TOWN OF LAKE PARK
SEA LEVEL RISE VULNERABILITY, RISK & ADAPATION ANALYSIS

JANUARY 26, 2021

TOWN OF LAKE PARK
PUBLIC WORKS DEPARTMENT
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WRMA
WATER RESOURCES | ENGINEERING

ACKNOWLEDGMENTS

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Section 1 Introduction

As a part of the Town of Lake Park (the Town) – Seawall/Bulkhead Condition Assessment, Water Resources Management Associates, Inc. (WRMA) was tasked with performing a sea level rise vulnerability, risk and adaptation analsyis. This report details the technical methodology utilized to determine future flood hazards and damages due to anticpated sea level rise within a 50-year time horizon, along with an overall risk assessment and recommendations for adaption planning.

WRMA’s analysis was conducted using the Unified Sea Level Rise Projection – 2019 Update, prepared by the Southeast Florida Regional Climate Change Compact.

> *“The 2019 Projection is based on projections of sea level rise developed by the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (IPCC, 2014), as well as projections from the National Oceanic and Atmospheric Administration (NOAA) (Sweet et al., 2017), and accounts for regional effects, such as gravitational effects of ice melt, changes in ocean dynamics, vertical land movement, and thermal expansion from warming of the Florida Current that produce regional differences in Southeast Florida’s rate of sea level rise compared to global projections.”*

Unified Sea Level Rise Projection Report (2019 Update) – Executive Summary

Projected values of sea level rise for the Town were extracted from this report for each decadal year up to the year 2070. The analysis scenario years are: 2020, 2030, 2040, 2050, 2060, and 2070. The extracted SLR values formed the basis for determining tidal and coastal surge flood elevations for each scenario. Please note that all elevations in this report refer to the North American Vertical Datum of 1988 (NAVD88), in U.S. feet. Further information on the Compact Projection can be referenced in **Section 2.1** of this report.

For the tidal inundation analysis WRMA referenced the National Oceanic and Atmospheric Administration’s tide guage (Station ID: 8722670) at the Lake Worth Pier. The Town of Lake Park is adjacent to the Lake Worth Lagoon, and this station is the closest active station nearest the Town and the Lagoon. For the coastal surge analysis WRMA referred to the Federal Emergency Management Agency Flood Insurance Study for Palm Beach County, Florida, effective October 5, 2017.

Flood extents and depths for each analysis were evaluated upon a topographic Digital Elevation Model (DEM). The DEM utilized for this analysis has a resolution of 2.5 ft, and was derived from Palm

Beach County light detection and ranging (LiDAR) data produced for the United States Geological Survey 3D Elevation Program. The USGS LiDAR data has a vertical accuracy equal to 0.59 ft (18 cm) at the 95% confidence interval.

The results of WRMA's technical analsysis produced 12 coastal flood maps, attached in **Appendices A** and **B**. **Section 4** of this report outlines several adaptation pathways for flood risk, risk reduction and resiliency.

Section 2 Methodology

2.1 Projecting Sea Level Rise

Sea level rise (SLR) is the byproduct of a number of compounding factors, many of which are attributed to the high concentrations of heat-trapping greenhouse gases emitted into Earth's atmosphere since the early 20th century (EPA, NASA, IPCC). These factors include but are not limited to global temperature rise, the gravitational effects of melting ice masses, changes to dynamic systems within the ocean such as the Gulf Stream, thermal expansion of the warming ocean, and even vertical land movement. The combined effects of these interellated factors and others manifest in uneven rates of sea level rise across disparate locations. Subsequently, given the SLR variability between regions across the globe, there are regional projections for sea level rise in addition to the global projections.

WRMA chose to refer to the 2019 Unified Sea Level Rise Projection, published by the Southeast Florida Regional Climate Change Compact. The Compact was formed by several counties in Southeast Florida when they recognized the need to unify the diversity of SLR projections for the region. The Compact published its first report in 2011, and provided an update in 2015. The 2019 Projection is the third and latest update, which provides the anticipated sea level rise in the Southeast Florida region through 2120.

Due to the fact sea level rise is highly dependent upon the amount of greenhouse gas emissions generated in the next decade and onward (Compact, 2019), projections of SLR are banded across several Representative Concentration Pathways (RCPs) which account for the uncertainty of future human activity. The Compact's final projection consists of four separate SLR curves sourced from the latest scientific reseach. This selection reflects the spectrum of RCP outcomes as well as the varying levels of conservatism necessary for planning and development needs.

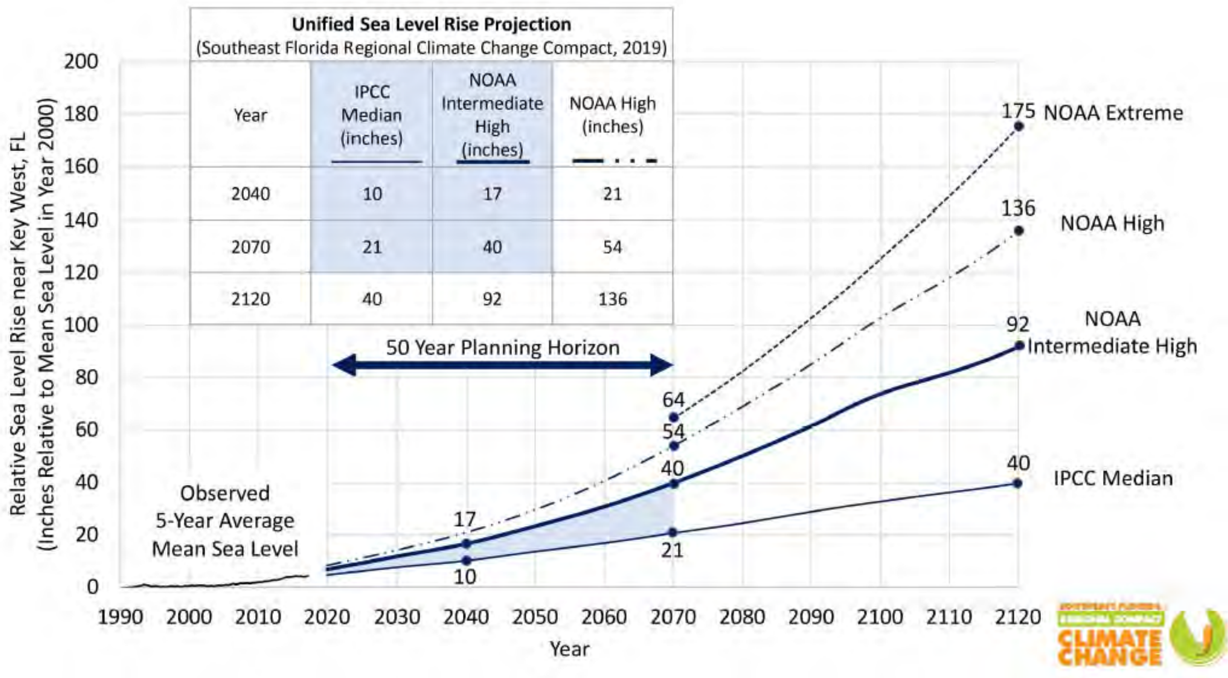


Figure 1 – Unified Sea Level Rise Projection

The Unified Sea Level Rise Projection, seen in **Figure 1**, consists of three planning horizons:

1. **short term**: by 2040, sea level is projected to rise 10 to 17 inches above 2000 mean sea level.
2. **medium term**: by 2070, sea level is projected to rise 21 to 54 inches above 2000 mean sea level.
3. **long term**: by 2120, sea level is projected to rise 40 to 136 inches above 2000 mean sea level.

The National Oceanic and Atmospheric Administration (NOAA) Extreme curve is displayed for informational purposes, but not recommended for design. The Intergovernmental Panel on Climate Change (IPCC) Median curve represents the most likely average sea level before 2070. The blue shaded zone between the IPCC Median and the NOAA Intermediate-High curves is generally recommended for projects within a short-term planning horizon.

Aside from design life, project requirements also vary by criticality. Infrastructure such as hospitals and emergency access routes demand higher levels of conservatism. Using the higher estimate curves is appropriate in those cases. However, generally higher estimate curves represent less likely outcomes and therefore require discretionary judgment in their selection.

To better account for inter-decadal variances and the critical nature of the Town's bulkhead adaptation planning, WRMA selected the NOAA Intermediate High curve as the baseline for calculating tidal and coastal surge flood elevations. The SLR for each decadal year along this curve is shown below:

Table 1 – Sea Level Rise by Decade

DATUM: FEET 2000 MSL			
YEAR	IPCC MED 50%	NOAA2017 INT-HIGH	NOAA2017 HIGH
2000	0.00	0	0
2010	0.19	0.3	0.33
2020	0.39	0.56	0.69
2030	0.63	0.98	1.18
2040	0.84	1.38	1.74
2050	1.13	1.94	2.46
2060	1.40	2.56	3.38
2070	1.72	3.31	4.49
2080	2.03	4.17	5.74
2090	2.40	5.12	7.09
2100	2.72	6.14	8.56
2120	3.29	7.64	11.32

2.2 Tidal Inundation Mapping

Tidal inundation, also known as “sunny day flooding”, is the result of high tide water overtopping into low lying coastal areas. In the case of sea level rise, tidal inundation has the prospect of becoming more than the occasional nuisance from king tides, but rather a daily issue. Southeast Florida has a semidiurnal tide pattern, meaning it experiences two high and two low tides every lunar day. Consequently, while projected sea level rise induced tidal inundation in the Town could occur on a daily basis, it could also happen twice per day due to the semidiurnal tide pattern.

The NOAA Office for Coastal Management, and generally accepted engineering practice, dictate using the highest average daily tide for mapping tidal inundation. Given SE Florida’s semidiurnal tide pattern, there are two average high tides: The Mean High Water (MHW), and the Mean Higher High Water (MHHW). For the purposes of this study WRMA used the MHHW at the Lake Worth Pier tide gauge (Station ID: 8722670) as the reference for projecting the future highest tide.

Normally NOAA’s published MHHW values are based on a National Tidal Datum Epoch (NTDE). The epoch is an averaging period of 19 years, with the present NTDE extending from 1983 to 2001. Given this period does not reflect the baseline condition of the Compact’s 2019 Projection, WRMA forward adjusted the MHHW from the mid-point of the current epoch (1992) to the year 2000, at a rate of annual sea level rise consistent with NOAA’s calculated sea level rise trend for the Lake Worth Pier station. For that station, the relative sea level rise trend is 3.74 mm/year with a 95% confidence interval of +/- 0.56 mm/year, based on monthly mean sea level data from 1970 to 2019.

Table 2 – Lake Worth Pier Tide Levels

Lake Worth Pier Tide Levels (NAVD88)		
Mean Level	NTDE	Year 2000
MHHW	0.55	0.65
MHW	0.37	0.47
MSL	-0.97	-0.87
MLW	-2.35	-2.25
MLLW	-2.51	-2.41

With the baseline tide condition set at the MHHW in the year 2000, WRMA calculated the anticipated highest tide for each decade up to the year 2070. **Table 3** shows the values used in determining inundated topography within the DEM for each scenario year.

Table 3 – Tidal Inundation Elevations

MHHW (NAVD88)		
Ref Curve:	NOAA Intermediate High	
Year	SLR (inches)	Elevation
2020	6.7	1.21
2030	11.8	1.63
2040	16.6	2.03
2050	23.3	2.59
2060	30.7	3.21
2070	39.7	3.96

2.3 Coastal & Riverine Flood Mapping

In regard to flood risk mapping, FEMA designates the Special Flood Hazard Area (SFHA) as the area with a special flood or mudflow, and/or flood related erosion hazard. The purchase of flood insurance is mandatory in the SFHA per the National Flood Insurance Program's floodplain management regulations. Therefore, WRMA used the SFHA as the reference floodplain for estimating damages in each decadal SLR scenario.

Typically, the SFHA is defined by the land area inundated by the 1% annual chance flood (the 100-year flood, or base flood). The corresponding base floodplain consists of areas flooded by coastal waterbodies and rivers/canals. The Town of Lake Park is exposed to both sources of flooding. In addition to these, Lake Park is also subject to surcharge flooding from inadequate drainage. However, drainage flooding is not normally considered in a FEMA Flood Insurance Study (FIS).

In coastal areas, the floodplain is the sum effects of the astronomical tide, coastal surge, and wave action. Coastal surge is the result of water being pushed towards the land, causing a rise in water level above and beyond that produced by astronomical tides. Wave action is a representative term describing the combined effects from (1) the mass transport and onshore accumulation of water by deepwater waves (*wave setup*) and (2) the inland propagation of high velocity cresting waves (*wave runup*). Coastal surge and wave action can be produced by high surface winds or seismic events. In the case of Florida, those effects are produced by hurricanes or similarly strong storm events. In riverine areas, the floodplain is the result of the insufficient conveyance of flow from an upstream watershed.

FEMA creates coastal Flood Insurance Rate Maps (FIRMs) and Regulatory Base Flood Elevations (BFEs) by modeling the aforementioned components. For coastal areas, BFEs are the sum of the stillwater elevation (SWEL) plus wave runup, or the wave crest elevation, whichever is greater. A summary graphic of FEMA's designations for various coastal flood hazard zones and BFEs is shown in **Figure 2**.

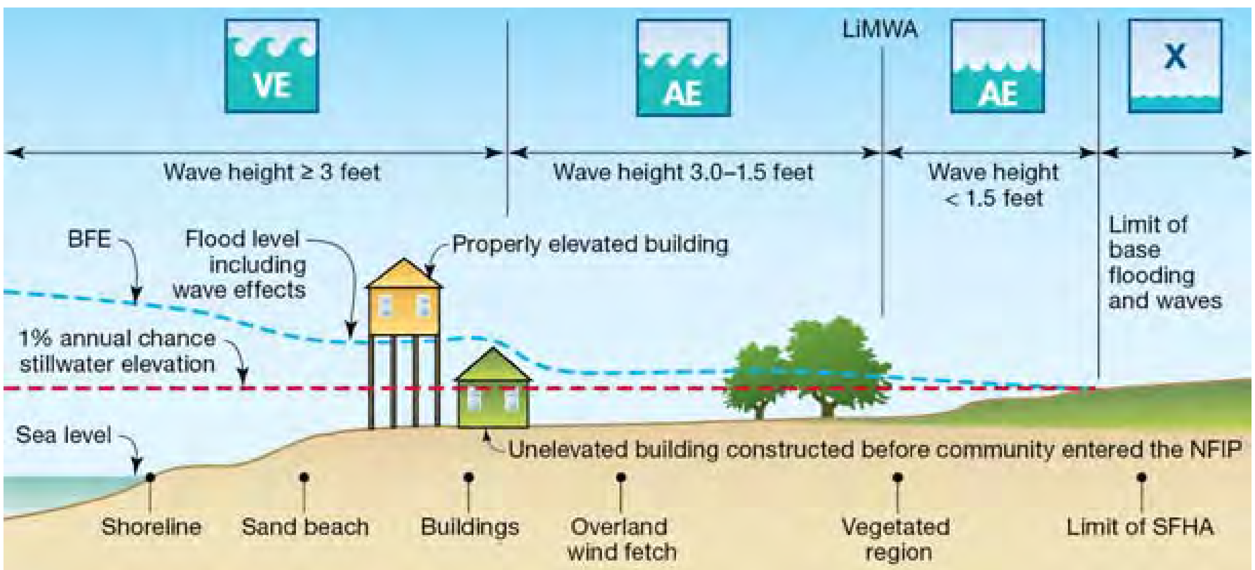


Figure 2 – FEMA Coastal Transect depicting Flood Hazard Areas

Due to the limited scope of this study, WRMA did not fully model the future base flood in the same manner as FEMA, but instead used an approximate method which is practically representative of FEMA's end product.

In review of FEMA's effective FIRMs for the Town of Lake Park, it was determined that the inland extent of coastal flooding in Lake Park closely matches the 1% annual chance stillwater elevation (SWEL), not including wave setup, of the Lake Worth Lagoon. This means that wave runup has little to no effect on the inland extent of the current base flood in the Town, due to the extensive fetch of urban obstructions such buildings and roads. However, wave action is sensitive to increases in water depth. Significantly higher water levels could allow waves to propagate further inland, and thus modeling that effect for the Town may be warranted for more extreme cases and longer time-horizons of sea level rise, such as the projections for 2100 and beyond.

With regard to riverine flooding, full riverine analysis requires topographic/bathymetric data and modeling at a level of detail outside the scope of this study. Given that riverine flooding is relevant for the Town, WRMA included those riverine areas which are flooded in the current FEMA base floodplain map for the C-17 Canal along the Western boundary. Riverine base flood elevations were kept constant throughout each SLR scenario for cost estimating purposes.

In consideration of coastal BFEs, WRMA approximated flood elevations by adding the decadal SLR on top of the current BFEs. Note from **Figure 2**, BFEs can be higher than the stillwater due to wave action, and typically decrease as water moves further inland. Where areas are *newly* inundated in a future scenario and lacked a BFE, WRMA assigned a BFE equal to the 1% SWEL + SLR (projected 1% SWEL).

Summarily, the inland extent of the projected base flood was approximated by the current 1% SWEL + SLR and current riverine flooding, and the depth of flooding was approximated by the current BFE + SLR (riverine BFEs are constant, new BFEs set at the projected 1% SWEL).

2.4 Monetary Cost Estimation

Part of evaluating flood risk reduction interventions is balancing the costs of intervention versus avoided damages (benefits). This is known as Benefit-Cost Analysis (BCA). WRMA estimated monetary damages incurred in each decadal SLR scenario, for both tidal inundation and coastal floods separately. In addition, a qualitative vulnerability assessment of vital at-risk infrastructure across the Town is provided in **Section 3** this report.

2.4.1 Tidal Inundation Damage Estimation

As mentioned in **Section 2.1**, tidal inundation will eventually occur on a daily basis (potentially twice per day). Because of this, damages due to projected tidal inundation are associated with a Permanent Loss of Function (PLOF).

PLOF is taken to be the result of the irrecoverable physical loss of structures by repetitive tidewater damage, and/or the blocking of property access by tidewaters to the point where they are functionally uninhabitable.

Given the aforementioned, PLOF damages were assumed to be a total loss at market value. To determine the PLOF for each inundated parcel, WRMA applied 2019 real property tax assessment data from the Palm Beach County Property Appraiser's office. The PLOF was calculated as the sum total market value of each building within an inundated parcel.

2.4.2 Coastal Flood Damage Estimation

To determinate monetary damages incurred in each decadal coastal flood scenario, three types of costs were estimated for every flooded building:

- **Structural damage** – includes physical damage to the building structure for a given flood depth, as a percentage of the building's replacement value;
- **Contents damage** – includes damage to items within the structure that are not permanently installed and below a given flood depth, as a percentage of the estimated contents value;
- **Temporary Loss of Function (TLOF)** – includes the costs associated with not being able to inhabit the structure until physical damages are restored.

To calculate these three costs WRMA employed accepted "Depth-Damage Functions" (DDFs), which as the moniker implies, calculates damage as a function of flood depth – the future BFE, in the case of this study. The structural and contents DDFs were sourced from a 2006 report published by the U.S. Army Corps of Engineers (USACE), New Orleans District. The aforementioned DDFs were developed for the USACE by Gulf Engineers & Consultants, Inc., in consultation with building, construction, repair, restoration, and insurance experts, as well as owners & operators. The TLOF DDF was developed by WRMA, using research published in the FEMA Baseline Standard Economic Value Methodology Report (2016). DDFs in general require a reference factor for determination. Derivation of the DDFs used and their corresponding reference factors is discussed in the following subsections.

2.4.2.1 Structure DDF

For the structural damages portion, it is important to clarify that costs here are not associated with market value. Due to the temporary nature of coastal flood events, structural damages are able to be repaired and therefore costs are based upon the building replacement value (BRV). There are various methods to estimate BRVs, but all are associated with the cost of materials and labor (union or not). To avoid unnecessary complexities, WRMA calculated BRVs by multiplying size of the structures in square feet (sf) by the construction costs ($/sf), as determined by data from RS Means[1]. Those construction costs reflect unit pricing in the West Palm Beach area and vary by the types of buildings found within the Town of Lake Park. The final BRV unit costs used are shown in **Table 4.** For review of the Structure DDF, refer to **Appendix C**.

2.4.2.2 Contents DDF

Costs associated with flood damages to contents are relative to the estimated total contents value within each building. Through field surveys the USACE has developed contents-to-structure value ratios (CSVRs), which can be used as an effective means of estimating the total contents value typical for various types of structures. These ratios calculate the total contents value as a percentage of the BRV. Ultimately, total content values were estimated in this report by the following formula:

$$Total\ Contents\ Value = (Building\ Square\ Footage)\ \times \left(\frac{BRV\ \$}{sf}\right) \times\ (CSVR)$$

The USACE report provides three categories of CSVRs (CSVR1, CSVR2, CSVR3) for selection, each one developed for different purposes and means of research & analysis. WRMA elected to use CSRV1 – which is based on typical structure and content values as determined by expert opinions. CSVR1 in particular was used to develop their depth-damage relationships for contents. The final CSVRs used for each building type in the Town are shown in **Table 4**. For review of the Contents DDF, refer to **Appendix C**.

2.4.2.3 Temporary Loss of Function DDF

A temporary loss of function incurs costs associated with tenant displacement. Per FEMA methodology, displacement costs consist of a one-time disruption cost along with recurring monthly rental costs until the structure is once again serviceable. **Table 2** of the FEMA Baseline Standard Economic Value Methodology Report (2016) provides these as units costs by square footage, varying by type. The unit costs used for each building type in the Town are shown in **Table 4**.

[1] For additional information on construction costs from RS Means please see https://www.rsmeans.com/

To calculate the total displacement unit cost for development of a TLOF DDF, the time of displacement was required. **Table 3** of the FEMA report provides average recovery times by occupancy type and ranges of flood depth (typically 4-foot intervals). The recovery times are a function of the structure's physical restoration time, contractor availability, hazardous materials removal, various inspections and permitting. The displacement times used for each building type in the Town are shown below in **Table** 5.

The final displacement unit costs for the TLOF DDF were calculated by using the following equation:

$$\frac{Displacement\ Cost\ \$}{sf} = \left(\frac{Disruption\ Cost\ \$}{sf}\right) + \left[\left(\frac{Rental\ Cost}{sf/month}\right) \times (Displacement\ months)\right]$$

For review of the Temporary Loss of Function DDF, refer to **Appendix C**.

