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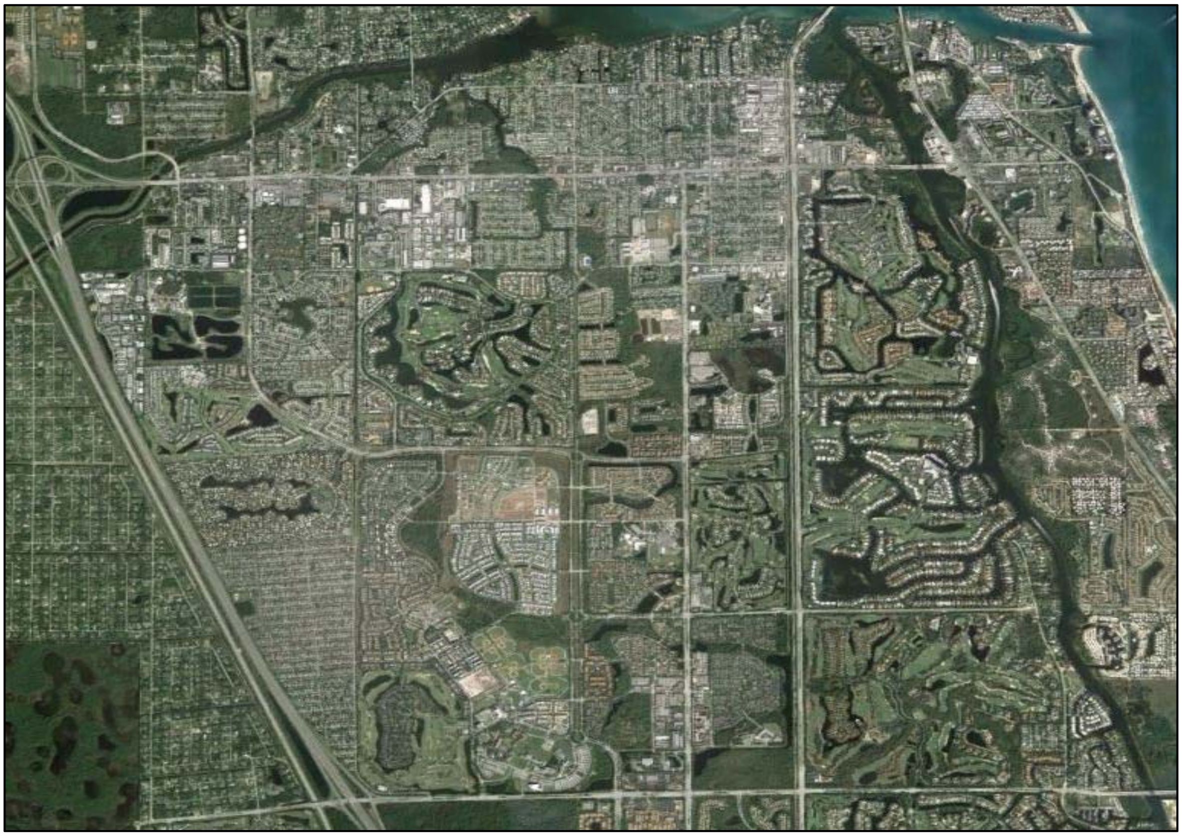

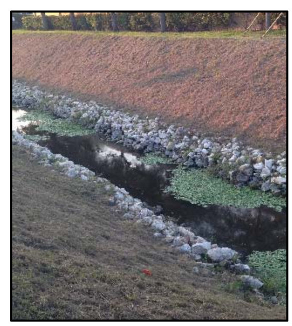

Town of Jupiter
Water Quality Master Plan
(Jones and Sims Creeks)

Final Report
Hazen No. 44250-010
September 15, 2015

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Executive Summary

The Loxahatchee River was recently classified as being impaired along certain segments for water quality parameters such as Chlorophyll α, fecal coliform, and dissolved oxygen (DO). Water quality data were collected by the Loxahatchee River District (LRD) at five sampling locations along Jones and Sims Creeks (four grab sample locations and one datasonde location). These data were compared to the current Florida Department of Environmental Protection (FDEP) criteria in order to determine which parameters were of greatest concern in both creeks. After a detailed analysis of water quality data was completed, drainage area characteristics were analyzed in order to identify potential pollutant sources and corresponding remedial actions.

Fecal coliform and Chlorophyll α levels commonly exceeded the FDEP criteria in three of the four grab sample locations. Based on the high percentage of residential area within both drainage areas, the elevated fecal coliform levels may have been primarily attributable to pet waste. Based on sucralose concentrations, which are an indicator of either treated or untreated human waste, a portion of the fecal coliform load may have originated from septic tanks. Active septic tanks exist in the Sims Creek drainage area and in areas such as Pennock Point, which is outside of the drainage area but may still have an effect due to tidal fluctuations. The elevated Chlorophyll α concentrations may have been a result of stagnant water in each creek, which increases the availability of nutrients to be assimilated by aquatic vegetation. A high nutrient input to each creek may have also played a role in the observed Chlorophyll α concentrations. DO levels are directly related to Chlorophyll α and were typically lower in the upstream reach of both creeks, further indicating that stagnant water may have been detrimental to the water quality in these locations.

Due to the developed nature of both drainage areas, it is recommended that a series of programmatic efforts such as educational flyers and signage be implemented prior to other actions which may require more capital. Furthermore, additional water quality samples should be collected in both creeks, particularly in the upstream reach of Jones Creek. These additional data may allow for greater spatial and temporal specificity of the pollutant sources and could allow for a more effective approach to be developed for reducing pollutant loads in both creeks.

Section 1.0
Introduction

The Loxahatchee River was recently classified as being impaired along certain segments for water quality parameters such as Chlorophyll α, fecal coliform, and DO. Jones and Sims Creeks are primary tributaries of the Loxahatchee River. Historical monitoring of these creeks has shown evidence of pollution relative to the existence of Chlorophyll α and fecal coliform. Evaluating the drainage area for both creeks is a proactive approach to identifying areas for pollution reduction in advance of pending regulation. This will improve the health of these tributaries as well as contribute to the continued protection and enhancement of the Loxahatchee Estuary.

While a Total Maximum Daily Load (TMDL) was developed for fecal coliform by the Florida Department of Environmental Protection (FDEP) in May 2012, it was developed for the Waterbody Identification Number 3226C, which includes the entire drainage area between the S-46 structure on the western edge of Jupiter and the confluence with the northwest fork of the Loxahatchee River located approximately one mile downstream. The drainage areas for Jones and Sims Creeks are sub basins within this previously evaluated drainage area and predominantly consist of residential land use. A TMDL has not yet been established by FDEP for the Southwest Fork of the Loxahatchee River for other pollutants.

The Loxahatchee River District (LRD) provided water quality data for multiple parameters of interest, though the primary pollutants analyzed for the purposes of this report are Total Nitrogen (TN), Total Phosphorus (TP), fecal coliform, Chlorophyll α, and DO. TN and TP are nutrients which primarily originate from fertilizer, animal waste, human waste, or organic debris (e.g. yard waste). Fecal coliform levels are typically dictated by animal and human waste while Chlorophyll α and DO can be dependent on a variety of conditions including temperature, amount of sunlight, and availability of nutrients.

A total of five sampling locations within the Jones and Sims Creeks drainage areas were utilized for the water quality analysis. Both tributaries contain an upstream and downstream grab sample location: one near Indiantown Road and another at the confluence with the Southwest Fork of the Loxahatchee River. Although the upstream sampling location in Sims Creek is upstream of the turbidity barrier and therefore technically located within the North Palm Beach Heights Water Control District (NPBHWCD) Canal, this location is referred to as the upstream sampling location of Sims Creek throughout this report since it is labelled as Sims Creek in water quality data collected by LRD. Jones Creek contains a third location where a datasonde is installed to continually measure parameters such as water level and conductivity (see **Figure 1-1** at the end of this section). Other sampling locations in the Southwest Fork of the Loxahatchee River were also referenced to further evaluate observed fecal coliform trends. In addition to the sampling locations of interest, the watersheds associated with the Jones and Sims Creek tributaries are also illustrated in **Figure 1-1**. Land use and rainfall characteristics were coupled with the obtained water quality data to determine potential sources of pollutants within each drainage area. It is important to note that Egret Landing was excluded from the analysis. Under certain conditions surface water may be passed through Egret Landing into Sims Creek; however, under normal operating conditions this area is not hydraulically connected to Sims Creek, and as such was not included in this evaluation.

Following the analysis of the water quality data and the comparison of those data to the current FDEP standards, pollutants of concern were identified. FDEP provides separate surface water quality standards for estuarine and freshwater systems. Jones Creek and the downstream reach of Sims Creek are classified as estuarine systems while the upstream reach of Sims is classified as freshwater. The freshwater and estuarine classifications were used to compare water quality data to the appropriate FDEP criteria. After identifying pollutants of concern the sources of these pollutants were then estimated based on available data, leading to the formation of pollutant reduction strategies and a corresponding implementation plan. This implementation plan is to act as a guide for the Town of Jupiter when considering future actions aimed at remediating the water quality issues in Jones and Sims Creeks.

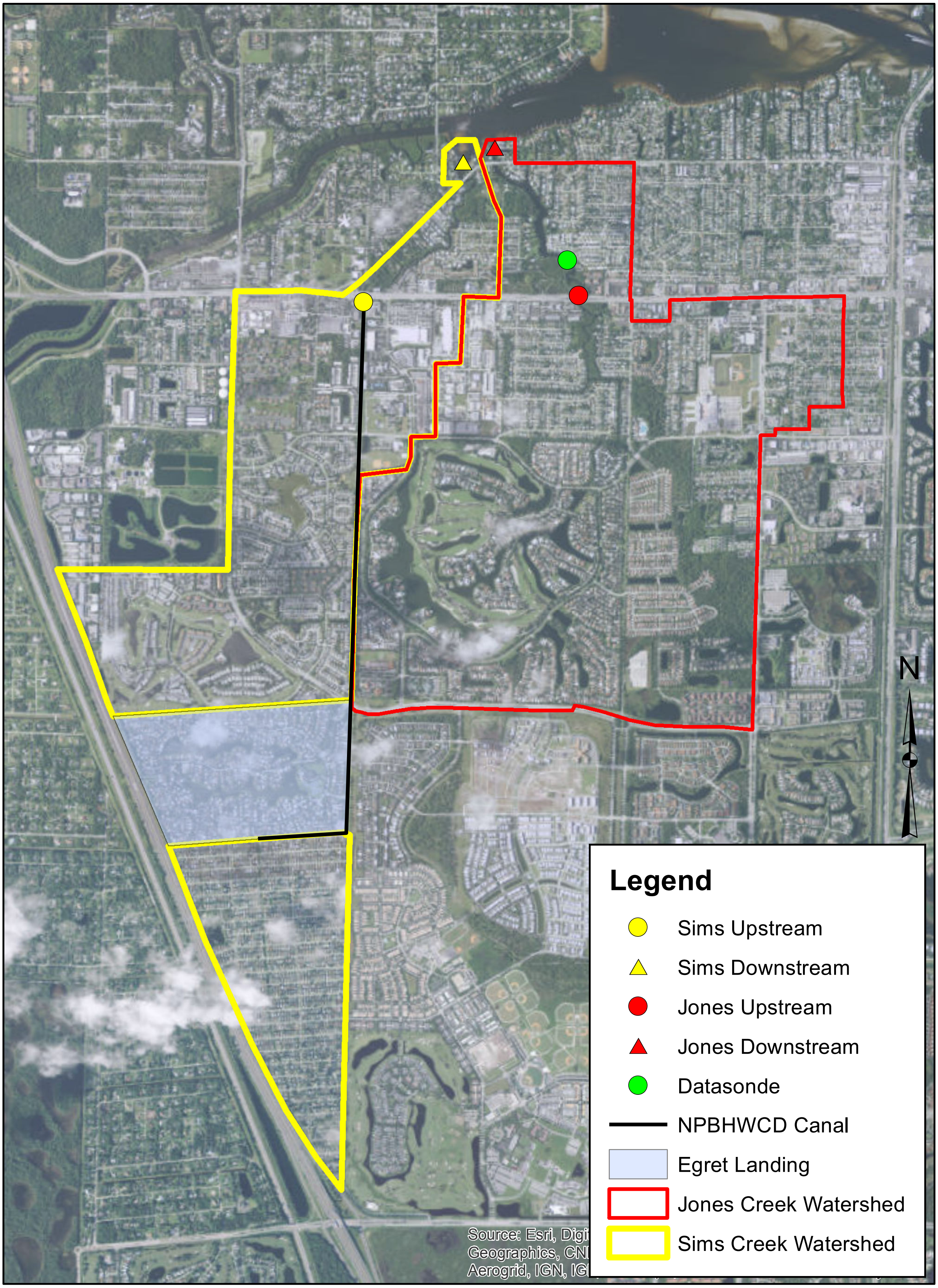

Figure 1-1 - Jones and Sims Creek Drainage Areas

Section 2.0
Data Analysis

2.1 Data Comparison

The data provided by LRD were compiled and compared to the various water quality criteria outlined by FDEP. The current FDEP numeric nutrient criteria (NNC) for TN, TP, and Chlorophyll α along with the proposed FDEP limits for DO, fecal coliform, and enterococci are provided in **Table 2.1**. Many of the parameters require samples to be collected at a higher frequency than the currently available data. For example, many of the criteria are based on daily or monthly geometric means, but the data provided typically consisted of one sample every two months. Furthermore, the FDEP criteria which stipulate that 10% of samples shall not exceed a specified threshold are exceeded if only a small number of samples during the five years exceeded the threshold due to the small number of total samples. In these cases, the annual geometric mean (AGM) was compared to the 10% exceedance criteria for sake of comparison.

The annual average concentrations measured by LRD between January 1, 2010 and December 31, 2014 for TN, TP, and Chlorophyll α are compared to the current FDEP criteria in **Table 2.2**. This time frame was used in the analysis because data for all parameters were collected throughout the entire period. While pollutants had been monitored prior to January 1, 2010 these additional data did not lead to conclusions which differ from those presented in this report and were therefore not included in the evaluation. Comparisons of DO, fecal coliform, and enterococci to FDEP criteria are provided in **Table 2.3** and the percent of total samples which failed to meet the respective FDEP 10% exceedance criteria are provided in **Table 2.4**.

Table 2.1
Summary of FDEP Criteria for the Parameters of Interest

	FDEP Criteria		Notes
	Freshwater	Estuarine	
Total Nitrogen	1.54 mg/L as AGM[1]	1.26 mg/L as AGM[2]	Annual Geometric Means (AGM) shall not be exceeded more than once in a three year period
Total Phosphorus	0.12 mg/L as AGM[1]	0.075 mg/L as AGM[2]	
Chlorophyll α	20 µg/L as AGM[3]	5.5 mg/L as AGM[2]	
Dissolved Oxygen	38% Saturation[4]	42% Saturation[4]	No more than 10% of the daily average percent DO saturation are to be below the levels shown. For estuarine waters the seven-day average DO percent saturation shall not be below 51% more than once in any twelve week period and the 30-day average DO % saturation shall not be below 56% more than once per year.
Fecal Coliform	400[5]	43[5]	Most Probable Number (MPN) counts shall not exceed the value shown in more than 10% of samples or exceed 800 in any one day. For freshwater the monthly average shall not exceed 200 and in estuarine water the median value must not be more than 14.
Enterococci		135 CFU/100 mL[6]	Monthly geometric mean shall not exceed 35 CFU/100 mL. A value of 135 CFU/100 mL shall not be exceeded on 10% of samples during any 30 day period. Monthly geometric means shall be based on a minimum of 5 samples over a 30 day period.

