Preliminary Acquired Data Analysis Report for the Greens Bayou Watershed

September 2024

This document was prepared by the Houston-Galveston Area Council for the stakeholders of Greens Bayou. It was prepared in cooperation with the Texas Commission on Environmental Quality and the United States Environmental Protection Agency.

This project has been funded wholly or in part by the U.S. Environmental Protection Agency under assistance agreement 582-24-50226 to the Texas Commission on Environmental Quality. The contents of this document do not necessarily reflect the views and policies of the U.S. Environmental Protection Agency nor does the U.S. Environmental Protection Agency endorse trade names or recommend the use of commercial products mentioned in this document.

Houston-Galveston Area Council

Texas Commission on Environmental Quality

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Abbreviations List

AU	Assessment Unit
CFU	Colony Forming Units
CRP	Clean Rivers Program
E. coli	*Escherichia coli*
DMR	Discharge Monitoring Report
DO	Dissolved Oxygen
EPA	United States Environmental Protection Agency
H-GAC	Houston-Galveston Area Council
MGD	Millions of Gallons per Day
mg/L	Milligrams Per Liter
mL	Milliliters
SAS	Statistical Analysis Software
SSO	Sanitary Sewer Overflow
SWQMIS	Surface Water Quality Monitoring Information System
TCEQ	Texas Commission on Environmental Quality
Texas Integrated Report	Texas Integrated Report of Surface Water Quality for Clean Water Act Sections 305(b) and 303(d)
WPP	Watershed Protection Plan
WWTF	Wastewater Treatment Facility

SECTION 1: INTRODUCTION

Greens Bayou flows east and south from its headwaters near the crossing of State Highway 249 and the Sam Houston Tollway. The Greens Bayou watershed is composed of the drainage area of the classified segments Greens Bayou Above Tidal (1016) and Houston Ship Channel Tidal (1006), as well as smaller unclassified segment tributaries including Halls Bayou (1006D), and a network of natural and manmade drainage channels. This watershed area spans approximately 208 square miles within Harris County (**Figure 1**).

Land cover in the watershed is mostly developed with the exception of some forested and woody wetland areas clustered around the waterways that run through the area (**Figure 1**). Major transportation corridors include Interstate 10, Interstate 45, Interstate 69/US Highway 59, the Hardy Toll Road, the Sam Houston Tollway/Beltway 8, State Highway 90 and State Highway 249. The watershed overlaps portions of Houston, Humble, Atascocita, and Cloverleaf. Pollution associated with development is still expected to be an issue with growing populations.

To improve water quality and address other concerns related to water resources, a watershed protection plan (WPP) is being developed by the stakeholders of the Greens Bayou watershed[1]. As part of the WPP development process, water quality data analyses were conducted for the Greens Bayou watershed to provide stakeholders with an understanding of water quality conditions. To understand the current status of surface water quality in the Greens Bayou watershed area, the Houston-Galveston Area Council (H-GAC) has analyzed the most recent monitoring and report data and summarized the results of these analyses herein. These assessments will highlight any short-term changes in water quality observed in recent years.

This document includes:

- A summary of the design and purpose of each analysis
- A description of the data sources considered for each analysis which include ambient water quality monitoring data, discharge monitoring report (DMR) data from WWTFs, and reports of sanitary sewer overflows (SSOs).
- An overview of the implications of the results of the analyses.

[1] For more information, see the project website for the Greens Bayou Watershed Partnership (http://www.greensbayoupartnership.weebly.com/).

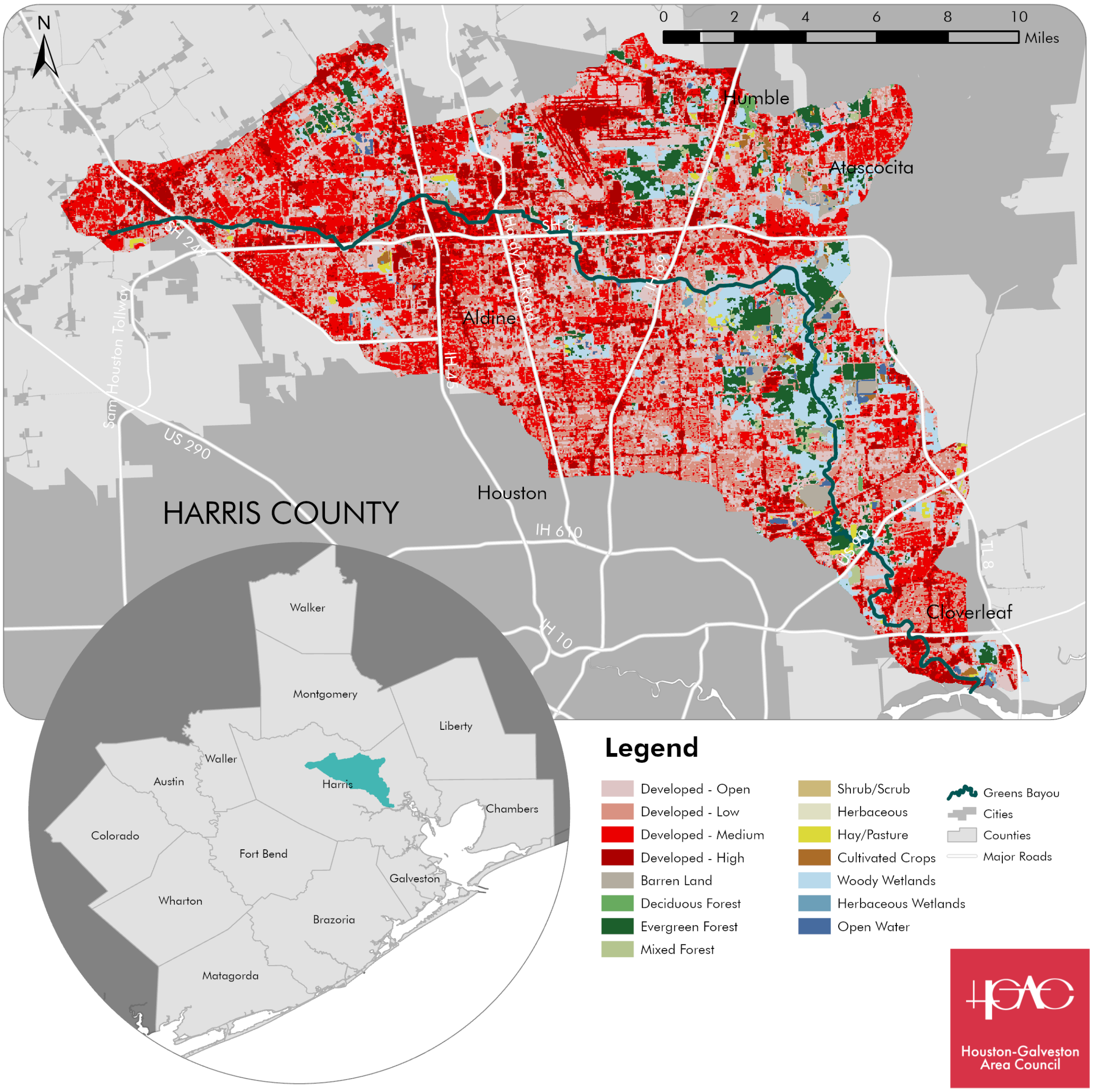


***Figure 1.** Regional Context and Land Cover in the Greens Bayou Watershed*

SECTION 2: ANALYSIS PURPOSE AND DESIGN

2.1 Purpose

Based on assessments from the *2022 Texas Integrated Report of Surface Water Quality for Clean Water Act Sections 305(b) and 303(d)* (Texas Integrated Report)[2] produced by the Texas Commission on Environmental Quality (TCEQ), the primary water quality issues in the Greens Bayou watershed include recreational, fish consumption, general, and aquatic life use impairments and concerns caused by high levels of Enterococcus and *Escherichia coli* (*E. coli*), low levels of dissolved oxygen, and high levels of nutrients. These parameters have been noted in several assessment units (AUs) in segments of Greens Bayou and its tributaries. Additional concerns and feedback will be solicited from the stakeholders during the formal stakeholder process. Issues commonly identified in other Houston-area watersheds can include sediment loading (from development), changes in flow velocity and volume, illegal dumping, trash, and bank erosion.

2.2 Project Design

To form a more current understanding of the condition of surface water quality in stream segments throughout the Greens Bayou watershed, the following analyses were designed to address the needs outlined below.

- General Understanding
    - Describe the extent of the challenges impacting water quality in the watershed.
    - Visualize whether water quality is spatially variable, and if so, identify focus areas.
- Source Identification
    - Analyze DMR data from Texas Pollutant Discharge Elimination System permitted WWTFs to verify whether their discharges comply with permit limits.
    - Quantify the frequency, distribution and causes of SSOs in the watershed.

To answer these requirements data were acquired and evaluated according to the standards below.

- Data Acquisition
    - The most recent data available collected between January 2019 and December 2023 from monitoring stations throughout the watershed area will be retrieved from the Surface Water Quality Monitoring Information System (SWQMIS) to characterize ambient conditions.
    - The most recent data available collected between January 2019 and December 2023 from DMR and SSO reports from within the watershed will be used to characterize wastewater quality.
    - Individual parameters from the aforementioned sources that will be included in the analysis are indicated in **Table 1**.
- Data Evaluation
    - Ambient (SWQMIS) Data
        - Evaluate the relative character of water quality of segments.
        - Identify trends for parameters of concern, by segment.
    - DMR Bacteria Data

[2] The State of Texas assesses its waterways every two years, based on seven-year sets of SQMIS data. These assessments form the basis by which segments (defined portions of waterways) and their tributaries are classified as having impairments (inability to meet a state water quality standard for which a numerical or other specific limit exists) or concerns (levels of parameters which exceed screening levels or other criteria, but for which numerical or specific limits do not exist).

        - Evaluate the primary parameter of concern for compliance with WWTF permit limits.
        - Evaluate the general level of compliance for WWTFs.
    - SSO Report Data
        - Evaluate the frequency, volume, and causes of SSOs by stream segment.

Table 1. *Data Sources for Parameters of Concern*

Parameter of Concern	SWQMIS Data	DMR Data	SSO Data
Ammonia Nitrogen	X		
Bacteria (*Escherichia coli* (*E. coli*) and Enterococci)	X	X	
Dissolved Oxygen (DO)	X		
Nitrate Nitrogen	X		
pH	X		
SSO Cause			X
SSO Frequency/Volume			X
Temperature	X		
Total Phosphorous	X		

SECTION 3: EVALUATIONS

3.1 Overview

The latest available data from SWQMIS, DMR, and SSO databases, Statistical Analysis Software (SAS) and the spatial analysis platform ArcGIS Pro 3.1 were used to generate statistical results and evaluate geographical trends and variations in the data. The results of all analyses conducted for this report were reviewed by project staff, and pertinent outcomes were selected for the focus of discussion in this document. The full data and evaluation worksheets for these efforts are available on request but are not included in this report for sake of brevity.

3.2 Ambient Data

Ambient water quality data are collected at over 400 sites in the 13-county Houston-Galveston region by H-GAC, local partners, and TCEQ as part of the Clean Rivers Program (CRP). In general, most monitoring stations are sampled by CRP partners on a quarterly frequency for a suite of field, bacteriological, and conventional parameters. Waterways are inherently dynamic systems, and water quality at any given time can vary greatly dependent on conditions at the time. However, a history of samples provides a more representative view of the range of conditions that may be present in that waterway. Ambient data are important for characterizing waterways because they represent a range of conditions and have a historical aspect that allows for the identification of trends over time. The final determination of the regulatory status of each segment is based primarily on these ambient data. The goals and decisions for the WPPs were established in part due to the regulatory status, and therefore ambient data are important sources of information for informing stakeholder decisions.

Data collected by CRP partners and incorporated into SWQMIS include several parameters characterizing conventional, bacteriological, and other field conditions of surface water at each site. Based on parameters commonly identified as impairments or concerns for each of the water bodies in the West Lake Houston basin such as fecal indicator bacteria, DO, and nutrients, a subset of the SWQMIS dataset for stations throughout the watershed areas was selected. Other parameters were added to provide context for environmental conditions such as temperature, pH, instantaneous flow, and TSS. The parameters focused on in this analysis include:

- Ammonia Nitrogen – a measure of specific nitrogenous compound that can impact aquatic life and is an indicator of nutrient levels and potentially of improperly treated sewage effluent.
- DO, grab – an indicator of the ability of the waterway to support aquatic life.
- Bacteria – *E. coli* and Enterococci which are common in the intestines of all warm-blooded animals used as an indicator of the presence of fecal wastes. Due to this relationship, it may also be used as a proxy indicator of the safety of waterways for human recreation as fecal waste can be a vector for human pathogens. The state water quality geomean standard for *E. coli* concentrations is 126 colony forming units per 100 milliliters (CFU/100 mL) and the single sample standard is 399 CFU/100 mL. *E. coli* is used as the indicator bacteria in freshwater systems. The state water quality geomean standard for Enterococci concentrations is 35 colony forming units per 100 milliliters (CFU/100 mL) and the single sample standard is 130 CFU/100 mL. Enterococci is used as the indicator bacteria in tidally influenced systems.
- Instantaneous Flow – a measure of water volume over time.
- Nitrate and Nitrite – a measure of nitrogenous compounds and indicator of nutrient levels.
- pH – an indicator of the acidity or basicness of water, which may affect aquatic life and other uses.

- Temperature – an indicator of a waterway's ability to hold oxygen, and a means for correlating other indicators to conditions in the waterways.
- Total Phosphorus – an indicator of nutrient levels, especially in relation to potential for algal blooms and depressed DO in elevated levels.
- TSS – a measure of the number of suspended particles in water that indicates the potential of light infiltration in the water column and the presence of particulate matter on which bacteria may seek shelter.

For all the ambient water quality data analyses, statistical significance is defined as a p-value of 0.0545 or less. Any significance not based on this statistical review (e.g., seasonal trends, qualitative comments) will be specifically described as not being related to this significance threshold. The quantitative analysis for the ambient conditions was conducted using SAS. Statistical analyses in the graphs of Appendix A are based on a LOESS curve rather than a straight regression curve to better indicate change in trend over time for disparate stations.

3.2.1 Monitoring in the Greens Bayou Watershed

The Greens Bayou watershed has 28 active water quality monitoring stations (**Figure 2**). Data from the 5,333 samples conducted between 2019 and 2023 were used to assess water quality of each stream segment (**Table 2**). This dataset captures the recent water quality conditions before the implementation of the Greens Bayou WPP. Trend analyses of the acquired data for each parameter within each segment were performed and visualized with a series of graphs (**Appendix A: Ambient Monitoring Data**).

Table 2. *Greens Bayou Watershed Segments, Stations, and Samples, 2019 to 2023*

Segment Number	Segment Name	Stations	Sample Number	Earliest Event	Latest Event
1006	Houston Ship Channel Tidal	11279, 16664, 16981, 18363, 21008	1,223	1/8/2019	2/26/2024
1006D	Halls Bayou	11126, 11127, 15862, 15863, 15864, 17490, 17491	1,336	1/15/2019	9/14/2022
1006F	Big Gulch	16662	122	1/31/2019	9/15/2022
1006H	Spring Gully	16663	185	1/31/2019	9/20/2022
1006I	Unnamed Tributary of Halls Bayou	16666, 16667	123	1/15/2019	9/8/2022
1006J	Unnamed Tributary of Halls Bayou	16665	185	1/16/2019	9/14/2022
1016	Greens Bayou	11369, 11370, 11371, 11376, 13778, 17495	1,170	1/15/2019	11/29/2023
1016A	Garners Bayou	11125, 16589	404	1/15/2019	9/6/2022
1016B	Unnamed Tributary of Greens Bayou	16590	194	1/31/2019	9/15/2022
1016C	Unnamed Tributary of Greens Bayou	22090	195	1/15/2019	9/6/2022
1016D	Unnamed Tributary of Greens Bayou	16676	196	1/15/2019	1/27/2023

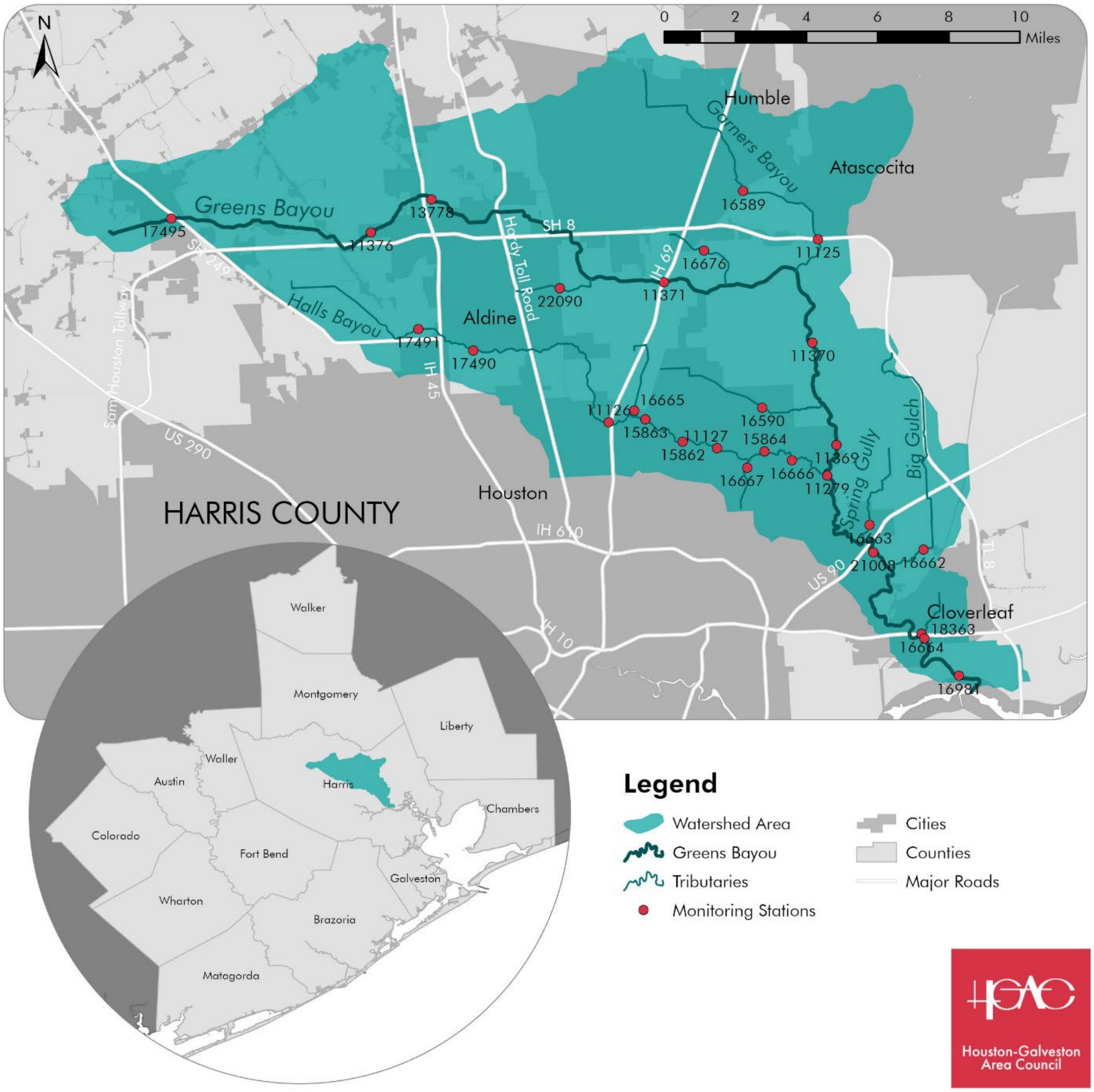


Figure 2. *Active Monitoring Sites in the Greens Bayou Watershed*

Sub-sections of each stream segment classified as assessment units (AUs) are the basic unit of analysis for the Texas Integrated Reports produced by TCEQ. The *2022 Texas Integrated Report* deemed several AUs in the Greens Bayou watershed impaired for recreation use due to high levels of fecal indicator bacteria (*E. coli*). These AUs and others within the watershed were also flagged as concerns for aquatic life and general use due to high nutrient levels and depressed oxygen (**Table 3**).

Table 3. *2022 Texas Integrated Report Status of Greens Bayou Waterways*

Impairments or Concerns				
Segment	**AU(s)**	**Parameter**	**Use**	**Category or Level of Concern**
1006	03	PCBs and Dioxin	Fish Consumption	NS, 5a
		Total Phosphorus and Nitrate	General	CS
1006	05	PCBs and Dioxin	Fish Consumption	NS, 5a
		Enterococcus	General	NS, 5c
		Total Phosphorus and Nitrate	General	CS
1006D	01	Nitrate and Total Phosphorus	General	CS
		E. coli	Recreation	NS,4a
1006D	02	Total Phosphorus and Nitrate	General	CS
		E. coli	Recreation	NS, 4a
1006F	01	*E. coli*	Recreation	NS, 4a
1006H	01	*E. coli*	Recreation	NS, 4a
1006I	01	Dissolved oxygen grab	Aquatic life	CN
		Dissolved oxygen grab	Aquatic life	CS
		E. coli	Recreation	NS, 4a
1006J	01	Dissolved oxygen grab	Aquatic life	CS
		E. coli	Recreation	NS, 4a
1016	01	Total Phosphorus and Nitrate	General	CS
1016	02	Total Phosphorus, Nitrate, Ammonia	General	CS
		E. coli	Recreation	NS, 4a
1016	03	Total Phosphorus and Nitrate	General	CS
		E. coli	Recreation	NS, 4a
1016A	02	Total Phosphorus and Nitrate	General	CS
		E. coli	Recreation	CN
1016A	03	Total Phosphorus and Nitrate	General	CS
		E. coli	Recreation	NS, 4a
1016B	01	*E. coli*	Recreation	NS, 4a
1016C	01	Total Phosphorus, Nitrate, and Ammonia	General	CS
		E. coli	Recreation	NS, 4a
1016D	01	Dissolved oxygen grab	Aquatic life	NS, 5c
		Dissolved oxygen grab	Aquatic life	CS
		Total Phosphorus and Ammonia	General	CS
		E. coli	Recreation	NS, 4a

Greens Bayou Watershed Monitoring Results

A summary of ambient data for each segment of the Greens Bayou watershed, represented as the geomean of each parameter for data collected between 2019 and 2023 (**Table 4**), found that there were 21 instances of geomeans exceeding criteria or screening levels (grey shading), while most instances (no shading) were either in compliance with criteria or better than the screening level. Temperature, and flow are parameters for which the data are not compared to criteria or screening levels (italic text).

Table 4. *Greens Bayou Watershed Monitoring Results by Segment, 2019 to 2023 Geomean*

Parameter	Criteria	Unit	Houston Ship Channel, 1006	Halls Bayou, 1006D	Big Gulch, 1006F	Spring Gully, 1006H	Unnamed Tributary Of Halls Bayou, 1006I	Unnamed Tributary Of Halls Bayou, 1006J	Greens Bayou, 1016	Garners Bayou, 1016A	Unnamed Tributary Of Greens Bayou, 1016B	Unnamed Tributary Of Greens Bayou, 1016C	Unnamed Tributary Of Greens Bayou, 1016D
Ammonia Nitrogen	0.33	mg/L	0.19	0.16	0.10	0.11	0.13	0.12	0.18	0.20	0.10	0.29	0.81
DO, grab	Various	mg/L	4.28	6.28	6.63	6.82	5.79	5.20	7.18	6.89	7.21	3.91	2.91
E. coli	126	CFU/ 100mL	409.11	935.37	425.13	256.89	3,001.54	300.00	505.15	358.99	212.01	3,230.60	1,991.58
Enterococci	35	CFU/ 100mL	124.64	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Instantaneous Flow	NA	Cubic Feet Per Second	*No Data*	*18.26*	*No Data*	*No Data*	*No Data*	*4.30*	*36.82*	*20.82*	*No Data*	*No Data*	*1.10*
Nitrate Nitrogen	1.95	mg/L	0.08	5.52	0.37	0.10	0.41	0.15	5.29	4.50	0.28	1.30	0.19
pH	9 (high) 6.5(low)	NA	7.47	7.60	7.48	7.15	7.68	7.65	7.75	7.53	7.63	7.43	7.45
Temperature	NA	Degrees Celsius	*21.70*	*22.71*	*21.62*	*20.74*	*20.42*	*21.59*	*22.89*	*22.42*	*21.08*	*21.56*	*21.05*
Total Phosphorus	0.69	mg/L	0.57	1.67	0.25	0.14	0.07	0.22	1.34	1.59	0.05	0.55	0.42

Greens Bayou Watershed Trends

Trends in the data were determined by examining all parameters collected from surface water samples in the Greens Bayou watershed and how measurements for those parameters have changed over time. The results in **Table 5** only indicate significant improvements or worsening trends. Results for parameters with stable trends over time are not represented. Consequently, parameter measurements that remained consistently above water quality standards (such as *E. coli*) throughout the study period are not captured by this summary. Graphs depicting the results of all analyses can be found in **Appendix A: Ambient Monitoring Data**.

Table 5. *Greens Bayou Watershed Water Quality Trends by Segment, 2019 to 2023*

Segment	Parameter	Trend
Houston Ship Channel, 1006	DO	Improving
Houston Ship Channel, 1006	*E. coli*	Improving
Houston Ship Channel, 1006	Temperature	Deteriorating
Houston Ship Channel, 1006	pH	Improving
Halls Bayou, 1006D	DO	Improving
Halls Bayou, 1006D	*E. coli*	Deteriorating
Halls Bayou, 1006D	Temperature	Deteriorating
Big Gulch, 1006F	Ammonia Nitrogen	Improving
Spring Gully, 1006H	DO	Improving
Spring Gully, 1006H	pH	Improving
Unnamed Tributary of Halls Bayou, 1006I	DO	Improving
Greens Bayou, 1016	Temperature	Deteriorating
Greens Bayou, 1016	Total Phosphorus	Deteriorating
Garners Bayou, 1016A	pH	Improving
Unnamed Tributary of Greens Bayou, 1016B	Nitrate Nitrogen	Deteriorating
Unnamed Tributary of Greens Bayou, 1016D	Ammonia Nitrogen	Improving
Unnamed Tributary of Greens Bayou, 1016D	*E. coli*	Improving

Greens Bayou Watershed Ambient Analysis Summary

Of the ambient water quality parameters observed, geomean values for fecal indicator bacteria levels measured between 2019 and 2023 exceeded state water quality standards most frequently. All segments observed in this analysis showed geomean values for fecal indicator bacteria exceeding criteria levels. In the trend analysis of data collected between 2019 and 2023, *E. coli* levels show signs of significant improvement on Houston Ship Channel (1006) and an unnamed tributary of Greens Bayou (1016D). However, bacteria levels are so far above the standard, particularly on the latter segment, that this trend is not expected to continue to the point of compliance with the geomean standard. On Halls Bayou (1006D), trends indicate deteriorating conditions regarding *E. coli* pollution. All other segments showed stable trends for bacteria, however, this was due to regular observed exceedances of the geomean standard.

Nutrients also continue to pose a challenge to water quality in the Greens Bayou watershed. Total phosphorous and nitrate nitrogen geomeans exceeded screening levels on Halls Bayou (1006D), Greens Bayou (1016), and Garners Bayou (1016A). The geomean for ammonia nitrogen measurements for an unnamed tributary of Greens Bayou (1016D) also exceeded screening levels though a trend analysis from 2019 to 2023 indicates improvement over time.

Another parameter of interest in this watershed is DO. Though the criteria for DO varies depending on the waterway, Section 307.10 Appendix D in the Texas Administrative Code indicates that DO levels in two unnamed tributaries of Greens Bayou (1016C and 1016D) were below the criteria[3]. The trend analysis of data collected between 2019 and 2023 does not indicate significantly improving or worsening trends for DO on these segments. However, improving trends for DO were observed on tidally influenced segments such as Houston Ship Channel (1006), Halls Bayou (1006D), Spring Gully (1006H), and an unnamed tributary of Halls Bayou (1006I).

3.3 DMR Bacteria Data

Discharges from wastewater treatment plants are regulated by water quality permits from TCEQ which require stringent limits for effluent quality. Generally, wastewater treatment plants in the Houston region are able to meet their permits. However, because human waste has an appreciable pathogenic potential, identifying trends in permit exceedances for indicator bacteria by WWTFs is important in understanding overall impacts to waterways. Discharges from WWTFs are monitored on a regular basis (with a frequency dependent on plant size and other factors). The data from these required sampling events are submitted to and compiled by TCEQ as DMRs. As with any self-reported data, there is an expectation that some degree of uncertainty or variation from conditions may occur, but these DMRs are the most comprehensive data available for evaluating WWTFs in the watersheds.

Discharge from WWTFs is assessed for compliance with state water quality standards. In the case of the indicator bacteria *E. coli* and Enterococci, the permitted geomean standard is 126 CFU/100 mL and 35 CFU/100 mL, respectively, whereas the grab sample standard is 399 CFU/100 mL and 130 CFU/100 mL, respectively. For this project, staff evaluated bacteria data associated with WWTF permits, from the same time period as the most recently available ambient water quality data, January 2019 through December 2023, and compliance with permit limits for bacteria were compared across segments, plant types, years, and seasons.

Of the 117 permitted domestic outfalls in the Greens Bayou watershed, 111 submitted DMRs. Of those, 97.1% of reports were in compliance with the bacteria standard (**Table 6**). The disparity between the

[3] For more information, see Section 307.10 Appendix D in the Texas Administrative Code document (https://texreg.sos.state.tx.us/fids/202203625-6.pdf)

number of samples exceeding the geomean standard compared to samples exceeding the grab standard could indicate high variability in the data. Higher rates of exceedance from specific sites may be overshadowed by the broad scope of this analysis.

Table 6. *Greens Bayou Watershed DMR Bacteria Exceedance Statistics, 2019 to 2023*

Parameter	Number of Plants	Percent of Reports
Plants Reporting Bacteria	111	
Total Records	4,822	
Exceedances of Geomean	30	0.6%
Exceedances of Single Grab	111	2.3%
Total Exceedances	141	2.9%

Looking at the number of annual exceedances did not suggest any pattern to the frequency of exceedances. Although the lowest number of exceedances relative to other years for both geomean and grab samples occurred in 2021, this did not represent a strong trend (**Table 7**).

Table 7. *Greens Bayou Watershed DMR Bacteria Exceedances by Year*

Exceedances	2019	2020	2021	2022	2023	Total
By Geomean	7	7	3	8	5	30
By Grab	22	29	12	17	31	111
Total	29	36	15	25	36	141

The rate of exceedance by plant size was also considered as part of this analysis (**Table 8** and **Table 9**). Plant size refers to the amount of volume in millions of gallons per day (MGD) that each WWTF is permitted to discharge. From the data analyzed, grab samples generally exceed the standard at a higher rate than geomeans. The highest prevalence of exceedances by plant size occurred at the variable, 1-5 MGD and 5-10 MGD level for grab samples. The highest one-year percent exceedance (10.5%) occurred in 2020 in the variable size category.

Table 8. *Greens Bayou Watershed DMR Bacteria Goemetric Mean Exceedance Rates by Plant Size, 2019 to 2023*

Relative Plant Size	Number of Plants	2019	2020	2021	2022	2023
Variable/Intermittent Discharge	13	1.5%	5.6%	0.0%	0.7%	0.0%
< 0.1 MGD	45	1.4%	0.0%	0.5%	0.9%	0.0%
0.1-0.5 MGD	17	0.5%	0.0%	1.0%	1.0%	1.6%
0.5-1 MGD	19	0.0%	0.0%	0.0%	0.9%	0.0%
1-5 MGD	14	0.6%	0.0%	0.0%	0.6%	1.2%
5-10 MGD	3	0.0%	0.0%	0.0%	0.0%	0.0%

Table 9. Greens Bayou Watershed DMR Bacteria Grab Sample Exceedance Rates by Plant Size, 2019 to 2023

Relative Plant Size	Number of Plants	2019	2020	2021	2022	2023
Variable/Intermittent Discharge	13	4.5%	10.5%	3.2%	2.2%	1.4%
< 0.1 MGD	45	1.0%	1.9%	0.9%	0.5%	1.5%
0.1-0.5 MGD	17	1.0%	0.5%	0.5%	2.1%	2.6%
0.5-1 MGD	19	0.9%	1.3%	0.9%	1.8%	3.1%
1-5 MGD	14	4.8%	4.8%	1.8%	3.0%	7.8%
5-10 MGD	3	8.0%	0.0%	0.0%	0.0%	2.8%

3.3.1 Summary of DMR Bacteria Data

Overall, the results of the analyses of DMR bacteria data indicated that the total number of exceedances reported was small relative to the total number of DMR reports submitted for the period of 2019 to 2023 (141 out of 4,822 records). No significant trends were observed when the data was viewed as annual frequencies of exceedance or exceedance rates by plant size. While WWTFs may be appreciable contributors to pollution under certain conditions in localized areas, the DMR analysis indicates that they are not likely a significant driver of segment bacteria impairments due to the comparatively few exceedances. However, due to the relatively higher risk of pathogens from human waste, and proximity to developed areas, WWTF exceedances are likely still a point of concern for stakeholders.

3.4 SSOs

Though SSOs occur episodically, they represent a high-risk vector for bacteria contamination because they can have concentrations of bacteria several orders of magnitude higher than treated effluent. Untreated sewage can contain large volumes of raw fecal matter, making it a significant health risk where SSOs are sizeable and/or chronic issues. The causes of SSOs vary from equipment failure to infiltration of rainwater into sewer pipes. Data used for these analyses are self-reported and may vary in quality. Even in the best of circumstances, the ability to accurately gauge SSO volumes or even occurrences in the field are limited by several factors. Actual SSO volumes and incidences are generally expected to be greater than reported due to these fundamental challenges. Known causes of SSOs were broken into four broad categories with several subcategories each, to reflect the breakdown in the TCEQ SSO database. It should be noted, however, that this categorization depends on the accuracy of the data reported by the utilities. Additionally, while a single cause is typically listed on the SSO report, many SSOs are caused by a combination of factors.

This study considered five years of TCEQ SSO violation data from January 2019 through December 2023. There were 676 SSO records from 31 plants considered for the Greens Bayou watershed, which were broken down by year and cause, for number and volume.

There was not a strong trend in number of SSOs over time for the five years examined (**Table 10** and **Figure 3**). In terms of cause by number, the general category of malfunctions and operational issues accounted for 23.4%, blockages accounted for 58.4%, weather-related issues accounted for 17.8% of the overall total, and 0.4% were listed as unknown causes.

Table 10. Number of Annual SSO Events in Greens Bayou Watershed

CAUSE	2019	2020	2021	2022	2023
Weather	**8**	**20**	**21**	**19**	**52**
Rain / Inflow / Infiltration	8	20	20	19	52
Severe Freezing Weather			1		
Malfunctions	**12**	**65**	**47**	**20**	**14**
WWTF Operation or Equipment Malfunction	1	27	26	13	6
Power Failure				1	
Lift Station Failure	5	5	3	2	2
Collection System Structural Failure	6	33	18	4	5
Equipment Failure					1
Blockages	**61**	**108**	**74**	**94**	**58**
Blockage in Collection System-Other Cause	18	32	16	20	12
Blockage in Collection System Due to Fats/Grease	42	75	52	73	46
Blockage Due to Rags/Wipes	1	1	6	1	
Unknown Cause			**1**	**2**	
Total	**81**	**193**	**143**	**135**	**124**

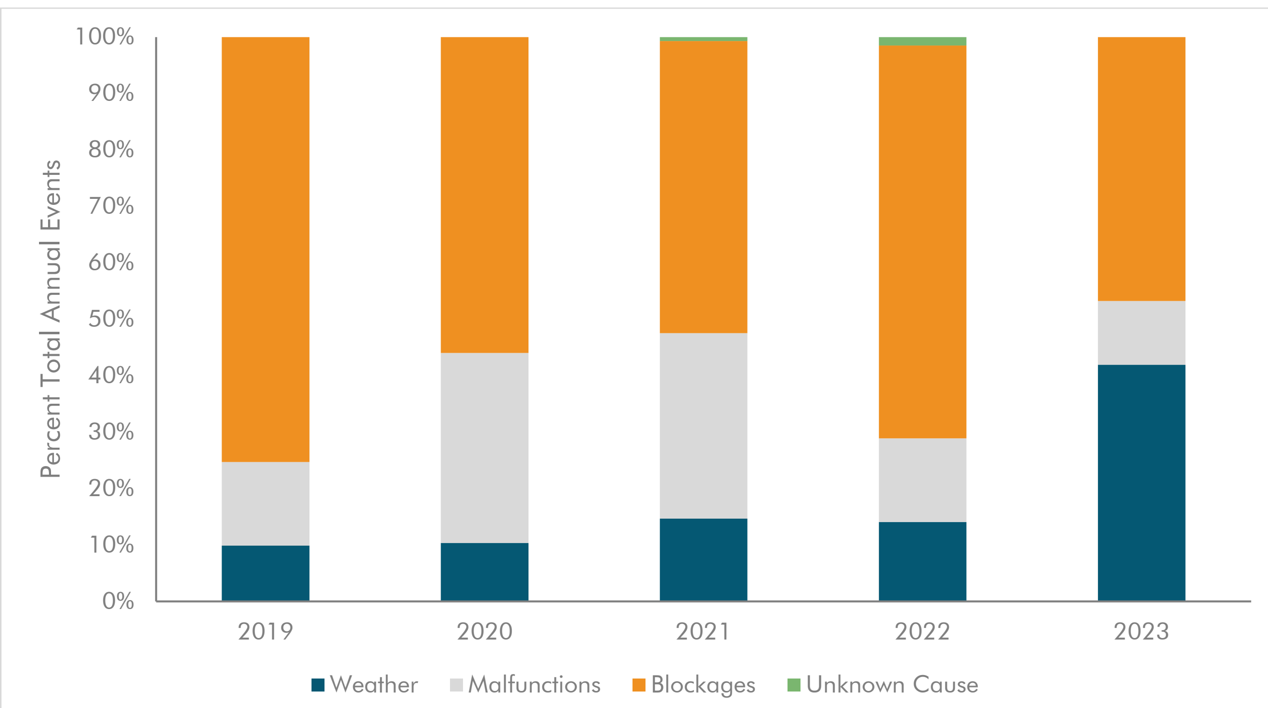


Figure 3. *Percent Total Annual SSO Events in Greens Bayou Watershed*

While number of SSO events informs how frequently these overflows impact the basin, volume of overflow is an indicator of the magnitude of impact. Of the total volume of overflows reported from 2019 to 2023, malfunctions were responsible for 43.5%, weather contributed 27.4%, blockages comprised 29.0%, and unknown causes led to the remaining 0.1% (**Table 11** and **Figure 4**). These overall contributions are important to consider in a general sense for estimating impacts to the watershed area.

Table 11. *Annual SSO Events by Volume (in Gallons) in Greens Bayou Watershed*

CAUSE	2019	2020	2021	2022	2023
Weather	**132,520**	**3,484**	**8,041**	**1,429**	**104,721**
Rain / Inflow / Infiltration	132,520	3,484	7,041	1,429	104,721
Severe Freezing Weather			1,000		
Malfunctions	**42,525**	**48,136**	**111,446**	**117,169**	**78,499**
WWTF Operation or Equipment Malfunction	1,000	41,042	31,139	108,334	1,930
Power Failure				50	
Lift Station Failure	10,130	2,205	3,000	5,200	44,375
Collection System Structural Failure	31,395	4,889	77,307	3,585	26,744
Equipment Failure					5,450
Blockages	**42,784**	**26,381**	**91,923**	**62,798**	**42,413**
Blockage in Collection System-Other Cause	12,195	10,014	12,034	3,896	20,744
Blockage in Collection System Due to Fats/Grease	30,589	16,367	79,692	58,872	21,669
Blockage Due to Roots/Rags/Debris			197	30	
Unknown Cause				**500**	
Total	**217,829**	**78,001**	**211,410**	**181,896**	**225,633**

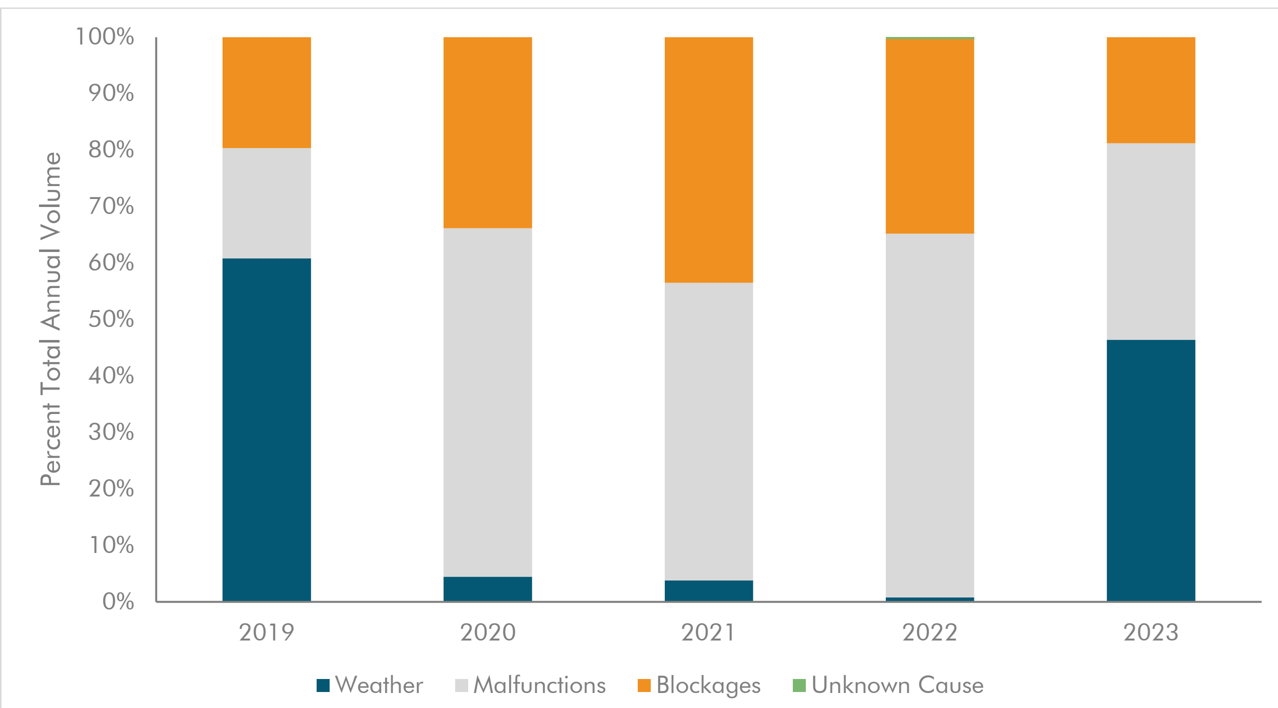


Figure 4. *Percent Total Annual SSO Volume in Greens Bayou Watershed*

3.4.1 Summary of SSO Analyses

The highest volume of flows relative to other years occurred in 2023, but there was not a strong annual trend in number of SSOs. In terms of general cause, blockages accounted for the highest number of events respective to the other general categories of weather, malfunctions, and unknown causes. In terms of volume, malfunctions contributed the highest overflow observed between 2019 and 2023.

While these data are useful, it should be noted that they are also self-reported and may vary in quality. Overflow volumes and numbers of events may be greater than the values recorded in the report data, and causes may be overgeneralized due to multiple factors ultimately resulting in SSOs.

In watersheds where bacteria and nutrient loading are of particular concern, the impacts of SSOs are important to understand due to their concentrations of untreated human waste. These events pose a high risk to human health especially due to their proximity to urban populations. Further, despite their episodic occurrences, SSOs can be extreme loading sources in the sense of volume introduced in a short time frame. Though SSOs do not have the same potential to cause chronic impacts on waterways as effluent from high volume WWTFs, for the aforementioned reasons, it is still critical to consider SSO management among the best management practices selected to improve water quality in the waterways of Greens Bayou and other surrounding watersheds.

SECTION 4: OUTCOMES AND IMPLICATIONS

This analysis of ambient, DMR, and SSO report data contributes to the continued characterization of water quality concerns in the waterways of Greens Bayou. Findings from this report can be used to inform stakeholders as they work to implement best management practices outlined in the WPP.

Data collected between January 2019 and December 2023 were used to determine what parameters of water quality are of greatest concern and the extent to which their impacts have been observed throughout the waterways. As indicated in the *2022 Texas Integrated Report* results for this watershed, a geomean analysis of the SWQMIS dataset identified high levels of fecal indicator bacteria as the most pervasive impact to water quality throughout the waterways. Further, elevated nutrient (nitrate nitrogen and total phosphorous) levels were also highlighted as concerns in segments such as Halls Bayou (1006D), Greens Bayou (1016), and Garners Bayou (1016A). Depressed DO levels were observed on two of the unnamed tributaries to Greens Bayou (1016C and 1016D). Slight discrepancies between the geomean analyses in this report and the results of the *2022 Texas Integrated Report* are most likely due to the incomplete temporal overlap of datasets observed for each report.

According to the analyses in this report, permitted wastewater effluent is unlikely to be a widespread or chronic water quality issue but requires further investigation on limited spatial scales and timeframes. However, understanding these discharges is still critical to the development of this project as WWTFs without permit limits for certain nutrients act as source loads—particularly in effluent-dominated streams. Further, as treatment facilities for human waste, improper treatment indicators identified in DMR analyses can have greater implications for risk to human health.

An analysis of SSO reports from the watershed indicated that for the number of SSO events, blockages were among the most common for the general cause categories, while malfunctions were among the most common for volume of overflow. However, it is important to note that while only one cause is usually listed on the report, multiple compounding factors can lead to SSOs. Ultimately, causes listed in SSO reports are prone to a degree of subjectivity as opposed to more quantitative measurements. While the episodic overflow volumes reported during these events are relatively small compared to the scale of effluent produced by WWTFs, SSO inputs are of particular concern due to the untreated nature of the sewage associated with them and the subsequent risk to human health.

