Baffin Bay Tributaries Study

Final Report for
CMP Project # 20-029-000-B736

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Executive Summary

The goal of the Baffin Bay Tributary Study is to determine the contribution of select water quality parameters during high streamflow events from three main tributaries of Baffin Bay, including Petronila Creek Above Tidal, San Fernando Creek Above Tidal, and Los Olmos Creek Tidal. Routine monthly water quality data at Los Olmos Creek Tidal was also collected that will be used by the Texas Commission on Environmental Quality (TCEQ) for water quality assessments to fill a data-gap for the creek.

Data collection occurred from January 2020 through December 2020 with one high flow event occurring in mid-May. The high flow event was monitored on two consecutive days following the rain event. Three stations were identified for high flow event water quality monitoring: Los Olmos Creek Tidal at US 77 (TCEQ Station 13034), San Fernando Creek Above Tidal at US 77 (TCEQ Station 13033), and Petronila Creek Above Tidal at FM 892 (TCEQ Station 13094). Data from the high flow event will not be used by TCEQ for assessment purposes but will be made available to researchers at Harte Research Institute (HRI) at Texas A&M University – Corpus Christi (TAMU-CC) and Texas Water Resources Institute (TWRI) for nutrient modelling purposes.

The first five months of the study period coincided with drought conditions at all three sampling locations. A rain event on May 15th resulted in high flow events on both Petronila and San Fernando creeks with maximum flow rates of approximately 300 ft^3/s on Petronila Creek and 300 ft^3/s on San Fernando Creek. Data collection occurred on May 16th and 17th immediately following the rain event. Los Olmos Creek Tidal was also monitored following the rain event but flows were low compared with flows on Petronila and Sen Fernando creeks. The remainder of the study period had average precipitation rates with monthly water quality monitoring on Los Olmos Creek Tidal occurring at low flow conditions. Water quality parameters analyzed for the study include alkalinity, chloride, sulfate, total dissolved solids (TDS), ammonia, nitrate nitrogen, nitrite nitrogen, total phosphorus, total kjeldahl nitrogen (TKN), total organic carbon (TOC), total suspended solids (TSS), chlorophyll-*a* and pheophytin. A data summary of the sampling events is provided for the sampling project.

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Acknowledgements

Sampling for the study was conducted from January through December 2020, during the COVID-19 pandemic. NRA could not have fulfilled the obligations required to complete the study without the data from the laboratories at the City of Corpus Christi Water Utilities Laboratory (WUL) and the Texas A&M Corpus Christi Center for Coastal Studies Lab (CCSL). Nueces River Authority (NRA) staff would like to show its appreciation to these labs for allowing NRA to keep submitting samples to fulfill the needs of the contract. We are also grateful for the Texas General Land Office (TxGLO) Coastal Management Program (CMP) for financial support, interest and expertise.

Figure 1. Los Olmos Creek Tidal at US-77 (TCEQ Station 13034)

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Introduction

Surface water quality monitoring in Texas is conducted by the Texas Commission on Environmental Quality (TCEQ) and its Clean Rivers Program (CRP) partners to assess the status of water quality of rivers, lakes, and estuaries throughout the state. TCEQs Surface Water Quality Monitoring (SWQM) program monitors and evaluates physical, chemical, and biological characteristics of aquatic systems at more than 1,800 surface waters sites statewide. The data is used to characterize existing conditions, evaluate the effectiveness of water quality control programs, and to identify trends. To improve and maintain the quality of water in the state, the TCEQ establishes criteria to protect designated uses including aquatic life, water supply, and recreation against degradation. Evaluating support of the designated uses includes developing segment specific criteria for dissolved oxygen, temperature, pH, dissolved minerals, toxic substances, and bacteria. Impairment criteria for each parameter are listed below.

Parameter	Criteria	Calculation Used for Impairment*
TDS, chloride, and sulfate	Segment specific	Average of samples are above the criteria
DO (for High Aquatic Life Use)	3.0 mg/L** grab minimum	10% of samples are below either criteria
pH	6.5 su*** and 9 su	10% of samples are above or below the criteria
E. coli	126 cfu**** 394 cfu	Geometric mean is greater than the criteria 25% of samples are above the criteria
Enterococci	35 cfu 89 cfu	Geometric mean is greater than the criteria 25% of samples are above the criteria

Figure 2. TCEQ Impairment criteria by parameter

*The percent of samples exceeding the criteria or screening level varies somewhat with small sample sizes (between 10 and 20). When sample sizes are greater than 20 samples, the percentage shown in the calculation column is much more accurate.

**mg/l: milligrams per liter

***su: standard units

****cfu: colony forming units

TCEQ assesses nutrient parameters using a screening level process in which ammonia, phosphorus, nitrate nitrogen, and chlorophyll-*a* are used as preliminary indicators of possible water quality degradation. The following chart (Figure 3) explains the potential causes and impacts when water quality screening levels for nutrient parameters are not met.

Parameter	Cause	Impact
Ammonia	Ammonia is excreted by animals and is produced during the decomposition of plants and animals. It is an ingredient in many fertilizers and is also present in sewage, storm water runoff, certain industrial wastewaters, and runoff from animal feedlots.	Elevated levels of ammonia in the environment can adversely affect fish and invertebrate reproductive capacity and reduced growth of the young.
Nitrates & Total Phosphorus	Nutrients are found in effluent released from wastewater treatment plants (WWTP)s, fertilizers, and agricultural runoff carrying animal waste from farms and ranches. Soil erosion and runoff from farms, lawns, and gardens can add nutrients to the water.	These nutrients increase plant and algae growth. When plants and algae die, the bacteria that decompose them use oxygen so that is no longer available for fish and other living aquatic life. High levels of nitrate and nitrites can produce nitrite toxicity, or "brown blood disease," in fish. This disease reduces the ability of blood to transport oxygen throughout the body.
Chlorophyll-*a*	Modifications to the riparian zone, human activity that causes water increases in organic matter, nutrients, bacteria, and over abundant algae.	Chlorophyll-*a* is the photosynthetic pigment found in all green plants, algae, and cyanobacteria. Elevated levels indicate abundant plant growth which could lead to reduced DO levels.

Figure 3. Causes and impacts of excess nutrient parameters

Data used for water quality characterization is generally conducted on a quarterly basis to account for temporal variability of water quality parameters. In cases where additional data is needed on a waterbody, monitoring frequencies can increase to a monthly schedule. For inclusion into the State's water quality assessments, data must be unbiased with respect to flow. Targeted high flow monitoring events, although useful for research purposes, are not allowed for water quality assessments.

Data gathered for this study includes monthly surface water quality data at Los Olmos Creek Tidal that will be used by TCEQ for assessment purposes and data from targeted high flow events that will be used by researchers for non-regulatory purposes.

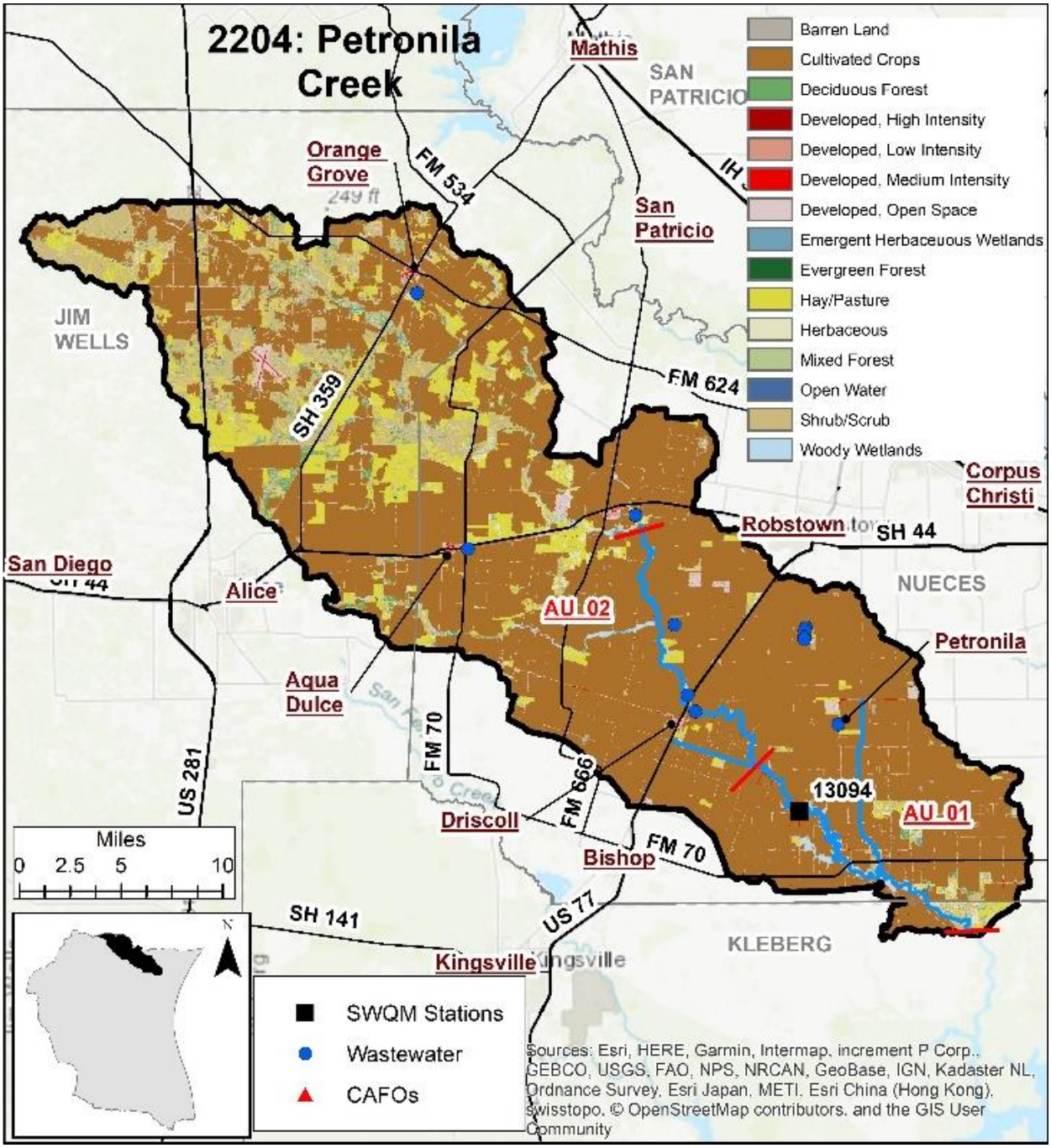

Figure 4. Petronila Creek Watershed

Study Locations

Petronila Creek Above Tidal (Segment 2204) - Segment 2204 is a shallow creek (< 2.0 m depth) that flows 44 miles from the confluence of Aqua Dulce and Banquete creeks in Nueces County to a point 0.6 miles upstream of a private road crossing near Laureles Ranch in Northern Kleberg County. Petronila Creek drains to Alazan Bay, a tertiary bay, connected to the northern portion of Baffin Bay. Its watershed is 1,867,755 acres. Land use is dominated by cultivated cropland with cotton, corn and sorghum being the most common crops observed. The northwestern end of the watershed is a mixture of cultivated cropland, hay or pasture, shrub or scrub and mixed forest. There are nine regulated dischargers of effluent to Petronila Creek and/or the tributaries of the creek. There is one USGS streamgage located at crossing of FM 665 near the City of Driscoll.

Surface water quality monitoring assessments for Segment 2204 indicate impairments exist for total dissolved solids (TDS), sulfate, chloride since 1999. In response to the dissolved mineral impairments, Total Maximum Daily Load (TMDL) projects for TDS, sulfate, and chloride have been developed that include increased water quality monitoring of the main stem and select tributary stations. Segment 2204 also has a water quality impairment due to elevated levels of indicator bacteria (*E.* coli) since the 2016 water quality assessment and a screening level concern for chlorophyll-*a* which indicates possible degradation of water quality.