Table 4 – DDF Reference & Input Factors

Building Type	BRV[2] ($/sf)	CSVR1	Disruption[3] ($/sf)	Rental[3] ($/sf/month)
Warehouse	$98.16	2.56	$1.04	$0.29
Store, Retail	$123.56	3.67	$1.19	$1.26
Apartment, 1-3 Story	$148.27	0.43	$0.89	$0.66
Single Family Home	$114.00	0.71	$0.89	$0.74
Restaurant	$207.07	0.83	$1.19	$1.26
Garage, Auto Sales	$111.15	3.67	$1.04	$0.52
Town Hall, 2-3 Story	$177.73	0.44	$1.04	$1.48
Office, 1 Story	$173.10	0.44	$1.04	$1.48
Garage, Service Station	$185.37	3.97	$1.04	$0.29
Church	$163.46	0.79	$1.04	$1.11
Post Office	$121.90	0.79	$1.04	$1.48
Office, 2-4 Story	$173.51	0.44	$1.04	$1.48
School, Elementary	$158.25	0.44	$1.04	$1.11
Factory, 1 Story	$115.13	2.56	$1.04	$0.22
Community Center	$119.91	0.79	$1.04	$1.48

[2] RS Means square footage estimates were escalated from the release year 2011 to 2020 $ using the Consumer Price Index (CPI) Inflation Calculator, https://www.bls.gov/data/inflation_calculator.htm

[3] Disruption and Displacement unit costs were escalated from the year of the FEMA report (2016) to 2020 $ using the Consumer Price Index (CPI) Inflation Calculator, https://www.bls.gov/data/inflation_calculator.htm

Table 5 – Temporary Loss of Function Displacement Times

	Mid. Displacement Time (months)			
Building Type	**0 to 4 ft**	**4 to 8 ft**	**8 to 12 ft**	**Over 12 ft**
Warehouse	4.5	4.5	4.5	4.5
Store, Retail	16	18.5	31	24
Apartment, 1-3 Story	10.5	13.5	24	24
Single Family Home	10.5	13.5	24	24
Restaurant	15	19.5	26	25
Garage, Auto Sales	16	18.5	31	24
Town Hall, 2-3 Story	14	18.5	25	24
Office, 1 Story	14	18.5	25	24
Garage, Service Station	15	19.5	26	25
Church	16	18.5	31	24
Post Office	14	18.5	25	24
Office, 2-4 Story	14	18.5	25	24
School, Elementary	14	18.5	25	24
Factory, 1 Story	16	20.5	27	24
Community Center	14	18.5	25	24

Section 3 Vulnerability Assessment

3.1 Tidal Inundation Analysis

Fundamentally, tidal inundation in the Town will be felt when the future MHHW overtops the seawall *and* flows into low-lying terrain (below the MHHW). Terrain higher than the MHHW will effectively block the floodwater, however erosive conditions may emerge as SLR increases. Additionally, WRMA reviewed potential impacts from stormsewer infrastructure hydraulically connected to the Lake Worth Lagoon for each scenario year. Early-onset “sunny-day” inundation may occur as low-lying drainage inlets/manholes surcharge from the tide-induced tailwater condition at the outfalls without flap gates or inline valves.

In regard to seawall overtopping, Javier E. Bidot Associates, PSC., Corp. was contracted to survey cross sections of the existing seawall/bulkhead along Lake Shore Drive (Lake Park) for the Seawall Condition Assessment Project.

Included in **Figure 3** are:

- The profile of the seawall cap (gray fill);
- Elevations of the decadal MHHW (small-dotted lines and blue fill);
- The ground elevation profile set back 30 feet westward from the seawall face (green dashed line).

Station 0+00 begins at the northern end of the Lake Park Harbor Marina, in close proximity to the Southern Outfall. The final Station, 29+16, terminates at the northern end of Lake Park near E Jasmine Drive.

For the following subsections, please refer to **Figure 3** below and the maps in **Appendix A**. It should be noted that the impacts and risks described in each scenario following are cumulative.

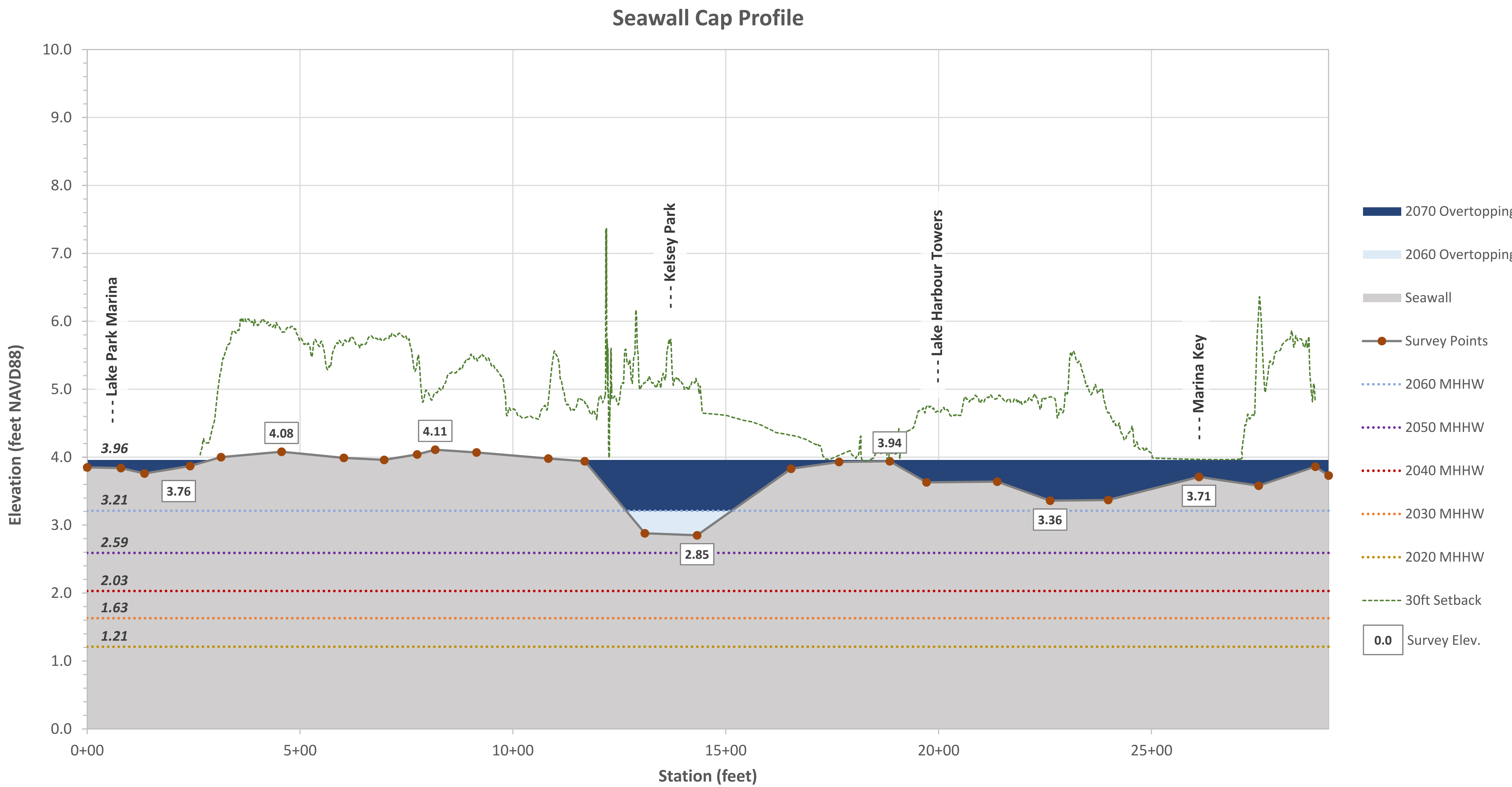


Figure 3 – Town of Lake Park Existing Seawall Profile (Elevation)

3.1.1 2020 Tidal Inundation

No tidally induced flooding is projected in this scenario. However, sunny-day flooding may be emergent in the years leading to 2030.

3.1.2 2030 Tidal Inundation

Potential sunny-day flooding during king tides (Spring/Fall)

(Assuming no valves at outfalls)

3.1.3 2040 Tidal Inundation

Potential sunny-day flooding during king tides (Spring/Fall)

(Assuming no valves at outfalls)

3.1.4 2050 Tidal Inundation

WRMA's analysis showed that the increase in projected Sea Level Rise tailwater may begin to surface onto Lake Shore Drive by 2050 at inlet/manhole locations below elevation 2.59. Since inundation due to overtopping of the seawall does not occur in this scenario, relatively low inundated areas due to drainage surcharge may be isolated. The majority of floodwater will be concentrated at the sag in Lake Shore Drive's roadway profile, around Kelsey Park. Commercial and residential structures may not be physically damaged, but parcel access may be restricted.

Furthermore, a cluster of properties located on the northern edge of the Town surround a branch end of the Earman River, otherwise known as "South Lake". The aforementioned properties are bounded by Flagler Blvd, W Kalmia Dr and Northlake Blvd. By the year 2050, some of these properties may begin to experience minor but daily river water encroachment from the rear (waterfront side) as the water level may exceed the elevation of the existing seawall at high tide or king tide.

3.1.5 2060 Tidal Inundation

Figure 3 shows that the seawall may be overtopped in 2060 at Kelsey Park, and that by 2070 a more substantial portion of the seawall may be overtopped. While the apparent overtopping alone might raise concern, it must be put into context.

Shown in **Figure 3**, is a dashed green line which represents the existing LiDAR ground profile 30 feet behind (inland) the seawall. With this as context, it can be seen that while the seawall is overtopped at Kelsey Park in 2060, the park itself is not inundated due to the higher adjacent ground elevation.

Due to overland gradients, by 2060 the previously isolated surcharge in 2050 would become interconnected and span the entire length of Lake Shore Drive. The water level may rise above the roadway profile crests below elevation 3.21. For reference, **Figure 4** displays the roadway's LiDAR profile taken at the eastern edge of pavement, along with the MHHWs from 2050 to 2070. Access will be restricted for properties without secondary access from N Federal Hwy (U.S. 1). Properties near Kelsey Park, specifically the condominiums at 810 Lake Shore Dr and 510 Lake Shore Dr, may experience physical inundation from floodwaters.

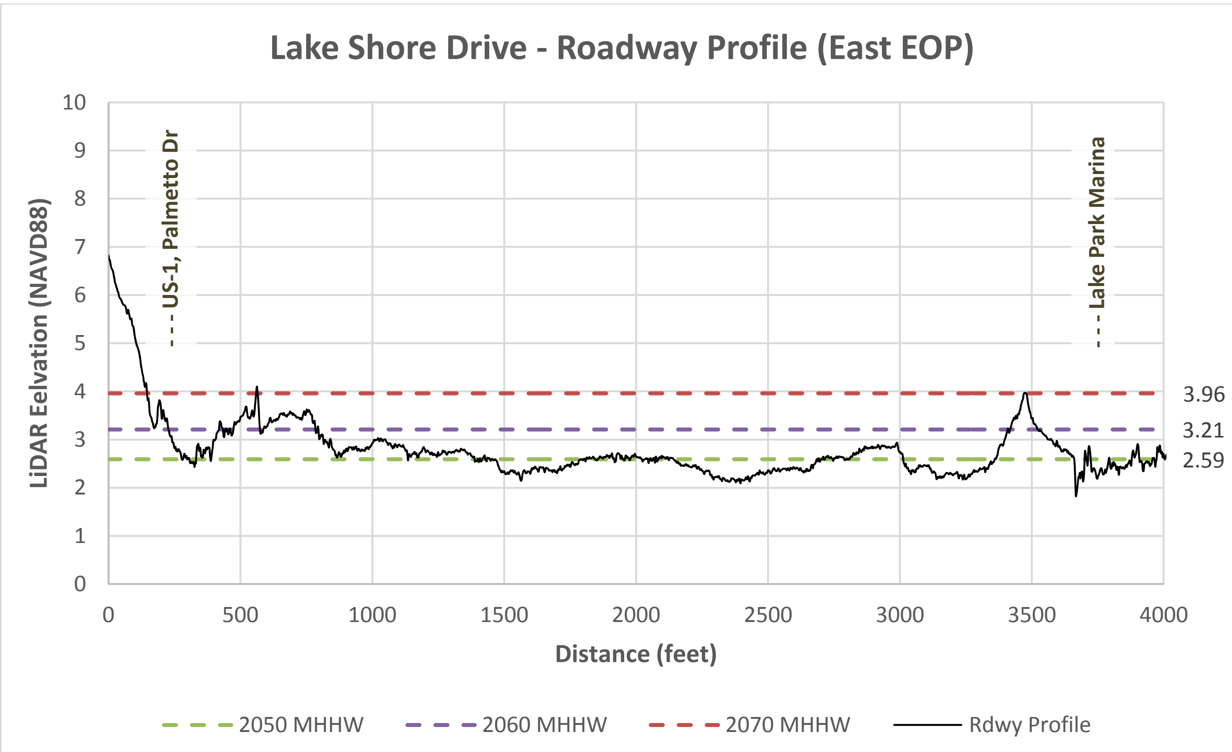


Figure 4 – Lake Shore Drive Roadway Profile

Also receiving significant inundation from drainage is the Lake Park marina. Potential surcharge stemming from a detention pond located within the marina would extend across the marina ground surface and past the marina driveway onto Lake Shore Drive, traveling south towards the boat ramp. The same condition applies for the marina's parking areas south of the ramp. Given the extent of flooding, WRMA has concluded the Lake Park Harbor Marina may become inaccessible by 2060, resulting in a permanent loss of function, unless flood mitigation measures are developed and implemented. Aside from this, it should be noted that average water surface elevation at the harbor may be high relative to the marina's existing ground elevation, effectively prohibiting boats from mooring to the docks in a safe manner.

Kelsey Park may be substantially inundated from floodwaters along the west side of Lake Shore Drive. While the west side Park area will remain accessible from U.S. 1, the east side park area may be isolated due to inundation on Lake Shore Drive. A significant portion of the lawn on the eastern edge of the west side Park area may be under water, including the two tennis courts west of Lake Shore Drive.

The cluster of South Lake properties mentioned in the previous subsection might experience more pronounced daily flooding from the rear (waterfront side), especially the residential properties on the south end of the loop. Erosion of the adjacent lawns may occur as a consequence of daily tidewater overtopping. Building structure damage is likely, especially considering higher-than-average high tides. The average water surface elevation is also likely to overtop the existing docks along the seawall, rendering them non-functional.

3.1.6 2070 Tidal Inundation

Substantial overtopping of the seawall is projected to occur by 2070. Despite this, subsequent inundation along the seawall may not occur due to the higher adjacent ground elevations in areas north of the Lake Park marina, which is the exception. The marina represents the lowest significant portion of Lake Park's primary coastline and as such, overland tidal inundation will stem from the marina initially.

In addition to the inundated condominiums near Kelsey Park, several more buildings located along Lake Shore Drive, south of Evergreen Dr, may experience structural inundation. Those properties that are completely access restricted and/or structurally inundated are considered to experience a *permanent loss of function* (See **Section 2.4.1**).

The extent of flooding in Kelsey Park will also expand by 2070, relative to the projected 2060 extents. Access issues within the park are shown to worsen, with only half of the west side Park area accessible by 2070. The inundation is shown to encircle both tennis courts on the west side of Lake Shore Drive, as well as the two building structures adjacent (west of) the tennis courts. A substantial portion of the lawn on the northeast and southeast corners of the west side park area is likewise shown to be inundated.

Several of the properties around South Lake are likely to experience structural inundation by 2070. The existing docks along the river seawall are shown to be submerged. Additionally, a small area nearby – at the corner of Northern Dr and Flagler Blvd – may experience minor drainage surcharge, though this is not expected to restrict access or cause structural damage.

3.1.7 Tidal Inundation Vulnerability and Risk Assessment

WRMA's analysis has determined that the overall risk associated with tidal inundation is low in the 30-year time horizon but will eventually become severe by 2070. The estimated monetary costs in each decadal scenario are shown below in **Table 6**.

Table 6 – Tidal Inundation Damages & Risk Assessment

Scenario Year	Buildings Inundated	Buildings Blocked	Parcel Units (PLOF)	PLOF Costs	Risks	Overall Risk Assessment
2020	0	0	0	-	-	Low
2030	0	0	0	-	King Tides	Low
2040	0	0	0	-	King Tides	Low
2050	0	0	0	-	Drainage + King Tides	Moderate
2060	3	31	433	**$105,362,000**	Drainage + King Tides	High
2070	15	107	692	**$154,675,000**	Drainage + Overtopping	Severe

Table 6 indicates an abrupt and significant transition of cost between 2050 and 2060. This leap in cost primarily reflects the losses of property access as a result of Lake Shore Drive being perpetually inundated by encroaching SLR-induced drainage surcharge in 2060, and then by a combination of drainage surcharge and seawall overtopping in 2070. Referring to **Figure 4**, along Lake Shore Drive, WRMA estimates an average daily flood depth of 3 inches in 2050, 8 inches in 2060, and 15 inches by 2070.

The total PLOF costs are driven high due to the high-occupancy residential structures along Lake Shore Drive being rendered functionally uninhabitable. The vulnerable properties include: Lake Shore and Lake View Condominiums, Cedar Crest Apartments, Lake Harbor Towers, Marina Key, and Bay Reach Condominiums.

The qualitative impacts to critical facilities are also high. These facilities, namely Kelsey Park and the Lake Park Harbor Marina, are vital assets and historical attractions to the Town; not to mention the waterfront area in general is of high economic value to the Town. Please refer to **Section 4.2** for methods and measures of adapting to future tides.

Additionally, the risks from the effects of king tides cannot be discounted. A “king tide” is a non-scientific term used to describe an abnormally high tide. Tides in general occur as a result of the moon's gravitational pull on our oceans, and when the Moon is closer to Earth it exerts greater gravitation pull and correspondingly higher tides. Six to eight times per year the Earth, Sun, and Moon align at a time coincident with the Moon’s closest point in its orbit (its perigee), resulting in what is known as a perigean spring tide. Perigean spring tides in the Fall and Spring typically produce the greatest king tides. However, despite being a known phenomenon these tides aren’t normally used in tidal inundation mapping due to their seasonal and geographic variability.

The exact timing of the highest king tide for a particular location on Earth is influenced by local factors such as water temperatures, rainfall, storms, and variations in ocean currents. In Florida, the highest king tides are generally experienced in the Fall, when seasonal factors like currents and warmer temperatures bring sea levels to their highest for the year.

Flooding from the king tides can lead to road closures, overwhelmed storm drains, and compromised infrastructure. This flooding is commonly called "nuisance flooding." According to NOAA, on average, nuisance flooding has increased about 50 percent in the last 20 years.

In addition, major coastal flooding can occur when perigean spring tides occur simultaneously with strong onshore winds and barometric pressure changes from a coastal storm. Coupled with increasing sea level rise, king tide flooding is expected to increase and therefore are likely to become a concerning issue in the decades preceding 2070.

To illustrate the possible magnitude of king tides Florida can experience, the following king tides were recorded in 2019 at the Lake Worth Pier tide gauge:

- Fall – November 28, 2019 – 1.64 NAVD88
- Spring – April 19, 2019 – 1.05 NAVD88

The fall king tide on 11/28/2019 was approximately 3 times higher the average highest high tide throughout the current tidal epoch (0.55 NAVD88). Low-lying drainage infrastructure in the Town could be a point of vulnerability by 2030, when nearly a foot of sea level rise is projected to occur. Based on the 2030 SLR projection, significant damage is not likely, if at all. However, by 2050, the risk will be appreciably higher as sea level rise may enable king tides to overtop the Town's seawall several times per year. The corresponding nuisance flooding could potentially yield high flood depths. Given the possibility of physical damages by king tides in 2050, WRMA has highlighted the 2050 scenario as having moderate flood risk.

Lastly, progressive projected Sea Level Rise between 2020 and 2070 is likely to have substantial disruptive impacts on the Town's stormsewer infrastructure to effectively convey stormwater runoff discharges to the Lagoon. As the Mean Sea Level (MSL) continues to rise throughout the 50-year time horizon, the higher Lake Worth Lagoon tailwater elevation will eventually act like a bottleneck or plug. Outfalls already partially submerged under the current MSL will experience progressively worse drainage efficiency until they are fully submerged, at which point the effective drainage capacity for those systems will be the storage volume of the tributary pipes themselves. Future storm events that occur at times coincident with high tide may produce widespread flooding as the stormsewer system in its current state, will not be able to effectively convey runoff due to SLR-induced surcharge.

3.2 Coastal Flood Analysis

The most well-known and highest risks to coastal areas such as the Town of Lake Park come from high intensity winds generated by Tropical Storms and Hurricanes. However, storm surges ("storm tides") can also cause tremendous damage, especially if they coincide with high tide. Storm surges can raise water levels by as much as 20 feet or more above mean sea level (MSL). As a result of Climate Change induced global sea level rise, storm surges that occur today are eight inches higher than they would have been in 1900. Inundation from storm surge is described in terms of height above ground level. For example, a storm surge prediction of 10 feet above ground level for a particular area means that forecasters expect 10 feet of water to cover that area.

Storm surges can cause fatalities and extensive property loss, including erosion of beaches, damage to coastal habitats, and the undermining of foundations for vital infrastructure like roads, railroads, bridges, buildings and pipelines.

The Town of Lake Park is affected by coastal surge inundation along the US Highway 1 corridor and along the north (South lake) and west (C-17 Canal) boundaries. The tidal coastal surge inundation moves across Singer Island to the Lake Worth Lagoon and up the Earman River and the C-17 Canal. Coastal surge storm events can also have a direct impact on the stormwater management system as it affects all coastal outfalls. Storm Surge Inundation Maps (SSIMs) are prepared by NOAA, FEMA and published at the state and local level for coordinated emergency management and evacuation response operations.

The United States Federal Emergency Management Agency (FEMA), under its National Flood Insurance Program (NFIP) has also mapped the potential from flooding due to coastal storm surges. These areas are shown on FEMA’s Flood Insurance Rate Maps (FIRMS) published as part of the Palm Beach Countywide Flood Insurance Study (FIS). FEMA FIRM #12099C0387F (Panel 387) and 12099C0391F.

Storm Surge Inundation Maps (SSIMs) and Flood Insurance Rate Maps (FIRMs) both identify areas that are subject to inundation from coastal storm surge. For the purpose of Climate Change/Sea Level Rise assessment, it is appropriate to explain the differences between these two products.

