MIAMI WATERKEEPER®

Report to the City of Fort Lauderdale: Year 1 Weekly Water Monitoring

made possible with the support from

Contract # 10022020-MWK

TABLE OF CONTENTS

Executive Summary 1

Introduction 1

Water Quality Monitoring Summary Highlights 3

About this proposal 3

Weekly water sampling at ten high-value recreation sites 4

Swim Guide app development and City of Fort Lauderdale Banner Ad 10

Methods 11

Methods of Analysis 12

Results 12

Data Summary 12

Swim Guide Summary 15

Physical-Chemical Parameters 15

Analysis 21

Entire Period of Study 21

Wet Season vs. Dry Season Analysis 23

Conclusions 25

Fort Lauderdale Water Quality 25

Recommendations to improve water quality in Fort Lauderdale 27

Future Work 28

EXECUTIVE SUMMARY

On November 13, 2020, the City of Fort Lauderdale and Miami Waterkeeper entered into a contract with Miami Waterkeeper to provide weekly water quality monitoring at ten locations within the City. Sample collection began on January 12, 2021, and concluded on January 12, 2022. At the weekly sampling sites, samples for the analysis of the fecal indicator bacteria (FIB) enterococci were collected, along with parameters such as dissolved oxygen (DO), chlorophyll *a*, salinity, turbidity, and temperature. Sample collection, processing, and analyses were performed under protocols similar to that of the Florida Department of Health (DOH)'s Florida Healthy Beaches Program. The FDOH sets the threshold of FIB at 70 MPN for public recreation; levels greater than 70 MPN indicate possible risks to human health. Miami Waterkeeper collected samples from an exceeding site a second time in the same week, referred to as a "resample".

Informative data have been generated from the results of one year of monitoring in Fort Lauderdale, providing a baseline understanding of water quality in these valuable recreational waterways. There were 53 regular sample collection events for fecal indicator bacteria (FIB) enterococci at each of ten sites in Fort Lauderdale rivers, canals, and lakes where watersports and other recreational activities frequently occur. There were a total of 216 resamples taken for sites that exceeded 70 MPN in the initial weekly sampling; 139 of these resamples remained in exceedance. The four official City Designated Watersport Activity Area sites (Sunrise Bay at Hugh Taylor Birch State Park -- 3.8% exceedance, Lake Sylvia -- 9.4% exceedance, Sandbar at SE 10th Street -- 13.2% exceedance, and Middle River at George English Park -- 17.0% exceedance) had the best water quality, consistently meeting recreational water quality standards for FIB. Three sites consistently exceeded recreational water quality with high FIB levels: Sweeting Park (98.1% exceedance), Himmarshee Canal (88.7% exceedance), and Tarpon River (69.8% exceedance).

Miami Waterkeeper recommends continued or expanded monitoring of recreational water quality sites in the City of Ft. Lauderdale. We also recommend experimental designs aimed at source-tracking nutrient and bacteria contamination at the four "high exceedance" sites. We suggest adding signage at all water sampling sites.

INTRODUCTION

Visiting a beach or waterway is the number one activity of Florida's tourists, undeniably the biggest draw for the state's $112 billion in annual tourism revenue. Almost half a million people are directly employed in Florida's ocean economy. Florida's tourism industry, job market, recreation, environment, and even Florida's culture depends on having clean water.

Despite their importance, Florida's waterways are also particularly vulnerable to pollution

because of our low elevation, porous limestone geology, aging infrastructure, and the threat of sea-level rise. Without clean water, our ocean economy, job market, recreation, environment, and culture are all at risk. If we don't protect our water, we risk jeopardizing our coastal community and environment for all future generations.

Miami Waterkeeper defends the public's right to use and enjoy clean water by focusing on clean water for all, ecosystem protection, and sea-level rise readiness in South Florida. Our scope of work is diverse, centered on urgent water issues including clean water for all, ecosystem protection, and sea-level rise readiness in South Florida. Miami Waterkeeper's jurisdiction spans a watershed that serves more than 5 million people across Miami-Dade and Broward counties and encompasses the mid-section of the Florida Reef Tract. As part of our science and research platform, our water quality monitoring program samples 22 locations weekly in Miami-Dade and Broward Counties to determine the level of the fecal indicator bacteria (FIB) enterococci and the safety of the water for swimming or other activities and immediately shares the results with the public.

The recreational use of waterways is valuable to the Fort Lauderdale community; however, relatively little data about water quality was readily available to the residents or visitors who use it for that purpose. While the Florida Department of Health (DOH) monitors local beaches, the data is hard to find and focuses on beaches rather than inland waterways such as canals, rivers, or lakes. Miami Waterkeeper has addressed both of these gaps for the City's water quality data network over the last year through a contract with the City of Fort Lauderdale. Our weekly water quality monitoring program mirrors the DOH methodology and frequency for ten inland waterways for which publicly accessible water quality data is a necessity. This data, along with DOH data, are updated on the free Swim Guide application and website as soon as they are available.

Water quality issues can seriously impact the health of those who come into contact with recreational water. Sewage leaks have impacted the canals and rivers where residents and visitors enjoy kayaking, paddleboarding, canoeing, and other recreational watersports.

With information about water quality from the same locations taken over time, we can gather baseline data about conditions and also inform the public about changes in water quality. This report summarizes data collected during the first year of sampling ten sites weekly in the City of Fort Lauderdale. We are pleased to report that the project's goals were not only met, but exceeded.

WATER QUALITY MONITORING SUMMARY HIGHLIGHTS

- **746** total (including both regular samples and resamples) water quality samples collected and analyzed for FIB since January 12, 2021, along with dissolved oxygen, temperature, salinity, turbidity, and chlorophyll *a* measured at the site.
- **355** total FIB exceedances were reported.
  - **216** FIB exceedances resulted from weekly water quality sampling
  - **139** of resamples remained in exceedance of FIB
- Expanded Swim Guide to include new sites and highlight the City of Fort Lauderdale's Sponsorship
  - **11,626** total Swim Guide app views at the City of Fort Lauderdale sponsored locations.
  - At **1,444** views, Himmarshee Canal is the most frequently viewed Swim Guide location.

Four sites stood out as having excellent water quality based on the weekly sample analysis:

- Sunrise Bay Hugh Taylor Birch State Park (3.8% exceedance)
- Lake Sylvia (9.4% exceedance)
- Sandbar at SE 10th Street (13.2% exceedance)
- Middle River George English Park (17.0% exceedance)

These four sites are the official City Designated Watersport Activity Areas.

Three sites stood out as having consistently poor water quality based on the weekly sample analysis:

- New River North Fork at Sweeting Park (98.1% exceedance)
- Himmarshee Canal (88.7% exceedance)
- Tarpon River at Rio Vista Boulevard (69.8% exceedance)

Water quality challenges in these areas warrant further investigation.

ABOUT THIS PROPOSAL

The City of Fort Lauderdale contracted with Miami Waterkeeper on November 13, 2020 to initiate water monitoring at 10 locations, focusing on areas of high recreational value. Sample collection began January 12, 2021. This contract concluded on January 12, 2022.

The aims of the contract were to:

- Provide weekly water quality monitoring at ten City of Fort Lauderdale sites through January 12, 2022

- Provide a baseline understanding of fecal indicator bacteria (FIB) in local waterways
- Inform the local community about water quality issues via the Swim Guide app, web platforms, and social media

Per our original proposal, we conducted the following water quality monitoring tasks:

1. Weekly water sampling at ten high-value recreation sites

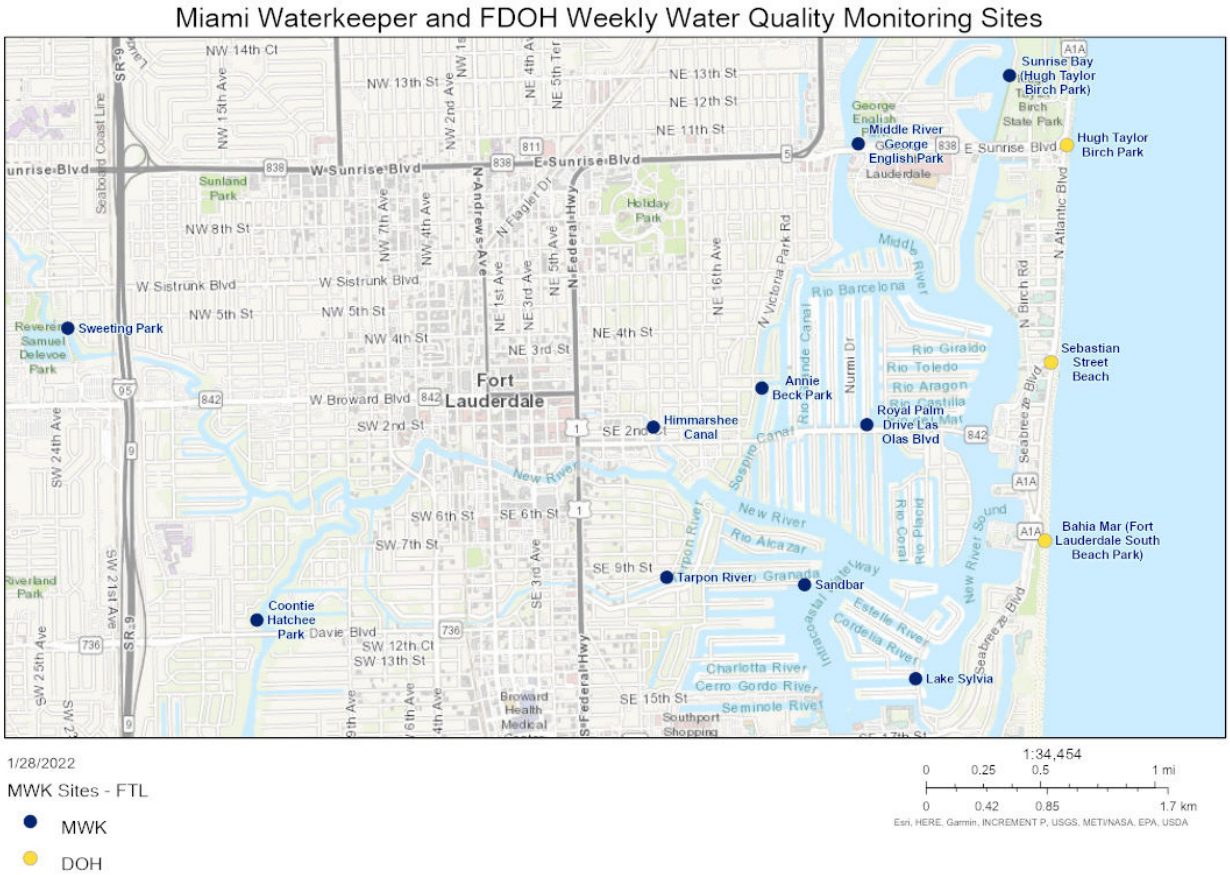

Figure 1. Miami Waterkeeper (blue) and FDOH (yellow) weekly water quality monitoring sites.

