aquifer recharge, alternative water supply, and water recycling projects, drought prevention, reduction, or mitigation projects, acquisition of property integral to the project or will mitigate the environmental impact of a project, a combination of projects secured by a common security pledge or submitted under one application by an SRF program.

- State Revolving Fund (SRF) loans - Florida's State Revolving Fund (SRF) is made up of three programs - Clean Water State Revolving Fund, Drinking Water State Revolving Fund, and State Revolving Fund Management. Both the Clean Water and the Drinking Water SRF Programs are funded through money received from federal grants as well as state contributions. These funds then "revolve" through the repayment of previous loans and interest earned. While these programs offer loans, grant-like funding is also available for qualified small, disadvantaged communities, which reduces the amount owed on loans by the percentage that the community qualifies. The Clean Water State Revolving Fund (CWSRF) Program provides low-interest loans to local governments to plan, design, and build or upgrade stormwater and nonpoint source pollution prevention projects. Discounted assistance (e.g., very low interest rates, grants, etc.) are available. Interest rates on loans are below market rates and vary based on the economic and financial ratings of the community.

3.4 Regulatory and Water Quality CIP Considerations

This section provides a summary of the City's water quality requirements and an analysis of the current and proposed (post-CIP) water quality treatment being provided.

3.4.1 BMP Treatment Train Concept for Stormwater Quality

A stormwater Best Management Practice (BMP) is a method or combination of methods found to be effective and feasible to prevent or reduce the amount of pollution generated by nonpoint sources to a level compatible with water quality goals or requirements.

BMPs are classified as:

1. Prevention - avoiding the generation of pollutants.
2. Reduction - reducing or redirecting of pollutants.
3. Treatment - capturing and treating pollutants.

Methods for controlling pollutants in stormwater runoff are further categorized as non-structural or structural BMPs and are often used in concert to control pollution in stormwater runoff.

- *Nonstructural BMPs* are practices that improve water quality by reducing the accumulation and generation of potential pollutants at or near their source and do not require physical construction of a facility but provide for the development of pollution control programs that include prevention, operations and maintenance, education, and regulation.
- *Structural BMPs* involve design and construction a facility for controlling quantity and quality of urban runoff. These structures treat runoff at either the point of generation or the

point of discharge and require routine maintenance such as retention/detention system, aquifer recharge systems, oil water separators, trash screens, and grit chambers.

The effective combination of both types of BMPs for stormwater management is known as a BMP treatment train. Each additive BMP provides additional benefit but at an added cost.

3.4.2 Pre/Post CIP Implementation Constraints

Stormwater runoff flows off the land areas into the City's rivers, canals, waterways, and ultimately into the ICW and to the Atlantic Ocean. For a capital improvement project or a program of projects such as this SWMP to be permittable for construction, the SFWMD through Broward County Surface Water Licensing Division requires an analysis demonstrating that there is no pre/post impact to the existing stages in the conveyance canals and waterways resulting from the CIP implementation for the protection of existing structures in the floodplain. Additionally, there are many parallel regulatory programs in place that govern stormwater discharge for the protection the receiving waters of stormwater runoff and any associated pollutant load from the City.

The City's current NPDES permit allows for municipal stormwater discharges as long as they meet applicable water quality standards and implement Best Management Practices (BMPs) that reduce pollutants to the "maximum extent practicable". In the State of Florida, the annual report is submitted to the Florida Department of Environmental Protection (FDEP) as this agency has delegated authority from the EPA to implement the program on their behalf.

The proposed CIP implementation will be restricted or governed by the City's ability to find a public and regulatory acceptable balance between reducing flooding in the City for its residents and the level of protection provided for water quality, while considering the associated additional costs of stormwater treatment. Due to the changing regulatory trend for stricter limitations for new discharges, the SWMP CIP Alternatives included the maximum amount of stormwater recharge/disposal and water quality treatment prior to discharge that could be implemented so that the City is prepared for the likely requirement to implement that regulatory scenario. The treatment systems can then be selectively eliminated during design if found to be cost prohibitive and if regulators can agree on a balanced approach between flood reduction and environmental protection.

Broward County SWLD also tends to enforce an arbitrary limit of 1 cfs/acre for pump station capacity. In low lying areas where the Broward County seawall ordinance is also in effect, this may not be achievable without flooding of property. Broward County will need to decide if a variance to this historic limitation will be granted or take on the liability of structural flooding due to competing requirements.

3.4.3 Stormwater Quality Impact Analysis

To evaluate compliance with water quality regulatory requirements, calculations were performed for each major basin citywide for three conditions: 1) Existing Conditions including near-term improvements which are in final design, permitting, or pending construction, 2) Alternative 1 LOS CIP, and 3) Alternative 2 LOS CIP. The evaluation included consideration of the following BMP stormwater quality treatment elements:

1. Swales
2. Exfiltration systems
3. Stormwater gravity wells
4. Stormwater Pumped recharge wells
5. Dry/wet retention/detention systems

It should be noted that the City standard SWPS design now includes an influent pollution control device (swirl separator, upstream oil-water separator and grit chamber or other), but no assigned credit is given for the additional mechanical water quality treatment from these devices.

