ESA 50 YEARS 1969-2019

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memorandum

date April 9, 2021

to Brandon Johnson

from David Tomasko, Ph.D.
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subject Little Bayou / Basin Q Water Quality Analysis

Background

Stantec and ESA are assisting the City of St. Petersburg (City) with the Little Bayou Basin Q Water Quality Improvements project.

ESA is providing this Draft Technical Memorandum as an update on the following tasks: 1) determination of impairment status for water quality, 2) development of a pollutant loading model for TN, and 3) development of an empirical model to determine associations between pollutant loads and ecosystem responses.

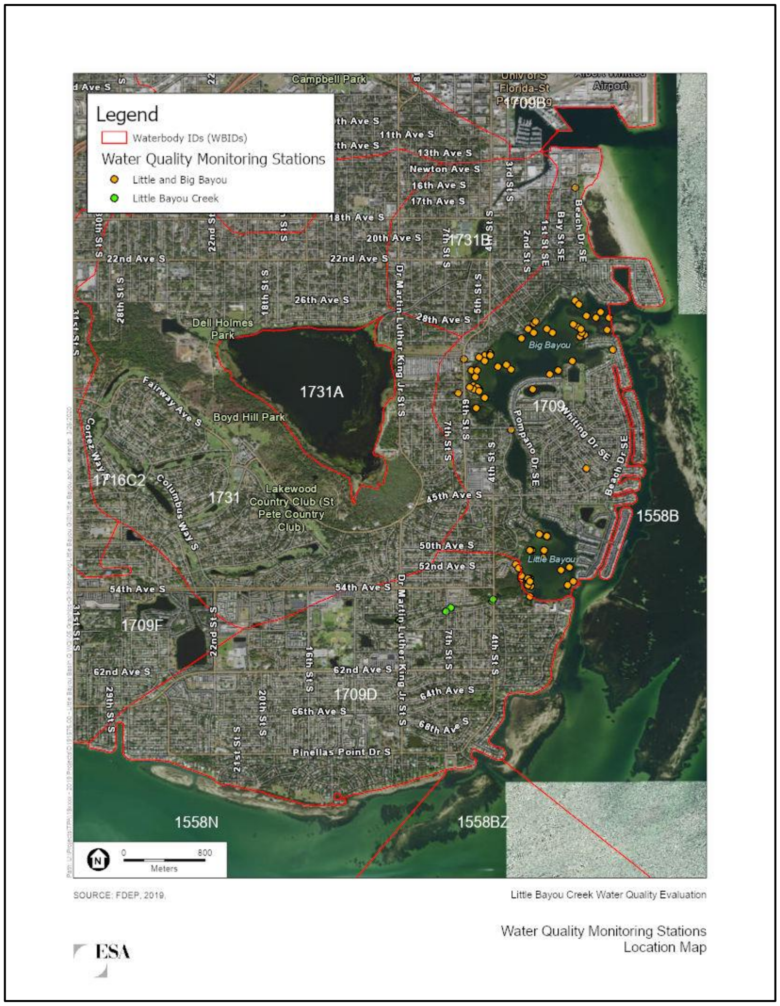
Impairment status for water quality

Little Bayou Creek (Little Bayou- Basin Q) is located in the southern portion of Saint Petersburg and discharges into Little Bayou, which is in turn connected with both Big Bayou and Lower Tampa Bay (Figure 1).

As seen in Figure 1, the Waterbody Identification (WBID) for "Little Bayou" actually refers to the combination of Little Bayou and Big Bayou, both of which are included as WBID 1709, which FDEP refers to as "Big Bayou Estuary". However, that portion of Little Bayou Creek which flows into the western border of Little Bayou is actually part of a separate WBID, 1709D. As a result, according to FDEP, Little Bayou Creek (WBID 1709D) discharges into the Big Bayou Estuary (WBID 1709). There is no separate WBID for Little Bayou itself. As well, the WBID for Little Bayou Creek (1709D) includes neighborhoods where stormwater runoff drains to the south, toward Lower Tampa Bay. As seen in Figure 1, the WBID for Little Bayou Creek (1709D) includes both Pinellas Point Park and Katherine B. Tippetts Park, which clearly do not drain north east towards Little Bayou.

FDEP assigns each WBID to one of five Groups distributed around the State. Little Bayou Creek (WBID 1709D) is within Group 1- Tampa Bay. Each year, FDEP performs a comprehensive evaluation of the water quality conditions for each WBID within one of the five Groups and determines compliance with the water quality standards (F.A.C. 62-302). Waterbodies which fail to meet the mandated water quality standards are placed on the "Verified Impaired" List. As such, each WBID is evaluated for compliance with existing water quality standards every five years.

Figure 1 – Overview map of Little Bayou, Big Bayou, various WBID boundaries used by FDEP, and the location of water quality sampling locations listed in FDEP's Impaired Waters Rule (IWR) Run 58.



ESA reviewed the most recent FDEP Comprehensive Verified List (from November 26, 2019) to identify any potential parameters of concern within the WBIDs of Big Bayou Estuary (1709) and Little Bayou Creek (1709D). In 2009, Little Bayou Creek (WBID 1709D) was identified as impaired for Dissolved Oxygen (DO) and Nutrients due to elevated phytoplankton production, as measured as chlorophyll-a. However, it is important to note that during the time of that evaluation, Little Bayou Creek was classified as an estuarine system and therefore, subject to the water quality standards of a Class III Marine waterbody. Additionally, water quality standards have been modified since that assessment. In prior years, the DO criteria for a class III-Marine waterbody was 4.0 mg/L while the chlorophyll-a criterion was 11 ug/L. It is unclear when FDEP changed the waterbody classification from class III-Marine to Class III-Freshwater, which is the present category for Little Bayou Creek. In 2019, Little Bayou Creek was listed as impaired for bacteria (*Escherichia coli*) and Nutrients based upon elevated Total Phosphorus (TP), based upon the WBID (1709D) then being categorized as a Class III-Freshwater stream.

ESA was tasked with reviewing the available water quality data within the Little Bayou Creek watershed. All water quality data associated with the Little Bayou Creek (WBID 1709D) and Big Bayou Estuary (WBID 1709) were retrieved from the most recent FDEP comprehensive water quality database used for impairment determinations (IWR Run 58). As can be seen in Figure 1, the water quality stations for both Little Bayou and Big Bayou (both part of WBID 1709) are randomly located throughout both systems. In contrast, the water quality data from Little Bayou Creek (WBID 1709D) are from fixed locations (Figure 2).

Figure 2 – Overview map of Little Bayou Creek (WBID 1709D) and the location of water quality sampling locations.