Parameter	Nutrient Screening Levels for Petronila Creek Above Tidal	Calculation Used for Concern
Ammonia-Nitrogen	0.33 mg/l	20% of samples are above the criteria
Nitrate	1.95 mg/l	
Total phosphorus	0.69 mg/l	
Chlorophyll-a	14.1 µg/l	

Figure 5. Screening levels for nutrient parameters for Petronila Creek Above Tidal

Figure 6. Petronila Creek Above Tidal at FM 892 (Station 13094)

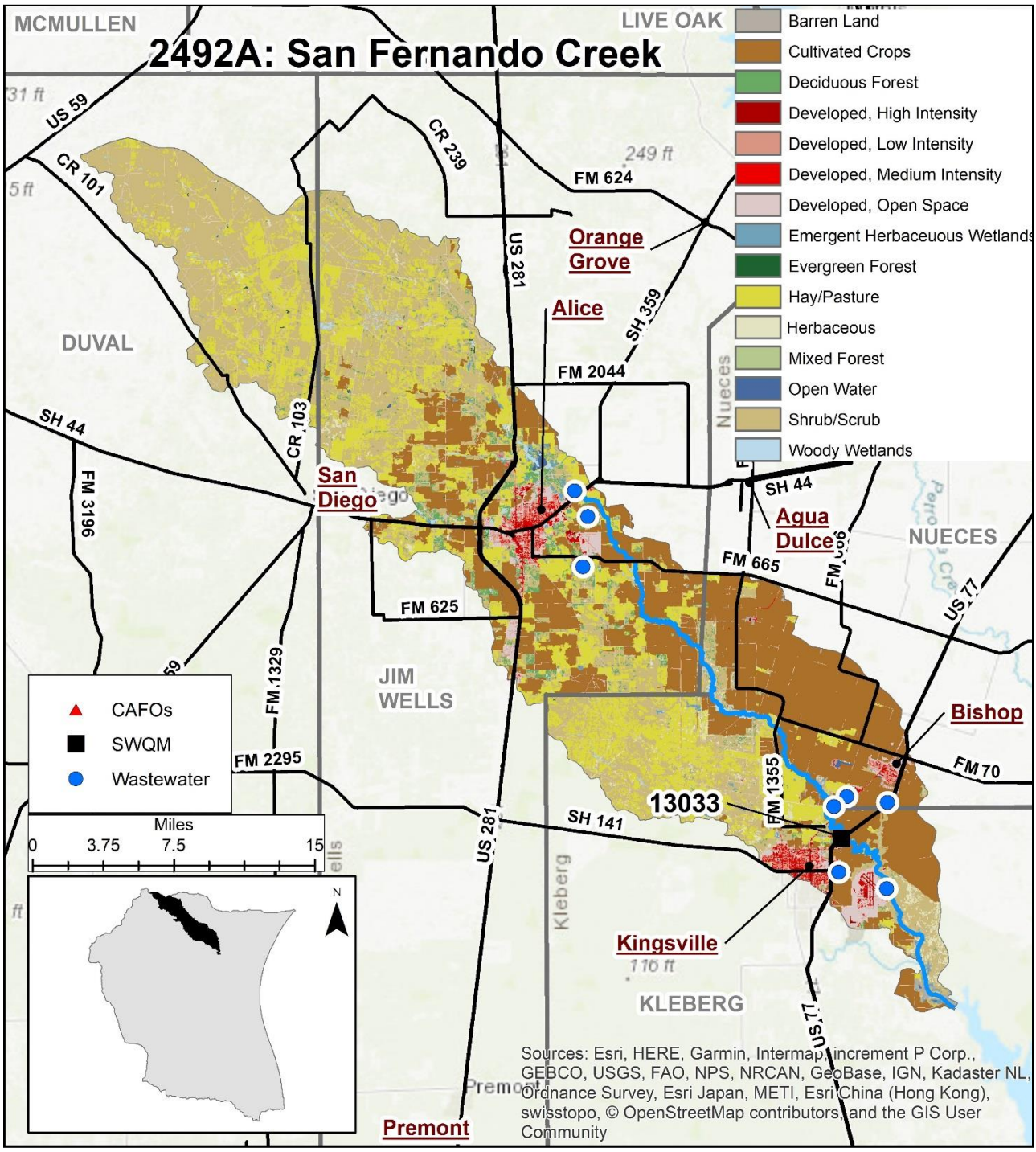

Figure 7. San Fernando Creek Watershed

San Fernando Creek Above Tidal (Segment 2492A) - Segment 2492A is a shallow creek (< 2.0 m depth) that flows 45.6 miles from a point just east of the Nueces Jim Wells county line to the confluence of Cayo del Grullo, an arm of Baffin Bay located in Kleberg County. Its watershed is 288,572 acres. Land use in the northwestern portion of the watershed is dominated by a mixture of hay or pasture and shrub or scrub. Land use in the middle portion of the watershed includes the City of Alice and an increase in cultivated crops. The southeastern portion of the watershed consists of mostly cropland north of the creek and hay/pasture and shrub scrub south of the creek and the City of Kingsville. There are eight regulated dischargers of effluent to San Fernando Creek and/or the tributaries of the creek.

Segment 2492A has been on the TCEQ 303(d) list of impaired water bodies since 2006 due to elevated levels of indicator bacteria (Enterococcus). In 2014, the indicator bacteria for the station was changed to *E. coli* after determining that the station is located in the above tidal portion of the creek. Segment 2492A was found to also be impaired for indicator bacteria *(E. coli*) since the 2016 assessment. Additionally, Segment 2492A has nutrient screening level concerns for nitrate, total phosphorus, and chlorophyll-*a*.

Parameter	Nutrient Screening Levels for San Fernando Creek Above Tidal	Calculation Used for Concern
Ammonia-Nitrogen	0.33 mg/l	20% of samples are above the criteria
Nitrate	1.95 mg/l	
Total phosphorus	0.69 mg/l	
Chlorophyll-a	14.1 µg/l	

Figure 8. Screening levels for nutrient parameters for San Fernando Creek Above Tidal

Figure 9. San Fernando Creek at US-77 near Kingsville (Station 13033)

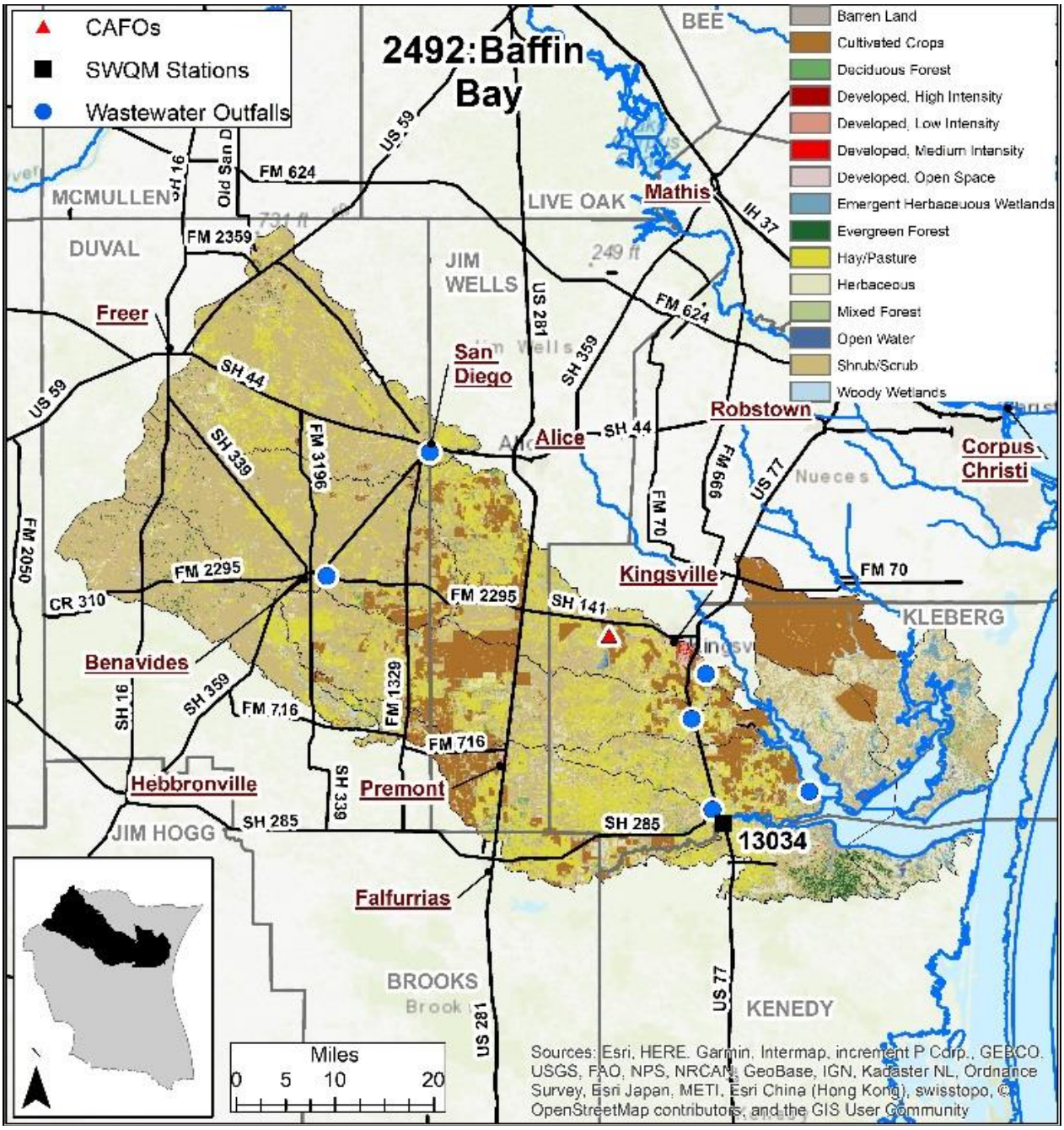

Figure 10. Baffin Bay and Los Olmos Creek Watershed

Los Olmos Creek Tidal (Segment 2492B) – Segment 2492A is a shallow (< 0.5 m) tidal stream that flows from a point 6.8 miles southwest of Riviera to its confluence with Laguna Salada, which is an arm of Baffin Bay. The watershed in largely rural but includes small. Land use is predominantly hay/pasture, cultivated crops, and shrub/scrub. There are six regulated dischargers of effluent to Los Olmos Creek and/or the tributaries of the creek and bay.

Segment 2492B was added to NRA's routine quarterly Clean Rivers Program (CRP) monitoring schedule for TCEQ Fiscal Year 2018-2019. This project will help fill this data gap for Segment 2492B for future water quality assessments.

Parameter	Nutrient Screening Levels for Los Olmos Creek Tidal	Calculation Used for Concern
Ammonia-Nitrogen	0.46 mg/l	20% of samples are above the criteria
Nitrate	1.10 mg/l	
Total phosphorus	0.66 mg/l	
Chlorophyll-a	21.0 µg/l	

Figure 11. Screening levels for nutrient parameters on Los Olmos Creek

Figure 12. Los Olmos Creek at US-77 south of Riviera (Station 13034)

Meteorological data – During monthly site visits at each station, NRA field staff recorded meteorological information including air temperature, wind direction, wind velocity and precipitation data including days since last precipitation, amount of precipitation in the past day and past seven days. Precipitation data were obtained from multiple sources with the links provided below.

https://wrcc.dri.edu/cgi-bin/cliMAIN.pl?tx4810
https://www.weather.org/weather-history/
https://www.wunderground.com/

Sample collection - Surface water quality data including field and laboratory data were collected on a monthly basis from January 2020 through December 2020 at Los Olmos Creek Tidal Station 13034. Rain event sampling took place over two days immediately following a rain event on May 16th and 17th. Field data including water depth, water temperature, pH, dissolved oxygen and specific conductance were obtained using a Hydrolab MS5 datasonde according to the latest version of the TCEQ SWQM Procedures Manual (RG-415, 2012). The datasonde was calibrated before each sampling event and post calibrated immediately after returning from the field. Water samples were taken from the centroid of flow (point of maximum flow) at each station using a sample bucket that was pre-rinsed with site sample water. Surface water quality samples were collected, preserved with acid when applicable, stored on ice, and delivered to the laboratories that afternoon for analysis.