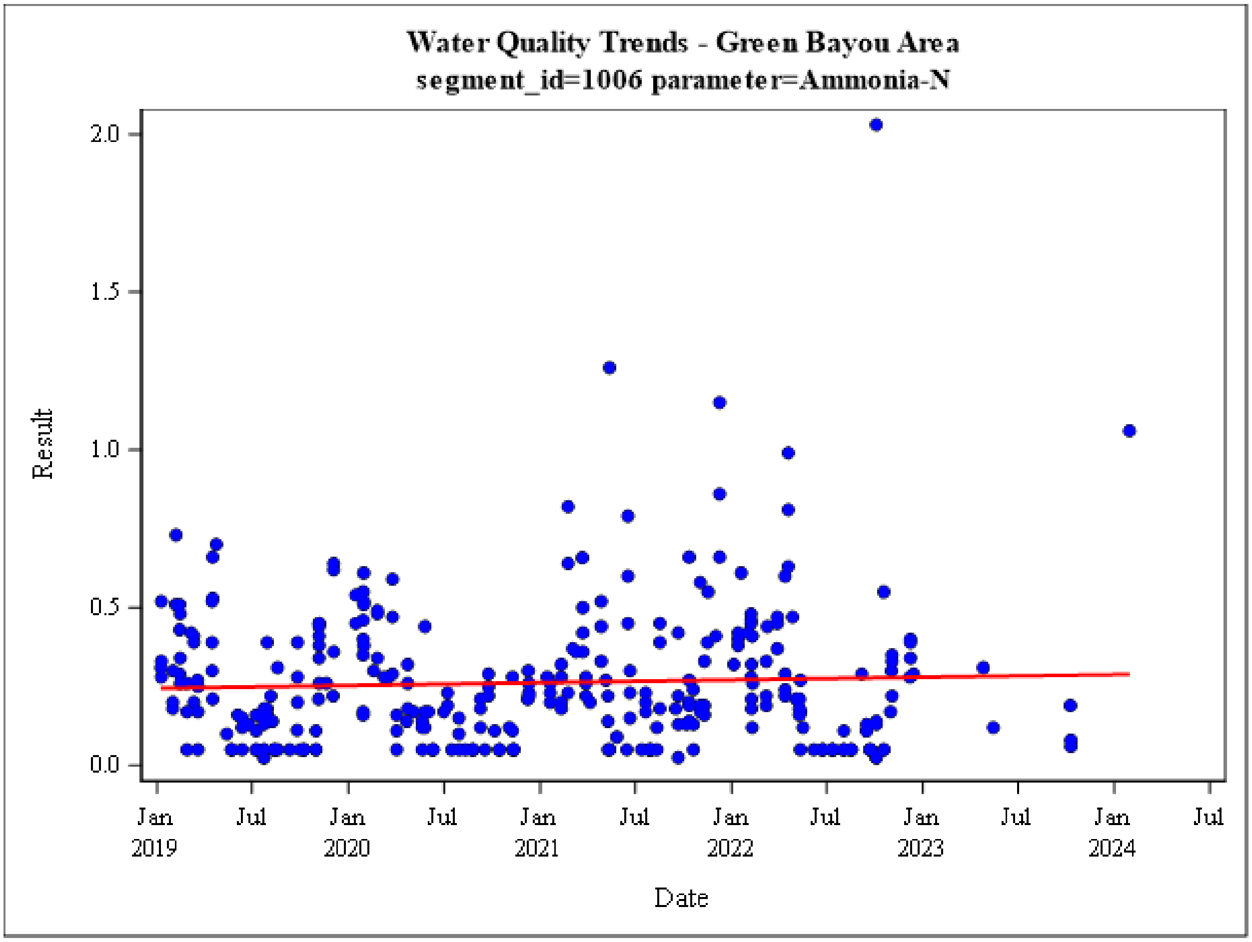
As populations in the watershed continue to grow, the balance of pollutant sources and current hydrologic processes could be altered significantly in the coming years. These changes could result in further water quality impacts without intervention. Subsequent efforts should be made to identify causes and sources of the primary parameter of concern (indicator bacteria), and to characterize nutrient sources further to identify areas within the project watershed most vulnerable to pollutant loadings and/or best suited for the implementation of management strategies.

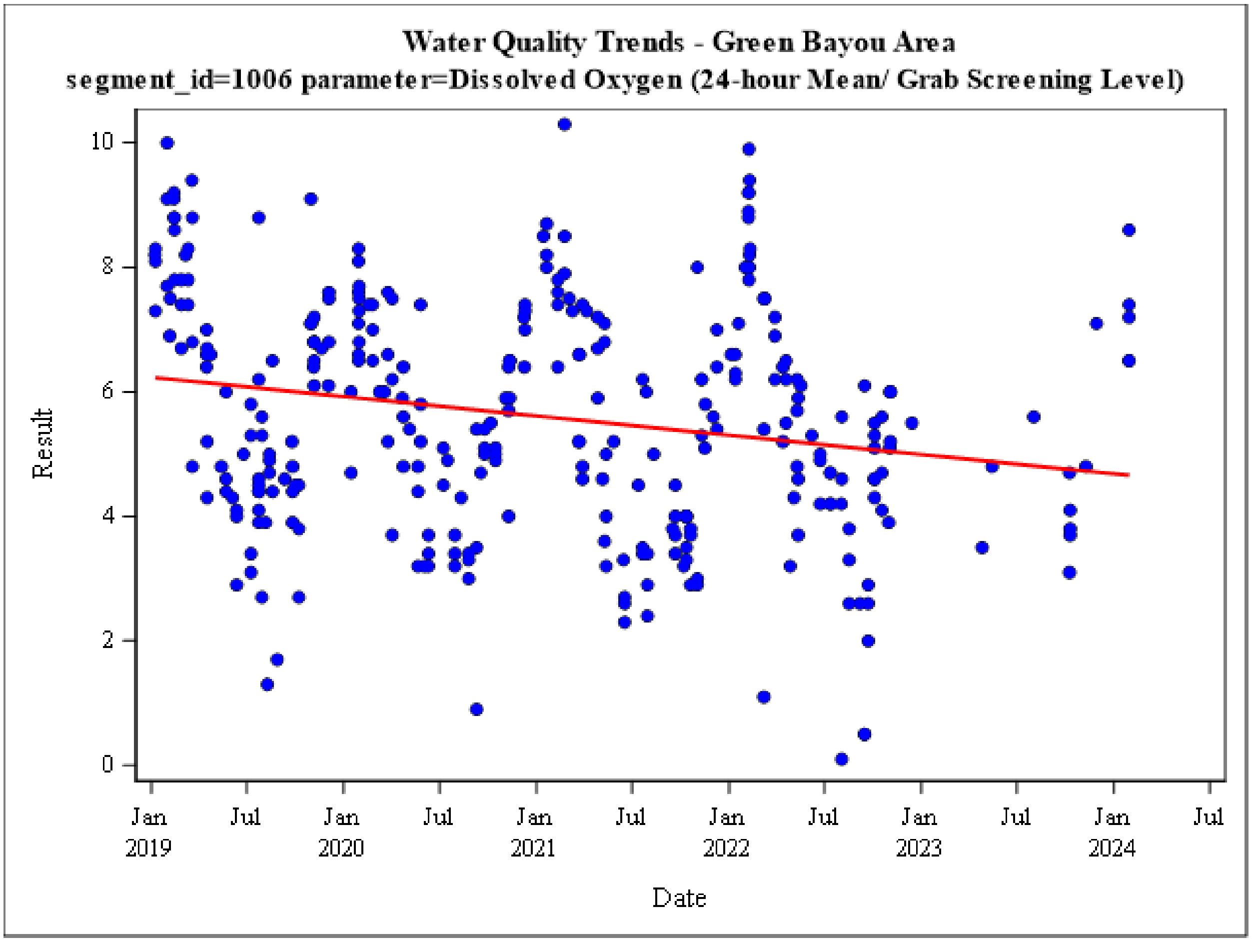
APPENDIX A: AMBIENT MONITORING DATA

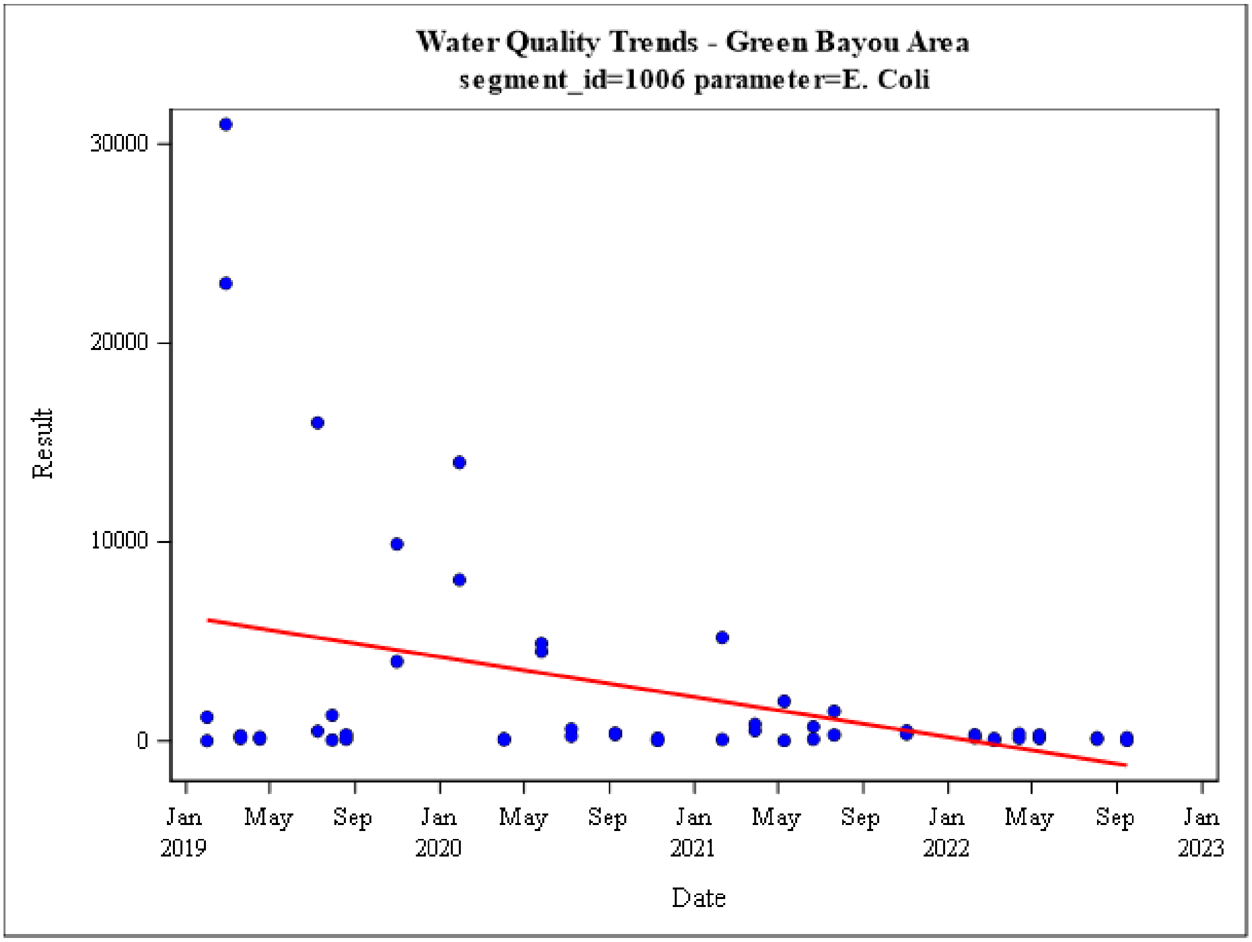
The following figures represent the results, by segment, for all parameters evaluated. The period of observation is 2019 through 2023, although data may vary as indicated in the charts. The regression analyses for ambient conditions were conducted using SAS.

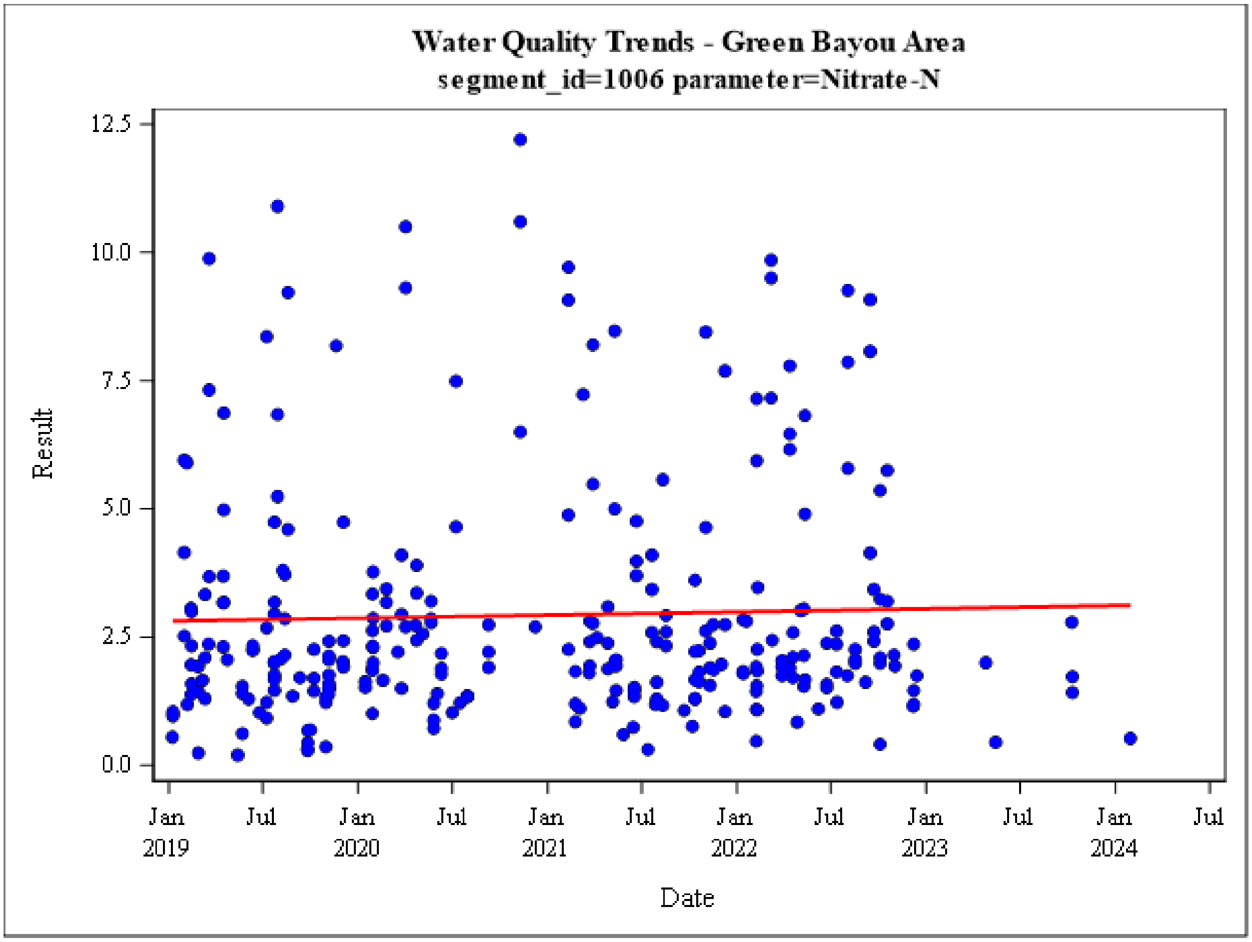
Greens Bayou Watershed

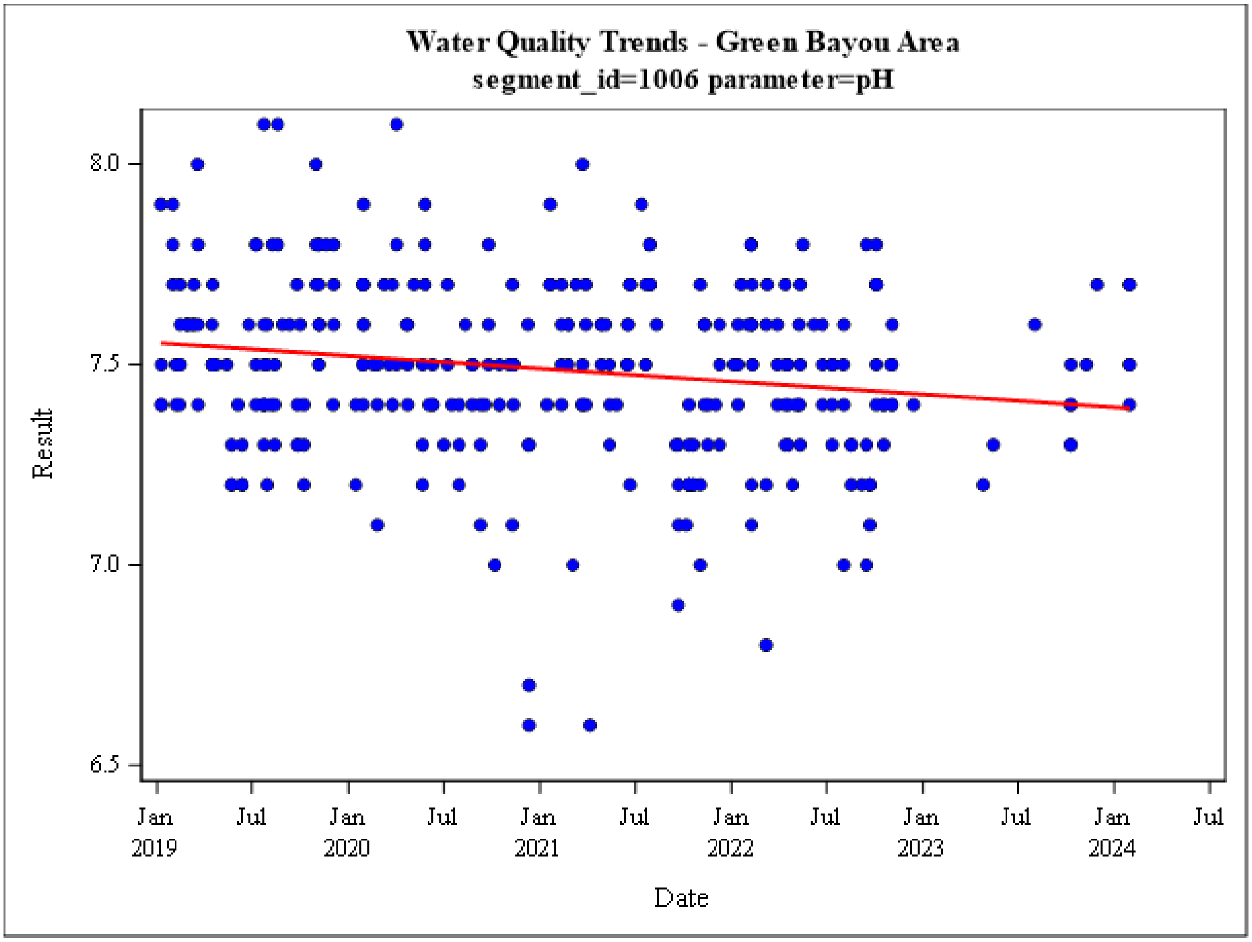
Houston Ship Channel (1006)

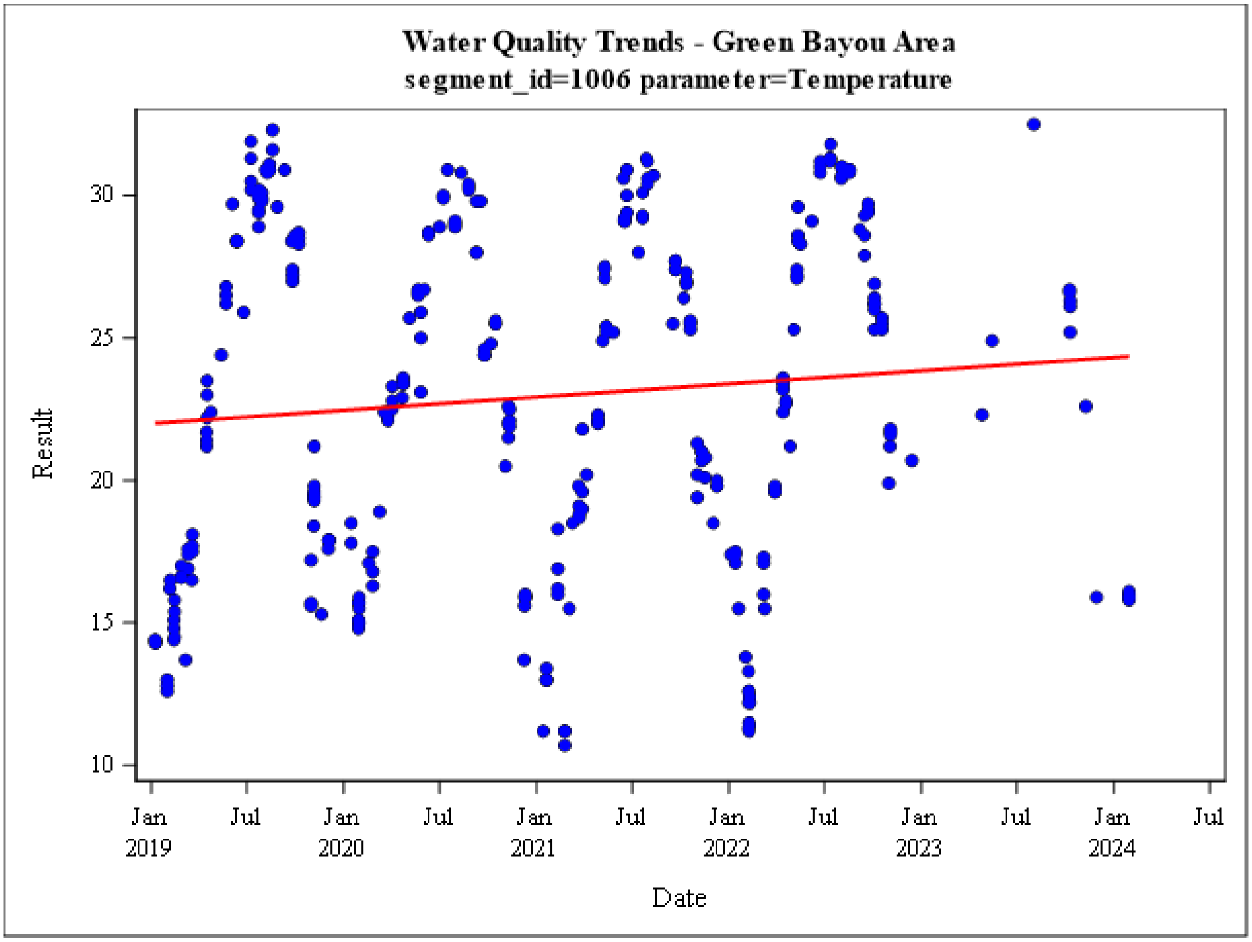


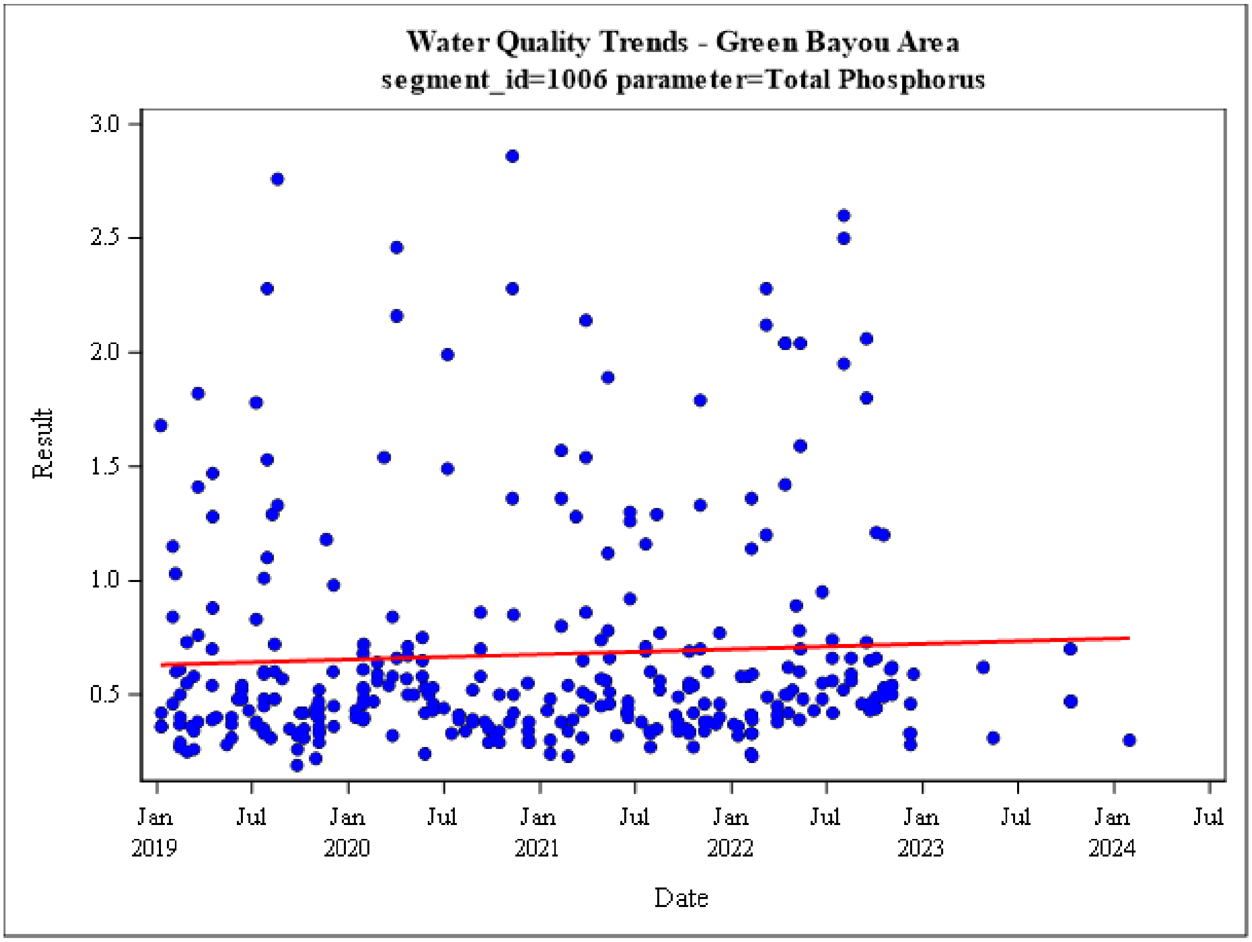

Water Quality Trends - Green Bayou Area
segment_id=1006 parameter=Dissolved Oxygen (24-hour Mean/ Grab Screening Level)
Result
10
8
6
4
2
0
Jan 2019
Jul
Jan 2020
Jul
Jan 2021
Jul
Jan 2022
Jul
Jan 2023
Jul
Jan 2024
Jul
Date


Water Quality Trends - Green Bayou Area
segment_id=1006 parameter=E. Coli
Result
30000
20000
10000
0
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
May
Sep
Jan 2022
May
Sep
Jan 2023
Date


Water Quality Trends - Green Bayou Area
segment_id=1006 parameter=Nitrate-N
Result
12.5
10.0
7.5
5.0
2.5
0.0
Jan 2019
Jul
Jan 2020
Jul
Jan 2021
Jul
Jan 2022
Jul
Jan 2023
Jul
Jan 2024
Jul
Date

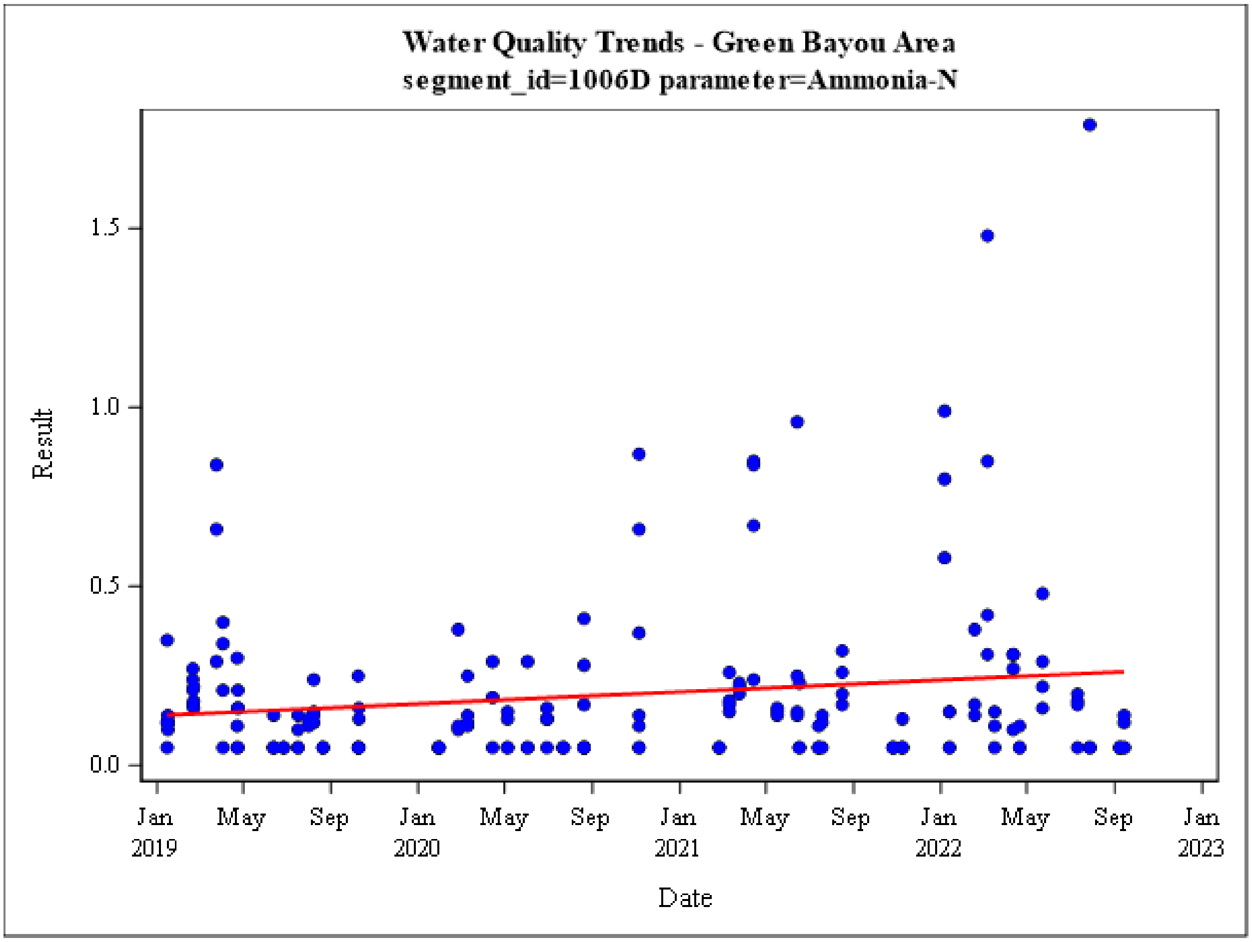

Water Quality Trends - Green Bayou Area
segment_id=1006 parameter=pH
Result
8.0
7.5
7.0
6.5
Jan 2019
Jul
Jan 2020
Jul
Jan 2021
Jul
Jan 2022
Jul
Jan 2023
Jul
Jan 2024
Jul
Date

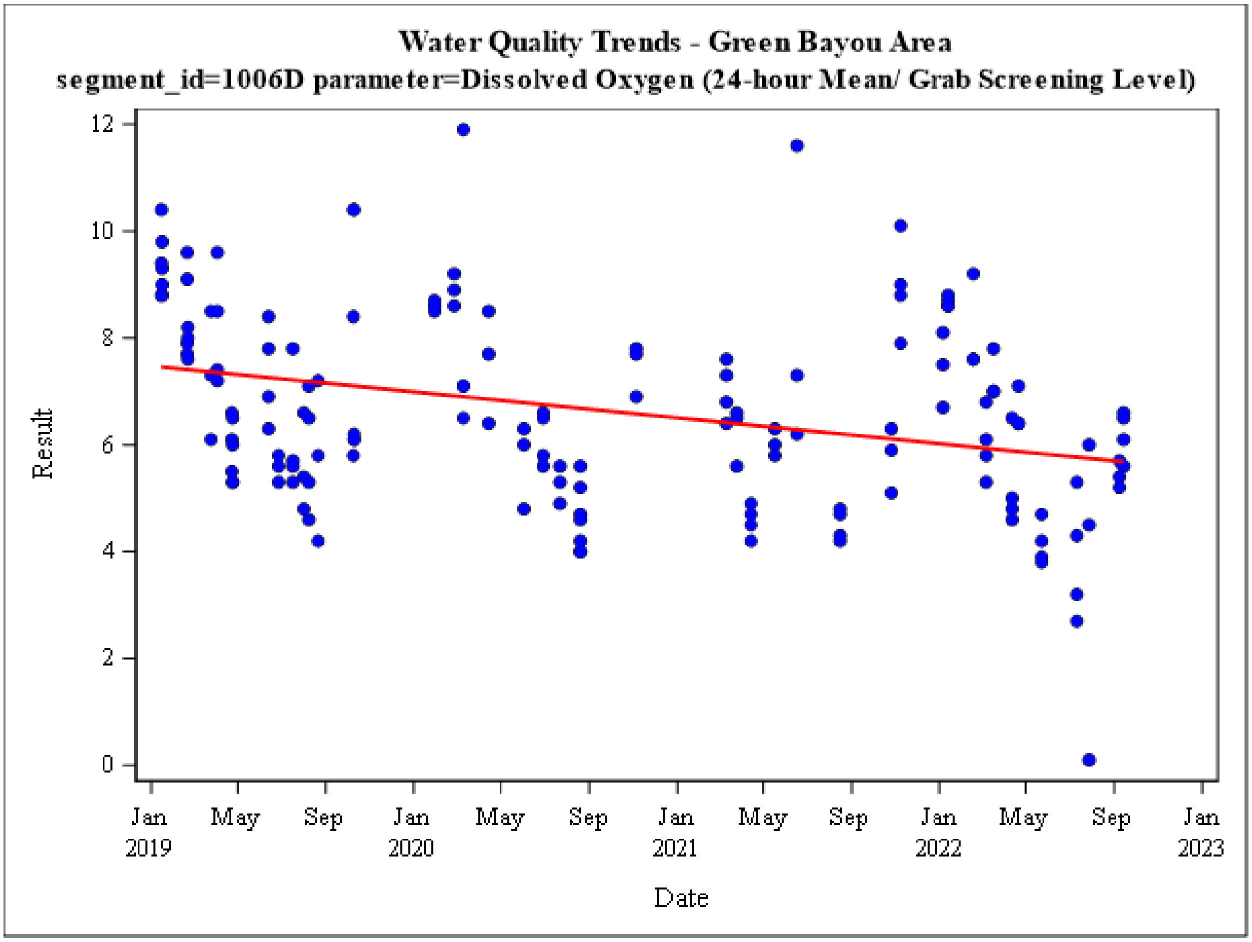

Water Quality Trends - Green Bayou Area
segment_id=1006 parameter=Temperature
Result
30
25
20
15
10
Jan 2019
Jul
Jan 2020
Jul
Jan 2021
Jul
Jan 2022
Jul
Jan 2023
Jul
Jan 2024
Jul
Date

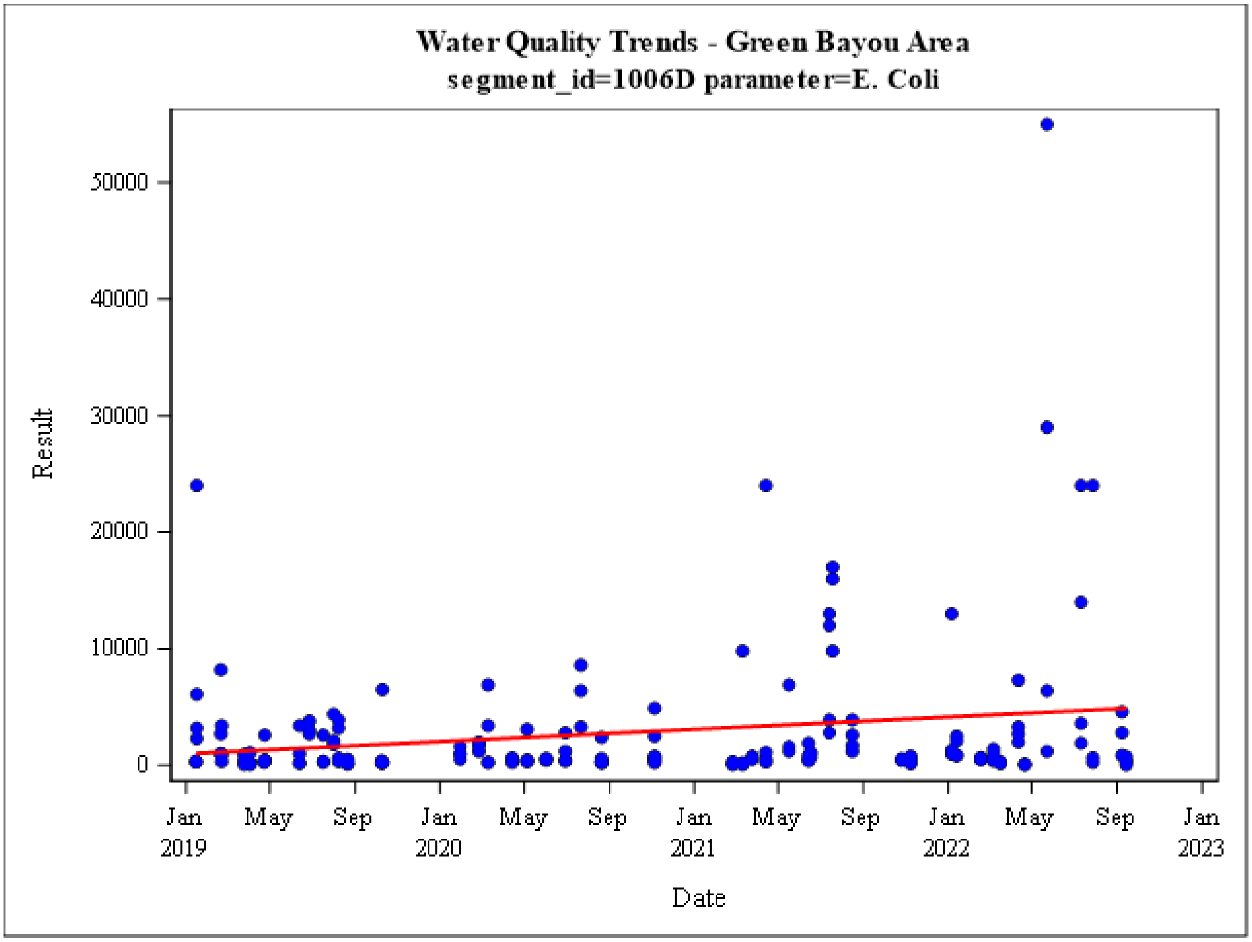


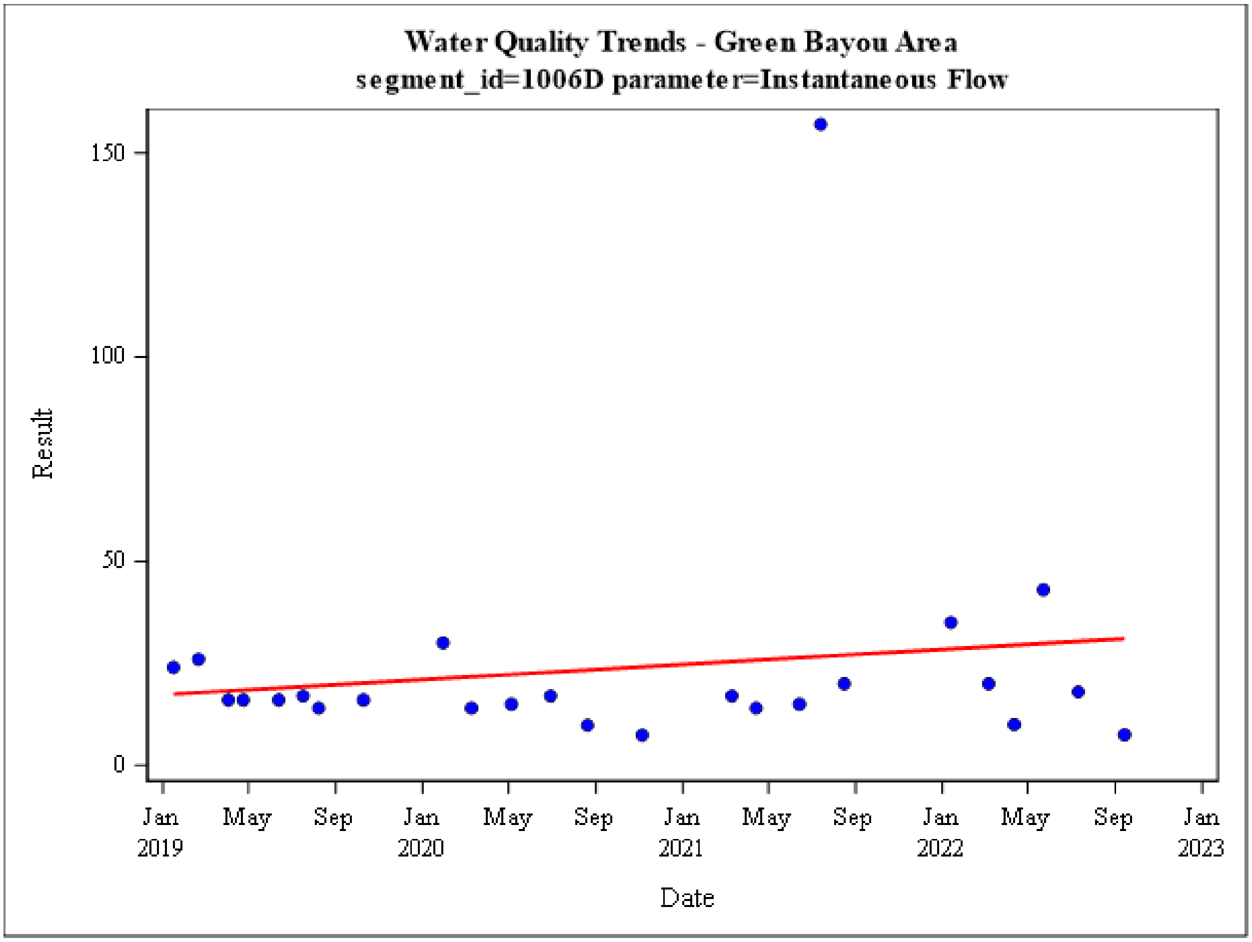
Water Quality Trends - Green Bayou Area
segment_id=1006 parameter=Total Phosphorus
Result
3.0
2.5
2.0
1.5
1.0
0.5
Jan 2019
Jul
Jan 2020
Jul
Jan 2021
Jul
Jan 2022
Jul
Jan 2023
Jul
Jan 2024
Jul
Date

Halls Bayou (1006D)




Water Quality Trends - Green Bayou Area
segment_id=1006D parameter=Dissolved Oxygen (24-hour Mean/ Grab Screening Level)
Result
0
2
4
6
8
10
12
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
May
Sep
Jan 2022
May
Sep
Jan 2023
Date


Water Quality Trends - Green Bayou Area
segment_id=1006D parameter=E. Coli
Result
50000
40000
30000
20000
10000
0
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
May
Sep
Jan 2022
May
Sep
Jan 2023
Date