By definition, retention stormwater BMPs hold or retain stormwater on a permanent basis, whereas detention BMPs are designed to temporarily store or detain water which eventually returns to the system. Each of these types of proposed facilities (based on the shallow aquifer disposal and treatment process), can be considered "retention" facilities for water quality treatment credits.

Regulatory Requirements

Regulatory requirements for Broward County / SFWMD include a treatment volume for wet detention that is the greater of either:

1. 1-inch over the full project area, or
2. 2.5 inches over the impervious area portion.

Based on current 2022 Florida Water Body Classification, there are no active specifically identified pollutants of concern for total maximum daily load (TMDL) limits for impaired receiving waterbodies nor any identified outstanding Florida waters (OFW) classifications within the City of Hollywood PSMS. Therefore, the calculated required treatment volumes currently have no additional regulatory multipliers.

Broward County has a delegation agreement with SFWMD requiring an Environmental Resource Permit (ERP) for projects with 10 acres of total land area and/or 2 acres of impervious surfaces (Environmental Resource Permit Application). An Environmental Review Approval is required prior to the issuance of a building permit by the County or any municipal building department. The Surface Water Management Program is responsible for licensing all construction of surface water management systems as required under Broward County Code of Ordinances (Code), Chapter 27, Article V, renewal of operation licenses, and certain environmental resource, wetland resource and surface water management. A Broward County Surface Water Management License is required prior to activities that alter the flow of surface water (i.e. construction of impervious surfaces, paving, grading, and drainage). Jurisdiction is the entire County excluding areas within the independent water control districts. As the program consists of many integrated projects of the next 20+ years, the County can issue a conceptual permit for the entire system CIP, and then issue individual permits to construct and operate as phased portions come on-line, if they are in accordance with the overall approved SWMP. If the model is kept up to date, it can continue to be used to demonstrate compliance for each phase of the CIP construction, with the overall conceptual ERP requirements.

Pre/Post CIP Water Quality Calculations Analysis and Summary

An analysis of the Citywide required water quality volume was performed based on the two regulatory wet detention volume requirement scenarios. With the exception of Hollywood Beach (which is an FDOT-owned and operated system discharging into the intracoastal waterway and is permitted directly through SFWMD separately by FDOT), the requirement of 2.5 inches over the impervious area was less than the 1 inch over the entire area requirement with non-parking structure roof areas removed, therefore, the three major watershed basins (East, Central and West Basins) all require a wet detention volume of 1” over total area and the Hollywood Beach Basin requires 2.5” over the impervious area resulting in 1.08” over the total area.

Existing (Pre-CIP) Conditions

The existing (pre-CIP project) water quality features primarily consist of exfiltration facilities and the series of pond and swale surface detention features within the City limits. The inventory of the existing detention/retention BMP operations was identified using the latest waterbody GIS shapefile. The coverage was further enhanced with additional detention/retention locations using satellite imagery and LiDAR-based digital elevation maps. Treatment volumes were calculated from initial and final modeled storage volumes from a water quality-based model simulation.

The SWMM model was run applying a water quality storm event with depth of 2.5 inches and duration of 6 hours.

- A depth of 2.5” was selected to ensure the model was consistent with a runoff volume of 2.5” over the impervious area or 1” over total area.
- Determination of the rainfall duration was a 2-step process.
    - A 75-year hourly rainfall record from the most complete data set of the nearest rain gage (Miami International Airport) was analyzed to define rainfall events based on a minimum dry period of 12 hours between events, and the rainfall depth and duration was calculated for each defined event. The analysis reveals that there were approximately 300 rainfall events of 2.5 inches or greater (4 per year) in the 75-year period, resulting in a return period of 3 months.
    - NOAA Atlas 14 rainfall duration and depth data were then used to evaluate an appropriate duration for the 2.5-inch event. As shown in **Figure 3-10**, rainfall depths were plotted against the log of the number of events per year, for return periods including the 10-year (log = -1), 5-year (log = -0.7), 2-year (log = -0.30) and 1-year (log = 0) return periods. An exponential regression curve was then plotted to estimate the corresponding rainfall depth for a 3-month return period (value of the exponential curve at log = 0.6). Data were evaluated for durations including 6, 12, and 24 hours. The 6-hour duration Atlas 14 data and exponential regression curve shown in Figure XXX results in the desired rainfall depth of 2.5 inches with a 3-month return interval (R^2

=0.998). The simulation duration was set to 12 hours to account for runoff time of concentration and drawdown impacts on the treatment volume.