Site Locations:

Ten recreational locations in the City of Fort Lauderdale were selected in coordination with the Department of Public Works (Figure 1). These included:

- The canal at Annie Beck Park
- Himmarshee Canal
- Lake Sylvia
- Middle River at George English Park
- New River North Fork at Sweeting Park
- New River South Fork at Coontie Hatchee Park
- The canal at Royal Palm Drive and Las Olas Boulevard
- The Sandbar at SE 10th Street
- Sunrise Bay at Hugh Taylor Birch State Park
- Tarpon River

Site Descriptions:

From our data, we have been able to develop some insights about the ten recreational sites in our study. If monitoring continues, we can measure changes to water quality results, including improvements from the City's actions or possible hot spots.

Annie Beck Park is approximately 2.4 acres and is located in the Victoria Park neighborhood. It is located next to the Rio Navarro canal. It offers amenities such as nature trails, open areas, and a waterfront suitable for kayak launching. Slow flow, organic film/biofilm on the surface of the water, and floating leaves and vegetation are frequently noted at this site.

Annie Beck Park

Himmarshee Canal was a tributary of the New River, historically a major artery in and out of the Everglades. The word translates to "new water" or "new river." The Himmarshee Canal now starts near US1/Federal Highway and traverses the neighborhoods of Colee Hammock and Beverly Heights as it flows under Las Olas Blvd and out to the New River. Floating vegetation, foam/organic film on the surface of the water, and slow flow are frequently noted at this site.

Himmarshee Canal

Lake Sylvia is designated by the City of Fort Lauderdale as a Watersports Activity Area suitable for water skiing, tubing, kneeboarding, and wakeboarding. Lake Sylvia is within the Harbor Beach neighborhood.

Lake Sylvia

Middle River at George English Park is designated by the City of Fort Lauderdale as a Watersports Activity Area suitable for water skiing, tubing, kneeboarding, and wakeboarding. George English Park is approximately 19.7 acres and offers such amenities as kayaking, paddleboarding, fishing, boat access/ramp, and walking/jogging trails.

Middle River at George English Park

New River North Fork at Sweeting Park is approximately 0.3 acres along the North Fork of the New River and has amenities such as fishing, a dock, and park benches. Sweeting Park had the highest mean enterococci. Regardless of the season, this site almost always exceeds the DOH standard of 70 MPN. The site has slow-moving water, low water levels, a muddy bottom/shoreline, and large amounts of vegetation. It also frequently has biofilm or other organic material on the surface. Trash and plastic is very frequently found at the site, along with occasional dead iguanas.

New River North Fork at Sweeting Park

New River South Fork at Coontie Hatchee Park is approximately 2.6 acres along the South Fork of the New River and has amenities such as a kayak/canoe launch, waterfront views, bicycle racks, fitness trail with stations, picnic tables, and pavilions. Foam on the surface of the water, floating vegetation, and some trash are noted at this site.

New River South Fork at Coontie Hatchee Park

Royal Palm Drive at Las Olas Boulevard is located within the Nurmi Isles neighborhood north of Las Olas Blvd. A smell is noted at this site, but it is inconsistent.

Royal Palm Drive at Las Olas Boulevard

The Sandbar at SE 10th Street is designated by the City of Fort Lauderdale as a Watersports Activity Area suitable for water skiing, tubing, kneeboarding, and wakeboarding. It is also a popular area for boaters to moor and enjoy the water.

Sandbar at SE 10th Street

Sunrise Bay at Hugh Taylor Birch State Park is designated by the City of Fort Lauderdale as a Watersports Activity Area suitable for water skiing, tubing, kneeboarding, and wakeboarding. Sunrise Bay is within the Coral Ridge neighborhood and is adjacent to Hugh Taylor Birch State Park. Hugh Taylor Birch is the city's own "Central Park," complete with gopher tortoises and boat access from the Intracoastal waterway.

Sunrise Bay at Hugh Taylor Birch State Park

Tarpon River at Rio Vista Boulevard The Tarpon River intersects with the New River at two locations, SW 8th Ave and Ponce De Leon Drive. The Tarpon River traverses the neighborhoods of Tarpon River, Downtown Fort Lauderdale, and Rio Vista. Along the way, at SW 11th Street, is the Tarpon Cove Park, which has amenities such as fishing and water frontage. Floating vegetation, brown water, foam/biofilm on the surface, and construction has been noted at this site.

Tarpon River at Rio Vista Boulevard

2. Swim Guide app development and City of Fort Lauderdale Banner Ad

We publish our weekly water quality testing information along with the water quality testing information produced by the state DOH for Broward County beaches via the Swim Guide Application, our social media channels, and our website www.miamiwaterkeeper.org/water_monitoring. Numeric data are also available for the public to download from our website.

The Swim Guide app is available on both web and mobile devices. The app had 11,626 views from January 12, 2021, to January 12, 2022, at the City of Fort Lauderdale-sponsored sites. The app utilizes an easy-to-read "stoplight" format, with green indicating good water quality (0-70 CFU/MPN enterococci per 100 mL sample) and red indicating poor water quality (71+ CFU/MPN enterococci per 100 mL sample). Historical data is also accessible. All of our weekly monitoring sites and the most recent results are available to the public for easy access.

With the sponsorship of recreational sites, a banner ad is included on the Swim Guide pages of the funded sites, indicating the city, village, or entity that sponsors sample collection and analysis. The City of Fort Lauderdale's banner ads have been featured on the pages for all ten Fort Lauderdale sites since January 2021.

Additional Monitoring Locations:

Overall, Miami Waterkeeper is currently sampling 22 locations in Miami-Dade and Broward weekly, with support from the Frohring Foundation, the Environmental Protection Agency (EPA), the Village of Key Biscayne, Batchelor Foundation, and Bass Pro Shops, in addition to the City of Fort Lauderdale.

On June 14, 2021, during the period of study in the watersheds of Fort Lauderdale, we also began an EPA-funded study of levels of nutrients, nitrate isotopes, and molecular source tracking of FIB at all of our regular Miami-Dade County sites and at ten locations with inland waterways in northern Biscayne Bay. These additional sampling locations provide the context within which the Fort Lauderdale water quality data can be placed.

METHODS

Our proposal implemented our fecal indicator bacteria (FIB) monitoring program to include ten sites in rivers, canals, and lakes of high recreational value in the City of Fort Lauderdale. Sample collection was on a weekly basis, along with a follow-up resampling and reanalysis when the recreational water quality threshold of 70 MPN for recreational water use, set by the State of Florida, based on the recommendations of the EPA, is exceeded. We used the IDEXX system for weekly routine sampling collection and enumeration of the FIB enterococci present in water quality samples. The IDEXX system only presents results as whole numbers. Prior to collecting samples, precautions are taken to ensure that sampling bottles are sterile. This includes the use of an autoclave to sanitize the bottles of any bacteria or impurities with heat and pressure. Gloves are used at all times when handling the samples so they do not become contaminated with bacteria. Samples are collected at approximately 6-12 inches below the surface to best capture conditions where recreational activities take place. The samples were collected without making contact with the bottom or stirring up sediment. Samples were collected facing the oncoming current, so as not to contaminate the sample with the sample collector's bacteria or sediment put into suspension.

Our sample collection, processing, and analysis protocols are based on the EPA Method 1600 protocol and the Florida Department of Health (DOH) standards for enterococci. Our field technicians include part-time staff or interns from local universities who are trained in the collection of field samples, sample processing, and laboratory analyses. Field and laboratory technicians are both audited in the first month of independent sampling. After the initial audit, they are then audited (observed by a full-time staff member) again every six months.

- 0-70 MPN/CFU enterococci per 100 mL sample: Below threshold. Considered within the allowable limit. Safe for swimming. "Green"
- 71+ MPN/CFU enterococci per 100 mL sample: Exceedance. Considered not safe for swimming; resample necessary. "Red"

Quality Control: With each analytical batch, a sample selected at random is collected and analyzed in duplicate. Every batch also includes a blank, which is analyzed to evaluate aseptic technique, sanitation practices of the laboratory, and the sterility of laboratory equipment.

We also collected water quality data on environmental conditions at the time of sample collection, such as weather, tide, temperature, and rainfall. Our field technicians make weather observations on site, determining whether conditions at the time of sample collections are sunny, cloudy, or rainy; we also determine the direction of the current (right to left, left to right, straight toward, or still). Our wind speed and air temperature data are taken from the

NavClock app, which pulls from NOAA weather sites. Rainfall and tide are taken from the NOAA NCEI database.

Miami Waterkeeper used two YSI EXO1 devices to monitor physical-chemical conditions, including dissolved oxygen, temperature, turbidity, salinity, and chlorophyll a. YSI data are taken as close to the depth for sampling as possible (6-12 inches below the surface, in the middle of the water column). Calibrations are performed every six months.

Methods for Analysis

Three sets of analyses were performed. The first set was an evaluation of the entire period of study. Means for the ten Fort Lauderdale sites were determined. From the ANOVA, linear regression was performed from the period of the contract with the City of Fort Lauderdale. A model was built using multiple regression. This same process was repeated for the wet season analysis and the dry season analysis. The third set of analyses was a comparison, using MANOVA, of the wet season data versus the dry season data.