Water Quality Trends - Green Bayou Area
segment_id=1006D parameter=Instantaneous Flow
150
100
50
0
Result
Jan 2019
May
Sep
Jan 2020
May
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May
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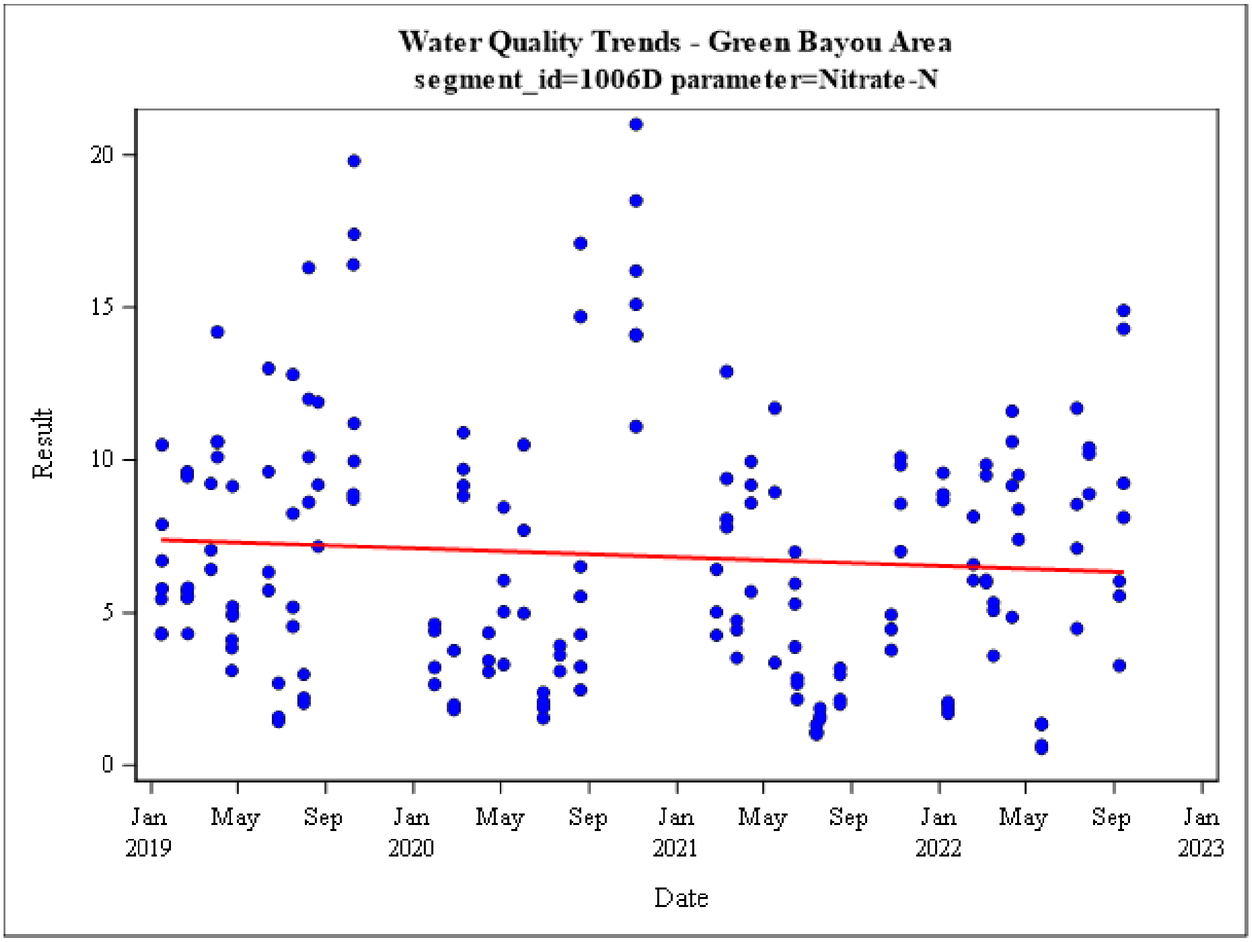
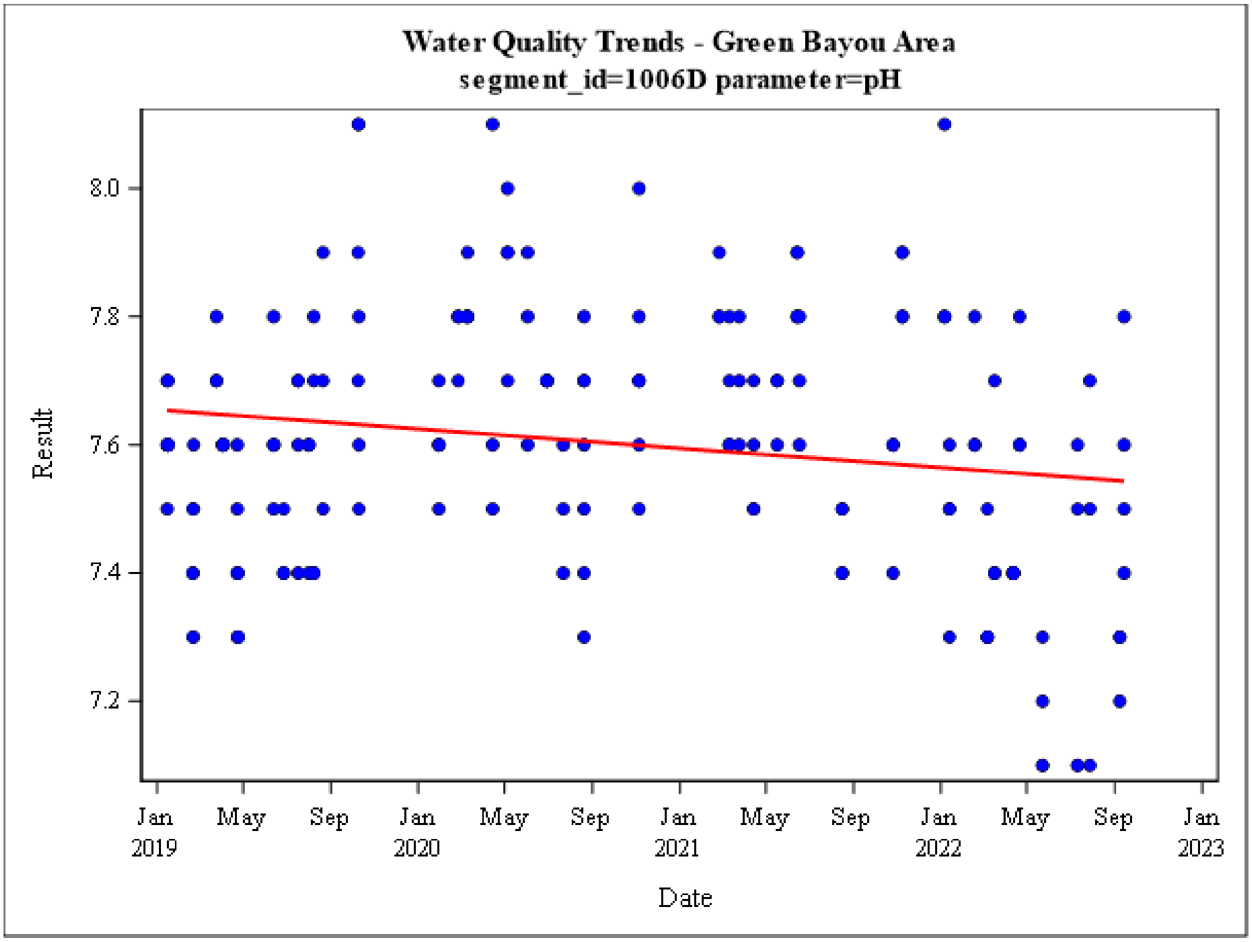
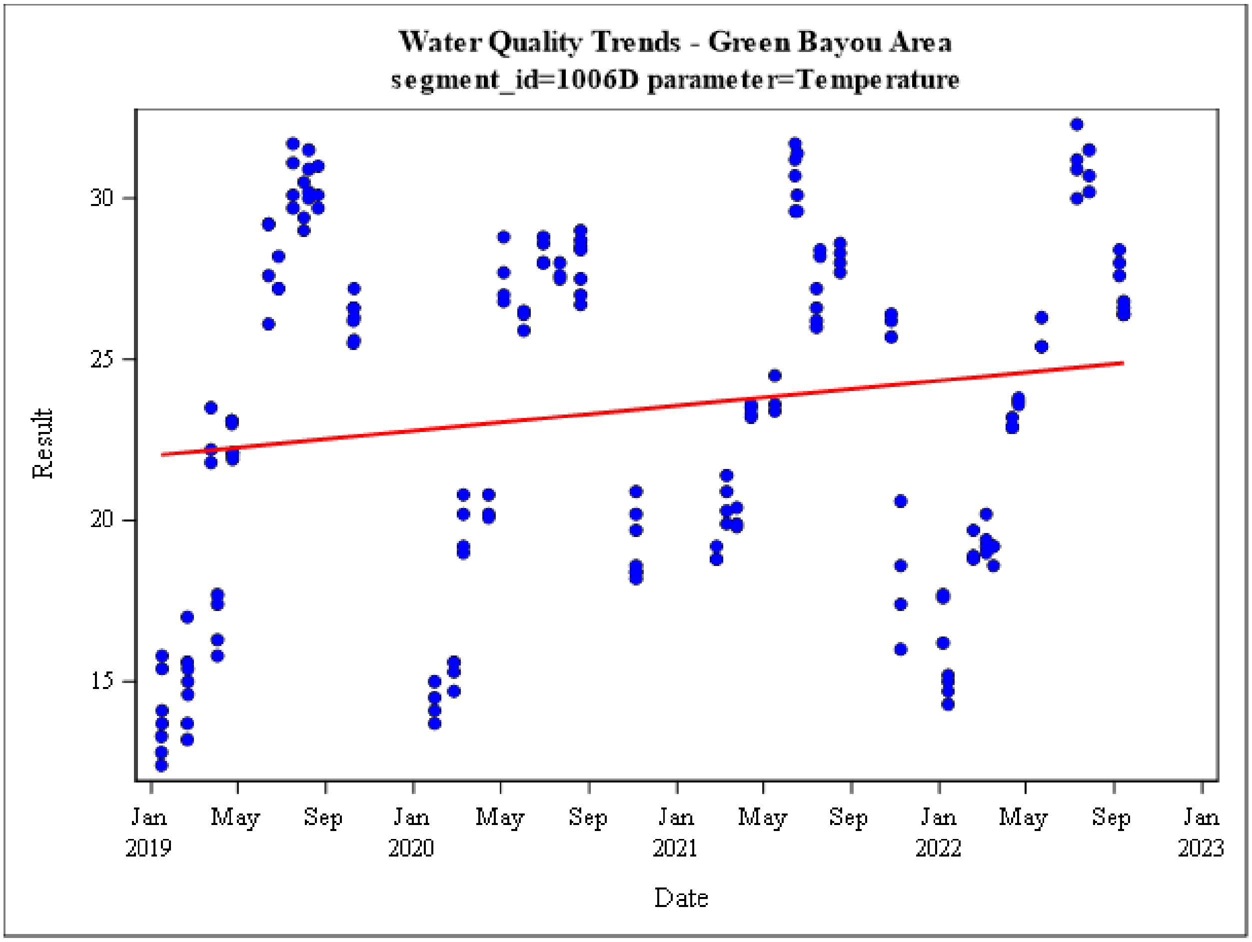
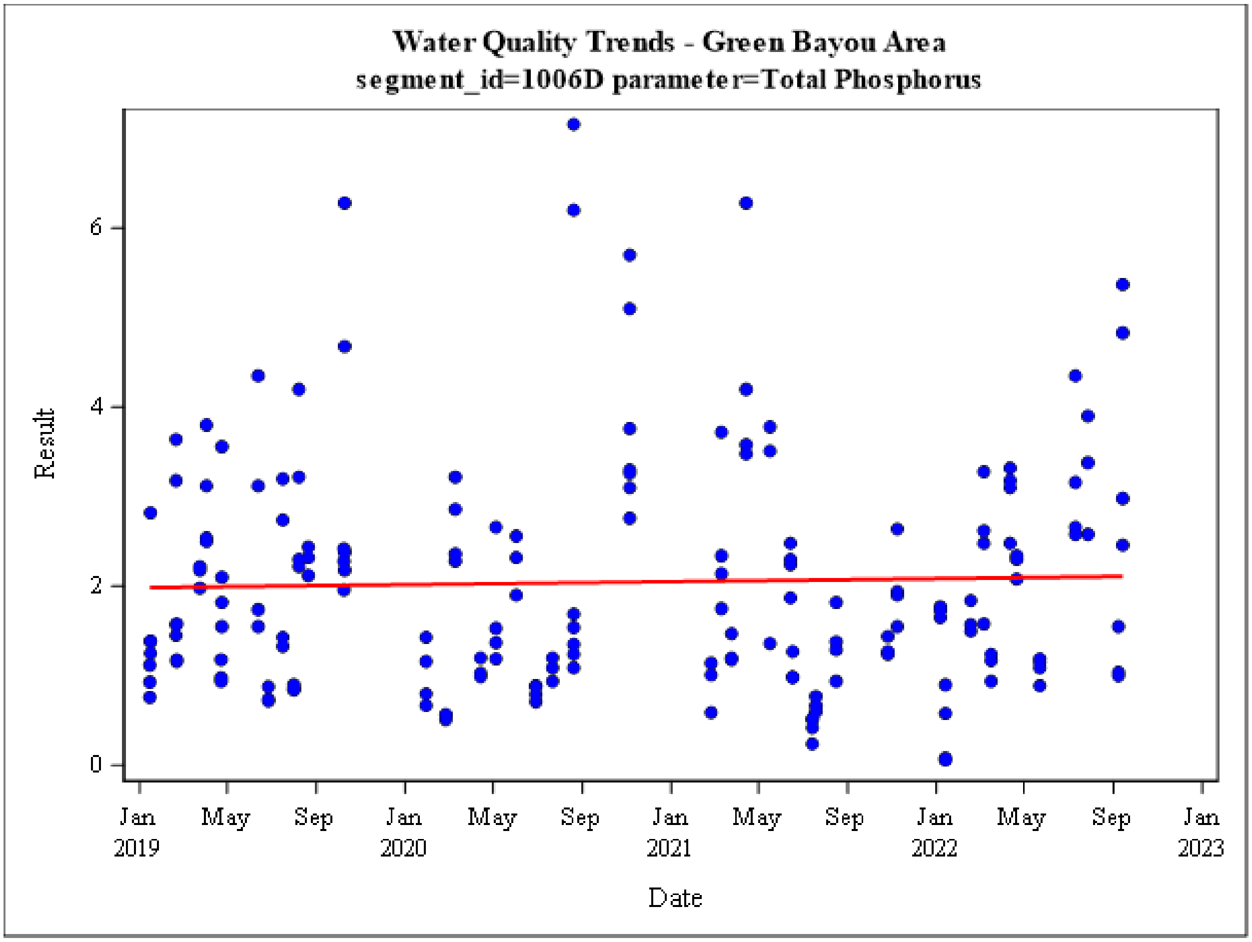
May
Sep
Jan 2023
Date

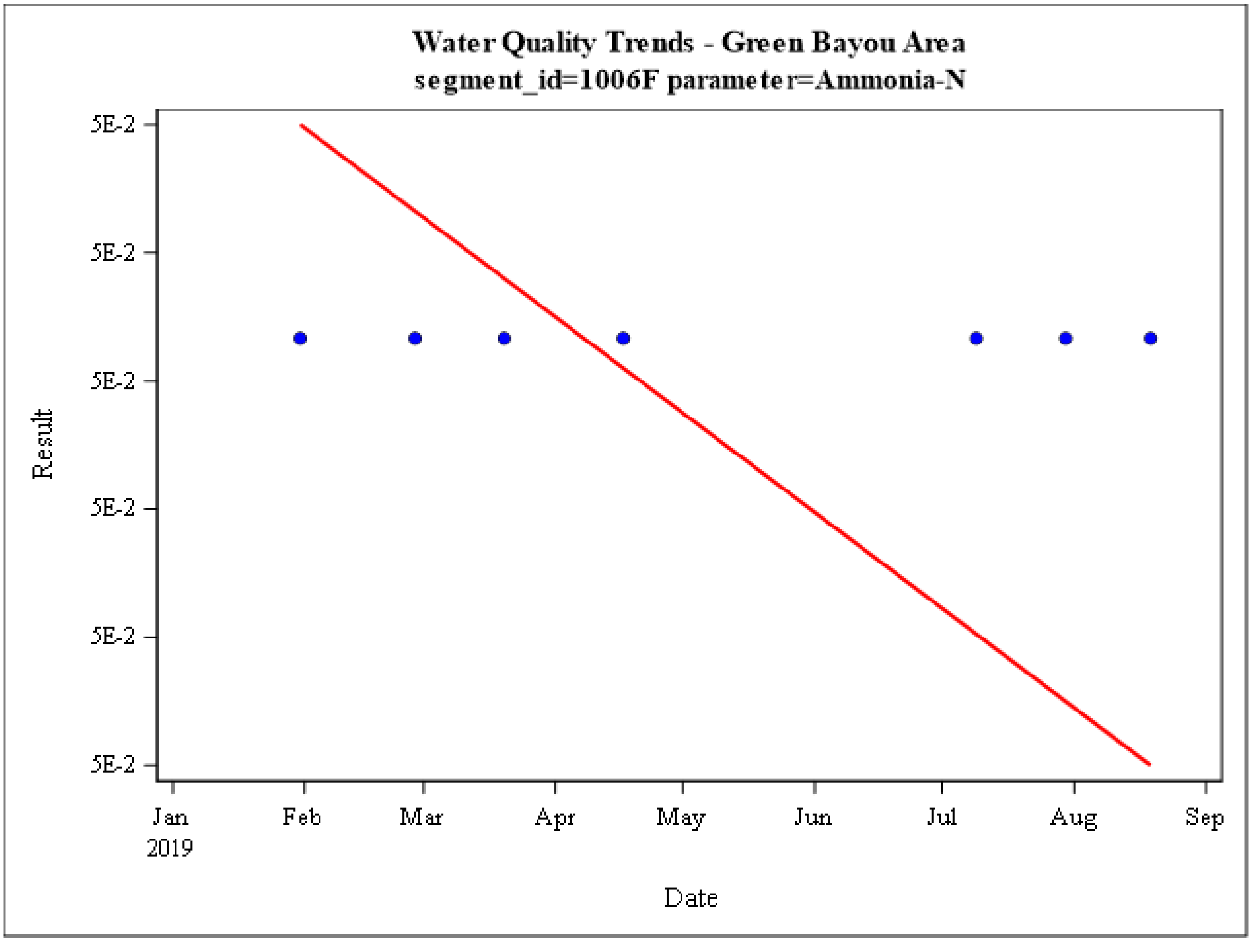

Water Quality Trends - Green Bayou Area
segment_id=1006D parameter=Nitrate-N
Result
20
15
10
5
0
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
May
Sep
Jan 2022
May
Sep
Jan 2023
Date

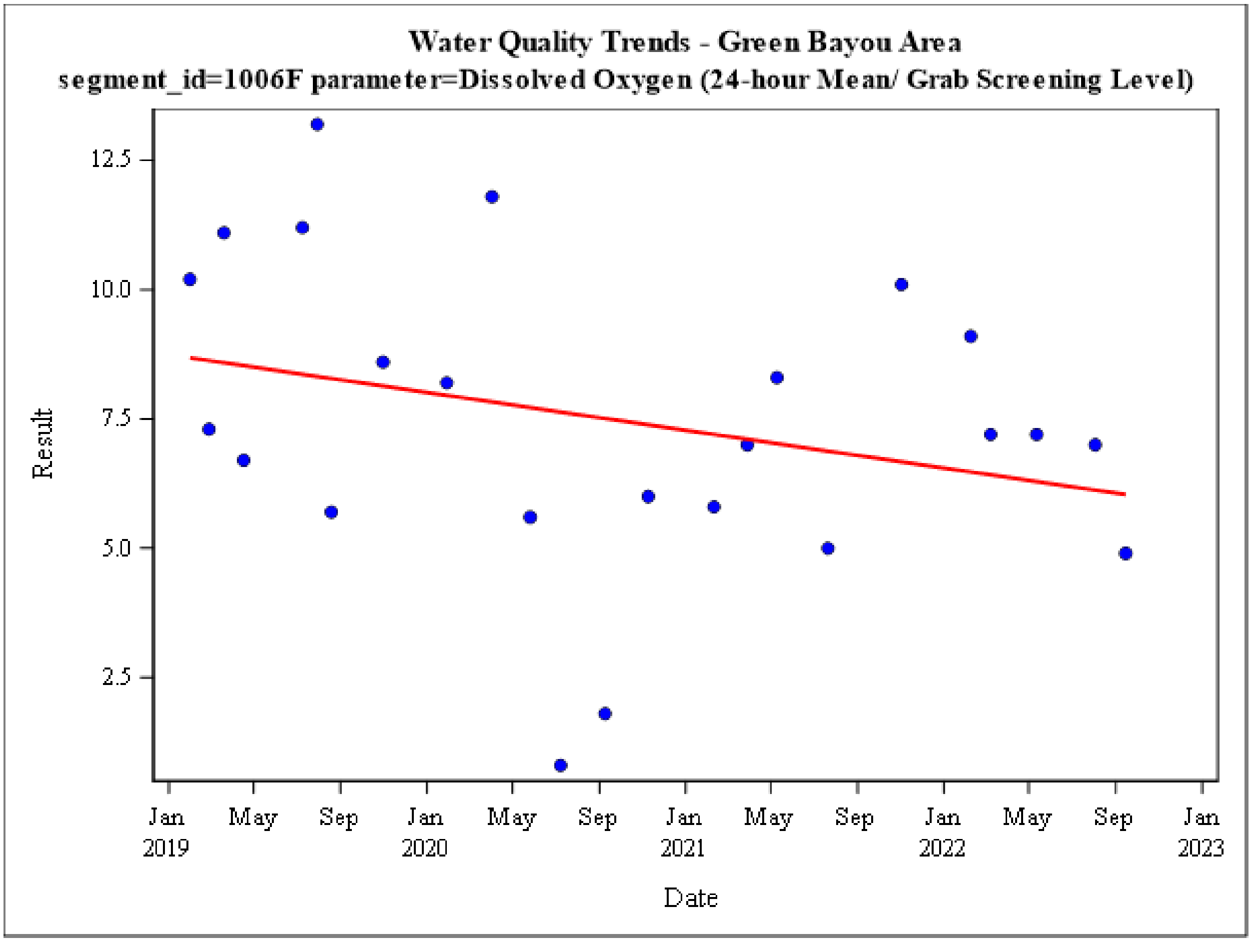

Water Quality Trends - Green Bayou Area
segment_id=1006D parameter=pH
Result
8.0
7.8
7.6
7.4
7.2
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
May
Sep
Jan 2022
May
Sep
Jan 2023
Date


Water Quality Trends - Green Bayou Area
segment_id=1006D parameter=Temperature
Result
30
25
20
15
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
May
Sep
Jan 2022
May
Sep
Jan 2023
Date


Water Quality Trends - Green Bayou Area
segment_id=1006D parameter=Total Phosphorus
Result
0
2
4
6
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
May
Sep
Jan 2022
May
Sep
Jan 2023
Date

Big Gulch (1006F)




Water Quality Trends - Green Bayou Area
segment_id=1006F parameter=Dissolved Oxygen (24-hour Mean/ Grab Screening Level)
12.5
10.0
7.5
5.0
2.5
Result
Jan 2019
May
Sep
Jan 2020
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Sep
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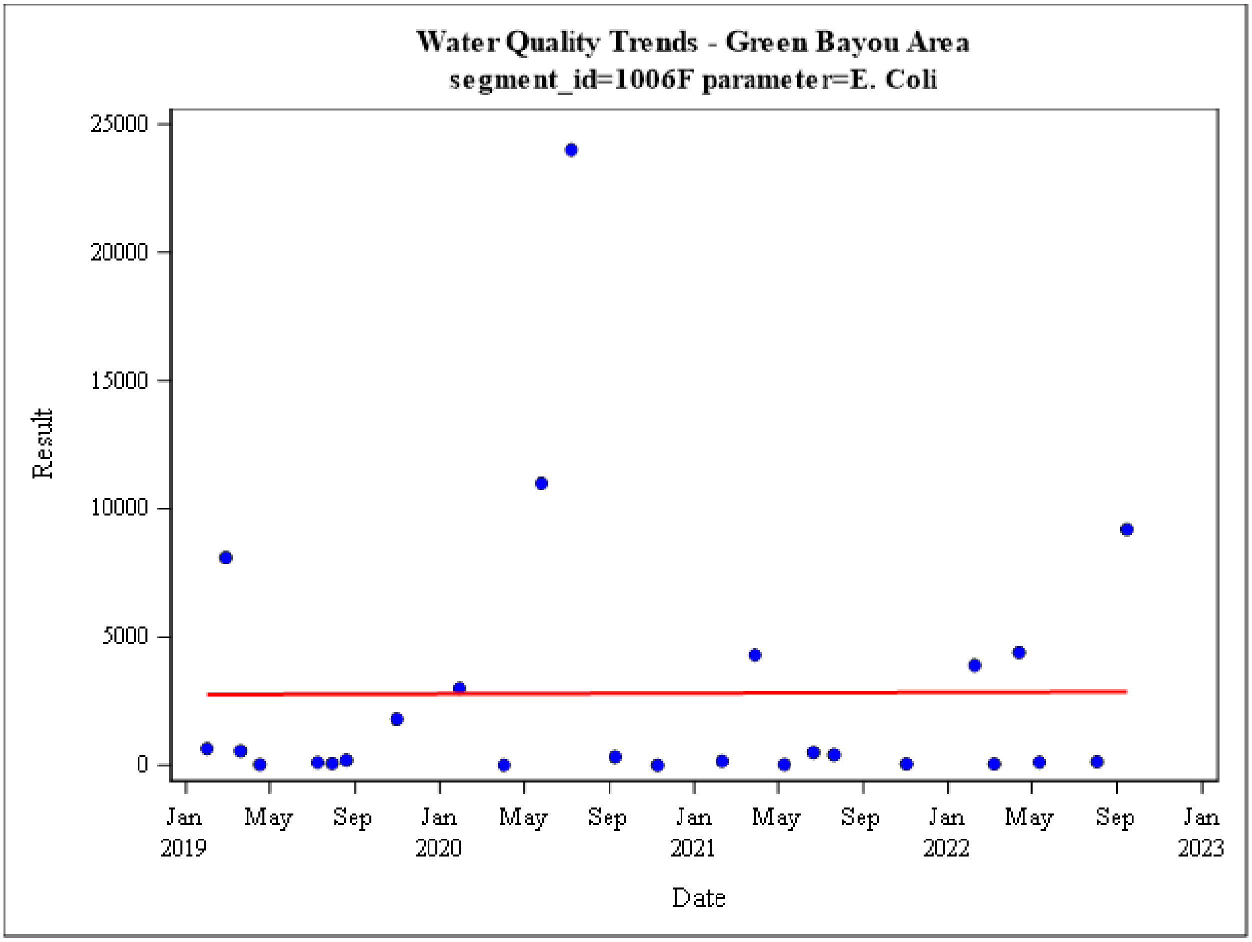
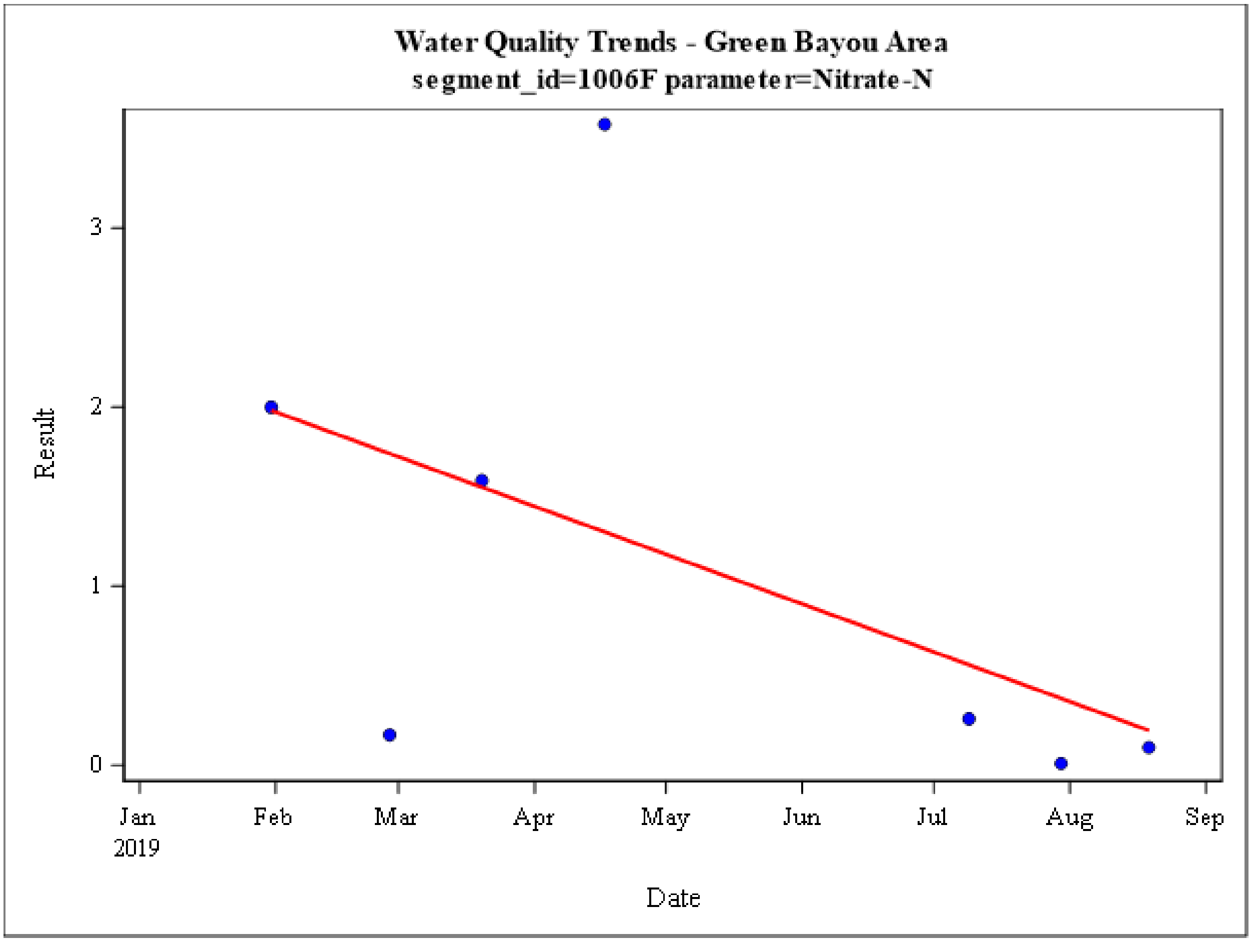
Jan 2022
May
Sep
Jan 2023
Date


Water Quality Trends - Green Bayou Area
segment_id=1006F parameter=E. Coli
25000
20000
15000
10000
5000
0
Result
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
May
Sep
Jan 2022
May
Sep
Jan 2023
Date


Water Quality Trends - Green Bayou Area
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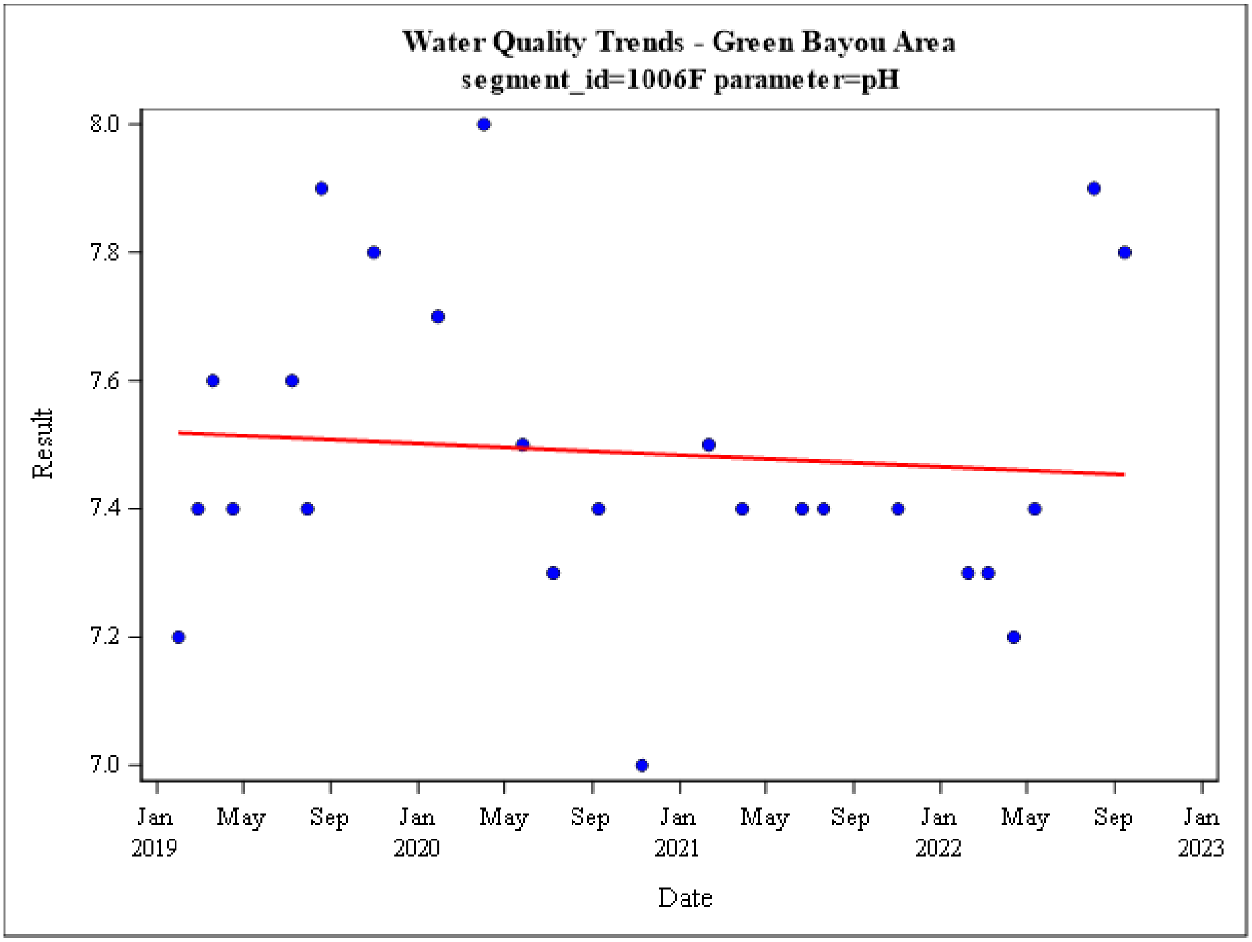
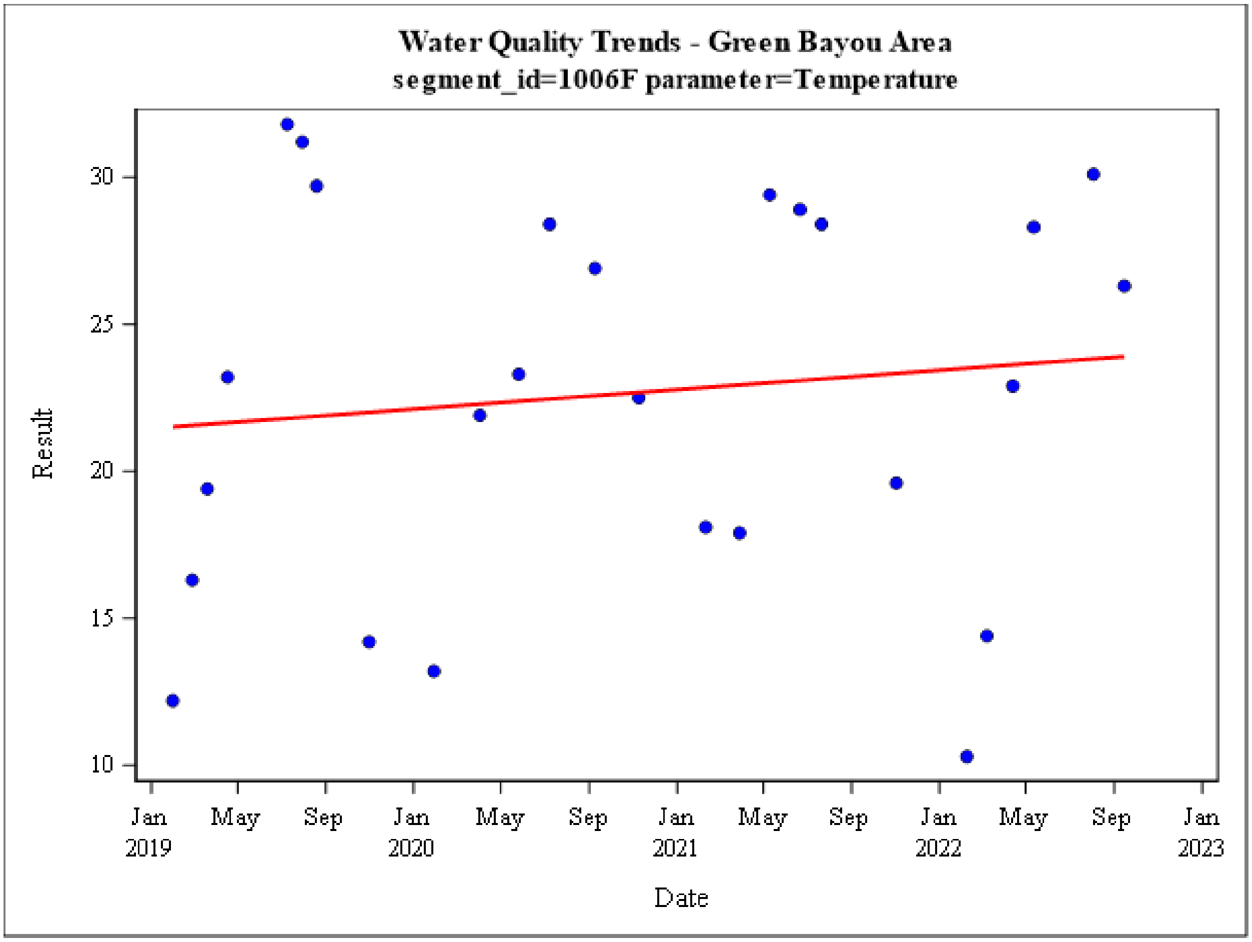
Result
0
1
2
3
Jan
2019
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Date


Water Quality Trends - Green Bayou Area
segment_id=1006F parameter=pH
Result
8.0
7.8
7.6
7.4
7.2
7.0
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
May
Sep
Jan 2022
May
Sep
Jan 2023
Date


Water Quality Trends - Green Bayou Area
segment_id=1006F parameter=Temperature
Result
30
25
20
15
10
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
May
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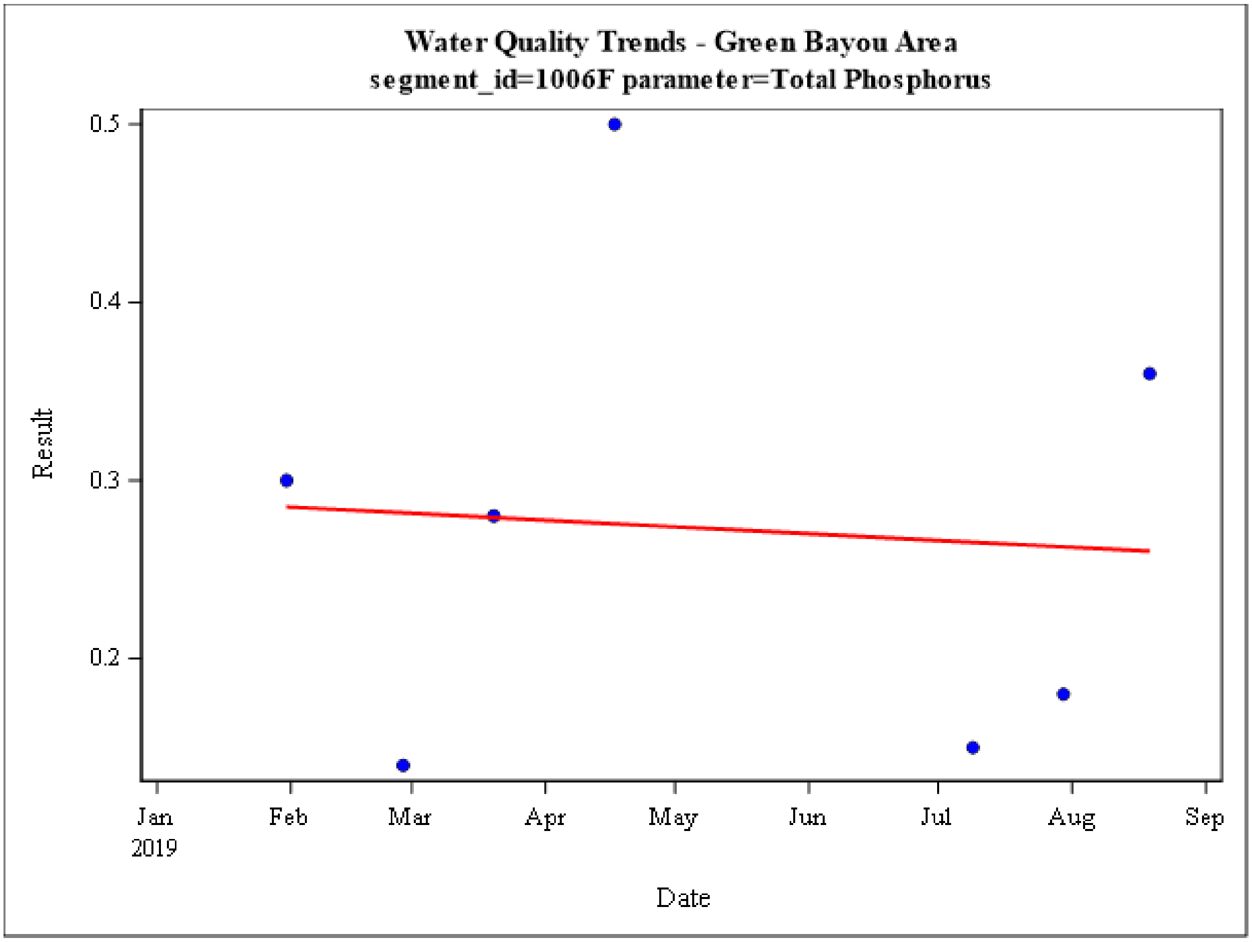
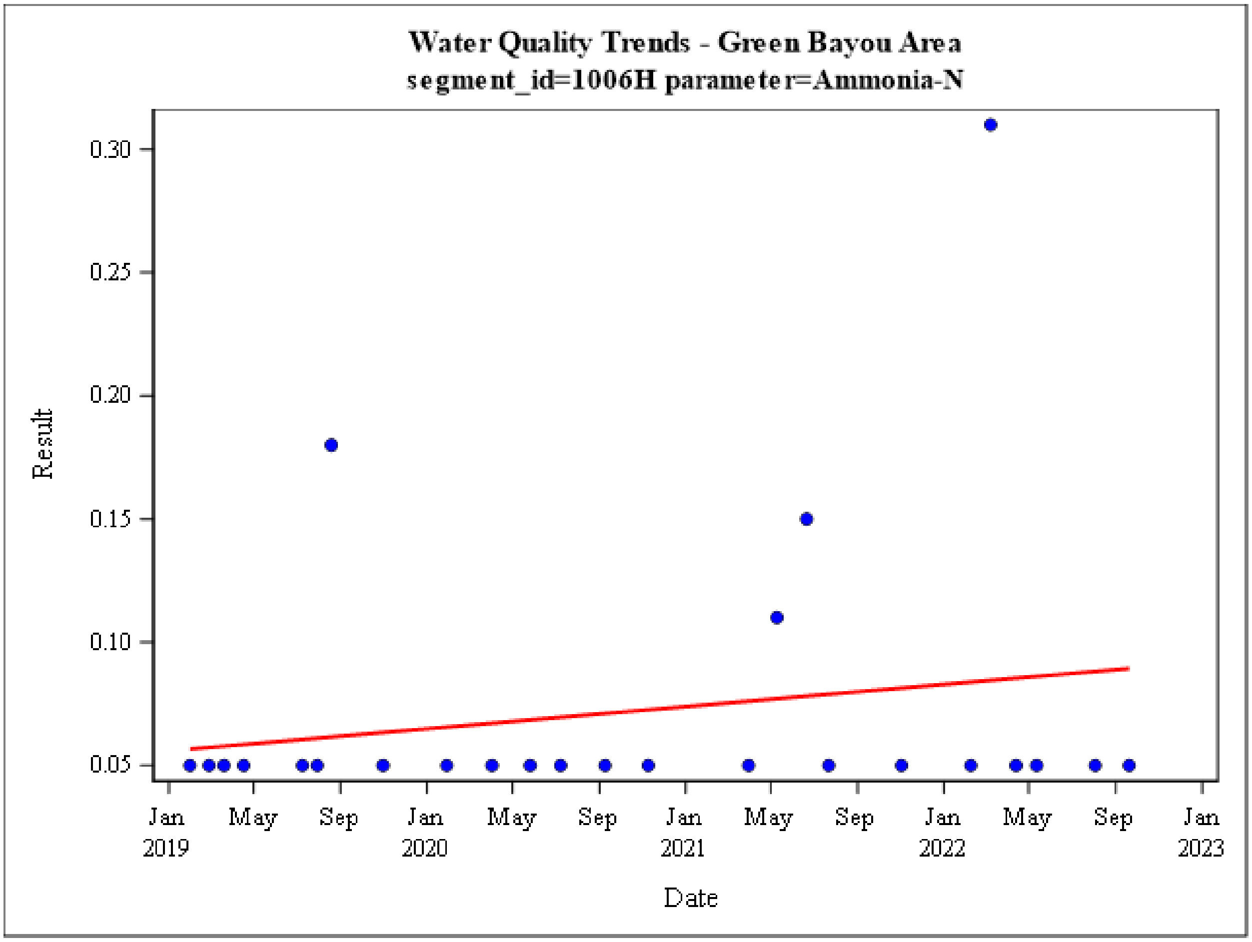
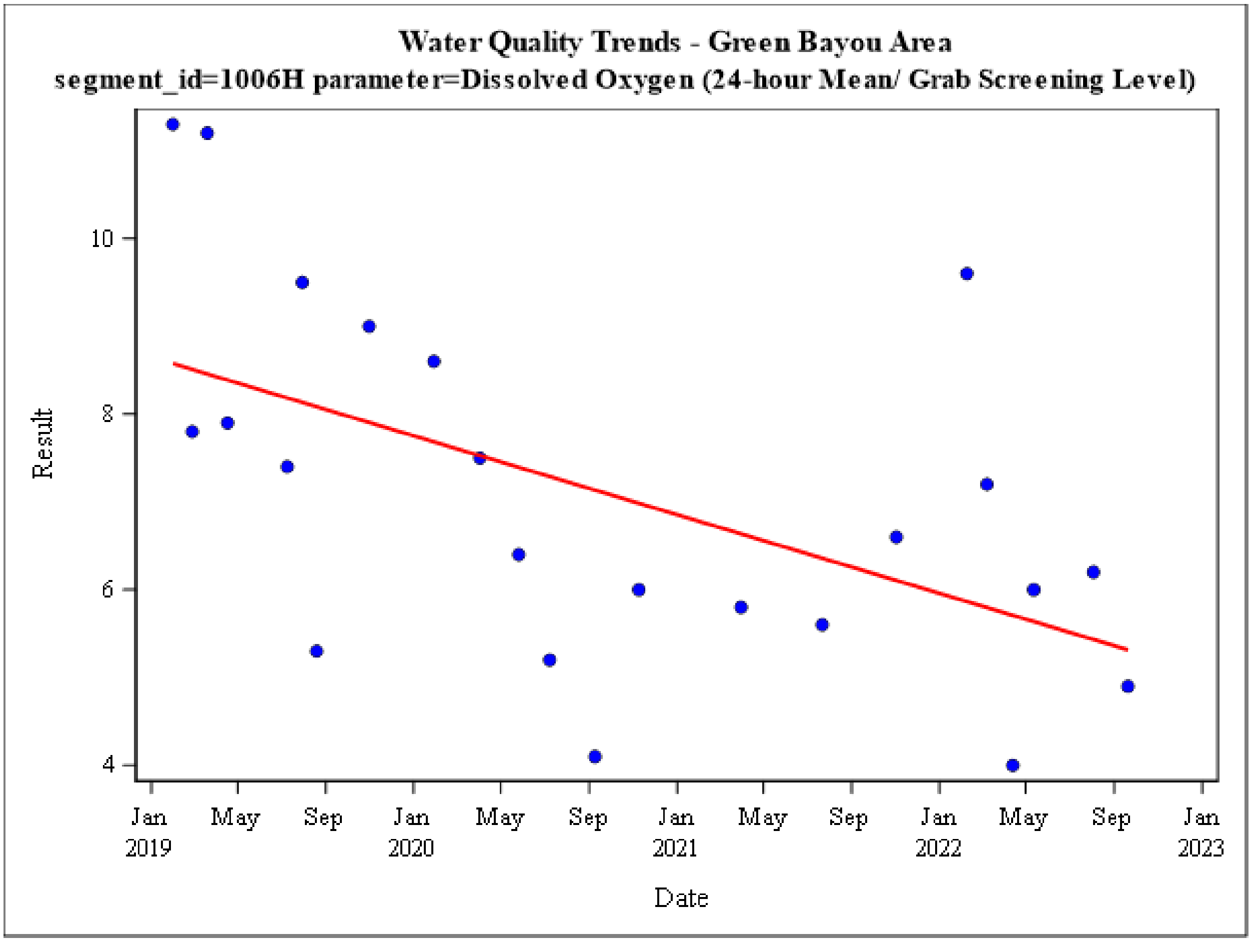
Jan 2022
May
Sep
Jan 2023
Date