- Water quality volume calculations for existing exfiltration trenches were performed using the appropriate rating curves used in the SWMM basin models to represent the existing exfiltration facilities. The provided water quality volume for an exfiltration facility was calculated as the one-hour flow volume based on flow (cfs) corresponding to a value of H = 3 feet from ground surface to water table/saturated soil conditions.
- The sum of the hourly flows (Q) (in cfs) for all exfiltration facilities was calculated and then converted to an hourly total flow volume as Total Q (cfs) * 3600 sec/hr/43,560 sqft/acre.

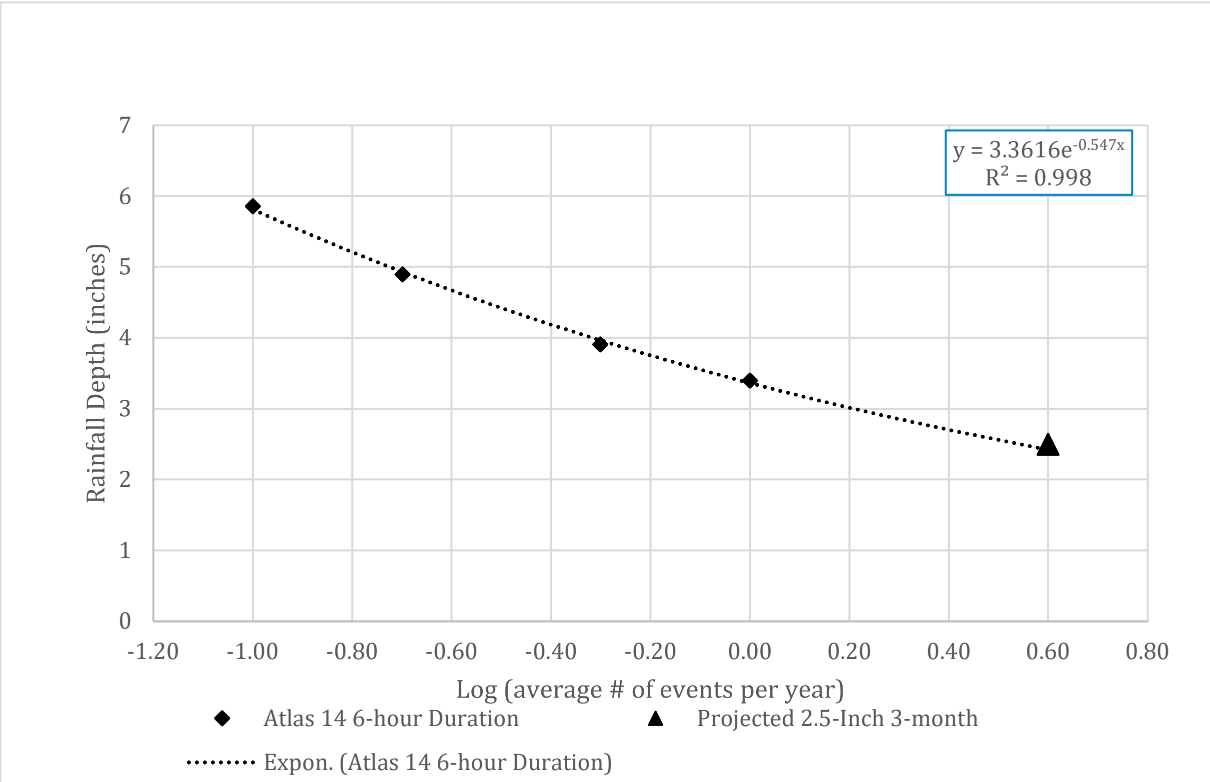


Figure 3-10 NOAA Atlas 14 Projected Return Interval for 2.5" 6-hr Storm Event at Gage MIA

Post-CIP Conditions

For Alternative 1 and Alternative 2, the provided water quality volume includes all existing facilities, the near-term proposed projects, and the recommended CIP. New CIP detention / retention improvements were calculated using the proposed pond dimensions as well as structure inverts. The resulting water quality treatment volume was then multiplied by the appropriate dry detention or retention multiplier (1.33 for dry detention, 2.0 for retention) to determine the equivalent wet detention water quality volume. The provided storage for new exfiltration facilities and gravity wells were calculated using the same methodology applied for existing exfiltration facilities. For proposed stormwater recharge / pumped recharge wells in the East and Central basins (locations of 10,000 TDS groundwater or greater), the SWMM basin models water quality simulations provided flow-based pumped recharge well (retention) time series. A volume multiplier of 2 was then used to determine equivalent wet detention water quality volume.

The provided water quality volume was totaled by model basin and on a Citywide basis and was then converted to an equivalent volume in terms of inches over total area for comparison to the required water quality volume of 1 and 1.08 inches over the total area.

Table 3-3 provides the results of the analysis. For each SWMM basin model, the table lists the total acreage, impervious acreage, and the provided equivalent wet detention water quality volume in terms of acre-feet and inches over the total area. The Citywide totals are also presented.