Storm Surge Inundation Maps are a component of a Hurricane Evacuation Study. The areas of surge inundation shown on the maps reflect potential flooding from different types of hurricanes within a storm surge category with no consideration of wave action or probability. The result is intended to be a conservative estimate of possible surge inundation from hurricanes which is used for long range hurricane planning purposes and population protection. The SSIM is not intended to be used for regulatory or insurance purposes.

Flood Insurance Rate Maps identify the areas subject to flooding associated with a water elevation that has a 1% chance of being equaled or exceeded in any given year. The FIRM identifies flood risk zones and base flood elevations that include the impacts of wave action. The FIRM is a regulatory and insurance product developed within a Flood Insurance Study and is used to support the NFIP.

Both SSIM and FIRM maps can be looked at when determining where to build proposed structures, as each will help assess the overall flood risk in a given area. The SSIM provides surge inundation from various categories of hurricanes, while the FIRM provides the 1% annual chance flood with wave action, and the combination of the two will give a more complete picture of risk. Both maps can also be useful for general coastal planning applications if the user understands their limitations.

A major difference between the two products is that the FIRMs are based on a flood with a certain probability of occurring, while the SSIMs are not. The 1% annual chance water level is a statistical measure and varies throughout a region. No single storm event would produce the 1% annual chance water level everywhere in that region. While certain types of hurricanes within a storm surge category may be capable of producing or exceeding a 1% annual chance water level in a given area, other types of hurricanes within that storm category may not. Additionally, there may be hurricane scenarios within multiple categories that have the potential to produce or exceed the 1% annual chance water level for an area. Therefore, the 1% annual chance water level for an area cannot be directly related to any particular category of hurricane.

WRMA selected FEMA's Special Flood Hazard Area (SFHA) Flood Insurance Rate Map as the representative floodplain for each decadal SLR scenario. As described in **Section 2.4.2**, the Town of Lake Park's SFHA is fundamentally equivalent to the area inundated under the 1% annual chance stillwater elevation (SWEL). WRMA approximated the extent of the future base flood by adding projected sea level rise to the current 1% SWEL. High ground areas inundated by current day wave action, as modeled in the effective FEMA FIS, were also incorporated.

Additionally, for each coastal surge scenario year, WRMA reviewed potential impacts from stormsewer infrastructure hydraulically connected to the Lake Worth Lagoon. Areas found to be inundated by tailwater surcharge were included in each flood map.

For the following subsections, please refer to the coastal flood maps in **Appendix B**. Please note that the impacts and risks described in each scenario are cumulative through each successive decade.

3.2.1 2020 Base Flood

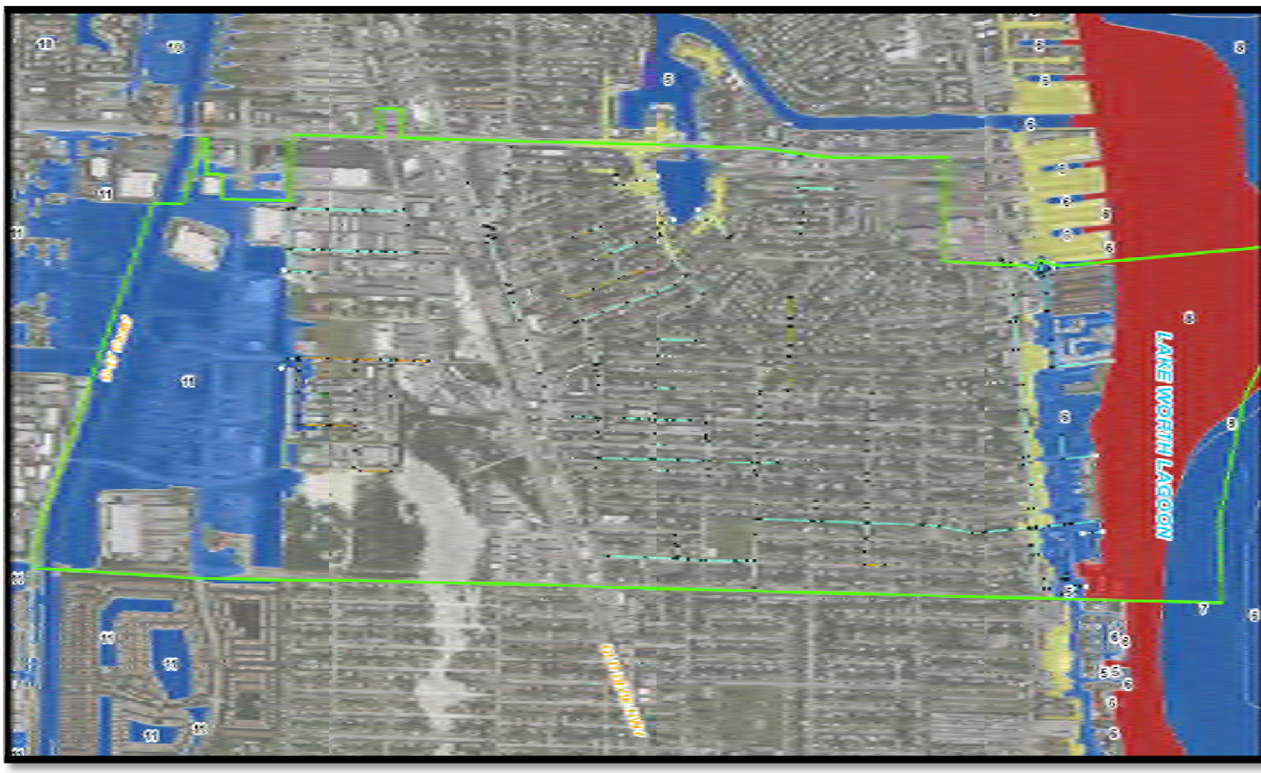


Figure 5 – FEMA Flood Hazard Areas - Effective 2017

The current FEMA SFHA, effective 2017, is shown above in **Figure 5**. The blue-shaded zones represent the base floodplain of the current 1% (100-year) annual chance storm event. The red-shaded zone represents the same base floodplain where waves greater than 3 feet may occur. The yellow-shaded zone represents the current 0.2% (500-year) annual chance storm event, which was not studied in this analysis.

The FEMA flood map indicates that coastal surge from the Lake Worth Lagoon overtops the primary seawall in the present-day scenario. Waves potentially greater than 3 feet will propagate inland from the Lagoon. With the exception of the Bay Reach Condominiums, coastal flooding in the current

100-year event will inundate the waterfront area and extend to the west, just short of N Federal Hwy (U.S. 1). Numerous structures of various use type will be inundated, including those above the 1% annual chance SWEL which are also still vulnerable to wave action.

Along the Western regions of the Town, properties along the C-17 Canal may be subjected to riverine surge, with base flood elevations reaching up to 11 feet. Properties at risk in that area include but are not limited to: Kohl’s, PetsMart, Aldi Food Market, RaceTrac, and the U.S. Army Reserve facility. However, the large retail stores of Lowe’s Home Improvement and the Walmart Supercenter are elevated above the projected floodplain.

Towards the north side of the Town, stormwater drainage located in Flagler Blvd, Northern Dr, and W Kalmia Dr, in the vicinity of South Lake, may be subject to tailwater surcharge from the coastal surge along the Earman River, which will inundate a few of the adjacent residential properties.

3.2.2 2030 Base Flood

By 2030 there is relatively little change in the projected flooded areas along the Lagoon waterfront. The Bay Reach Condominiums may be subject to more inundation, but would still be mostly dry.

Properties to the north may see a more pronounced increase in the frequency of flooding. Several more single-family homes around South Lake are shown to be inundated as surcharge from previously isolated drainage networks on Flagler Blvd become interconnected by inundation. The surcharge may also extend into and obstruct a portion of Northlake Blvd. Traffic will be inhibited from the corner of Poplar Ct to the west approach of the South Lake bridge.

This is a significant risk to note. North Lake Blvd serves as the primary escape route for residents of the Town, as it provides direct access to I-95. Should 12 inches of sea level rise be realized, WRMA recommends developing a plan to divert traffic east of the bridge. Coordination with FDOT and local officials to the north (North Palm Beach) and south (Riviera Beach) will be essential, as U.S. 1 may also be obstructed by inundation in some locations.

3.2.3 2040 Base Flood

The 2040 1% SWEL may slightly extend out the western extent of Lagoon flooding, with 6 additional buildings being flooded in the waterfront area. Five of the six buildings are within the Bay Reach Condominiums, which would still be largely intact.

South Lake may likewise see more impacts. Drainage surcharge at South Lake will propagate further upstream, now penetrating into Poplar Dr and Palmetto Dr. The higher water surface elevation may inundate more single-family homes.

3.2.4 2050 Base Flood

By 2050, nearly every property east of U.S. 1 could be inundated from the coastal base flood, including all of Beach Reach Condominiums. The facility at Earl Stewart Toyota would also be inundated.

Stormwater drainage outfall connections (assumed without valves) will permit the Lagoon floodwaters into U.S. 1, though this surcharge will be very minor. U.S. 1 will remain traversable throughout the length of the Town.

The drainage situation along the northern boundary of the Town will continue to degrade. Earman river coastal surge will affect all three stormsewer networks draining to South Lake and localized flooding will become interconnected and completely encircle the residences situated on the riverfront. Flooding will branch out to the north, south, and east from this general area. At this point, flooding will only slightly extend into Poplar Ct, Magnolia Dr, and Laurel Dr.

3.2.5 2060 Base Flood

Coastal flooding from the Lagoon is projected to extend beyond U.S. 1 by 2060. The inundation on U.S. 1 will be concentrated at the sag (low point) between Cypress Dr and Date Palm Dr (approx. location of Dunkin' Donuts). This location coincides with the alignment of the Southern Outfall, the primary outfall of the Town. All drainage from U.S. 1 (within the limits of the Town) is routed to this particular location before being discharged to the Lagoon. As such, surcharge along U.S. 1 will stem from this junction and will exacerbate the overland flooding from the Lagoon. However, the average flood depth at this location and others along US-1 is likely traversable in this scenario. Flooding will continue to extend out from South Lake, inundating all directly adjacent properties and extending as far south as W Jasmine Drive.

3.2.6 2070 Base Flood

By 2070 coastal flooding from the Lagoon is projected to extend into residential side streets west of U.S. 1, inundating approximately 30 additional structures in the corresponding areas. Flooding will be concentrated at properties surrounding Park Avenue.

The U.S. 1 right-of-way itself is shown to be flooded from Hawthorne Drive to Bayberry Drive. Flood depths up to 2 feet will prevent use of this road as an escape route.

Due to the loss of North Lake Blvd in addition to U.S. 1 (preceding 2070) the Town should consider diverting all Lake Park traffic to Park Avenue and Silver Beach Road, and west to Old Dixie Hwy.

In addition to the properties directly adjacent to South Lake, the block bounded by W Kalmia Drive, Palmetto Dr, and W Jasmine Dr is shown to be completely surrounded by floodwater. All but one structure in that block will be inundated. Several more properties on streets extending from the loop will be also inundated. Floodwaters in the area will extend as far south as W Ilex Dr., and access will be restricted along the following streets: Flagler Blvd, W Kalmia Dr, W Jasmine Dr, and Poplar Drive. Northlake Blvd will be inundated as far west as Prosperity Farms Rd.

3.2.7 Coastal Flood Vulnerability and Risk Assessment

In general, risks associated with the 1% annual chance flood are high throughout all scenarios. The estimated monetary costs in each decadal scenario are shown below in **Table 7**.

Table 7 – Coastal Flood Damages

Scenario Year	Buildings Inundated[4]	Structure Damages	Contents Damages	TLOF Damages	Total Est. Damages
2020	64	$18,211,000	$15,909,000	$4,208,000	**$38.3M**
2030	76	$22,787,000	$25,178,000	$5,198,000	**$53.2M**
2040	95	$29,656,000	$40,269,000	$6,600,000	**$76.5M**
2050	141	$43,871,000	$72,039,000	$8,766,000	**$124.7M**
2060	162	$54,662,000	$86,951,000	$9,686,000	**$151.3M**
2070	219	$70,017,000	$111,440,000	$12,236,000	**$193.7M**

Table 8 – Coastal Flood Percent Damages by Use Class

	Percent Damages by Building Use Class				
Scenario Year	Residential	Office	Commercial	Industrial	Public/Rec.
2020	69%	5%	17%	2%	7%
2030	69%	5%	17%	2%	7%
2040	71%	4%	16%	2%	6%
2050	75%	4%	15%	2%	5%
2060	75%	4%	14%	1%	5%
2070	78%	3%	14%	1%	4%

As shown in the **Appendix B** coastal flood maps, a large portion of flooding stems from the C-17 Canal, with a base flood elevation of 11 feet NAVD88. As many as 57 structures are shown to be

[4] Structures in the Westlake area are not included in Table 7.

inundated because LiDAR elevations for that area register below the BFE. However, South Florida Water Management District - Environmental Resource Permits (ERPs) dating from 2002, for properties in this area, known as Westlake, mandate that any new construction must have a building first floor elevation of 13 feet NGVD29 (11.5 feet NAVD88). This value comes from previous FIS studies and a 2002 hydraulic study of the C-17 Canal performed by Mock Roos. Given that current properties in the Westlake area were not constructed until 2002 and later, they are subject to the permits' mandate and as such, said properties have building structures with first floors at or above the BFE, despite having adjacent finished grades less than the BFE.

In light of this, WRMA assumed no flood damages would occur for structures located in the Westlake area. However, it should be noted that a future rise in the base flood elevation of a foot or more could result in significant inundation and subsequent potential damage, approaching $100M. This is due to the large concentration of multi-family structures and somewhat higher property valuations in the Westlake area. Of note are the large square-footage community storefronts (Kohls, PetsMart, etc.). The Westlake area commercial structures have high real estate valuations, and their contents are also highly valued relative to other residential and office properties.

The costs shown in **Table 7** only represent areas inundated by the Lake Worth Lagoon or the South Lake (Earman River) area. The brunt of calculated damages come from the waterfront areas along the Lake Worth Lagoon. Though the spatial extent of this flooding does not significantly change until 2060, associatively high base flood elevations due to wave action increase the potential for damage and the associated costs.

There is also a substantial risk to residential properties throughout the Town, as is shown by the figures in **Table 8**. On average, residential inundation accounts for 70% of the total damages to the Town. The next largest category is represented by commercial structures. Risk to residences is particularly high for the properties on Lake Park's northern border, adjacent to the Earman River (South Lake). These properties are vulnerable to the tailwater condition of the river. South Lake is the outlet for three stormsewer networks, serving a drainage area of 169 acres. Tailwater surcharge will not only inundate these properties but also prevent use of Northlake Blvd as viable escape route for much of the Town. Measures to adapt to this challenge are discussed in **Section 4.2**.

3.2.8 Cultural and Infrastructure Overlay

While future Sea Level Rise inundation will affect primarily residential and recreational property along Lake Shore Drive, coastal surge inundation may impact the Town's infrastructure much further inland as shown on the **Appendix B** maps. Coastal surge inundation may impact key Town infrastructure including roads, utilities, and fire protection and medical (hospital) facilities.

Roads: Portions of Northlake Blvd, Polk Avenue, US Highway 1 and Congress Avenue will be temporarily closed due to high water. Daily maximum traffic volumes (based on 2020 data) would be affected as follows:

- Congress Avenue: Approximately 25,000 trips (Between Northlake and Silver Beach Road)
- Northlake Blvd: Approximately 45,000 trips (Between Congress and SR811 -Dixie Highway)
- US Highway 1: Approximately 26,000 trips (Between Northlake Blvd and Silver Beach Road)

Water and Sewer System: Wastewater refers to the Town's sanitary sewer system and wastewater treatment plants which is currently owned and operated by the Seacoast Utility Authority. Water supply is provided by both surface water and groundwater accessed by wells. The infrastructure associated with this system includes the wells and intake systems and any lines that connect supply to the water treatment plant, and the distribution system to end users (both residents and businesses).

Water and sewer services for the Town of Lake Park are provided by Seacoast Utility Authority (SUA). Asset maps from SUA do not include any water treatment plants or booster pump stations located within the Town. However, water service, under the projected scenarios, could be restrictive including boil alerts due to groundwater and saltwater intrusion effects.

Figure 6 shows that the Seacoast Utility sewer system includes a number of sanitary lift stations within the Town jurisdiction. There are no wastewater treatment facilities located within the Town limits. **Figure 6** also indicates that out of nine (9) sanitary lift stations, seven (7) could potentially be impacted (shaded in blue) by inundation from a SLR-influenced tidal coastal surge storm event. Sanitary service may be temporarily suspended following projected coastal inundation events, pending lift station assessment and repairs.

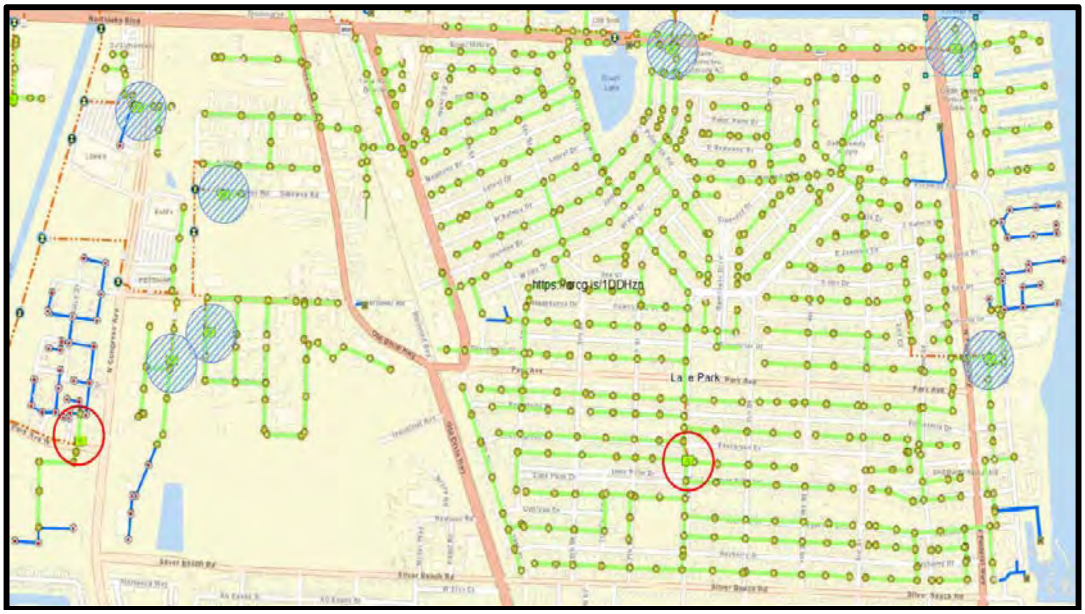


Figure 6 – Seacoast Utility Authority Sewer System for Town of Lake Park

Medical (Hospital) Facilities: There are no hospital facilities located in the Town of Lake Park.

Town of Lake Park Emergency Management Facilities: The Town's emergency management command post is located at the Public Works Department facilities located at 640 Old Dixie Highway and the Town's Town Hall Emergency Shelter is located at 535 Park Avenue. Neither of these facilities would be affected by inundation from a tidal coastal surge storm event.

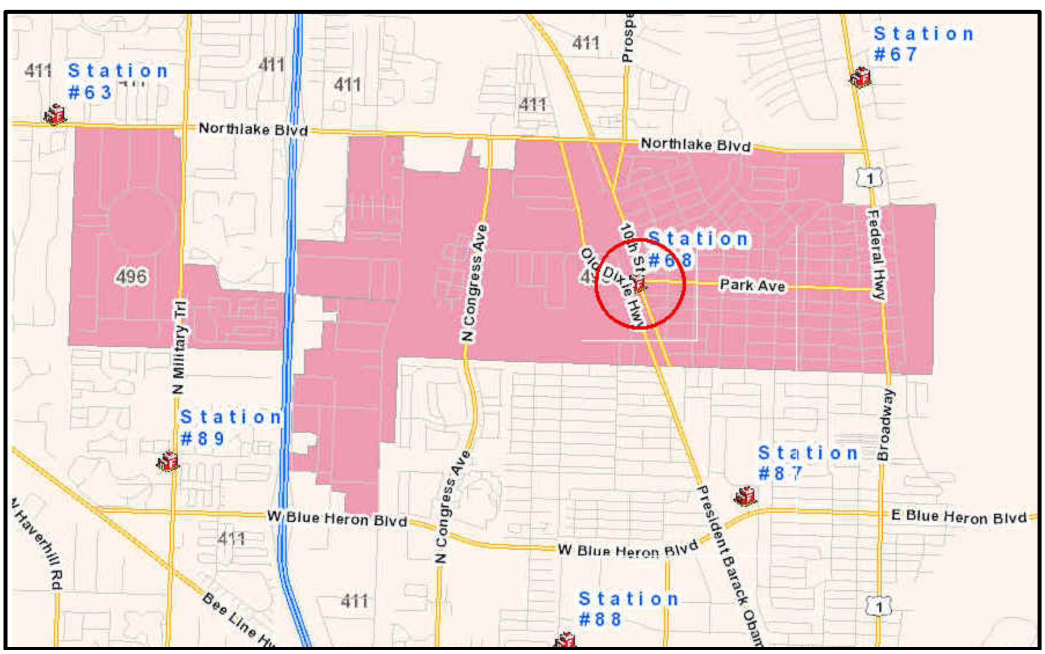


Figure 7 – Fire Station No. 68 for Town of Lake Park

Fire Station Facilities: Fire protection service for the Town of Lake Park is provided by Palm Beach County. **Figure 7** indicates that the Palm Beach County Fire Station #68 is located at Park Avenue and Old Dixie Highway. This facility would not be impacted by inundation from a tidal coastal surge storm event.

Kelsey Theatre: One of the Town's more well known cultural assets is the Kelsey theatre located at 700 Park Ave, would not be affected by inundation from a tidal coastal surge event.

Bostrom Park: Bostrom Park is located between Date Palm Dr and Bayberry Dr, West of 6^{th} St, would not be affected by inundation from a tidal coastal surge event.

Lake Park Elementary School: The Lake Park Elementary School is located at 410 3^{rd} St, would not be affected by inundation from a tidal coastal surge event.

Coastal Middle & High School: The Middle/High School is located at 730 5^{th} St, would not be affected by inundation from a tidal coastal surge event.

First Baptist Church of Lake Park: The Baptist Church is located at 625 Park Ave, would not be affected by inundation from a tidal coastal surge event.