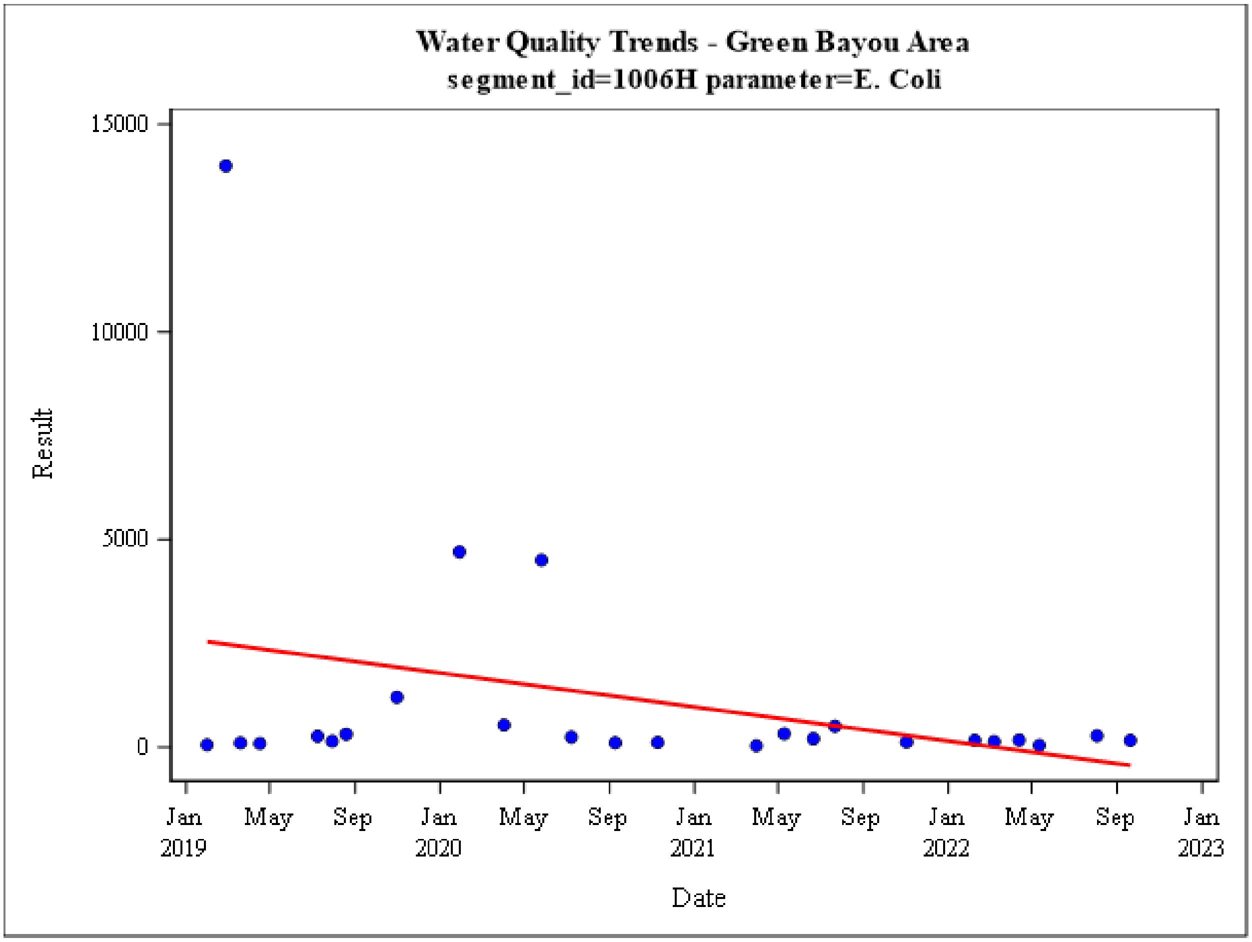

Water Quality Trends - Green Bayou Area
segment_id=1006F parameter=Total Phosphorus
0.5
0.4
0.3
0.2
Result
Jan
2019
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Date

Spring Gully (1006H)

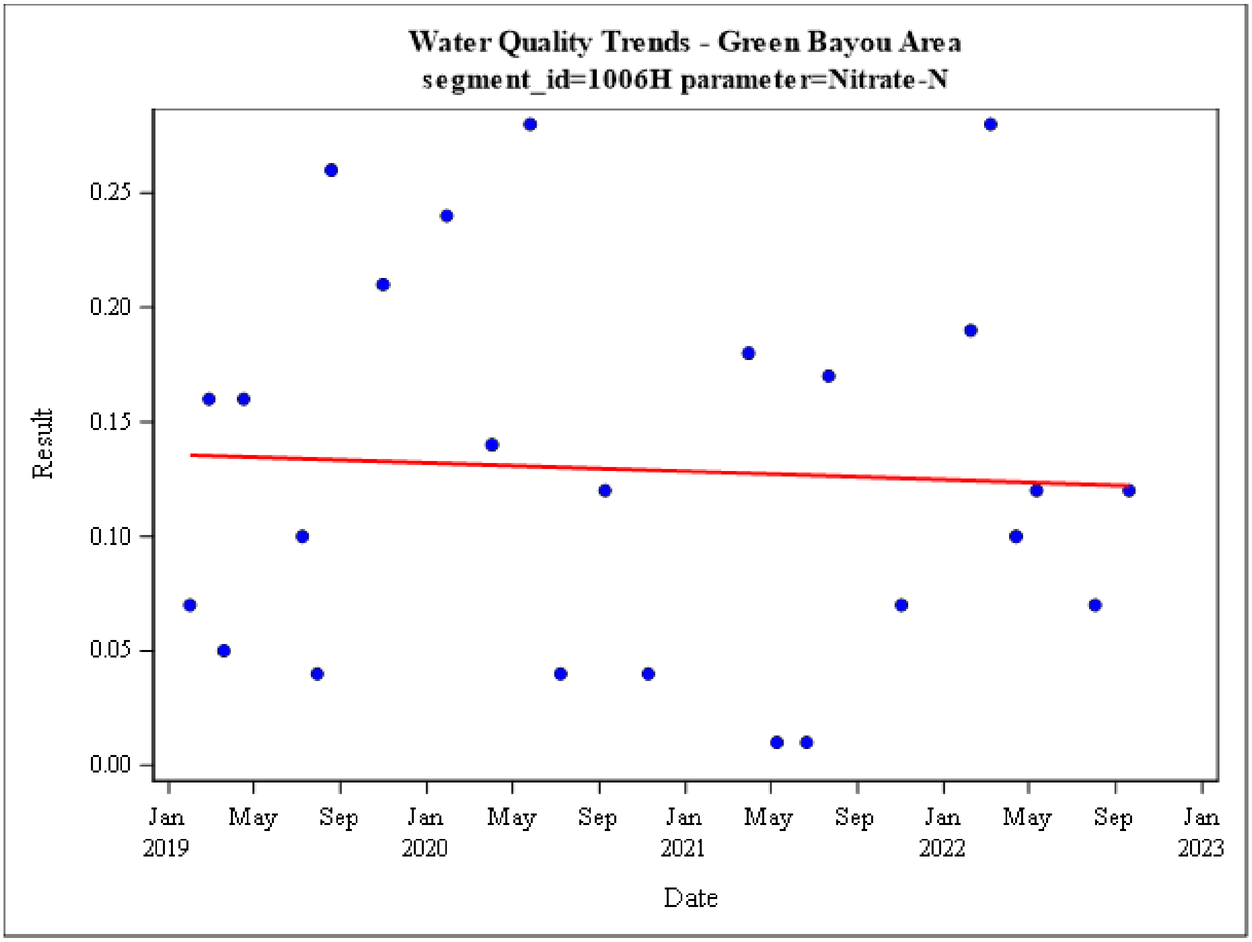




Water Quality Trends - Green Bayou Area
segment_id=1006H parameter=Dissolved Oxygen (24-hour Mean/ Grab Screening Level)
Result
10
8
6
4
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
May
Sep
Jan 2022
May
Sep
Jan 2023
Date



Water Quality Trends - Green Bayou Area
segment_id=1006H parameter=E. Coli
Result
15000
10000
5000
0
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
May
Sep
Jan 2022
May
Sep
Jan 2023
Date


Water Quality Trends - Green Bayou Area
segment_id=1006H parameter=Nitrate-N
Result
0.00
0.05
0.10
0.15
0.20
0.25
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
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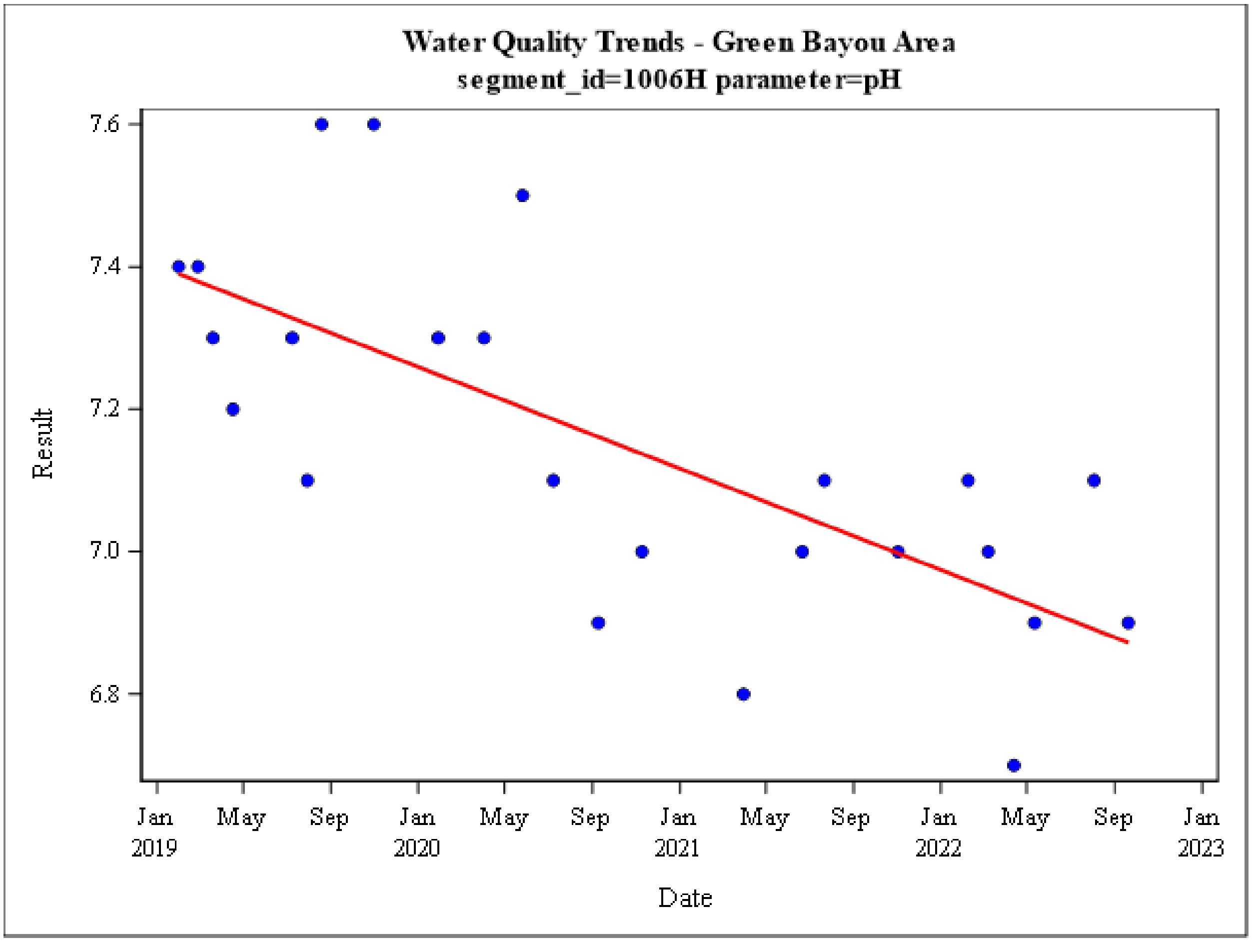
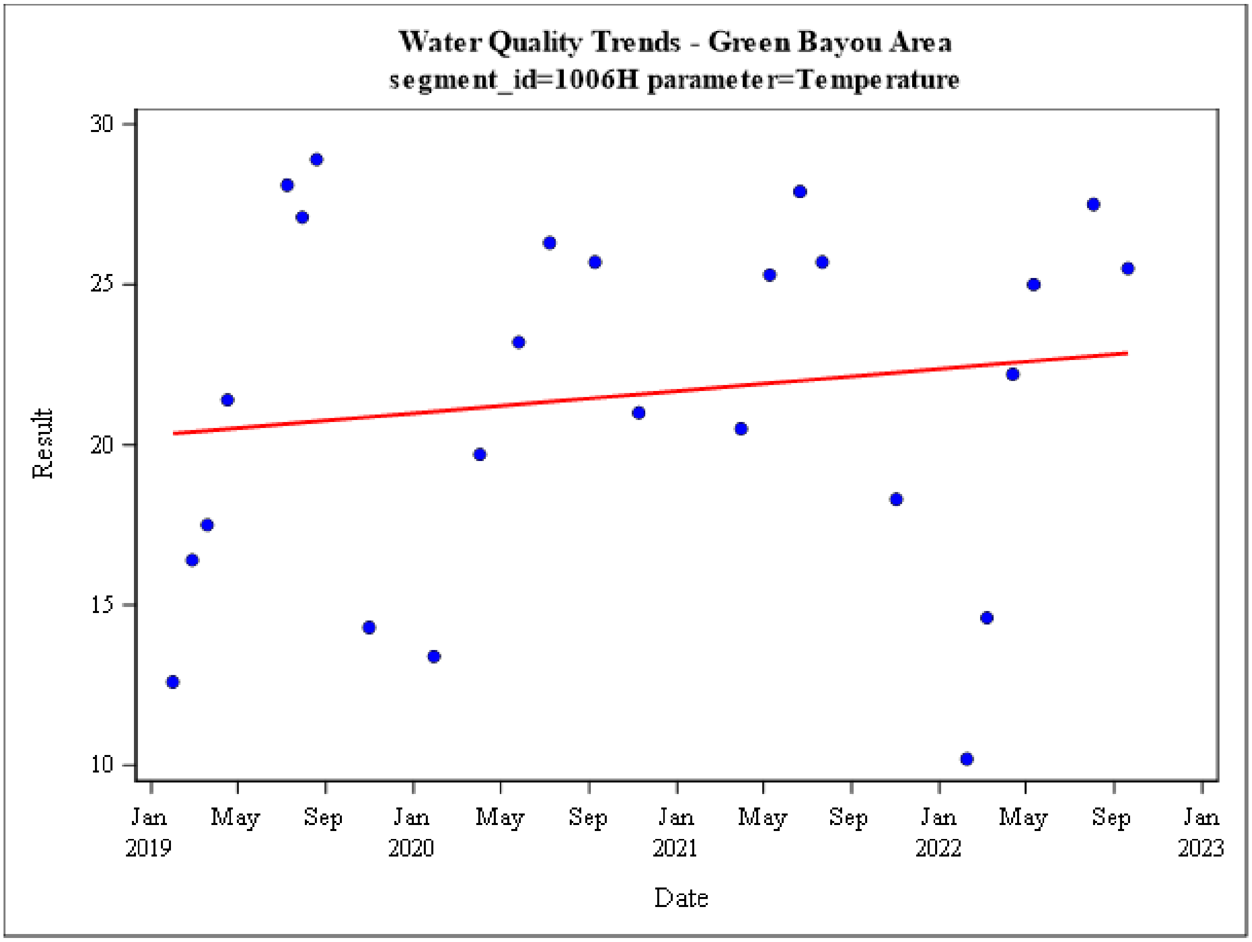
Jan 2022
May
Sep
Jan 2023
Date


Water Quality Trends - Green Bayou Area
segment_id=1006H parameter=pH
Result
7.6
7.4
7.2
7.0
6.8
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
May
Sep
Jan 2022
May
Sep
Jan 2023
Date


Water Quality Trends - Green Bayou Area
segment_id=1006H parameter=Temperature
Result
30
25
20
15
10
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
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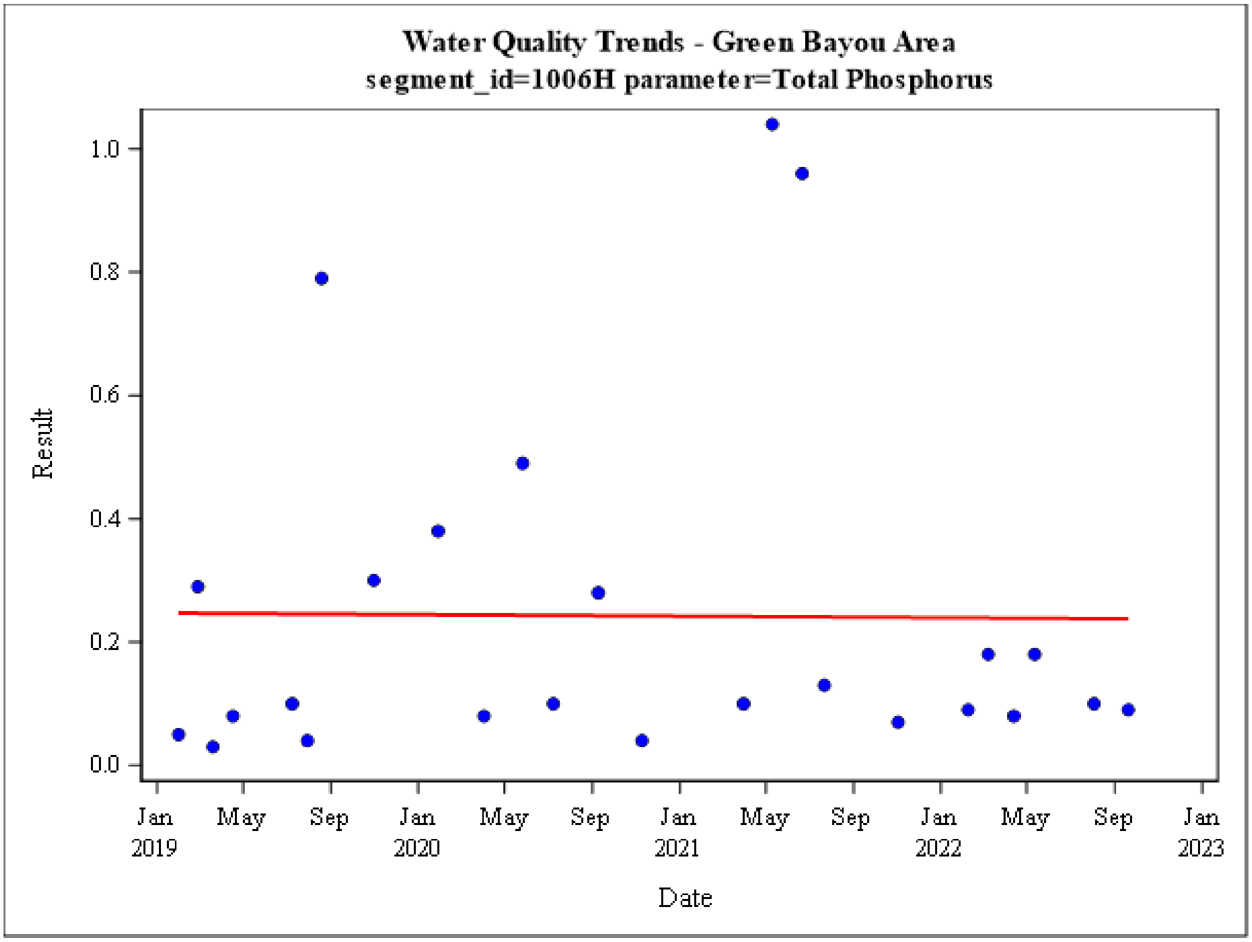
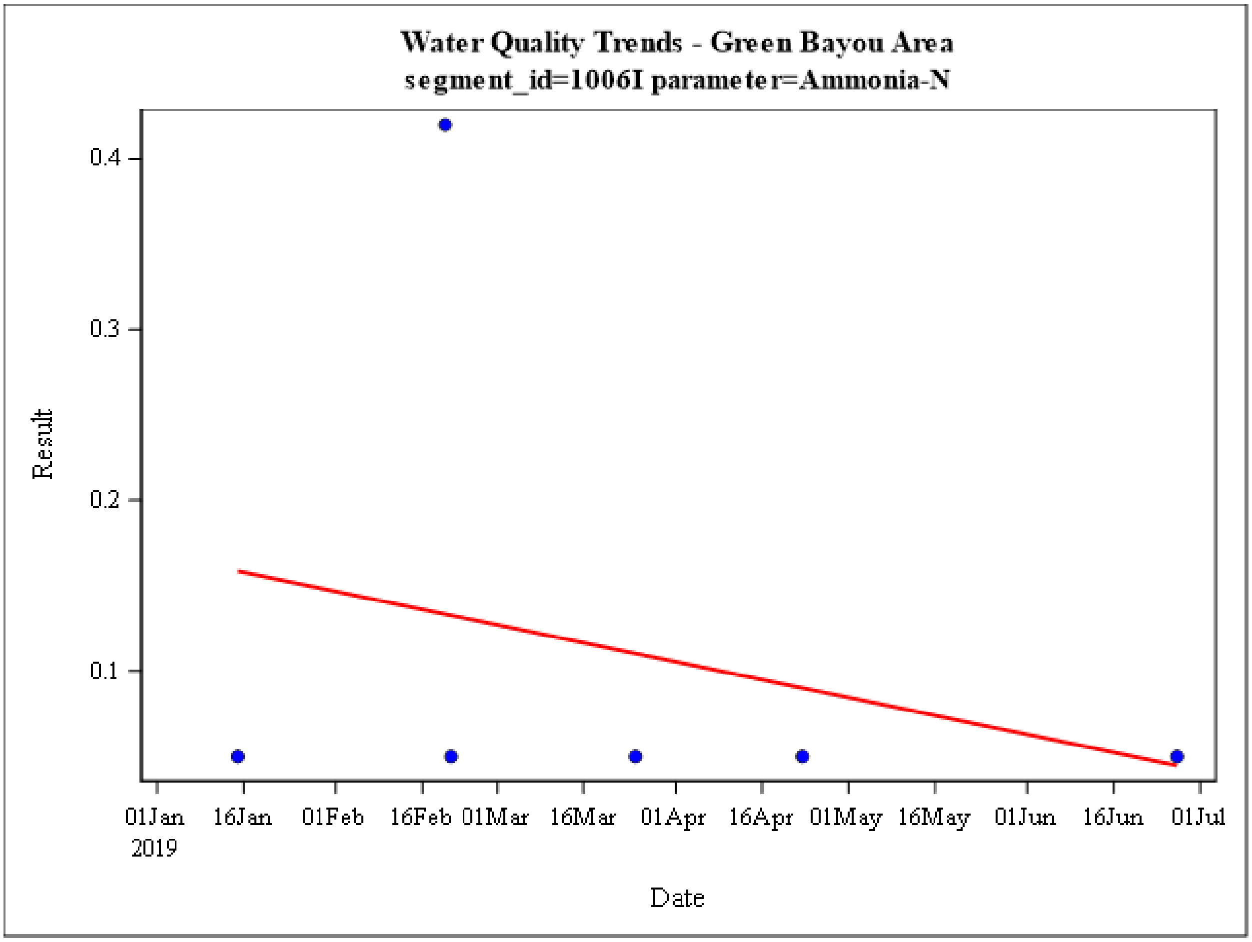
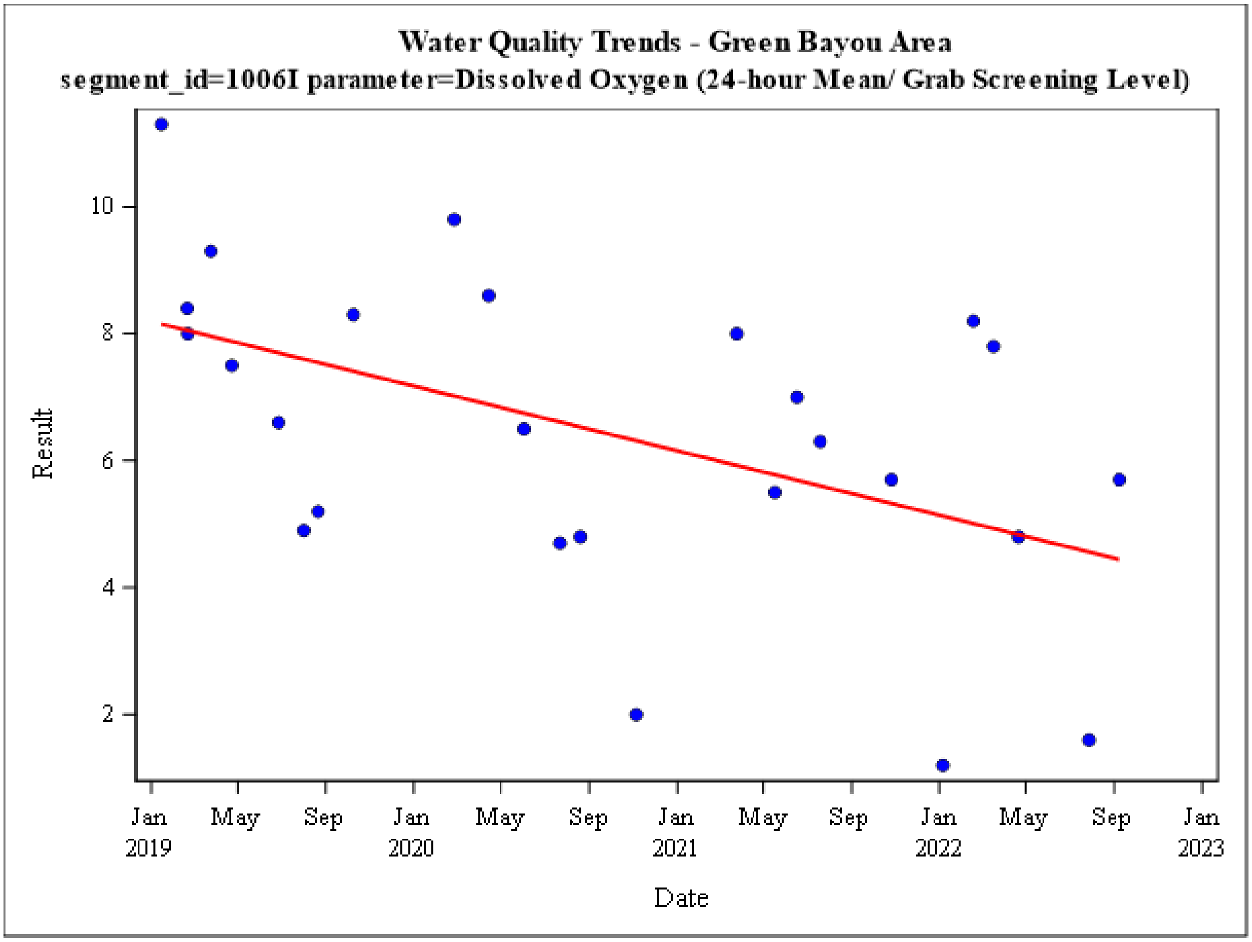
Sep
Jan 2022
May
Sep
Jan 2023
Date

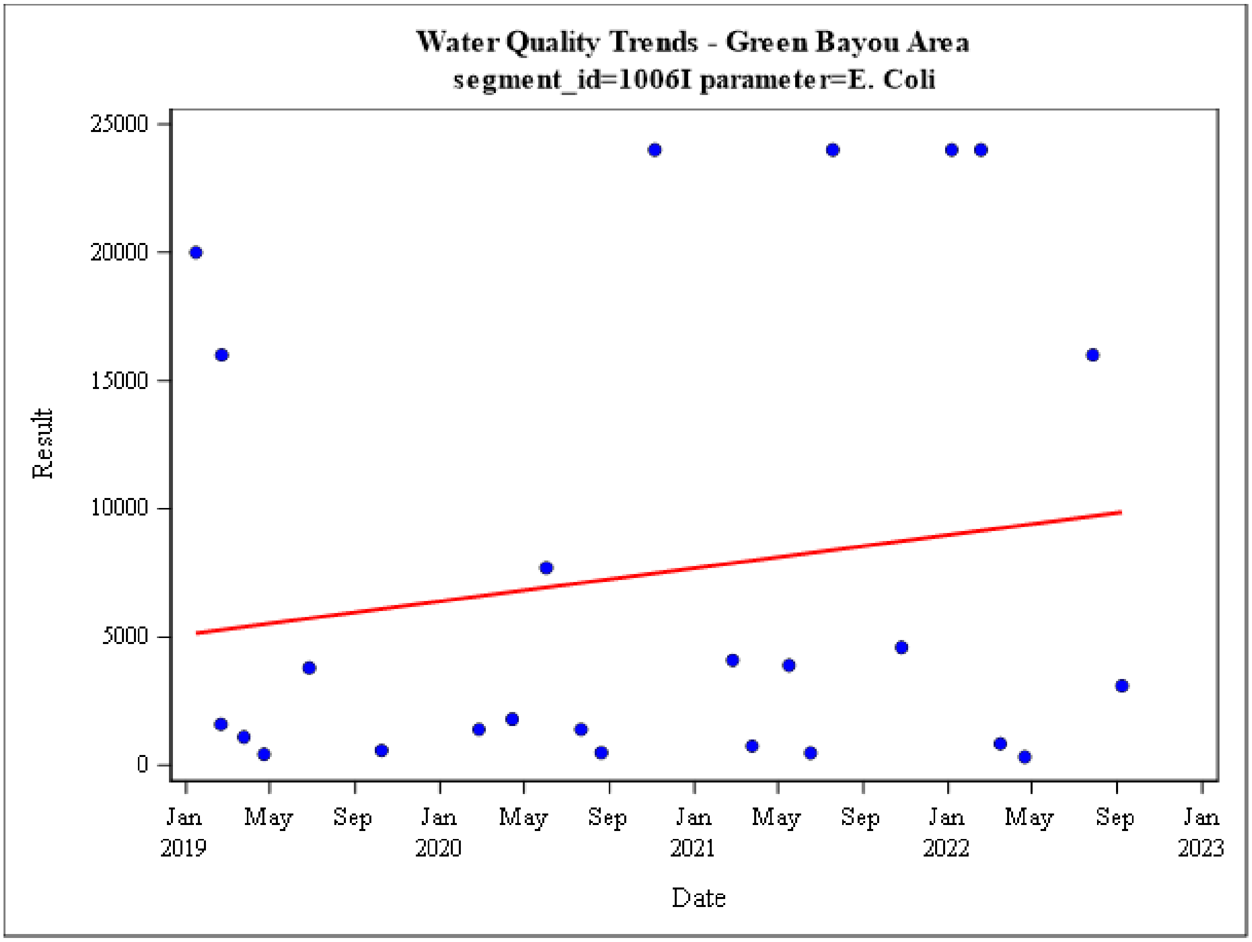


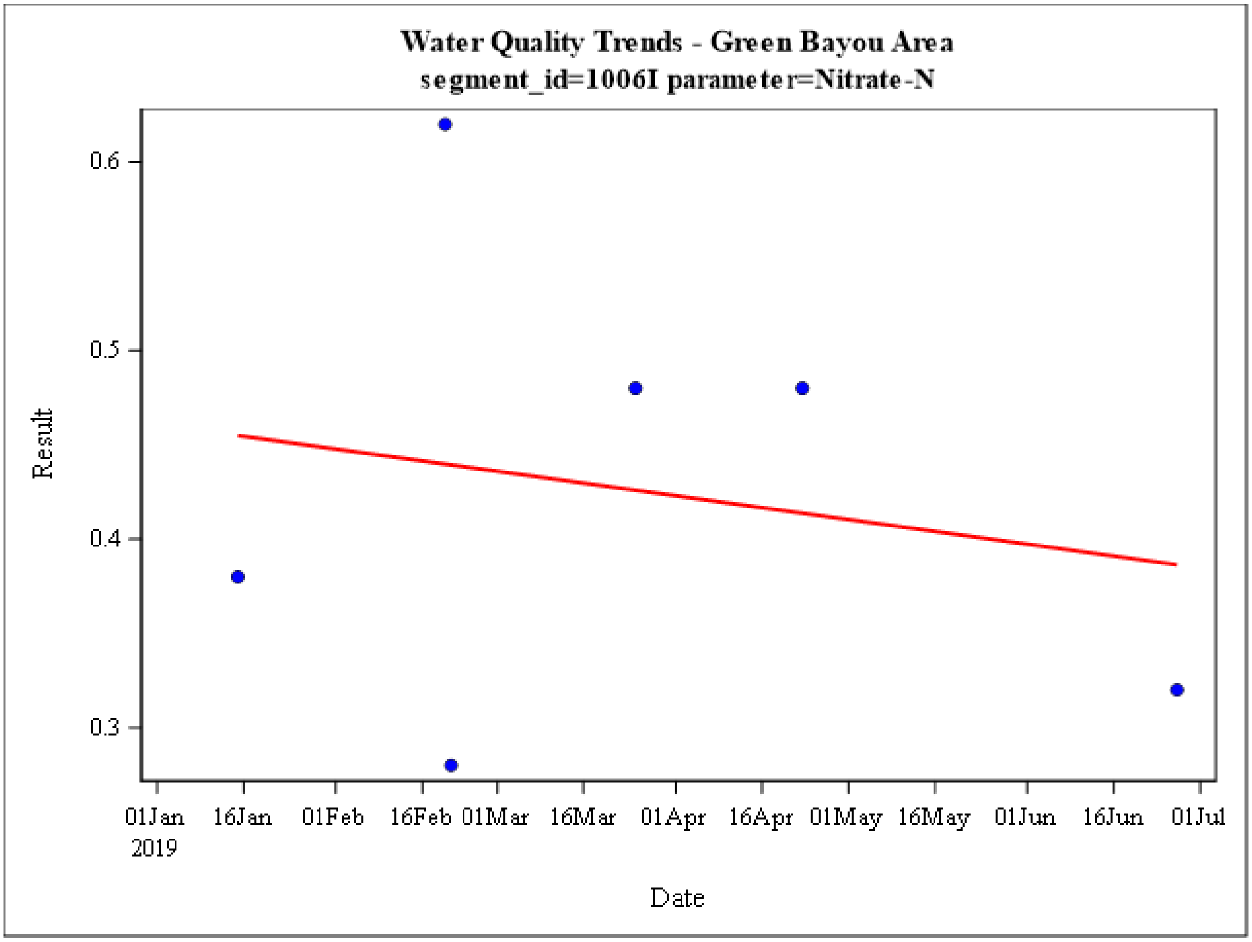
Water Quality Trends - Green Bayou Area
segment_id=1006H parameter=Total Phosphorus
Result
1.0
0.8
0.6
0.4
0.2
0.0
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
May
Sep
Jan 2022
May
Sep
Jan 2023
Date

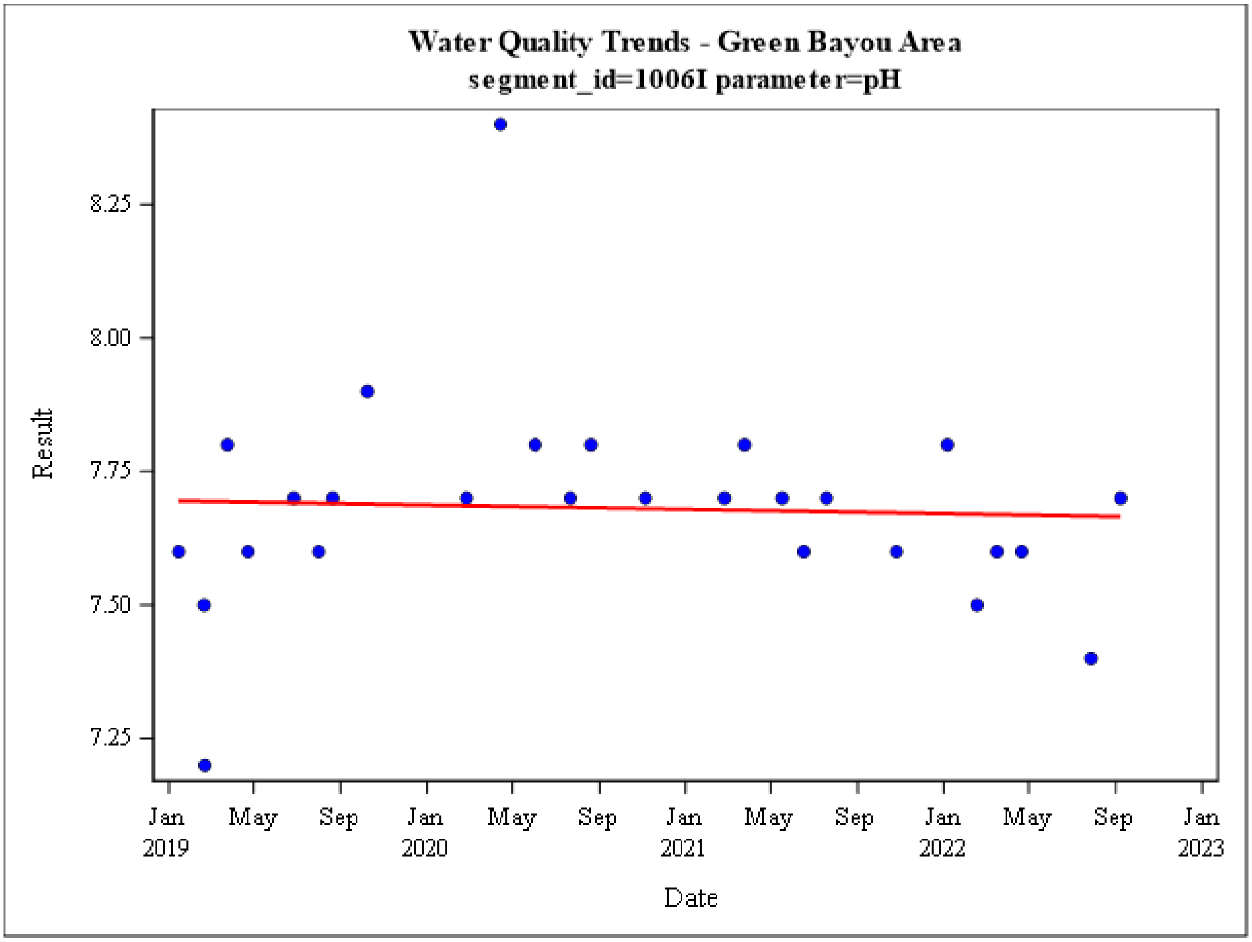
Unnamed Tributary of Halls Bayou (1006I)

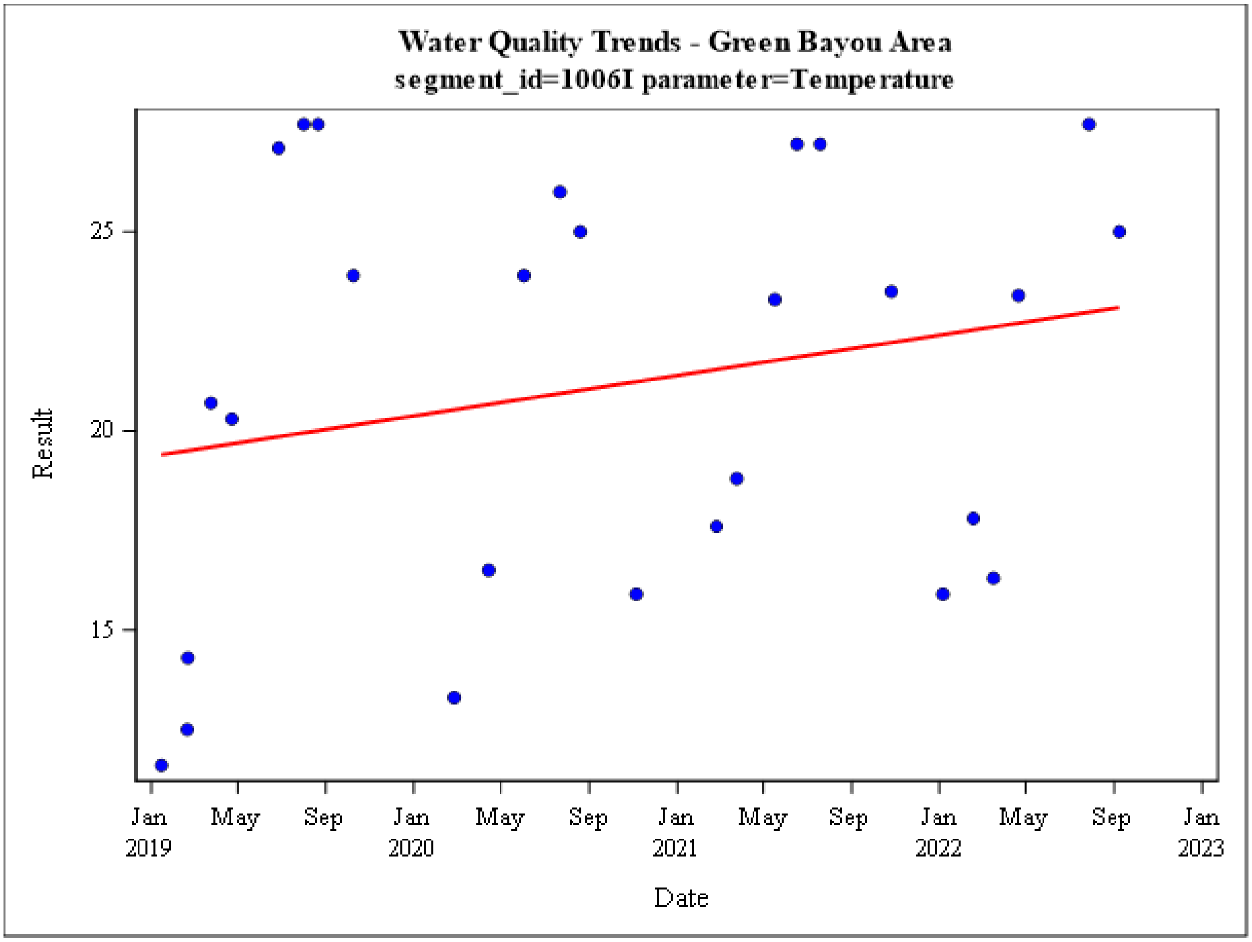


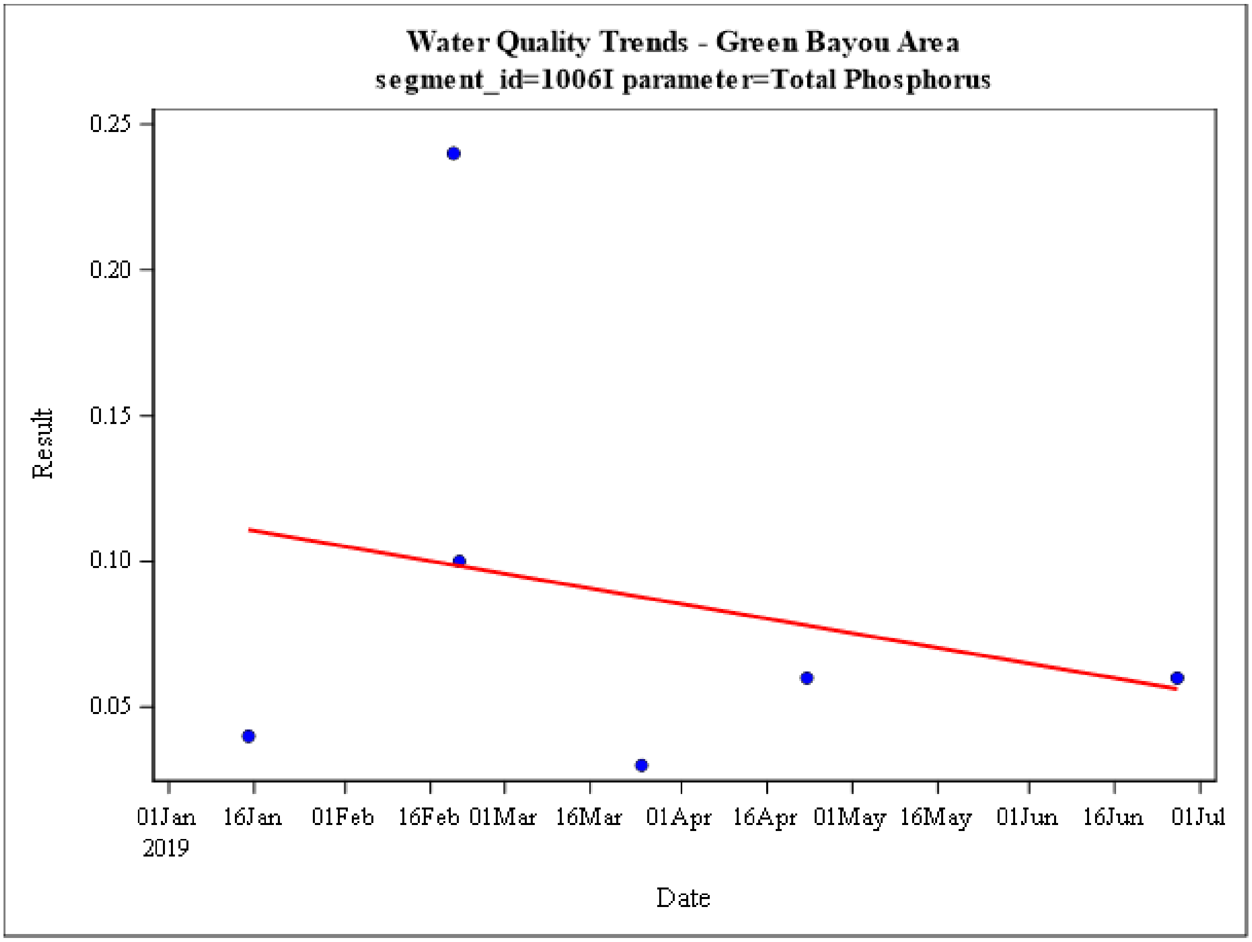

Water Quality Trends - Green Bayou Area
segment_id=1006I parameter=Dissolved Oxygen (24-hour Mean/ Grab Screening Level)
Result
10
8
6
4
2
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
May
Sep
Jan 2022
May
Sep
Jan 2023
Date


