Identifying Stormwater Sources of Microbial Contamination at Bruce Beach, Pensacola, FL

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Technical Report to City of Pensacola

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Executive Summary

Bruce Beach is a downtown waterfront 10-acre parcel of land currently slated to be transformed into a park. Councilwoman Hill provided support to the Bream Fishermen Association in partnership with UWF, Center for Environmental Diagnostics and Bioremediation to collect samples for fecal indicator bacteria. We enumerated bacteria within *Enterococcus* species using the Enterolert (QT) method which detects culturable *Enterococci* species. Sampling at three locations at Bruce Beach between February and August 2021 revealed that levels of *Enterococci* were above acceptable threshold levels for human health exposure (70 MPN/100 mL) over fifty (50%) percent of the time. The Florida Department of Health Beach Action Value is 70 MPN/100 mL.

Based on the preliminary study results at Bruce Beach, the City of Pensacola requested UWF sample stormwater drains discharging in downtown Pensacola in the Bruce Beach vicinity to identify the potential source of contamination at Bruce Beach. Sampling occurred at 29 unique locations over 13 sampling dates between August 31, 2021, and February 3, 2022. Only flowing water was collected for analysis of *Enterococcus*. Sites with consistently low values were not resampled.

The Tanyard region bounded by Reus and DeVilliers streets to the East and West and Intendencia streets and Government to the North and South were often high even during extended dry periods. The lowest elevations of our sampling sites occur in the vicinity of the former Main Street wastewater treatment plant on Government near DeVilliers. Two locations sampled in this area (site GH and the wetland near GH) often had water flowing out of the ground and onto the street. *Enterococcus* levels at these two locations could be very high immediately following rain events and could remain above 2,000 MPN/100 mL even 4 days following a rain event. The Corrine Jones stormwater pond is connected to the Washerwoman Creek site by stormwater pipes. Despite this connection between Washerwoman Creek and Corrine Jones, *Enterococcus* levels were usually between 4 and 40 times higher at Washerwoman Creek than at Corrine Jones. High levels at the GH site coincided with high levels in Washerwoman Creek. While this is not evidence of causation and we cannot conclude that water flows from GH to Washerwoman Creek, these two sites are 0.2 miles apart and at similar elevations. Thus, we believe that the source leading to high GH values is likely also affecting

Washerwoman Creek. The values at Reus and Zarragossa were often too high to be enumerated (>24,196 MPN/100 mL). This site is about 0.13 miles from GH. Identifying the source to the Tanyard region between Reus, DeVilliers and Government streets would likely provide the greatest benefit to Washerwoman Creek.

Given the very low elevation in the Tanyard region, it seems likely that water from Pensacola Bay may enter stormwater outlets during high tides. We observed this at Washerwoman Creek. Higher Bay water levels could reduce the drainage capacity and lead to water draining more slowly or backing up the pipes. Our data suggest that tidal fluctuations in addition to rain events may be affecting *Enterococcus* levels in the stormwater pipes.

With the new and continuing development in downtown Pensacola, increased rainfall and sea level rise, flooding will disproportionately affect low-lying areas like the Tanyard neighborhood. We suggest the following next steps to improve conditions in this area.

- Locations with consistently high *Enterococcus* counts (e.g., Reus and Zarragossa) should be the highest priority for identifying the exact source of these levels. Further studies with the City of Pensacola and Emerald Coast Utility Authority (ECUA) engineers will be needed.
- Improve infrastructure to minimize public exposure to potential pathogens: Minimize infiltration into stormwater pipes (missing or cracked mortar), add bathrooms at Bruce Beach to prevent local sources of human waste at the park, and reconfigure stormwater outfalls into Pensacola Bay to minimize intrusion of Bay water into drains.

Background

The environmental landscape that was present during the settlement of the city of Pensacola is still having an impact on current conditions in this region. Early maps from Spanish and British colonial periods reveal two creeks bounding the early settlement: Washerwoman to the west and Cadet to the east. Washerwoman Creek was spring fed, originating near the present-day Spring and Gregory Streets. The 1908 Coast and Geodetic Survey map shows the remnants of wetlands and Washerwoman creek (Fig. 1). As the city grew, Washerwoman Creek was routed underground and these wetland and low-lying areas were paved over. The creek currently returns to the surface just south and west of present day 455 W. Main Street. North Hill, which is roughly a mile north of the study area is situated on an escarpment, a topographic feature that is a historic sand dune from the Pleistocene era. Elevation drops while traveling south on Palafox, Spring, Reus, DeVilliers, Coyle, and A Streets, between Garden and Cervantes Streets. The topography drops to less than 10-foot elevation south of Government Street.

The Main Street wastewater treatment plant was built in 1937 and sited at the lowest elevation to take advantage of hydrology and gravity flow through the sewer lines. It was damaged by extensive flooding during hurricane Ivan in 2004 and removed in 2010, when the Central Water Reclamation Facility in Cantonment was completed. The Main Street plant was bounded by W. Government to the north, Main Streets to the south, S. Clubbs to the west and S. DeVilliers to the east. According to the city engineers, flow from the Corrine Jones Park stormwater pond is routed underground to Washerwoman Creek through a stormwater pipe. A pumping station on W. Government and DeVilliers Streets near the former site of the Main Street sewage treatment plant pumps sewage to the current treatment plant in Cantonment. The City of Pensacola maintains stormwater infrastructure, oversees management, and provides upgrades for the city. Emerald Coast Utilities Authority provides the same services for sewage, which includes maintaining sewage infrastructure to capture untreated sewage, and either through, gravity-fed or forced-main, pumping untreated sewage to the Central Water Reclamation Facility for treatment.

Bruce Beach is the local name of the area between Main Street and Pensacola Bay where Washerwoman Creek emerges. During the early 20th century, Bruce Beach was part of the active port facilities and included a drydock. Between the 1950s and 1970s during segregation, it was the location where the African American community could swim, first in the Bay and then in a swimming pool which was built in the 1960s. The pool closed in 1970 and the property was abandoned until 2014 when it was proposed as a site for a fish hatchery following the Deepwater Horizon oil spill.

Currently, this 10-acre parcel at Bruce Beach is slated to be transformed into a city park complete with swimming, a sandy beach, trails, and kayak access. In August 2020, City of Pensacola Councilwoman Ann Hill contacted the Bream Fishermen Association to see what was known about the condition of the water quality at Bruce Beach since no one was monitoring this area regularly. She provided support to the Bream Fishermen Association in partnership with UWF, Center for Environmental Diagnostics and Bioremediation to collect samples from the site and analyze for water quality, specifically fecal indicator bacteria which we measured by determining culturable *Enterococcus* bacteria concentrations.

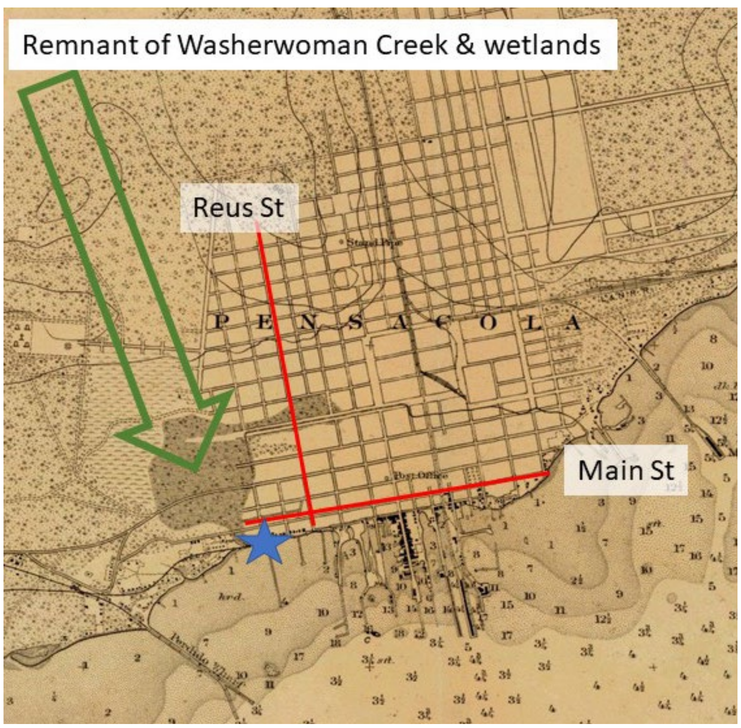


Figure 1-Enlargement of 1908 Coast and Geodetic Survey Map. Blue star indicates mouth of Washerwoman Creek. Green arrow indicates remnant wetlands. Reus and Main Streets outlined in red.

Enterococcus is a commonly used indicator of the presence of fecal material in water. It is often used by departments of health to indicate potential health risks for recreational use of marine and freshwater (U.S. EPA 2012). Some studies have shown related incidence of gastroenteritis or skin rashes to high *Enterococcus* levels (Byappanahalli et al 2015, González-Fernández et al 2021), although it is not a perfect predictor of disease occurrence (Hellein et al 2011 Harwood et al. 2013). Microbial, viral or protozoan pathogens can sicken swimmers and others who use rivers and streams for recreation or eat raw shellfish or fish with diseases of the skin, eyes, ears and respiratory tract (U.S. EPA 2012). The Florida Department of Health standard dictates the "Beach Action Value" (BAV) which is that culturable Enterococci (fresh + marine) do not exceed 70 MPN/100 mL, where MPN stands for most probable number and mL means milliliters.

Water sampling was done weekly between February and August 2021 at 3 locations in the Bruce Beach Park: Washerwoman Creek, along the beach on Pensacola Bay (sandy shoreline) and in the mitigated wetland area. Water from the Washerwoman Creek site was collected at the stormwater outfall where the creek emerges as a stormwater outfall. The other two sites are on Pensacola Bay where many people launch kayaks, fish or swim. Between February 8 and August 24, 2021, levels of *Enterococcus* were above the 70 MPN/100 mL threshold over fifty (50%) percent of the time at the three sites sampled (Fig 2). Samples at the 3 locations were particularly high on April 12, April 19, May 3, June 8, June 22, July 6 and July 20 (Fig 2) which coincided with rain events.

Preliminary results of this study were presented to City of Pensacola staff in June and July. We presented these results to the City Council in July and again in August 2021. Based on these high values in a public recreation area, the city felt it was beneficial to expand the study to identify the potential source(s) to Bruce Beach. The city provided additional funding to examine *Enterococcus* levels in the stormwater drains in downtown Pensacola in the Washerwoman Creek and the Bruce Beach area.

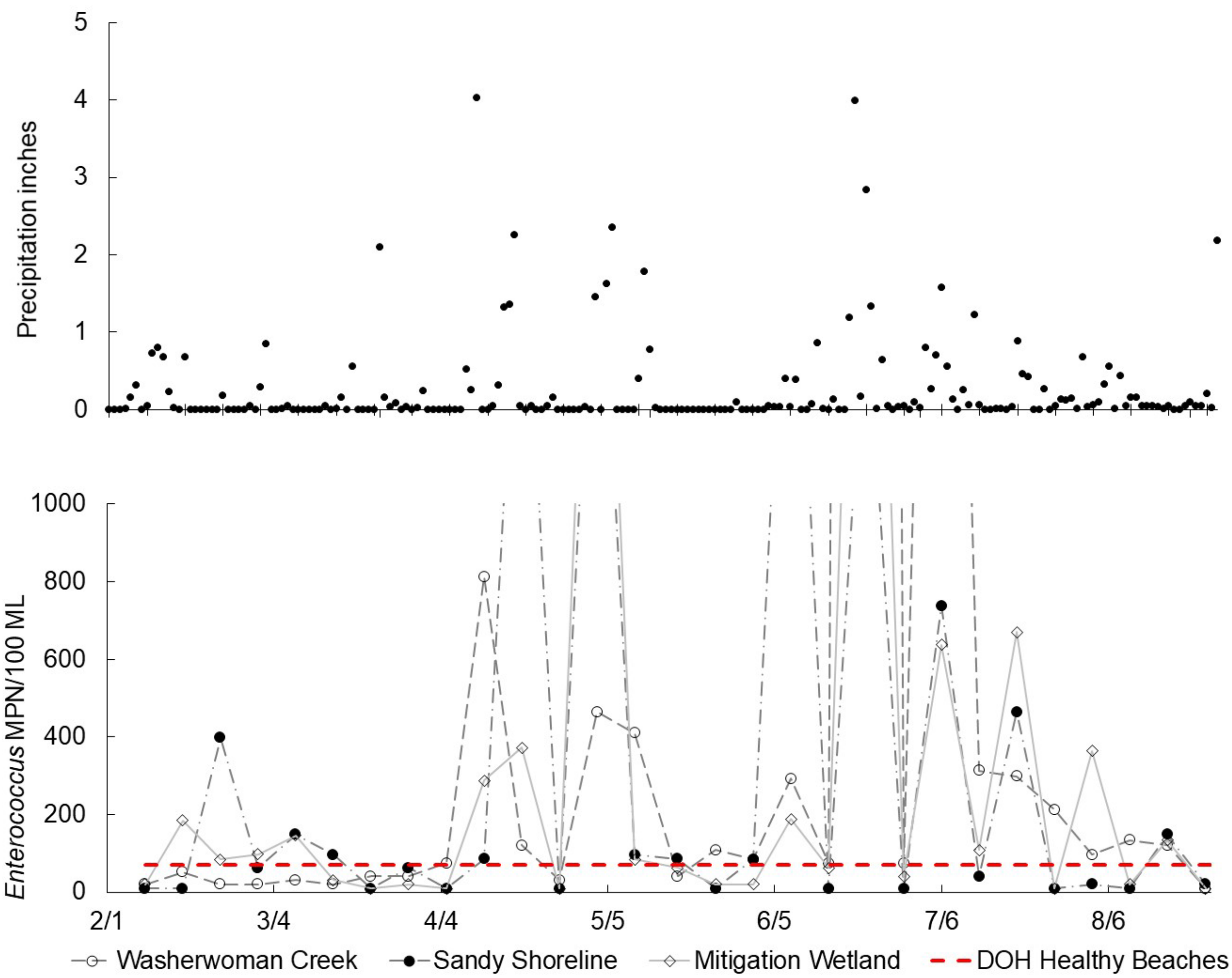


Figure 2 -Precipitation and *Enterococcus* values at Bruce Beach study locations between February 2021 and August 14, 2021. Top panel is precipitation in inches, bottom panel is *Enterococcus* in MPN/100 mL. Dashed red line is the Florida Department of Health BAV standard of 70 MPN/100 mL. Values greater than 1000 MPN/100 mL are not shown.

Study Design and Methods

The City of Pensacola and ECUA provided maps of the subsurface infrastructures (stormwater and sewage) (Fig. 3). To understand potential bacterial sources to Washerwoman Creek and the Bruce Beach area, stormwater inlets upgradient of Bruce Beach were sampled. Sampling design and strategies were based on the street grid pattern and a feedback loop. Stations that samples with *Enterococcus* concentrations less than the 70 MPN/100 mL threshold within 48 hours after a rain event were not resampled. The inlets varied from shallow street-level inlets (Figure 4) to remnants of deeper brick-lined circular, square, or rectangular shaped wells (3-feet, 5-feet, and upwards of 10-feet deep) which serve to consolidate stormwater from other nearby inlets (Figure 4). The older, aged stormwater inlets were often observed to have seepages or infiltration of groundwater through cracks in the conveyance structure or most often, where the grout between bricks have worn away and offered easy access for groundwater infiltration (Figure 5).

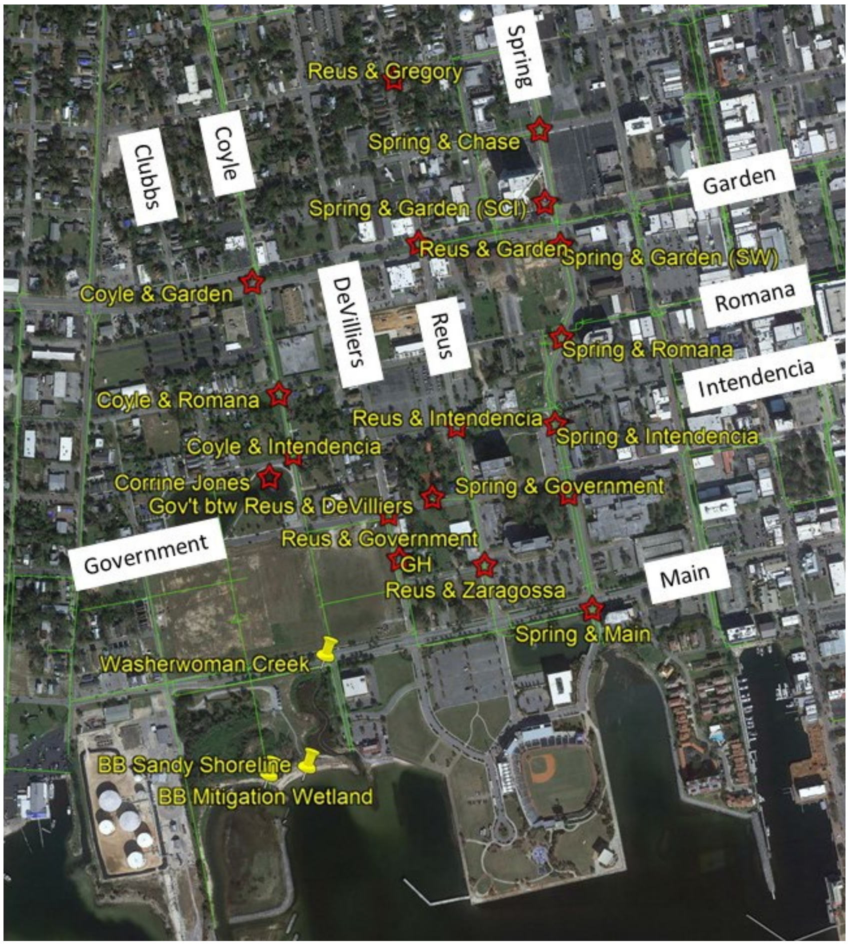
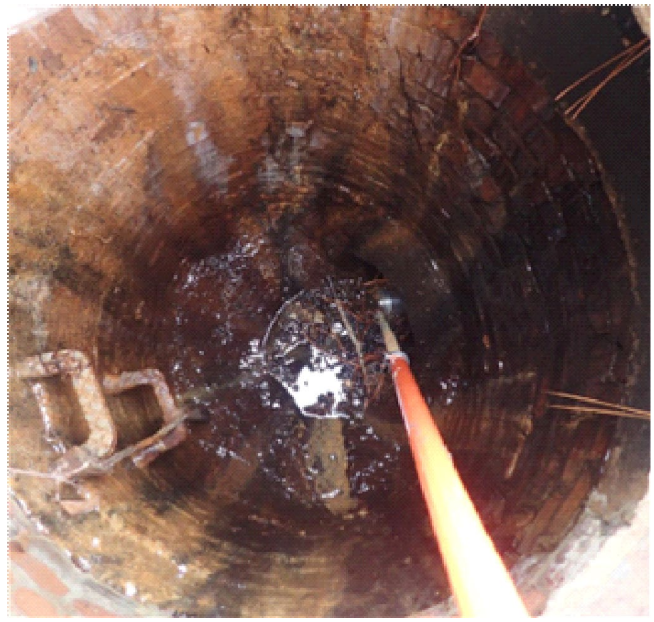


Figure 3 - Downtown Pensacola showing stormwater pipes in green and BFA/UWF sampling locations in stormwater inlets as red stars and Bruce Beach sampling locations as yellow pins.