[1]Rule 62-302.531 F.A.C.
[2]Rule 62-302.532 F.A.C.
[3]Rule 62-303.351 F.A.C.
[4]Rule 62-302.533 F.A.C.
[5]Rule 62-302.530 F.A.C.
[6]Proposed by FDEP

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Table 2.2

Comparison of Observed TN, TP, and Chlorophyll α Concentrations in Jones and Sims Creeks to the Current FDEP Criteria

Monitored Parameter	Current FDEP Estuarine AGM Criteria	Annual Geometric Mean (AGM) Calculated From Data Provided by Loxahatchee River District														
		Jones Upstream (Estuarine)					Jones Downstream (Estuarine)					Sims Downstream (Estuarine)				
		2010	2011	2012	2013	2014	2010	2011	2012	2013	2014	2010	2011	2012	2013	2014
Total Nitrogen (mg/L)	1.26	0.78	0.58	0.71	0.47	0.67	0.42	0.44	0.39	0.41	0.35	0.52	0.66	0.56	0.55	0.68
Total Phosphorus (mg/L)	0.075	0.10	0.07	0.10	0.08	0.09	0.05	0.04	0.04	0.05	0.04	0.05	0.05	0.05	0.06	0.07
Chlorophyll α (μg/L)	5.50	20.45	8.32	11.54	8.50	10.74	12.53	8.02	10.17	10.92	8.72	14.69	10.65	11.34	10.49	12.50
	Current FDEP Freshwater AGM Criteria	Sims Upstream (Freshwater)														
		2010	2011	2012	2013	2014										
Total Nitrogen (mg/L)	1.54	1.16	1.07	1.21	0.93	0.99										
Total Phosphorus (mg/L)	0.12	0.06	0.05	0.05	0.08	0.08										
Chlorophyll α (μg/L)	20.00	24.55	12.60	13.58	19.54	21.76										

Legend

Legend
Meets FDEP Criteria
Fails to Meet FDEP Criteria
Not Sampled

Table 2.3

Comparison of Observed DO, Fecal Coliform, and Enterococci Levels in Jones and Sims Creeks to the Current FDEP Criteria

Monitored Parameter	Current FDEP Estuarine Criteria	Annual Geometric Mean (AGM)														
		Jones Upstream (Estuarine)					Jones Downstream (Estuarine)					Sims Downstream (Estuarine)				
		2010	2011	2012	2013	2014	2010	2011	2012	2013	2014	2010	2011	2012	2013	2014
Dissolved Oxygen (% Saturation)	42[1]	29.55	35.41	22.12	40.72	28.90	70.59	68.12	77.98	80.58	65.44	76.69	61.88	69.91	69.84	55.77
Fecal Coliform (CFU/100 mL)	43[2]	363.56	521.70	711.47	337.53	398.73	208.91	250.88	81.33	214.60	161.11	745.07	478.37	296.41	488.98	726.06
Enterococci (CFU/100 mL)	35[3]	NS	NS	NS	199.00	248.97	NS	109.54	65.28	118.32	92.56	NS	328.17	202.57	140.65	313.12
	Current FDEP Freshwater Criteria	Sims Upstream (Freshwater)														
		2010	2011	2012	2013	2014										
Dissolved Oxygen (% Saturation)	38[1]	71.93	59.81	52.74	45.33	65.35										
Fecal Coliform (CFU/100 mL)	400[2]	65.89	92.82	64.56	164.64	174.68										
Enterococci (CFU/100 mL)	N/A	NS	NS	NS	533.10	45.30										

[1]Daily minimum limit for 90% of total samples

[2]Daily MPN maximum limit for 90% of samples

[3]Monthly geometric mean (proposed by FDEP)

NS = Not Sampled

Legend

Meets FDEP Criteria
Fails to Meet FDEP Criteria
Not Sampled

Note: The FDEP requirements listed for dissolved oxygen, fecal coliform, and enterococci require a greater number of samples in order for a direct comparison to be made. Since a total of 6-8 samples were collected by LRD during each of the five years evaluated the FDEP criteria for each parameter were directly compared to the annual geometric mean (AGM) calculated for each parameter.

Table 2.4
Percent of Total Samples Which Failed to Meet FDEP Criteria

	Percent of Total Samples Collected Between January 1, 2010 and December 31, 2014 that Failed to Meet FDEP 10% Criteria			
Sampling Location	**Jones Upstream**	**Jones Downstream**	**Sims Upstream**	**Sims Downstream**
Dissolved Oxygen	67.7	12.9	8.3	9.6
Fecal Coliform	100.0	90.3	8.3	96.8
Enterococci	50.0	28.6	50.0	59.1

Legend
Meets FDEP Criteria
Fails to Meet FDEP Criteria
Not Sampled

2.2 Data Review

Data collected from each of the four grab sample stations along Jones and Sims Creeks indicate TN levels met the FDEP NNC for the Southwest Fork of the Loxahatchee River while potentially problematic concentrations of TP were only observed at the upstream monitoring station of Jones Creek. TP concentrations recorded at the downstream monitoring station of Jones Creek and in both locations in Sims Creek met the current FDEP criteria. No clear or consistent trend in TP concentrations existed in Jones Creek, although local peak concentrations were often observed during the wet season months (**Figure 2-1**). Local maximum concentrations were also typically observed during the wet season months in Sims Creek, with higher concentrations being measured more recently (**Figure 2-2**). Chlorophyll α concentrations exceeded FDEP criteria in three of the four grab sample locations with the exception being the upstream sampling location of Sims Creek. Although the measured Chlorophyll α concentrations were similar for both Sims Creek sampling locations, the FDEP criteria are different at the two locations since the upstream reach is classified as freshwater. Summaries of Chlorophyll α concentrations for Jones and Sims Creeks are provided in **Figure 2-3** and **Figure 2-4**, respectively. Similar to TP concentrations, no significant increasing or decreasing trend in Chlorophyll α was observed and local maximum concentrations were typically observed during the wet season months. All figures depicting pollutant concentrations are based on 6-8 samples collected annually while all rainfall data were collected on a daily basis.

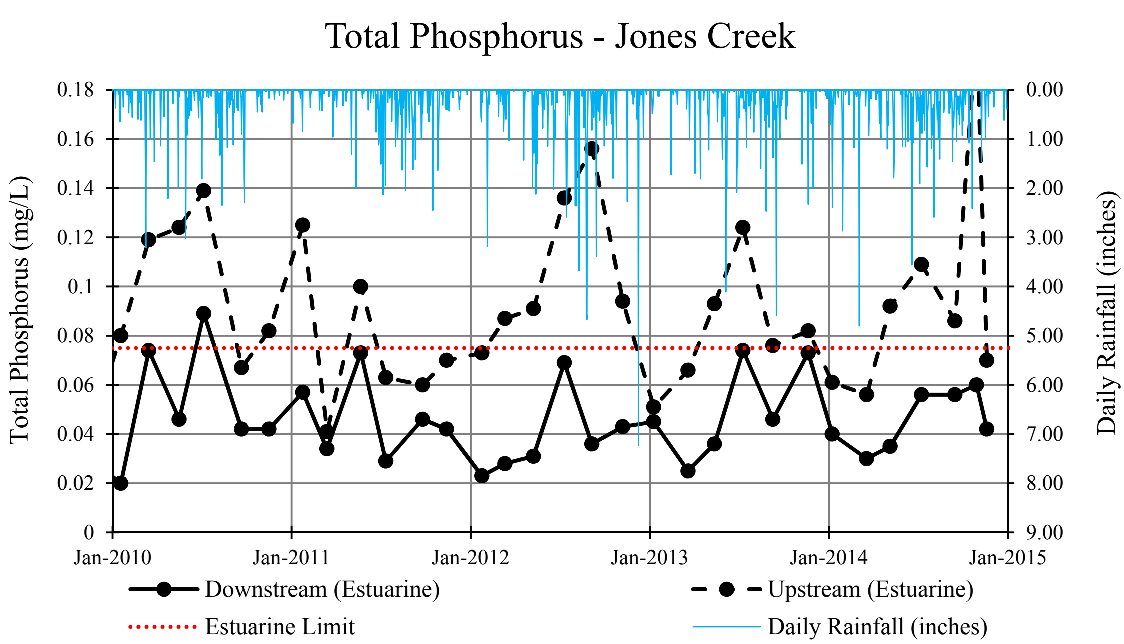

Figure 2-1: Total Phosphorus Concentrations Measured at Both Monitoring Locations Along Jones Creek

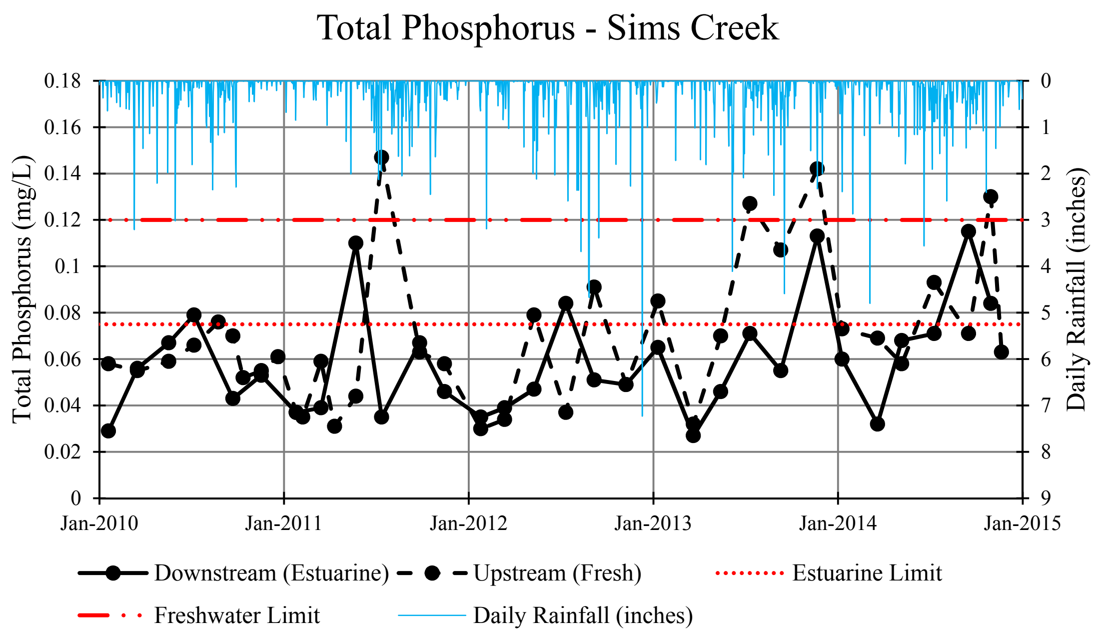

Figure 2-2: Total Phosphorus Concentrations Measured at Both Monitoring Locations Along Sims Creek

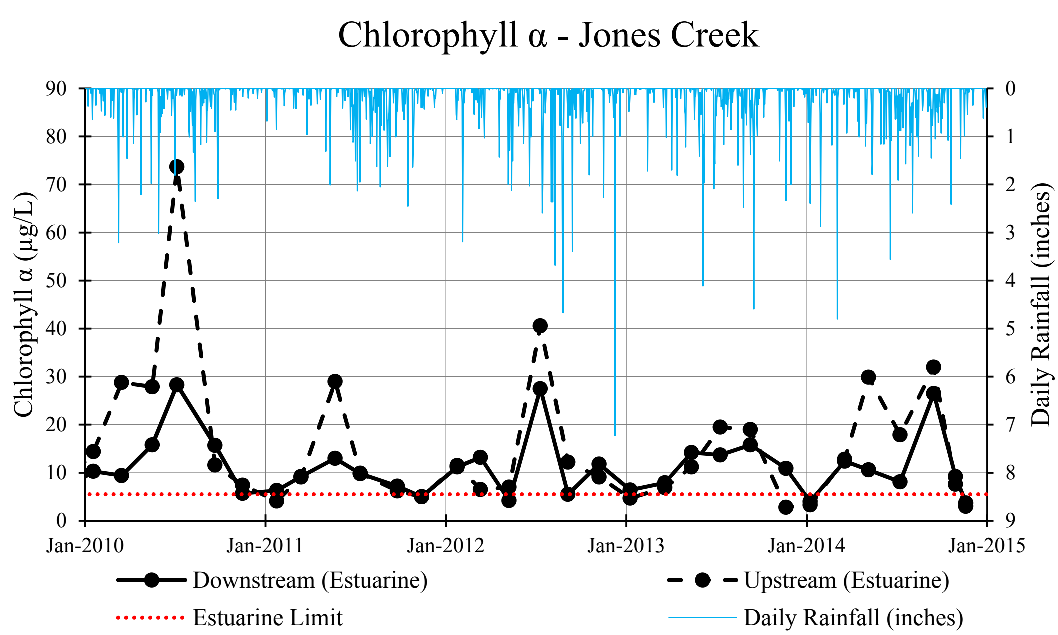

Figure 2-3: Chlorophyll α Concentrations Measured at Both Monitoring Locations Along Jones Creek

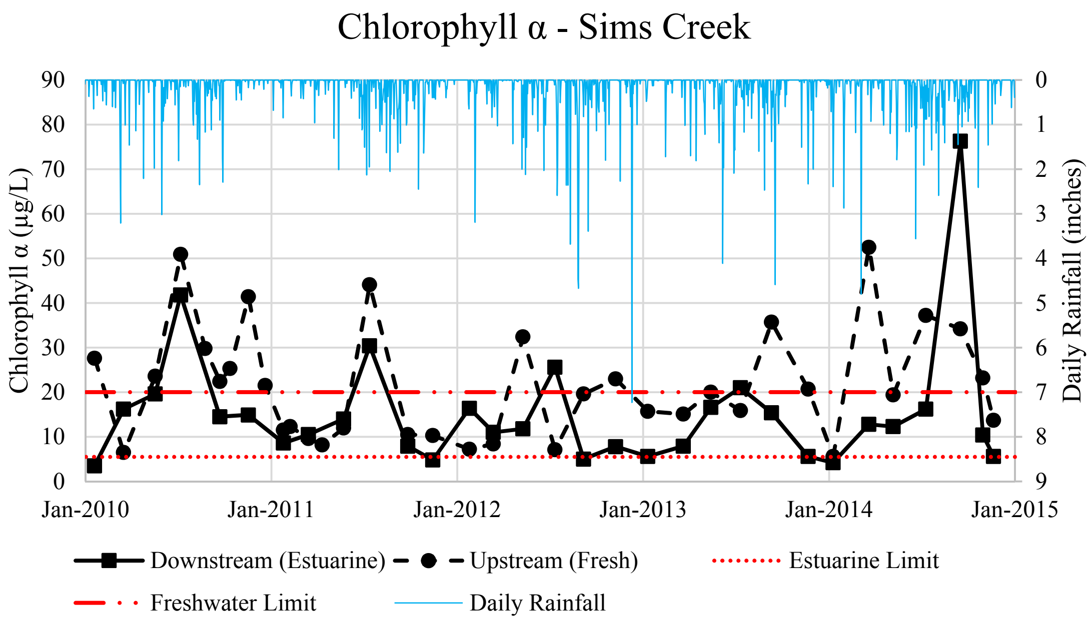

Figure 2-4: Chlorophyll α Concentrations Measured at Both Monitoring Locations Along Sims Creek

Measured DO, fecal coliform, and enterococci levels often failed to meet the current FDEP water quality criteria. The calculated AGM for DO failed to meet the threshold at which 90% of daily samples shall be above in each of the five years analyzed at the upstream grab sample location in Jones Creek, while the downstream grab sample location in Jones Creek met the FDEP criteria each year (**Figure 2-5**). Both sampling locations in Sims Creek indicated that DO levels met the 10% and AGM FDEP criteria in each of the five years analyzed (**Figure 2-6**). The comparison between the AGM of DO levels and the criteria outlined by FDEP is not entirely valid for determining compliance since the criteria refer to daily geometric means but the comparison was necessary due to the low sample count in each of the years of interest.

