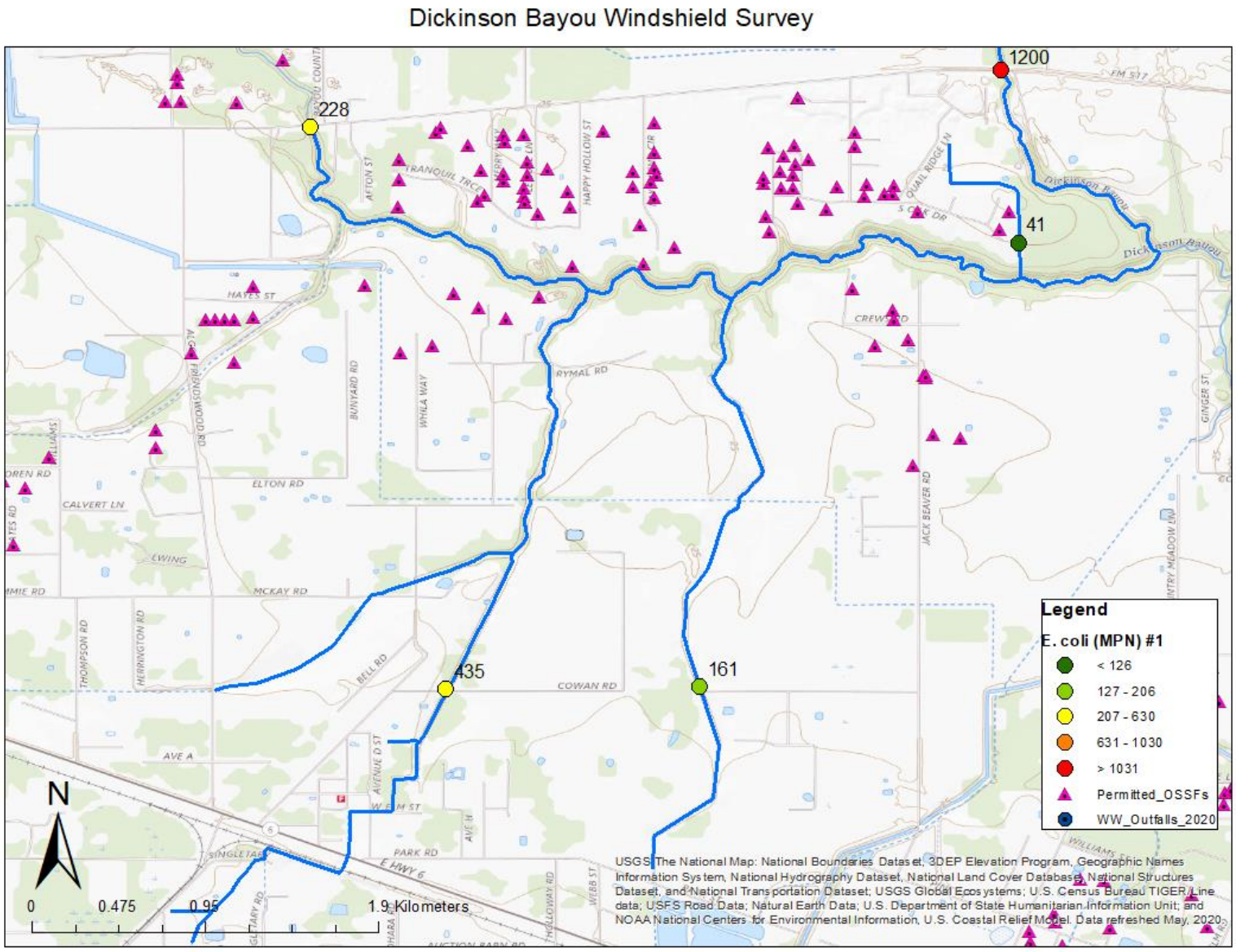

Figure 1. Map of Windshield Survey bacteria results from March 5, 2021.

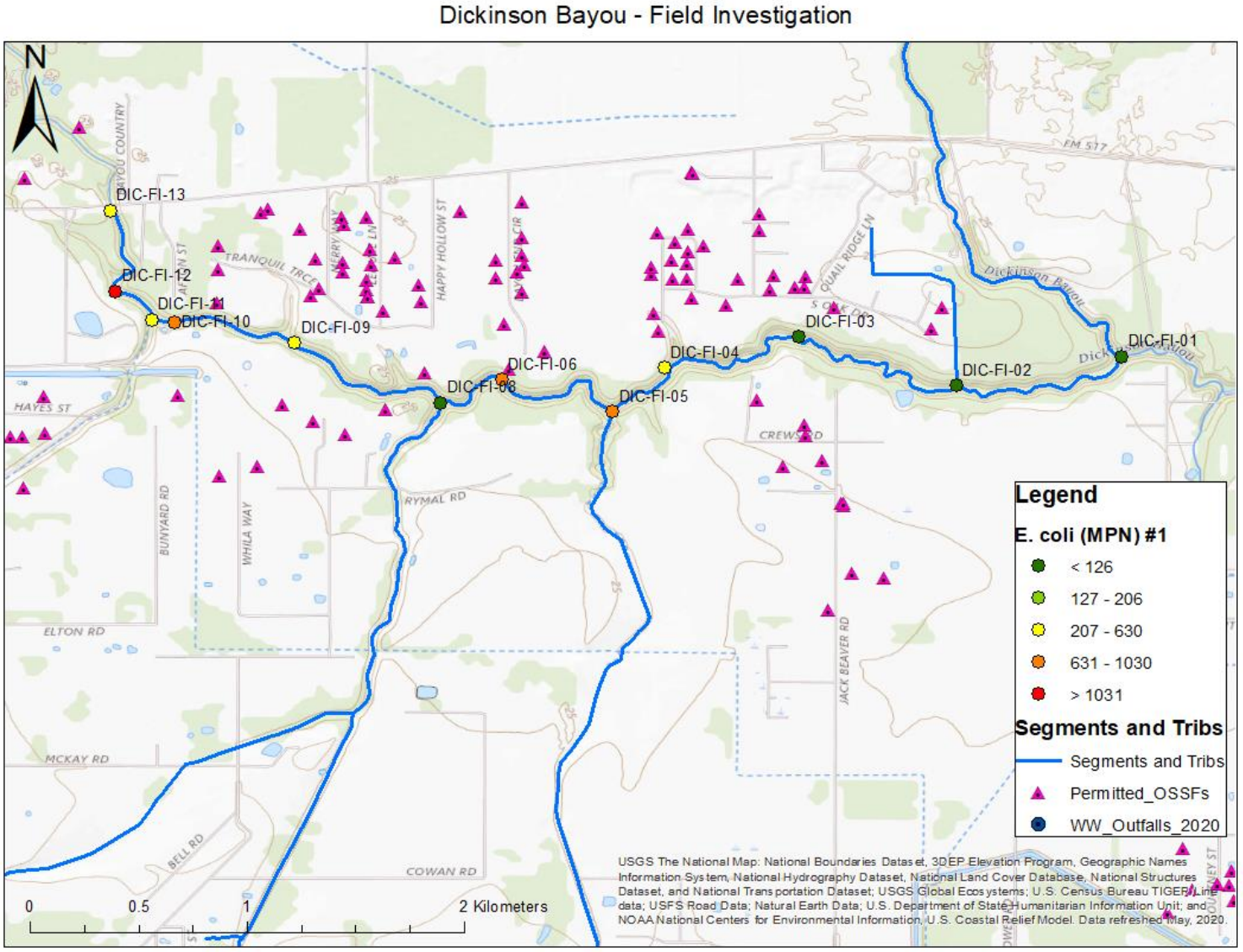

Figure 2. Map of Field Investigation bacteria results from April 12, 2021. Results displayed are the raw bacteria levels from the samples collected downstream of permitted outfalls, or directly from un-permitted outfalls.

Table 1. *E. coli* bacteria results measured during the field investigation. Rows highlighted in gray are recommended for further investigation by the proper authorities. ID = inner diameter, DS = downstream, US = upstream. NA = Sample was not taken from or in relation to a pipe or outflow.

Sample ID	Latitude	Longitude	Material of Outfall	ID of pipe (in)	Water depth in pipe (in)	DS or direct sample *E. coli* (MPN)	US *E. coli* (MPN/ 100mL)	Difference (DS-US)	Comments
DIC-FI-01	29.53670	-95.09703	NA	NA	NA	41	NA	NA	Ambient sample taken at downstream extent of AU
DIC-FI-02	29.42855	-95.13507	NA	NA	NA	31	NA	NA	Ambient sample in DIC upstream of trib, trib not flowing
DIC-FI-03	29.43055	-95.14159	NA	NA	NA	97	NA	NA	Ambient sample in DIC behind neighborhood
DIC-FI-04	29.42929	-95.14716	NA	NA	NA	275	NA	NA	Ambient sample in DIC
DIC-FI-05	29.42747	-95.14932	NA	NA	NA	988	NA	NA	Ambient sample up trib 2. Right bank
DIC-FI-06	29.42879	-95.15391	2-PVC	2.00	0.10	1020	813	207	Unable to determine if flowing because submerged, left bank
DIC-FI-08	29.42784	-95.15643	NA	NA	NA	75	NA	NA	Ambient sample up trib 3, Right bank
DIC-FI-09	29.43033	-95.16251	NA	NA	NA	414	NA	NA	Ambient sample in DIC
DIC-FI-10	29.43118	-95.16746	NA	NA	NA	638	NA	NA	Ambient sample in DIC
DIC-FI-11	29.43128	-95.16843	NA	NA	NA	529	NA	NA	Ambient sample up small tributary from Bayou Wildlife Zoo
DIC-FI-12	29.43246	-95.16994	NA	NA	NA	3450	NA	NA	Ambient sample up small tributary from Bayou Wildlife Zoo. Sheen on water from trib
DIC-FI-13	29.43581	-95.17014	NA	NA	NA	426	NA	NA	Ambient sample taken downstream side of FM 517 bridge. Most upstream point of AU

Referral site: DIC-FI-05

This site is located at the most downstream section of tributary #2 to Dickinson Bayou on the right bank. An ambient sample was collected from the tributary with a bacteria value of 988 MPN/100ML. Further investigation of potential bacteria sources contributing to this tributary is recommended. Photo taken facing upstream in the tributary which enters the bayou on its right bank.

Referral site: DIC-FI-06

This site is located at in a residential area. The outflow pipe was a long, submerged PVC pipe with an inner diameter of approximately 2 inches. It appeared that the pipe ran underground from near a home along the stream and was unpermitted. We were unable to confirm whether the pipe was flowing, but the water sample collected downstream of the outflow had an *E. coli* bacteria value of 1020 MPN/100ML while the upstream value was only 813. This indicates that the outflow from this unregulated pipe may be contributing to the elevated bacteria count in the stream and further investigation is recommended. Photo taken shows mentioned PVC pipe along the left bank.

Referral site: DIC-FI-11

This site is located along the right bank of Dickinson Bayou just downstream of site DIC-FI-12 in a rural, residential area. Like DIC-FI-12, this site describes an ambient sample collected from a tributary flowing from the Bayou Wildlife Zoo located off of FM517 on the right bank of Dickinson Bayou. The bacteria value of the sample collected directly from the tributary was 529 MPN/100ML. Further investigation of potential bacteria sources contributing to this tributary is recommended. Photo taken shows tributary flowing from within the Bayou Wildlife Zoo fence.

Referral site: DIC-FI-12

This site is located along the right bank of the stream and describes an ambient sample collected from a connecting tributary. The water sample was collected directly from the tributary and had an *E. coli* bacteria count of 3450 MPN/100ML. This tributary runs through the Bayou Wildlife Zoo. Further investigation of potential bacteria sources contributing to this tributary is recommended. Photo taken shows tributary coming from the Bayou Wildlife Zoo.

Referral site: DIC-FI-13

This site is located at the most upstream point of the Dickinson Bayou assessment unit in question. There is no pipe or outflow associated with this location, but an ambient sample was collected on the downstream side of the FM 517 bridge crossing. This sample had an *E.coli* bacteria value of 426 MPN/100ML. This indicates that there is likely a bacteria source contributing to the bayou upstream of assessment unit 1104_01. Further investigation upstream of the studied assessment unit by the proper authorities is recommended. Photo taken from just downstream of the bridge crossing at FM517 facing downstream.

Unnamed Tributary to Gum Bayou (1103G_01)
Bacteria Monitoring Report

May 19, 2021

Prepared by:

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Introduction and Methods

Unnamed tributary to Gum Bayou (TCEQ assessment unit: 1103G_01) was identified by the Houston-Galveston Area Council (HGAC) as having high 7-year geomean for bacteria (*E. coli*) concentrations during regular ambient monitoring through the Clean Rivers Program. As a result, this tributary to Gum Bayou has undergone a bacteria investigation study where bacteria samples were collected at strategic locations along the entire length of the segment in order to aid in pinpointing potential sources, and then refer those sources for investigation by the proper authorities.

There are two separate field events that have taken place to date. 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 segment are not stormwater. A Windshield Survey (WS) acted both as a reconnaissance survey, and initial spatial assessment of ambient bacteria levels throughout the segment and its tributaries. During the WS, surface grab samples for bacteria were collected from bridge crossings and other public access points along the assessment unit and from the most downstream point publicly accessible on each tributary. The WS helped the field crew understand the ambient bacteria levels in the assessment unit on a spatial scale and prioritize tributaries for the Field Investigation (FI).

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 segment. 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 un-permitted outfalls. Permitted outfalls included waste water facilities and municipal separate storm sewer systems (MS4). Any pipe greater than 12 inches 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 un-permitted outfall, which was any other flowing source of water that was not assumed to be permitted including flowing small (<12 inch diameter) “homemade” pipes and tributaries.

When a flowing un-permitted 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 un-permitted 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.

Assessment Units, collection and laboratory methods, and data handling practices are detailed in the Appendix J to the H-GAC Multi-Basin Clean Rivers Program FY 2020-2021 Quality Assurance Project Plan (QAPP). The field crew carefully documented the 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.

Results

Windshield Survey

The windshield survey was conducted on February 26, 2021; it had been 15 days since the last significant rainfall in the watershed. A total of 8 bacteria samples were collected during the WS, 6 on the main stream assessment and 2 on tributaries to the AU (Figure 1). Bacteria results from the ambient water samples collected during the WS ranged from 20 to 1670 MPN/100ML.

Field Investigation

Based on the results of the windshield survey, focus during the field investigation was placed on the main AU and three previously unsampled tributaries. The FI was conducted on April 5, 2021 (6 days since last significant rainfall) and a total of 22 bacteria samples were collected. The values of the bacteria samples collected from downstream of permitted outfalls, or directly from un-permitted outfalls are illustrated in Figure 2. A total of 4 locations with elevated *E. coli* bacteria levels measured during the FI are recommended for further investigation by the proper authorities. These locations are summarized in Table 1 (gray rows). Each of these referrals are summarized by site herein.

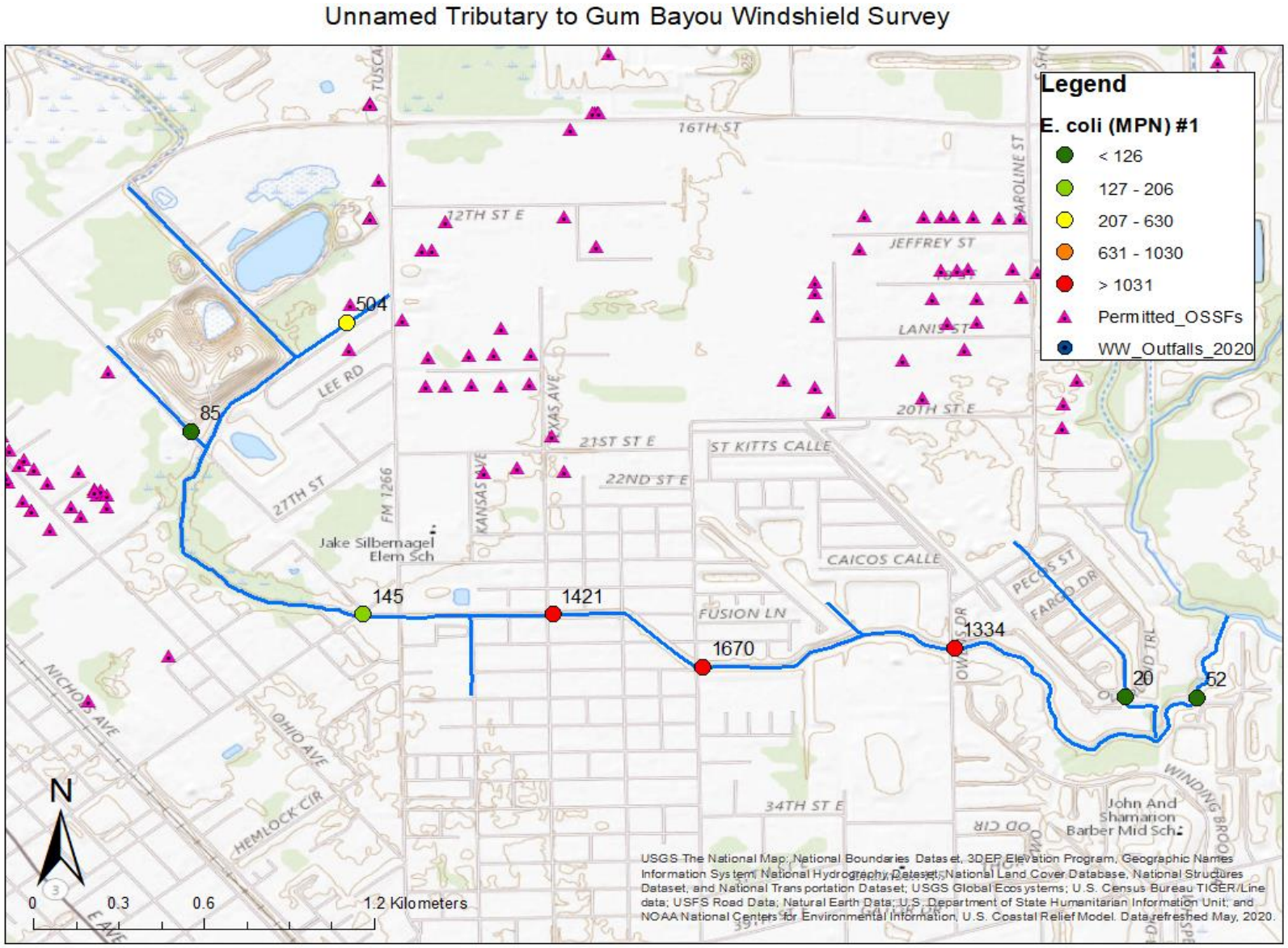


Figure 1. Map of Windshield Survey bacteria results from February 26, 2021.

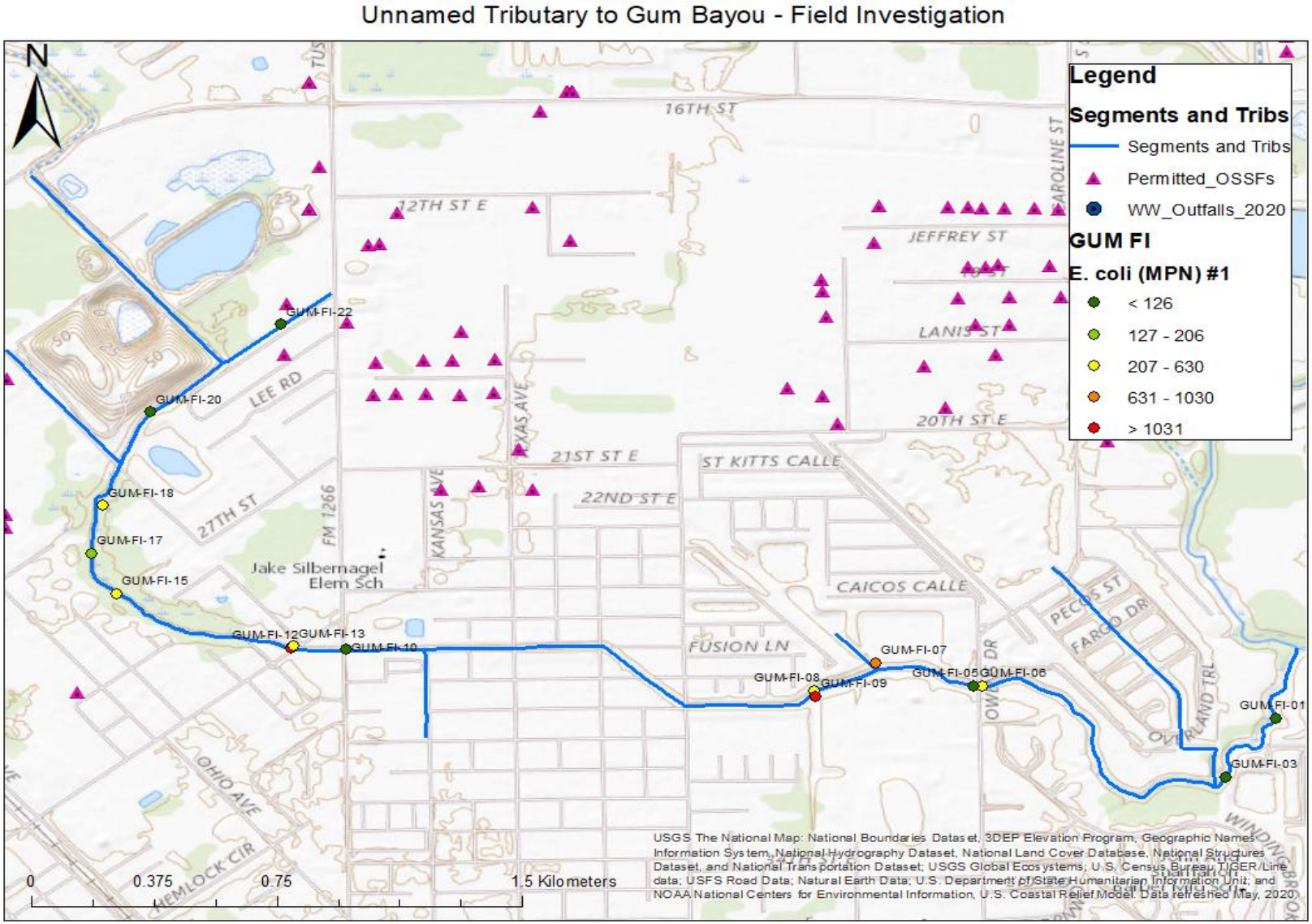


Figure 2. Map of Field Investigation bacteria results from April 5, 2021. Results displayed are the raw bacteria levels from the samples collected downstream of permitted outfalls, or directly from un-permitted outfalls.