Figure 4- Shallow stormwater outfall.

Figure 5- Deep stormwater outfall showing groundwater seeps entering through the joints between bricks (seen as darker streaks)



The first samples were collected on August 31, 2021, following Hurricane Ida (29-30 Aug 2021). Sampling was conducted once a week initially and then every 2 – 4 weeks later in the study (Table 1). Approximately 13 stormwater manhole inlets were sampled each time. A low-lying area with wetland characteristics, pooled water at S. DeVilliers between Zaragossa and W. Government Streets was incorporated into sampling regime whenever standing water was present. These are sites GH and wetland next to GH (Figure 2). The sampling strategy was refined as results were received from the lab. Final samples were collected on February 3, 2022 (Table 1).

Water levels in the outfalls varied in depth between 10 and 100 cm. Stormwater manhole inlets at Spring and Main, and Spring and Garden at the SCI Building had clear, flowing water which we believe is coming from the underground, spring-fed Washerwoman Creek. Other outfalls, such as Reus and Zaragoza, were filled with trash collected from three inlets and always had about 50 cm of standing water, presumed to be groundwater.

At each outfall, the lid was removed, and conditions assessed based on recent weather conditions, including whether it had rained within the last 48 hours (Table 1) and if there was seeping or flowing water in the outlet. Water samples were collected by a dipper which was triple rinsed with site water before the sample was collected for lab analysis. If water was entering the stormwater inlet through obvious seepage, this water was captured as the representative sample. Samples were immediately placed on ice for transport to the laboratory.

Table 1 – Rainfall over 48-hour period prior to sampling. Data from Pensacola airport (NOAA 2022).

Date	Rainfall inches
8/31/2021	6.24
9/7/2021	0
9/14/2021	0.47
9/16/2021	4.66
10/5/2021	9.55
10/12/2021	0
10/19/2021	0
11/9/2021	0
11/16/2021	0
11/23/2021	0.22
12/7/2021	0
1/18/2022	0
2/3/2022	1.85

Enterococcus analyses were conducted using the Enterolert (QT) method. Analysis of samples began less than 6 hours of collection time in a NELAC certified laboratory: Wetlands Research Laboratory, University of West Florida (State of Florida Certification # E71969). The lower limit of detection was 10 MPN/100 mL. Samples with values greater than 24,196 MPN/100 mL could not be quantified with accuracy. Because the data has both lower and upper limits of detection, medians, 10^{th} and 90^{th} percentiles were calculated for the *Enterococcus* values, using the values 10 or 24,196 MPN/100 mL for values outside of the detection limits. Based on the likely flow of stormwater in the pipes, data was separated into 7 regions based on the major north south street (Coyle, DeVilliers, Reus and Spring) and whether the samples were collected from stormwater inlets north of Government Street or Government Street and south. Median, 90^{th} and 10^{th} percentiles were calculated for these regions. Rainfall data were downloaded from the National Weather Service site at Pensacola Airport (NOAA 2022a) and elevation data were downloaded from NOAA tide gauge (NOAA 2022b).

Results

The highest rainfall amounts occurred between August 25, 2001, and October 27, 2021 (Fig 6). The highest rainfall occurred on October 4th (Fig. 6, Table 1). Rainfall events during November and December 2021 were less than 0.5 inches. The data are presented in three parts:

1. Samples collected during the initial rainy period between August 31 and October 5, which is outlined in red on Fig. 6
2. Samples collected during the low rainfall period between Oct 12 and December 7, which is outlined in yellow on Fig. 6
3. Samples collected on January 18 and February 3, 2022 following some small rainfall events, which is outlined in green on Fig. 6.

When the *Enterococcus* values were separated by region, the highest median values occurred on Reus Street, particularly south of Government (24,196 MPN/100 mL) while the lowest median value occurred on Coyle Street north of Government (41 MPN/100 mL) (Table 2). DeVilliers south of Government and Reus north of Government had high median values, 3,455 and 839 MPN/100 mL, respectively. Except for Spring south of Government, the 90th percentile for other regions was above 2,280 MPN/100 mL. The 10th percentile or lower end of the distribution was less than 100 MPN/100 mL at all locations except for Reus south of Government. What this means is that almost all regions had occasional very high values (as seen with the 90th percentiles above 2,280 MPN/100 mL), but 2 regions south of Government (DeVilliers and Reus) were consistently high with medians above 3,455 MPN/100 mL.

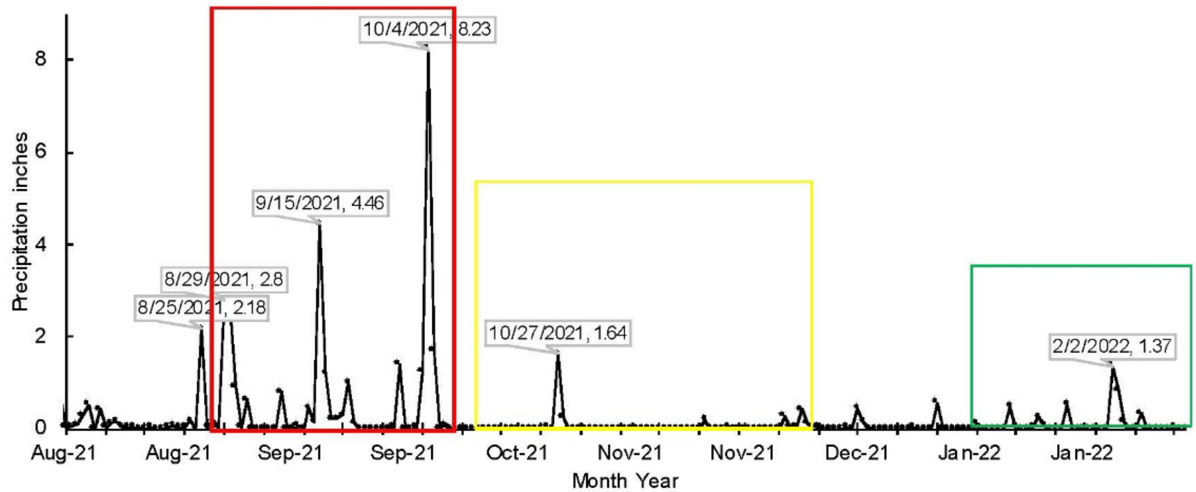


Figure 6 - Precipitation from Pensacola Airport between August 1, 2021, and February 16, 2022 (NOAA 202a). The red box outlines samples collected between August 31 and October 5, 2021, yellow box outlines samples collected between October 14 and December 7, 2021 and green box outlines samples collected between January 18 and February 3, 2022.

Table 2 - Median, 90th and 10th percentiles of *Enterococcus* values. Locations were categorized based on the north south street and whether they were collected north of Government Street or not. Number of observations in each of these categories is included.

North/South Street	Orientation to Government	Median	90th percentile	10th percentile	number of observations
Coyle	North	41	24,196	10	49
Coyle	South	63	5,794	10	31
DeVilliers	South	3,455	24,196	90	20
Reus	North	839	6,131	73	31
Reus	South	24,196	24,196	4,968	14
Spring	North	160	2,280	10	23
Spring	South	186	886	36	6

If we examine individual sampling stations, only eight locations had medians less than 70 MPN/100 mL. They were mainly along Spring Street and Coyle Street. Locations along Reus

Street and DeVilliers Street (GH and Wetland next to GH) had the highest median. The median at Reus and Zaragossa, the wetland next to GH and Government and Reus (mid street) were above 10,000 MPN/100 mL, although Government and Reus (mid street) was only sampled once. This region bounded by Reus and DeVilliers streets to the East and West and Intendencia streets and Government to the North and South were often high even during extended dry periods (Appendix 1).

Table 3 – Median, range in values and number of *Enterococcus* samples collected at 29 locations.

Location	Median MPN/100 mL	Range MPN/100 mL	Number of samples collected
Spring & Chase	243	243	1
Spring and Garden SCI (NW)	10	10-31	3
Spring and Garden (SW)	63	10-2,603	7
Spring and Romana	715	305-19,863	6
Spring and Intendencia	52	10-243	5
Spring and Government	517	41-1,012	4
Spring and Main	64	31-97	2
Reus and Gregory	839	839	1
Reus and Garden	202	30-24,196	11
Reus and Intendencia (NW)	2,247	181-24,196	13
Reus and Intendencia (SW)	379	110-24,196	3
Reus and Intendencia (NE)	10	10	1
Reus and Intendencia (SE)	2,481	108-4,884	3
GH - Private Residence	10,462	10-24,196	13
Wetland Next to GH	9,143	3,706-24,196	5
Government and Reus (mid street)	24,196	10462	1
Government between Reus and DeVililers	2,613	2,755-15,531	2
Reus and Zarragossa	24,196	193-24,196	12
Coyle and Garden	30	20-8,164	5
Coyle and Romana (SW)	24,196	31-24,196	4
Coyle and Romana (NW)	10	10-63	6
Coyle and Romana (NE)	10	10-30	6
Coyle and Intendencia (NW)	225	10-860	6
Coyle and Intendencia (SW)	96	10-1,597	5
Coyle and Intendencia (NE)	238	72-24,196	5
Corrine Jones Stormwater Pond	10	10-10,462	11
Bruce Beach Washerwoman Creek	131	10-24,196	11
Bruce Beach Sandy Shoreline	15	10-9,208	10
Bruce Beach Mitigation Wetland	36	10-4,160	10

Five sites were sampled on almost all trips (Fig. 7). They were Reus and Garden, Reus and Intendencia (NW), Reus and Zarragossa, GH, and Corrine Jones stormwater pond. Except for the

Corrine Jones stormwater pond, all locations were always above the 70 MPN/100 mL threshold with Reus and Zarragossa above quantification 10 out of 13 sampling trips (Fig. 7). This was the site with the most consistent and highest *Enterococcus* levels. Other locations in this low-lying area such as GH, and wetland next to GH were also usually above the 70 MPN/100 threshold.

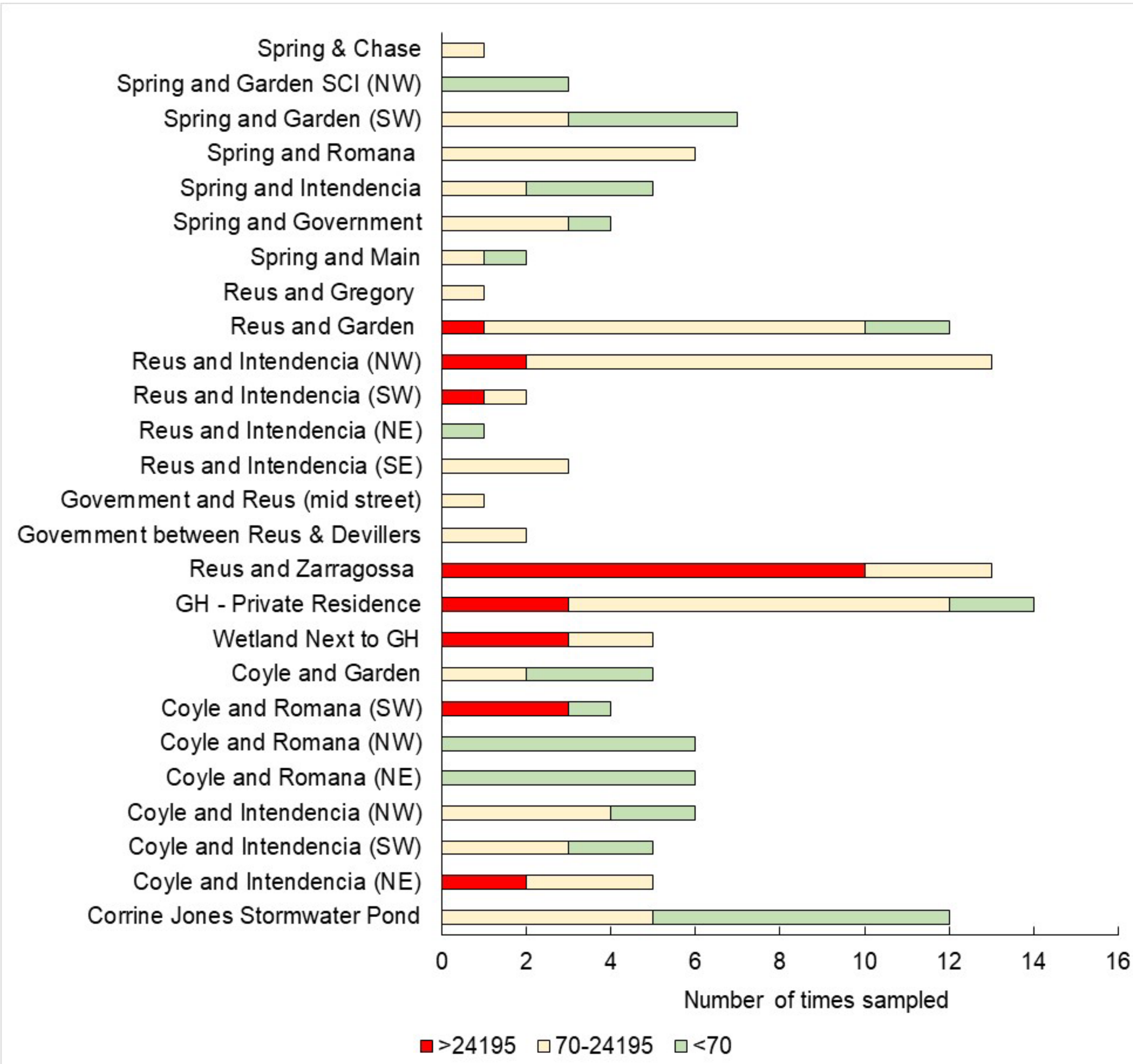


Figure 7 - Sampling locations and the number of times each site was sampled. Color bars indicate the range in value on each sampling date with red at or above quantification limits (24,195), tan indicating samples were between 70 and 24,195 MPN/100 mL and green indicating samples were 70 MPN/100 mL or less.

Some of the locations along Intendencia were also often high. This includes Reus and Intendencia (NW) and Coyle and Intendencia (NE). Most of the locations along Spring Street were not as high, with Spring and Garden SCI (NW) always below the threshold. Between August 31, 2021, and October 4, 2021, the periods with the highest rainfall, 75% of the samples collected were above the 10 MPN/100 mL detection limit. 67% of the samples were above the DOH Healthy Beaches standard of 70 MPN/100 mL, while 18% were 24,196 MPN/100 mL or greater (Appendix 1). Reus and Zarragossa Street was above the detection limit on all five sampling dates. Other sites that were consistently high (above 1000 MPN/100 mL) were GH, Reus and Intendencia (NW), Government between Reus and DeVilliers, and Spring and Romana. Although samples from all three separate manhole covers at Reus and Intendencia were above 70 MPN/100 mL, each had a slightly different pattern suggesting that they receive water from different upstream sources. The only site that was always below 70 MPN/100 mL was Spring and Garden at SCI (NW).

Between October 12, 2021, and December 7, 2021, two samples were collected within 48 hours of a rain event while four samples were collected during dry periods. Thirty seven percent of the samples were below detection limits (10 MPN/100 mL) (Appendix 1). Only 13% of the samples exceeded 24,196 MPN/100 mL. The Reus and Zarragossa inlet were above the quantification limit of 24,196 MPN/100 mL on every sampling date whether it rained during the preceding 48 hours or not (Appendix 1). The NW corner of Reus and Intendencia was also high, above 480 MPN/100 mL during all sampling dates. In contrast to the previous sampling period, only forty five percent of the samples were above detection and only twenty seven percent were above the DOH standard. Despite very little rain during this period, thirteen percent of the sites were at or above 24,196 MPN/100 mL. During this period, multiple manhole stormwater inlets were sampled at the Coyle and Romana intersection and Coyle and Intendencia intersection. All Coyle and Intendencia sites were above 70 MPN/100 mL on November 23 and December 7, with the highest values occurring at Coyle and Intendencia (NE) following a 0.22-inch rain event. In contrast, the 3 Coyle and Romana sites were below 70 MPN/100 mL, except for Coyle and Romana (SW) on November 9, 2021.