Multiple samples collected from Jones Creek indicated an exceedance of the FDEP maximum fecal coliform level of 800 CFU/100 mL (**Figure 2-7**). Data collected from Sims Creek suggest fecal coliform levels commonly exceeded the FDEP maximum limit at the downstream sampling location but never exceeded this limit in the upstream sampling location (**Figure 2-8**). FDEP criteria stipulate that fecal coliform levels exceeding 800 CFU/100 mL shall not be measured in any single sample.

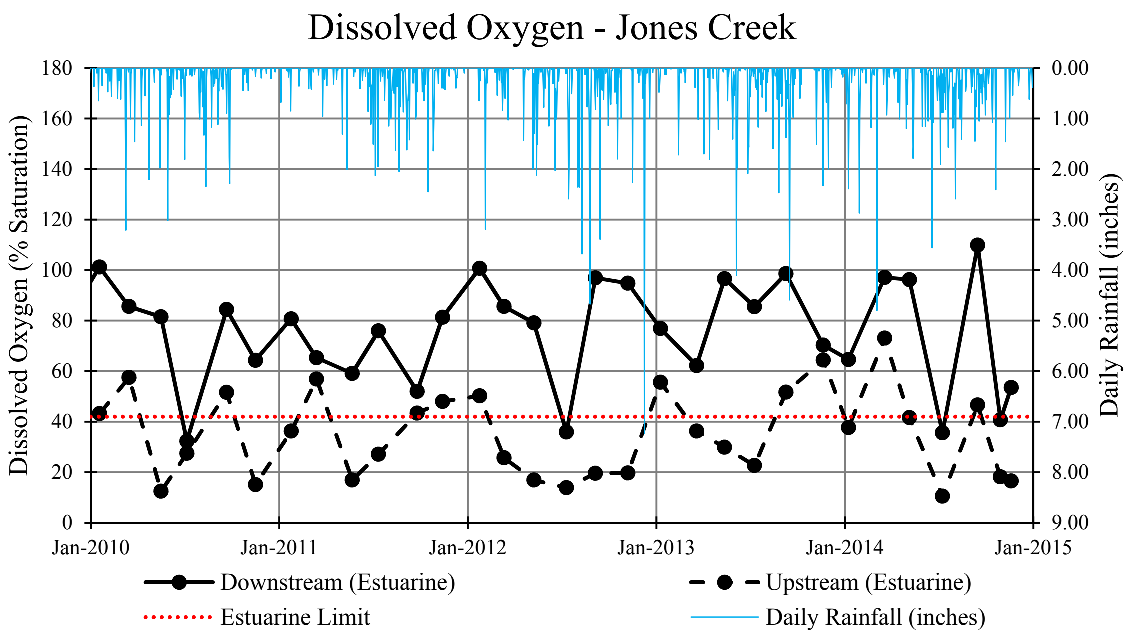

Figure 2-5: Dissolved Oxygen Levels Measured at Both Monitoring Locations Along Jones Creek

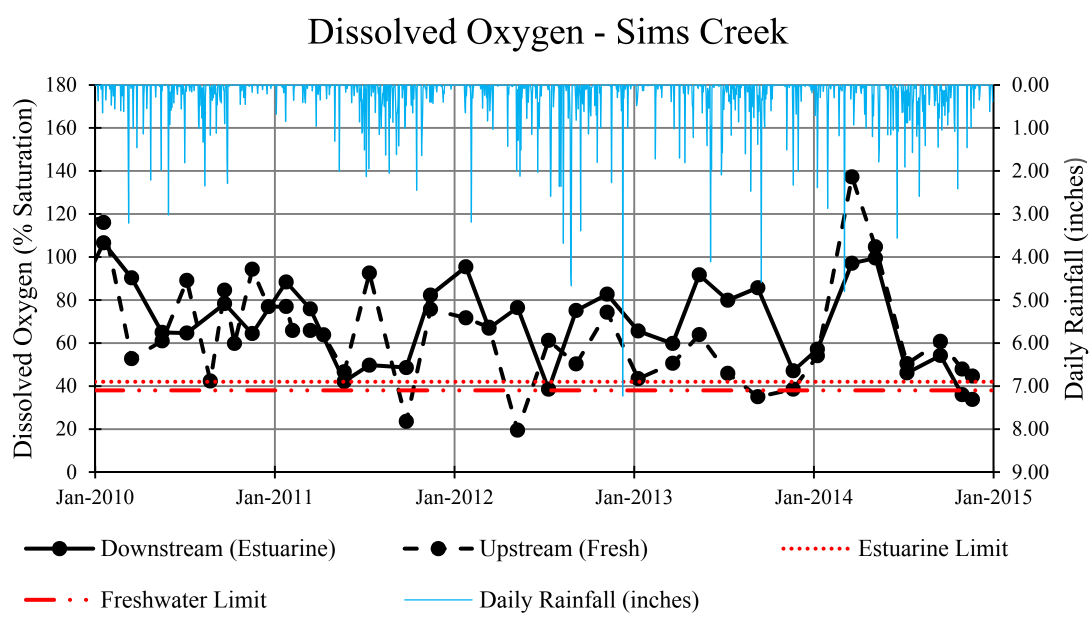

Figure 2-6: Dissolved Oxygen Levels Measured at Both Monitoring Locations Along Sims Creek

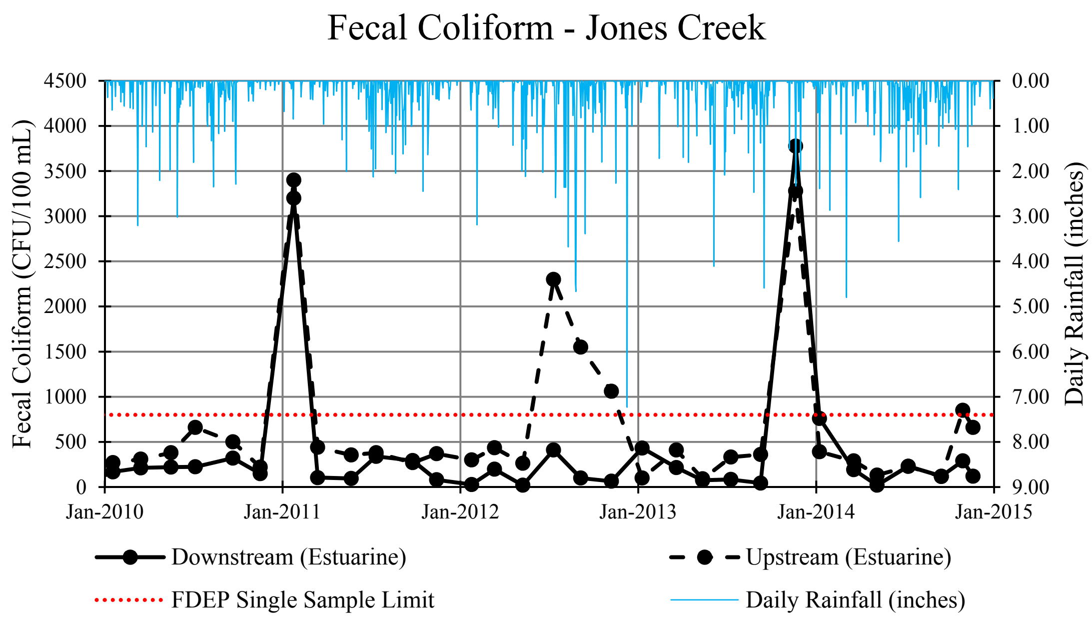

Figure 2-7: Fecal Coliform Levels Measured at Both Monitoring Locations Along Jones Creek

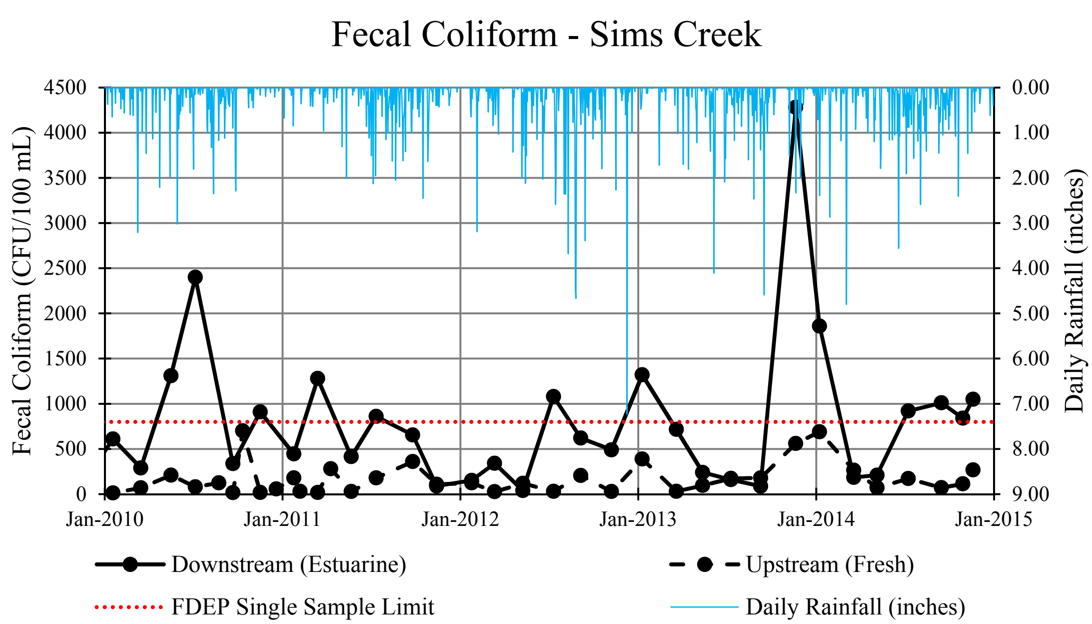

Figure 2-8: Fecal Coliform Levels Measured at Both Monitoring Locations Along Sims Creek

Enterococci is another parameter which was measured by LRD in Jones and Sims Creeks. The presence of enterococci is treated similarly to fecal coliform and is recommended by the Environmental Protection Agency (EPA) to be used when analyzing water quality in marine environments due to their ability to survive in salt water. The measured enterococci levels fluctuated in the same manner as the fecal coliform levels in both creeks and typically exceeded the FDEP standard. Therefore, due to the greater number of fecal coliform samples collected compared to the enterococci samples, the enterococci results were not used in the water quality analyses. Enterococci levels were used strictly to validate the accuracy of the fecal coliform data since three of the four grab sample locations were in brackish environments.

Sucralose concentrations were measured in Jones and Sims Creeks in order to identify the potential presence of human waste in both creeks. Sucralose is an artificial sweetener that is commonly measured as an indicator of human waste since it is not naturally occurring and is only present in products that humans consume. The presence of sucralose does not necessarily represent untreated human waste as it is not removed in the wastewater treatment process and is not consumed in the natural environment. Rather, the presence of sucralose indicates that treated or untreated human waste has mixed with surface water at some point upstream of the sampling location. Sucralose concentrations have only recently been evaluated in surface waters with greater scrutiny as its use as a tracer has become more established. Sucralose concentrations measured in samples collected in 2012 and 2014 are plotted with the daily rainfall in **Figure 2-9** and **Figure 2-10**, respectively.

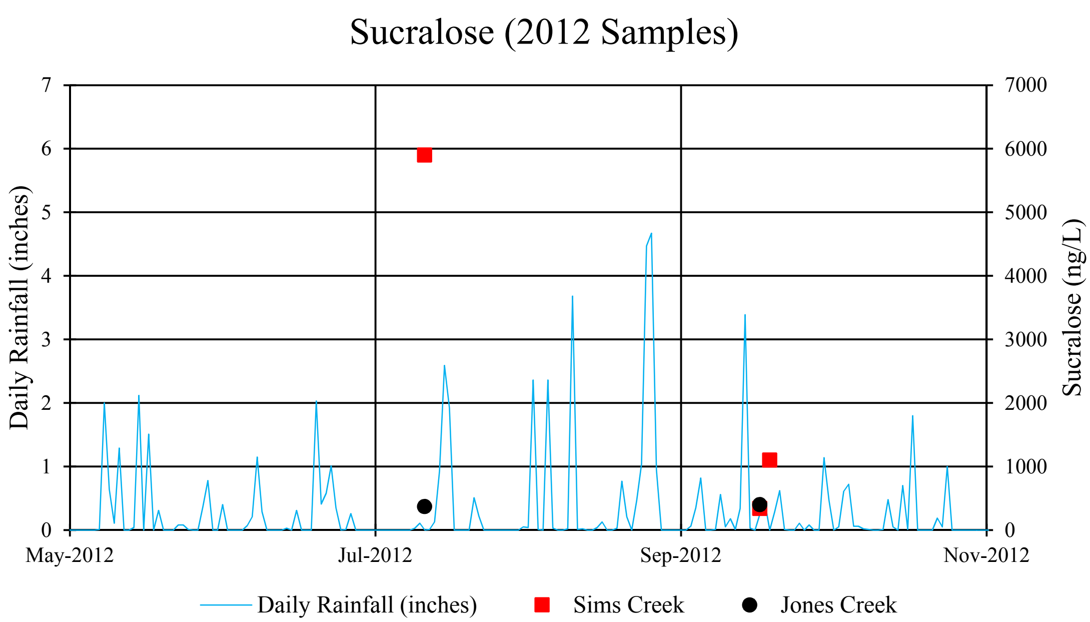

Figure 2-9: Sucralose Concentrations in Samples Collected in 2012

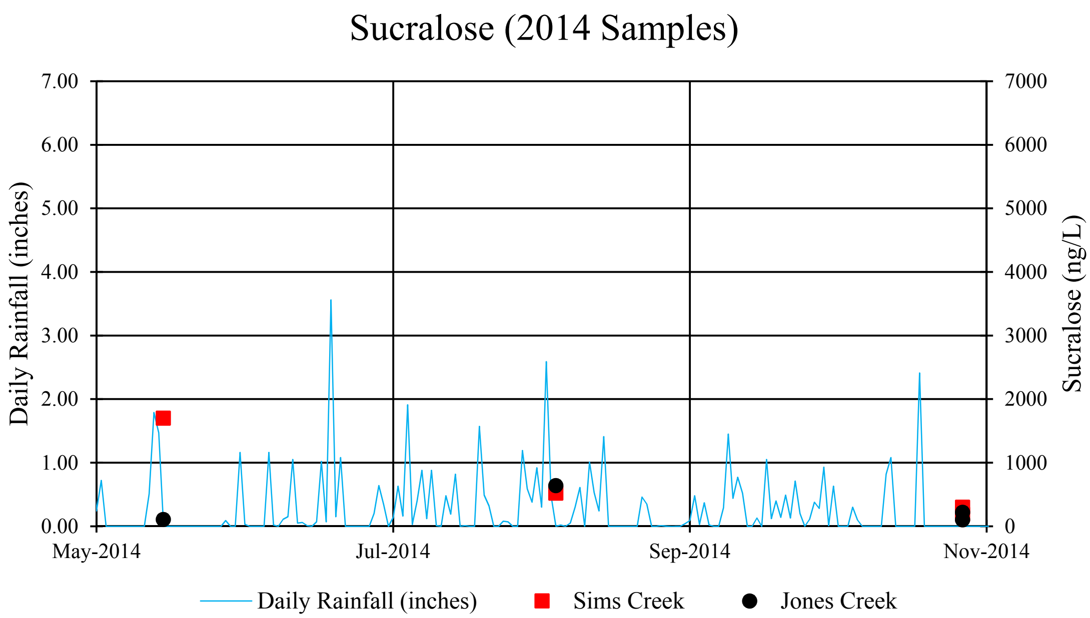

Figure 2-10: Sucralose Concentrations in Samples Collected in 2014

Section 3.0
Identification of Potential Pollutant Sources

3.1 Nutrient Sources

The AGM for TN was calculated as being lower than the FDEP criteria at each of the four grab sample locations since January 1, 2010. In many cases, the AGM was significantly lower than the standard. It therefore appears that TN concentrations may be acceptable based on the current NNC. However, based on the abundance of aquatic vegetation in Sims Creek, it is likely that a reduction to the current NNC will be required once a TMDL is developed since imbalances in flora and fauna dictate the site specific NNC.