Figure 13. Sampling from the bridge at Los Olmos Creek Tidal Station 13034

Sample Analysis – Surface water samples were collected and analyzed for nutrient components by two laboratories. Nutrient samples including ammonia, nitrate, nitrite, total kjeldahl nitrogen (TKN), and total phosphorus were analyzed by the City of Corpus Christi Water Utilities Lab (WUL). All analytes were analyzed by the WUL using National Environmental Laboratory Accreditation Program (NELAP) accredited methods. Chlorophyll-*a* and pheophytin samples were analyzed at the Texas A&M University Corpus Christi's Center for Coastal Studies Laboratory (CCSL). NELAP accreditation for chlorophyll-*a* and pheophytin parameters are not required by TCEQ.

Site Observations – Bat guano was observed on the bank of Los Olmos Creek Tidal during site visits contributing bacteria and nutrients (nitrogen and phosphorus) to the waterbody.

Figure 14. Bat guano droppings on the high tide lines on Los Olmos Creek Tidal

Figure 15. Bat guano droppings on the bank of Los Olmos Creek Tidal

Results

Meteorological and Hydrological – Average annual precipitation in the study area is 28.98 inches per year based on data from Kingsville. The study area received below average rainfall from January through the middle part of May 2020 resulting in very low streamflow values at all stations. In the middle part of May 2020, episodic rain events, some heavy, resulted in increased streamflow due to surface runoff. The yearly precipitation total for 2020 was 26.22 inches in Kingsville.

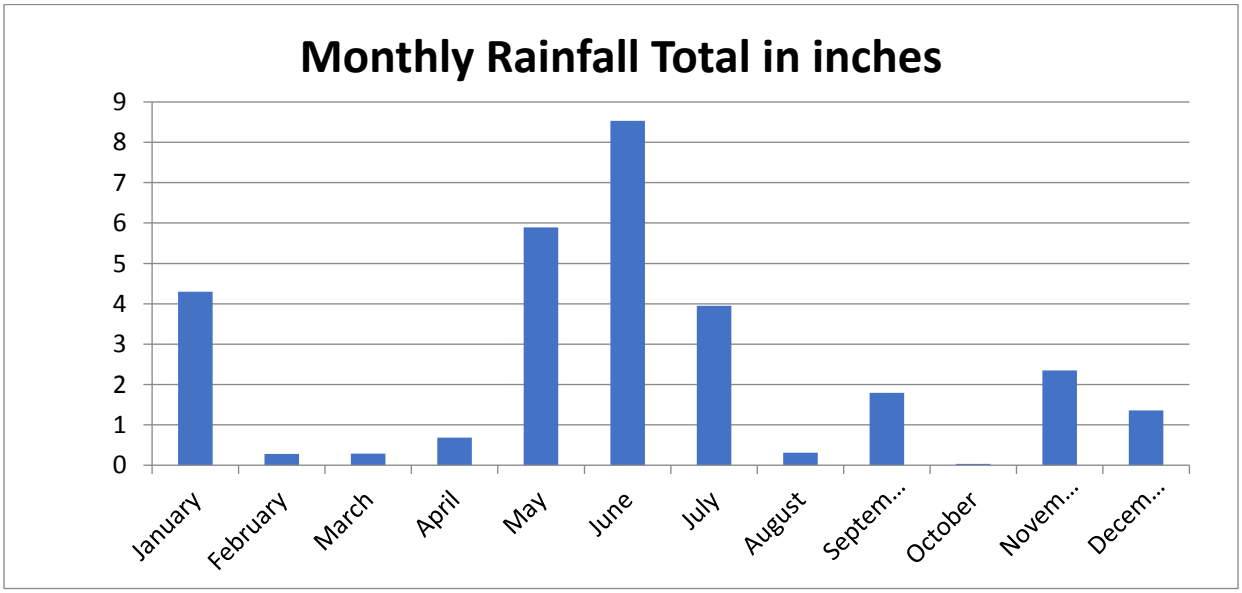

Figure 16. Monthly rainfall amounts in 2020 in Kingsville, Texas

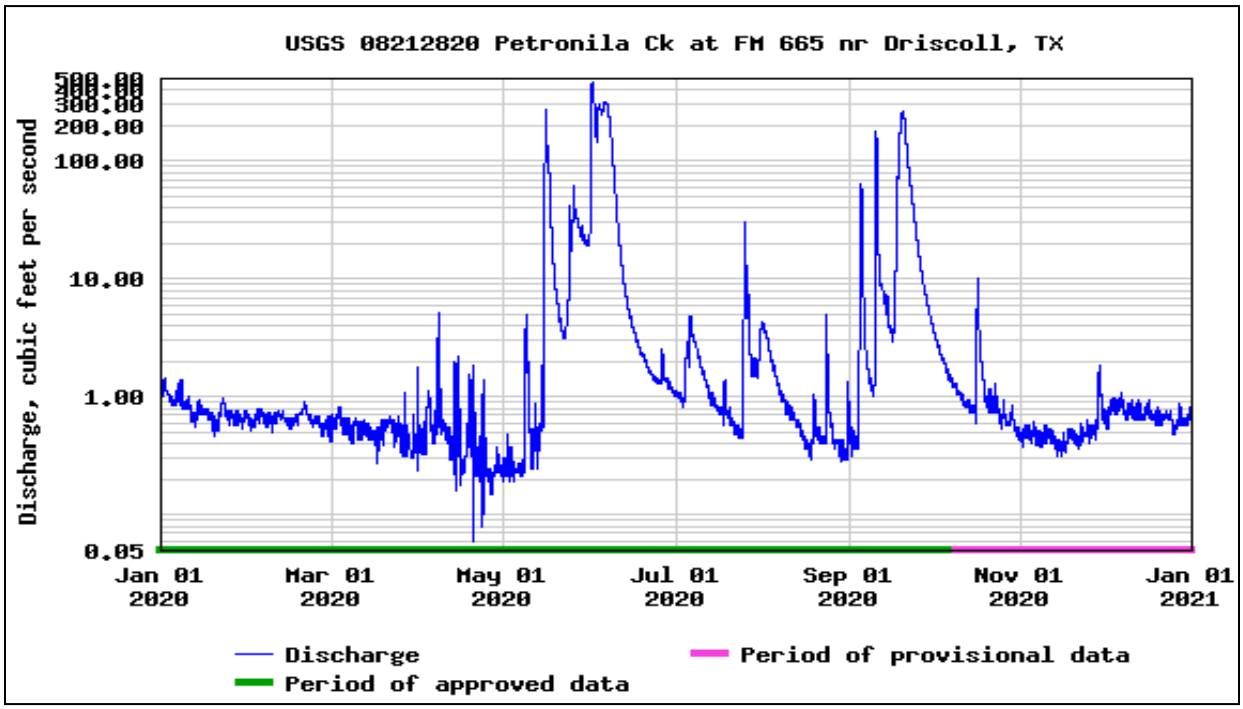

Figure 17. USGS sourced streamflow at Petronila Creek Above Tidal at FM 665

Monthly Water Quality Data on Los Olmos Creek Tidal

Ammonia nitrogen – Ammonia concentrations ranged from less than 0.1 mg/L to 0.6 mg/L. The limit of quantification (LOQ) for ammonia is 0.1 mg/L and the TCEQ screening level is 0.46 mg/L. Ammonia nitrogen concentrations were very low in the segment with 11 out of 12 samples being below the limit of detection of laboratory equipment. The mean concentration was < 0.14 mg/L.

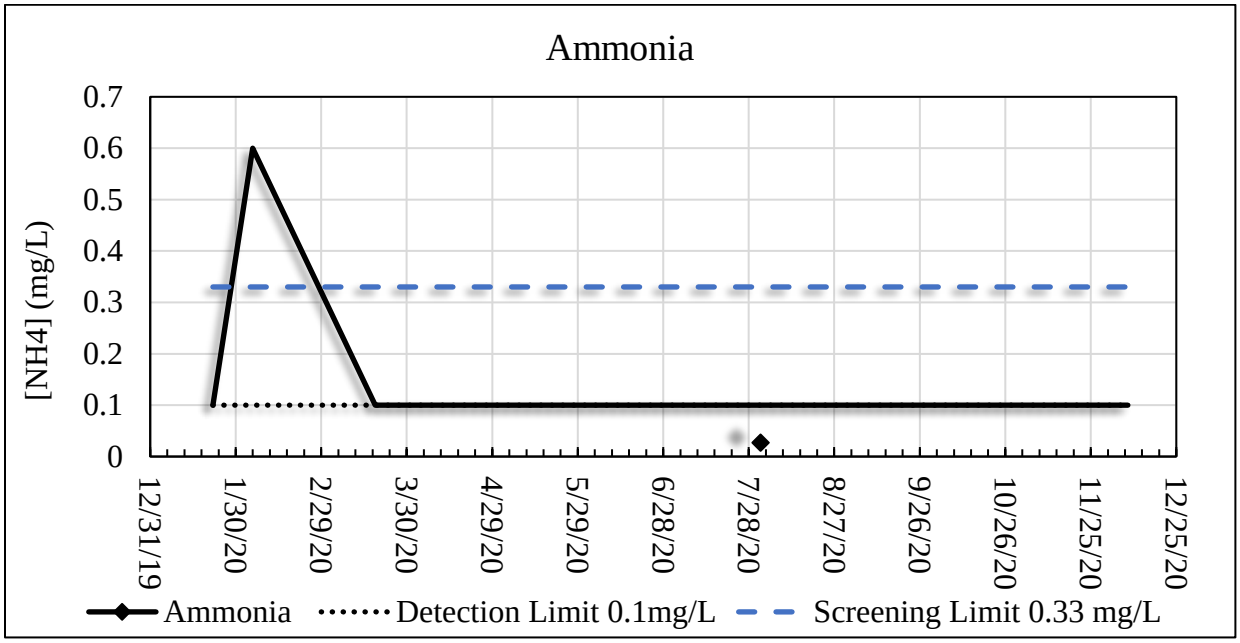

Figure 18. Monthly ammonia concentrations on Los Olmos Creek Tidal

Nitrate Nitrogen – Nitrate nitrogen concentrations ranged from less than 0.025 mg/L to 29.2 mg/L. The LOQ for nitrate nitrogen is 0.025 mg/L and the TCEQ screening level is 1.10 mg/L. Out of 12 nitrate samples collected, 8 were below the LOQ and 3 were above the screening level. The annual mean nitrate nitrogen concentration in Los Olmos Creek Tidal was 4.32 mg/L. The highest concentrations occurred from April to June 2020.