During the two winter sampling dates, seventy four percent of the samples contained *Enterococci* concentrations above the DOH standard of 70 MPN/100 mL (Appendix 1). During the January 18, 2022 sampling event, no trash was observed at the Reus and Zarragossa site which had its lowest value of the study (193 MPN/100 mL). Many of the sites that were high during the August to October 5th sampling period were also high on these dates. This included GH, wetland next to GH, Reus and Garden and Reus and Intendencia (NW). Multiple manhole covers were sampled on Coyle and Romana and Coyle and Intendencia. As in the Oct-Dec period, the Coyle and Romana (SW) site was higher than could be enumerated while the other two sites at that intersection were below 63 MPN/100 mL. Similarly, the pattern of the three sites at the Coyle and Intendencia intersection was different on each date, with the NE site being highest in January, but the SW site being highest in February.

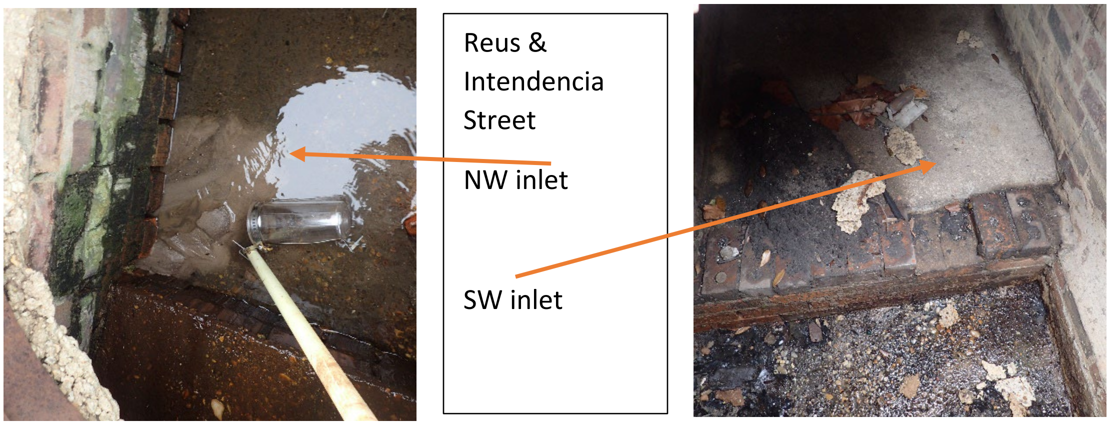
Reus and Zarragossa Streets

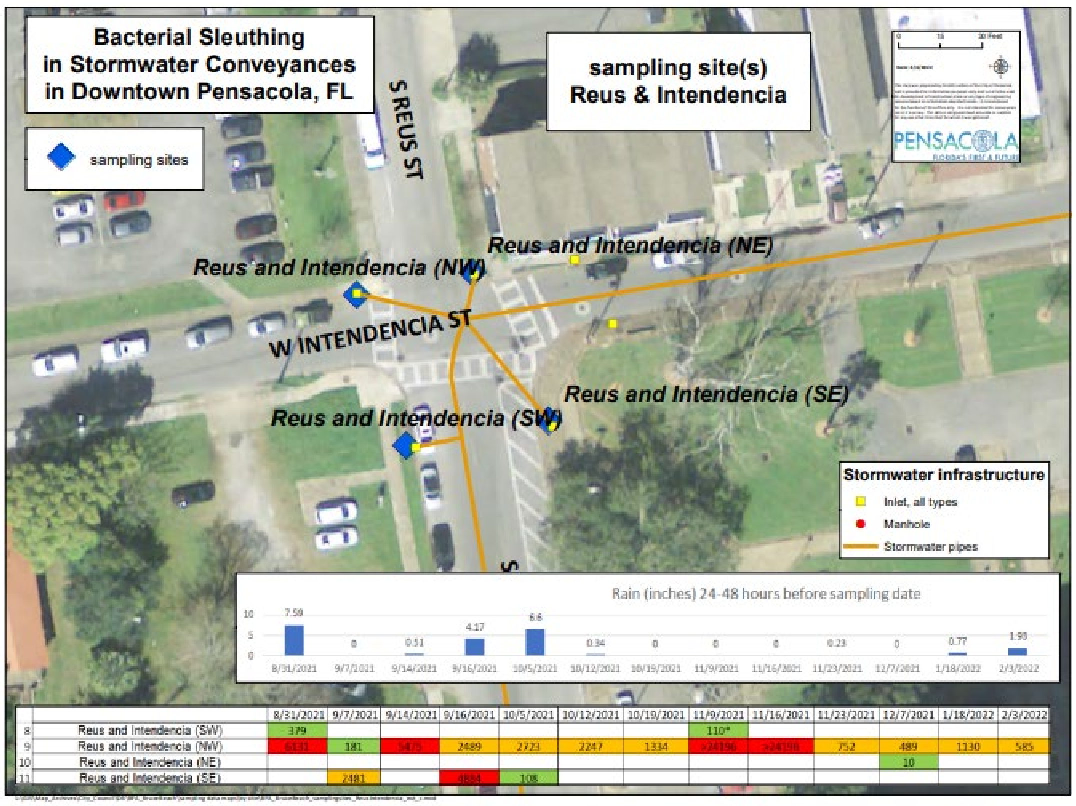
A single inlet was sampled at this location during each sampling event (Fig. 8). *Enterococcus* levels were consistently too high to be enumerated (above 24,196 MPN/100 mL) in all samples collected between August and December. The photo on top left was typical for this site showing stormwater with lots of trash (Fig. 8). There was no trash on January 18th; it appeared to have been cleaned out. This was also the date with the lowest value, although at 193 MPN/100 mL, it was still above the threshold. On February 2nd, the last day it was sampled it was 2,613 MPN/100 mL.

Figure 8 - Reus and Zarragossa intersection showing sampling location. Photo (left) - typical view in stormwater inlet.

Reus and Intendencia Streets

Four separate inlets were sampled at this intersection (Fig 9). Are these 4 stormwater pipes connected? This was not evident during this study. On some occasions flowing water was observed and sampled in some inlets, while no water was flowing in the inlets on the other side of the intersection. Reus and Intendencia (NW) was consistently high. The lowest value (181 MPN/100 mL) occurred on September 7, 2021 with most values above 1000 MPN/100 mL. These values were high even following extended dry periods (Fig 10).





		8/31/2021	9/7/2021	9/14/2021	9/16/2021	10/5/2021	10/12/2021	10/19/2021	11/9/2021	11/16/2021	11/23/2021	12/7/2021	1/18/2022	2/3/2022
8	Reus and Intendencia (SW)	379							110*					
9	Reus and Intendencia (NW)	6131	181	5475	2489	2723	2247	1334	>24196	>24196	752	489	1130	585
10	Reus and Intendencia (NE)											10		
11	Reus and Intendencia (SE)		2481		4884	108								

Figure 9 - Reus and Intendencia intersection showing locations of 4 stormwater inlets sampled.

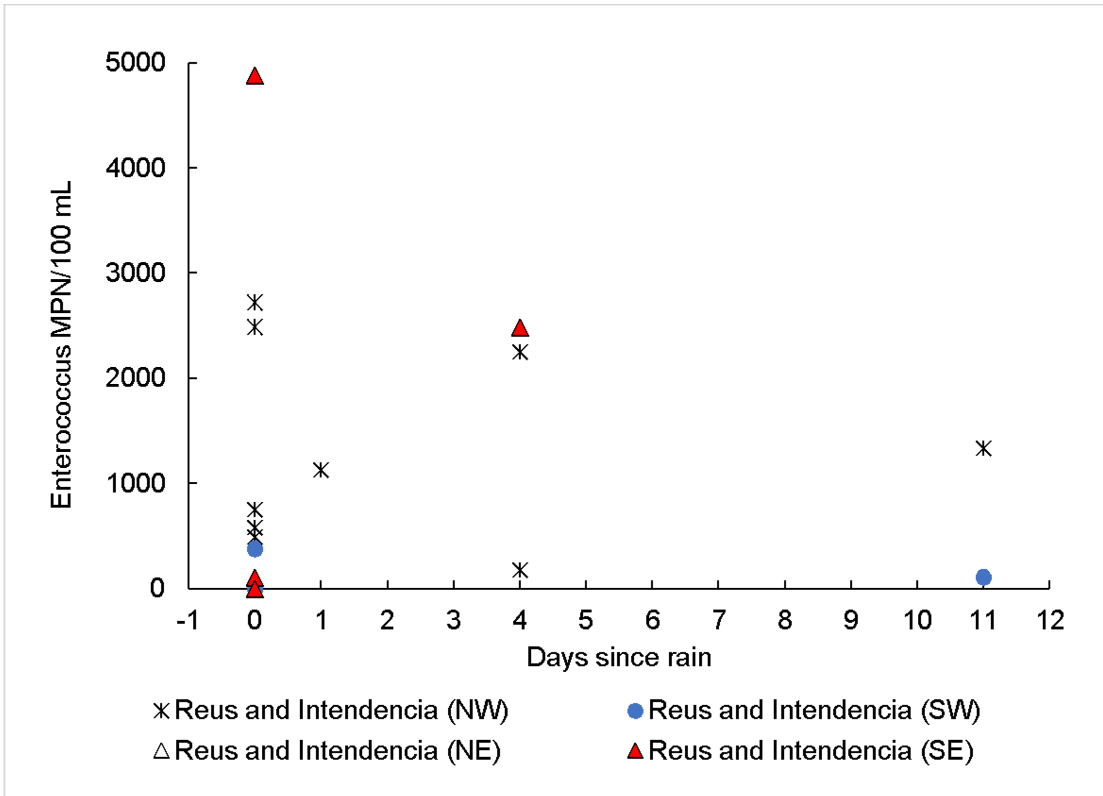


Figure 10 - *Enterococcus* in MPN/100 mL versus days since rain at Reus and Intendencia intersection. Zero represents no rain within 48 hours of sampling.

Lower DeVilliers, Reus and Coyle sites

The wetland identified in Figure 1 would have been the lowest area prior to the settlement of Pensacola and development of the City. South of Garden Street, between the areas east of A Street and west of Spring Street have some of the lowest elevations and a high-water table, which is why standing water accumulates after wet weather events (Nienhuis, undated, Murphy 2019). The lowest elevation of our sampling sites occurred in the vicinity of the former Main Street wastewater treatment plant.

During rain events, site GH on DeVilliers (between Government and Zarragossa) and the ephemeral wetland property next to GH can have either standing or flowing water. During some sampling events, water flowed out of the ground in the grassy area into storm drains, and occasionally these stormwater inlets overflowed across the street into other lower profile inlet drains. *Enterococcus* levels were often very high immediately following rain events and could remain above 2000 MPN/100 mL even 4 days following a rain event (Fig 11). However, by 11 days, *Enterococcus* levels dropped below the 70 MPN/100 mL threshold.

Dr. Melanie Beazley of the University of Central Florida analyzed samples collected on November 9, 2021 at GH and Reus and Zaragossa for biomarkers specific to humans, birds and dogs using quantitative PCR. Only biomarkers of human *E.coli* were found in the two water samples. Dog and bird biomarkers were below detection (Beazley 2021, Appendix 2).

Potential *Enterococcus* Sources to Bruce Beach

The Corrine Jones stormwater pond is connected to the Washerwoman Creek site by stormwater pipes. *Enterococcus* levels at Corrine Jones were highest on August 31 and October 5, following the two highest rain events of this study. Despite this connection between Washerwoman Creek and Corrine Jones, *Enterococcus* levels at Washerwoman Creek were usually higher than those at Corrine Jones, between 4 and 40 time higher (Appendix Table 1). This suggests there are other sources, perhaps from the east or west of Coyle Street. High levels at the GH site coincided with high levels in Washerwoman Creek (Fig. 12). While this is not evidence of causation and we cannot conclude that water flows from GH to Washerwoman Creek, these two sites are 0.2 miles apart and at similar elevations. Thus, we believe that the source leading to high values at GH is likely also affecting Washerwoman Creek. The exceedingly high values at Reus and Zarragossa about 0.13 miles from GH suggests this should be the priority area to investigate. Identifying the source to this area would likely provide the greatest benefit to Washerwoman Creek.

Determining the underground flow paths in this very complex system is a challenge. Given the very low elevation in this region, it is possible that water from Pensacola Bay may enter stormwater outlets during high tides (Nienhuis undated). We have observed water from the Bay flowing into the stormwater culvert at Washerwoman Creek at high tide. Higher Bay water levels could reduce the drainage capacity and lead to water draining more slowly or backing up in the pipes. Our data suggest that tidal fluctuations in addition to rain events may be affecting *Enterococcus* levels in the stormwater pipes. Samples collected along Garden, Intendencia and Government streets were compared based on whether the tide was rising or falling when samples were collected and the recent rain history (0, 1, 4 or 11 days since a rain event). Samples collected from the locations on Government Street within 24 hours of a rain event contained

Enterococcus levels above 10,000 MPN/100 mL on falling tides but about 2000 MPN/100 mL on rising tides (Fig 13). Possible explanations for this are that the source of the *Enterococcus* was further upgradient or Pensacola Bay water diluted the source or both. The opposite patterns occurred on Intendencia and Garden streets with 24 hours of a rain event. On Intendencia Street, *Enterococcus* levels were highest during a rising tide, about 2000 MPN/100 mL, while those on falling tides were lower, about 700 MPN/100 mL (Fig 13). In contrast, 4 days after rain events, levels were similar, less than 100 MPN/100 mL on both tides.

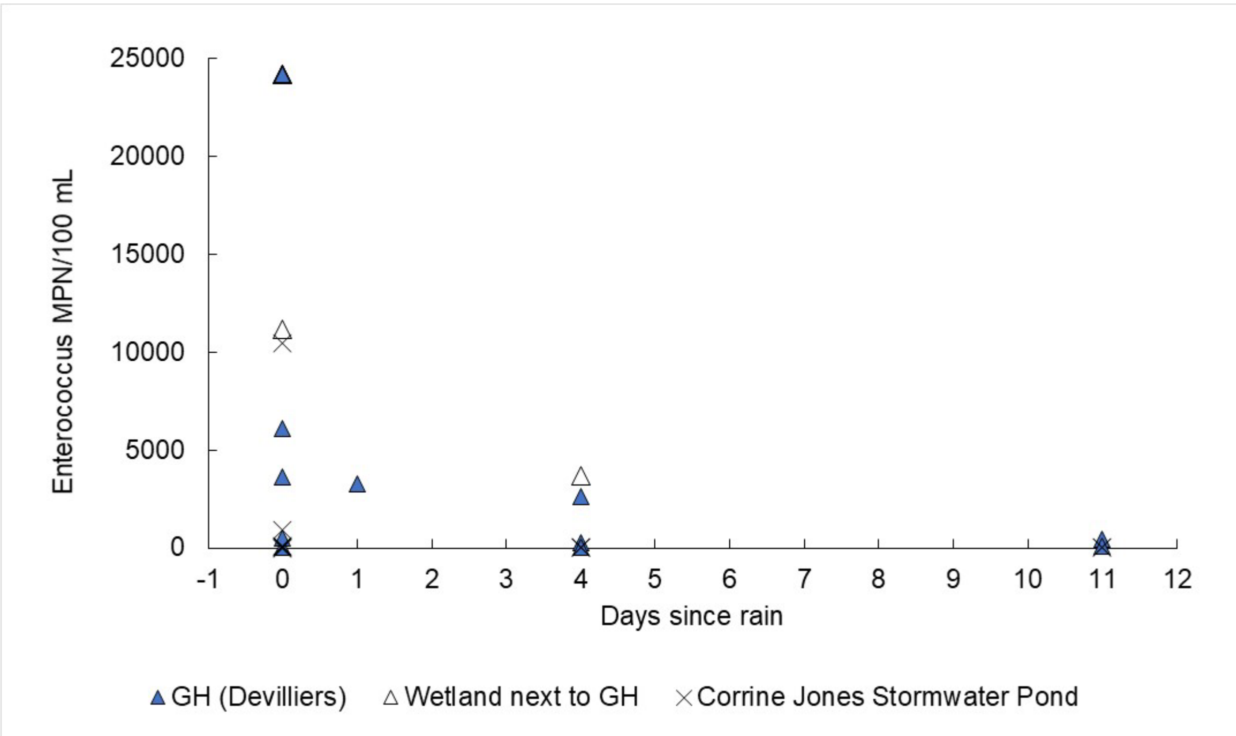


Figure 11 - *Enterococcus* (MPN/100 mL) at sites GH on DeVilliers, Wetland next to GH and Corrine Jones stormwater pond versus days since rain.