Table 3-3 Comparison of Required and Provided Water Quality Volume

Parameters	SWMM Basin Models				Citywide Totals
	Hollywood Beach	East Model (West of Intracoastal)	Central Model	West Model	
Area (acre)	656	5,584	9,802	5,332	21,374
Impervious Area (acre)	284	1,674	3,281	1,746	6,984
Existing Equivalent Wet Detention Water Quality Volume (acre-ft)	36.6	378.1	166.0	140.7	722
Alt 1 Total Equivalent Wet Detention Water Quality Volume (acre-ft)	36.6	876.6	1,782.7	802.9	3,499
Alt 2 Total Equivalent Wet Detention Water Quality Volume (acre-ft)	36.6	638.4	764.0	482.2	1,921
Existing Equivalent Wet Detention Water Quality Volume (inches over area)	0.67	0.81	0.20	0.32	0.41
Alt1 Equivalent Wet Detention Water Quality Volume (inches over area)	0.67	1.88	2.18	1.81	1.96
Alt 2 Equivalent Wet Detention Water Quality Volume (inches over area)	0.67	1.37	0.94	1.09	1.08
Required Equivalent Wet Detention Water Quality Volume (inches over area) *	1.08	1.00	1.00	1.00	1.00

*Hollywood Beach required volume of 2.5" over impervious area.

As shown, the water quality volume greatly increases with either CIP alternative over the existing conditions.

- On a citywide basis, the existing facilities result in a provided equivalent wet detention water quality volume of 0.41 inches over the total area, which is below the 1" over total area requirement.
- Both Alternatives 1 and 2 provide substantially greater water quality volume than required citywide, with 95 to 96 percent of the water quality volume provided by CIP exfiltration trenches and gravity wells and the remaining 4 to 5 percent provided by pumped recharge wells and retention/detention features. Basins that did not meet their individual required water quality volume are highlighted in bold italics.

Each project will need to provide water quality calculations showing compliance with the proposed masterplan values and any special conditions imposed by the conceptual ERP. This information will also be used by the City to supplement its on-going NPDES MS4 permit reporting process.

The CIP elements proposed add water quality treatment to a great extent inherently as part of their flood control function as it was demonstrated that the installation of the proposed system of Citywide exfiltration trenches and gravity wells alone will provide 573 to 1,332 acre-feet of water quality retention volume (based on Alternative 2 and Alternative 1, respectively) of additional water quality treatment volume beyond the existing condition, or 1,146 to 2,664 acre-feet of equivalent wet detention volume. The non-point source runoff that does eventually make its way to the canals and the Intracoastal Waterway will be greatly improved post-CIP. Enhanced operations and maintenance procedures for increased street sweeping, enhanced system cleaning, and the pollution control devices proposed at the existing and new SWPSs will also improve the water quality of the discharge from the existing outfalls greatly.

3.4.4 Pre/Post CIP Implementation Canal Stages and Flows Impact Analysis

The following approach was used to demonstrate the offsite impacts of the proposed CIP implementation for both alternatives. Boundary conditions are set at the ocean inlets and control gates, and the remaining PSMS channels, lakes, canals, conveyance ditches, and the intracoastal waterway are all explicitly modeled and vary with conditions. To simulate the movement of the overland flood water through the City, the model was created as a pseudo-2D analysis with extensive use of interlaced overland flow channels interconnecting the subcatchments to accurately represent the flow interaction and movement back and forth between all basins at varying elevations during the simulations.

To be permittable, projects may not adversely impact neighboring municipalities to protect the existing building properties from worsened flooding.

The City of Hollywood can be divided into multiple watersheds to ascertain these offsite impacts:

1. East Watershed - flows primarily into the Intracoastal Waterway (ICW)
2. West Watershed - flows into the canals of the Central Broward Water Control District in the north, and South Broward Drainage District to the South
3. Central Watershed - flows into the C-10 Canal and to a lesser extent into the C-11 Canal.

The Citywide model was run for the near-term scenario to establish a baseline for stages and flows into the discharge waterbodies. The near-term scenario represents existing conditions for most of the City, but also includes planned and permitted projects such as the additional of four FDOT pump stations on Hollywood beach, multiple smaller City drainage projects, and the Turnpike Conveyance Ditch improvements project.

The Alternative 1 and 2 models were subsequently run to simulate the 5-year and 10-year 24-hour; and the 25-year and 100-year 72-hour design storms with the same upstream inflow boundary conditions and downstream tailwater conditions. The 25-year 72-hour design storm was used to compare existing conditions to Alternative 1 and 2 CIP implementation modified flows to adjacent waterbodies in accordance with SFWMD requirements.