St. Johns Lutheran Church: The Lutheran Church is located at 241 Cypress Dr, would not be affected by inundation from a tidal coastal surge event.

Bethlehem Baptist Church: The Baptist Church is located at 425 Crescent Dr, would not be affected by inundation from a tidal coastal surge event.

Kelsey Park: Kelsey Park, located on the Eastern portion of the Town on Park Ave, would be significantly affected by inundation from a tidal coastal surge event. The impacts to Kelsey Park are discussed in depth in **Section 3.1**.

Lake Park Marina: The Marina, located at 105 Lake Shore Drive, would be significantly affected by inundation from a tidal coastal surge event. The impacts to the marina are discussed in depth in **Section 3.1**.

Section 4 Adapting to Sea Level Rise

4.1 Resiliency and Flood Risk Reduction

The impacts of coastal flooding can be severe and long-lasting. WRMA's analysis of flood risks for the Town of Lake Park have shown that sea level rise will escalate those risks, with associated costs potentially doubling by 2070. Addressing such risks will be a challenge for communities in the coming decades. Extreme flood events are becoming relatively more extreme, and a question for many communities is where to draw the line in terms of future flood protection.

Does a community protect for the 100-year storm, or the 50-year storm? Costs associated with hard flood protections for extreme events are typically very high and may not be within the budgetary constraints of a community, even if the benefit-cost ratio is greater than 1.0. Public health & safety is of course the governing factor, but it is often the case that protecting for smaller more frequent events is the only economically feasible option.

Every community is unique, and however extreme the risks are, the best starting point for any community pursuing flood risk reduction is promoting what is known as *Resiliency*. Resiliency is the ability of a facility or infrastructure to withstand and quickly recover from natural hazards. In practice, resiliency can be implemented at all levels of design. This includes architectural and structural design, utility and water resources design and roadway design. Implementing resiliency into the Town's planning and development strategies now, can have a substantial impact in reducing the scale and potential cost of future flood mitigation projects in later decades.

There are four main considerations in promoting resiliency:

- **Prioritizing Assets**

  Implementing resiliency begins with the identification of critical assets. These are assets which the public's health and safety are reliant upon, such as hospitals, pump stations, treatment facilities, government facilities, escape routes, ect. It is important that should the community as a whole not have sufficient protection against certain natural hazards, these assets will remain in service or return to service as soon as possible, in the event of a catastrophe.

- **Determining Useful Life**

  Useful life represents the total expected service life of a facility, beyond the intended lifespan for which it was designed. It is not uncommon for some buildings designed for only 30 years to remain in use an additional 20 years, or even 50 years. The siting of more permanent infrastructure such as government buildings or sewer outfalls contemplate projected sea level rise and potential areas that may be prone to inundation, and final designs should reflect some level of conservatism and flexibility for extended service life.

- **Identifying Hazards**

  In conjunction with useful life, the consideration of hazards is also of great importance, which must not only account for today's climate but also extend to future climate conditions which may present additional hazards throughout the useful life of a facility. In the case of the Town, future hazards consist of daily tidal inundation, coastal flooding from extreme storm events, and also extreme heat as a result of global temperature rise.

- **Flexibility**

  In accounting for potential useful life and future hazards, designers can manage for uncertainty by planning for adaption. For instance, a flood wall's structure and foundation can be designed to support an integral increase in height should the need arise.

  Designing for adaption from the outset, could reduce the overall barrier to entry for higher-level protections to an affordable point. Not doing so may result in having to reinforce the infrastructure or rebuild it altogether, which could be outside budgetary constraints if not practically impossible.

These factors will inform designers and planners on what measures can be taken to cost-effectively manage flood risk and make communities more resilient.

4.2 Adaptation Pathways

4.2.1 Tidal Adaptation

With regard to the present and future risks to the Town of Lake Park, there are several measures available to make the Town more resilient and substantially reduce overall flood risk.

Figure 8 displays the type of risk and adaptation planning process that should be undertaken by the Town of Lake Park to address Climate Change-Seal Level Rise threats.

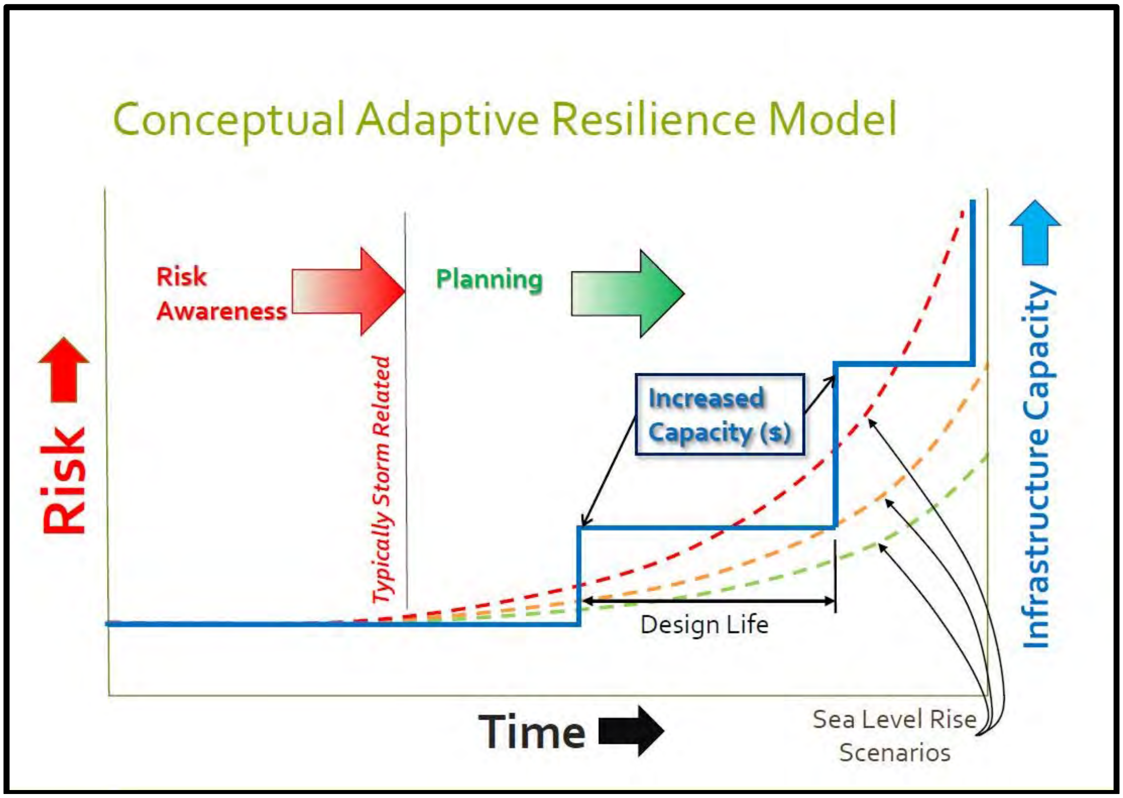


Figure 8 – SFWMD 2013, The Implications of Sea level Rise on Water Management

First, all critical facilities within the future floodplains (as depicted in the **Appendix A** and **B** flood maps) should be considered for reinforcement. Options for reinforcement include:

- Dry Flood-Proofing
    - If ceiling heights permit, raising the first-floor elevation may be practical for facilities near the fringe of the floodplain;
    - Floodwalls (permanent or deployable) at an appropriate future BFE
        - A quick estimation for the future BFE is to take the current FEMA BFE and add an amount of sea level appropriate for the expected useful life of the facility
- Wet Flood-Proofing
    - Not occupying the first floor (still usable for storage and access purposes)
    - Raising vulnerable utilities and infrastructure within the first floor above the future BFE

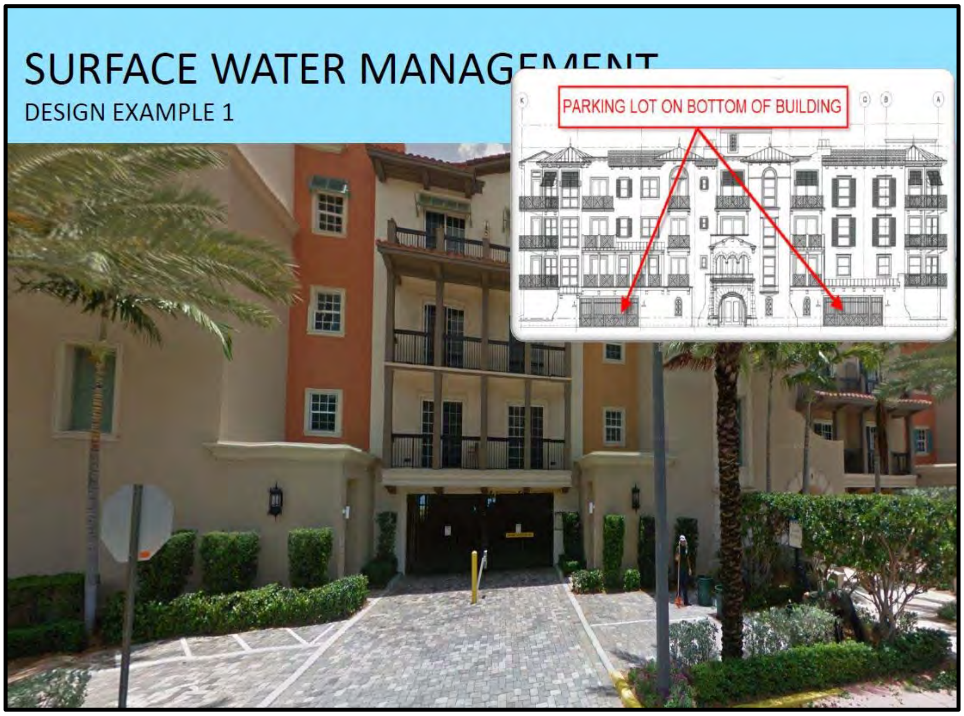


Figure 9 – Broward Co., Sea Level Rise & Flooding Planning for Future Conditions: Ex. 1

Figure 10 – Broward Co., Sea Level Rise & Flooding Planning for Future Conditions: Ex. 2

Reinforcement may not be practical (e.g. older buildings) in some instances, in which case relocation of the facility may be required if the secondary (backup) location for operations is not outside of the projected floodplain.

Roadways will also have to be raised to provide the required level of mobility service. Existing and new roads will have to be designed to “accommodate” the upward improvements as SLR progresses (add new base/subgrade layers to initial foundation design).

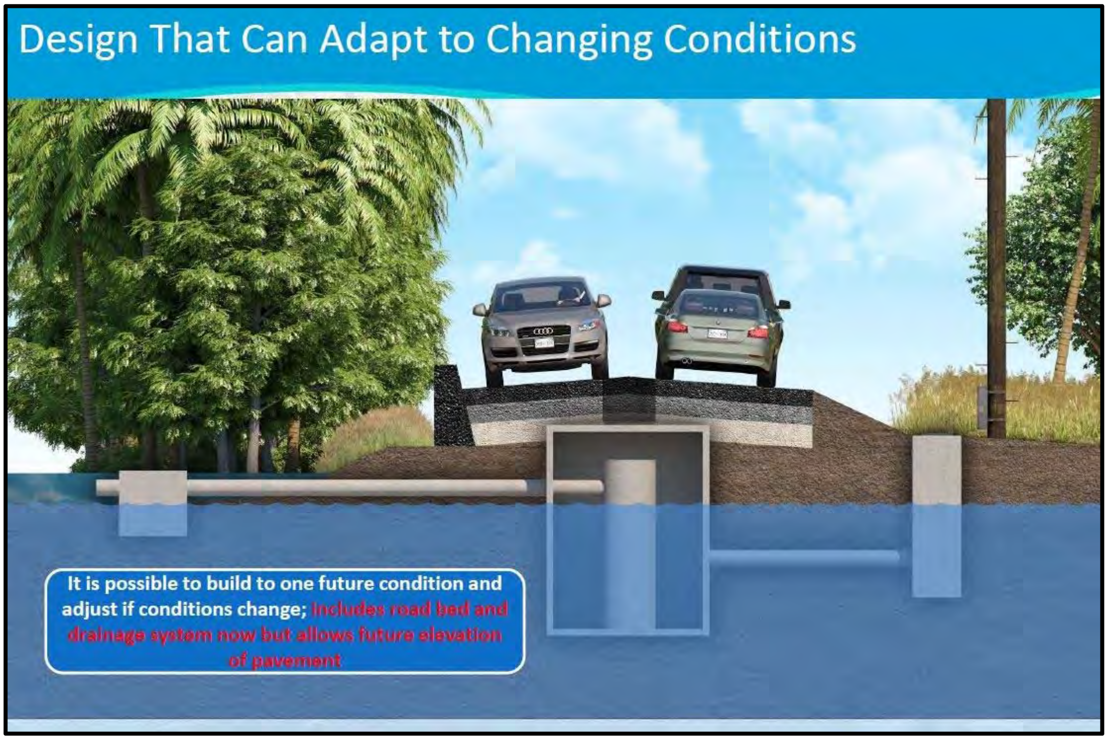


Figure 11 – Monroe Co., Design that Can Adapt to Changing SLR Conditions

Waterfront property will have to adapt to the changing SLR by incremental seawall design such as is currently being implemented by the City of Ft. Lauderdale, Florida.

WRMA’s analysis noted much of the projected inundation is induced as a result of tailwater surcharge through the Town stormsewer outfall networks, specifically along Lake Shore Drive and the streets adjacent to South Lake.

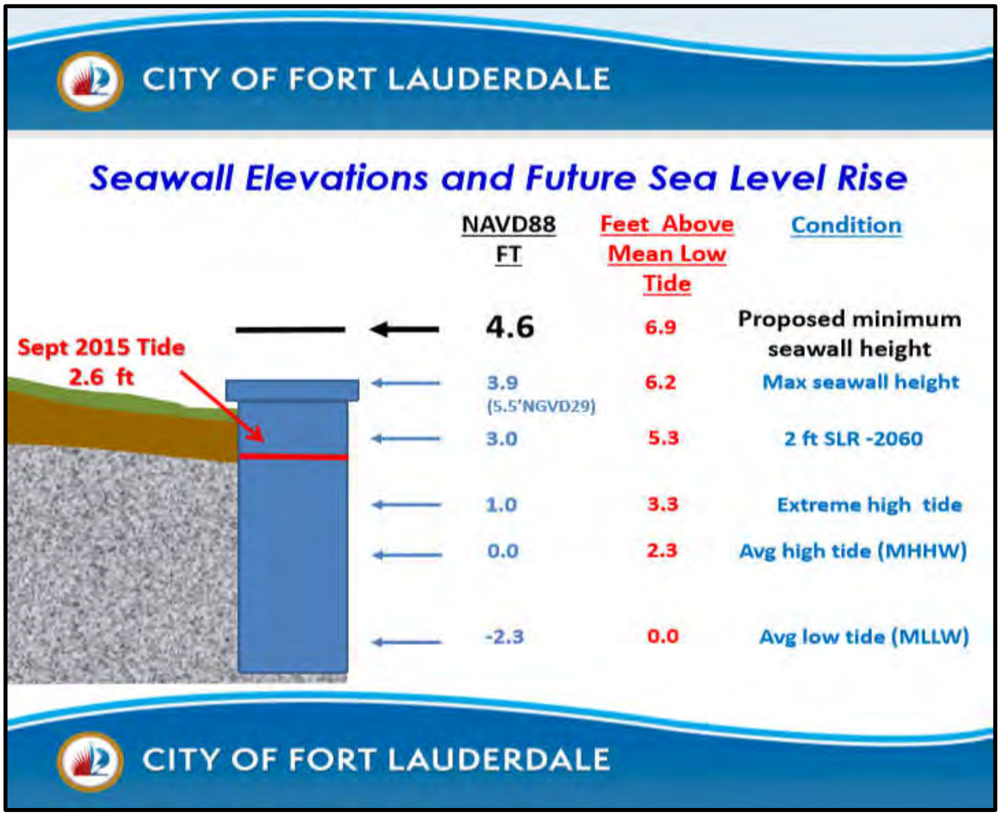


Figure 12 – City of Ft. Lauderdale, FL, Seawalls and Future Sea Level Rise

The Town of Lake Park has already begun to address the impacts of "Sunny Day" SLR flooding along Lake Shore Drive, with the development of two projects to provide flood relief. The Lake Shore Drive Drainage Improvements Project, to be implemented in FY2021, will consolidate three outfalls along the right-of-way into the Lake Worth Lagoon into a single outfall to be located at Kelsey Park together with a Sea Level Rise pump station and Bio-detention facility for water quality treatment. Additionally, the Southern Outfall Priority Rehabilitation Project, currently under development, will replace the older 72" CAP outfall along the Town Marina with a newer outfall to be fitted with a valve and a pump station to offset future SLR impacts. The project will also include a Bio-detention facility for water quality treatment.

Addressing the drainage surcharge from the rising tailwater at South Lake will be critical for ensuring North Lake Blvd is a viable escape route during coastal surge events. The same measure will also be critical along Lake Shore Drive, which should protect the surrounding areas from tidal inundation until around 2060, at which point the roadway grade may be too low regardless of any proposed redesign of the drainage system, especially considering the impacts from future king tides. At that time, Lake Shore Drive will need to have been reconstructed and a new roadway profile established to a minimum elevation above the 2060 (or later) MHHW. Any design would be contingent on other concurrent or completed flood protection projects preceding 2060. Design and construction for Lake Shore Drive flood mitigation should be *completed* by 2050, or earlier as evolving conditions dictate. Planning and coordination should take place on a timeline that will permit construction prior to the projected impacts in 2060.

Figure 13 – Town of Lake Park, 2020, Stormwater Masterplan Update

In the event that drainage redesigns or new drainage systems are infeasible, the installation of pump stations may be necessary. Proposed pump stations should discharge to outfalls elevated as high as practicable, so as not to be submerged under projected high tides.

As noted in **Section 3.1.6**, the Lake Park Marina is projected to be overtopped by 2070. Stopping floodwaters there will be critical in protecting properties along Lake Shore Drive. Either the marina and adjoining roads (driveway, south end of Lake Shore Dr) will have to be raised, or a flood barrier will have to be put in place. The flood barrier could be permanent or deployable in nature, or a hybrid solution.

Deployable barriers are reliant upon human operation and can be prone to mechanical failures without regular maintenance. Conversely, permanent barriers are reliable but typically expensive. Town leaders will need to determine which path to choose, considering the risks and potential economic impact from loss of waterfront areas. It should be noted that the 2070 projected rise in sea level at the marina may be too high, and thereby unsafe for boaters mooring to the dock. Given this projection, raising the ground elevation of the marina, may prolong the useful life of the marina beyond 2060, should the Town wish to keep it in operation.

4.2.2 Costal Storm Surge Adaptation

Regarding coastal storm surge, in terms of hard flood protections against the Lagoon and C-17, there are three options available (though they are not mutually exclusive). The options are:

1) Constructing floodwalls (permanent and deployable);
2) Raising roadways;
3) Raising the seawall bulkhead.

If one alone would not be sufficient, the goal would be to provide a seamlessly integrated flood protection system consisting of two or all three options.

A potential fourth option could be in-water flood barriers crossing the Lagoon. That, however, would require extraordinary funding, planning and permitting at the State or Federal level.

Potential alignments would vary by storm recurrence interval and future scenario sea level rise. As such, benefit-cost analyses would be required for each recurrence interval and corresponding SLR, before a best value engineering judgment could be made.

Lastly, any and all future development in the Town of Lake Park should be conducted utilizing the concepts outlined in **Section 4.1**, with projected sea level rise considered. FEMA has published guidelines for planners and designers which explain how to adapt their standards to future SLR. Another excellent resource is New York City's Climate Resiliency Design Guidelines (Ver. 4), produced under the Mayor's Office of Recovery and Resiliency.

WRMA will address additional Climate Change/Sea Level Rise Resiliency Adaptation Design Options at a public workshop to be conducted in February 2021 to present the results of this limited Vulnerability, Risk and Adaptation assessment for the Town of Lake Park, Florida.

4.2.3 The Cost of Sea Level Rise Adaptation

When projected sea level rise begins to overtop the seawall, flooding will occur along coastal streets. The resulting flooding puts not only homes and cars at risk, but can cause roads to be shut down and prevent access to important infrastructure like schools and hospitals.

As the sea level rises higher, the salt water intrusion can mix with drinking water, ruining water wells. It can also cause sewage systems to back up into the streets, creating health hazards. The aforementioned has already begun to occur in Monroe, Miami-Dade, and Broward County. The groundwater levels in some places are not high enough relative to the rising sea levels, which has caused saltwater to intrude into the drinking water. In Southeast Florida, there are 12 wastewater treatment plants with property 1-3 feet below the current sea level.

Roads: Flooding can swamp low-lying roads, making commuting difficult or impossible as SLR increases.

Drinking Water: Lake Worth Lagoon is brackish and/or mixed with salty Ocean water, and as it rises higher with Sea Level Rise, salt water may mix with drinking water, ruining water wells and or infiltrating centralized water main systems.

Sewage Systems: Higher Sea Level Rise at the LWL will mean more underground pressure on sewage systems (varying freshwater/seawater density). If these systems become damaged, they present a health hazard and can be very costly to repair.

Sealevelrise.org reports that in Miami Beach there are 1,185 residential properties already at risk from repeated tidal flooding. By 2033 that number will increase to 3,890 as sea levels rise. In Hollywood, 2,104 properties at risk will turn into 3,548 within 15 years. In Saint Petersburg, there are 3,140 properties at risk, which will become 4,545, and in Fort Lauderdale, there are 1,266 properties at risk, which will increase to 3,205 by 2033.

Municipalities in Florida are either currently or planning on spending over $4 billion to address Sea Level Rise impacts. Some recent examples are:

- *Miami Beach*: Miami Beach has allocated $400 million towards seawalls, pumps and raising roads in their masterplan;

- *Fort Lauderdale*: Fort Lauderdale has developed a $1 billion stormwater plan to deal with increasing flooding;
- *Broward County*: Broward County has developed a $250 million plan to protect sewage systems from flooding.

The cost of a typical preliminary design for a typical road SLR elevation project performed by Monroe County in 2017 is presented in **Figure 14**. The Case study was for retrofitting the impact of Sea Level Rise in coastal roads at the Twin Lakes Community in Key Largo, Florida.