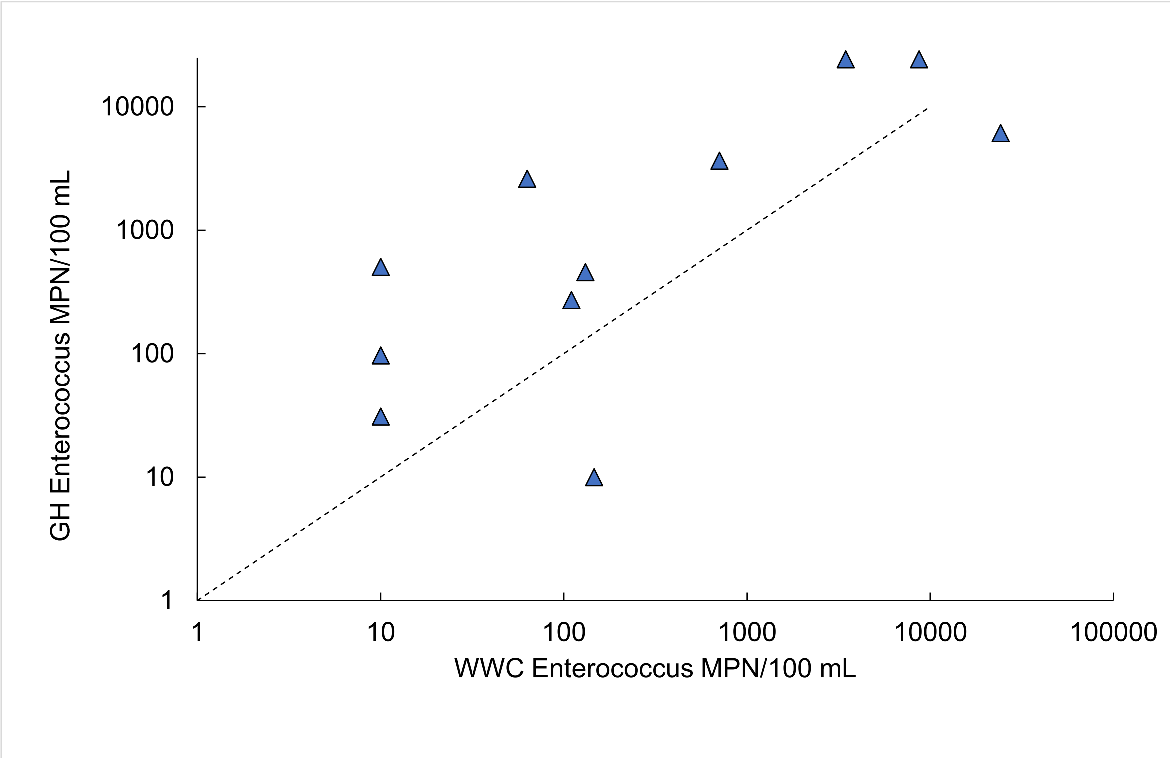


Figure 12 - *Enterococcus* at Washerwoman Creek (WWC - x axis) versus at GH site (y axis). Dotted line is 1:1 line.

This study reports *Enterococcus* values in stormwater inlets in downtown Pensacola and six locations above ground (GH, wetland next to GH, Corrine Jones, and the three Bruce Beach sites). The assay used is specific for culturable *Enterococcus* bacteria. This is the bacterial indicator recommended by the U.S. EPA for marine and freshwaters (U.S. EPA 2012). The public is rarely exposed to stormwater while it is in the pipes, except during extreme flooding events. However, at some locations like the Tanyard neighborhood (DeVilliers and Government), stormwater is not confined to stormwater drains and emerges from underground (Murphy 2019). We show that residents in this region can be exposed to in stormwater with high *Enterococcus* levels. In additions, levels can also be above the Florida Department of Healthy Beach Action Value standard at Bruce Beach where Washerwoman Creek emerges before entering Pensacola Bay. As Snyder (2006) observed in the urban bayous, our data showed that *Enterococcus* increased with increasing rainfall. This relationship was strongest at the three Bruce Beach sites and Corrine Jones.

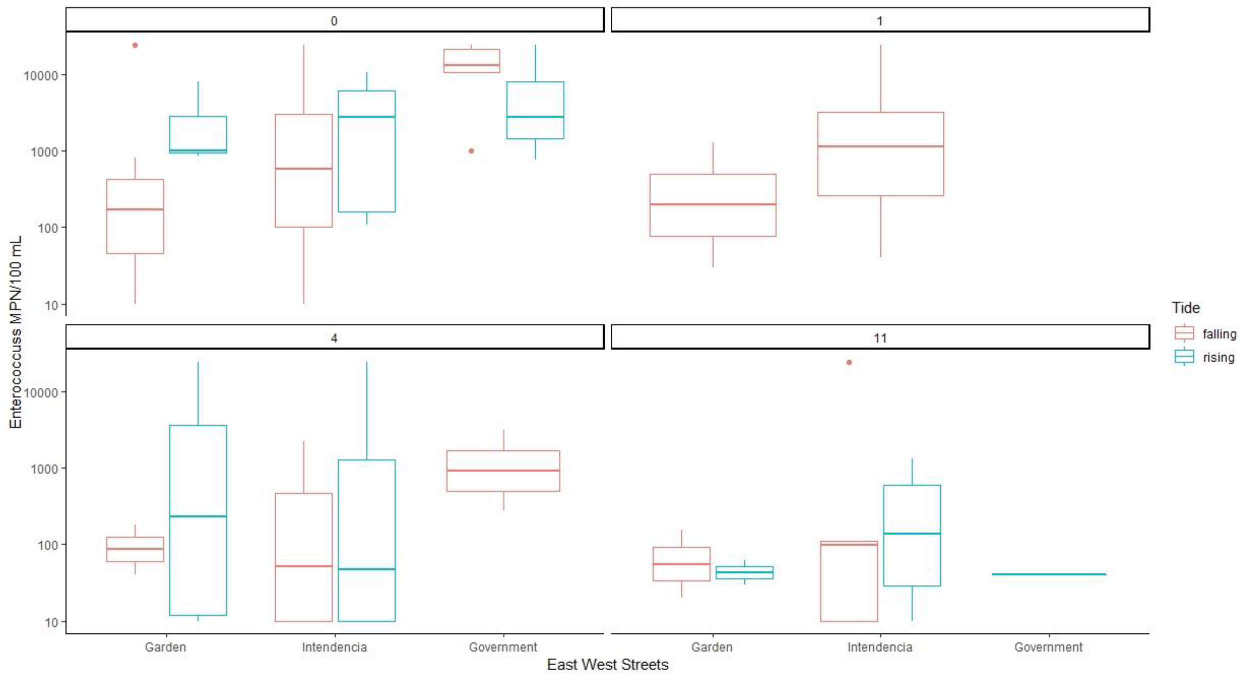


Figure 13 - Box plot of *Enterococcus* at sites located along Garden, Intendencia and Government Streets. Colors indicate whether water levels in Pensacola Bay were rising (blue) or falling (red) during the morning sample collection. Top left panel – precipitation within last 24 hours. Top right panel – 24 hours since last precipitation event. Bottom left panel – 4 days since last precipitation event. Bottom right panel – 11 days since last precipitation event. Note y axis is log scale.

Recommendations and Next Steps

With the new and continuing development in downtown Pensacola, increased rainfall and sea level rise, flooding will disproportionately affect low-lying areas like the Tanyard neighborhood. This will increase the potential exposure of residents and visitors in areas where stormwater reaches the surface. We suggest the following next steps to improve conditions in this area.

- The locations with the consistent and highest *Enterococcus* levels (e.g., Reus and Zarragossa, DeVillers) should be the highest priority for identifying the exact source of high *Enterococcus* levels. Further studies with City of Pensacola and ECUA engineers will be needed to track down the source of these fecal indicator bacteria.
- Improve infrastructure to minimize public exposure to potential pathogens.
    a. Minimize infiltration into stormwater pipes as is currently happening where mortar is missing or cracked

b. Add bathrooms at Bruce Beach to prevent local sources of human waste at the park
c. Reconfigure stormwater outfalls into Pensacola Bay to minimize intrusion of bay water into drains.

Acknowledgements

We thank the many undergraduate and graduate students who assisted in the field sampling for this project and the earlier Bruce Beach study. They are Shay Harvin, Julianna O'Bar, Hope Ebert, Jessica Marquis, Maisha Epps, David Kawula, Joel Lukens. We thank Jeremy Bosso and John Harmuth for *Enterococcus* analyses. We thank Brad Hinote (City Engineer), Roger Williams (Stormwater Engineer) for his coordination between us and his staff, Miriam Woods for GIS maps of the study sites, City of Pensacola workers Chris Johnson, Sean Gray, Roy Trawick, Walter Benjamin, Jonathan Laborde and John Buskey for their help rain or shine. We thank Wendy Gavin, (ECUA Wastewater Infrastructure Engineer), and David Forte (Deputy City Administrator for City of Pensacola) for organizing this effort. And lastly, we thank Councilwoman Anne Hill for her support for this project as well as the earlier Bruce Beach Study, and the Paddling Trail Study. This study was funded by the City of Pensacola. Support was also provided by CEDB.

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Appendices

Appendix 1 – *Enterococcus* values (MPN/100 mL) between August 31, 2021 and February 3, 2022.

Appendix 2 – Beazley Report

Appendix 3 – Nienhuis Report

Appendix 4 – Murphy Report

Appendix 5 - GIS maps and photographs of each sampling location

Appendix 1 – *Enterococcus* values (MPN/100 mL) between August 31, 2021 and February 3, 2022.

Date	8/31 2021	9/7 2021	9/14 2021	9/16 2021	10/5 2021	10/12 2021	10/19 2021	11/9 2021	11/16 2021	11/23 2021	12/7 2021	1/18 2022	2/3 2022
Spring and Chase	243	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Spring and Garden SCI (NW)	31	10	10	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Spring and Garden (SW)	n.d.	2,603	813	52	860	41	63	n.d.	10	n.d.	n.d.	n.d.	n.d.
Spring and Romana	19,863	n.d.	441	305	5,172	368	988	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Spring and Intendencia	n.d.	n.d.	52	243	160	10	10	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Spring and Government	n.d.	n.d.	1,012	n.d.	759	275	41	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Spring and Main	n.d.	n.d.	n.d.	n.d.	n.d.	97	31	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Reus and Gregory	839	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Reus and Garden	759	4,106	223	n.d.	1,014	181	30	154	24,196	41	73	1,292	171
Reus and Intendencia (NW)	6,131	181	5,475	2,489	2,723	2,247	1,334	24,196	24,196	752	489	1,130	585
Reus and Intendencia (SW)	379	n.d.	n.d.	24,196	n.d.	n.d.	n.d.	110	n.d.	n.d.	n.d.	n.d.	n.d.
Reus and Intendencia (NE)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	10	n.d.	n.d.
Reus and Intendencia (SE)	n.d.	2,481	n.d.	4,884	108	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Government and Reus (mid street)	n.d.	n.d.	n.d.	10,462	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Government between Reus & Devillers	n.d.	n.d.	n.d.	15,531	2,755	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Reus and Zarragossa	24,196	14136	24,196	24,196	24,196	24,196	24,196	24,196	24,196	24,196	24,196	193	2,613
GH - Private Residence	24,196	2,613	24,196	24,196	6,131	272	457	97	31	10	504	3,255	3,654
Wetland Next to GH	n.d.	n.d.	24,196	24,196	24,196	3,706	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	11,199

Appendix Table 1 continued													
Date	8/31 2021	9/7 2021	9/14 2021	9/16 2021	10/5 2021	10/12 2021	10/19 2021	11/9 2021	11/16 2021	11/23 2021	12/7 2021	1/18 2022	2/3 2022
Coyle and Garden	241	20	n.d.	n.d.	8,164	n.d.	n.d.	20	n.d.	n.d.	n.d.	30	n.d.
Coyle and Romana (SW)	24,196	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	24,196	31	n.d.	n.d.	24,196	n.d.
Coyle and Romana (NW)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	10	10	10	10	10	63
Coyle and Romana (NE)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	10	10	10	10	10	30
Coyle and Intendencia (NW)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	10	10	860	857	263	187
Coyle and Intendencia (SW)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	10	96	1,597	41	839
Coyle and Intendencia (NE)	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	72	24,196	107	24,196	238
Corrine Jones Stormwater Pond	933	10	86	n.d.	10,462	10	41	10	10	10	10		98
Bruce Beach Washerwoman Creek	8,664	63	3,448		24,196	110	131	10	10	146	10		706
Bruce Beach Sandy Shoreline	9,208	10	435	n.d.	5,794	10	10	10	20	10	63	n.d.	n.d.
Bruce Beach Mitigation Wetland	4,160	10	122	n.d.	3,076	41	31	20	10	10	122	n.d.	n.d.

Appendix 2 – Beazley Report

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Orlando, FL 32816
407-823-2171; cell: 678-371-8693

UNIVERSITY OF CENTRAL FLORIDA

12/22/21

Pensacola Stormwater Microbial Source Tracking and Metal Analysis Preliminary Report 2021

Prepared For: Pensacola, Florida AGU Thriving Earth Exchange Project
Gloria G. Horning, Ph.D.

Prepared by: Beazley Research Laboratory
Melanie J. Beazley, Ph.D.

This report provides a preliminary summary of stormwater analyses performed by the Beazley Research Laboratory at the University of Central Florida for the Pensacola, Florida AGU Thriving Earth Exchange Project to analyze Pensacola area stormwater runoff for microbial fecal sources and metal concentration.

Microbial Source Tracking

Pathogenic bacteria released from the fecal material of humans and animals cause illness and pose major health hazards when present in drinking water. Fecal bacteria enter natural waters through leaky septic systems, urban runoff that carries human and animal waste, and runoff from agricultural and farm systems. Distinguishing the source of fecal bacteria is important for developing strategies for mitigation of these contaminants.

Microbial source tracking (MST) studies are used to distinguish the source of fecal material (i.e., human or animal). Certain bacterial strains are associated with the fecal material of particular host organisms and can be analyzed using genotypic markers. *Escherichia coli* (*E. coli*) is typically used as a primary indicator of fecal contamination in water. *E. coli*, however, is ubiquitous among all organisms and cannot be attributed to a specific host source. Microbial source tracking identifies specific bacteria that are associated with the fecal material of certain animals, e.g., human, dog, avian, and rumen.

Metal Analysis

Stormwater runoff containing toxic heavy metals is a concern for public health and can create environmental hazards. Typical metals of concern include cadmium (Cd), copper (Cu), nickel (Ni), lead (Pb), chromium (Cr), zinc (Zn), and arsenic (As).

The primary goal of this preliminary study was to analyze Pensacola stormwater samples using genetic biomarkers specific to the fecal material of human, dog, and bird. Heavy metal analysis was also performed.

Sample Collection and Processing

Stormwater samples (~ 1 L) were collected by the Panhandle Watershed Alliance in Pensacola, Florida on November 9, 2021 and shipped overnight on dry ice to the Beazley Research Laboratory at the University of Central Florida. Two samples were received by 11:00 am on November 10, 2021 and were labeled "GH - 1051" and "Reus + Zarragossa - 1059" (Fig. 1).

Samples were immediately filtered on a sterile 0.2 µm filter and the filter stored at -80°C prior to DNA extraction. Samples were visually distinct as GH was fairly clear with low debris and Reus+Zarragossa contained high color and debris (Fig.2).

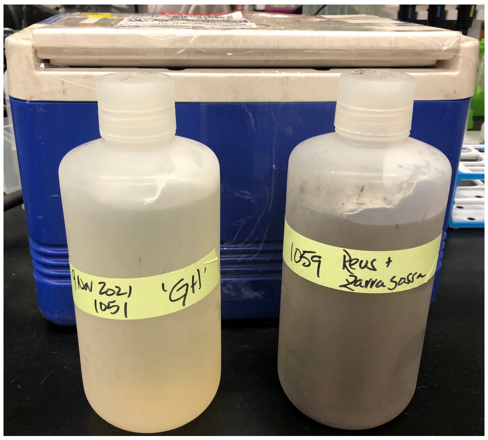


Figure 2. Stormwater samples received on 11/10/21

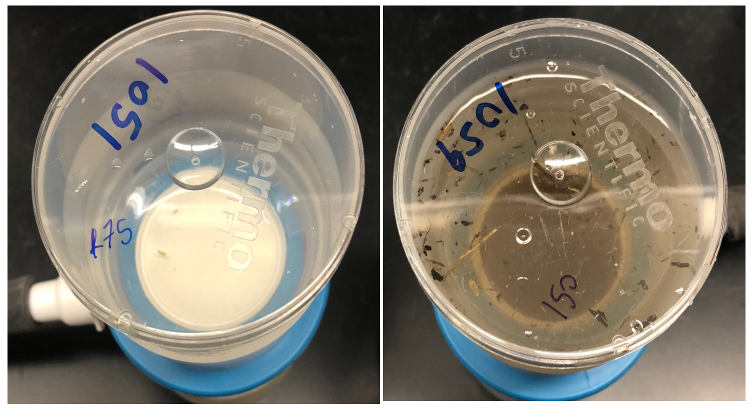


Figure 1. Filtered samples GH-1051 (left) and Reus/Zarragossa-1059 (right)

DNA was extracted from water filters using established methods and amplified by qPCR using genetic biomarkers specific to human, dog, and bird. Quantitative results are reported in gene copies per 100 mL of stormwater. All reactions were performed in triplicate including positive controls, method blanks, and no-template controls.

Sample filtrates were collected and analyzed by inductively coupled plasma mass spectrometry (ICP-MS) for metal analysis.