Table 1. *E. coli* bacteria results measured during the field investigation. Rows highlighted in gray are recommended for further investigation by the proper authorities. ID = inner diameter, DS = downstream, US = upstream. NA = Sample was not taken from or in relation to a pipe or outflow.

Sample ID	Latitude	Longitude	Material of Outfall	ID of pipe (in)	Water depth in pipe (in)	DS or direct sample E. coli (MPN/100mL)	US E. coli (MPN/ 100mL)	Difference (DS-US)	Comments
GUM-FI-01	29.47419	-95.02126	Concrete	25.00	0.75	63	120	-57	Outfall is apron-like, no top. Covered in vegetation. Right Bank
GUM-FI-03	29.47242	-95.02265	Plastic or Plastic Coated	24.00	1.75	98	161	-63	Pipe is submerged but water appears to be moving out. Algae covered pipe. Right Bank
GUM-FI-05	29.47515	-95.02934	Concrete	40.00	0.13	393	NA	NA	Outflow from pipe pools and then falls into stream. One sample taken from this flow, no upstream sample. Right Bank
GUM-FI-06	29.47515	-95.02958	Metal	50.00	0.50	85	NA	NA	Drainage pipe from along road by baseball fields. Pools up before flowing into stream, only one sample taken. Right Bank
GUM-FI-07	29.47585	-95.03228	Earthen	NA	1.75	933	NA	NA	Taken directly from stream downstream from pond. Trib 2, Left Bank
GUM-FI-08	29.47501	-95.03398	Earthen	NA	11.00	216	NA	NA	Ambient sample taken directly from trib.
GUM-FI-09	29.47485	-95.03395	Earthen	NA	6.00	3450	NA	NA	Ambient sample taken from stream. Trib 3 by the high school. On Right Bank
GUM-FI-10	29.47627	-95.04685	Earthen	NA	NA	75	31	44	Open earthen drainage ditch. 2.5 inch for 11 - stream very shallow.
GUM-FI-12	29.47629	-95.04836	Concrete	25.00	6.00	24200	369	23831	Sheen on water coming from pipe. Same upstream sample for 12 and 13. Right Bank
GUM-FI-13	29.47635	-95.04831	Concrete	25.00	0.50	299	369	-70	Same upstream sample for 12 and 13. Left Bank
GUM-FI-15	29.47793	-95.05318	Earthen	NA	0.25	292	10	282	Small tributary flowing into stream. Scum on surface of stream. Homes around. Looks as if area was recently cleared by machinery. On left bank
GUM-FI-17	29.47912	-95.05387	Concrete	30x93	4.75	146	NA	NA	Rectangular drainage hole. Appears to be trib/pond on private property.
GUM-FI-18	29.48056	-95.05356	Earthen	NA	NA	216	31	185	private property. Farm with chickens in stream. Upstream lat long (29.48192, -95.05301)
GUM-FI-20	29.48336	-95.05225	Metal	25.00	0.13	96	20	76	Pipe rusted out on the bottom. Water is very dark (black/brown) with strong sulfuric smell.
GUM-FI-22	29.48598	-95.04865	Plastic or Plastic Coated	25.00	NA	30	NA	NA	Sample pulled from pool in front of covered pipe connected to private pond. Most upstream portion of segment.

Referral site: GUM-FI-12

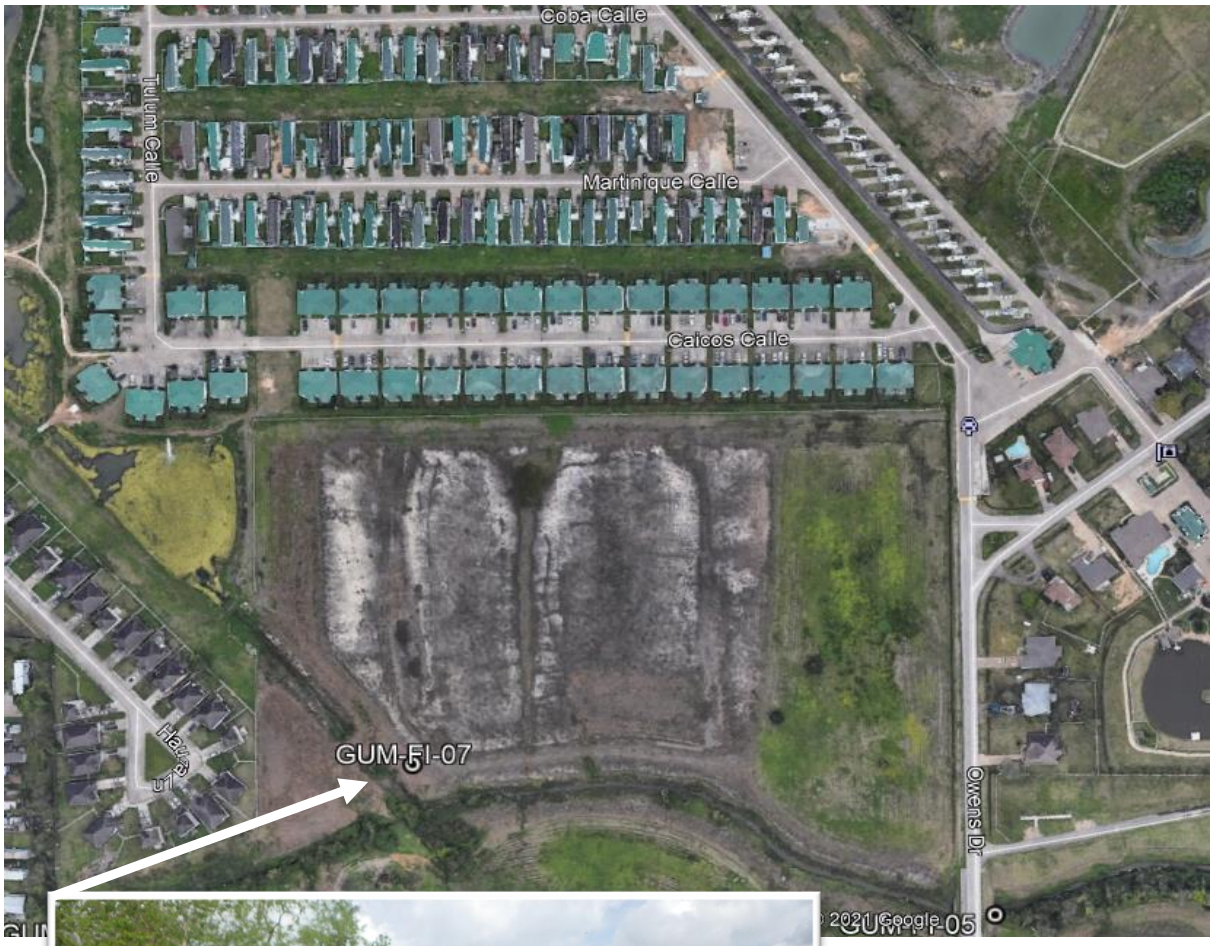
This site is a drainage ditch along the right bank located underneath a bridge**.** This is a concrete pipe, 25 inches in diameter, with a water depth in the pipe of 6 inches. The highest bacteria value of >24,200 MPN/100ML was collected downstream of the outflow. The upstream sample had an *E. coli* bacteria value of 369 MPN/100ML. A sheen was also observed coming from this drainage pipe flowing into the main stream assessment unit. Further investigation is necessary to identify potential bacteria sources. Photo taken shows the concrete drainage pipe facing the right bank.

Referral site: GUM-FI-09

This site is located in the third tributary, which runs alongside a high school**.** The sample collected was an ambient sample taken within the tributary. The *E. coli* bacteria value associated with this sample was of 3,450 MPN/100ML. This indicates high levels of bacteria in this tributary, further investigation is necessary. Note: there appears to be a livestock program at the school near this tributary. Photo taken shows the upstream habitat of the tributary and its location along the high school.

Referral site: GUM-FI-07

This site is located on the second tributary along the main AU. This site includes one ambient sample collected at a downstream point on the tributary. The *E. coli* bacteria value associated with this sample was 933 MPN/100ML. This sample was collected downstream of a neighborhood and rental park including townhomes, houses, and mobile homes. There is a pond upstream of the sample as well, which could also contribute to the high bacteria load. Photo taken shows the upstream habitat of the second tributary.



Referral site: GUM-FI-05

This site is located at the right bank on the downstream side of the Owens Dr. bridge crossing. The outfall was a roadside drainage pipe made of concrete with an inner diameter of 40 inches. The water depth in the pipe was 0.13 inches. Only one sample was collected at this location because the water pooled before flowing into the stream. This sample had an *E. coli* bacteria value of 393 MPN/100ML. This value indicates that there is a bacteria source further upstream contributing to this outfall. Runoff in this ditch is likely from the high school or nearby neighborhoods but further investigation is needed. Photo taken shows the concrete drainage pipe with pooling water before falling and flowing into the stream.

Mimosa Ditch (1007U_01)
Bacteria Monitoring Report

Environmental Institute of Houston

March 25, 2021

Jenny Oakley, Ph.D.
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Environmental Institute of Houston
University of Houston-Clear Lake

Introduction and Methods

Mimosa Ditch (TCEQ assessment unit: 1007U_01) was identified by the Houston-Galveston Area Council (HGAC) as having high 7-year geomean for bacteria (*E. coli*) concentrations during regular ambient monitoring through the Clean Rivers Program. As a result, Mimosa Ditch has undergone a bacteria investigation study where bacteria samples were collected at strategic locations along the entire length of the segment in order to aid in pinpointing potential sources, and then refer those sources for investigation by the proper authorities.

There are two separate field events that have taken place to date. 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 segment are not stormwater. A Windshield Survey (WS) acted both as a reconnaissance survey, and initial spatial assessment of ambient bacteria levels throughout the segment and its tributaries. During the WS, surface grab samples for bacteria were collected from bridge crossings and other public access points along the assessment unit and from the most downstream point publicly accessible on each tributary. The WS helped the field crew understand the ambient bacteria levels in the assessment unit on a spatial scale and prioritize tributaries for the Field Investigation (FI).

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 segment. 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 un-permitted outfalls. Permitted outfalls included waste water facilities and municipal separate storm sewer systems (MS4). Any pipe greater than 12 inches 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 un-permitted outfall, which was any

other flowing source of water that was not assumed to be permitted including flowing small (<12 inch diameter) "homemade" pipes and tributaries.

When a flowing un-permitted 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 un-permitted 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.

Assessment Units, collection and laboratory methods, and data handling practices are detailed in the Appendix J to the H-GAC Multi-Basin Clean Rivers Program FY 2020-2021 Quality Assurance Project Plan (QAPP). The field crew carefully documented the 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.

Results

Windshield Survey

The windshield survey was conducted on March 9, 2021; it had been 8 days since the last significant rainfall in the watershed. A total of 7 bacteria samples were collected during the WS (Figure 1). Bacteria results from the ambient water samples collected during the WS ranged from <10 to 399 MPN/100ML.

Field Investigation

The 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 un-permitted outfalls are illustrated in Figure 2. A total of 4 locations with elevated *E. coli* bacteria levels measured during the FI are recommended for further investigation by the proper authorities. These locations are summarized in Table 1. Each of these referrals are summarized by site herein.

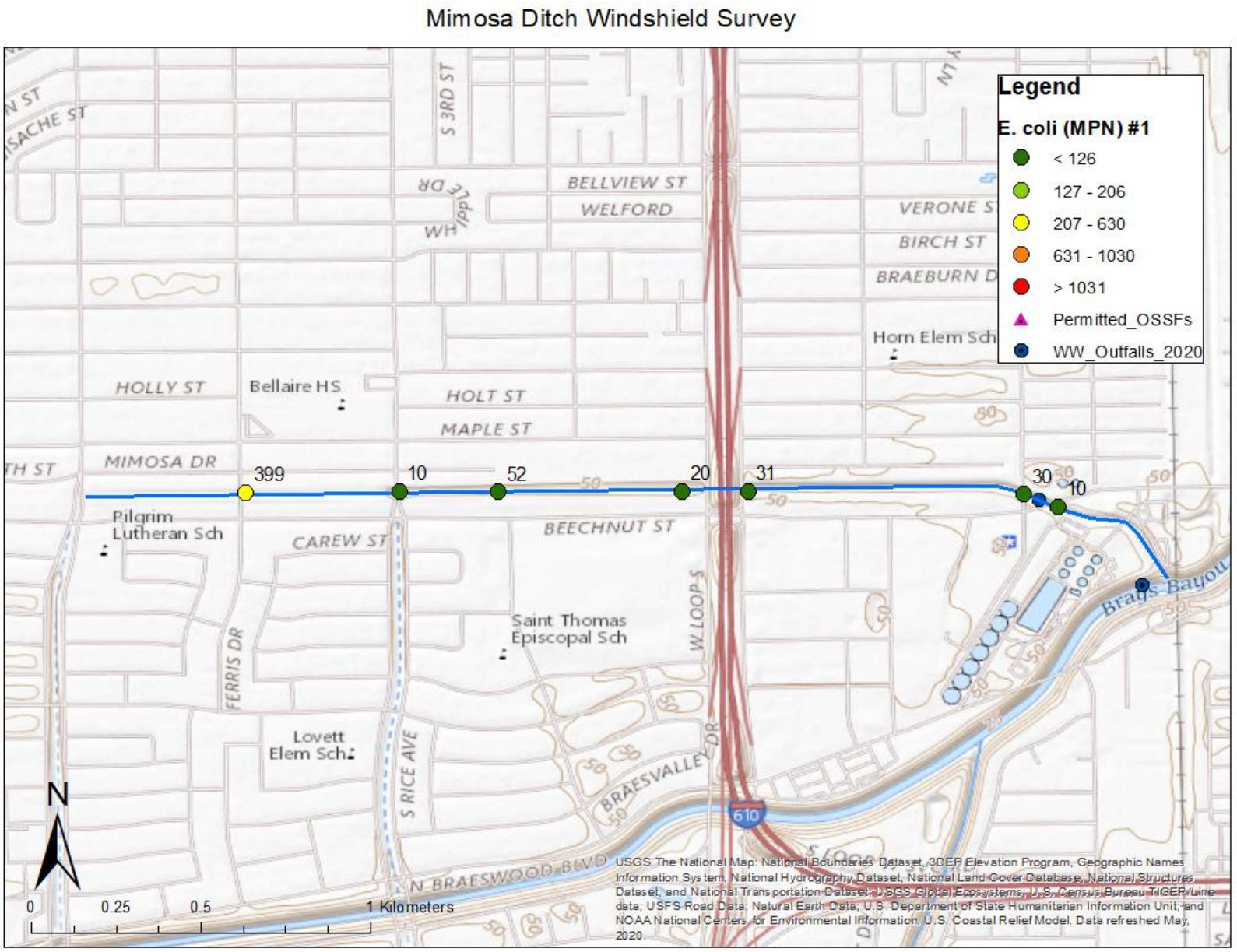


Figure 1. Map of Windshield Survey bacteria results from March 9, 2021.

Figure 2. Map of Field Investigation bacteria results from March 12, 2021. Results displayed are the raw bacteria levels from the samples collected downstream of permitted outfalls, or directly from un-permitted outfalls.

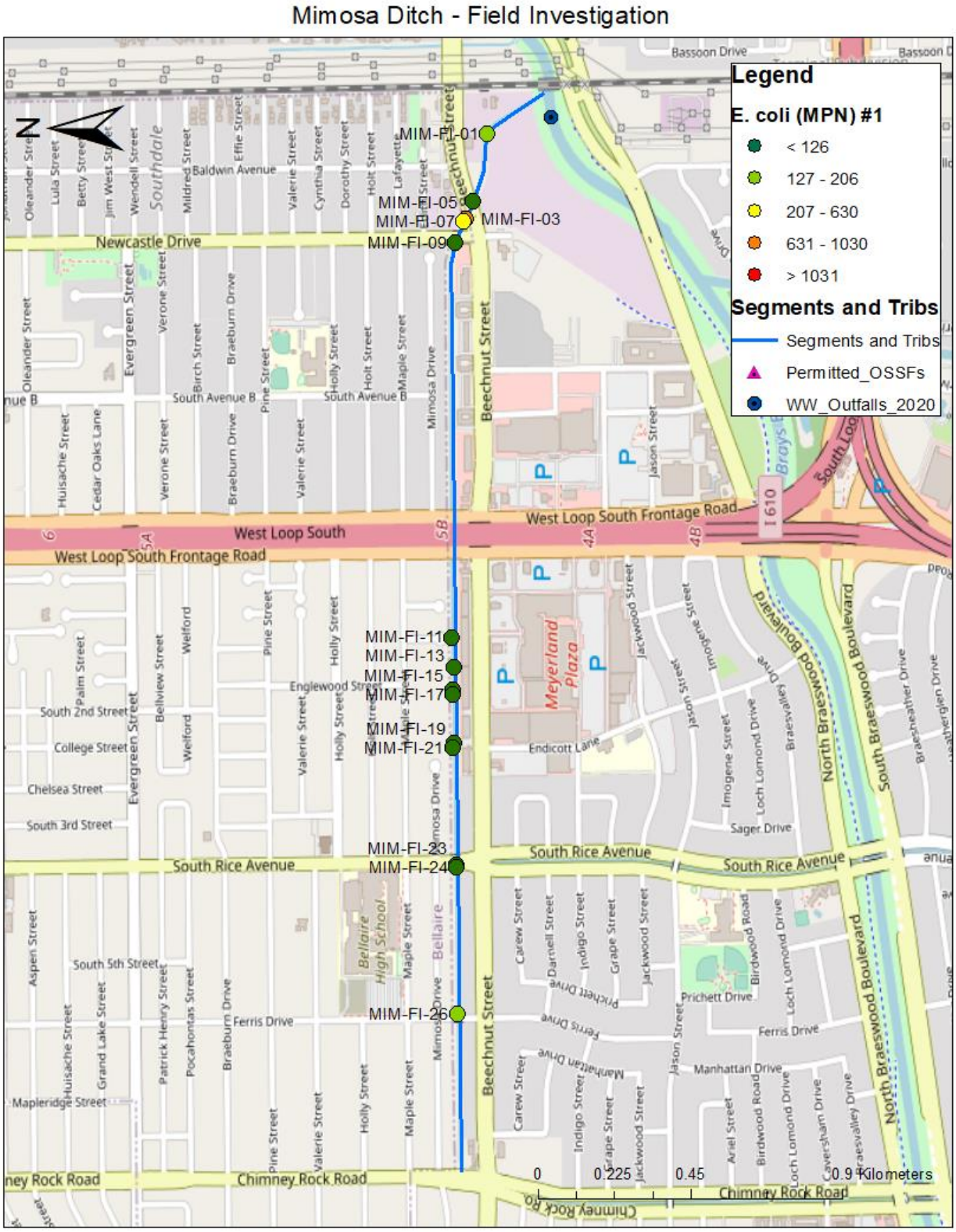


Table 1. *E. coli* bacteria results measured during the field investigation. Rows highlighted in gray are recommended for further investigation by the proper authorities. ID = inner diameter, DS = downstream, US = upstream. NA = Sample was not taken from or in relation to a pipe or outflow.

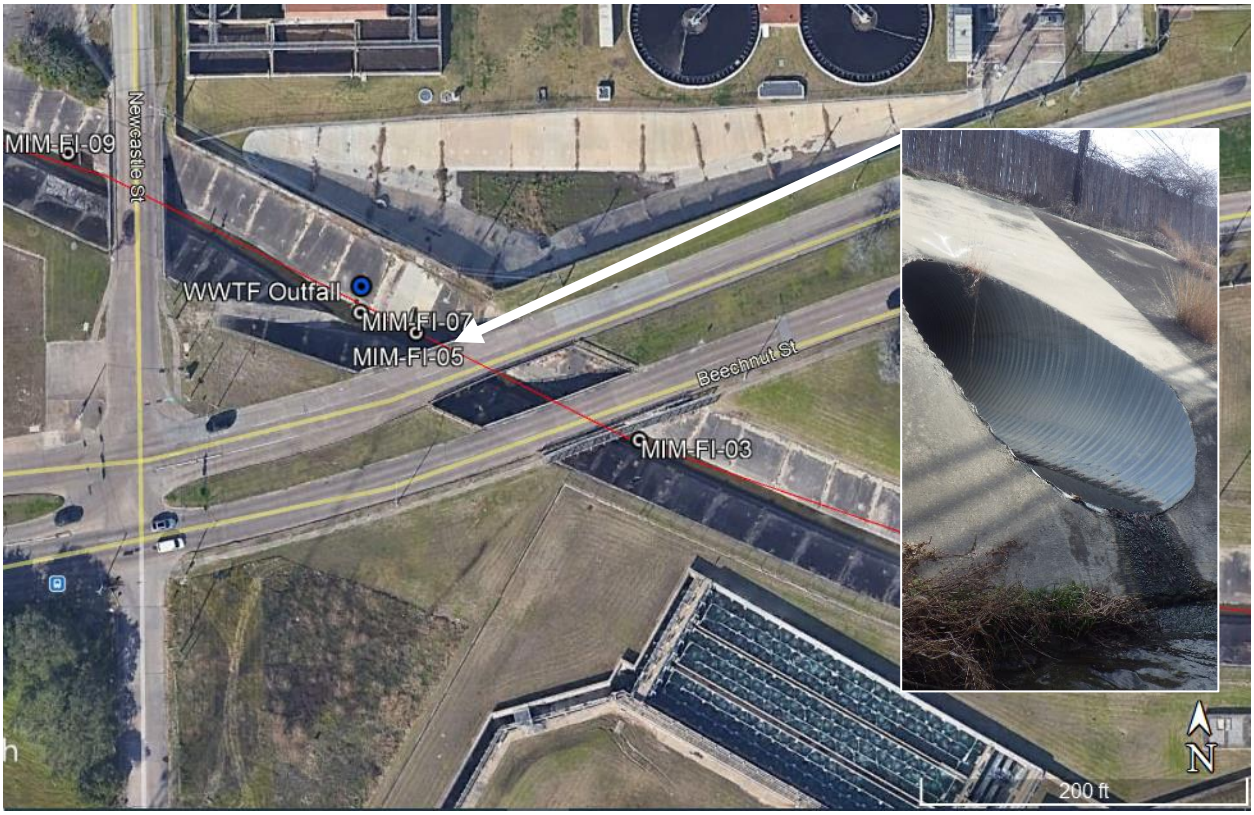
Sample ID	Latitude	Longitude	Material of Outfall	ID of pipe (in)	Water depth in pipe (in)	DS or direct sample *E. coli* (MPN/100mL)	US *E. coli* (MPN/ 100mL)	Difference (DS-US)	Comments
MIM-FI-01	29.68903	-95.44833	Metal	12.00	1.00	169	108	61	Spray from pipe running under bridge, looks cracked
MIM-FI-03	29.68940	-95.45011	Metal	40.00	2.00	10	262	-252	
MIM-FI-05	29.68959	-95.45058	Metal	70.00	1.00	683	119	564	Just downstream of permitted wastewater outflow, upstream sample taken downstream of permitted pipe.
MIM-FI-07	29.68965	-95.45065	Metal	37.00	4.00	313	160	153	Permitted wastewater outflow
MIM-FI-09	29.68988	-95.45121	Concrete	100.00	2.00	110	95	15	Two large concrete square outflows. Sample taken from outside pipe flowing faster with a sheen
MIM-FI-11	29.68997	-95.46173	Metal	23.00	0.50	63	63	0	A large amount of leaf litter, residential area
MIM-FI-13	29.68992	-95.46252	Metal	50.00	1.00	< 10	10	0	A smaller pvc pipe was present and sample was taken for both pipes as one as they were close together and the flow mixed. The pvc pipe was 4 in diameter, 1/8 in water depth, and sample was taken 3 m from pipe as well, pvc location 29.68993, -95.46251. A lot of vegetation in front of large pipe, palm tree was growing in front of large pipe
MIM-FI-15	29.68996	-95.46314	Metal	36.00	1.50	31	41	-10	
MIM-FI-17	29.68994	-95.46326	Plastic or Plastic Coated	4.00	0.06	74	10	64	
MIM-FI-19	29.68991	-95.46454	Metal	52.00	1.50	10	10	0	
MIM-FI-21	29.68996	-95.46467	Plastic or Plastic Coated	22.00	0.13	20	10	10	pipe is made of HDPE- plastic type material
MIM-FI-23	29.68986	-95.46780	Concrete	80.00	1.00	< 10	NA	NA	Large concrete apron leading from two square openings
MIM-FI-24	29.68984	-95.46786	Concrete	70.00	2.00	121	199	-78	
MIM-FI-26	29.68983	-95.47175	Concrete	60.00	0.80	132	NA	NA	Top of segment, two concrete square drains. No water in segment above this point.