RESULTS

Data Summary

Site	MPN (number of observations) Std Deviation	Water Temperature C (number of observations) Std Deviation	DO% (number of observations) Std Deviation	DO mg/L (number of observations) Std Deviation	Salinity ppt (number of observations) Std Deviation	Turbidity NTU (number of observations) Std Deviation	Chl a ug/L (number of observations) Std Deviation	Chl RFU (number of observations) Std Deviation
Annie Beck Park	173 (53) 495.75	27.45 (53) 3.05	81.03 (53) 9.02	5.66 (53) 0.64	22.47 (53) 5.95	1.60 (53) 1.45	1.23 (53) 0.76	0.31 (53) 0.19
Coontie Hatchee Park	75 (53) 64.24	27.08 (52) 3.18	68.50 (52) 3.18	5.18 (52) 0.91	11.60 (52) 7.76	2.51 (52) 5.80	3.07 (52) 1.51	0.77 (52) 0.38
Himmarshee Canal	355 (53) 636.56	26.85 (53) 3.08	64.64 (53) 11.93	4.69 (53) 0.89	17.58 (53) 7.37	1.40 (53) 1.08	1.87 (53) 1.10	0.46 (53) 0.28
Lake Sylvia	26 (53) 47.83	27.09 (53) 3.19	92.06 (53) 6.61	6.19 (53) 0.52	30.74 (53) 3.96	1.55 (53) 1.39	0.32 (53) 0.68	0.08 (53) 0.17
Middle River George English Park	46 (53) 79.78	27.24 (53) 3.25	82.16 (53) 8.59	5.76 (53) 0.67	22.39 (53) 6.80	1.17 (53) 0.75	1.33 (53) 1.26	0.34 (53) 0.31
Royal Palm Drive Las Olas	78 (53) 171.22	27.20 (52) 3.03	81.12 (52) 8.57	5.60 (52) 0.67	25.45 (52) 5.51	1.24 (52) 0.65	1.01 (52) 0.84	0.25 (52) 0.21
Sandbar	41 (53) 66.46	27.17 (53) 2.99	98.97 (53) 10.48	6.67 (53) 0.67	29.18 (53) 4.47	1.80 (53) 3.64	0.66 (53) 1.05	0.17 (53) 0.26
Sunrise Bay Hugh Taylor Birch State Park	32 (53) 103.26	26.99 (52) 3.12	83.46 (52) 9.78	5.75 (52) 0.76	26.47 (52) 4.65	1.10 (52) 0.80	1.12 (52) 1.14	0.28 (52) 0.28
Sweeting Park	707 (53) 1605.52	26.76 (52) 3.00	63.74 (52) 21.93	5.09 (52) 1.56	4.56 (52) 4.66	5.84 (52) 23.41	10.90 (52) 7.01	2.74 (52) 1.73
Tarpon River	452 (53) 1314.73	27.09 (52) 3.28	71.53 (52) 17.21	5.23 (52) 1.01	17.87 (52) 7.53	7.36 (52) 18.11	2.50 (52) 1.30	0.64 (52) 0.32

Table 1. A summary of FIB enterococci values and physical-chemical parameters that were collected with the YSI EXO1.

After the first year (January 12, 2021-January 12, 2022):

- 746 total samples, revealing 355 total exceedances (47.6% of samples exceeded recreational water thresholds)
- 530 samples were a part of weekly monitoring
- 216 samples were resampling of sites that exceeded 70 MPN in the initial weekly sampling; of these, 139 remained in exceedance

Site	Total Samples	Total Exceedances	Overall Exceedance Percentage	Total Weekly Samples	Weekly Exceedances	Weekly Percent Exceedance	Total Resamples	Resample Exceedance	Resample Exceedance Percentage
New River North Fork at Sweeting Park	105	99	94.3%	53	52	98.1%	52	47	90.4%
Himmarshee Canal	100	85	85.0%	53	47	88.7%	47	38	80.9%
Tarpon River at Rio Vista Boulevard	90	64	71.1%	53	37	69.8%	37	27	73.0%
Annie Beck Park	75	37	49.3%	53	22	41.5%	22	15	68.2%
New River South Fork at Coontie Hatchee Park	77	33	42.9%	53	24	45.3%	24	9	37.5%
Royal Palm Drive and Las Olas Boulevard	64	13	20.3%	53	11	20.8%	11	2	18.2%
Middle River at George English Park	62	9	14.5%	53	9	17.0%	9	0	0.0%
Sandbar at SE 10th Street	60	7	11.7%	53	7	13.2%	7	0	0.0%
Lake Sylvia	58	6	10.3%	53	5	9.4%	5	1	20.0%
Sunrise Bay at Hugh Taylor Birch State Park	55	2	3.6%	53	2	3.8%	2	0	0.0%

Table 2. Summary of FIB enterococci data for all samples, weekly samples, and resamples collected between January 12, 2021, and January 12, 2022. Ranked by exceedance.

With the support of the City, we have been able to increase our understanding of the extent of water pollution in the waterways of Fort Lauderdale and evaluate its impacts on recreation opportunities in the area. Three key areas of poor water quality have been identified: Sweeting Park, Himmarshee Canal, and Tarpon River. A baseline of water quality conditions in the waterways of the City can be determined from this dataset.

As seen in Figures 2 and 3, Lake Sylvia and Sunrise Bay had some of the lowest mean enterococci MPNs through the period of study. During the dry season, Middle River George English Park (35 MPN, standard deviation 60.83), and Lake Sylvia (35 MPN, standard deviation 63.51) had the lowest mean enterococci MPN. Himmarshee Canal (489 MPN, standard deviation 863.54), Tarpon River (671 MPN, standard deviation 1790.23), and Sweeting Park (751 MPN, standard deviation 1830.98), had the highest mean enterococci MPN during the dry season. In the wet season, Sunrise Bay (15 MPN, standard deviation 12.45), Lake Sylvia (17 MPN, standard deviation 19.44), Sandbar (24 MPN, standard deviation 29.35), and Royal Palm Drive Las Olas (26 MPN, standard deviation 30.53) had the lowest mean enterococci MPN. The sites with the highest mean enterococci MPN in the wet season were Himmarshee Canal (215 MPN, standard deviation 165.65), Tarpon River (224 MPN, standard deviation 395.31), Annie Beck Park (252 MPN, standard deviation 687.96), and Sweeting Park (661 MPN, standard deviation 1367.75).

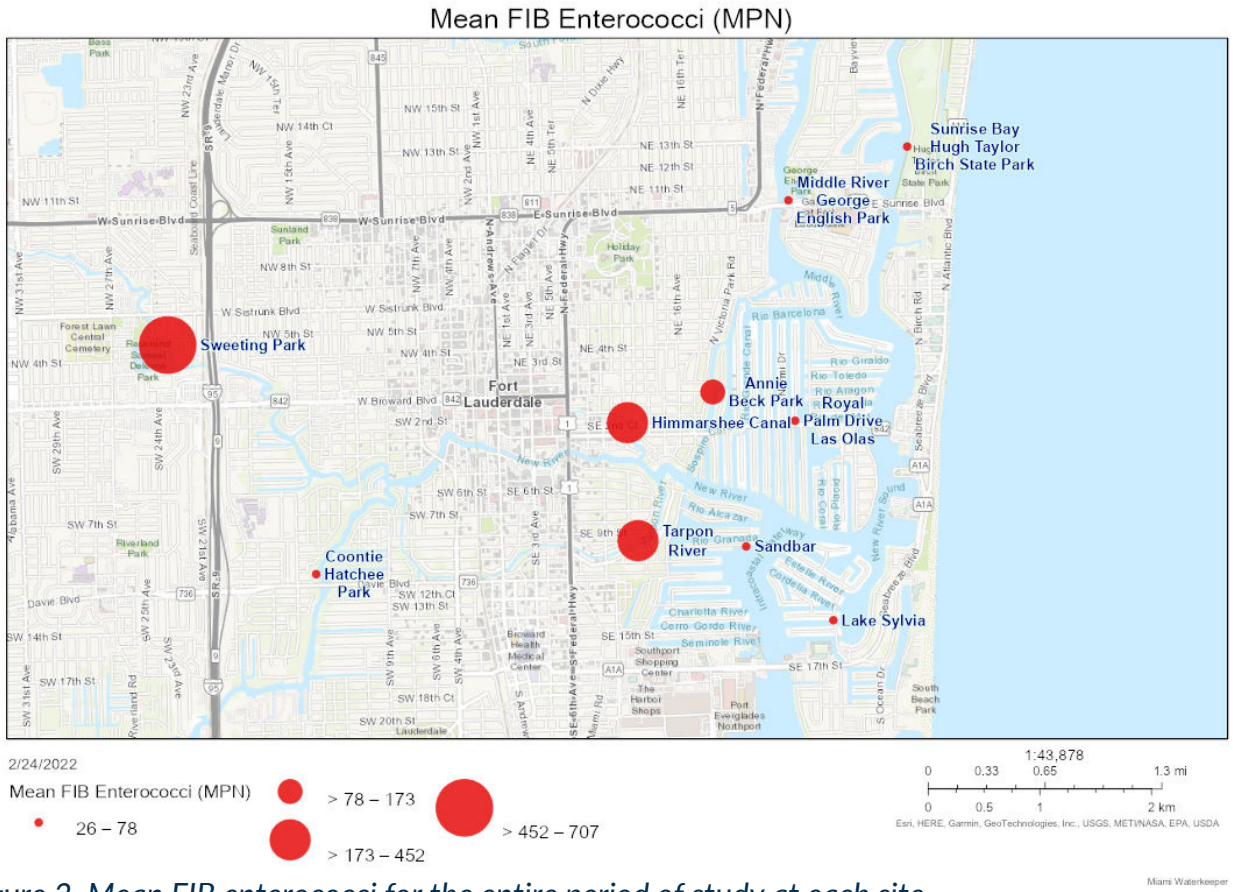

Figure 2. Mean FIB enterococci for the entire period of study at each site.

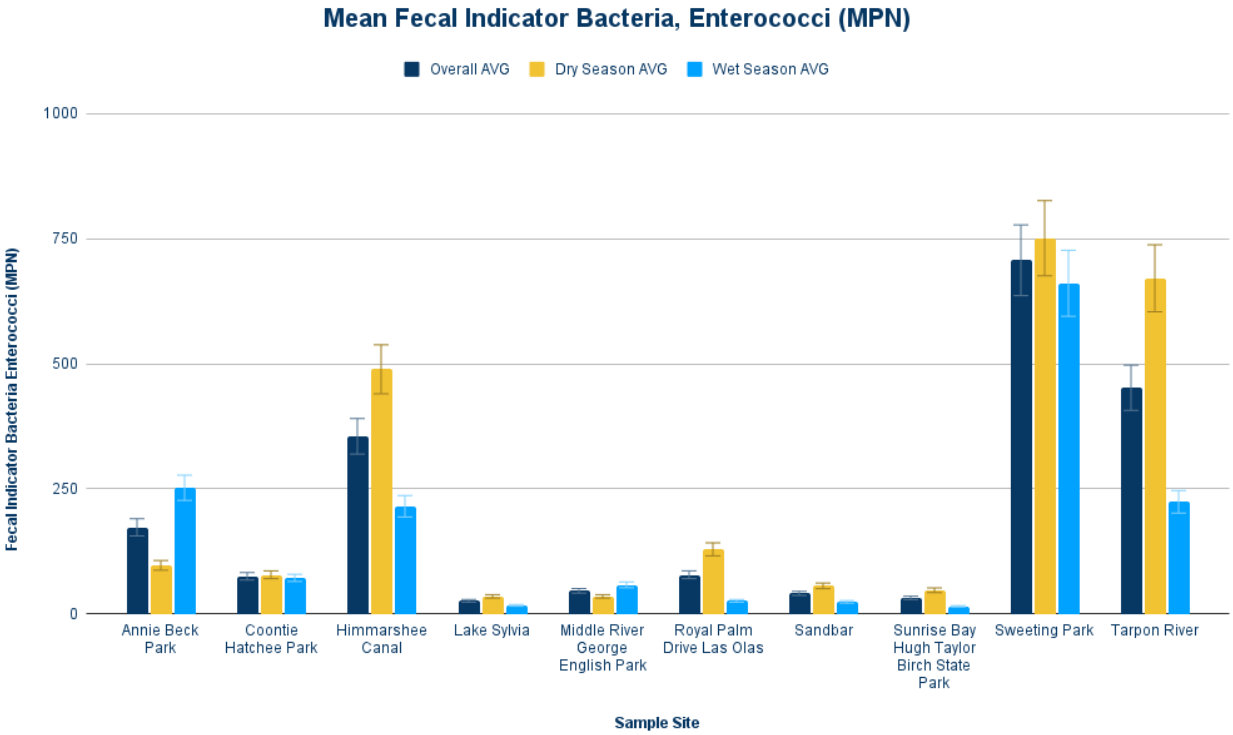

Figure 3. Mean enterococci MPN for all Fort Lauderdale sites, January 12, 2021 - January 12, 2022.

