City of Delray Beach Intracoastal Waterway Water Level & Infrastructure Vulnerability Study

Submitted to:
City of Delray Beach

Submitted by:
Aptim Environmental & Infrastructure, Inc.

Project No. 631233074
October 2018

CITY OF DELRAY BEACH
INTRACOASTAL WATERWAY
WATER LEVEL & INFRASTRUCTURE VULNERABILITY STUDY

TABLE OF CONTENTS

List of Tables

List of Figures

List of Appendices

CITY OF DELRAY BEACH
INTRACOASTAL WATERWAY
WATER LEVEL & INFRASTRUCTURE VULNERABILITY STUDY

1. EXECUTIVE SUMMARY

In recent years, the City of Delray Beach has experienced more frequent and increased flooding within its coastal communities, streets, parks, and other facilities that border the Intracoastal Waterway, primarily due to seasonal high tide events, commonly referred to as King Tides. Similar to other coastal Florida communities, the City seeks to assess its vulnerability to future seasonal flooding and to identify potential options to protect its infrastructure and citizen's property, and has begun this work with the 2018 Intracoastal Waterway Water Level & Infrastructure Vulnerability Study.

In support of the City's goals for this study, Aptim Environmental & Infrastructure, Inc. (APTIM) was retained to review available water level data, analyze return periods of extreme events, and consider sea level rise guidance to determine water level projections for the City's requested 30-year and 75-year planning horizons. Based on the water level analyses performed in this study, it is recommended that the City use elevation 4.4 feet when planning for infrastructure improvements on a 30-year planning horizon.

Field investigations were performed to catalogue existing conditions of seawalls, stormwater inlets and outlets, and backflow prevention devices along approximately 4 miles of the ICW and the adjoining canals within the City's study area in early 2018. Analyses of the collected field data were performed to support the City in assessing its vulnerability to future seasonal flooding and to identify options to protect its infrastructure and citizen's property. To allow for additional analysis, all of the collected data was incorporated into an interactive geodatabase with hyperlinked videos, and observation reports.

The City is primarily vulnerable to coastal flooding due to low or unmaintained seawalls, and low or unprotected stormwater inlets under both private and public ownership. Considering the 30-year planning elevation of 4.4 ft., approximately 85% of waterfront parcels are vulnerable and require seawall raisings to prevent flooding, and 58 public stormwater inlets are vulnerable and unprotected by a backflow prevention device. Through analyses of current conditions and in consultation with City staff, the following recommendations for improving resilience to coastal flooding have been concluded from this study:

- Implement seawall repairs and raisings to publically owned seawalls following the developed ranking table.
- Systematically install backflow prevention devices, develop standards for maintenance of backflow prevention devices, and monitor for structural or hydraulic decay of the public stormwater system.
- Perform public outreach and educate residents about the contributing factors to coastal flooding and develop guidelines for improvements to private seawalls and stormwater systems.

To guide implementation of seawall and stormwater system improvements by private residents, the City may develop ordinances to mandate elevations and timing of improvements to improve resiliency to coastal flooding City-wide. In pursuing a City Guided Implementation method, the City should weigh the benefits of implementing a time specific resiliency goal versus allowing for ongoing sea level rise and recurring storms to trigger improvements.

2. INTRODUCTION

The City of Delray Beach (City) has experienced more frequent and increased seasonal flooding within its coastal communities, streets, parks, and other facilities that border the Intracoastal Waterway (ICW) in recent years (Figure 1). These seasonal flooding events have been primarily caused by inundation from the ICW during elevated water levels. Similar to other coastal Florida communities, the City seeks to assess its vulnerability to future seasonal flooding and to identify potential options to protect its infrastructure and citizen's property, and has begun this work with the 2018 Intracoastal Waterway Water Level & Infrastructure Vulnerability Study (study).

In support of the City's goals for this study, Aptim Environmental & Infrastructure, Inc. (APTIM) was retained to review available water level data, analyze return periods of extreme events, and consider sea level rise guidance to determine water level projections for the City's requested 30-year and 75-year planning horizons. Field investigations were also performed to catalogue existing conditions of seawalls, stormwater inlets and outlets, and backflow prevention devices along approximately 4 miles of the ICW and the adjoining canals within the City's study area in early 2018.

Figure 1. Flooding within the City of Delray Beach (October 5, 2017).

Based on the current conditions found and the projected water levels, recommendations on infrastructure (i.e. seawall heights and retrofitting stormwater outfalls) and planning are provided to assist the City in developing future Capital Improvement Plans.

In response to flooding and high water events that have been occurring, this study aims to inventory current conditions and develop practical recommendations to reduce the risks of high tide flooding for both public and private properties. While these recommendations reduce the risk of high tide flooding, this study was not envisioned to bring recommendations that prevent flooding at all storm return frequencies. In addition, it is anticipated to take several years to implement the study's recommendations, which is appropriate considering the low rate of sea level rise, including its observed recent acceleration and the City's 30-year planning horizon.

3. GEOGRAPHIC SETTING & DATUMS

The City is located in southeast Florida within Palm Beach County. The City's coastal barrier island separates the Atlantic Ocean from the ICW, which to the north is tidally connected to the ocean by South Lake Worth Inlet, also known as Boynton Inlet, and to the south by Boca Raton Inlet as shown in Figure 2. The extents of this study area are highlighted in yellow in Figure 2.

For purposes of this analysis, all elevations are in feet referenced to NAVD, unless specifically noted otherwise. Where source data is in another datum, it was converted to NAVD based on published National Oceanic and Atmospheric Administration (NOAA) tidal benchmarks. For this study, two local tidal benchmarks were used: "Gage 8722761, South Delray Beach FL" where NAVD is reported as 2.23 feet above MLLW, and "Gage 8722746, Delray Beach FL" which indicates that NAVD is 2.31 feet above MLLW.

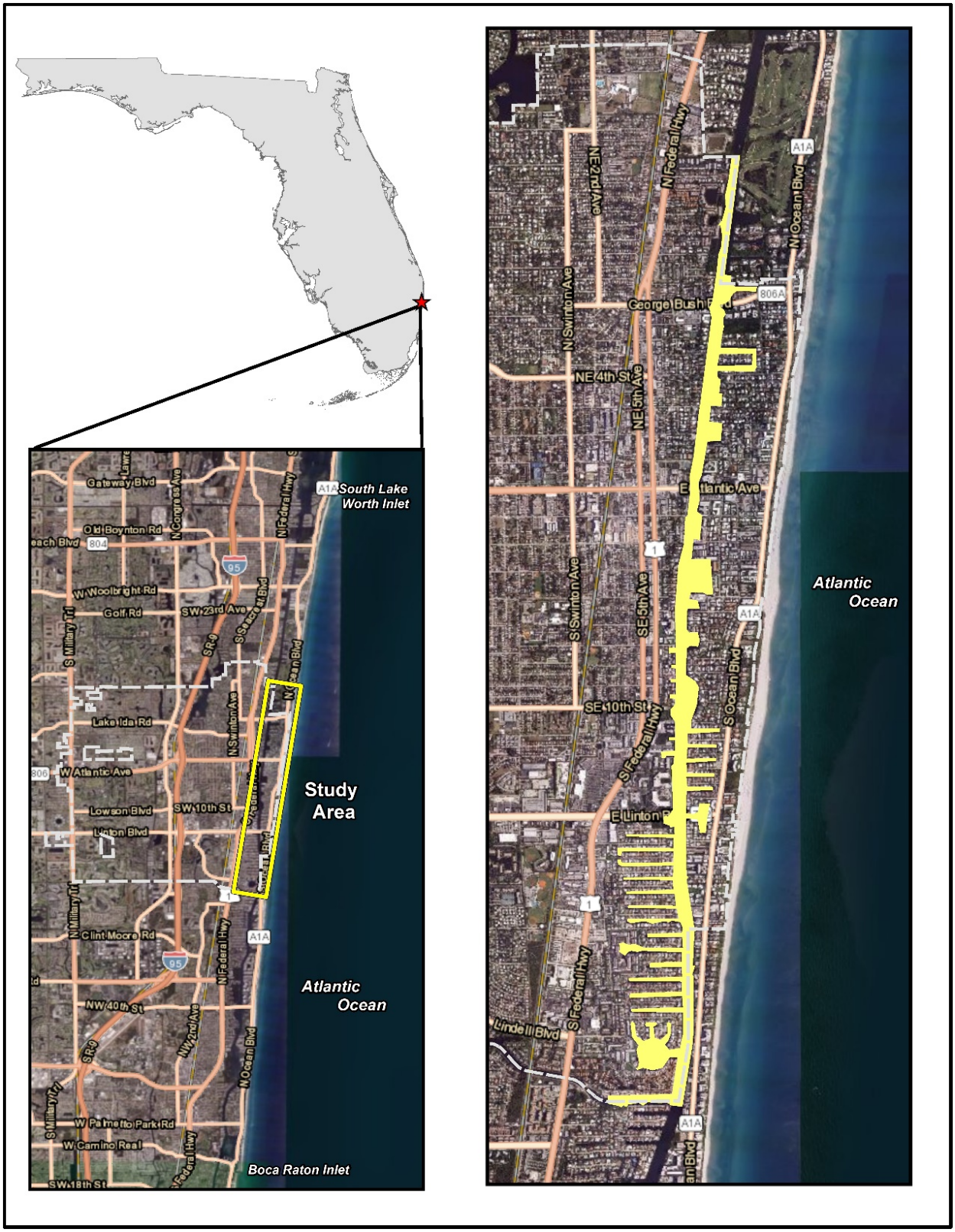


Figure 2. Project Location Map.

4. WATER LEVEL PROJECTION

To assist with future planning, the City requested projections of future water levels at 30-year and 75-year planning horizons. This section describes analysis of past water levels, rates of past sea level rise, future sea level rise projections, and recurrent storm induced water levels.

4.1 Components Influencing Water Levels

The City's water levels within the ICW are influenced by several components including astronomical tides, local winds, stormwater discharge from inland rain, ocean storm surge, and sea level rise. Each of these components are discussed briefly in the following section.

4.1.1 Astronomical Tides

The nearest measured water levels along the open coastline are those from the NOAA tide gage located at the Lake Worth Fishing Pier (Station ID 8722670), shown in Figure 4. Astronomical solar and lunar tides are "bulges" in the earth's water levels due to the gravitational forces of the sun and moon. NOAA provides estimates of 28 tidal constituents that affect tides at the Lake Worth pier. Of these 28 constituents, seven (7) constituents are major contributors to the predicted tides while the remaining constituents are minor. The constituents and their associated magnitudes are provided in Appendix A. From these constituents, NOAA makes daily tidal predictions for locations throughout the country.

From NOAA's daily tidal predictions for 2017, the expected maximum predicted water levels were determined to be between approximately +1.0 to +1.5 feet NAVD except for the months of February and March (Figure 3). Maximum levels coincided within a few days of the new moon in the early months of the year and within a few days of the full moon in the later months of the year.

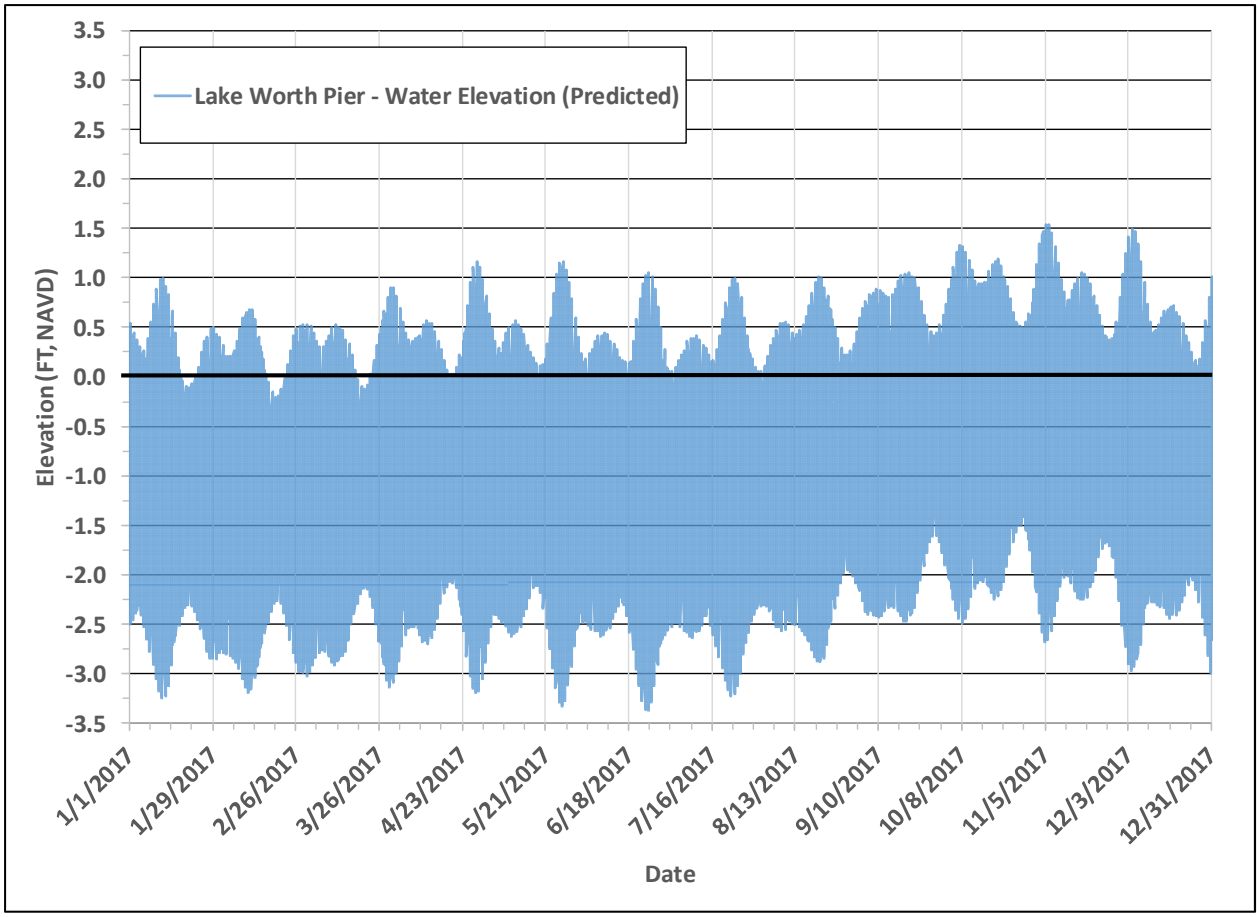


Figure 3. Lake Worth Pier – 2017 Predicted Water Levels by NOAA.

4.1.2 Ocean Storm Surge

The passage of tropical systems with their associated wind fields and low central pressures can force ocean water to accumulate along the coast of the Atlantic Ocean creating an ocean storm surge. The ocean storm surge can affect the tides and flow of water through adjacent tidal inlets and reach the ICW. Strong northeasterly wind and wave events associated with extratropical nor'easter storms, even if distant, can also create a storm surge influencing water levels in the ICW. There are also variations in the Gulfstream current and other oceanographic processes that affect the tide in the Atlantic Ocean. These processes can positively or negatively affect the tide and will be categorized for this evaluation as ocean storm surge.

The ICW of Delray Beach is connected to the Atlantic Ocean through two (2) tidal inlets in the neighboring cities: South Lake Worth Inlet, also known as Boynton Inlet, to the north and Boca Raton Inlet to the south (Figure 2). At the Lake Worth Fishing Pier (Station ID 8722670), NOAA provides predicted water levels based on astronomical tides, and measured water levels (Figure 5). The difference between the predicted tides and the measured tides represents the ocean storm surge. For 2017, the deviations averaged 0.3 feet with the maximum positive deviation occurring on September 10, 2017 attributable to the passing of Hurricane Irma.

Figure 4. Key Study Locations.

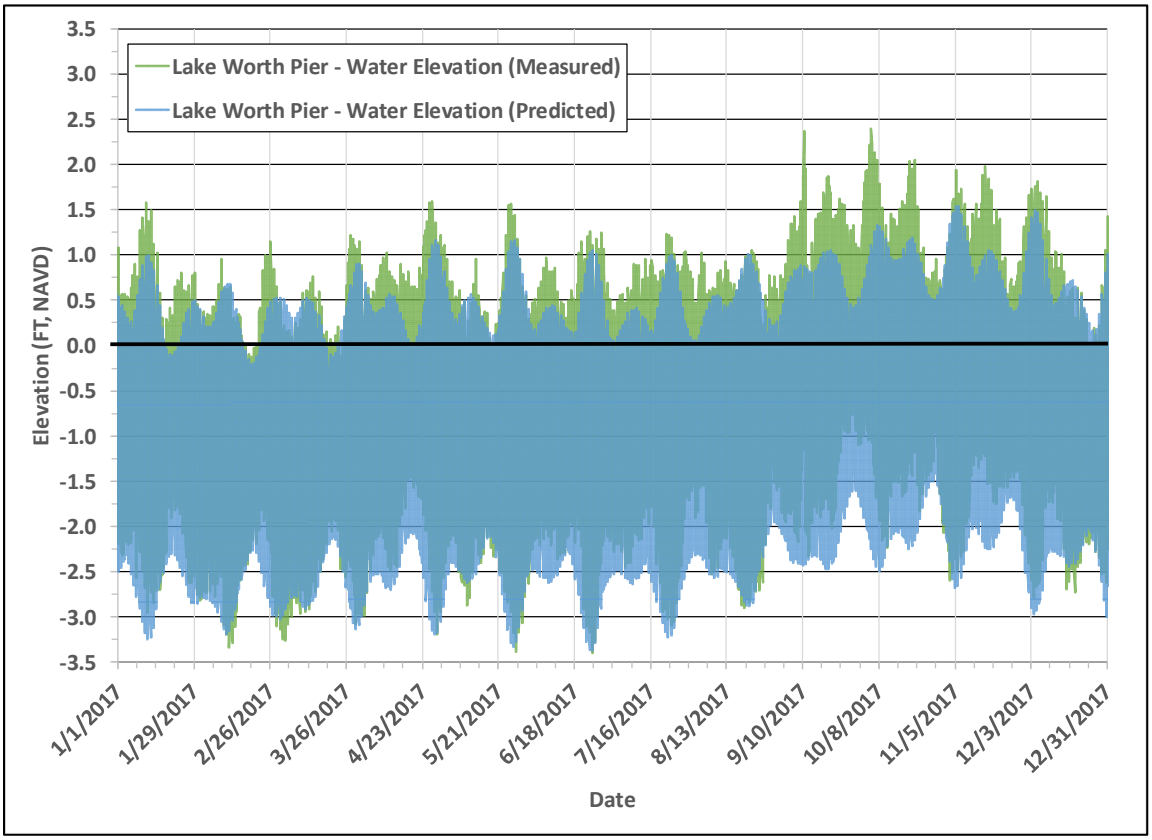


Figure 5. Lake Worth Pier – 2017 Predicted and Measured Water Levels.

4.1.3 Other Components

4.1.3.1 Stormwater Discharge from Inland Rain

Rain accumulates creating surface water, which within the City and partially within Palm Beach County is managed locally by the Lake Worth Drainage District and regionally by the South Florida Water Management District (SFWMD). Management of the stormwater is intended to provide flood protection and drainage for agricultural, urban and residential lands, and to regulate groundwater table elevations to prevent saltwater intrusion. As part of this management effort, stormwater is discharged through outfall pipes from properties adjacent to the ICW and through a regional network of canals.

The C-15 regional canal, at the southern boundary of the City limits, discharges throughout the S40 water control structure into the ICW. The SFWMD records discharge rates at the structure and tail water elevations downstream. The SFWMD gages provide a 30+ year record of water levels within the ICW.

The discharges into the ICW and the maximum daily water levels within the ICW at the S40 water control structure from 2017 are shown in Figure 6. The maximum daily water levels for the SFWMD tail water gage S40T were overlain on the water levels obtained from the Lake Worth Pier and are shown to be in good agreement. While there is overall agreement between the water level gages, the remaining deviations highlight the localized effects and interactions of the various components that influence water levels. Deviations in water levels were compared to the stormwater discharges at the S40 structure to determine if there was correlation between the events. It was found that for most discharge rates and durations, the effects of stormwater discharge on the water levels within the ICW were minimal.

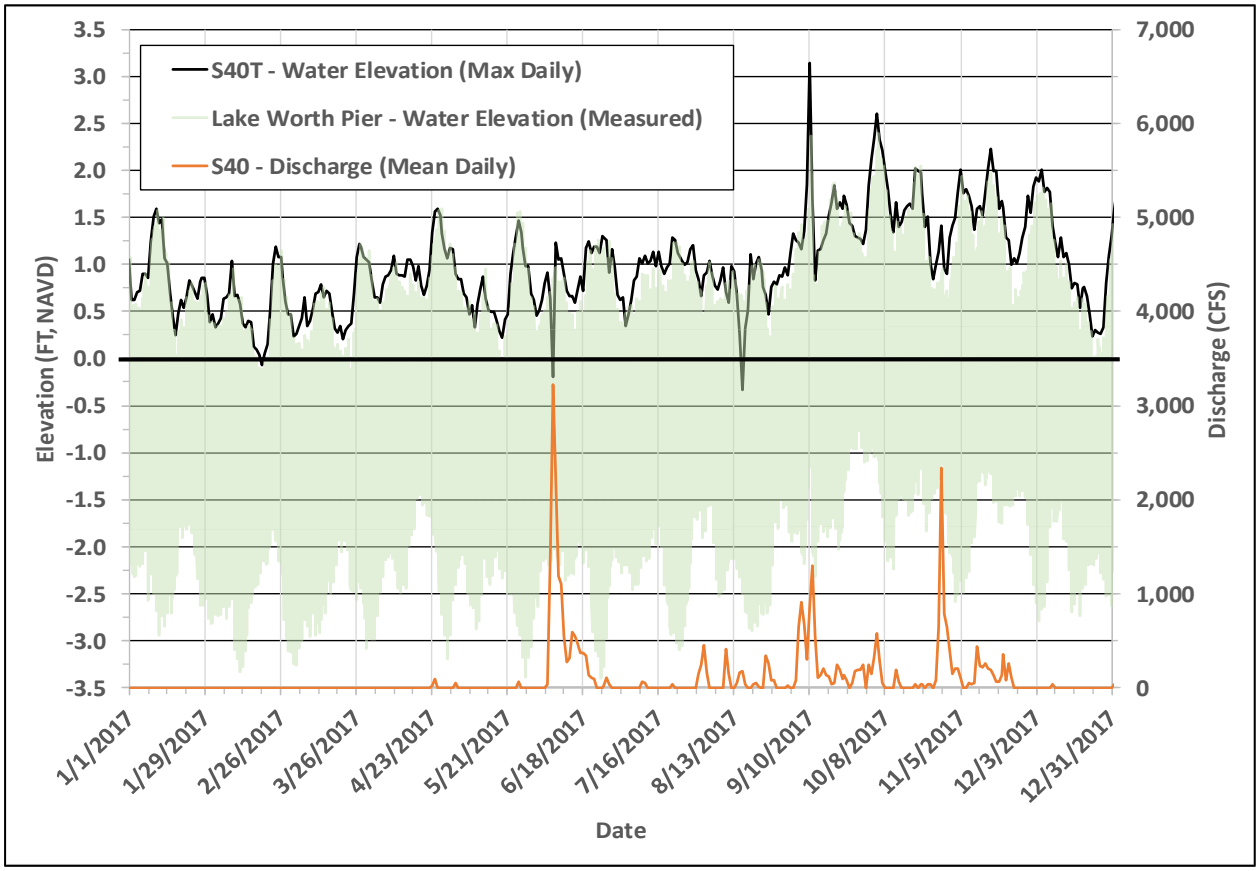


Figure 6. SFWMD S40T Gage – 2017 Measured Water Levels in comparison to Lake Worth Pier measurements and C15 discharge rates for 2017.

4.1.3.2 Local Winds

Atmospheric conditions generate high and low pressures and gradients in both air and sea temperatures. These conditions result in winds at both a regional and local scale that create friction on the water's surface. Depending on the strength, direction, and persistence of these winds, this forcing can cause localized fluctuations in water levels. In particular, northerly and southerly winds can force water from Lake Worth Lagoon (to the north) and Lake Boca (to the south) through the ICW elevating water levels within Delray Beach. Local winds may account for some of the minor deviations between the gages presented in Figure 6. Nevertheless, due to the generally mild winds and short durations of those winds in Delray Beach, this study will assume that the wind effects on the water levels within the ICW are minimal.

4.1.3.3 Sea Level Rise

Since the south Florida land is relatively stable, projections of future sea level rise may be based on relative sea level rise derived from the most local, longest term tidal measurements. As shown by Harris (1981), the use of a long record reduces the standard error in linear regression analysis. The longest data record for southeast Florida is in Key West (NOAA gage 8724580), which was analyzed by the Southeast Florida Regional Compact for Climate Change (SFRCCC) for local projections of future sea level rise (SFRCCC, 2015). Sea level rise projections have also been made by the United States Army Corps of Engineers (USACE, 2013) and NOAA. It should be noted that these projections are based on assumed scenarios with varying levels of probability they will occur, further discussion can be found in NOAA's Technical Report NOS CO-OPS 083 (NOAA, 2017). A comparison of these published projections to the monthly mean sea level (MSL) as measured in Key West, is shown in Figure 7. Relative Mean Sea Level as shown on the y-axis of Figure 7 refers to the difference between the measured monthly MSL and the MSL in January 1992.

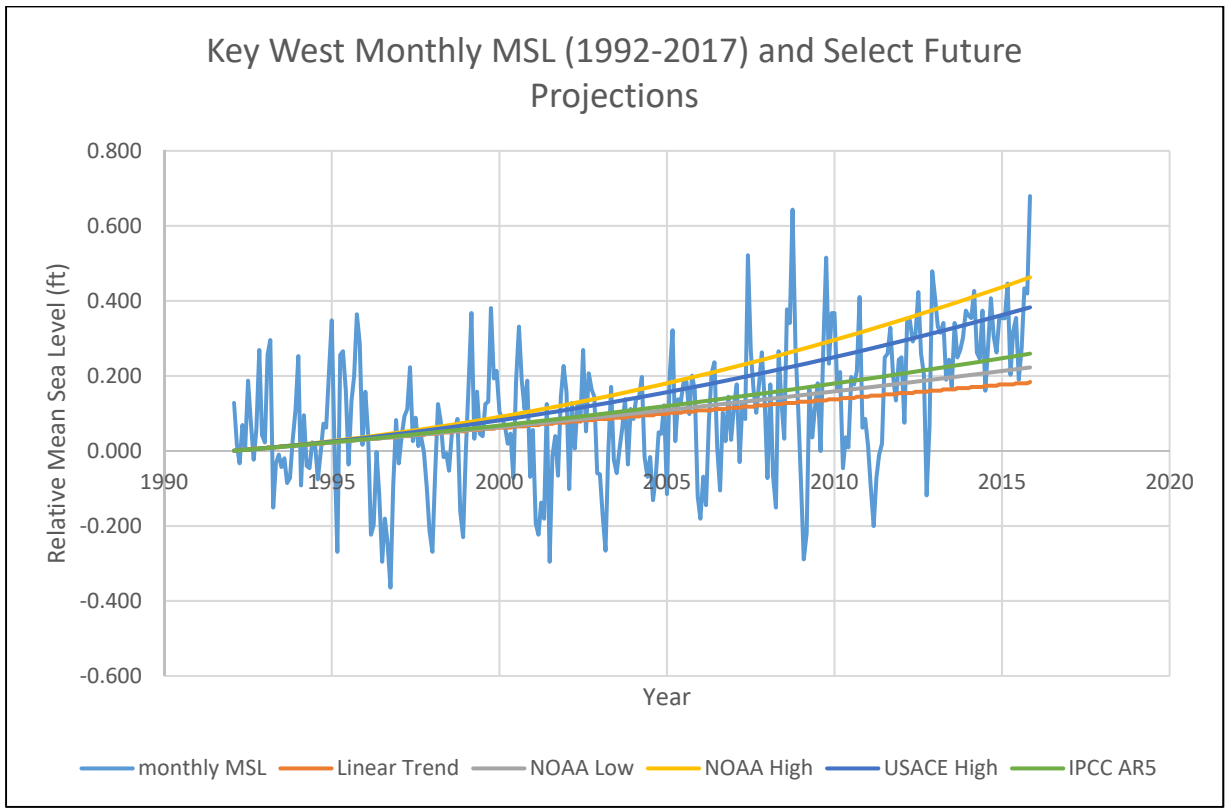


Figure 7. Sea Level Rise Projections (SFRCCC 2015) overlain on Measured Monthly MSL at Key West, FL (NOAA).

Based on the data comparison illustrated in Figure 7, several preliminary observations can be made:

1. Monthly sea level in Key West varies between +0.4 feet and -0.2 feet about any of the long-term trends. The variations in any year are approximately equivalent to 25 years of sea level rise from 1992 to 2017.
2. Sea level in Key West is rising at an increasing rate. Utilization of the historical linear trend (by NOAA), does not compare favorably with the measurements since approximately 2010.
3. The United Nations Intergovernmental Panel on Climate Change (IPCC) AR5-RCP8.5 curve and the USACE High curve appear to fit the Key West (1992-2017) data trend the best.
4. Sea level has risen approximately 0.3 feet between 1992 and 2017 in Key West.

4.2 Local Water Levels

The SFWMD gage S40T provides a 30+ year record of water levels within the ICW, and may be used as a baseline for evaluating historical water levels and future projections. A potential disadvantage to using data from this gage is its location relative to the discharge of water control structure, which could potentially reflect the tail water elevations rather than the water levels of the surrounding ICW. To evaluate this effect, the SFWMD data was overlain on water level data provided by the City from a gage located at White Drive in the ICW within the City (Figure 8). The White Drive gage was located approximately 1.5 miles north of the S40T gage and the southern boundary of the City limits. The White Drive dataset covers a relatively short time period of June 30, 2017 to November 27, 2017 with three data gaps, of which one gap occurred during the passage of Hurricane Irma on September 10, 2017. The White Drive gage showed reasonable agreement with the SFWMD S40T gage, confirming that the S40T data could be used as a proxy for ICW elevation data in Delray Beach and that the discharge had relatively minimal effect on the measurements. According to the S40T gage, the average daily maximum water level for 2017 was +1.0 feet, NAVD.

NOAA also provides predicted tides at two locations within the Delray Beach ICW. These predictions are derived from measurements at the Miami Harbor, Government Cut with observations within Delray Beach from April 1 to May 31, 1973. NOAA used these short observations to compare the primary measurements in Miami Harbor to Delray Beach and determined an appropriate vertical adjustment to the amplitude of the Miami Harbor, Government Cut tide and a time delay to account for the delay in the tide maximums arriving in Delray Beach. The NOAA predicted high tides in the ICW at Delray Beach (Station ID 8722761) are shown in Figure 8 to highlight that these local tide predictions are not accurate for evaluating maximum water levels and the potential for coastal flooding.

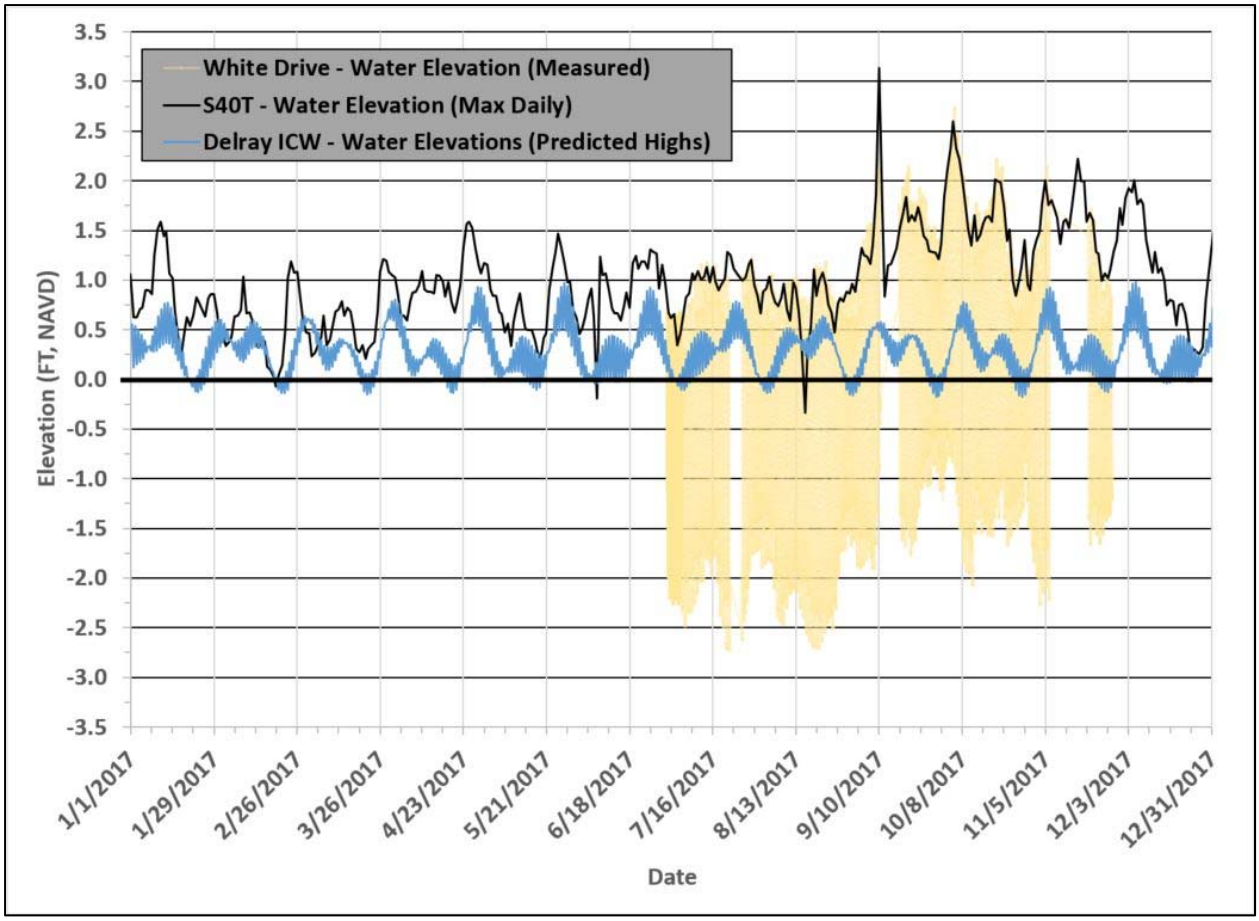


Figure 8. Measured vs. Predicted 2017 Water Levels.

4.2.1 Return Period Analysis

A return period analysis is a statistical analysis that utilizes historical data to determine the average recurrence interval of a particular event used for assessing risk. For this study, a recurrence interval was defined as the probability of a particular maximum water level being exceeded in any given year.

A return period analysis was performed on the SFWMD S40T daily maximum water level data to determine the likelihood of exceedance of maximum water levels within the ICW. A 32-year record of water levels from 1985 to 2017, inclusive, was obtained from the SFWMD. The maximum event during the 32-year record was a +3.1 feet, NAVD event that occurred on September 10, 2017 associated with the passing of Hurricane Irma. Likewise, six of the top ten water elevation events are associated with the passage of a named hurricane (Table 1). The remaining elevated water levels appear to be associated with unspecified ocean storm surges coupled with seasonal (fall) high tides. The tidal data revealed a long-term trend of mild rises in water levels. The long-term trend was then subtracted from each respective year of the data set, yielding just the fluctuations of the maximum daily tidal elevations above or below the long-term trend. It is important to note that this de-trending results in elevation fluctuations that are not tied to a datum, as the datum connection is tied to the long-term trend in the data. Using this de-trended database will allow the results of the statistical analysis to be applied in any future year, as will be shown in subsequent sections.

Table 1. Top Ten Water Elevations at S40T

Rank	Date	Feet NAVD88	Associated Storm Event
1	9/10/2017	3.14	Hurricane Irma
2	11/16/1996	3.10	
3	10/13/1996	2.98	
4	10/28/2012	2.97	Hurricane Sandy
5	9/25/2004	2.84	Hurricane Jeane
6	9/29/2015	2.66	Hurricane Joaquin
7	9/4/2004	2.64	Hurricane Frances
8	10/17/2016	2.61	
9	10/5/2017	2.60	
10	10/15/1999	2.59	Hurricane Irene

Note: Water levels converted to 2018 mean sea level

From the de-trended dataset, a peaks-over-threshold method was employed. An elevation fluctuation threshold was set at +1.3 feet, which resulted in 40 events during the 32 year record where the de-trended water level measured by the S40T gage exceeded the threshold. A Weibull distribution was then used to develop a best fit line for these 40 events and assign the probability of an event occurring in a given year expressed as return periods (Figure 9). The analysis determined that a 5-year return period event (20% chance of exceedance during any given year) had a water level fluctuation above the long-term trend of approximately +1.8 feet, and a 40-year return period event had a water level of +2.4 feet.

Due to the fact that statistical uncertainty increases as the return period exceeds the recorded length of the dataset, it is not recommended to use return period projections beyond twice the length of the measured record. In this study, there was a sufficiently long history of data (32 years) to have statistical confidence for the desired return periods. The water level fluctuation of +1.8 feet associated with a 5-year return period event, has been used to develop water level predictions presented in this study.

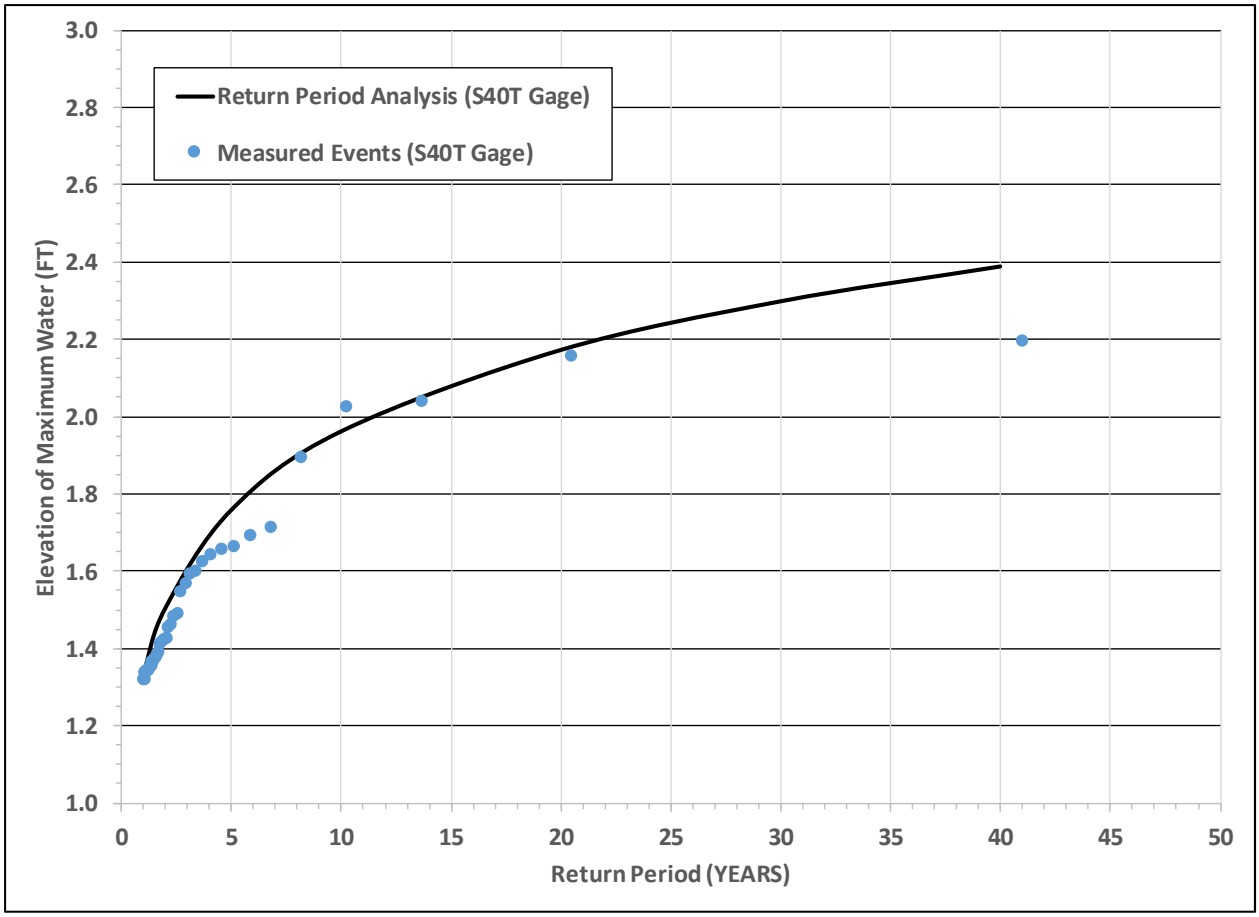


Figure 9. Maximum Water Levels (not adjusted for Sea Level Rise) for Various Return Periods.

4.2.2 Future Sea Level Rise

Sea level rise has been evaluated and future projections made by various climate change experts, federal agencies, and local community compacts. The Southeast Florida Regional Climate Change Compact (SFRCCC) provides guidance regarding sea level rise projections for consideration within southeast Florida. The latest guidance, October 2015, references projections of accelerated sea level rise made by the IPCC, USACE, and NOAA and establishes methods for applying the projections to a particular situation. The recommended projections from lowest to highest rates of acceleration are listed below:

- IPCC AR5 Medium Rate (RCP8.5)
- USACE High Rate (NRC Curve III)
- NOAA High Rate

The City has identified 30-year and 75-year planning horizons for consideration with its Strategic Plan and Capital Improvement Plan. From the analysis of past sea level trends, the best fit of the Key West data appears to be the USACE High curve or the IPCC AR5 RCP8.5 curve (Figure 7). Future projections of these curves using the approach of Knuutti (2002) yields the sea level increases reported in Table 2.

Table 2. Future Mean Sea Level Projections using Selected Trend Curves

	Increase in MSL Relative to 2018			
	USACE High Curve		IPCC Curve	
Year	Inches	Feet	Inches	Feet
2048	12.5	1.1	7.1	0.6
2093	48.9	4.1	24.0	2.0

4.2.3 Total Water Level Projections

To determine the water levels to use in long term planning, a total water level projection can be computed by summing together the daily maximum water level, the expected sea level rise, the water level associated with the 5-year return period event, and a "freeboard" or safety factor. As an example, the total water level projection for the City of Delray Beach in 2048 (30-year planning horizon) can be found by summing the following:

- The average daily maximum water level in 2017 was +1.0 feet, NAVD (Section 4.2, first paragraph).
- The expected sea level rise for 30 years is 0.6 to 1.1 feet (Table 2).
- The expected water level above the average daily maximum associated with return period events in any given year (Figure 9). The water level associated with a 5-year return period event is 1.8 feet.
- In addition, an amount of "freeboard" or safety factor, which can be defined by the City. It is recommended that a minimum of 0.5 feet be utilized.