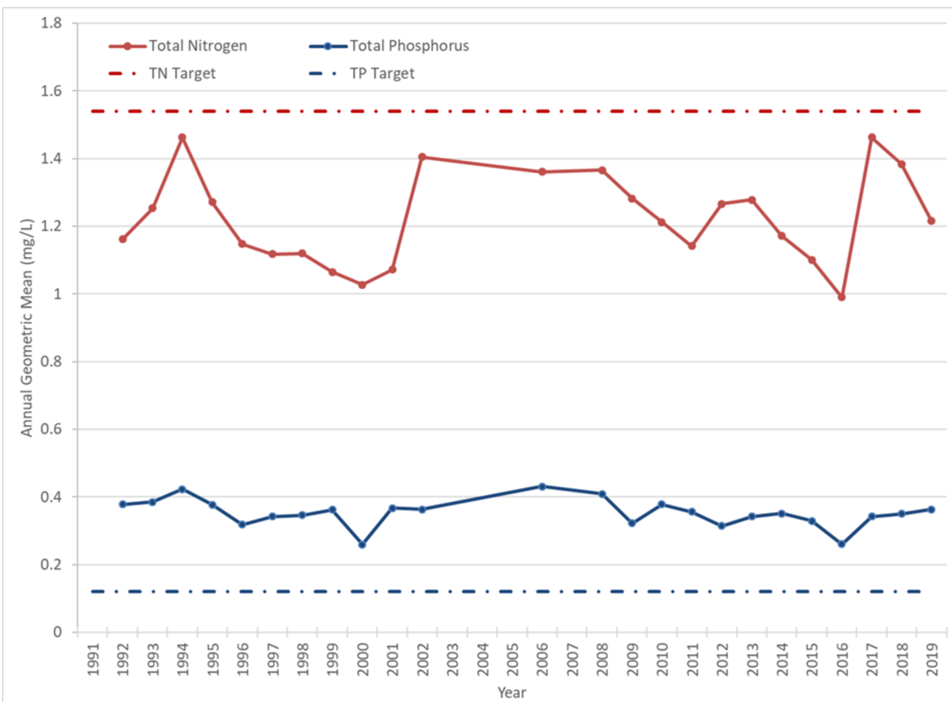
The five water quality stations listed by FDEP for the Little Bayou Creek watershed (WBID 1709D) are actually from three locations: 1) Little Bayou Creek at Dr. Martin Luther King, Jr. Street South, 2) Little Bayou Creek at 7th Street South, and 3) Little Bayou Creek at 4th Street South. The only water quality monitoring station which appears to be currently sampled is station 21FLCOSP51-02 located at 7th Street S and Little Bayou Creek. This sampling location was originally monitored by FDEP (21FLPDEM51-02) from April 2008 through December 2012. In June 2013, the City incorporated this monitoring station into their monitoring program. The remaining water quality monitoring locations either have limited datasets or were discontinued in 2002.

For WBID 1709, the use of a randomized, stratified sampling design meant that station locations varied each time that data were collected. To aid in data analysis, these data were assigned to the sampling entity to better characterize the temporal element of the sampling program. As such, data collected by the Florida, Fish and Wildlife Conversation Commission (21FLGFWF) were all from different locations within the WBID. The entire data set for WBID 1709, as contained within IWR Run 58 were field parameters, such as salinity/specific conductance, DO, pH, and water temperature. There was one station (21FLPDEM50-01) with a more robust dataset including both field parameters and both nutrients and chlorophyll-a data; however, this station was located between Little and Big Bayou and is therefore not suitable for determining the water quality of the waterbody downstream from Little Bayou Creek itself. As well, water quality from that location – the only station with nutrients and chlorophyll-a data in IWR Run 58, was not recent, it was only for the period of January 1991 to November 2002.

Based on this combination of WBID delineations, monitoring station locations, monitoring programs, and parameter lists, an independent evaluation of impairment for nutrients, DO and bacteria was performed to assist in providing guidance to the City. The FDEP criteria for nutrients stipulate that the annual geometric means may not exceed the relevant Numeric Nutrient Concentration (NNC) criterion more than once within a consecutive three-year period.

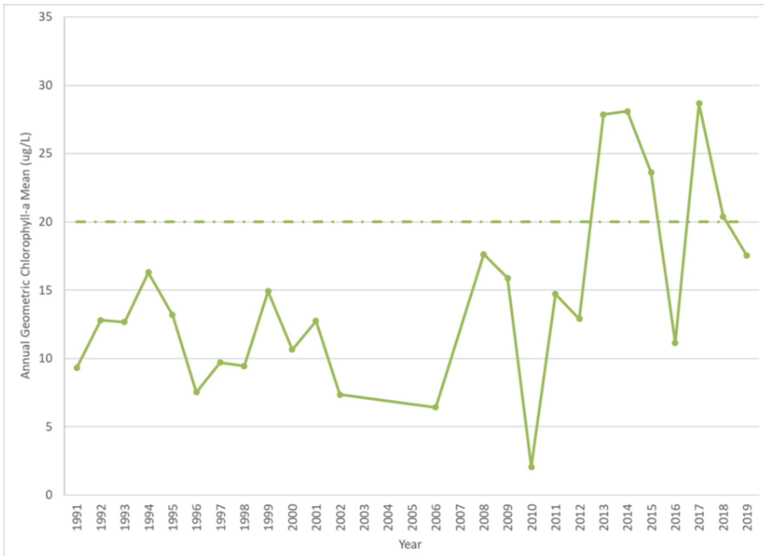
Due to the limitations of the data set outlined above, the water quality analyses were restricted to stations within Little Bayou Creek (WBID 1709D) with nutrient results shown in Figure 3.

Figure 3 – Annual geometric mean values for Total Nitrogen (TN) and Total Phosphorus (TP) for water quality within Little Bayou Creek (WBID 1709D). Dashed lines represent relevant NNC criteria for both TN (1.54 mg/L) and TP (0.12 mg/L).



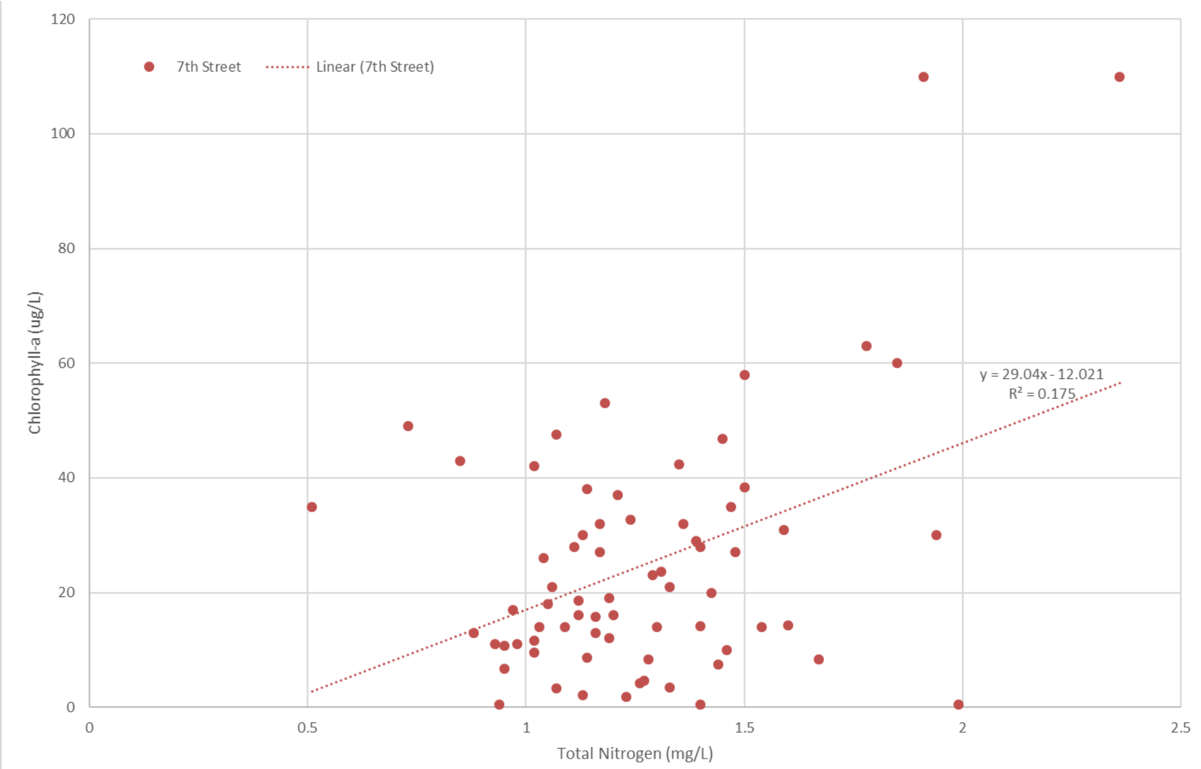
Based on ESA's independent evaluation of available water quality data, Little Basin Creek (WBID 1709D) would be classified as impaired for elevated TP, but not TN. When evaluating the chlorophyll-a data, elevated concentrations since 2013 resulted in sufficient annual geometric mean exceedances of 20 µg/L to classify the waterbody as impaired for chlorophyll-a (Figure 4).