3.4.4.1 East Watershed Analysis

Due to the size and depth of the ICW, additional peak flows and/or total flow volumes are not expected to increase stages or otherwise adversely affect neighboring municipalities of Hallandale Beach, Dania Beach, or Fort Lauderdale. As of this writing, there are no known permitting issues for flows to the Intracoastal other than potential environmental requirements issues, which have been addressed as discussed previously. The peak stage in the ICW is predicted to be 0.02 ft higher in the 25-year storm within the City of Hollywood in Alternative 1 (there is no increase in Alternative 2). This increase, which is within the accuracy of the model, attenuates to 0 at the City boundaries; however, the model does not extend far enough into Hallandale Beach or Fort Lauderdale to accurately assess this value further.

The total number of pumped pumped recharge wells used to provide water quality in the east may be augmented to reduce flows to the ICW if this becomes necessary for future permitting.

3.4.4.2 West Watershed Analysis

For the West Watershed, the peak model stages and flows were compared at the model boundary at two significant locations:

1. The SBDD S-1 Canal (Model Node SBDD12, and Model Link SBDD12) just south of the intersection of Pines Boulevard and S. University Drive. This location is about one-half mile outside of the City Limit; however, it is the first point downstream of the confluence of the PSMS that could be affected by the proposed CIP Alternatives.

2. The CBWCD Canal (Model Node BC_CBDD_10, and Model Link BC_CBDD_10) just south of Stirling Road and east of N. University Drive, adjacent to the CBWCD pump station, downstream of their control structure. Again, this location is more than one-half mile outside of the City Limit; however, in this case it is both downstream of the CIP Alternatives within the City, and downstream of the proposed Alternative 1 pump station and detention pond.

Table 3-4 presents the peak stages, peak flows, and total flow volumes at these 2 locations, for the Near-Term Conditions, Alternative 1 and Alternative 2 models, for the 25-year 72-hour design storm. The results indicate that the peak stages and flows in the canals under the proposed alternative conditions remain the same or slightly less than the peak stages and flows under existing conditions. Though Alternative 1 does provide some pumped flows to the CBWCD PSMS, the extensive exfiltration systems offset these additional flows. Note that similar results were found for the other simulated storms; namely, that no adverse offsite impacts are expected to occur.

Table 3-4 Stage and Flow Comparisons for West Watershed: 25-year, 72-hour Design Storm

Node	Location	Stage (ft NAVD)			Peak Flow (cfs)			Total Flow Volume (acre-ft)		
		NT	Alt 1	Alt 2	NT	Alt 1	Alt 2	NT	Alt 1	Alt 2
SBDD12	Pines & University	5.53	5.39	5.44	226	191	200	763	601	615
BC_CBDD_10	Stirling & University	5.01	5.01	5.01	265	230	237	603	499	334

3.4.4.3 Central Watershed Analysis

The Central Watershed is characterized by flows to the Hollywood (C-10) Canal, C-10 Spur Canal, and the C-11 Canal, though relatively little of the City flows are tributary to the C-11 Canal. The C-11 Canal is known as the Dania Cutoff Canal east of the South River Canal where it cuts through the City. The Dania Cutoff Canal and the Hollywood Canal converge in Dania Beach to form the lower reach of the Dania Cutoff Canal which flows to the ICW. For consistency, seawalls in Broward County, including Dania Beach, have been raised to an elevation of 5 ft-NAVD, matching the same seawall height in the City of Hollywood and to meet the Broward County Ordinance concerning future seawall heights. By raising seawall elevations, portions of the existing floodplains for the Dania Cutoff and Hollywood Canals are removed in the future from the canal's natural floodplain, which increases stages in these canals, as that storage is no longer available to the canal. However, the seawalls also reduce peak flow to the canals from the other areas in the larger storms, as they do within the City, as overland sheetflow is cutoff and trapped behind the seawall. It is beyond the scope of this project to determine how other municipalities in Broward County will address this situation as they meet the seawall ordinance; therefore, the seawalls have been raised but no other changes made to the offsite portions of the model. Since the addition of seawalls can increase stages, the pre-post analysis for the Central Basin Canals will consist primarily for flows out of the City.

For the Central Model, peak stages and flows were compared at the City boundary at two locations, as well as at the downstream end of the Dania Cutoff Canal:

1. The Hollywood (C-10) Canal (Model Node BC_CHC98309, and Model Link BC_CHC98309) just north of the Stirling Road Bridge across the canal. This location is a few hundred feet downstream of the City Limit; however, it is the first point downstream of the confluence of the PSMS that may be affected by the CIP Alternatives.

2. The Dania Cutoff (C-11) Canal (Model Node AL_CDCO98235, and Model Link AL_CDCO98235) about one-quarter mile east of the SW 30th Avenue Bridge, at the edge of the City Boundary.

3. The Dania Cutoff (C-11) Canal (Model Node BC_CDCO98201, and Model Link BC_CDCO98201) immediately upstream of the outfall to the ICW.

Table 3-5 presents the peak stages, peak flows, and total flow volumes at these 3 locations, for the Near-Term Conditions, Alternative 1 and Alternative 2 models, for the 25-year 72-hour design storm.