While the TN concentrations measured at each sampling location met the current FDEP NNC between January 1, 2010 and December 31, 2014, the AGM for TP exceeded the NNC twice at the upstream grab sample location of Jones Creek (see **Table 2.2**). Since the criteria specify that the FDEP limit shall not be exceeded more than once in a three year period, the results indicated TP as being a pollutant of concern in Jones Creek. When taking into account the assumption that a 0.5-inch runoff event scours the majority of pollutants on ground surface, the data appeared to suggest a decreasing trend between TP concentrations in Jones Creek as the number of days since the last runoff event of this size increased (**Figure 3-1**). The 0.5-inch runoff event being a scouring event was used based on the South Florida Water Management District (SFWMD) criteria stipulating that for retention systems the first 0.5 inches of runoff must be retained to satisfy the water quality requirements. Based on the observed relationship between rainfall and TP concentrations, the TP load may have been primarily dependent on runoff from the surrounding area.

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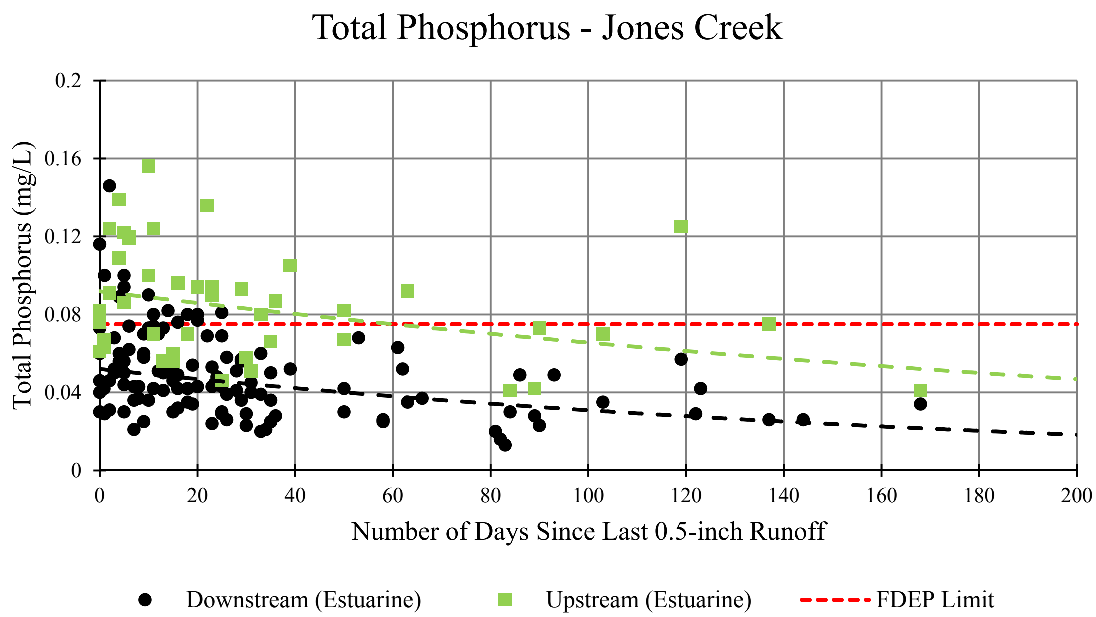

Figure 3-1: Comparison of TP Concentration in Jones to Number of Days Since Last 0.5-inch Runoff

Due to the predominantly residential land use within the Jones Creek drainage area, the primary source of phosphorus may have likely been residential fertilizer usage. There is a greater likelihood of residential fertilizer misuse compared to commercial misuse due to a potential lack of knowledge on how to properly apply fertilizer and/or not knowing which fertilizer type is appropriate. The Loxahatchee Club golf course purposefully does not include phosphorus as part of its fertilizing plan due to a lack of need for the turf type used. While the golf course does not actively use phosphorus, the use of reclaimed water for irrigation purposes may initially be identified as a potential pollutant source due to the elevated nutrient concentrations in reclaimed water compared to potable water. The effluent TP concentration from the LRD Wastewater Treatment Plant fluctuates between 1 and 4 mg/L. Although the effluent TP concentrations are in this range, the concentrations leaving the sprinkler head at the end of the distribution system are typically at least 50% lower based on data outlined in the presentation titled "Nutrient Cycling in a Reuse Distribution System Significantly Lowers Landscape Irrigation Nutrient Loading Estimates" [Arrington, 2013]. Furthermore, the TP concentrations measured in canals downstream of areas which use reclaimed water typically don't exceed 0.1 mg/L [Arrington, 2013]. Average TP concentrations measured at the upstream grab sample location in Jones Creek were typically near 0.1 mg/L and low levels of sucralose indicate there was some human waste (either treated or untreated) migrating to the creek. However, assuming that dilution must occur between the Loxahatchee Club Golf Course and the upstream grab sample location, the golf course is likely not the only source of Phosphorus or sucralose within the Jones Creek drainage area and other factors, such as residential fertilizer usage, may play a significant role in the observed levels.

In a study completed by EW consultants, results indicated a reduction of applied fertilizer of approximately 25% may be possible when irrigating with reclaimed water [*Abacoa Reclaimed Water Fertilization Study*, 2015]. Although the Loxahatchee Club does not use Phosphorus, reducing the amount of Nitrogen applied to the golf course may help improve the Chlorophyll α and DO concentrations currently observed in Jones Creek. In addition to the commercial and residential use of fertilizer within the Jones Creek drainage area, animal waste may have also had a significant impact based on the consistently elevated observed fecal coliform levels (see **Figure 2-6**). The impact of animal waste on TP concentrations may be more significant in Jones Creek compared to Sims Creek due to the greater number of residential properties adjacent to the creek with little to no buffer to treat stormwater prior to discharge into the surface water body. Runoff from areas within the Sims Creek drainage area is typically routed through wet detention ponds or other stormwater management structures prior to reaching the creek, allowing for a potential increase in pollutant removal and therefore lower observed TP concentrations.

TP concentrations measured at the downstream sampling location in Jones Creek were generally less than those measured at the upstream sampling location. This suggests that there was a higher concentration upstream with dilution occurring before reaching the downstream location, tidal mixing and dilution reduced concentrations in the downstream reach, and/or there was a high level of assimilation between the upstream and downstream sampling locations. It is unlikely that residual contamination from septic tanks was a significant contributor to the TP levels based on the apparent inverse relationship between TP concentration and number of days since the last 0.5-inch runoff event. The length of time which has passed (10+ years in most areas of the Jones Creek watershed) since the conversion from septic to sewer also suggests that legacy pollution is likely not a major contributor to the observed pollutant concentrations. The observed relationship between rainfall and TP concentrations was indicative of pollution driven by overland flow and was reinforced by the annual patterns (observed in **Figure 2-1**), which showed peak concentrations typically observed during the wet season months.

The AGM for Chlorophyll α consistently exceeded the FDEP NNC for each of the past four years in three of the four grab sample locations (see **Table 2.2**). The only sampling location which appeared to have acceptable levels based on the FDEP criteria was the upstream sampling location of Sims Creek. However, concentrations measured at this location were similar to those measured at each of the other three sampling locations and only met the FDEP criteria due to its freshwater classification. Since there is a clear presence of excessive aquatic vegetation a reduction in the Chlorophyll α limit may be necessary once a TMDL is developed. Chlorophyll α is measured as a surrogate for algal biomass due to the lower cost and time required to measure, but does not directly affect water quality. In addition to algal biomass, elevated chlorophyll α levels may also be indicative of an abundance of floating aquatic vegetation. This abundance of algae and/or aquatic vegetation may indicate fast nutrient uptake within the upstream reach of Sims Creek (NPBHWCD Canal), resulting in TN and TP concentrations being observed as meeting the FDEP criteria at both sampling locations in Sims Creek. Not only can algae and floating aquatic vegetation directly impact nutrient and chlorophyll α levels, it can also lead to depleted DO within the water column as dieback occurs. The relationship between the measured Chlorophyll α and DO levels for the upstream reaches of Jones and Sims Creeks are provided as **Figure 3-2** and **Figure 3-3**, respectively. As seen in the figures, the maximum Chlorophyll α concentrations commonly coincided with minimum DO levels in the upstream reach of each creek.

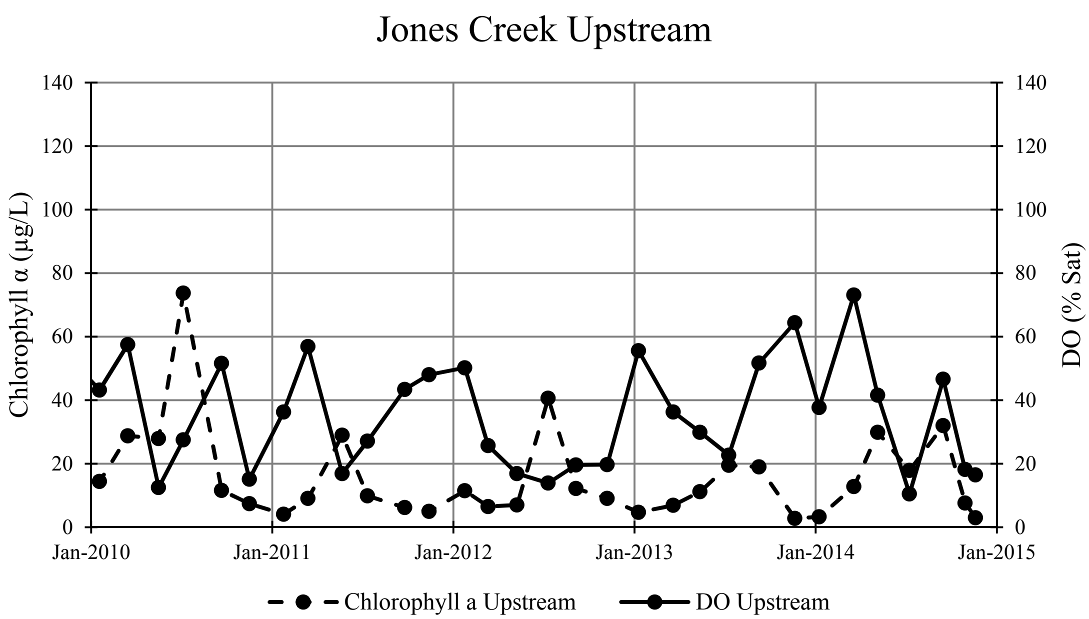

Figure 3-2: Comparison Between Chlorophyll α and DO Levels in the Upstream Reach of Jones Creek

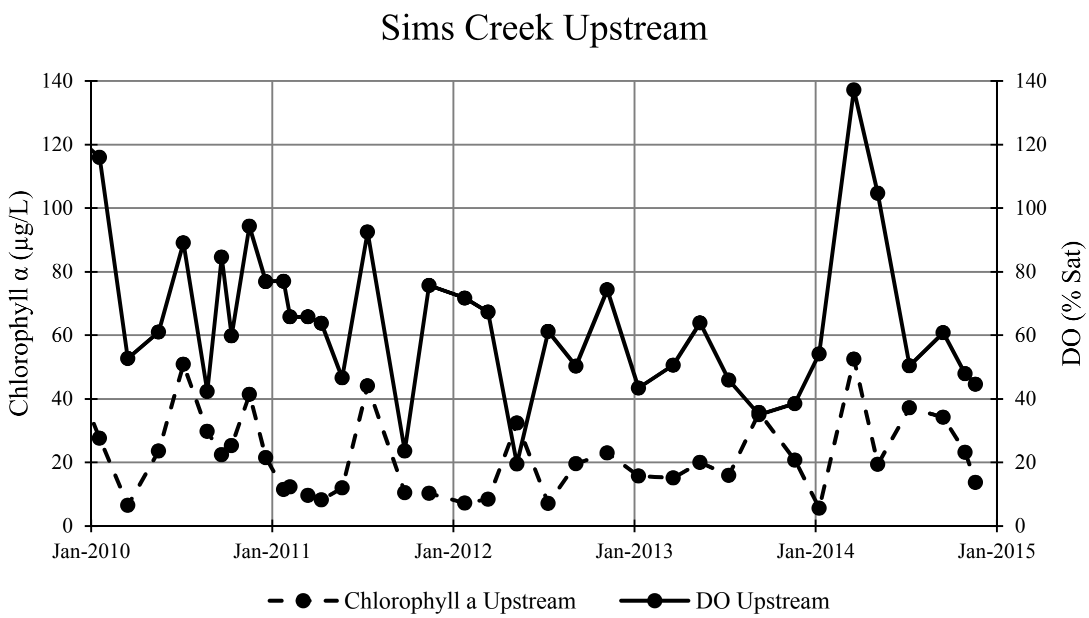

Figure 3-3: Comparison Between Chlorophyll α and DO Levels in the Upstream Reach of Sims Creek

An example of excess floating aquatic vegetation present in the upstream reach of Sims Creek is provided in **Figure 3-4**. While vegetation can increase DO through photosynthesis during daytime hours, DO can also be depleted during nighttime hours through respiration and/or aerobic degradation of organic matter resulting from dieback occurring. The same effects can result from aquatic vegetation blocking light from penetrating the water column during daytime hours. Therefore, reducing the presence of algae and floating aquatic vegetation might also increase the DO levels in areas which did not meet the FDEP criteria. Excess algae and floating aquatic vegetation may have been attributable to nutrients in runoff and/or stagnant water making the nutrients in the creek more readily available to be assimilated. While nutrients were not a concern in the upstream reach of Sims Creek, attempting to decrease the nutrients in runoff may improve other aspects of water quality such as Chlorophyll α and DO concentrations. Other actions such as physically removing excess vegetation and maintaining a more steady baseflow in each creek could also directly benefit the Chlorophyll α and DO levels.

Figure 3-4: Floating Aquatic Vegetation Growth in the North Palm Beach Heights Water Control District (NPBHWCD) Canal (Sims Creek)

While the water quality in the upstream reach of Sims Creek met the FDEP freshwater criteria, it failed to meet the estuarine criteria which governs the downstream reach of Sims Creek. Special conditions of the original surface water management permit (SFMWD permit number 50-01364-S) state that "the District reserves the right to require that water quality treatment methods be incorporated into the drainage system if such measures are shown to be necessary" and "the permittee shall be responsible for the correction of any water quality problems that result from the construction or operation of the surface water management system". The permittee (North Palm Beach Heights Water Control District) may therefore be obligated to take action due to the observed exceedances in the downstream reach despite currently meeting the FDEP criteria in the upstream reach.
To summarize:

- TN did not appear to be a parameter of concern in Jones and Sims Creeks as it was not measured in excess of the FDEP criteria in any of the sampling locations. However, based on the vegetation characteristics, reducing nutrient loads may be required once a TMDL is developed.