Swim Guide Summary

On Swim Guide, we received many visits for the data on the ten recreational sites, indicating high public interest in the results (Table 3).

Site	Mobile Phone Visits	Internet Visits	Total Visits
Annie Beck Park	241	1,050	1,291
Himmarshee Canal	325	1,119	1,444
Lake Sylvia	147	1,217	1,364
Middle River at George English Park	155	875	1,030
New River North Fork at Sweeting Park	357	636	993
New River South Fork at Coontie Hatchee Park	280	696	976
Royal Palm Drive and Las Olas Boulevard	123	744	867
Sandbar at SE 10th Street	366	985	1,351
Sunrise Bay at Hugh Taylor Birch State Park	112	817	929
Tarpon River at Rio Vista Boulevard	385	996	1,381

Table 3. Summary of Swim Guide visits to each individual sample site.

Physical-Chemical Parameters

Parameters collected include DO%, DO mg/L, turbidity, chlorophyll *a* RFU, chlorophyll *a* ug/L, water temperature, and salinity. See Figures 4-13 for mean chlorophyll *a*, dissolved oxygen, salinity, water temperature, and turbidity concentrations at all of the sites. It is important to note that some sites had fewer observations for physical-chemical parameters due to technical difficulties or physical obstacles that prevented data recording.

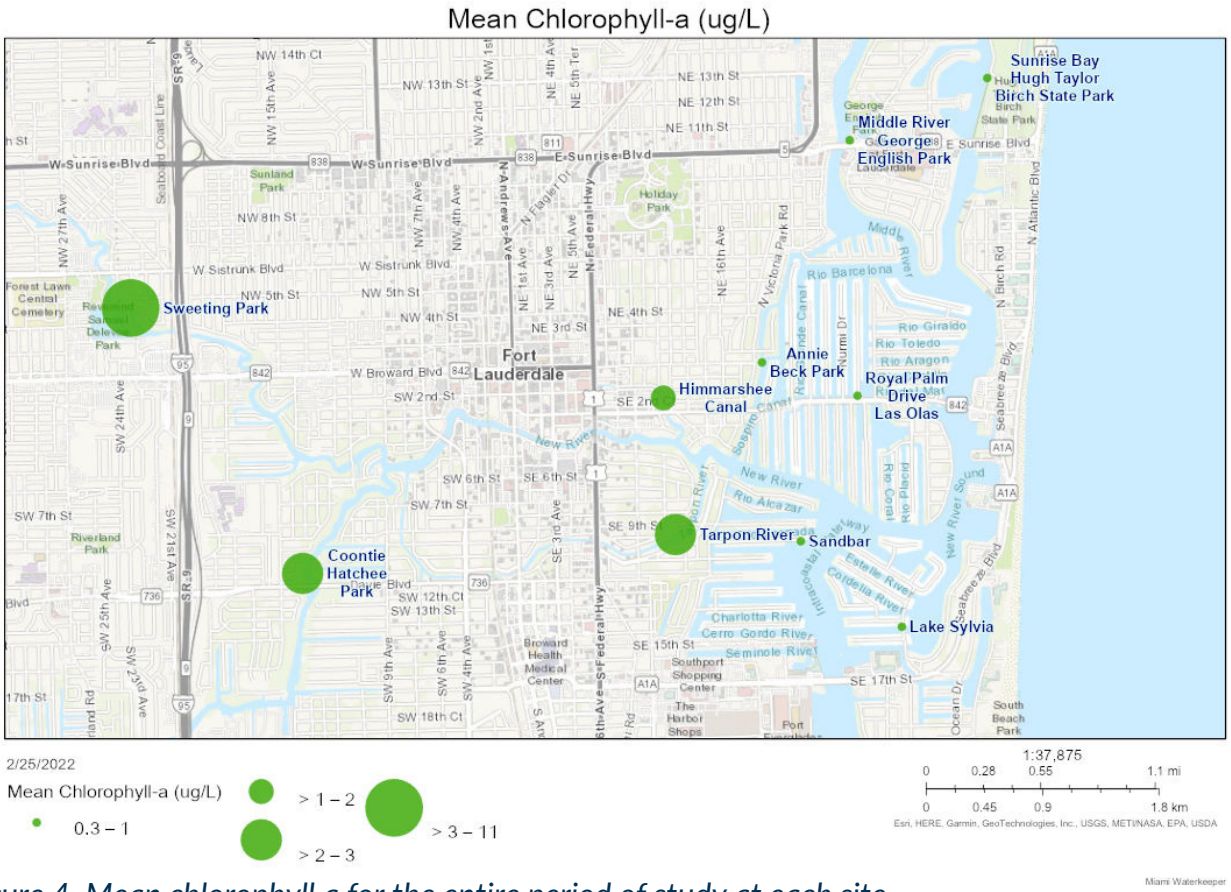

Figure 4. Mean chlorophyll a for the entire period of study at each site.

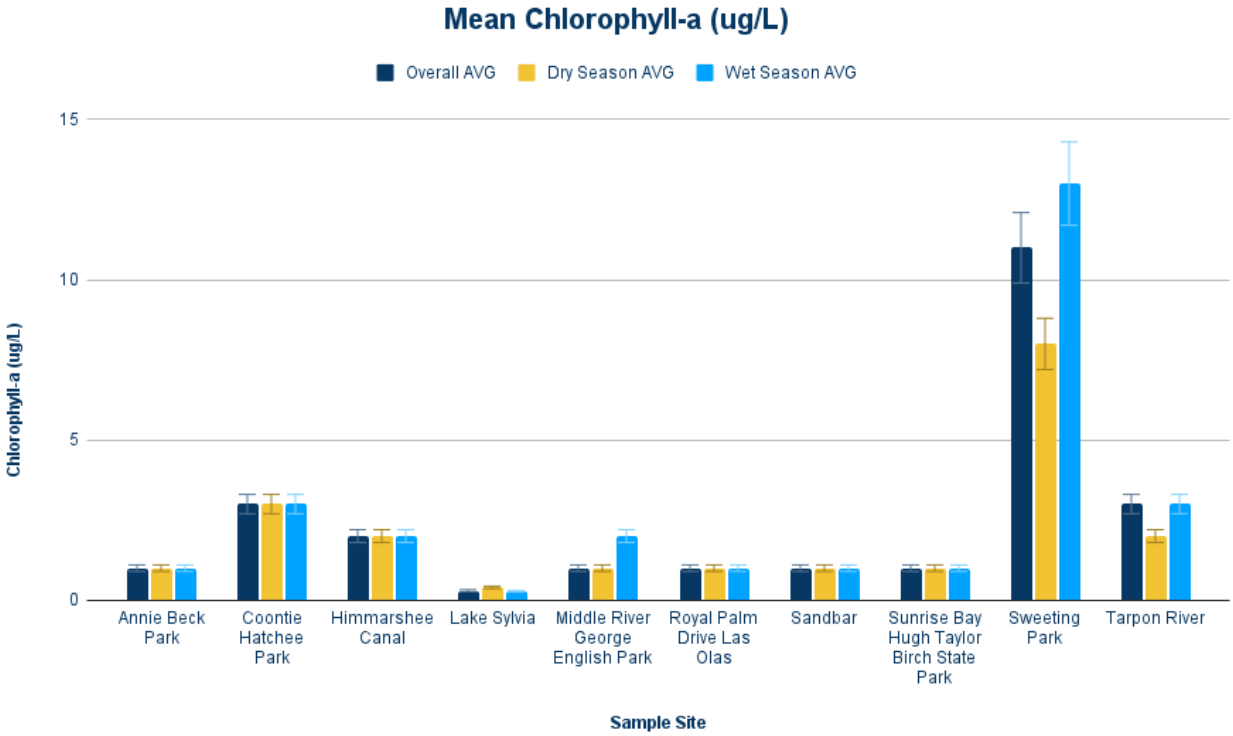

Figure 5. Mean chlorophyll a for all Fort Lauderdale sites, January 12, 2021 - January 12, 2022.

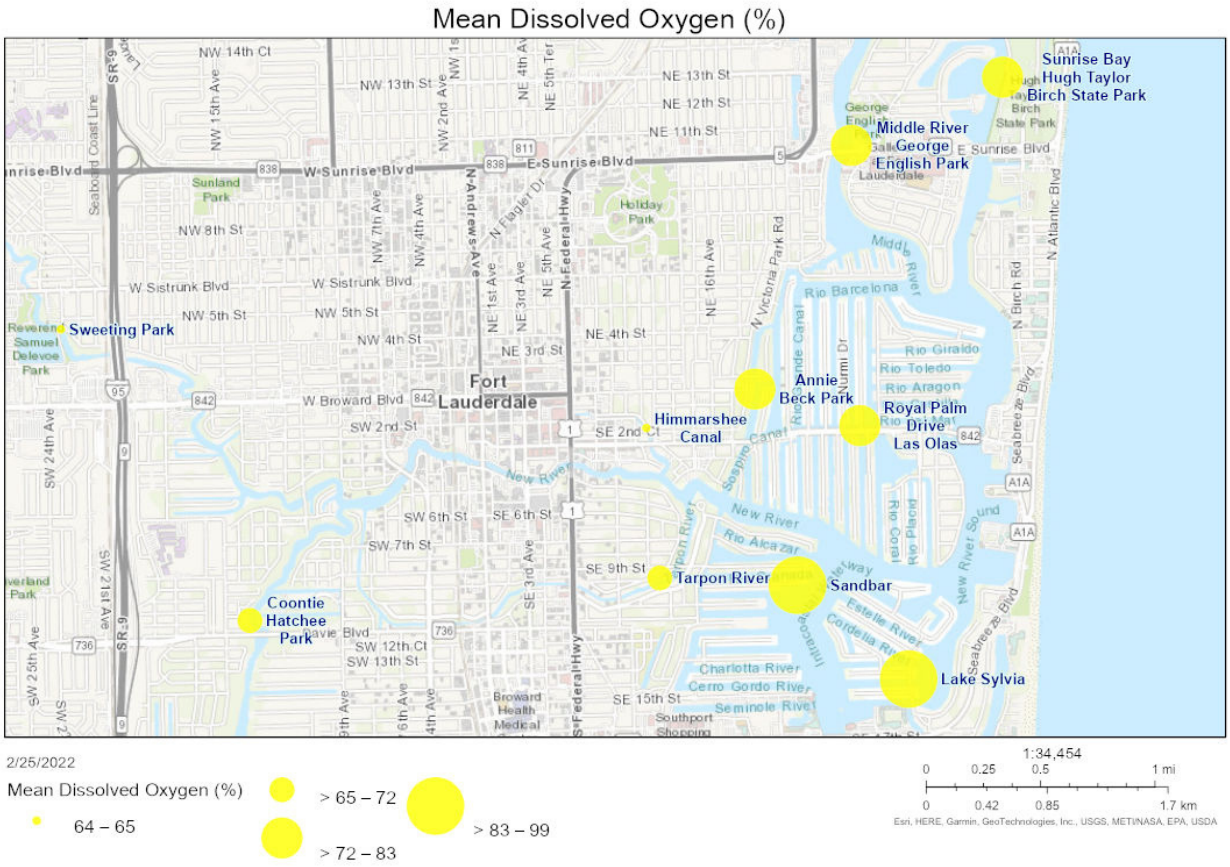

Figure 6. Mean dissolved oxygen measurements for the entire period of study at each site.