Water Quality Trends - Green Bayou Area
segment_id=1006I parameter=E. Coli
Result
25000
20000
15000
10000
5000
0
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
May
Sep
Jan 2022
May
Sep
Jan 2023
Date

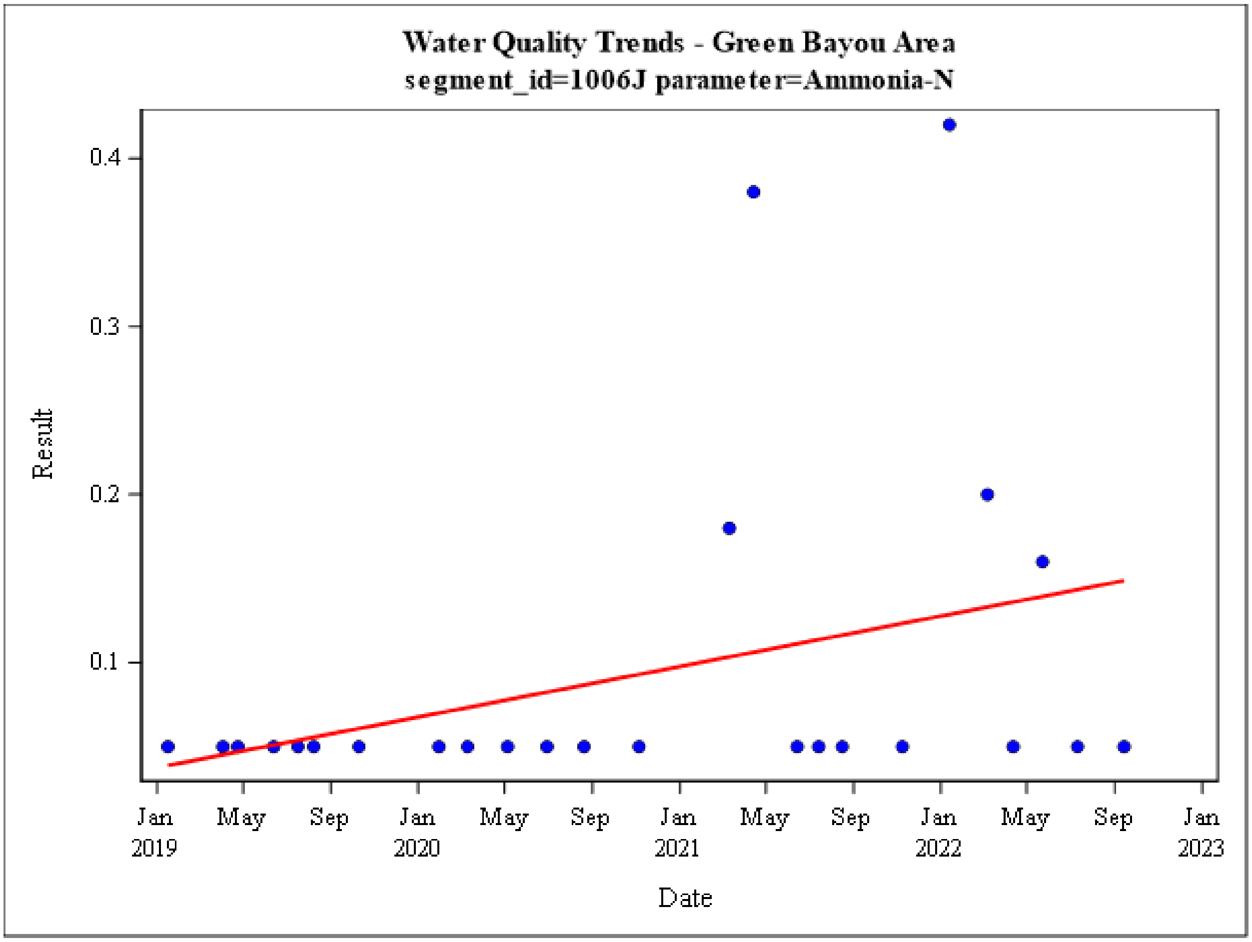

Water Quality Trends - Green Bayou Area
segment_id=1006I parameter=Nitrate-N
0.6
0.5
0.4
0.3
Result
01Jan 2019
16Jan
01Feb
16Feb
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
16Jun
01Jul
Date

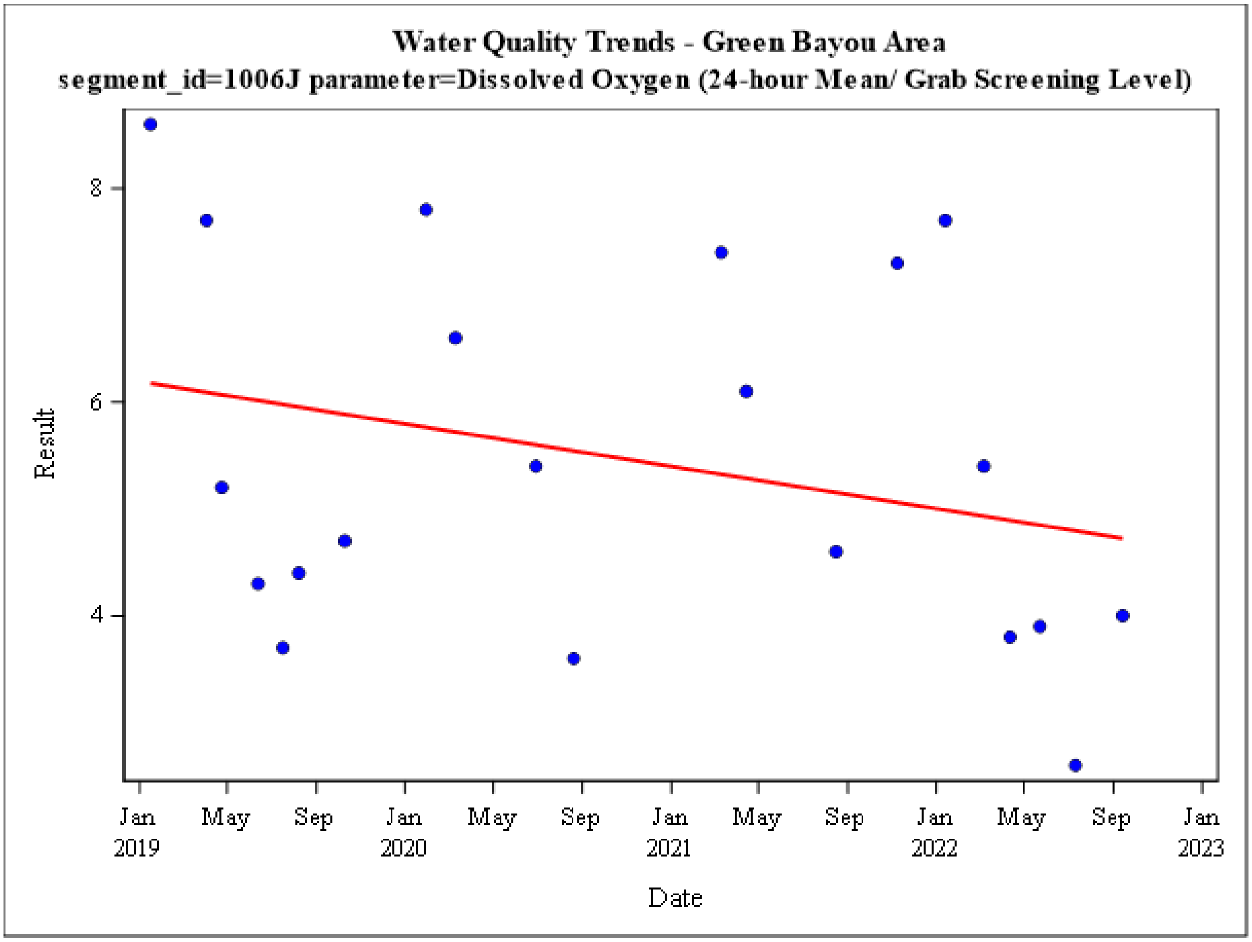

Water Quality Trends - Green Bayou Area
segment_id=1006I parameter=pH
Result
8.25
8.00
7.75
7.50
7.25
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
May
Sep
Jan 2022
May
Sep
Jan 2023
Date

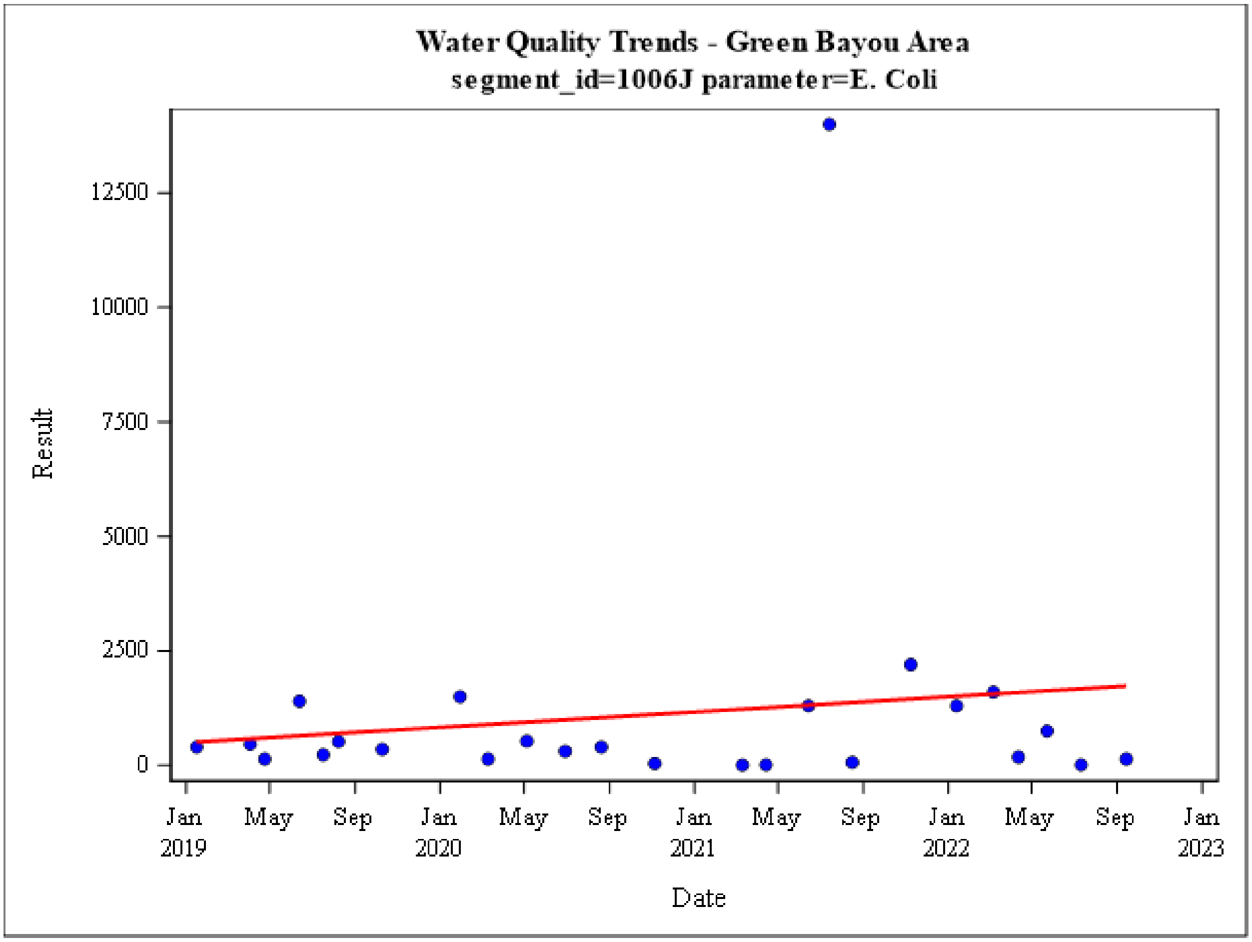

Water Quality Trends - Green Bayou Area
segment_id=1006I parameter=Temperature
Result
25
20
15
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
May
Sep
Jan 2022
May
Sep
Jan 2023
Date

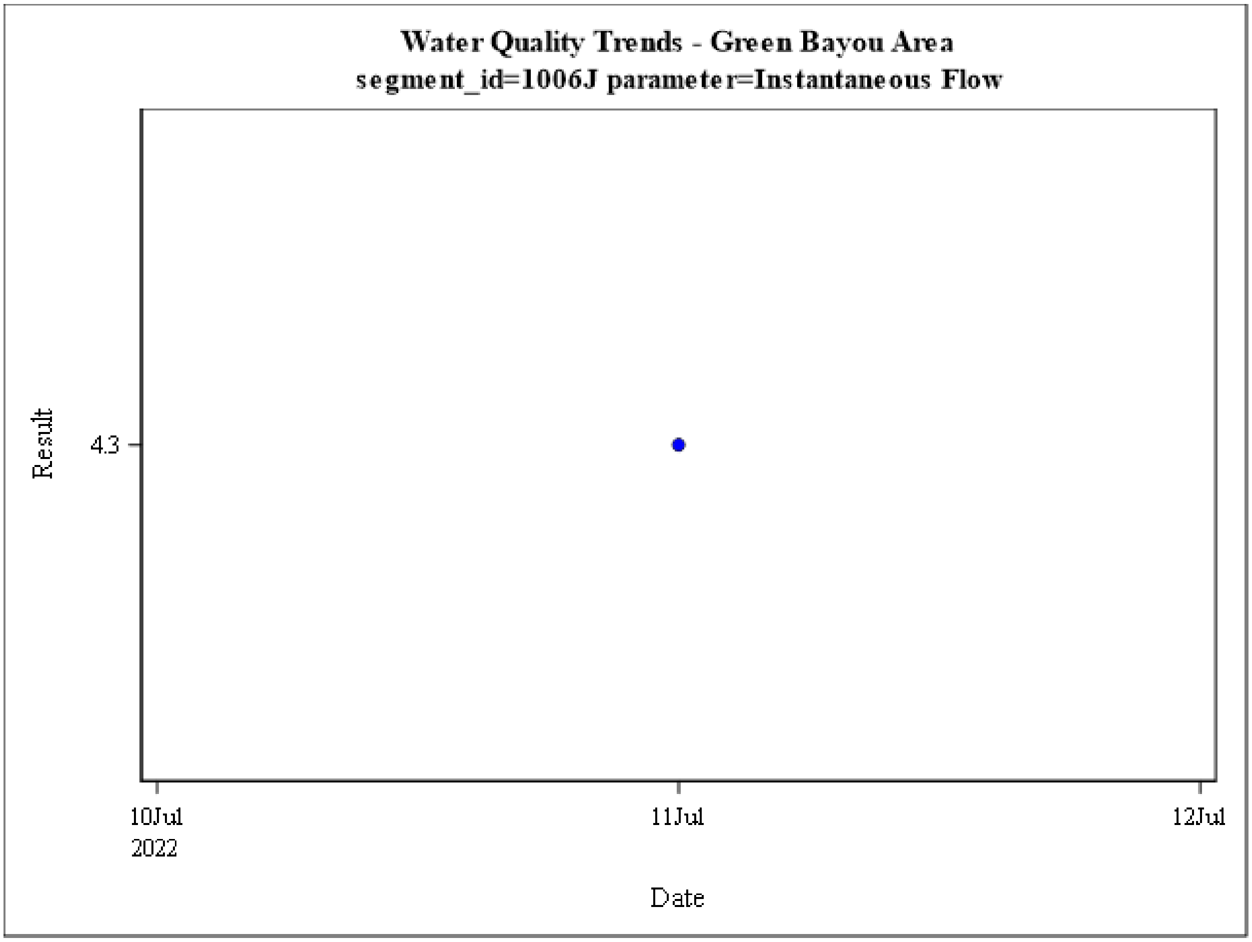

Water Quality Trends - Green Bayou Area
segment_id=1006I parameter=Total Phosphorus
0.25
0.20
0.15
0.10
0.05
Result
01Jan 2019
16Jan
01Feb
16Feb
01Mar
16Mar
01Apr
16Apr
01May
16May
01Jun
16Jun
01Jul
Date

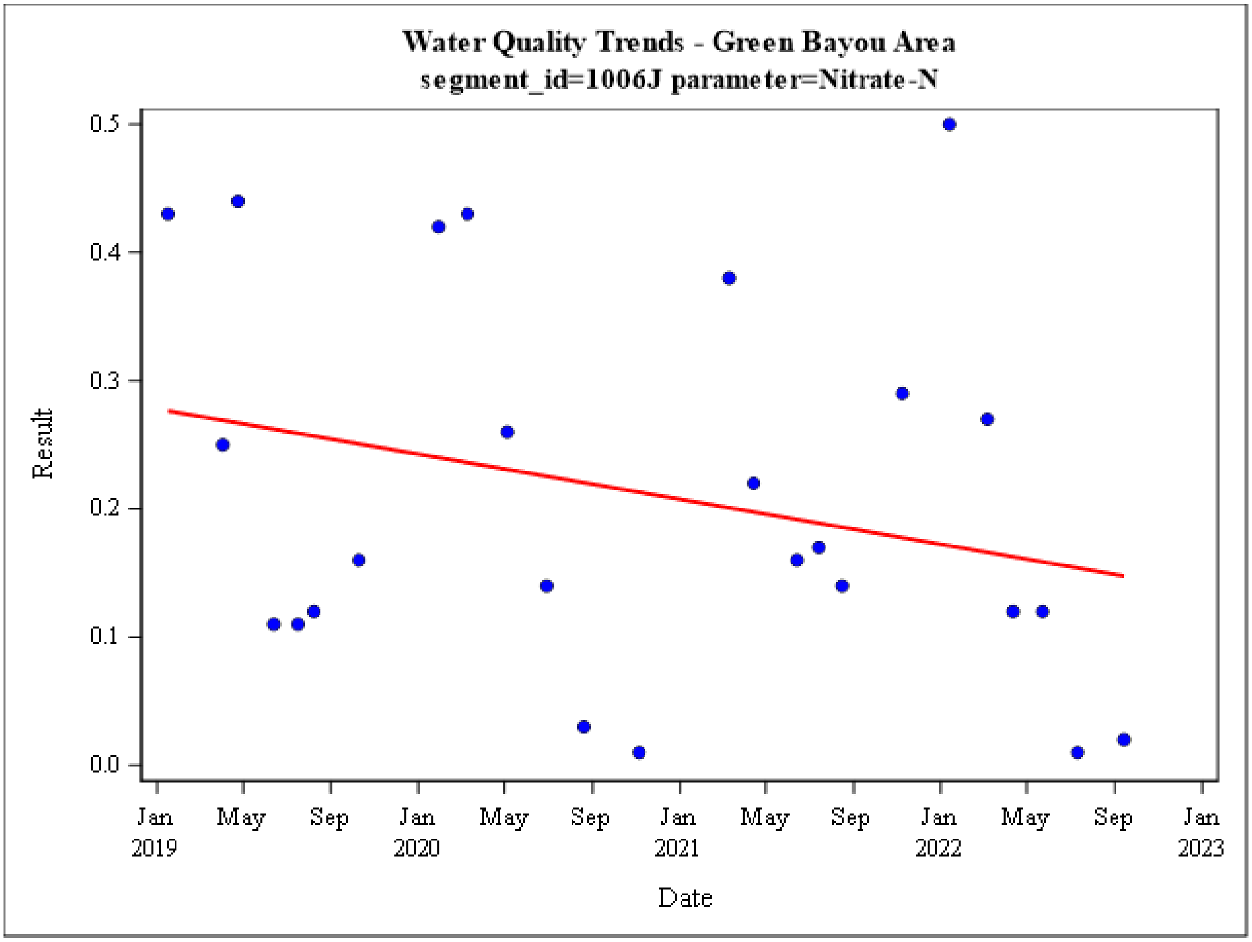
Unnamed Tributary of Halls Bayou (1006J)

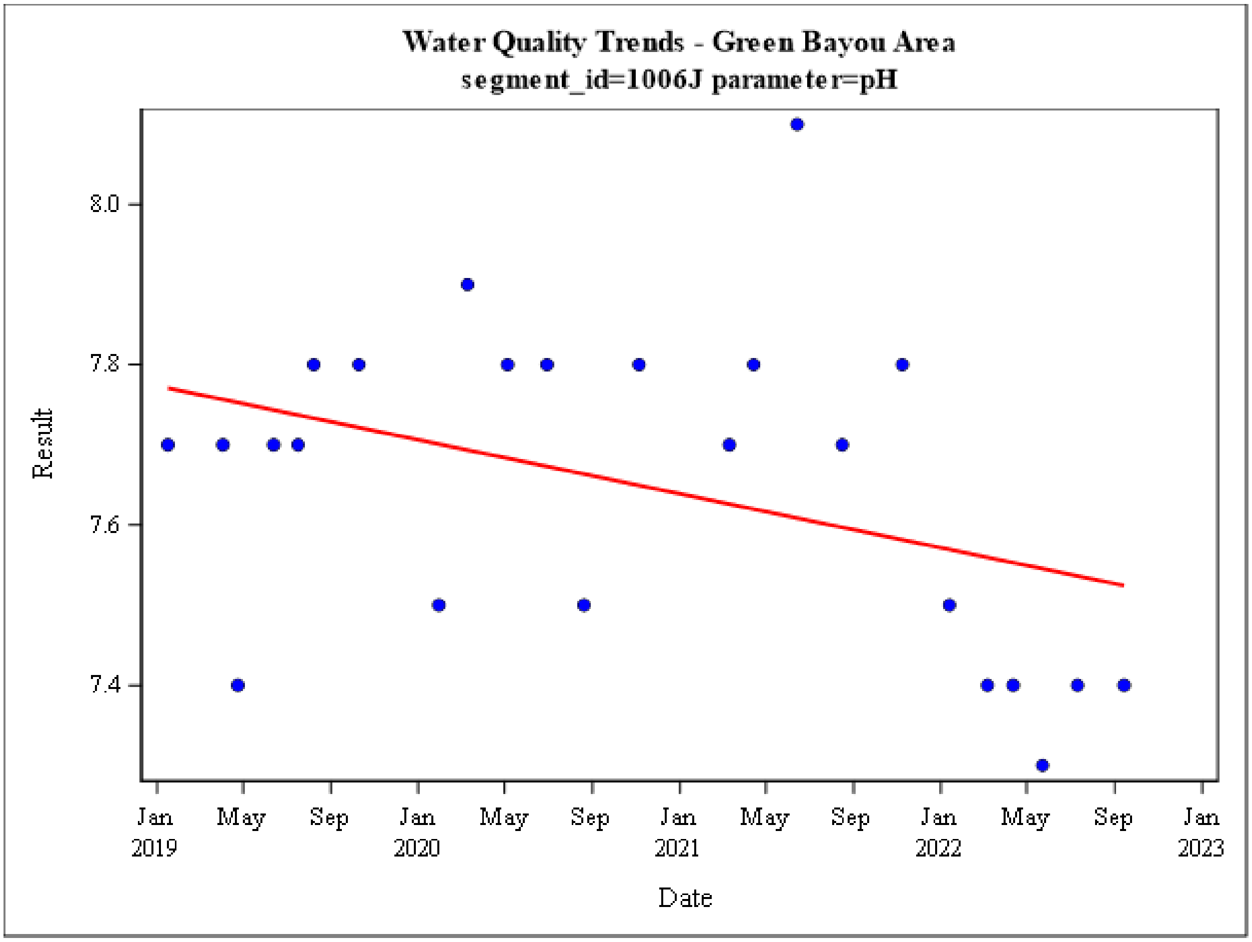


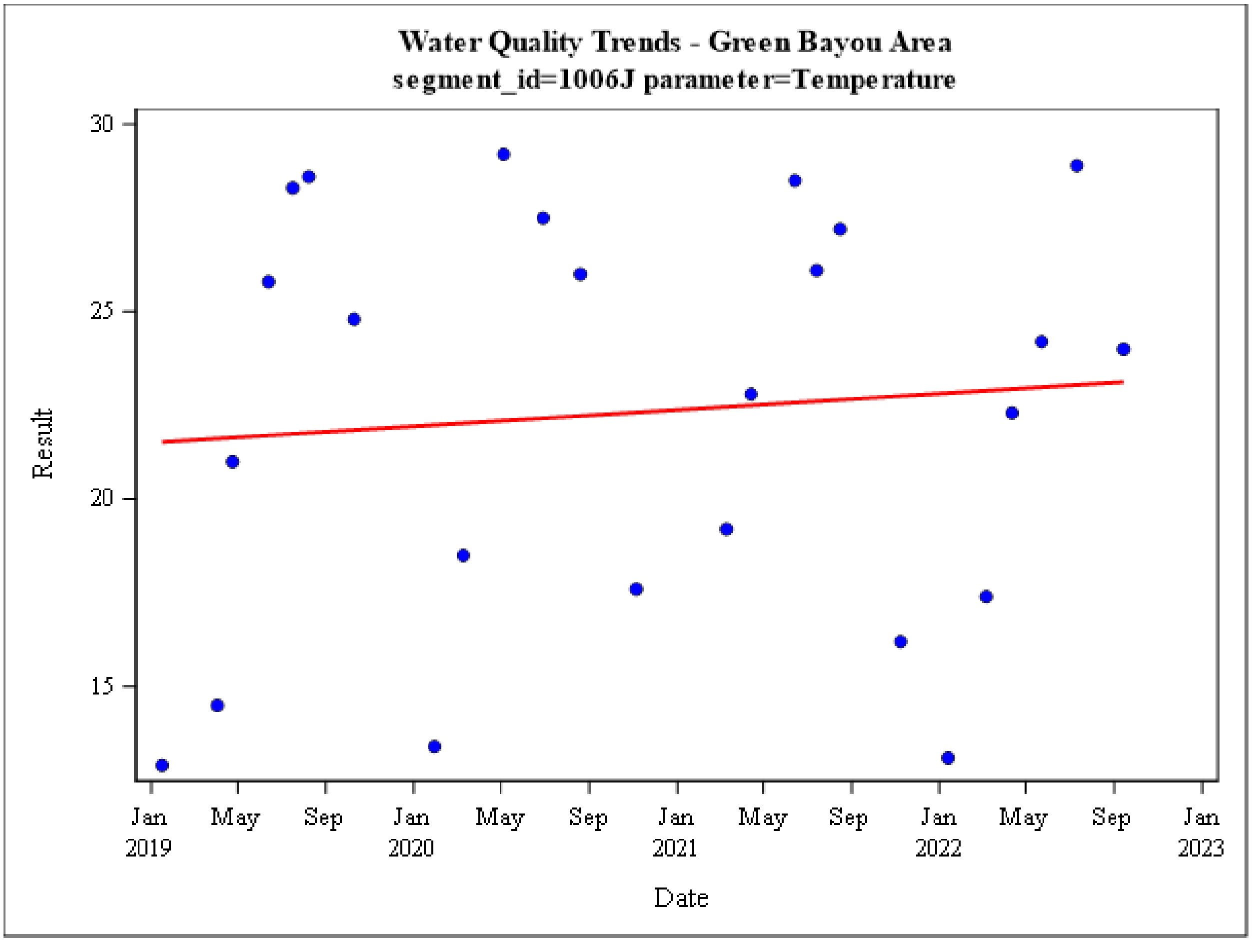

Water Quality Trends - Green Bayou Area
segment_id=1006J parameter=Dissolved Oxygen (24-hour Mean/ Grab Screening Level)
8
6
4
Result
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
May
Sep
Jan 2022
May
Sep
Jan 2023
Date

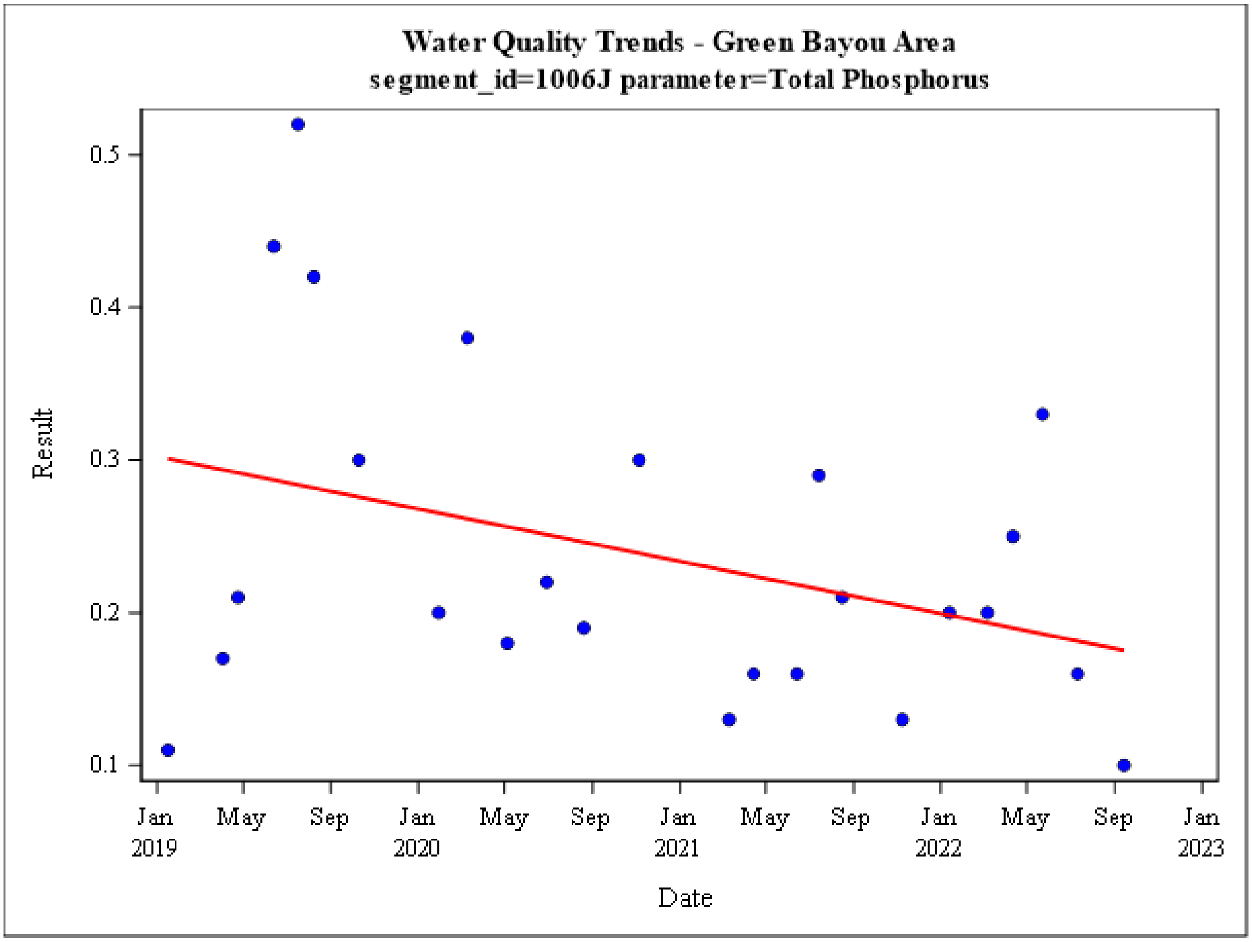

Water Quality Trends - Green Bayou Area
segment_id=1006J parameter=E. Coli
Result
12500
10000
7500
5000
2500
0
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
May
Sep
Jan 2022
May
Sep
Jan 2023
Date


Water Quality Trends - Green Bayou Area
segment_id=1006J parameter=Instantaneous Flow
Result
4.3
10Jul
2022
11Jul
12Jul
Date


Water Quality Trends - Green Bayou Area
segment_id=1006J parameter=Nitrate-N
Result
0.0
0.1
0.2
0.3
0.4
0.5
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
May
Sep
Jan 2022
May
Sep
Jan 2023
Date

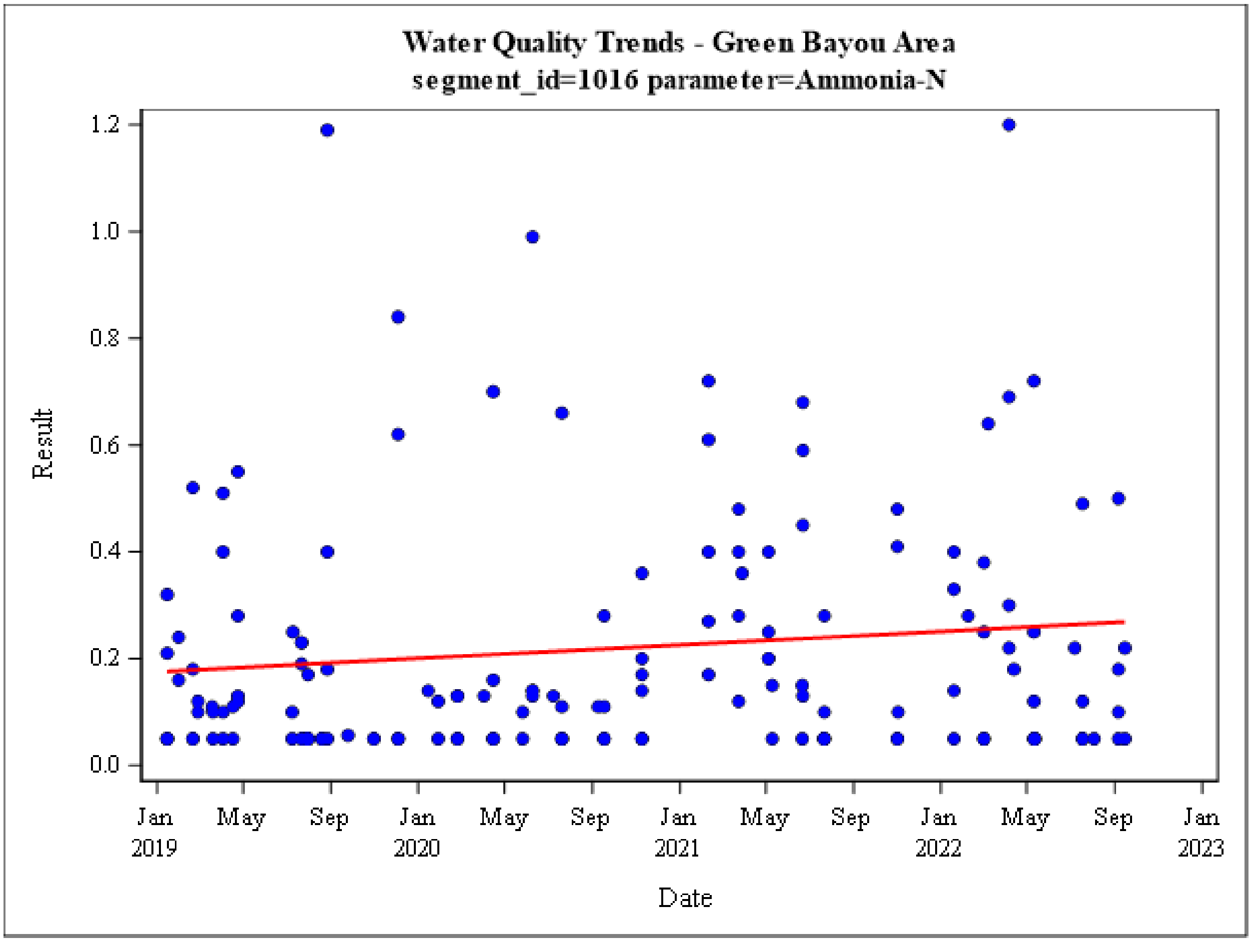

Water Quality Trends - Green Bayou Area
segment_id=1006J parameter=pH
Result
8.0
7.8
7.6
7.4
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
May
Sep
Jan 2022
May
Sep
Jan 2023
Date

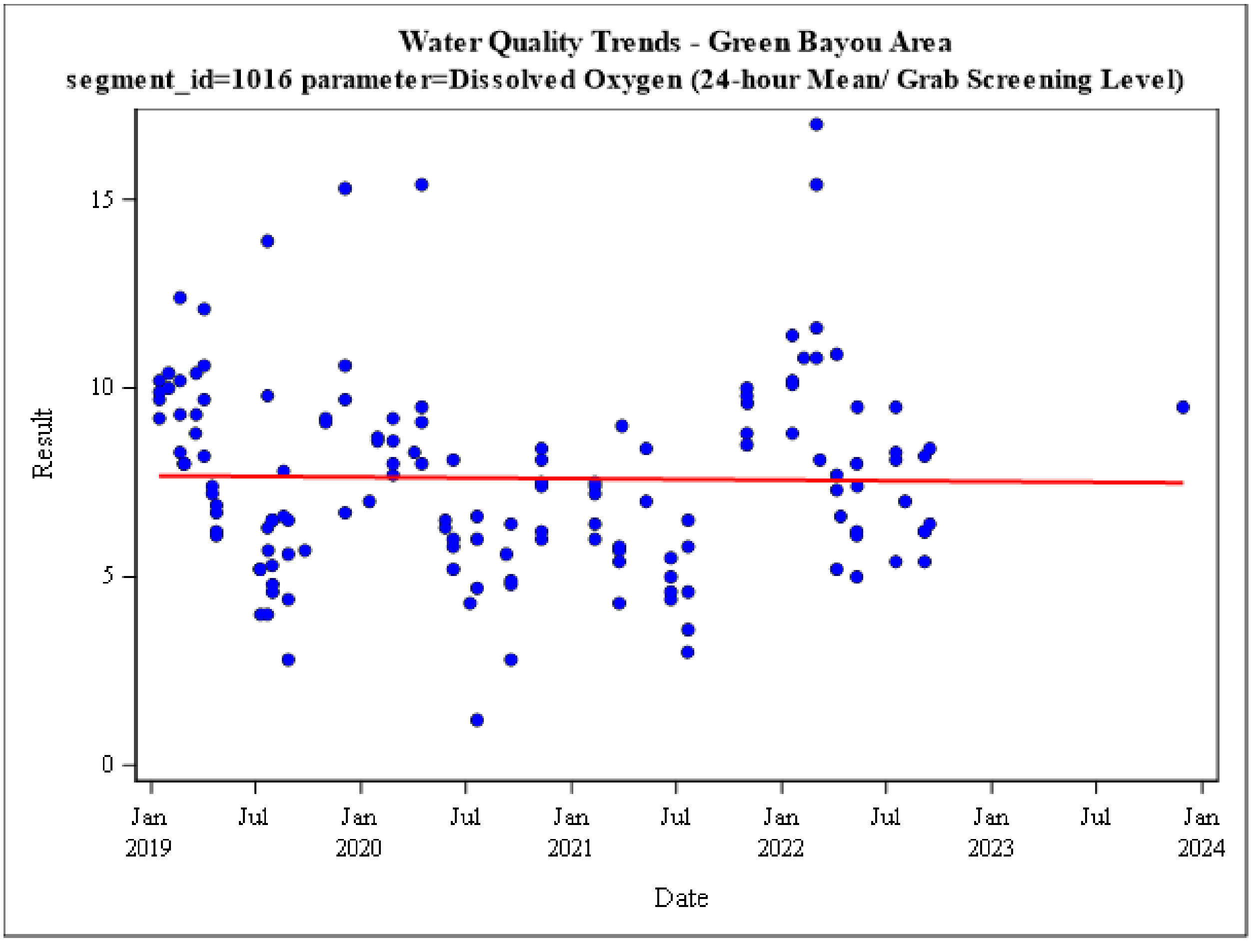

Water Quality Trends - Green Bayou Area
segment_id=1006J parameter=Temperature
30
25
20
15
Result
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
May
Sep
Jan 2022
May
Sep
Jan 2023
Date