- Concentrations of TP were an immediate concern at the upstream sampling location of Jones Creek. Measured TP concentrations appeared to decrease as the number of days following a 0.5-inch runoff event increased, implying that the observed levels may be dependent on pollutants conveyed in overland flow.

- Chlorophyll α was a concern in three of the four grab sample locations and may have been a result of excess nutrients being discharged to the creeks or stagnant water allowing nutrients to become more available to be assimilated by aquatic or terrestrial vegetation. Chlorophyll α concentrations were similar at each of the four grab sample locations and only met the FDEP criteria in the upstream reach of Sims Creek due to the freshwater classification at that location.

3.2 Fecal Bacteria Sources

In both sampling locations in Jones Creek and the downstream sampling location of Sims Creek, fecal coliform levels were measured as exceeding the FDEP maximum limit of 800 CFU/100 mL. In order to determine if the fecal coliform levels were attributable predominantly to groundwater or runoff during storm events, fecal coliform levels in Jones and Sims Creeks were compared to the number of days since the last 0.5-inch runoff event for each sampling date (**Figure 3-5** and **Figure 3-6**, respectively). Similar to TP concentrations in Jones Creek, the greatest fecal coliform levels were typically observed soon after a significant rainfall event had occurred. This suggests that the greatest contribution to the fecal coliform levels originated from the surface (e.g. animal feces) and was dependent primarily on overland flow to migrate into the creeks rather than being a constant pollutant source via groundwater recharge. Further evidence that rainfall had a significant impact on the fecal coliform levels is that 2.33 inches of total rainfall occurred on November 21, 2014, which was the same day that the highest fecal coliform levels were recorded in three of the four grab sample locations. Although the time of day at which the rainfall occurred is unknown, it is assumed that it occurred prior to or during the time samples were collected. It is recommended that stormwater samples be collected during or immediately following future significant rainfall events to further establish the effect of runoff on pollutant concentrations within Jones and Sims Creeks.

The only sampling location within Jones and Sims Creeks which consistently exhibited fecal coliform levels in compliance with the FDEP criteria is upstream of a flow barrier (constant head weir located in Sims Creek), although the levels exceeded the estuarine limits outlined by FDEP. An analysis of fecal coliform levels observed at sampling locations in the Southwest Fork of the Loxahatchee River was completed in order to identify whether the primary source of fecal coliform originated within the Jones and Sims Creek drainage areas or if it was instead originating from the Southwest Fork and migrating into Jones and Sims Creeks during high tide. A comparison of fecal coliform levels in Jones and Sims Creeks to levels recorded at the River Road and Pennock Point sampling locations are provided in **Figure 3-7** and **Figure 3-8**. While there did appear to be some degree of correlation in the fecal coliform levels measured within Jones and Sims Creeks and in the Southwest Fork, levels in the Southwest Fork were commonly lower than those observed in the two creeks. Furthermore, sampling locations further upstream within the Southwest Fork (S.R. 706) and downstream (Railroad) consistently showed acceptable fecal coliform levels. Based on these locations being in compliance with the FDEP criteria, it is unlikely that the Southwest Fork water quality was a cause of the fecal coliform levels observed in Jones and Sims Creek since the levels measured in the Southwest Fork are commonly lower and are only elevated in areas nearest the confluence of Jones and Sims Creeks.

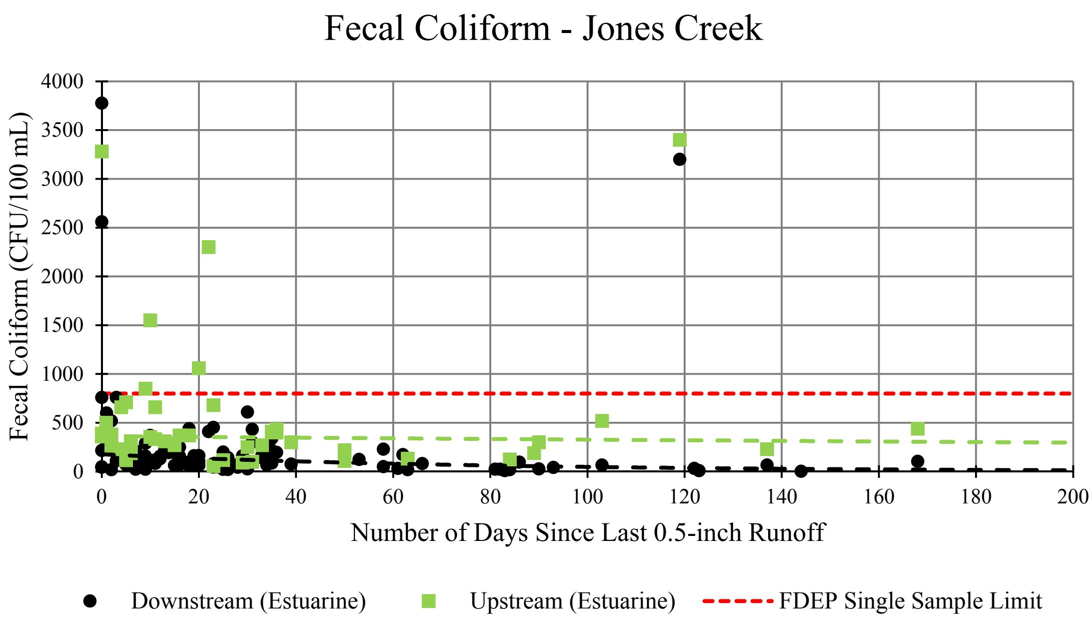

Figure 3-5: Comparison of Fecal Coliform Levels Measured in Jones Creek to Number of Days Since Last 0.5-inch Runoff Event

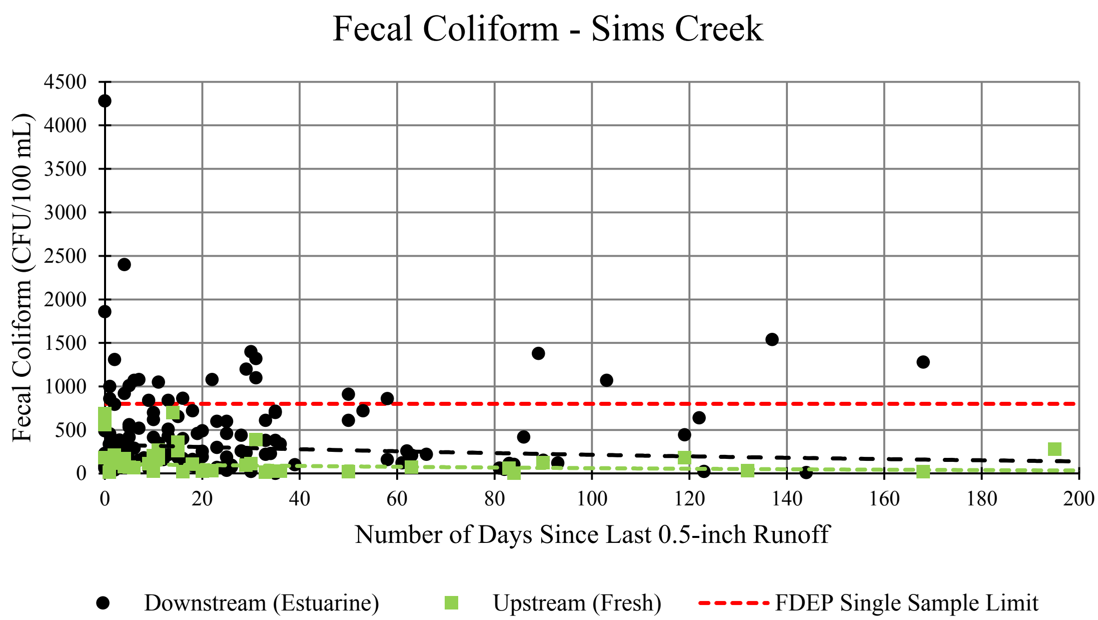

Figure 3-6: Comparison of Fecal Coliform Levels Measured in Sims Creek to Number of Days Since Last 0.5-inch Runoff Event

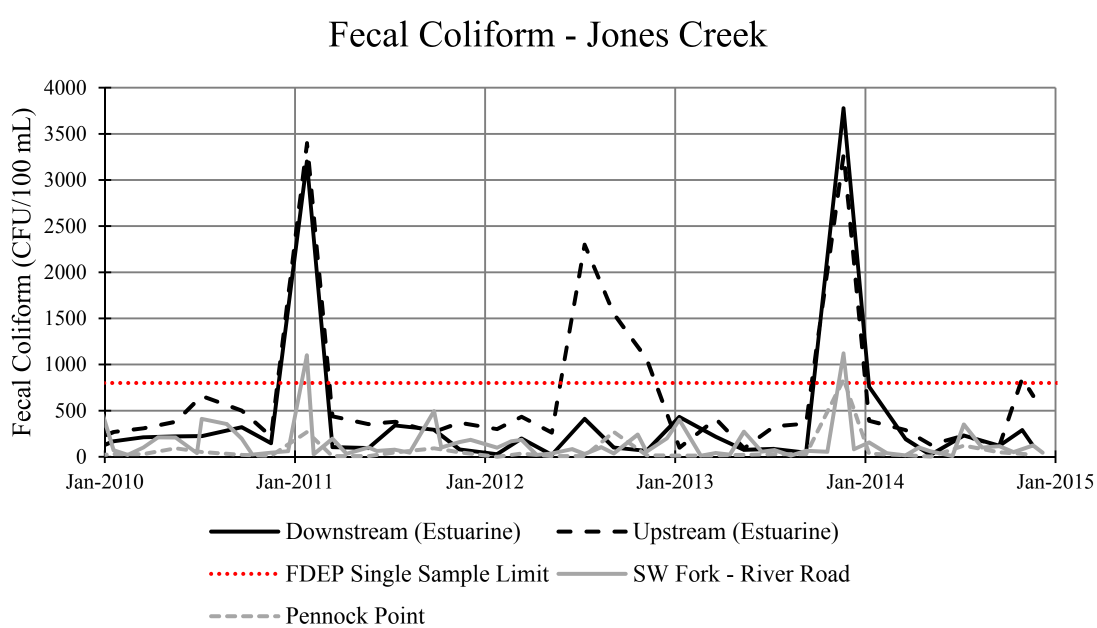

Figure 3-7: Comparison of Fecal Coliform Levels Measured in Jones Creek to Levels Measured at the River Road and Pennock Point Sampling Locations

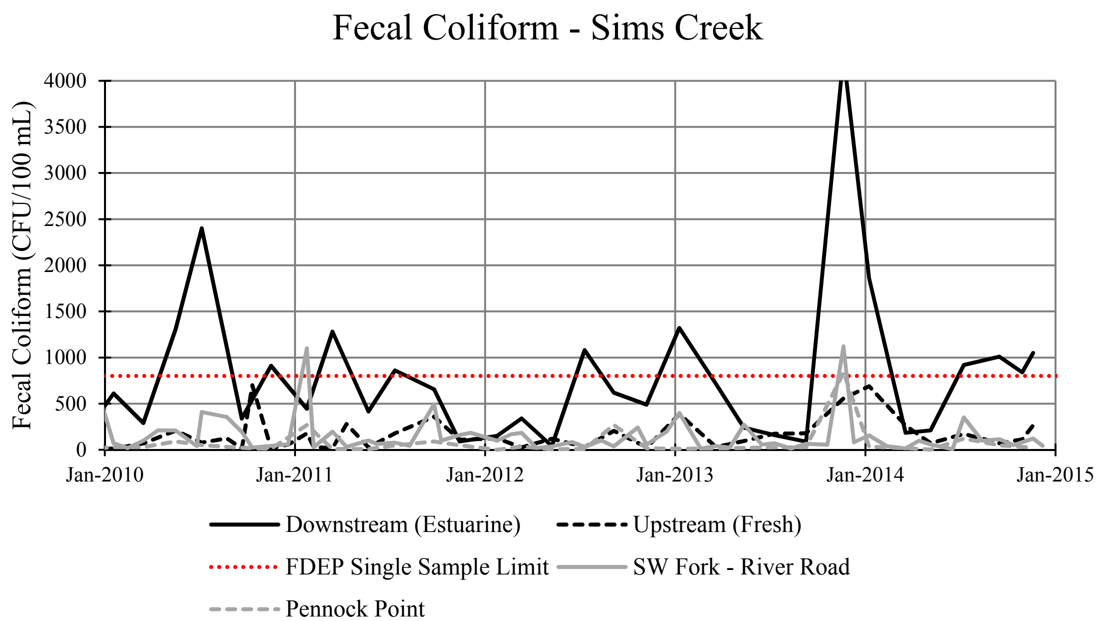

Figure 3-8: Comparison of Fecal Coliform Levels Measured in Sims Creek to Levels Measured at the River Road and Pennock Point Sampling Locations

Although analyzed differently, similar correlations between rainfall and fecal coliform levels were drawn during the formation of the fecal coliform TMDL for the Southwest Fork of the Loxahatchee River, which stated that a correlation exists between exceedances in fecal coliform levels and moderate to large rainfall events. Table 5.4 in the developed TMDL outlines the percent of samples collected during events which exceeded the 90% threshold outlined by FDEP. The results indicated the greatest percentage of exceedances were observed during medium size rainfall events (82% of samples) while the least number of exceedances were observed when samples were collected during periods of no rainfall (45% of all samples). This further demonstrates that rainfall may have been a controlling factor relative to observed fecal coliform levels in the receiving water body. While large rainfall events may likely scour the same mass of pollutants from ground surface, fewer exceedances were observed following moderately sized rainfall events likely due to dilution of the fecal coliform load. Conductivity data collected from the datasonde deployed in Jones Creek showed no clear decrease following rainfall events, as would typically be expected. This lack of correlation suggests that water quality parameters, such as fecal coliform levels, are affected by many complex factors (e.g. tidal mixing, incoming vs outgoing tide, etc.). This additional complexity in the system may explain the lack of a strong correlation between monitored water quality parameters and factors that affect the observed levels, such as rainfall and land use.

Unlike fecal coliform levels and TP concentrations, sucralose concentrations in Sims Creek typically increased as the numbers of days since the last 0.5-inch runoff event increased (**Figure 3-9**). This relationship was based on a very small sample size and may differ once additional samples are collected in the future. However, based on the available data, the indication is that the observed sucralose concentrations in Sims Creek may have been groundwater driven and were therefore higher when flows in the creek were lower. A potential cause of the elevated sucralose concentrations in groundwater within the Sims Creek drainage area is the presence of two active septic tanks (located at 5800 and 5942 Center Street). Based on the typical sucralose concentrations recorded in wastewater effluent, septic tanks, and runoff from areas irrigated with reclaimed water (**Table 3.1**), the elevated concentrations measured in Sims Creek appeared to be impacted the greatest by highly concentrated sources, potentially due to the close proximity of the monitoring location to the septic tank parcels (i.e. not entirely a result of reclaimed water usage by the Golf Club of Jupiter).