Referral site: MIM-FI-01

This site is a leaking metal pipe, ~ 12 inches in diameter that runs along the bridge (perpendicular to the segment) within the waste water treatment facility property, downstream of Beechnut St. The sample was collected where the leaking/spraying water was entering the segment and it had a bacteria value of 169 MPN/100ML. The ambient sample collected just upstream of the bridge outside of the influence of the leaking pipe had a bacteria value of 108 MPN/100ML (MIM-FI-02) indicating that the leaking pipe may be a source of elevated bacteria. Photo of leaking pipe taken looking upstream.

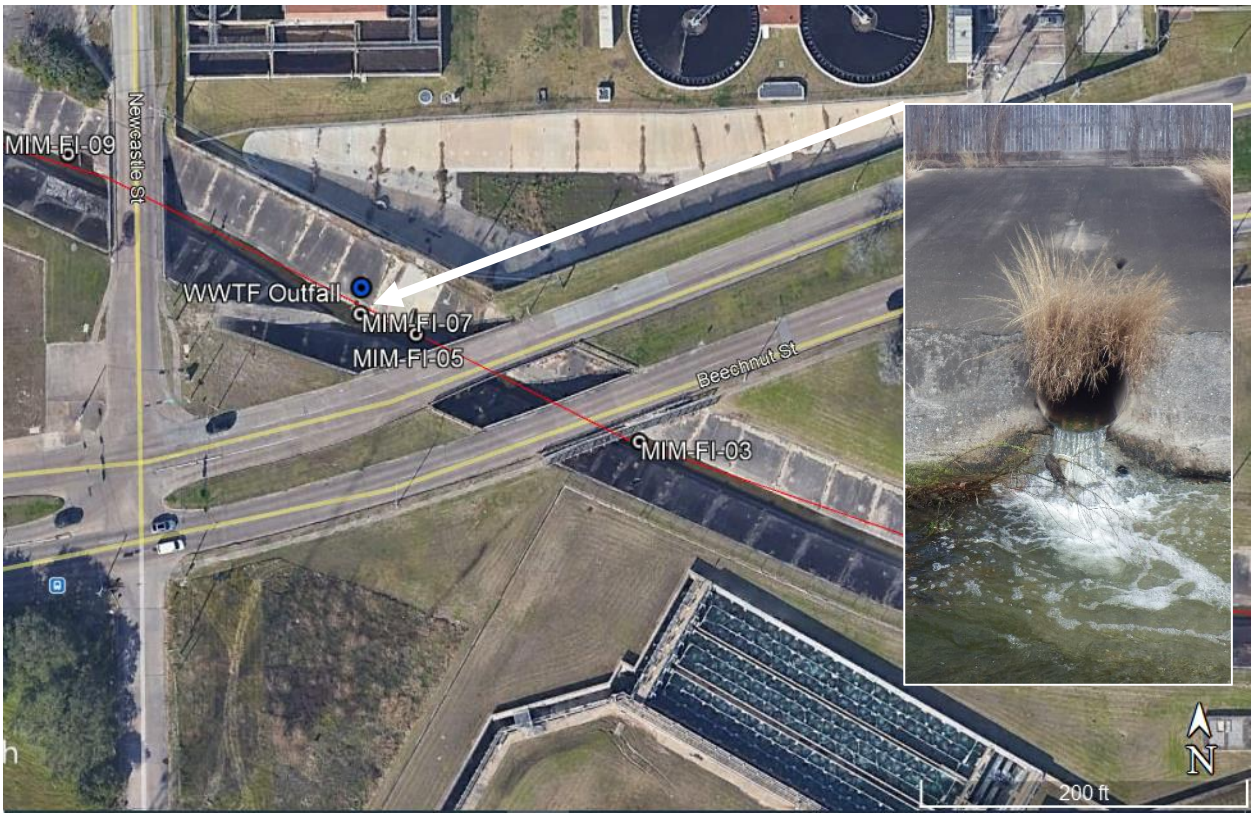
Referral site: MIM-FI-05

This site is a metal pipe, ~ 70 inches in diameter coming out of the left bank located just downstream of the permitted waste water treatment facility outfall between Newcastle St. and Beechnut St. The sample collected in the mixing zone, just downstream of the outfall had a bacteria value of 683 MPN/100ML, and the ambient sample collected just upstream of the outfall (mid channel) had a bacteria value of 119 MPN/100ML (MIM-FI-06) indicating that the outfall is likely a source of elevated bacteria. Photo of pipe taken looking onto the left bank from slightly upstream.



Referral site: MIM-FI-07

This site is a metal pipe, ~ 37 inches in diameter coming out of the left bank and is believed to be the permitted waste water treatment facility outfall between Newcastle St. and Beechnut St. The sample collected in the mixing zone, just downstream of the outfall had a bacteria value of 313 MPN/100ML, and the ambient sample collected just upstream of the outfall (mid channel) had a bacteria value of 160 MPN/100ML (MIM-FI-08) indicating that the outfall is likely a source of elevated bacteria. Photo of pipe taken looking onto the left bank from mid-channel. 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 waste water treatment facility outfall, but that all of those things were observed upstream of it. Chlorine levels were not tested.



Referral site: MIM-FI-26

This site is at the top of the segment where two ~60 inch tall square concrete culverts enter from the left bank at the bridge crossing of Ferris Dr. The sample taken just downstream of the culverts was 132 MPN/100ML indicating that there is likely a bacteria source upstream of this location. The ambient sample taken further downstream at Rice Ave was also elevated (199 MPN/100ML). Note, the segment upstream of this bridge crossing on Mimosa Ditch was dry. Photo of culverts taken looking onto the left bank.

Mustang Bayou
(2432A_02)
Bacteria Monitoring Report

July 19, 2021

Prepared by:

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Story Lesher
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Introduction and Methods

Mustang Bayou (TCEQ assessment unit: 2432A_02) was identified by the Houston-Galveston Area Council (HGAC) as having high 7-year geomean for bacteria (*E. coli*) concentrations during regular ambient monitoring through the Clean Rivers Program. As a result, Mustang Bayou has undergone a bacteria investigation study where bacteria samples were collected at strategic locations along the entire length of the segment in order to aid in pinpointing potential sources, and then refer those sources for investigation by the proper authorities.

There are two separate field events that have taken place to date. 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 segment are not stormwater. A Windshield Survey (WS) acted both as a reconnaissance survey, and initial spatial assessment of ambient bacteria levels throughout the segment and its tributaries. During the WS, surface grab samples for bacteria were collected from bridge crossings and other public access points along the assessment unit and from the most downstream point publicly accessible on each tributary. The WS helped the field crew understand the ambient bacteria levels in the assessment unit on a spatial scale and prioritize tributaries for the Field Investigation (FI).

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 segment. 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 un-permitted outfalls. Permitted outfalls included waste water facilities and municipal separate storm sewer systems (MS4). Any pipe greater than 12 inches 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 un-permitted outfall, which was any other flowing source of water that was not assumed to be permitted including flowing small (<12 inch diameter) “homemade” pipes and tributaries.

When a flowing un-permitted 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 un-permitted 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.

Assessment Units, collection and laboratory methods, and data handling practices are detailed in the Appendix J to the H-GAC Multi-Basin Clean Rivers Program FY 2020-2021 Quality Assurance Project Plan (QAPP). The field crew carefully documented the 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.

Results

Windshield Survey

The windshield survey was conducted on two dates, March 5 and March 10, 2021, due to inclement weather conditions later on the first day. March 5th sampling was conducted 4 days since the last significant rainfall and March 10th sampling was 5 days after. A total of 16 bacteria samples were collected during the WS, 8 on the first day and 8 on the second. 12 samples were collected from the main stream segment and 6 were collected on tributaries to the bayou (Figure 1). Bacteria results from the ambient water samples collected during the WS ranged from <10 to 5,170 MPN/100ML.

Field Investigation

The FI was also conducted across two days, April 5 and April 6, 2021 (8 and 9 days respectively since last significant rainfall) due to time constraints on the first day. A total of 39 bacteria samples were collected, 32 on the first day of sampling and 7 on the second. The values of the bacteria samples collected from downstream of permitted outfalls, or directly from un-permitted outfalls are illustrated in Figure 2. A total of ten locations with elevated *E. coli* bacteria levels measured during the FI are recommended for further investigation by the proper authorities. These locations are summarized in Table 1. Each of these referrals are summarized by site herein.

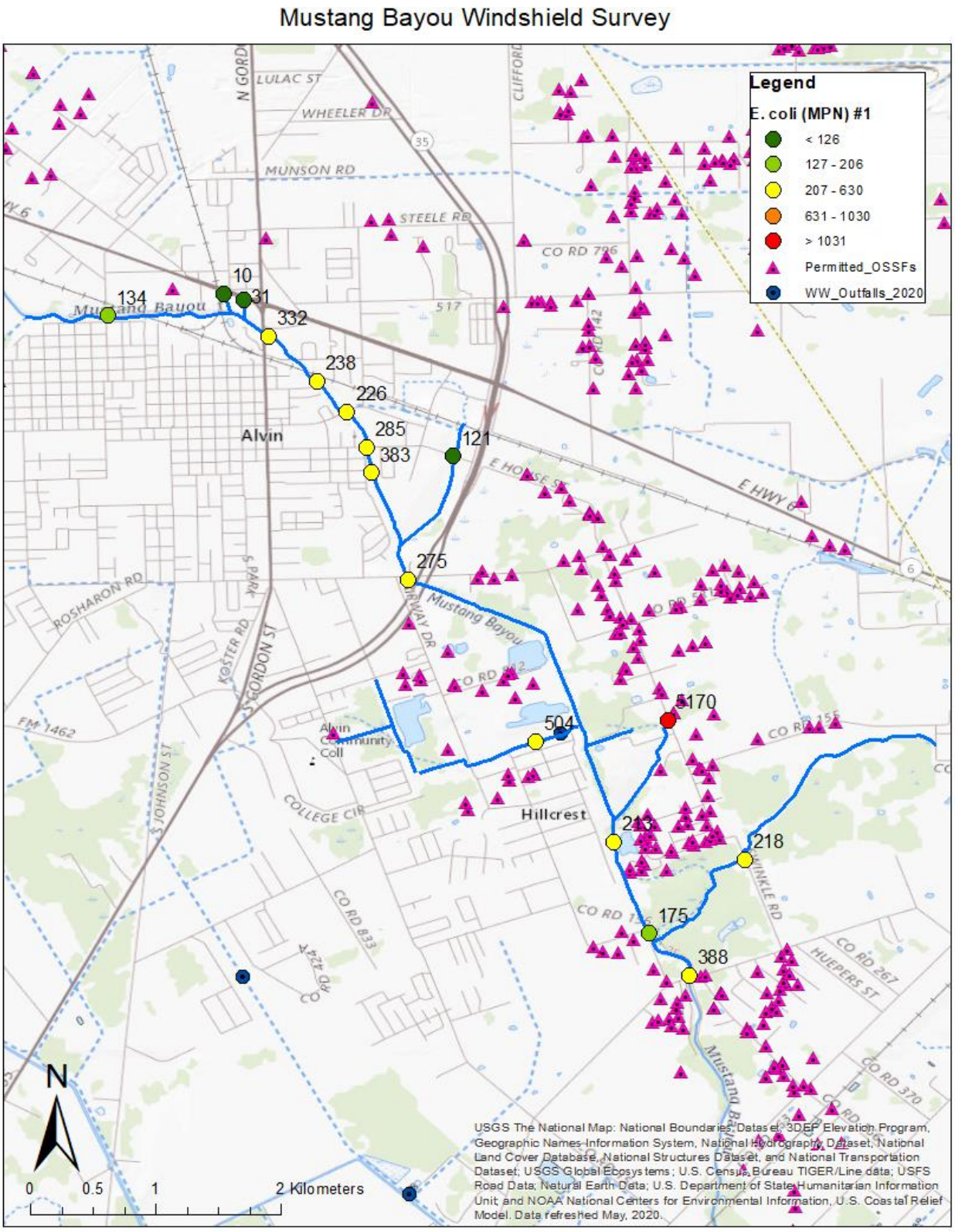


Figure 1. Map of Windshield Survey bacteria results from March 5 and March 10, 2021.

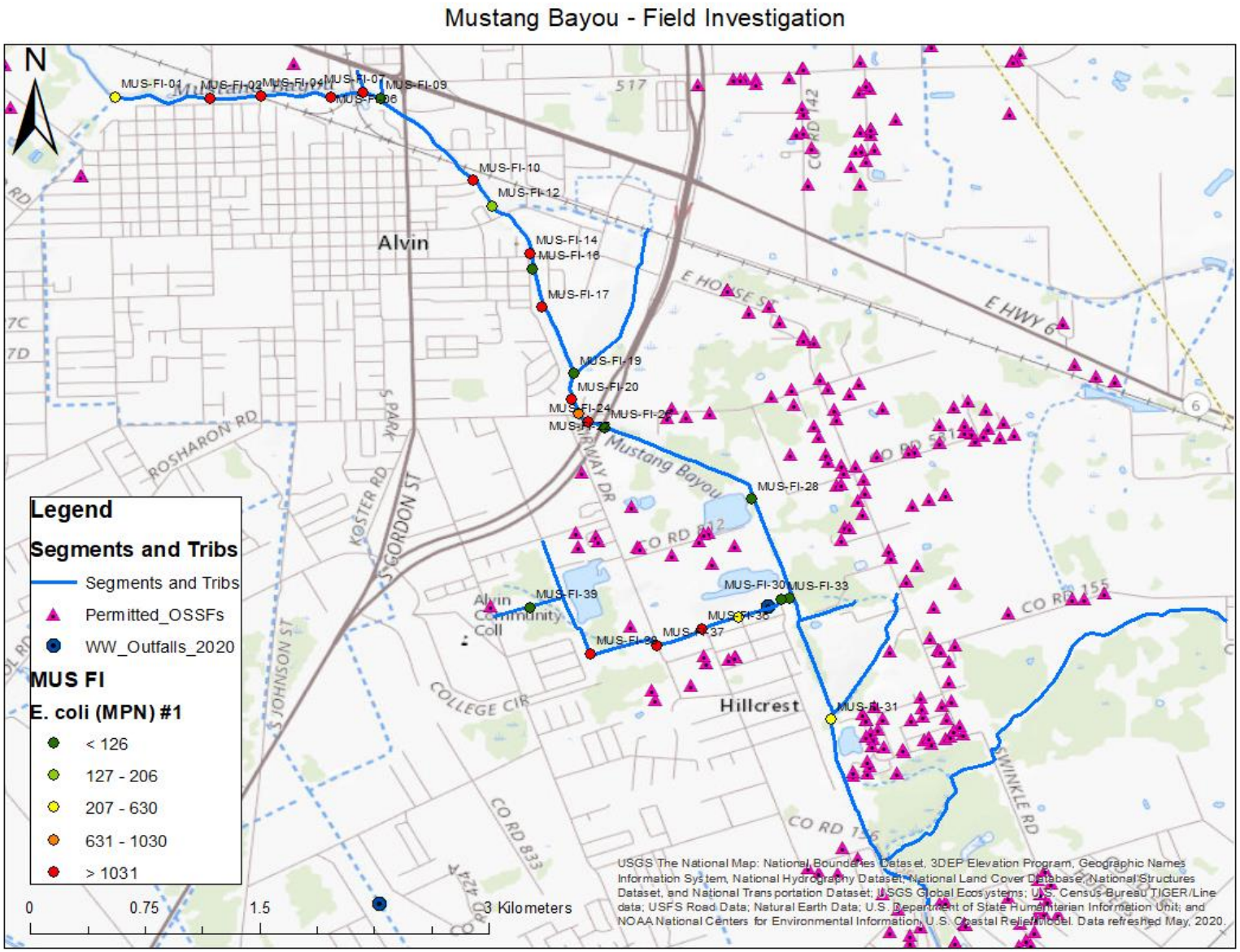


Figure 2. Map of Field Investigation bacteria results from April 5 and April 6, 2021. Results displayed are the raw bacteria levels from the samples collected downstream of permitted outfalls, or directly from un-permitted outfalls

Table 1. *E. coli* bacteria results measured during the field investigation. Rows highlighted in gray are recommended for further investigation by the proper authorities. ID = inner diameter, DS = downstream, US = upstream. NA = Sample was not taken from or in relation to a pipe or outflow.

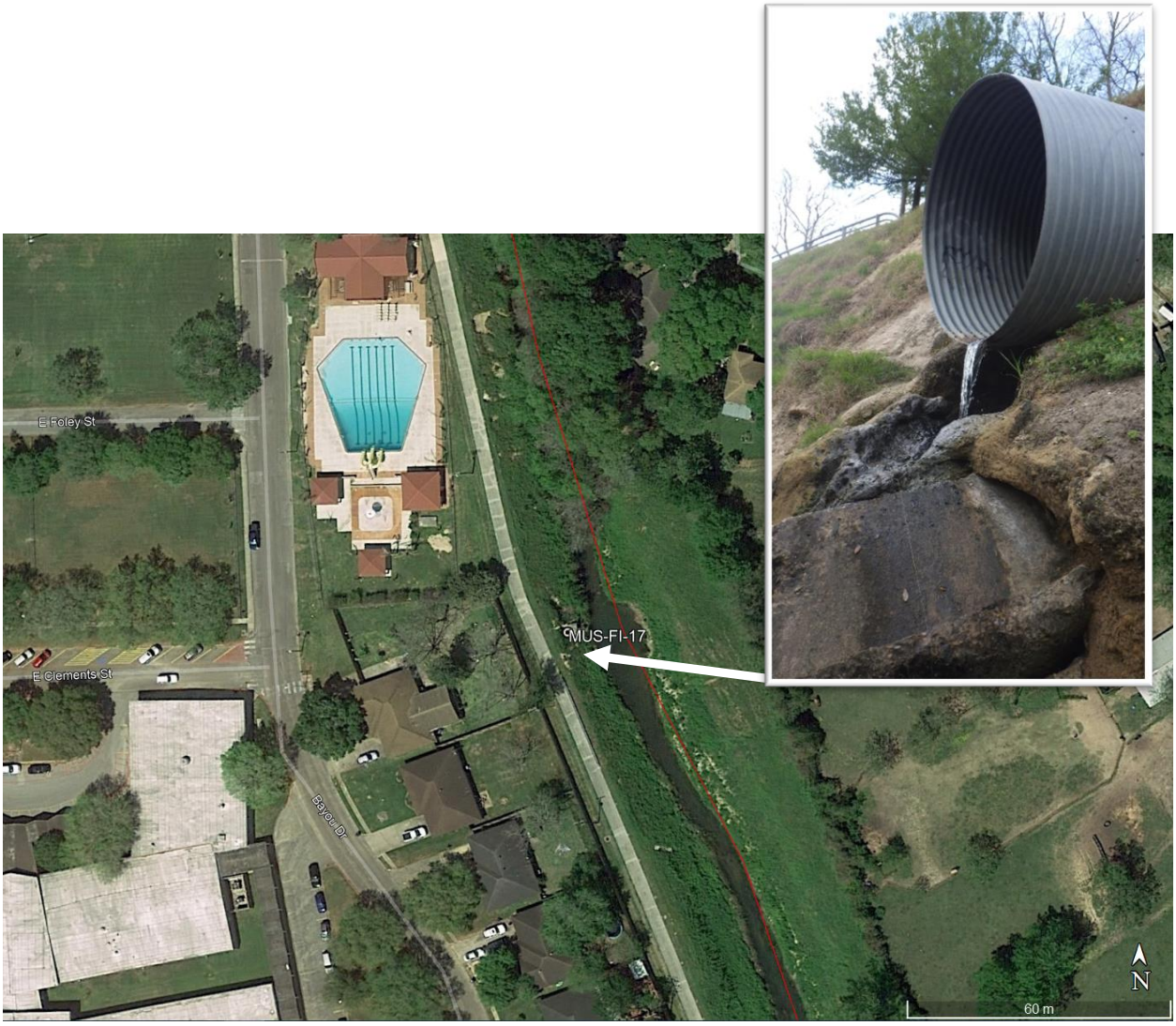
Sample ID	Latitude	Longitude	Material of Outfall	ID of pipe (in)	Water depth in pipe (in)	DS or direct sample *E. coli* (MPN/100mL)	US *E. coli* (MPN/ 100mL)	Difference (DS-US)	Comments
MUS-FI-01	29.42818	-95.26121	Earthen	NA	NA	269	NA	NA	Ambient sample taken for point of reference.
MUS-FI-02	29.42810	-95.25562	Concrete	40.00	0.38	3870	259	3611	
MUS-FI-04	29.42826	-95.25265	Metal	58.00	1.00	24200	2380	21820	Bottom rusted out - took sample directly from outflow. Smells of effluent.
MUS-FI-06	29.42817	-95.23857	Earthen	NA	NA	15500	NA	NA	Water not visibly flowing and appears stagnant. Took sample about 15ft up the trib. Water appears somewhat cloudy. Numerous dogs barking - potential kennel nearby.
MUS-FI-08	29.42844	-95.24668	Metal	40.00	0.50	4110	19900	-15790	
MUS-FI-09	29.42809	-95.24564	Earthen	NA	NA	41	NA	NA	Sampled from trib about 10m upstream into trib. Water appears cloudier than receiving waters.
MUS-FI-10	29.42326	-95.24013	Metal	40.00	0.50	3260	933	2327	Pipe broken and simply flowing down. Took sample in mixing zone, see pictures. Right bank.
MUS-FI-12	29.42174	-95.23904	Metal	24.00	7.50	199	275	-76	No visible flow, pipe submerged right bank. Pipe bent and sediment filling bottom.
MUS-FI-14	29.41895	-95.23679	Plastic or Plastic Coated	56.00	1.50	2380	504	1876	Right bank. Large amounts of water. Water very cloudy, visible mixing.
MUS-FI-16	29.41804	-95.23665	Earthen	NA	NA	63	NA	NA	Pipe collapsed and removed. Pool of water near collapsed pipe. Very murky and smells of effluent. Right bank.
MUS-FI-17	29.41580	-95.23611	Metal	60.00	1.00	24200	754	23446	Right bank. Consistent flow. Smells like effluent.
MUS-FI-19	29.41188	-95.23424	Earthen	NA	NA	41	NA	NA	Tributary, left bank. No visible flow. Connected for a long ways. Taken 10m from connection to Mustang.
MUS-FI-20	29.41035	-95.23434	Concrete	30.00	0.13	1120	1310	-190	Sheet flow down concrete. Trickle of water.
MUS-FI-22	29.40951	-95.23396	Metal	68.00	0.50	908	1450	-542	Right bank.
MUS-FI-24	29.40904	-95.23337	Concrete	45.00	0.75	4350	34	4316	Algae growing with water flowing down concrete ledge. Right bank. Water passes through concrete rubble.
MUS-FI-26	29.40872	-95.23240	Plastic or Plastic Coated	36.00	0.13	10	563	-553	Right bank. Just a trickle.
MUS-FI-28	29.40449	-95.22375	Metal	60.00	6.00	10	211	-201	Connected to water retention pond. Can see all the way through pipe. Right bank.
MUS-FI-30	29.39868	-95.22153	Earthen	NA	NA	10	NA	NA	Tributary right bank. Waste water treatment pipe upstream on trib.
MUS-FI-31	29.39150	-95.21908	Metal	46.00	0.50	241	265	-24	Right bank. Two culverts present. Only one has flow.
MUS-FI-33	29.39859	-95.22203	Plastic or Plastic Coated	12.00	0.50	10	144	-134	Waste water outflow. Trib 4.
MUS-FI-35	29.39753	-95.22456	Earthen	NA	NA	594	NA	NA	Sample taken from isolated pool between neighborhood and golf course. Similar location to high bacteria sample from WS. Lots of algae. Trib 4.
MUS-FI-36	29.39684	-95.22670	Earthen	NA	NA	24200	NA	NA	Sample taken from isolated pool within golf course. Very murky. Trib 4.
MUS-FI-37	29.39589	-95.22936	Earthen	NA	NA	7270	NA	NA	Sample taken from isolated pool by checkpoint 2. Water very murky and stagnant. Trib 4.
MUS-FI-38	29.39536	-95.23323	Concrete	20.00	0.25	3650	NA	NA	One sample pulled from pool outside of drainage pipe. Area looks recently dredged. Trib 4.
MUS-FI-39	29.39810	-95.23681	Concrete	26.00	0.75	10	NA	NA	Connects pond in assisted living facility to stream. Very blue color pooling and moving upstream. Trib 4.