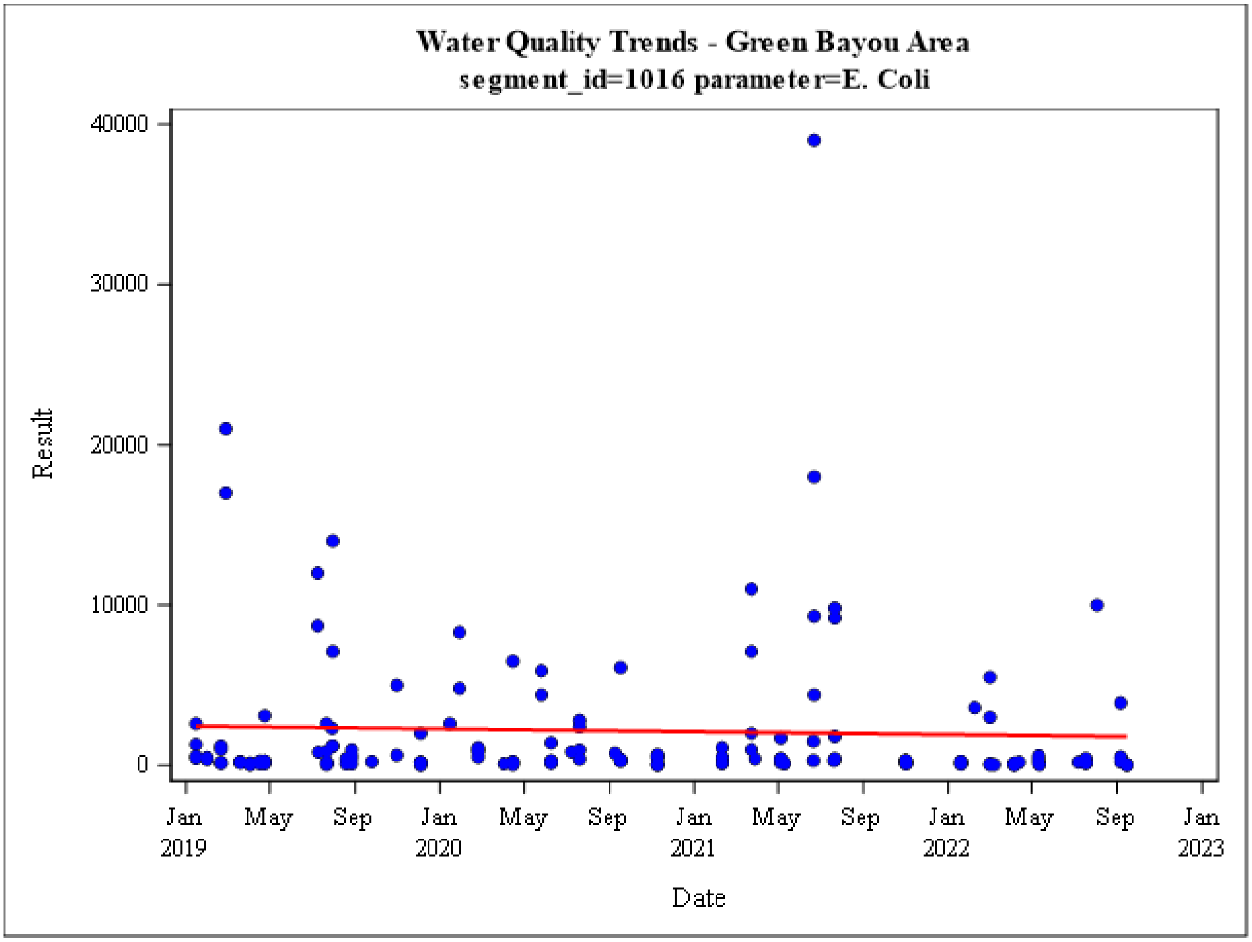


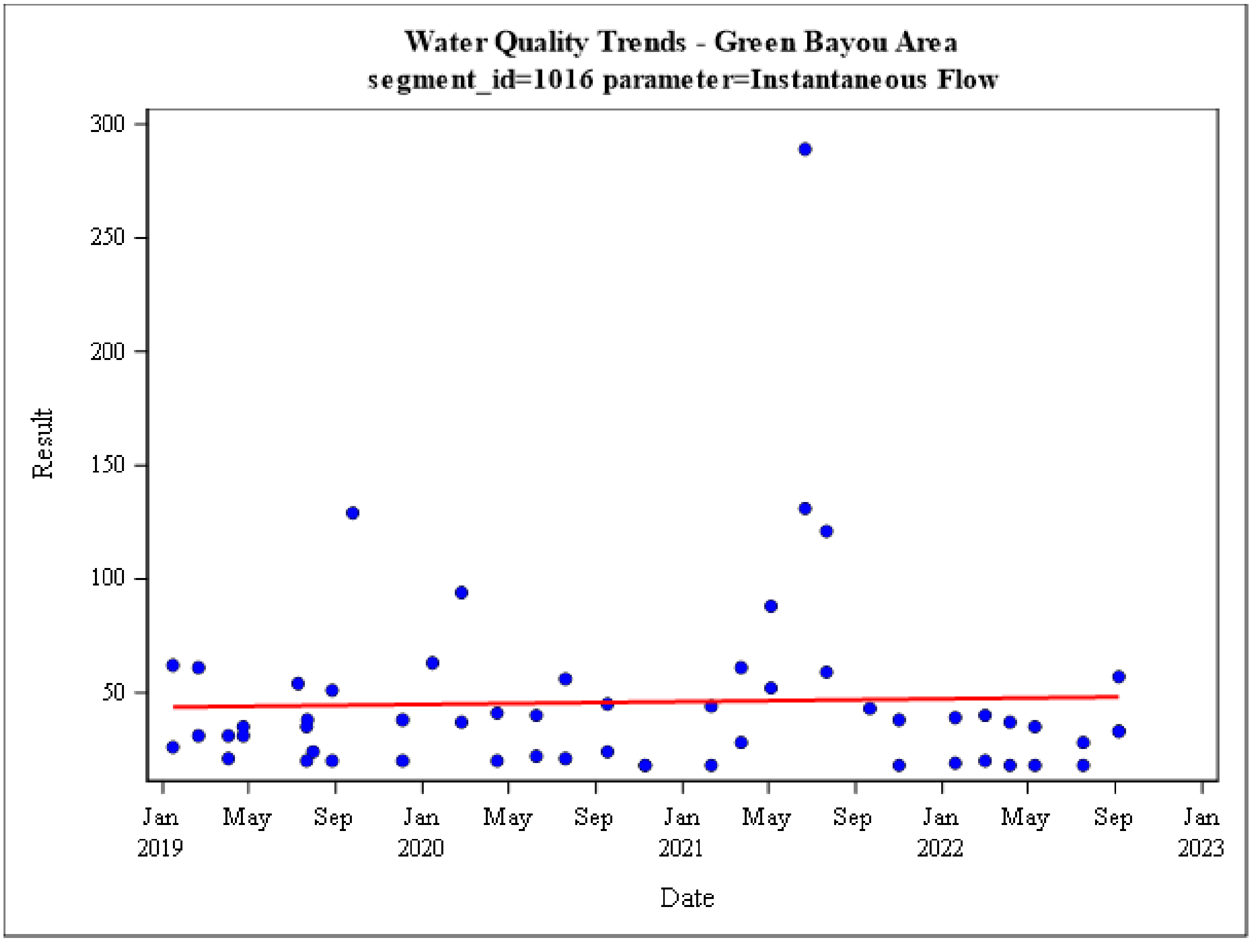
Water Quality Trends - Green Bayou Area
segment_id=1006J parameter=Total Phosphorus
Result
0.1
0.2
0.3
0.4
0.5
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
May
Sep
Jan 2022
May
Sep
Jan 2023
Date

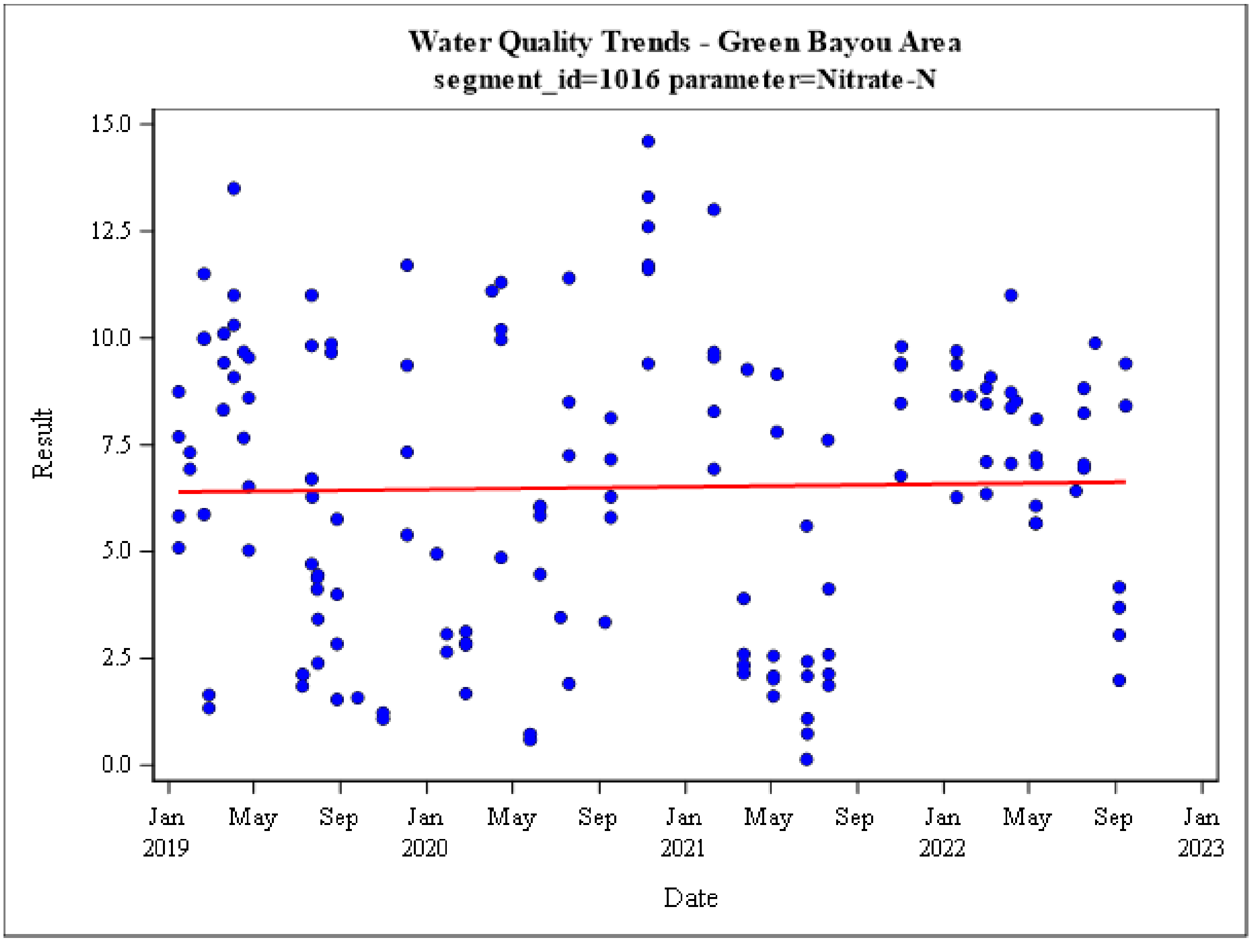
Greens Bayou (1016)

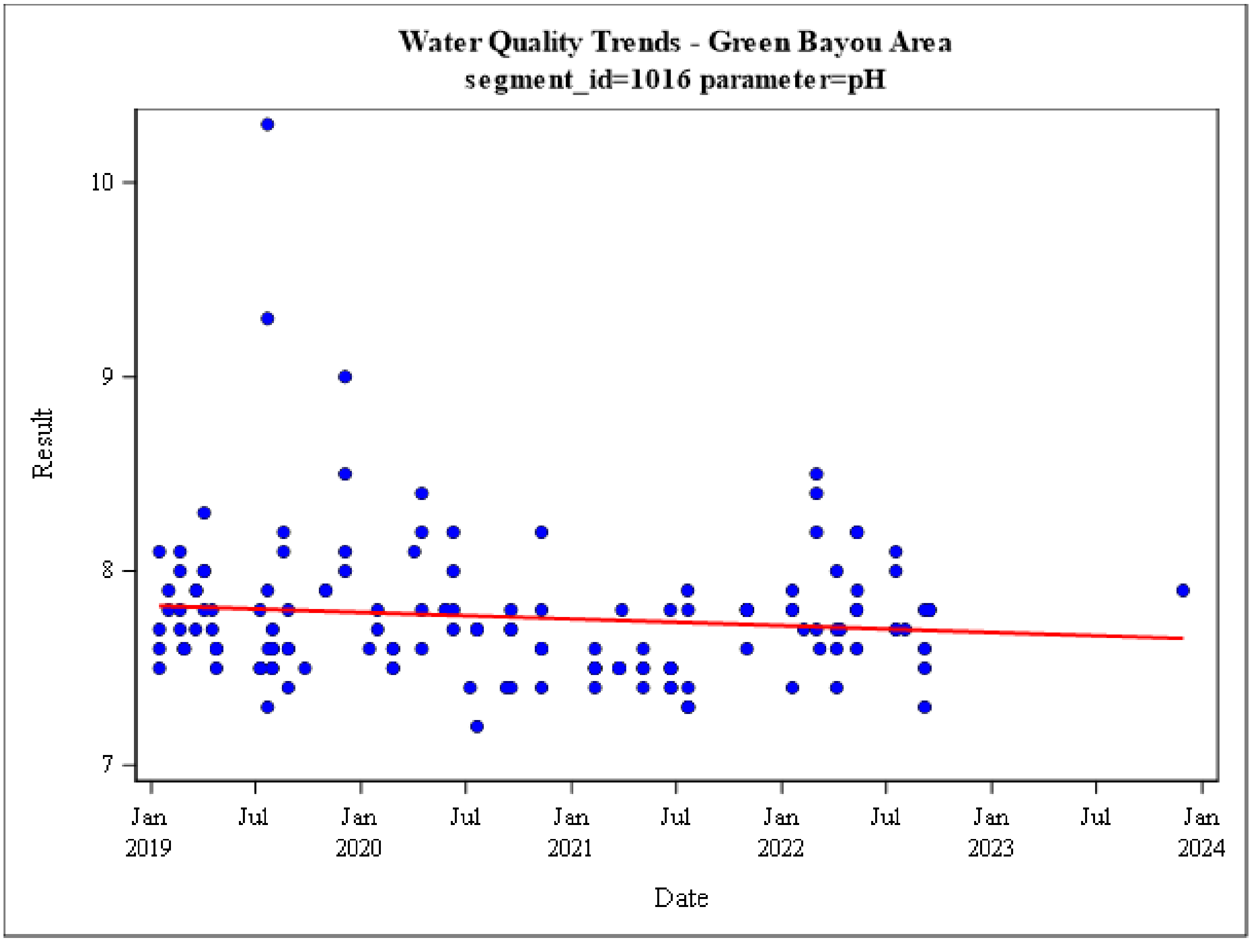


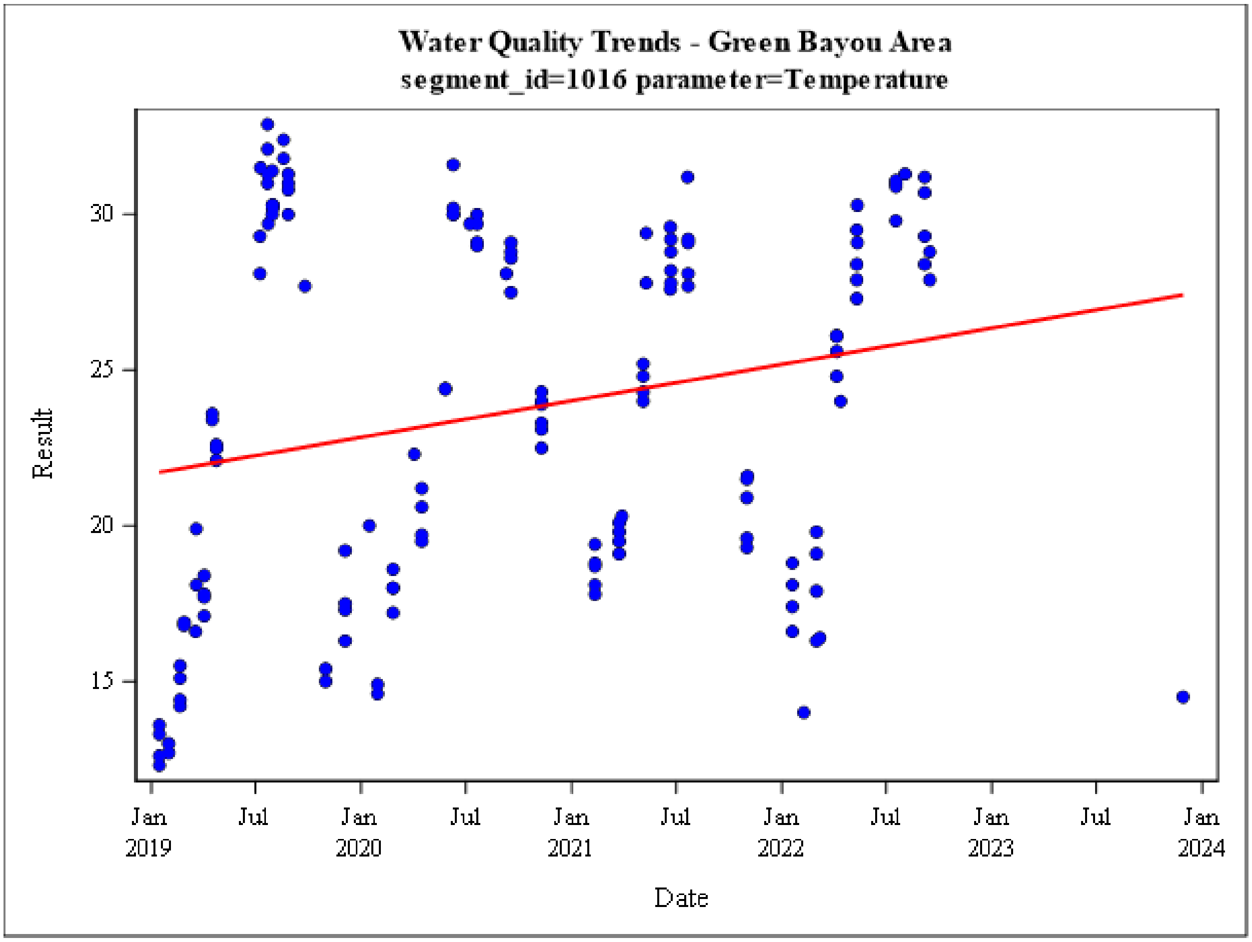

Water Quality Trends - Green Bayou Area
segment_id=1016 parameter=Dissolved Oxygen (24-hour Mean/ Grab Screening Level)
Result
0
5
10
15
Jan 2019
Jul
Jan 2020
Jul
Jan 2021
Jul
Jan 2022
Jul
Jan 2023
Jul
Jan 2024
Date

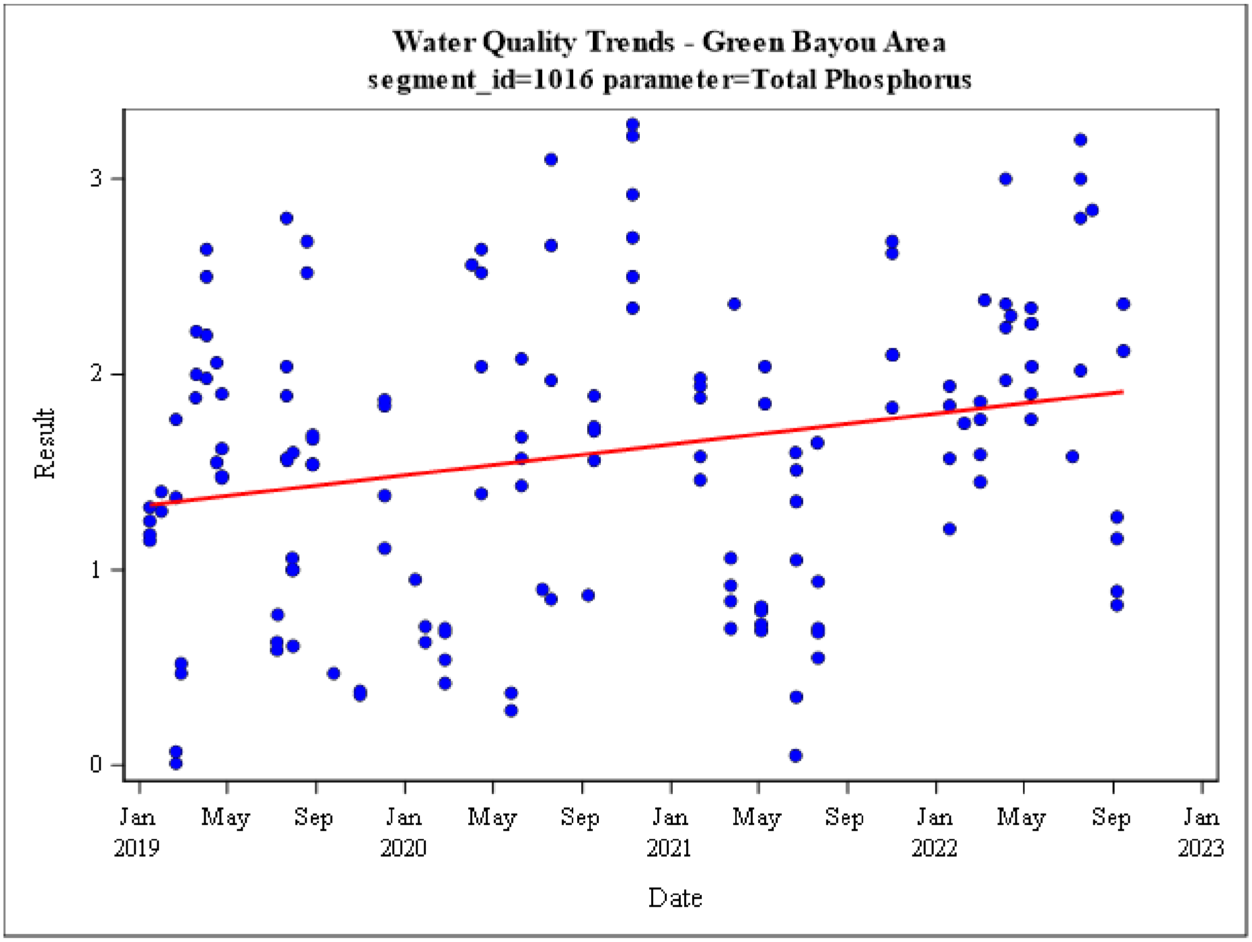

Water Quality Trends - Green Bayou Area
segment_id=1016 parameter=E. Coli
Result
40000
30000
20000
10000
0
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
May
Sep
Jan 2022
May
Sep
Jan 2023
Date


Water Quality Trends - Green Bayou Area
segment_id=1016 parameter=Instantaneous Flow
Result
300
250
200
150
100
50
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
May
Sep
Jan 2022
May
Sep
Jan 2023
Date

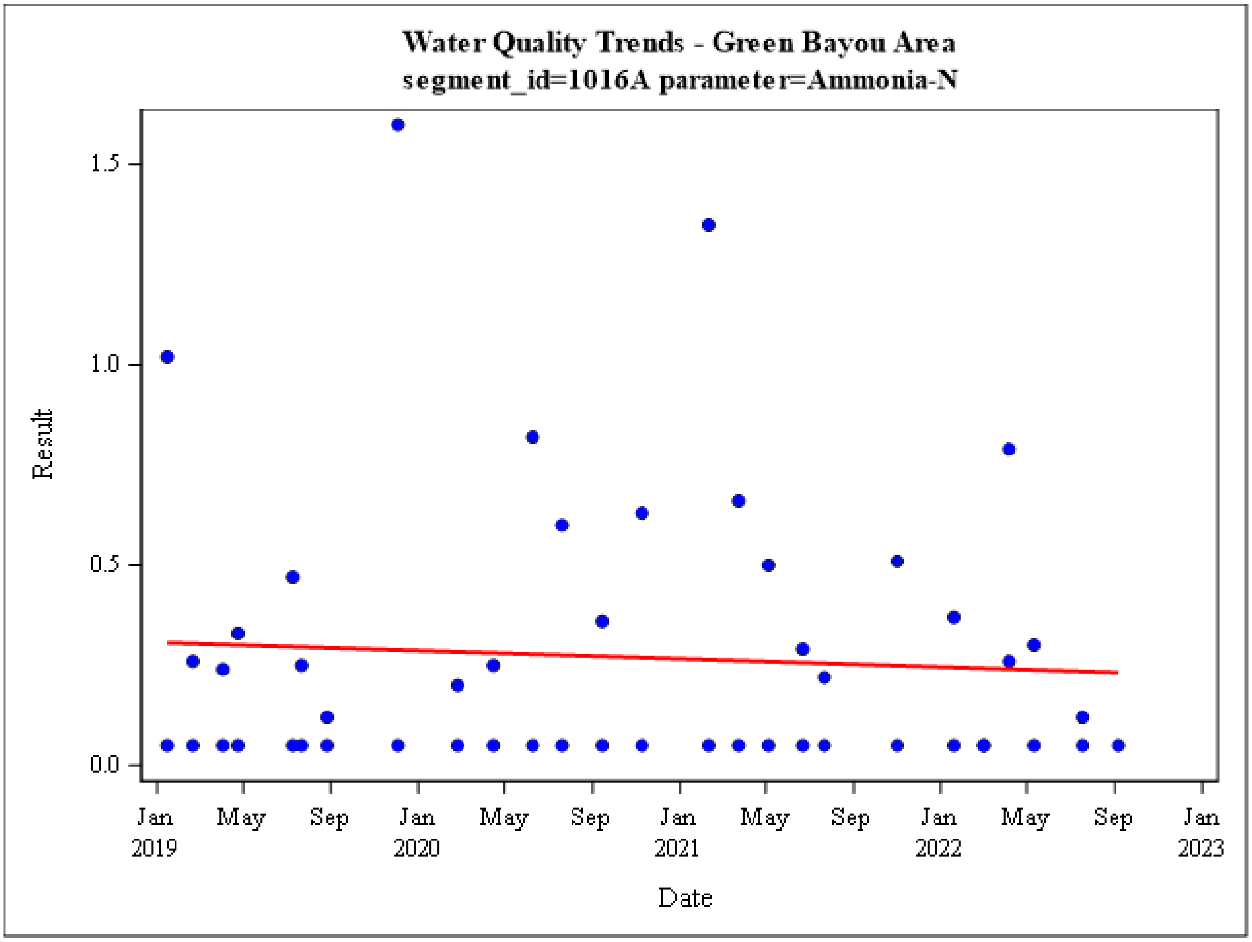

Water Quality Trends - Green Bayou Area
segment_id=1016 parameter=Nitrate-N
Result
15.0
12.5
10.0
7.5
5.0
2.5
0.0
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
May
Sep
Jan 2022
May
Sep
Jan 2023
Date

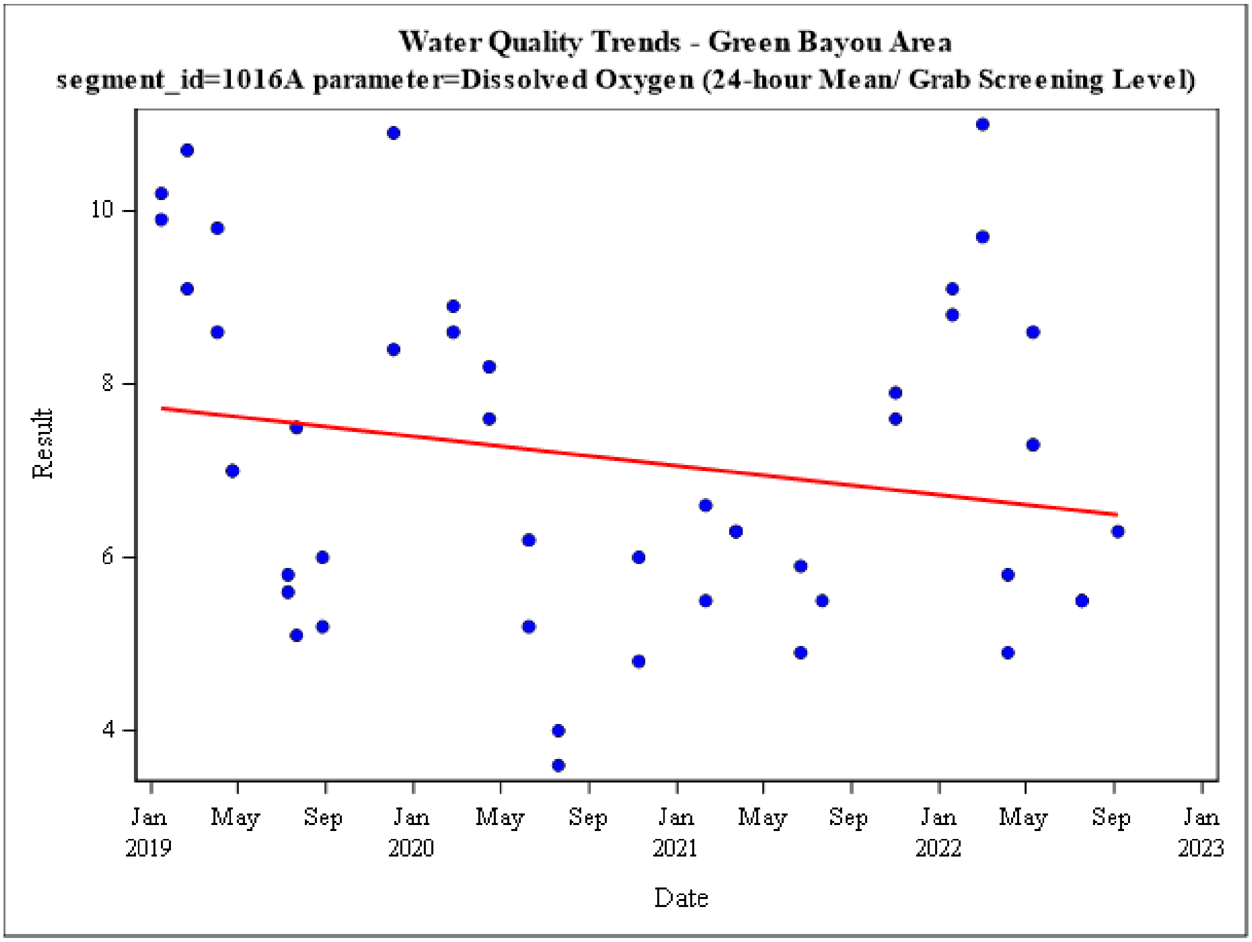

Water Quality Trends - Green Bayou Area
segment_id=1016 parameter=pH
Result
10
9
8
7
Jan 2019
Jul
Jan 2020
Jul
Jan 2021
Jul
Jan 2022
Jul
Jan 2023
Jul
Jan 2024
Date

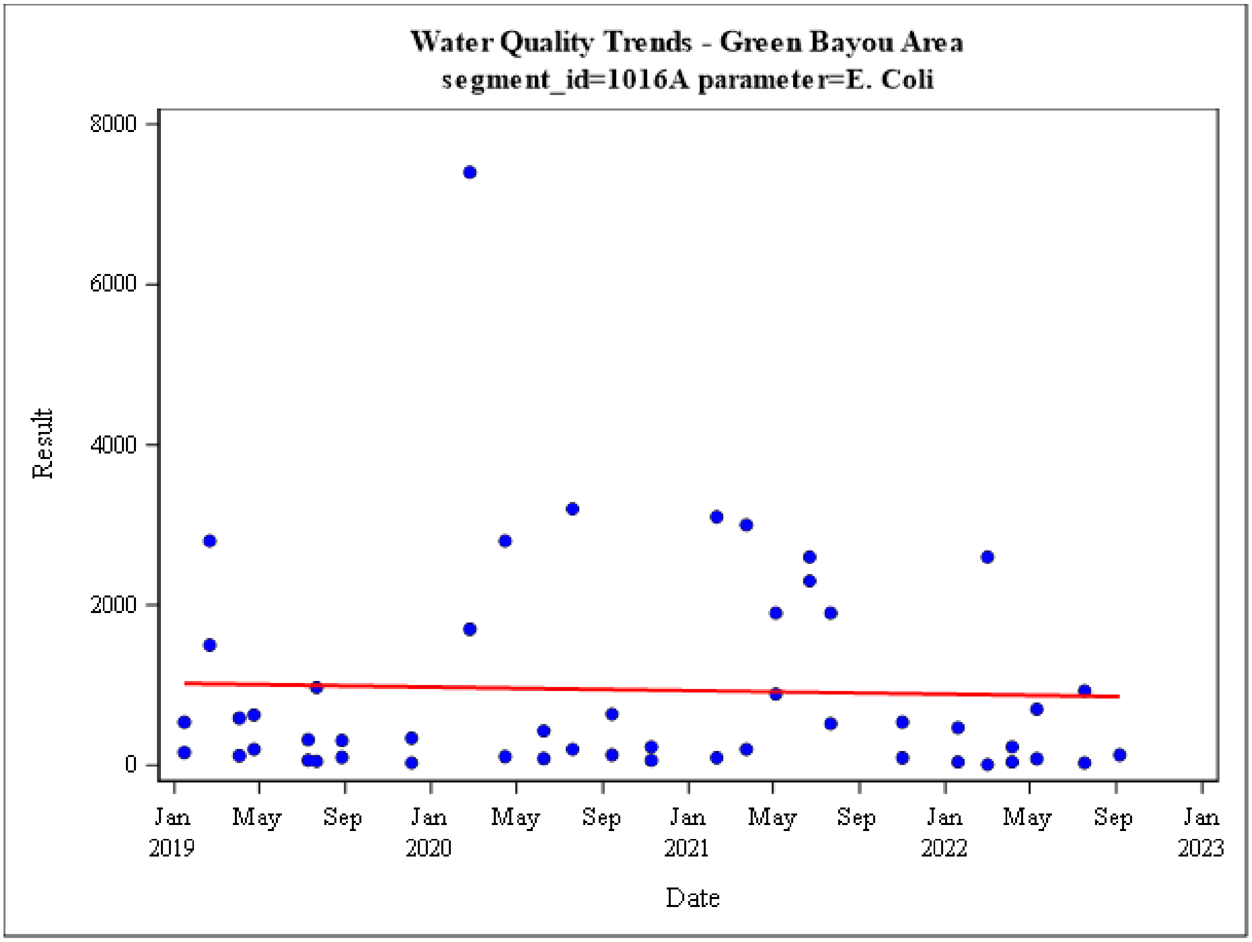

Water Quality Trends - Green Bayou Area
segment_id=1016 parameter=Temperature
Result
30
25
20
15
Jan 2019
Jul
Jan 2020
Jul
Jan 2021
Jul
Jan 2022
Jul
Jan 2023
Jul
Jan 2024
Date

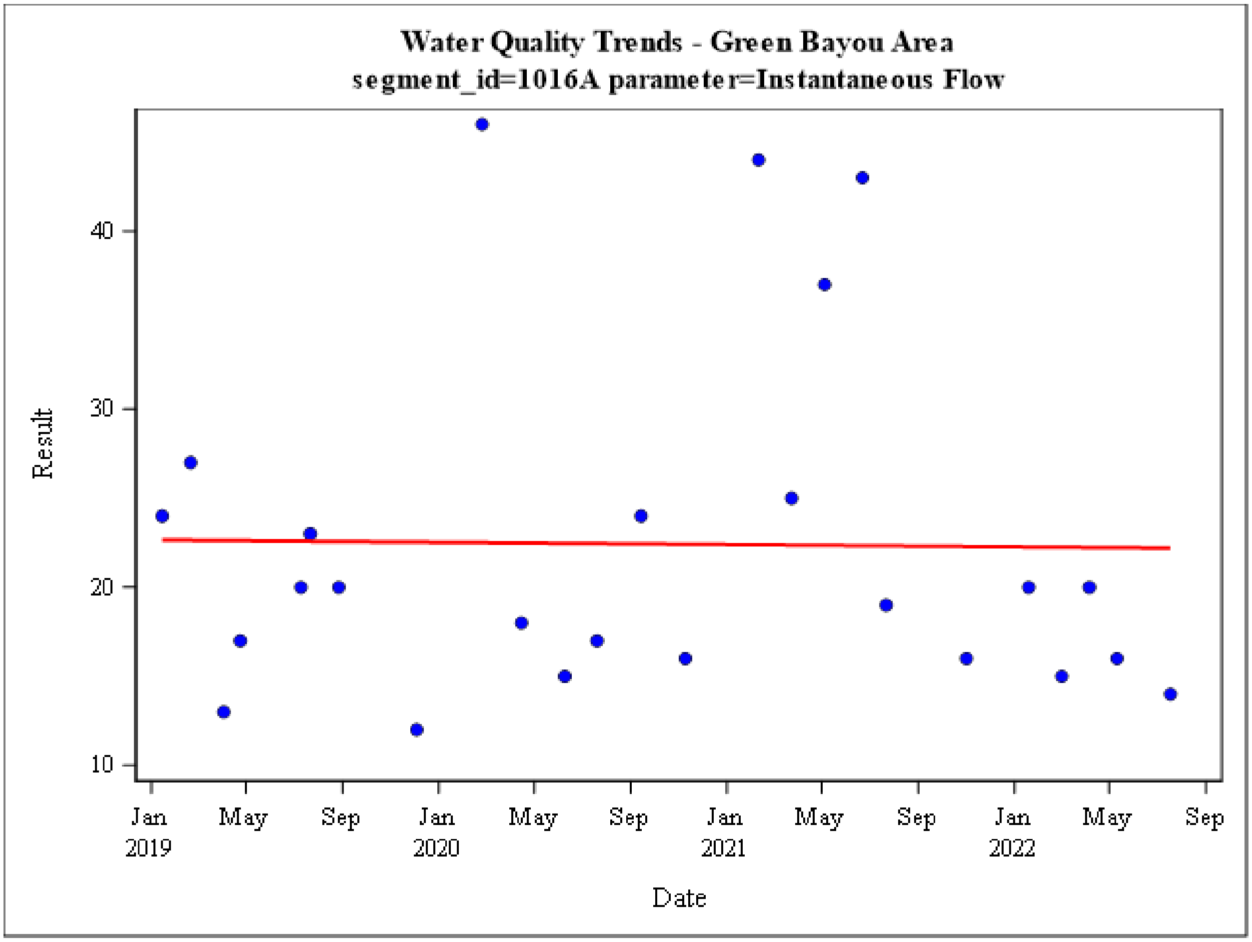

Water Quality Trends - Green Bayou Area
segment_id=1016 parameter=Total Phosphorus
Result
3
2
1
0
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
May
Sep
Jan 2022
May
Sep
Jan 2023
Date

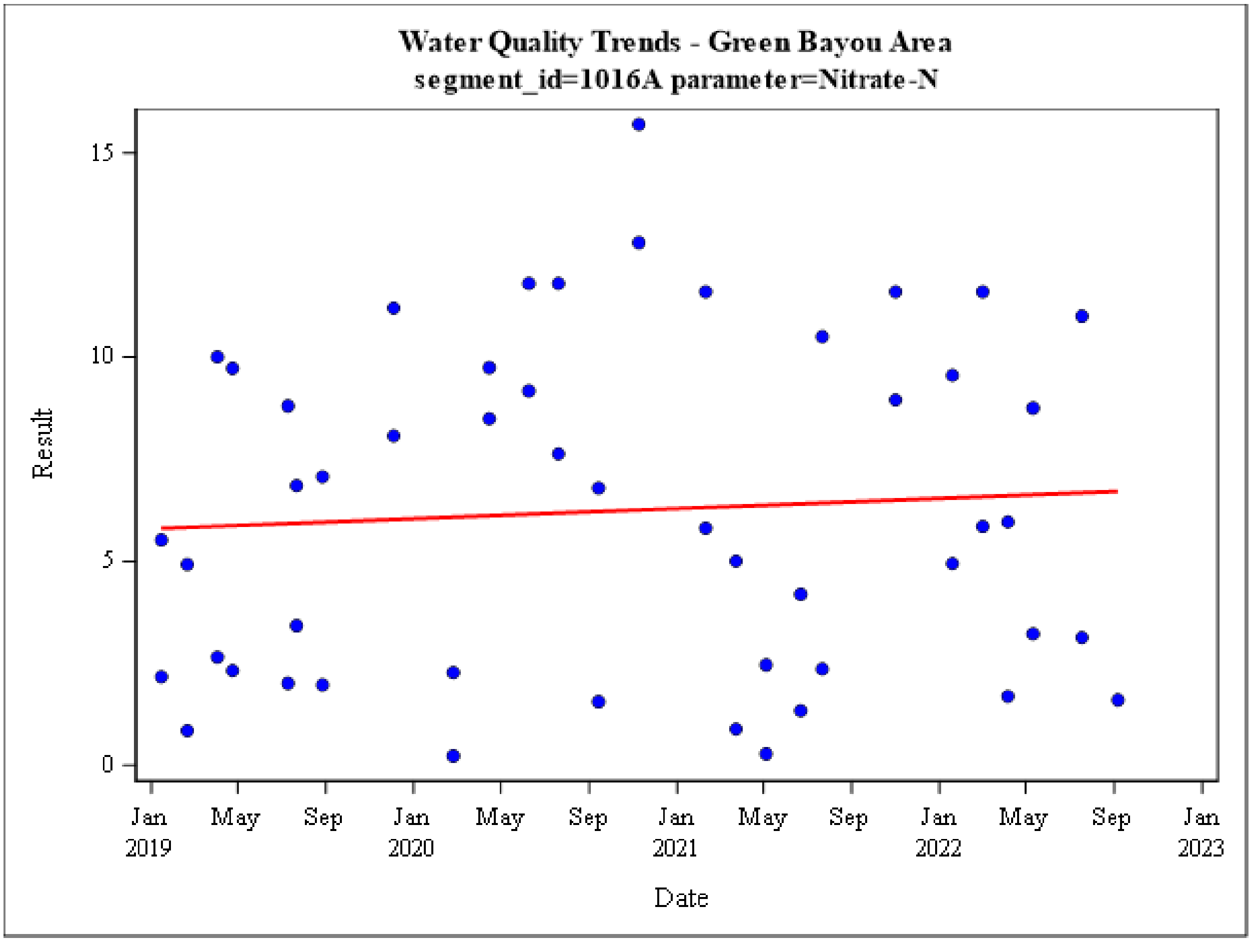
Garners Bayou (1016A)

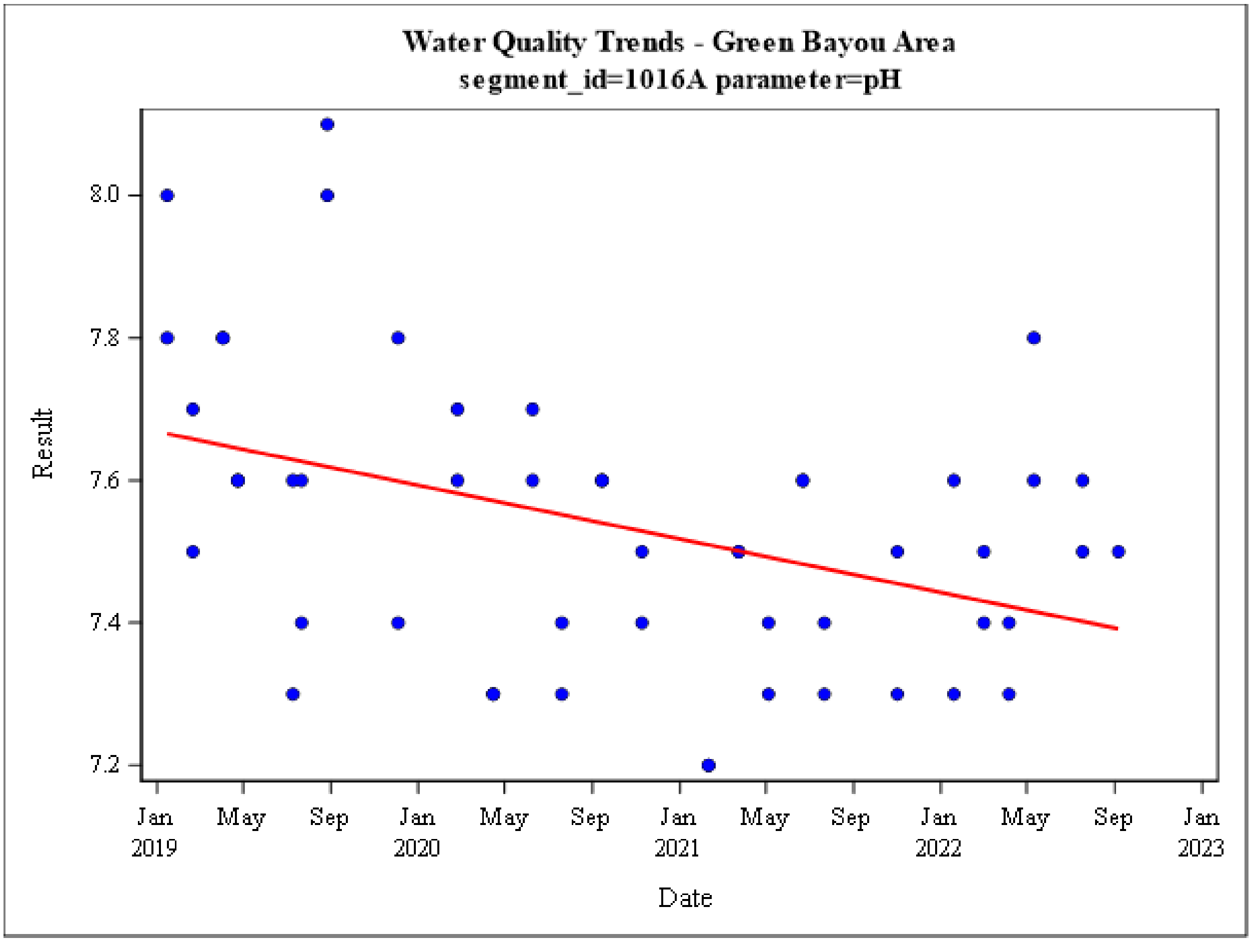


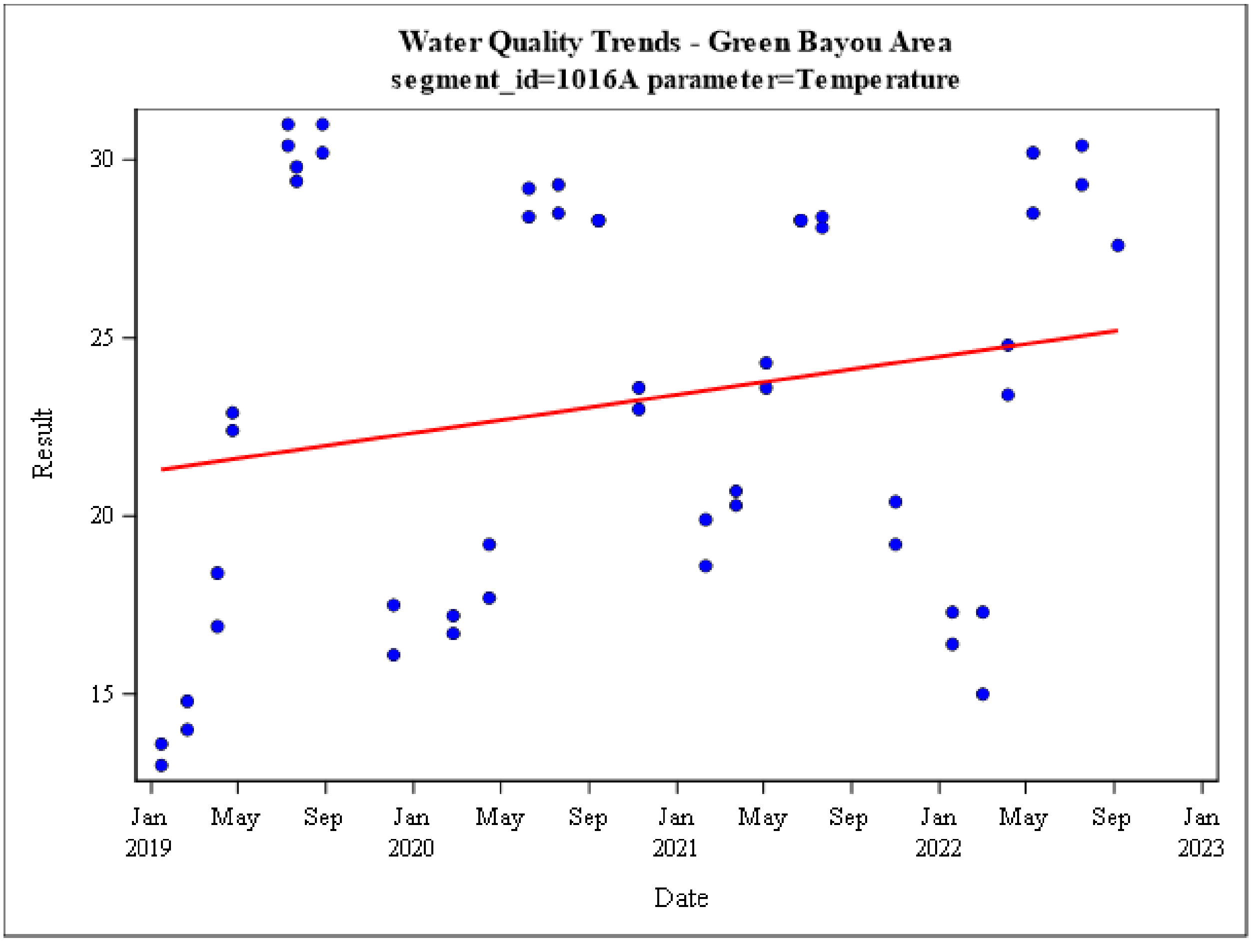

Water Quality Trends - Green Bayou Area
segment_id=1016A parameter=Dissolved Oxygen (24-hour Mean/ Grab Screening Level)
Result
10
8
6
4
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
May
Sep
Jan 2022
May
Sep
Jan 2023
Date