Therefore, for a 30-year planning horizon, it is recommended that the City prepare for elevations of 3.9 to 4.4 feet, NAVD. Using the results of this study, the calculation was also completed for a 75-year planning horizon and resulted in a recommendation to prepare for 5.3 to 7.4 feet NAVD by year 2093. However, caution should be applied before implementing the 75-year elevations until additional sea level rise data is collected in the coming decades.

5. EXISTING CONDITIONS ASSESSMENTS

Between January and May 2018, APTIM surveyors and engineers performed field investigations to catalogue the existing conditions of tidally influenced seawalls, stormwater outfalls and inlets, and backflow prevention devices throughout the study area. Methods and results of these field investigations are discussed below, presented within maps in the appendices, and all data is compiled within a geodatabase digital deliverable to the City.

5.1 Topographic Surveys

The elevations of public stormwater inlets and outfalls, and representative elevations of each waterfront parcel's seawall or revetment throughout the study area were surveyed by APTIM surveyors. This survey is in accordance with Chapter 5J-17, Florida Administrative Code (F.A.C.) Standards of Practice established by the Florida Board of Professional Surveyors and Mappers pursuant to Chapter 472 of the Florida Statutes. All work was conducted under the direct supervision and responsible charge of a Professional Surveyor and Mapper (PSM) who is registered in the State of Florida.

Prior to the start of the survey, reconnaissance of the monuments was conducted to confirm that survey control was in place and undisturbed. Real Time Kinematic Global Navigation Satellite Systems (RTK GNSS) and Florida Permanent Reference Network GNSS (FPRN GNSS) was used to locate and confirm survey control for this project. The vertical accuracy of control data meets the accuracy requirements of ± 0.16 feet as set forth in Section 01000 and Chapter 5J-17, F.A.C. The horizontal accuracy of the control data meets the Geospatial Positioning Accuracy Standards, Range VIII of a maximum ± 0.66 feet. In order to achieve required accuracy, the topographic surveys were controlled using 2nd order published monuments, specifically PM BH R-192 1974 and 2nd order monument USCGS P 315 with PID number AD2703 from the National Geodetic Survey (NGS) (Table 3). These 2nd order monuments were used as horizontal and vertical positioning checks at the beginning and end of each day utilizing FPRN GNSS. FPRN GNSS network consists of nearly 100 continuously operating reference stations (CORS) located throughout Florida. Each CORS site provides Global Positioning System carrier phase and code range measurements in support of 3-dimensional positioning activities throughout Florida. The control check shots were acquired using the Trimble survey style Topo Shot, at a minimum of 5 epochs.

Table 3. Control Monument Information

Florida State Plane East Zone NAD 83/2011 NAVD 88 US Survey Feet			
Monument Name	**Northing**	**Easting**	**Elevation**
PM BH R-192 1974	761715.957	962893.586	14.12
USCGS P 315	779560.335	964698.906	20.23

Upon completion of the control reconnaissance and establishment, operations collecting topographic data for seawall parcels, revetment parcels, stormwater intakes, and outfalls were initiated. All topographic data in the project area was collected using extended rod RTK GNSS rovers and differential leveling techniques (where necessary). Topo shots were taken at a minimum of 5 epochs for every position collected on seawalls, revetments, stormwater intakes, and outfalls. All vertical data were collected in the North American Vertical Datum of 1988 (NAVD88) relative to geoid model 12a. All horizontal data were collected in the Florida State Plane Coordinate System, East Zone, North American Datum of 1983/2011 (NAD83/11). All horizontal and vertical data were collected in U.S. survey feet.

For the purposes of this study, a representative elevation for each waterfront parcel's seawall or revetment was collected. Elevations were taken as close to the center of the parcel along the seawall as possible. Many of the parcels had obstructions like boardwalks or docks that would not allow for a center shot to be made; in those cases, shots were taken around the obstruction as close to the center point as possible. Revetment elevations were taken in the center of the parcel at the top of the structure.

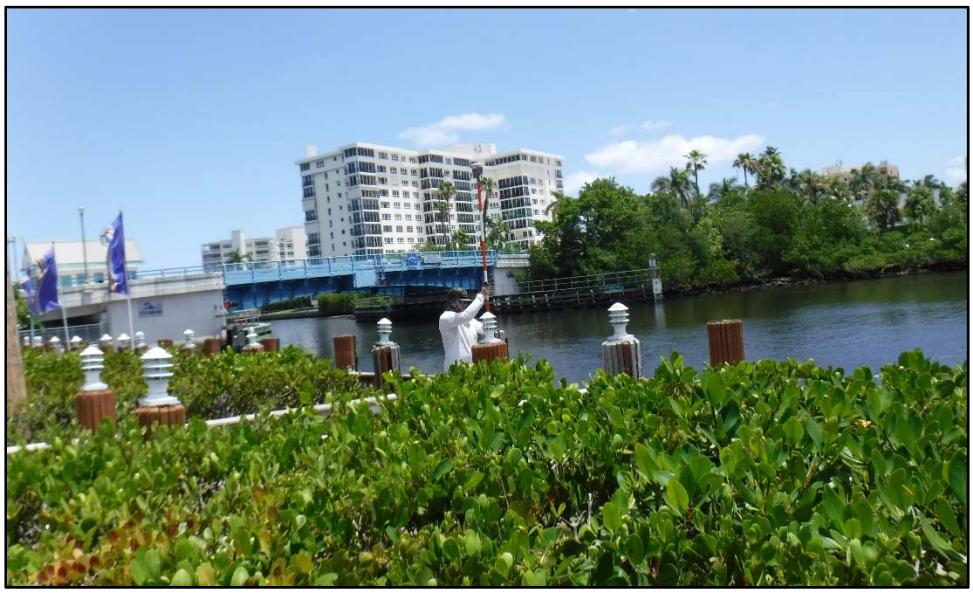


Figure 10. APTIM Conducting Topographic Surveys of the Seawall at Marine Way.

Based on the stormwater maps provided by the City, APTIM located, observed, and surveyed 103 stormwater inlets and outfalls that flow directly to the ICW, or into the adjacent canal system. The majority of the inlets and outfalls identified represent publicly owned stormwater systems. Incidental to the intended scope of work, a few private inlets and outfalls were located. The public outfalls include those that are the responsibility of the City, Palm Beach County, and the Florida Department of Transportation (FDOT).

Outfall elevations were collected at the base of the outfall using an invert that offset the horizontal position up to a few feet from the edge of the pipe. However, multiple levels were attached to the invert ensuring the measured elevations were accurate. If the outfall had a duckbill, an elevation was taken just below the pipe where the pipe met the duckbill. All stormwater intake elevations were taken in the center of the inlet. The inlets surveyed generally represent the first stormwater inlet upstream of the discharge pipe. In most cases, the first upstream inlet (intake) was the lowest inlet elevation of the stormwater pipe network. One exception to this general observation occurred on the west side of the Linton Boulevard Bridge, where APTIM determined that the lowest elevation in the stormwater pipe network was not at the closest inlet located on the bridge approach ramp. In this case, APTIM located the lowest elevation inlet in the network for use throughout the analyses of this study.

Figure 11. Surveying the Invert Elevation for an Outfall Pipe Located Along Marine Way (left). Example of a Stormwater Inlet Upstream of a Discharge at SE 3rd Street (right).

Upon completion of the field work, survey data was edited and reduced with Microsoft Excel 2016, HYPACK 2017, and ArcMap 10.6. Seven (7) survey maps were prepared in ArcMap 10.6, one (1) project location map and six (6) plan view maps. Each plan view map utilizes a 2017 aerial photograph and has elevations clearly labeled for every seawall parcel, revetment parcel, storm water intake, and outfall within the study site. These signed and sealed survey maps are provided in Appendix B. All survey data was provided as part of the geodatabase digital deliverable and used as the basis for analyses throughout this study.

5.2 Assessment of Public Seawalls

Topside structural inspections were conducted by a Florida licensed Professional Engineer (P.E.) at publically owned seawalls within the study area. APTIM reviewed the provided GIS shapefiles, property appraiser parcel data, and coordinated with the City to determine that 29 seawall segments were publically owned, accessible within the study area, and not currently included in an improvement project. In addition, the City has an easement across one panel of the private seawall at 808 Seasage Drive; this segment was also observed. The majority of inspections were conducted in early January 2018. SE 9th Court and Seaspray Avenue inspections were conducted in April 2018 because they were inaccessible by land, and Seasage Drive was inspected in fall 2018. Based on the information obtained during the topside structural observations and in consultation with the City project manager, underwater structural assessments were deemed unnecessary for the purposes of this study.

Observation reports with location maps were developed for each seawall segment and include seawall type, cap elevation and dimensions, condition, photographs and other pertinent observations. An example of the information contained within the observation report is provided as Figure 12. Condition assessments follow American Society of Civil Engineers (ASCE)'s Routine Underwater Condition Assessment Criteria listed in Table 4. The full set of observation reports along with an overview map are provided in Appendix C as well as hyperlinked to each site within the geodatabase digital deliverable.

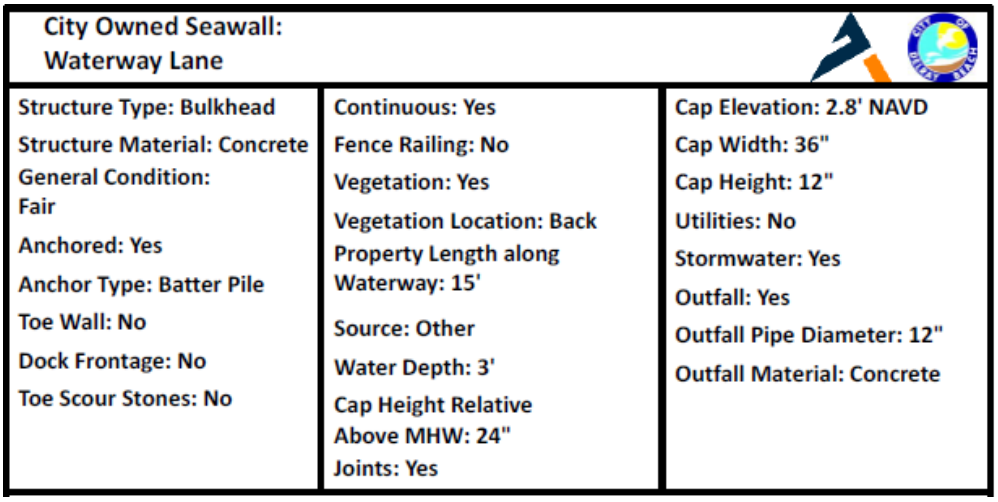


Figure 12 Example Seawall Observation.

Table 4. Routine Underwater Condition Assessment Ratings (ASCE, 2001)

Rating		Description
6	Good	No visible damage, or only minor damage is noted. Structural elements may show very minor deterioration, but no overstressing is observed. No repairs are required.
5	Satisfactory	Limited minor to moderate defects or deterioration are observed, but no overstressing is observed. No repairs are required.
4	Fair	All primary structural elements are sound, but minor to moderate defects or deterioration is observed. Localized areas of moderate to advanced deterioration may be present but do not significantly reduce the load-bearing capacity of the structure. Repairs are recommended, but the priority of recommended repairs is low.
3	Poor	Advanced deterioration or overstressing is observed on widespread portions of the structure but does not significantly reduce the load-bearing capacity of the structure. Repairs may be carried out with moderate urgency.
2	Serious	Advanced deterioration , overstressing, or breakage may have significantly affected the load-bearing capacity of primary structural components. Local failures are possible and loading restrictions may be necessary. Repairs may need to be carried out on a high-priority basis with urgency.
1	Critical	Very advanced deterioration, overstressing, or breakage has resulted in localized failure(s) of primary structural components. More widespread failures are possible or likely to occur, and load restrictions should be implemented as necessary. Repairs may need to be carried out on a very high priority basis with strong urgency.

5.3 Rapid Seawall Assessments

Throughout the study area, a rapid assessment was conducted of private and public parcels to evaluate the current condition of the waterfront structures fronting each parcel. An above water (boat) investigation of the existing structures was performed by a team led by a P.E. with coastal structures evaluation expertise in accordance with the ASCE Waterfront Facilities Inspection and Assessment Manual - No. 130 (ASCE, 2001). Observations were limited to the exposed portions of each structure that could be documented while passing each structure by boat at idle speed.

Specific attributes of each structure were recorded including the structure type, material type, and condition. Structure types included seawalls, revetments, and vegetated shorelines. Material type included steel, concrete, timber, vinyl, rock, and mangroves/vegetation. Parcels with multiple waterfront structures were divided into multiple entries. The condition of each structure was evaluated based on multiple structural criteria and visible deterioration to construction materials. Structural criteria included rotation, breakage, or settlement of components. Deterioration included visible cracking, corrosion, spalling, or rotting. Displaced rock with exposure of underlying soil was considered as revetment deterioration. A rating was assigned based on the field observations for each individual structure and the criteria established in the Routine Underwater Condition Assessment Ratings (ASCE, 2001; Table 4). The results of the rapid structural assessment are included within the geodatabase digital deliverable and the ratings were color coded and displayed on maps included in Appendix E.

In addition to the rapid structural assessment, a concurrent GPS-referenced video record was collected. The video camera was mounted on the landward side of the boat near the waterline to further document the waterfront structures along the study area's shoreline. The continuous video provided a visual record of the rapid seawall assessment and facilitated quality control of the structural observations. The videos were digitized and included as hyperlinked files with the geodatabase digital deliverable, an example screenshot is displayed in Figure 13.

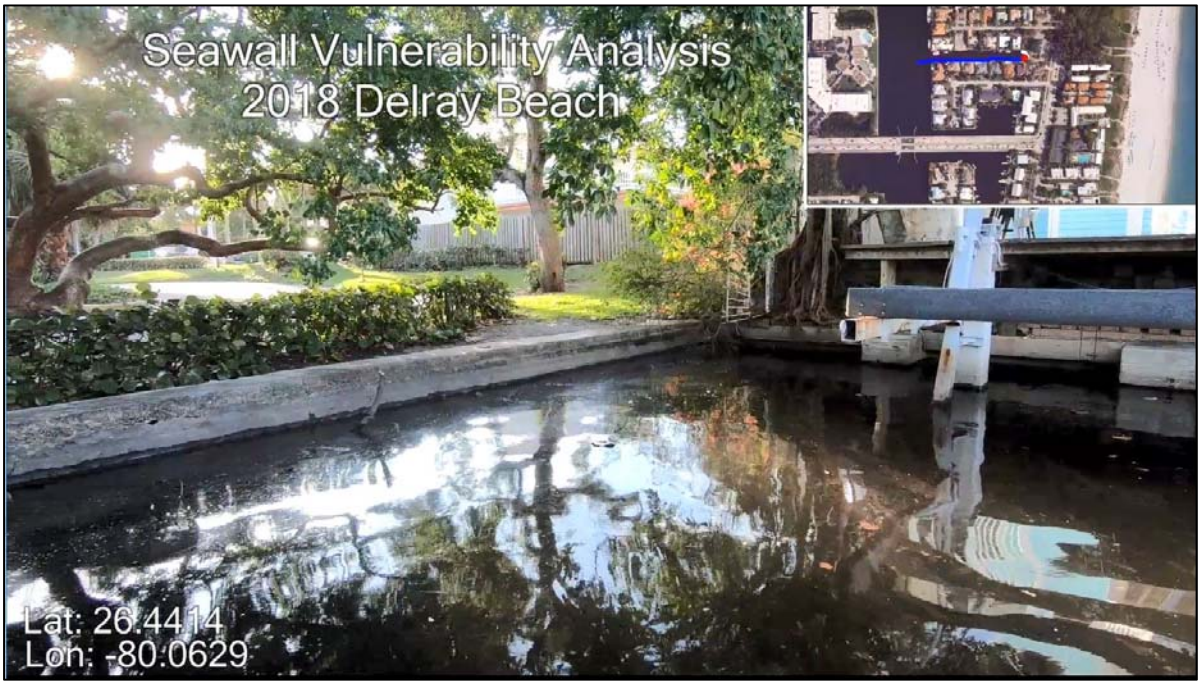


Figure 13. Screenshot from GPS-Coordinated Video West of Atlantic Dunes Park.

5.4 Outfall & Backflow Prevention Device Investigations

In addition to surveying outfall elevations, APTIM conducted observations of the outfalls and backflow prevention devices throughout the study area. During these observations, a P.E. determined the dimensions and material of the outfall, and photographed the current conditions to assist the City in future management (Figure 14).

Figure 14. APTIM Conducting Outfall Observations.

Currently, there are three types of backflow prevention devices installed throughout the study area including: flap gates, duckbills (both straight and recurved) and inline check valves (Figure 15). In support of this study, APTIM inventoried 27 backflow prevention devices. Results of these investigations are presented within Appendices F and G, provided in the geodatabase digital deliverable and discussed further in the analysis section of this report. The City has previously identified select outfalls for future installation of inline check valves, these locations are indicated within Appendix F by a [PI] label for proposed inline check valve.

Figure 15. Examples of Functioning Backflow Prevention Devices Currently Installed (left: inline valve, center: flap gate, right: recurved duckbill valve).

6. ANALYSIS

Analyses of the collected data were performed to support the City in assessing its vulnerability to future seasonal flooding and to identify options to protect its infrastructure and citizen's property. To allow for additional analysis, all of the collected data was incorporated into an interactive geodatabase with hyperlinked videos, and observation reports.

6.1 Seawall Elevations

For the purposes of this study, 942 survey points were collected to represent seawall elevations of 857 waterfront parcels within the study area. Elevations were then color coded and presented in a map series for analysis, this map series is provided as Appendix D. Spatial distribution of seawall elevations indicate that elevations vary throughout the City due to the timing of development and now redevelopment of waterfront properties. The City does not contain any uniformly high or low geographic areas.

To assess the vulnerability of seawall overtopping in the City, the frequency of seawall elevations was determined using 0.5 foot elevation brackets (Figure 16). In order to relate the seawall elevations to the recommended 30-year planning elevations, a separate bracket for 3.9 to 4.4 feet was included and then all elevations above the upper range of 4.4 feet were grouped together. Figure 16 presents a summary of the elevations and distribution of points within the various elevation brackets measured throughout the study area. Considering the 30-year planning elevation range of 3.9 to 4.4 ft. NAVD, approximately 85% of waterfront parcels are vulnerable because they are at or below elevation 4.4 ft. and require seawall raisings to prevent flooding.

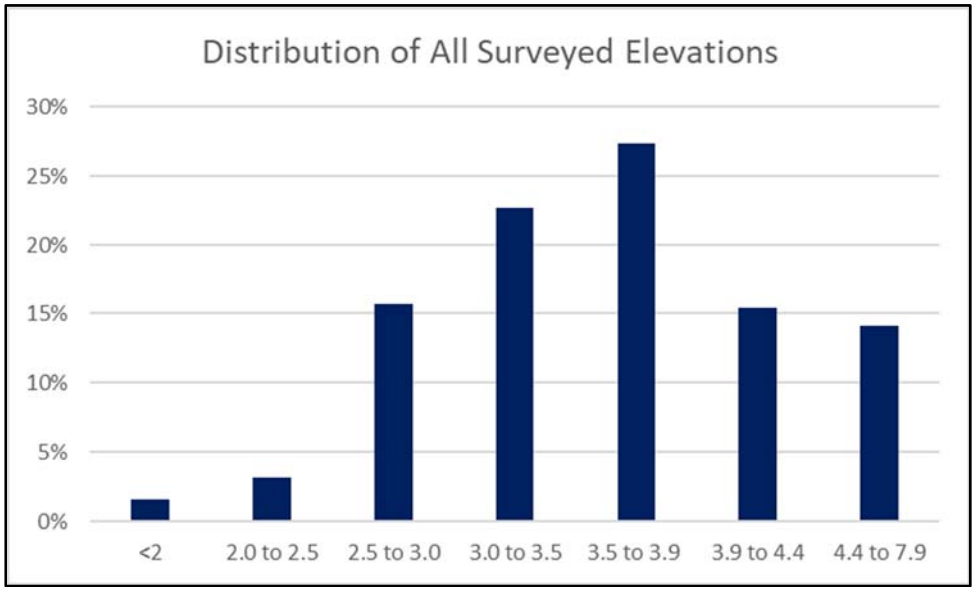


Figure 16. Seawall Elevation Summary
(Frequency of occurrence % vs. elevation (ft. NAVD)).

Figure 17 displays the distribution of elevations for the 29 public sites inspected during this study and presented in Appendix C. Of the publically owned sites, 22 seawalls and one (1) revetment are below elevation 4.4 feet and identified as vulnerable.

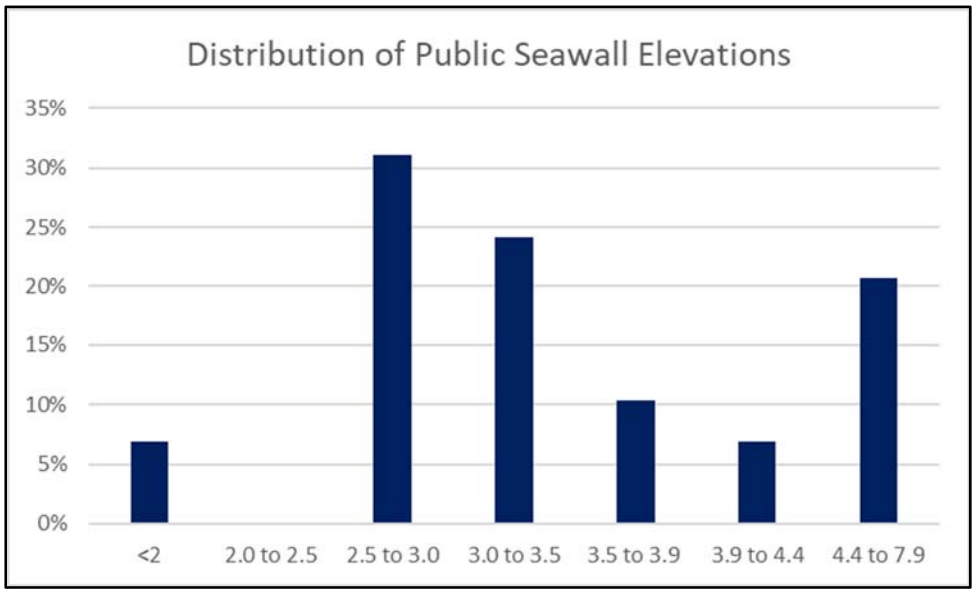


Figure 17. Elevation Summary of Public Seawalls (Frequency of occurrence % vs. elevation (ft. NAVD)).

6.2 Seawall Conditions

Rapid structural assessments were conducted of 897 seawalls within the 857 waterfront parcels of the study area in accordance with the criteria listed in Table 4. Results of these assessments were color coded and presented in Appendix E to spatially analyze the structural condition of seawalls throughout the study area. Similarly to the elevation analysis, this rapid structural assessment found that conditions varied throughout the study area and that there were not entire regions of the same condition. Table 5 presents a summary of the seawall conditions throughout the study area by ownership. These analyses found that there are a total of 48 privately owned seawalls that are in the critical or serious classification. Seawalls throughout the study area are of various lengths, therefore a percentage based on linear foot was calculated to quantify the percentage of public and private seawalls in each structural condition.

Table 5. Seawall Condition Summary

	Good	Satisfactory	Fair	Poor	Serious	Critical
Public	1	16	9	3	0	0
Private	48	170	450	152	41	7
Total %	4%	19%	53%	18%	5%	1%

6.2.1 Public Seawall Conditions

Publically owned seawalls were inspected beyond the rapid assessment to assist the City in planning for repairs, cap raising and seawall replacements for its seawalls (Appendix C). Based on the results of those inspections, and in consultation with City staff, a ranking scheme was developed with the order of importance shown in Table 6. Based on this ranking scheme, a recommended order for improvement was determined and is presented in Table 7.

Table 6. Order of Importance

Highest	SF	Structural Seawall Failures
	LK	Water and Soil Leaks
	SD	Structural Seawall Decay and Repairs
	CE	Cap Elevation Issues
Lowest	NA	No Action

Within the cap elevation issues (CE) category, individual seawalls were ranked by the seawall elevation (from lowest to highest) and did not consider the potential severity of upland flooding or damage, or the structural condition of the seawall and cap. Where there were multiple issues at a seawall, such as NE 1st Court, Basin Drive, and Bucida Road, which require two different types of improvement, the seawalls were repeated in Table 7 since the City may wish to budget and plan for the improvements as two separate projects. The ID letters presented in the second column corresponds to the detailed observation reports in Appendix C.

According to the Palm Beach County Property Appraiser records, not all of the sites ranked for this study are owned by the City and additional coordination with other public agencies may be required. In order to perform seawall and stormwater improvements on the walls adjacent to the Atlantic Dunes Park parking lots, the City should plan to coordinate with Palm Beach County. The parcel including the seawall at Spanish Circle is listed as owned by Tropic Harbor Association and has limited access due to a locked gate at the marina. The revetment at the S40 structure is owned by the SFWMD and not publically accessible by land as the upland parcel is owned by Pelican Harbor Homeowners Association.

Table 7. Recommended Order of Seawall Improvements

Ranking Number	ID Letter	Site name (street name or other landmark)	Condition Assessment	Cap Elevation (Ft, NAVD)	Ranking Criteria	Recommendation
1	Q	Island Drive Bridge Abutment SE	Poor-Serious	4.26	SF	Replace seawall
2	D	NE 1st Court	Fair	2.77	LK	Repair leak in seawall
3	W	Basin Drive	Fair to poor	5.13 & 3.78	LK	Repair the City reported leaks in wall
4	Z	Bucida Road	Fair to poor	3.18	LK	Repair the City reported leaks in wall. Replace seawall if appropriate.
5	A	NE 5th Street	Fair to poor	3.43	LK	Raise cap. Repair the City reported leaks. Replace seawall if appropriate.
6	S	Beach Drive	Poor to Fair	2.79	SD	Replace seawall
7	O	Island Drive Bridge Abutment NW	Fair	3.87	SD	Remove upland trees and replace cap
8	Y	Casuarina Rd	Satisfactory	5.06	SD	Repair crack in cap
9	AA	Atlantic Dunes Park NW Lot between White Drive and Rhodes Villa Ave	Satisfactory	1.65	CE	Raise cap Address stormwater plan for parking lot Coordinate with County
10	BB	Atlantic Dunes Park SW Lot between Del Haven Drive and Rhodes Villa	Satisfactory	2.54	CE	Raise cap Address stormwater plan for parking lot Coordinate with County
11	CC	Del Haven Drive	Satisfactory	2.58	CE	Raise cap
12	E	SE 3rd Street	Satisfactory	3.66	CE	Raise lower portion of wall which is at least a foot lower
13	U	Waterway Lane	Fair	2.75	CE	Raise cap
14	H	SE 10th St. (Knowles Park)	Satisfactory	2.76	CE	Raise cap
15	C	NE 2nd Street	Fair	2.77	CE	Raise cap
16	D	NE 1st Court	Fair	2.77	CE	Raise cap
17	M	Spanish Circle	Satisfactory	2.9	CE	Raise cap
18	F	SE 7th Street	Satisfactory	2.91	CE	Raise cap
19	B	NE 4th Street	Satisfactory	3.03	CE	Raise cap
20	Z	Bucida Road	Satisfactory	3.18	CE	Raise cap
21	X	Lowry Street	Satisfactory	3.24	CE	Raise cap
22	G	Opposite SE 9th Court	Fair	3.29	CE	Raise cap. Remove upland trees
23	T	Seaspray Avenue	Fair	3.36	CE	Raise and replace cap. Remove upland trees
24	R	Island Drive Bridge Abutment SW	Satisfactory	3.39	CE	Raise cap
25	P	Island Drive Bridge Abutment NE	Satisfactory	3.56	CE	Raise cap
26	W	Basin Drive	Fair to poor	5.13,3.78	CE	Raise cap on low portion
27	V	Thomas Street	Satisfactory to Fair	5.3	CE	Raise cap on lower gravity wall portion
28	DD	808 Seasage Drive[A]	Fair to poor	3.9	LK	Seawall panel was minimally repaired. Monitor for soil leakage.
29	N	SFWMD R/W Revetment structure at S40	Satisfactory	NA	NA	No action
30	K	Tropic Boulevard North side	Satisfactory	6.13	NA	No action
31	L	Tropic Boulevard South side	Satisfactory	6.5	NA	No action
32	I	Mangrove Park Ramp - North and West	Satisfactory	4.58	NA	No action
33	J	Mangrove Park Ramp - South and East	Satisfactory	4.65	NA	No action

Note: A 808 Seasage Drive is privately owned, but has a City easement over the northern portion of the private parcel.

Based on the findings of this study, while the City can improve publically owned seawalls against future high tides, this effort may not prevent future flooding without private owner improvements. For example, consider the seawall at NE 1st Court (Figure 18), where the existing elevation is 2.77 feet NAVD. The City can raise the seawall to the adopted future elevation, but flooding will not be prevented until the adjoining seawall (upper right corner) is also raised.

Figure 18. View of the North End of the Seawall Cap at NE 1st Court.

6.3 Stormwater System

The Appendix F map series presents the results of the stormwater system survey and backflow prevention device observations. Review of this map series allows for understanding of the coupled system that reveals low infrastructure at the inlet or outfall end and corresponds well with observed sunny day flooding events. A summary of the stormwater system ordered by inlet elevation was created and provided in Table 8 to guide future system improvements. The table includes the City's street inlet name that was obtained from the City's stormwater atlas, surveyed horizontal coordinates and vertical elevation of the inlet, the outfall invert elevation, and the observed or proposed backflow prevention device. The outfall name as defined by APTIM using the road name and general flow direction is provided for general reference and may aid in understanding the geographic context of individual inlets.

In order to assess the vulnerability of the inlets, the inlet elevations were compared to the high 30-year projected water level of 4.4 ft. NAVD and determined that 86 of the 103 inlets surveyed are below elevation 4.4 ft. and vulnerable to future tidal flooding. Currently, there is a variety of backflow prevention devices installed and the City has plans for five (5) additional installations of inline valves. The existing backflow prevention devices along with the City's planned installments will protect 28 of the vulnerable inlets. The remaining 58 unprotected inlets below 4.4 ft. may require installation of a prevention device to prevent tidal flooding.

Many of the existing subtidal duckbill valves are encrusted with oysters and barnacles that prevent them from sealing closed (see photographs in Appendix G). Regular maintenance to remove obstructions may improve the function of these backflow prevention devices.

Table 8. Stormwater System Summary (Page 1 of 2)

Row ID	Street Inlet Elevation (ft, NAVD)	Street Inlet City Name	Northing	Easting	Outfall Invert (ft, NAVD)	APTIM Outfall Name	Observed Backflow Prevention[D]	City Reported Backflow Prevention (type, location)
1	0.2	16C090	775664.051	962907.925	1.2 -1.5	Basin_Dr_N_1 Basin_Dr_N_2	Duckbill Flapgate-sealed	
2	0.6	16C031	777402.273	963639.163	-2.1	Beach_Dr_N	Grouted	
3	0.7	21C069	768137.456	962832.726	-1.1	Brooks_Ln_N	Duckbill	Proposed inline, catch basin
4	0.9	16C066	776005.129	963245.88	-0.06	Thomas_St_W_1	Flapgate	
5	0.9	21CC074	767772.033	962795.691	-1.2	White_Dr_S_2	None	Proposed inline, catch basin
6	1.0	16C041	776859.657	963218.57	-0.4 -0.6	Waterway_Ln_W_1 Waterway_Ln_W_2	None Flapgate-sealed	
7	1.2	16C626	775615.132	962384.95	-1.7	NE1st_Ct_E	None	
8	1.3	16C221	775918.718	962406.18	-4.3	NE2nd_St_E_1-FDOT	None	
9	1.4	16C445	773958.204	962188.057	-1.4	SE1st_St_E_3	Duckbill	
10	1.4	21C072	767421.892	962639.829	-1.4	RhodesVilla_Ave_N_2	Duckbill	Proposed inline, catch basin
11	1.4	16C615	772623.952	962030.488	-5.9 -0.05	SE3rd_St_E_1 SE3rd_St_E_2	None None	
12	1.5	16C178	773281.495	962765.209	-2.5	Ingraham_Ave_W	Duckbill	
13	1.5	16C515	773389.836	962108.319	-3.3	Marine_Way_E_1	Duckbill	Inline, discharge
14	1.5	21C139	768473.062	962353.054	-1.2	Lewis_Cove_Rd	Duckbill	
15	1.6	28C291	763869.563	961976.31	Not found[A]	Dogwood_Dr_E	None	
16	1.6	16C086a	774355.481	962252.811	0.6	Marine_Way_E_4	Flapgate	
17	1.6	09C106b	777375.027	962998.749	-0.9 -1.1 -1.1	Beach_Dr_W_1 Beach_Dr_W_2 Beach_Dr_W_3	Duckbill Duckbill Flapgate-sealed	
18	1.6	21C002	771609.77	962522.189	-2.8	Bucida_Rd_N	None	
19	1.6	16C024	771929.574	962794.738	-2.1	Casuarina_Rd_N	Not observed	Tideflex inline, discharge
20	1.7	16C680	773631.704	962137.775	-3.2	Marine_Way_E_2	Duckbill	Inline, discharge
21	1.7	09C127	780317.811	962783.144	-0.7	Bond_Way_E	None	
22	1.7	16C163	773910.979	962786.825	-0.2	Macfarlane_Dr_W_3	None	
23	1.8	28C017	764212.214	961894.201	-1.9	Cypress_Dr_E	Duckbill	
24	1.8	21C145	768863.124	962873.999	-0.6	Poinsettia_Rd_S	None	Inline, catch basin
25	1.8	21C057	769375.907	962695.036	-3.5	Seasage_Dr_W	None	Proposed inline, catch basin
26	1.9	28C171	761702.681	961643.787	-0.3	Jasmine_Dr_N2	None	
27	1.9	28C106	763880.593	961283.581	-0.4	Dogwood_Dr_N	None	
28	1.9	16C592	773859.823	962126.18	-3.2	Marine_Way_E_3	Duckbill	Inline, discharge
29	1.9	16C335D	775269.201	962359.855	-2.5	NE1st_St_E_1	None	
30	2.0	28C015	764603.155	961787.501	-1.2	Banyan_Dr_N_2	None	
31	2.0	09C270	779095.179	963362.778	Channel	George Bush BLVD W_1	No pipe	
32	2.0	09C025	778222.87	963621.271	-2.3	Harbor_Dr_S	None	Inline, catch basin
33	2.0	21C394	771941.251	961813.546	-1.0	SE4th_St_E	Duckbill	
34	2.0	16C025	777204.76	963206.97	-3.8	Seaspray_Ave_W	None	
35	2.1	28C164	761702.417	961196.992	-0.5	Jasmine_Dr_N_1	None	
36	2.1	09C035	777800.293	963056.774	-0.8	Island_Dr_W	None	
37	2.1	21C066	768094.522	962381.527	-1.3	Brooks_Ln_S	None	
38	2.1	09C189	777884.423	962707.472	-4.0	NE5th_St_E	None	
39	2.2	28C115	763116.005	961347.562	-1.5	Fern_Dr_S	None	
40	2.2	28C112	763151.872	961604.661	-0.04	Fern_Dr_N	None	
41	2.2	28C002	766019.027	962523.899	-0.8	DelHarbour_Dr_N	None	
42	2.3	28C109	763514.58	961497.682	-0.03	Evergreen_Dr_N	None	
43	2.3	09C470	777800.609	963690.15	1.6	Island_Dr_N	None	
44	2.3	21C181	767804.926	962394.399	-0.9	White_Dr_N	None	
45	2.3	21C029a	768902.048	962469.732	-2.0	Poinsettia_Rd_W	None	
46	2.3	21C054	770063.273	962490.395	-1.3	Azalea_Rd_W	None	Inline, discharge
47	2.3	21C034	770865.669	962722.385	-1.8	Tamarind_Rd_W_1	Inline	Inline, discharge
48	2.3	21C072B	767423.58	962360.45	0.1	RhodesVilla_Ave_N_1	None	
49	2.4	28C140	762392.521	961809.044	-1.1	Hyacinth_Dr_S_2	None	
50	2.4	21C173	770435.244	961878.995	-0.6	SE8th_St_E	None	
51	2.5	33C009	760342.952	961169.907	-4.5	Spanish_Cir_N	Duckbill	
52	2.5	16C192	772577.983	963001.87	-0.2 -0.1	Venetian_Dr_W_1 Venetian_Dr_W_2	Duckbill Duckbill	
53	2.5	09C033	778219.822	963080.737	-1.3	Harbor_Dr_W	None	

Table 8. Stormwater System Summary (Page 2 of 2)

Row ID	Street Inlet Elevation (ft, NAVD)	Street Inlet City Name	Northing	Easting	Outfall Invert (ft, NAVD)	APTIM Outfall Name	Observed Backflow Prevention[D]	City Reported Backflow Prevention (type, location)
54	2.6	16C222C	775967.522	962250.591	-3.2	NE2nd_St_E_2-City	None	
55	2.6	28C145	762386.664	961447.269	-1	Hyacinth_Dr_S_1	None	
56	2.6	28C075	764226.421	961264.029	-0.07	Cypress_Dr_N	None	
57	2.6	28C013	764904.229	961773.419	-1.3	Allamanda_Dr_E	None	
58	2.6	16C085a	774400.436	962241.366	1.2	Marine_Way_E_5	Flapgate	
59	2.6	21C183	767709.693	962389.084	0.09	White_Dr_S_1	None	
60	2.7	28C032	762031.942	961287.544	-2.0	Iris_Dr_S	None	
61	2.7	28C006A	765970.309	961748.528	-0.9	Eve_St_N_2	None	
62	2.7	21C077A	767033.465	962500.61	-0.9	DelHaven_Dr_S	None	Proposed inline, catch basin
63	2.8	28C175	761606.401	961993.625	-0.4	Jasmine_Dr_E	None	
64	2.8	28C009	765598.27	961759.971	-1.1	Tropic_Blvd_E	None	
65	2.9	28C129	762746.815	961064.865	-1.7	Gardenia_Dr_S	None	
66	2.9[B]	21C178	769717.79	961745.097	0.5	SE9th_St_N	None	
67	2.9	16C605	774626.388	962098.31	-4.8	Atlantic_Ave_E	None	
68	2.9	09C042	778608.383	962567.291	-1.2	Palm_Trail_E_2	None	
69	3.1	28C184	761221.205	960695.339	-3.0	Spanish_Trail_E_2	None	
70	3.1	28C069	764571.335	961245.928	-2.9	Banyan_Dr_N_1	None	
71	3.2	28C134	762767.425	961978.268	-0.2	Gardenia_Dr_E	None	
72	3.3	28C179	761250.736	961582.513	-1.0	Jasmine_Ct_S	None	
73	3.3	28C066	764917.748	961214.552	-2.0	Allamanda_Dr_N	None	
74	3.4	28C084	761212.456	960762.416	-3.0	Spanish_Trail_E_1	Duckbill	
75	3.4	28C011	765250.045	961763.846	-0.4	Bolender_Dr_E_1	None	
76	3.4	20C005	766293.055	961763.157	0.3	McCleary_St_N	None	
77	3.6	16335a	775282.124	962140.18	-4.1 -4.4	NE1st_St_E_2 NE1st_St_E_3	None	
78	3.7	Unknown	782212.733	963007.868	-1.5	Palm_Trail_E_3	Flapgate	
79	3.7	16P122	774279.834	962610.873	-0.7 -0.8 -0.8	Macfarlane_Dr_W_4 Macfarlane_Dr_W_5 Macfarlane_Dr_W_6	Duckbill Duckbill Duckbill	
80	4.0	28C081	764085.143	960597.568	-0.9	Spanish_Trail_E_3	None	
81	4.0	21C100	770791.921	961517.304	-2.4	SE7th_St_E	None	
82	4.1	28C078	764430.435	960578.881	-1.2	Spanish_Trail_E_4	None	
83	4.1	28C046	765611.447	961261.516	-0.8	Tropic_Blvd_N_3	None	
84	4.1	28C037	766271.681	961260.791	-0.2	McCleary_St_S_2	None	
85	4.1[B]	16C631	773442.473	962608.508	-2.2	Macfarlane_Dr_W_1	None	
86	4.3	28C309	764672.457	960566.098	-0.9	Spanish_Trail_E_5	None	
87	4.4	28C050B	765258.217	960732.684	-0.3	Bolender_Dr_N_1	None	
88	4.4	28C043	766264.73	960800.212	-0.2	McCleary_St_S_1	None	
89	4.4[C]	28C285	766589.746	961358.057	-1.3	Linton_Blvd_E_1	None	
90	4.5	21C126	769378.373	961450.517	-2.9	SE9th_CT_E_1	None	
91	4.5	28C292	766606.194	962893.689	-2.6	Linton_Blvd_W	None	
92	4.6	28C051	765263.148	961272.175	-0.2	Bolender_Dr_N_2	None	
93	4.9	28C040	765952.059	961260.125	0.2	Eve_St_N_1	None	
94	5.0	28C1040	765602.686	960632.203	2.3	Tropic_Blvd_N_2	None	
95	5.3	21C081	771644.571	961495.344	1.6	SE5th_St_E	None	
96	5.6	28C104	765571.615	960563.944	0.8	Tropic_Blvd_S_1	None	
97	5.6	16C810	773902.822	961757.178	-3.9	SE1st_St_E_1	Duckbill	
98	5.7	28C086	765364.373	960402.567	-0.5	Bolender_Dr_E_2	None	
99	5.8	28C102	765603.66	960562.969	0.8	Tropic_Blvd_N_1	None	
100	5.9	21C513	768422.893	961860.426	0.3	Mangrove Park	None	
101	6.3	09C113	779073.745	962657.402	-0.1	GeorgeBush_Blvd_E_1	None	
102	7.8	09C120	779149.131	962722.147	-1.3	GeorgeBush_Blvd_E_2	None	
103	8.5	16C461	773953.241	961462.736	-4.3	SE1st_St_E_2	None	

Notes:

[A] The outfall pipe appeared to be buried within a rock revetment.

[B] The stormwater atlas indicates that this is part of a private stormwater system.

[C] This is the lowest inlet elevation in the system, not the closest one to the outfall.

[D] Backflow prevention device observed at end of pipe.

7. RECOMMENDATIONS

In order to reduce coastal flooding and improve the City's resiliency against rising water levels, the vulnerable seawalls and stormwater systems identified within this study should be addressed. Based on the water level projection calculations performed and current 2018 water levels, it is recommended that the City use the 2048 values in Table 9 for planning purposes; then as additional data becomes available on sea level rise rates, the water level projection for 2093 can be reassessed. The recommended planning elevations in Table 9 represent the range of water levels expected to occur during a 5-year return period storm plus a 0.5 foot safety factor, within the next 30 years or 75 years.