Referral site: MUS-FI-36

This site is located within a golf course along the fourth tributary of the Mustang Bayou segment. An ambient sample was collected from an isolated pool within the channel of the tributary. The *E. coli* bacteria value from the sample collected was 24,200 MPN/100ML. The water in the pool was very murky. It is recommended that this area is investigated further. Photo taken shows the vegetated pool where the sample was collected.

Referral site: MUS-FI-17

This site is located on the right bank in a residential area. The pipe associated with this site is metal with an inner diameter of 60 inches. There was 1 inch of water in the pipe with a consistent flow. The downstream sample collected bacteria value of 24,200 MPN/100ML while the upstream sample was 754 MPN/100ML, giving a difference of 23,446 MPN/100ML. The field crew noted that the water flowing from the pipe smelled of effluent. Further investigation is recommended. Photo taken **s**hows pipe and amount of outflow.



Referral site: MUS-FI-04

This site is located in a residential area and is a metal pipe with an inner diameter of 58 inches. The water in the pipe was 1 inch deep and the field crew noted that it smelled of effluent. The bacteria value of 24,200 MPN/100ML was collected directly from the pipe which had rusted out on the bottom. The upstream sample had an *E. coli* bacteria value of 2,380 MPN/100ML, giving a difference of 21,820. Further investigation is necessary. Photo taken shows rusted out bottom of pipe.

Referral site: MUS-FI-06

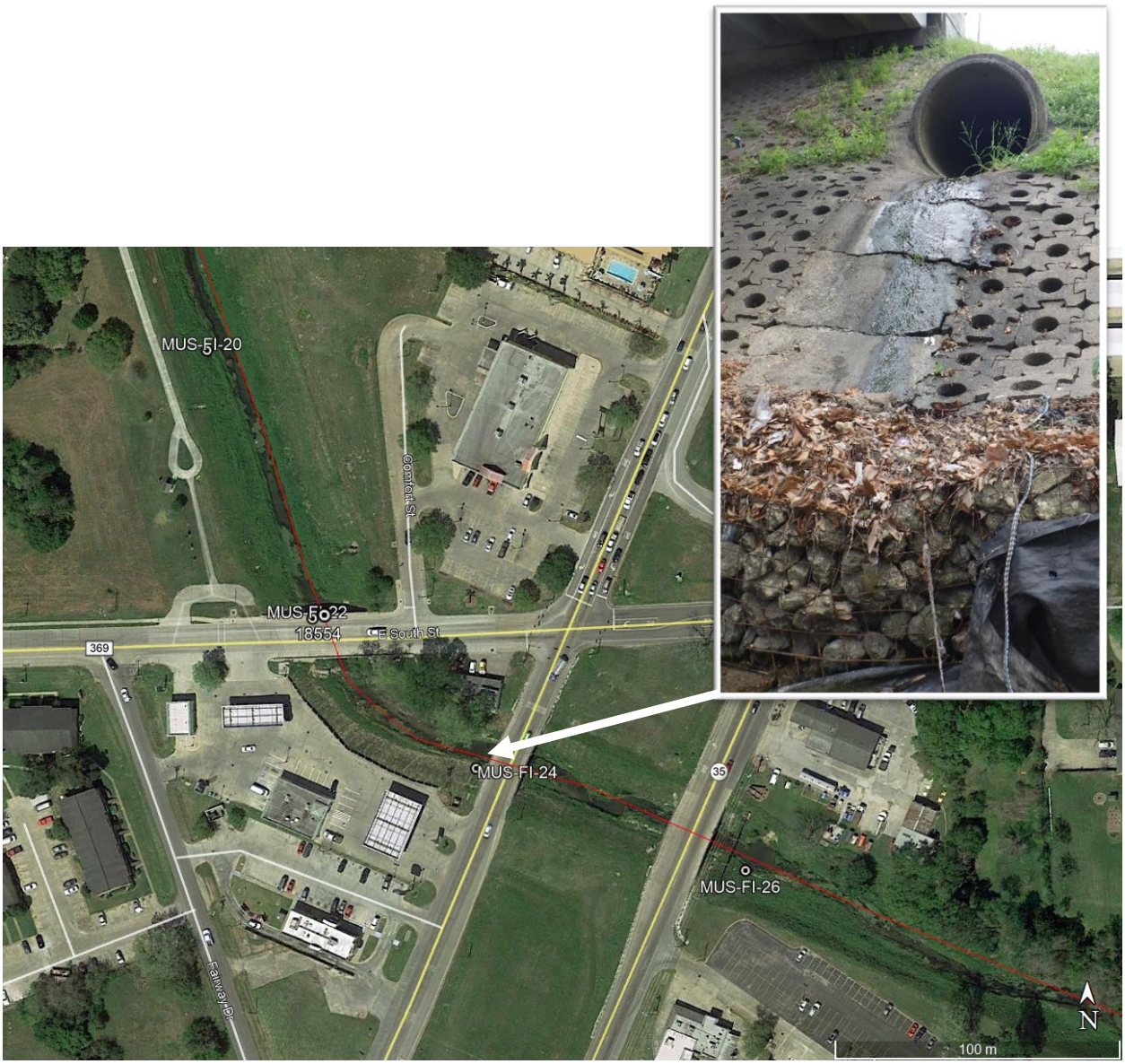
This site is located at just downstream of MUS-FI-04. An ambient sample was collected in this tributary (about 15 ft upstream in the tributary). Cloudy water and no flow was observed by the field crew. This ambient sample had an *E. coli* bacteria value of 15,500 MPN/100ML. Further investigation is suggested. Photo taken facing upstream in the tributary sampled.

Referral site: MUS-FI-37

This site was located along the fourth tributary to the Mustang Bayou assessment unit. An ambient sample was pulled from an isolated pool within the channel of the tributary. The water in this pool was murky and stagnant. The *E. coli* bacteria value of this sample was 7,270 MPN/100ML. Further investigation is suggested. Photo taken shows the pool sampled.

Referral site: MUS-FI-24

This site is located on the right bank in a commercial area with high vehicle traffic. The pipe is concrete with an inner diameter of 45 inches. The depth of water in the pipe was 0.75 inches, which then flows through concrete rubble before entering the stream. There was some algae growing along the path of flow. The bacteria value of 4,350 MPN/100ML was collected at the downstream location. The upstream sample had a value of 34 MPN/100ML, giving a difference of 4316 MPN/100ML. Photo taken concrete pipe and rubble on the right bank.



Referral site: MUS-FI-38

This site is located along the fourth tributary of Mustang Bayou near a neighborhood. The pipe located at this site was concrete and 20 inches in diameter. There was about 0.25 inches of water in the pipe at the time of sampling. The sample was collected from a pool outside the pipe where the water sits before flowing into the stream. The stream looked recently dredged along this portion of the tributary. The sample collected at this location had an *E. coli* bacteria value of 3,650 MPN/100ML. Further investigation is suggested. Photo taken shows pipe and pooling in recently dredged area.

Referral site: MUS-FI-02

This site is located at next to a bridge in a mainly residential area. The pipe is 40 inches in diameter and made of concrete. Water depth within the pipe was 0.38 inches. The upstream sample had an E. coli bacteria value of 259 MPN/100ML while the downstream was 3,870 MPN/100ML. Further investigation is needed to identify the bacteria source at this site. Photo taken shows concrete pipe on the right bank.

Referral site: MUS-FI-10

This site is located in a residential area and the pipe was located along the right bank. The pipe is metal with a 40-inch diameter and 0.5 inches of water within. The pipe was broken with water flowing straight down into the stream. The downstream sample was taken in this mixing zone, which had a bacteria value of 3,260 MPN/100ML. The upstream sample had a bacteria value of 933 MPN/100ML, with a difference of 2,327 MPN/100ML. This site is located just downstream of a park. Further investigation is suggested. Photo taken of the pipe on the right bank with rusted out bottom.

Referral site: MUS-FI-14

This site is located on the right bank in an area with many townhomes and a dog park. The corrugated plastic/plastic coated pipe had a diameter of 56-inches with consistent water flow, about 1.5 inches within the pipe. The sample collected from the mixing zone had an *E. coli* bacteria value of 2,380 MPN/100ML. The upstream sample was 504 MPN/100ML, giving a difference of 1,876 MPN/100ML. This site is downstream of a dog park which could be contributing bacteria, but further investigation is necessary. Photo taken of the plastic pipe on the right bank.

Robinson Bayou (1101D_01)
Bacteria Monitoring Report

Environmental Institute of Houston

March 23, 2021

Jenny Oakley, Ph.D.
Associate Director, Research Programs
Environmental Institute of Houston
University of Houston-Clear Lake

Introduction and Methods

Robinson Bayou (TCEQ assessment unit: 1101D_01) was identified by the Houston-Galveston Area Council (HGAC) as having high 7-year geomean for bacteria (*E. coli*) concentrations during regular ambient monitoring through the Clean Rivers Program. As a result, Robinson Bayou has undergone a bacteria investigation study where bacteria samples were collected at strategic locations along the entire length of the segment in order to aid in pinpointing potential sources, and then refer those sources for investigation by the proper authorities.

There are two separate field events that have taken place to date. 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 segment are not stormwater. A Windshield Survey (WS) acted both as a reconnaissance survey, and initial spatial assessment of ambient bacteria levels throughout the segment and its tributaries. During the WS, surface grab samples for bacteria were collected from bridge crossings and other public access points along the assessment unit and from the most downstream point publicly accessible on each tributary. The WS helped the field crew understand the ambient bacteria levels in the assessment unit on a spatial scale and prioritize tributaries for the Field Investigation (FI).

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 segment. 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 un-permitted outfalls. Permitted outfalls included waste water facilities and municipal separate storm sewer systems (MS4). Any pipe greater than 12 inches 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 un-permitted outfall, which was any other flowing source of water that was not assumed to be permitted including flowing small (<12 inch diameter) “homemade” pipes and tributaries.

When a flowing un-permitted 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 un-permitted 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.

Assessment Units, collection and laboratory methods, and data handling practices are detailed in the Appendix J to the H-GAC Multi-Basin Clean Rivers Program FY 2020-2021 Quality Assurance Project Plan (QAPP). The field crew carefully documented the 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.

Results

Windshield Survey

The windshield survey was conducted on February 9, 2021; it had been 4 days since the last significant rainfall in the watershed. A total of 10 bacteria samples were collected during the WS, 6 on Robinson Bayou and 4 on tributaries to the Bayou (Figure 1). Bacteria results from the ambient water samples collected during the WS ranged from 10 to 857 MPN/100ML.

Field Investigation

The results from the WS were used to prioritize the Field Investigation 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 Trib 1: 355 MPN/100ML and Unnamed Trib 2: 794 MPN/100ML). The FI was conducted on March 11, 2021 (6 days since last significant rainfall) and a total of 53 bacteria samples were collected. The values of the bacteria samples collected from downstream of permitted outfalls, or directly from un-permitted outfalls are illustrated in Figure 2. A total of 9 locations with elevated *E. coli* bacteria levels measured during the FI are recommended for further investigation by the proper authorities. These locations are summarized in Table 1. Each of these referrals are summarized by site herein.

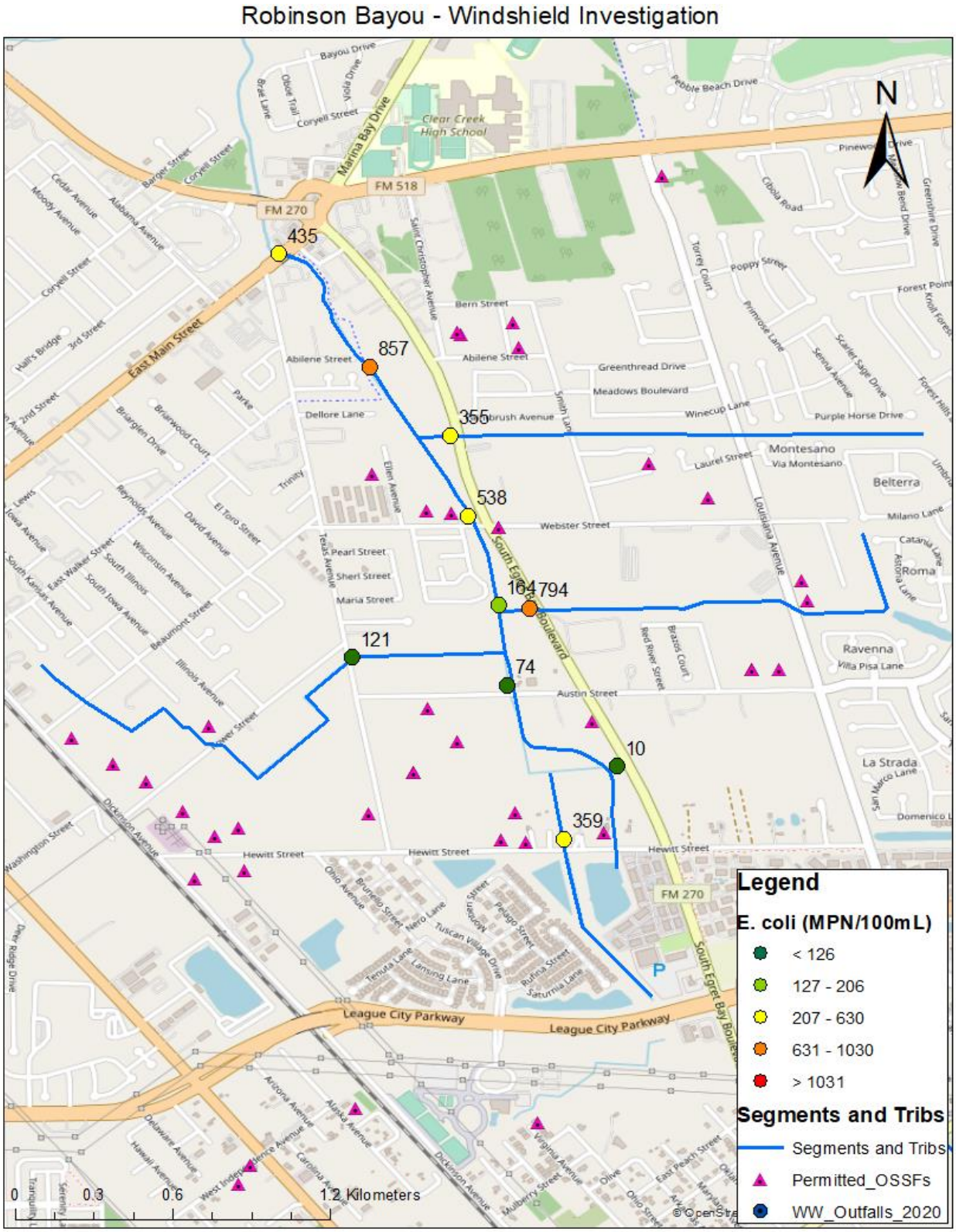


Figure 1. Map of Windshield Survey bacteria results from February 9, 2021.