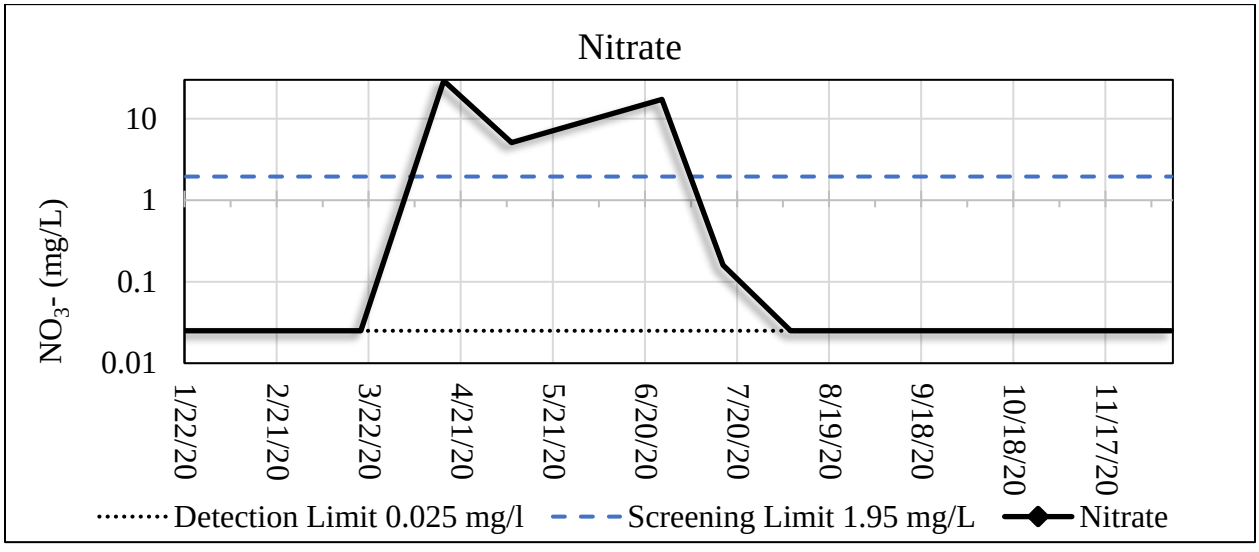

Figure 19. Monthly nitrate nitrogen concentrations on Los Olmos Creek Tidal

Monthly Water Quality Data on Los Olmos Creek Tidal

Nitrite Nitrogen – Nitrate nitrogen concentrations ranged were all less than 0.02 mg/L. The LOQ for nitrite nitrogen is 0.02 mg/L, however no TCEQ screening level exist for this parameter.

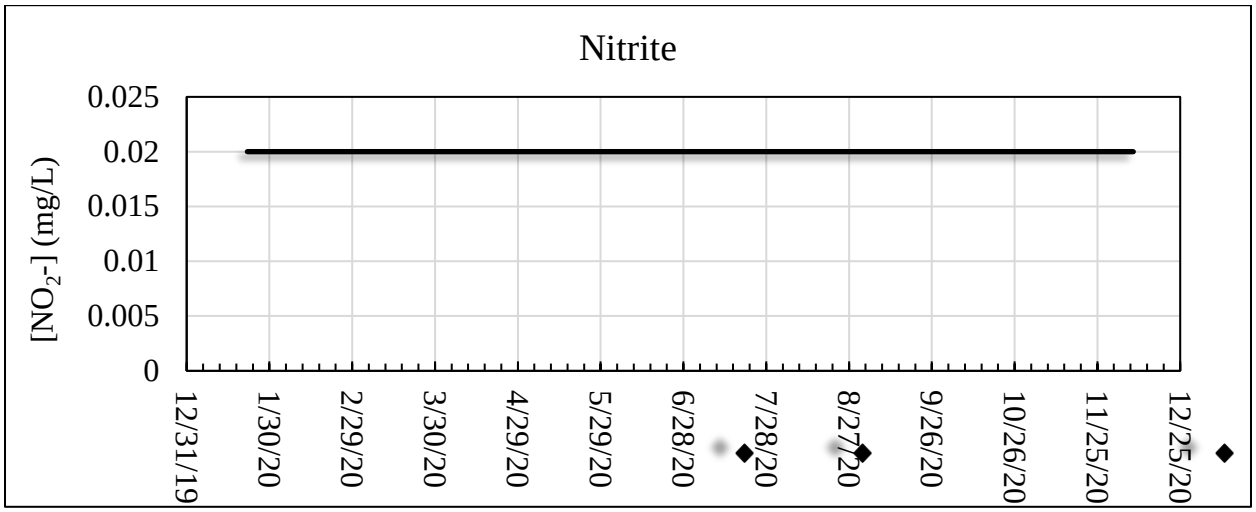

Figure 20. Monthly nitrite nitrogen concentrations on Los Olmos Creek Tidal

Total Kjedahl Nitrogen (TKN) – TKN concentrations ranged from 0.7 mg/L to 8.7 mg/L. The LOQ for TKN is 0.2 mg/L, however no TCEQ screening levels exist for this nutrient parameter. The annual mean TKN concentration of Los Olmos Creek was 3.18 mg/L.

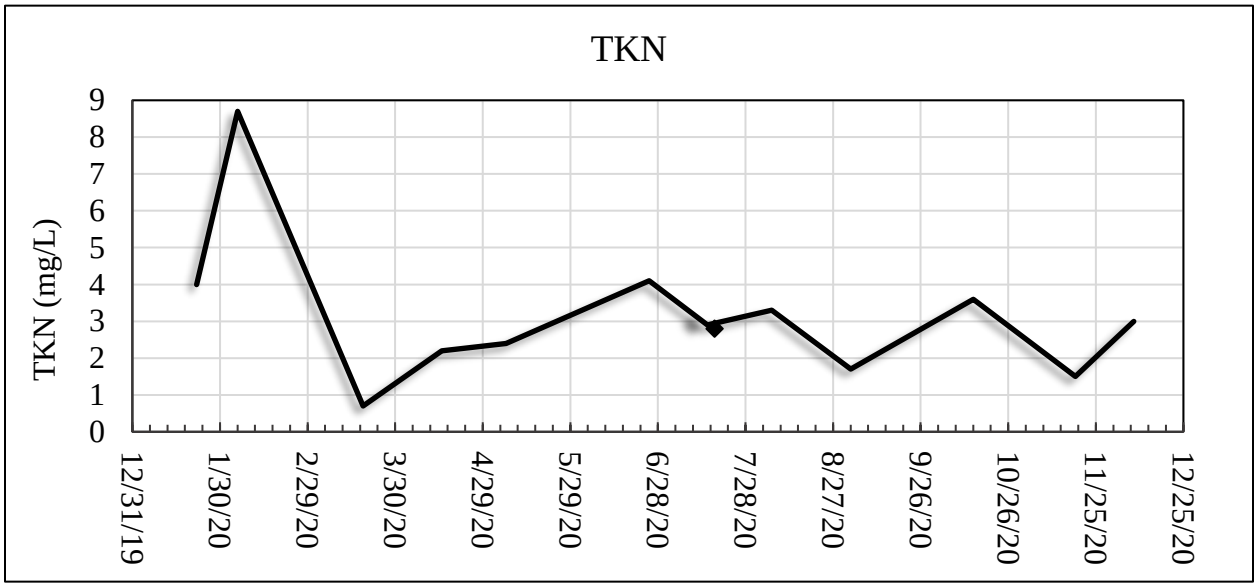

Figure 21. Monthly TKN concentrations on Los Olmos Creek Tidal

Monthly Water Quality Data on Los Olmos Creek Tidal

Total Phosphorus – Total Phosphorus concentrations ranged from less than 0.2 mg/L to 0.85 mg/L. The LOQ for total phosphorus is 0.06 mg/L and the TCEQ screening level is 0.66 mg/L. Out of 12 total phosphorus samples submitted for analysis, only one was above of the screening level. The annual mean concentration of total phosphorus concentration in Los Olmos Creek Tidal was 0.37 mg/L.

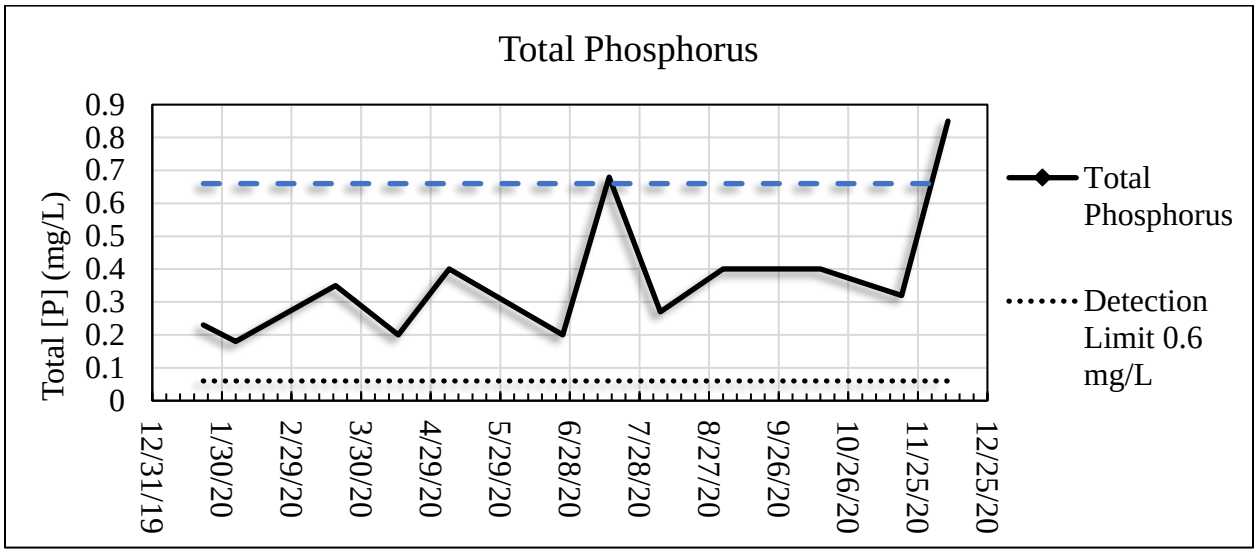

Figure 22. Monthly total phosphorus concentrations on Los Olmos Creek Tidal

Chlorophyll a – Chlorophyll *a* concentrations ranged from less than 2.0 µg/L to 346.3 µg/L. The LOQ for chlorophyll is 2.0 µg/L and the TCEQ screening level is 21.0 µg/L. Out of 12 total samples submitted for analysis, one was below the LOQ and 11 were at or above the screening level. The annual mean concentration of chlorophyll-*a* concentration in the main stem of Los Olmos Creek Tidal was 125.6 µg/L.

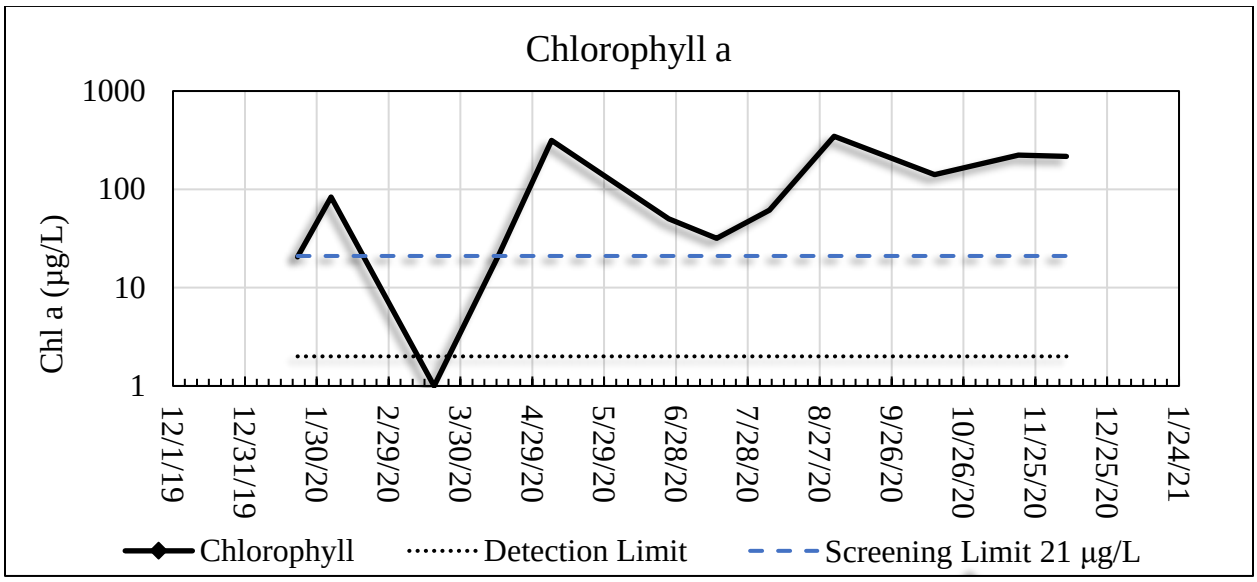

Figure 23. Monthly chlorophyll-*a* concentrations on Los Olmos Creek Tidal

Monthly Water Quality Data on Los Olmos Creek Tidal

Specific Conductance (SpC) - Specific conductance ranged from 67,300 µmhos/cm to >100,000 µmhos/cm which is the maximum value that can be measured by NRA's Hydrolab datasonde. The lowest result for SpC was recorded in August one week after a high tide event that was associated with the passage of Hurricane Hannah just south of the study area in late July 2020.