Table 9. Recommended Planning Elevations for Infrastructure

	Feet, NAVD	
Year	Low	High
2048	3.9	4.4
2093	5.3	7.4

Note: Low range values based on USACE High Curve for SLR, while higher range values are based on IPCC Curve.

As demonstrated throughout this report, the City is vulnerable to coastal flooding due to low or unmaintained seawalls, and low or unprotected stormwater inlets under both private and public ownership. Although these appear to be the primary causes of upland flooding reported currently within the City, they may not be the only causes. The long term rise in sea level will result in higher water tables within upland areas. If the upland areas are low in elevation relative to the water table, upland flooding may also occur. In addition to the seawall and stormwater system recommendations provided, it is advised that the City monitor its public properties for the occurrence of flooding due to rising water table levels over the next decade(s) and develop strategies to address this potential problem.

While the City can endeavor to make improvements to publicly owned systems, improvements on private parcels will also need to be undertaken. Section 8 discusses a variety of implementation techniques. In general, it is recommended that the City perform public outreach and educate residents about the contributing factors to coastal flooding and develop guidelines for improvements to private seawalls and stormwater systems. The City may consider providing select data and maps from this study via an online portal for residents to better understand the conditions of their privately owned parcels. Recommendations based on the data collected for this study, are provided in the following sections for the City's consideration.

7.1 Seawalls

Publically owned seawall recommendations are based on site observations and supplemental observations provided by City staff. Structural observations performed for this study revealed that resiliency can be improved through structural replacements, cap raisings, leak repairs, and other structural improvements, though seawall replacement is not necessary at each site. Utilizing collected data to guide City priorities and optimize efforts and expenditures, it is recommended that the City systematically implement seawall repairs and raisings to publically owned seawalls following the developed ranking in Table 7. Note that seawall replacement includes raising the seawall cap to proposed City standards (Table 9). As some of these repairs and/or replacements will occur years into the future, an updated inspection of the structure will be required prior to construction, as additional structural repairs and/or replacements may be required at that time.

It is recommended that the City determine an implementation plan for moving forward to encourage private seawall improvements. At a minimum, the current City codes shall be reviewed and enforced. Prior to construction of a private seawall repair or replacement, additional structural inspections may be required as the rapid structural assessments performed for the purposes of this study, were not meant to replace a structural inspection of the complete wall. Adoption of minimum elevation standards (Table 9) by code is recommended.

7.2 Stormwater System

Recommendations for stormwater system improvements are made based on the coupled analysis of inlet and outfall elevations, results of backflow prevention device observations, and consultations with City staff. In summary, it is recommended that the City systematically install backflow prevention devices, develop standards for maintenance of backflow prevention devices, monitor for structural or hydraulic decay of the stormwater system, and provide guidelines to assist the owners of private outfalls and stormwater systems to improve and protect those private systems from future flooding events.

7.2.1 Capital Improvements

To reduce sunny day flooding events and comply with the 30-year planning elevation for projected water levels, the City should develop a capital improvement plan to provide backflow prevention devices for the 58 inlets currently without protection and below elevation 4.4 feet. It is recommended that the order of priority for installations follow from lowest inlet elevation to the highest inlet elevation as presented in Table 8. Protection at all 58 unprotected outlets that are below the 30-year planning elevation (4.4 ft.), could be achieved within 10 years if City funding was identified to allow for improvements to approximately six (6) inlets per year. The City may determine through appropriate engineering studies, observations, and analyses whether the protection should be installed within the outfall pipe, or immediately downstream of the last inlet on a case by case basis.

7.2.2 System Maintenance

The stormwater system observations obtained through this study, revealed opportunities for improvements within the currently installed infrastructure, largely related to maintenance. The following recommendations, listed in order of importance, are made to assist the City with the initial development of a maintenance plan and will need to be customized for City implementation:

1. All existing external backflow prevention devices should be inspected and cleaned twice per year for oysters, barnacles, and any other blockages. It is recommended that inspections are scheduled around April and September of each year prior to rainy season, and seasonal high tides. Once the rate of oyster and barnacle growth is known, the cleaning frequency may need to be adjusted.

2. All existing internal backflow prevention devices should be inspected and cleaned twice per year for blockages. Similarly to the external maintenance, is recommended that internal inspections are scheduled around April and September of each year prior to rainy season, and seasonal high tides.

3. APTIM's outfall observations estimated the percent of blockage by oysters. It is recommended that the City review the stormwater observation memo in Appendix G and identify those outfalls that are blocked by greater than 10 percent. Then have those discharge pipes cleaned as an initial priority.

4. City staff have reported that the pump at Basin Drive is frequently operating, even without a source of stormwater runoff. A detailed stormwater pump, discharge pipe, and seawall inspection should

be performed at Basin Drive to determine the source of water leakage that is causing the pump to run.

5. During a brief seawall inspection at Waterway Drive, APTIM observed water flowing back toward the pump within the inlet at the road shortly after the pump had run. There is no backflow prevention device at the outfall of this discharge pipe. A detailed stormwater pump, discharge pipe, and seawall inspection should be performed at Waterway Drive to determine if the pump is running frequently, without a source of stormwater runoff, and what may be the cause.

7.2.3 System Monitoring & Future Capital Improvement

In addition to installation of backflow prevention devices and maintenance of the currently installed devices, the City should continue to monitor the performance of the stormwater networks under higher water levels and with long term sea level rise. The rise in tidal water levels will also affect local groundwater elevations. It is expected that with the age of the City's stormwater system, some structural and/or hydraulic decay may have occurred, or will occur in the future. In the event of higher groundwater elevations and decayed pipes, leakage into the pipes may occur, which would circumvent efforts of backflow prevention. Re-lining of stormwater pipes may be necessary, as has been the case in limited sections of the City.

7.2.4 Private Stormwater System Improvements

In the future, existing private outfalls and inlets may require improvements. The conditions of private systems were not quantified as part of this study. It is recommended that the City provide guidance to private owners on an as needed basis, as residents endeavor to improve private stormwater systems.

8. IMPLEMENTATION

Based on the analysis of water levels presented within this report and input from City staff, it is recommended that the elevations within Table 9 be used for planning and implementation of public and private improvement projects along the ICW and adjacent tidal canals. To implement the previously described recommendations, there are at least three ways to achieve the desired goals City-wide:

- Public/Private Partnership for Implementation,
- City Guided Implementation, and
- City Implementation.

These options are described further in the following sections.

8.1 Public/Private Partnership for Implementation

With the goal of reducing the City's vulnerability to flooding, the City will endeavor to maintain public seawalls and improve the City's public stormwater system. This would be accomplished by incremental improvements following the ranking tables developed in this study for maintenance, repair, raising, and/or replacement of City owned seawalls and installation of backflow prevention in the existing public stormwater system. These incremental improvements aim to keep water out of the streets due to elevated ICW water levels. In addition, the projected 30-year water levels from this vulnerability study may be adopted as standard for all public projects within the City.

Under the public/private partnership, the responsibility to maintain, raise, repair, and replace private seawalls would remain with the private owners without mandate of elevation, or timeline by the City, except

as required by the existing City code. Similarly, the responsibility for maintenance of private stormwater systems, including the installation of backflow prevention, will remain with the private owners. The City staff may provide guidelines for the maintenance or improvement of the private stormwater systems, upon request.

The City currently has the following language within the City code to require seawalls are maintained at a minimal level as to not threaten or endanger public health, safety or welfare, or impede navigability or use of the adjacent water body.

> Section 100.04 SEAWALLS:
> (A) It shall be unlawful and constitute a public nuisance for any property owner to maintain or allow to be maintained property owned by him located adjacent to any natural or artificial canal, stream or other body of water in a condition requiring construction of a seawall or maintenance or repair of an existing seawall.
> (B) Construction of a seawall or repair or maintenance of an existing seawall shall be deemed necessary when the lack of a seawall or need for maintenance or repair of an existing seawall causes a situation that threatens or endangers the public health, safety or welfare, or that impedes the navigability of any canal, stream or other body of water, or that endangers swimming or other water sports.

While the existing ordinance has not likely been used to require private owners to raise their seawalls to any prescribed height, the lack of elevation of any seawall that causes flooding during elevated tidal waters of the ICW could be interpreted to endanger the public health, safety, or welfare.

The advantage of this approach is its ease of implementation since no changes to the City code are required. The City can adopt elevation standards for publicly owned projects and implement them accordingly. Since private owners are not required to raise their seawalls or to do so by a certain time, this may be the favorable implementation option for some residents.

The main disadvantage of this approach is that the timeline to improve the resiliency of the portion of the City affected by elevated waters within the ICW is indefinite. It is likely that the City could fund and implement its responsibilities to public infrastructure within approximately 10 years, but private infrastructure improvements could languish much longer, or not be made at all. This approach may also burden the Code Enforcement Department and the City Attorney's office with interpreting and enforcing the existing City code for elevated tidal waters of the ICW. The enforcement of existing code is subjective without any listed deadlines for compliance and elevation standards. Lastly, implementation of this approach is difficult for those few properties within the City that do not contain seawalls. This burdens Code Enforcement and the City's Attorney's office with determining when an un-walled property requires a seawall.

8.2 City Guided Implementation

With the goal of reducing the City's vulnerability to flooding, the City will endeavor to maintain public seawalls and improve the City's public stormwater system. This would be accomplished by incremental improvements following the ranking tables developed in this study for maintenance, repair, raising, and/or replacement of City owned seawalls and installation of backflow prevention in the existing public stormwater system. These incremental improvements aim to keep water out of the streets due to elevated ICW water levels. In addition, the projected 30-year water levels from this vulnerability study may be adopted as standard for all public projects within the City. The City would lead the implementation through the funding and implementation of the recommended improvements within approximately10 years.

To guide implementation of seawall improvements by private residents and to guide implementation of private stormwater system improvements, the City may develop ordinances to mandate elevations and timing of improvements to assure a reduction in vulnerability City-wide. There are two general options for the ordinances:

8.2.1 Ordinance with Elevation Requirements Only

The City may elect to adopt seawall elevation standards that all new seawalls and seawall repairs would be required to meet. This option does not require repairs or replacement on a certain timeline, rather the private owner determines when to undergo the work. This option would be triggered when a private resident submits a permit application for a seawall improvement, or when improvements to the upland property exceed 50% of the existing value, or by a different trigger identified by the City.

An example of this approach is found in the City of Miami Beach. The City of Miami Beach, which contains 63 miles of seawalls with three miles being publically owned, is working toward implementing an ordinance of this type. Currently, homeowners are not being required to raise or replace existing seawalls, but all new seawalls are required to be more resilient and meet the May 2016 Miami Beach seawall construction guidelines. On March 9, 2016, the Miami Beach City Commission adopted the projections of the Southeast Florida Regional Climate Change Compact Unified Sea Level Rise Projections. Based on the adopted projections, the guidelines in Table 10 were developed. An interim elevation of 4.0 ft. NAVD is included as an option for private seawalls where raising the seawall to the recommended 5.7 ft. NAVD would cause negative consequences to private views for low lying homes. If a wall is built to 4.0 ft. NAVD, it is required that the structural design accommodate future retrofit for an extension up to elevation 5.7 ft. NAVD. The City of Miami Beach's ordinance is provided as an example in Appendix H.

Table 10. City of Miami Beach Seawall Construction Guideline Elevations

Private Seawall Elevation (FT. NAVD)	
Existing	3.2
Interim	4.0
Proposed	5.7
Public Seawall Elevation (FT. NAVD)	
Existing	3.2
Proposed	5.7

Although there is no required timeline, it is expected that within 20 years the majority of seawalls within the study area will require repairs or the homes will be improved to a level that will trigger them to meet the seawall elevation standards. Therefore, the advantage of this method is that at some point in the future, there should be a higher level of protection from rising waters throughout the City.

Implementation of this option in the City of Delray Beach requires adoption of a revised seawall ordinance and an update to the City's permitting policies and procedures. As other local municipalities have done, the City will need to educate residents on the implications of the revised ordinance and provide guidance on best management practices as residents conform. It is possible that some waterfront residents will oppose this alternative as some may be unable to afford the seawall improvements.

8.2.2 Ordinance with Elevation and Timeline Requirements

The City may elect to enact an ordinance requiring seawall elevation standards be implemented on a timeline to ensure City-wide goals are met. This option would require public education about current private seawall elevations and City enforcement of deadlines. The advantage to this type of ordinance is that the City becomes more resilient by a prescribed date. The disadvantage to this approach is that garnering public support for this mandated improvement to private property may be a challenge. The public must be educated, then the ordinance can be adopted, and then enforced. In most cases, the ordinance will require the expenditure of private money for private improvements that create private and public benefits. There may be some residents who cannot afford to or choose to not afford the seawall improvements within the prescribed timeframe.

A related but not identical example is The City of Fort Lauderdale, which has ordinances guiding residents on how and when raising of seawalls must be achieved. While the City of Fort Lauderdale does not mandate a specific date for achieving compliance, ongoing seasonal high tides, storm surges, and sea level rise will trigger citations under their ordinance that require seawall raising. The City of Fort Lauderdale's ordinance is provided in Appendix H as an example.

Located south of Delray Beach within Broward County, the City of Fort Lauderdale is also a member of the South Florida Regional Climate Change that the City of Delray Beach participates in. After the seasonal high tides in 2015 and 2016, the City of Fort Lauderdale adopted, updated and began enforcing a new seawall ordinance to reduce tidal flooding (City of Fort Lauderdale, 2016a and b).

The City of Fort Lauderdale's ordinance contains two provisions under which, a property owner may receive a code violation: (1) failing to maintain a seawall in good repair and (2) requiring owners to prevent tidal waters entering their property from impacting other properties or the public right of way. If cited, the property owner has 60 days to demonstrate progress towards making a repair, and 365 days to fully remedy the situation. The ordinance also states that if there is any required seawall repair that meets the substantial repair threshold, it must be constructed to meet the minimum elevation requirements established by the City of Fort Lauderdale (Table 11). To assist with public outreach, Fort Lauderdale has launched a website dedicated to seawall information for the public. The website contains frequently asked questions and answers, along with key resources for residents regarding this regulation (City of Fort Lauderdale, 2016c).

Requiring the prevention of tidal waters from impacting neighbors' property or the public right of way may be a reasonable way of encouraging neighborhoods to improve seawalls without mandating a specific timeframe. If this type of ordinance is pursued, while the goal would be steady systematic improvements to the seawall system and the City's resiliency, a single storm surge event may result in widespread citations and subsequent challenges to the marine industry to assist homeowners in complying with the ordinance.

Table 11. City of Fort Lauderdale Ordinance Requirements as of December 6, 2016

Property's FEMA Flood Insurance Rate Map Location	Minimum Allowable Height (FT NAVD88)	Maximum Allowable Seawall or Dock Elevation (FT NAVD88)
In floodplain with base flood elevation greater than or equal to 5.0 ft. NAVD88	3.9	Base flood elevation of the property
In floodplain with base flood elevation equal to 4.0 ft. NAVD 88	3.9	5
In an X zone, not in a floodplain	3.9	Meet the definition of grade as determined by Section 47-2.2(g)(1)(a)

8.3 City Responsible for Implementation

A third option that the City of Delray Beach may consider is to improve resilience in the City by assuming maintenance responsibilities for both public and private seawalls and all public and private stormwater outfalls along the ICW through the creation of a special assessment district. Once the district is established, the district would determine City-wide the order of priority for seawall and stormwater system improvements to make the City more resilient against coastal flooding. These projects would be funded by public funds collected as annual assessments from affected residents. The construction would be managed by the assessment district.

An example of this type of program is within the City of Punta Gorda. Located on the west coast of Florida within Charlotte County, Punta Gorda is known as Florida's Harborside Hometown. Surrounded by Charlotte Harbor and with a unique layout of neighborhoods, Punta Gorda is touted as a boater's haven with many waterfront canal lots. The City of Punta Gorda recently developed a system of maintaining seawalls and canal systems through two canal maintenance assessment districts: Punta Gorda Isles and Burnt Store Isles. Through these districts, Punta Gorda is responsible for maintenance of 109 miles of seawalls, dredging, and mangrove trimming along 54 miles of canals. The current level of assessments are shown in Table 12 and Punta Gorda's documentation for the assessment district is provided in Appendix H.

Table 12. City of Punta Gorda's Assessment Districts and Annual Assessments.

Punta Gorda Isles Canal Maintenance Assessment District		
FY 2018 Assessment Rate:	$550	per single family residential lot
FY 2017 Assessment Rate:	$550	per single family residential lot
Burnt Store Isles Canal Maintenance Assessment District		
FY 2018 Assessment Rate:	$555	per single family residential lot
FY 2017 Assessment Rate:	$570	per single family residential lot

The primary advantage of this approach is that the district could provide equal quality of seawall repair and replacement throughout the City. There is a potential for construction cost savings from private marine contractors by creating projects of grouped single properties. This approach would assure the City that all new or repaired seawalls are built to the same minimum elevation standards.

In contrast to Punta Gorda, Delray's waterfront was developed over time and is being redeveloped over time, resulting in a wide range of seawall conditions and elevations. The maps generated during this study can be used to illustrate these varied conditions. If this approach is pursued, the created district (City) would then assume responsibility for all seawalls within the defined district. The created district may require assistance from City staff to implement the improvements. Due to the varied conditions City-wide, the need for improvements varies dramatically from one area to the next while all properties would pay the district equally.

In addition to the challenge of varied seawall conditions, there are at least three additional considerations that should be well defined prior to acceptance by residents. (1) Due to the wide range of existing seawall conditions throughout the City, procedures on how the created district would determine priorities for improvements would need to be identified. (2) If this program creates additional work for City staff, the funding for new employees must either be included in the created district's budget or funded by the City. (3) Since the program would focus strictly on seawalls and not include private docks or other amenities, procedures would need to be defined for private owners who have or desire a private dock or other waterfront amenities. It is currently unclear how the cost of construction of additional features could be interfaced within a district seawall program.

8.4 Implementation Summary

The presented approaches to implementing private infrastructure improvements represent a range of options and other options or hybrid combinations could also be considered to suit the City's goals. It is our opinion that the option of City Guided Implementation be further considered by the City of Delray Beach. The current Public/Private Partnership may fail to achieve the desired resiliency within the City. City Implementation would assume significantly more responsibility by the City than it currently has, and implementation may be more challenging than the other options. In pursuing the City Guided Implementation, the City should weigh the benefits of implementing a time specific resiliency goal versus allowing for ongoing sea level rise and recurring storms to trigger improvements.

9. LITERATURE CITED

ASCE Manuals and Reports on Engineering Practice No. 101, 2001.

City of Delray Beach, 2017, White Drive gage, unpublished tidal data provided by the City of Delray Beach.

City of Fort Lauderdale, "Ordinance C-16-13", June 2016.

City of Fort Lauderdale, "Ordinance C-16-27, November 2016.

City of Fort Lauderdale, Seawall Maintenance website: https://gyr.fortlauderdale.gov/greener-government/climate-resiliency/seawall-maintenance

Harris, D.L., "Tides and Tidal Datums in the United States", Special Report No. 7, U. S. Army Corps of Engineers Coastal Engineering Research Center, February 1981.

Knuuti, K. Planning for Sea Level Rise: U.S. Army Corps of Engineers Policy," Coastal Disasters Conference 2002, pp. 549-560., 2002.

NOAA tide gage Lake Worth Pier data obtained from https://tidesandcurrents.noaa.gov/waterlevels.html?id=8722670

NOAA, "Global and Regional Sea Level Rise Scenarios for the United States," NOAA Technical Report NOS CO-OPS 083, January 2017.

SFWMD S40T gage and S40 discharge gage data obtained from https://www.sfwmd.gov/science-data/dbhydro

Southeast Florida Regional Climate Change Compact Sea Level Rise Work Group (Compact). October 2015. Unified Sea Level Rise Projection for Southeast Florida. A document prepared for the Southeast Florida Regional Climate Change Compact Steering Committee. 35 p.

U.S. Army Corps of Engineers, "Incorporating Sea Level Change in Civil Works Programs", ER 1100-2-8162, 31 December 2013.

APPENDIX A

TIDAL HARMONIC CONSTITUENTS AT LAKE WORTH PIER

Harmonic Constituents for 8722670, Lake Worth Pier, Atlantic Ocean FL

Constituent #
Order in which the National Ocean Service lists the constituents

Name
Common name used to refer to a particular constituent, subscript refers to the number of cycles per day

Amplitude
One-half the range of a tidal constituent

Phase
The phase lag of the observed tidal constituent relative to the theoretical equilibrium tide

Speed
The rate change in the phase of a constituent, expressed in degrees per hour. The speed is equal to 360 degrees divided by the constituent period expressed in hours

Description
The full name of the tidal constituent

Showing Harmonic Constituents for

8722670 Lake Worth Pier, Atl…

Data Units (•) Feet
( ) Meters

Timezone (•) Local
( ) GMT

Submit

Please refer to the Tide and Current Glossary (/glossary.html) for definitions of terms. Amplitudes are in feet. Phases are in degrees, referenced to Local. Z_0 (MSL): 0 feet

Constituent #	Name	Amplitude	Phase	Speed	Description
1	M2	1.335	228.8	28.984104	Principal lunar semidiurnal constituent
2	S2	0.223	245.0	30.0	Principal solar semidiurnal constituent
3	N2	0.315	211.8	28.43973	Larger lunar elliptic semidiurnal constituent
4	K1	0.19	143.8	15.041069	Lunar diurnal constituent
5	M4	0.01	257.1	57.96821	Shallow water overtides of principal lunar constituent
6	O1	0.148	166.5	13.943035	Lunar diurnal constituent
9	S4	0.007	318.5	60.0	Shallow water overtides of principal solar constituent
10	MN4	0.007	246.3	57.423832	Shallow water quarter diurnal constituent
11	NU2	0.059	210.5	28.512583	Larger lunar evectional constituent
13	MU2	0.043	213.5	27.968208	Variational constituent
14	2N2	0.046	199.8	27.895355	Lunar elliptical semidiurnal second-order constituent
15	OO1	0.007	145.9	16.139101	Lunar diurnal
16	LAM2	0.013	250.0	29.455626	Smaller lunar evectional constituent
17	S1	0.013	174.0	15.0	Solar diurnal constituent
18	M1	0.007	181.2	14.496694	Smaller lunar elliptic diurnal constituent
19	J1	0.013	138.2	15.5854435	Smaller lunar elliptic diurnal constituent
21	SSA	0.177	68.0	0.0821373	Solar semiannual constituent
22	SA	0.259	204.3	0.0410686	Solar annual constituent
25	RHO	0.007	163.0	13.471515	Larger lunar evectional diurnal constituent
26	Q1	0.033	165.5	13.398661	Larger lunar elliptic diurnal constituent
27	T2	0.026	232.0	29.958933	Larger solar elliptic constituent
28	R2	0.007	100.7	30.041067	Smaller solar elliptic constituent
30	P1	0.059	144.8	14.958931	Solar diurnal constituent
31	2SM2	0.007	244.3	31.015896	Shallow water semidiurnal constituent
32	M3	0.007	178.9	43.47616	Lunar terdiurnal constituent

Constituent #	Name	Amplitude	Phase	Speed	Description
33	L2	0.033	227.5	29.528479	Smaller lunar elliptic semidiurnal constituent
35	K2	0.059	244.6	30.082138	Lunisolar semidiurnal constituent
37	MS4	0.007	198.4	58.984104	Shallow water quarter diurnal constituent

Return to Top

Show nearby stations

Products available at 8722670 Lake Worth Pier, Atlantic Ocean, FL

TIDES/WATER LEVELS

Water Levels (/waterlevels.html?id=8722670)

NOAA Tide Predictions (/noaatidepredictions.html?id=8722670)

Harmonic Constituents (/harcon.html?id=8722670)

Sea Level Trends (/sltrends/sltrends_station.shtml?id=8722670)

Datums (/datums.html?id=8722670)

Bench Mark Sheets (/benchmarks.html?id=8722670)

Extreme Water Levels

Reports (/reports.html?id=8722670)

METEOROLOGICAL/OTHER

Meteorological Observations (/met.html?id=8722670)

Water Temp/Conductivity

PORTS®

This station is not a member of PORTS®

OPERATIONAL FORECAST SYSTEMS

This station is not a member of OFS

INFORMATION

Station Home Page (/stationhome.html?id=8722670)

Data Inventory (/inventory.html?id=8722670)

Measurement Specifications (/measure.html)

Information

About CO-OPS (/about.html)
Take Our Survey (/survey.html)
Disclaimers (/disclaimers.html)
Contact Us (/contact.html)

Privacy Policy (/privacy.html)

Products

PORTS (/ports.html)
OFS (/models.html)
Tide Predictions (/tide_predictions.html)
Currents (/cdata/StationList?type=Current+Data&filter=active)
More about products... (/products.html)

Programs

Mapping and Charting Support (/mapping.html)
Maritime Services (/maritime.html)
COASTAL (/coastal.html)
More about programs... (/programs.html)

Partners

Hydrographic Survey Support (/hydro.html)
Marsh Restoration (/marsh.html)
GoMOOS (/gomoos.html)
TCOON (/tcoon.html)

Revised: 08/08/2018
NOAA (http://www.noaa.gov) / National Ocean Service (http://oceanservice.noaa.gov)
Web site owner: Center for Operational Oceanographic Products and Services

APPENDIX B

TOPOGRAPHIC SURVEY MAPS

2018 CITY OF DELRAY BEACH
SEAWALL VULNERABILITY ANALYSIS
TOPOGRAPHIC SURVEY

2018 CITY OF DELRAY BEACH CONTROL			
MON ID	NORTHING	EASTING	MON. ELEV.
USCGS P 315	779560.30	964698.90	20.23
PM BH R-192 1974	761715.96	962893.59	14.12

NOTES:

1. DATE OF SURVEY: JANUARY 22, 2018 THRU MAY 10, 2018.
2. THE INFORMATION ON THIS MAP REPRESENTS THE RESULTS OF THE SURVEY ON THE DATE INDICATED AND CAN ONLY BE CONSIDERED AS INDICATING THE GENERAL CONDITIONS EXISTING AT THE TIME.
3. COORDINATES ARE IN FEET BASED ON THE VERTICAL AND HORIZONTAL DATA THAT WAS COLLECTED AND PRESENTED RELATIVE TO THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) AND THE FLORIDA STATE PLANE COORDINATE SYSTEM BASED ON THE TRANSVERSE MERCATOR PROJECTION, EAST ZONE, NORTH AMERICAN DATUM OF 1983/2011 (NAD83/11).
4. LANDS WERE NOT ABSTRACTED FOR RIGHTS-OF-WAY, EASEMENTS, OWNERSHIP OR OTHER INSTRUMENTS OF RECORD.
5. UNDERGROUND AND SUBAQUEOUS IMPROVEMENTS AND/OR UTILITIES WERE NOT LOCATED AS PART OF THIS SURVEY AND SHOULD BE FIELD VERIFIED PRIOR TO ANY DREDGING OR CONSTRUCTION ACTIVITIES.
6. AIDS TO NAVIGATION WERE NOT LOCATED DURING THIS SURVEY. NOT FOR NAVIAGATION.
7. HORIZONTAL AND VERTICAL POSITIONING WAS CONTROLLED USING FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION SECOND ORDER MONUMENTS USCGS P 315, ELEVATION 20.226' NAVD88 AND PM BH R-192 1974, ELEVATION 14.120' NAVD88.
8. TOPOGRAPHIC RTK DATA CORRECTIONS WERE APPLIED USING THE FLORIDA PERMANENT REFERENCE NETWORK
9. HORIZONTAL POSITIONING FOR OUTFALLS ARE APPROXIMATE, VERTICAL POSITIONING IS SURVEY GRADE
10. SEAWALLS WITH APPROXIMATE HORIZONTAL POSITIONS AS SHOWN ON SURVEY PLANS WERE LOCATED WITH RTK GPS ON THE PARCEL BOUNDARY OR IMMEDIATELY ADJACENT TO THE PARCEL BOUNDARY AND SHIFTED WITHIN THE PARCEL FOR ILLUSTRATION AND PLAN READABILITY
11. THIS SURVEY IS NOT VALID WITHOUT THE SIGNATURE AND RAISED SEAL OF A FLORIDA LICENSED SURVEYOR AND MAPPER WHICH CAN BE FOUND ON THE SURVEY REPORT NOTES AND CERTIFICATION SECTION OF THE SURVEY REPORT. THE MAP AND REPORT ARE NOT FULL AND COMPLETE WITHOUT THE OTHER.
12. ADDITIONS OR DELETIONS TO SURVEY MAPS OR REPORTS BY OTHER THAN SIGNING PARTY OR PARTIES IS PROHIBITED WITHOUT WRITTEN CONSENT OF THE SIGNING PARTY OR PARTIES.
13. THIS MAP IS INTENDED TO BE DISPLAYED AT A SCALE OF 1"/300' OR SMALLER.

LEGEND

ID	IDENTIFICATION
MON.	MONUMENT
M. DATE	MONUMENT DATE
M.ELEV.	MONUMENT ELEVATION
AZ	AZIMUTH
MAR	MARCH
AUG	AUGUST
ST	STREET
BLVD	BOULEVARD
AVE	AVENUE
PV	PLAN VIEW
CS	COVER SHEET
APTIM	APTIM COASTAL PLANNING & ENGINEERING INC.
NAVD	NORTH AMERICAN VERTICAL DATUM 1988
FDEP	FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION
NAD	NORTH AMERICAN DATUM 1983
⊕	FDEP "A" MONUMENT
⊙	RANGE MONUMENT
FLA	FLORIDA
PH.	PHONE
C.O.A.	CERTIFICATE OF AUTHORIZATION
COMM.	COMMISSION
NO.	NUMBER
RTK	REAL TIME KINEMATIC
⊠	STORMWATER INTAKES
●	DRAINAGE OUTFALL
●	SEAWALL ELEVATIONS
□	REVETMENT ELEVATIONS
×	SEA WALL ELEVATION W/APPROXIMATE HORIZONTAL

CERTIFICATION:

I HEREBY CERTIFY THAT THIS HYROGRAPHIC AND TOPOGRAPHIC SURVEY IS TRUE AND CORRECT TO THE BEST OF MY KNOWLEDGE AND BELIEF AS DELINEATED UNDER MY DIRECTION. I FURTHER CERTIFY THAT IT MEETS THE STANDARDS OF PRACTICE SET FORTH IN CHAPTER 5J-17, ADOPTED BY THE FLORIDA BOARD OF PROFESSIONAL SURVEYORS AND MAPPERS, PURSUANT TO SECTION 472.027 OF THE FLORIDA STATUTES.

JEFFERY ANDREWS , P.S.M
FLORIDA PROFESSIONAL SURVEYOR AND MAPPER LS5805
APTIM COASTAL PLANNING AND ENGINEERING, INC. C.O.A. FL#4028
2481 N.W. BOCA RATON BLVD.
BOCA RATON, FLORIDA 33431

01/02/2018
DATE

NOT TO SCALE

APTIM
ENVIRONMENTAL AND INFRASTRUCTURE, INC.
2481 N. W. BOCA RATON BOULEVARD
BOCA RATON, FL 33431
PH. (561) 391-8102
FAX (561) 391 9116
COA FL #8051

No.	Description	Date

Designed by: M.Lowiec
Drawn by: J.Walker
Date: May 2018
Checked by: M.Lowiec
Reviewed by: M.Lowiec
Submitted by: M.Lowiec
Plot Scale: AS NOTED
Comm. No.: 631233074

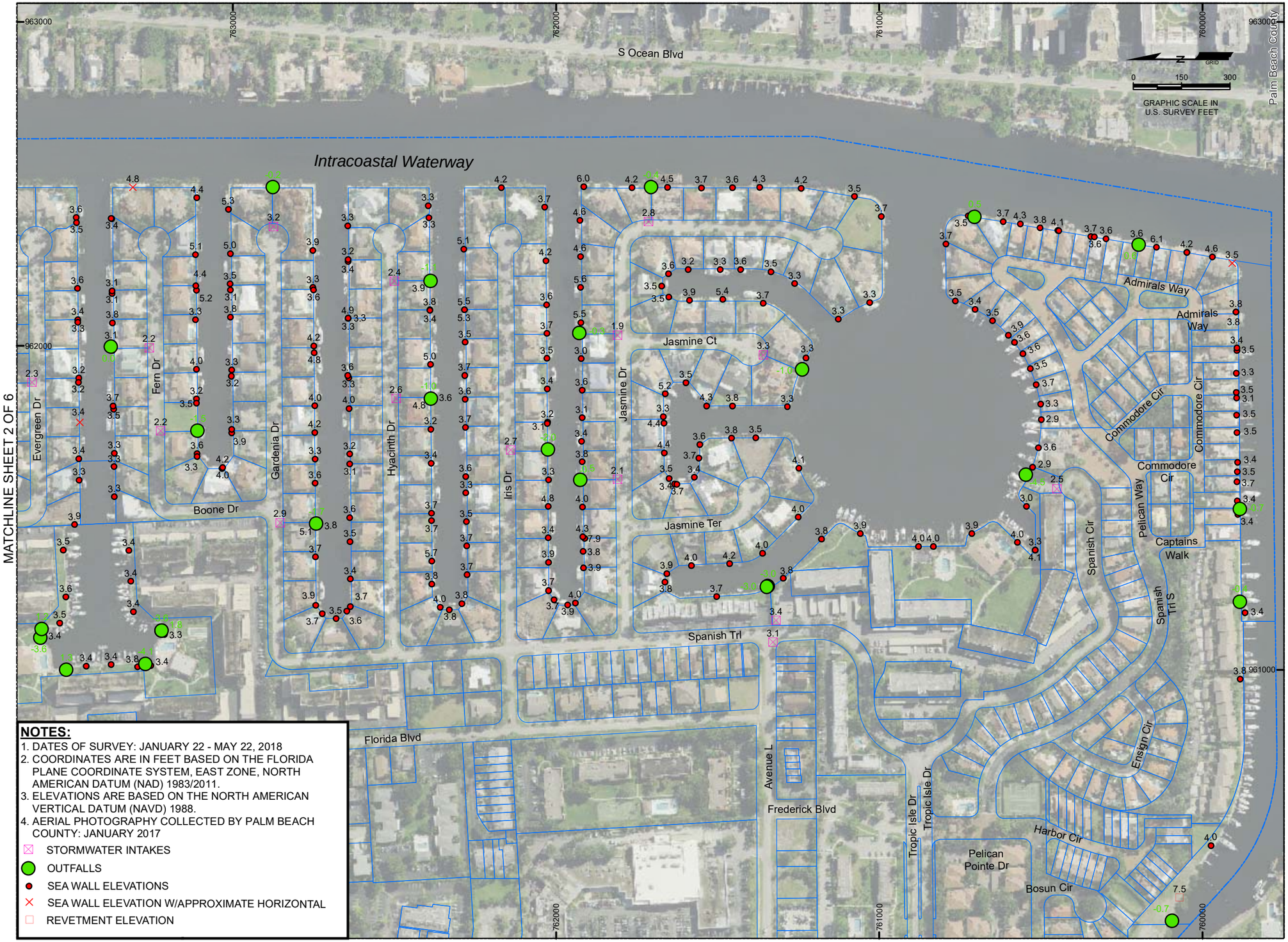
Reference Files:

2018 CITY OF DELRAY BEACH
SEAWALL VULNERABILITY ANALYSIS
TOPOGRAPHIC SURVEY

COVER SHEET AND PROJECT LOCATION MAP

DRAWING NO.
CS

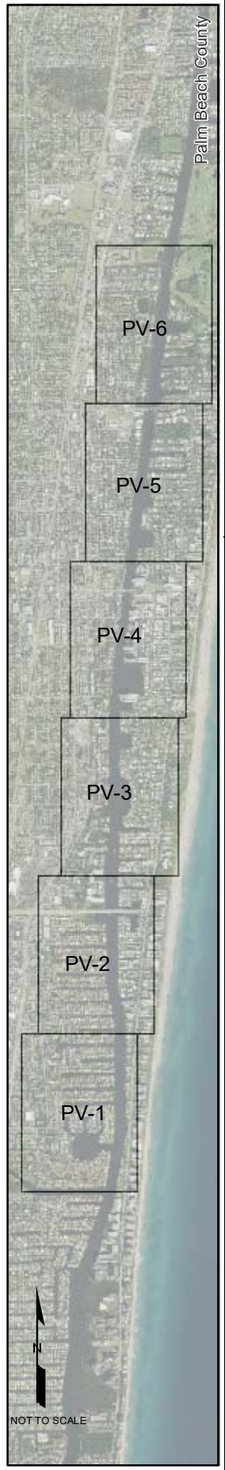
Document Path: \\cpefs01\Projects\Palm Beach\Delray Beach\631233074 Seawall Vulnerability\Survey\GIS\MXD\FINAL\CS.mxd



NOTES:

1. DATES OF SURVEY: JANUARY 22 - MAY 22, 2018
2. COORDINATES ARE IN FEET BASED ON THE FLORIDA PLANE COORDINATE SYSTEM, EAST ZONE, NORTH AMERICAN DATUM (NAD) 1983/2011.
3. ELEVATIONS ARE BASED ON THE NORTH AMERICAN VERTICAL DATUM (NAVD) 1988.
4. AERIAL PHOTOGRAPHY COLLECTED BY PALM BEACH COUNTY: JANUARY 2017

- STORMWATER INTAKES
- OUTFALLS
- SEA WALL ELEVATIONS
- SEA WALL ELEVATION W/APPROXIMATE HORIZONTAL
- REVETMENT ELEVATION



APTIM
ENVIRONMENTAL AND INFRASTRUCTURE, INC.
2481 N. W. BOCA RATON BOULEVARD
BOCA RATON, FL 33431
PH. (561) 391-8102
FAX (561) 391 9116
COA FL #8051

No.	Date	Description
	06/08/18	UPDATED OUTFALL ELEVATION AT FERN, DR. N

Designed by: M.Lowiec
Drawn by: J.Walker
Date: April 2018
Plot Scale: AS NOTED
Checked by: B.Bussard
Reviewed by: M.Lowiec
Submitted by: M.Lowiec
Comm. No.: 631233074

Reference Files:

2018 CITY OF DELRAY BEACH
SEAWALL VULNERABILITY ANALYSIS
TOPOGRAPHIC SURVEY

PLAN VIEW

DRAWING NO.

PV1

SHEET 1 OF 7

Document Path: P:\Palm Beach\Delray Beach\631233074 Seawall Vulnerability\Survey\GIS\MXD\FINAL\PV1_FINAL.mxd

MATCHLINE SHEET 4 OF 7

MATCHLINE SHEET 2 OF 7

963000 962000 961000 767000 766000 765000 764000

S Ocean Blvd

Intracoastal Waterway

Rhodes Villa Ave

Del Haven Dr

Dusty Miller Dr

Del Harbour Dr

Bermuda Gardens Rd

E Linton Blvd

McCleary St

Eve St

Tropic Blvd

Bolender Dr

Allamanda Dr

Banyan Dr

Cypress Dr

Dogwood Dr

Boone Dr

Spanish Trl

Avenue C

Florida Blvd

Palm Beach County

WETLAND CONNECTIONS NO INLET

GRAPHIC SCALE IN U.S. SURVEY FEET

0 150 300

GRID N

NOTES:

1. DATES OF SURVEY: JANUARY 22 - MAY 22, 2018
2. COORDINATES ARE IN FEET BASED ON THE FLORIDA PLANE COORDINATE SYSTEM, EAST ZONE, NORTH AMERICAN DATUM (NAD) 1983/2011.
3. ELEVATIONS ARE BASED ON THE NORTH AMERICAN VERTICAL DATUM (NAVD) 1988.
4. AERIAL PHOTOGRAPHY COLLECTED BY PALM BEACH COUNTY: JANUARY 2017

- STORMWATER INTAKES
- OUTFALLS
- SEA WALL ELEVATION
- SEA WALL ELEVATION W/APPROXIMATE HORIZONTAL
- REVETMENT ELEVATION

PV-6 PV-5 PV-4 PV-3 PV-2 PV-1

N

NOT TO SCALE

APTIM
ENVIRONMENTAL AND INFRASTRUCTURE, INC.
2481 N. W. BOCA RATON BOULEVARD
BOCA RATON, FL 33431
PH: (561) 391-8102
FAX (561) 391 9116
COA FL #8051

No.	Date	Description
	06/08/18	REMOVED INLET 28C284
	06/08/18	REMOVED INLET NO NAME 6, ADDED 28C013

Designed by: M.Lowiec
Drawn by: J.Walker
Date: April 2018
Plot Scale: AS NOTED
Checked by: B.Bussard
Reviewed by: M.Lowiec
Submitted by: M.Lowiec
Comm. No.: 631233074
Reference Files:

2018 CITY OF DELRAY BEACH
SEAWALL VULNERABILITY ANALYSIS
TOPOGRAPHIC SURVEY

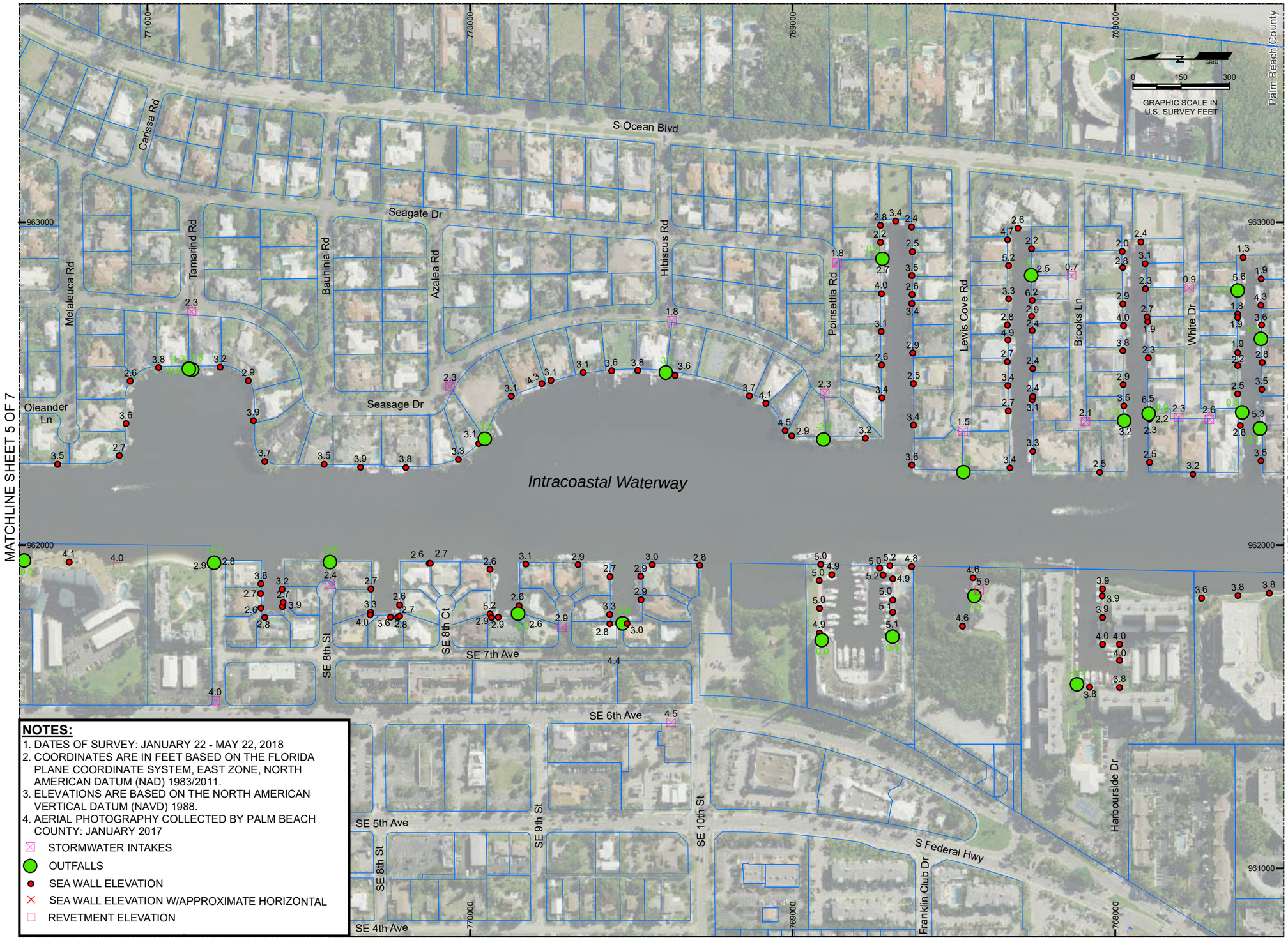
PLAN VIEW

DRAWING NO.