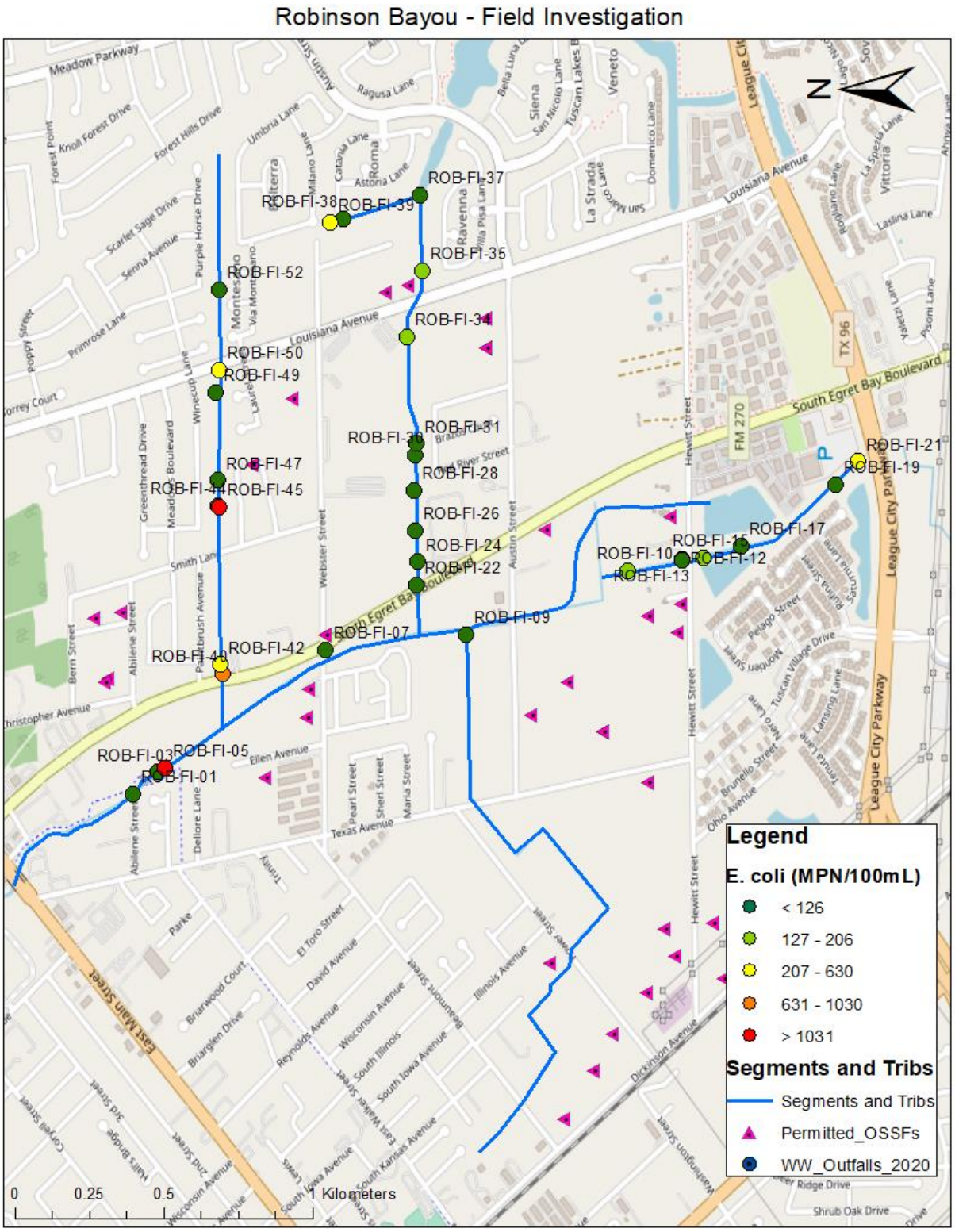


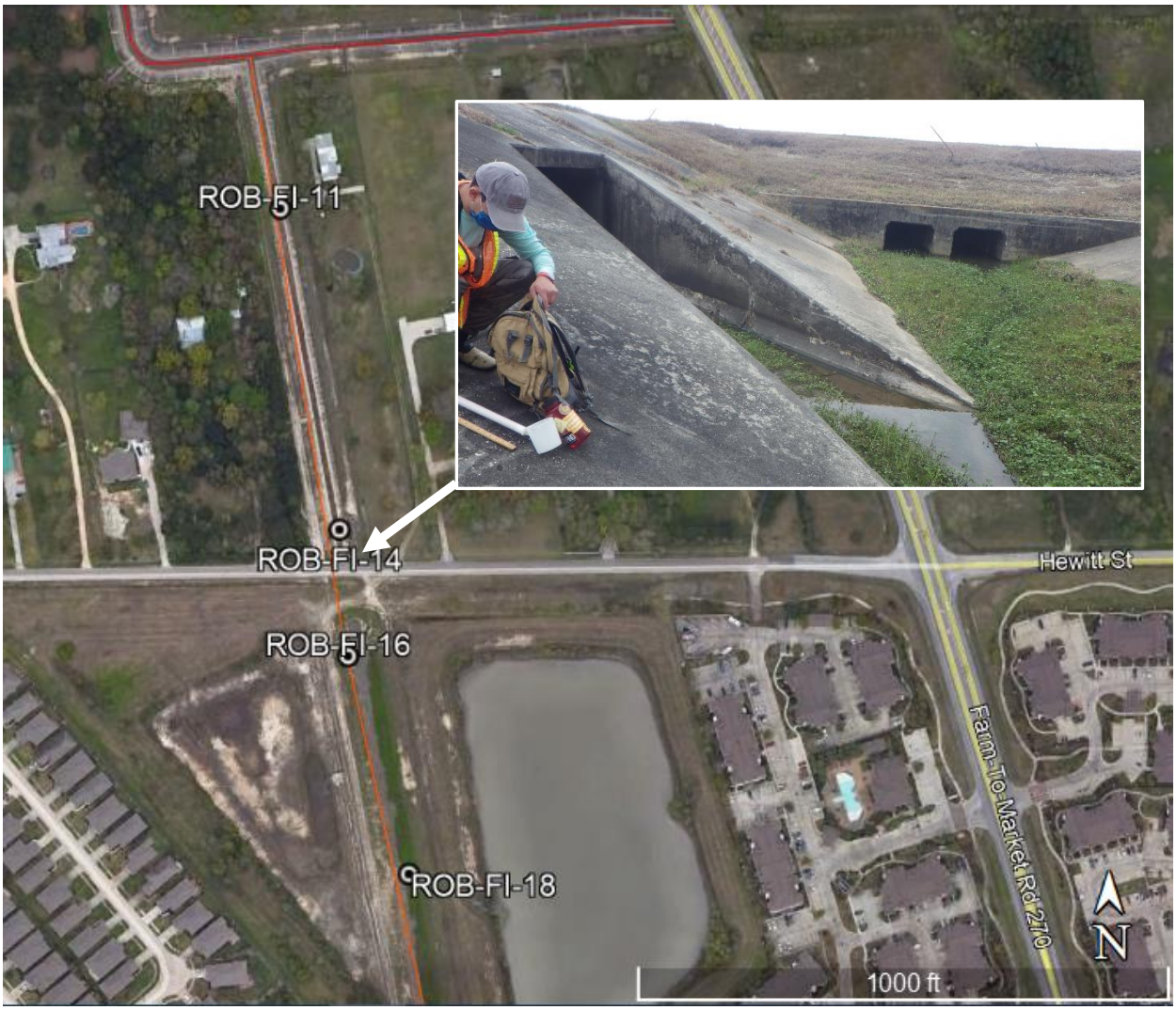
Figure 2. Map of Field Investigation bacteria results from March 11, 2021. Results displayed are the raw bacteria levels from the samples collected downstream of permitted outfalls, or directly from un-permitted outfalls.

Table 1. *E. coli* bacteria results measured during the field investigation. Rows highlighted in gray are recommended for further investigation by the proper authorities. ID = inner diameter, DS = downstream, US = upstream. NA = Sample was not taken from or in relation to a pipe or outflow.

Sample ID	Latitude	Longitude	Material of Outfall	ID of pipe (in)	Water depth in pipe (in)	DS or direct sample *E. coli* (MPN)	US *E. coli* (MPN)	Difference (DS-US)	Comments
ROB-FI-01	29.51723	-95.07550	Plastic or Plastic Coated	60.00	0.13	86	75	11	Dip sampler immediately downstream and upstream of inflow. Dead carp at outfall.
ROB-FI-03	29.51646	-95.07484	Plastic or Plastic Coated	24.00	4.00	75	74	1	Pipe doesn't appear to be flowing very much but submerged in bayou. Can hear water dripping up in pipe.
ROB-FI-05	29.51624	-95.07472	Plastic or Plastic Coated	70.00	2.00	1400	132	1268	Large pipe, barely trickling. Sampled downstream of pipe but in small earthen ditch
ROB-FI-07	29.51139	-95.07114	Concrete	32.00	0.13	98	132	-34	Downstream sample taken in stagnant pool, upstream taken in the middle of a flowing ditch.
ROB-FI-09	29.50714	-95.07069	Earthen	NA	NA	20	NA	NA	Sample taken at trib #3 approximately 15m from connection with Robinson Bayou.
ROB-FI-10	29.50225	-95.06876	Metal	24.00	8.00	132	122	10	
ROB-FI-13	29.50060	-95.06841	Concrete	87.00	2.00	3650	7700	-4050	Same upstream sample as ROB-FI-12. Square cement culvert. Right bank.
ROB-FI-12	29.50061	-95.06845	Plastic or Plastic Coated	72.00	3.00	63	7700	-7637	Same upstream sample as ROB-FI-13. Round PVC culvert, left bank.
ROB-FI-15	29.49995	-95.06836	Concrete	37.00	1.50	189	20	169	Ducks at site.
ROB-FI-17	29.49883	-95.06800	Plastic or Plastic Coated	60.00	2.00	110	10	100	Outflow from pond nearby.
ROB-FI-19	29.49597	-95.06615	Concrete	48.00	3.50	10	121	-111	Outflow from connected pond nearby - waterfowl in pond.
ROB-FI-21	29.49527	-95.06545	Concrete	58.00	0.50	613	NA	NA	Top of segment, 3 square concrete pipes.
ROB-FI-22	29.50863	-95.06918	Concrete	25.00	0.06	41	63	-22	Trib #2 start. Vertical drop from pipe with a steady trickle.
ROB-FI-24	29.50859	-95.06848	Plastic or Plastic Coated	40.00	2.00	74	20	54	Draining from nearby construction site. Small trickle from pipe.
ROB-FI-26	29.50866	-95.06754	Plastic or Plastic Coated	24.00	3.00	51	74	-23	Small stream. Lots of vegetation and algae in pipe.
ROB-FI-28	29.50870	-95.06633	Metal	30.00	2.00	63	134	-71	Small trickle from pipe. Lots of algae.
ROB-FI-30	29.50869	-95.06524	Metal	30.00	0.38	31	NA	NA	Smells wastewater effluent. Taken as a direct sample off cement apron, break in apron, water flows under.
ROB-FI-31	29.50865	-95.06491	Concrete	59.00	0.75	52	52	0	Water flowing down cement apron into ditch
ROB-FI-34	29.50892	-95.06167	Concrete	35.00	0.06	161	135	26	Culvert draining water covered portion of segment in right culvert. Approx. 28 m from latitude and longitude.
ROB-FI-35	29.50847	-95.05967	Plastic or Plastic Coated	60.00	1.50	146	20	126	Pipe empties to concrete apron into riprap side ditch then into segment.
ROB-FI-37	29.50852	-95.05740	Concrete	NA	NA	20	NA	NA	Cement Spillway draining large pond
ROB-FI-38	29.51087	-95.05810	Plastic or Plastic Coated	35.00	0.50	10	NA	NA	Creek braided upstream at outfall, took sample directly from outfall.
ROB-FI-39	29.51126	-95.05821	Plastic or Plastic Coated	57.00	14.50	383	NA	NA	Trib #2. Top of segment, sampled at base of pipe
ROB-FI-40	29.51451	-95.07185	Concrete	45.00	0.13	691	315	376	Unnamed trib #1 start. Pipe coming out under bridge. Approximately 4 m downstream of latitude and longitude.
ROB-FI-42	29.51457	-95.07159	Plastic or Plastic Coated	50.00	1.00	256	448	-192	Pipe on Right bank elevated and dribbling down riprap
ROB-FI-44	29.51465	-95.06678	Plastic or Plastic Coated	40.00	0.50	121	4880	-4759	Right bank pipe same upstream as below
ROB-FI-45	29.51461	-95.06682	Plastic or Plastic Coated	23.00	0.13	5480	4880	600	Left bank pipe same upstream as above
ROB-FI-47	29.51463	-95.06602	Plastic or Plastic Coated	25.00	0.13	122	309	-187	Left bank pipe dribbling into riprap
ROB-FI-49	29.51472	-95.06336	PVC	4.00	0.50	< 10	NA	NA	Small white pvc pipe coming out of right bank approx. 12 m from segment flowing over grass down hill.
ROB-FI-50	29.51460	-95.06269	Concrete	50.00	7.00	216	122	94	2m upstream of latitude and longitude. Left bank under bridge. Square culvert submerged, but can hear water flowing in the darkness. Another culvert square cement on right bank.
ROB-FI-52	29.51462	-95.06026	Concrete	70.00	0.25	1110	31	1079	Right bank large square

Referral site: ROB-FI-14 (Upstream sample from sites ROB-FI-12 and -13)

This site is located at the fourth unnamed tributary to Robinson Bayou and Hewitt St. The highest bacteria value of 7700 MPN/100ML was collected just downstream of the bridge crossing, with another high value (3650 MPN/100ML) collected just below the flowing culvert on the right bank. The ambient sample taken immediately upstream of the bridge (ROB-FI-16) had a low bacteria value (20 MPN/100ML) and the next sample downstream (ROB-FI-11) also had a relatively low bacteria value (122) indicating that there is likely a source somewhere under the bridge. It appeared that the culvert on the right bank as well as the two culverts directly under the bridge (pictured below) all connect through to the upstream side of the bridge. The field crew did not enter the culverts at the time of the FI. Photo taken downstream of bridge facing upstream. The right bank culvert and bridge culverts are in the field of view.



Referral site: ROB-FI-05

This site is a large ~70inch diameter corrugated plastic pipe protruding from the left bank located on the main assessment unit of Robinson Bayou near the end of Cameo Ct. The sample taken just downstream of the outfall pipe was 1400 MPN/100ML. The ambient sample taken immediately upstream of the outfall had a relatively lower bacteria value (132 MPN/100ML) indicating that there is likely a bacteria source contributing to this outfall pipe. Photo of pipe taken looking onto the left bank.

Referral site: ROB-FI-52

This site is a large ~70inch diameter concrete square culvert protruding from the right bank located near the top of the unnamed tributary 1 to Robinson Bayou near the intersection of Primrose Ln and Purple Horse Dr. The sample taken just downstream of the outfall pipe was 1100 MPN/100ML. The ambient sample taken immediately upstream of the outfall had a low bacteria value (31 MPN/100ML) indicating that there is likely a source feeding this outfall pipe. Photo of culvert taken looking onto the right bank.

Referral site: ROB-FI-21

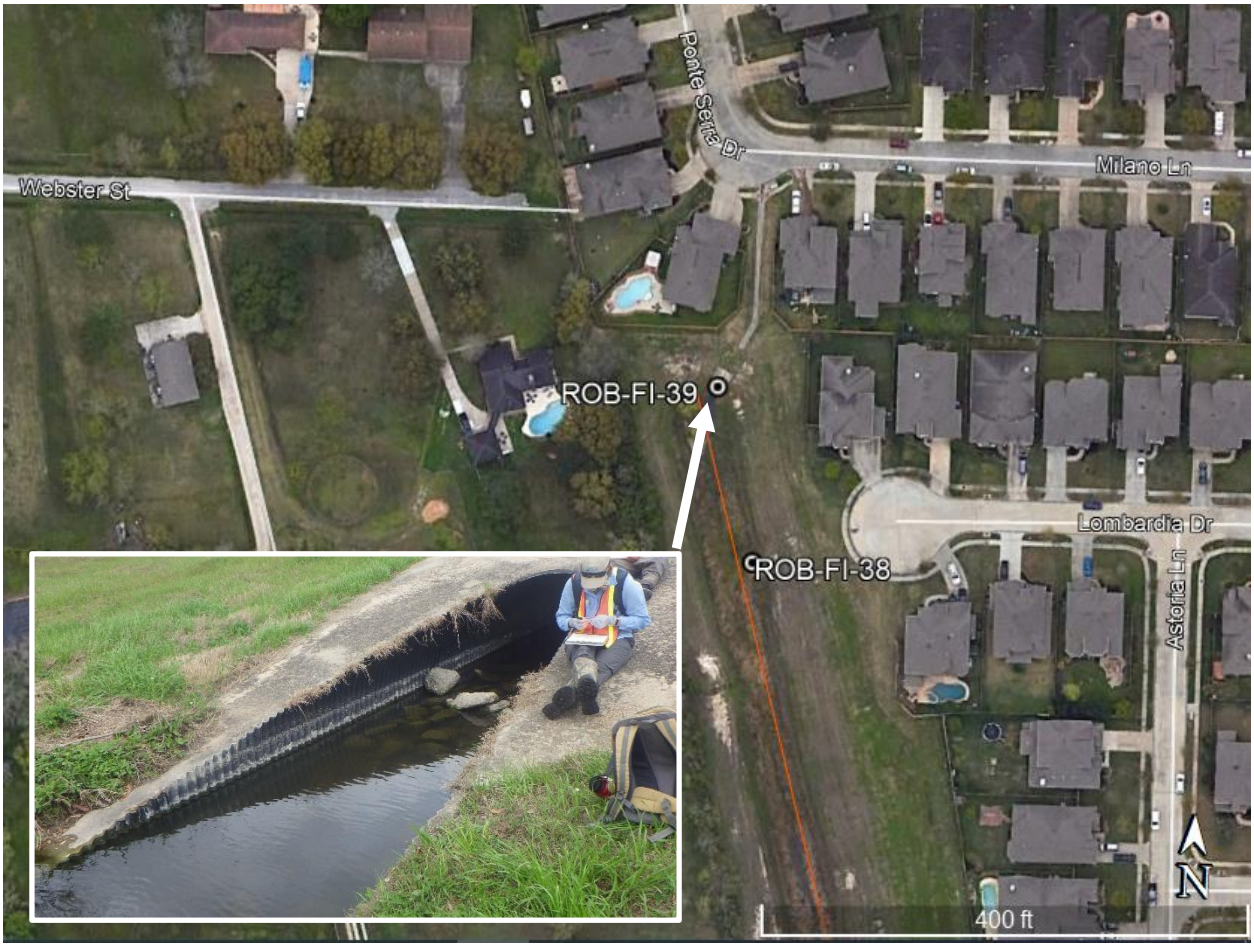
This site is the top of the unnamed tributary 4 to Robinson Bayou and consists of three large ~58inch diameter concrete square culverts from under League City Parkway/96. The sample taken just downstream of the culverts was 613 MPN/100ML. The ambient sample taken downstream (ROB-FI-19) had a relatively low bacteria value (121 MPN/100ML) indicating that there is likely a source upstream of the sampled culverts. Photo of the culverts facing upstream from the sample location.

Referral site: ROB-FI-45

This site is on the unnamed tributary 1 to Robinson Bayou and consists of one ~23inch diameter corrugated metal pipe coated in plastic protruding from the left bank upstream of Smith Ln. The sample taken just downstream of the culverts was 5480 MPN/100ML, while the ambient sample taken upstream of the pipe was high as well (4880 MPN/100ML) but still nearly 600MPN/100ML less than the downstream sample. The downstream sample taken at the pipe in the same vicinity but on the right bank was significantly lower (121 MPN/100ML). The ambient sample taken upstream (ROB-FI-47) had a relatively lower bacteria value (309 MPN/100ML) indicating that there is likely a source in or near the identified pipe. Photo of the two pipes facing upstream (pipe in question is on the right-hand side of the photo).

Referral site: ROB-FI-39

This site is the top of the unnamed tributary 2 to Robinson Bayou and consists of one ~57inch diameter corrugated plastic pipe near the cul-de-sac intersection of Ponte Serra Dr. and Milano Ln. The sample taken just downstream of the culvert was 383 MPN/100ML. There is likely a source upstream of the segment that drains into this pipe. Photo of the pipe facing upstream from the sample location.



Referral site: ROB-FI-40

This site is on the unnamed tributary 1 to Robinson Bayou and consists of one ~45 inch diameter cement pipe protruding from the right bank under the bridge crossing of FM 270. The sample taken just downstream of the culvert was 691 MPN/100ML, while the ambient sample taken upstream of the bridge was only 315 MPN/100ML indicating that there is likely a source contributing to the identified pipe. Photo of the pipe from under the bridge. NOTE: the latitude, longitude was taken approx. 4 m upstream of the bridge.

Referral site: ROB-FI-15

This site is just upstream of the highest priority referral (ROB-FI-14), on the unnamed tributary 4 to Robinson Bayou and consists of one ~37 inch diameter cement pipe protruding from the left bank just upstream of the Hewitt St. bridge. The sample taken just downstream of the culvert was 189 MPN/100ML, while the ambient sample taken upstream of the site was only 20 MPN/100ML indicating that there may be a source contributing to the identified pipe. Note: ducks were observed near the site just prior to sampling. Photo of the pipe from left bank, looking upstream.

Referral site: ROB-FI-35

This site is just upstream of Louisiana Ave. on the unnamed tributary 2 to Robinson Bayou and consists of one ~60 inch diameter corrugated plastic pipe protruding from the left bank. The sample taken just downstream of the culvert was 146 MPN/100ML, while the ambient sample taken upstream of the site was only 20 MPN/100ML indicating that there may be a source contributing to the identified pipe. Photo of the pipe looking upstream.

Unnamed Tributary of White Oak Bayou (1017E_01) Bacteria Monitoring Report

May 18, 2021

Prepared by:

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Introduction and Methods

This Unnamed Tributary of White Oak Bayou (TCEQ assessment unit: 1017E_01) was identified by the Houston-Galveston Area Council (HGAC) as having high 7-year geomean for bacteria (*E. coli*) concentrations during regular ambient monitoring through the Clean Rivers Program. As a result, the tributary of White Oak Bayou has undergone a bacteria investigation study where bacteria samples were collected at strategic locations along the entire length of the segment in order to aid in pinpointing potential sources, and then refer those sources for investigation by the proper authorities.

There are two separate field events that have taken place to date. 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 segment are not stormwater. A Windshield Survey (WS) acted both as a reconnaissance survey, and initial spatial assessment of ambient bacteria levels throughout the segment and its tributaries. During the WS, surface grab samples for bacteria were collected from bridge crossings and other public access points along the assessment unit and from the most downstream point publicly accessible on each tributary. The WS helped the field crew understand the ambient bacteria levels in the assessment unit on a spatial scale and prioritize tributaries for the Field Investigation (FI).

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 segment. 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 un-permitted outfalls. Permitted outfalls included waste water facilities and municipal separate storm sewer systems (MS4). Any pipe greater than 12 inches 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 un-permitted outfall, which was any other flowing source of water that was not assumed to be permitted including flowing small (<12 inch diameter) “homemade” pipes and tributaries.

When a flowing un-permitted 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 un-permitted 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.

Assessment Units, collection and laboratory methods, and data handling practices are detailed in the Appendix J to the H-GAC Multi-Basin Clean Rivers Program FY 2020-2021 Quality Assurance Project Plan (QAPP). The field crew carefully documented the 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.

Results

Windshield Survey

The windshield survey was conducted on March 10, 2021; it had been 4 days since the last significant rainfall in the watershed. A total of 13 bacteria samples were collected during the WS from this stream (Figure 1). Bacteria results from the ambient water samples collected during the WS ranged from 10-1990 MPN/100ML.

Field Investigation

The FI was conducted on March 22, 2021 (5 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 un-permitted outfalls are illustrated in Figure 2. Based on the data collected, 3 outfall locations with elevated *E. coli* bacteria levels measured during the FI are recommended for further investigation by the proper authorities. These locations are summarized in Table 1 (gray rows). In addition, 6 locations were flagged (yellow cells in Table 1) where ambient samples had elevated bacteria levels with no obvious explanations. Investigation of these areas or a second field investigation are recommended as well. Each of these referrals are summarized by site, herein.

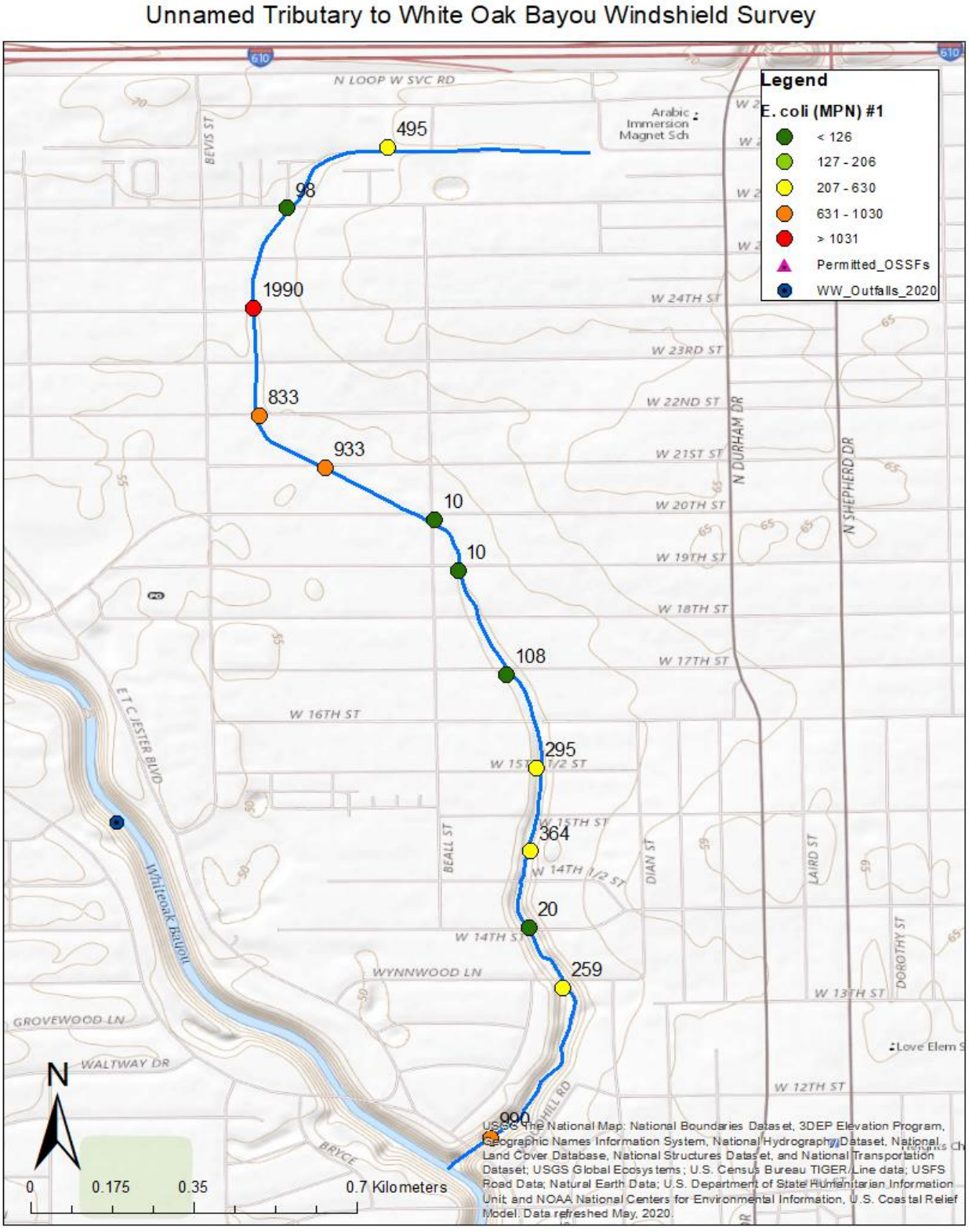

Figure 1. Map of Windshield Survey bacteria results from March 10, 2021.