Figure 4 – Annual geometric mean values for chlorophyll-a (µg/L) within Little Bayou Creek (WBID 1709D). Dashed line represents relevant chlorophyll-a criteria for Class III-freshwater systems of 20 µg/L.



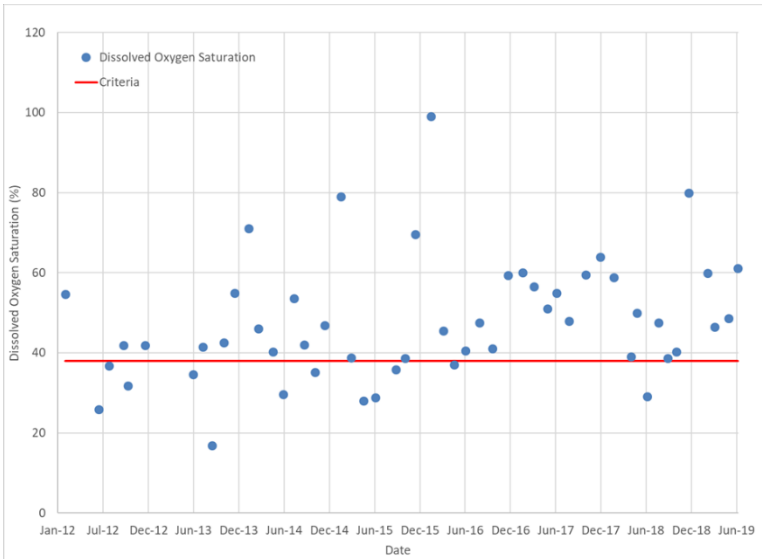
Nutrient availability typically drives phytoplankton production (as measured by chlorophyll-a concentrations); therefore, chlorophyll-a concentrations can be directly influenced by one nutrient or both (co-limitation). Due to the phosphate-rich geology of the region, nitrogen is typically the limiting nutrient within the surrounding rivers and estuaries. Generally speaking, a TN:TP ratio between 10 and 30 is considered a balanced system indicating that nitrogen and phosphorus concentrations are both directly linked to phytoplankton production. Due to elevated TP concentrations within Little Bayou Creek, the TN:TP ratio is consistently below 10 and typically below 5 indicating elevated phosphorus in the system which is supported by the nutrient impairment determination. A TN:TP ratio below 10 indicates that nitrogen is likely the limited nutrient of concern within Little Bayou Creek. This conclusion is further supported by the lack of a relationship between TP and chlorophyll a at either station (4th or 7th Street). Which suggests that manipulation of phosphorus is not likely to have a direct impact on phytoplankton production. However, there is a statistically significant relationship between TN and Chlorophyll-a at the 7th Street location (Figure 5; $p=0.003$, $r^2=0.17$), yet TN is not identified as a parameter of concern based on implementation of the NNC. The discrepancy might be due to misalignment of the regional NNC criteria for this particular water body. Based upon the best-fit linear equation between TN and Chlorophyll-a, a TN target of 1.10 mg/L for a respective measurement at the 7th Street monitoring station is predicted to equate to a chlorophyll –a of 20 ug/L. It is important to note that TN concentrations at the 7th Street monitoring site explains only 17% of the variability in chlorophyll, indicating that other factors (or combination of factors) are driving phytoplankton production beyond nitrogen availability (i.e., residence time). Prior to establishing alternative targets for Little Bayou Creek, it is recommended that monitoring is continued within the creek (particularly at the 7th street station which is an established long-term monitoring station) and initiated in the direct receiving water body (Little Bayou).

Figure 5 – Direct linear relationship between total nitrogen and chlorophyll-a concentrations at the 7th Street monitoring station ($p<0.05$, $r^2=0.17$)



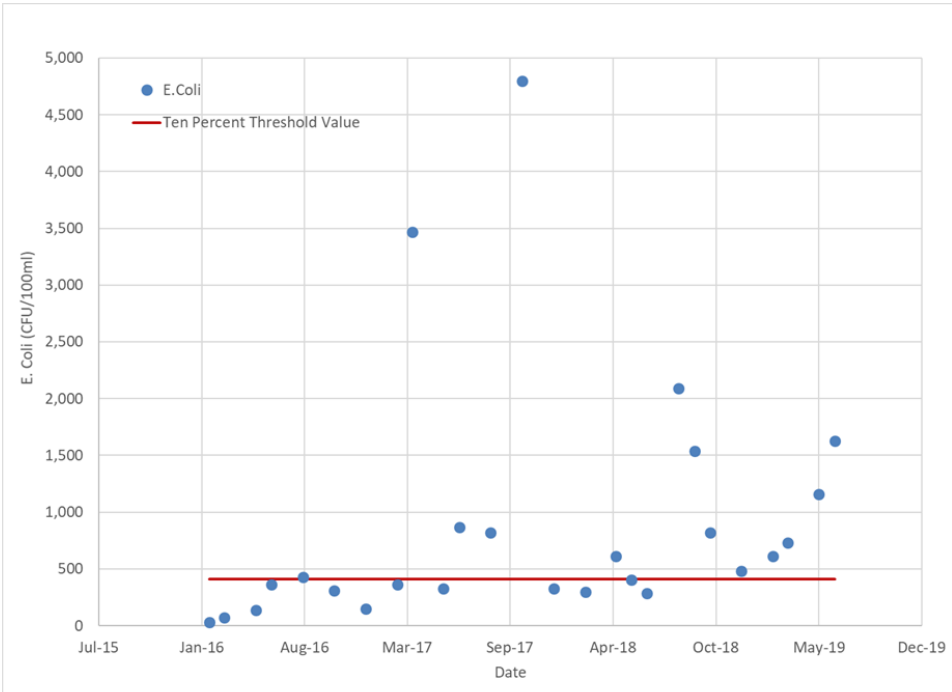
Recent modifications to FDEP's DO standard resulted in a change from concentration-based values to percent saturation (FAC 62-302.533). Little Bayou Creek is located within the "Peninsula" bioregion of Florida which means that "no more than 10 percent of the daily average percent DO saturation values shall be below" 38 percent saturation. Based upon the review of data from January 2012 through June 30, 2019, the average percent DO saturation 10th percentile value is 30 percent saturation indicating that the waterbody fails to meet the DO criteria (Figure 6).

Figure 6 – Dissolved oxygen (percent saturation) compared to regulatory criteria. Data from Little Bayou Creek (WBID 1709D). Red line represents relevant DO criterion of 38 percent saturation for Class III Freshwater Streams within Peninsular Florida.



Similar to DO, there have been recent revisions to the bacteria water quality standards used by FDEP, as it transitioned from the use of "Fecal Coliform" bacteria to *Escherichia coli* (E. coli) bacteria, for Class III freshwater systems such as Little Bayou Creek (WBID 1709D). FDEP's standard states that the concentration of E. coli shall not exceed "the Ten Percent Threshold Value (TPTV) of 410 in 10% or more of the samples during any 30-day period". The current monitoring program within the Little Bayou Creek is limited to monthly sampling, as such, any single value over 410 Colony Forming Units (CFU)/100ml would fail to meet the water quality standard. Figure 7 presents the E. coli data collected within WBID 1709D compared to the E coli criterion and shows many monthly events with values elevated above the regulatory standard.

Figure 7 – Abundance of E. coli bacteria compared to regulatory criteria. Data from Little Bayou Creek (WBID 1709D). Red line represents relevant criterion of 410 CFU/100 ml for Class III Freshwater waterbodies.