PV2

SHEET 3 OF 7

Document Path: P:\Palm Beach\Delray Beach\631233074 Seawall Vulnerability\Survey\GIS\MXD\FINAL\PV2_FINAL.mxd



NOTES:

1. DATES OF SURVEY: JANUARY 22 - MAY 22, 2018
2. COORDINATES ARE IN FEET BASED ON THE FLORIDA PLANE COORDINATE SYSTEM, EAST ZONE, NORTH AMERICAN DATUM (NAD) 1983/2011.
3. ELEVATIONS ARE BASED ON THE NORTH AMERICAN VERTICAL DATUM (NAVD) 1988.
4. AERIAL PHOTOGRAPHY COLLECTED BY PALM BEACH COUNTY: JANUARY 2017

STORMWATER INTAKES
OUTFALLS
SEA WALL ELEVATION
SEA WALL ELEVATION W/APPROXIMATE HORIZONTAL
REVETMENT ELEVATION

APTIM
ENVIRONMENTAL AND INFRASTRUCTURE, INC.
2481 N. W. BOCA RATON BOULEVARD
BOCA RATON, FL 33431
PH. (561) 391-8102
FAX (561) 391 9116
COA FL #8051

No.	Date	Description
	06/08/18	REMOVED INLET 21C100
	04/08/18	ADDED INLET 21C100

Designed by: M.Lowiec
Drawn by: J.Walker
Date: April 2018
Checked by: B.Bussard
Reviewed by: M.Lowiec
Submitted by: M.Lowiec
Plot Scale: AS NOTED
Comm. No.: 631233074
Reference Files:

2018 CITY OF DELRAY BEACH
SEAWALL VULNERABILITY ANALYSIS
TOPOGRAPHIC SURVEY

PLAN VIEW

DRAWING NO.

PV3

SHEET 4 OF 7

Document Path: P:\Palm Beach\Delray Beach\631233074 Seawall Vulnerability\Survey\GIS\MXD\FINAL\PV3_FINAL.mxd

Andrews Ave
Bronson Ave
Palm Ave
Seabreeze Ave
East Rd
E Atlantic Ave
Miramar Dr
Sandoway Park
Coconut Row
Ocean Ter
Gleason St
Ingraham Ave
Nassau St
Bay St
Langer Way
Casuarina Rd
Coralina Ln
Seagate Dr
S Ocean Blvd
Palm Beach County
Venetian Dr
Bucida Rd
Seasage Dr
Macfarlane Dr
Intracoastal Waterway
Marine Way
Palm Sq
NE 1st St
NE 7th Ave
SE 1st St
SE 2nd St
SE 3rd St
SE 4th St
SE 5th St
SE 6th Ave
SE 7th Ave
SE 5th Ave
E Mallory Cir
N Mallory Cir
W Mallory Cir
S Mallory Cir
773000
774000
775000
772000
963000
962000

GRID
0 150 300
GRAPHIC SCALE IN U.S. SURVEY FEET

MATCHLINE SHEET 6 OF 7

MATCHLINE SHEET 4 OF 7

NOTES:

1. DATES OF SURVEY: JANUARY 22 - MAY 22, 2018
2. COORDINATES ARE IN FEET BASED ON THE FLORIDA PLANE COORDINATE SYSTEM, EAST ZONE, NORTH AMERICAN DATUM (NAD) 1983/2011.
3. ELEVATIONS ARE BASED ON THE NORTH AMERICAN VERTICAL DATUM (NAVD) 1988.
4. AERIAL PHOTOGRAPHY COLLECTED BY PALM BEACH COUNTY: JANUARY 2017

- STORMWATER INTAKES
- OUTFALLS
- SEA WALL ELEVATION
- SEA WALL ELEVATION W/APPROXIMATE HORIZONTAL
- REVETMENT ELEVATION

PV-6
PV-5
PV-4
PV-3
PV-2
PV-1

N
NOT TO SCALE

APTIM
ENVIRONMENTAL AND INFRASTRUCTURE, INC.
2481 N. W. BOCA RATON BOULEVARD
BOCA RATON, FL 33431
PH. (561) 391-8102
FAX (561) 391-9116
COA FL #8051

No.	Date	Description
	06/08/18	REMOVED INLETS: 19, 18, 17, 16C636, MACFAR_SOUTH1, 16C577, 16C578, 16C579, 16C245
	06/08/18	ADDED INLETS: 16395a, 16C481, 16C176, 16C515
	06/08/18	INLET 16C024 POSITION WAS ADJUSTED

Designed by: M.Lowiec
Drawn by: J.Walker
Date: April 2018
Checked by: B.Bussard
Reviewed by: M.Lowiec
Submitted by: M.Lowiec
Plot Scale: AS NOTED
Comm. No.: 631233074

Reference Files:

2018 CITY OF DELRAY BEACH
SEAWALL VULNERABILITY ANALYSIS
TOPOGRAPHIC SURVEY

PLAN VIEW

DRAWING NO.
PV4
SHEET 5 OF 7

Document Path: P:\Palm Beach\Delray Beach\631233074 Seawall Vulnerability\Survey\GIS\MXD\FINAL\PV4_FINAL.mxd

MATCHLINE SHEET 7 OF 7

MATCHLINE SHEET 5 OF 7

Andrews Ave
Harmon Ct
Sandpiper Ln
Crestwood Dr
Hammond Rd
Harbor Dr
Beach Dr
Seaspray Ave
Sandoway Ln
Laing St
Vista Del Mar Dr N
Thomas St
Palm Beach County
Luke Ln
Sea Ln
Seabreeze Ave
Basin Dr
Island Dr
Waterway Ln
N Vista Del Mar Dr
S Vista Del Mar Dr
Intracoastal Waterway
George Bush Blvd
Palm Trl
Fisher Ln
NE 9th Ave
NE 8th Ave
NE 7th Ave
NE 6th St
NE 5th St
NE 4th St
NE 3rd St
NE 2nd St
NE 1st Ct
964000
963000
962000
779000
778000
777000
776000

GRAPHIC SCALE IN U.S. SURVEY FEET
0 150 300
GRID N

PV-6
PV-5
PV-4
PV-3
PV-2
PV-1

N
NOT TO SCALE

NOTES:

1. DATES OF SURVEY: JANUARY 22 - MAY 22, 2018
2. COORDINATES ARE IN FEET BASED ON THE FLORIDA PLANE COORDINATE SYSTEM, EAST ZONE, NORTH AMERICAN DATUM (NAD) 1983/2011.
3. ELEVATIONS ARE BASED ON THE NORTH AMERICAN VERTICAL DATUM (NAVD) 1988.
4. AERIAL PHOTOGRAPHY COLLECTED BY PALM BEACH COUNTY: JANUARY 2017

STORMWATER INTAKES
OUTFALLS
SEA WALL ELEVATION
SEA WALL ELEVATION W/APPROXIMATE HORIZONTAL
REVETMENT ELEVATION

APTIM
ENVIRONMENTAL AND INFRASTRUCTURE, INC.
2481 N. W. BOCA RATON BOULEVARD
BOCA RATON, FL 33431
PH: (561) 391-8102
FAX (561) 391 9116
COA FL #8051

No.	Date	Description
	06/08/18	REMOVED INLETS: 19C029 AND 19C068
	06/08/18	ADDED INLET: 16C222C

Designed by: M.Lowiec
Drawn by: J.Walker
Date: April 2018
Plot Scale: AS NOTED
Checked by: B.Bussard
Reviewed by: M.Lowiec
Submitted by: M.Lowiec
Comm. No.: 631233074

Reference Files:

2018 CITY OF DELRAY BEACH
SEAWALL VULNERABILITY ANALYSIS
TOPOGRAPHIC SURVEY

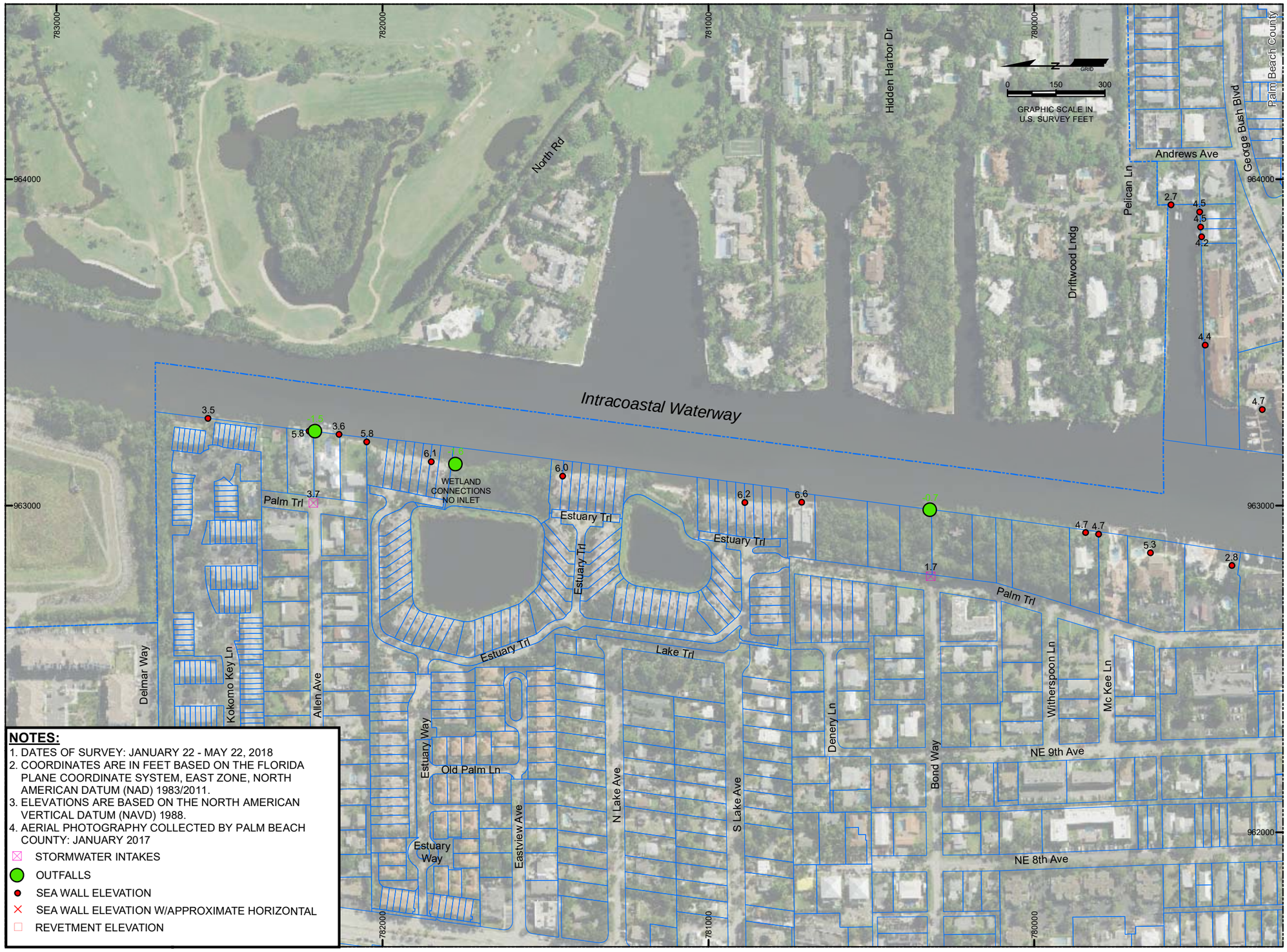
PLAN VIEW

DRAWING NO.

PV5

SHEET 6 OF 7

Document Path: P:\Palm Beach\Delray Beach\631233074 Seawall Vulnerability\Survey\GIS\MXD\FINAL\PV5_FINAL.mxd



MATCHLINE SHEET 6 OF 7

NOTES:

1. DATES OF SURVEY: JANUARY 22 - MAY 22, 2018
2. COORDINATES ARE IN FEET BASED ON THE FLORIDA PLANE COORDINATE SYSTEM, EAST ZONE, NORTH AMERICAN DATUM (NAD) 1983/2011.
3. ELEVATIONS ARE BASED ON THE NORTH AMERICAN VERTICAL DATUM (NAVD) 1988.
4. AERIAL PHOTOGRAPHY COLLECTED BY PALM BEACH COUNTY: JANUARY 2017

- STORMWATER INTAKES
- OUTFALLS
- SEA WALL ELEVATION
- SEA WALL ELEVATION W/APPROXIMATE HORIZONTAL
- REVETMENT ELEVATION

APTIM
ENVIRONMENTAL AND INFRASTRUCTURE, INC.
2481 N. W. BOCA RATON BOULEVARD
BOCA RATON, FL 33431
PH. (561) 391-8102
FAX (561) 391 9116
COA FL #8051

No.	Date	Description

Designed by: M.Lowiec
Drawn by: J.Walker
Date: April 2018
Plot Scale: AS NOTED
Checked by: B.Bussard
Reviewed by: M.Lowiec
Submitted by: M.Lowiec
Comm. No.: 631233074

Reference Files:

2018 CITY OF DELRAY BEACH
SEAWALL VULNERABILITY ANALYSIS
TOPOGRAPHIC SURVEY

PLAN VIEW

DRAWING NO.

PV6

SHEET 7 OF 7

Document Path: P:\Palm Beach\Delray Beach\631233074 Seawall Vulnerability\Survey\GIS\MXD\FINAL\PV6_FINAL.mxd

APPENDIX C

ASSESSMENT OF PUBLIC SEAWALLS

City Owned Seawalls

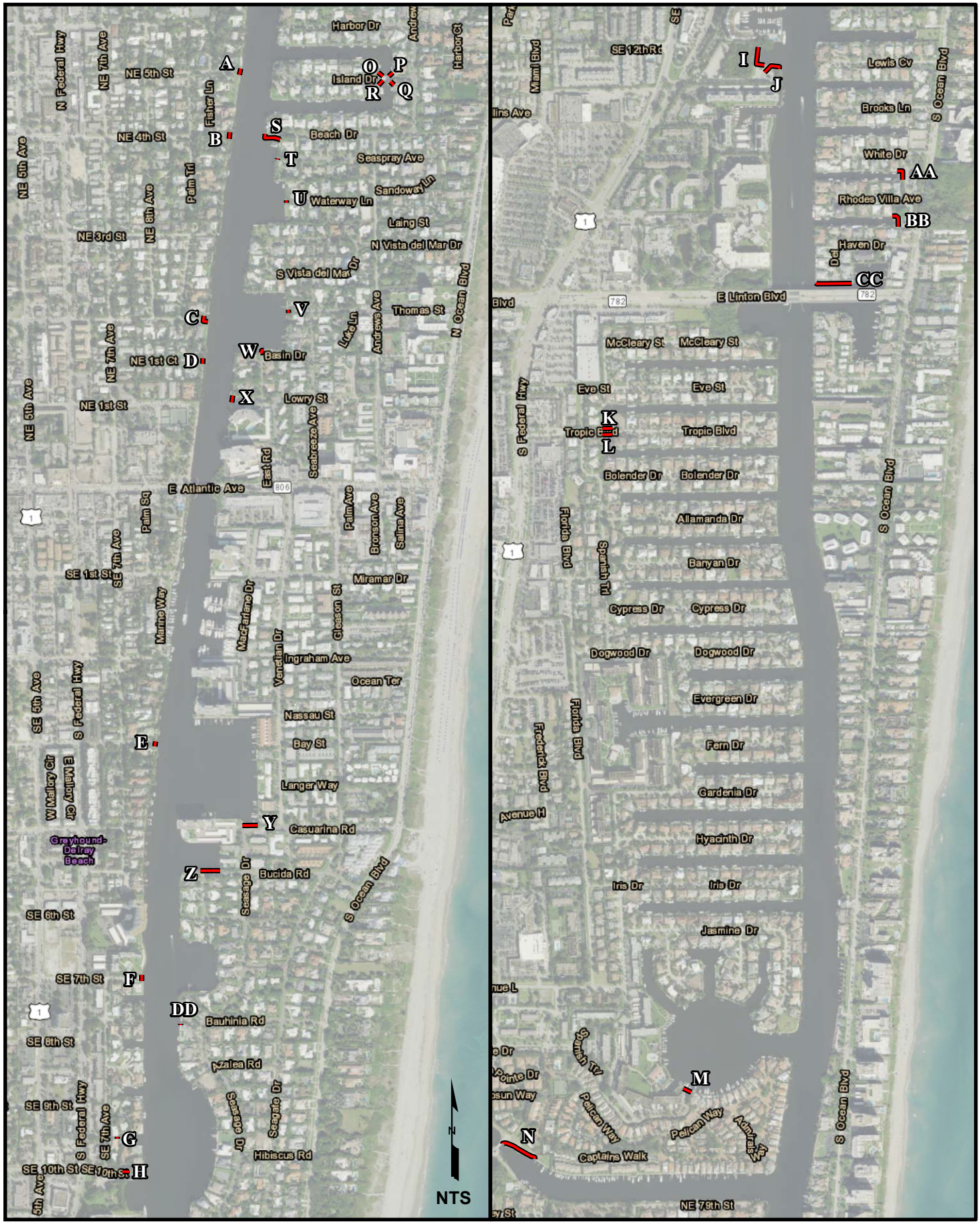
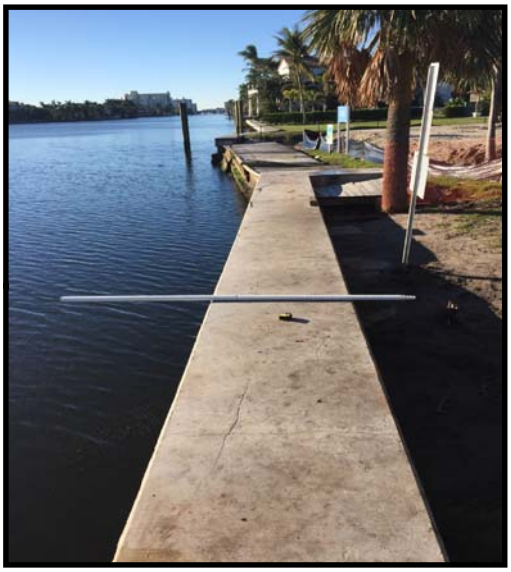


Table of Contents

City Owned Seawall:
NE 5th Street

January 5, 2018 Representative Photographs:



City Owned Seawall:
NE 5th Street

Structure Type: Bulkhead	**Continuous: Yes**	**Cap Elevation: 3.4' NAVD**
Structure Material: Concrete	**Fence Railing: No**	**Cap Width: 42"**
General Condition: Poor	**Vegetation: Yes**	**Cap Height: 18"**
Anchored: Yes	**Vegetation Location: Back**	**Utilities: No**
Anchor Type: Batter Pile	**Property Length along Waterway: 48.6'**	**Stormwater: Yes**
Toe Wall: No	**Source: Plat**	**Outfall: Yes**
Dock Frontage: No	**Water Depth: 5'**	**Outfall Pipe Diameter: 48"**
Toe Scour Stones: No	**Cap Height Relative Above MHW: 48"**	**Outfall Material: Steel**
	Joints: No	

Field Notes:
There are longitudinal cracks on the back of the cap. There are two transverse cracks in the top of the cap. The wood deck landward of cap is in poor condition. There is a longitudinal crack in the cap front along most of the cap. There is a crack in the southeast corner of the cap. City reported the wall leaks.

City Owned Seawall:
NE 4th Street

January 5, 2018 Representative Photographs:

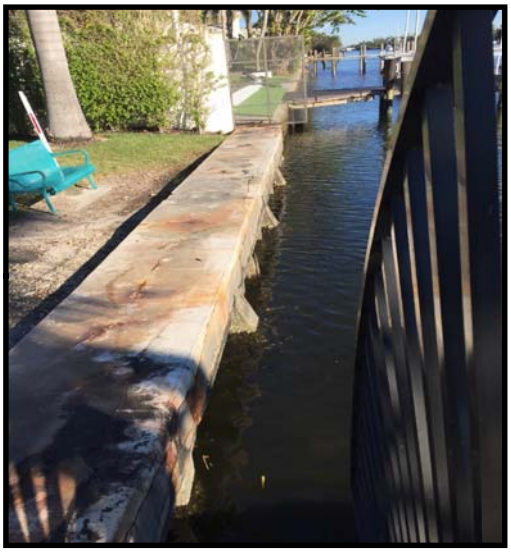
City Owned Seawall:
NE 4th Street

Structure Type: Bulkhead	**Continuous: Yes**	**Cap Elevation: 3' NAVD**
Structure Material: Concrete	**Fence Railing: No**	**Cap Width: 30"**
General Condition: Satisfactory	**Vegetation: No**	**Cap Height: 24"**
Anchored: Unknown	**Vegetation Location: N/A**	**Utilities: No**
Anchor Type: N/A	**Property Length along Waterway: 50'**	**Stormwater: Yes**
Toe Wall: No	**Source: Field Measure**	**Outfall: Yes**
Dock Frontage: No	**Water Depth: 3'**	**Outfall Pipe Diameter: 12"**
Toe Scour Stones: No	**Cap Height Relative Above MHW: 42"**	**Outfall Material: PVC**
	Joints: No	

Field Notes:
The construction appears to be a recent cap over an old seawall cap.

City Owned Seawall:
NE 2nd Street

January 5, 2018 Representative Photographs:



City Owned Seawall:
NE 2nd Street

Structure Type: Bulkhead	**Continuous: Yes**	**Cap Elevation: 2.8' NAVD**
Structure Material: Concrete	**Fence Railing: No**	**Cap Width: 42"**
General Condition: Fair	**Vegetation: No**	**Cap Height: 18"**
Anchored: Yes	**Vegetation Location: Back**	**Utilities: No**
Anchor Type: Batter Pile	**Property Length along Waterway: 40'**	**Stormwater: Yes**
Toe Wall: No	**Source: Field Measure**	**Outfall: Yes**
Dock Frontage: No	**Water Depth: 3'**	**Outfall Pipe Diameter: 36"**
Toe Scour Stones: No	**Cap Height Relative Above MHW: 36"**	**Outfall Material: Concrete**
	Joints: No	

Field Notes:
There are two outfalls: one 36 inch diameter and one 48 inch diameter. Both neighbors' property boundaries are not apparent. North neighbor appears to be managing grass at north end of street end. A resident reports flooding at 2nd, 4th, and 5th street ends. Bad flooding occurs at 5th. The cap has rust stains throughout. There are longitudinal cracks on the top and the front of the cap.

City Owned Seawall:
NE 1st Court

January 5, 2018 Representative Photographs:

City Owned Seawall:
NE 1st Court

Structure Type: Bulkhead	**Continuous: Yes**	**Cap Elevation: 2.8' NAVD**
Structure Material: Concrete	**Fence Railing: No**	**Cap Width: 42"**
General Condition: Fair	**Vegetation: Yes**	**Cap Height: 24"**
Anchored: Yes	**Vegetation Location: Back**	**Utilities: No**
Anchor Type: Batter Pile	**Property Length along Waterway: 44.2'**	**Stormwater: Yes**
Toe Wall: No	**Source: Plat**	**Outfall: Yes**
Dock Frontage: No	**Water Depth: 4'**	**Outfall Pipe Diameter: 12"**
Toe Scour Stones: No	**Cap Height Relative Above MHW: 32"**	**Outfall Material: Concrete**
	Joints: No	

Field Notes:
The seawall leaks at north end. Ladder installed by private owner. Vegetation is one overhanging seagrape, two coconut palms, one seagrape tree, and weeds. There are longitudinal cracks in the front and the top of cap. Soil losses are apparent. North adjoiner is a concreted rubble seawall with a concrete cap. Base of seawall extends into the street right of way. Note: North adjoiner raised cap elevation slightly by April 2018.

City Owned Seawall:
SE 3rd Street

January 5, 2018 Representative Photographs:

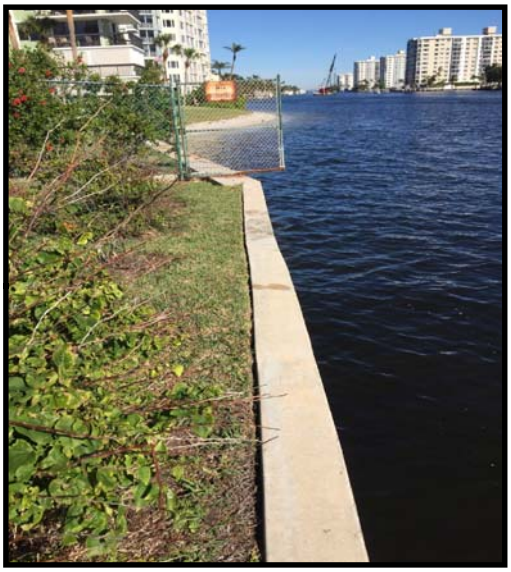
City Owned Seawall:
SE 3rd Street

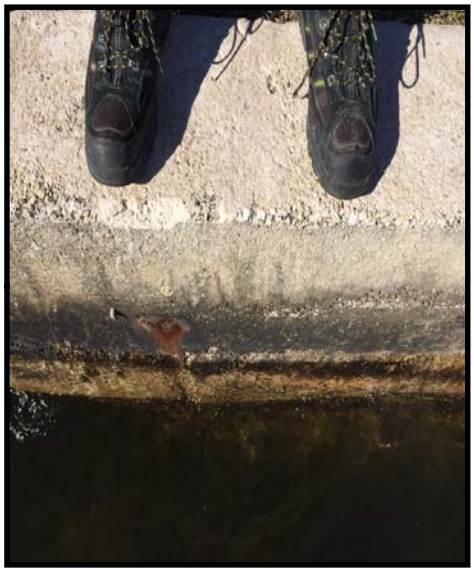
Structure Type: Bulkhead	**Continuous: Yes**	**Cap Elevation: 3.7' NAVD**
Structure Material: Concrete	**Fence Railing: No**	**Cap Width: 13"**
General Condition: Satisfactory	**Vegetation: No**	**Cap Height: 0"**
Anchored: Unknown	**Vegetation Location: Back**	**Utilities: No**
Anchor Type: N/A	**Property Length along Waterway: 36'**	**Stormwater: Yes**
Toe Wall: No	**Source: Plat**	**Outfall: Yes**
Dock Frontage: No	**Water Depth: 4'**	**Outfall Pipe Diameter: 12"**
Toe Scour Stones: No	**Cap Height Relative Above MHW: 48"**	**Outfall Material: PVC**
	Joints: Yes	

Field Notes:
This is a poured wall. There is no cap. There is a horizontal crack in the front face of the concrete, but only in the north half. This is possibly a gravity wall. There are two outfall pipes. 12 inch PVC over a 60 inch concrete pipe which is slightly angled to the northeast. There is an old seawall at the south end. It is unclear where the property boundary is. The south seawall is lower. See photos.

City Owned Seawall:
SE 7th Street

January 5, 2018 Representative Photographs:





City Owned Seawall:
SE 7th Street

Structure Type: Bulkhead	**Continuous: Yes**	**Cap Elevation: 2.9' NAVD**
Structure Material: Concrete	**Fence Railing: No**	**Cap Width: 12"**
General Condition: Satisfactory	**Vegetation: Yes**	**Cap Height: 0"**
Anchored: Unknown	**Vegetation Location: Back**	**Utilities: No**
Anchor Type: N/A	**Property Length along Waterway: 44'**	**Stormwater: Yes**
Toe Wall: No	**Source: Plat**	**Outfall: Yes**
Dock Frontage: No	**Water Depth: 4'**	**Outfall Pipe Diameter: 36"**
Toe Scour Stones: No	**Cap Height Relative Above MHW: 36"**	**Outfall Material: Concrete**
	Joints: No	

Field Notes:
Vegetation is rose bushes. Wall is two types: poured concrete on north half and pile and panel on the south half. Outfall present. No inlet observed.

City Owned Seawall:
SE 9th Court

April 13, 2018 Representative Photographs:

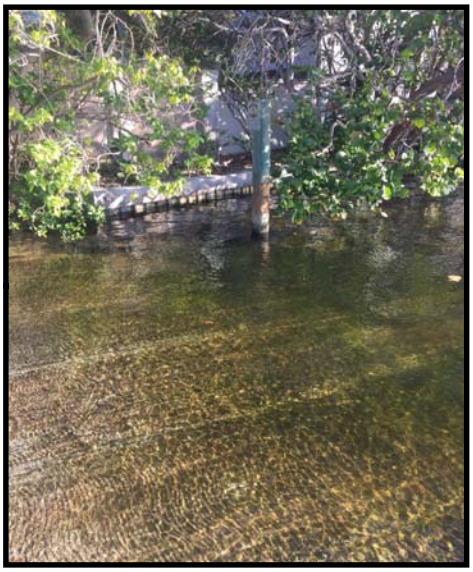
City Owned Seawall:
SE 9th Court

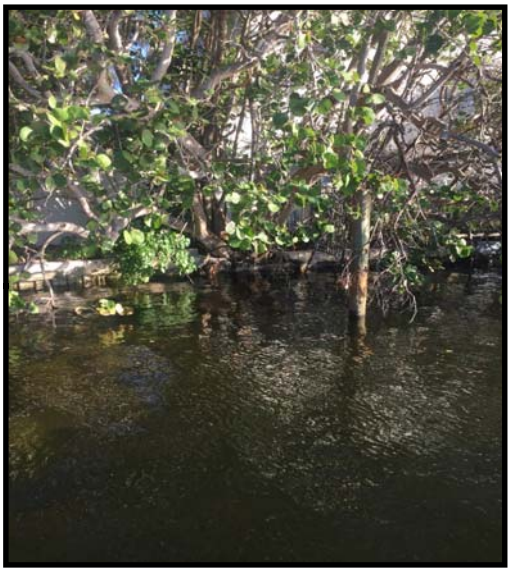
Structure Type: Bulkhead	**Continuous: Yes**	**Cap Elevation: 3.3' NAVD**
Structure Material: Concrete	**Fence Railing: No**	**Cap Width: 12"**
General Condition: Fair	**Vegetation: Yes**	**Cap Height: 12"**
Anchored: Unknown	**Vegetation Location: Back**	**Utilities: No**
Anchor Type: N/A	**Property Length along Waterway: 16'**	**Stormwater: Yes**
Toe Wall: No	**Source: Other**	**Outfall: Yes**
Dock Frontage: No	**Water Depth: 4'**	**Outfall Pipe Diameter: 42"**
Toe Scour Stones: No	**Cap Height Relative Above MHW: 36"**	**Outfall Material: Concrete**
	Joints: No	

Field Notes:
Overhanging seagrape tree needs to be removed. Ownership of land is uncertain.

City Owned Seawall:
SE 10th Street (Knowles Park)

January 30, 2018 Representative Photographs:





City Owned Seawall:
SE 10th Street (Knowles Park)

Structure Type: Bulkhead	**Continuous: Yes**	**Cap Elevation: 2.8' NAVD**
Structure Material: Other	**Fence Railing: No**	**Cap Width: 15"**
General Condition: Satisfactory	**Vegetation: Yes**	**Cap Height: 15"**
Anchored: Unknown	**Vegetation Location: Over Property Length along Waterway: 50'**	**Utilities: No**
Anchor Type: N/A	**Source: Other**	**Stormwater: No**
Toe Wall: No	**Water Depth: 36'**	**Outfall: No**
Dock Frontage: No	**Cap Height Relative Above MHW: 24"**	**Outfall Pipe Diameter: 0"**
Toe Scour Stones: No	**Joints: Yes**	**Outfall Material: N/A**

Field Notes:
This is the side wall to the Knowles Park boat ramp aka 10th Street. Ownership is uncertain.

City Owned Seawall:
Mangrove Park Ramp - North and West

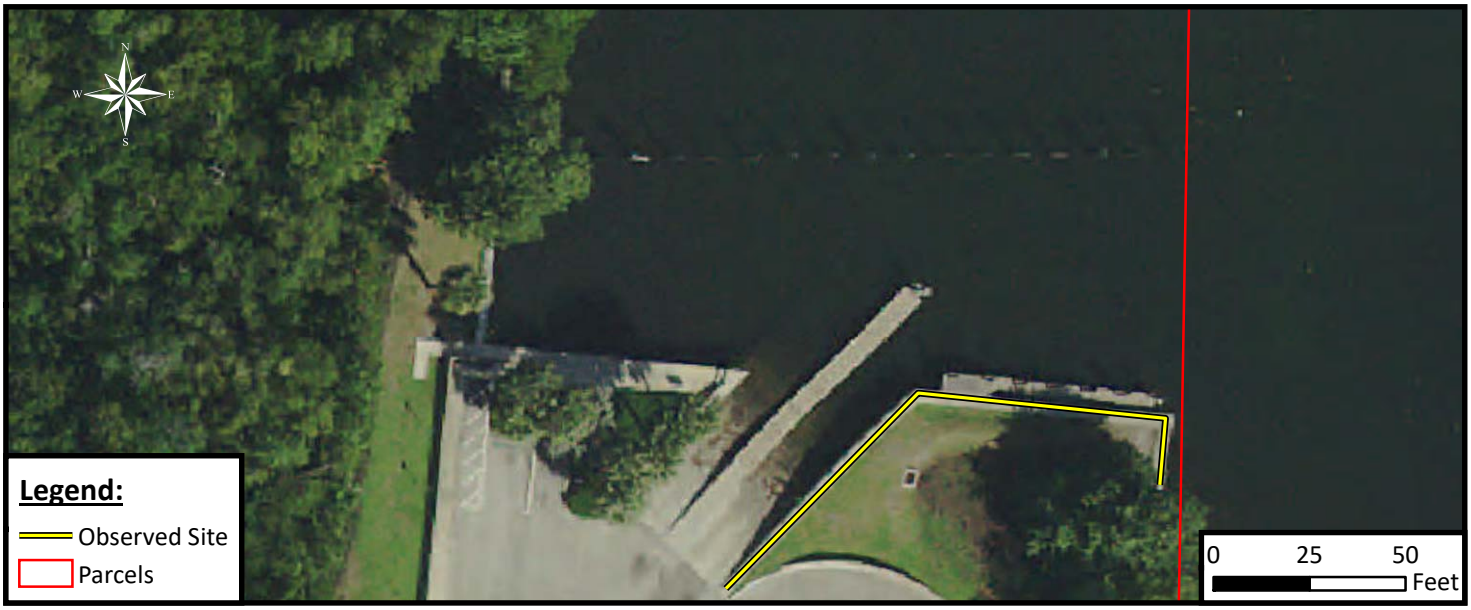
January 5, 2018 Representative Photographs:

City Owned Seawall:
Mangrove Park Ramp - North and West

Structure Type: Bulkhead	**Continuous: No**	**Cap Elevation: 4.6' NAVD**
Structure Material: Concrete	**Fence Railing: No**	**Cap Width: 43"**
General Condition: Satisfactory	**Vegetation: Yes**	**Cap Height: 32"**
Anchored: Yes	**Vegetation Location: Back**	**Utilities: No**
Anchor Type: Tie Back	**Property Length along Waterway: 180'**	**Stormwater: No**
Toe Wall: No	**Source: Other**	**Outfall: No**
Dock Frontage: No	**Water Depth: 5'**	**Outfall Pipe Diameter: 0"**
Toe Scour Stones: Yes	**Cap Height Relative Above MHW: 42"**	**Outfall Material: N/A**
	Joints: Yes	

Field Notes:
North wall has two legs. North piece is old pile and panel with a 2 feet wide cap. Toe stones in corner. East wall is newer. It is a pile and panel seawall, with two batter piles at the east end. North end terminates in mangroves.

City Owned Seawall:
Mangrove Park Ramp - South and East



January 5, 2018 Representative Photographs:

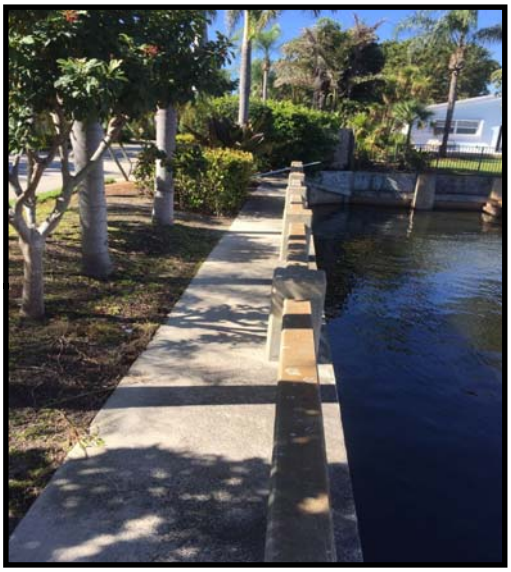
City Owned Seawall:
Mangrove Park Ramp - South and East

Structure Type: Bulkhead	**Continuous: No**	**Cap Elevation: 4.7' NAVD**
Structure Material: Concrete	**Fence Railing: No**	**Cap Width: 36"**
General Condition: Satisfactory	**Vegetation: No**	**Cap Height: 30"**
Anchored: Unknown	**Vegetation Location: Other**	**Utilities: No**
Anchor Type: N/A	**Property Length along Waterway: 160'**	**Stormwater: Yes**
Toe Wall: No	**Source: Other**	**Outfall: Yes**
Dock Frontage: Yes	**Water Depth: 6'**	**Outfall Pipe Diameter: 12"**
Toe Scour Stones: Yes	**Cap Height Relative Above MHW: 42"**	**Outfall Material: CMP**
	Joints: Yes	

Field Notes:
The wall is the south part of the ramp bulkhead. Terminates in mangroves. Outfall is from the overflow of a storm water basin. Dock is low relative to mean high water for boat access.

City Owned Seawall:
Tropic Boulevard - North Side

January 5, 2018 Representative Photographs:



City Owned Seawall:
Tropic Boulevard - North Side

Structure Type: Bulkhead	**Continuous: Yes**	**Cap Elevation: 6.1' NAVD**
Structure Material: Concrete	**Fence Railing: Yes**	**Cap Width: 45"**
General Condition: Satisfactory	**Vegetation: Yes**	**Cap Height: 18"**
Anchored: Yes	**Vegetation Location: Back**	**Utilities: No**
Anchor Type: Batter Pile	**Property Length along Waterway: 80'**	**Stormwater: Yes**
Toe Wall: No	**Source: Other**	**Outfall: Yes**
Dock Frontage: No	**Water Depth: 4.5'**	**Outfall Pipe Diameter: 24"**
Toe Scour Stones: No	**Cap Height Relative Above MHW: 60"**	**Outfall Material: CMP**
	Joints: No	

Field Notes:
The outfall is adjacent to the inlet immediately landward of the cap. A concrete pipe is connected under the causeway.

City Owned Seawall:
Tropic Boulevard - South Side

January 5, 2018 Representative Photographs:

City Owned Seawall:
Tropic Boulevard - South Side

Structure Type: Bulkhead	**Continuous: Yes**	**Cap Elevation: 6.5' NAVD**
Structure Material: Concrete	**Fence Railing: Yes**	**Cap Width: 45"**
General Condition: Satisfactory	**Vegetation: Yes**	**Cap Height: 18"**
Anchored: Yes	**Vegetation Location: Back**	**Utilities: No**
Anchor Type: Batter Pile	**Property Length along Waterway: 77'**	**Stormwater: Yes**
Toe Wall: No	**Source: Other**	**Outfall: Yes**
Dock Frontage: No	**Water Depth: 5'**	**Outfall Pipe Diameter: 24"**
Toe Scour Stones: No	**Cap Height Relative Above MHW: 60"**	**Outfall Material: CMP**
	Joints: No	

Field Notes:
A concrete pipe is connected under the causeway. There is a landscaped upland.

City Owned Seawall:
Spanish Circle

January 5, 2018 Representative Photographs:

City Owned Seawall: Spanish Circle

Structure Type: Bulkhead	**Continuous: Yes**	**Cap Elevation: 2.9' NAVD**
Structure Material: Concrete	**Fence Railing: Yes**	**Cap Width: 16"**
General Condition: Satisfactory	**Vegetation: Yes**	**Cap Height: 10"**
Anchored: Unknown	**Vegetation Location: Back**	**Utilities: No**
Anchor Type: N/A	**Property Length along Waterway: 69'**	**Stormwater: Yes**
Toe Wall: No	**Source: Plat**	**Outfall: Yes**
Dock Frontage: Yes	**Water Depth: 3.5'**	**Outfall Pipe Diameter: 24"**
Toe Scour Stones: No	**Cap Height Relative Above MHW: 18"**	**Outfall Material: Concrete**
	Joints: No	

Field Notes:
Limited access due to locked gate and overhanging dock. Outfall located during outfall survey.