Table 3-5 Stage and Flow Comparisons for Central Watershed: 25-year, 72-hour Design Storm

Node	Location	Stage (ft NAVD)			Peak Flow (cfs)			Total Volume (1000 acre-ft)		
		NT	Alt 1	Alt 2	NT	Alt 1	Alt 2	NT	Alt 1	Alt 2
BC_CDCO98201	Stirling Rd @ C-10	4.09	4.20	4.15	2,370	2,550	2,370	4.3	4.5	4.3
AL_CDCO98235	City Bound. @ C-11	4.26	4.24	4.25	1,820	1,820	1,820	6.6	6.6	6.6
BC_CHC98309	Mouth of DC Canal	2.61	2.60	2.60	7,770	6,650	6,810	13.5	13.3	13.2

The results indicate that the peak flows in the canals under the proposed alternative conditions remain the same or slightly less than the peak flows Citywide under existing conditions for

CDM Smith

Alternative 2. Though both alternatives provide pump stations which add flows to the canals, the extensive exfiltration systems, as well as the pumped recharge into the Biscayne Aquifer east of the salinity barrier offset these additional flows.

The additional flows in Alternative 1 at Stirling Road, where the flows leave the City are not significantly mitigated by these measures, and therefore it is unlikely that Alternative 1 is permittable in the Central Watershed, though it remains a viable option both in the East and West Watersheds. If the City chooses to seek the Alternative 1 solution, additional detention storage and/or additional pumped exfiltration to the aquifer may be necessary to meet permittable flows. This will likely erode the benefit-cost ratio, though it should remain well above 1.

3.4.4.4 Pre-post CIP Flows and Stages Analysis Summary

As discussed above, the raised seawalls in Broward County outside the City limits affect the peak stages in the Canals at the City Boundary, particularly in the Hollywood Canal at Stirling Road. Though the peak stage rises only up to 0.1 ft in Alternative 1, the peak is well under the seawall elevation even for the 100-year design storm. It is unlikely that the CIP alternatives would increase flood levels outside the City Boundary for either alternative. As discussed above, anticipating the implementation of the Broward County Ordinance for seawall heights for areas of the County outside the City limits makes it difficult to confirm this until other areas develop their stormwater plans.

3.4.5 Maintaining Existing Historic Flow Paths

3.4.5.1 Stormwater Runoff Flow Paths

The City's stormwater system topographically and physically connects to many tributary areas outside of the City's limits that contribute to the flow of stormwater through the City's system. These connections are considered to be "historic" flow paths, and by regulation, cannot be severed or diverted due to the possibility of moving or exacerbating flooding elsewhere, and are inherently accounted for along with the City's runoff as contributing flow from the City into the receiving waters. The stormwater model accounts for these historic flow paths in both the extended area boundary conditions and piped system connections, in particular, Hallandale Beach's PSMS south of Moffett Street and east of Federal Highway.

Peak model stages were compared at critical locations outside the City Boundary to show that the City's CIP Alternatives will both continue the historic flow paths across the City Boundaries, but also actually reduce flooding in some offsite areas as well. Note that the previous section showed a reduction in peak stage in both the CBWCD PSMS and the SBDD PSMS, thus those neighborhood are not repeated here.

1. Pond north of Stirling Road and east of Park Road in Dania Beach (Model Node BC_AGE999632). This location represents and outfall from the FDOT PSMS which primarily serves Stirling Road, including portions of both the City of Hollywood and the City of Dania Beach.

2. Sheridan Road immediately north of the City Boundary (Model Node BC_NID10043). This node is representing the intersection at SE 5th Street in Dania Beach, but multiple nodes in this neighborhood show similar results.

3. Hallandale Beach at the intersection of NE 12th Avenue and NE 10th Street (Model Node HA_NE04C102), which represents multiple intersections south of Moffett Street, north of Atlantic Shores Boulevard and east of Federal Highway in Hallandale Beach.

Table 3-6 presents the peak stages at these 3 locations, for the Near-Term Conditions, Alternative 1 and Alternative 2 models, for the 25-year 72-hour design storm.

Table 3-6 Stage Comparisons for Outside Municipalities: 25-year, 72-hour Storm

Node	Location	Stage (ft NAVD)		
		NT	Alt 1	Alt 2
BC_AGE999632	Dania Bch: Stirling Rd & Park	4.99	3.11	3.13
BC_NID10043	Dania Bch: Sheridan & SE 5th	4.70	4.64	4.68
BC_CHC98309	Mouth of DC Canal	3.75	3.43	3.46

Additional Items of note:

1. There are three existing ponds north of Stirling Road in the City of Dania Beach in Ravenswood Estates which the FDOT's PSMS outfalls into (located east and west of Park Road). The proposed CIP pump stations will draw down these ponds prior to the onset of the storm, which creates excess capacity in the lakes. However, since these ponds are outside the City, no attempt has been made to utilize this excess capacity in the alternatives by incorporating these ponds in some manner with additional connected piping. It would be beneficial for the City to involve both the City of Dania Beach and FDOT in a partnership to use this excess capacity in the shard lakes to further improve flooding in the area for all three entities. This will result in a further reduction/attenuation of peak flows into the Hollywood Canal, which will help with some of the peak flow issues noted in the previous section.