Initial Results – Conceptual Cost Estimates for Design Scenarios

	Twin Lakes – Key Largo		Sands Community – Big Pine	
Elevation	Length of Roadway Elevated	Total Roadway and Drainage Cost	Length of Roadway Elevated	Total Roadway and Drainage Cost
6"	0.25 miles	$0.92 million	0.3 miles	$2.22 million
12"	0.7 miles	$4 million	0.35 miles	$2.63 million
18"	0.8 miles	$5.8 million	1.3 miles	$8.9 million
28"	0.9 miles	$7.3 million	1.5 miles	$10.5 million

Costs factored in: Maintenance of traffic, mobilization, design, construction, 15% of costs for construction engineering and inspection, 25% contingency and stormwater features.

Costs not factored in: right-of-way (~12" is threshold), driveway improvements

Figure 14 – Estimated Cost for Design Scenarios (Source: WSP/PB, Monroe County, 2017)

The cost of a typical preliminary design for a typical road SLR elevation project can be extensive due to the various considerations that must be contemplated during the planning and design process. The complexity of the design can substantially increase construction costs if major re-construction or reconfiguration of existing utility lines is required to implement and SLR project. **Figure 15** displays an example graphic from Monroe County (2017) of a sample road right-of-way, and the local conditions that may impact final design recommendations on an SLR project.

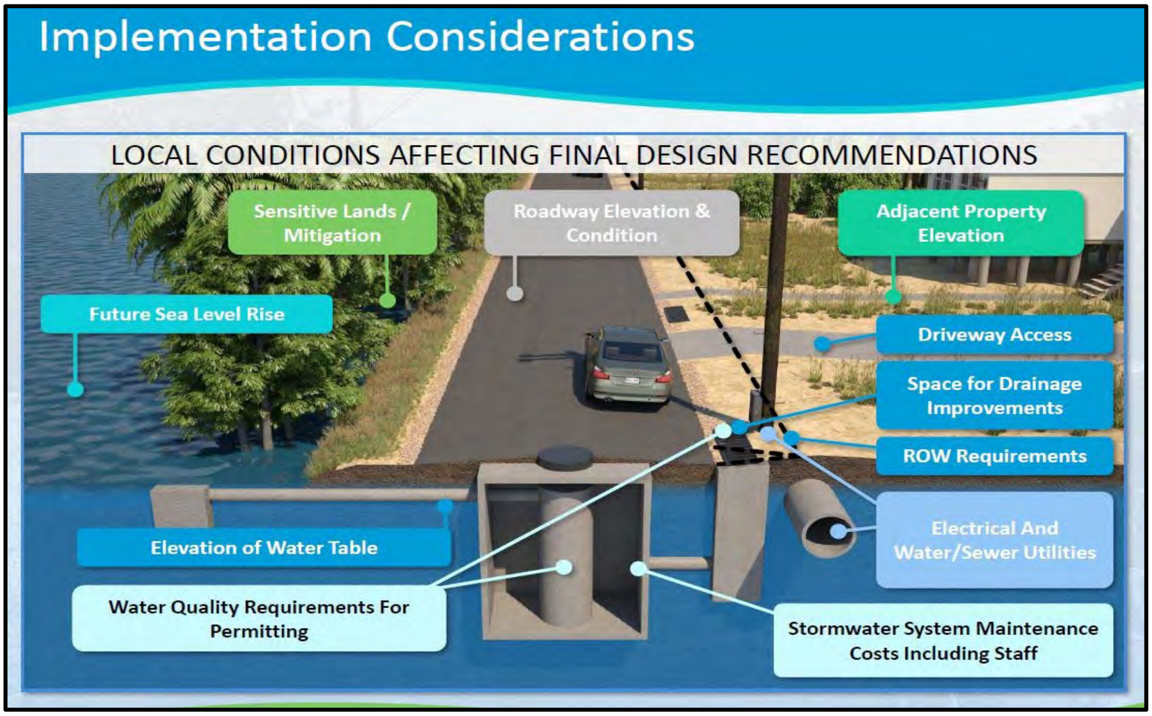


Figure 15 – Implementation Considerations for SLR Projects (Monroe Co., 2017)

Section 5 Town of Lake Park Phyical Bulkhead Data

5.1 Field Investigations and Condition Assessment

The Town of Lake Park physical bulkhead and seawall infrastructure has been studied in detail for the Town of Lake Park Sea Level Rise Vulnerability, Risk & Adaptation Analysis. The topographic survey performed for this study (Deliverable No. 1) entailed a topographic longitudinal and cross-sectional survey of the survey on the entire seawall length. A structural condition assessment of the seawall was conducted (Deliverable No. 2) which included a very detailed structural field investigation of the Seawall/Bulkhead system. A summary of these report findings is provided below.

Topographic Survey (Deliverable #1)

A topographic survey using traditional field survey techniques was conducted to obtain elevations along approximately 5000 linear feet of seawall along the Town's waterfront. Twenty-four cross sections of the bulkhead were also obtained at selected intervals. **Figure 16** shows a typical cross section data acquisition scheme.

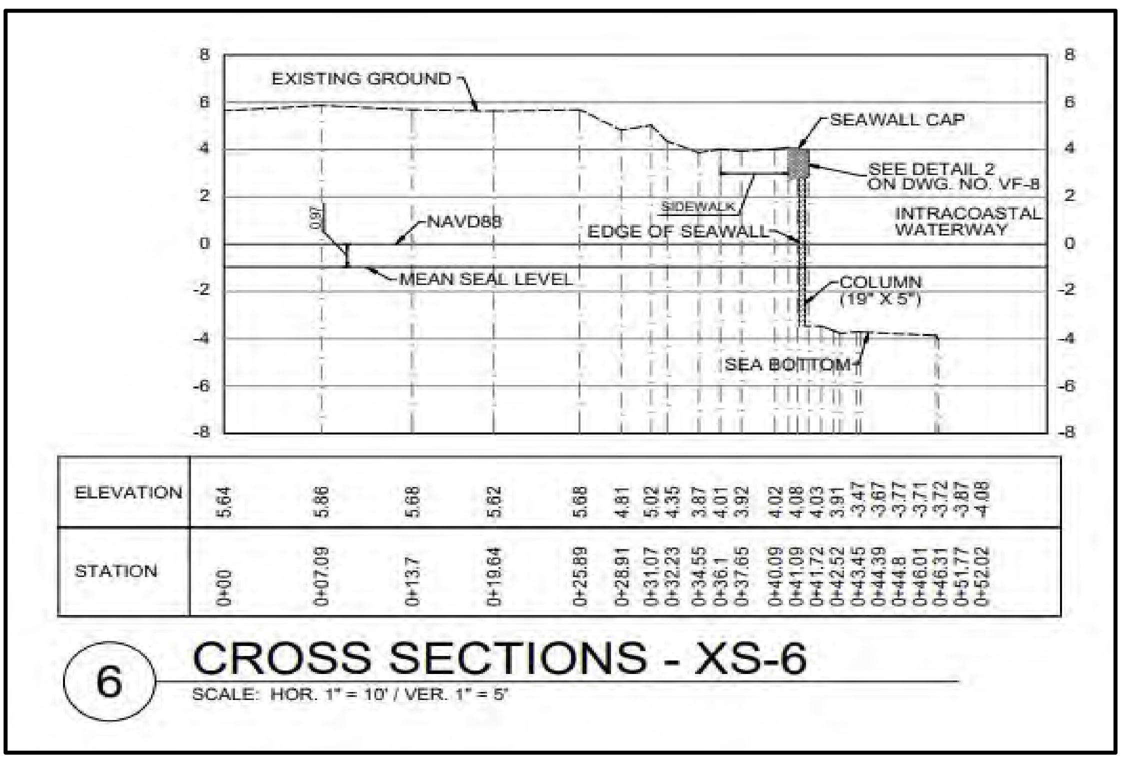


Figure 16 – Cross-Section 6 Topographic Data

Field Investigations and Condition Assessment (Deliverable #2)

The Town of Lake Park waterfront along the Lake Worth Lagoon is approximately 0.8 miles long extending from Silver Beach Road to Palmetto Drive (south to north). The subject area was divided into six (6) Exhibits. The overall site location and Exhibits are shown in **Figure 17**.

Figure 17 – Exhibits Studied in the Structural Condition Assessment

A team of two engineers used snorkel equipment and completed the above and below water field inspection. Underwater inspection of the seawall system was conducted in accordance with the American Society of Civil Engineers (ASCE) Underwater Investigations Standard Practice Manual. While one inspector obtained measurements and documented the wall from the water, the a second inspector recorded observations from the upland side. Notes and photographs were captured to document the field conditions. Based on the findings of the field investigation and review of the available documents received from the Town, four (4) locations were selected to perform exploratory excavations. The purpose of the exploratory excavations was to assess the seawall components that were not exposed during the visual inspection and to reveal the condition of the tie back systems, depth of the seawall and/or source of upland material loss.

The structural assessment also included an invasive bulkhead/seawall testing component. Ten (10) locations were selected to perform concrete core sampling. Ardaman & Associates, collected samples from the concrete cap and concrete panel of the existing seawall. The samples were sent to a laboratory for compressive strength and chloride content testing. The 4" diameter cores were advanced to a depth sufficient for compressive strength testing and the core holes were patched with hand-mixed concrete mix upon completion. A 1-inch-thick sample from the cores was crushed and tested for chloride content. The outside face of the seawall was probed at the areas determined by the engineers to evaluate the existing conditions along the seawall and check for any obvious signs of deterioration.

Exhibit 1 – Lake Park Marina

The bulkhead portrayed in Exhibit 1 extends along Lake Park Marina (Refer to **Figure 18**).

Figure 18 – Exhibit 1 of the Lake Park Marina

The stationing was established every 50 ft beginning from the southernmost corner of Pier 7. The numbering for the stationing restarted at the end of the pier (at the gate), where a different type of structure was observed. The stationing for Exhibit 1 ended at the north corner of Lake Park Marina property. The details of stationing for Exhibit 1 are shown in the table below:

Table 9 – Exhibit 1 Stationing

Location	Stations	Type
Exhibit 1 – Section 1	0+00 to 1+35	Open bents (Pier 7)
	1+35 to 2+42	Breakwater with bents and panels (Pier 6)
Exhibit 1 – Section 2	0+00 to 2+42	Bulkhead with piles and panels

Exhibit 2 – Lake Harbour Towers

The bulkhead shown in Exhibit 2 extends along the east side of the Lake Harbor Towers at 301, 401, and 501 Lake Shore Drive (**Figure 19**).

Figure 19 – Exhibit 2 North of the Marina

Stationing was established every 50 ft beginning at south corner of 301 Lake Shore Drive property and ending at the north corner of 501 Lake Shore Drive property. The details of stationing for Exhibit 2 are shown in the table below:

Table 10 – Exhibit 2 Stationing

Location	Stations	Type
301 Lake Shore Drive	0+00 to 3+06	Bulkhead with solider piles and panels
401 Lake Shore Drive	3+06 to 5+30	
501 Lake Shore Drive	5+30 to 7+75	

Exhibit 3 – Kelsey Park

The bulkhead portrayed in Exhibit 3 extends along Kelsey Park (**Figure 20**).

Figure 20 – Exhibit 3 at Kelsey Park

The stationing was established every 50 ft beginning from the south corner of the bulkhead and ended at the north corner of the Kelsey Park property. The details of stationing for Exhibit 3 are shown in the table below:

Table 11 – Exhibit 3 Stationing

Location	Stations	Type
Exhibit 3	0+00 to 8+66	Bulkhead with piles and panels

Exhibit 4 – Lake Harbour Towers East

The bulkhead shown in Exhibit 4 extends along Lake Harbour Towers East at 801 Lake Shore Drive (**Figure 21**).

Figure 21 – Exhibit 4 at Harbour Towers East

The stationing was established every 50 feet beginning from the south corner of the bulkhead to the north corner of the property. The details of stationing for Exhibit 4 are shown in the table below:

Table 12 – Exhibit 4 Stationing

Location	Stations	Type
Exhibit 4 – Section 1	0+00 to 2+77	Bulkhead with solider piles, panels, and tiebacks
Exhibit 4 – Section 2	2+77 to 3+70	Bulkhead with king piles, panels, and batter piles

Exhibit 5 – Marina Key

The bulkhead portrayed in Exhibit 5 extends along Marina Key (**Figure 22**).

Figure 22 – Exhibit 5 at Marina Key

The stationing was established every 50 feet beginning from the south corner of the bulkhead and ended at the north corner. The stationing was restarted for the 32 feet wide easement adjacent to the Marina Key property on the north side. The details of stationing for Exhibit 5 are shown in the table below:

Table 13 – Exhibit 5 Stationing

Location	Stations	Type
Exhibit 5 – Section 1	0+00 to 6+24	Bulkhead with king piles, panels, and batter piles
Exhibit 5 – Section 2	0+00 to 0+32	Bulkhead with piles and panels (Easement)

Exhibit 6 – Bay Reach

The bulkhead portrayed in Exhibit 6 extends along Bay Reach Condominiums at 1001 Lake Shore Drive (**Figure 23**).

Figure 23 – Exhibit 6 at Bay Reach Condominiums

Structural assessment was not conducted on this bulkhead since it has been recently replaced and developed (within 5 years). The only area that was inspected was the easement on the north side of the property.

5.2 Structural Assessment Summary, Conclusions and Recommendations

Based on the structural assessment, concrete coring and exploratory excavations, a summary of recommendations was provided for each exhibit. The assigned rating and the remaining useful life of the subject structures for each exhibit are summarized in the table below:

Table 14 – Rating Table and Remaining Useful Life

Location	*Rating	Initial Repair/Replacement Urgency	Remaining Useful Life after Performing the Repairs
Exhibit 1 – Section 1 (Pier 7)	Fair	Repair within 6 months	20 years w/periodic maintenance
Exhibit 1 – Section 1 (Pier 6)	Fair	Repair within 6 months	20 years w/periodic maintenance
Exhibit I – Section 2 (Bulkhead)	Satisfactory	-	30 years w/periodic maintenance
Exhibit 2	Serious	Replacement within 6 months	Design life ended
Exhibit 3	**Serious	Repair within 6 months	25 years w/periodic maintenance
Exhibit 4	Fair	Repair within 6 months	15 years w/periodic maintenance
Exhibit 5 – Section 1	Fair	Repair of piles and replacement of cap within 5 years	15 years w/periodic maintenance
Exhibit 5 – Section 2 (Easement)	Serious	Replacement within 6 months	Design life ended
Exhibit 6	Good	-	40 years w/periodic maintenance – recently replaced

*In accordance with the ASCE Underwater Investigation Standard Practice Manual. Refer to Appendix I.
**Structural elements are in Satisfactory condition. The overall rating will be Satisfactory after repairing the gaps.
Note: Effect of future sea level rise is not considered.

5.3 Replacement Options Recommendations

For each of the exhibits, after performing the initial repairs, it is necessary to perform periodic maintenance repairs in order to maintain the integrity of the structures during their remaining useful life. Towards the end of design life, the cost associated with the maintenance repair throughout the coming years usually exceeds the cost of replacement. At this stage, it is recommended that the structures be replaced.

Structural Construction Options

Different and most common structural replacement options are listed below. The feasibility of using each system depends on the site conditions, depth of water, permitting restrictions, desired design life, constructability and budget.

Steel Sheet Piles Bulkhead: Steel sheet pile bulkheads consist of steel sheets that will be driven in front of the existing bulkheads. A concrete cap will be installed on top of the sheet piles. For the lateral support, a tieback system including deadmen and tie rods, or alternatively, helical anchors can be used.

Concrete Sheet Pile Bulkhead: Concrete sheet piles consist of precast pre-stressed concrete sheets with tongue and groove edges. The concrete sheet pile wall will be driven in front of the existing wall. A concrete cap will be installed on top of the concrete sheet piles. For the lateral support, a tieback system including deadmen and tie rods, or alternatively, helical anchors can be used.

Concrete Pile and Panel: Concrete pile and panel system consist of pre-stressed precast concrete king piles and precast concrete panels. C concrete batter piles, a tieback system including deadmen and tie rods, or helical anchors can be used for lateral support. A concrete cap will be installed on top of the king piles, batter piles and the panels.

Truline Bulkhead: Truline panels consist of interlocking vinyl cells that will be installed in front of the existing bulkhead. The inside of the cells will be cleared and rebars will be installed. Then the cell will be filled with concrete. A concrete cap will be installed on top of the panels. For the lateral support, a tieback system including deadmen and tie rods, or alternatively, helical anchors can be used.

Sustainable Construction

New stabilization options are gaining attention as an alternative to traditional shoreline stabilization techniques. These alternative methods can reduce damage and erosion while simultaneously providing ecosystem services to society, including food production, nutrient and sediment removal and water quality improvement.

Living Shoreline: Living shorelines provide important environmental functions, such as regulating water quality (temperature, clarity, nutrients, and contaminants) and sustaining critical habitat for a variety of aquatic and terrestrial organisms (invertebrates, fish, amphibians, reptiles, shorebirds and waterfowl, and mammals). A living shoreline is made of mostly native material to maintain the continuity of the natural land-water interface and reduce erosion while enhancing coastal resilience. The adverse effects of traditional shoreline stabilization methods can be significant, as hard erosion-control solutions do not provide the water quality or habitat benefits of a natural or restored vegetated shoreline.

Bio-enhanced Concrete forms: Another approach to enhance both the structural strength and durability, and the biological and ecological value of the shoreline infrastructure is to incorporate products such as bio-enhancing concrete additives and specifically designed forms into precast or cast-on-site concrete elements. The coastline will become a resilient, blue-green infrastructure that fosters marine life.

Gabion Bulkhead: Gabions are strong steel cages filled with inorganic materials like rock and concrete blocks. They will be designed to withstand the site conditions and the wave energy. Gabions banks are constructed to protect the coast against erosion due to water and waves. Gabions will withstand alternative tension and compression without losing structural passage of water throughout the structure.

5.4 Seawall Restoration Financial Assessment

The following quantities and costs associated with the recommendations for each exhibit are based on the observations from the field investigation and all pricing is estimated based on prior projects and final opinions of cost will require contractor input and confirmation. Based on this field investigation, the following cost estimate elements are presented:

- *Initial Repair/Replacement*: The initial repair/replacement costs for the full length of the bulkhead is approximately $5 Million Dollars. This value does not account for the periodic maintenance that is needed for the remaining useful life of the structures.

- *Sea Level Rise Adjustment:* After the initial repair/replacement, raising bulkhead caps and installing tiebacks is recommended to account for sea level rise. The estimated cost for the bulkheads not replaced in the initial phase is estimated to be approximately $2 Million Dollars.

- *Replacement Options:* Towards the end of the structures' design life, it is recommended to completely replace the seawalls. The costs associated with different types of seawall systems are provided per linear foot.

- *Sustainable Construction:* Implementing sustainable solutions such as living shorelines and bio-enhanced concrete will add costs to the repair and replacement estimates. The additional costs are listed per 100 linear feet of seawall (living shorelines) and per unit cost for bio-enhanced concrete materials.

Table 15 – Initial Repair/Replacement Costs

Initial Repair/Replacement

Description	Quantity	Unit	Unit Cost	Extended Cost
Exhibit 1				
Pier 7 – Crack Repairs	135	LF	$ 360.00	$ 48,600
Pier 6 – Crack Repairs	523	LF	$ 360.00	$ 18,280
Exhibit 2				
Complete Bulkhead Replacement	775	LF	$ 3,500.00	$ 2,712,500
Exhibit 3				
Cap – Crack Repair	866	LF	$ 120.00	$ 103,920
Piles and Panels – Gap Repair	16	EA	$ 1,500.00	$ 24,000
Exhibit 4				
Batter Piles – Major Repair	41	EA	$ 1,200.00	$ 49,200
King Piles - Repair	9	EA	$ 800.00	$ 7,200
Cap – Crack Repair	370	LF	$ 120.00	$ 44,400
Exhibit 5				
Batter Piles – Repair	25	EA	$ 800.00	$ 20,000
King Piles – Repair	8	EA	$ 800.00	$ 6,400
Cap – Replacement	624	LF	$ 50.00	$ 156,000
Exhibit 6 – Easement				
Complete Bulkhead Replacement	32	LF	$ 3,500.00	$ 112,000

Sub-Total	$ 3,472,500
General Conditions (10%)	$ 374,250
Mobilization (5%)	$ 173,625
Bond and Insurance (5%)	$ 173,625
Contractor Overhead and Profit (10%)	$ 347,250
Contingency (10%	$ 347,250
Total Probable Construction Cost	**$ 4,861,500**

Table 16 – Sea Level Rise Adjustment, Replacement & Sustainable Construction Costs

Sea Level Rise Adjustment

Description	Quantity	Unit	Unit Cost	Extended Cost
Exhibit 1				
Raising the Bulkhead Cap	242	LF	$ 250.00	$ 60,500
Additional Tieback Anchors	40	EA	$ 3,000.00	$ 120,000
Exhibit 3				
Raising the Bulkhead Cap	866	LF	$ 250.00	$ 216,500
Additional Tieback Anchors	110	EA	$ 3,000.00	$ 330,000
Exhibit 4				
Raising the Bulkhead Cap	370	LF	$ 250.00	$ 92,500
Additional Tieback Anchors	50	EA	$ 3,000.00	$ 150,000
Exhibit 5				
Raising the Bulkhead Cap	624	LF	$ 250.00	$ 156,000
Additional Tieback Anchors	80	EA	$ 3,000.00	$ 240,000

Sub-Total	$1,365,500
General Conditions (10%)	$ 136,550
Mobilization (5%)	$ 68,275
Bond and Insurance (5%)	$ 68,275
Contractor Overhead and Profit (10%)	$ 136,550
Contingency (10%	$ 136,550
Total Probable Construction Cost	**$1,911,700**

Replacement Options

Description	Unit	Unit Cost
Replacement Cost per Linear Feet of Bulkhead		
Concrete King Pile and Panels Bulkhead	LF	$ 1,500.00
ECO Seawall	LF	$ 2,000.00
Steel Sheet Pile Bulkhead	LF	$ 2,500.00
Concrete Sheet Pile Bulkhead with GFRP/CFRP	LF	$ 5,500.00

Sustainable Construction

Description	Quantity	Unit	Unit Cost	Extended Cost
Living Shoreline (for 100 Linear Feet of shoreline)				
Riprap Breakwater	185	CY	$ 120.00	$ 22,200
Soil Mix for Planter	370	CY	$ 30.00	$ 11,100
Mangrove	2500	SF	$ 0.40	$ 1,000
Total (for 100 Linear Feet of shoreline)				**$ 34,300**

Eco-Concrete Unit Costs	Unit	Unit Cost
ECO Seawall Panels	SF	$ 70.00
ECO Mat (8 ft by 15 ft)	EA	$ 1,500.00
Tide Pool Armor (4 ft by 4 ft by 4ft block)	EA	$ 900.00

Section 6 References

Southeast Florida Regional Climate Change Compact. Unified Sea Level Rise Projection for Southeast Florida. Third Update. 2019.