City Owned Seawall:
SFWMD R/W Revetment at Structure S40

January 5, 2018 Representative Photographs:

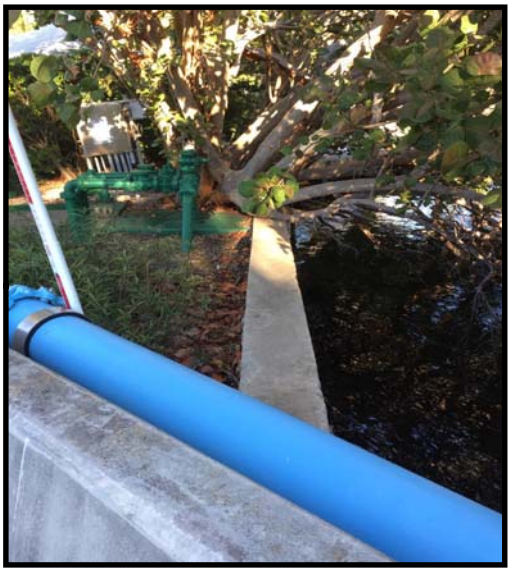
City Owned Seawall:
SFWMD R/W Revetment at Structure S40

Structure Type: Revetment	**Continuous: No**	**Cap Elevation: N/A**
Structure Material: Rock	**Fence Railing: No**	**Cap Width: N/A**
General Condition: Fair	**Vegetation: Yes**	**Cap Height: N/A**
Anchored: N/A	**Vegetation Location: Back**	**Utilities: No**
Anchor Type: N/A	**Property Length along Waterway: 250'**	**Stormwater: Yes**
Toe Wall: No	**Source: Other**	**Outfall: Yes**
Dock Frontage: No	**Water Depth: N/A**	**Outfall Pipe Diameter: 24"**
Toe Scour Stones: No	**Cap Height Relative Above MHW: N/A**	**Outfall Material: CMP**
	Joints: N/A	

Field Notes:
No access from north side. Visible from south bank. Pipe information from outfall inspection.

City Owned Seawall:
Island Drive Bridge Abutment NW

January 4, 2018 Representative Photographs:



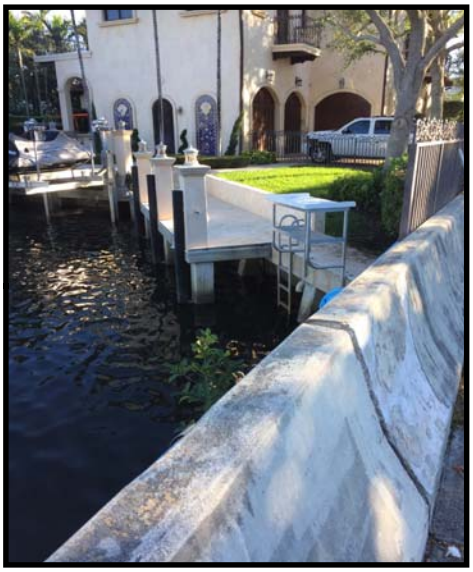
City Owned Seawall:
Island Drive Bridge Abutment NW

Structure Type: Bulkhead	**Continuous: Yes**	**Cap Elevation: 3.9' NAVD**
Structure Material: Concrete	**Fence Railing: No**	**Cap Width: 16"**
General Condition: Fair	**Vegetation: Yes**	**Cap Height: 11"**
Anchored: Unknown	**Vegetation Location: Over Property Length along Waterway: 45'**	**Utilities: Yes**
Anchor Type: N/A		**Stormwater: Yes**
Toe Wall: Yes	**Source: Other**	**Outfall: Yes**
Dock Frontage: No	**Water Depth: 3'**	**Outfall Pipe Diameter: 8"**
Toe Scour Stones: No	**Cap Height Relative Above MHW: 50"**	**Outfall Material: Steel**
	Joints: No	

Field Notes:
There are three large sea grape trees overhanging the bulkhead. Cap has minor longitudinal cracks. There is a lift station landward of the bulkhead. There is a water level gage on site. The seawall cap joint is open at the bridge.

City Owned Seawall:
Island Drive Bridge Abutment NE

January 4, 2018 Representative Photographs:

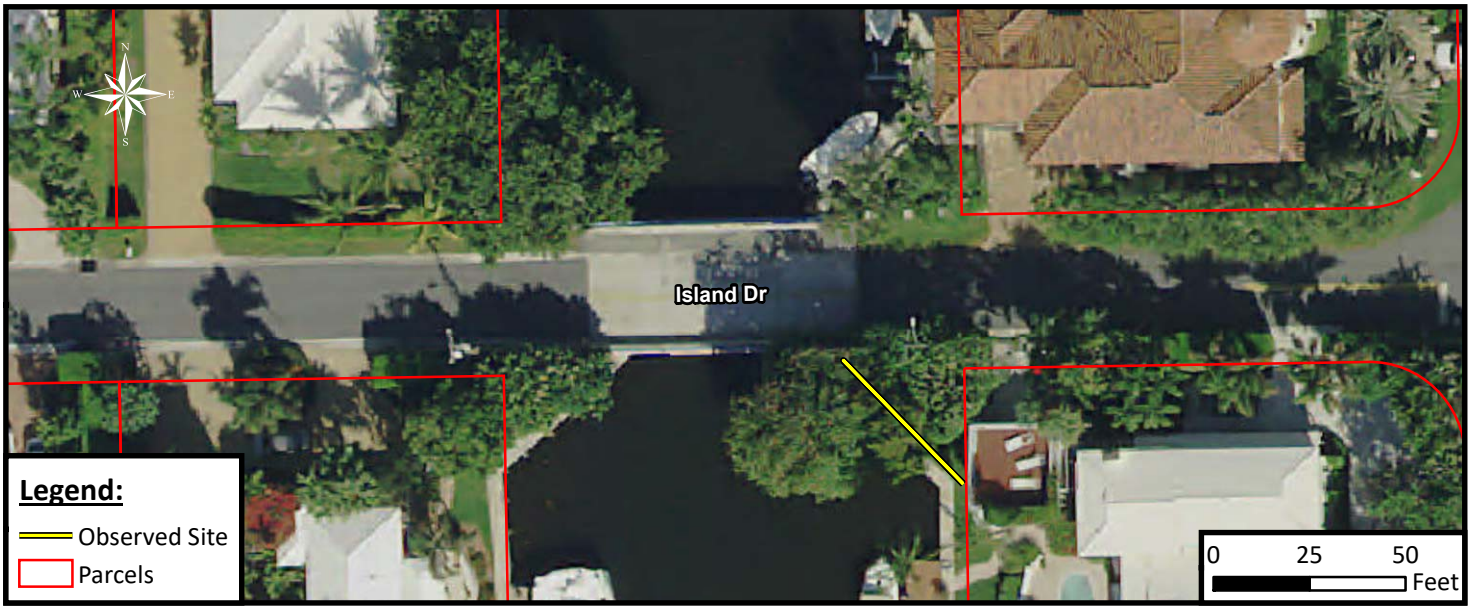


City Owned Seawall:
Island Drive Bridge Abutment NE

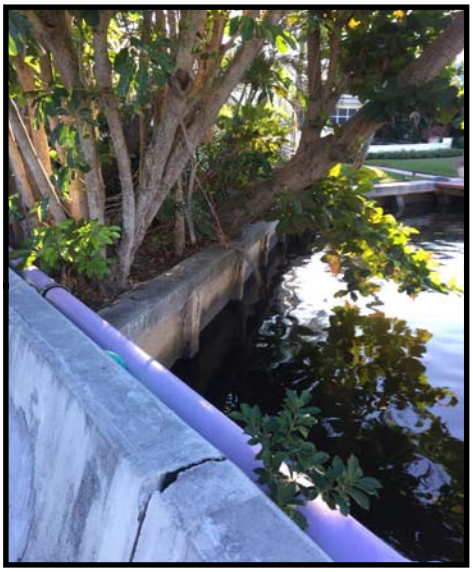
Structure Type: Bulkhead	**Continuous: Yes**	**Cap Elevation: 3.6' NAVD**
Structure Material: Concrete	**Fence Railing: Yes**	**Cap Width: 36"**
General Condition: Good	**Vegetation: No**	**Cap Height: 15"**
Anchored: Yes	**Vegetation Location: Back**	**Utilities: Yes**
Anchor Type: Batter Pile	**Property Length along Waterway: 34'**	**Stormwater: No**
Toe Wall: Unknown	**Source: Other**	**Outfall: No**
Dock Frontage: Yes	**Water Depth: 4'**	**Outfall Pipe Diameter: 0"**
Toe Scour Stones: Unknown	**Cap Height Relative Above MHW: 48"**	**Outfall Material: N/A**
	Joints: No	

Field Notes:
The seawall is fenced off. There is no access. Some measurements estimated from adjacent bridge. Utilities cross the cap. The cap and the wall were repaired with the adjacent private property. The cap matches aesthetics of the adjoining property.

City Owned Seawall:
Island Drive Bridge Abutment SE



January 4, 2018 Representative Photographs:



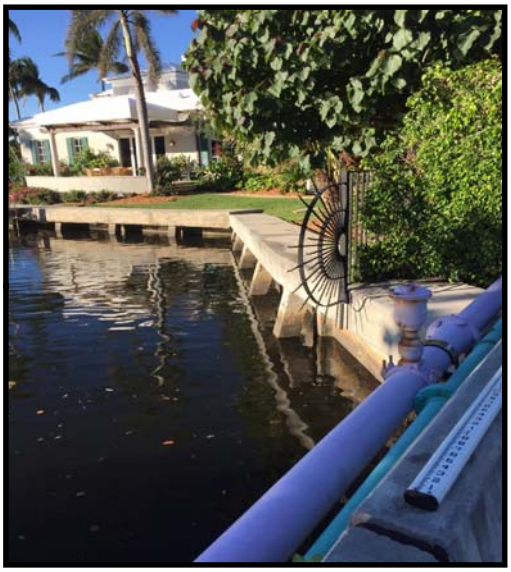
City Owned Seawall:
Island Drive Bridge Abutment SE

Structure Type: Bulkhead	**Continuous: Yes**	**Cap Elevation: 4.3' NAVD**
Structure Material: Concrete	**Fence Railing: Yes**	**Cap Width: 10"**
General Condition: Poor	**Vegetation: Yes**	**Cap Height: 14"**
Anchored: Unknown	**Vegetation Location: Over Property Length along Waterway: 40'**	**Utilities: Yes**
Anchor Type: N/A	**Source: Other**	**Stormwater: No**
Toe Wall: Yes	**Water Depth: 3'**	**Outfall: No**
Dock Frontage: No	**Cap Height Relative Above MHW: 60"**	**Outfall Pipe Diameter: 0"**
Toe Scour Stones: No	**Joints: No**	**Outfall Material: N/A**

Field Notes:
There is a large overhanging tree overturning the seawall. Original piles contain vertical cracks. Private fence prevents access to the seawall.

City Owned Seawall:
Island Drive Bridge Abutment SW

January 4, 2018 Representative Photographs:



City Owned Seawall:
Island Drive Bridge Abutment SW

Structure Type: Bulkhead	**Continuous: Yes**	**Cap Elevation: 3.4' NAVD**
Structure Material: Concrete	**Fence Railing: Yes**	**Cap Width: 42"**
General Condition: Satisfactory	**Vegetation: Yes**	**Cap Height: 19"**
Anchored: Yes	**Vegetation Location: Back**	**Utilities: Yes**
Anchor Type: Batter Pile	**Property Length along Waterway: 49'**	**Stormwater: No**
Toe Wall: No	**Source: Other**	**Outfall: No**
Dock Frontage: No	**Water Depth: 3'**	**Outfall Pipe Diameter: 0"**
Toe Scour Stones: No	**Cap Height Relative Above MHW: 60"**	**Outfall Material: N/A**
	Joints: No	

Field Notes:
A private fence prevents access to the seawall. The seawall includes a repaired cap and batter piles which are similar to the adjoining wall. Water utilities cross over the cap.

City Owned Seawall:
Beach Drive

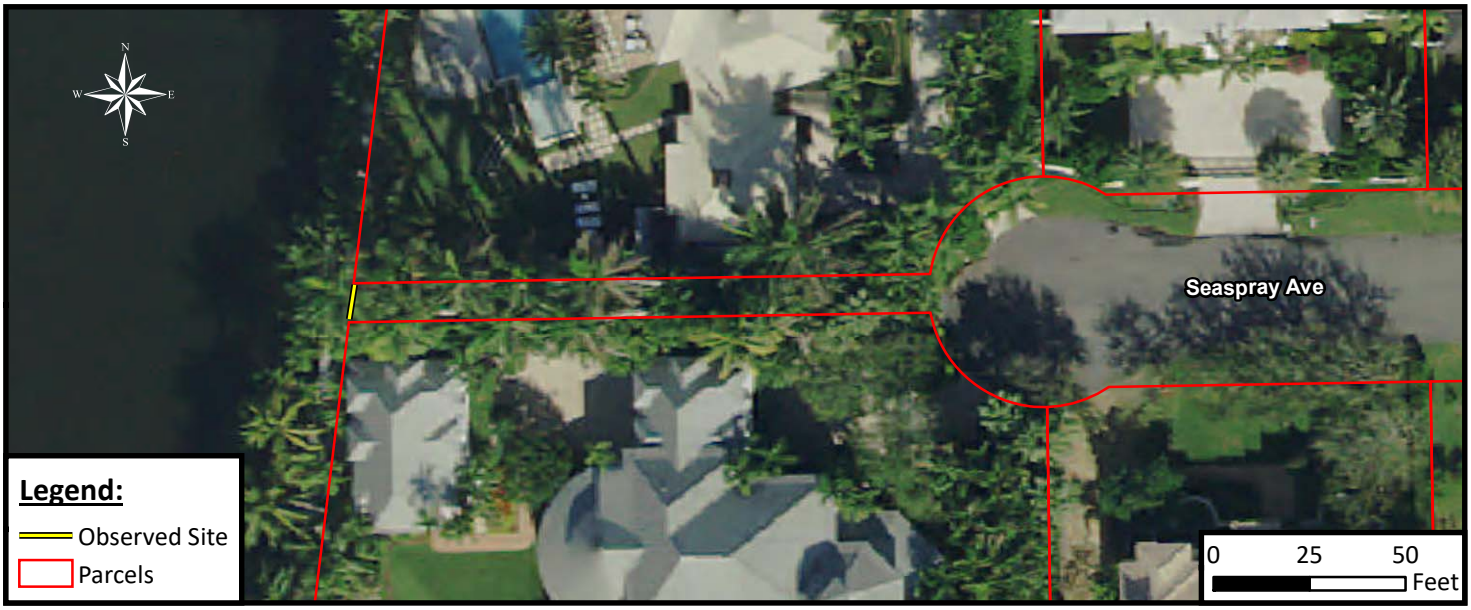
January 4, 2018 Representative Photographs:

City Owned Seawall:
Beach Drive

Structure Type: Bulkhead	**Continuous: Yes**	**Cap Elevation: 2.8' NAVD**
Structure Material: Concrete	**Fence Railing: No**	**Cap Width: 36"**
General Condition: Poor	**Vegetation: Yes**	**Cap Height: 15"**
Anchored: Yes	**Vegetation Location: Back**	**Utilities: No**
Anchor Type: Batter Pile	**Property Length along Waterway: 155'**	**Stormwater: Yes**
Toe Wall: No	**Source: Other**	**Outfall: Yes**
Dock Frontage: No	**Water Depth: 3'**	**Outfall Pipe Diameter: 12"**
Toe Scour Stones: Yes	**Cap Height Relative Above MHW: 36"**	**Outfall Material: Concrete**
	Joints: No	

Field Notes:
Wall zig zags. East end is in poor condition. West end is in fair condition condition. There are toe stones in east corner. There are two duckbill backflow valves at the wall. There is one flap gate in the mud. All outfalls are in the east end of the wall.

City Owned Seawall:
Seaspray Avenue



April 13, 2018 Representative Photographs:

City Owned Seawall:
Seaspray Avenue

Structure Type: Bulkhead	**Continuous: Yes**	**Cap Elevation: 3.4' NAVD**
Structure Material: Concrete	**Fence Railing: Yes**	**Cap Width: 12"**
General Condition: Fair	**Vegetation: Yes**	**Cap Height: 18"**
Anchored: Unknown	**Vegetation Location: Back**	**Utilities: No**
Anchor Type: N/A	**Property Length along Waterway: 10'**	**Stormwater: Yes**
Toe Wall: No	**Source: Plat**	**Outfall: Yes**
Dock Frontage: No	**Water Depth: 3'**	**Outfall Pipe Diameter: 24"**
Toe Scour Stones: No	**Cap Height Relative Above MHW: 36"**	**Outfall Material: Concrete**
	Joints: No	

Field Notes:
No access from road. Densely vegetated. Outfall was located during outfall observation.

City Owned Seawall:
Waterway Lane

January 30, 2018 Representative Photographs:

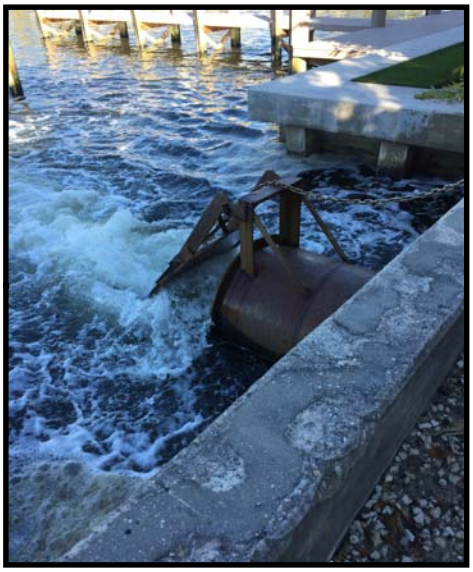
City Owned Seawall:
Waterway Lane

Structure Type: Bulkhead	**Continuous: Yes**	**Cap Elevation: 2.8' NAVD**
Structure Material: Concrete	**Fence Railing: No**	**Cap Width: 36"**
General Condition: Fair	**Vegetation: Yes**	**Cap Height: 12"**
Anchored: Yes	**Vegetation Location: Back**	**Utilities: No**
Anchor Type: Batter Pile	**Property Length along Waterway: 15'**	**Stormwater: Yes**
Toe Wall: No	**Source: Other**	**Outfall: Yes**
Dock Frontage: No	**Water Depth: 3'**	**Outfall Pipe Diameter: 12"**
Toe Scour Stones: No	**Cap Height Relative Above MHW: 24"**	**Outfall Material: Concrete**
	Joints: Yes	

Field Notes:
There are two outfalls. One has a flapgate. One is open. The open one discharged via the pump while on site for one minute.

City Owned Seawall:
Thomas Street

January 4, 2018 Representative Photographs:



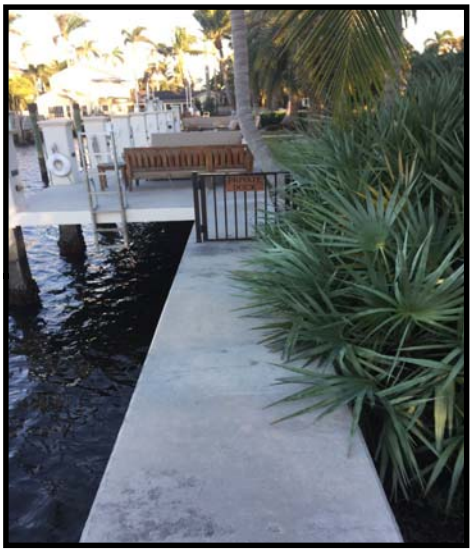
City Owned Seawall: Thomas Street

Structure Type: Bulkhead	**Continuous: Yes**	**Cap Elevation: 5.3' NAVD**
Structure Material: Concrete	**Fence Railing: No**	**Cap Width: 12"**
General Condition: Satisfactory	**Vegetation: No**	**Cap Height: 0"**
Anchored: Unknown	**Vegetation Location: N/A**	**Utilities: Yes**
Anchor Type: N/A	**Property Length along Waterway: 25'**	**Stormwater: Yes**
Toe Wall: No	**Source: Other**	**Outfall: Yes**
Dock Frontage: No	**Water Depth: 5'**	**Outfall Pipe Diameter: 36"**
Toe Scour Stones: No	**Cap Height Relative Above MHW: 54"**	**Outfall Material: Other**
	Joints: Yes	

Field Notes:
There is a storm water flap gate present. There was active discharge. South 7 feet of wall is concrete masonry gravity wall which is one foot lower in elevation. The flap appeared to close on pump shut down. There is no cap on the wall, just a poured concrete wall.

City Owned Seawall:
Basin Drive

January 4, 2018 Representative Photographs:



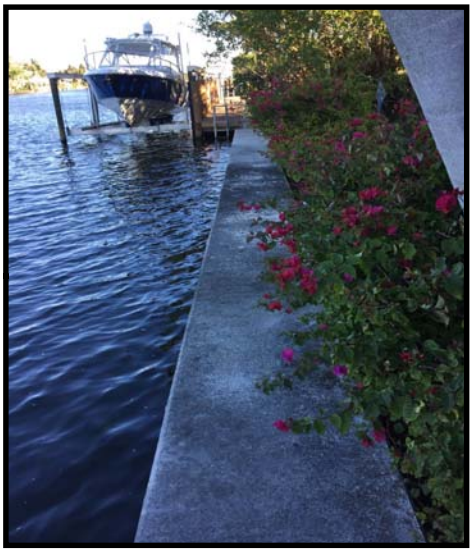
City Owned Seawall:
Basin Drive

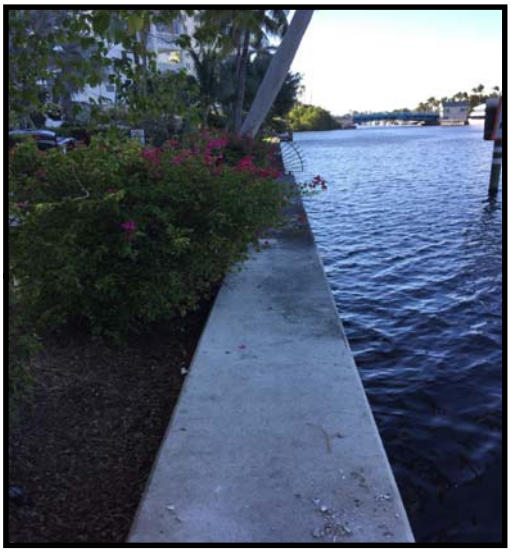
Structure Type: Bulkhead	**Continuous: Yes**	**Cap Elevation: 3.8' NAVD**
Structure Material: Concrete	**Fence Railing: No**	**Cap Width: 42"**
General Condition: Fair	**Vegetation: Yes**	**Cap Height: 18"**
Anchored: Yes	**Vegetation Location: Back**	**Utilities: Yes**
Anchor Type: Batter Pile	**Property Length along Waterway: 44'**	**Stormwater: Yes**
Toe Wall: No	**Source: Other**	**Outfall: Yes**
Dock Frontage: No	**Water Depth: 3'**	**Outfall Pipe Diameter: 12"**
Toe Scour Stones: No	**Cap Height Relative Above MHW: 48"**	**Outfall Material: Other**
	Joints: Yes	

Field Notes:
Storm pump is onsite. There is a duckbill backflow prevention device above MHW. There is a flap valve on an adjacent pipe below MHW. Wall is z shaped. City reported that the wall leaks.

City Owned Seawall:
Lowry Street

January 4, 2018 Representative Photographs:



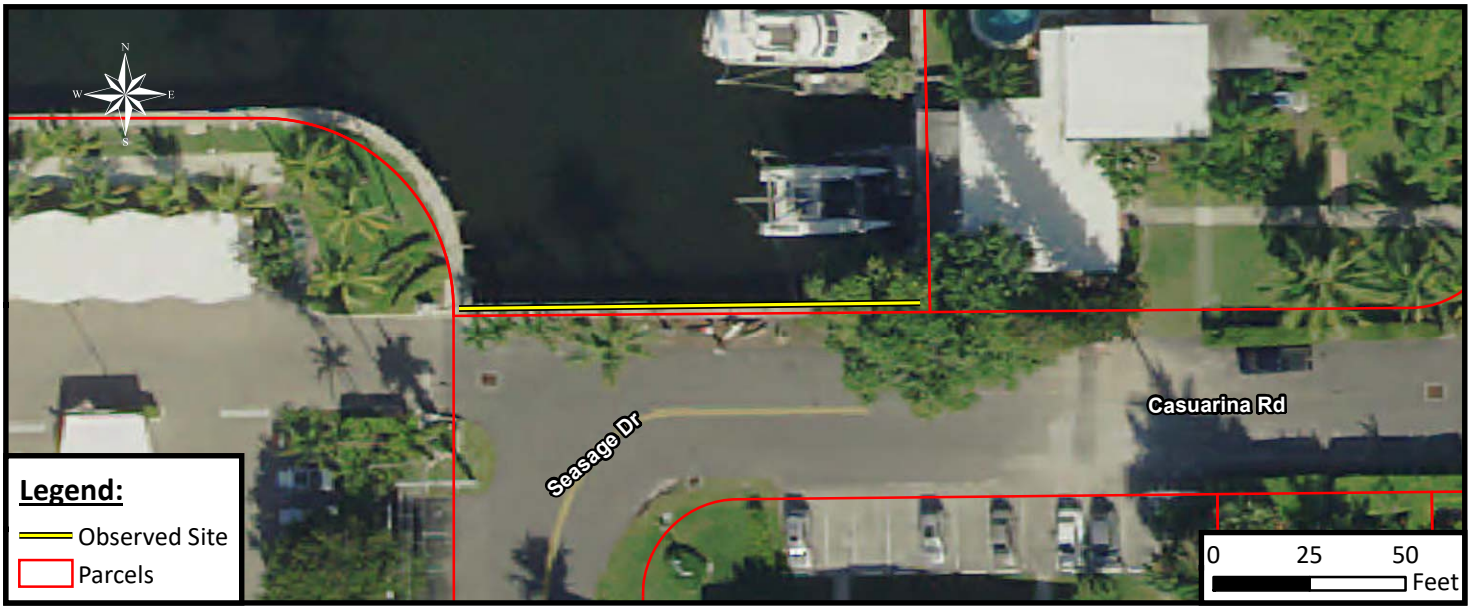


City Owned Seawall:
Lowry Street

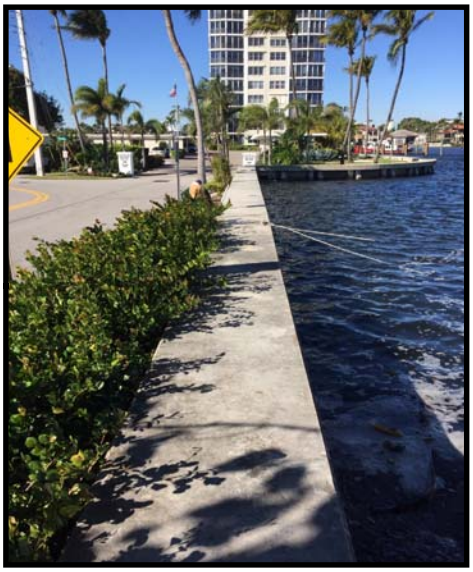
Structure Type: Bulkhead	**Continuous: Yes**	**Cap Elevation: 3.2' NAVD**
Structure Material: Concrete	**Fence Railing: No**	**Cap Width: 37"**
General Condition: Satisfactory	**Vegetation: Yes**	**Cap Height: 18"**
Anchored: No	**Vegetation Location: Back**	**Utilities: Yes**
Anchor Type: Batter Pile	**Property Length along Waterway: 54'**	**Stormwater: No**
Toe Wall: No	**Source: Plat**	**Outfall: No**
Dock Frontage: No	**Water Depth: 5'**	**Outfall Pipe Diameter: 0"**
Toe Scour Stones: No	**Cap Height Relative Above MHW: 24"**	**Outfall Material: N/A**
	Joints: No	

Field Notes:
There is a gas line sign on site.

City Owned Seawall:
Casuarina Road - North Side



January 4, 2018 Representative Photographs:



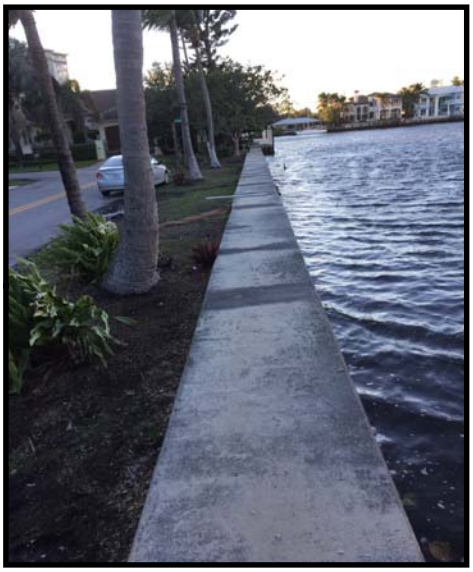
City Owned Seawall:
Casuarina Road - North Side

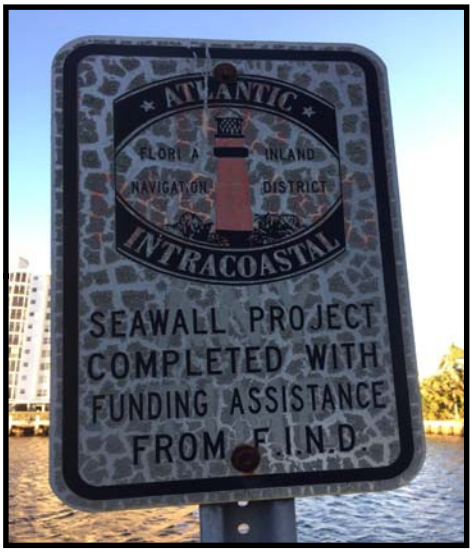
Structure Type: Bulkhead	**Continuous: Yes**	**Cap Elevation: 5.1' NAVD**
Structure Material: Concrete	**Fence Railing: No**	**Cap Width: 42"**
General Condition: Satisfactory	**Vegetation: Yes**	**Cap Height: 19"**
Anchored: Unknown	**Vegetation Location: Back**	**Utilities: No**
Anchor Type: Batter Pile	**Property Length along Waterway: 125'**	**Stormwater: Yes**
Toe Wall: No	**Source: Other**	**Outfall: Yes**
Dock Frontage: No	**Water Depth: 5'**	**Outfall Pipe Diameter: 18"**
Toe Scour Stones: No	**Cap Height Relative Above MHW: 42"**	**Outfall Material: Concrete**
	Joints: No	

Field Notes:
Storm water inlet is nearby. The outfall was not seen. Outfall was identified during a separate outfall observation. There is a crack in the cap at the west adjoining wall. There is Coco plum and palms landward of the wall. Adjoining owner installed a cleat in the cap to assist in mooring their boat.

City Owned Seawall:
Bucida Road - North Side

January 3 & February 28, 2018 Representative Photographs:





City Owned Seawall:
Bucida Road - North Side

Structure Type: Bulkhead	**Continuous: Yes**	**Cap Elevation: 3.2' NAVD**
Structure Material: Concrete	**Fence Railing: No**	**Cap Width: 42"**
General Condition: Fair	**Vegetation: Yes**	**Cap Height: 18"**
Anchored: Yes	**Vegetation Location: Back**	**Utilities: No**
Anchor Type: Batter Pile	**Property Length along Waterway: 155'**	**Stormwater: Yes**
Toe Wall: No	**Source: Other**	**Outfall: Yes**
Dock Frontage: No	**Water Depth: 3'**	**Outfall Pipe Diameter: 36"**
Toe Scour Stones: No	**Cap Height Relative Above MHW: 36"**	**Outfall Material: Other**
	Joints: No	

Field Notes:

The seawall is a pile and panel concrete wall with relatively new batter piles and a cap replacement. There is a stormwater inlet nearby, but no observed discharge pipe in the immediate vicinity of the wall. The outfall was located during outfall observations. There is one joint (0.25 inches wide) in the wall which is not sealed. There are occasional cross cap cracks at the old pile locations. Vegetation is five palms, one gumbo limbo, dirt and weeds.

City Owned Seawall: Atlantic Dunes Park - NW Lot between White Drive and Rhodes Villa Avenue

January 12, 2018 Representative Photographs:

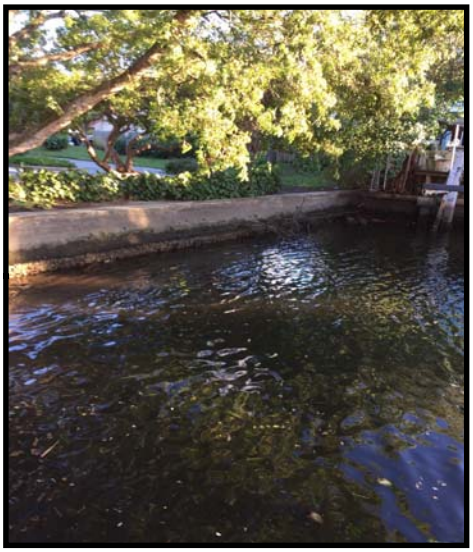
City Owned Seawall: Atlantic Dunes Park- NW Lot between White Drive and Rhodes Villa Avenue

Structure Type: Bulkhead	**Continuous: Yes**	**Cap Elevation: 1.6' NAVD**
Structure Material: Rock	**Fence Railing: No**	**Cap Width: 24"**
General Condition: Satisfactory	**Vegetation: Yes**	**Cap Height: 1"**
Anchored: Unknown	**Vegetation Location: Back**	**Utilities: No**
Anchor Type: N/A	**Property Length along Waterway: 95'**	**Stormwater: Yes**
Toe Wall: No	**Source: Other**	**Outfall: Yes**
Dock Frontage: No	**Water Depth: 1'**	**Outfall Pipe Diameter: 6"**
Toe Scour Stones: No	**Cap Height Relative Above MHW: 3"**	**Outfall Material: PVC**
	Joints: No	

Field Notes:
Outfall was privately constructed.

City Owned Seawall: Atlantic Dunes Park - SW Lot between Del Haven Drive and Rhodes Villa Avenue

January 3, 2018 Representative Photographs:



City Owned Seawall: Atlantic Dunes Park - SW Lot between Del Haven Drive and Rhodes Villa Avenue

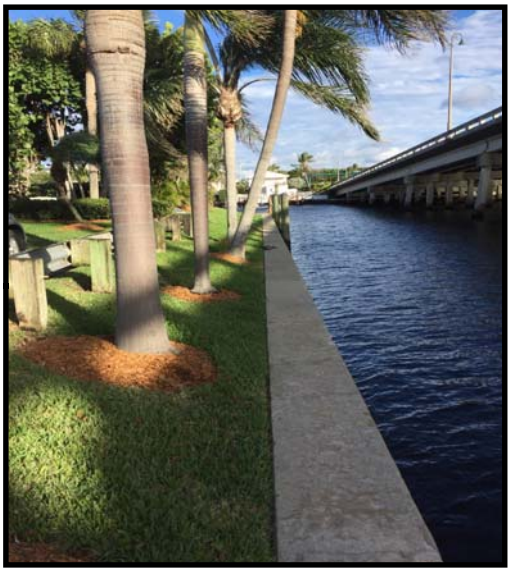
Structure Type: Other	**Continuous: Yes**	**Cap Elevation: 2.5' NAVD**
Structure Material: Concrete	**Fence Railing: No**	**Cap Width: 24"**
General Condition: Satisfactory	**Vegetation: Yes**	**Cap Height: 36"**
Anchored: No	**Vegetation Location: Back**	**Utilities: No**
Anchor Type: N/A	**Property Length along Waterway: 114'**	**Stormwater: No**
Toe Wall: Yes	**Source: Other**	**Outfall: N/A**
Dock Frontage: No	**Water Depth: 1'**	**Outfall Pipe Diameter: 0"**
Toe Scour Stones: No	**Cap Height Relative Above MHW: 36"**	**Outfall Material: N/A**
	Joints: No	

Field Notes:

Seawall appears to be a gravity wall over a poured toe wall. Concrete fascia exists over rubble. This is similar to the north west adjoining property. Two large trees behind wall. Short sea grape hedge behind. Wall is L shaped in plan view.

City Owned Seawall:
Del Haven Drive

January 3, 2018 Representative Photographs:



City Owned Seawall:
Del Haven Drive

Structure Type: Bulkhead	**Continuous: No**	**Cap Elevation: 2.6' NAVD**
Structure Material: Concrete	**Fence Railing: No**	**Cap Width: 24"**
General Condition: Satisfactory	**Vegetation: Yes**	**Cap Height: 24"**
Anchored: Unknown	**Vegetation Location: Back**	**Utilities: No**
Anchor Type: N/A	**Property Length along Waterway: 286'**	**Stormwater: No**
Toe Wall: No	**Source: Other**	**Outfall: No**
Dock Frontage: Yes	**Water Depth: 3.5'**	**Outfall Pipe Diameter: 0"**
Toe Scour Stones: Yes	**Cap Height Relative Above MHW: 30"**	**Outfall Material: N/A**
	Joints: Yes	

Field Notes:
Joints in cap are cold joints. Toe stones are small 1 ft. Dock space is 60 feet. Unknown control of dock. Upland vegetation is grass and mixed palm trees. Cap has random small chips and spalls on waterway edge. Overall good shape. Sprinkler line behind cap services private grass and palms.

City Owned Seawall:
808 Seasage Drive (City Easement)

October 5, 2018 Representative Photographs:

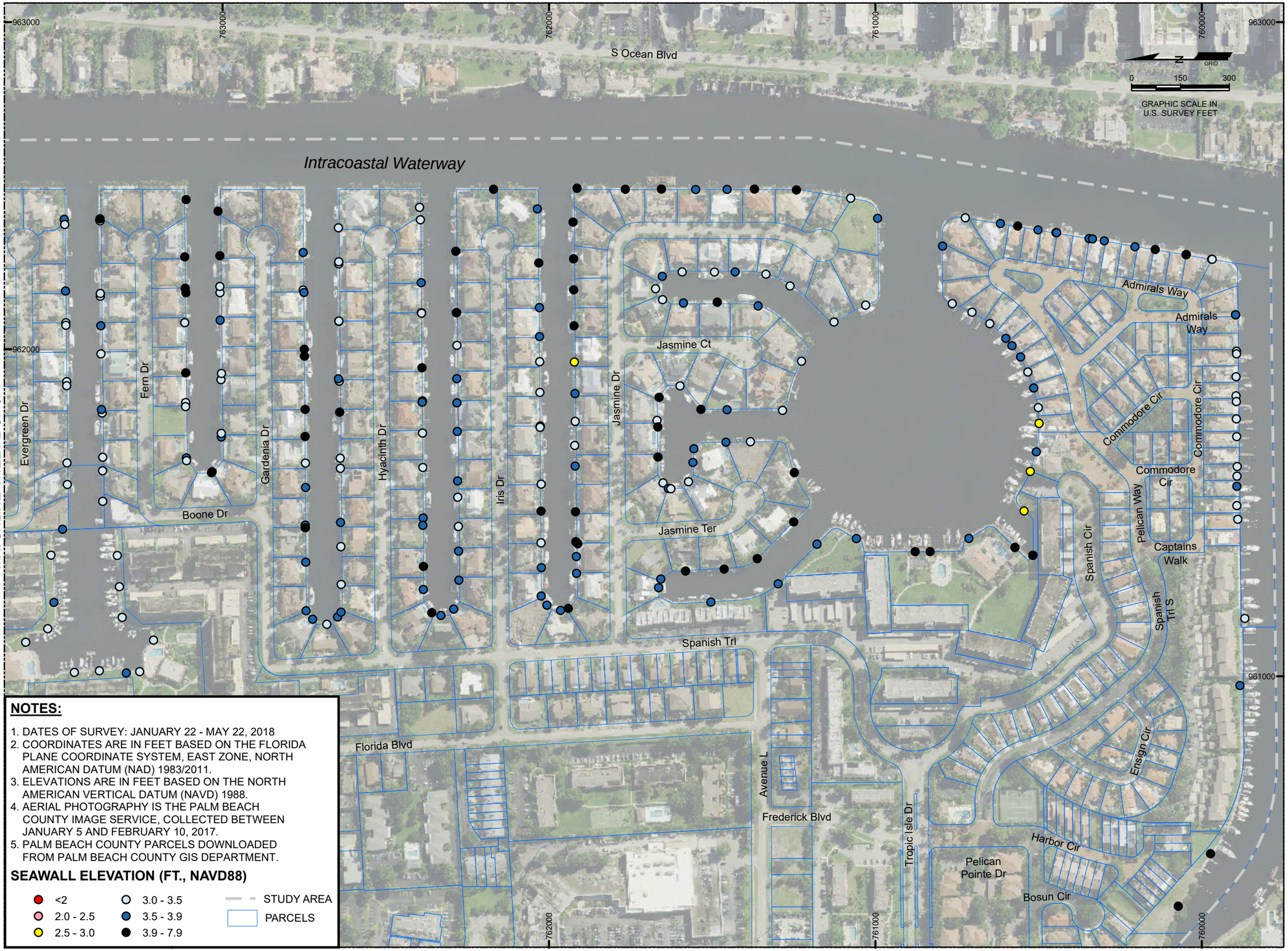
City Owned Seawall:
808 Seasage Drive (City Easement)

Structure Type: Bulkhead	**Continuous: Yes**	**Cap Elevation: 3.9' NAVD**
Structure Material: Concrete	**Fence Railing: No**	**Cap Width: 36"**
General Condition: Fair	**Vegetation: Yes**	**Cap Height: 18"**
Anchored: Yes	**Vegetation Location: Back**	**Utilities: No**
Anchor Type: Batter Pile	**Property Length along Waterway: 10'**	**Stormwater: Yes**
Toe Wall: No	**Source: Field Measure**	**Outfall: Yes**
Dock Frontage: No	**Water Depth: 4'**	**Outfall Pipe Diameter: 15"**
Toe Scour Stones: No	**Cap Height Relative Above MHW: 36"**	**Outfall Material: Concrete**
	Joints: No	

Field Notes:
This property is privately owned with a city easement across one seawall panel. Historic outfall is grouted shut. A diagonal crack exists across the panel originating at the storm water outfall pipe. The crack has been patched with hydraulic cement. Upland soil loss repair was evident. Long term monitoring is appropriate.