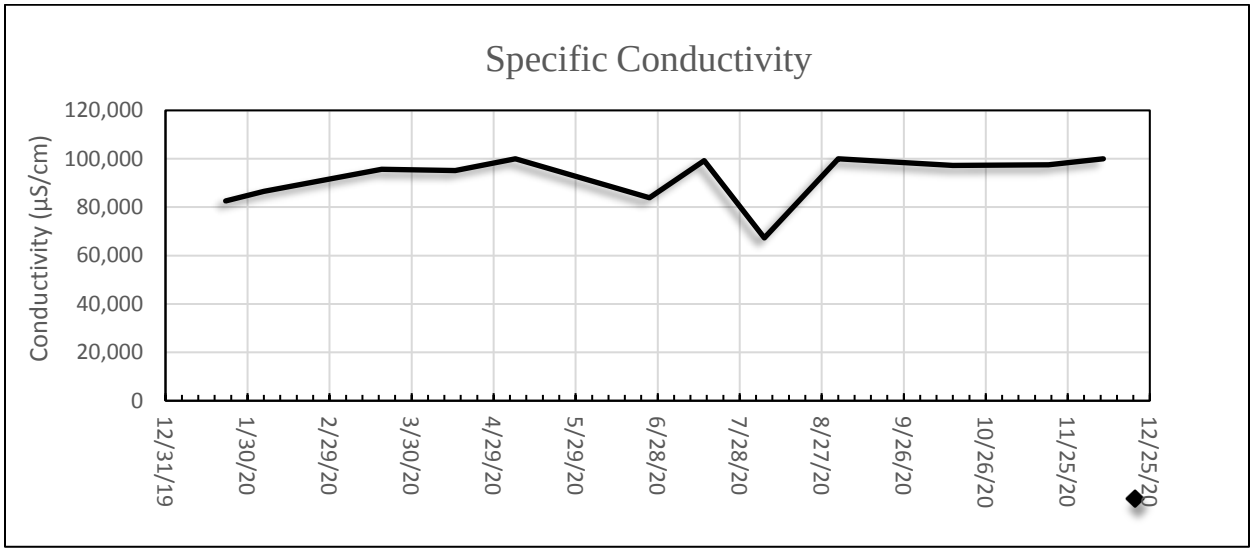

Figure 24. Monthly specific conductance concentrations on Los Olmos Creek Tidal

Salinity – Salinity results ranged from 45.8 psu to >70.7 psu which is the maximum value that can be measured by NRA's Hydrolab datasonde. Values greater than 70.7 occurred in May, September, and December. The lowest recorded measurement occurred in August one week after a high tide event that was associated with the passage of Hurricane Hannah in late July 2020.

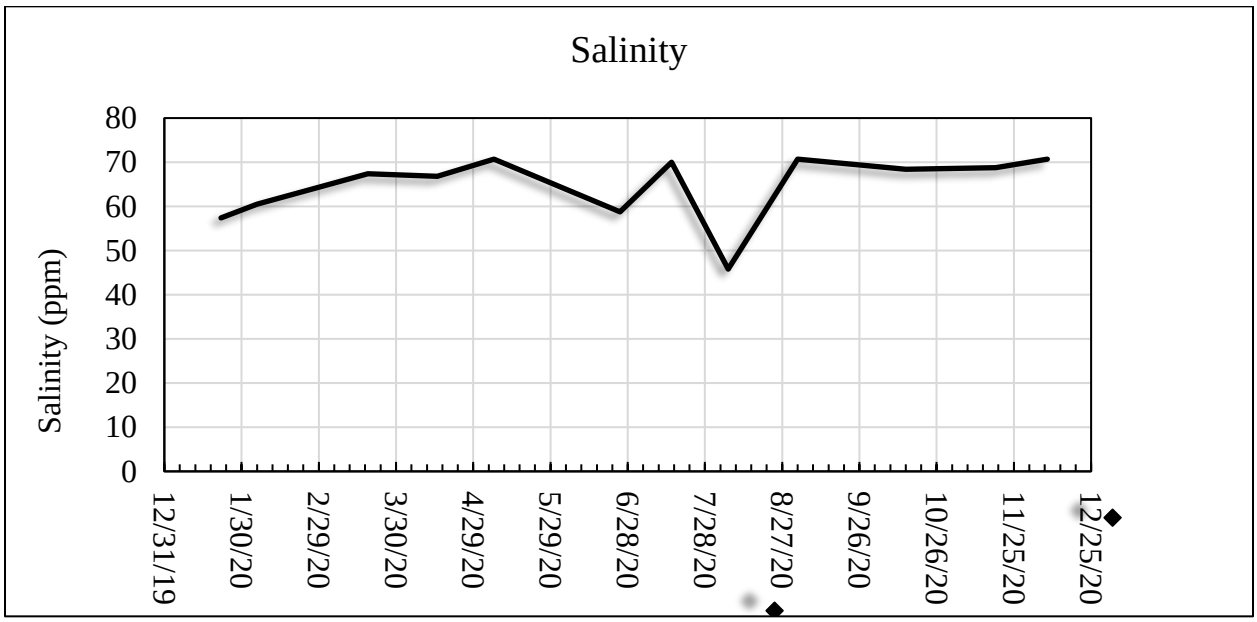

Figure 25. Monthly salinity concentrations at Los Olmos Creek Tidal

Monthly Water Quality Data on Los Olmos Creek Tidal

Dissolved Oxygen – Dissolved oxygen values ranged from 2.7 mg/L to 6.3 mg/L. Out of 12 field measurements made for dissolved oxygen, three were below the 3.0 mg/L screening level. The annual mean concentration of dissolved oxygen in Los Olmos Creek was 4.6 mg/L.

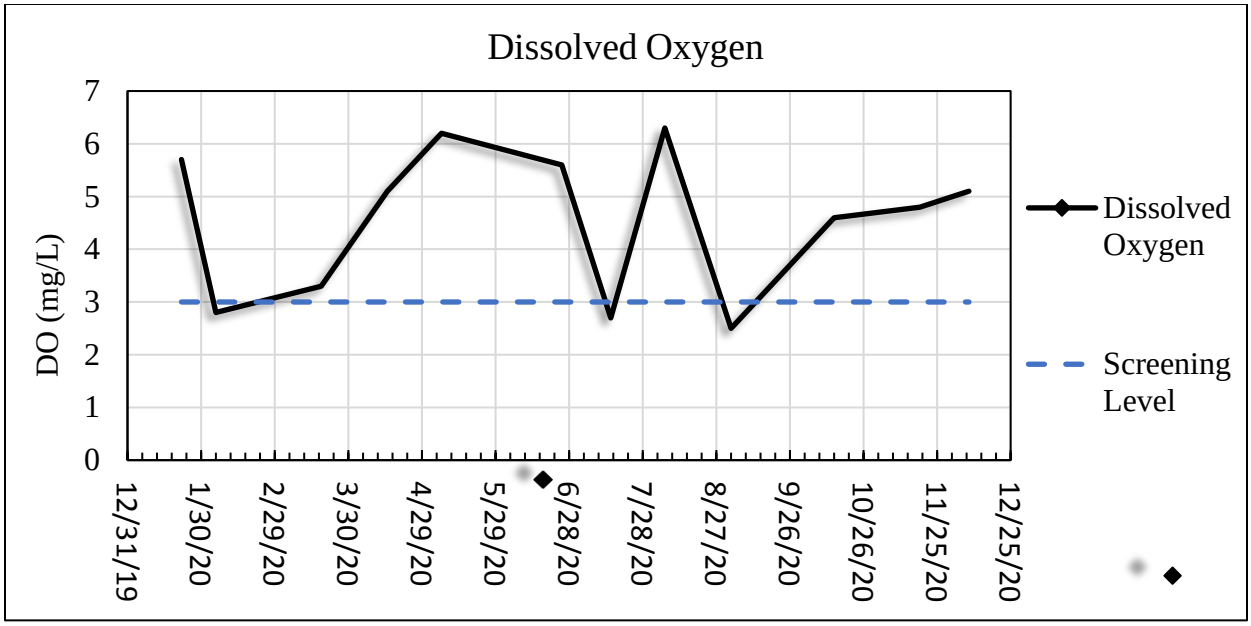

Figure 26. Monthly dissolved oxygen concentrations on Los Olmos Creek Tidal

Bacteria – Bacteria results values ranged from 407 cfu/100 mL to greater than 2,419.6 cfu/100 mL (enterococcus). Twelve out of twelve monthly routine samples collected for the study were over TCEQs contact recreation standard of 35 cfu/100 mL.

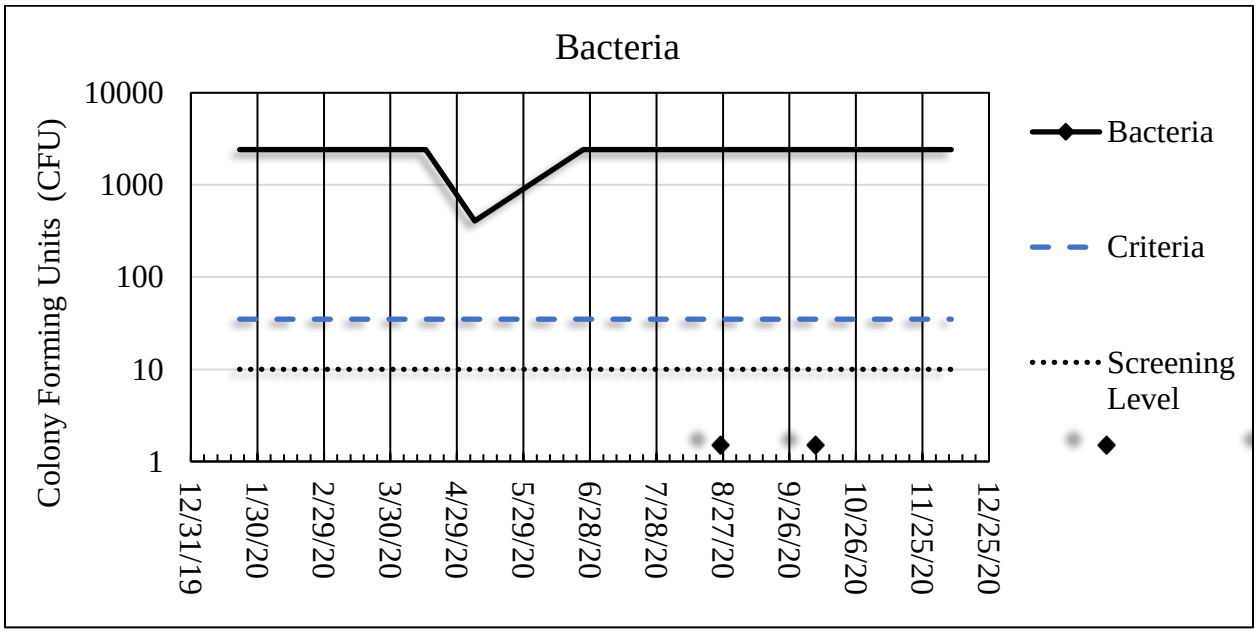

Figure 27. Monthly bacteria (enterococcus) concentrations on Los Olmos Creek Tidal