Based upon the findings displayed in Figures 4 to 7, the Little Bayou Creek watershed (WBID 1709D) would be determined to be impaired for TP, DO, Chl-a and E. coli bacteria. However, there is insufficient data to determine if the downstream waters of Little Bayou, the southern portion of the Big Bayou Estuary WBID (1709) are similarly impaired.

It should also be noted that Little Bayou Creek was not found to be impaired for TN, which is the nutrient of concern for the marine and estuarine waters of Tampa Bay (e.g., Johansson 1991, Johansson and Greening 1999, Tomasko et al. 2005, Greening and Janicki 2006, Greening et al. 2016). Therefore, while elevated TP could potentially be a problem for the creek itself, it may not be a problem for the downstream waters of Little Bayou. Also, while E. coli can be an indicator of human and/or animal waste, E. coli levels can be elevated due to the influence of non-fecal, natural soil bacteria in tropical settings (Fujioka et al. 1999, Solo-Gabrielle et al., 2000). Similarly, E. coli can be elevated simply due to the presence of decomposing algae (Ksoll et al. 2007) just as fecal coliform bacteria have been attributed to decomposing grass clippings (Tomasko et al. 2017). As relates to the issue of impairment for E. coli bacteria, additional steps are warranted to better identify specific bacterial sources, to allow for the development of projects or programs that are more likely to be able to bring about improvements in water quality.

<u>Pollutant Loading Model for Total Nitrogen</u>

The watershed boundaries provided by the City were presented to ESA in GIS format, and those boundaries were then overlaid on top of the latest land use/land cover maps produced for the region, as available from the

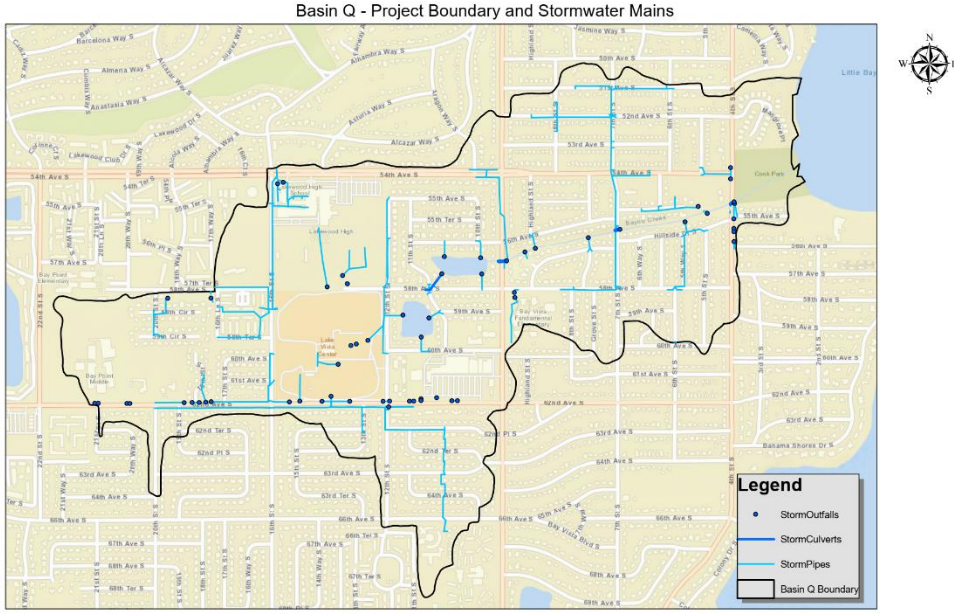
Southwest Florida Water Management District. The Little Creek watershed is approximately 536 acres, and is comprised largely of high density residential housing (67%) and institutional (17%). The classification of high density residential is self-evident, but the term "institutional" refers to a Florida Land Use Cover Classification System (FLUCCS) code for areas that are interpreted as educational or recreational complexes, including associated parking lots.

The pollutant loading model constructed for the Little Bayou watershed was based on standard spreadsheet-based model approaches reviewed and approved by FDEP for TMDL development. More specifically, the pollutant loading model was based on the loading model used by the Tampa Bay Estuary Program (TBEP) for its nitrogen management consortium (i.e., Pribble et al. 2001). The steps involved in model development include the following:

- Development of watershed boundaries / watershed delineation
    - Based on GIS files provided by the City
- Use of GIS to determine land use/land cover characteristics of the watershed
- Use of GIS to determine the soil types of the watershed
- Quantifying the spatial distribution of the overlap of land use/land cover and soil types for the watershed
- Developing estimates of rainfall consistent with the time-step of model development used in recent TN loading models for Tampa Bay (i.e., Pribble et al. 2001)
    - The TN loading model used by the Tampa Bay Estuary Program estimates loads from the wet and dry season, and then adds them to develop an estimate of TN loads on a calendar year basis
- Developing estimates of runoff coefficients consistent with the overlap of land use/land cover and soil types
    - The TBEP loading model uses separate runoff coefficients for wet and dry season months for each land use/land cover and soil type combination
- Using time-appropriate rainfall-runoff estimates for each category of land use/land cover for the watershed
- Combining runoff volumes with the event mean concentration (EMC) values for TN most aligned with the land use/land cover and soil type categories to estimate monthly TN loads
    - The TBEP loading model uses only one EMC value for each land use/land cover category – the EMC values do not differ between wet and dry seasons
- Combining TN loads for both wet and dry season months to produce annual load estimates for each year, for the period of 1996 to 2019

The watershed boundaries for Little Bayou Creek, and the layout of major stormwater drainage features, are displayed in Figure 8.

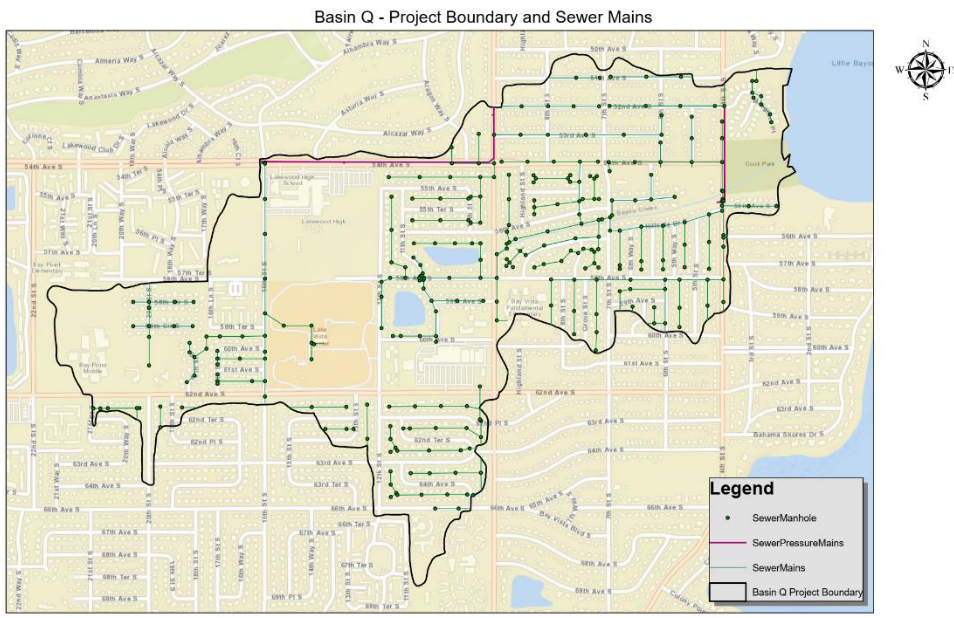
Figure 8 – Watershed boundaries and major stormwater drainage features of the Little Bayou Creek watershed. Figure provided by City of St. Petersburg.



As shown in Figure 7, Little Bayou Creek watershed, which is approximately 537 acres, is much smaller than FDEP's WBID boundaries for Little Bayou Creek (1709D; see Figure 1).