APPENDIX D

SEAWALL ELEVATION ANALYSIS

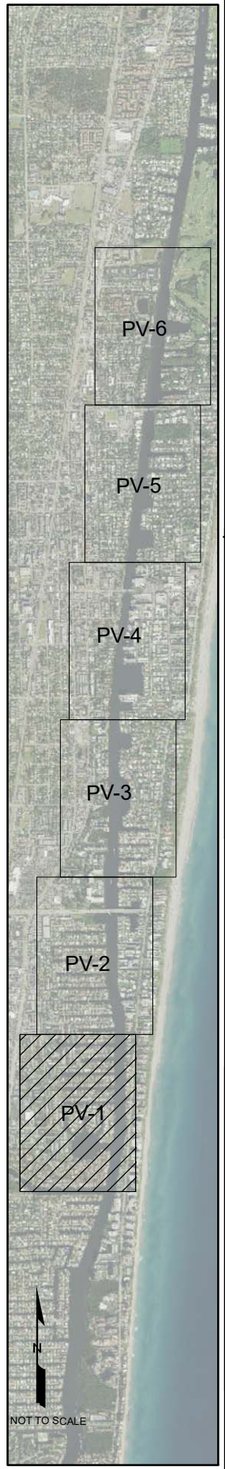


NOTES:

1. DATES OF SURVEY: JANUARY 22 - MAY 22, 2018
2. COORDINATES ARE IN FEET BASED ON THE FLORIDA PLANE COORDINATE SYSTEM, EAST ZONE, NORTH AMERICAN DATUM (NAD) 1983/2011.
3. ELEVATIONS ARE IN FEET BASED ON THE NORTH AMERICAN VERTICAL DATUM (NAVD) 1988.
4. AERIAL PHOTOGRAPHY IS THE PALM BEACH COUNTY IMAGE SERVICE, COLLECTED BETWEEN JANUARY 5 AND FEBRUARY 10, 2017.
5. PALM BEACH COUNTY PARCELS DOWNLOADED FROM PALM BEACH COUNTY GIS DEPARTMENT.

SEAWALL ELEVATION (FT., NAVD88)

<2	3.0 - 3.5	STUDY AREA
2.0 - 2.5	3.5 - 3.9	PARCELS
2.5 - 3.0	3.9 - 7.9	



APTIM
ENVIRONMENTAL AND INFRASTRUCTURE, INC.
2481 N. W. BOCA RATON BOULEVARD
BOCA RATON, FL 33431
PH. (561) 391-8102
FAX (561) 391 9116
COA FL #8051

No.	Date	Description

Checked by: D.Mann
Reviewed by: M.Lowiec
Submitted by: T.Brenner
Comm. No.: 631233074
Designed by: M.Lowiec
Drawn by: H.Vollmer
Date: May 2018
Plot Scale: AS NOTED
Reference Files:

2018 CITY OF DELRAY BEACH
SEAWALL VULNERABILITY ANALYSIS
SEAWALL ELEVATION ANALYSIS

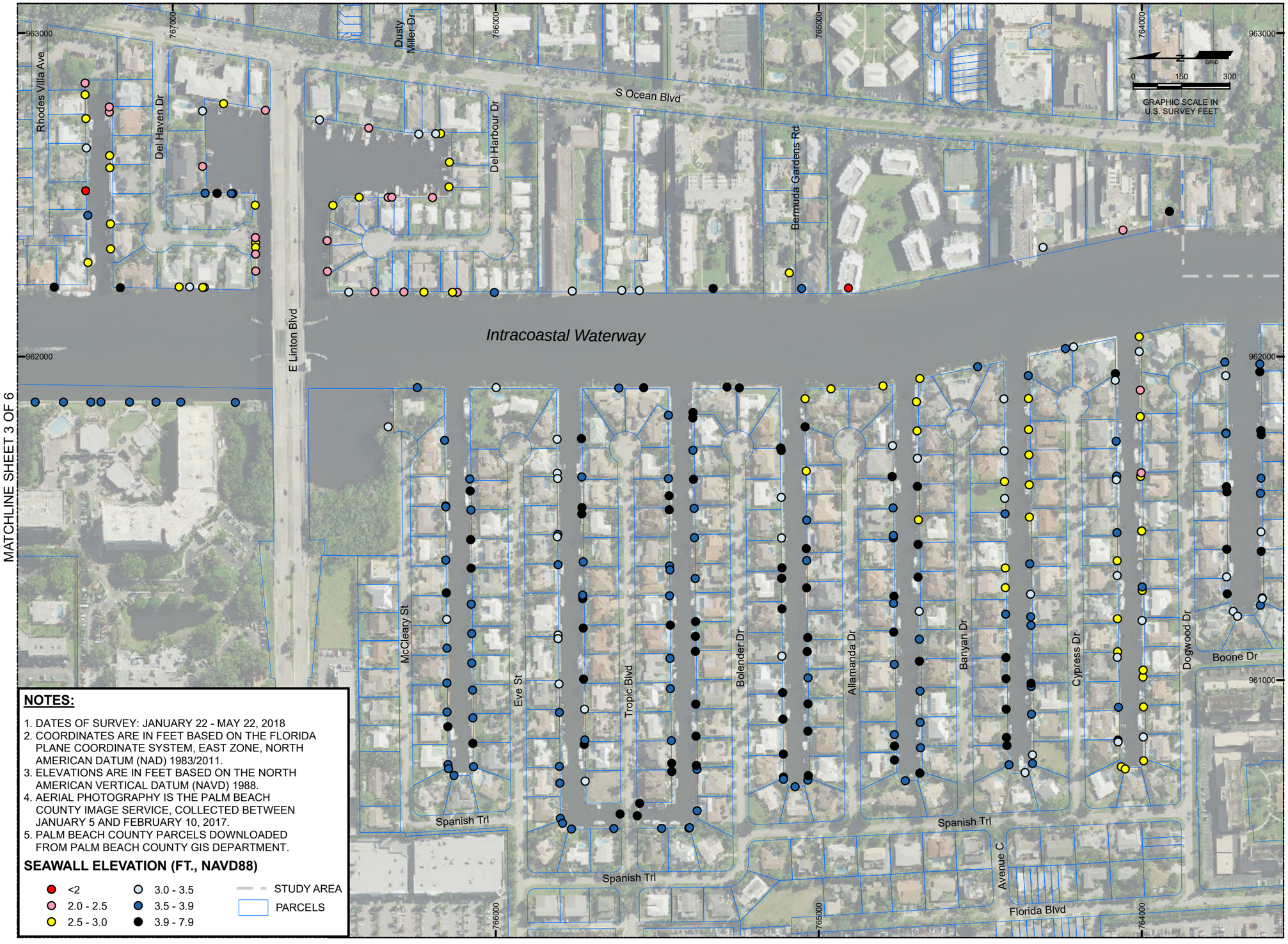
PLAN VIEW

DRAWING NO.

PV1

SHEET 1 OF 6

Document Path: G:\Enterprise\Palm_Beach\631233074\Seawall Topo Appendix 1.mxd



NOTES:

1. DATES OF SURVEY: JANUARY 22 - MAY 22, 2018
2. COORDINATES ARE IN FEET BASED ON THE FLORIDA PLANE COORDINATE SYSTEM, EAST ZONE, NORTH AMERICAN DATUM (NAD) 1983/2011.
3. ELEVATIONS ARE IN FEET BASED ON THE NORTH AMERICAN VERTICAL DATUM (NAVD) 1988.
4. AERIAL PHOTOGRAPHY IS THE PALM BEACH COUNTY IMAGE SERVICE, COLLECTED BETWEEN JANUARY 5 AND FEBRUARY 10, 2017.
5. PALM BEACH COUNTY PARCELS DOWNLOADED FROM PALM BEACH COUNTY GIS DEPARTMENT.

SEAWALL ELEVATION (FT., NAVD88)

- <2
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- 3.5 - 3.9
- 3.9 - 7.9
- STUDY AREA
- PARCELS

APTIM
ENVIRONMENTAL AND INFRASTRUCTURE, INC.
2481 N. W. BOCA RATON BOULEVARD
BOCA RATON, FL 33431
PH. (561) 391-8102
FAX (561) 391 9116
COA FL #8051

No.	Date	Description

Designed by: M.Lowiec
Drawn by: H.Vollmer
Date: May 2018
Plot Scale: AS NOTED
Checked by: D.Mann
Reviewed by: M.Lowiec
Submitted by: T.Brenner
Comm. No.: 631233074

Reference Files:

2018 CITY OF DELRAY BEACH
SEAWALL VULNERABILITY ANALYSIS
SEAWALL ELEVATION ANALYSIS

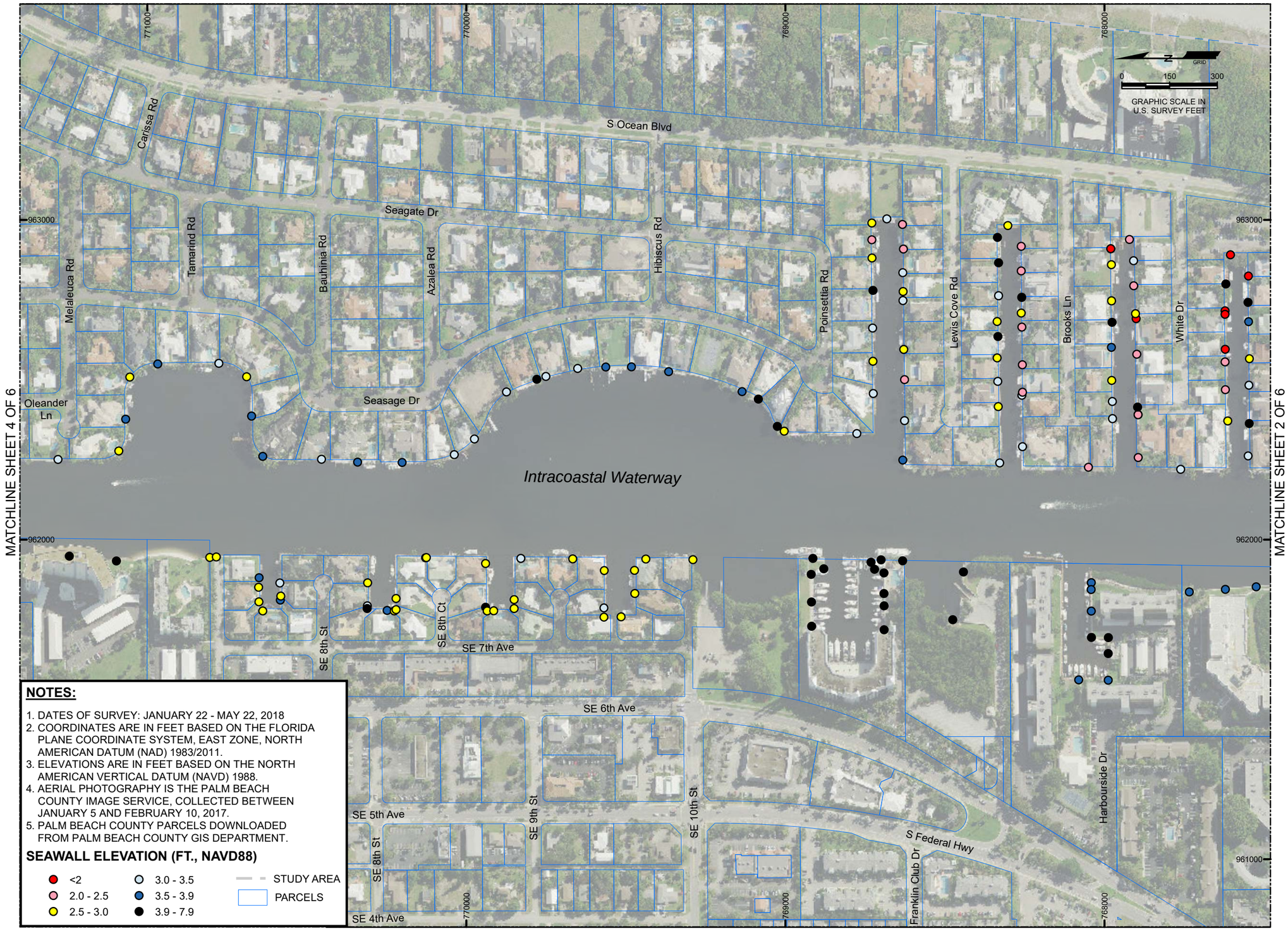
PLAN VIEW

DRAWING NO.

PV2

SHEET 2 OF 6

Document Path: G:\Enterprise\Palm_Beach\631233074\Seawall Topo Appendix 2.mxd



NOTES:

1. DATES OF SURVEY: JANUARY 22 - MAY 22, 2018
2. COORDINATES ARE IN FEET BASED ON THE FLORIDA PLANE COORDINATE SYSTEM, EAST ZONE, NORTH AMERICAN DATUM (NAD) 1983/2011.
3. ELEVATIONS ARE IN FEET BASED ON THE NORTH AMERICAN VERTICAL DATUM (NAVD) 1988.
4. AERIAL PHOTOGRAPHY IS THE PALM BEACH COUNTY IMAGE SERVICE, COLLECTED BETWEEN JANUARY 5 AND FEBRUARY 10, 2017.
5. PALM BEACH COUNTY PARCELS DOWNLOADED FROM PALM BEACH COUNTY GIS DEPARTMENT.

SEAWALL ELEVATION (FT., NAVD88)

<2	3.0 - 3.5	STUDY AREA
2.0 - 2.5	3.5 - 3.9	PARCELS
2.5 - 3.0	3.9 - 7.9	

APTIM
ENVIRONMENTAL AND INFRASTRUCTURE, INC.
2481 N. W. BOCA RATON BOULEVARD
BOCA RATON, FL 33431
PH. (561) 391-8102
FAX (561) 391 9116
COA FL #8051

No.	Date	Description

Designed by: M.Lowiec
Drawn by: H.Vollmer
Date: May 2018
Plot Scale: AS NOTED
Checked by: D.Mann
Reviewed by: M.Lowiec
Submitted by: T.Brenner
Comm. No.: 631233074

Reference Files:

2018 CITY OF DELRAY BEACH
SEAWALL VULNERABILITY ANALYSIS
SEAWALL ELEVATION ANALYSIS

PLAN VIEW

DRAWING NO.

PV3

SHEET 3 OF 6

Document Path: G:\Enterprise\Palm Beach\631233074\Seawall Topo Appendix 3.mxd

MATCHLINE SHEET 5 OF 6

MATCHLINE SHEET 3 OF 6

Andrews Ave
Bronson Ave
Palm Ave
Seabreeze Ave
East Rd
Gleason St
Venetian Dr
Macfarlane Dr
Seasage Dr
Seagate Dr
S Ocean Blvd
Miramar Dr
Sandoway Park
Coconut Row
Ocean Ter
Nassau St
Bay St
Ingraham Ave
Langer Way
Casuarina Rd
Coralina Ln
Bucida Rd
E Atlantic Ave
Intracoastal Waterway
Marine Way
Palm Sq
NE 1st St
SE 1st St
SE 2nd St
SE 3rd St
SE 4th St
SE 5th St
SE 6th Ave
SE 7th Ave
SE 5th Ave
E Mallory Cir
N Mallory Cir
W Mallory Cir
S Mallory Cir

775000
774000
773000
772000
963000
962000
774000
773000
772000

0 150 300
GRAPHIC SCALE IN U.S. SURVEY FEET

N
GRID

NOTES:

1. DATES OF SURVEY: JANUARY 22 - MAY 22, 2018
2. COORDINATES ARE IN FEET BASED ON THE FLORIDA PLANE COORDINATE SYSTEM, EAST ZONE, NORTH AMERICAN DATUM (NAD) 1983/2011.
3. ELEVATIONS ARE IN FEET BASED ON THE NORTH AMERICAN VERTICAL DATUM (NAVD) 1988.
4. AERIAL PHOTOGRAPHY IS THE PALM BEACH COUNTY IMAGE SERVICE, COLLECTED BETWEEN JANUARY 5 AND FEBRUARY 10, 2017.
5. PALM BEACH COUNTY PARCELS DOWNLOADED FROM PALM BEACH COUNTY GIS DEPARTMENT.

SEAWALL ELEVATION (FT., NAVD88)

- <2
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- 3.5 - 3.9
- 3.9 - 7.9
- STUDY AREA
- PARCELS

PV-6
PV-5
PV-4
PV-3
PV-2
PV-1

N
NOT TO SCALE

APTIM
ENVIRONMENTAL AND INFRASTRUCTURE, INC.
2481 N. W. BOCA RATON BOULEVARD
BOCA RATON, FL 33431
PH. (561) 391-8102
FAX (561) 391 9116
COA FL #8051

No.	Date	Description

Designed by: M.Lowiec
Drawn by: H.Vollmer
Date: May 2018
Plot Scale: AS NOTED
Checked by: D.Mann
Reviewed by: M.Lowiec
Submitted by: T.Brenner
Comm. No.: 631233074

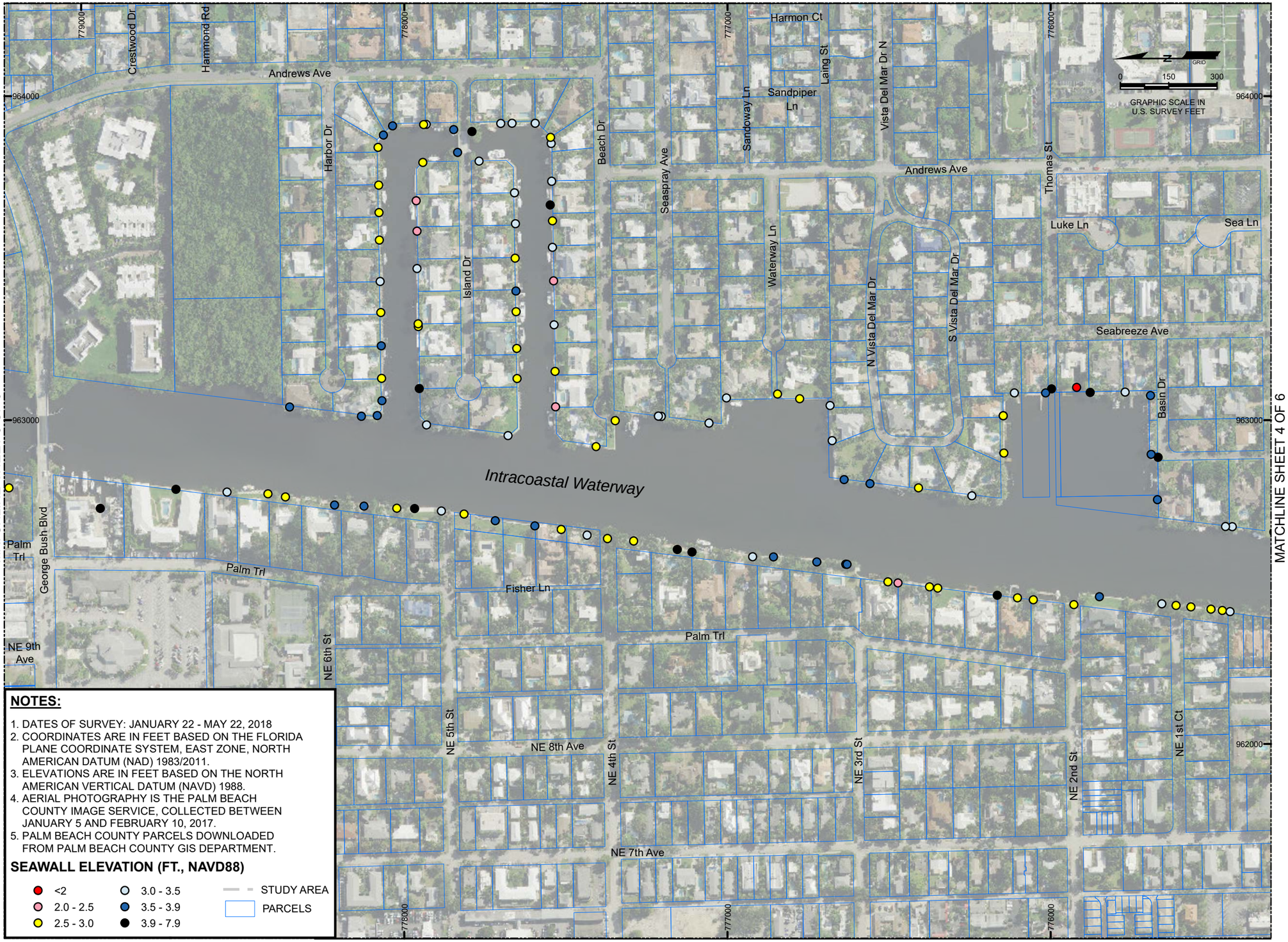
Reference Files:

2018 CITY OF DELRAY BEACH
SEAWALL VULNERABILITY ANALYSIS
SEAWALL ELEVATION ANALYSIS

PLAN VIEW

DRAWING NO.
PV4
SHEET 4 OF 6

Document Path: G:\Enterprise\Palm_Beach\631233074\Seawall Topo Appendix 4.mxd



NOTES:

1. DATES OF SURVEY: JANUARY 22 - MAY 22, 2018
2. COORDINATES ARE IN FEET BASED ON THE FLORIDA PLANE COORDINATE SYSTEM, EAST ZONE, NORTH AMERICAN DATUM (NAD) 1983/2011.
3. ELEVATIONS ARE IN FEET BASED ON THE NORTH AMERICAN VERTICAL DATUM (NAVD) 1988.
4. AERIAL PHOTOGRAPHY IS THE PALM BEACH COUNTY IMAGE SERVICE, COLLECTED BETWEEN JANUARY 5 AND FEBRUARY 10, 2017.
5. PALM BEACH COUNTY PARCELS DOWNLOADED FROM PALM BEACH COUNTY GIS DEPARTMENT.

SEAWALL ELEVATION (FT., NAVD88)

- <2
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- 3.5 - 3.9
- 3.9 - 7.9
- STUDY AREA
- PARCELS

APTIM
ENVIRONMENTAL AND INFRASTRUCTURE, INC.
2481 N. W. BOCA RATON BOULEVARD
BOCA RATON, FL 33431
PH. (561) 391-8102
FAX (561) 391 9116
COA FL #8051

No.	Date	Description

Designed by: M.Lowiec
Drawn by: H.Vollmer
Date: May 2018
Plot Scale: AS NOTED
Checked by: D.Mann
Reviewed by: M.Lowiec
Submitted by: T.Brenner
Comm. No.: 631233074

Reference Files:

2018 CITY OF DELRAY BEACH
SEAWALL VULNERABILITY ANALYSIS
SEAWALL ELEVATION ANALYSIS

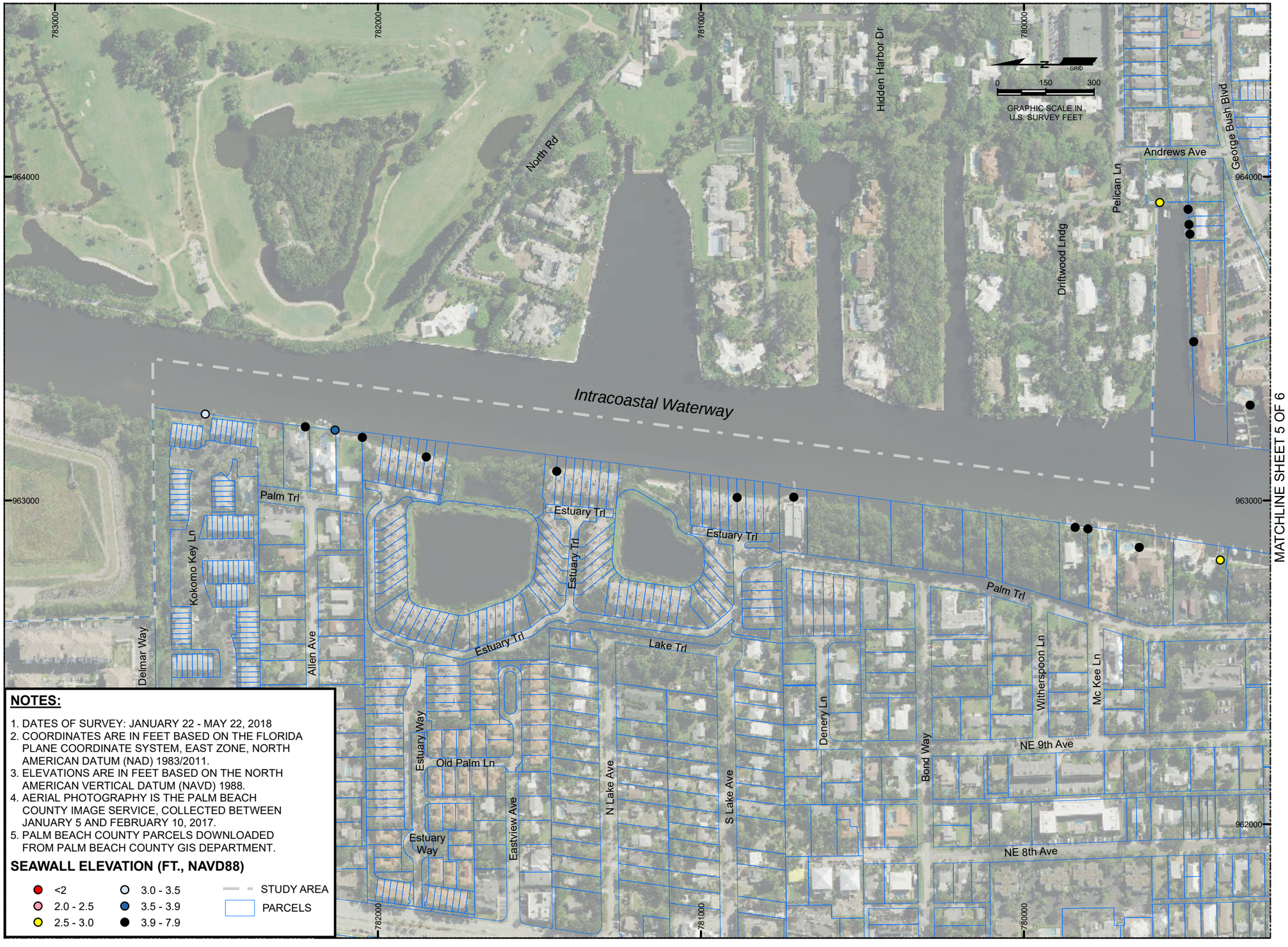
PLAN VIEW

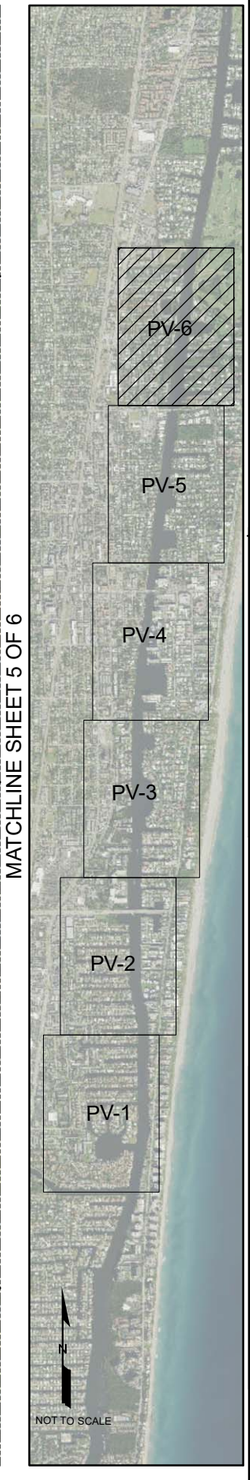
DRAWING NO.

PV5

SHEET 5 OF 6

Document Path: G:\Enterprise\Palm_Beach\631233074\Seawall Topo Appendix 5.mxd





NOTES:

1. DATES OF SURVEY: JANUARY 22 - MAY 22, 2018
2. COORDINATES ARE IN FEET BASED ON THE FLORIDA PLANE COORDINATE SYSTEM, EAST ZONE, NORTH AMERICAN DATUM (NAD) 1983/2011.
3. ELEVATIONS ARE IN FEET BASED ON THE NORTH AMERICAN VERTICAL DATUM (NAVD) 1988.
4. AERIAL PHOTOGRAPHY IS THE PALM BEACH COUNTY IMAGE SERVICE, COLLECTED BETWEEN JANUARY 5 AND FEBRUARY 10, 2017.
5. PALM BEACH COUNTY PARCELS DOWNLOADED FROM PALM BEACH COUNTY GIS DEPARTMENT.

SEAWALL ELEVATION (FT., NAVD88)

<2	3.0 - 3.5	STUDY AREA
2.0 - 2.5	3.5 - 3.9	PARCELS
2.5 - 3.0	3.9 - 7.9	

APTIM
ENVIRONMENTAL AND INFRASTRUCTURE, INC.
2481 N. W. BOCA RATON BOULEVARD
BOCA RATON, FL 33431
PH. (561) 391-8102
FAX (561) 391 9116
COA FL #8051

No.	Date	Description

Designed by: M.Lowiec
Drawn by: H.Vollmer
Date: May 2018
Plot Scale: AS NOTED
Checked by: D.Mann
Reviewed by: M.Lowiec
Submitted by: T.Brenner
Comm. No.: 631233074

Reference Files:

2018 CITY OF DELRAY BEACH
SEAWALL VULNERABILITY ANALYSIS
SEAWALL ELEVATION ANALYSIS

PLAN VIEW

DRAWING NO.

PV6

SHEET 6 OF 6

Document Path: G:\Enterprise\Palm_Beach\631233074\Seawall Topo Appendix 6.mxd

APPENDIX E

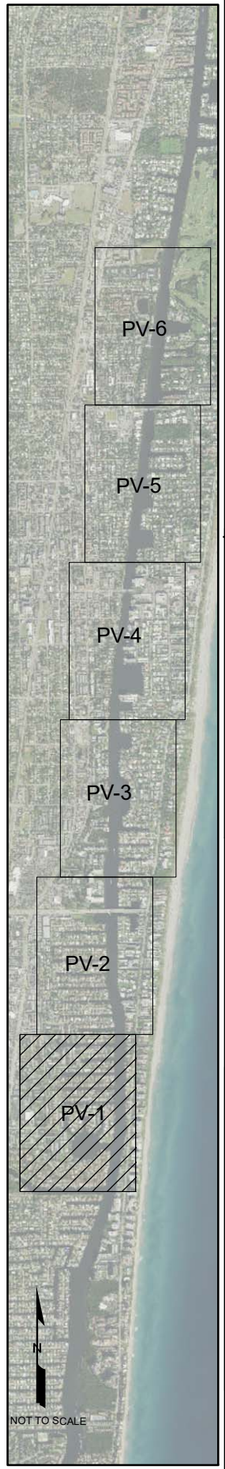
RAPID SEAWALL ASSESSMENT

NOTES:

1. DATES OF SURVEY: MARCH 8 AND 14, 2018
2. COORDINATES ARE IN FEET BASED ON THE FLORIDA PLANE COORDINATE SYSTEM, EAST ZONE, NORTH AMERICAN DATUM (NAD) 1983/2011.
3. SEAWALL CLASSIFICATIONS CONSISTENT WITH ASCE UNDERWATER CONDTION ASSESSMENT RATINGS (2011).
4. AERIAL PHOTOGRAPHY IS THE PALM BEACH COUNTY IMAGE SERVICE, COLLECTED BETWEEN JANUARY 5 AND FEBRUARY 10, 2017.
5. PALM BEACH COUNTY PARCELS DOWNLOADED FROM PALM BEACH COUNTY GIS DEPARTMENT.

RAPID STRUCTURAL ASSESSMENT

CRITICAL — SERIOUS — POOR — SATISFACTORY — FAIR — GOOD — STUDY AREA — P PUBLIC



APTIM
ENVIRONMENTAL AND INFRASTRUCTURE, INC.
2481 N. W. BOCA RATON BOULEVARD
BOCA RATON, FL 33431
PH. (561) 391-8102
FAX (561) 391 9116
COA FL #8051

No.	Description	Date

Reference Files:

Designed by: M.Lowiec
Drawn by: H.Vollmer
Date: May 2018
Plot Scale: AS NOTED
Checked by: D.Mann
Reviewed by: M.Lowiec
Submitted by: T.Brenner
Comm. No.: 631233074

2018 CITY OF DELRAY BEACH
SEAWALL VULNERABILITY ANALYSIS
RAPID SEAWALL ASSESSMENT

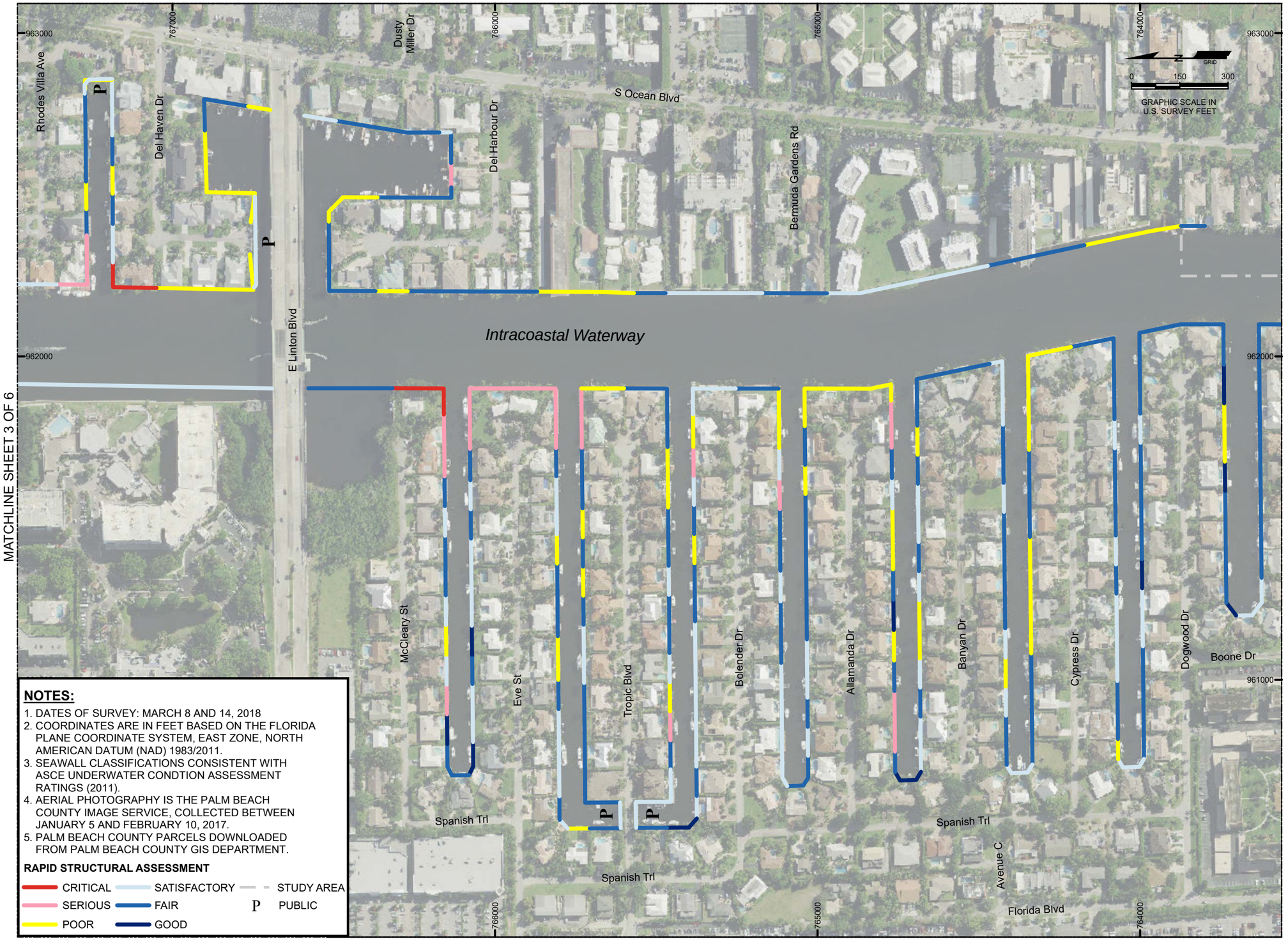
PLAN VIEW

DRAWING NO.

PV1

SHEET 1 OF 6

Document Path: G:\Enterprise\Palm_Beach\631233074\Rapid Seawall Appendix 1.mxd



NOTES:

1. DATES OF SURVEY: MARCH 8 AND 14, 2018
2. COORDINATES ARE IN FEET BASED ON THE FLORIDA PLANE COORDINATE SYSTEM, EAST ZONE, NORTH AMERICAN DATUM (NAD) 1983/2011.
3. SEAWALL CLASSIFICATIONS CONSISTENT WITH ASCE UNDERWATER CONDTION ASSESSMENT RATINGS (2011).
4. AERIAL PHOTOGRAPHY IS THE PALM BEACH COUNTY IMAGE SERVICE, COLLECTED BETWEEN JANUARY 5 AND FEBRUARY 10, 2017.
5. PALM BEACH COUNTY PARCELS DOWNLOADED FROM PALM BEACH COUNTY GIS DEPARTMENT.

RAPID STRUCTURAL ASSESSMENT

CRITICAL | SERIOUS | POOR | SATISFACTORY | FAIR | GOOD | STUDY AREA | P PUBLIC

APTIM
ENVIRONMENTAL AND INFRASTRUCTURE, INC.
2481 N. W. BOCA RATON BOULEVARD
BOCA RATON, FL 33431
PH. (561) 391-8102
FAX (561) 391 9116
COA FL #8051

No.	Date	Description

Designed by: M.Lowiec
Drawn by: H.Vollmer
Date: May 2018
Plot Scale: AS NOTED
Checked by: D.Mann
Reviewed by: M.Lowiec
Submitted by: T.Brenner
Comm. No.: 631233074

Reference Files:

2018 CITY OF DELRAY BEACH
SEAWALL VULNERABILITY ANALYSIS
RAPID SEAWALL ASSESSMENT

PLAN VIEW

DRAWING NO.

PV2

SHEET 2 OF 6

Document Path: G:\Enterprise\Palm_Beach\631233074\Rapid Seawall Appendix 2.mxd

MATCHLINE SHEET 4 OF 6

MATCHLINE SHEET 2 OF 6

771000
770000
769000
768000
963000
962000
961000

S Ocean Blvd
Carissa Rd
Melaleuca Rd
Tamarind Rd
Bauhinia Rd
Seagate Dr
Azalea Rd
Hibiscus Rd
Poinsettia Rd
Lewis Cove Rd
Brooks Ln
White Dr
Oleander Ln
Seasage Dr
Intracoastal Waterway
SE 8th St
SE 8th Ct
SE 7th Ave
SE 6th Ave
SE 5th Ave
SE 9th St
SE 10th St
S Federal Hwy
Harbourside Dr
Franklin Club Dr
SE 4th Ave

P

N
GRID
0 150 300
GRAPHIC SCALE IN U.S. SURVEY FEET

PV-6
PV-5
PV-4
PV-3
PV-2
PV-1

N
NOT TO SCALE

NOTES:

1. DATES OF SURVEY: MARCH 8 AND 14, 2018
2. COORDINATES ARE IN FEET BASED ON THE FLORIDA PLANE COORDINATE SYSTEM, EAST ZONE, NORTH AMERICAN DATUM (NAD) 1983/2011.
3. SEAWALL CLASSIFICATIONS CONSISTENT WITH ASCE UNDERWATER CONDTION ASSESSMENT RATINGS (2011).
4. AERIAL PHOTOGRAPHY IS THE PALM BEACH COUNTY IMAGE SERVICE, COLLECTED BETWEEN JANUARY 5 AND FEBRUARY 10, 2017.
5. PALM BEACH COUNTY PARCELS DOWNLOADED FROM PALM BEACH COUNTY GIS DEPARTMENT.

RAPID STRUCTURAL ASSESSMENT

CRITICAL — SATISFACTORY — STUDY AREA
SERIOUS — FAIR — P PUBLIC
POOR — GOOD

APTIM
ENVIRONMENTAL AND INFRASTRUCTURE, INC.
2481 N. W. BOCA RATON BOULEVARD
BOCA RATON, FL 33431
PH. (561) 391-8102
FAX (561) 391 9116
COA FL #8051

No.	Date	Description

Designed by: M.Lowiec
Drawn by: H.Vollmer
Date: May 2018
Plot Scale: AS NOTED
Checked by: D.Mann
Reviewed by: M.Lowiec
Submitted by: T.Brenner
Comm. No.: 631233074

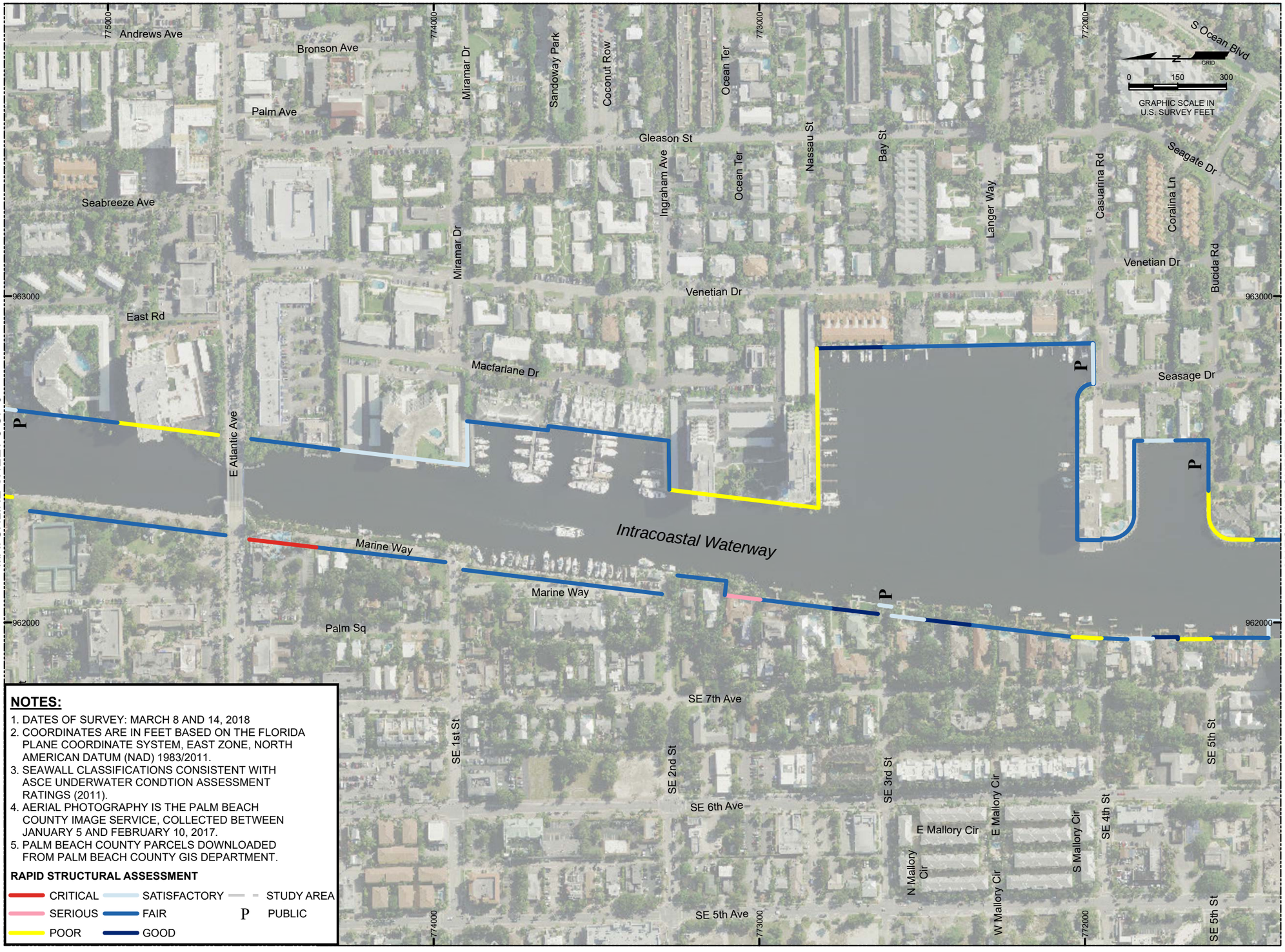
Reference Files:

2018 CITY OF DELRAY BEACH
SEAWALL VULNERABILITY ANALYSIS
RAPID SEAWALL ASSESSMENT

PLAN VIEW

DRAWING NO.
PV3
SHEET 3 OF 6

Document Path: G:\Enterprise\Palm Beach\631233074\Rapid Seawall Appendix 3.mxd

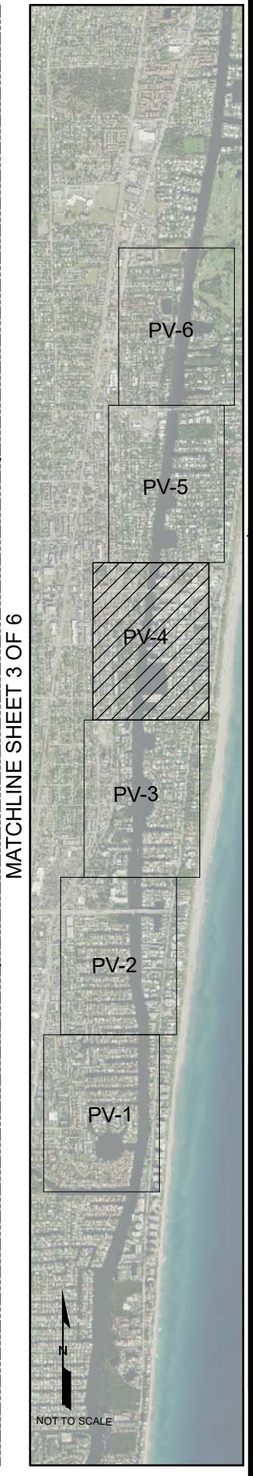


NOTES:

1. DATES OF SURVEY: MARCH 8 AND 14, 2018
2. COORDINATES ARE IN FEET BASED ON THE FLORIDA PLANE COORDINATE SYSTEM, EAST ZONE, NORTH AMERICAN DATUM (NAD) 1983/2011.
3. SEAWALL CLASSIFICATIONS CONSISTENT WITH ASCE UNDERWATER CONDTION ASSESSMENT RATINGS (2011).
4. AERIAL PHOTOGRAPHY IS THE PALM BEACH COUNTY IMAGE SERVICE, COLLECTED BETWEEN JANUARY 5 AND FEBRUARY 10, 2017.
5. PALM BEACH COUNTY PARCELS DOWNLOADED FROM PALM BEACH COUNTY GIS DEPARTMENT.