High Flow Event Results

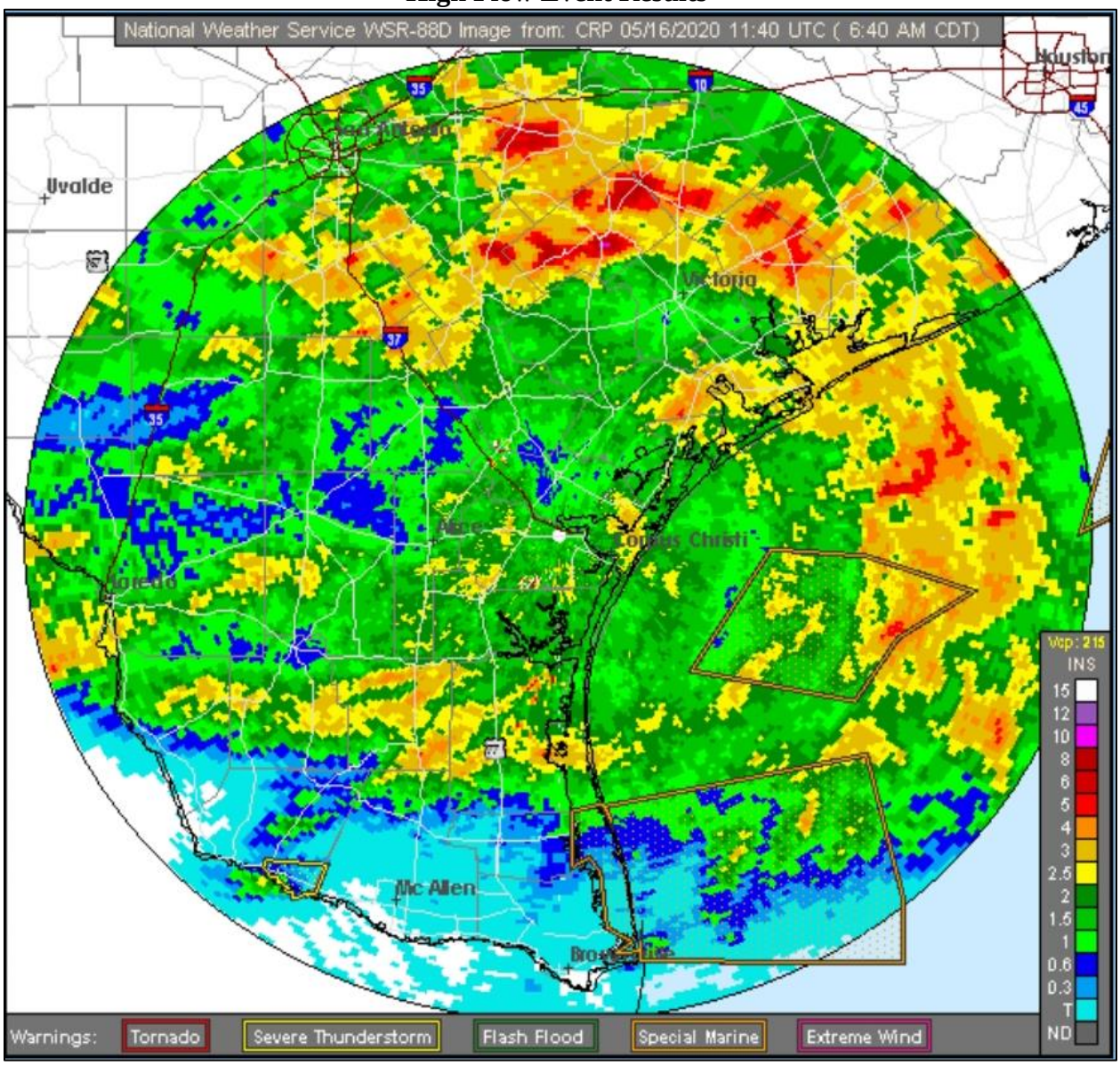

Figure 28. Rainfall totals in Texas from May 16th, 2020 storm event

Around midnight on May 16th, the National Weather Service radar indicated that a rain event would likely be approaching the study area. Preparations were made ahead of the storm to try to catch the first flow event with a second monitoring trip to occur the flowing day as per the protocol for the study. A large band of showers moved through the area and as the rain event concluded it was determined that a reconnaissance trip out to the sites to assess the conditions was necessary. The results of the rain event monitoring event are summarized is the following section. High Flow event data will not be used by TCEQ for assessment purposes.

High Flow at Petronila Creek Above Tidal - A USGS streamgage located on Petronila Creek at FM 665 (Station 13094) was used to verify a high flow event. Samples from Station 13094, which is approximately 10 miles downstream, were taken at 9:45am on May 16th at a flow rate of approximately 170 ft^3/sec and again on May 17th at a flow rate of approximately 200 ft^3/sec.

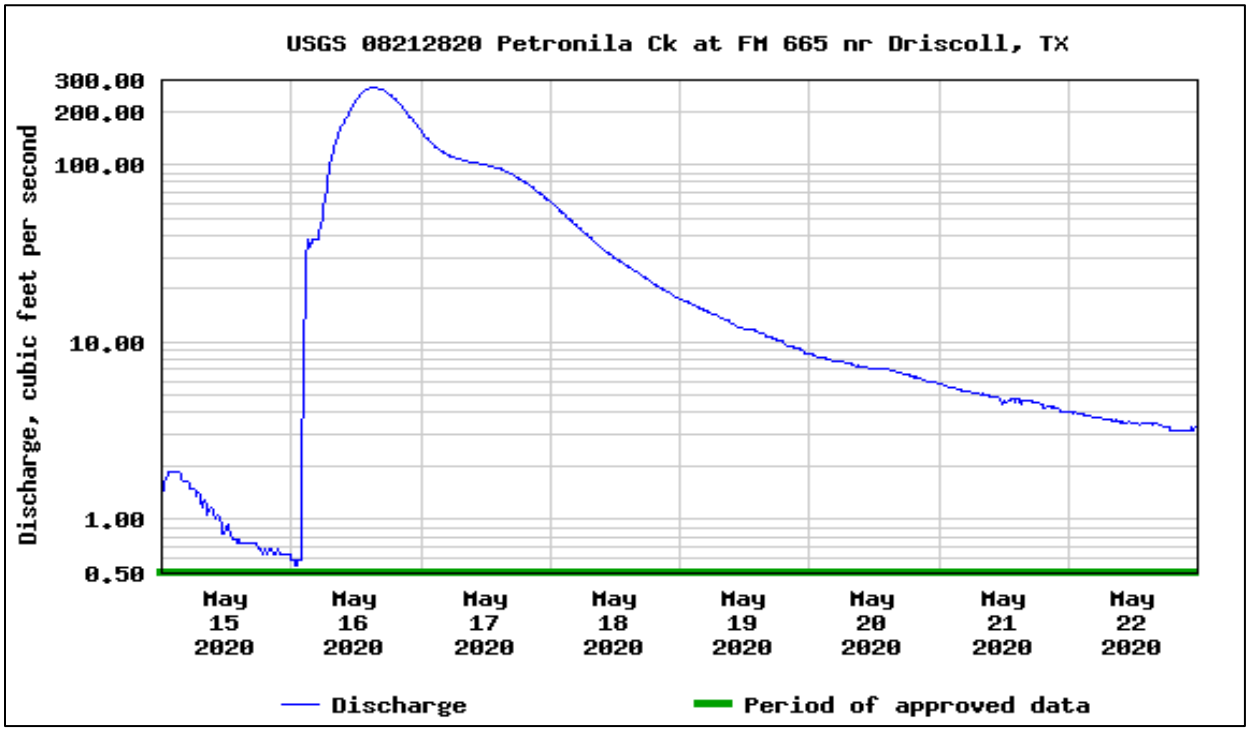

Figure 29. USGS sourced high flow data on Petronila Creek at FM 665 near Driscoll

Figure 30. Petronila Creek Above Tidal at approx. 170 ft^3/sec on May 16th

High flow event at San Fernando Creek Above Tidal - Site reconnaissance on May 16th at Station 13034 on San Fernando Creek indicated a high flow event was underway. Samples were taken at 10:20 am at a flow rate of approximately 300 ft^3/sec. A subsequent monitoring event occurred on the second day, May 17th, at a flow rate of approximately 200 ft^3/sec.

Figure 31. San Fernando Creek Above Tidal at approx. 300 ft^3/sec on May 16th

Figure 32. San Fernando Creek Above Tidal at approx. 200 ft^3/sec on May 17th

High Flow Event at Los Olmos Creek Tidal - Site reconnaissance on May 16th at Station 13034 on Los Olmos Creek Tidal indicated that the site had minimal freshwater inflow at the time of monitoring based on the still elevated salinity levels of 58.4 ppt. Datasonde values obtained on the monthly monitoring trip May 7th indicated a salinity greater than 70.7 ppt. The water level was slightly higher than past monthly site visits and the water appeared to be moving downstream, albeit slightly. The decision was made to take water samples for analysis on May 16th and 17th to complete the date set for the project.