The City supplied a summary of the wastewater infrastructure of the Little Bayou Creek watershed, which showed no outfalls into the creek or into the downstream waters of Little Bayou (Figure 9).

Figure 9 – Watershed boundaries and major wastewater infrastructure features of the Little Bayou Creek watershed. Figure provided by City of St. Petersburg.



Based on assets shown in Figures 8 and 9, it was assumed that TN loads to Little Bayou were dominated by stormwater runoff, which was the focus of the TN loading model for the Little Bayou Creek watershed.

Originally, the pollutant loading model was intended to be based on monthly time-steps. However, a detailed review of the TN loading model for Tampa Bay (i.e., Zarbock et al. 1994, Pribble et al. 2001) revealed that stormwater loads for the Tampa Bay watershed are not based on monthly load estimates, but quantities of runoff separately calculated for both the wet and dry seasons. In addition, the loading model was intended to be run from June 2013 to June 2019, to compare pollutant loads from the watershed to water quality in Little Bayou itself. However, as discussed above, there are no nutrient or chlorophyll-a data for Little Bayou, the data is only from the creek draining into Little Bayou. Therefore, there is no opportunity to compare watershed-level nutrient loads to water quality in the receiving waters, since the receiving waters (Little Bayou) are not sampled for water quality for the parameters of concern.

In response, ESA, Stantec and the City discussed and agreed on using an ecosystem response model as a viable alternative approach to developing a linked loading model. Since there are no water quality data from Little Bayou itself in FDEP's IWR Run 58, it was determined that annual TN loads would be compared to estimates of seagrass coverage in Little Bayou, since the seagrass mapping efforts for Tampa Bay include estimates of seagrass coverage in Little Bayou, based on aerial photography that covers both Little Bayou and Big Bayou. The water quality management paradigm for Tampa Bay involves comparing TN loads to water quality, and then water quality to seagrass coverage (e.g., Johansson and Greening 1999, Tomasko et al. 2005, Greening and Janicki 2006, Greening et al. 2016) – this approach simply involves the direct comparison of TN loads to seagrass coverage, without the intermediate step of examining water quality (since such data don't exist for Little Bayou).

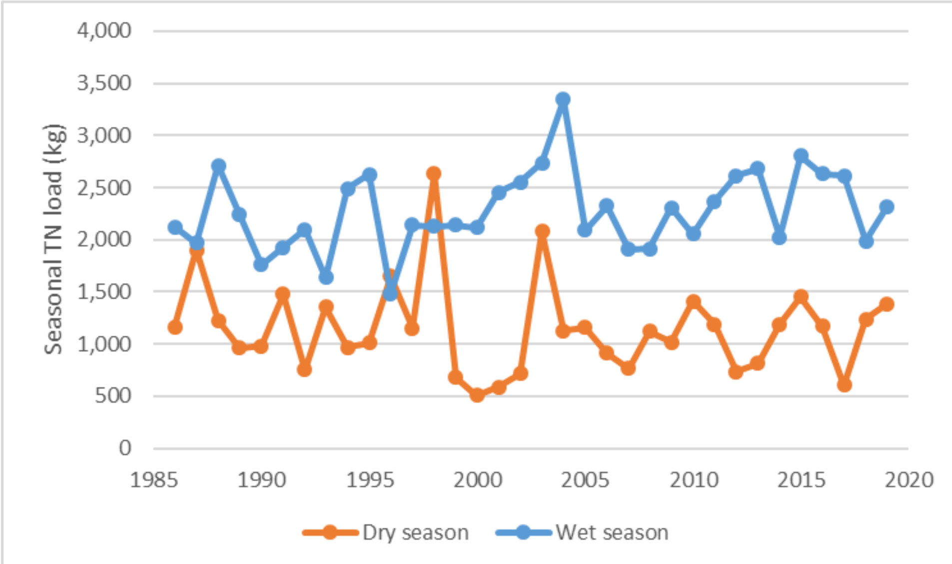
This modified approach thus extended the timespan of the model runs from 6 years (2013 to 2019) up to 34 years (1986 to 2019) although the time step of the loading model had been reduced from monthly estimates to wet season and dry season estimates only, to be in alignment with the TN loading model used by the TBEP. The modeling effort involved was similar between the original concept and the model outlined above, which involved 72 vs. 68 time steps.

Rainfall data for both wet and dry seasons were obtained from the Southwest Florida Water Management District for the period of 1986 to 2019 for the Tampa Bay watershed. These rainfall amounts were then combined with GIS-based estimates of the amount of watershed with each of the following major land use types: High density residential (Florida Land Use/Land Cover Classification System [FLUCCS] code 1300), Commercial and Services (1400), Institutional (1700), Recreational (1800) and Upland Hardwood Forest (4300). High density residential comprised 67% of the watershed, followed by Institutional, at 17% and Recreational, at 7%. The remaining land use/land cover categories together comprised less than 10% of the watershed.

Spatial estimates of each land use/land cover and soil type combination were converted from acres to square meters, and rainfall was converted from inches to cm (and then to meters). The runoff coefficients used in Pribble et al. (2001) which were first listed in Zarbock et al. (1994), were then used to convert rainfall to a volume of runoff in cubic meters, which was then converted to liters. These volumes of runoff generated for each of the main land use types of the watershed, on a wet season and dry season basis, were then multiplied by the EMC value for TN for each land use type, and stormwater TN load was quantified as kg TN / yr for each land use type. The units were then summed for each land use in the watershed, to produce a watershed-level TN load for each year.

Figure 10 displays the quantity of wet and dry season TN loads from the Little Bayou Creek watershed, based on the approaches outlined above.

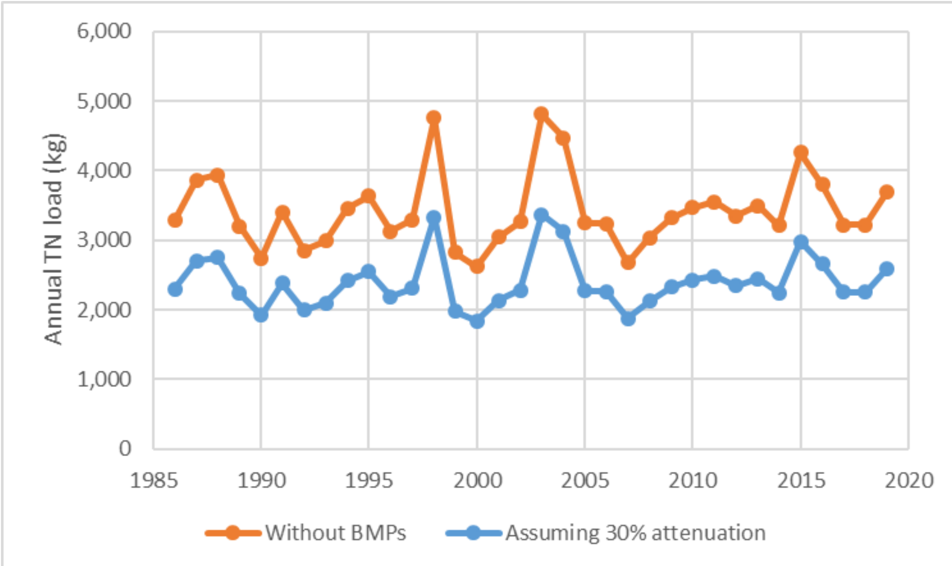
Figure 10 – Watershed-wide TN loads (kg) from stormwater runoff from the Little Bayou Creek watershed. Values are displayed for wet and dry seasons.