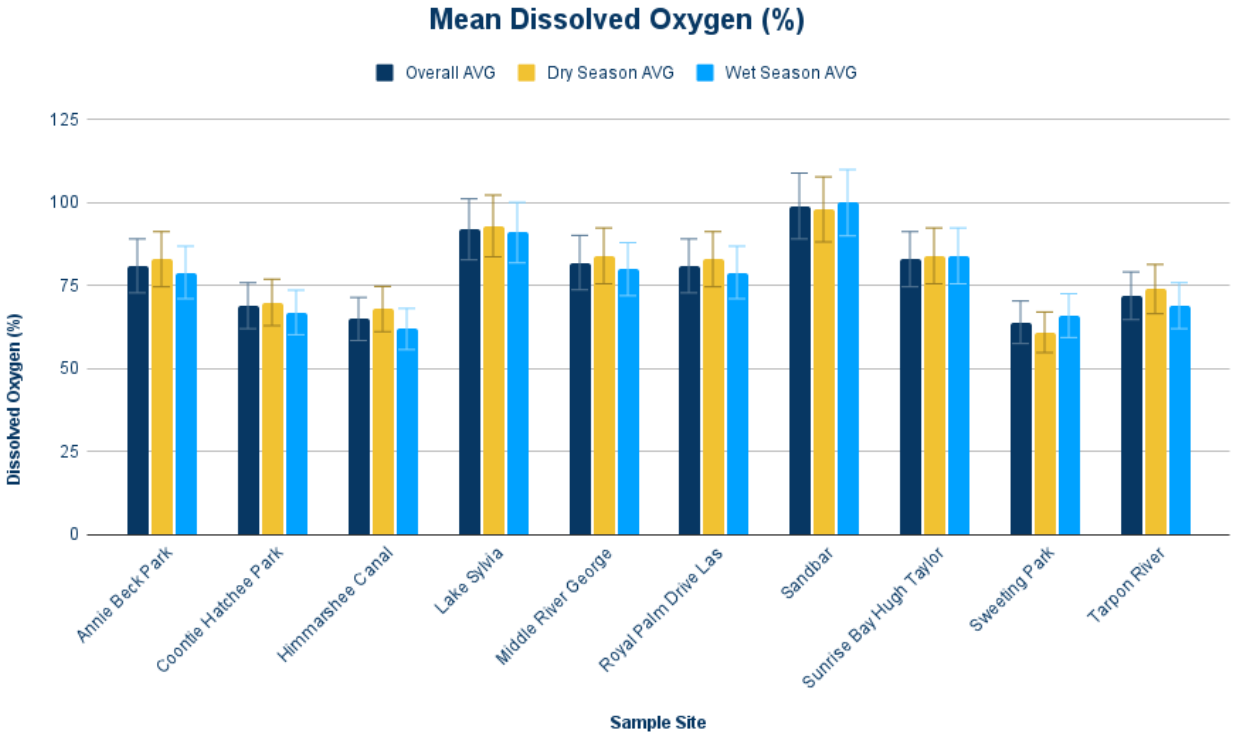

Figure 7. Mean DO for all Fort Lauderdale sites, January 12, 2021 - January 12, 2022.

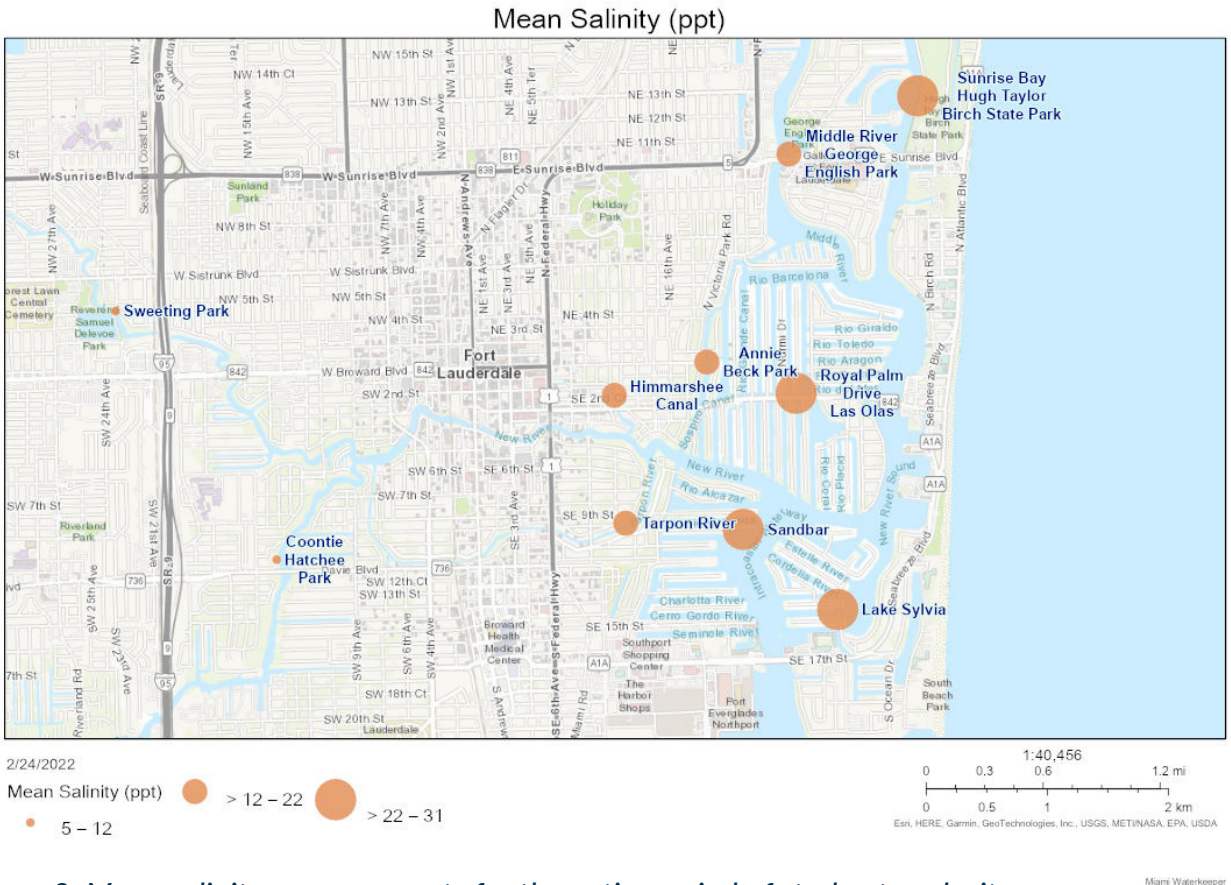

Figure 8. Mean salinity measurements for the entire period of study at each site.

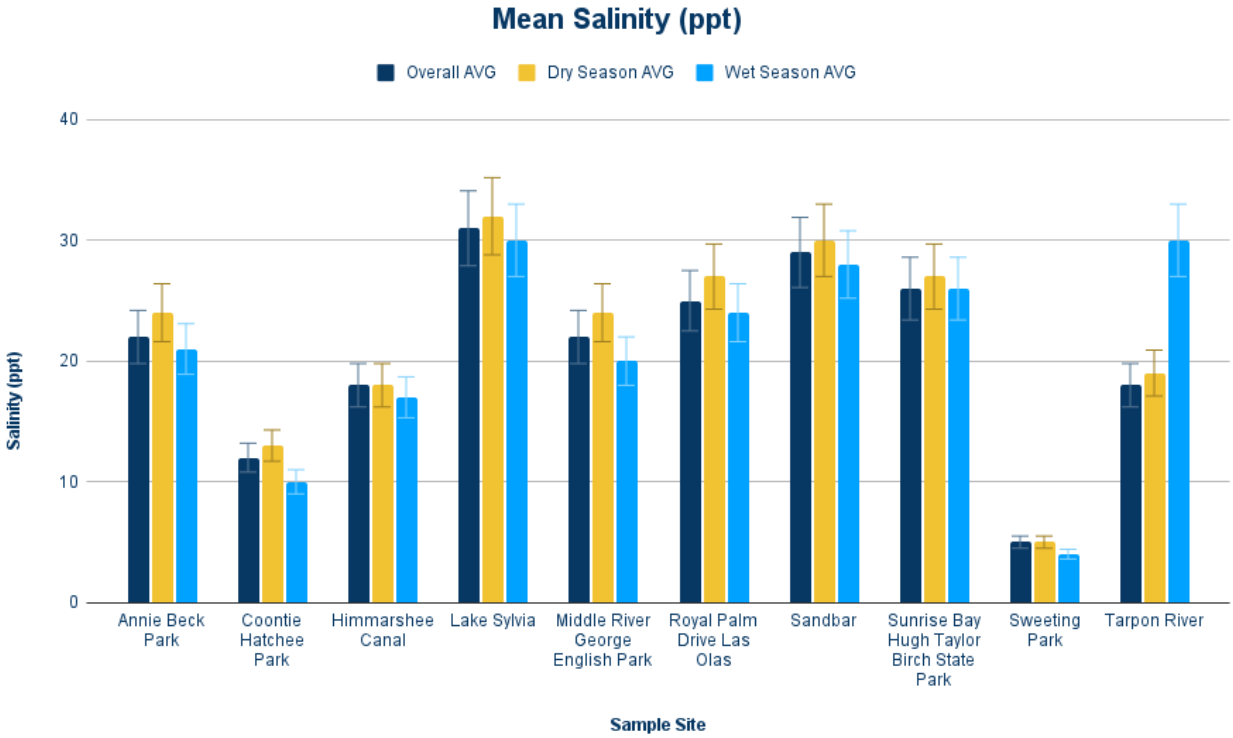

Figure 9. Mean salinity for all Fort Lauderdale sites, January 12, 2021 - January 12, 2022.