Figure 33. Los Olmos Creek Tidal (Station 13034) on May 16th

Figure 34. Los Olmos Creek Tidal (Station 13034) on May 17th

High Flow Event Data Results

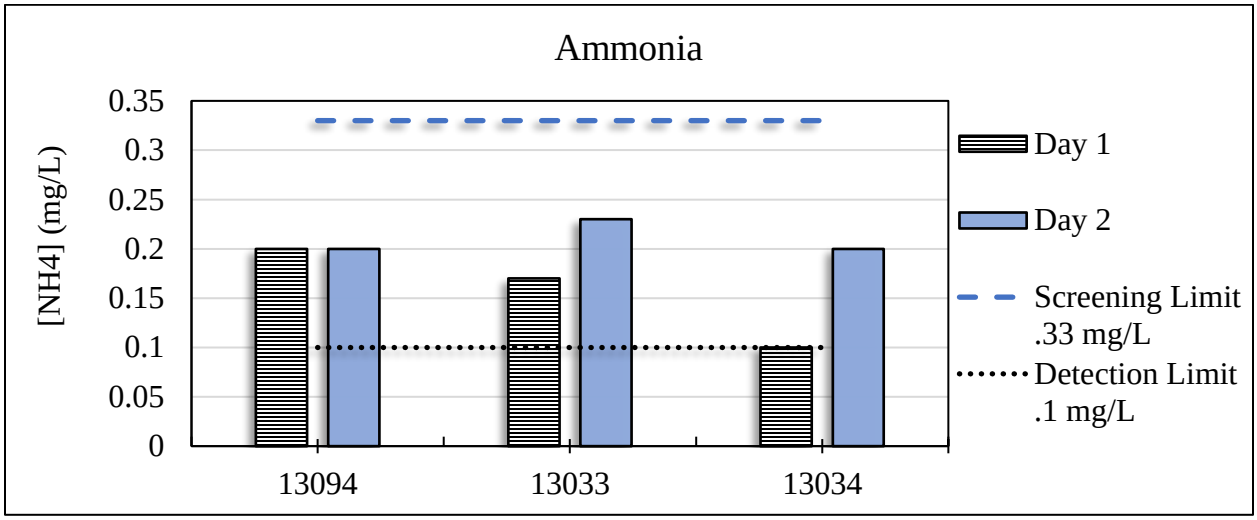

Figure 35. High flow event data for ammonia

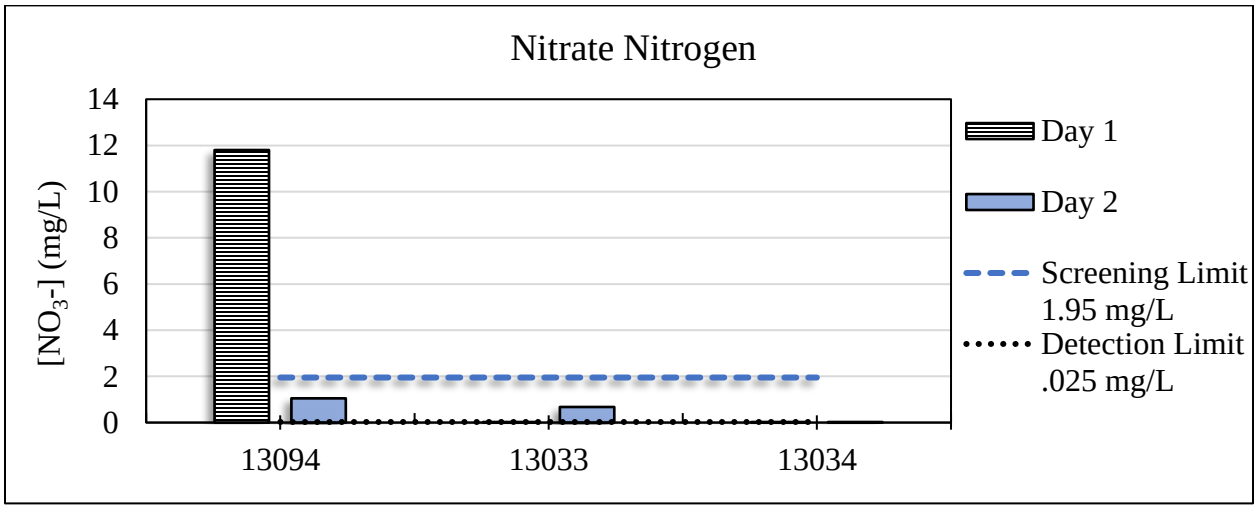

Figure 36. High flow event data for nitrate nitrogen

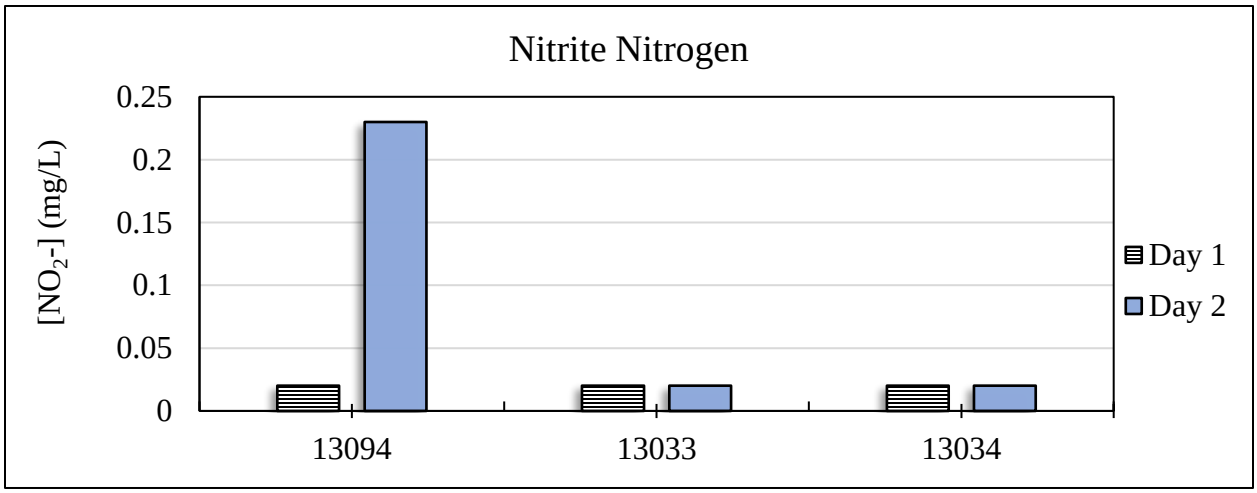

Figure 37. High flow event data for nitrite nitrogen

High Flow Event Data Results

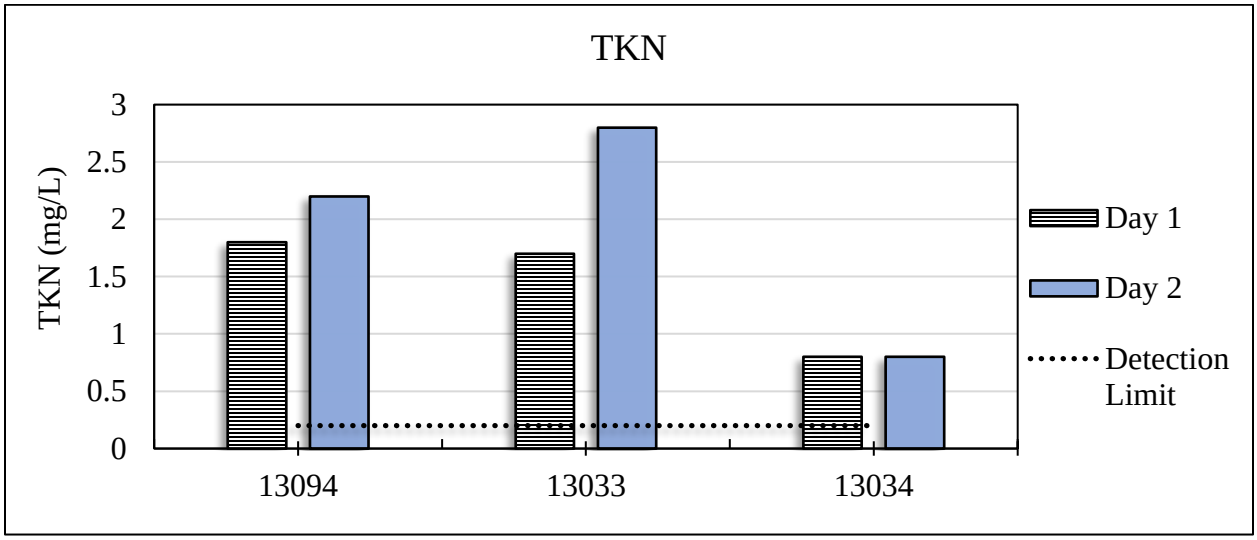

Figure 38. High flow event data for TKN

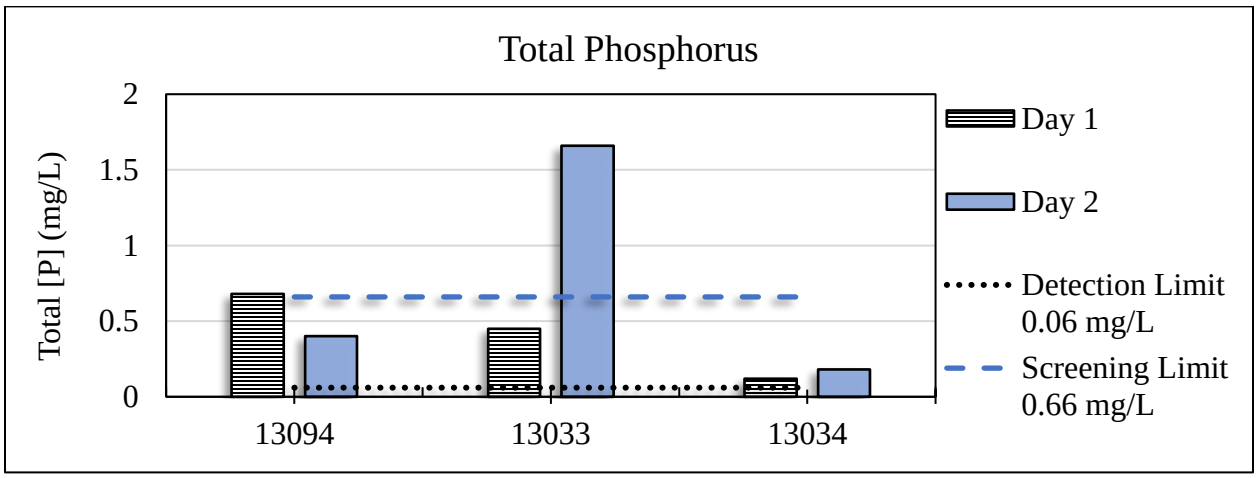

Figure 39. High flow event data for total phosphorus

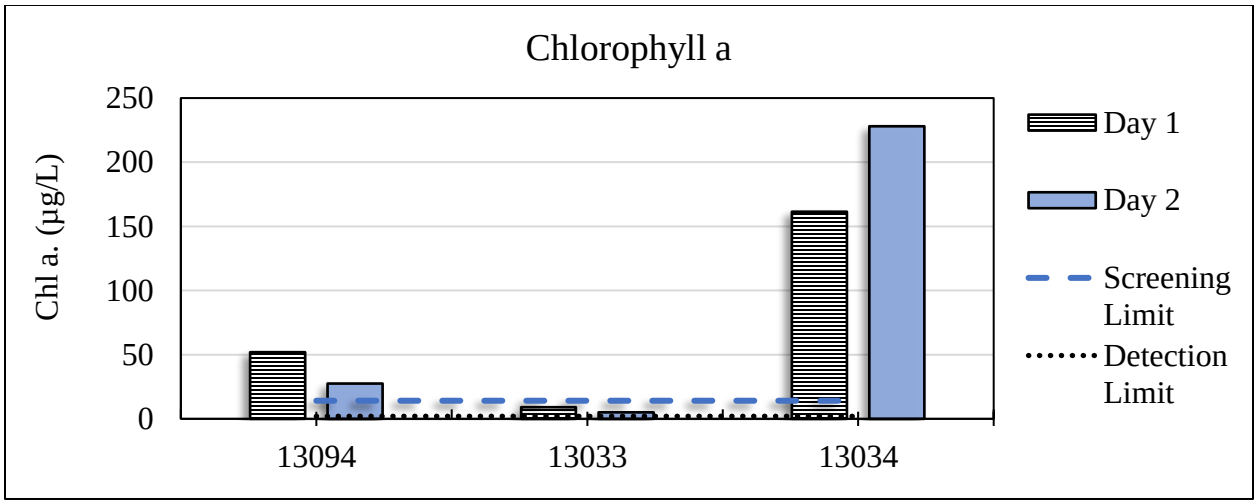

Figure 40. High flow event data for chlorophyll-*a*

High Flow Event Data Results

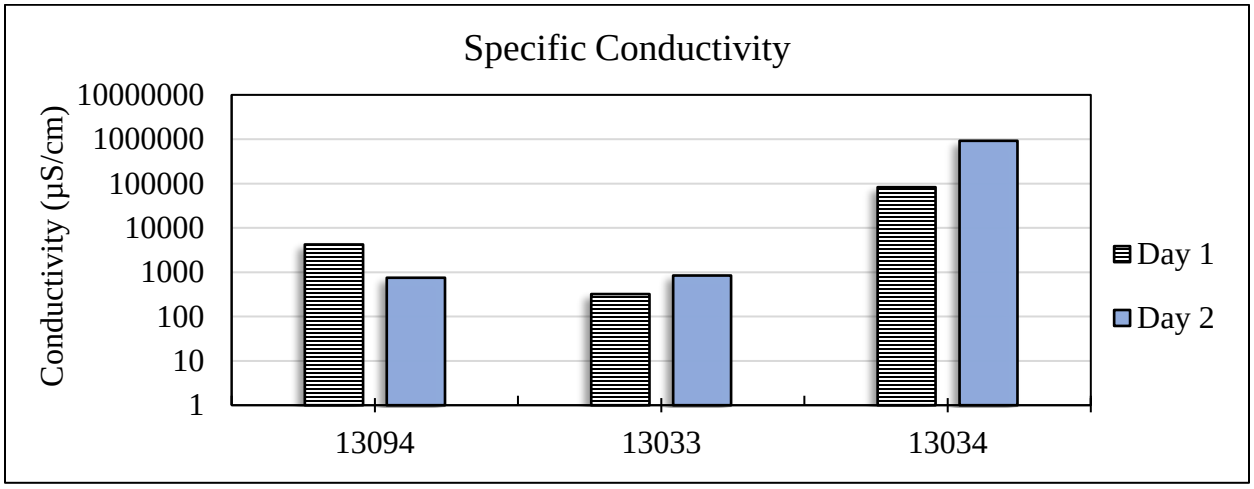

Figure 41. High flow event data for specific conductance

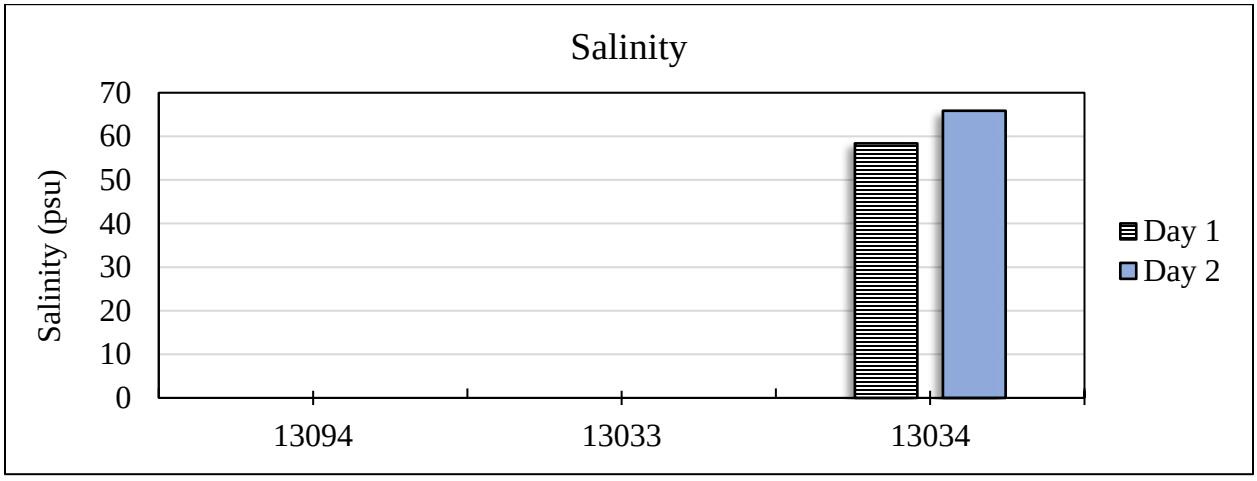

Figure 42. High flow event data for salinity

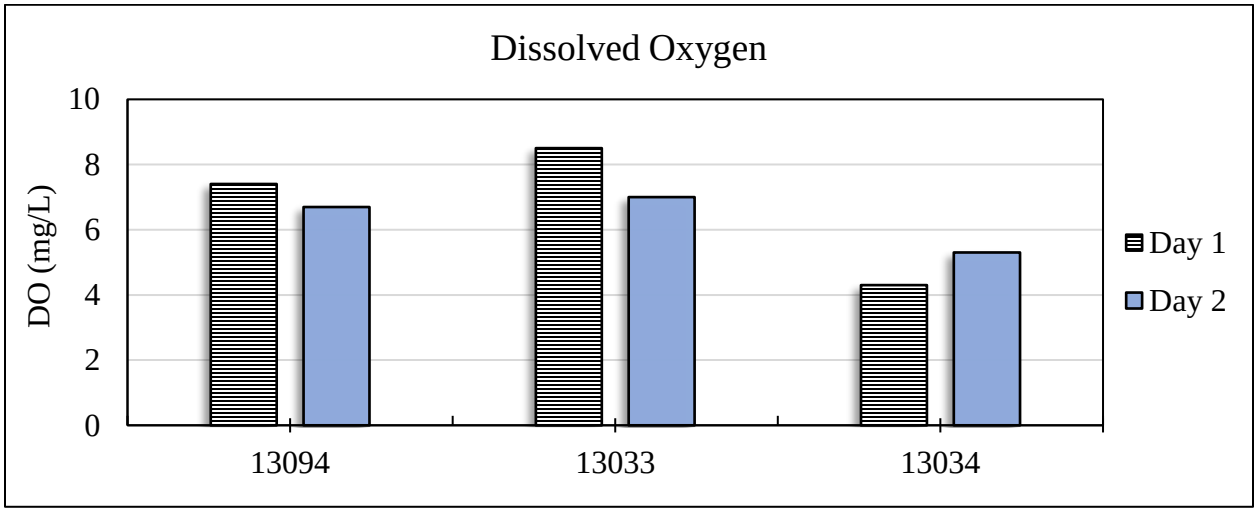

Figure 43. High flow event data for dissolved oxygen

High Flow Event Data Results

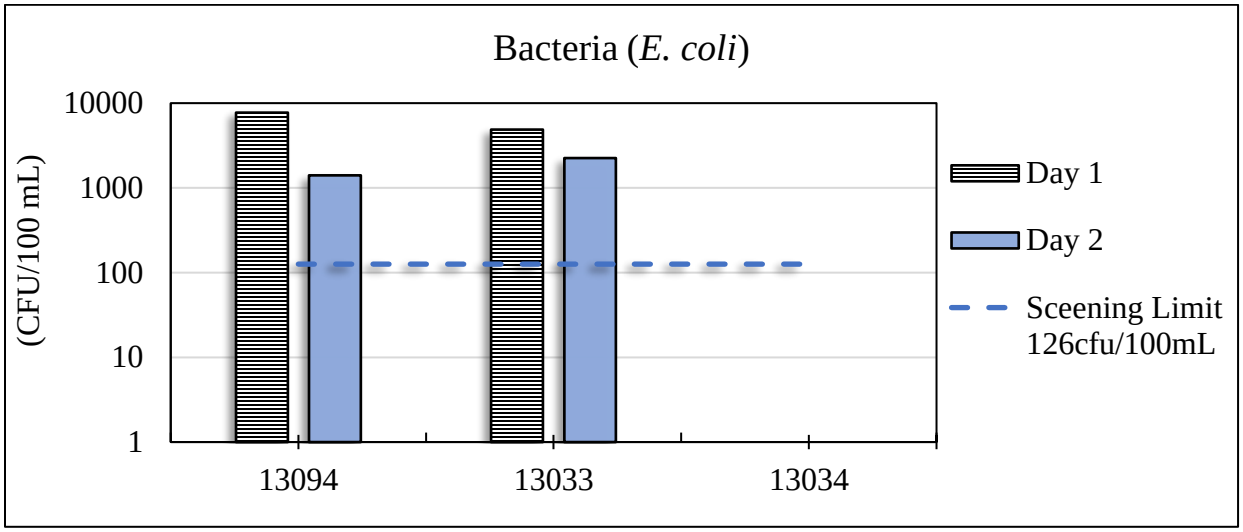

Figure 44. High flow event data for bacteria (*E. coli*) at Stations 13094 and 13033

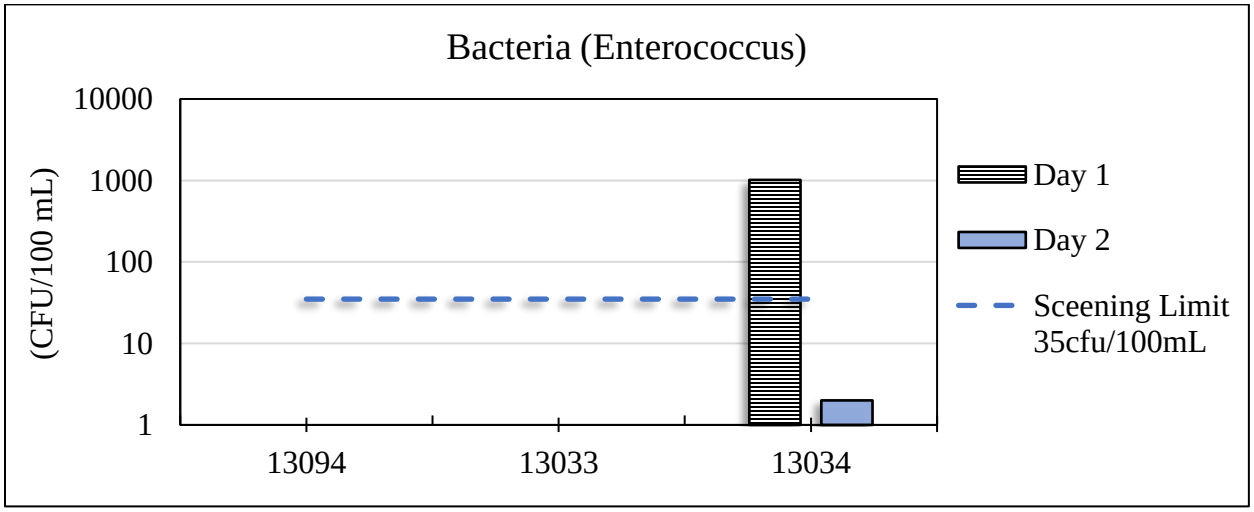

Figure 45. High flow event data for bacteria (Enterococcus) at Station 13034

Figure 46. High flow event samples from Petronila, San Fernando and Los Olmos creeks

Conclusions

Los Olmos Creek Monthly Monitoring - Los Olmos Creek Tidal is a shallow waterbody (< 0.5 m) with sporadic freshwater inflows, minimal circulation, elevated nutrient inputs, and extremely high specific conductance, and salinity values. Monthly data collected from January through December 2020 show increased concentrations nutrients and bacteria. Nutrient screening level concern exceedances were identified for nitrate nitrogen and chlorophyll-*a.* Bacteria results indicate that the water body has elevated concentration of indicator bacteria (Entrococcus) with average concentrations (>2,300 cfu/100 mL) being two orders of magnitude higher than the bacteria indicator standard for marine waters set by the state (35 cfu/100 mL).