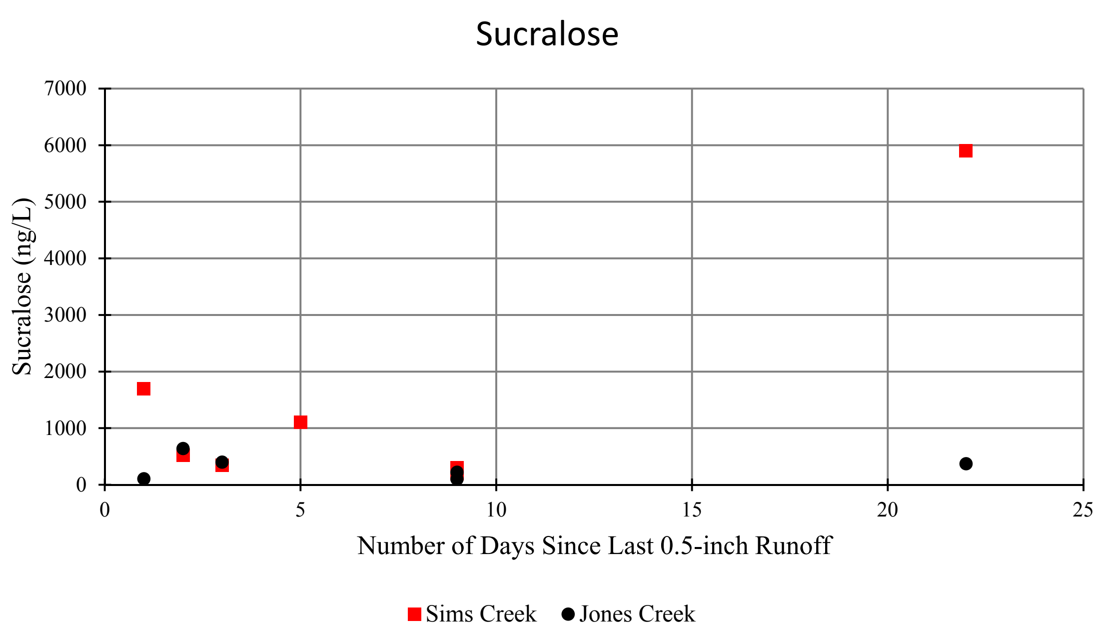

Figure 3-9: Sucralose Concentrations Measured Along Jones and Sims Creek

Table 3.1
Summary of Sucralose Concentrations From Different Sources

Source	Typical Sucralose Concentration (ng/L)
Wastewater Treatment Plant Effluent[1]	27,000
Septic Tank[2]	40,000
Runoff From Area Irrigated With Reclaimed Water[2]	1,100

[1] Schmidt H., P. Waller, J. Oppenheimer, M. Badruzzaman, J. Pinzon, and J. Jacangelo, No Sweetener in Your Stormwater, but What About Your Reclaimed Water?, Florida Water Resources Journal, Feb. 2013.

[2] Jacangelo, J. G., Development of Markers for Differentiating Sources of Nutrient Loading in Florida Waterways

Unlike Sims Creek, the sucralose data collected from Jones Creek showed relatively constant sucralose concentrations regardless of whether or not the sample was collected during a wet or dry period. The main source of sucralose within the Jones Creek drainage area may have likely been the application of reclaimed water at the Loxahatchee Club Golf Course. Another potential source of sucralose to both Jones and Sims creeks was flow from the Loxahatchee River during high tide. Based on the high density of active septic tanks in Pennock Point, north of Jones and Sims Creeks, this may have been a pollutant source which affected levels recorded in Jones and Sims Creeks. As previously discussed, the constant head weir located in Sims Creek may have acted as a barrier to these sources originating from the Southwest Fork. Although the septic tanks north of the Southwest Fork may have contributed to the pollutant load, based on the comparison between fecal coliform levels in the Southwest Fork and levels observed in Jones and Sims Creek it is unlikely that pollutants flowing into Jones and Sims Creek from the Southwest Fork during high tide is a major concern. Additional water quality sampling in the Southwest Fork which tests for sucralose and fecal coliform levels is recommended at the location described in Section 4.4. These data may that the primary fecal coliform and sucralose sources are located within the Jones and Sims Creek drainage areas.

It is important to note that while sucralose is not easily broken down, the constituents that sucralose is a surrogate for (e.g. fecal bacteria) may be removed via physical or chemical processes between the pollutant source and the monitoring location. Therefore, the presence of elevated sucralose concentrations may not always be coincident with elevated pollutant concentrations. However, based on the elevated fecal coliform levels observed in each creek the sucralose was likely an accurate tracer for pollutants such as fecal bacteria in this scenario.

To summarize:

- The elevated fecal coliform levels were likely a result of animal feces throughout the drainage areas with a potential contribution from human waste originating from active septic tanks.
- Fecal coliform levels in both Jones and Sims Creeks were often higher in the days following a rainfall event, implying that the primary source may have been located on ground surface and dependent on overland flow.
- Taking into account the sucralose data, a portion of the fecal coliform present in Sims Creek was likely a result of groundwater recharge into the creek since the highest sucralose concentrations were measured during the driest period at the downstream sampling location. The elevated sucralose concentrations observed in Sims Creek may have also been a result of the sampling location's close proximity to the two parcels still on septic and/or contamination originating within the Loxahatchee River flowing to the monitoring location during high tide.

Section 4.0
Pollutant Reduction Strategies

4.1 Total Phosphorus and Total Nitrogen

4.1.1 List of Strategies

1. Communicate the information outlined in the EW Consultants study which indicated a decrease in fertilizer application rates of 25% is feasible when irrigating with reclaimed water.
2. Encourage residents to reduce fertilizer usage based on soil conditions.
3. Encourage proper disposal of yard waste, particularly in residential areas adjacent to Jones Creek.

4.1.2 Discussion of Benefits and Drawbacks

- In areas that use reclaimed water for irrigation purposes within the Jones and Sims Creek drainage areas (i.e. The Golf Club of Jupiter and Loxahatchee Club Golf Course), the total applied fertilizer load could be reduced by 25% without sacrificing turf health and/or appearance due to the elevated nutrient concentrations in reclaimed water [*Abacoa Reclaimed Water Fertilization Study*, 2015]. While the upstream reach of Sims Creek did not exhibit nutrient concentrations which fail to meet FDEP criteria, the abundance of aquatic vegetation is indicative of an imbalance of flora and therefore it may be required that the maximum nutrient concentration be reduced upon formation of a TMDL.

  These potential changes in fertilizer application rates would be relatively easy to execute since there would be a clear financial benefit to both golf courses if a long term reduction in fertilizer usage were possible. Another benefit to this strategy would be the low cost associated with implementing any changes. While the Loxahatchee River District already communicates nutrient data to reuse customers so they can make fertilizer application adjustments, the results stemming from this new analysis of reclaimed water usage for irrigation should also be communicated so the fertilizer usage by reuse customers can be adjusted appropriately. This pollutant reduction strategy has no apparent drawback since there would be mutual interest in making this adjustment if a reduction was deemed feasible.

- Encouraging residents within the Jones and Sims Creek drainage areas to adjust their fertilizer application rates based on the soil conditions would also be a low cost strategy for reducing nutrient loads in each creek. This strategy would require the collection of representative soil samples and determination of an appropriate fertilizer application rate for each neighborhood based on those results. In addition to being low cost, it would require minimal time for the Town to prepare and execute an effective strategy aimed at educating the residents throughout the area of the potential impacts from improper fertilizer application.

- While there is no direct evidence that it is occurring, improperly disposing of leaves and grass clippings can be a large source of nutrients within a drainage area, making the proper disposal of these materials critical. This strategy would again require little capital and could be executed quickly. Residents (particularly those adjacent to Jones Creek) should be encouraged not to dispose of their yard waste in the adjacent stream. It is estimated that one bushel of grass clippings contains approximately 0.1 pounds of phosphorus, which is enough to then produce 30 to 50 pounds of algae. Therefore, putting grass clippings into the adjacent creek may not only increase nutrient loads but also exacerbate the existing problems with Chlorophyll α and DO.

The primary drawback to these programmatic efforts (encouraging residents to reduce fertilizer usage and dispose of yard waste properly) is that it may be difficult to get public participation with an issue that many residents may feel does not affect them. Summarizing water quality information in quarterly flyers or web based reports may be a good way to demonstrate how activities of residents can impact local water quality. While reducing the fertilizer application rates in residential areas could save those who live in the area money, the savings would not be nearly as significant as it would be with the two golf courses. The perceived benefits may not be substantial enough to get significant participation, but at the low required cost the strategy should be implemented nonetheless.

Although the Town of Jupiter ordinance number 21-13 addresses fertilizer usage and yard waste disposal, enforcement of the laws outlined in the ordinance can be very difficult. For this reason it is important that the information outlined in the ordinance be communicated to the local residents to ensure the laws are fully understood. For example, it should be made clear to the residents who live adjacent to Jones and Sims Creeks that it is illegal to apply fertilizer within 10 feet of the creek. Furthermore, it should be made clear that it is illegal to intentionally wash, sweep, or blow grass clipping and vegetative material into water bodies, sidewalks, stormwater drains, or roadways per section 23-97 of the ordinance. Mailing informative flyers on the current laws to the residents in both drainage areas may result in greater compliance and would likely be more effective than attempting to increase enforcement.

4.2 Chlorophyll α and Dissolved Oxygen

4.2.1 List of Strategies

1. Maintaining a more steady baseflow in both creeks to decrease the potential of nutrients being assimilated by aquatic vegetation.
2. Periodic physical removal of aquatic vegetation.

4.2.2 Discussion of Benefits and Drawbacks

- Maintaining a steadier baseflow throughout both creeks may help reduce the potential for stagnation to occur in the upstream reaches, which are not significantly affected by tidal fluctuations. This reduction in stagnant water would likely make nutrients within the creeks less available to be assimilated by aquatic vegetation therefore reducing the potential for excess vegetative growth.

  The first issue with this pollutant load reduction strategy is that the potential benefits are not guaranteed even if the construction of a system to create said baseflow were completed. Furthermore, with each drainage area being heavily developed the logistics of routing water to the upstream reaches would become complex and could result in costly construction. Lastly, fresh water would be required for Sims Creek due to the presence of the salinity barrier. The cost associated with tapping into a constant source of fresh water to do this may end up being too costly and infeasible from a regulatory standpoint.

- Periodically removing aquatic vegetation from the upstream reach of Sims Creek may help improve the Chlorophyll α and DO levels in the downstream reach. If the vegetation mass were reduced, there may be less depletion of DO when dieback occurs. This solution is much more feasible and would carry a lower cost compared to maintaining a more steady baseflow. In addition to the potential water quality benefits, physical removal of aquatic vegetation would reduce the risk of stormwater infrastructure components getting clogged during high flow events and improve general aesthetics. The current method to control the aquatic vegetation in the NPBHWCD Canal consists of the periodic use of herbicides, which can lead to the release of nutrients and DO depletion during the subsequent decay of plant matter [*Helfrich* et al., 2009]. The release of nutrients after use of aquatic herbicides typically leads to the need for the herbicide to be used more frequently since regrowth will occur at a faster rate [*Helfrich* et al., 2009]. Although the upstream reach meets the chlorophyll α and DO criteria, these actions may be resulting in the downstream reach failing to meet the stricter estuarine criteria. It is recommended that physical removal be examined as an alternate method for vegetation removal in the upstream reach of Sims Creek.

One of the drawbacks for this strategy is that it would be a recurring action requiring consistent resources. The physical removal of vegetation would have to occur once regrowth occurs within the channel in order to maintain compliance with the Chlorophyll α and DO FDEP criteria. Additionally, this action could suspend sediments within the creek which could then potentially be transported downstream.

4.3 Fecal Bacteria and Sucralose

4.3.1 List of Strategies

1. Convert the two parcels in Sims Creek that are on septic over to sewer.
2. Increase the number of pet waste receptacles and/or educational signage in public parks.
3. Encourage residents to discard pet waste instead of leaving it in their yards, particularly those who live adjacent to Jones Creek.
4. Place signs in public areas requesting people not feed wildlife (e.g. birds).

4.3.2 Discussion of Benefits and Drawbacks

- Converting the two remaining parcels currently on septic over to sewer would likely reduce the fecal coliform levels as evidenced by a reduction in sucralose concentrations measured in the downstream monitoring location of Sims Creek. While sucralose itself is not harmful to human health or to water quality, a reduction in sucralose may be indicative of a reduction in human fecal bacteria and/or nutrient concentrations.

  The drawback to this strategy is that it would require cooperation from the residents who currently live in those two locations and the cost may become significant if there is resistance to convert. It is recommended that the Town and LRD work with the residents to identify options for converting these parcels to sewer.

- One of the main reasons pet waste is not properly discarded is likely due to lack of accessible disposal areas. Placing pet waste receptacles in public parks along with signs encouraging owners to properly dispose of the waste (e.g. **Figure 4-1**) would decrease the potential for waste to be left on the ground. This would be a relatively low cost strategy and could be quickly executed by the Town. If pet waste receptacles were made available, a collection schedule would need to be created which would result in an increase in time required for waste pickup. It is also recommended that the Town contact condominium and apartment complexes to determine their interest in the installation of these receptacles throughout their properties. There may be mutual benefit to doing so since the complexes may see an increase in cleanliness while the Town may see decreases in pollutant levels in Jones and Sims Creeks. The low capital cost associated with this proposed measure (see Section 5.1) would make it possible for the Town to provide all necessary materials while the complex supplies the labor to collect the waste on a weekly basis through the existing maintenance or landscaping services.

Figure 4-1: Sims Creek Drainage Area
Pet Waste Reduction Measure

- The actions that residents who live adjacent to Jones Creek take likely have the greatest potential to negatively affect the water quality due to the lack of a buffer area between them and the creek. This is not the case in the upstream reach of Sims Creek where stormwater must flow through the stormwater network where pollutant removal can occur prior to discharge into the creek. While the downstream reach of Sims Creek does contain residences immediately adjacent to it, the density is much lower than what is present in Jones Creek. Placing a focus on having residents in the Jones Creek drainage area and lower Sims Creek drainage area discard their pet waste rather than letting it linger in their yard could result in a significant reduction in observed fecal coliform levels. In addition to having a potentially significant impact, the strategy would be relatively easy to implement and would not demand much time or capital to execute.

The impact of pet waste collection programs on nearby water quality has not yet been accurately quantified. However, many programs have been evaluated in terms of weight of pet waste collected. In a study which examined the results of a similar pet waste reduction effort, pet waste receptacles were placed in residential areas and educational materials were distributed. A total of seven pet waste receptacles were placed at three different sites and during the one year study a total of 1,826 pounds of pet waste were collected [*Public Outreach and Stewardship Workplan,* 2014]. With each gram of dog waste containing approximately 23 million fecal coliform bacteria [*Van der Wel,* 1995], the potential benefit to the surrounding surface waters is significant.

In addition to attempting to quantify load reduction, the habits of pet owners were also evaluated. Numerous polls of dog owners have been completed to evaluate the behavior of pet owners with respect to their pet's waste. The results vary depending on location but in general, between 31% and 41% of dog owners rarely or never clean up their pet's waste [*Pollution Prevention: Animal Waste Collection*]. Assuming these statistics correlate closely with the habits of those who live in the Jones and Sims Creek drainage areas, there may be an efficient method to reduce pet waste without significant capital being required.

Similar to the other programmatic strategies, the effectiveness of this strategy is entirely dependent on community involvement. Unlike the reduction of fertilizer application which may carry a financial benefit for the residents, removing pet waste from yards may not be seen as an action that directly effects home owners. Therefore, it may be more difficult to get those being targeted to cooperate with the Town's requests.

- Public parks are a common area where families visit to observe and occasionally feed the local wildlife. The placement of signs in these areas requesting visitors to refrain from feeding the wildlife could help control the populations, particularly with birds. The feeding of birds can artificially increase the population since the birds would no longer be dependent on the natural availability of food. This strategy would be a very low cost option and would have no continuous cost associated with it. Since fecal bacteria levels commonly exceeded the FDEP single sample limit, any programmatic efforts to reduce the levels should be taken due to their typically low cost. The only drawback to this strategy is that the water quality benefits may not be immediately recognizable and may not be noticeable until the bird population has a chance to equilibrate with the change in food availability.