2. The City of Hollywood has already started discussions with the City of Hallandale Beach regarding partnership in resolving flooding issues near Moffett Street, east of Federal Highway as the City's proposed infrastructure also greatly assists the Hallandale Beach LOS due to the area's topography. The reductions provided in Table 3-5 may be significantly improved if the PSMS in Halladale Beach runoff was also directed to the proposed City SWPS and the SWPS capacity were to be increased.

3. The area of Boulevard Heights in west Hollywood is problematic to address as the drainage area falls under the jurisdiction of SBDD. Initial discussions with the SBDD indicated that no additional flow could be sent west through their system as it was at capacity and limited due to their permitted discharge with SFWMD. This resulted in the SWMP-proposed CIP pumping with a large capacity SWPS many miles to the east to the Orangebrook GC to meet the desired LOS. A parallel analysis in the SWMP model analysis revealed the existence of several culvert bottlenecks in the SBDD secondary canal and S-1 canal serving this area that, if removed, will allow a portion of the stormwater to flow to the west through the SBDD system by gravity and not impact stages in other areas of their system. The existing flooding in the City of Pembroke Pines which is adjacent just to the west of this neighborhood benefits greatly from these improvements as well. It would be beneficial for the City to engage in a joint project with the

SBDD and Pembroke Pines to implement this CIP which would further reduce the Hollywood SWMP CIP for the area.

3.5 Increased System Operation and Maintenance Program

As part of the CIP, continuous cleaning and maintenance of the City's stormwater assets is a vital component in maintaining the desired LOS and to minimize the amount of time standing water takes to disperse after a storm, especially as the number of assets to be maintain begin to expand with the CIP implementation.

3.5.1 System Debris Cleaning

In South Florida, sand and debris are constantly entering the system at the catch basins, and without proper and regular maintenance, the debris begins to flow through storm sewer pipes which then empty into the receiving water canals, allowing pollutants and unsuitable material into the water system, or clog the system reducing its intended performance. Eventually, debris settlement within the catch basins and pipes forms flow restrictions and bottlenecks and reduces the capacity of the system, resulting in backups and exacerbated flooding on the surface streets, even though the proper size and quantity of pipes are in place underground. Stormwater system pipe maintenance is typically accomplished using a high-pressure water jet to break up the material in the pipes and a high-capacity flush and vacuum hose to capture it for disposal in a tank truck. Many municipalities contract these services out to vendors.

After an initial thorough cleaning of the full system within a two-year period, the City should:

- Set a goal of continuing to complete the entire system's cleaning approximately every 2-years in a continuous cycle tracked in the GIS or asset management system.
- The system should then be evaluated the during that 2-year cycle for re-current hot spots for maintenance and optimized in the third cycle based on the collected data.
- Operations staff and equipment should be increased accordingly such that it does not become the bottleneck to the process.
- As CIP areas are completed and new collection pipe mileage is added, the City will need to budget for additional cleaning equipment and staff (or additional contract maintenance) to keep the system performing at its design capacity. Staff workshops should be held annually to discuss shortfalls in equipment and personnel skillset and budgeted for appropriately from SWU revenue funds.
- By tracking expenditures and assigning a performance metric to the level of service being provided and extrapolating the cost out to the new CIP areas, the portion of the SWU dedicated to O&M can be calculated and rates adjusted as necessary to meet the future anticipated expenditures.

A second type of debris clogging occurs at the at-grade surface inlets. Floating vegetation such as leaves and other floatable trash flows to the inlets with the first flush and can physically form a tight layer on top of the grate as it accumulates and get compressed by the pressure of the water above, tightening the blockage and hampering the flow of stormwater into the catch basin.

Currently City O&M dispatches staff to rake and remove the debris off the inlets in the known worst areas and re-establish the flow into the system. Some municipalities have had limited success by enforcing leaf blowing into the streets by landscape companies, but the natural leaf fall in certain areas may counteract any benefit. Public education to report the blockage is also important. There are vendors which provide products consisting of fabrics, inserts, and extended grates, which may help, but all require continual maintenance as well.