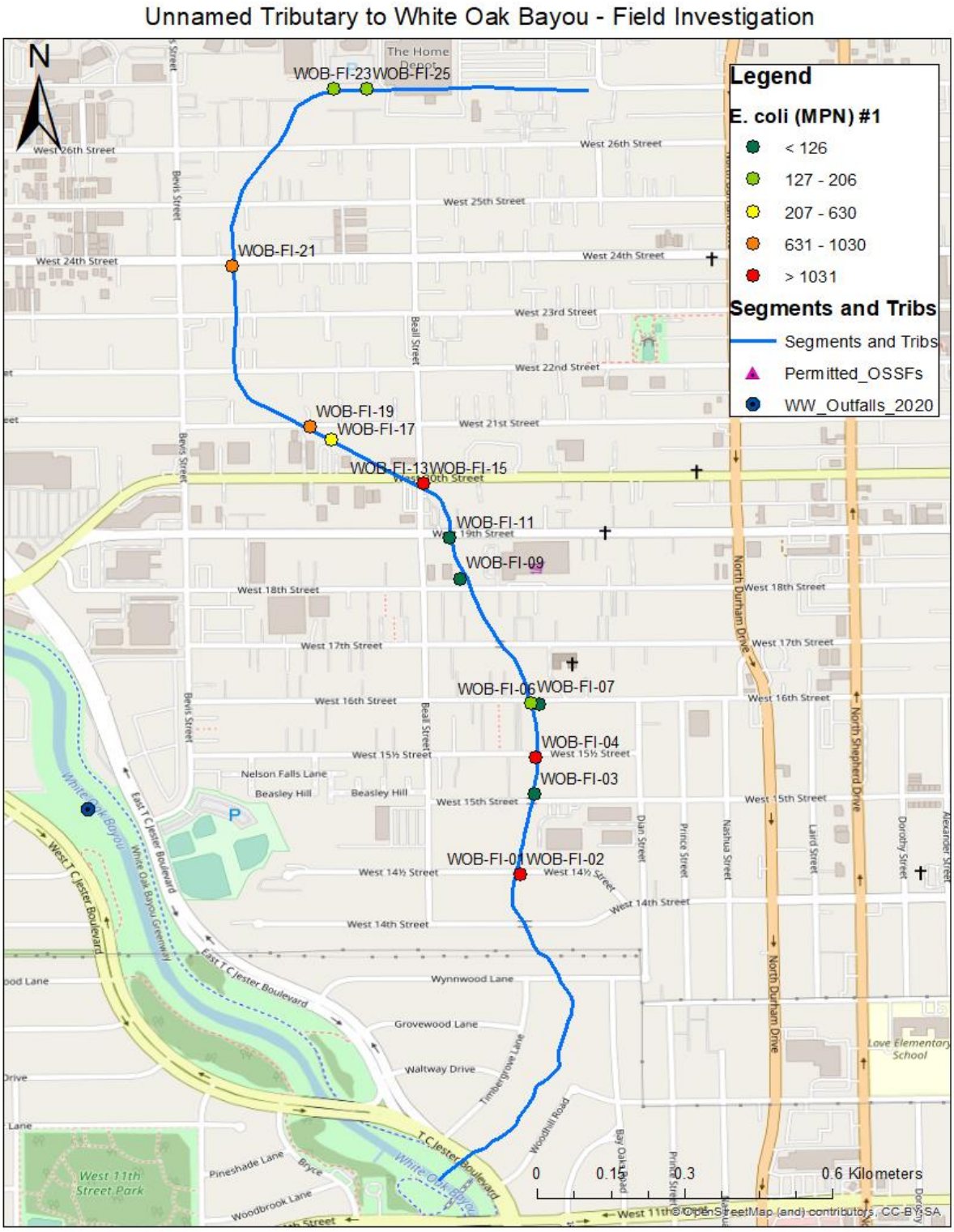

Figure 2. Map of Field Investigation bacteria results from March 22, 2021. Results displayed are the raw bacteria levels from the samples collected downstream of permitted outfalls, or directly from un-permitted outfalls.

Table 1. Top drainage locations with elevated *E. coli* bacteria levels measured during the field investigation recommended for further investigation by the proper authorities. ID = inner diameter, DS = downstream, US = upstream.

Sample ID	Latitude	Longitude	Material of Outfall	ID of pipe (in)	Water depth in pipe (in)	DS or direct sample *E. coli* (MPN/100mL)	US *E. coli* (MPN/ 100mL)	Difference (DS-US)	Comments
WOB-FI-01	29.79647	-95.41622	Metal	9.00	0.50	4350	NA	NA	Sample taken from broken concrete apron leading from pipe. No upstream sample needed.
WOB-FI-02	29.79647	-95.41622	Metal	6.00	NA	3870	NA	NA	Direct sample taken from broken pipe running over stream. No upstream sample taken.
WOB-FI-03	29.79795	-95.41597	Metal	63.00	7.50	74	NA	NA	Sample taken from isolated pool by pipe that connects to stream. Foam at mixing point.
WOB-FI-04	29.79862	-95.41595	Metal	25.00	0.13	1780	1720	60	
WOB-FI-06	29.79959	-95.41589	Concrete	50.00	45.00	41	1550	-1509	Same upstream sample for 06 and 07. Effluent smell.
WOB-FI-07	29.79962	-95.41603	Earthen	4.00	1.00	132	1550	-1418	Same upstream sample for 06 and 07. Difficult to identify source. Steady flow.
WOB-FI-09	29.80189	-95.41733	Concrete	23.00	7.50	< 10	52	-42	Under bridge, pipe half submerged, can hear water flowing.
WOB-FI-11	29.80264	-95.41752	Concrete	18.00	0.13	52	< 10	42	Stormwater drain from road.
WOB-FI-13	29.80363	-95.41800	Concrete	24.00	0.75	< 10	2280	-2270	Under road. Shallow, hard to take upstream sample.
WOB-FI-15	29.80363	-95.41800	Concrete	30.00	0.13	1620	109	1511	Just downstream of 13-14. Under road; was not initially flowing, but started when we were sampling 13-14; cloudy
WOB-FI-17	29.80444	-95.41969	Earthen	23.00	0.06	381	1440	-1059	Orange growth under pipe outflow.
WOB-FI-19	29.80466	-95.42007	Earthen	NA	0.50	882	1330	-448	Seeping from ground but good flow; maybe broken pipe under road.
WOB-FI-21	29.80761	-95.42150	Earthen	22.00	0.06	776	908	-132	Construction site on bank; porta-potty.
WOB-FI-23	29.81084	-95.41963	Metal	24.00	0.06	161	1620	-1459	
WOB-FI-25	29.81085	-95.41903	Metal	24.00	0.06	203	213	-10	Sample 26 is end of stream.

Referral site: WOB-FI-01

This site is located where the main assessment unit intersects with W 14 ½ Street, between Beall Street and Dian Street. This pipe is located on the left bank and is a metal pipe with an inner diameter of 9 inches. Just one sample was taken here from the broken concrete apron leading from the pipe with a bacteria value of 4350 MPN/100ML. This site, WOB-FI-01 was located just downstream of site WOB-FI-02, which is also recommended for referral. Photo taken looking at left bank, showing pipe in the bank with a broken concrete apron.

Referral site: WOB-FI-02

This site describes a sealed, permitted metal pipe with an inner diameter of about 6 inches 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 is broken and leaking water into the stream along the left bank, see photo. One direct sample was taken here from the leaking pipe with a bacteria value of 3870 MPN/100ML. It appears that this permitted pipe is in need of repair and has been leaking high bacteria water into the stream. Photos were taken from the left bank and show the broken area of the pipe and where the leaking water has been running into the stream bed.

Referral site: WOB-FI-15

This site is 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 and has an inner diameter of about 30 inches. The sample taken just downstream of the outfall pipe was 1620 MPN/100ML. The ambient sample taken upstream of the outfall had a relatively low bacteria value (109 MPN/100ML) 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. Photo taken from downstream shows pipe location on the left bank under the road.

Unnamed Tributary of Greens Bayou (1016D_01) Bacteria Monitoring Report

Environmental Institute of Houston

May 10, 2021

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Introduction and Methods

Unnamed Tributary of Greens Bayou (TCEQ assessment unit: 1016D_01) was identified by the Houston-Galveston Area Council (HGAC) as having high 7-year geomean for bacteria (*E. coli*) concentrations during regular ambient monitoring through the Clean Rivers Program. As a result, the Unnamed Tributary of Greens Bayou has undergone a bacteria investigation study where bacteria samples were collected at strategic locations along the entire length of the segment in order to aid in pinpointing potential sources, and then refer those sources for investigation by the proper authorities.

There are two separate field events that have taken place to date. 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 segment are not stormwater. A Windshield Survey (WS) acted both as a reconnaissance survey, and initial spatial assessment of ambient bacteria levels throughout the segment and its tributaries. During the WS, surface grab samples for bacteria were collected from bridge crossings and other public access points along the assessment unit and from the most downstream point publicly accessible on each tributary. The WS helped the field crew understand the ambient bacteria levels in the assessment unit on a spatial scale and prioritize tributaries for the Field Investigation (FI).

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 segment. 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 un-permitted outfalls. Permitted outfalls included waste water facilities and municipal separate storm sewer systems (MS4). Any pipe greater than 12 inches 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 un-permitted outfall, which was any other flowing source of water that was not assumed to be permitted including flowing small (<12 inch diameter) “homemade” pipes and tributaries.

When a flowing un-permitted 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 un-permitted 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.

Assessment Units, collection and laboratory methods, and data handling practices are detailed in the Appendix J to the H-GAC Multi-Basin Clean Rivers Program FY 2020-2021 Quality Assurance Project Plan (QAPP). The field crew carefully documented the 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.

Results

Windshield Survey

The windshield survey was conducted on March 9, 2021; it had been 8 days since the last significant rainfall in the watershed. A total of 11 bacteria samples were collected during the WS (Figure 1). Bacteria results from the ambient water samples collected during the WS ranged from <10 to 1560 MPN/100ML.

Field Investigation

The FI was conducted on March 22, 2021 (4 days since last significant rainfall) and a total of 47 bacteria samples were collected. The values of the bacteria samples collected from downstream of permitted outfalls, or directly from un-permitted outfalls are illustrated in Figure 2. This AU flows through a number of jurisdictions, so map of the FI results are also presented with the appropriate jurisdictions identified in Figure 3. A total of 5 locations with the most elevated *E. coli* bacteria levels measured during the FI are recommended for further investigation by the proper authorities. These locations are summarized in Table 1 (gray rows). Each of these referrals are summarized by site herein.

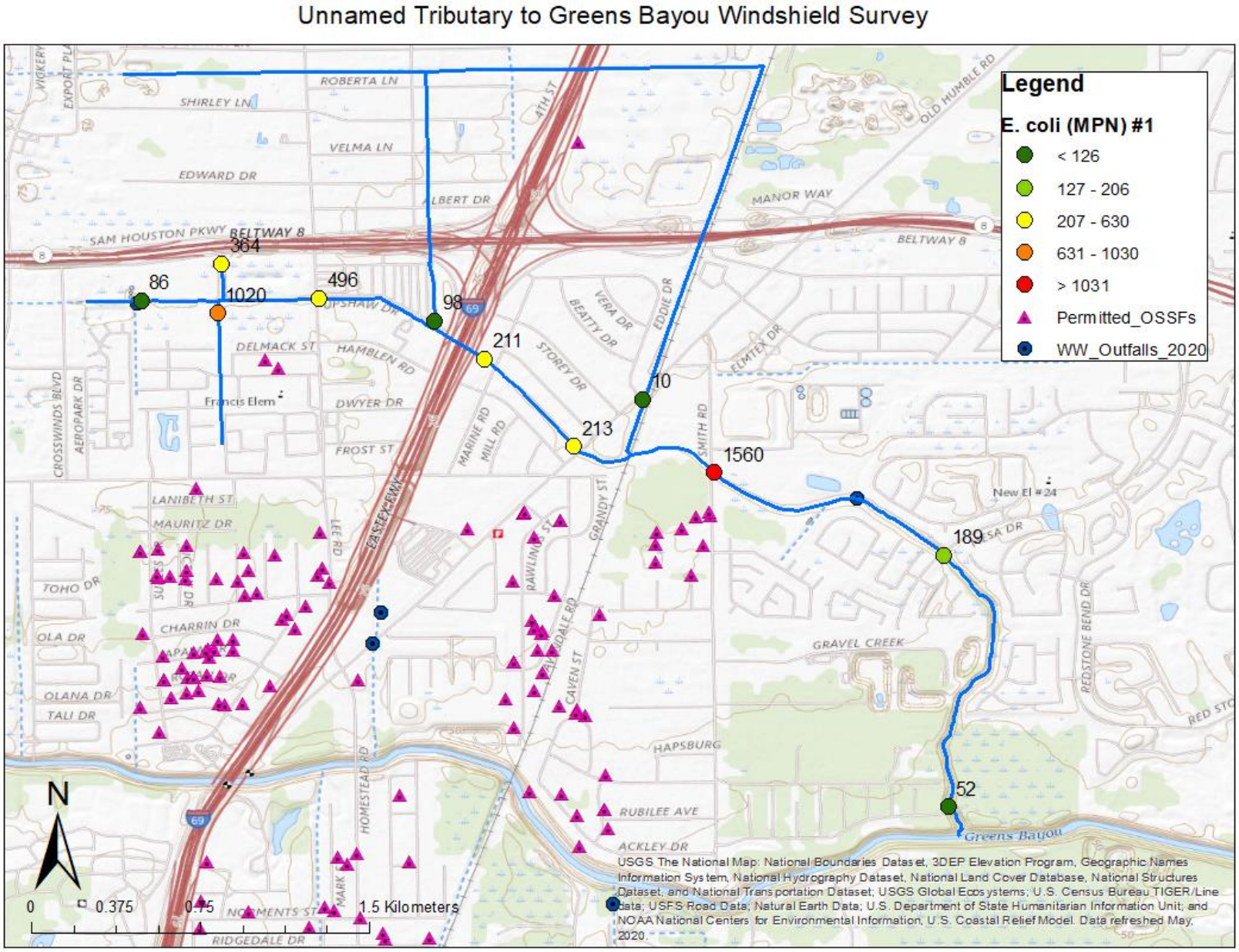

Figure 1. Map of Windshield Survey bacteria results from March 9, 2021.

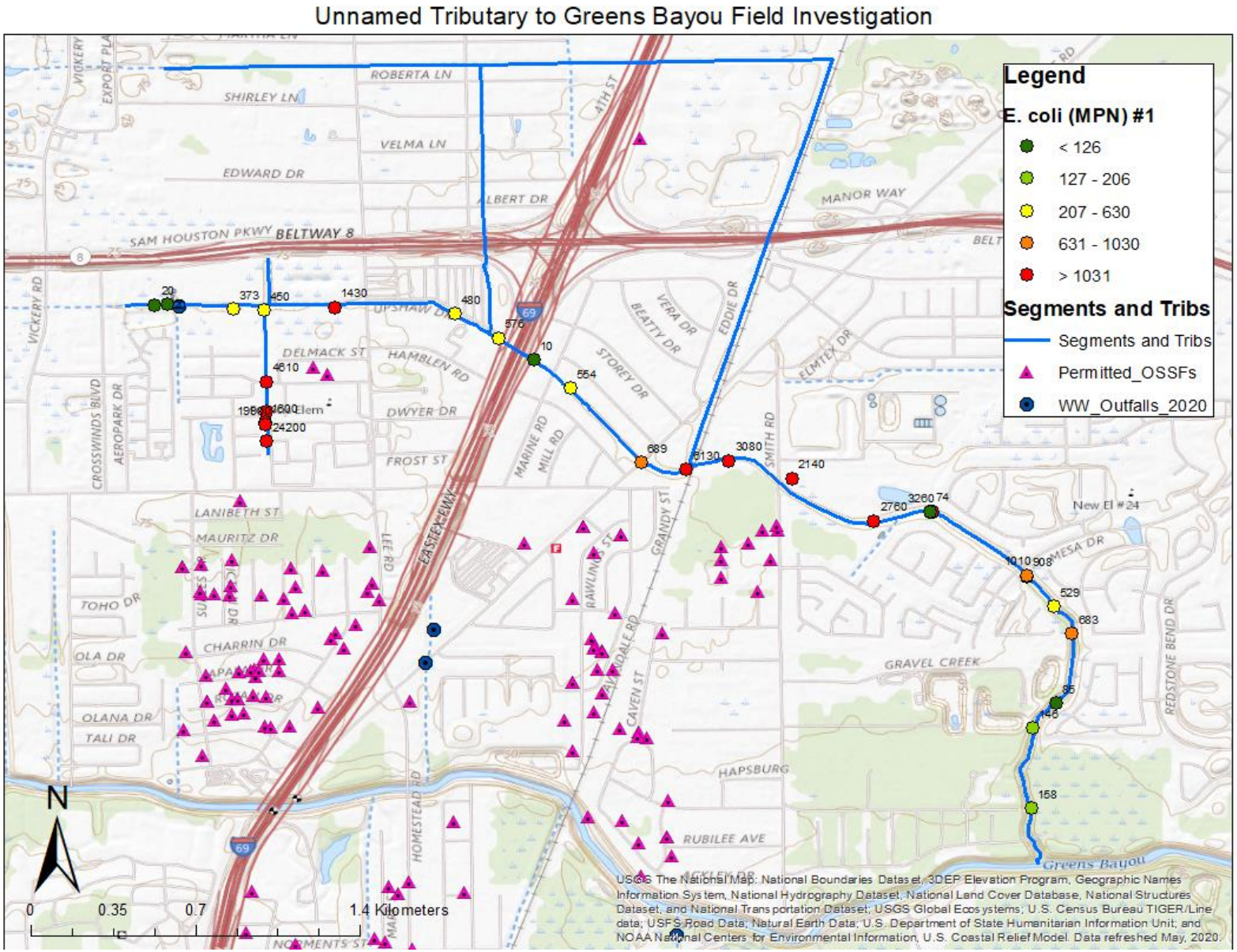

Figure 2. Map of Field Investigation bacteria results from March 22, 2021. Results displayed are the raw bacteria levels from the samples collected downstream of permitted outfalls, or directly from un-permitted outfalls.

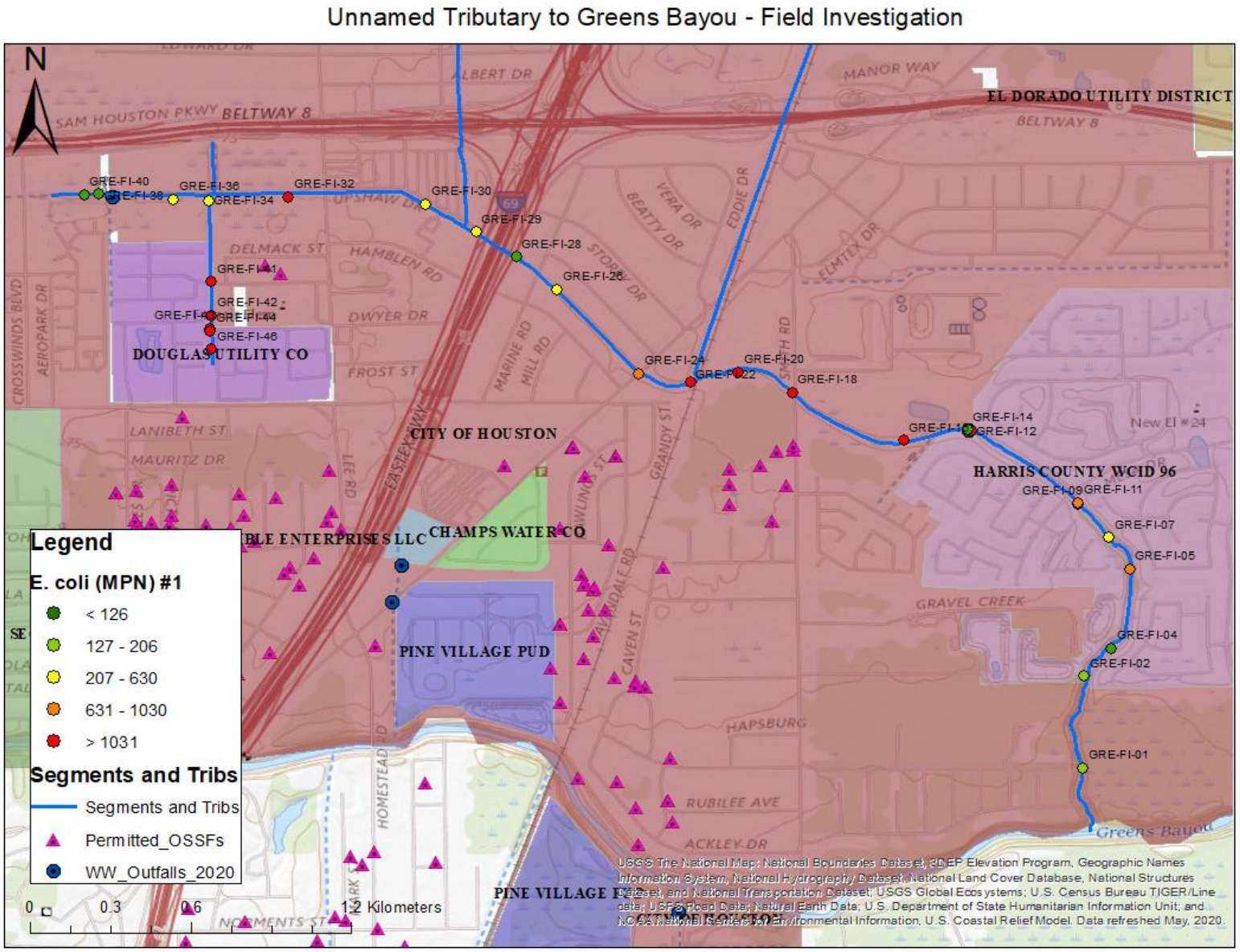

Figure 3. Map of Field Investigation bacteria results from March 22, 2021. Results displayed are the raw bacteria levels from the samples collected downstream of permitted outfalls, or directly from un-permitted outfalls.