4.4 General Strategies

- If the resources are available, future storm event samples and routine grab samples collected by LRD, the Town of Jupiter, or others should be obtained from each of the locations depicted in **Figure 4-2**. These additional sampling locations may assist in identifying more specific pollutant sources. If sufficient resources are not available to collect storm samples and grab samples at each location then it is recommended that the two creeks be analyzed in series. Analyzing the two creeks in series will allow for increased spatial and temporal detail of the collected water quality data, potentially leading to more effective implementation of pollutant reduction strategies. In addition to the grab and storm samples being collected at the proposed locations, grab samples should continue to be collected from the four existing locations, but at a higher frequency (e.g. every two weeks). The most important collection points for the routine grab samples are those within the Jones Creek drainage area, since fecal coliform levels were commonly observed as exceeding the FDEP single sample limit. These grab samples may help better identify where in the drainage area fecal coliforms are originating and could therefore help influence the Town's future actions.

  In addition to grab samples, it is recommended that more datasondes be incorporated into the water quality monitoring of Jones and Sims Creeks. Due to the time and high cost of additional sondes, Jones and Sims Creeks should be monitored independently since this would allow for more instrumentation to be deployed within the same creek simultaneously.

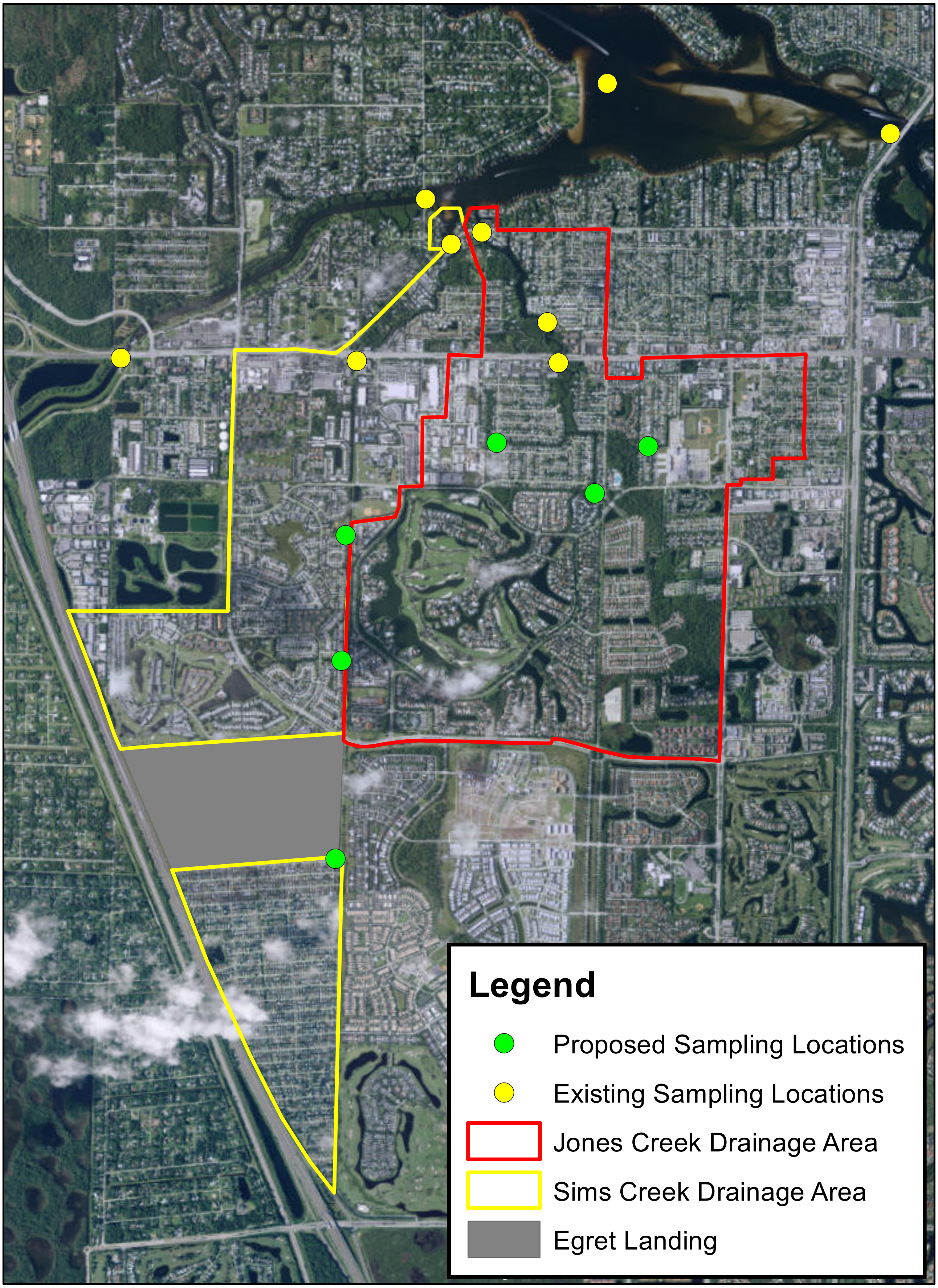

Figure 4-2 - Proposed Locations for Future Water Quality Sampling

- Of the proposed sampling locations illustrated in **Figure 4-2**, samples should be collected from the point where Indian Creek discharges to the NPBHWCD Canal, if resources to do so are available. These samples can either be collected manually or by using an automatic sampler and should be tested for fecal coliform, TN, and TP. These samples could help indicate whether maintenance to improve the pollutant removal efficiency may be necessary or if a change in BMPs is warranted. The estimated pollutant removal for different types of BMPs is summarized in **Table 4.1**. Based on the magnitude of exceedance of fecal coliforms compared to the other water quality parameters, it is recommended that the storm event sampling only be conducted if resources are available after collecting fecal coliform samples at the higher sampling frequency previously proposed.

Table 4.1
Estimated Percent Removal of Pollutants for Common BMPs

BMP / Design	Total Suspended Solids	Total Phosphorus	Total Nitrogen	Trace Metals	Bacteria
Dry Retention Pond	61[1]	19[1]	31[1]	40[1]	Insufficient Knowledge
Wet Detention Pond	67[1]	48[1]	31[1]	25[1]	65[1]
Exfiltration Trench	70[2]	50[2]	50[2]	70[2]	70[2]

[1]*United States Environmental Protection Agency*

[2]*SFWMD Best Management Practices for South Florida Urban Stormwater Management Systems, April 2002*

Section 5.0
Pollutant Load Reduction Model

A spreadsheet based model was created to evaluate the impact of the improvements proposed within the Jones and Sims Creek drainage areas. While the model provides an estimate as to what the effect of future actions may have on the pollutant load discharged to the Southwest Fork of the Loxahatchee River, additional water quality monitoring is highly recommended in order to more accurately locate the source(s) of pollutants. Based on additional water quality data, the Town could more accurately determine which BMPs may require maintenance or which areas are in need of additional BMPs. The developed model allows the Town to estimate the load reduction from these actions.

The model was created by separating the Jones and Sims Creek drainage areas into six sub drainage areas each (**Figure 5-1**). The total (untreated) loads originating from each sub basin were estimated by taking into account soil properties, land cover, land use, pollutant event mean concentrations (EMCs), and rainfall distribution. Areas permitted with either an Environmental Resource Permit (ERP) or Surface Water Management Permit (SWM) were then delineated (**Figure 5-2**) and based on the type of stormwater management provided (e.g. wet detention, swale, exfiltration trench, etc.), pollutant reductions were estimated. Cumulative loads originating from the entire drainage areas of Jones and Sims Creeks and the estimated nutrient reductions from existing BMPs are summarized below in **Table 5.1**.

Table 5.1
Existing Total Nutrient Loads and Load Reductions

Drainage Area	Annual TN (lb)	Annual TP (lb)
Sims Creek – Total Load	3,365	546
Sims Creek – Existing Load Reduction	604	98
Jones Creek – Total Load	5,926	961
Jones Creek – Existing Load Reduction	694	113

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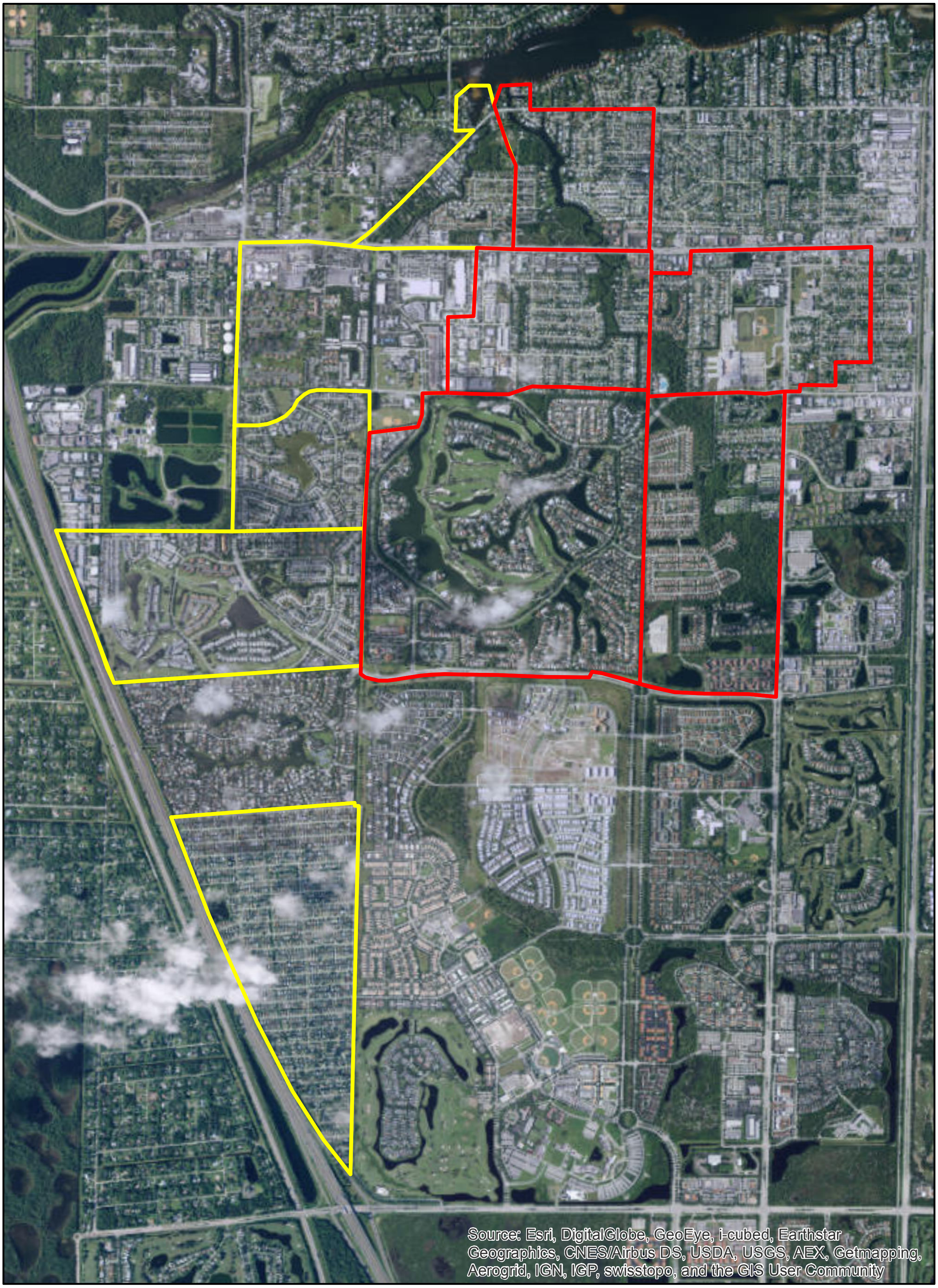

Figure 5-1 - Sub Basin Delineations

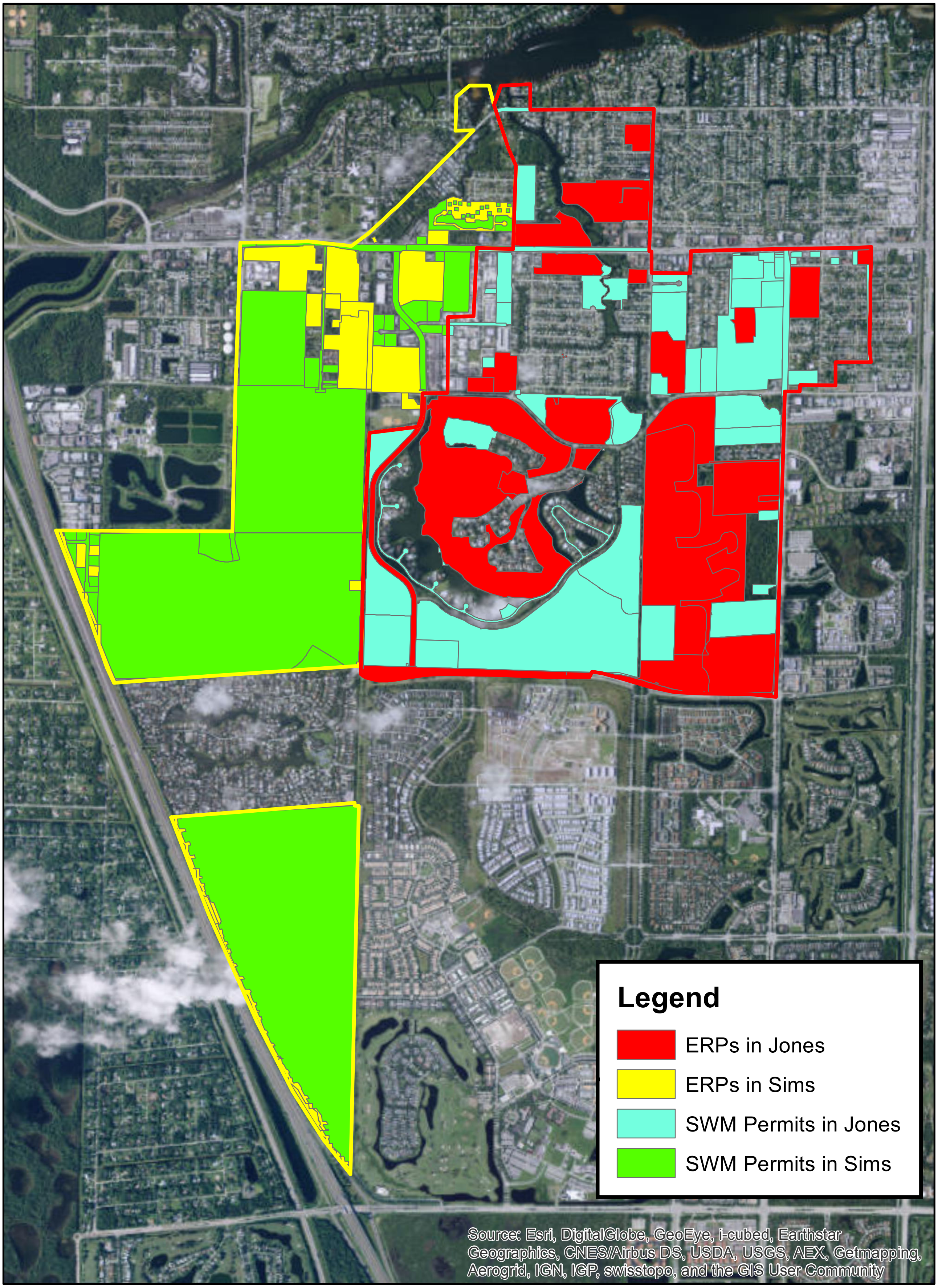

Figure 5-2 - Permitted Areas

While the model was used to determine the annual TN and TP load discharged to the Southwest Fork of the Loxahatchee River, the benefits of programmatic efforts were quantified on a case by case basis. For example, a reduction in fertilizer usage of 25% has no apparent disadvantages to the turf health or appearance in areas which use reclaimed water for irrigation [*Abacoa Reclaimed Water Fertilization Study*, 2015]. Based on the application rates throughout the 70 fertilized acres at the Loxahatchee Club Golf Course, a fertilizer reduction of 25% would result in an approximate reduction of 2,134 lbs of applied Nitrogen. The actual reduction within the Jones Creek would be significantly less after taking into account attenuation by the golf course turf.