RAPID STRUCTURAL ASSESSMENT

CRITICAL — SERIOUS — POOR — SATISFACTORY — FAIR — GOOD — STUDY AREA — P PUBLIC



APTIM
ENVIRONMENTAL AND INFRASTRUCTURE, INC.
2481 N. W. BOCA RATON BOULEVARD
BOCA RATON, FL 33431
PH. (561) 391-8102
FAX (561) 391 9116
COA FL #8051

No.	Date	Description

Designed by: M.Lowiec
Drawn by: H.Vollmer
Date: May 2018
Plot Scale: AS NOTED
Checked by: D.Mann
Reviewed by: M.Lowiec
Submitted by: T.Brenner
Comm. No.: 631233074

Reference Files:

2018 CITY OF DELRAY BEACH
SEAWALL VULNERABILITY ANALYSIS
RAPID SEAWALL ASSESSMENT

PLAN VIEW

DRAWING NO.

PV4

SHEET 4 OF 6

Document Path: G:\Enterprise\Palm_Beach\631233074\Rapid Seawall Appendix 4.mxd

MATCHLINE SHEET 6 OF 6

MATCHLINE SHEET 4 OF 6

Andrews Ave
Harbor Dr
Island Dr
Beach Dr
Seaspray Ave
Sandoway Ln
Waterway Ln
Harmon Ct
Sandpiper Ln
Laing St
Vista Del Mar Dr N
N Vista Del Mar Dr
S Vista Del Mar Dr
Thomas St
Luke Ln
Sea Ln
Seabreeze Ave
Basin Dr
Crestwood Dr
Hammond Rd
Intracoastal Waterway
Palm Trl
George Bush Blvd
Fisher Ln
NE 9th Ave
NE 6th St
NE 5th St
NE 8th Ave
NE 4th St
NE 3rd St
NE 2nd St
NE 1st Ct
NE 7th Ave

964000
963000
962000
779000
778000
777000
776000

GRAPHIC SCALE IN U.S. SURVEY FEET
0 150 300
GRID N

P

PV-6
PV-5
PV-4
PV-3
PV-2
PV-1

N
NOT TO SCALE

NOTES:

1. DATES OF SURVEY: MARCH 8 AND 14, 2018
2. COORDINATES ARE IN FEET BASED ON THE FLORIDA PLANE COORDINATE SYSTEM, EAST ZONE, NORTH AMERICAN DATUM (NAD) 1983/2011.
3. SEAWALL CLASSIFICATIONS CONSISTENT WITH ASCE UNDERWATER CONDTION ASSESSMENT RATINGS (2011).
4. AERIAL PHOTOGRAPHY IS THE PALM BEACH COUNTY IMAGE SERVICE, COLLECTED BETWEEN JANUARY 5 AND FEBRUARY 10, 2017.
5. PALM BEACH COUNTY PARCELS DOWNLOADED FROM PALM BEACH COUNTY GIS DEPARTMENT.

RAPID STRUCTURAL ASSESSMENT

CRITICAL — SATISFACTORY — STUDY AREA
SERIOUS — FAIR — P PUBLIC
POOR — GOOD

Document Path: G:\Enterprise\Palm_Beach\631233074\Rapid Seawall Appendix 5.mxd

APTIM
ENVIRONMENTAL AND INFRASTRUCTURE, INC.
2481 N. W. BOCA RATON BOULEVARD
BOCA RATON, FL 33431
PH. (561) 391-8102
FAX (561) 391 9116
COA FL #8051

No.	Description	Date

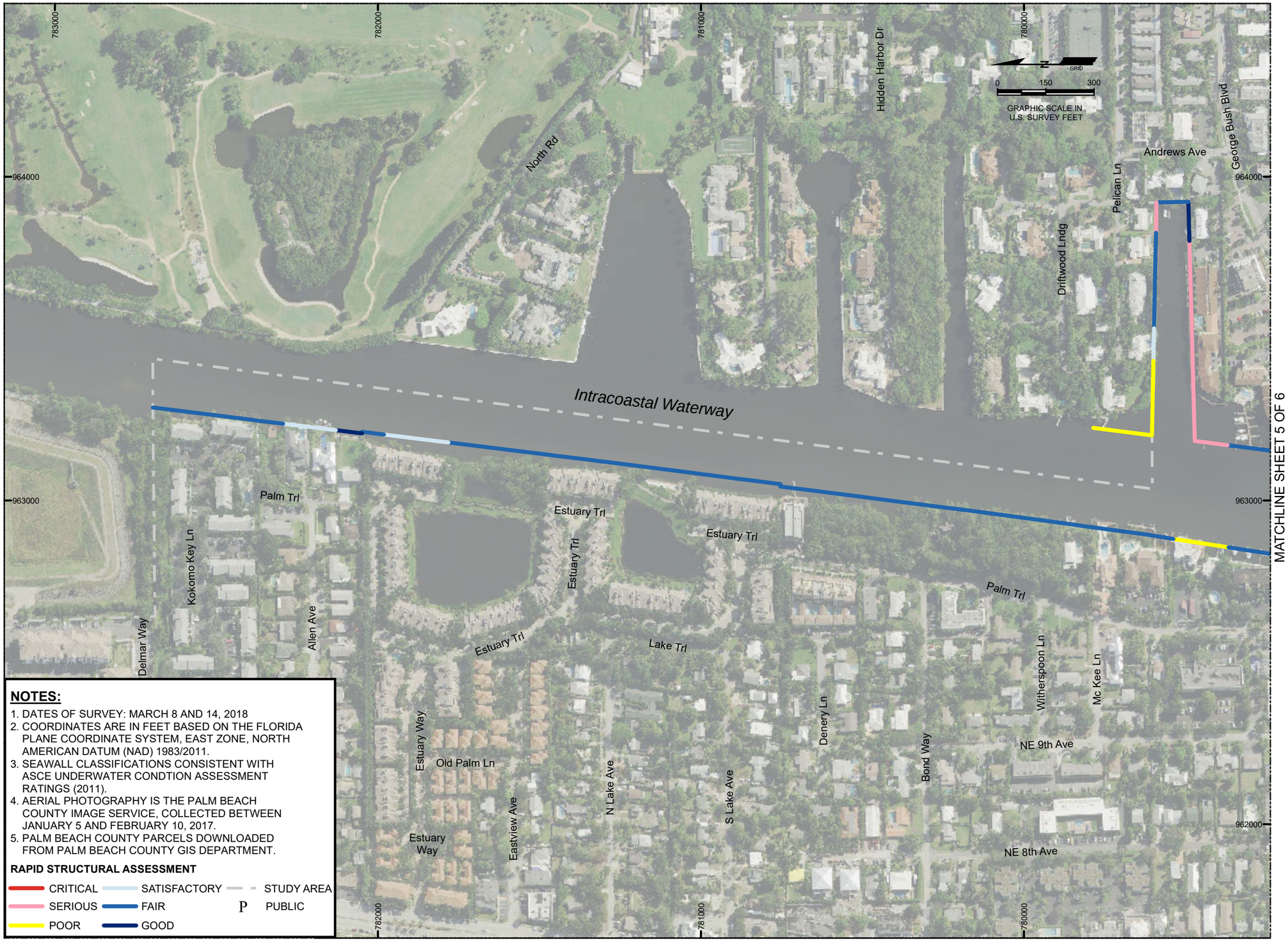
Designed by: M.Lowiec
Drawn by: H.Vollmer
Date: May 2018
Plot Scale: AS NOTED
Checked by: D.Mann
Reviewed by: M.Lowiec
Submitted by: T.Brenner
Comm. No.: 631233074

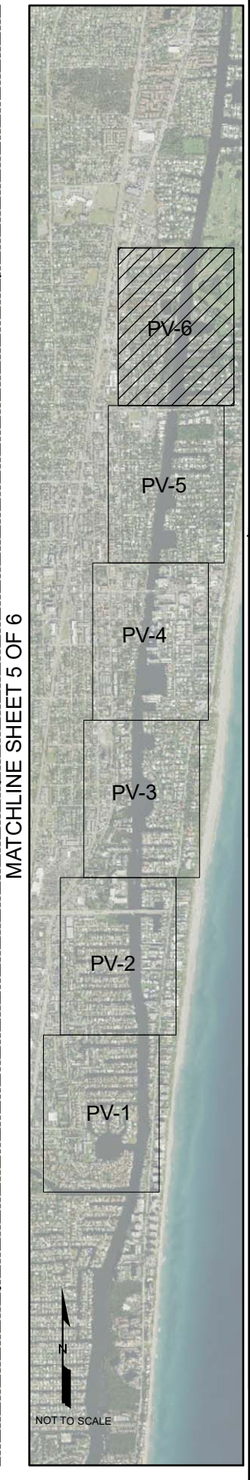
Reference Files:

2018 CITY OF DELRAY BEACH
SEAWALL VULNERABILITY ANALYSIS
RAPID SEAWALL ASSESSMENT

PLAN VIEW

DRAWING NO.
PV5
SHEET 5 OF 6





NOTES:

1. DATES OF SURVEY: MARCH 8 AND 14, 2018
2. COORDINATES ARE IN FEET BASED ON THE FLORIDA PLANE COORDINATE SYSTEM, EAST ZONE, NORTH AMERICAN DATUM (NAD) 1983/2011.
3. SEAWALL CLASSIFICATIONS CONSISTENT WITH ASCE UNDERWATER CONDTION ASSESSMENT RATINGS (2011).
4. AERIAL PHOTOGRAPHY IS THE PALM BEACH COUNTY IMAGE SERVICE, COLLECTED BETWEEN JANUARY 5 AND FEBRUARY 10, 2017.
5. PALM BEACH COUNTY PARCELS DOWNLOADED FROM PALM BEACH COUNTY GIS DEPARTMENT.

RAPID STRUCTURAL ASSESSMENT

CRITICAL — SERIOUS — POOR — SATISFACTORY — FAIR — GOOD — STUDY AREA — P PUBLIC

APTIM
ENVIRONMENTAL AND INFRASTRUCTURE, INC.
2481 N. W. BOCA RATON BOULEVARD
BOCA RATON, FL 33431
PH. (561) 391-8102
FAX (561) 391 9116
COA FL #8051

No.	Date	Description

Designed by: M.Lowiec
Drawn by: H.Vollmer
Date: May 2018
Plot Scale: AS NOTED
Checked by: D.Mann
Reviewed by: M.Lowiec
Submitted by: T.Brenner
Comm. No.: 631233074

Reference Files:

2018 CITY OF DELRAY BEACH
SEAWALL VULNERABILITY ANALYSIS
RAPID SEAWALL ASSESSMENT

PLAN VIEW

DRAWING NO.

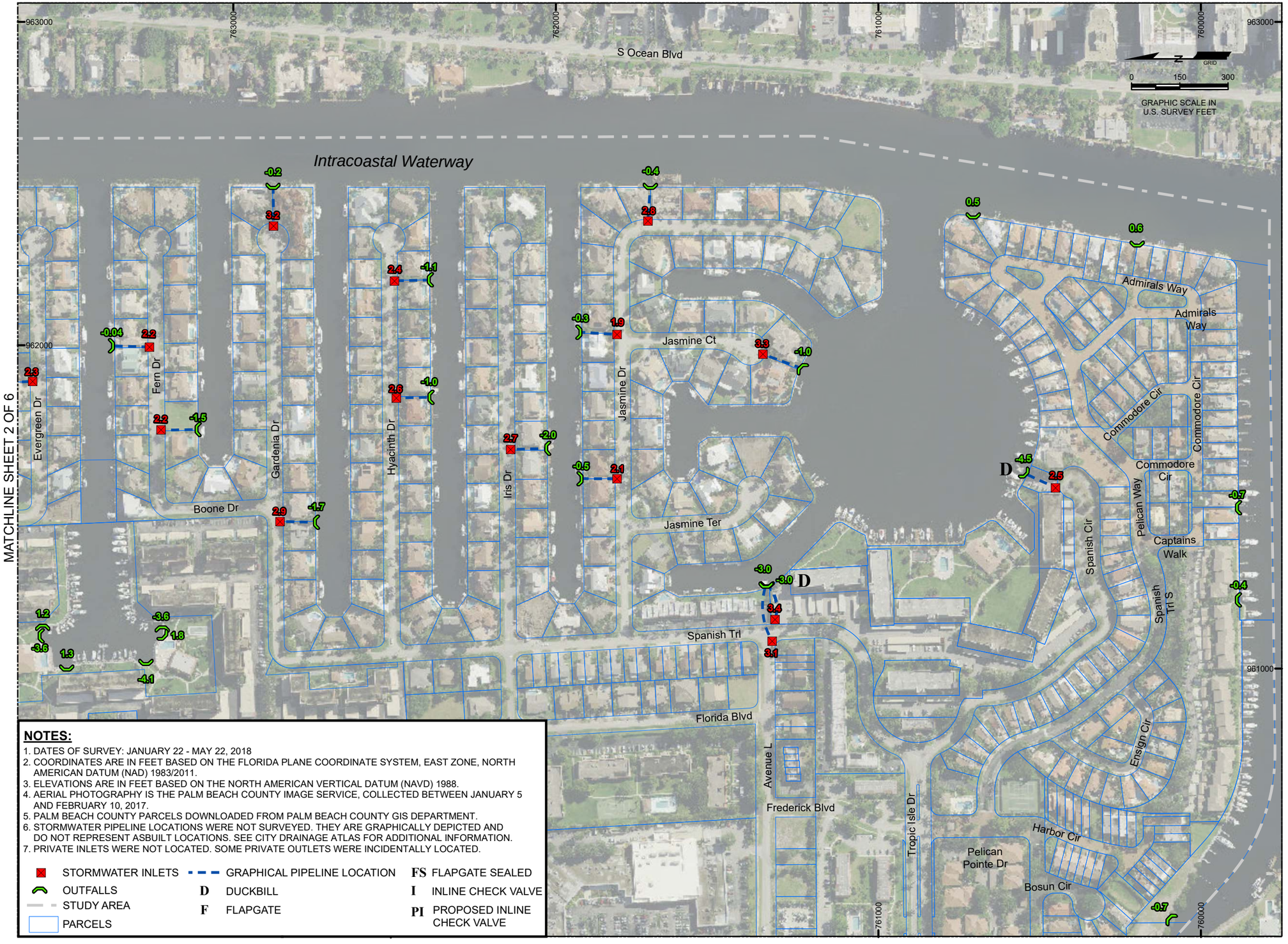
PV6

SHEET 6 OF 6

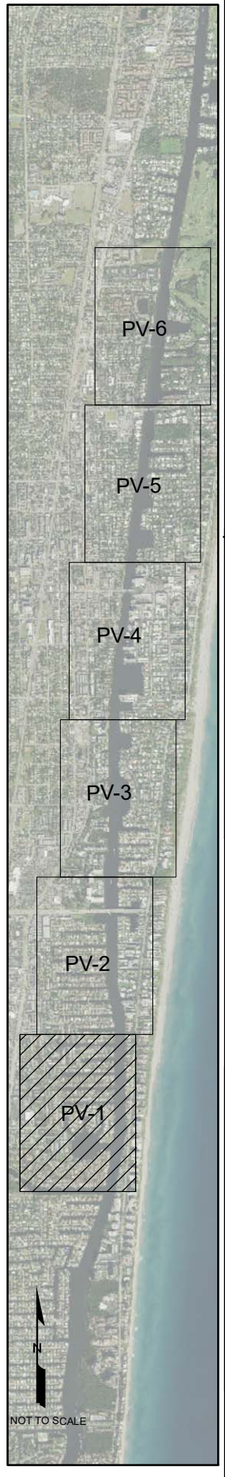
Document Path: G:\Enterprise\Palm_Beach\631233074\Rapid Seawall Appendix 6.mxd

APPENDIX F

STORMWATER SYSTEM SURVEY



MATCHLINE SHEET 2 OF 6



NOTES:

1. DATES OF SURVEY: JANUARY 22 - MAY 22, 2018
2. COORDINATES ARE IN FEET BASED ON THE FLORIDA PLANE COORDINATE SYSTEM, EAST ZONE, NORTH AMERICAN DATUM (NAD) 1983/2011.
3. ELEVATIONS ARE IN FEET BASED ON THE NORTH AMERICAN VERTICAL DATUM (NAVD) 1988.
4. AERIAL PHOTOGRAPHY IS THE PALM BEACH COUNTY IMAGE SERVICE, COLLECTED BETWEEN JANUARY 5 AND FEBRUARY 10, 2017.
5. PALM BEACH COUNTY PARCELS DOWNLOADED FROM PALM BEACH COUNTY GIS DEPARTMENT.
6. STORMWATER PIPELINE LOCATIONS WERE NOT SURVEYED. THEY ARE GRAPHICALLY DEPICTED AND DO NOT REPRESENT ASBUILT LOCATIONS. SEE CITY DRAINAGE ATLAS FOR ADDITIONAL INFORMATION.
7. PRIVATE INLETS WERE NOT LOCATED. SOME PRIVATE OUTLETS WERE INCIDENTALLY LOCATED.

STORMWATER INLETS	GRAPHICAL PIPELINE LOCATION	FS	FLAPGATE SEALED
OUTFALLS	D	DUCKBILL	I	INLINE CHECK VALVE
STUDY AREA	F	FLAPGATE	PI	PROPOSED INLINE CHECK VALVE
PARCELS				

APTIM
ENVIRONMENTAL AND INFRASTRUCTURE, INC.
2481 N. W. BOCA RATON BOULEVARD
BOCA RATON, FL 33431
PH. (561) 391-8102
FAX (561) 391 9116
COA FL #8051

No.	Date	Description

Designed by: M.Lowiec
Drawn by: H.Vollmer
Date: May 2018
Plot Scale: AS NOTED
Checked by: D.Mann
Reviewed by: M.Lowiec
Submitted by: T.Brenner
Comm. No.: 631233074

Reference Files:

2018 CITY OF DELRAY BEACH
SEAWALL VULNERABILITY ANALYSIS
STORMWATER SYSTEM SURVEY

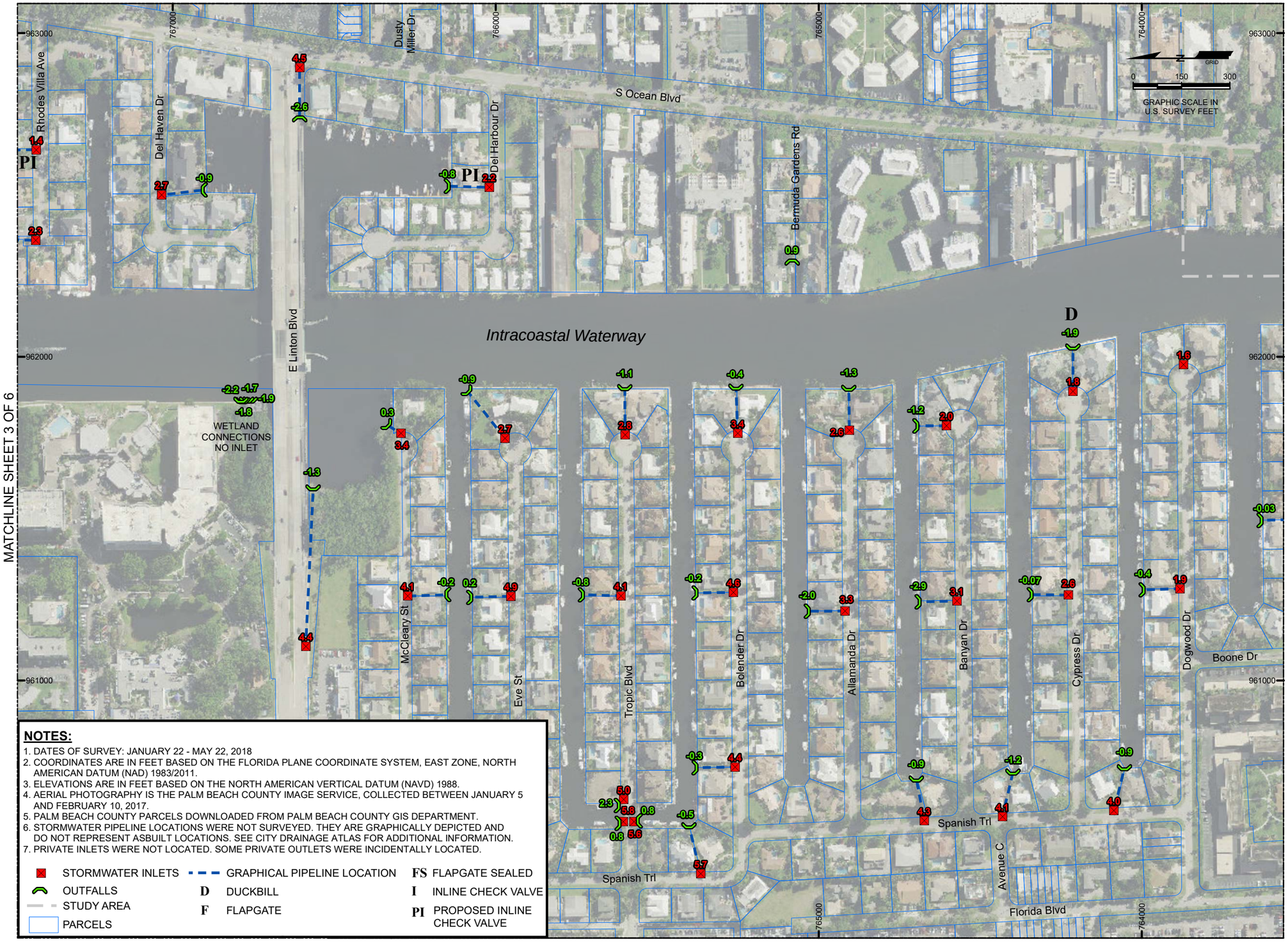
PLAN VIEW

DRAWING NO.

PV1

SHEET 1 OF 6

Document Path: G:\Enterprise\Palm_Beach\631233074\Stormwater Appendix 1.mxd



NOTES:

1. DATES OF SURVEY: JANUARY 22 - MAY 22, 2018
2. COORDINATES ARE IN FEET BASED ON THE FLORIDA PLANE COORDINATE SYSTEM, EAST ZONE, NORTH AMERICAN DATUM (NAD) 1983/2011.
3. ELEVATIONS ARE IN FEET BASED ON THE NORTH AMERICAN VERTICAL DATUM (NAVD) 1988.
4. AERIAL PHOTOGRAPHY IS THE PALM BEACH COUNTY IMAGE SERVICE, COLLECTED BETWEEN JANUARY 5 AND FEBRUARY 10, 2017.
5. PALM BEACH COUNTY PARCELS DOWNLOADED FROM PALM BEACH COUNTY GIS DEPARTMENT.
6. STORMWATER PIPELINE LOCATIONS WERE NOT SURVEYED. THEY ARE GRAPHICALLY DEPICTED AND DO NOT REPRESENT ASBUILT LOCATIONS. SEE CITY DRAINAGE ATLAS FOR ADDITIONAL INFORMATION.
7. PRIVATE INLETS WERE NOT LOCATED. SOME PRIVATE OUTLETS WERE INCIDENTALLY LOCATED.

STORMWATER INLETS	GRAPHICAL PIPELINE LOCATION	FS	FLAPGATE SEALED
OUTFALLS	D DUCKBILL	I	INLINE CHECK VALVE
STUDY AREA	F FLAPGATE	PI	PROPOSED INLINE CHECK VALVE
PARCELS			

APTIM
ENVIRONMENTAL AND INFRASTRUCTURE, INC.
2481 N. W. BOCA RATON BOULEVARD
BOCA RATON, FL 33431
PH. (561) 391-8102
FAX (561) 391 9116
COA FL #8051

No.	Date	Description

Designed by: M.Lowiec
Drawn by: H.Vollmer
Date: May 2018
Plot Scale: AS NOTED
Checked by: D.Mann
Reviewed by: M.Lowiec
Submitted by: T.Brenner
Comm. No.: 631233074

Reference Files:

2018 CITY OF DELRAY BEACH
SEAWALL VULNERABILITY ANALYSIS
STORMWATER SYSTEM SURVEY

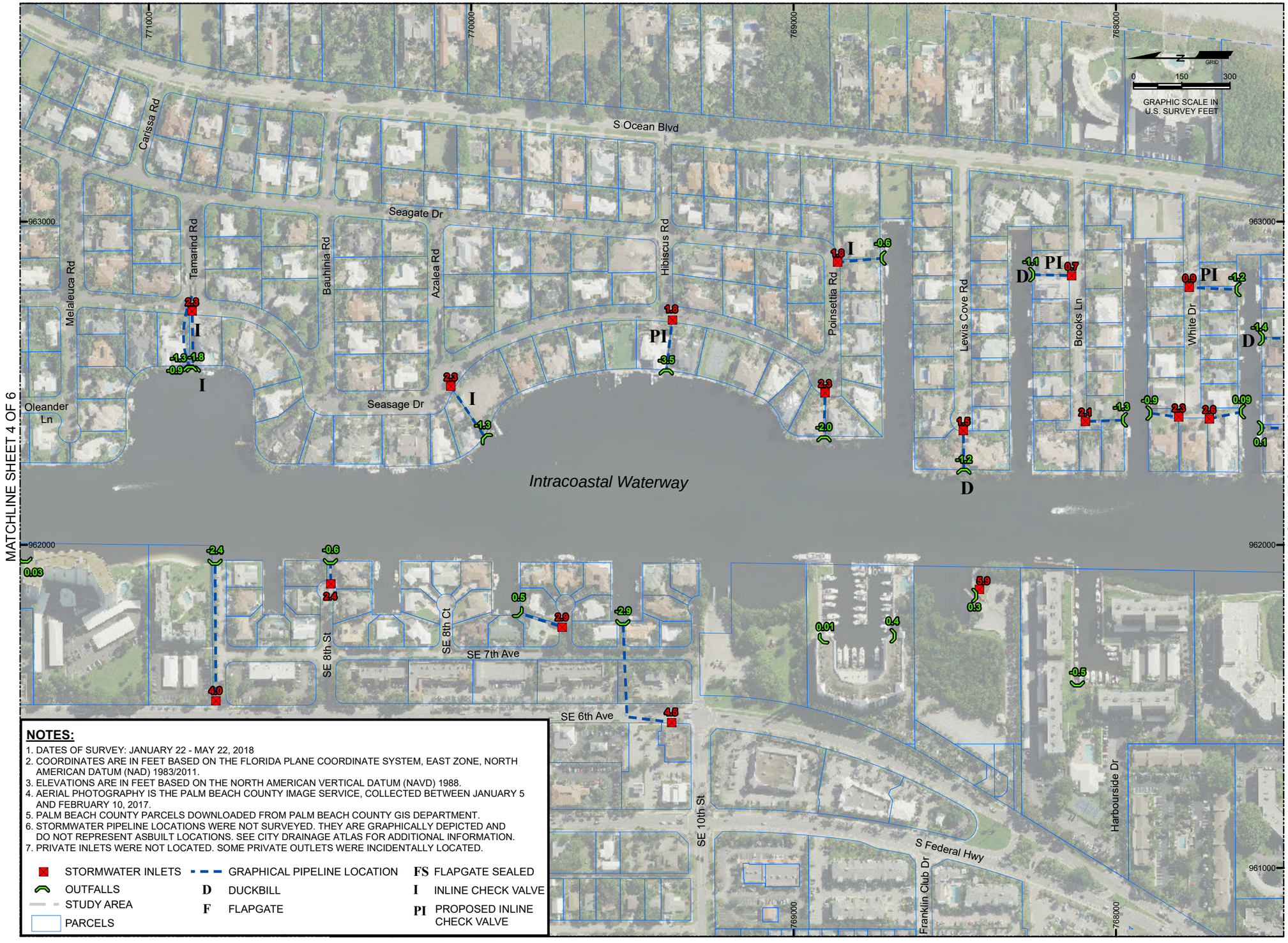
PLAN VIEW

DRAWING NO.

PV2

SHEET 2 OF 6

Document Path: G:\Enterprise\Palm_Beach\631233074\Stormwater Appendix 2.mxd



Document Path: G:\Enterprise\Palm Beach\631233074\Stormwater Appendix 3.mxd

APTIM
ENVIRONMENTAL AND INFRASTRUCTURE, INC.
2481 N. W. BOCA RATON BOULEVARD
BOCA RATON, FL 33431
PH. (561) 391-8102
FAX (561) 391 9116
COA FL #8051

No.	Date	Description

Designed by: M.Lowiec
Drawn by: H.Vollmer
Date: May 2018
Plot Scale: AS NOTED
Checked by: D.Mann
Reviewed by: M.Lowiec
Submitted by: T.Brenner
Comm. No.: 631233074

Reference Files:

2018 CITY OF DELRAY BEACH
SEAWALL VULNERABILITY ANALYSIS
STORMWATER SYSTEM SURVEY

PLAN VIEW

DRAWING NO.

PV3

SHEET 3 OF 6

MATCHLINE SHEET 5 OF 6

MATCHLINE SHEET 3 OF 6

Palm Ave
Gleason St
Seabreeze Ave
East Rd
Miramar Dr
Ingraham Ave
Ocean Ter
Nassau St
Bay St
Langer Way
Casuarina Rd
Coralina Dr
Seagate Dr
Venetian Dr
Bucida Rd
Seasage Dr
Macfarlane Dr
E Atlantic Ave
Marine Way
Intracoastal Waterway
Palm Sq
NE 1st St
NE 7th Ave
SE 1st St
SE 2nd St
SE 3rd St
SE 4th St
SE 5th St
SE 6th Ave
SE 5th Ave
E Mallory Cir
N Mallory Cir
W Mallory Cir
S Mallory Cir
963000
962000
775000
774000
773000
772000

GRID
0 150 300
GRAPHIC SCALE IN U.S. SURVEY FEET

PV-6
PV-5
PV-4
PV-3
PV-2
PV-1
N
NOT TO SCALE

NOTES:

1. DATES OF SURVEY: JANUARY 22 - MAY 22, 2018
2. COORDINATES ARE IN FEET BASED ON THE FLORIDA PLANE COORDINATE SYSTEM, EAST ZONE, NORTH AMERICAN DATUM (NAD) 1983/2011.
3. ELEVATIONS ARE IN FEET BASED ON THE NORTH AMERICAN VERTICAL DATUM (NAVD) 1988.
4. AERIAL PHOTOGRAPHY IS THE PALM BEACH COUNTY IMAGE SERVICE, COLLECTED BETWEEN JANUARY 5 AND FEBRUARY 10, 2017.
5. PALM BEACH COUNTY PARCELS DOWNLOADED FROM PALM BEACH COUNTY GIS DEPARTMENT.
6. STORMWATER PIPELINE LOCATIONS WERE NOT SURVEYED. THEY ARE GRAPHICALLY DEPICTED AND DO NOT REPRESENT ASBUILT LOCATIONS. SEE CITY DRAINAGE ATLAS FOR ADDITIONAL INFORMATION.
7. PRIVATE INLETS WERE NOT LOCATED. SOME PRIVATE OUTLETS WERE INCIDENTALLY LOCATED.

STORMWATER INLETS	GRAPHICAL PIPELINE LOCATION	FS	FLAPGATE SEALED
OUTFALLS	D DUCKBILL	I	INLINE CHECK VALVE
STUDY AREA	F FLAPGATE	PI	PROPOSED INLINE CHECK VALVE
PARCELS			

APTIM
ENVIRONMENTAL AND INFRASTRUCTURE, INC.
2481 N. W. BOCA RATON BOULEVARD
BOCA RATON, FL 33431
PH. (561) 391-8102
FAX (561) 391 9116
COA FL #8051

No.	Date	Description

Designed by: M.Lowiec
Drawn by: H.Vollmer
Date: May 2016
Plot Scale: AS NOTED
Checked by: D.Mann
Reviewed by: M.Lowiec
Submitted by: T.Brenner
Comm. No.: 631233074

Reference Files:

2018 CITY OF DELRAY BEACH
SEAWALL VULNERABILITY ANALYSIS
STORMWATER SYSTEM SURVEY

PLAN VIEW

DRAWING NO.

PV4

SHEET 4 OF 6

Document Path: G:\Enterprise\Palm_Beach\631233074\Stormwater Appendix 4.mxd

MATCHLINE SHEET 6 OF 6

MATCHLINE SHEET 4 OF 6

Andrews Ave
Harmon Ct
Sandpiper Ln
Crestwood Dr
Hammond Rd
Harbor Dr
Island Dr
Beach Dr
Seaspray Ave
Sandoway Ln
Laing St
Vista Del Mar Dr N
Waterway Ln
N Vista Del Mar Dr
S Vista Del Mar Dr
Thomas St
Luke Ln
Sea Ln
Seabreeze Ave
Basin Dr
Intracoastal Waterway
George Bush Blvd
Palm Trl
Fisher Ln
NE 9th Ave
NE 6th St
NE 8th Ave
NE 4th St
NE 3rd St
NE 2nd St
NE 1st Ct
NE 7th Ave
964000
963000
962000
779000
778000
777000
776000

GRAPHIC SCALE IN U.S. SURVEY FEET
0 150 300

SWALE

PV-6
PV-5
PV-4
PV-3
PV-2
PV-1
N
NOT TO SCALE

NOTES:

1. DATES OF SURVEY: JANUARY 22 - MAY 22, 2018
2. COORDINATES ARE IN FEET BASED ON THE FLORIDA PLANE COORDINATE SYSTEM, EAST ZONE, NORTH AMERICAN DATUM (NAD) 1983/2011.
3. ELEVATIONS ARE IN FEET BASED ON THE NORTH AMERICAN VERTICAL DATUM (NAVD) 1988.
4. AERIAL PHOTOGRAPHY IS THE PALM BEACH COUNTY IMAGE SERVICE, COLLECTED BETWEEN JANUARY 5 AND FEBRUARY 10, 2017.
5. PALM BEACH COUNTY PARCELS DOWNLOADED FROM PALM BEACH COUNTY GIS DEPARTMENT.
6. STORMWATER PIPELINE LOCATIONS WERE NOT SURVEYED. THEY ARE GRAPHICALLY DEPICTED AND DO NOT REPRESENT ASBUILT LOCATIONS. SEE CITY DRAINAGE ATLAS FOR ADDITIONAL INFORMATION.
7. PRIVATE INLETS WERE NOT LOCATED. SOME PRIVATE OUTLETS WERE INCIDENTALLY LOCATED.

STORMWATER INLETS	GRAPHICAL PIPELINE LOCATION	FS	FLAPGATE SEALED
OUTFALLS	D DUCKBILL	I	INLINE CHECK VALVE
STUDY AREA	F FLAPGATE	PI	PROPOSED INLINE CHECK VALVE
PARCELS			

APTIM
ENVIRONMENTAL AND INFRASTRUCTURE, INC.
2481 N. W. BOCA RATON BOULEVARD
BOCA RATON, FL 33431
PH. (561) 391-8102
FAX (561) 391 9116
COA FL #8051

No.	Description	Date

Designed by: M.Lowiec
Drawn by: H.Vollmer
Date: May 2018
Plot Scale: AS NOTED
Checked by: D.Mann
Reviewed by: M.Lowiec
Submitted by: T.Brenner
Comm. No.: 631233074

Reference Files:

2018 CITY OF DELRAY BEACH
SEAWALL VULNERABILITY ANALYSIS
STORMWATER SYSTEM SURVEY

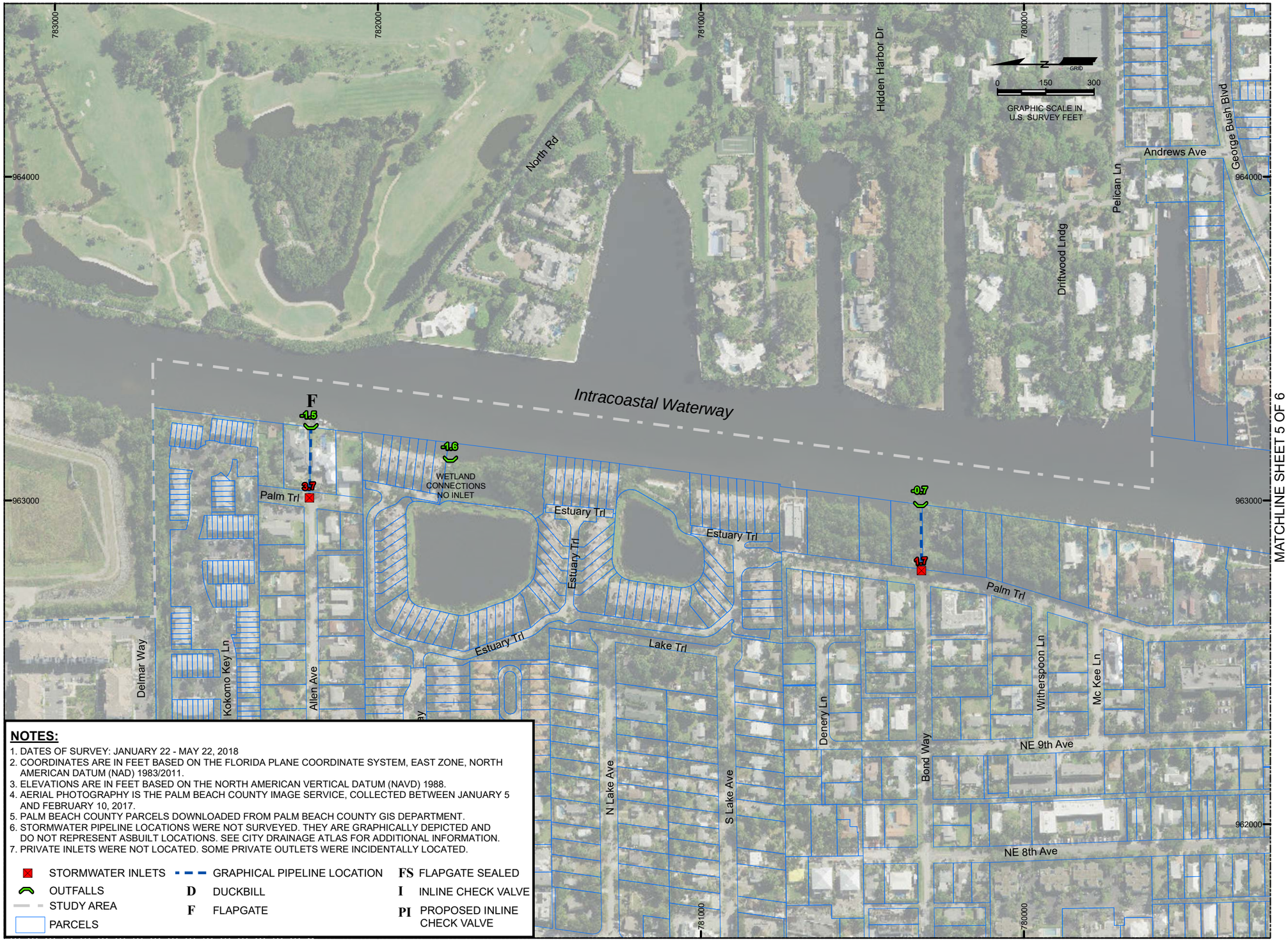
PLAN VIEW

DRAWING NO.