Table 1. Field Investigation results with top locations with elevated *E. coli* bacteria levels measured during the field investigation recommended for further investigation by the proper authorities highlighted in gray. ID = inner diameter, DS = downstream, US = upstream. NA = Sample not associated with an outfall.

Sample ID	Latitude	Longitude	Material of Outfall	ID of pipe (in)	Water depth in pipe (in)	DS or direct sample *E. coli* (MPN/100mL)	US *E. coli* (MPN/ 100mL)	Difference (DS-US)	Comments
GRE-FI-01	29.91837	-95.27787	Earthen	NA	NA	158	NA	NA	Sample taken directly from flowing water on right bank. Trickling through trash.
GRE-FI-02	29.92145	-95.27782	Metal	25.00	NA	146	384	-238	Unable to tell water depth in pipe - bottom rusted out.
GRE-FI-04	29.92240	-95.27691	Metal	54.00	2.50	85	NA	NA	Sampled from riprap downstream of pipe.
GRE-FI-05	29.92505	-95.27630	Metal	72.00	0.25	683	798	-115	
GRE-FI-07	29.92611	-95.27699	Metal	42.00	1.00	529	663	-134	
GRE-FI-09	29.92725	-95.27804	Metal	64.00	2.50	908	1780	-872	Two outfalls on opposite banks. Same upstream sample for both.
GRE-FI-11	29.92730	-95.27804	Metal	79.00	4.00	1010	1780	-770	Cannot see flow, but can hear water flowing in the pipe. Same upstream sample as previous pipe.
GRE-FI-12	29.92972	-95.28163	Metal	48.00	0.13	3260	4610	-1350	Trickling out of pipe. Can hear trickling water coming from inside pipe. Left Bank.
GRE-FI-14	29.92974	-95.28174	Concrete	72.00	3.45	74	8660	-8586	Square outfall. One closed off, the other flowing. One side measures 39 in by 35 in. Left Bank.
GRE-FI-16	29.92938	-95.28389	Metal	36.00	0.50	2760	3450	-690	Left bank, water barely trickling out.
GRE-FI-18	29.93100	-95.28704	Concrete	64.00	13.50	2140	3870	-1730	Pipe submerged on left bank.
GRE-FI-20	29.93168	-95.28945	Concrete	48.00	0.13	3080	4610	-1530	Water dripping into stream, barely an inch deep. Left bank.
GRE-FI-22	29.93133	-95.29107	Metal	24.00	0.50	6130	933	5197	Water cloudy and staining ground as it leaves pipe. Milky white color. Right bank.
GRE-FI-24	29.93162	-95.29280	Concrete	34.00	3.00	689	657	32	Steady flow from culvert. Domestic ducks present. Under downstream road, left bank.
GRE-FI-26	29.93445	-95.29554	PVC	4.00	NA	554	< 10	544	Pipe submerged, outflow in center of stream, coming out of left bank, pipe will not move.
GRE-FI-28	29.93555	-95.29692	Concrete	98.00	8.00	10	NA	NA	Homeless encampment under overpass. Was informed that they use this area to bathe. Just downstream of bridge underpass.
GRE-FI-29	29.93638	-95.29827	Earthen	NA	NA	576	NA	NA	Upstream of 59 mid channel of ditch.
GRE-FI-30	29.93731	-95.29996	Metal	24.00	0.13	480	670	-190	Sample taken downstream of pipe expected to have mostly pipe water, dripping slowly.
GRE-FI-32	29.93756	-95.30457	Plastic or Plastic Coated	34.00	7.00	1430	1850	-420	Took sample at base of pipe. Can't tell if flowing, pipe submerged. Snake at site, swam up pipe before sample.
GRE-FI-34	29.93743	-95.30726	Concrete	78.00	11.00	450	471	-21	Sample taken from Trib 4 on the downstream side of the bridge. Upstream the sample was taken on the main segment upstream of the trib.
GRE-FI-36	29.93748	-95.30844	Plastic or Plastic Coated	34.00	9.00	373	108	265	Water appears to not be flowing. Pipe submerged. Sampled anyway. Large number of turtles, 34-37.
GRE-FI-38	29.93768	-95.31098	Plastic or Plastic Coated	24.00	0.25	20	292	-272	10" white PVC pipe just 3m downstream of 38, dripping slowly.
GRE-FI-40	29.93764	-95.31145	Metal	66.00	2.25	20	NA	NA	Top of segment flowing out of pipe on right bank. Sampled just 3m downstream of pipe, good flow.
GRE-FI-41	29.93471	-95.30717	Concrete	45.00	2.25	4610	NA	NA	Took sample just downstream of McCracken Rd. No visible flowing pipe between here and downstream influence.
GRE-FI-42	29.93357	-95.30716	Earthen	NA	NA	> 24200	NA	NA	Sampled in center of ditch. Strange cloudy/milky water. No observed pipes/inflow, lots of trash.
GRE-FI-43	29.93315	-95.30721	Concrete	32.00	0.13	1600	NA	NA	Sampled just downstream of pipe. Many dogs in yards along the bank. Left bank.
GRE-FI-44	29.93307	-95.30721	Unknown	NA	NA	19900	288	19612	Hole with black water just upstream of 43.
GRE-FI-46	29.93244	-95.30717	Metal	24.00	9.00	> 24200	171	24029	Pipe collapsed, diameter estimated. Full of floating trash.

Referral site: GRE-FI-42

This site is located in the center of Tributary #4 to the main segment near Mendota Ln cul-de-sac. There are fences along each bank. Access must be from the nearest downstream bridge crossing at McCrackin Road. A change in water color in the ditch was observed. Water in this area appeared cloudy/milky but there was no apparent flowing source in the direct vicinity, so an ambient sample was collected mid-channel in the earthen tributary and had a bacteria value of >24,200 MPN/100ML. The ambient sample collected downstream of the site near McCracken Rd had a bacteria value of 46,10 MPN/100ML and the sample taken upstream of this location (GRE-FI-43) was taken near a submerged pipe, but had a bacteria value of 1600 MPN/100ML. This suggests that there may be a leak somewhere under the tributary in this area which may be a source of elevated bacteria. Photo of section of tributary with discolored water where sample was taken.

Referral site: GRE-FI-46

This site is a metal pipe, ~ 24 inches in diameter coming out of the right bank located near the top of the tributary #4 of the segment. The pipe is difficult to see (indicated in red circle below) due to bank vegetation, trash in the water, and the fact that it is partially collapsed. The sample collected in the mixing zone, just downstream of the outfall had a bacteria value of >24,200 MPN/100ML, and the ambient sample collected just upstream of the outfall (mid channel) had a bacteria value of 171 MPN/100ML indicating that the outfall is likely a source of elevated bacteria. Photo of pipe taken looking onto the right bank. NOTE: further upstream there was an isolated pool that should also be investigated, although no samples were taken at the time of the FI. It appeared that there was a water source coming up from the ground in this area. The banks are fenced on both sides. The best access to this site is in the grass "ally" behind the southern houses on Vickita Dr (Blue Pathway marked on map)

Referral site: GRE-FI-44

This site is a deeper pool (hole) with very dark (black/grey) water just upstream of GRE-FI-43 near the left bank on the Tributary #4. There are fences along each bank. Access must be from the nearest downstream bridge crossing at McCrackin Road. The sample collected in the pool of dark water had a bacteria value of 19,900 MPN/100ML, and the ambient sample collected just upstream of the area (mid channel) had a bacteria value of 288 MPN/100ML indicating that the outfall is likely a source of elevated bacteria. Photo of dark pool taken looking onto the right bank.

Referral site: GRE-FI-22

This site is a metal pipe, ~ 24 inches in diameter coming out of the right bank of the main stem of the Unnamed Tributary to Greens Bayou, located just upstream of the rail-road track crossing between Old Humble Road and Smith Rd. The water flowing from the pipe was cloudy and the ground around the pipe was "stained" a milky white color. The sample collected in the mixing zone, just downstream of the outfall had a bacteria value of 6130 MPN/100ML, and the ambient sample collected just upstream of the outfall (mid channel) had a bacteria value of 933 MPN/100ML indicating that the outfall is likely a source of elevated bacteria. Photo of pipe taken looking onto the right bank.

Referral site: GRE-FI-26

This site is a small pvc pipe, ~ 4 inches in diameter coming out of the left bank and extending into mid-channel, fully submerged. It is located on the main segment of the Unnamed Tributary of Greens Bayou between Old Humble Rd. and the Eastex Freeway frontage road. The field team could not tell if water was flowing from the pipe and could not lift the pipe above the water to aid in that determination. Therefore, a sample was collected in the mixing zone, just downstream of the potential outfall and had a bacteria value of 554 MPN/100ML, and the ambient sample collected just upstream of the outfall (mid channel) had a bacteria value of <10 MPN/100ML indicating that the outfall is likely a source of elevated bacteria. Photo of pipe taken looking down into the water, difficult to see, but running up and down in the right half of the image.

BACTERIA MONITORING REPORT

White Oak Creek (1004J_01), Tributary to the West Fork of the San Jacinto River

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1.0 Introduction and Methods

1.1 Project Background

White Oak Creek (TCEQ assessment unit: 1004J_01) was identified by the Houston-Galveston Area Council (H-GAC) as having a high 7-year geometric mean for bacteria (*E. coli*) concentrations during regular ambient monitoring through the Clean Rivers Program. As a result, this tributary to the West Fork of the San Jacinto River has undergone a bacteria investigation study where bacteria samples were collected at strategic locations along the length of the segment in order to aid in pinpointing potential sources, and then refer those sources for investigation by the proper authorities. White Oak Creek is one of ten assessment units (AUs) identified and monitored as part of this Bacteria Monitoring Project (Figure 1).

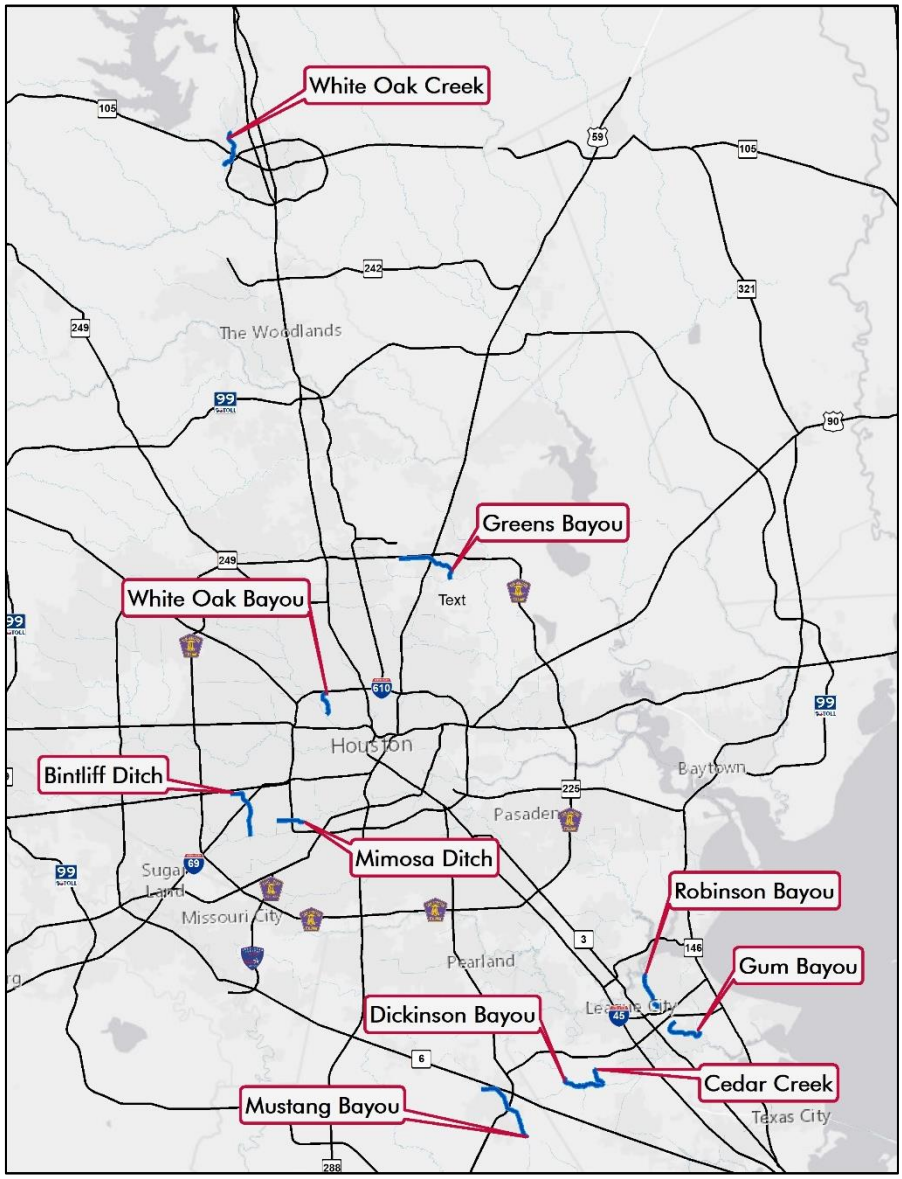

Figure 1. Map of all Targeted Bacteria Monitoring Project Watersheds

1.2 Methods

Two separate field monitoring events have taken place on White Oak Creek to date, a windshield survey (WS) and a field investigation (FI). All field events are conducted during dry weather (after 3 or more days without significant rainfall in the watershed). The assumption is that during dry weather sampling, any water flowing into White Oak Creek is not stormwater.

The WS serves as the initial reconnaissance of the AU to determine ambient bacteria levels at different sections of waterway. Surface grab samples for bacteria were collected from bridge crossings and other access points along the AU from the most downstream point accessible to the point upstream where White Oak Creek branches into east and west forks. Samples were also collected upstream of the confluence on each of the forks to provide an assessment of the bacteria load possibly being contributed from upstream waters of the targeted AU. The results of the WS provided information on bacteria concentrations that were used to prioritize sampling during the FI.

The FI is a more in-depth survey where the monitoring field crew walks the entire AU over one or multiple days depending on the length of the AU. During the FI, any source of flowing water was sampled, whether from a pipe, culvert, natural tributary, or earthen ditch. When flowing water was observed from what was suspected or confirmed to be a permitted source two samples were collected: the first immediately downstream of the outfall where the flowing outfall was mixing with the ambient water, and the second upstream of the outfall outside of the realm of influence from the outfall. The difference between the upstream and downstream sample was used to determine if the outfall was contributing elevated levels of bacteria to the waterway. If the flowing water was from a suspected unpermitted source, such as a small "homemade" pipe or natural tributary, then a single sample was collected directly from the source. Samples from unpermitted pipes were collected from end-of-pipe, and samples from tributaries were collected far enough upstream from the confluence that there was no mixing with the receiving water.

Assessment Units, collection methods, laboratory methods, and data handling practices are detailed in the Appendix J to the H-GAC Multi-Basin Clean Rivers Program FY 2020-2021 Quality Assurance Project Plan (QAPP). Information on outfalls, sample locations, present weather, and more was recorded on a field sheet and in the ESRI Collector App, and pictures were taken of each sample location. Left and right bank references were oriented following the Texas Commission on Environmental Quality's (TCEQ) Surface Water Quality Monitoring (SWQM) procedures, with the left and right banks determined when a person is facing downstream.

2.0 Results

Assessment Unit: White Oak Creek (1004J_01)
Assessment Unit Distance: 2.96 miles
Seven-Year Relative Bacteria Geomean: 25.27 MPN/100 mL
Dates Sampled: January 29, 2021 (WS) and April 28, 2021 (FI)

2.1 Windshield Survey

The windshield survey (WS) was conducted on January 29, 2021, 19 days since the last significant rainfall in the watershed. A total of nine samples were taken during the WS at bridge crossings and other access points (Table 1). Seven samples were collected along 1004J_01 and one sample on each of the two forks (1004A_01 and 1004B_01) feeding into the targeted AU (Figure 2). Samples were labeled from downstream to upstream with the most downstream sample labeled as "WOC-WS-01".

Table 1 WS Results from sampling on 1/29/21 on White Oak Creek in Conroe, Texas. Samples taken at bridge crossings and other easily accessible points.

Sample ID	Latitude	Longitude	Water Depth (in.)	Sample E. coli (MPN)	Comments
WOC-WS-01	30.31925	-95.51112	2	1020	WOC accessed behind City of Conroe Lift Station, sample taken in stream directly downstream of a tributary running alongside of the lift station, coming from an outfall/ditch on O'Grady St.
WOC-WS-02	30.32748	-95.50114	5.5	1640	
WOC-WS-03	30.33216	-95.50175	4	3780	Sampled about 15m downstream from detention pond outfall.
WOC-WS-04	30.33594	-95.50029	3	8160	
WOC-WS-05	30.33883	-95.50117	3.5	2990	Large flowing outfall coming out below end of cul-de-sac. We heard water flowing in City of Conroe sanitary sewer manhole, but we are unsure if flows to the outfall as it is downhill and to the side of outfall opening. Sample taken downstream of large dam outfall/tributary and upstream of cul-de-sac outfall.
WOC-WS-06	30.34052	-95.50342	4.5	4350	
WOC-WS-07	30.34997	-95.50523	7.5	1050	A lot of new construction occurring in Madison Bend subdivision.
WOC-WS-08	30.35229	-95.50366	5	389	Tree growing out of sanitary sewer manhole located in backyard of house along the creek.
WOC-WS-09	30.35027	-95.50542	3	5170	Accessed by confluence, then walked upstream. All upstream access in gated communities. Dairy located up stream on west fork according to Shane Simpson.

Bacteria concentrations from the WS ranged from 389 to 8,160 MPN/100mL, though all results were greater than the standard of 126 MPN/100mL. A spike in *E. coli* levels was noted between sample 05 (2,990 MPN/100mL) and the downstream sample 04 (8,160 MPN/100mL), though a strong flow originating from under a residential cul-de-sac was noted

between the two samples. Another increase in *E. coli* levels was noted between samples 07 (1,050 MPN/100mL) downstream of the confluence of the two forks and the downstream sample 06 (4,350 MPN/100mL) at FM 3083. Much of the area between the two is under construction for a new or expanded residential area. One key finding of the WS was that while the sample upstream on the East Fork of White Oak Creek (1004A_01) was 389 MPN/100mL, the sample on the West Fork of White Oak Creek (1004B_01) was significantly higher at 5,170 MPN/100mL. The West Fork sample was taken closer to the confluence than the East Fork because no public access was found within a reasonable distance, so the field crew walked upstream from the confluence to a point where no mixing would occur.

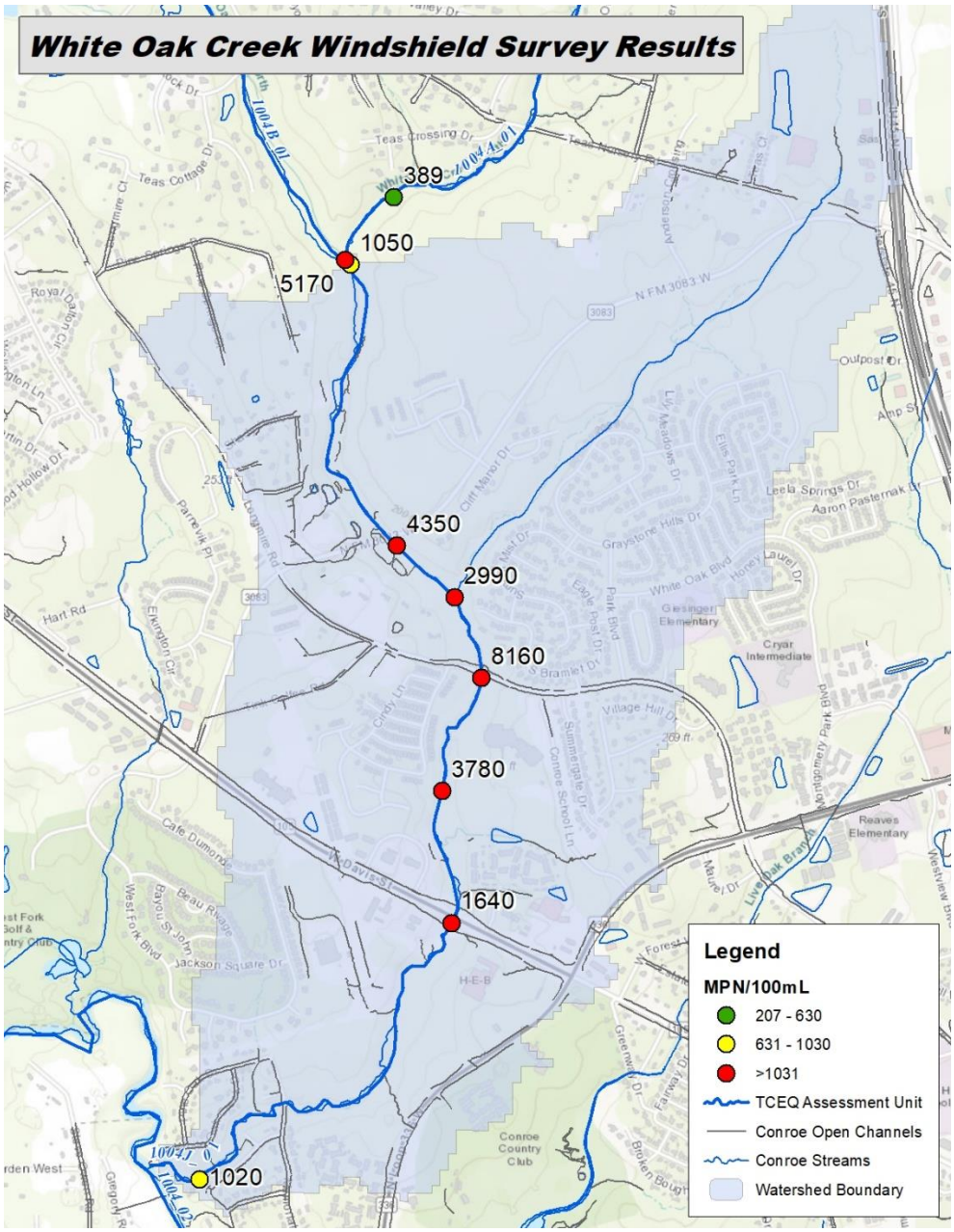

Figure 2. White Oak Creek Watershed Survey Results Mapped

2.2 Field Investigation

The field investigation (FI) took place on April 28, 2021, 44 days since the last significant rainfall in the watershed. White Oak Creek does not have many access points outside of what was sampled during the WS, and 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 (WOC-1-01) Although White Oak Creek is shallow, the sediment is a very fine sand and is difficult to walk through. Sink holes were often created as the field crew trekked along. To sample as much of the AU as possible during the first FI, the section between Memorial Drive and SH 105/Davis Street was not walked as the WS did not reveal a spike in *E. coli* levels between the two points. The field crew focused more on the concerning results from the WS that were located upstream of SH 105/Davis Street. In order to get the samples to the lab on time, the field crew was unable to walk the last 0.25 to 0.5 miles of the AU up to the two forks.