Programmatic efforts such as increasing public awareness on the impacts of improperly managed pet waste and the installation of pet waste receptacles in appropriate locations within both drainage areas are expected to have a significant impact on the observed fecal coliform levels. The load of pet waste discarded in pet waste stations is significant, as quantified in a study where seven total stations were installed and a total of 1,826 lbs of pet waste were collected over a one year deployment [*Public Outreach and Stewardship Workplan*, 2014]. With a single gram of dog waste containing approximately 23 million fecal coliform bacteria, the potential reduction in observed fecal coliform levels is significant [*Van der Wel*, 1995]. While this indicates there are benefits associated with the implementation of pet waste receptacles, the corresponding impacts on water quality are difficult to model directly since many variables exist which affect the implemented action's effectiveness. Examples of these variables include the degree of public participation, spatiality of those who participate, and the level of attenuation of the fecal coliforms prior to being discharged to adjacent surface waters. Furthermore, while this particular study resulted in the collection of 1,826 lbs of waste, it is invalid to claim that a reduction of 1,826 lbs of waste within the drainage area resulted since a portion of the waste collected would have likely been discarded appropriately in the absence of the implemented receptacles. For these reasons, the results of these efforts were not modeled for the Jones and Sims Creek drainage areas but due to the low capital cost associated with the implementation of this measure it is recommended that the Town proceed with incorporating this into future actions in order to reduce the fecal coliform levels in both creeks.

While no specific structural improvements are recommended until more detailed water quality data are collected within the Jones and Sims Creek drainage areas, the pollutant reduction model evaluates the efficacy of many possible actions. Since the locations of potential future changes are variable and the magnitude of improvement could also vary, the model allows the user to input the location, level of BMP improvement, and the type of BMP being altered/improved. The model output provides the estimated annual reduction in pollutant load discharged to the Southwest Fork of the Loxahatchee River stemming from future actions after taking into account parameters such as land use, location, and anticipated BMP removal efficiencies.

Despite the variability in potential future actions, an example of the pollutant reduction model output follows. A scenario which included the construction of a littoral zone within the existing wet detention ponds located in Indian Creek was modeled and resulted in annual reductions of 73.8 lb TN and 23.94 lb TP being discharged to the Southwest Fork. This reduction corresponds to approximate reductions within the Sims Creek drainage area of 2.6% and 5.3% for TN and TP, respectively. This decrease in annual load was calculated using the estimated increase in pollutant removal efficiency and the drainage area impacted by the corresponding BMP. Similar analyses can be completed for any permitted area if alterations to existing BMPs are proposed. Additionally, the model provides the option for the user to specify characteristics of new BMPs to quantify their potential benefit.

Section 6.0
Cost and Labor Estimate for Proposed Actions

Based on the analysis of water quality data collected within Jones and Sims Creeks, a list of proposed actions has been developed to help assist the Town with improving the water quality in both creeks. Estimates of the capital cost and man-hours associated with these actions are provided below.

6.1 Pet Waste Receptacles in Areas with Significant Pet Traffic

Based on the elevated fecal coliform levels and their apparent relationship to rainfall, it is recommended that efforts be taken to reduce pet waste in the Jones and Sims Creek drainage areas. The solution which is likely the simplest to implement and may result in the greatest benefit is the installation of pet waste receptacles in public parks where the density of dogs is typically the highest. The cost estimate for the materials and time required for installing these receptacles is provided in **Table 6.1**.

Table 6.1
Cost Estimate for Pet Waste Receptacle Installation and Maintenance

Item	Price	Note
Pet Waste Receptacle	$199.00 per receptacle	Source: www.dogwastedepot.com
Installation	0.5 man-hours per receptacle	
Price per 400 Waste Bags	$59.00	Amount of bags required based on demand
Continuous Waste Pickup	0.25 man-hours per receptacle	At least one pickup per week required

The typical recommendations are that one receptacle be placed every 500 feet in park areas or one be installed for every 50 dogs that may pass the location daily [*www.zerowasteusa.com*]. It is recommended that these values be used as a guide when initially implementing these measures and be adjusted based on actual use. Fortunately, very few resources are required for the purchase and installation of the receptacles and therefore adjustments in the density and/or placement of receptacles can be easily made. If residential areas such as condos and apartments volunteer to implement similar measures, it is recommended to initially place one receptacle on the property for every

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fifty housing units and increase as needed based on actual demand (www.zerowasteusa.com).

6.2 Additional Water Quality Monitoring

Additional water quality monitoring is recommended for the primary purpose of more accurately identifying fecal coliform sources within the Jones and Sims Creek drainage areas. A secondary advantage of increased sampling is to evaluate the effectiveness of BMPs within the drainage areas (e.g. wet detention pond in Indian Creek discharging to the NPBHWCD Canal). Additional grab samples should be collected biweekly (or as frequently as possible if the resources for biweekly sampling are not available) at the locations depicted in **Figure 4-2**. Furthermore, storm event sampling should take place at these newly proposed locations, if the resources to do so are available.

The most cost effective solution would be to relocate datasondes currently owned and operated by LRD. This may easily be achieved if the datasondes are currently located in areas where collecting water quality data at a high frequency is not critical. If LRD datasondes are not available, it is recommended that the feasibility of purchasing additional instruments (approximately $12,000 per datasonde) be evaluated. The capital cost associated with additional datasondes for water quality monitoring extends past the purchase of the hardware. The analysis and processing of the data is time intensive and a recurring cost. Based on LRD input, it is estimated that 75% of one staff member's time is devoted to the management of ten monitoring locations. For this reason, it is recommended that relocation of existing datasondes be evaluated first with the purchase of additional datasondes being the alternative.

While the placement of datasondes in Jones and/or Sims Creeks would allow for the collection of data at a sufficiently high temporal resolution, the measured parameters would not allow for direct identification of fecal coliform sources. Therefore, the data collected from the proposed storm event/routine grab sample locations will assist in determining when and where the greatest fecal coliform load appears to be originating and can also be used to verify the TN and TP data collected by any datasondes installed within the creeks. These grab samples should at a minimum be collected from the two proposed sampling locations in the upstream reach of Jones Creek with a minimum of one sample being collected every other week. Samples should be collected during outgoing tide in an effort to collect the water originating from upstream. Fecal coliform samples were historically collected once every two months at the existing sampling locations on Indiantown Road and Center Street. It is recommended, if possible, to collect fecal coliform samples at these existing locations once every two weeks in order to have uniformity in sampling frequency within the dataset. However, if the resources are not available for collection and processing at this frequency, the preference would be to first collect samples from the two proposed Jones Creek locations and the existing sampling location in the downstream reach of Sims Creek.

Based on input from the Town and LRD, the collection and processing of water quality samples should be possible through a joint effort, with the Town collecting the samples and LRD processing the samples in their facilities. Since fecal coliform samples require a short hold time between collection and processing, LRD should be consulted prior to all sampling events to ensure there is sufficient time to process the samples in the LRD lab. It is requested that samples be collected on Monday or Tuesday since the LRD lab already processes bacteria samples on those days. Samples must be dropped off at the LRD lab (2500 Jupiter Park Drive) by 3 PM on the same day they are collected. Basic equipment such as bottles, gloves, and datasheets can be provided by LRD along with training of Town of Jupiter employees to ensure proper sampling technique. The additional materials needed by the Town of Jupiter for the sampling and an estimate of man-hours for the described sampling is provided in **Table 6.2**.

Table 6.2
Cost Estimates for Additional Sampling

Item	Estimated Cost
Sampling Pole	$150
Cooler for Sample Storage	$40
Ice for Sample Preservation	$5 Per Sample Event
Sample Collection and Delivery	0.5 Man-Hours Per Sample Location

6.3 Public Education and Awareness

A potentially significant improvement in water quality may be observed following actions to educate the public and increase their awareness of the current water quality issues in the Jones and Sims Creek drainage areas. While such actions have already been taken, these efforts have been broader in nature and did not focus solely on the residents within Jones and Sims Creeks. Educational materials should focus on ways to reduce nutrient (TN and TP) and fecal coliform levels in both creeks since these pollutants typically originate from human activities. It is recommended that a flyer be created and mailed to applicable residents which outlines the causes and effects of elevated nutrient and fecal coliform levels. Current regulations related to yard waste and fertilizer usage should be summarized since many residents are likely unaware that such laws are already in place. Simple infographics may also be helpful for communicating the current water quality issues being experienced in both creeks. Flyers should be distributed quarterly or made available on the Town website for at least one year while the proposed higher frequency sampling is occurring. The informational material on each flyer should typically stay the same, though it may be helpful if updated water quality data is communicated so residents can track any changes in water quality as the public outreach progresses. A cost estimate for the production and distribution of the proposed flyers is provided in **Table 6.3**.

Table 6.3
Cost Estimate for Production and Distribution of Informative Flyers

Item	Estimated Cost
Design of Informative Flyer	20 Man-Hours
Analyze New Fecal Coliform Data	6 Man-Hours Per Quarter
Update Flyer With New Water Quality Data	2 Man-Hours Per Quarter
Compile Addresses for Residences of Interest	4 Man-Hours
Flyer Printing and Mailing	$0.50 Per Household

While educational flyers may be the most direct method for educating the public, other methods such as web-based materials and lessons in local elementary schools may also prove to be beneficial. These actions should be taken depending on the resources available to the Town to complete such tasks. These actions are not recommended as the top priority due to the indirect method in which the information is conveyed and the reduced likelihood that the information would result in actions taken by homeowners throughout the drainage areas.

Section 7.0
Conclusions

Based on the evaluation of pollutant exceedances within Jones and Sims Creeks and the estimated sources of those pollutants a series of actions are recommended. These actions would assist the Town in remediating the current water quality issues within Jones and Sims Creeks as well as to help better identify the pollutant sources and the mechanisms which allow for the migration of pollutants into the creeks. The recommendations are as follows:

- Programmatic efforts aimed at reducing nutrient and fecal coliform levels in Jones and Sims Creeks should be executed prior to any other actions being taken. These efforts may result in significant improvements in water quality while only requiring minimal resources to implement. Examples of the recommended programmatic practices include placing signage requesting residents not feed the local wildlife, adding pet waste receptacles in public parks, encouraging residents to reduce their fertilizer application rate, and informing the public of the negative water quality impacts that yard waste can have if not properly disposed of. Additional public outreach and education can be achieved through educational programs at local elementary schools outlining the effects that human activities can have on local water quality. It is also important to notify residents that laws pertaining to fertilizer usage and yard waste already exist since many may be unaware. Specific attention should be paid to neighborhoods such as Jupiter River Estates, where a large number of residences are directly adjacent to the residential canals which extend from Jones Creek (with no buffer or BMPs to mitigate runoff impacts).

- Conduct water quality sampling timed specifically during large rainfall events to gain a better understanding of the effects runoff has on pollutant concentrations in each creek. Not only should samples be taken at the current sampling locations along Jones and Sims Creeks, but also at stormwater system outfalls (e.g. the outfall which discharges runoff from Indian Creek into Sims Creek). These samples could provide a better spatial understanding as to where the areas of greatest concern are located.

- Based on the results from the additional sampling, the effectiveness of existing BMPs should be evaluated. Based on that evaluation, a determination should be made as to whether the BMP type should be changed/enhanced or if maintenance is needed.

- Continue to communicate with property owners to convert the two properties located in the Sims Creek drainage area currently on septic over to sewer. This would likely decrease the fecal coliform levels in Sims Creek, as evidenced by a reduction in sucralose concentrations, by reducing the amount of human waste being discharged into the creek via groundwater.

- If all other proposed strategies prove to be ineffective at significantly improving water quality, a method for maintaining a more steady baseflow in each creek could be further evaluated. While this action carries the greatest cost relative to the rest of the strategies, it may be the only action, other than addressing the existing BMPs, which does not require community involvement to improve the water quality. This action would likely have a greater benefit for Jones Creek due to the failure to meet FDEP criteria for both DO and Chlorophyll α in the upstream reach.

An implementation plan which prioritizes the proposed actions based on their feasibility and the assumed cost to benefit ratio is provided in **Table 7.1**. The primary pollutants listed in the provided table are those which would be directly affected by the proposed action. The secondary pollutants are those which would likely be affected if the primary pollutant concentrations were changed.

Table 7.1
Implementation Plan for Jones and Sims Creek Drainage Areas

Priority Number	Description of Proposed Actions	Primary Targeted Pollutant	Secondary Pollutants	Comments
1	Educate the public about the potential negative impacts fertilizer, yard waste, and animal waste can have on the surrounding water quality. Focus primarily on those living adjacent to Jones Creek due to the lack of stormwater treatment prior to discharge to the creek.	TN, TP, and fecal bacteria	Chlorophyll α and DO	Programmatic solutions that would require very little time and capital by the Town. Potential for significant water quality improvement exists if there is a high level of participation by residents. These programmatic efforts could also be aided by educational programs at local elementary schools.
2	Perform additional water quality sampling.	All pollutants of concern	N/A	Action will help Town more accurately identify areas of concern and potentially justify actions which require more capital.

Table 7.1 (continued)
Implementation Plan for Jones and Sims Creek Drainage Areas

Priority Number	Description of Proposed Actions	Primary Targeted Pollutant	Secondary Pollutants	Comments
3	Communicate results of EW Consultants study which indicated a reduction in fertilizer usage of 25% is possible when irrigating with reclaimed water.	TN and TP	Chlorophyll α and DO	Golf course and Town would have mutual interest in reducing fertilizer application rates. Would be easy solution if a reduction in fertilizer usage is deemed as being appropriate.
4	If additional water quality testing indicates bird fecal bacteria may be an issue, place signs requesting that visitors not feed wildlife in public parks.	Fecal bacteria	TN and TP	Low cost solution that has no continuous cost associated with it. Water quality benefits may be minimal and not noticeable until after populations equilibrate to change in available food.
5	Convert the two remaining parcels on septic in Sims Creek drainage area to sewer.	Fecal bacteria, as evidenced by sucralose	TN and TP	These septic tanks appear to be a significant source of fecal bacteria as evidenced by sucralose based on available data.
6	Physical removal of aquatic vegetation.	Chlorophyll α	DO	Recurring cost associated with the action but removal of excess vegetation would reduce potential for DO depletion along with reduced clogging of system during high flow events.
7	Perform maintenance and evaluation of existing BMPs.	TN, TP, and fecal bacteria	Chlorophyll α and DO	Strategy should be formulated upon completion of additional water quality sampling.
8	Maintaining a constant baseflow within each creek.	Chlorophyll α and DO	N/A	Solution has high cost associated with it and may not be feasible due to freshwater classification in the NPBHWCD canal. Should only be examined if all other solutions fail to produce results.

Section 8.0
References

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