Ammonia – Ammonia concentrations in the Los Olmos Creek Tidal Watershed were very low throughout the study period. The highest concentration occurred during dry weather monitoring in February with a value of 0.6 mg/L.

Nitrate Nitrogen – Nitrate nitrogen results over the year-long study showed a strong seasonal trend with the highest numbers occurring during the spring months (April – June). However, 8 out of 12 samples collect were below the detection limit of laboratory equipment. Due to the extremely elevated concentrations collected from April through June, the average concentration of nitrate was 4.32 mg/L.

Nitrite Nitrogen - Nitrite nitrogen results were all very low during the study period. Values were all below the detection limits of laboratory equipment which is 0.02 mg/L. In Texas, screening levels for this parameter does not yet exist.

Total Kjeldahl Nitrogen - Total kjeldahl nitrogen concentrations showed moderate variability with no seasonal trend or correlation to other forms of nitrogen.

Total Phosphorus – Total phosphorus results indicated moderate concentrations and minimal variability for this parameter. The average concentration over the course of the study was 0.37 mg/L, which is below the screening level of 0.66 mg/L for Los Olmos Creek Tidal.

Bacteria – Bacteria concentrations over the course of the study were highly elevated and likely at least partially attributed to the bat colony that resides under the bridge.

Chlorophyll-a – Chlorophyll-*a* concentrations over the course of the study were highly elevated and likely attributed to nitrate, TKN, and total phosphorus concentrations.

Recommendations

NRA recommends a continuation of data collection efforts on Los Olmos Creek Tidal to further characterize the water quality to account for seasonal and climactic variability. Due to the proximity of the bat colony to the sampling location, it is recommended that the sampling station be moved away from the bridge crossing.