A total of 29 samples were collected at 18 locations (Table 2). Most sample locations were from small flowing tributaries, though some were determined or suspected to come from outfalls or sources set further back from the banks.

Table 2 FI Results from sampling on 4/28/21 on White Oak Creek in Conroe, Texas. ID = inner diameter of pipe. DS/US = downstream/upstream sampling points. For direct samples only the E. coli result is listed. When a sample was taken DS and US, if the Difference column is a positive number it indicates a higher DS than US value and that the source could be contributing E. coli to the waterway. Rows highlighted in gray are recommended for further investigation by the proper authorities.

Sample ID	Latitude	Longitude	Material of Outfall	ID of Pipe (in.)	Water Depth in Pipe (in.)	DS or direct sample E. coli (MPN)	US E. Coli (MPN)	Difference (DS-US)	Comments
WOC-1-01	30.319149	-95.511133	other	--	0.1	801	733	68	Small tributary coming from left bank from O'Grady St.
WOC-1-02	30.319668	-95.510052	other	--	0.05	1,110	860	250	Small, very shallow, slow flowing tributary on left.
WOC-1-03	30.319963	-95.509597	other	--	<0.1	1,270	1,500	-230	Water trickling down from left bank over pile of discarded bricks.
WOC-1-04	30.321249	-95.508859	concrete	72	0.1	3,450	4,350	-900	Large concrete culvert on right bank, flowing into small eddy, not into flowing part of stream.
WOC-1-05	30.321601	-95.507538	concrete	18	<0.1	3,650	4,350	-700	Outfall on right bank just upstream of bridge at Memorial Dr.
WOC-1-06	30.328107	-95.501033	other	--	0.1	173	--	--	Small tributary on left bank with aquatic

Sample ID	Latitude	Longitude	Material of Outfall	ID of Pipe (in.)	Water Depth in Pipe (in.)	DS or direct sample E. coli (MPN)	US E. Coli (MPN)	Difference (DS-US)	Comments
									vegetation. Sample taken 6ft up stream in tributary.
WOC-1-07	30.328659	-95.500962	other	--	0.25	860	--	--	Sample taken 6ft upstream in tributary
WOC-1-08	30.330213	-95.501682	other	--	0.05	1,110	--	--	Sample taken 6ft upstream in tributary from WOC
WOC-1-09	30.334755	-95.500696	other	--	3.0 up 4.0 down	3,970	4,880	-910	
WOC-1-10	30.335941	-95.500233	concrete	40	2.5 up 4 down <0.1 pipe	6,130	8,160	-2,030	Water from pipe is a little more than a trickle.
WOC-1-11	30.336244	-95.500066	other	--	2	331	--	--	Tributary appears to come out of ornamental pond. Barely a trickle down by WOC, but pools up by road in ditch. Sample taken from tributary.
WOC-1-12	30.337487	-95.500683	other	--	1.25	74	--	--	Sample taken 6ft up in tributary.
WOC-1-13	30.338130	-95.500841	other	--	4.5	10	--	--	Sample taken 6ft up in tributary.
WOC-1-14	30.338747	-95.501256	concrete	--	3 down 2 up <0.5 in wide flow from dam	10,500	12,000	-1,500	Concrete outfall is from dam like structure on a tributary. About 100m upstream of confluence w/WOC where samples were taken up and downstream.
WOC-1-15	30.340638	-95.503751	other	--	1.0	< 10	--	--	Possible water coming from ornamental pond. Appears to come out of ground, smells like groundwater.
WOC-1-16	30.340684	-95.503720	other	--	2 down 2 up	3,610	4,350	-740	Outfall flow appears to split under bridge. Sample taken downstream and

Sample ID	Latitude	Longitude	Material of Outfall	ID of Pipe (in.)	Water Depth in Pipe (in.)	DS or direct sample E. coli (MPN)	US E. Coli (MPN)	Difference (DS-US)	Comments
									upstream of both flows. Birds under bridge.
WOC-1-17	30.346034	-95.505943	other	--	4 down 4 up	10,500	9,210	1,290	Upstream of some open area w/bulkhead on creek that has pipe coming out of it.
WOC-1-18	30.347082	-95.505009	concrete	40	0.25	13,000	17,300	-4,300	

In most instances where a downstream and upstream sample were collected, the outfalls and tributaries appeared to dilute the *E. coli* levels rather than add to them. Three sampled sites did indicate a possible addition of *E. coli* to the waterway and are detailed more in referral sections 2.3 and 2.4. Sites 07 and 08 were direct samples, and site 17 used a downstream and upstream sample. Results from all three of these sites indicate that close to or greater than 1,000 MPN/100mL could be contributed by the sites. Results from sites 01 and 02, located within McDade Estates near the confluence with the West Fork of the San Jacinto River, also indicated the addition of lower levels of *E. coli* to White Oak Creek and could be worth investigating.

Despite the identification of a few potential bacteria sources along the downstream portion of the waterway, more investigation is needed on White Oak Creek as the source(s) of the highest bacteria levels were unable to be identified. A secondary field investigation is recommended, specifically to target the upstream portion of the waterway as both the WS and FI results reflected particularly high bacteria concentrations at the confluence with 1004B_01 and 1004A_01. It is possible that a major source is located in the upstream portion of the waterway and becoming diluted in downstream waters.

Due to time constraints during the FI, the H-GAC field crew was unable to sample upstream of WOC-1-18. However, this sample contributes to the highest bacteria concentrations (13,000 MPN/100mL) found throughout the entire watershed (Figure 3). Since the WS survey suggested large bacteria contributions from1004B_01, H-GAC recommends targeting the West Fork of White Oak Creek (1004B_01) as the impairment source may be in the upstream assessment unit and reflected in the receiving waters of 1004J_01.

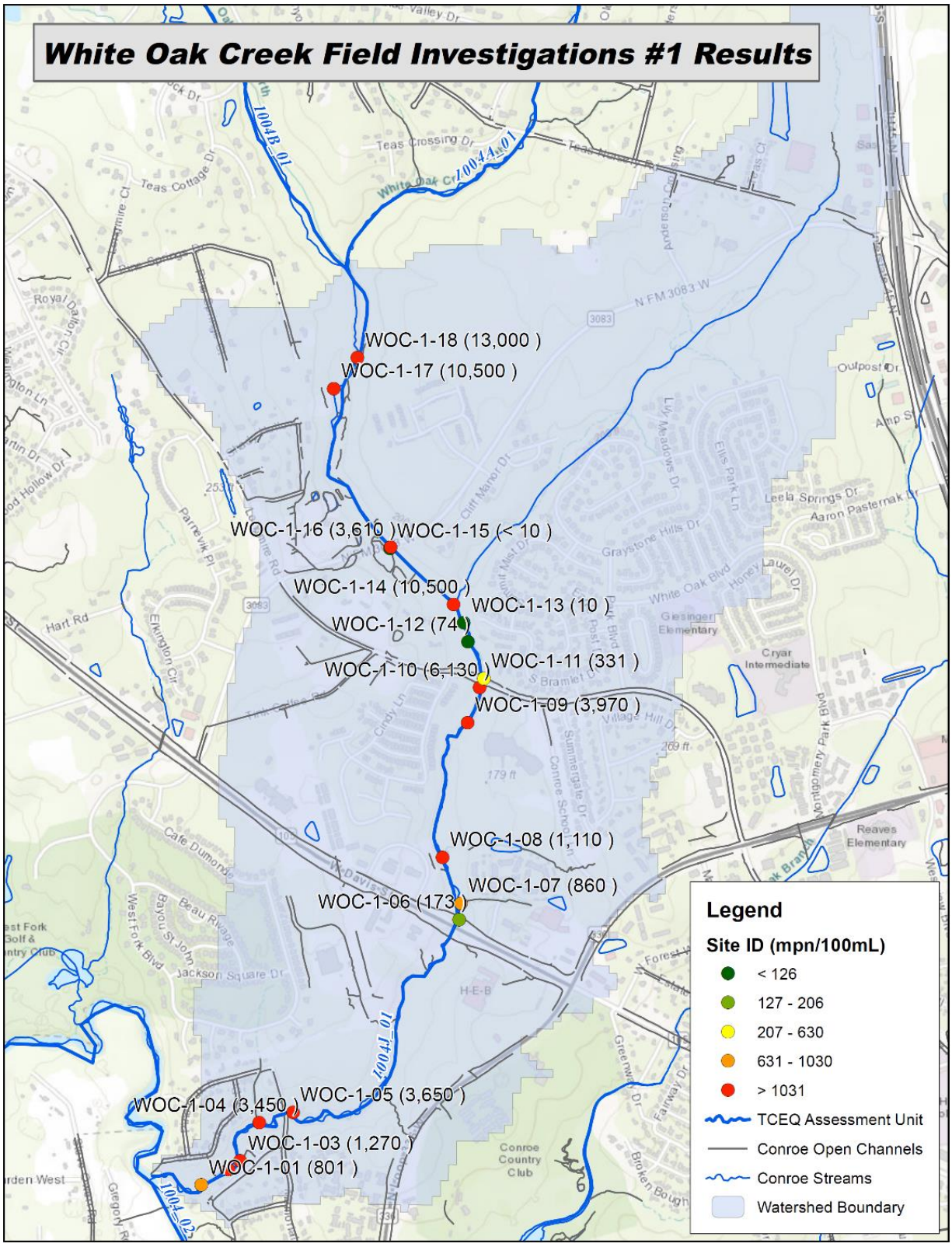

Figure 3. Results from the White Oak Creek Field Investigation

There was a large spike in the bacteria concentrations in samples between FM 3083 (WOC-1-16) and the dam outfall from a large drainage area downstream (WOC-1-14), but field crews did not find any other sources between the two to sample. It is worth noting that there was also a large spike in bacteria concentrations near FM 3083 during the WS. There are several large ponds on the right bank immediately downstream and upstream of the bridge on FM 3083, but no flow source was noted during the FI.

In addition, the two furthest upstream samples (WOC-1-17 and WOC-1-18) had significantly higher bacteria concentrations than anywhere else on the waterway besides the sample mentioned above near FM 3083 (WOC-1-16). The furthest upstream sample taken during the FI was near the bottom of a new subdivision under construction and had a result of 17,300 MPN/100mL. There was still approximately 0.25 to 0.5 miles upstream of the final sample site to the top of the AU where the West and East Forks of White Oak Creek diverge. As noted in the section 2.1, the WS results indicated a much higher bacteria concentration coming from West Fork than the East Fork, but that result was still just a fraction of the 17,300 MPN/100mL coming from upstream of the final sample point of the FI.

Potential sources could not be identified for these higher bacteria concentrations; therefore, no referrals could be made for correction. Further investigations are recommended to identify sources for future referral. These investigations would focus on the area around FM 3083 and upstream to the confluence of the two forks (1004B_01 and 1004A_01). It is recommended to sample both upstream assessment units to determine which waterway is contributing the most bacteria concentrations. Since the results in the upstream portion of the AU were significantly higher in the WS samples, it is also recommended to determine if the City of Conroe has reports of any Sanitary Sewer Overflows (SSOs) during the period leading up to the FI that could explain the increase.

2.3 Referral Site: WOC-1-07 and WOC-1-08

Coordinates: (30.328659, -95.500962) and (30.330213, -95.501682)

Two small tributaries on the right and left bank of White Oak Creek upstream of SH 105/W Davis Street are listed for referral (Figures 4 and Figure 5). The sites are downstream of an apartment complex and upstream of a shopping center. The tributaries have a low flow, but the exact origin of one of the tributaries is unknown (WOC-1-08). The City of Conroe provided GIS layers that indicate an open channel is found at WOC-1-07, which collects stormwater from a nearby residential community (Figure 6). The field crew took samples directly from the tributaries, upstream of the mixing zone with White Oak Creek, during the FI on April 28, 2021. The *E. coli* results were 860 MPN/100mL at site 07 and 1,110 MPN/100mL at site 08. Since both tributaries were sampled directly, it indicates that both are contributing bacteria to White Oak Creek at levels above the state standard.

During the WS in January, samples were taken upstream and downstream of the tributaries. The upstream sample WS-03 (upstream behind school) showed a bacteria concentration of 3,780 MPN/100mL, and the downstream sample WS-02 (downstream near bridge on SH 105/ W Davis St) results were 1,640 MPN/100mL. Since there was a high dilution rate, this indicates the tributaries were not contributing a large number of bacteria during the WS, however, further investigation is recommended based upon FI results.

Figure 4. WOC-1-07; Tributary into White Oak Creek

Figure 5. WOC-1-08; Tributary into White Oak Creek

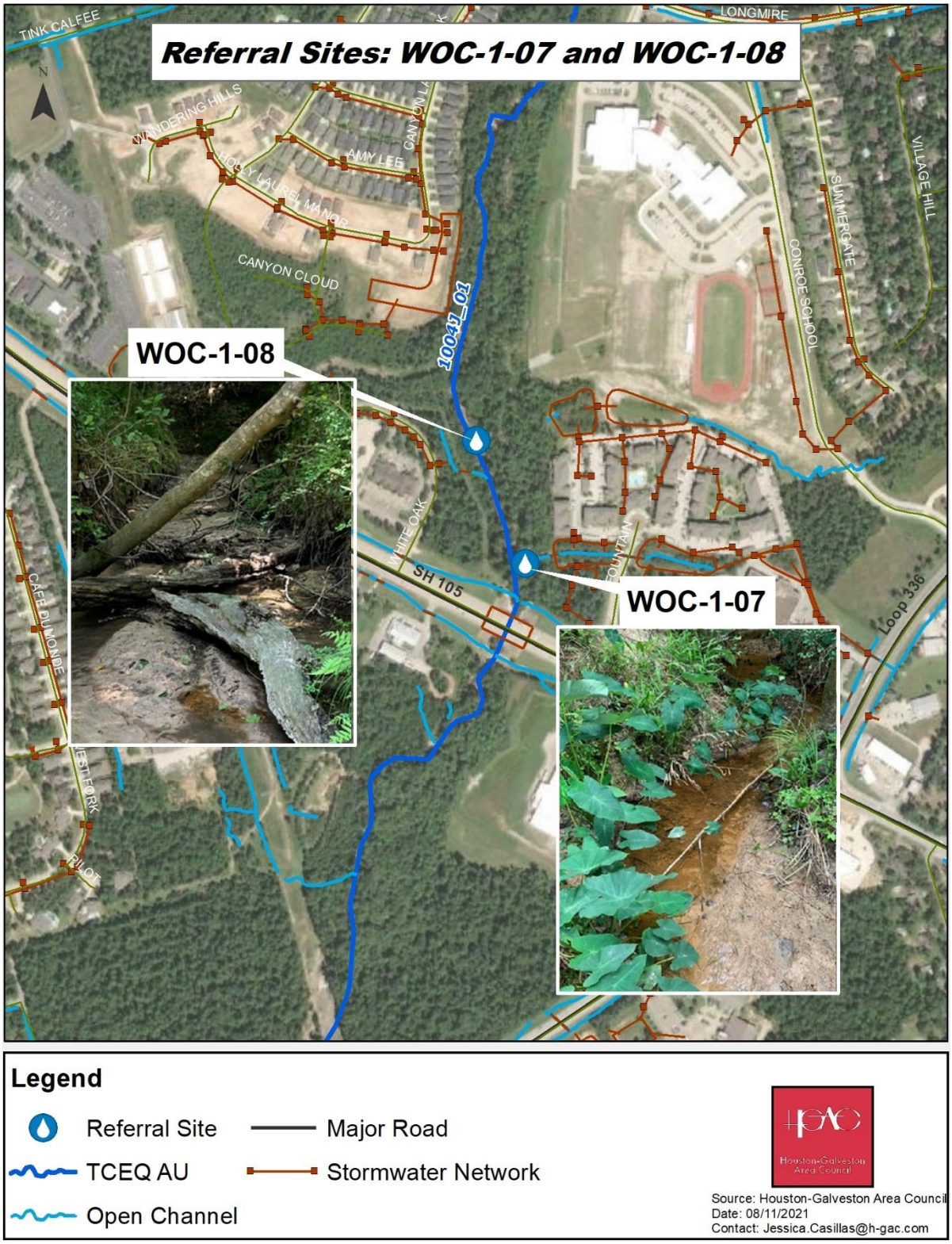

Figure 6. Location of Referral Sites of WOC-1-07 and WOC-1-08

2.4 Referral Site: WOC-1-17

Coordinates: (30.346034, -95.505943)

This referral site is located on a tributary on the right bank of White Oak Creek upstream of FM 3083 and downstream of the confluence of the two forks. The site is somewhat downstream of a new subdivision under construction and immediately upstream of a property with a bulkhead on the creek. The tributary is flowing enough to cut a shallow channel though the sandy bank, though the exact origin of the tributary is unknown (Figure 7 and Figure 8). The area around the tributary appears to be residential, with several properties nearby or adjacent to it. These properties have suspected unpermitted OSSFs and while others have known permitted systems (Figure 9). When the field crew sampled the site on April 28, 2021, the downstream sample *E. coli* results were 1,290 MPN/100mL higher than the upstream sample, indicating that the tributary is contributing high bacteria numbers to White Oak Creek, at a level ten times higher than the state standard for contact recreation.

Figure 7. View of shallow sandy tributary

Figure 8. Shallow tributary into White Oak Creek

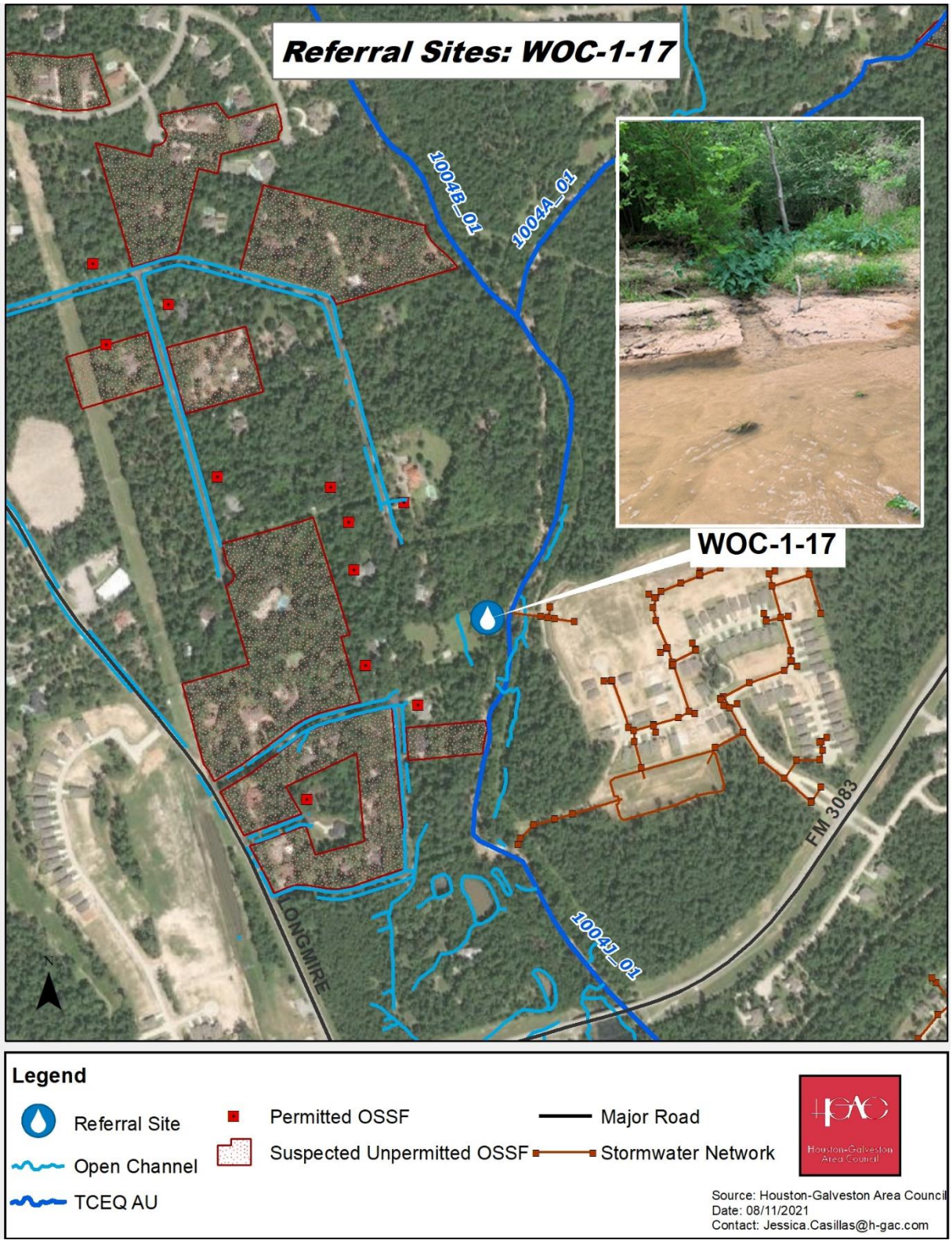

Figure 9. Location of Referral Site of WOC-1-17