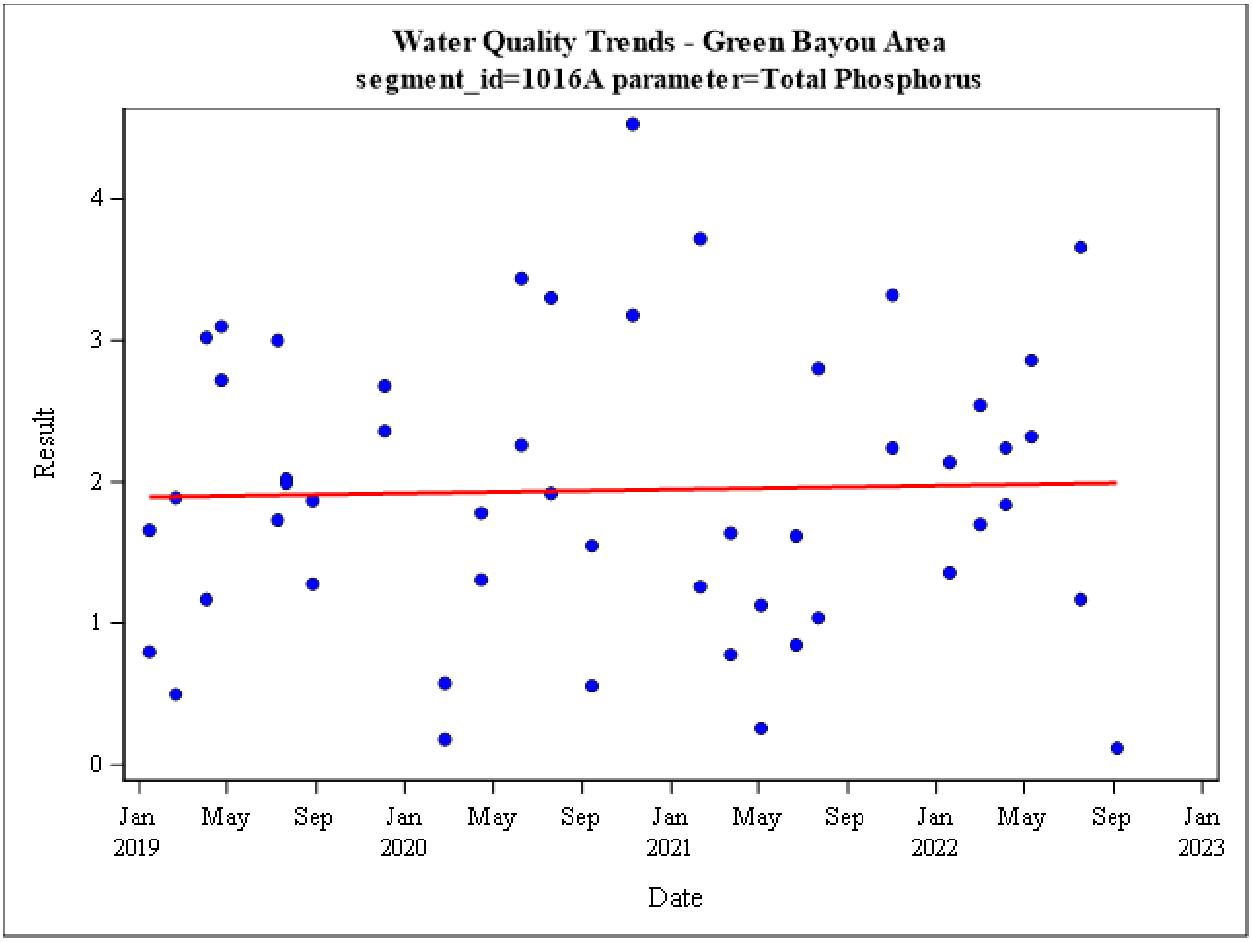

Water Quality Trends - Green Bayou Area
segment_id=1016A parameter=E. Coli
Result
8000
6000
4000
2000
0
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
May
Sep
Jan 2022
May
Sep
Jan 2023
Date


Water Quality Trends - Green Bayou Area
segment_id=1016A parameter=Instantaneous Flow
Result
40
30
20
10
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
May
Sep
Jan 2022
May
Sep
Date

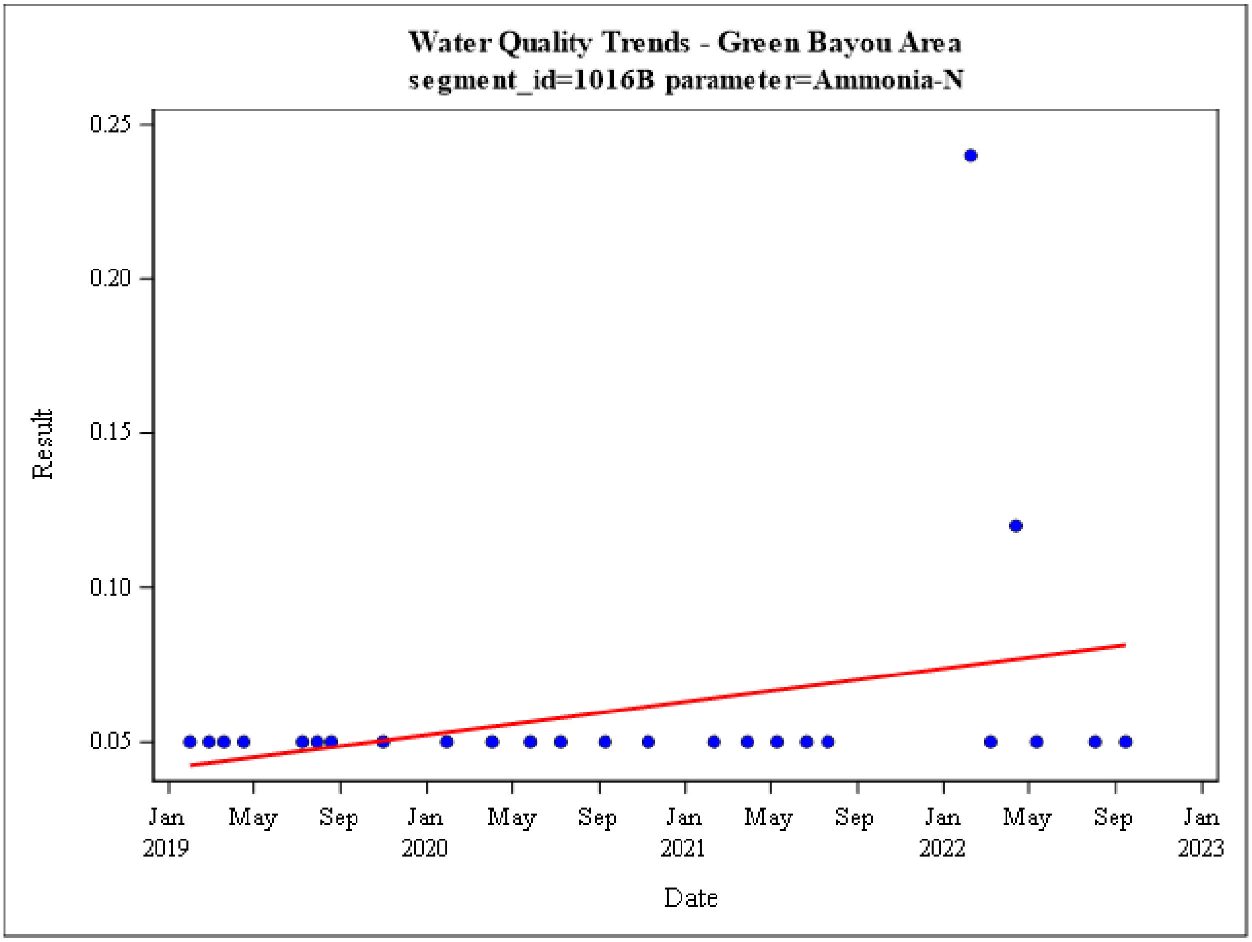

Water Quality Trends - Green Bayou Area
segment_id=1016A parameter=Nitrate-N
Result
15
10
5
0
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
May
Sep
Jan 2022
May
Sep
Jan 2023
Date

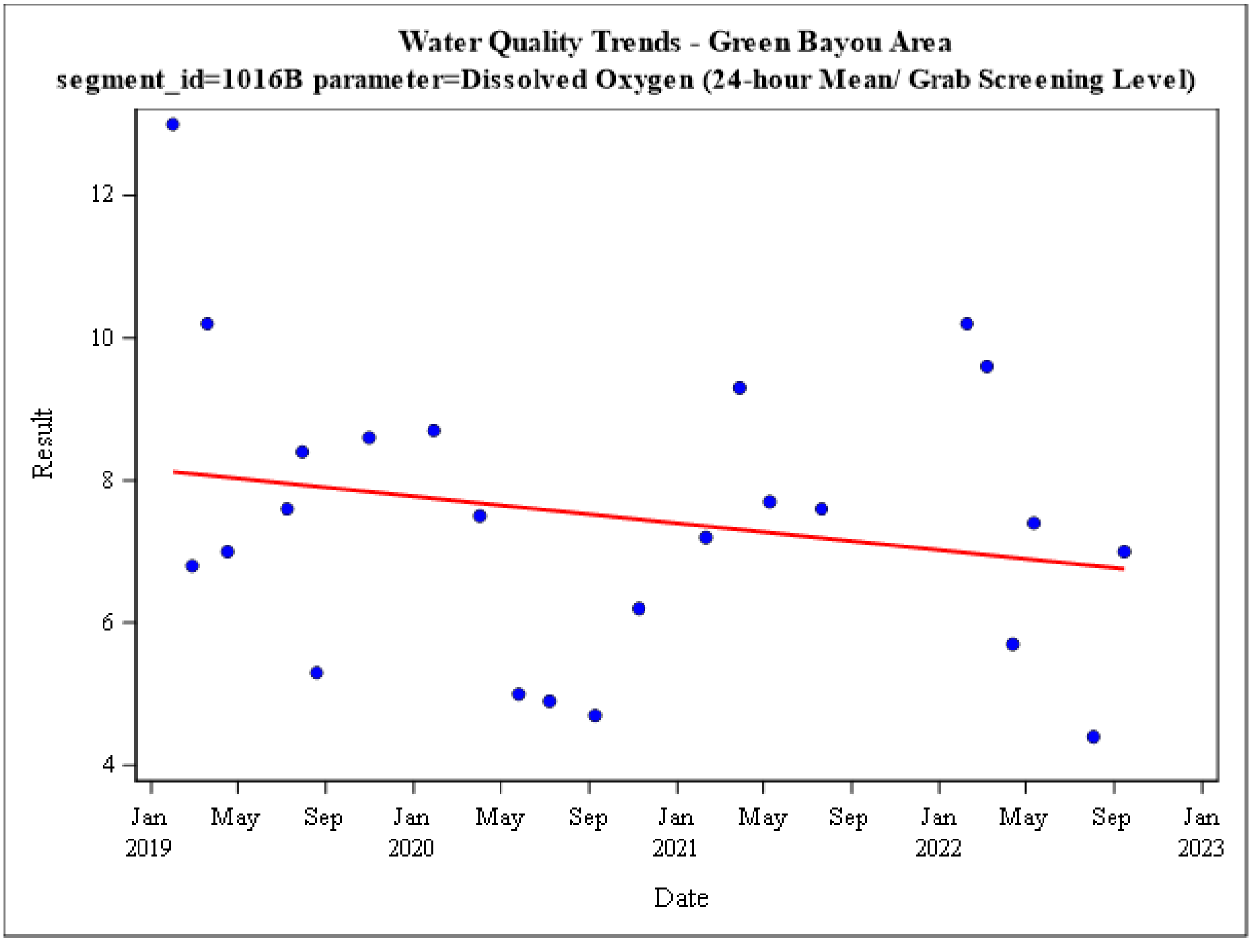

Water Quality Trends - Green Bayou Area
segment_id=1016A parameter=pH
Result
8.0
7.8
7.6
7.4
7.2
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
May
Sep
Jan 2022
May
Sep
Jan 2023
Date

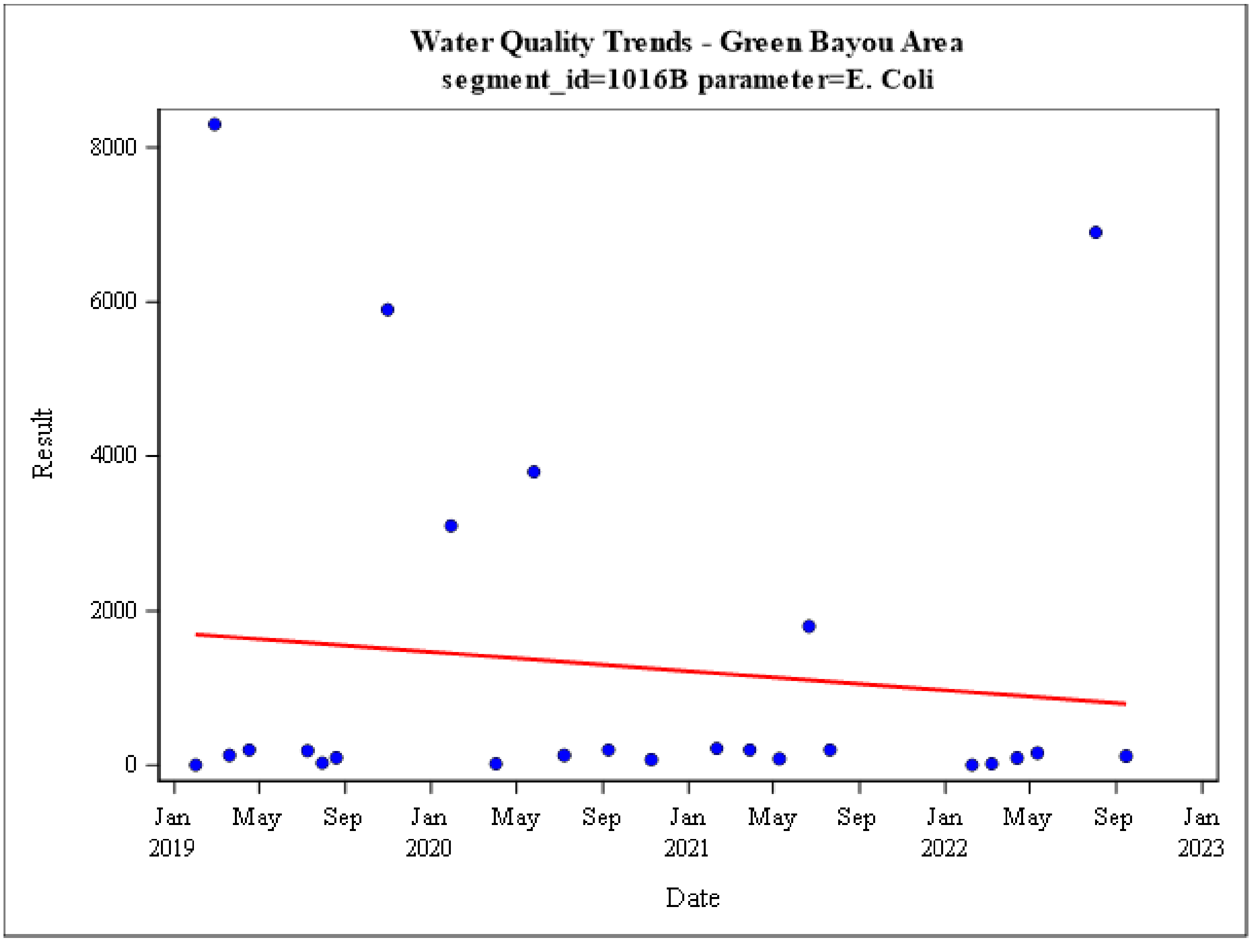

Water Quality Trends - Green Bayou Area
segment_id=1016A parameter=Temperature
Result
30
25
20
15
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
May
Sep
Jan 2022
May
Sep
Jan 2023
Date

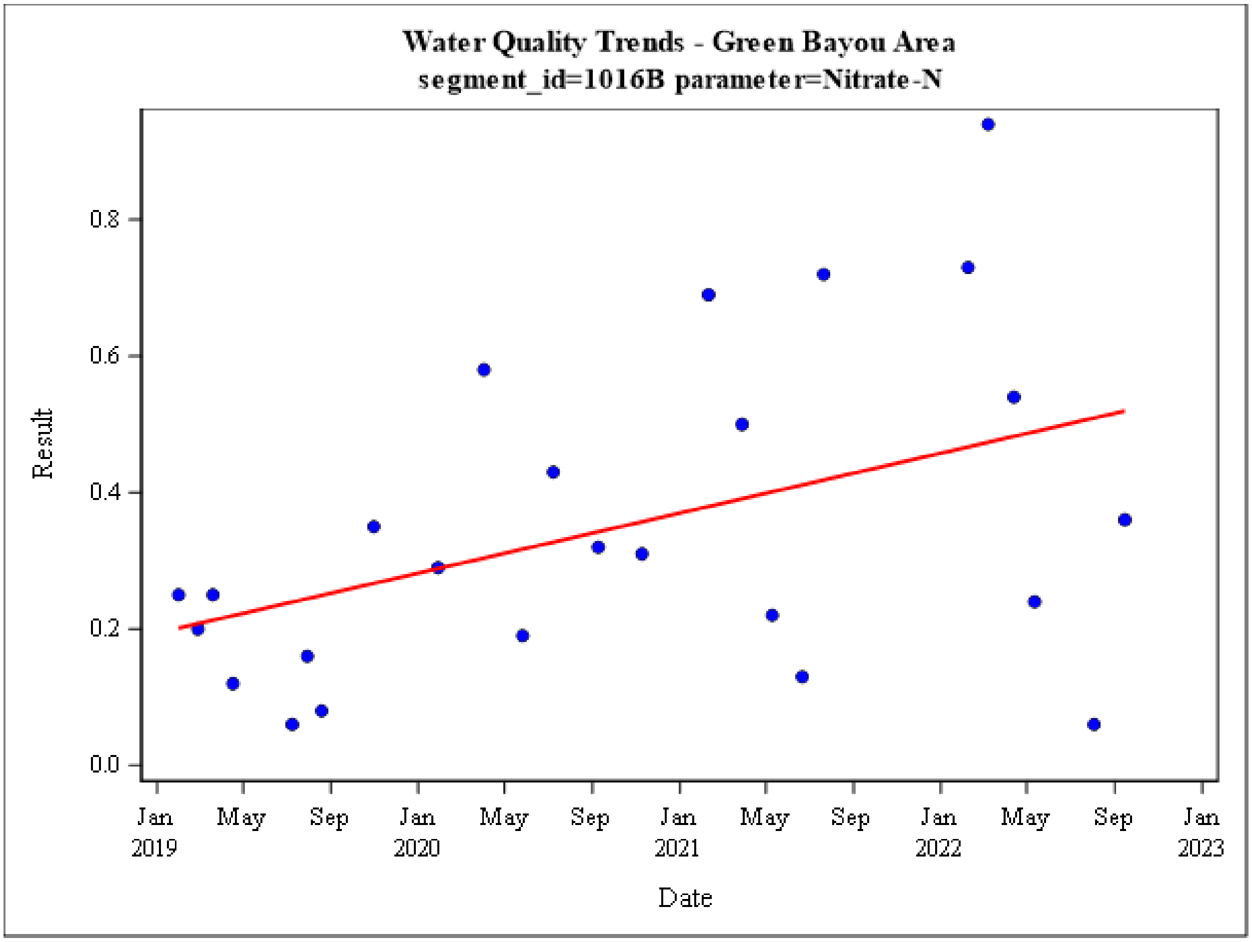

Water Quality Trends - Green Bayou Area
segment_id=1016A parameter=Total Phosphorus
Result
0
1
2
3
4
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
May
Sep
Jan 2022
May
Sep
Jan 2023
Date

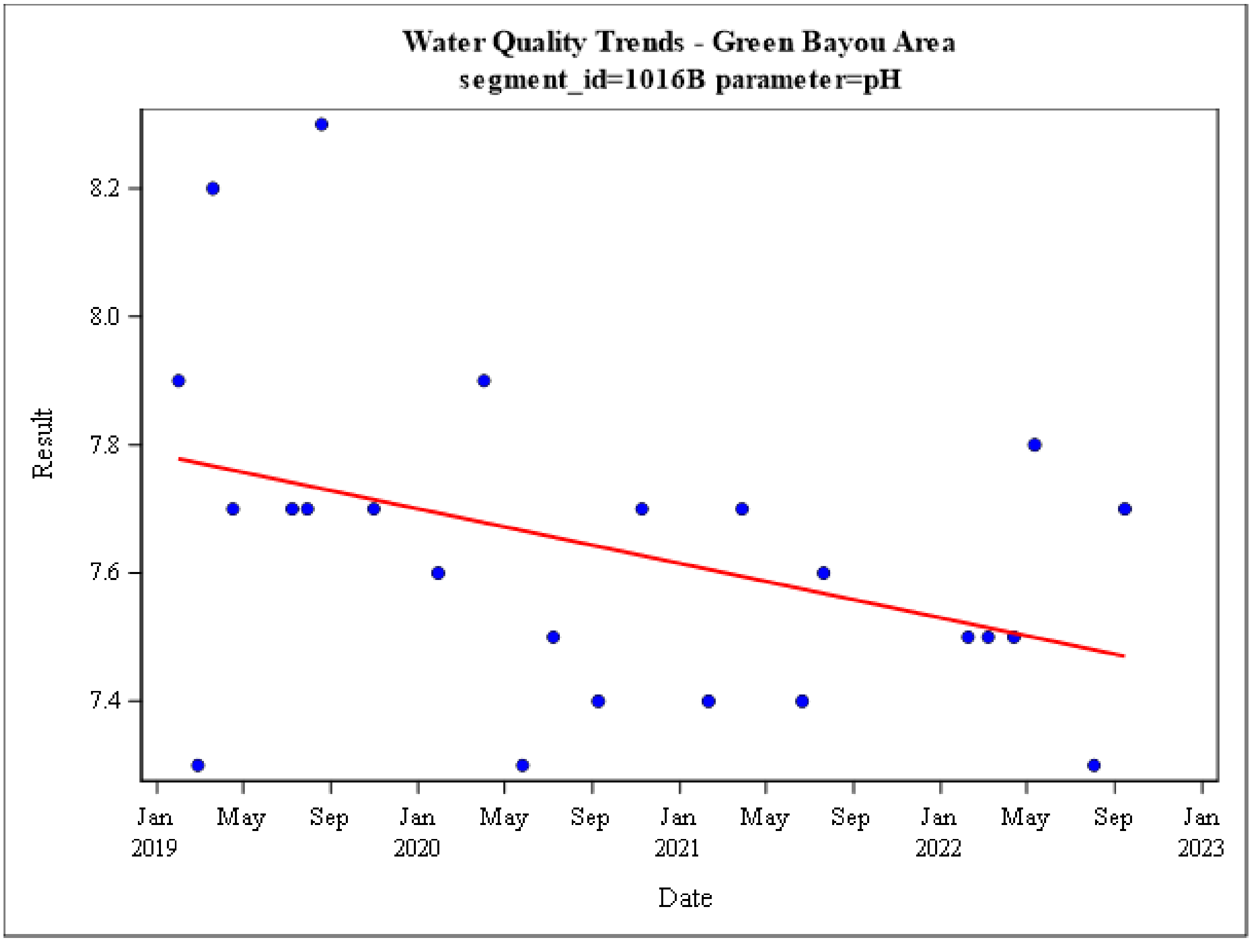
Unnamed Tributary of Greens Bayou (1016B)

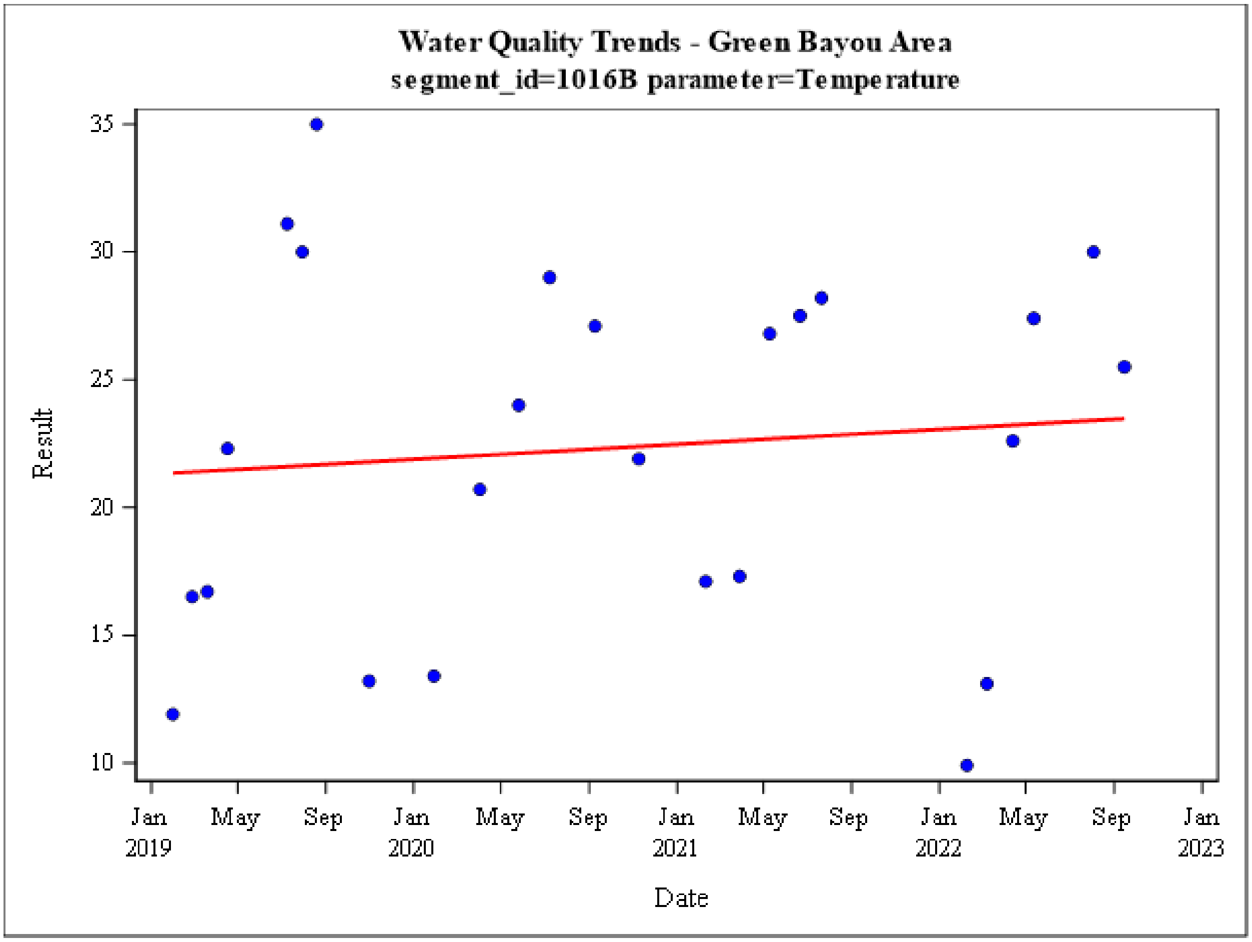



Water Quality Trends - Green Bayou Area
segment_id=1016B parameter=Dissolved Oxygen (24-hour Mean/ Grab Screening Level)
Result
Date
4
6
8
10
12
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
May
Sep
Jan 2022
May
Sep
Jan 2023

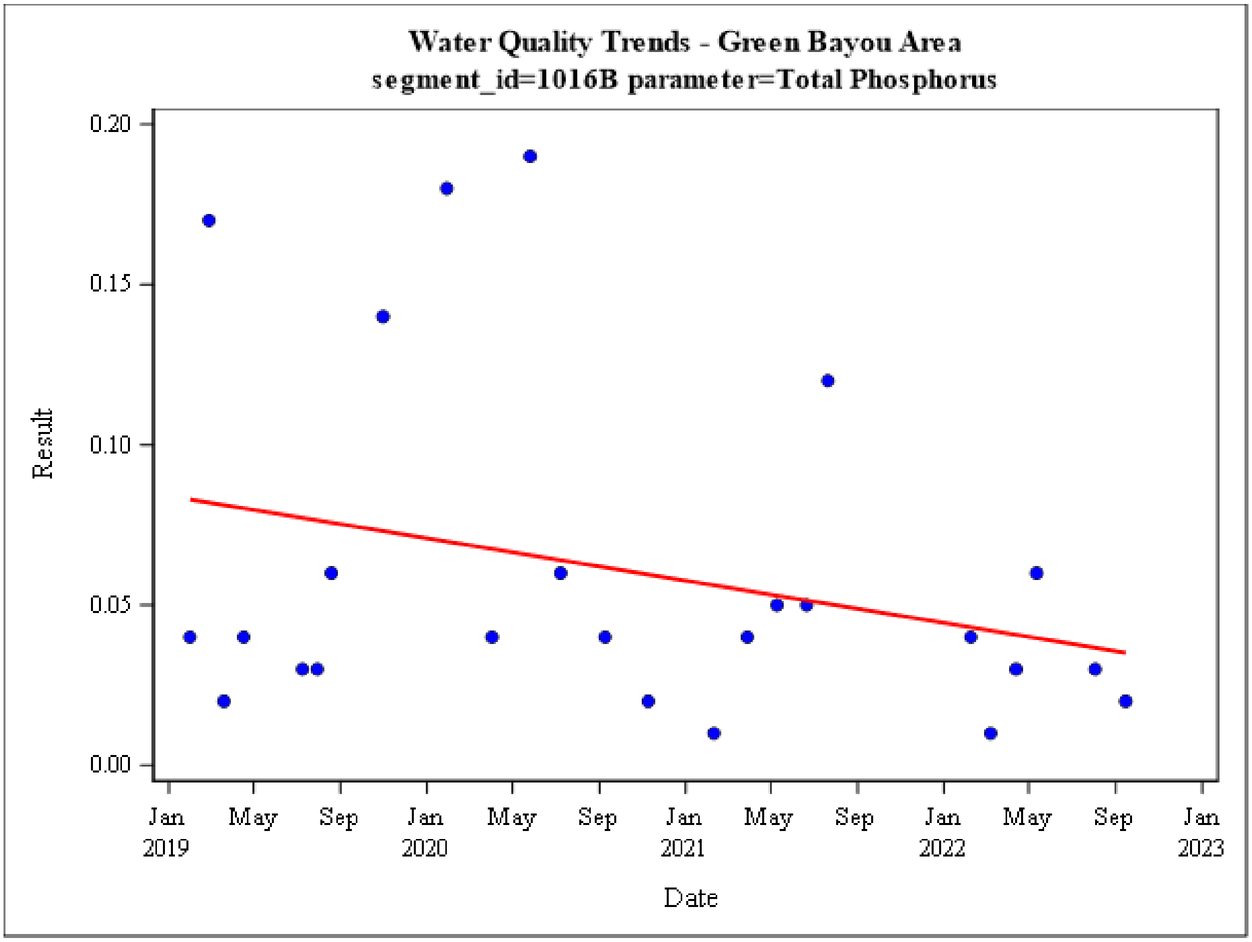

Water Quality Trends - Green Bayou Area
segment_id=1016B parameter=E. Coli
Result
8000
6000
4000
2000
0
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
May
Sep
Jan 2022
May
Sep
Jan 2023
Date


Water Quality Trends - Green Bayou Area
segment_id=1016B parameter=Nitrate-N
Result
0.0
0.2
0.4
0.6
0.8
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
May
Sep
Jan 2022
May
Sep
Jan 2023
Date

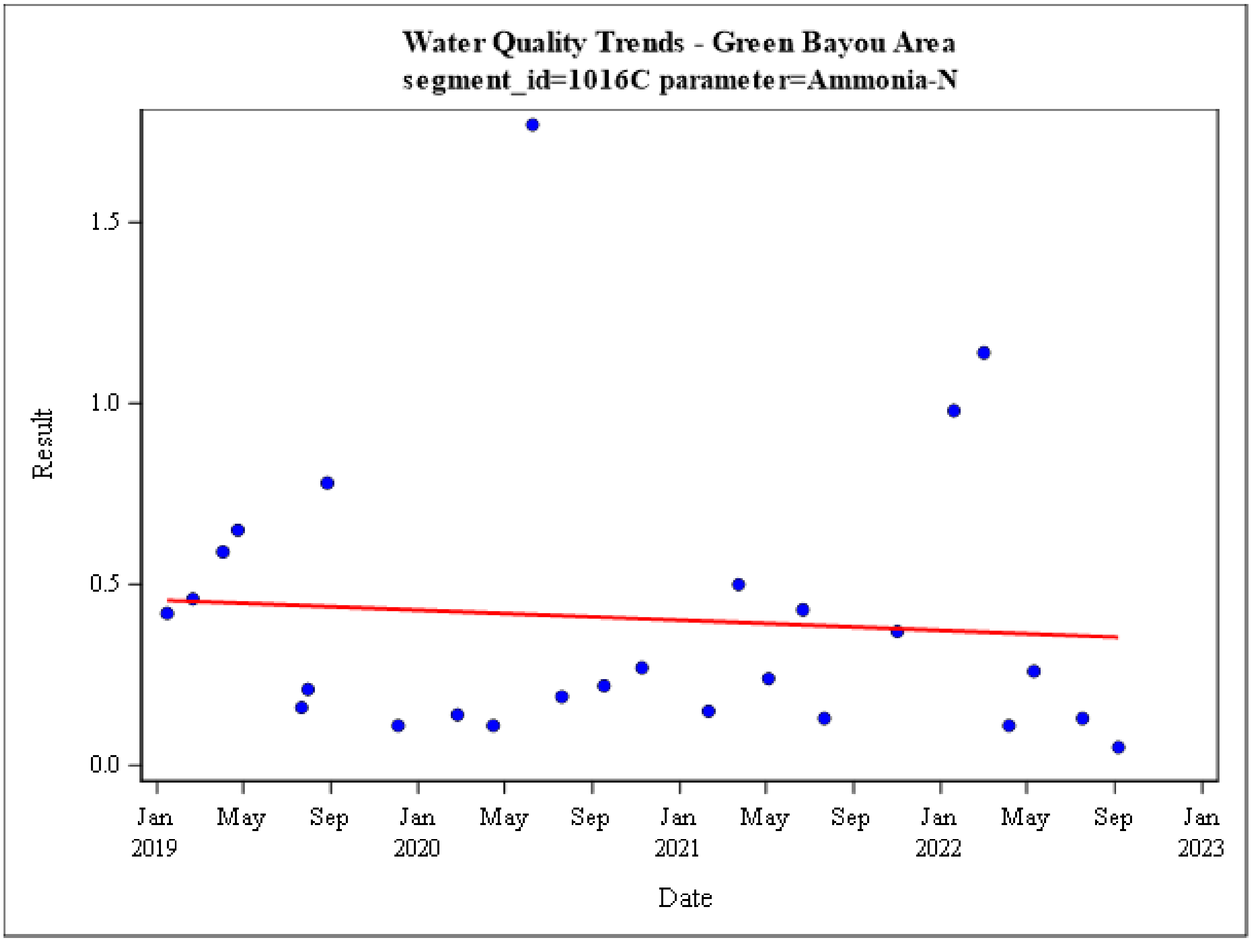

Water Quality Trends - Green Bayou Area
segment_id=1016B parameter=pH
Result
8.2
8.0
7.8
7.6
7.4
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
May
Sep
Jan 2022
May
Sep
Jan 2023
Date

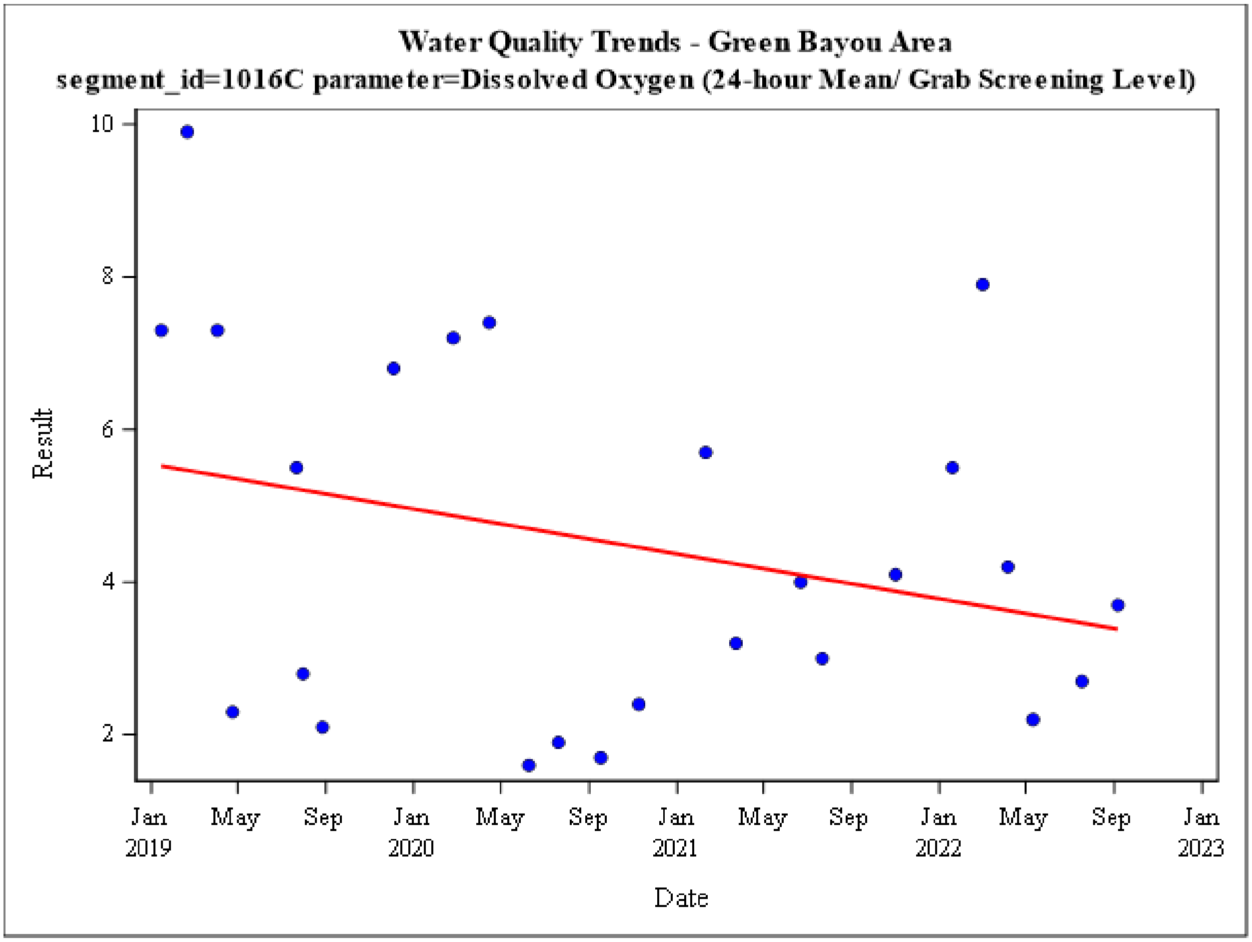


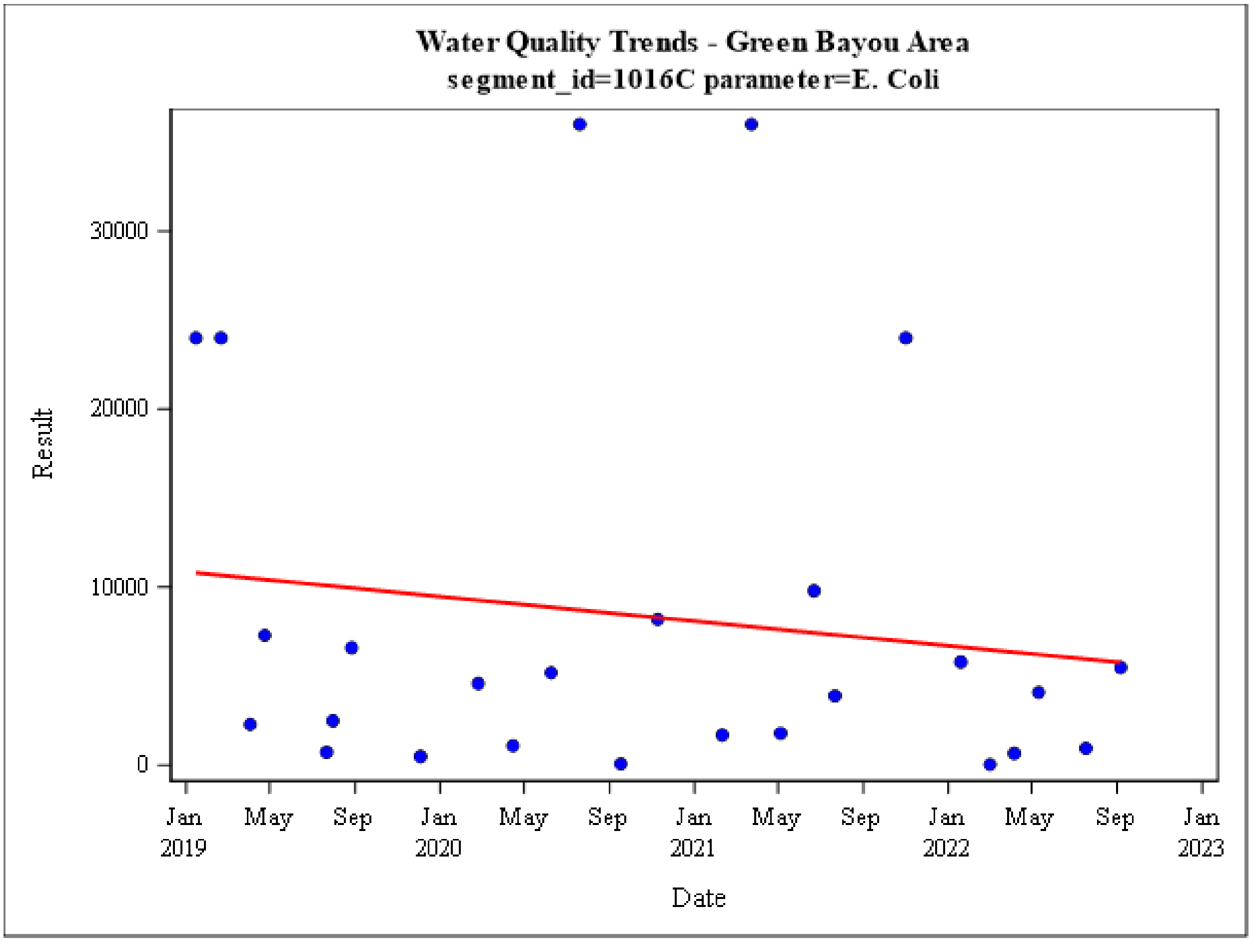
Water Quality Trends - Green Bayou Area
segment_id=1016B parameter=Temperature
Result
35
30
25
20
15
10
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
May
Sep
Jan 2022
May
Sep
Jan 2023
Date