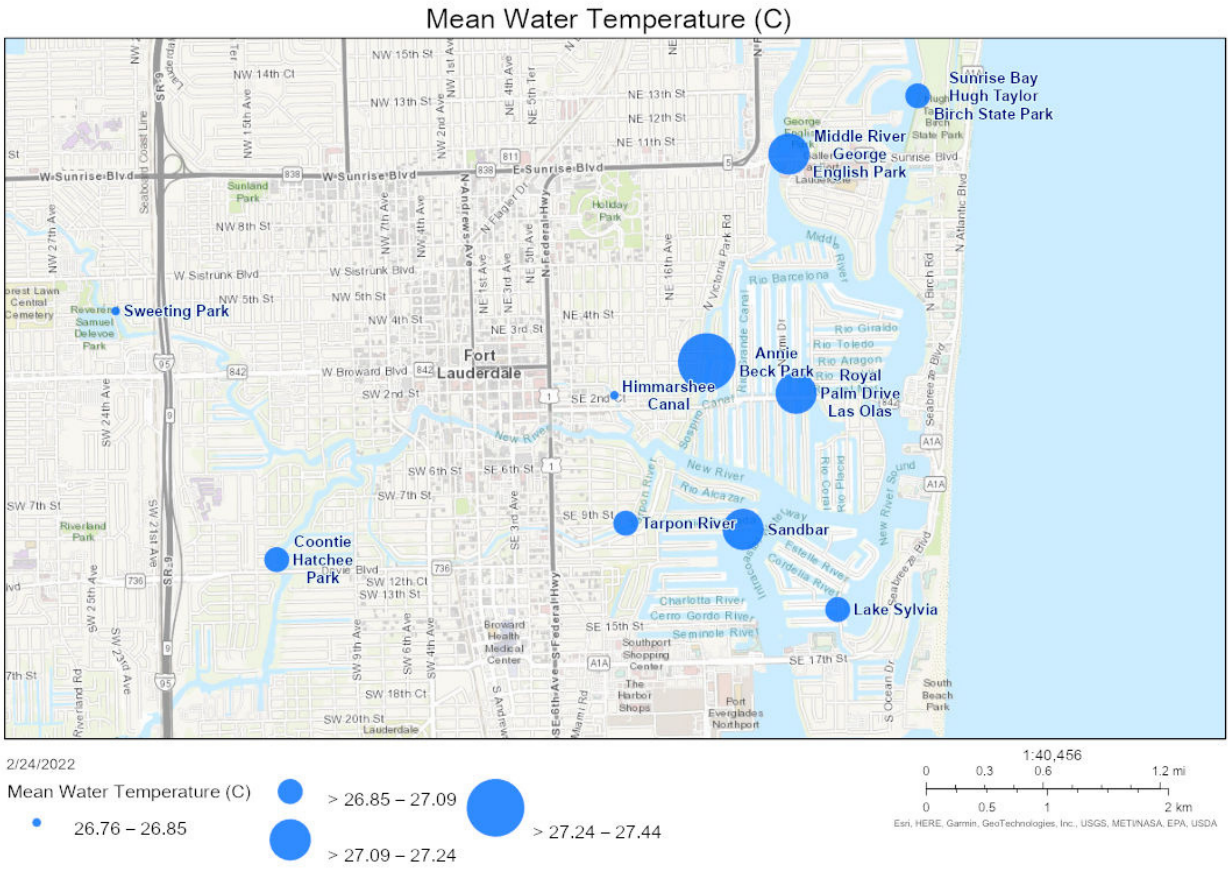

Figure 10. Mean water temperature measurements for the entire period of study at each site.

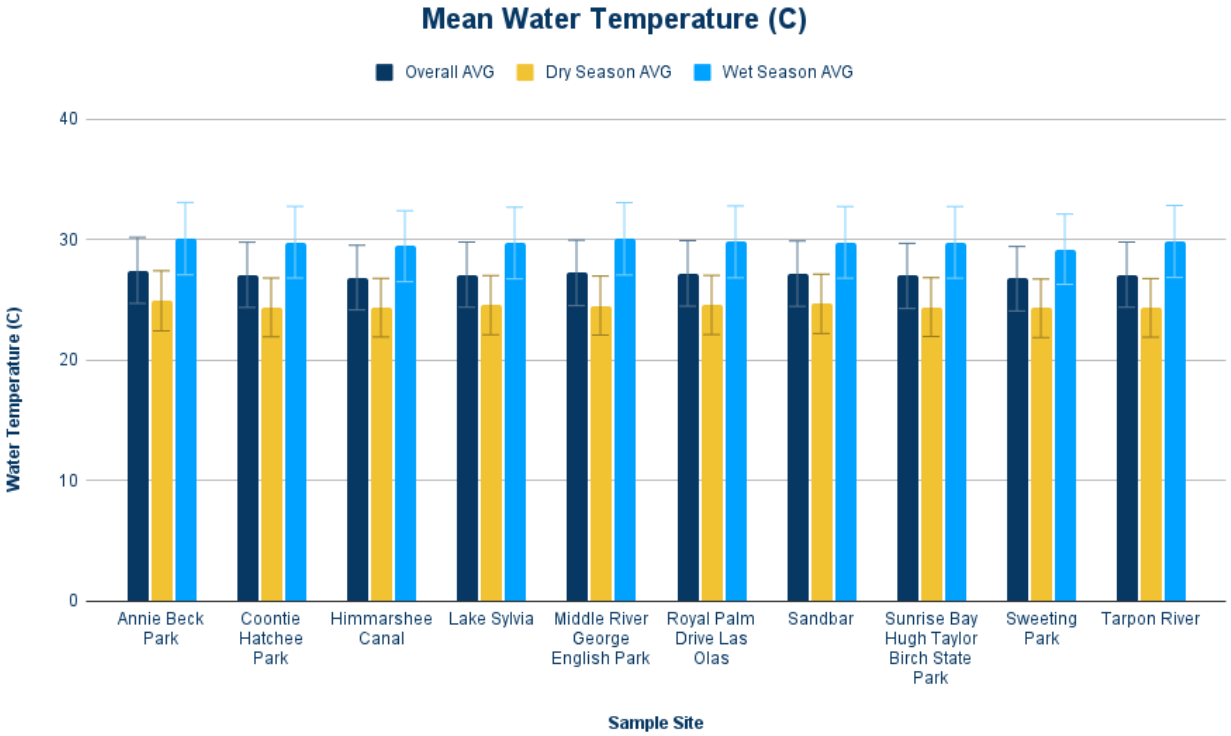

Figure 11. Mean water temperature for all Fort Lauderdale sites, January 12, 2021 - January 12, 2022.

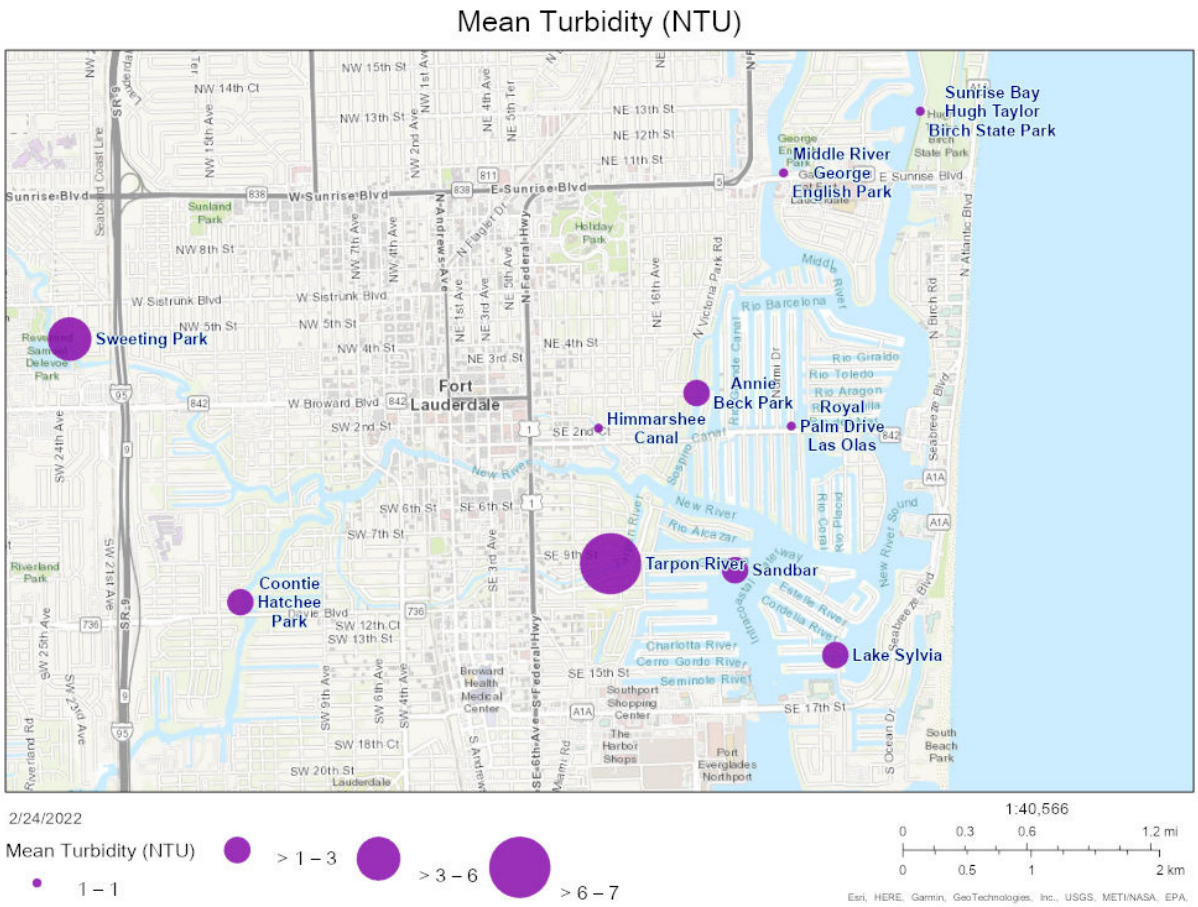

Figure 12. Mean turbidity measurements for the entire period of study at each site.