National Oceanic and Atmospheric Administration (NOAA) Tides and Currents. http://tidesandcurrents.noaa.gov, Station: 8722670, Lake Worth Pier, FL

Federal Emergency Management Agency (FEMA). Flood Insurance Study (FIS), Palm Beach County, Florida. FEMA FIS # 12099CV000A. October 2017.

Federal Emergency Management Agency (FEMA). National Flood Hazard Layer (NFHL), Palm Beach County, Florida. Last Study Effective October 2017. Last LOMR Effective December 2020. https://msc.fema.gov/portal/advanceSearch

Dewberry Engineers, Inc. Palm Beach County LiDAR Report for U.S. Geological Survey (USGS). USGS 3D Elevation Program Contract # G16PC00020. June 2019.

National Oceanic and Atmospheric Administration (NOAA). Detailed Method for Mapping Sea Level Rise Inundation. NOAA Office for Coastal Management. January 2017.

Palm Beach County Property Appraiser. Parcel Data. 2019. https://www.pbcgov.com/papa

Gulf Engineers & Consultants. Depth-Damage Relations for Structures, Contents, and Vehicles and Content-to-Structure Value Rations (CSVR) in Support of the Donaldsville to the Gulf, Louisiana, Feasibility Study. US Army Corps of Engineers (USACE), New Orleans District. March 2006.

Federal Emergency Management Agency (FEMA). Baseline Standard Economic Value Methodology Report. Benefit-Cost Sustainment and Enhancements. July 2016.

NYC Mayor’s Office of Recovery and Resiliency (ORR). Climate Resiliency Design Guidelines. Ver. 4.0. September 2020. https://www1.nyc.gov/assets/orr/pdf/NYC_Climate_Resiliency_Design_Guidelines_v4-0.pdf

Mock, Roos & Associates, Inc. C-17 Drainage Basin Study Final Report. South Florida Water Management District. January 2002.

South Florida Water Management District. Environmental Resource Permit No. 50-05227-P. December 2001.

United States Environmental Protection Agency (EPA). Sources of Greenhouse Gas Emissions. 2020. https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions

Intergovernmental Panel on Climate Change (IPCC). Special Report. 2020. https://www.ipcc.ch/sr15/

National Aeronautics and Space Administration (NASA). The Causes of Climate Change. 2020. https://climate.nasa.gov/causes/

Tom Di Liberto. King Tides Cause Flooding in Florida in Fall 2017. National Oceanic and Atmospheric Administration (NOAA). November 2017. https://www.climate.gov/news-features/event-tracker/king-tides-cause-flooding-florida-fall-2017

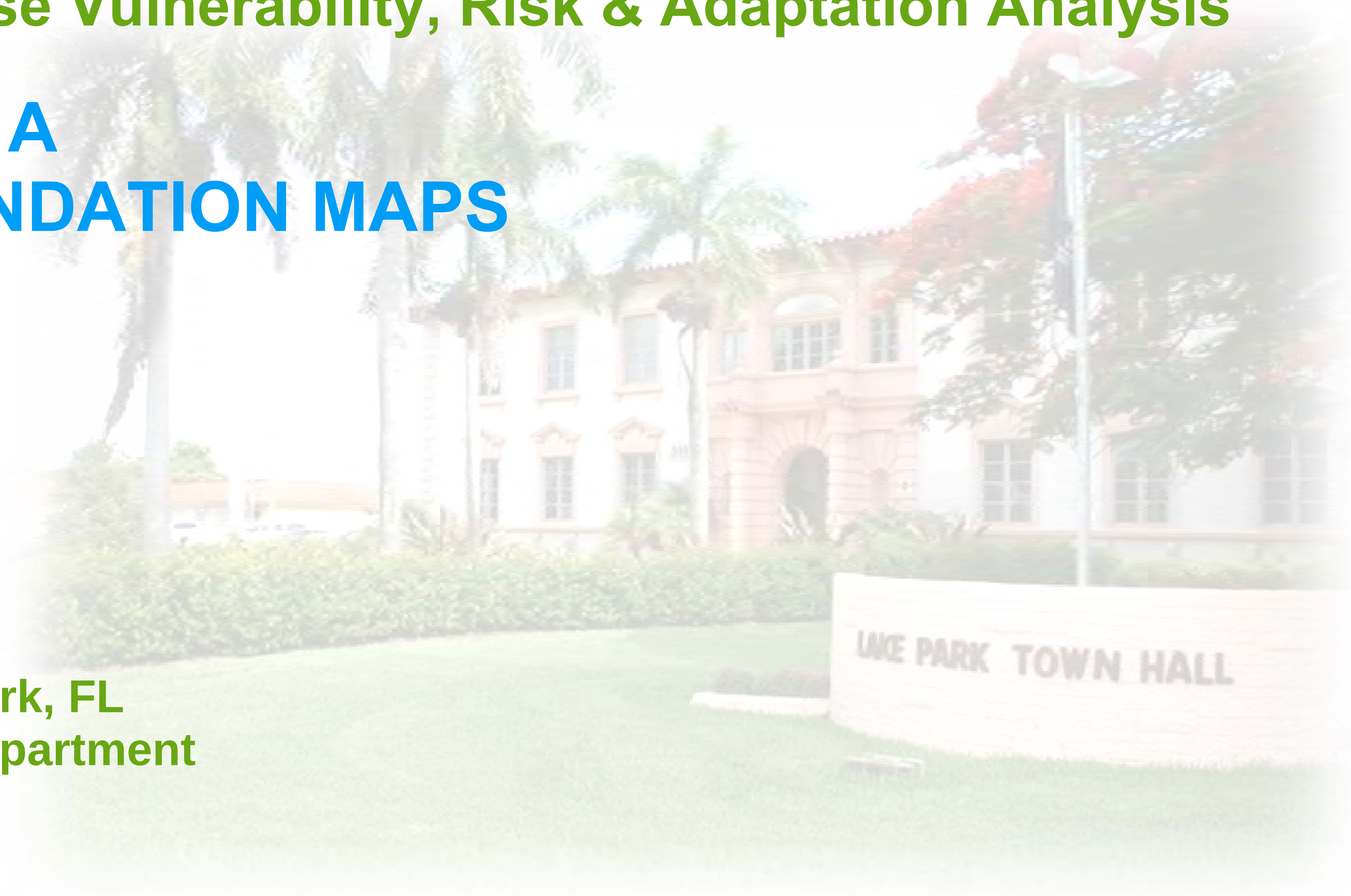
Town of Lake Park
Sea Level Rise Vulnerability, Risk & Adaptation Analysis

APPENDICES

WRMA

Town of Lake Park
Sea Level Rise Vulnerability, Risk & Adaptation Analysis

APPENDIX A
TIDAL INUNDATION MAPS

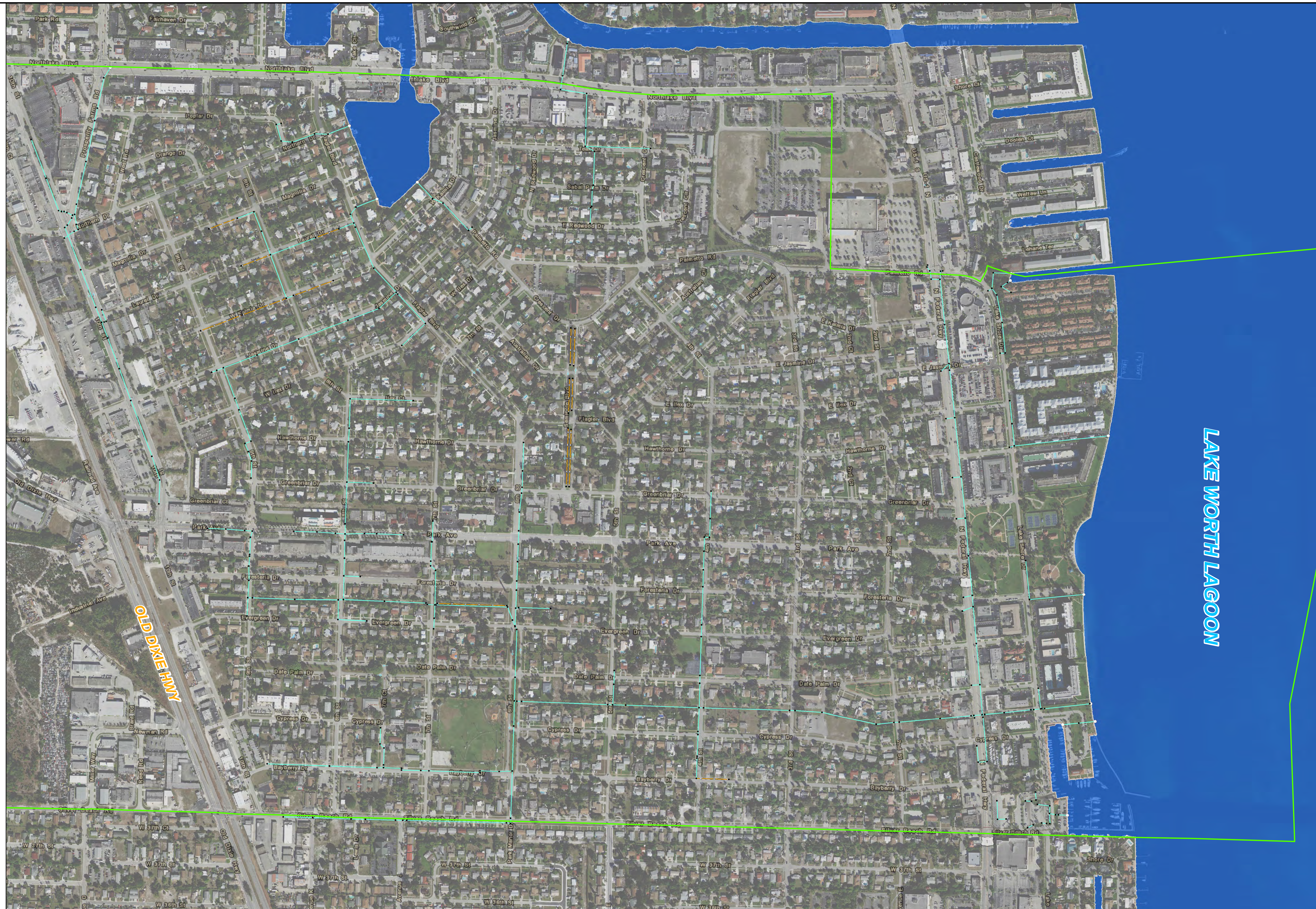


Town of Lake Park, FL
Public Works Department

January 26, 2021

WRMA

Note:
No inundation occurs west of Old Dixie Hwy. Therefore that area of the Town is not shown.



Legend

- Town Boundary
- Inlet/Manhole
- Outfall

Stormwater

- French Drain
- Pipe
- 2020 Inundation EL 1.21

750 375 0 750 Feet

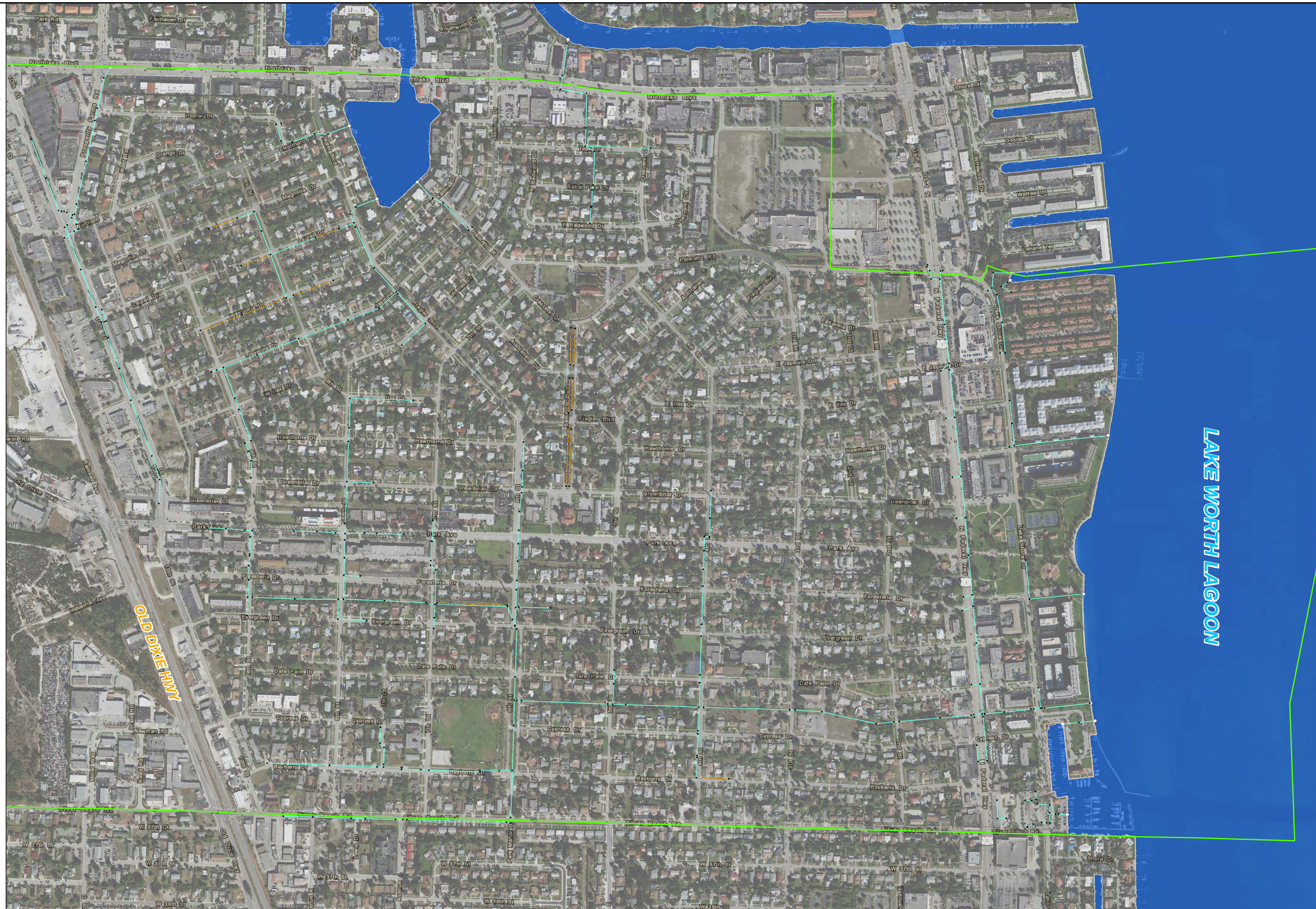
TOWN OF LAKE PARK, FL
S.L.R. VULNERABILITY ASSESSMENT

N

Town of Lake Park
Tidal Inundation Map - 2020

SCALE: 1 inch = 353 feet	BY: A.M.
COUNTY: PALM BEACH	CHECKED: R.M.
STATE: FLORIDA	REVISED: N/A

Note:
No inundation occurs west of Old Dixie Hwy. Therefore that area of the Town is not shown.



Legend

- Town Boundary
- Inlet/Manhole
- Outfall

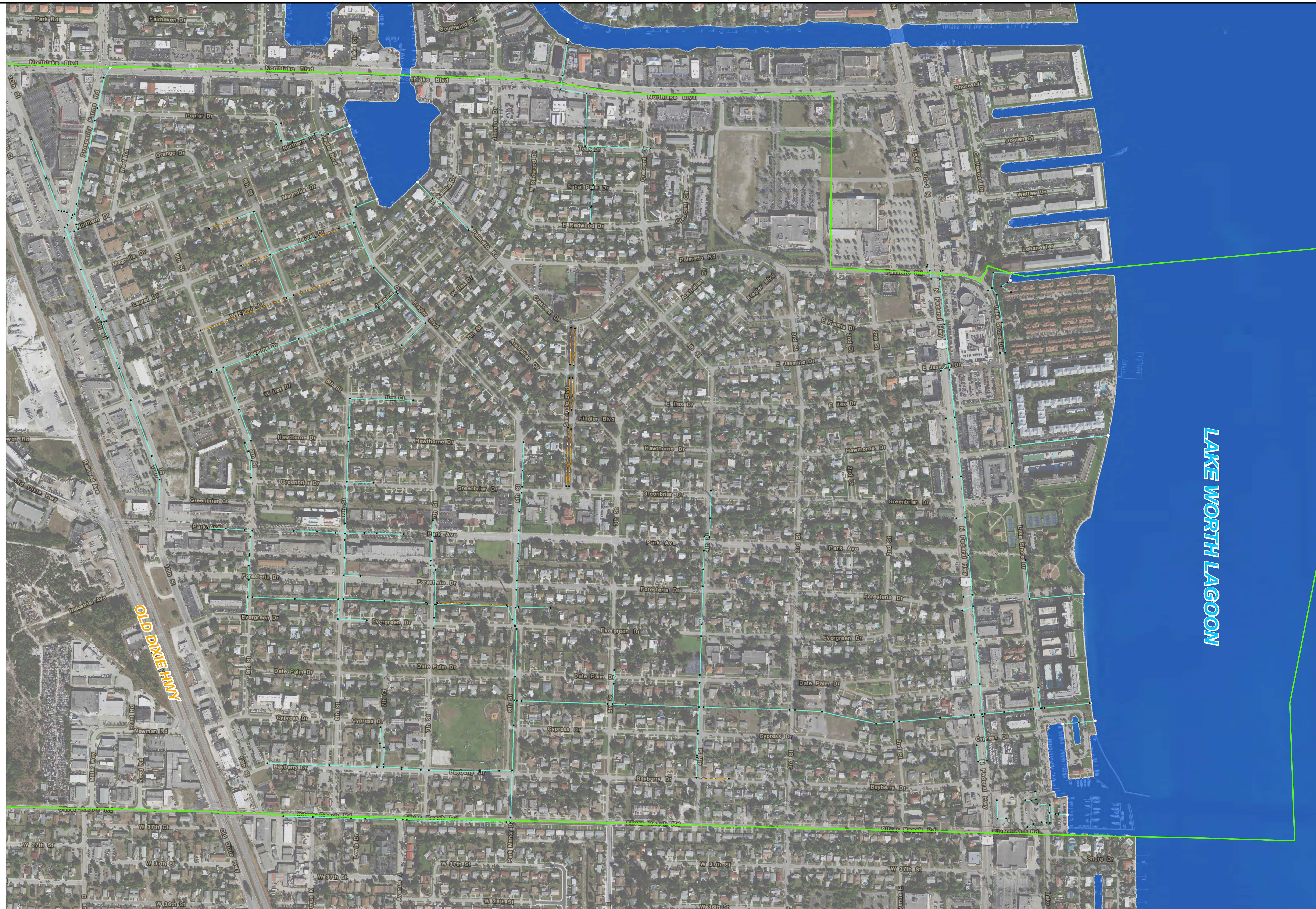
Stormwater

- French Drain
- Pipe
- 2030 Inundation EL 1.63

750 375 0 750 Feet

TOWN OF LAKE PARK, FL S.L.R. VULNERABILITY ASSESSMENT	N	Town of Lake Park Tidal Inundation Map - 2030	SCALE: 1 inch = 353 feet
			BY: A.M.
			COUNTY: PALM BEACH
			CHECKED: R.M.
			STATE: FLORIDA
			REVISED: N/A

Note:
No inundation occurs west of Old Dixie Hwy. Therefore that area of the Town is not shown.



Legend

- Town Boundary
- Inlet/Manhole
- Outfall

Stormwater

- French Drain
- Pipe
- 2040 Inundation EL 2.03

750 375 0 750 Feet

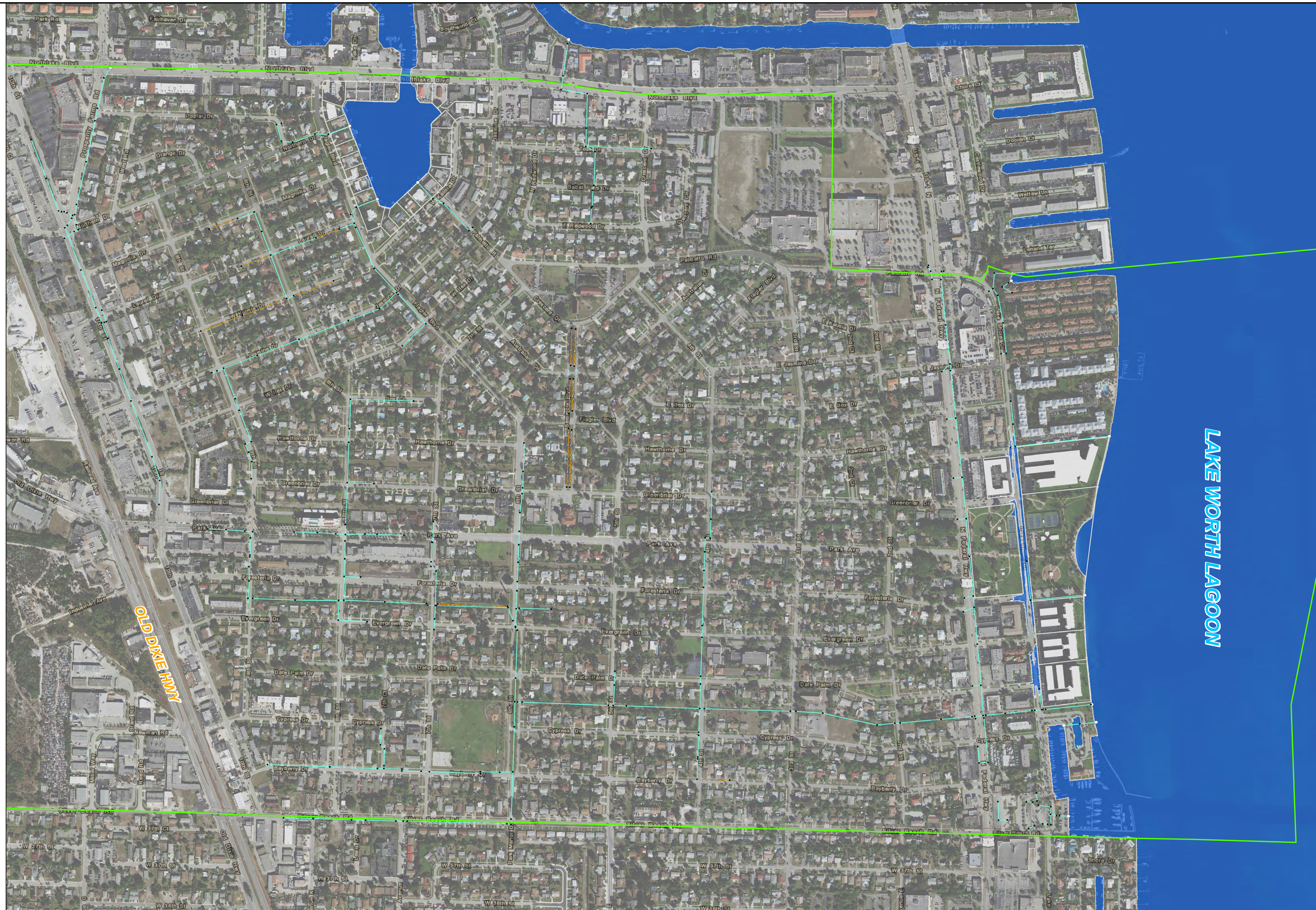
TOWN OF LAKE PARK, FL
S.L.R. VULNERABILITY ASSESSMENT

N

Town of Lake Park
Tidal Inundation Map - 2040

SCALE: 1 inch = 353 feet	BY: A.M.
COUNTY: PALM BEACH	CHECKED: R.M.
STATE: FLORIDA	REVISED: N/A

Note:
No inundation occurs west of
Old Dixie Hwy. Therefore that
area of the Town is not shown.