Results

Microbial Source Tracking

Sample Site	Human	Dog	Bird
GH - 1051	1,255	Not detected	Not detected
Reus + Zarragossa - 1059	794	Not detected	Not detected

Units = gene copies/100 mL of stormwater
Limits of detection (copies/100 mL): human - 0.022; dog - 0.022; bird - 0.022

Metal concentrations reported in µg/L units (parts per billion or ppb). All samples run in duplicate with %RSD < 5%. BD = below detection; ND = not detected

Metal	GH-1051 (ppb)	Reus + Zarragossa (ppb)	National Drinking Water Standard* (ppb)
Aluminum (Al)	13.6	26.2	50 to 200
Arsenic (As)	3.53	2.83	10
Barium (Ba)	98.3	29.7	2
Cadmium (Cd)	BD	BD	5
Calcium (Ca)	3952	3594	N/A
Chromium (Cr)	0.42	0.49	100
Cobalt (Co)	BD	BD	N/A
Copper (Cu)	4.93	ND	1000
Iron (Fe)	37.6	158	300
Lead (Pb)	6.86	1.10	15
Magnesium (Mg)	7216	5035	N/A
Manganese (Mn)	2.36	23.0	50
Nickel (Ni)	1.60	0.30	N/A
Phosphorus (P)	269	121	N/A
Strontium (Sr)	141	123	N/A
Vanadium (V)	0.78	1.45	N/A
Zinc (Zn)	ND	ND	5000

* National Primary and Secondary Drinking Water Regulations (for public water systems). N/A indicates there are no drinking water regulations for that metal.

Prepared by:

Melanie J. Beazley, Ph.D.
Beazley Research Laboratory

Appendix 3 – Nienhuis Report

Assessing Flooding and Hydrodynamics for Community Preparedness and Revitalization in the historic Tanyard neighbourhood, Pensacola, Florida

Jaap Nienhuis, Florida State University, Tallahassee, FL

Problem assessment

The historic neighborhood in Pensacola is frequently flooded. The neighborhood is a historic district that was inhabited long before development of modern storm drainage. That makes it unlikely the Tanyard originally experienced the frequency and intensity of flooding it does now. It is currently a FEMA Flood Hazard Area.

Residents report flooding is caused by intense rainfall. An assessment by NOAA indicates that sea-level rise is unlikely to independently cause flooding in downtown Pensacola (Fig. 1). Similarly, Tanyard flooding during tropical cyclones are more likely caused by extreme rainfall than storm surge, based on predictions from NOAA (Fig. 2).

Frequent summer rains overflow the storm drains. Sewer overflows have also been observed during storms, likely caused by storm water inflow into the sanitary sewer system through illicit connections.

Tanyard flooding is worsened during high tides in the Pensacola Bay. This makes flooding likely caused by a combination of insufficient storm drain capacity into Pensacola Bay (e.g. pipe diameter) as well as insufficient water level head in a gravity driven system (e.g. grades of the pipes).

Future change

It is important to note that Tanyard flooding will be exacerbated by sea-level rise. Even though assessments by NOAA indicate that sea-level rise or storm surge induced flooding is not a major concern by itself, elevated sea-level will worsen the Tanyard flooding because rainfall will not be able to drain into Pensacola Bay. Additionally, climate change will lead to an increase in the intensity and occurrence of extreme rainfall events.

Effectiveness of the Government Street Regional Stormwater Pond

As a potential solution to flooding in the Tanyard, the city of Pensacola developed the Government Street Regional Stormwater Pond at Corrine Jones Park. However, reports from residents indicate the retention pond has not been able to overcome flooding and that the retention pond does not drain sufficiently in between storm events.

Analysis of the engineering drawings of the retention pond show that a large part of the Tanyard neighborhood, mostly east of Coyle Street and south of Intendencia, continues to drain to the existing 84” storm pipes rather than being connected to the retention pond (see drawing attached). This part of the neighborhood continues to drain south into the Bay through existing storm drains, with insufficient grade or diameter to accommodate the flow during storms.

Potential solutions

A proposed check valve between the bay and the storm drain is unlikely to be a solution because the flooding is not caused by high tide, but by rainfall during high tide. Preventing the inflow of Bay water into the storm drain would not increase outflow during storms.

Potential solutions are the installation of pumps, the expansion of retention ponds that can drain to bay under sufficient grade (potentially during low tide) and/or the elimination of illicit connections to prevent storm water inflow into the sanitary sewer.

Future plans

The analysis can be greatly improved through more accurate mapping of the flood extent during storms, ideally accompanied by measures of rainfall intensity and tidal conditions in the Bay.

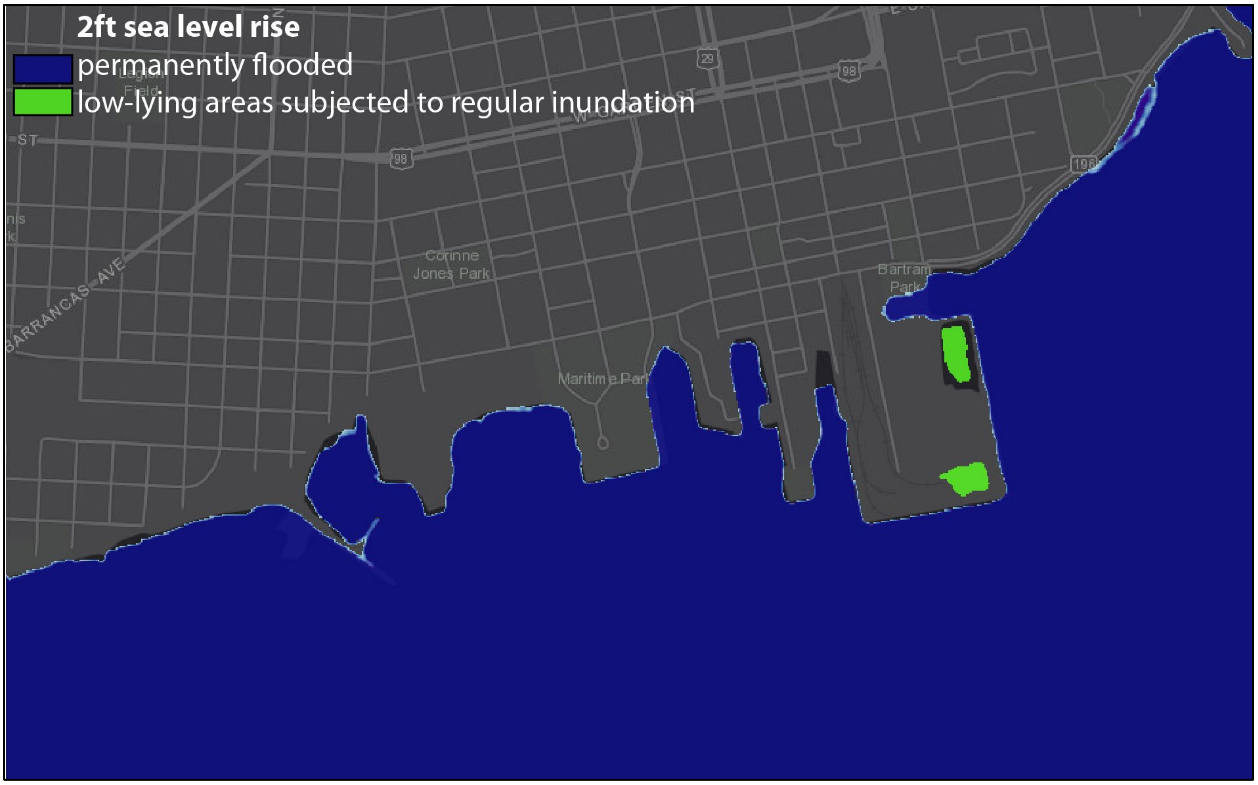


Figure 1. NOAA Assessment of sea-level rise hazards to downtown Pensacola and the Tanyard neighborhood, subjected to 2 ft (likely by 2100AD) sea level rise. Retrieved from: https://coast.noaa.gov/slr

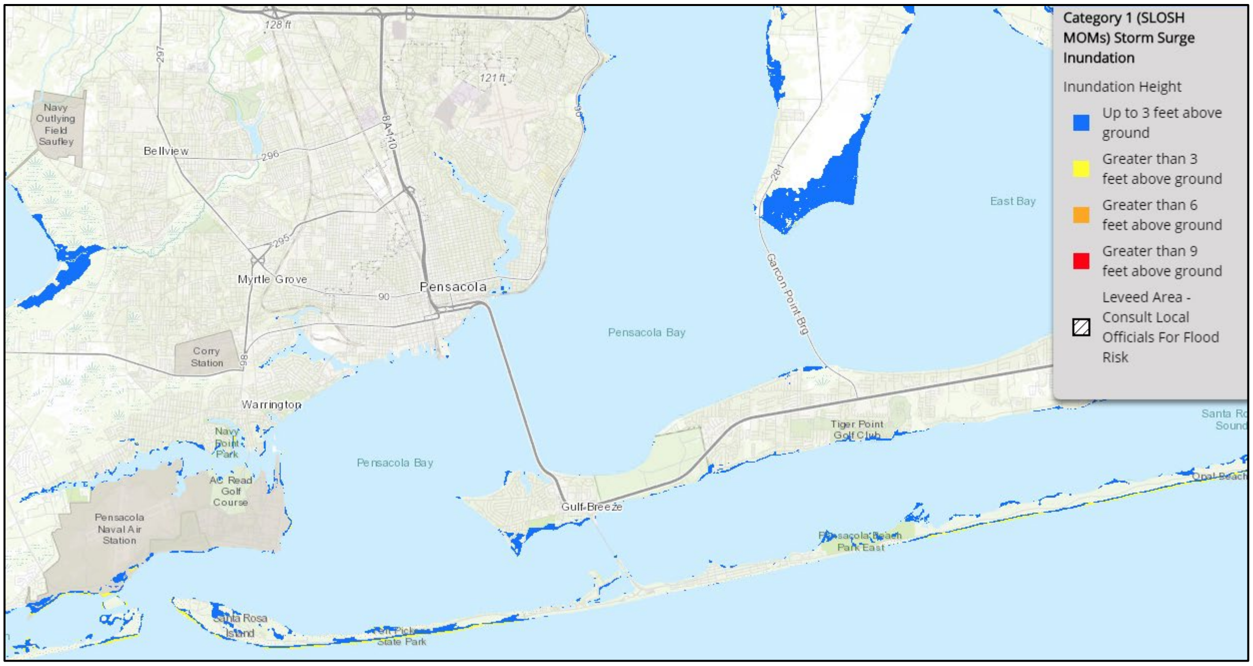
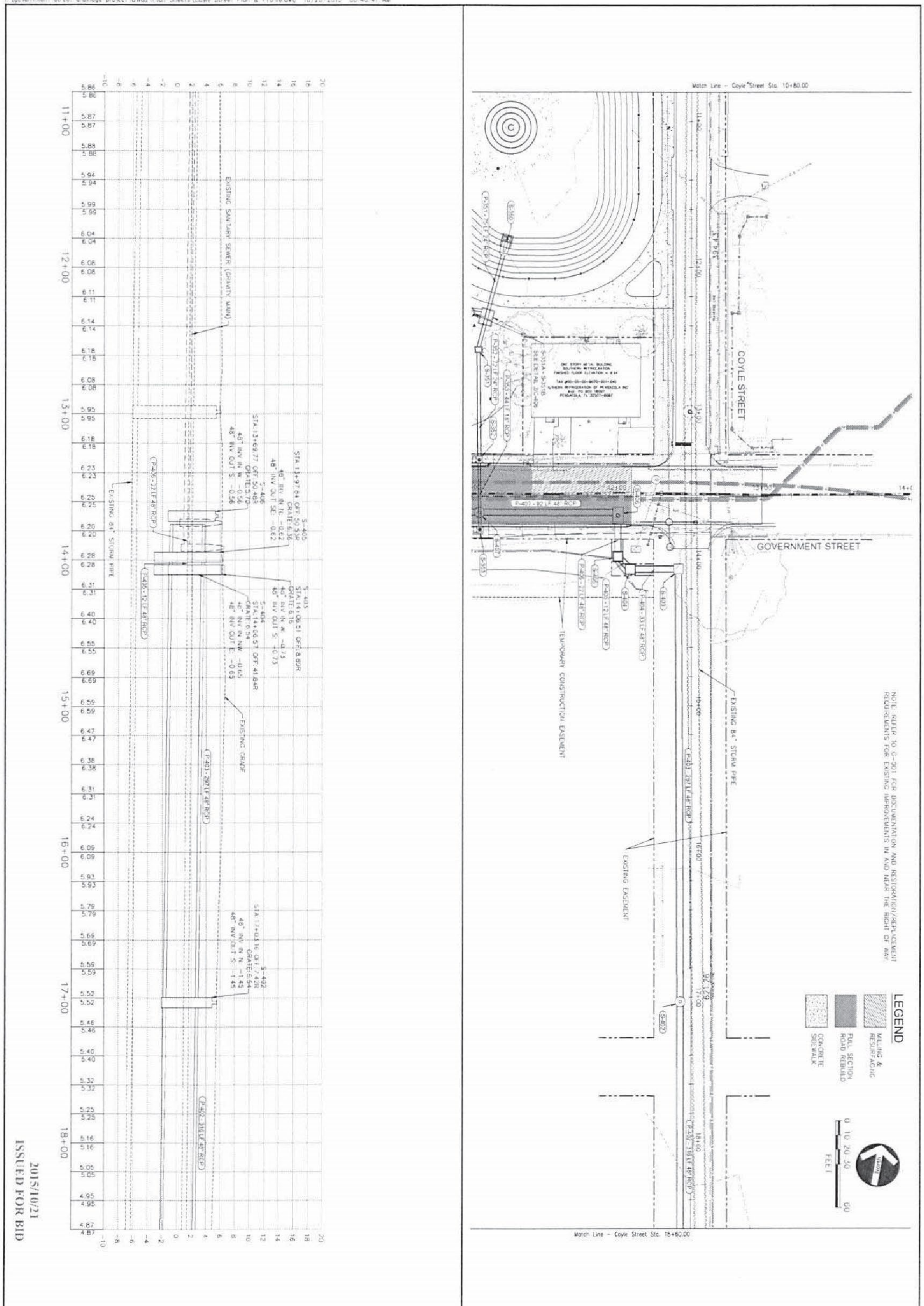


Figure 2. Maximum storm surge inundation in Pensacola estimated for cat. 1 hurricane winds. Retrieved from: https://www.nhc.noaa.gov/nationalsurge/

Resources:

1. Climate change leads to more extreme weather
   https://nca2014.globalchange.gov/highlights/report-findings/extreme-weather
2. Precipitation Extremes Under Climate Change
   O'Gorman, P.A. Curr Clim Change Rep (2015) 1: 49. https://doi.org/10.1007/s40641-015-0009-3
3. FEMA Floodmaps
   https://msc.fema.gov/portal/home
4. Historic map of downtown Pensacola
   http://wp.studeri.org/2014/10/helping-washerwomans-creek-find-daylight/



ATKINS

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PENSACOLA, FLORIDA 32504
PHONE NO. 850.478.9844
CERTIFICATE OF AUTHORIZATION NO. 24

GOVERNMENT STREET
REGIONAL STORMWATER POND
AT CORINNE JONES PARK

COYLE STREET
PLAN & PROFILE

C-151

Appendix 4 – Murphy Report

Honorable Grover Robinson IV
Mayor of Pensacola
222 W Main Street
Pensacola, FL 32502
January 9, 2019

Dear Mayor Robinson,

As we discussed earlier, I did evaluate the property and flooding problem stemming from Dr. Gloria Horning's home. Although I have been to the property several times, I have never formaly addressed the stormwater and or flooding there during the previous administration.

I am sending you a report on my findings based on my experience, and previous calls to this property. I wanted to you to have it before your visit to the property. Please feel free to contact me if you have any questions concerning this report.

Flood Elevation Tracts:

Looking at FEMA flood maps, I categorized three main areas; North of Garden Street, North of Main Street, and South of Main Street.

FEMA designates flood zones through authority from Congress to determine flood insurance needs and to discourage urban planners from developing properties in floodplains without using best practices. A hydraulic analysis from FEMA determines the *Base Flood Elevation,* (BFE) which determines predicted flood elevation above mean sea level. BFE is designated to each tract within a flood zone to be the level of the first habitable floor above the flood elevation.

Tracts North of Garden Street are not considered to be in a FEMA flood zone. Tracts South of Garden to Main Street are in the AE Flood Zone with a BFE of 7 feet. Tracts South of Main Street combine AE and VE Flood Zones with BFE's between 9 and up to 11 feet. FEMA advises development after 1968 to abide by the Federal Disaster Protection Act by building the first habitable floor above the BFE.

City of Pensacola Ordinance states for both flood zones AE and VE, that.. "*all new construction or substantial improvement to any residential building…shall have the lowest floor, including basement, elevated to no lower than three (3) feet* ***above*** *Base Flood Elevation Level.* [12-10-1] City Code. Additionally, this also includes commercial, industrial and non-residential buildings.

Dry Weather Flooding

With low water tables and and a diurnal tidal system, stormwater outfall(s) located in VE High Coastal Flood Zones receive tidal influence, which draws water into the stormwater inlets along communities just north of Main Street. During ***any*** rain events especially around high tide, flooding is exacerbated along many streets perpandicular to Main, including Ruess, DeVilliers and Clubbs, making transportation impassable.

During dry periods, tidal influence continues to fill stormwater inlets, reducing the capacity to drain water. On top of this, ECUA has been Dewatering to the inlets adding even more water to a system that cannot handle basic rain events. The Dewatering has also created illicit discharges, such as sand and gravel from this operation to the inlets due to poor perimiter controls on nearby construction sites. Here is a picture below:

Grade:

Dr. Horning's property lies in a depression due to a grade differential in each direction from her property. The amount of sheet flow increased from the property south of Main when it was raised to the FEMA BFE, increased by Three (3) feet and allowed to utilize fill for structural support to raise BFE without having to raise the structure itself to be placed on pilings for example. This created an elevation increase of up to 14-15 feet. However, it does state in the Land Development Code that as long as…"*the subject fill does not cause any adverse impacts to the structure onsite or **adjacent** structures."* Here is a photo below:

Dr. Horning's property is not necessarily adjacent, but is in close enough proximity to have created unnecessary stormwater south of Main Street.