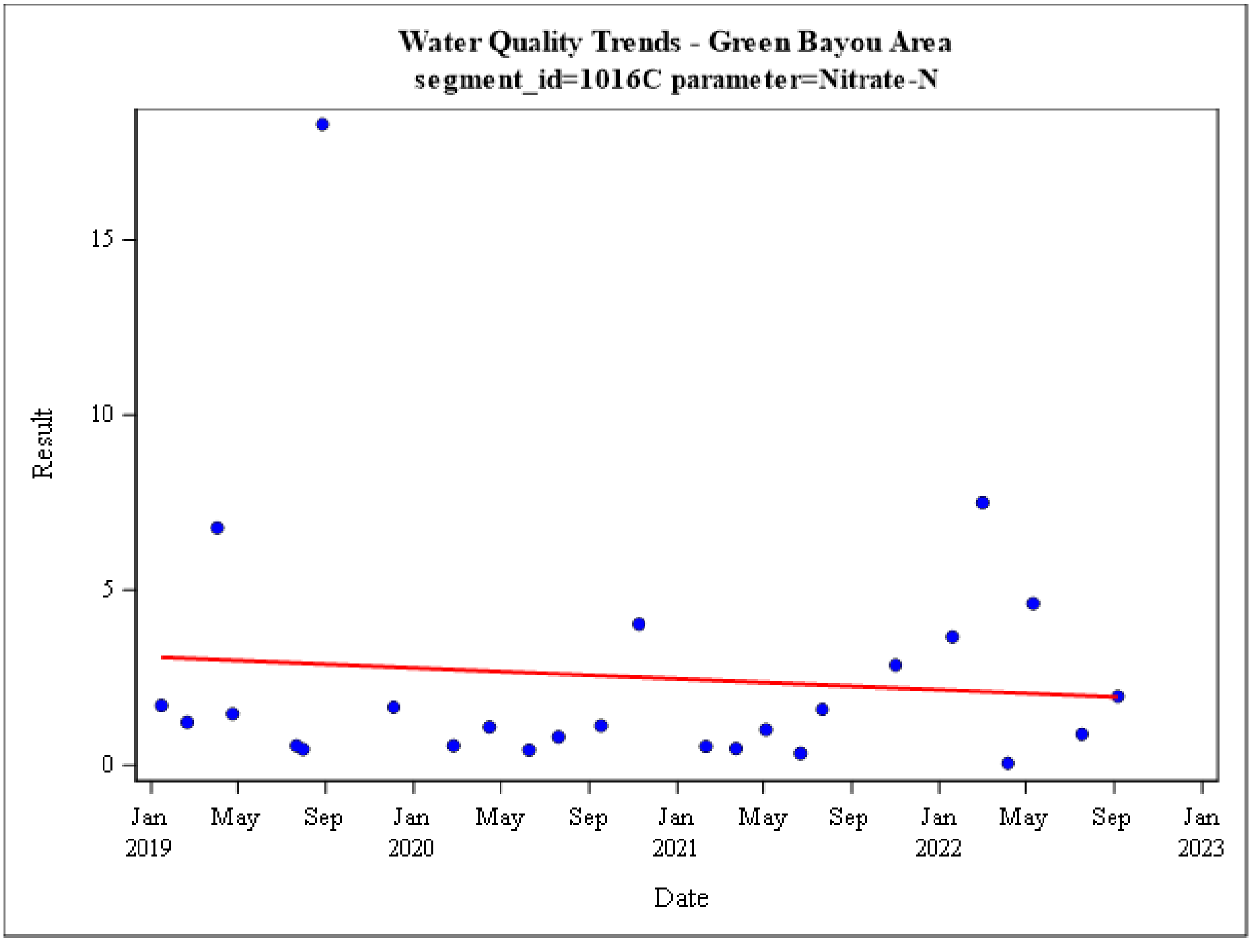

Water Quality Trends - Green Bayou Area
segment_id=1016B parameter=Total Phosphorus
0.20
0.15
0.10
0.05
0.00
Result
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
May
Sep
Jan 2022
May
Sep
Jan 2023
Date

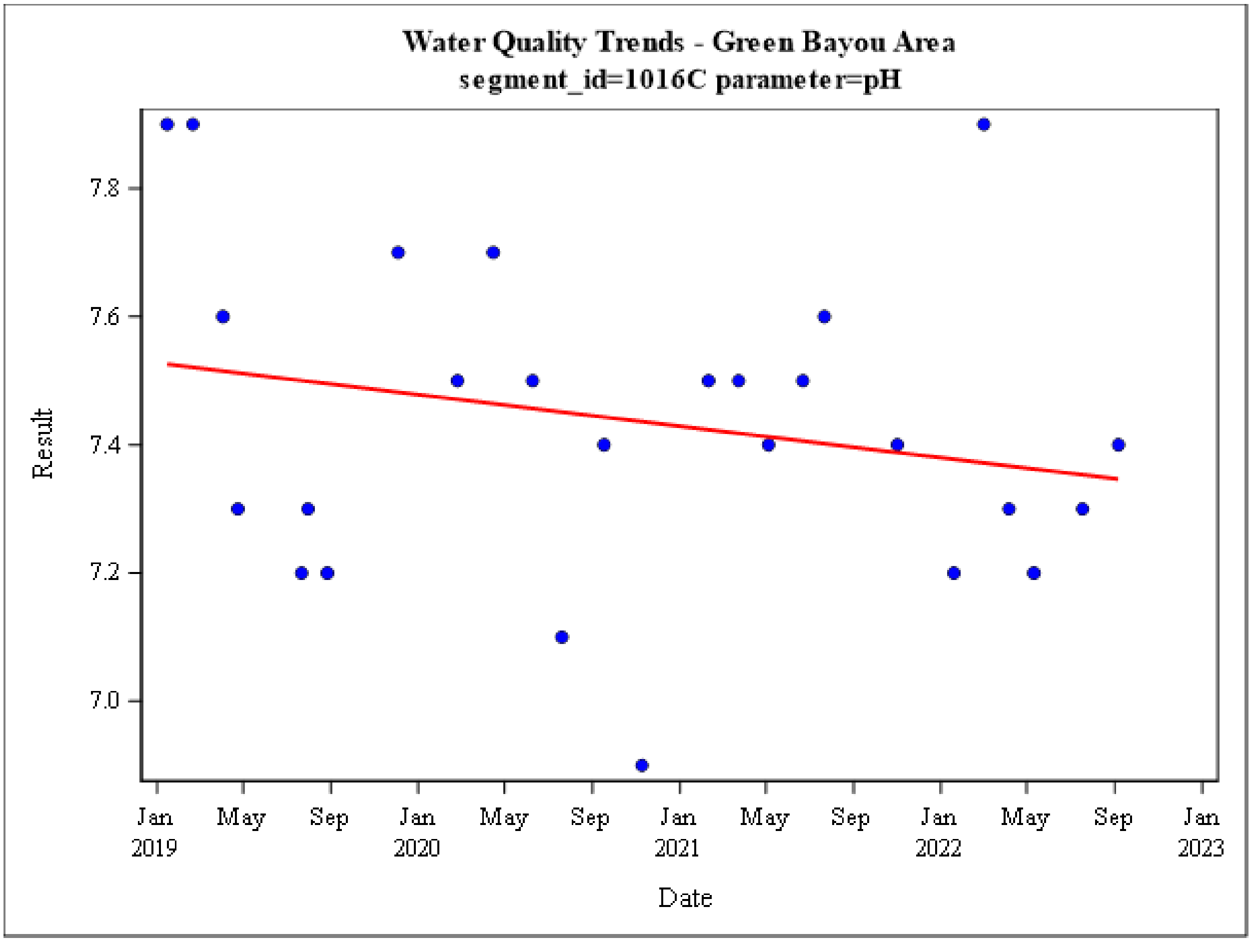
Unnamed Tributary of Greens Bayou (1016C)



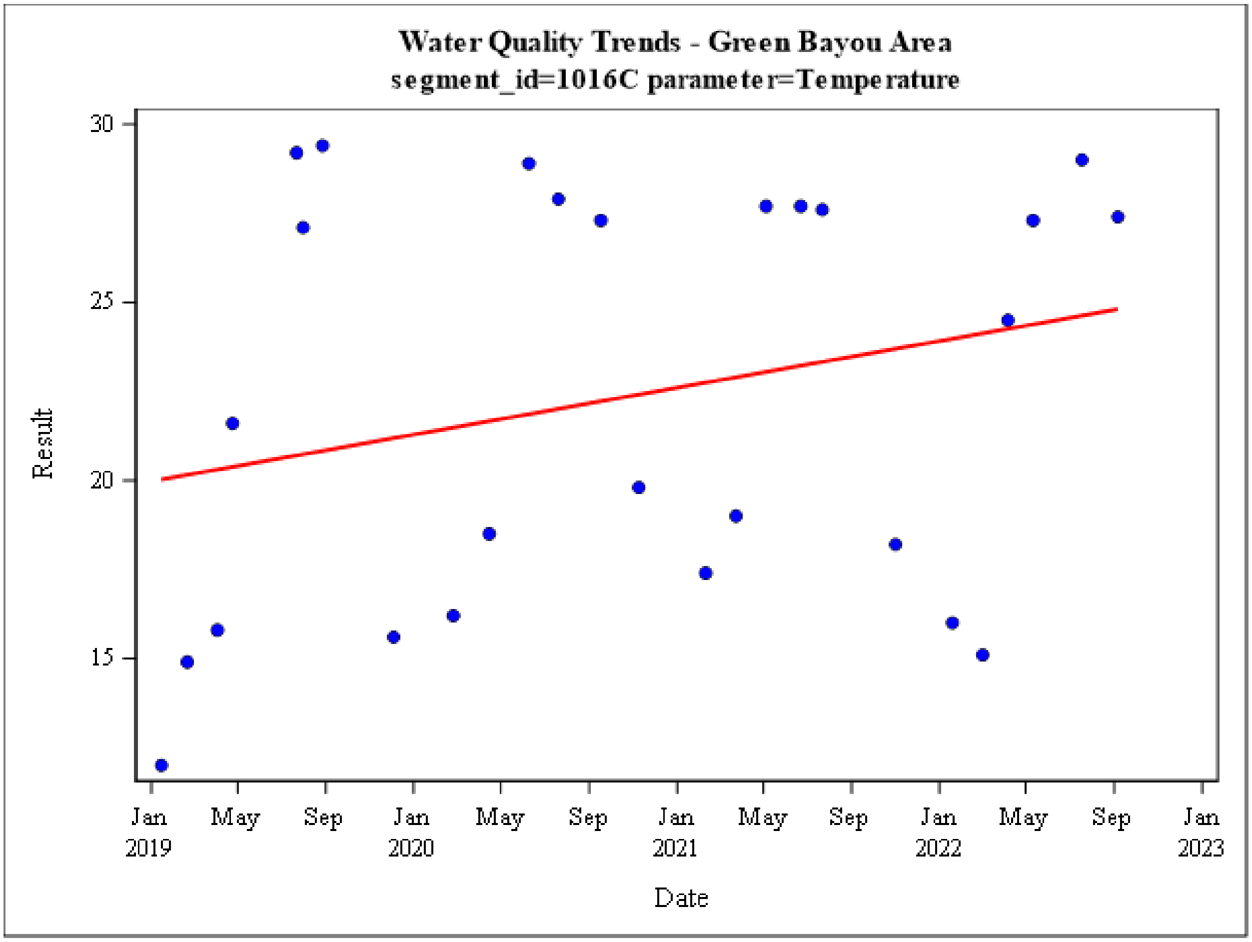

Water Quality Trends - Green Bayou Area
segment_id=1016C parameter=Dissolved Oxygen (24-hour Mean/ Grab Screening Level)
Result
10
8
6
4
2
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
May
Sep
Jan 2022
May
Sep
Jan 2023
Date

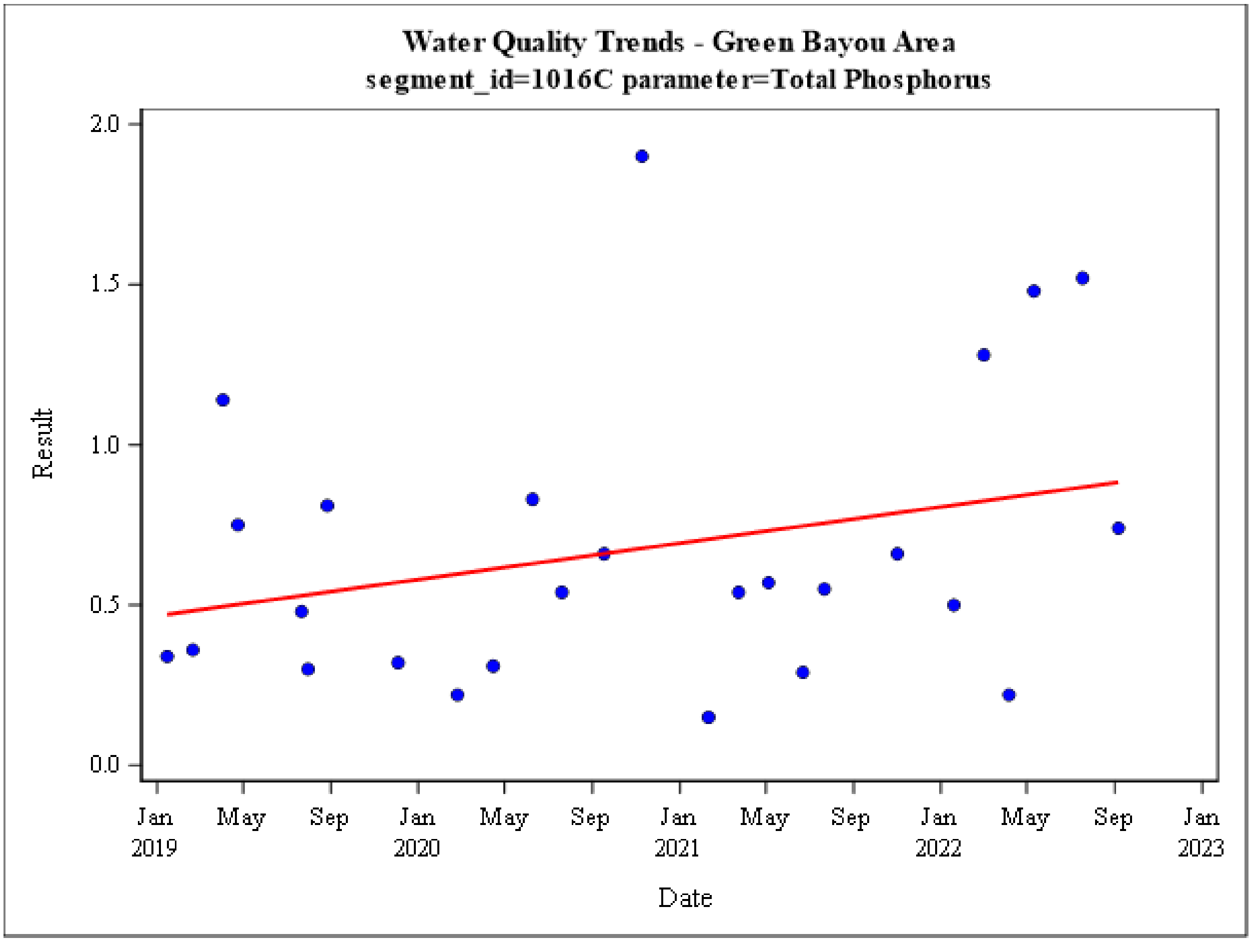

Water Quality Trends - Green Bayou Area
segment_id=1016C parameter=E. Coli
Result
30000
20000
10000
0
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
May
Sep
Jan 2022
May
Sep
Jan 2023
Date


Water Quality Trends - Green Bayou Area
segment_id=1016C parameter=Nitrate-N
Result
15
10
5
0
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
May
Sep
Jan 2022
May
Sep
Jan 2023
Date

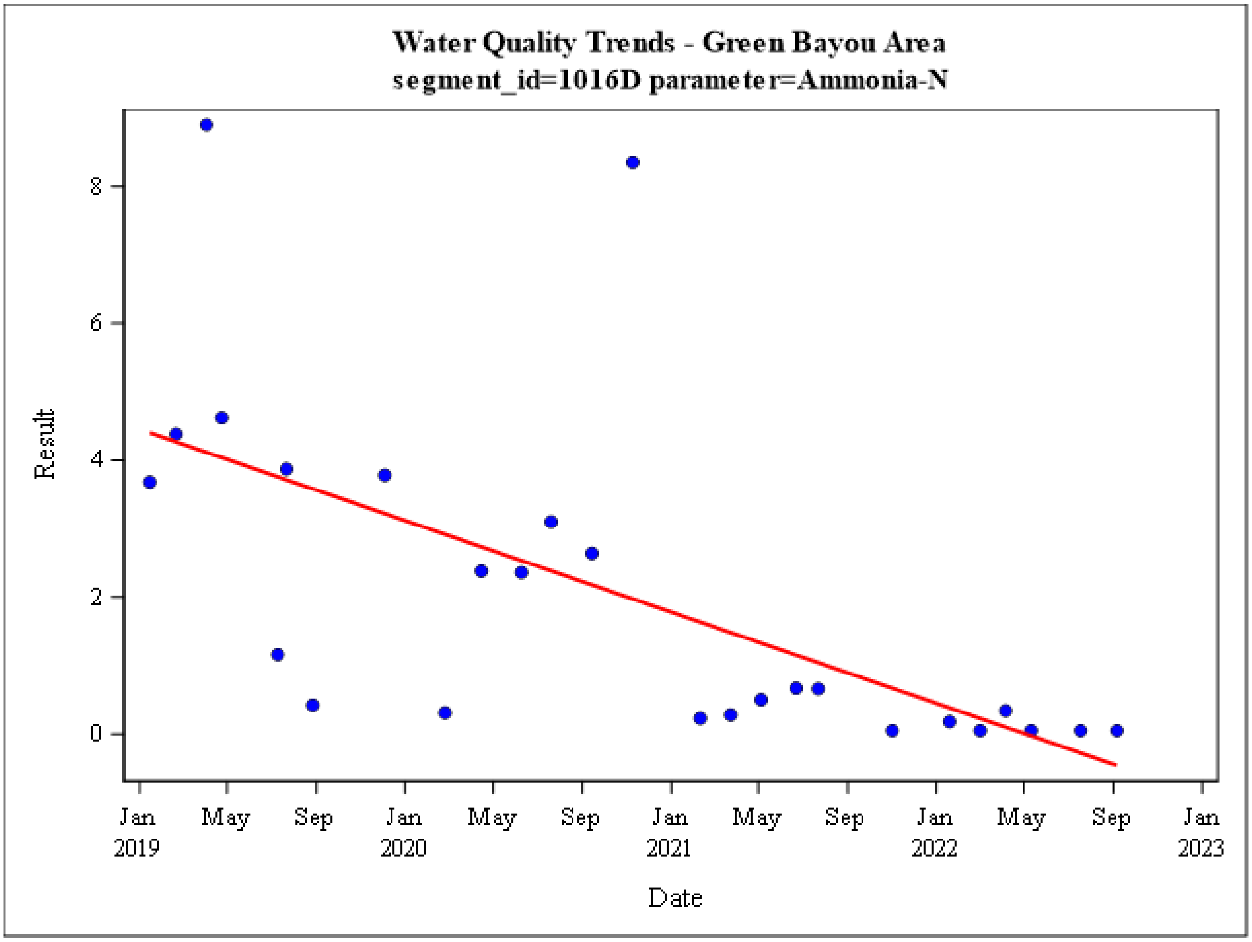


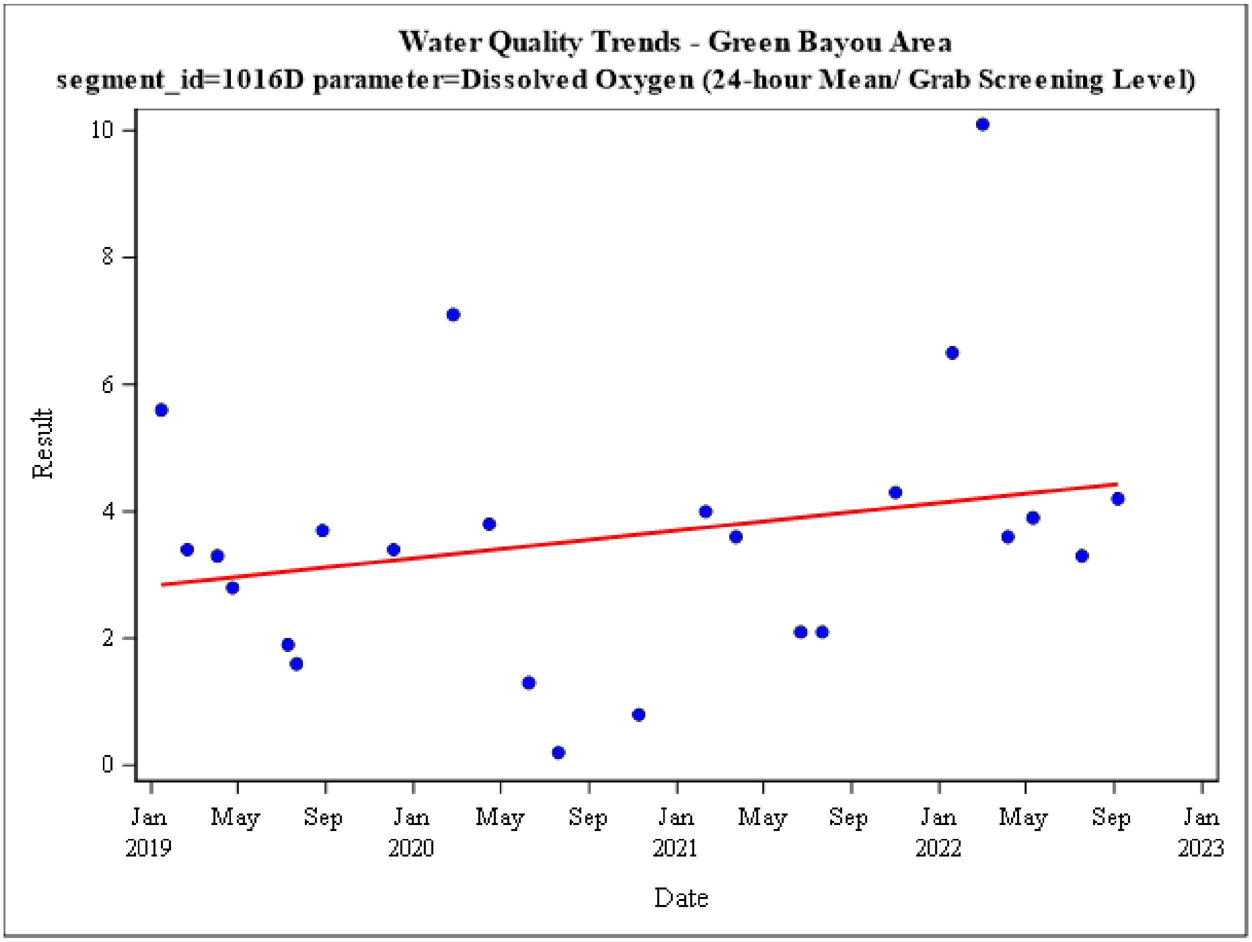
Water Quality Trends - Green Bayou Area
segment_id=1016C parameter=pH
Result
7.8
7.6
7.4
7.2
7.0
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
May
Sep
Jan 2022
May
Sep
Jan 2023
Date


Water Quality Trends - Green Bayou Area
segment_id=1016C parameter=Temperature
Result
30
25
20
15
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
May
Sep
Jan 2022
May
Sep
Jan 2023
Date

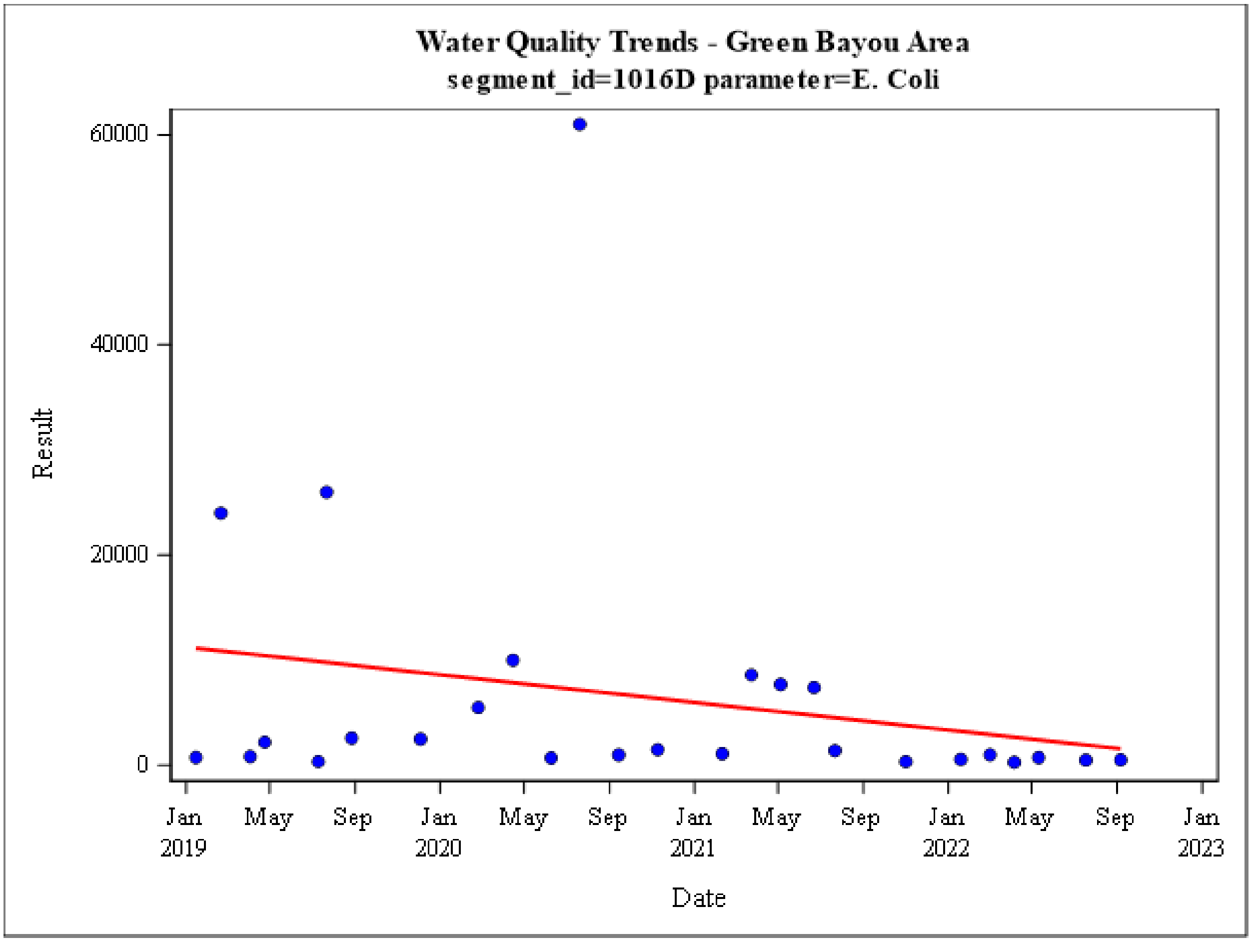

Water Quality Trends - Green Bayou Area
segment_id=1016C parameter=Total Phosphorus
Result
2.0
1.5
1.0
0.5
0.0
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
May
Sep
Jan 2022
May
Sep
Jan 2023
Date

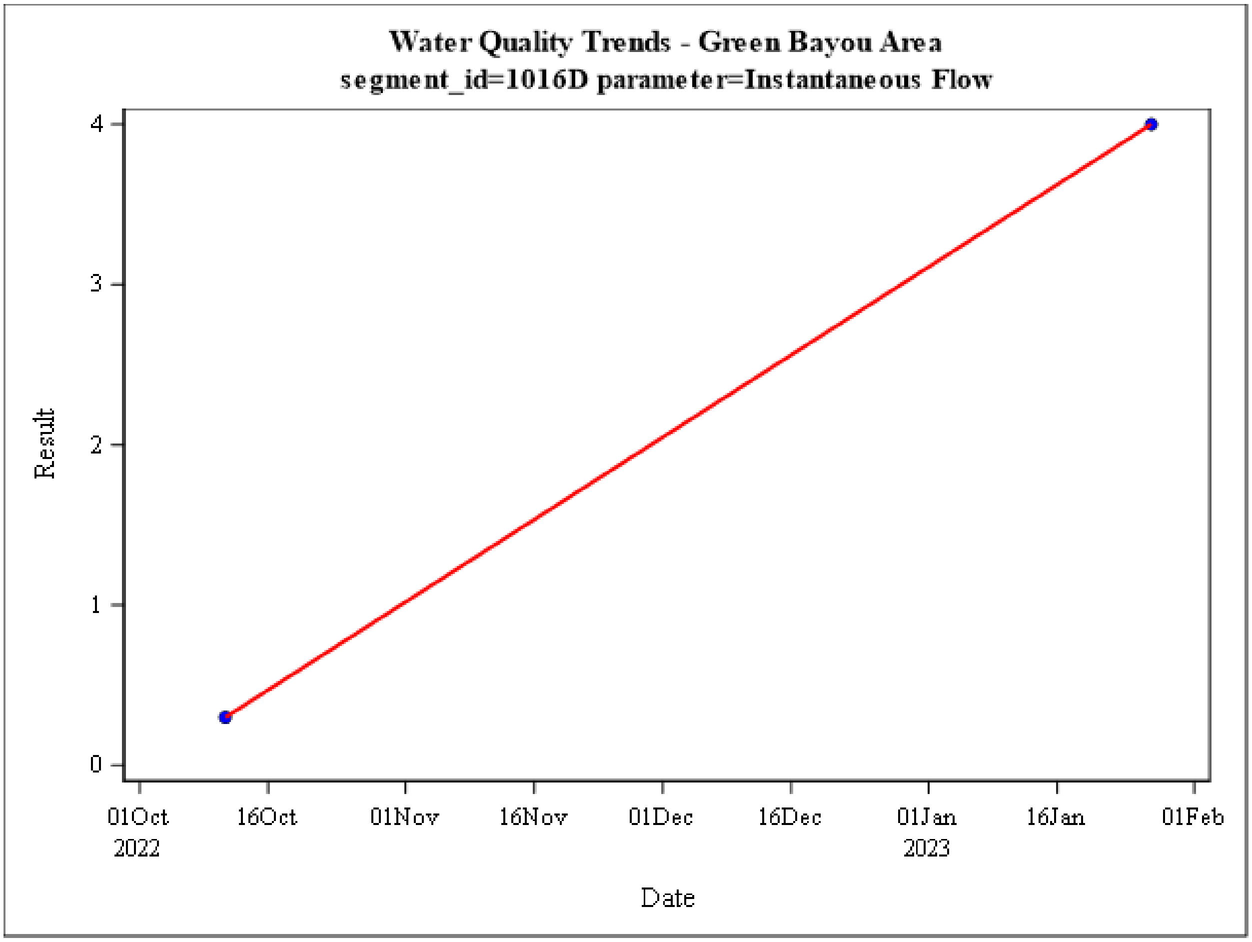
Unnamed Tributary of Greens Bayou (1016D)

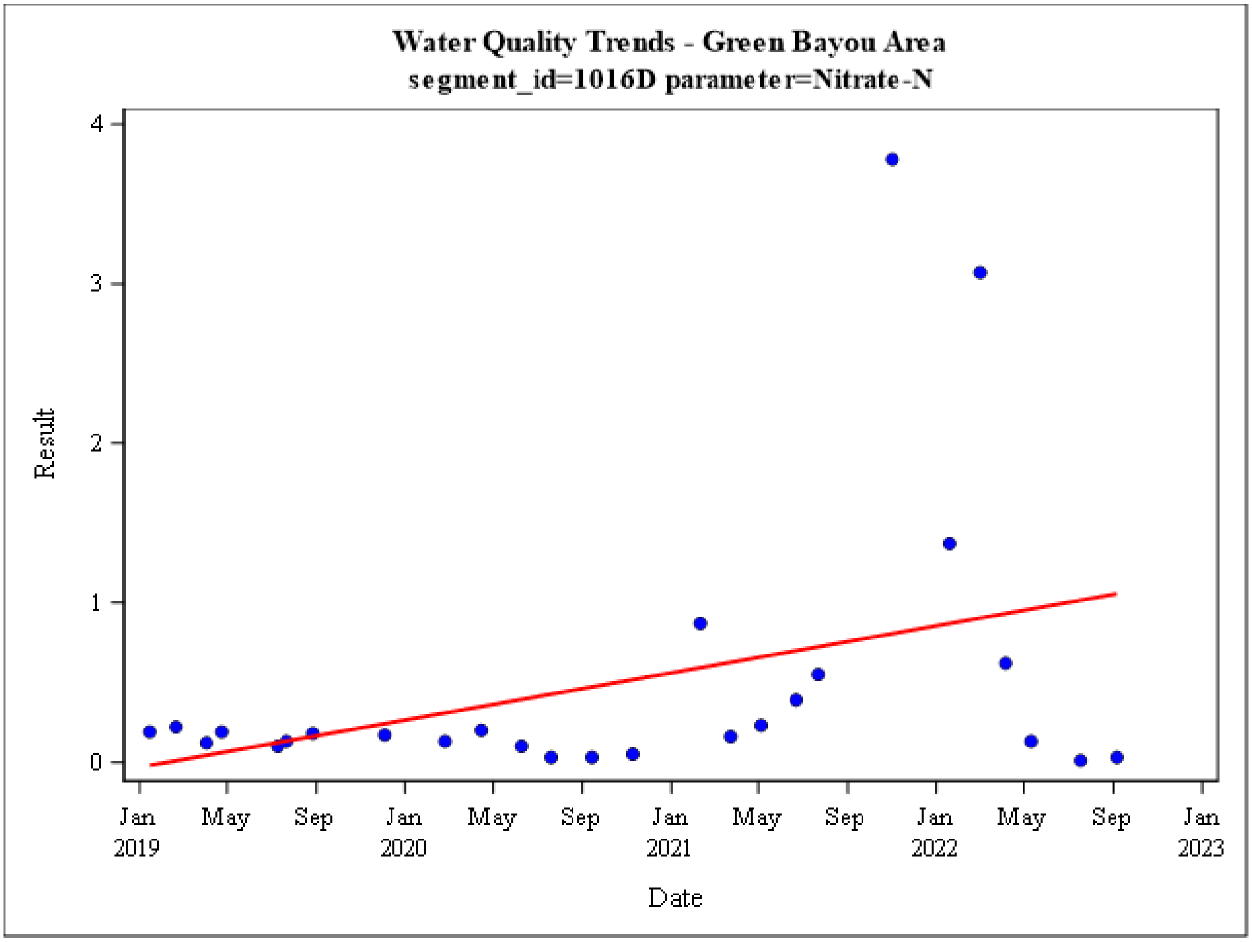


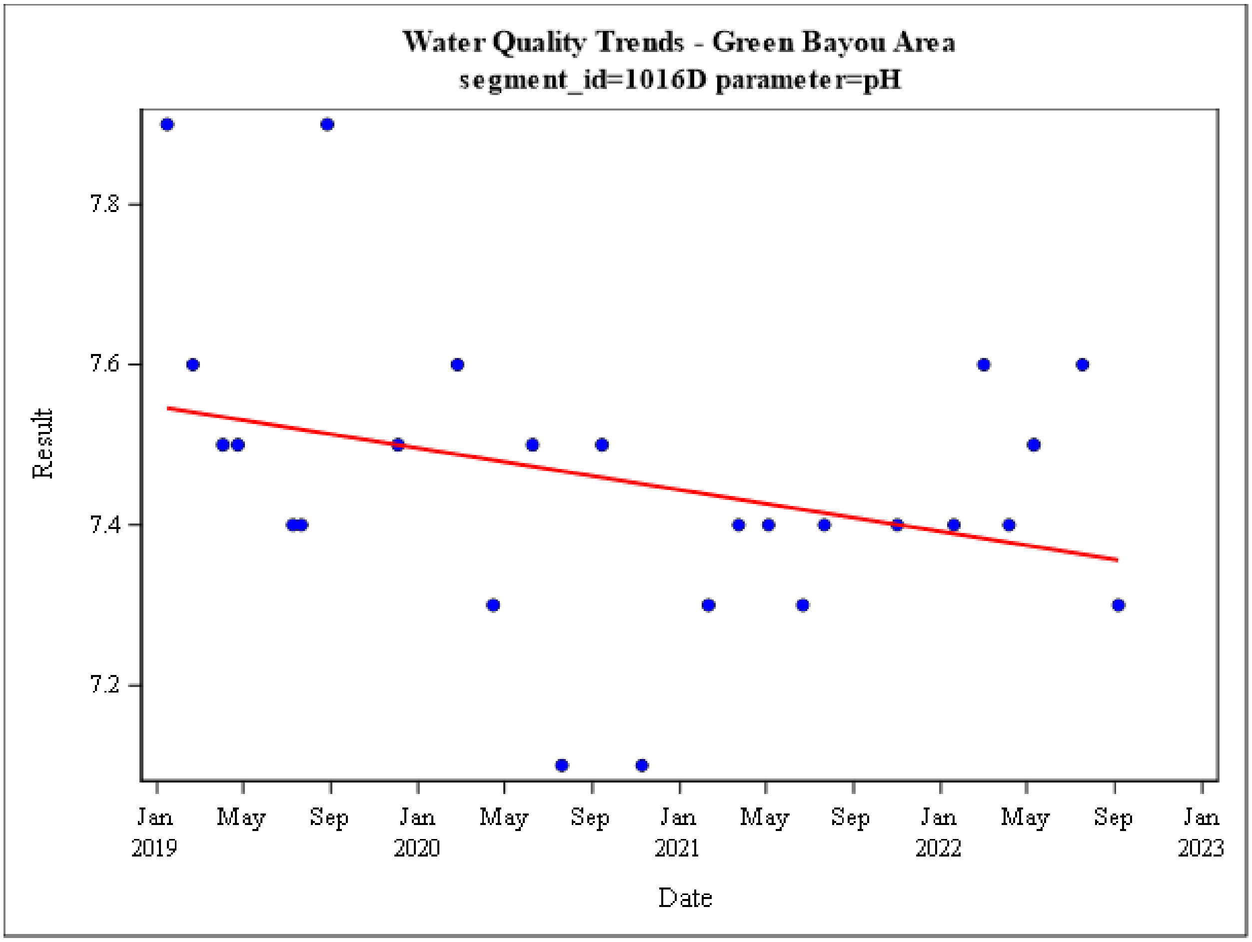


Water Quality Trends - Green Bayou Area
segment_id=1016D parameter=Dissolved Oxygen (24-hour Mean/ Grab Screening Level)
Result
10
8
6
4
2
0
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
May
Sep
Jan 2022
May
Sep
Jan 2023
Date

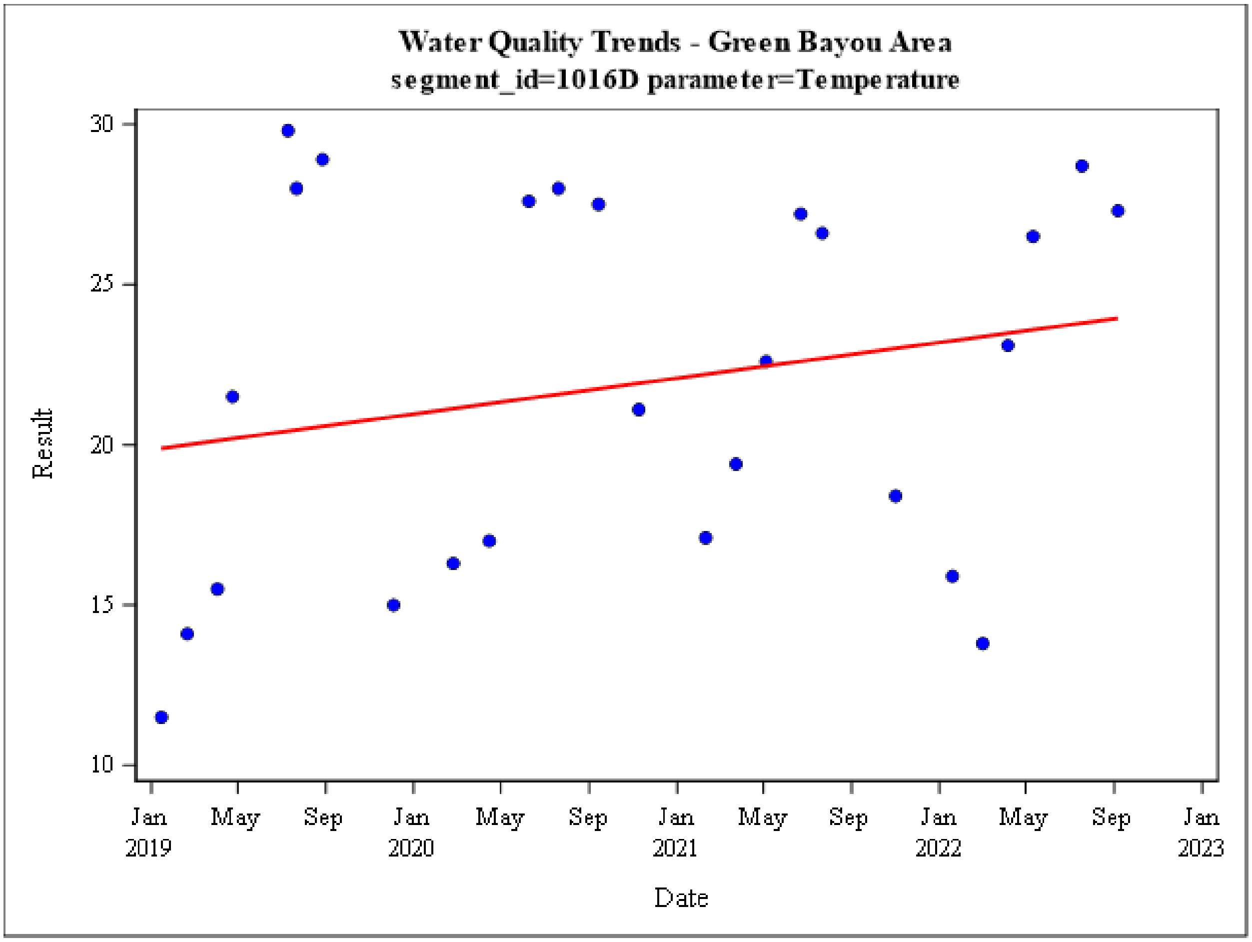

Water Quality Trends - Green Bayou Area
segment_id=1016D parameter=E. Coli
Result
60000
40000
20000
0
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
May
Sep
Jan 2022
May
Sep
Jan 2023
Date

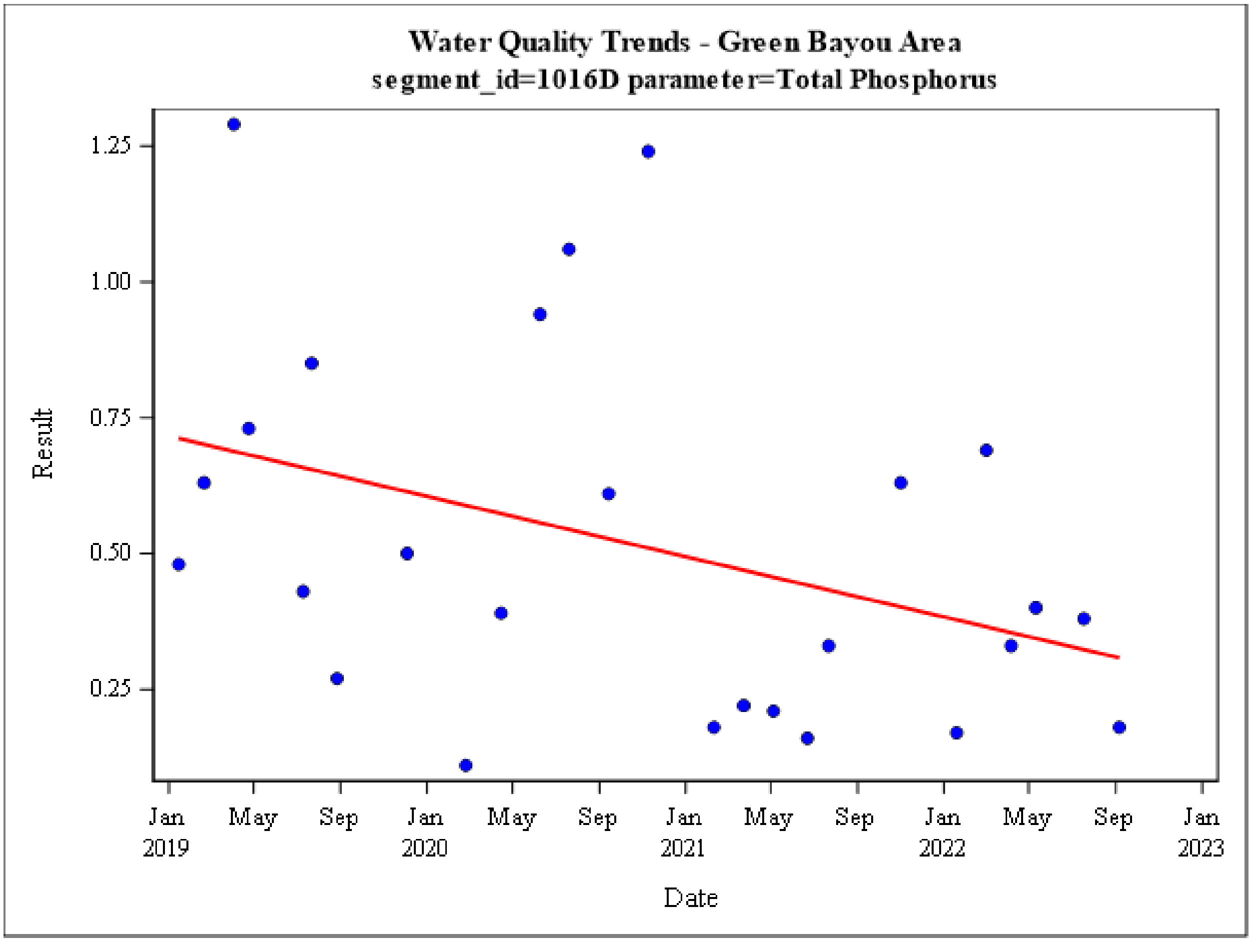

Water Quality Trends - Green Bayou Area
segment_id=1016D parameter=Instantaneous Flow
Result
0
1
2
3
4
01Oct
2022
16Oct
01Nov
16Nov
01Dec
16Dec
01Jan
2023
16Jan
01Feb
Date


Water Quality Trends - Green Bayou Area
segment_id=1016D parameter=Nitrate-N
Result
4
3
2
1
0
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
May
Sep
Jan 2022
May
Sep
Jan 2023
Date



Water Quality Trends - Green Bayou Area
segment_id=1016D parameter=pH
Result
7.8
7.6
7.4
7.2
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
May
Sep
Jan 2022
May
Sep
Jan 2023
Date


Water Quality Trends - Green Bayou Area
segment_id=1016D parameter=Temperature
Result
30
25
20
15
10
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
May
Sep
Jan 2022
May
Sep
Jan 2023
Date



Water Quality Trends - Green Bayou Area
segment_id=1016D parameter=Total Phosphorus
Result
1.25
1.00
0.75
0.50
0.25
Jan 2019
May
Sep
Jan 2020
May
Sep
Jan 2021
May
Sep
Jan 2022
May
Sep
Jan 2023
Date