Legend

- Town Boundary
- Inlet/Manhole
- Outfall

Stormwater

- French Drain
- Pipe
- 2050 Affected Buildings
- 2050 Affected Parcels
- 2050 Inundation EL 2.59

750 375 0 750 Feet

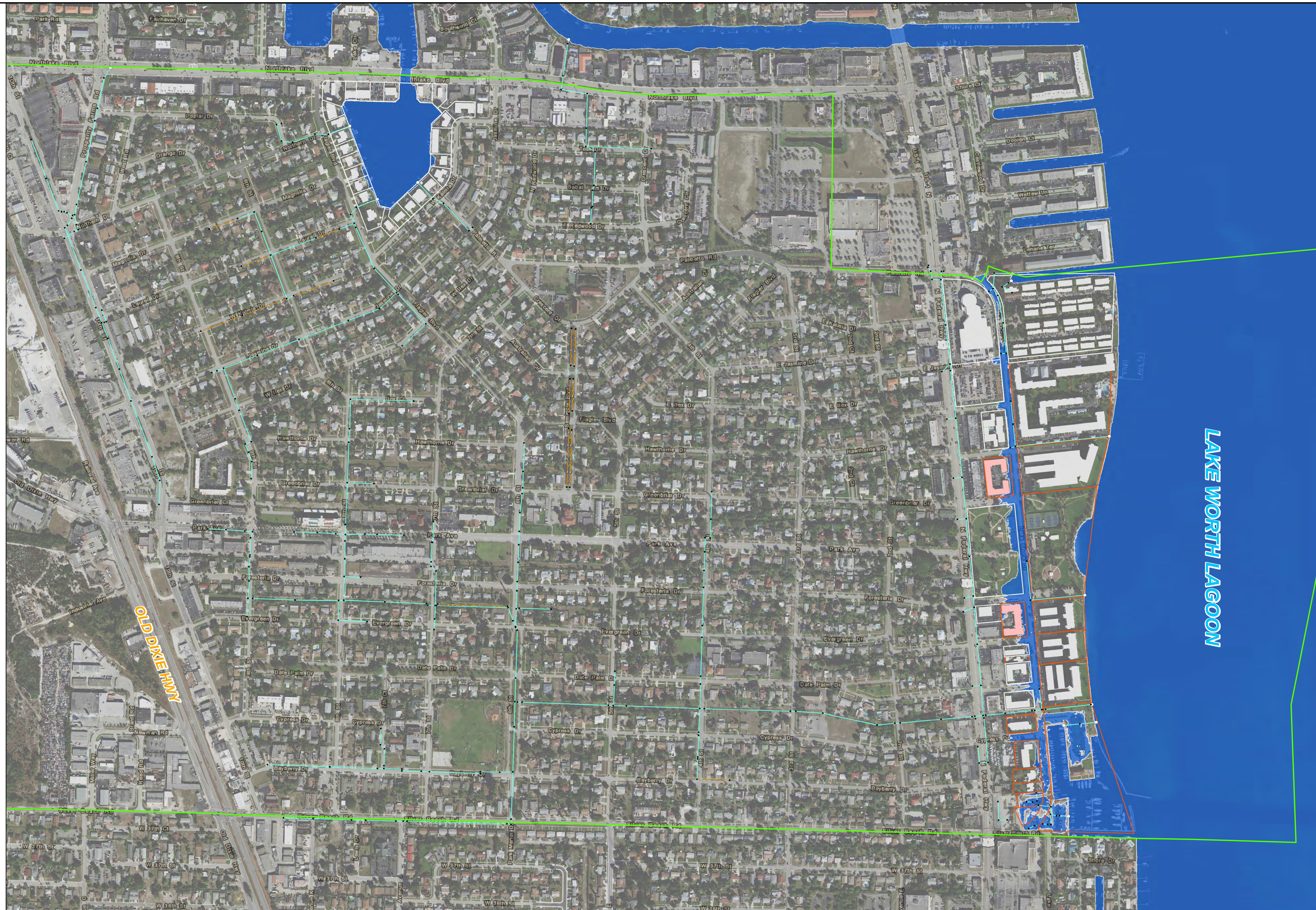
TOWN OF LAKE PARK, FL
S.L.R. VULNERABILITY ASSESSMENT

N

Town of Lake Park
Tidal Inundation Map - 2050

SCALE: 1 inch = 353 feet	BY: A.M.
COUNTY: PALM BEACH	CHECKED: R.M.
STATE: FLORIDA	REVISED: N/A

Note:
No inundation occurs west of Old Dixie Hwy. Therefore that area of the Town is not shown.



Legend

- Town Boundary
- Inlet/Manhole
- Outfall

Stormwater

- French Drain
- Pipe

2060 Affected Buildings

- Not Inundated
- Inundated

2060 Affected Parcels

- No
- Yes
- 2060 Inundation EL 3.21

750 375 0 750 Feet

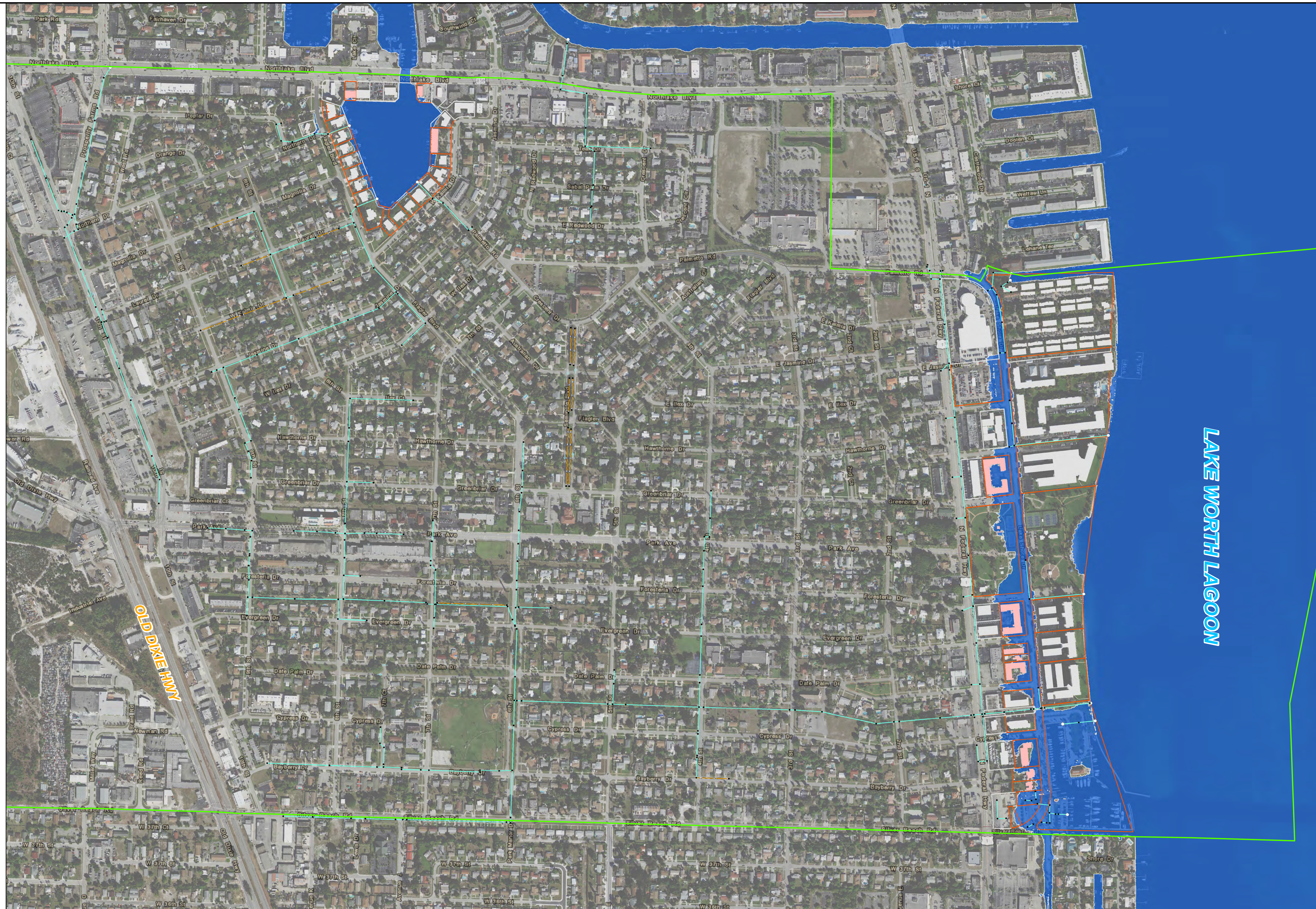
TOWN OF LAKE PARK, FL
S.L.R. VULNERABILITY ASSESSMENT

N

Town of Lake Park
Tidal Inundation Map - 2060

SCALE: 1 inch = 353 feet	BY: A.M.
COUNTY: PALM BEACH	CHECKED: R.M.
STATE: FLORIDA	REVISED: N/A

Note:
No inundation occurs west of Old Dixie Hwy. Therefore that area of the Town is not shown.



Legend

Town Boundary

Inlet/Manhole

Outfall

Stormwater

French Drain

Pipe

2070 Affected Buildings

Not Inundated

Inundated

2070 Affected Parcels

No LOF

PLOF

2070 Inundation EL 3.96

750 375 0 750 Feet

TOWN OF LAKE PARK, FL
S.L.R. VULNERABILITY ASSESSMENT

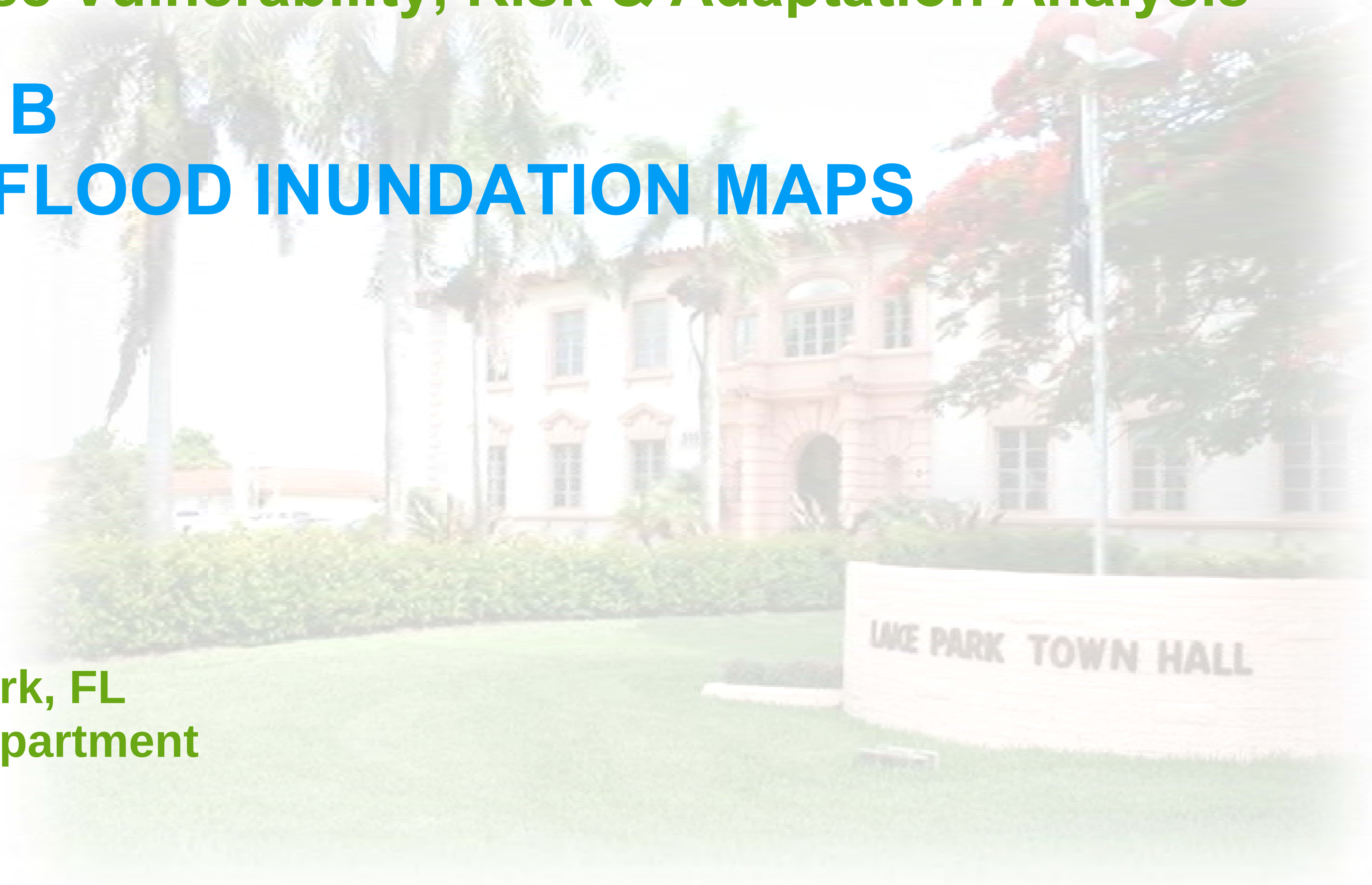
N

Town of Lake Park
Tidal Inundation Map - 2070

SCALE: 1 inch = 353 feet	BY: A.M.
COUNTY: PALM BEACH	CHECKED: R.M.
STATE: FLORIDA	REVISED: N/A

Town of Lake Park
Sea Level Rise Vulnerability, Risk & Adaptation Analysis

APPENDIX B
COASTAL FLOOD INUNDATION MAPS



Town of Lake Park, FL
Public Works Department

January 26, 2021

WRMA

Legend

- Town Boundary
- Inlet/Manhole
- Outfall

Stormwater

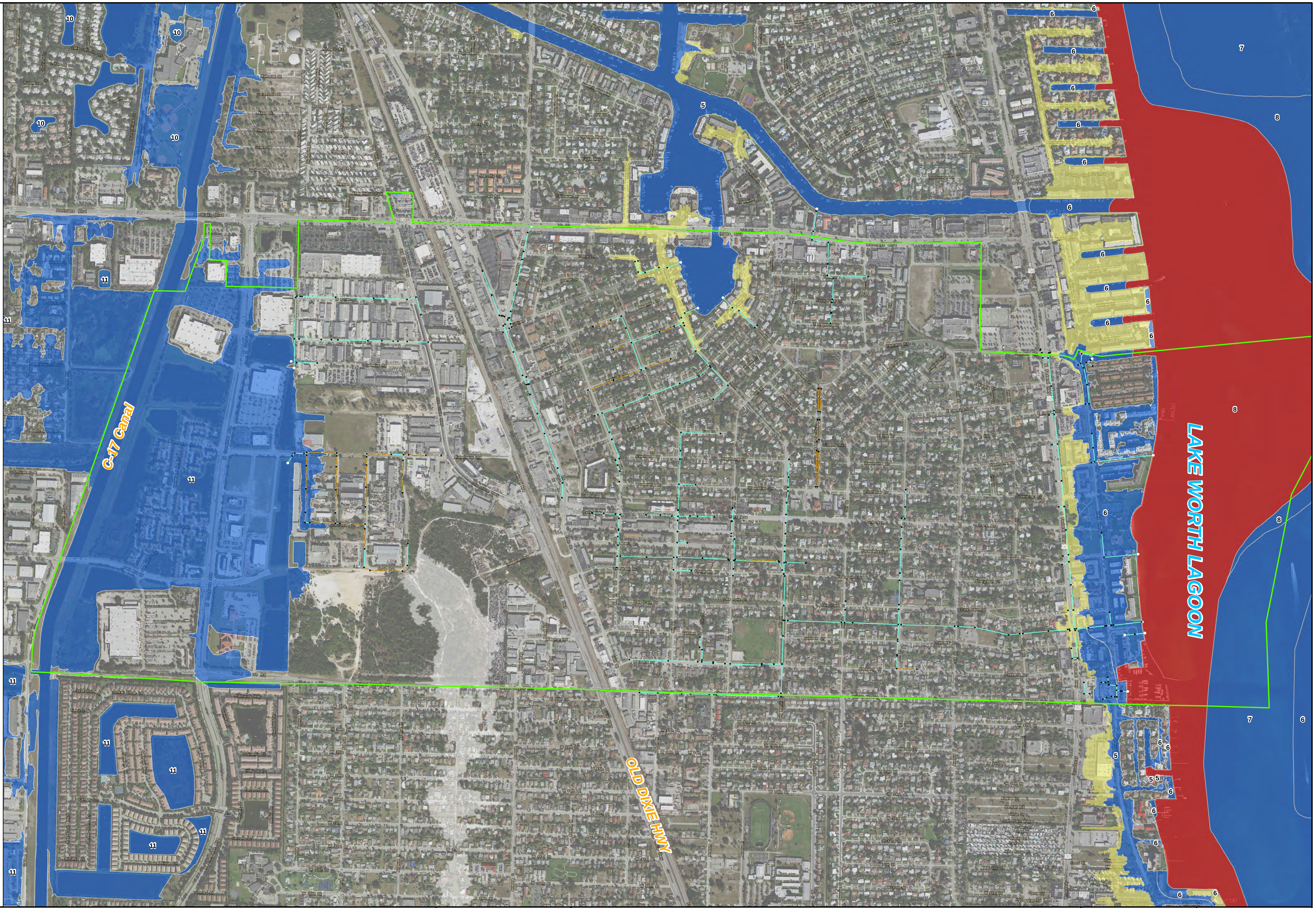
- French Drain
- Pipe

NFHL - Palm Beach Co 2017

Flood Zone

- A - Approx. Base Floodplain No BFE
- AE - Base Floodplain (1% Annual Chance)
- AH/AO - Minor Ponding/Shallow Flooding
- VE - Coastal Area, Wave Action >3ft
- X - (Shaded) within 0.2% Floodplain

1,100 550 0 1,100 Feet



TOWN OF LAKE PARK, FL
S.L.R. VULNERABILITY ASSESSMENT

N

Town of Lake Park
FEMA Flood Hazard Areas - Eff. 2017

SCALE: 1 inch = 561 feet	BY: A.M.
COUNTY: PALM BEACH	CHECKED: R.M.
STATE: FLORIDA	REVISED: N/A

TOWN OF LAKE PARK, FL S.L.R. VULNERABILITY ASSESSMENT	N	Town of Lake Park Coastal Flood Map - 2020	SCALE: 1 inch = 561 feet COUNTY: PALM BEACH STATE: FLORIDA
			BY: A.M. CHECKED: R.M. REVISED: N/A

TOWN OF LAKE PARK, FL
S.L.R. VULNERABILITY ASSESSMENT

N

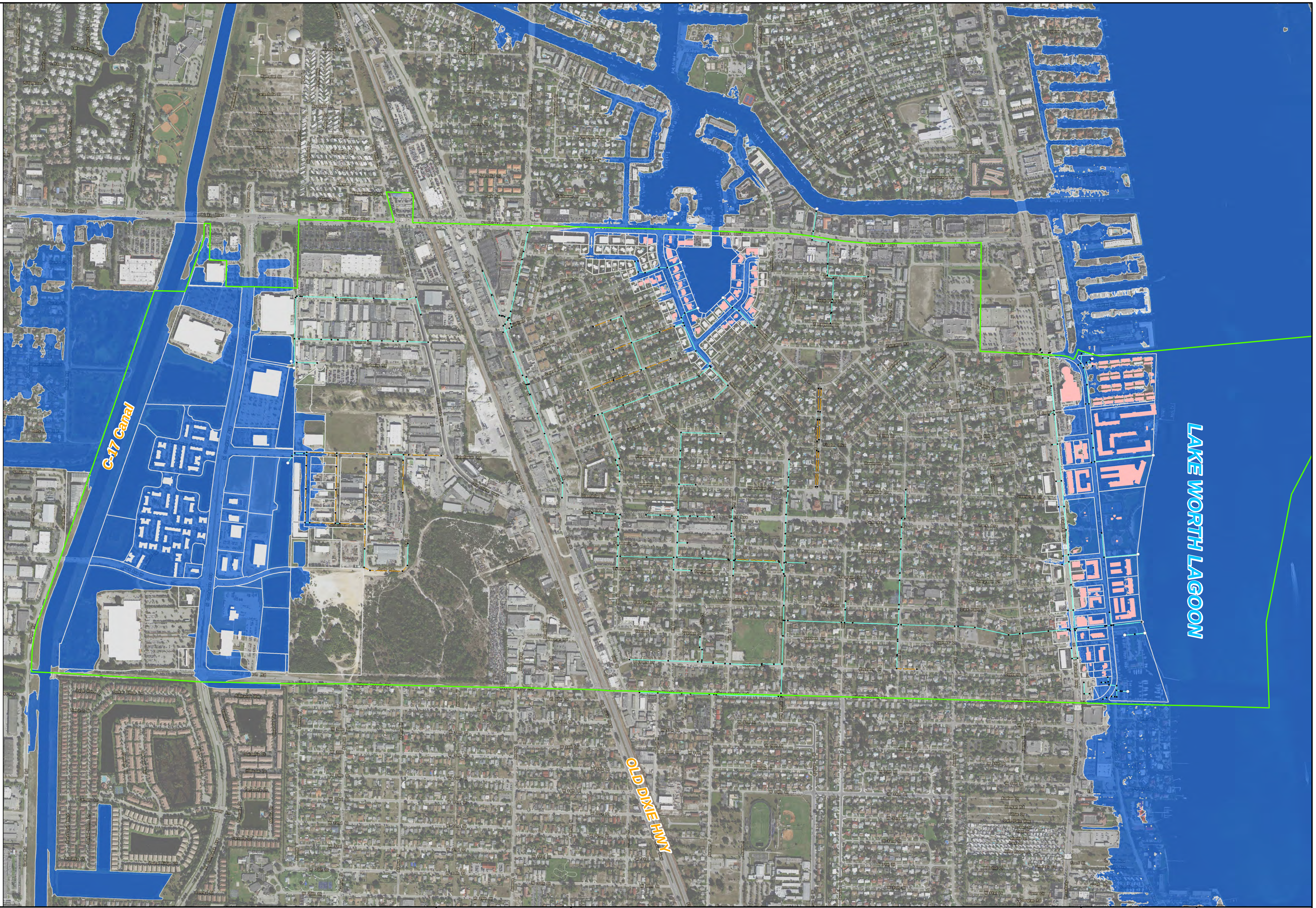
Town of Lake Park
Coastal Flood Map - 2030