Stormwater Infrastructure:

Zaragossa to Ruess and Government to Ruess contain no stormwater inlets. There are inlets located at DeVilliers and Zarragosa and the North side of Government and DeVilliers. These have been problematic for years due to tidal influence and ilicit discharges. Last year, I had to contact the City Public Works Department to have them vacuumed out. Half of a pickup truck bed was filled with an assortment of items that *mainly* consisted of contractor items. Several trees 12-18" and other assorted vegetation was also recovered growing inside the inlet due to an abundance of sedimentaion.

Many of the surrounding streets contain no curbs or ways to divert or infiltrate stormwater. Property owners there suffer due to receiving everyone else's stormwater drainage. I interviewed two additional residents there that reside close to Dr. Horning. One resident, Joe Behrend, at 320 W. Zarragossa (behind Dr. Horning's property) stated to me Monday that he has not been able to use his detached garage for months due to drainage issues. He's afraid that his vehicle will get stuck on the dirt driveway that leads to his garage. Here are some photos of curbless streets on Government Street and W. Zarragossa, East of DeVilliers:

There are several small tracts of land mainly owned by W Government LLC that fall west of the Union House Restaurant owned by Trustee of Sarah Groeger. These lots are currently vacant, but are used to dump landscape vegetation, compacting the soil even more so, which increases velocity of sheet flow to Dr. Horning's and Mr. Behrend's property. See photos below:

The Union House Restaurant creates a large amount of stormwater to properties west of it, including Dr. Horning's and Mr. Behrend's. For example, flat roofing with only a couple of downspouts generate an increase of volume and velocity of stormwater. Because the grade slopes west and the lots are compacted between the residents and this restaurant (not incuding low water tables *and* there is not enough stormwater infrastructure for the design and lot of this property), it is my opinion that this is part of the problem, which is an easy fix. Stormwater should be maintained and infiltrated just behind the restaurant, preventing the westward sheetflow movement through onsite attenuation or infiltration. I'm attaching photos below:

The first photo shows the driveway between the Union House Restaurant going towards Dr. Horning's and Mr. Behrend's property. This used to be W. Fort Rd and ran all the way through Clubbs Street.

The second photo shows the side of the building, also showing compaction of land, allowing increased volume and velocity of stormwater onto residents' property.

Fort Street W


FORT ST W
BLUE WAHOOS

Looking towards the Union House Restaurant from behind Mr. Behrend and Dr. Horning's residences. This is the avenue in which the water travels from the Union House westward.

ECUA:

The ECUA lift station has a dry detention pond on site at Government Street and DeVilliers. This pond is very shallow and tends to overflow during heavy rain or dewatering events to Government Street near DeVilliers from a cement "driveway" installed along the fence line, allowing stormwater to pass through. There is only one small grated inlet across the street from this pond, which is not capable of taking on that type of sheet flow. I would either recommend some type of weir device to divert overflow, evaluate the dry pond to see if there are impediments to stormwater infiltration or see if the pond is the right depth considering the change in frequency and intensity of rain and Dewatering events. Photos attached below:


ECUA Dry Detention Pond at the lift station on Government Street and DeVillers

Small Stormwater Grate Inlet on the corner of Government and DeVillers Streets.

i

The “Driveway” that encourages overflow to Government and DeViller’s Streets

Environmental Injustice:

Lastly, West Government Street towards the Corinne Jones Stormwater “Park” has several stormwater inlets for the new residential and *Gentrified* community. This is not available east of the pond where the underserved community resides. Many residents, such as 79 yr-old Hazel, Dr Horning and many others live with flooded properties, curbless streets and lack of sidewalks.

It comes across to the underserved community as though they aren’t important. Hazel was knocked down a year ago (while she stepped outside) from a UPS truck that came down her street after a rain event. The water that came off the tires was like a tidal wave. Luckily she was not seriously injured.

When I saw her Monday, She was trying to get her exercise in while pushing her walker. She was trying to cross DeVilliers, which was still wet and receiving run off from neighboring properties (dry day). Photos of the street below

Dry weather days in front of Dr. Horning's property

Just a block west, nice and numerous stormwater inlets. Dry Streets!
Located near Corinne Jones Stormwater Park, Government Street

Conclusion:

Dr. Horning and other residents need immediate relief. The temporary wall Dr. Horning built, but then removed proves the west stormwater transport theory. The Union House Restaurant was creating *some* of the problem. The FEMA Federal Protection Disaster Act of 1973 and the National Flood Insurance Act of 1968 created regulations including hydraulic analysis' to determine city planning and development using the BFE method. The City of Pensacola mandates three feet above BFE for new and restored development in flood zones AE and VE. We currently have properties using fill and other means *besides pilings* to meet the BFE qualifications in the Tanyards and Maritime Park areas. Developments under these circumstances are not to impede the full use of adjacent property owners and should have qualifying engineering studies on file. Stormwater infrastructure is either completely void or non-functioning in and around the Tanyards and City Hall community. This creates standing water, which interferes with safe transportation, property values and quality of life for those residents.

My temporary recommendations include another temporary wall, or graded driveway using gravel that meets the edge of the street along with a sump pump over on Old Stinky property, or re-evaluate the Union House property for proper stormwater controls. I feel that the Union House controls would also help give Mr. Behrend some relief.

Reducing compaction of the intermediate properties between the Union House and residents would also help reduce some volume and velocity of stormwater traveling from those properties as well.

Long-term solutions vary. They can include low impact development, curb and gutter, and reducing pervious development in flood zones as stated in the recommendations from the Climate Adaptation and Mitigation Task Force. Also, looking into re-evaluating the outfalls located in coastal areas with tidal influence and possible relocating them or closing them off and rerouting outfalls to safer ground less inundated to coastal influence, such as what the City of Naples accomplished.

Lastly, the City has a National Pollutant Discharge Elimination System (NPDES) Permit which has legal requirements to reduce flooding and illicit discharges to the Municiple Separate Stormwater Sewer System (MS4).

I would be happy to discuss this further if you would like. Immediate relief is seriously needed for these folks due to the length of time it's been sought after.

Thank You,
Laurie Murphy, CSI, CESCI

Appendix 5 – GIS maps and photographs of sampling locations

Corrine Jones Stormwater Pond

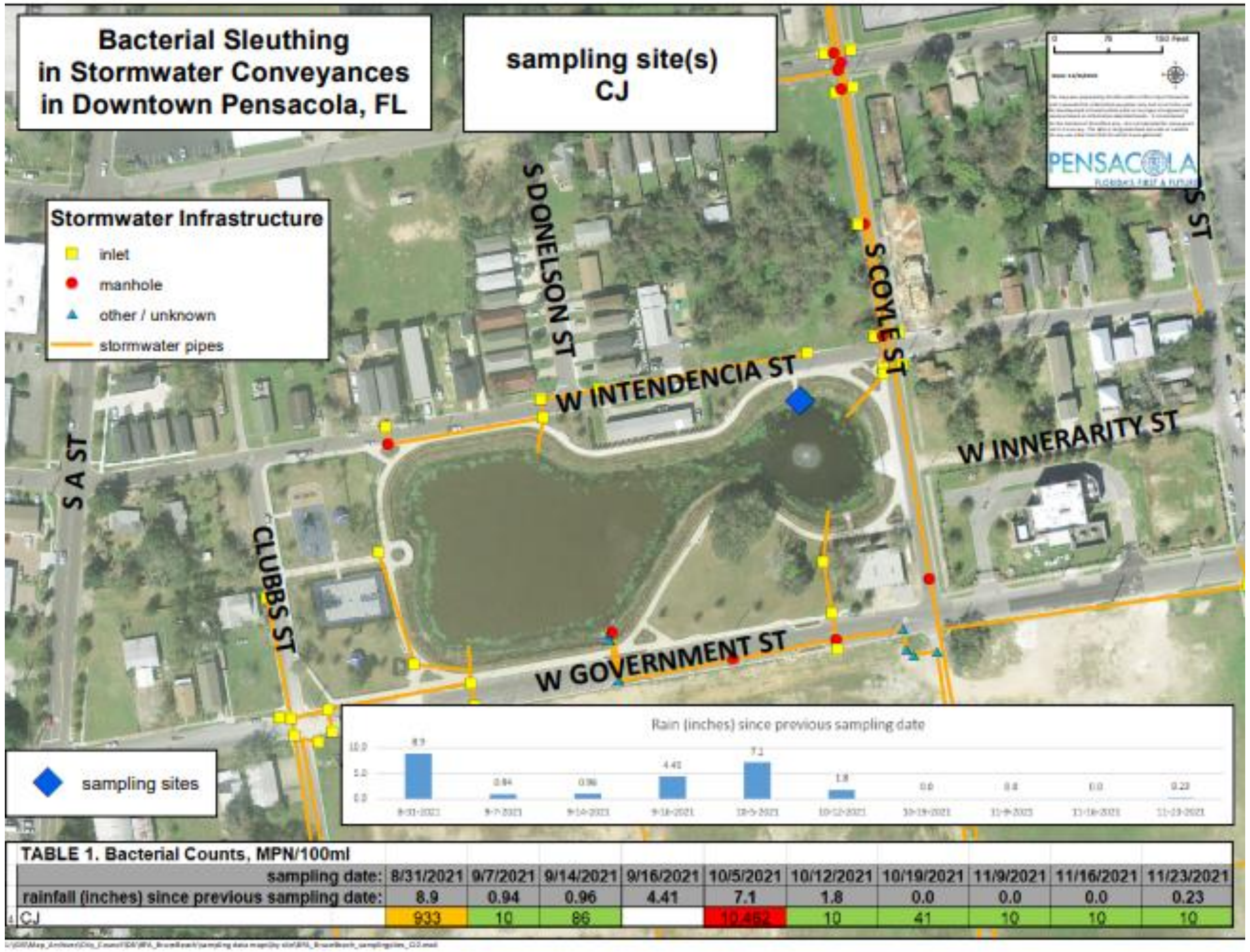


TABLE 1. Bacterial Counts, MPN/100ml

sampling date:	8/31/2021	9/7/2021	9/14/2021	9/16/2021	10/5/2021	10/12/2021	10/19/2021	11/9/2021	11/16/2021	11/23/2021
rainfall (inches) since previous sampling date:	8.9	0.94	0.96	4.41	7.1	1.8	0.0	0.0	0.0	0.23
CJ	933	10	86		10,462	10	41	10	10	10

Private Residence (GH) and Wetland next to GH

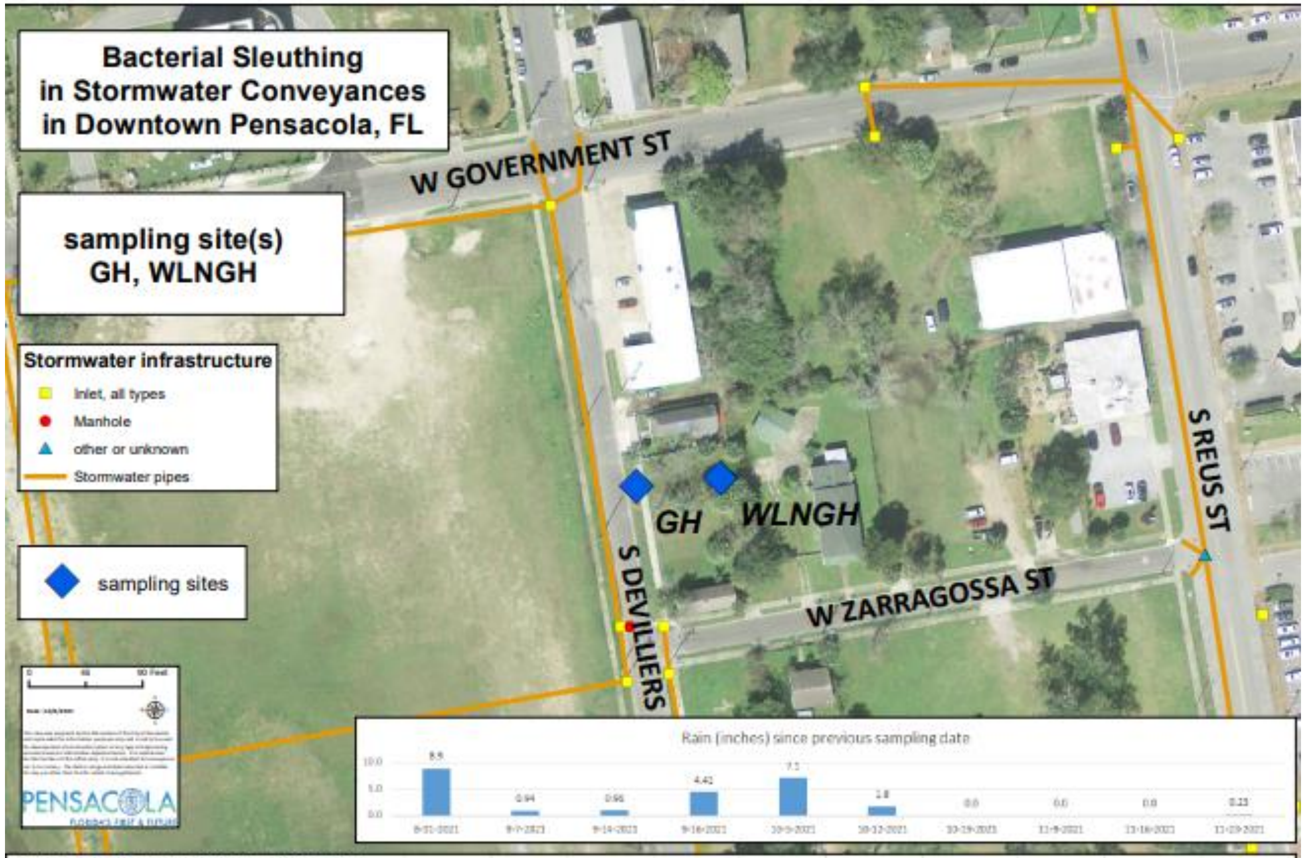


TABLE 1. Bacterial Counts, MPN/100ml										
sampling date:	8/31/2021	9/7/2021	9/14/2021	9/16/2021	10/5/2021	10/12/2021	10/19/2021	11/9/2021	11/16/2021	11/23/2021
rainfall (inches) since previous sampling date:	8.9	0.94	0.96	4.41	7.1	1.8	0.0	0.0	0.0	0.23
GH	> 24,196	2,613	> 24,196	> 24,196	6,131	272	457	97	31	10
WLNGH			> 24,196	> 24,196	24,196	3,076				

Diversity among Stormwater Inlets Sampled

Aged Infrastructure

Reus and Zarragossa

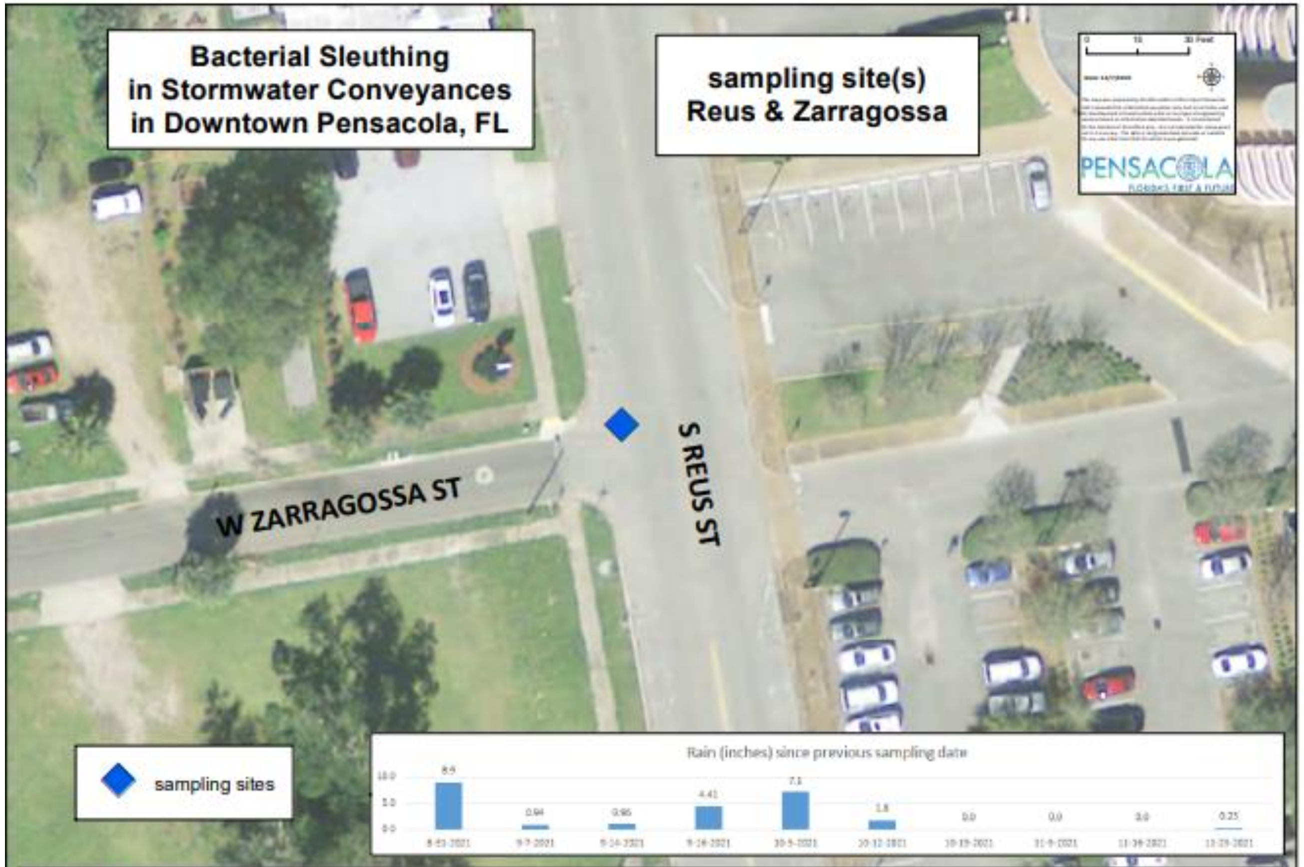


TABLE 1. Bacterial Counts, MPN/100ml										
sampling date:	8/31/2021	9/7/2021	9/14/2021	9/16/2021	10/5/2021	10/12/2021	10/19/2021	11/9/2021	11/16/2021	11/23/2021
rainfall (inches) since previous sampling date:	8.9	0.94	0.96	4.41	7.1	1.8	0.0	0.0	0.0	0.23
REUS & ZARRAGOSSA		14,136	> 24,196	> 24,196	24,196	> 24,196	> 24,196	> 24,196	> 24,196	> 24,196