Although the wet season has fewer months than the dry season, the greater amount of rainfall in the average wet season month results in the finding that the majority of TN loads occurs in the wet season in Tampa Bay. The only exceptions to this pattern were found in 1996, when 20.6" of wet season rainfall was 35% lower than the average value of 31.5", and in 1998, when 46.7" of dry season rainfall was more than double the dry season average of 20.4".

Wet and dry season loads were then added together to develop annual load estimates. To estimate the amount of TN reduction that would be possible if the entire watershed was to have stormwater Best Management Practices (BMPs) in place, annual TN load estimates were reduced by 30%, in line with the load reduction estimates associated with stormwater treatment with wet detention ponds, the most common stormwater BMP in the Tampa Bay region (Harper and Baker 2007). Results are shown in Figure 11.

Figure 11 – Annual watershed-wide TN loads (kg/yr) from stormwater runoff from the Little Bayou Creek watershed. Values are shown without BMPs and with 30% reduction due to assumed BMPs.



Over the period of 1986 to 2019, the average TN load from the Little Bayou Creek watershed averaged 3,415 kg TN/yr, or 2,390 kg TN/yr assuming stormwater loads reflected widespread BMP implementation. In comparison, stormwater runoff was estimated to contribute nearly 1.3 million kg TN /yr (1,427 tons TN/yr) from the larger Tampa Bay watershed (Janicki Environmental, Inc. 2008). Assuming no stormwater BMPs, the estimated TN load from the Little Bayou Creek watershed equals just under 0.3% of bay-wide TN loads from stormwater runoff. Assuming that stormwater runoff from the watershed benefits from BMP-type activities throughout the watershed-wide, TN loads would account for just more than 0.2% of bay-wide TN loads from stormwater runoff.

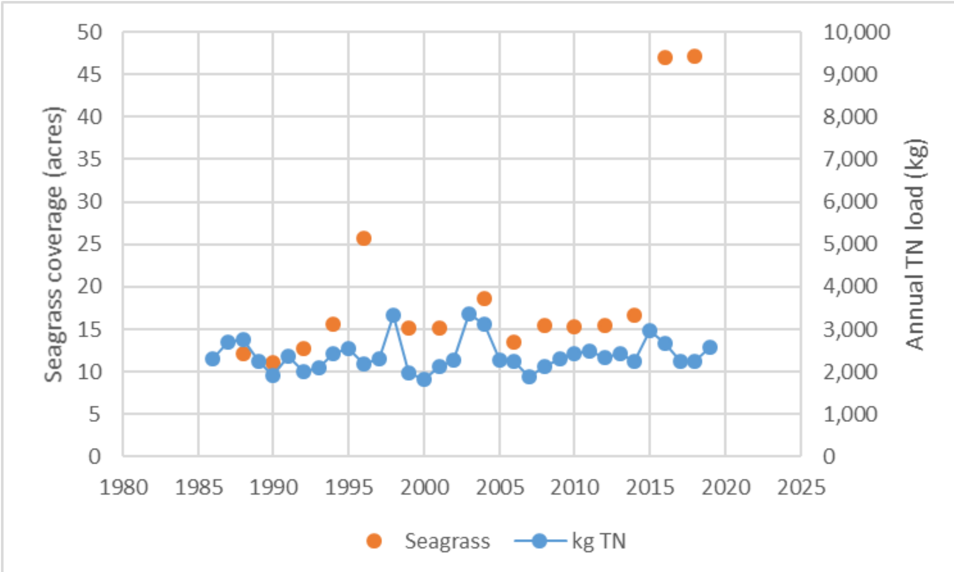
Empirical Relationships Between TN Loads and Ecosystem Responses

As discussed above, there were insufficient data to be able to develop a linked pollutant load – water quality model for Little Bayou. Instead, the loading model was extended back in time over 30 years, so that the entirety of bay-wide seagrass mapping efforts could be compared to watershed-level TN loads.

Seagrass data were obtained from the Southwest Florida Water Management District in GIS format, and the coverages for the 911 FLUCCS code (seagrass) were clipped for the boundaries of Little Bayou, Big Bayou and for the portion of Tampa Bay just offshore of Coquina Key. In this way, the status and trends of seagrass in waters directly downstream from the Little Bayou Creek watershed – Little Bayou – could be compared to annual TN load estimates from its contributing watershed. To test for seagrass trends slightly farther afield, the status and trends in seagrass coverage in Big Bayou were assessed, as well as for areas farther away still – those waters to the east of Coquina Key.

Figure 12 displays the trends over time of annual TN loads from the Little Bayou Creek watershed, along with estimated seagrass coverage in Little Bayou.

Figure 12 – Status and trends in watershed level TN loads from Little Bayou Creek (kg/yr) and seagrass coverage (acres) in Little Bayou.



Results in Figure 12 show that seagrass coverage was relatively stable between 1988 and 2014, with the exception of an approximate 100% increase between 1994 and 1996. This increase was not sustained up to 1999, perhaps due to the elevated TN loads that occurred concurrent with the 1997-1998 El Niño event. From 1999 to 2014, seagrass coverage remained at approximately 1,000 acres, until an increase of more than 2,000 acres between 2014 and 2016, which has been maintained up to the last year for which data are available, 2018.

The relationship between TN loads and seagrass coverage in Little Bayou was examined on a year to year time-step, as well as using 1 and 2-year time lags between nitrogen loads and seagrass coverage. Results were tested for statistically significant relationships using the non-parametric Pearson Product-Moment and Spearman's Rank Correlation tests, as the data failed the requirements of normality and homogeneity of variance required for parametric statistical tests. There was no statistically significant relationship found between TN loads and seagrass coverage on year to year, 1-year time lag, or 2-year time lag (Figures 13, 14, and 15, respectively).

Figure 13 – Relationship between seagrass coverage in Little Bayou and watershed-level TN loads (kg/yr) for the same year as photography was finalized for seagrass maps.

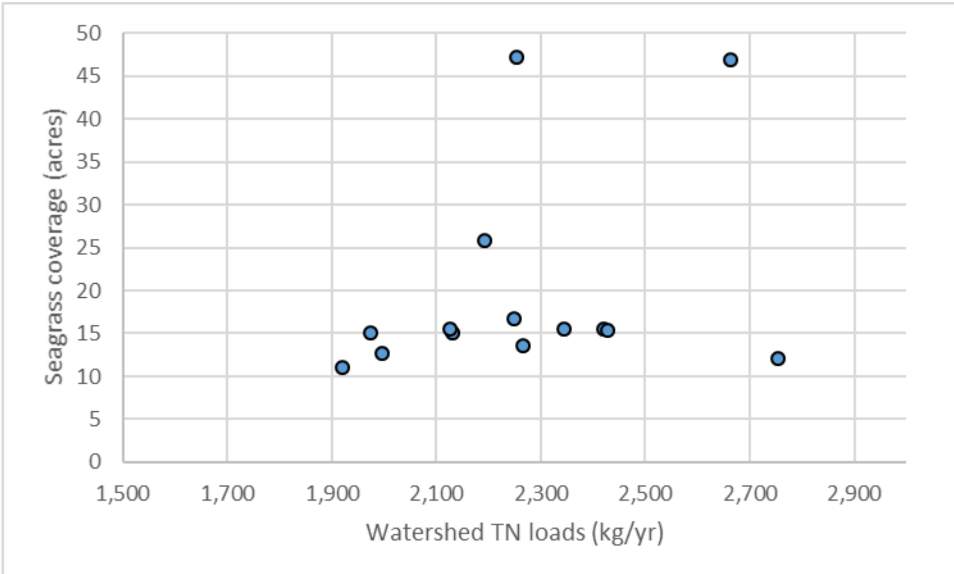


Figure 14 – Relationship between seagrass coverage in Little Bayou and the prior year's watershed-level TN loads (kg/yr).