SCALE: 1 inch = 561 feet	BY: A.M.
COUNTY: PALM BEACH	CHECKED: R.M.
STATE: FLORIDA	REVISED: N/A

TOWN OF LAKE PARK, FL
S.L.R. VULNERABILITY ASSESSMENT

Town of Lake Park
Coastal Flood Map - 2040

SCALE: 1 inch = 561 feet	BY: A.M.
COUNTY: PALM BEACH	CHECKED: R.M.
STATE: FLORIDA	REVISED: N/A



Legend

- Town Boundary
- Inlet/Manhole
- Outfall

Stormwater

- French Drain
- Pipe

2050 Affected Buildings

- Not Inundated
- Inundated
- 2050 Affected
- 2050 Base Flood

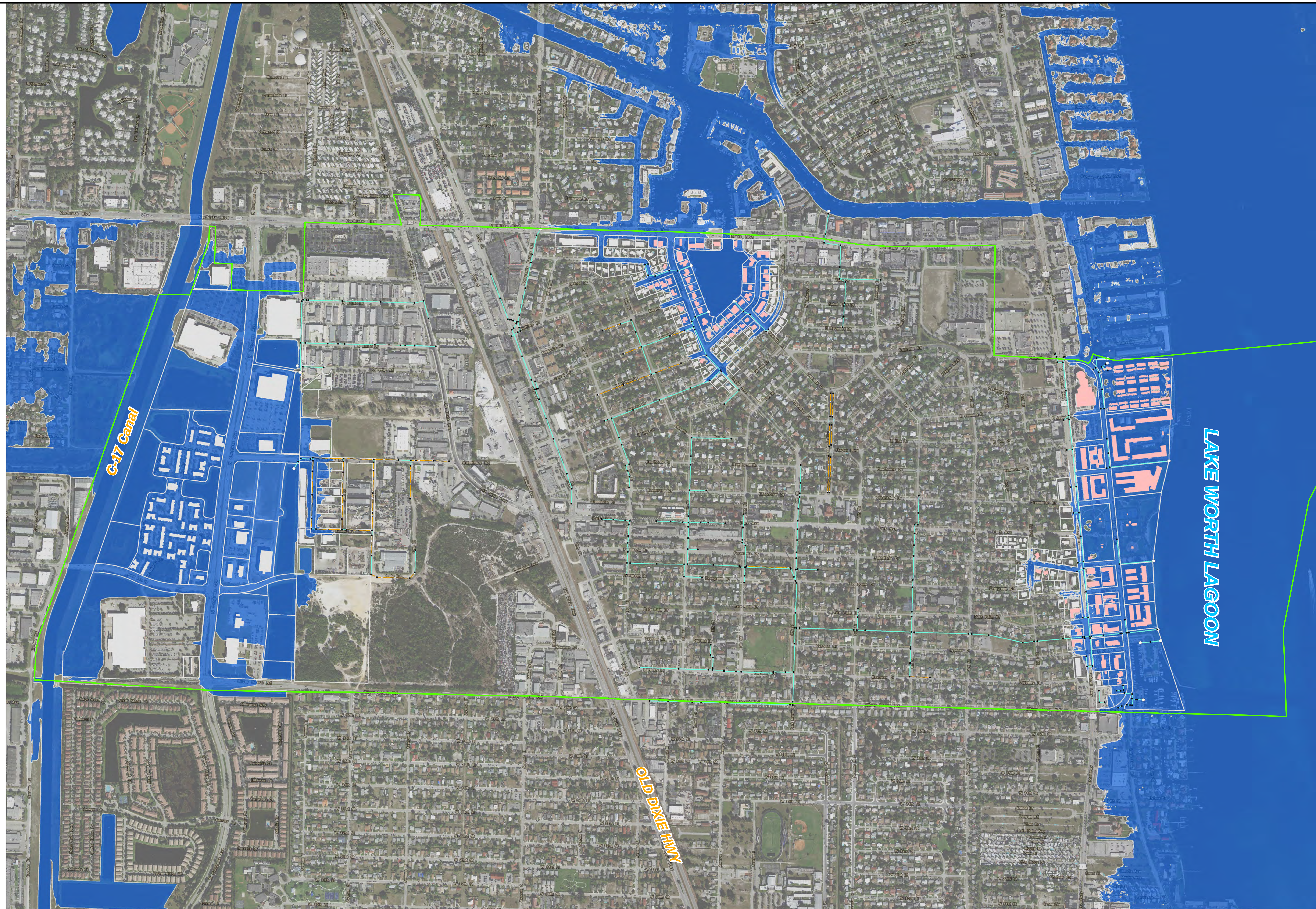
1,100 550 0 1,100 Feet

TOWN OF LAKE PARK, FL
S.L.R. VULNERABILITY ASSESSMENT

N

Town of Lake Park
Coastal Flood Map - 2050

SCALE: 1 inch = 561 feet	BY: A.M.
COUNTY: PALM BEACH	CHECKED: R.M.
STATE: FLORIDA	REVISED: N/A



Legend

- Town Boundary
- Inlet/Manhole
- Outfall

Stormwater

- French Drain
- Pipe

2060 Affected Buildings

- Not Inundated
- Inundated
- 2060 Affected
- 2060 Base Flood

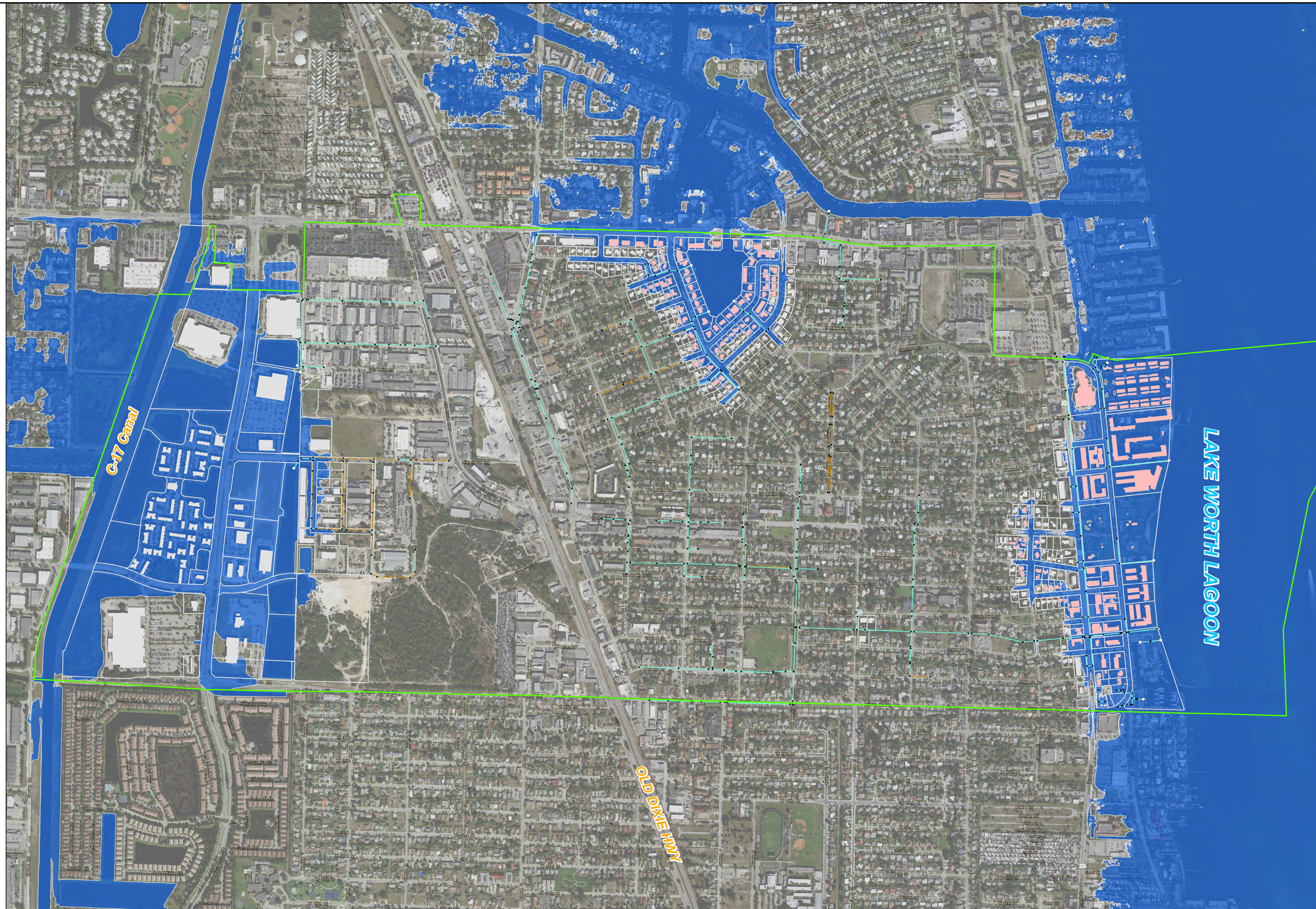
1,100 550 0 1,100 Feet

TOWN OF LAKE PARK, FL
S.L.R. VULNERABILITY ASSESSMENT

N

Town of Lake Park
Coastal Flood Map - 2060

SCALE: 1 inch = 561 feet	BY: A.M.
COUNTY: PALM BEACH	CHECKED: R.M.
STATE: FLORIDA	REVISED: N/A



Legend

- Town Boundary
- Inlet/Manhole
- Outfall

Stormwater

- French Drain
- Pipe

2070 Affected Buildings

- Not Inundated
- Inundated
- 2070 Affected
- 2070 Base Flood

1,100 550 0 1,100 Feet

TOWN OF LAKE PARK, FL
S.L.R. VULNERABILITY ASSESSMENT

N

Town of Lake Park
Coastal Flood Map - 2070

SCALE: 1 inch = 561 feet	BY: A.M.
COUNTY: PALM BEACH	CHECKED: R.M.
STATE: FLORIDA	REVISED: N/A

Town of Lake Park
Sea Level Rise Vulnerability, Risk & Adaptation Analysis

APPENDIX C
DEPTH DAMAGE FUNCTIONS (DDFs)

Town of Lake Park, FL
Public Works Department

January 26, 2021

WRMA

Structure DDF

	Damages as % of Building Replacement Value - by flood depth above grade																	
Building Type	0 ft	0.5 ft	1 ft	1.5 ft	2 ft	3 ft	4 ft	5 ft	6 ft	7 ft	8 ft	9 ft	10 ft	11 ft	12 ft	13 ft	14 ft	15 ft
Warehouse	0.041	0.166	0.189	0.212	0.245	0.271	0.354	0.363	0.369	0.38	0.491	0.514	0.529	0.542	0.547	0.548	0.554	0.555
Store, Retail	0	0.281	0.328	0.352	0.379	0.397	0.472	0.497	0.52	0.546	0.617	0.649	0.678	0.68	0.703	0.704	0.706	0.709
Apartment, 1-3 Story	0.059	0.191	0.253	0.26	0.301	0.321	0.43	0.469	0.475	0.476	0.52	0.619	0.643	0.657	0.676	0.696	0.696	0.704
Single Family Home	0.098	0.311	0.377	0.414	0.446	0.5	0.623	0.67	0.694	0.698	0.749	0.807	0.814	0.815	0.815	0.82	0.82	0.82
Restaurant	0	0.281	0.328	0.352	0.379	0.397	0.472	0.497	0.52	0.546	0.617	0.649	0.678	0.68	0.703	0.704	0.706	0.709
Garage, Auto Sales	0	0.281	0.328	0.352	0.379	0.397	0.472	0.497	0.52	0.546	0.617	0.649	0.678	0.68	0.703	0.704	0.706	0.709
Town Hall, 2-3 Story	0.006	0.143	0.186	0.214	0.235	0.262	0.309	0.313	0.33	0.346	0.436	0.51	0.541	0.568	0.601	0.604	0.616	0.618
Office, 1 Story	0	0.281	0.328	0.352	0.379	0.397	0.472	0.497	0.52	0.546	0.617	0.649	0.678	0.68	0.703	0.704	0.706	0.709
Garage, Service Station	0	0.281	0.328	0.352	0.379	0.397	0.472	0.497	0.52	0.546	0.617	0.649	0.678	0.68	0.703	0.704	0.706	0.709
Church	0	0.281	0.328	0.352	0.379	0.397	0.472	0.497	0.52	0.546	0.617	0.649	0.678	0.68	0.703	0.704	0.706	0.709
Post Office	0.006	0.143	0.186	0.214	0.235	0.262	0.309	0.313	0.33	0.346	0.436	0.51	0.541	0.568	0.601	0.604	0.616	0.618
Office, 2-4 Story	0	0.281	0.328	0.352	0.379	0.397	0.472	0.497	0.52	0.546	0.617	0.649	0.678	0.68	0.703	0.704	0.706	0.709
School, Elementary	0.006	0.143	0.186	0.214	0.235	0.262	0.309	0.313	0.33	0.346	0.436	0.51	0.541	0.568	0.601	0.604	0.616	0.618
Factory, 1 Story	0	0.281	0.328	0.352	0.379	0.397	0.472	0.497	0.52	0.546	0.617	0.649	0.678	0.68	0.703	0.704	0.706	0.709
Community Center	0.006	0.143	0.186	0.214	0.235	0.262	0.309	0.313	0.33	0.346	0.436	0.51	0.541	0.568	0.601	0.604	0.616	0.618

Contents DDF

	Damages as % of Total Contents Value - by flood depth above grade																	
Building Type	0 ft	0.5 ft	1 ft	1.5 ft	2 ft	3 ft	4 ft	5 ft	6 ft	7 ft	8 ft	9 ft	10 ft	11 ft	12 ft	13 ft	14 ft	15 ft
Warehouse	0	0.16	0.19	0.19	0.27	0.34	0.42	0.49	0.56	0.64	0.71	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Store, Retail	0	0.5	0.66	0.66	0.74	0.8	0.85	0.91	0.91	0.91	0.91	0.93	0.93	0.93	0.93	0.93	0.93	0.93
Apartment, 1-3 Story	0.216	0.252	0.312	0.352	0.384	0.463	0.514	0.567	0.616	0.627	0.634	0.693	0.693	0.732	0.752	0.77	0.782	0.784
Single Family Home	0.349	0.467	0.483	0.502	0.567	0.674	0.762	0.808	0.88	0.882	0.889	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Restaurant	0	0.16	0.57	0.73	0.96	0.98	1	1	1	1	1	1	1	1	1	1	1	1
Garage, Auto Sales	0	0.5	0.66	0.66	0.74	0.8	0.85	0.91	0.91	0.91	0.91	0.93	0.93	0.93	0.93	0.93	0.93	0.93
Town Hall, 2-3 Story	0	0.26	0.31	0.35	0.38	0.68	0.87	0.87	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
Office, 1 Story	0	0.26	0.31	0.35	0.38	0.68	0.87	0.87	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
Garage, Service Station	0.86	0.87	0.88	0.88	0.9	1	1	1	1	1	1	1	1	1	1	1	1	1
Church	0	0.09	0.12	0.14	0.17	0.9	1	1	1	1	1	1	1	1	1	1	1	1
Post Office	0	0.09	0.12	0.14	0.17	0.9	1	1	1	1	1	1	1	1	1	1	1	1
Office, 2-4 Story	0	0.26	0.31	0.35	0.38	0.68	0.87	0.87	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
School, Elementary	0	0.26	0.31	0.35	0.38	0.68	0.87	0.87	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
Factory, 1 Story	0	0.16	0.19	0.19	0.27	0.34	0.42	0.49	0.56	0.64	0.71	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Community Center	0	0.09	0.12	0.14	0.17	0.9	1	1	1	1	1	1	1	1	1	1	1	1

Temporary Loss of Function DDF

	Damages per Square Foot - by flood depth above grade																	
Building Type	0 ft	0.5 ft	1 ft	1.5 ft	2 ft	3 ft	4 ft	5 ft	6 ft	7 ft	8 ft	9 ft	10 ft	11 ft	12 ft	13 ft	14 ft	15 ft
Warehouse	$ 2.36	$ 2.36	$ 2.36	$ 2.36	$ 2.36	$ 2.36	$ 2.36	$ 2.36	$ 2.36	$ 2.36	$ 2.36	$ 2.36	$ 2.36	$ 2.36	$ 2.36	$ 2.36	$ 2.36	$ 2.36
Store, Retail	$ 21.42	$ 21.42	$ 21.42	$ 21.42	$ 21.42	$ 21.42	$ 21.42	$ 24.58	$ 24.58	$ 24.58	$ 24.58	$ 40.38	$ 40.38	$ 40.38	$ 40.38	$ 31.53	$ 31.53	$ 31.53
Apartment, 1-3 Story	$ 7.88	$ 7.88	$ 7.88	$ 7.88	$ 7.88	$ 7.88	$ 7.88	$ 9.87	$ 9.87	$ 9.87	$ 9.87	$ 16.85	$ 16.85	$ 16.85	$ 16.85	$ 16.85	$ 16.85	$ 16.85
Single Family Home	$ 8.68	$ 8.68	$ 8.68	$ 8.68	$ 8.68	$ 8.68	$ 8.68	$ 10.90	$ 10.90	$ 10.90	$ 10.90	$ 18.68	$ 18.68	$ 18.68	$ 18.68	$ 18.68	$ 18.68	$ 18.68
Restaurant	$ 20.15	$ 20.15	$ 20.15	$ 20.15	$ 20.15	$ 20.15	$ 20.15	$ 25.84	$ 25.84	$ 25.84	$ 25.84	$ 34.06	$ 34.06	$ 34.06	$ 34.06	$ 32.80	$ 32.80	$ 32.80
Garage, Auto Sales	$ 9.41	$ 9.41	$ 9.41	$ 9.41	$ 9.41	$ 9.41	$ 9.41	$ 10.71	$ 10.71	$ 10.71	$ 10.71	$ 17.25	$ 17.25	$ 17.25	$ 17.25	$ 13.59	$ 13.59	$ 13.59
Town Hall, 2-3 Story	$ 21.79	$ 21.79	$ 21.79	$ 21.79	$ 21.79	$ 21.79	$ 21.79	$ 28.46	$ 28.46	$ 28.46	$ 28.46	$ 38.10	$ 38.10	$ 38.10	$ 38.10	$ 36.61	$ 36.61	$ 36.61
Office, 1 Story	$ 21.79	$ 21.79	$ 21.79	$ 21.79	$ 21.79	$ 21.79	$ 21.79	$ 28.46	$ 28.46	$ 28.46	$ 28.46	$ 38.10	$ 38.10	$ 38.10	$ 38.10	$ 36.61	$ 36.61	$ 36.61
Garage, Service Station	$ 5.45	$ 5.45	$ 5.45	$ 5.45	$ 5.45	$ 5.45	$ 5.45	$ 6.77	$ 6.77	$ 6.77	$ 6.77	$ 8.69	$ 8.69	$ 8.69	$ 8.69	$ 8.39	$ 8.39	$ 8.39
Church	$ 18.82	$ 18.82	$ 18.82	$ 18.82	$ 18.82	$ 18.82	$ 18.82	$ 21.60	$ 21.60	$ 21.60	$ 21.60	$ 35.50	$ 35.50	$ 35.50	$ 35.50	$ 27.72	$ 27.72	$ 27.72
Post Office	$ 21.79	$ 21.79	$ 21.79	$ 21.79	$ 21.79	$ 21.79	$ 21.79	$ 28.46	$ 28.46	$ 28.46	$ 28.46	$ 38.10	$ 38.10	$ 38.10	$ 38.10	$ 36.61	$ 36.61	$ 36.61
Office, 2-4 Story	$ 21.79	$ 21.79	$ 21.79	$ 21.79	$ 21.79	$ 21.79	$ 21.79	$ 28.46	$ 28.46	$ 28.46	$ 28.46	$ 38.10	$ 38.10	$ 38.10	$ 38.10	$ 36.61	$ 36.61	$ 36.61
School, Elementary	$ 16.60	$ 16.60	$ 16.60	$ 16.60	$ 16.60	$ 16.60	$ 16.60	$ 21.60	$ 21.60	$ 21.60	$ 21.60	$ 28.83	$ 28.83	$ 28.83	$ 28.83	$ 27.72	$ 27.72	$ 27.72
Factory, 1 Story	$ 4.52	$ 4.52	$ 4.52	$ 4.52	$ 4.52	$ 4.52	$ 4.52	$ 5.50	$ 5.50	$ 5.50	$ 5.50	$ 6.92	$ 6.92	$ 6.92	$ 6.92	$ 6.27	$ 6.27	$ 6.27
Community Center	$ 21.79	$ 21.79	$ 21.79	$ 21.79	$ 21.79	$ 21.79	$ 21.79	$ 28.46	$ 28.46	$ 28.46	$ 28.46	$ 38.10	$ 38.10	$ 38.10	$ 38.10	$ 36.61	$ 36.61	$ 36.61