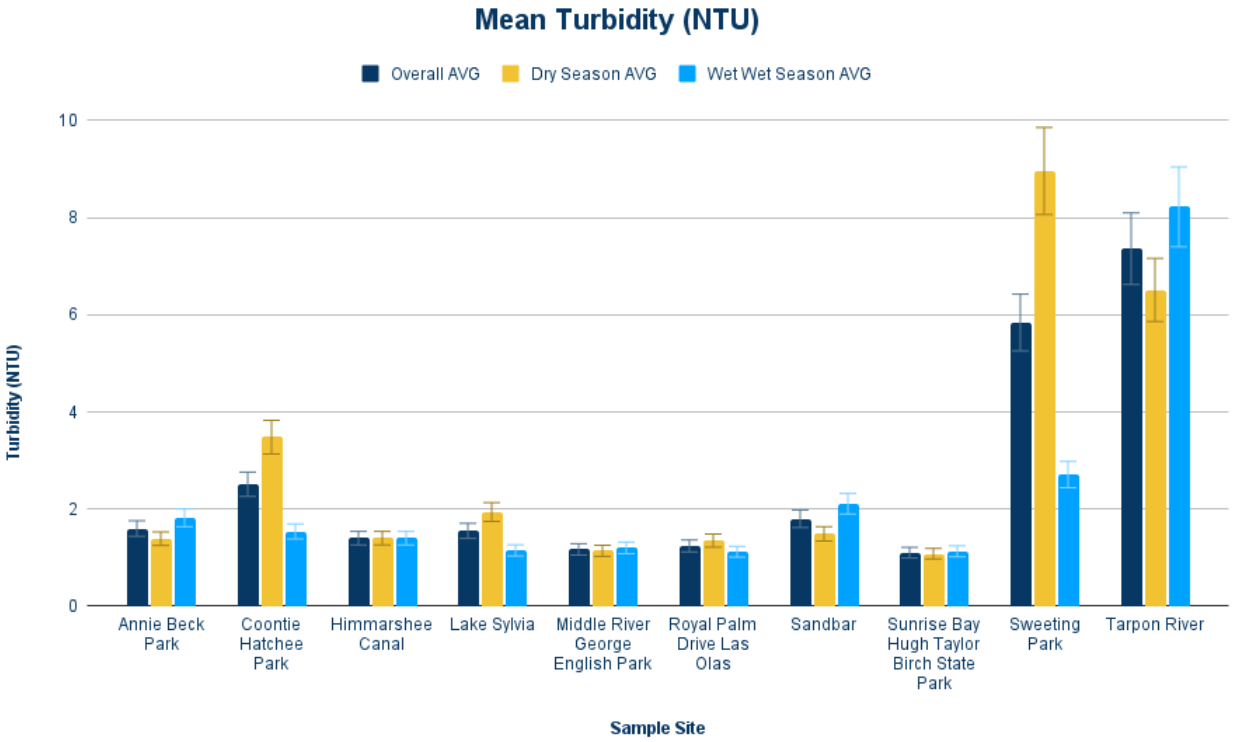

Figure 13. Mean turbidity for all Fort Lauderdale sites, January 12, 2021 - January 12, 2022.

ANALYSIS

Entire Period of Study

Fecal Indicator Bacteria

Significant differences (F= 5.65, p<.0001) were found in the mean enterococci MPN among the sites over the entire period of study. A post hoc Tukey test (alpha=.05) showed that mean MPN was significantly higher (at the 0.05 level) at Sweeting Park (707 MPN, standard deviation 1605.52), Tarpon River (452 MPN, standard deviation 1314.73), and Himmarshee Canal (355 MPN, standard deviation 636.56).

Chlorophyll a

Chlorophyll *a* ug/L was significant (F=84.11, p<0001) with the highest levels at Sweeting Park (10.90, standard deviation 7.01), Coontie Hatchee Park (3.07, standard deviation 1.51), Tarpon River (2.50, standard deviation 1.30), and Himmarshee Canal (1.87, standard deviation 1.10).

Dissolved Oxygen

DO % was significantly different among all the sites (F=43.56, p<.0001), with the lowest percentages at Sweeting Park (63.74, standard deviation 21.93), Himmarshee Canal (64.64, standard deviation 11.93), and Coontie Hatchee Park (68.50, standard deviation 3.18).

Salinity

Salinity was also significantly different (F=95.58, p<.0001), with the lowest salinities at Sweeting Park, (4.56, standard deviation 4.66), Coontie Hatchee Park (11.60, standard deviation 7.76), Himmarshee Canal (17.58, standard deviation 7.37), and Tarpon River (17.87, standard deviation 7.53).

Temperature and Turbidity

ANOVA indicated no significant differences among water temperature or turbidity at the Fort Lauderdale sites for the entire period of study. On average, all of the sites meet state standards for turbidity (<10 NTUs) year-round.

Regression Analyses

Linear regression was performed with MPN and each parameter for the Fort Lauderdale sites. The parameter demonstrating the greatest effect on enterococci MPN was DO % (F-value 18.73, p<.0001), likely due to the higher enterococci levels at sites with low wave action. The next greatest effect came from turbidity (F= 15.69, p <.0001), salinity (F-value 14.60, p<.0001), followed by chlorophyll *a* (F=19.45, <.0001). While these are early results that would require additional study to confirm, salinity and MPN likely had such a strong association due to the low salinity levels and high MPNs found at Sweeting Park, Tarpon River, Himmarshee Canal, Annie Beck Park, and Coontie Hatchee Park. The association between salinity and MPN may simply be due to the fact that these sites have lower wave action and are less saline in nature. The association with turbidity may be due to enterococci increases corresponding to unusual increases in wave action. The low wave action may also contribute to the increased enterococci and chlorophyll *a*. Sweeting Park and Coontie Hatchee Park are located inland, to the west of the other sites in the New River. Tarpon River, Himmarshee Canal, and Annie Beck Park are close to one another on the western edge of the canals.

Rainfall

In an evaluation of rainfall at the Fort Lauderdale sites for the entire period of study, the amount of rainfall 24 hours before the collection of samples was not significantly associated through linear regression with increased enterococci, salinity, turbidity, or chlorophyll *a*. Rainfall 24 hours before sample collection was significantly associated with water temperature (F-value 8.61, p=.004) and DO mg/L (F-value 20.79, p<.0001). Rainfall 3 days before sample collection was not significantly associated through linear regression with increased enterococci, water temperature, turbidity, chlorophyll *a*, DO mg/L, or salinity. Rainfall a week before sample collection was not significantly associated through linear regression with increased enterococci, turbidity, or chlorophyll *a*. It was significantly associated with water temperature (F-value 38.96, p<.0001), DO mg/L (F-value 11.40 p=.0008), and salinity (F-value 12.98 p=.0004). A t-test was conducted to analyze enterococci levels against the presence of rain. This was not found to be statistically significant (t=0.52, p=0.6).

Wet Season vs. Dry Season Analysis

Site	MPN (number of observations) Std Deviation	Water Temperature C (number of observations) Std Deviation	DO% (number of observations) Std Deviation	DO mg/L (number of observations) Std Deviation	Salinity (number of observations) Std Deviation	Turbidity (number of observations) Std Deviation	Chl a ug/L (number of observations) Std Deviation	Chl RFU (number of observations) Std Deviation
Annie Beck Park	97 (27) 155.77	24.92 (27) 1.91	83.00 (27) 7.73	6.01 (27) 0.49	23.83 (27) 5.28	1.39 (27) 1.30	1.07 (27) 0.80	0.27 (27) 0.20
Coontie Hatchee Park	78 (27) 44.77	24.37 (26) 1.98	70.47 (26) 12.42	5.46 (26) 0.87	12.81 (26) 7.61	3.48 (26) 8.15	2.64 (26) 1.37	0.66 (26) 0.35
Himmarshee Canal	489 (27) 863.54	24.35 (27) 1.84	67.57 (27) 9.00	5.09 (27) 0.68	18.29 (27) 6.95	1.40 (27) 1.02	1.79 (27) 1.28	0.44 (27) 0.32
Lake Sylvia	35 (27) 63.51	24.56 (27) 1.53	93.13 (27) 4.96	6.48 (27) 0.38	31.62 (27) 2.90	1.94 (27) 1.62	0.35 (27) 0.78	0.10 (27) 0.20
Middle River George English Park	35 (27) 60.83	24.52 (27) 1.94	84.43 (27) 6.33	6.13 (27) 0.54	24.47 (27) 4.81	1.14 (27) 0.49	1.17 (27) 1.52	0.29 (27) 0.38
Royal Palm Drive Las Olas	129 (27) 228.77	24.58 (26) 1.69	82.98 (26) 6.24	5.94 (26) 0.50	26.80 (26) 4.27	1.35 (26) 0.64	0.83 (26) 0.74	0.21 (26) 0.19
Sandbar	56 (27) 86.50	24.67 (27) 1.60	97.71 (27) 8.64	6.82 (27) 0.62	30.15 (27) 3.40	1.49 (27) 1.30	0.70 (27) 1.29	0.17 (27) 0.32
Sunrise Bay Hugh Taylor Birch State Park	47 (27) 142.38	24.40 (27) 1.79	84.17 (27) 5.72	6.03 (27) 0.50	27.14 (27) 4.03	1.08 (27) 0.53	1.01 (27) 1.15	0.25 (27) 0.29
Sweeting Park	751 (27) 1830.98	24.3 (26) 2.07	61.02 (26) 19.40	4.95 (26) 1.56	5.24 (26) 4.67	8.96 (26) 33.07	8.44 (26) 5.25	2.15 (26) 1.31
Tarpon River	671 (27) 1790.23	24.34 (26) 1.95	74.35 (26) 14.00	5.56 (26) 0.96	19.27 (26) 7.20	6.51 (26) 17.27	2.28 (26) 1.18	0.57 (26) 0.29

Table 4. Means for MPN, water temperature, dissolved oxygen, air temperature, salinity, turbidity, and chlorophyll a at Fort Lauderdale sites during the dry season (November-April). All parameters include a number of observations (data points) and standard deviation.