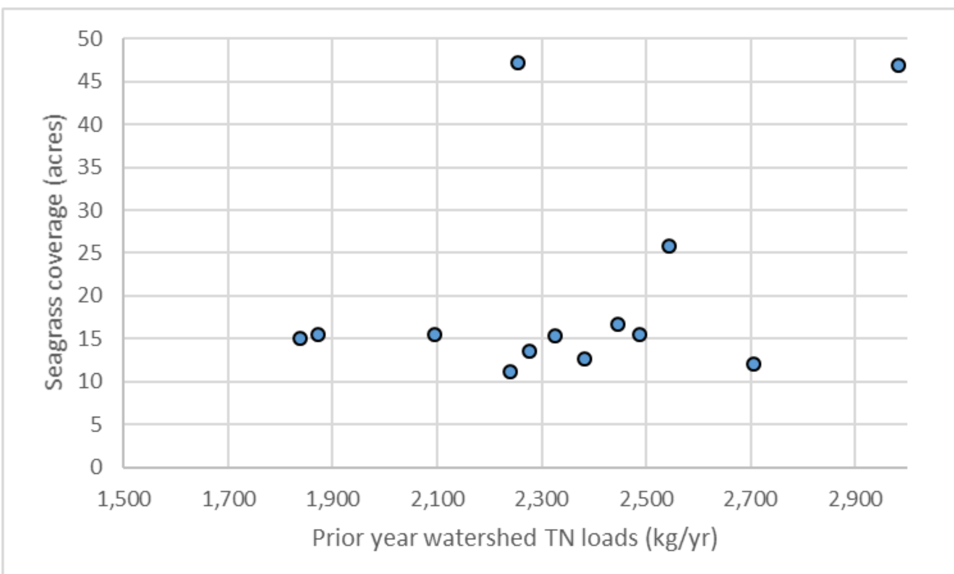
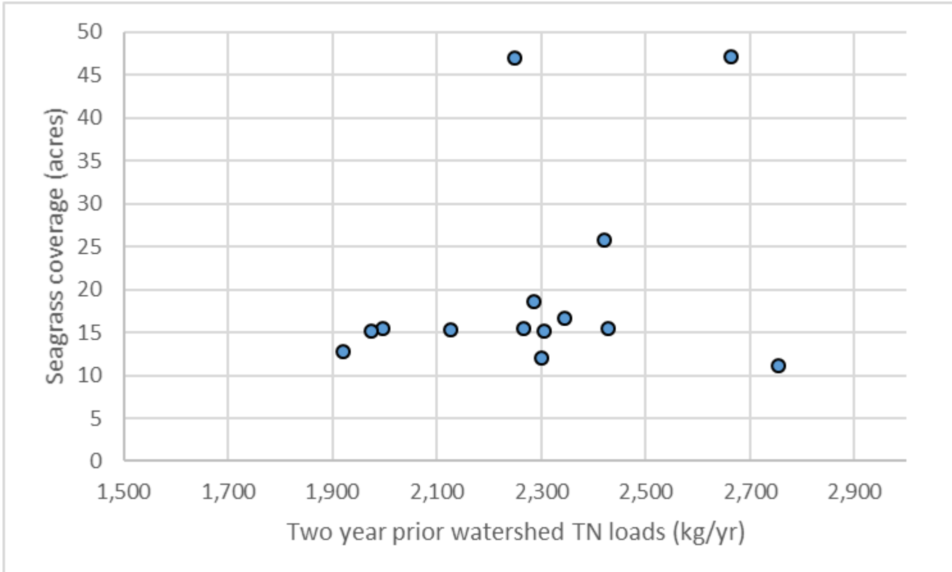


Figure 15 – Relationship between seagrass coverage in Little Bayou and watershed-level TN loads (kg/yr) from two years prior.



The results shown in Figures 12 to 14 do not support the hypothesis that there is a statistically significant relationship between TN loads from the Little Bayou Creek watershed and seagrass coverage in Little Bayou itself. However, the declines in seagrass coverage seen between 1996 and 1999, and then again between 2004 and 2006 (Figure 12) do suggest that declines in seagrass coverage would be expected after significant meteorological phenomena, such as the 1997-1998 El Niño event and the busy 2004 hurricane season.

The past 30 years have seen substantial increases in seagrass coverage in Little Bayou, Big Bayou, and the waters offshore of Coquina Key, with areas of increase much greater than areas of loss (Figures 16, 17 and 18, respectively).

Figure 16 – Trends in seagrass coverage between 1988 and 2018 in Little Bayou.

Figure 17 – Trends in seagrass coverage between 1988 and 2018 in Big Bayou.