Reus and Intendencia

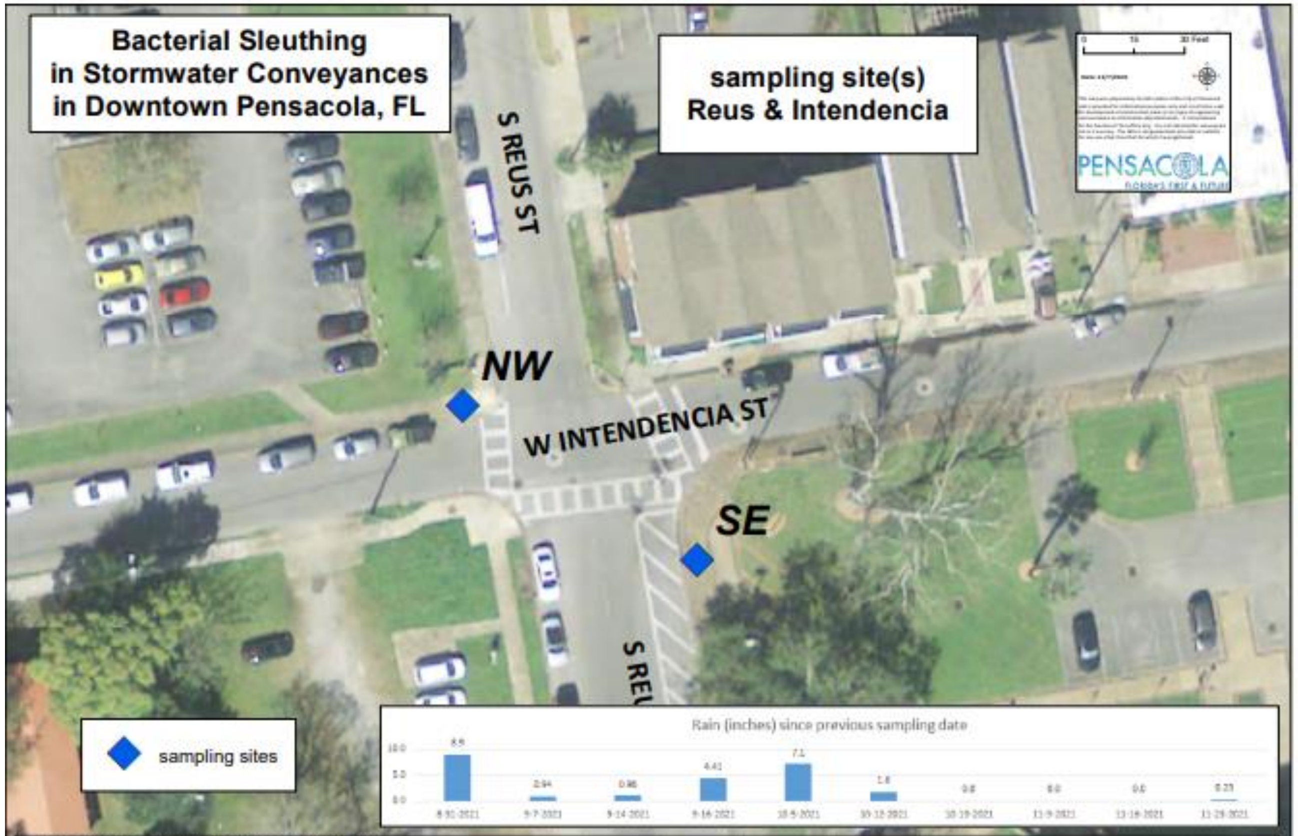


	TABLE 1. Bacterial Counts, MPN/100ml											
	sampling date:		8/31/2021	9/7/2021	9/14/2021	9/16/2021	10/5/2021	10/12/2021	10/19/2021	11/9/2021	11/16/2021	11/23/2021
	rainfall (inches) since previous sampling date:		8.9	0.94	0.96	4.41	7.1	1.8	0.0	0.0	0.0	0.23
18	REUS & INTENDENCIA	NW	6,131	181	5,475	2,489	2,723	2,247			> 24,196	752
19	REUS & INTENDENCIA	SE	379	2,481		4,884	108		1,334	> 24,196		

Reus and Garden

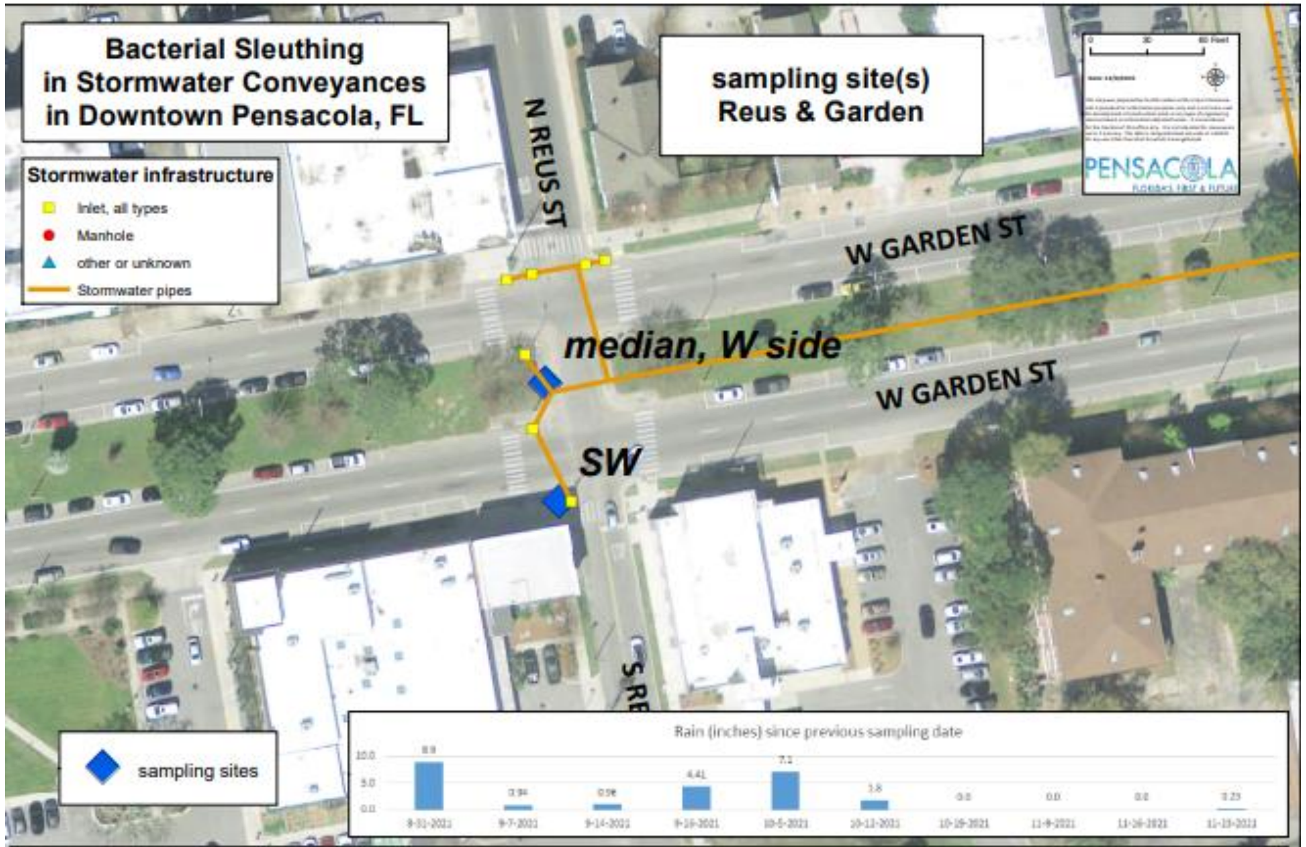


TABLE 1. Bacterial Counts, MPN/100ml

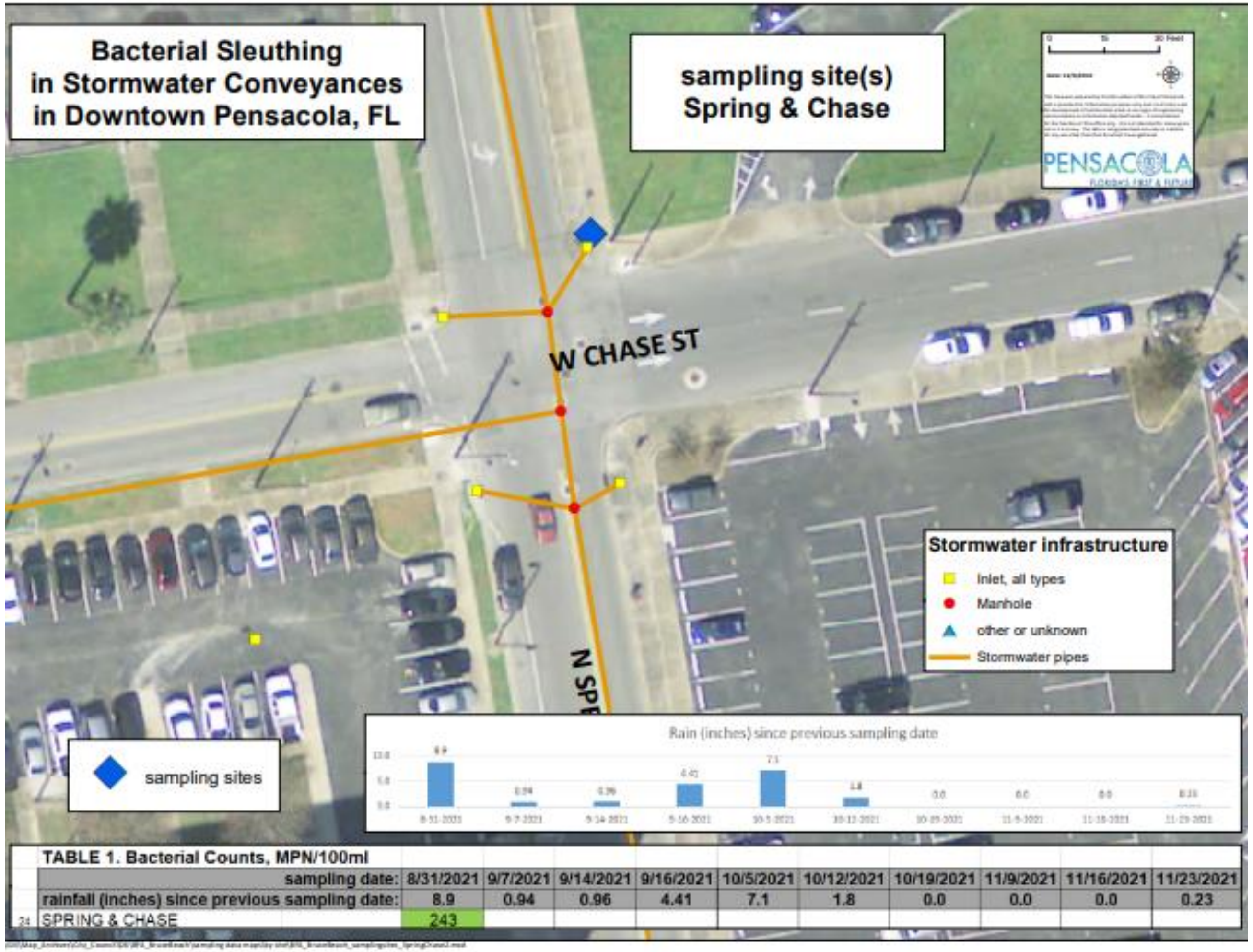
		sampling date:	8/31/2021	9/7/2021	9/14/2021	9/16/2021	10/5/2021	10/12/2021	10/19/2021	11/9/2021	11/16/2021	11/23/2021
	rainfall (inches) since previous sampling date:		8.9	0.94	0.96	4.41	7.1	1.8	0.0	0.0	0.0	0.23
16	REUS & GARDEN	SW					1,014					
17	REUS & GARDEN	median, W side	759	4,106	223			181	30		> 24,196	41

Government and Reus

TABLE 1. Bacterial Counts, MPN/100ml

		sampling date:	8/31/2021	9/7/2021	9/14/2021	9/16/2021	10/5/2021	10/12/2021	10/19/2021	11/9/2021	11/16/2021	11/23/2021
		rainfall (inches) since previous sampling date:	8.9	0.94	0.96	4.41	7.1	1.8	0.0	0.0	0.0	0.23
21	GOVERNMENT MB between Reus & DeVilliers	(NS)				10,462	2,755					
22	GOVERNMENT MB between Reus & DeVilliers	(SS)				15,531						

Spring and Chase



Spring and Garden

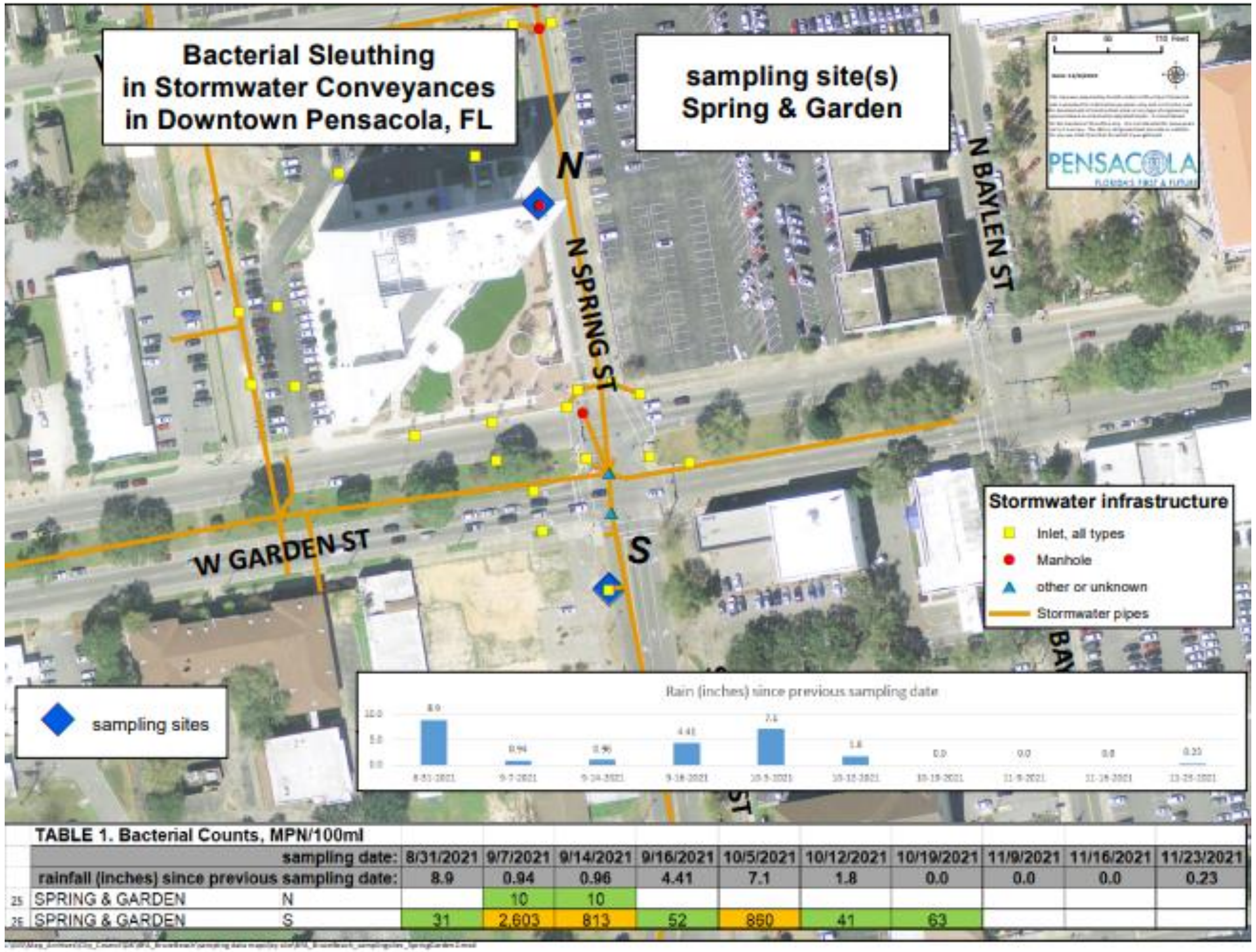


TABLE 1. Bacterial Counts, MPN/100ml

	sampling date:		8/31/2021	9/7/2021	9/14/2021	9/16/2021	10/5/2021	10/12/2021	10/19/2021	11/9/2021	11/16/2021	11/23/2021
	rainfall (inches) since previous sampling date:		8.9	0.94	0.96	4.41	7.1	1.8	0.0	0.0	0.0	0.23
25	SPRING & GARDEN	N		10	10							
26	SPRING & GARDEN	S	31	2,603	813	52	860	41	63			