Site	MPN (number of observations) Std Deviation	Water Temperature C (number of observations) Std Deviation	DO% (number of observations) Std Deviation	DO mg/L (number of observations) Std Deviation	Salinity (number of observations) Std Deviation	Turbidity (number of observations) Std Deviation	Chl a ug/L (number of observations) Std Deviation	Chl RFU (number of observations) Std Deviation
Annie Beck Park	252 (26) 687.96	30.08 (26) 1.21	78.99 (26) 9.92	5.30 (26) 0.58	21.05 (26) 6.36	1.82 (26) 1.59	1.41 (26) 0.68	0.35 (26) 0.17
Coontie Hatchee Park	72 (26) 80.51	29.79 (26) 1.15	66.52 (26) 17.97	4.90 (26) 0.88	10.40 (26) 7.88	1.54 (26) 0.61	3.49 (26) 1.55	0.87 (26) 0.39
Himmarshee Canal	215 (26) 165.65	29.46 (26) 1.54	61.60 (26) 13.89	4.27 (26) 0.89	16.84 (26) 7.84	1.40 (26) 1.17	1.94 (26) 0.90	0.49 (26) 0.23
Lake Sylvia	17 (26) 19.44	29.72 (26) 2.15	90.94 (26) 7.92	5.89 (26) 0.47	29.83 (26) 4.70	1.15 (26) 0.97	0.28 (26) 0.56	0.07 (26) 0.14
Middle River George English Park	58 (26) 95.45	30.07 (26) 1.32	79.80 (26) 10.03	5.38 (26) 0.57	20.23 (26) 7.91	1.20 (26) 0.96	1.50 (26) 0.91	0.39 (26) 0.21
Royal Palm Drive Las Olas	26 (26) 30.53	29.81 (26) 1.27	79.27 (26) 10.19	5.26 (26) 0.65	24.10 (26) 6.31	1.12 (26) 0.65	1.19 (26) 0.91	0.30 (26) 0.23
Sandbar	24 (26) 29.35	29.77 (26) 1.49	100.28 (26) 12.13	6.51 (26) 0.69	28.17 (26) 5.24	2.11 (26) 5.07	0.63 (26) 0.75	0.16 (26) 0.19
Sunrise Bay Hugh Taylor Birch State Park	15 (26) 12.45	29.78 (25) 1.25	82.69 (25) 12.91	5.45 (25) 0.88	25.75 (25) 5.23	1.13 (25) 1.02	1.23 (25) 1.13	0.31 (25) 0.28
Sweeting Park	661 (26) 1367.75	29.21 (26) 1.22	66.47 (26) 24.27	5.23 (26) 1.57	3.88 (26) 4.63	2.71 (26) 2.01	13.36 (26) 7.75	3.32 (26) 1.92
Tarpon River	224 (26) 395.31	29.85 (26) 1.54	68.71 (26) 19.80	4.89 (26) 0.97	16.48 (26) 7.74	8.22 (26) 19.23	2.73 (26) 1.39	0.70 (26) 0.35

Table 5. Means for MPN, water temperature, dissolved oxygen, air temperature, salinity, turbidity, and chlorophyll a at Fort Lauderdale sites during the wet season (May-October). All parameters include a number of observations (data points) and standard deviation.

Fecal Indicator Bacteria

During the wet season, the mean MPN (156 MPN, standard deviation 532.09) for the Fort Lauderdale sites was lower than in the dry season (239 MPN, standard deviation 888.52. However, ANOVA and a post hoc Tukey test (alpha=.05) showed that this was not a significant difference.

Chlorophyll a

Chlorophyll *a* was significantly different (F=5.54, p=.02) between the wet season and the dry season. When all sites were considered together, chlorophyll *a* was higher in the wet season. Sweeting Park had the highest chlorophyll *a* levels, followed distantly by Coontie Hatchee Park and then Tarpon River. This was the same in the dry season as well.

Dissolved Oxygen

DO mg/L was significantly different (F=40.21, p<.0001) with Sweeting Park, Himmarshee Canal, Coontie Hatchee Park, and Tarpon River being the lowest. Sandbar and Lake Sylvia were the highest. During the wet season, the sites with the highest DO% were the same as in the dry season, as were the lowest sites.

Salinity

Salinity was significantly different (F=8.07, p=.005), higher in the dry season. Lake Sylvia, Sandbar, and Sunrise Bay Hugh Taylor Birch State Park had the highest salinities during both dry and wet seasons.

Temperature and Turbidity

Water temperature was significantly different (F=1345.47, p<.0001), higher in the wet season, which corresponds to seasonal changes. In the wet season, temperatures were highest at Tarpon River, Middle River George English Park, and Annie Beck Park. During the dry season, Sandbar and Annie Beck Park were the highest. Turbidity was not significantly different when comparing the two seasons.

Regression Analyses

Linear regression was performed with MPN and each parameter for the Fort Lauderdale sites for both the wet season samples and the dry season samples.

In wet season, MPN was significantly associated with DO % (F-value 6.49, p=.01), salinity (F-value 11.24, p=.0009), and chlorophyll *a* ug/L (F-value 21.24, p<.0001). During dry season, MPN was significantly associated with DO % (F-value 15.78, p<.0001), salinity (F-value 7.43, p=.01), turbidity, (F-value 9.45, p=.002), and chlorophyll *a* ug/L (F-value 7.62, p=.006).

As with the overall analysis, the association with DO is likely due to the higher enterococci levels at sites with low wave action. Salinity and MPN likely had such a strong association due to the low salinity levels and high MPNs found at Sweeting Park, Tarpon River, Himmarshee Canal, Annie Beck Park, and Coontie Hatchee Park. The low wave action may also contribute to the increased enterococci and chlorophyll *a*.

Rainfall

An evaluation of rainfall at the Fort Lauderdale sites for the wet season and the dry season was also performed. During the dry season, rainfall 24 hours before sample collection was significantly associated with water temperature (F-value 9.88, p=.002). Rainfall 3 days before the collection was significantly associated with water temperature (F-value 6.13, p=.01), and DO mg/L (F-value 7.56, p=.007). Rainfall a week before the collection was significantly associated with DO mg/L (F-value 7.31, p=.008).

In the wet season, rainfall 24 hours before sample collection was significantly associated with DO% (F-value 4.14, p=.04) and DO mg/L (F-value 9.89, p=.002). Rainfall 3 days before collection was significantly associated with MPN (F-value 4.49, p=.04), DO% (F-value 4.86, p=.03), and DO mg/L (F-value 8.32, p=.005). Rainfall a week before the collection was significantly associated with DO mg/L (F-value 8.98, p=.003), and salinity (F-value 10.89, p=.001).

CONCLUSIONS

Fort Lauderdale Water Quality

Fecal Indicator Bacteria Levels

The results from one year of monitoring in Fort Lauderdale have generated informative data about the characteristics of the sites. They allow for a baseline understanding of water quality in Fort Lauderdale's valuable recreational waterways. The results show that three sites consistently have high FIB levels and exceed recreational water quality (Sweeting Park, Himmarshee Canal, and Tarpon River), and four sites consistently meet recreational water quality standards for enterococci (Lake Sylvia, Sunrise Bay Hugh Taylor Birch State Park, Sandbar, and Middle River George English Park). These four sites with the highest water quality are City Designated Watersport Activity Areas; many of the other sites have not been

analyzed under the DOH enterococci standard before, so the information from this first year of monitoring is especially useful in establishing a baseline for these areas. The three remaining sites are of intermediate quality. Seasonal difference and rainfall did not significantly affect FIB levels, except for the effect of rainfall three days before sample collection during the wet season.

It is important to note that this study was designed to inform recreational waterway users, not for tracking the sources of enterococci. To analyze the sources of enterococci, we would recommend implementing different experimental designs and methodologies. However, we provide these data with the hope that it could help to guide future studies.

Seasonal Differences

Significant differences between the wet and dry seasons included water temperature, DO mg/L, salinity, and chlorophyll *a*. The difference in enterococci levels between the seasons was not significant.

Potential Contributing Factors

Understanding the nature of the environments of the sampling sites may result in different management strategies. Some environmental factors at the sites may amplify the effects of stormwater and sewage inputs. The City has an estimated 1,000 stormwater outfalls and has recently been dealing with sewage spills. Some of the factors that influence enterococci levels include the amount of wave action, water movement, water depth, sediment type, debris, and vegetative load. A combination of slow-moving water, high vegetative load, debris, and muddy characteristics could contribute to the low DO percent conditions, high chlorophyll *a*, and high enterococci levels at Sweeting Park, as well as at Tarpon River and Himmarshee Canal, for example.

While management likely cannot address naturally-occurring environmental conditions such as wave action, there is a correlation between the high enterococci levels and the amounts of vegetation and trash floating in the canals and rivers, based on field notes. Excess vegetation, trash, or sediment can impede flow and allow increased bacterial proliferation.

We recommend increased removal of vegetation and trash where it builds up in the waterways and the storm drain system before it gets to the waterways. If herbicides are being used to control algae build-up in canals, we recommend that this practice cease immediately and transition to mechanical algae removal. This will remove nutrients from the water and improve water quality, rather than add chemicals and dissolved algae debris. We also recommend a nutrient study to understand which canals could be vulnerable to algae blooms.

To further address issues of the vegetation and trash in the canals, we also recommend increased street sweeping, regular stormwater maintenance, inspections, enforcement, and increased public awareness about dumping, debris, and trash. Storm drain grates and stormwater system cleaning through swales could also improve conditions.

Tracking Sources

Sweeting Park, Tarpon River, and Himmarshee Canal may require additional study to determine the sources of enterococci. Possible future studies could include more intensive sampling at these sites using IDEXX and/or additional methodologies such as molecular source tracking or isotope tracing. This may be especially informative in Tarpon River and perhaps at Middle River George English Park, which experienced sewage spills in 2020, and at Himmarshee Canal, which was a site of sewer spills between December 2019 through Jan 2020. These sites may now support environmental colonies of enterococci that may not be indicative of new FIB inputs. A study of the sediments could also reveal more about water quality issues and the next steps. Residual solids from the spill at George English Park have been already removed from the Middle River site during the monitoring contract period. This site had few exceedances, both before and after dredging of these sediments. According to City Staff, Tarpon River is the next location for residual solid removal and the Himmarshee Canal is in permitting. Additional monitoring to the west will also help to elucidate the sources of pollutants. Groundwater, sediment, and outfall monitoring can also be useful to track pollutant sources.

<u>Recommendations to improve water quality in Fort Lauderdale</u>

Signage

As these issues are being addressed, we recommend that signs be placed at the monitoring sites. Signs can have a QR code linking to the Swim Guide app page so that visitors have instant access to the latest water quality information. At the three sites which have regular exceedance rates, we recommend additional signage informing the public about water quality issues at those locations before recreating.

Ongoing Recreational FIB Monitoring

Continued monitoring, possibly with additional sampling sites, is recommended to increase the City's ability to evaluate changes in water quality and to inform the public about water quality.

Community Pollution Reporting

We would be happy to offer our 1,000 Eyes on the Water pollution monitoring program to the residents of the City of Fort Lauderdale, along with our pollution reporting program. This would help to engage the public to observe, document, and report pollution events. This has become an effective tool in the City of Miami as well, where it has led to many enforcement actions for illegal discharges.

Future Work

We are committed to continuing this work and to providing the City and its residents with regular weekly updates on enterococci levels in the City's waterways via an easy-to-use platform on our website, social media, and Swim Guide app. We look forward to working with the City of Fort Lauderdale and to educating and informing the thousands of residents and visitors who have come to rely on Swim Guide's information to make decisions about recreation in Fort Lauderdale's rivers, lakes, and canals.

PO Box 141596
Coral Gables, FL 33114-1596
305-905-0856

miamiwaterkeeper.org

hello@miamiwaterkeeper.org
/miamiwaterkeeper
@miamiwaterkeeper
@miamiwaterkpr

MIAMI WATERKEEPER®