PV5

SHEET 5 OF 6

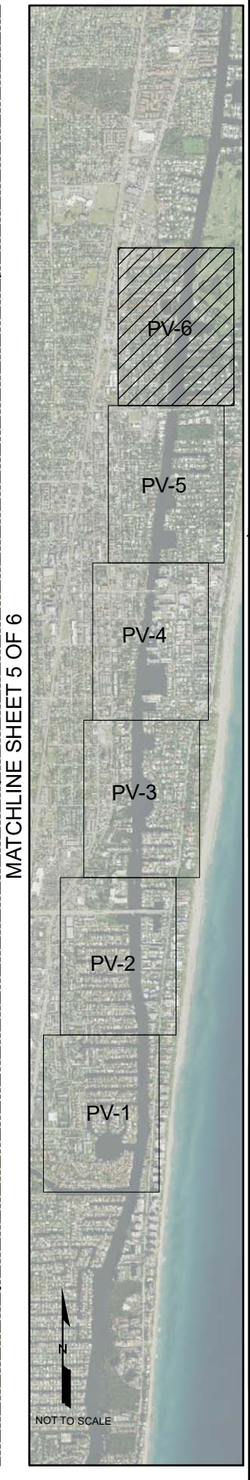
Document Path: G:\Enterprise\Palm_Beach\631233074\Stormwater Appendix 5.mxd



NOTES:

1. DATES OF SURVEY: JANUARY 22 - MAY 22, 2018
2. COORDINATES ARE IN FEET BASED ON THE FLORIDA PLANE COORDINATE SYSTEM, EAST ZONE, NORTH AMERICAN DATUM (NAD) 1983/2011.
3. ELEVATIONS ARE IN FEET BASED ON THE NORTH AMERICAN VERTICAL DATUM (NAVD) 1988.
4. AERIAL PHOTOGRAPHY IS THE PALM BEACH COUNTY IMAGE SERVICE, COLLECTED BETWEEN JANUARY 5 AND FEBRUARY 10, 2017.
5. PALM BEACH COUNTY PARCELS DOWNLOADED FROM PALM BEACH COUNTY GIS DEPARTMENT.
6. STORMWATER PIPELINE LOCATIONS WERE NOT SURVEYED. THEY ARE GRAPHICALLY DEPICTED AND DO NOT REPRESENT ASBUILT LOCATIONS. SEE CITY DRAINAGE ATLAS FOR ADDITIONAL INFORMATION.
7. PRIVATE INLETS WERE NOT LOCATED. SOME PRIVATE OUTLETS WERE INCIDENTALLY LOCATED.

STORMWATER INLETS	GRAPHICAL PIPELINE LOCATION	FS	FLAPGATE SEALED
OUTFALLS	D DUCKBILL	I	INLINE CHECK VALVE
STUDY AREA	F FLAPGATE	PI	PROPOSED INLINE CHECK VALVE
PARCELS			



APTIM
ENVIRONMENTAL AND INFRASTRUCTURE, INC.
2481 N. W. BOCA RATON BOULEVARD
BOCA RATON, FL 33431
PH. (561) 391-8102
FAX (561) 391 9116
COA FL #8051

No.	Date	Description

Designed by: M.Lowiec
Drawn by: H.Vollmer
Date: May 2018
Plot Scale: AS NOTED
Checked by: D.Mann
Reviewed by: M.Lowiec
Submitted by: T.Brenner
Comm. No.: 631233074

Reference Files:

2018 CITY OF DELRAY BEACH
SEAWALL VULNERABILITY ANALYSIS
STORMWATER SYSTEM SURVEY

PLAN VIEW

DRAWING NO.

PV6

SHEET 6 OF 6

Document Path: G:\Enterprise\Palm_Beach\631233074\Stormwater Appendix 6.mxd

APPENDIX G

BACKFLOW PREVENTION DEVICE OBSERVATIONS

APTIM
2481 NW Boca Raton Blvd
Boca Raton, FL 33431

631233074

May 18, 2018

Jeff Needle, P.E.
Environmental Services Department
City of Delray Beach
434 S. Swinton Ave
Delray Beach Florida 33444

Subject: City of Delray Beach Stormwater Outfalls
Backflow Prevention Device Observations

Dear Jeff:

This letter serves to summarize APTIM's observations of the backflow prevention devices currently installed within the study area and to provide preliminary recommendations. All recommendations are based on APTIM's limited observations during the Spring 2018 field investigations conducted for the Seawall Vulnerability Study and further observations are recommended for additional detail. For the purposes of this study, unique site names were generated based on the street name, direction and number of outfalls. Maps with outfall locations and names will be provided as part of the final report appendices. During the outfall observations, photographs of each backflow prevention device were taken and are presented below. Currently, there are three types of backflow prevention devices installed within the project area: flap gates, duckbills (both straight and recurved), and inline check valves.

Flap Gates

Functional

It appears that there are functioning flap gates at Thomas Street and at Palm Trail E-3 that seal. The Thomas drive pipe was discharging on both occasions that APTIM performed observations of the site. The invert elevation on the Thomas Street site is higher than most discharge pipes in the City and the discharge protrudes out from the seawall; likely as a result of these features, there is limited marine growth at this outfall. The Palm Trail E-3 discharge flap gate also protrudes out from the seawall. At the time of the site visit, the Palm Trail E-3 flap gate was opened and a few oysters were present, but the oysters did not appear to be affecting the seal. It is recommended that both flap gates be inspected twice per year to check the seals and clean off oysters and barnacles that are growing.

Thomas Street

Palm Trail E-3

Semi-Functional

Semi-functional flap gates exist at Marine Way E-4 and E-5. Both pipes are located within a stand of mangroves, which collect significant plant detritus and flotsam. There are flaps on the PVC pipes, but neither flap appeared to close due to debris and/or poor fit of the flap valve on the end of the pipe. On outfall Marine Way E-5, the PVC pipe was cut obliquely and doesn't allow the flap to fully close. With the small size of the flap (9 inch diameter pipe), and the lack of a rubber gasket, water may flow backward up the pipe during high tidal elevations. APTIM was informed that these outfalls will be reconstructed during an upcoming City seawall project in this area.

Marine Way E-4

Marine Way E-5

Non-functional

Non-functional flap gates exist at Basin Drive, Beach Drive, and Waterway Lane. These three flap gates are sealed shut either by oysters, corrosion, or through internal abandonment and grouting of the pipe. Alternate discharge pipes exist in those three locations to service the stormwater pumps. There also appear to be the remains of a flap gate on NE 5th Ave. At this site, the steel pipe has a large flange, and there are remnants of a hinge bolted to the bulkhead. As the inlet elevation is relatively high (3.4 feet NAVD), there is no immediate need to provide a new flap valve or alternate backflow prevention.

Basin Drive

Waterway Lane

NE 5th Street.
Pipe is in the center of the picture and the hinged frame is on the left side.

Beach Drive.
Historic flap gate is sealed shut by oysters. It is not functional.

Duckbill Check Valves

Duckbill check valves are present throughout the City. They are comprised of a preformed rubber nozzle that opens when the internal pressure increases and returns to its original shape when the internal water pressure decreases. During the outfall inspections, 17 duckbill check valves were observed in the study area.

Tideflex is a common manufacturer of duckbill check valves and their webiste advertises that “Tideflex Duckbill Check Valves have low headloss and achieve the tightest possible seal for backflow operations, particularly at low flow rates….They require no maintenance and have a long life span, making Tideflex Check Valves extremely cost effective. When you specify a Tideflex Check Valve, you are guaranteed a proven record of maintenance-free backflow prevention.” Unfortunately, the presence of oysters and barnacles within the Intracoastal Waterway prevent the duckbill check valves from fully closing in many locations and allow continued flow from the Intracoastal into the stormwater system. The following photographs illustrate the varied conditions observed:

Spanish Circle N.
Oysters are in the bottom of the duckbill preventing closure.

Cypress Drive E.
Oysters are in the bottom of the duckbill preventing closure.

Spanish Trail E 1.
Oysters prevent closure of the duckbill.

Marine Way E 1.
Duckbill does not seal.

Marine Way E 2.
Duckbill does not seal.

Marine Way E 3.
Duckbill does not seal.

SE 1st Street E 1.
Barnacles inside of duckbill prevent closure.

SE1st Street E 3.
Barnacles inside of duckbill prevent closure.

Venetian Dr W 1.
Clean. No oysters were present on the seawall.

Venetian Drive W 2.
A few barnacles were present inside, but the valve did seal.
No oysters were present on the seawall.

MacFarlane Drive W 4.
Barnacles in the bottom of the duckbill may prevent full closure.

MacFarlane Drive W 5.
Barnacles in the bottom of the duckbill may prevent full closure.

MacFarlane Drive W 6.
Barnacles in the bottom of the duckbill may prevent full closure.

Basin Drive N 1.
Duckbill is above MHW. Clean due to high invert elevation.

Rhodes Villa Ave N2.
Clean due to high invert elevation.

Beach Drive S 1 & Beach Drive S 2.
Seals but duckbill rests in sediment.

As evidenced by the performance of the duckbill backflow prevention devices, the duckbills are a means of controlling flows from the Intracoastal Waterway to the stormwater system, but they must be maintained. It is recommended that the valves be cleaned of oysters and barnacles twice per year with one cleaning just before wet season. Valves that are close to the bottom require a sediment sump to prevent sediment from building up in the bottom of the valve and preventing it from closure. Until the valves are cleaned, the performance of the local stormwater system cannot be fully assessed.

Inline Check Valves

The City reports having three inline check valves installed at the outfall end of pipes in the study area; with three others installed from the upstream pipe end or box. During APTIM's site visits, one inline check valve was observed at Tamarind Road W 1. The valve was sealed against the pipe and had one barnacle on the outside. This is consistent with manufacturer representative's statement that the valves do not allow marine growth. The inline check valve at Azalea Road W was not observed due to partial coverage by barnacle growth and the assumed location of the valve further up the pipe. Due to poor water quality conditions and a low invert elevation at Casuarina Road N, no inline check valve was seen.

From APTIM's observations, the inline check valve appears to be more resistant to marine growth and could require less maintenance than the duckbill check valves. It is recommended that the City consider additional installations to verify the reduced maintenance requirements. Once installed, valves should be inspected twice per year for marine growth and debris.

Tamarind Road W-1

APTIM

Summary

The City currently has three types of backflow prevention devices on the outfall ends of select outfall pipes within the study area. Based on APTIM's site visits, the following conclusions were made:

- Maintenance twice a year to check the valves, seals, and to remove marine growth is recommended.
- Three of the City's four flap gate valves require some maintenance to keep them fully functional.
- Duckbill check valves that are within the water column tend to accumulate barnacles and oysters, which prevents complete sealing of the valves.
- The Tamarind Road inline check valve appears to be functional, and generally free of debris. Continued observations should be performed to determine if inline check valves are more resistant to marine growth than other backflow prevention devices.

Sincerely,

Douglas W. Mann, P.E., D.CE.
Sr. Coastal Engineer

cc. Tara Brennner, P.E., P.G.

APPENDIX H

EXAMPLE ORDINANCES

CITY OF MIAMI BEACH

FREEBOARD

ORDINANCE NO. 2016-4009

AN ORDINANCE OF THE MAYOR AND CITY COMMISSION OF THE CITY OF MIAMI BEACH, FLORIDA, AMENDING SUBPART A – GENERAL ORDINANCES, OF THE CITY CODE, BY AMENDING CHAPTER 54 "FLOODS" AT SECTION 54-35, "DEFINITIONS," BY AMENDING THE DEFINITIONS FOR BASE FLOOD ELEVATION, CROWN OF ROAD, AND FREEBOARD, AND BY CREATING DEFINITIONS FOR CENTERLINE OF ROADWAY, CRITICAL FACILITY, FUTURE CROWN OF ROAD, MINIMUM FREEBOARD, MAXIMUM FREEBOARD, GREEN INFRASTRUCTURE, LOW IMPACT DEVELOPMENT (LID), AND SURFACE STORMWATER SHALLOW CONVEYANCE; BY AMENDING SECTION 54-45, "PERMIT PROCEDURES," TO REQUIRE A STORMWATER MANAGEMENT PLAN; BY AMENDING SECTION 54-47, "GENERAL STANDARDS," TO PROHIBIT SEPTIC SEWAGE SYSTEMS, AND INCLUDE REQUIREMENTS FOR STORAGE OF HAZARDOUS MATERIALS; BY AMENDING SECTION 54-48, "SPECIFIC STANDARDS," TO CLARIFY THE MINIMUM ELEVATION OF THE LOWEST FINISHED FLOOR FOR RESIDENTIAL AND NON-RESIDENTIAL CONSTRUCTION, AND REQUIRING A MINIMUM ELEVATION FOR GARAGE ENTRANCES; BY AMENDING SECTION 54-51, "STANDARDS FOR COASTAL HIGH HAZARD AREAS (V-ZONES)," TO CLARIFY THE MINIMUM ELEVATION OF THE LOWEST FLOOR OF ALL NEW CONSTRUCTION AND SUBSTANTIAL IMPROVEMENTS; PROVIDING CODIFICATION; REPEALER; SEVERABILITY; AND AN EFFECTIVE DATE.

WHEREAS, sea level rise and flooding is an ongoing concern of the City; and

WHEREAS, low lying infrastructure including buildings must also elevate in order to reduce risk or maintain low risk from potential flood damage; and

WHEREAS, it is appropriate to establish minimum freeboard requirements for residential and commercial structures to provide additional levels of protection to maintain consistency with U.S. Federal and state guidance, and

WHEREAS, these regulations will accomplish these goals and ensure that the public health, safety and welfare will be preserved.

NOW THEREFORE BE IT ORDAINED BY THE MAYOR AND CITY COMMISSION OF THE CITY OF MIAMI BEACH, FLORIDA:

SECTION 1. Section 54-35, "Definitions," is amended as follows:

* * *

Base Flood Elevation means ~~the water surface elevation associated with the base flood~~ .the regulatory elevation associated with building elevation, flood-proofing, protection of building systems and utilities and other flood protection provisions as identified in current FEMA Flood Insurance Rate Map (FIRM) panels. This elevation shall not be less than 8.0 ft. NGVD (6.44 ft. NAVD) in the City of Miami Beach.

* * *

~~Crown of road (*c*Center line)~~ of roadway means a line running parallel with the ~~highway~~ roadway right-of-way which is half the distance between the extreme edges of the official right-of-way width as shown on a map approved by the department of the public works.

* * *

Critical facility means a facility designated as an essential facility including, but not limited to: hospitals, fire, rescue, ambulance and police stations and emergency vehicle garages, emergency shelters, designated emergency preparedness, communications, and operation centers and other facilities required for emergency response, power generating stations and other public utility facilities required in an emergency ancillary structures (including, but not limited to, communication towers, fuel storage tanks, cooling towers, electrical substation structure, fire water storage tanks, or other structures housing or supporting water, or other fire-suppression material or equipment, water storage facilities and pump structures required to maintain water pressure for fire suppression building and other structures (including, but not limited to facilities that manufacture, process, handle, store, use, or dispose of such substances as hazardous fuels, hazardous chemicals, hazardous waste, or explosives) containing extremely hazardous materials.

Crown of road means the highest elevation of the roadway at a specific cross section.

Crown of road, future means the highest elevation of the crown of road as described in the adopted Miami Beach Stormwater Master Plan, located at exhibit X.

* * *

Freeboard means the additional height, usually expressed as a factor of safety in feet, above a flood level for purposes of floodplain management. Freeboard tends to compensate for many unknown factors, such as wave action, blockage of bridge or culvert openings, and hydrological effect of urbanization of the watershed, which could contribute to flood heights greater than the heights calculated for a selected frequency flood and floodway conditions. All new construction and substantial improvements to existing construction shall meet the minimum freeboard requirement, and may exceed the minimum freeboard requirement up to the maximum freeboard without such height counting against the maximum height for construction in the applicable zoning district

Freeboard, minimum equals one (1) foot.

Freeboard, maximum equals five (5') feet.

* * *

Green Infrastructure means natural vegetation, landscape design and engineered techniques that retain, absorb, and often cleanse stormwater runoff.

* * *

Low-Impact development (LID) means techniques that mimic natural processes to manage stormwater, and are frequently cheaper and more attractive than traditional stormwater management techniques.

* * *

Surface stormwater shallow conveyance means vegetated swales, permeable pavement, rain gardens, and rainwater/stormwater capture and infiltration devices.

* * *

SECTION 2. Section 54-45, "Permit Procedures," is amended as follows:

Application for a development permit shall be made to the building director or his/her designee on forms furnished by him or her prior to any development activities, and may include, but not be limited to, the following plans in duplicate drawn to scale showing the nature, location, dimension, and elevations of the area in questions, existing and proposed structures, earthen fill, storage of materials or equipment, drainage facilities, and the location of the foregoing. Specifically, the following information is required:

(1) Application stage:

* * *

(f) A stormwater management plan and site drainage calculations, for new constructions and substantial improvement, shall be prepared by a Florida licensed engineer in accordance with the ~~Public Works Department Manual and Procedures~~ CDM Smith 2011 Stormwater Plan, to demonstrate that adequate surface drainage shall be provided and surface run-off water shall be diverted to a storm conveyance or other approved point of collection, in accordance with Florida Building Code Sections 1804 and R401.3. The site shall be graded in manner to drain surface water away from foundation walls in accordance with Florida Building Code Sections 1804 and R401.3. All site drainage for new construction shall be designed and constructed in such a manner as to provide runoff rates, volume and pollutant loads not exceeding predevelopment conditions and prevent flooding adjacent properties.

* * *

SECTION 3. Section 54-47, "General Standards," is hereby amended as follows:

In all areas of special flood hazard, all development sites, including new construction and substantial improvements, shall be reasonably safe from flooding and meet the following provisions:

* * *

(16) Installation of new septic swage systems is prohibited in the City of Miami Beach Special Hazard Area.

(17) Hazardous materials shall be stored indoors in the City of Miami Beach Special Flood Hazard Area and shall be elevated no lower than Base Flood Elevation plus minimum freeboard.

* * *

SECTION 4. Section 54-48, "Specific Standards," is hereby amended as follows:

In areas mapped as "Zone X" (shaded and unshaded) on the City of Miami Beach Flood Insurance Rate Map (FIRM), all new construction and substantial improvement of any buildings (including manufactured homes) shall construct the lowest floor at an elevation of at least one foot above the highest adjacent grade or above the crown of the nearest street, whichever is higher.

In all A-zones where base flood elevation data have been provided (zones AE, A1-30, A (with base flood elevation), and AH), as set forth in section 54-37, the following provisions, in addition to those set forth in sections 54-47 54-47 and 54-49 54-49, shall apply:

(1) *Residential construction.*

(a) All new construction and substantial improvement of any residential building (including manufactured homes) shall have the lowest finished floor including electrical, heating, ventilation, plumbing, air conditioning equipment, cable, telephone, and other service facilities, including duct work elevated to no lower than the base flood elevation plus minimum freeboard. Should solid foundation perimeter walls be used to elevate a structure, there must be a minimum of two openings on different sides of each enclosed area sufficient to facilitate automatic equalization of flood hydrostatic forces in accordance with standards of subsection 54-48(3).

The following shall apply for single family residential garage structures:

When constructed as part of a detached or attached garage structure to the main home, garages shall be constructed no lower than adjusted grade, as defined in Section 114.1. Further, the overall height and structural composition of the first floor garage structure shall be designed and built to accommodate a future raised floor slab to meet the height of base flood elevation plus minimum freeboard, subject to the height limitations provided in Section 142-105.

When constructed under the main home, the associated driveway shall be sloped upward from the public right of way to a minimum elevation of adjusted grade, as defined in Section 114.1, and then may slope downward to a lower garage elevation.

The following shall apply to multifamily residential garage structures:

Access drives to garage structures shall be sloped upward from the public right of way to a minimum elevation of adjusted grade, as defined in Section 114.1, and then may slope downward to a lower garage elevation. Further, the overall height and structural composition of the first floor garage structure shall be designed and built to accommodate a future raised floor slab to meet the height of base flood elevation plus minimum freeboard.

(b) The lowest floor of an addition to the nonsubstantial improvement of a residential structure shall be elevated to no lower than the existing lowest finished floor elevation.

(2) *Nonresidential construction.*

(a) All new construction and substantial improvement of any commercial, industrial, or nonresidential building (including manufactured homes) shall have the lowest floor, including basement, electrical, heating, ventilation, plumbing, air conditioning equipment, cable, telephone, and other service facilities, including duct work, elevated to no lower than the base flood elevation plus minimum freeboard. All buildings located in A-zones may be floodproofed, in lieu of being elevated, provided that all areas of the building components, together with attendant utilities and sanitary facilities, below the base flood elevation, plus ~~one foot~~ minimum freeboard are watertight with walls substantially impermeable to the passage of water, and use structural components having the capability of resisting hydrostatic and hydrodynamic loads and the effects of buoyancy. A registered professional engineer or architect shall certify that the standards of this subsection are satisfied using the FEMA floodproofing certificate. Such certification along with the corresponding engineering data, and the operational and maintenance plans shall be provided to the floodplain administrator.

(b) The lowest floor of an addition to the nonsubstantial improvement of a commercial structure shall be elevated to no lower than the existing lowest finished floor elevation.

(c) All new construction and substantial improvements to critical facilities shall have the lowest floor, including electrical, heating, ventilation, plumbing, air conditioning equipment, cable, telephone, and other service facilities including duct work, elevated to no lower than the base flood elevation plus two (2) feet.

* * *

(4) *Standards for manufactured homes and recreational vehicles.*

(a) All manufactured homes that are placed, or substantially improved within ~~a~~zones A1-30, AH, and AE, on sites (i) outside of an existing manufactured home park or subdivision, (ii) in a new manufactured home park or subdivision, (iii) in an expansion to an existing manufactured home park or subdivision, or (iv) in an existing manufactured home park or subdivision on which a manufactured home has incurred "substantial damage" as the result of a flood, the lowest floor be elevated on a permanent foundation to no lower than the base flood elevation, plus freeboard and be securely anchored to an adequately anchored foundation system to resist flotation, collapse, and lateral movement.

* * *

SECTION 5. Section 54-51. "Standards for coastal high hazard areas (V-zones),"is amended as follows:

* * *

Located within areas of special flood hazard established in section 54-37 are coastal high hazard areas, designated as zones V1-V30, VE, or V (with BFE). The following provisions shall apply:

(2) All new construction and substantial improvements in zones V1-V30, VE, and V (with BFE) shall be elevated on pilings or columns so that:

(a) The bottom of the lowest horizontal structural member of the lowest floor (excluding the pilings or columns) is elevated to no lower than the base flood elevation, plus freeboard, whether or not the structure contains a basement; and

* * *

(c) For all structures located seaward of the coastal construction control line (CCCL), the bottom of the lowest horizontal structural member of the lowest floor of all new construction and substantial improvements of the habitable structures, as defined in Florida Building Code Section 3109, shall be elevated to the 100-year flood elevation established by the Florida Department of Environmental Protection, plus freeboard or the base flood elevation, plus freeboard, whichever is the higher.

* * *

(11) For all structures located seaward of the coastal construction control line (CCCL), the bottom of the lowest horizontal structural member of the lowest floor of all new construction and substantial improvements of the habitable structures, as defined in Florida Building Code Section 3109, shall be elevated to the flood elevation established by the Florida Department of Environmental Protection, plus freeboard or the base flood elevation, plus freeboard, whichever is higher. All non-elevation design requirements subsections 54-51(2) through (10) shall apply.

* * *

SECTION 6. CODIFICATION.

It is the intention of the Mayor and City Commission of the City of Miami Beach, and it is hereby ordained that the provisions of this ordinance shall become and be made part of the Code of the City of Miami Beach, Florida. The sections of this ordinance may be renumbered or relettered to accomplish such intention, and the word "ordinance" may be changed to "section", "article", or other appropriate word.

SECTION 7. REPEALER.

All ordinances or parts of ordinances in conflict herewith be and the same are hereby repealed.

SECTION 8. SEVERABILITY.

If any section, subsection, clause or provision of this Ordinance is held invalid, the remainder shall not be affected by such invalidity.

SECTION 9. EXCEPTIONS.

This ordinance shall not apply to anyone who filed a completed application package for Board of Adjustment, Historic Preservation Board or Design Review Board Approval with the Planning Department on or before June 8, 2016; or anyone who obtained a Building Permit Process Number from the Building Department on or before June 8, 2016.

SECTION 10. EFFECTIVE DATE.

This Ordinance shall take effect on June 8, 2016.

PASSED AND ADOPTED this 11 day of May, 2016.

Philip Levine, Mayor

ATTEST:

5/16

Rafael E. Granado, City Clerk

MIAMI BEACH INCORPORATED MARCH 26TH 1915

APPROVED AS TO FORM
AND LANGUAGE
AND FOR EXECUTION

5/12/16

City Attorney Date

First Reading: April 13, 2016
Second Reading: May 11, 2016

Verified By:

Thomas R. Mooney, AICP
Planning Director

CITY OF FORT LAUDERDALE

Sec. 47-19.3. - Boat slips, docks, boat davits, hoists and similar mooring structures.

(a) The following words when used in this section shall, for the purposes of this section, have the following meaning:

(1) *Mooring device* means a subset of mooring structures as defined herein including boat davits, hoists, boat lifts and similar devices that are erected on or adjacent to a seawall or dock and upon which a vessel can be moored. A mooring device does not include docks, slips, seawall or mooring pile.

(2) *Mooring structure* means a dock, slip, seawall, boat davit, hoist, boat lift, mooring pile or a similar structure attached to land more or less permanently to which a vessel can be moored.

(3) *NGVD 29* or the National Geodetic Vertical Datum of 1929 means the vertical control datum established for vertical control surveying in the United States of America by the General Adjustment of 1929. The datum is used to measure elevation or altitude above, and depression or depth below, mean sea level (MSL).

(4) *NAVD88* or the North American Vertical Datum means the vertical control datum of orthometric height established for vertical control surveying in the United States of America based upon the General Adjustment of the North American Datum of 1988.

(5) *Seawall* means vertical or near vertical structures placed between an upland area and a waterway. For the purposes of Section 47-19.3(f), rip rap is not considered a seawall.

(6) *Rip rap* means a foundation of unconsolidated boulders, stone, concrete or similar materials placed on or near a shoreline to mitigate wave impacts and prevent erosion.

(b) Boat davits, hoists and similar mooring devices may be erected on a seawall or dock subject to the following limitations on the number and location as follows:

(1) Except as provided herein, only one (1) mooring device per the first one hundred (100) feet of lot width or portion thereof, and one mooring device for each additional one hundred (100) feet of lot width. A second mooring device may be permitted within the lot area greater than one hundred (100) feet but less than two hundred (200) feet if approved as a Site Plan Level II permit, subject to the following criteria:

a. The location of the proposed mooring device will not interfere with the view from adjacent properties to a degree greater than the intrusion already permitted as a result of the berthing of a vessel at applicant's property within the setback and extension limitations provided in the Code.

b. The type of mooring device is the least intrusive and most compatible with the view from the waterway.

c. No conflict with a neighboring property owner's usage of the waterway will be created as a result of the additional mooring device.

Pursuant to Site Plan Level II review, the development review committee ("DRC") shall determine whether the proposed additional mooring device meets the criteria based on its location and the relationship of applicant's property to abutting properties with regard to height, angle of view of the device from abutting properties and the height, width and length of the mooring device proposed.

Approval of a Site Plan Level II development permit for an additional mooring device shall not be final until thirty (30) days after preliminary DRC approval and then only if no motion is approved by the City Commission seeking to review the application pursuant to the process provided in Section 47-26. The denial of an application for an additional mooring device may be appealed to the City Commission in accordance with the provisions of Section 47-26.

(2) In addition to the mooring device described in paragraph (b)(1) of this section, one (1) lift designed and used solely for the lifting of a personal watercraft (PWC) per development site is permitted. For purposes of this subsection (2) a PWC is as defined in F.S. Ch. 327.

(3) The cross section of the davit, hoist or other mooring device shall not exceed one (1) square foot and have a maximum height of six and one-half (6½) feet above lot grade.

(4) The lowest appendage of a vessel may not be hoisted greater than one (1) foot above a seawall cap or if no seawall, above the average grade of the upland property and properties abutting either side of the upland property, whichever is less.

(c) No boat slips, docks, boat davits, hoists, and similar mooring structures not including mooring or dolphin piles or a seawall, may be constructed by any owner of any lot unless a principal building exists on such lot and such lot abuts a waterway. Mooring structures, not including mooring or dolphin piles, shall not extend into the waterway more than twenty-five (25) percent of the width of the waterway or twenty-five (25) feet whichever is less as measured from the property line.

(d) Mooring or dolphin piles, shall not be permitted to extend more than thirty (30) percent of the width of the waterway, or twenty-five (25) feet beyond the property line, whichever is less.

(e) The City Commission may waive the limitations of Sections 47-19.3.(c), 47-19.3.(d) and 47-39.A.1.b.(12).(a) and 47-39.A.1.b.(12).(b) under extraordinary circumstances, provided permits from all governmental agencies, as required, are obtained after approval of the City Commission, after a public hearing and notification to property owners within three hundred (300) feet. In no event shall the extension exceed thirty (30) percent of the width of the waterway and no variance may be approved by the Board of Adjustment or other agency permitting an extension beyond the thirty percent (30%) limitation. Reflector tape shall be affixed to and continually maintained on all mooring or dolphin piles authorized under this

subsection to extend beyond the limitations provided in subsection (d). The reflector tape must be formulated for marine use and be in one (1) of the following uniform colors: international orange or iridescent silver. On all such piles, the reflector tape shall be at least five (5) inches wide and within eighteen (18) inches of the top of the pile.

(f) The top surface of a seawall shall have a minimum elevation of 3.9 feet NAVD88 (see table). The elevation of a seawall or dock shall not exceed a maximum of the base flood elevation (BFE) as identified in the corresponding FEMA Flood Insurance Rate Map (FIRM) for the property, except as specifically set forth herein. For properties with a BFE of 4.0 feet NAVD88, the minimum seawall elevation shall meet 3.9 feet NAVD88 and the maximum seawall or dock elevation shall be 5.0 feet NAVD88. For waterfront properties with a habitable finished floor elevation of less than 3.9 feet NAVD88, a seawall may be constructed at less than the stated minimum elevation if a waiver is granted by the City Engineer. For properties within an X zone, the minimum seawall elevation shall meet 3.9 feet NAVD88 and the maximum seawall or dock elevation shall meet the definition of grade as determined by subsection 47-2.2 (g)(1)(a). The maximum height of related structures attached to a seawall shall not exceed the elevation of the seawall to which the structure is attached. In the event of a conflict between subsection 47-19.5.B.Table 1, Note G: subsection 1.a.ii. and the requirements of this section, this section shall govern. Property owners choosing to construct seawalls at less than 5.0 feet NAVD88 are strongly encouraged to have the foundation designed to accommodate a future seawall height extension up to a minimum elevation of 5.0 feet NAVD88.

Property's FEMA Flood Insurance Rate Map Location	Minimum Allowable Seawall Elevation	Maximum Allowable Seawall or Dock Elevation
In a floodplain with a base flood elevation greater than or equal to 5.0 feet NAVD88	3.9 feet NAVD88	Base flood elevation of the property
In a floodplain with a base flood elevation equal to 4.0 feet NAVD88	3.9 feet NAVD88	5 feet NAVD88
In an X zone, not in a floodplain	3.9 feet NAVD88	Meet the definition of grade as determined by Section 47-2.2(g)(1)(a)

(1) Seawalls must be designed and built in a substantially impermeable manner to prevent tidal waters from flowing through the seawall while still allowing for the release of hydrostatic pressure from the upland direction.

(2) Fixed docks may be constructed at an elevation less than the elevation of the seawall to which it is attached but shall not be constructed at an elevation more than ten (10) inches above the seawall's elevation. The dock elevation may not exceed the maximum elevation as described in subsection (f) of this section. Floating docks shall be allowed and must be permitted and permanently attached to a marginal dock, finger pier, mooring pilings, or seawall.

(3) Seawall improvements constituting substantial repair at the time of permit application shall meet the minimum elevation and consider the design recommendations (see subsection (f) above) for the continuous seawall for the length of the property. For the purposes of this section, the substantial repair threshold shall mean the following:

(i) Any improvement to the seawall of more than fifty percent (50%) of the length of the structure, which for the purposes of this section, shall include both the seawall and cap; or

(ii) Any improvement to the seawall which results in an elevation change along more than fifty percent (50%) of the length of the structure.

(4) All property owners must maintain their seawalls in good repair. A seawall is presumed to be in disrepair if it allows for upland erosion, transfer of material through the seawall or allows tidal waters to flow unimpeded through the seawall to adjacent properties or public right-of-way. Property owners failing to maintain their seawalls may be cited. The owner of the property on which the seawall is constructed is required to initiate a process, including but not limited to hiring a contractor or submitting a building permit, and be able to demonstrate progress toward repairing the cited defect within sixty (60) days of receiving notice from the city and complete the repair within three hundred sixty-five (365) days of citation. If the required repair meets the substantial repair threshold, the property owner shall design, permit, and construct the seawall to meet the minimum elevation requirement and design requirement (see subsection 47-19.3(f)) within three hundred sixty-five (365) days of citation.

(5) Property owners with seawalls below the minimum elevation, or permeable erosion barriers such as rip rap, or a land/water interface of another nature shall not allow tidal waters entering their property to impact adjacent properties or public rights-of-way. Property owners failing to prevent tidal waters from flowing overland and leaving their property may be cited. The owner of the property is required to initiate a process, including but not limited to, hiring a contractor or submitting a building permit, and be

able to demonstrate progress toward addressing the cited concern within sixty (60) days of receiving notice from the city and complete the proposed remedy within three hundred sixty-five (365) days of citation.

(g) No boathouse, permanent covering, or temporary covering for a boat shall be permitted within the setback area required for the zoning district in which such shelter is to be located, nor shall any boathouse, permanent covering or temporary covering for a boat, or any other structure not otherwise specifically permitted, be permitted within or cover any public waterway.

(h) No watercraft shall be docked or anchored adjacent to residential property in such a position that causes it to extend beyond the side setback lines required for principal buildings on such property, as extended into the waterway, or is of such length that when docked or anchored adjacent to such property, the watercraft extends beyond such side setback lines as extended into the waterway. The owner of real property which would be entitled to the density limitation of a maximum of forty (40) units per acre pursuant to the terms for habitation of floating homes or vessels, Section 47-19.6, may apply for an exception to the setback requirements contained herein. An application for such exception shall be heard by the Planning and Zoning Board (board) at a public hearing called for that purpose. After the public hearing, the board shall make a recommendation to the City Commission that the application be granted or denied, or granted subject to conditions. If the board recommends that the application be either granted or granted subject to conditions, the City Clerk shall place the recommendation on the agenda of the City Commission for a public hearing at a regular meeting. The City Commission shall, by resolution, either grant the application, deny the application, or grant the application subject to such conditions as it finds necessary to the health, safety and general welfare of the citizens of the city. In deciding whether to grant or deny the application, the City Commission shall consider the neighborhood within which the applicant's property lies and the effect that the exception to the setbacks would have on the following:

(1) The surrounding property.

(2) The ability of adjacent property owners to enjoy abutting waterways.

(i) Waiver of limitations. Property owners of lands located on the Isle of Venice and Hendricks Isle may dock or anchor watercraft adjacent to their respective properties in a manner which extends beyond side setback lines, required by this section as approved by Resolution No. 85-270.

(Ord. No. C-97-19, § 1(47-19.3), 6-18-97; Ord. No. C-04-2, § 4, 1-12-04; Ord. No. C-10-44, § 2, 12-7-10 ; Ord. No. C-13-18, § 2, 6-4-13 ; Ord. No. C-16-13 , § 1, 6-21-16; Ord. No. C-16-27 , § 1, 12-6-16)

PUNTA GORDA

Chapter 6 BOATS, DOCKS AND WATERWAYS*

ARTICLE III. BURNT STORE ISLES CANAL MAINTENANCE ASSESSMENT DISTRICT

Sec. 6-33. Canal maintenance assessment district - - Creation.

There is hereby created a special district, to be known as the "Burnt Store Isles Canal Maintenance Assessment District," for the purpose of the maintenance of canals, waterways, and navigable channels, including the maintenance and reconstruction of bulkheads and retaining walls, which have been accepted or are hereafter accepted by the City of Punta Gorda, within the area comprising the district. The Burnt Store Isles Canal Maintenance Assessment District shall assume all of the assets, rights, liabilities and obligations of the former Burnt Store Isles Canal District created by City of Punta Gorda Ordinance No. 825-86, which is hereby dissolved.

Sec. 6-34. Same - - Area included within district.

(a) The land comprising the Burnt Store Isles Canal Maintenance Assessment District is that land within the City of Punta Gorda, Charlotte County, Florida, legally described as follows:
Punta Gorda Isles, Section 15, as per plat recorded in the Official Records of Charlotte County, Florida, including the channel to the city limits in Alligator Creek; less Commercial Lots 1 through 25, inclusive; and less Block 228; and less Block 229, Lots 2 through 9 and Lots 20 through 25, inclusive; and less Block 230, Lots 1 through 8, inclusive, and Lots 20 through 25, inclusive; and less Blocks 283 through 294, inclusive; and less Tracts A, B, C, D, E, F, G, H, I, and Burnt Store Golf Villas; and less lands zoned Environmentally Sensitive.

(b) The Burnt Store Isles Canal Maintenance Assessment District shall review and consider all requests to include lands not currently included within the district.

(1) Requirements. Requests for inclusion and acceptance of lands into the Canal Maintenance Assessment District shall require the following:

a. Submission of a written application by the property owner on such forms prescribed by the Canal Maintenance Division. The application must be signed and notarized by all owners of the property. If the property is part of a condominium association, an officer of the association authorized under its bylaws shall make the application on behalf of the property owners.
b. A copy of the deed or other evidence of property ownership.
c. A Digital Text File of the metes and bounds description of the property.
d. A written evaluation of the current condition of the existing seawall and seawall cap furnished by a Florida licensed marine contractor. Such written evaluation shall be obtained by the applicant at his/her sole cost and expense.

(2) Review. Upon receipt of a complete request for inclusion of lands into the Canal Maintenance Assessment District, the Canal Maintenance Division shall verify the current condition of the existing seawall and shall prepare the proposed amendment to Subsection (a) of this Section, and submit the request along with recommendation to the Burnt Store Isles Canal Advisory Committee. The Burnt Store Isles Canal Advisory Committee shall consider the request at a duly noticed public hearing and provide recommendation to the Burnt Store Isles Canal Maintenance Assessment District. The Burnt Store Isles Canal Maintenance Assessment District shall consider the request at a duly noticed public hearing and shall either approve or deny the request.

(3) Notice. Public Hearing Notice shall be advertised one time in a newspaper of general circulation at least fifteen (15) days prior to the public hearings.

(4) Fee. The fee for acceptance of lands into the Burnt Store Isles Canal Maintenance Assessment District shall be equal to the total assessment which would have been due on the property from the inception of the district. This fee shall be calculated by the Finance Department upon receipt of the application. In the event that the seawall and seawall cap have been replaced, the fee shall be prorated to the date of such replacement. If the seawall and seawall cap have been replaced within the three (3) years preceding the request, the fee shall be waived. The Burnt Store Isles Canal Maintenance Assessment District shall have the authority to deny the request based on, but not limited to, the condition of the seawall.

(Ord. No. 1673-11, <sec> 1, 3-16-11)

Sec. 6-35. Same -- Governing body; advisory committee.

The Burnt Store Isles Canal Maintenance Assessment District shall be governed by a board of five members, who shall be the
members of the city council of the City of Punta Gorda. The governing body shall appoint and be advised by a committee of five (5) residents of the district. The initial members of the advisory committee shall be the members of the advisory committee of the former Burnt Store Isles Canal District. The duties of the advisory committee include, but are not limited to:

(a) Representing the residents and property owners in the district;

(b) Reporting to and making recommendations to the city council on matters concerning functions of the district, to include holding public hearings on petitions for variances for the purpose of recommending to the City Council approval or denial of said variances from the provisions of section 6-6(c) or any other variance request located on land abutting and lying within six (6) feet of the seawall; and

(c) Working with the City Manager in determining priorities concerning work to be done by the district.

(Ord. No. 1669-11, <sec> 2, 3-2-11)

Sec. 6-36. Same -- Powers of district.

The Burnt Store Isles Canal Maintenance Assessment District shall have the following powers, to be exercised through its governing body, together with all other powers necessary to the effective maintenance of existing canals, waterways and navigable channels within the district, to the effective maintenance and reconstruction of bulkheads and retaining walls within the district, and to the imposition and collection of special assessments for such purposes:

(a) To sue and be sued in its own name;

(b) To adopt and use a seal;

(c) To acquire and own property in its own name;

(d) To enter into contracts to effectuate the purposes of the district;

(e) To borrow and expend money and to issue bonds and revenue certificates and other obligations of indebtedness in such manner and subject to such limitations as may be provided by law;

(f) To levy and collect annual special assessments on each subdivided lot within the district which is zoned for single-family residential use, pro-rated in the case of ownership of partial lots according to the proportion of the original subdivided lot area held, and, for all properties zoned otherwise, to levy and collect annual special assessments equal to one ten-thousandth of a single-family lot assessment for each square foot of land lying less than one hundred twenty (120) lineal feet from any dedicated canal or waterway, or from seawalls or bulkheads abutting Charlotte Harbor; and

(g) To provide for the levying of such assessments on annual tax bills, as non-ad valorem assessments, in accordance with Florida Statutes.

Sec. 6-37. Same -- annual assessments.

The Burnt Store Isles Canal Maintenance Assessment District shall each fiscal year levy an assessment sufficient to fund the necessary and expected expenses for such fiscal year and to provide a reasonable contingency fund for emergency repairs and replacements necessitated by natural disasters or other calamitous occurrences. Notices of proposed assessments shall be included, as non-ad valorem assessments, on the notices of proposed taxes mailed each year by the Charlotte County Tax Collector. Each year, the governing body of the district shall hold a public hearing on the amounts of assessments, with such hearing to be in conjunction with the City of Punta Gorda budget hearings. The district shall publish a notice of said public hearing at least five (5) days in advance thereof in a newspaper of general circulation in Charlotte County. At such public hearing, all persons assessed within the district shall have the opportunity to contest the amount of their assessments and the value of the special benefit to their properties upon which such assessment is based.

Sec. 6-38. Same -- finding of special benefit.

In creating the Burnt Store Isles Canal Maintenance Assessment District, the City Council finds and determines that the special benefits to each property owner in the district--through the sharing of costs of maintaining all canals, seawalls, and navigation channels in the district; through the shared use of such canals; by the property value created and enhanced by a functioning, well-maintained and safe canal system; and through the provision of a contingency fund for emergency repairs and replacements necessitated by natural disasters or other calamitous occurrences--exceeds each property owner's share of the costs of the necessary and expected expenses incurred by the district each year.

Sec. 6-39. Same -- use of City employees and equipment.

The City Manager is authorized and directed to use City employees and equipment in assisting the Burnt Store Isles Canal Maintenance District in performing its obligations and duties set out in this article and to charge the district the reasonable costs thereof incurred by the city. By accepting the use of such employees and equipment, the district shall agree to pay such costs, which shall be included in the annual assessments.

(Ord. No. 1156-96 <sec> 3, 07-03-96, Ord. No. 1163-96 <sec> 3, 09-18-96)