Spring and Romana

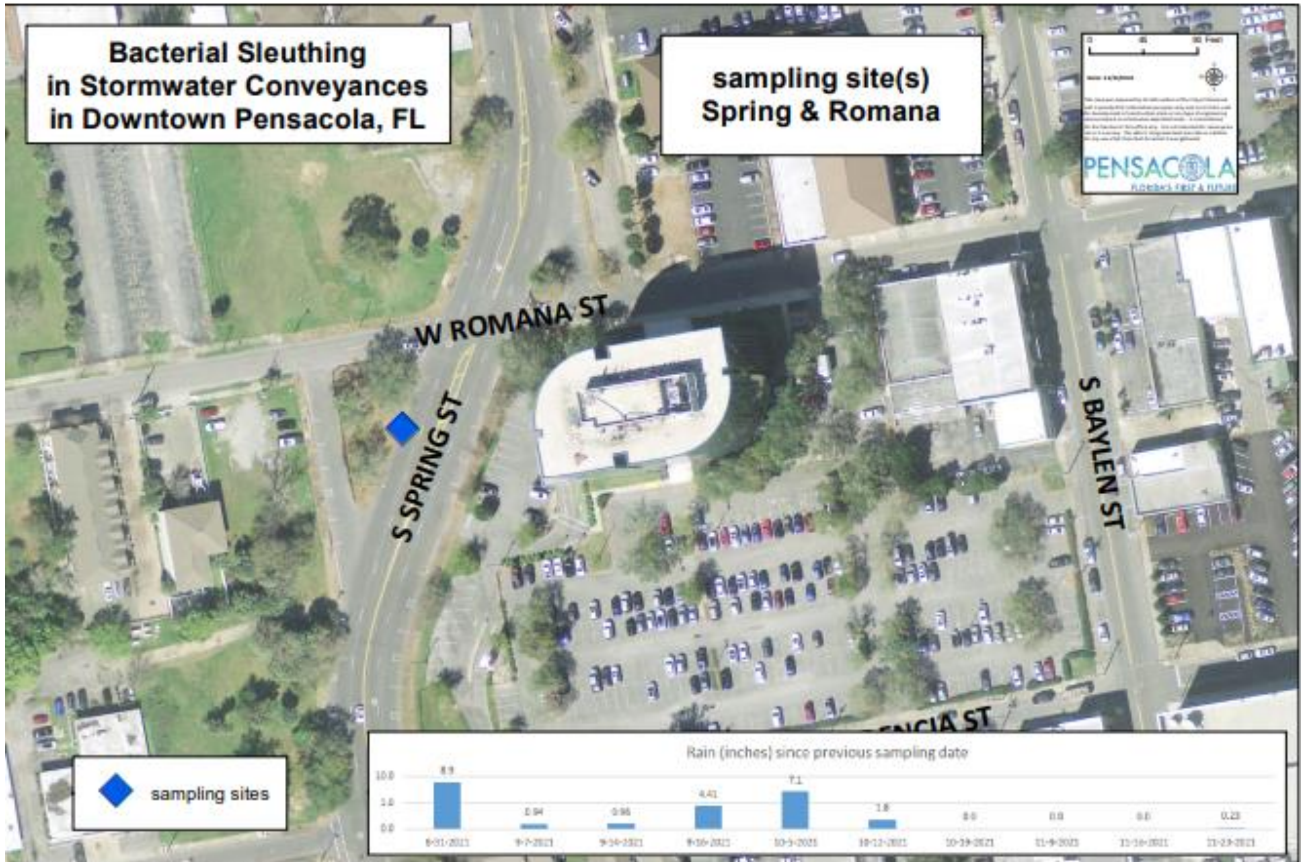
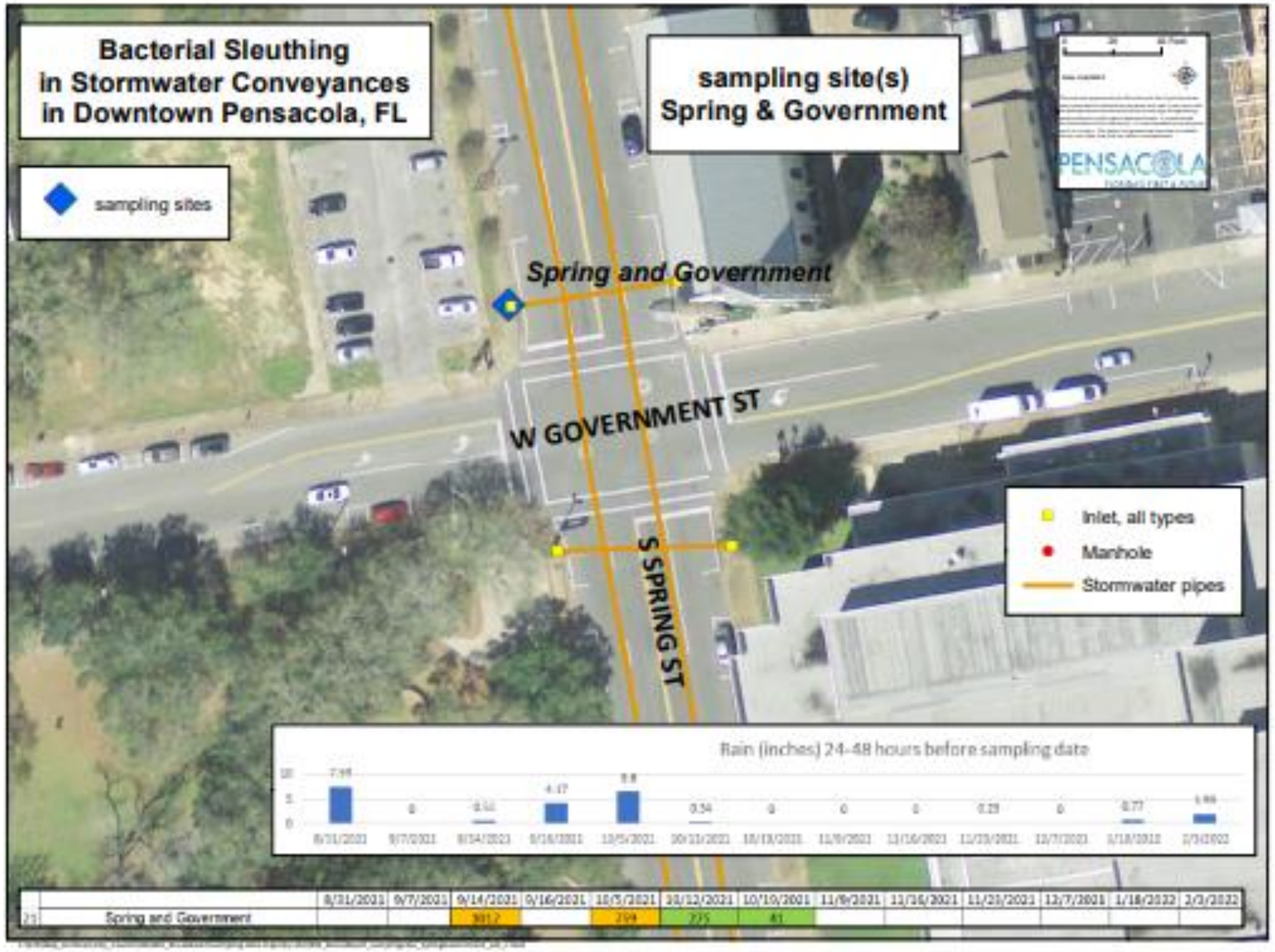


TABLE 1. Bacterial Counts, MPN/100ml										
sampling date:	8/31/2021	9/7/2021	9/14/2021	9/16/2021	10/5/2021	10/12/2021	10/19/2021	11/9/2021	11/16/2021	11/23/2021
rainfall (inches) since previous sampling date:	8.9	0.94	0.96	4.41	7.1	1.8	0.0	0.0	0.0	0.23
SPRING & ROMANA	19,863		441	305	6,172	368	988			

Spring and Intendencia

	TABLE 1. Bacterial Counts, MPN/100ml										
	sampling date:	8/31/2021	9/7/2021	9/14/2021	9/16/2021	10/5/2021	10/12/2021	10/19/2021	11/9/2021	11/16/2021	11/23/2021
	rainfall (inches) since previous sampling date:	8.9	0.94	0.96	4.41	7.1	1.8	0.0	0.0	0.0	0.23
29	SPRING & INTENDENCIA SW			52	243	160	10	10		10	

Spring and Government



Spring and Main

TABLE 1. Bacterial Counts, MPN/100ml										
sampling date:	8/31/2021	9/7/2021	9/14/2021	9/16/2021	10/5/2021	10/12/2021	10/19/2021	11/9/2021	11/16/2021	11/23/2021
rainfall (inches) since previous sampling date:	8.9	0.94	0.96	4.41	7.1	1.8	0.0	0.0	0.0	0.23
32 SPRING & MAIN						97	31			

Coyle and Garden

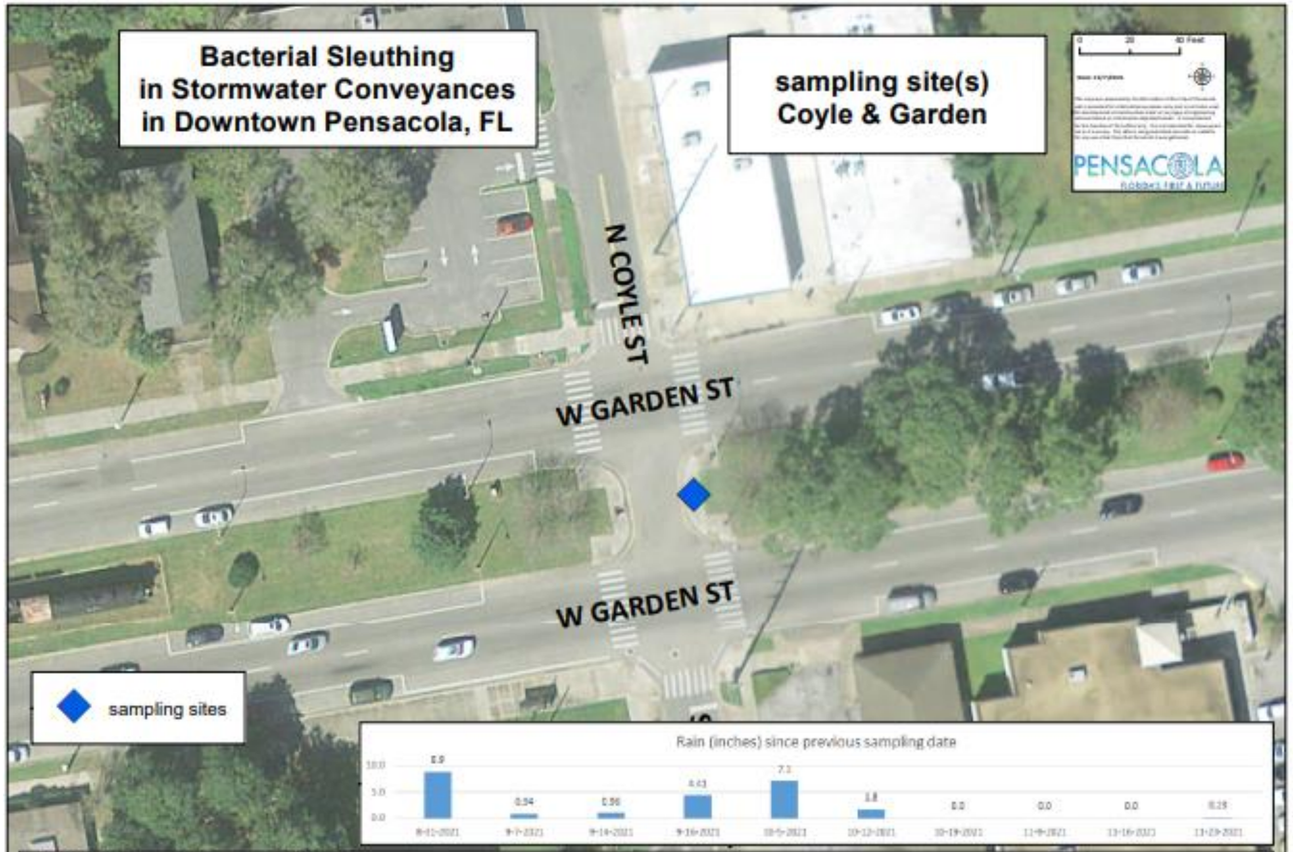
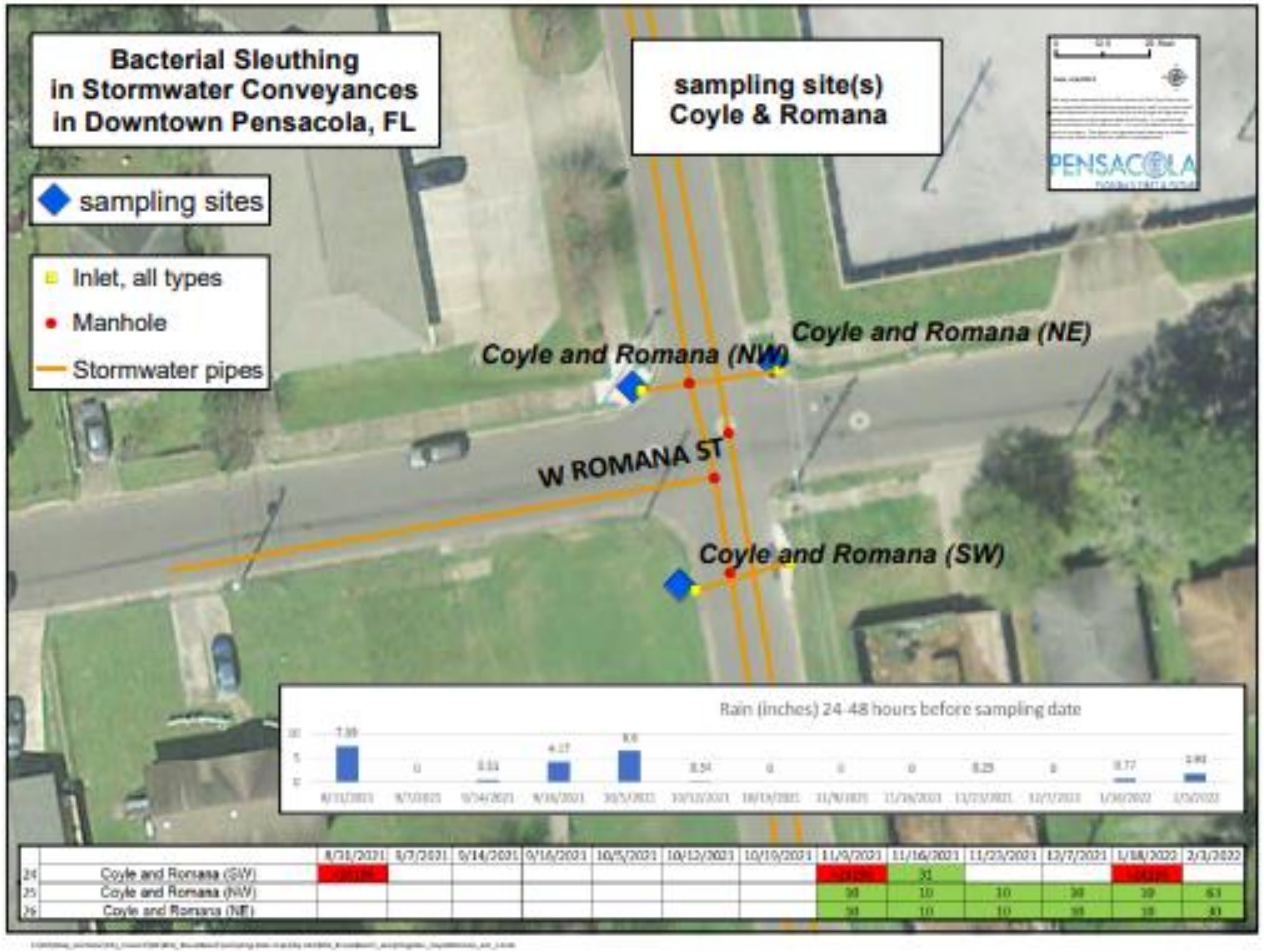


TABLE 1. Bacterial Counts, MPN/100ml										
sampling date:	8/31/2021	9/7/2021	9/14/2021	9/16/2021	10/5/2021	10/12/2021	10/19/2021	11/9/2021	11/16/2021	11/23/2021
rainfall (inches) since previous sampling date:	8.9	0.94	0.96	4.41	7.1	1.8	0.0	0.0	0.0	0.23
COYLE & GARDEN	241	20			8,164			20		

Coyle and Romana



Coyle and Intendencia