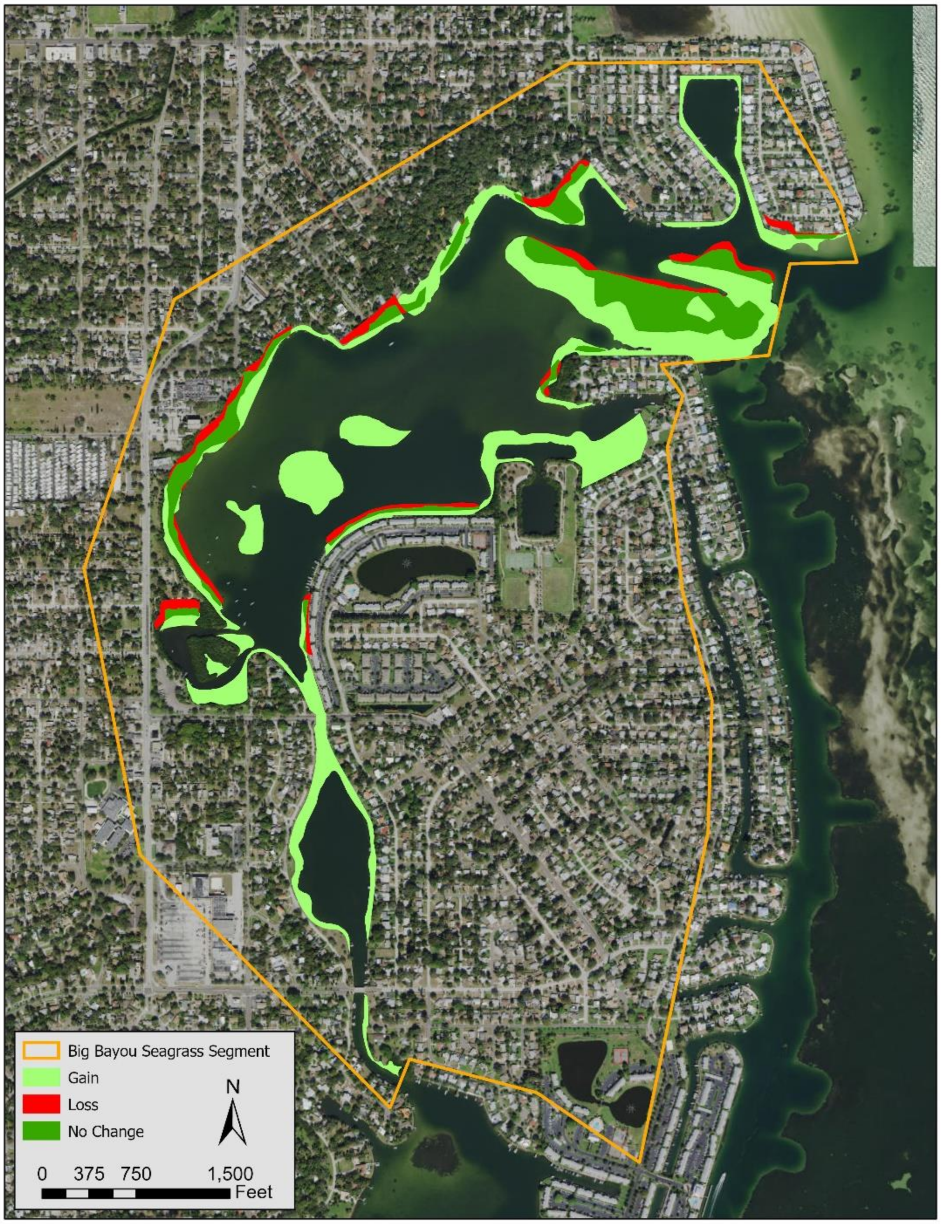
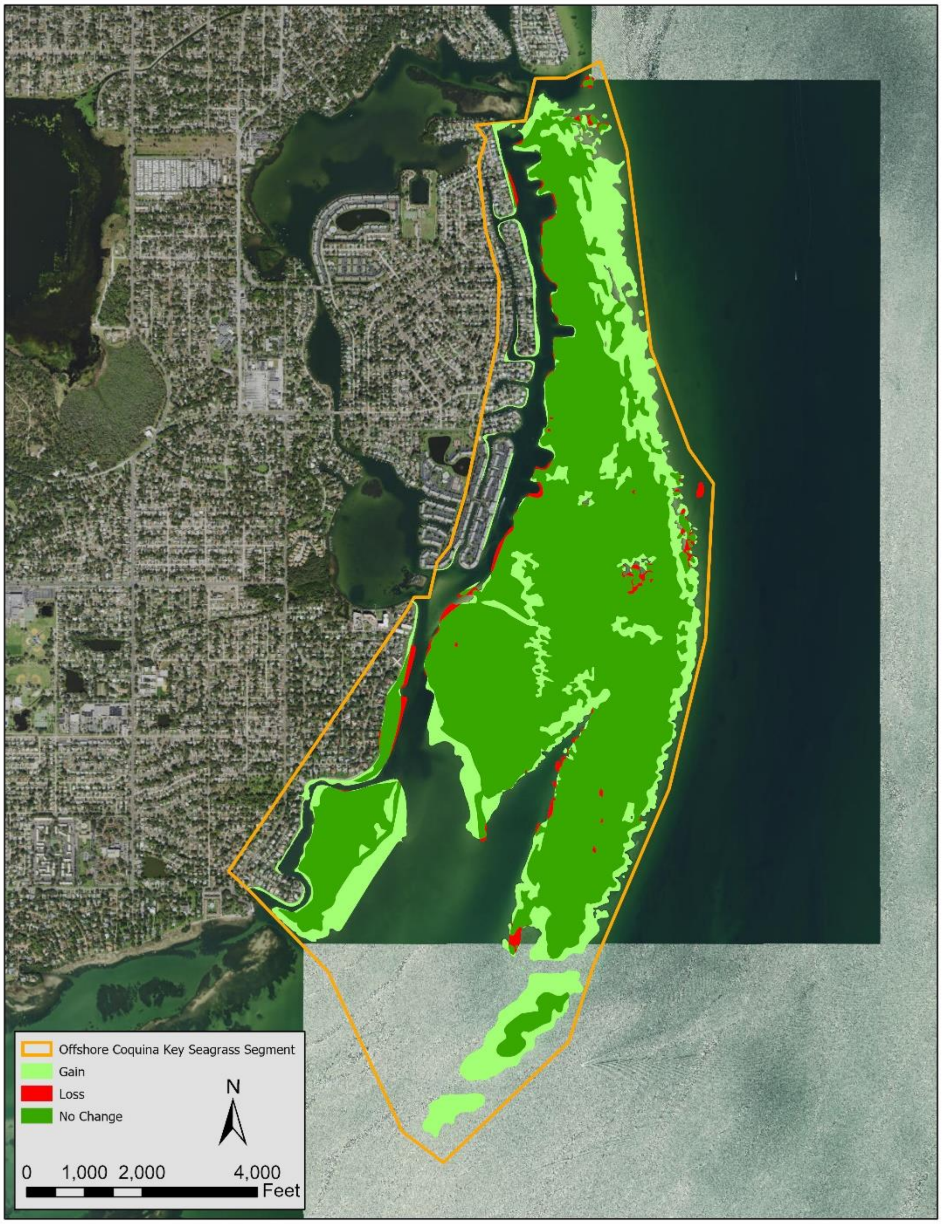


Figure 18 – Trends in seagrass coverage between 1988 and 2018 offshore of Coquina Key, which bounds Little Bayou on its east side.



Discussion

The analysis of water quality in the vicinity of Little Bayou was complicated by several factors related to non-technical issues, such as 1) the watershed boundaries of the creek are much smaller than the boundaries of the Little Bayou Creek WBID used by FDEP, 2) the creek itself has been classified by FDEP as both freshwater and marine, which have different water quality standards, and 3) while Little Bayou Creek discharges into Little Bayou, both Little Bayou and Big Bayou are classified as a single waterbody by FDEP, the WBID for Big Bayou Estuary. For these reasons, caution is needed related to referring to the relative health of the waterbody and watershed, and whether or not "impairment" of a WBID is actually for the waterbody in question. It is recommended that the WBID 1709D boundaries are re-evaluated as the separation between freshwater and marine conditions are unclear within the current extent.

In addition, the water quality criteria themselves have changed over time, as FDEP has changed both its prior DO and bacterial indicator criteria. While Little Bayou Creek (WBID 1709D) is "impaired" for both DO and E. coli bacteria, there are problems associated with both these water quality standards. For example, 6 of 14 (43%) reference sites from undisturbed locations in the western Everglades that that were used to develop a TN target for the Gordon River TMDL (FDEP 2008) failed the DO standard in that TMDL (FDEP 2008). That is a higher rate of "noncompliance" than the 30% of DO values that did not meet threshold values established for Little Bayou Creek.

And while TP values did exceed NNC criteria for streams, TN concentrations were well below threshold values listed in FDEP's NNC criteria (FAC 62-301). For Tampa Bay, nitrogen, not phosphorus, is the nutrient of greatest concern to resource managers (e.g., Johansson 1991, Johansson and Greening 1999, Tomasko et al. 2005, Greening and Janicki 2006, Greening et al. 2016).

While it is true that elevated levels of E. coli could indicate sewage or pets as a bacteria source, E. coli can also come from uncontaminated soils (Fujioka et al. 1999, Solo-Gabrielle et al., 2000) and decomposing vegetation (Ksoll et al. 2007). It is recommended that additional, and more specific tests should be undertaken to identify potential bacterial sources, to allow for the development of projects or programs that are more likely to be able to bring about improvements in water quality. Such efforts could include the identification of human sources from sewage overflows – which would involve the City's wastewater utility, or increased outreach to get more residents to pick up their pet wastes. Additional educational campaigns could target ongoing issues with public residents disposing of grass clippings in stormwater inlets as well as City maintenance crews to avoid cutting beneficial native plantings and directing the discharge of grass clippings away from waterways during mowing.

There is some evidence that abnormally wet years, such as occurred during the 1997-1998 El Niño and the 2004 hurricane season reduced seagrass coverage in Little Bayou. However, there was no overall statistically significant relationship found between annual TN loads from the Little Bayou Creek watershed and seagrass coverage in the receiving waters of Little Bayou, even with one and two-year time lags. As an indication that the areas downstream of Little Bayou Creek are not overly problematic, the trend over the past 30 years is of increased seagrass coverage in Little Bayou, Big Bayou, and offshore of Coquina Key.

These results suggest that rather than there being a "need" to improve water quality in the Little Bayou Creek watershed, perhaps a more focused approach to ecosystem management is warranted. Efforts to determine the specific source(s) of indicator bacteria, using more sophisticated techniques, should be initiated.

Based on a site visit to the watershed, ecosystem restoration and enhancement projects should be further investigated to reestablish what appears to have been an historical tidal connection between Little Bayou and lower Little Bayou Creek, including an approximately 0.5-acre pond just east of 4th Street South on the western boundary of Little Bayou Park.

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