3.5.2 Outfall and Backflow Prevention Device Maintenance

Importantly, the outfalls and new outfalls will need to have backflow prevention equipment which must be maintained in working order to prevent tidal flooding. Areas where the tide or groundwater appears to be bypassing the BFPs should be checked for cracks/leaks and infiltration and sealed or lined and a regular schedule for maintenance implemented to ensure a tight seal in the BFPs before king tide season. A parallel tidal flooding investigation during the SWMP revealed that the Wapro WaStop™ BFPs are currently outperforming other types of devices. The investigation also revealed that the existing units are installed in a manner that make them difficult to access and maintain (many locations are installed in the center of pipes and not installed on the upstream accessible end). The recommendation was made to create a City standard detail for the BFP installation based on the manufacturer's recommendations to be used on all new installations and to begin a retrofit program to replace the existing installations.

3.5.3 Maintenance Tracking

The maintenance progress and other maintenance data should be tracked within the GIS and linked to the City's workorder or CMOM asset database system, analyzed, and adjusted in frequency based on the results of recurrence in hot spots around the City. Past records which state vague information on the type of service call such as the generic "stormwater system problem" with no further detail or exact location should be improved going forward with dropdown lists for more descriptive issues and resolutions so that system maintenance patterns and trends can be established, categorized, and proactively predicted and addressed, rather than reactively resolved as is currently occurring.

3.5.4 Code Enforcement

Systems near construction sites are particularly vulnerable and all construction project's Stormwater Pollution Prevention Plan (SWPPP) should be strictly enforced. It is likely that areas of the City will see an immediate impact in improved water quality, reduced flooding, reduced duration of standing water, especially in the more frequent nuisance thunderstorms, from proactive system maintenance. Non-structural BMPs also fall under this maintenance program such as street sweeping, catch basin grate clearing, pump station inspections, and spot repairs to cracks and leaks in pipes. The City should evaluate its practices recurrently for conformance to recommended best practices published by EPA, SFWMD, Broward County, and FDEP as these are updated regularly.

The City's Pump station pollution control devices and other system settling chambers should be cleaned annually at a minimum and before the rainy season, so the first large storm does not result in a reportable plume of debris that accumulated over the dry season to be released into the receiving waters.

New development or redevelopment filling-in of the flood plain without providing offsetting directly connected compensating storage and maintaining existing flow paths should not be allowed to occur. Occasionally, a situation arises where the BC SWLD grants a construction permit based on the calculations demonstrating no impact; however, now that the City has the Citywide model, regional impacts of development can be analyzed to reveal impacts which may not have been evident at the limited scale of the permit application. The City should perform model runs under existing and future CIP scenarios to check for compliance and infrastructure sizing consistent with the SWMP.

3.5.5 Stormwater Design Standards

As more stormwater pump stations begin to come online, the City should standardize the pump stations layout, materials, and equipment for ease of maintenance and minimizing warehousing of spare parts. This includes developing:

- Standard layouts for different categories of SWPSs – below ground duplex and triplex submersible, and both a medium and a large above ground axial flow type station
- Standards for stormwater pumps, motors, valves, weirs/gates, electrical and standby power equipment, controls and instrumentation, SCADA system, discharge energy dissipation and outfall scour, and pollution control device
- Standard for outfall backflow preventers and installation

Workshops should be held with O&M Staff to understand maintenance issues and other modifications to make their jobs more efficient or safer.

Stormwater Pump Stations

The City's SWPSs capacities and types vary based on the service area and level of service provided. All stations should have a similar basic process schematic as shown in **Figure 3-11**. Each element is discussed in further detail below:

Figure 3-11 Process Schematic of City SWPSs

<u>Basic Operation</u>

The stormwater pump stations collect rainwater runoff in their wetwells from the street-level inlets and the storm sewer piping. The pump station works by imparting energy into the hydraulic system using a rotating element (impeller) to push large volumes water out and away from the lower-lying areas through a discharge piping system to an outfall at ground level. The flood stages upstream of the stations are thus lowered and these land areas are able to be drained where stormwater would otherwise accumulate and be trapped resulting in flooding. The pumps are triggered to operate when the water level in the wetwell rises to a pre-determined level by mechanical instruments such as floats or electronically by level transducers. If equipped, additional pumps are called to duty if the water level continues to rise. Falling water levels turn off the pumps in the opposite manner. The levels must be meticulously set to avoid continuously pumping ground water which rises and falls with tidal influence. Stormwater pumps in Hollywood are usually higher-volume, lower-head units as they need to keep up with the high inflow at the peak of the storm, but usually only need to pump to a nearby gravity outfall at the lower head tidal tailwater elevation, thus mainly overcoming the line losses in the run of pipe. One way check valves on the station discharge piping prevents the stormwater or tide on the discharge side from flowing back into the station.

Pollution Control Devices (PCDs)

Two types of PCDs are normally used in stormwater pumping systems:

- At the submersible-type pump stations, the stormwater first passes through a hydrodynamic vortex separator that captures sediments, oil, trash, and floatables. Neighboring Cities have standardized on the Downstream Defender™ device manufactured by Hydro International for their submersible SWPSs. According to manufacturer's literature, stormwater runoff is introduced tangentially into the side of the precast vortex chamber to establish rotational flow. A cylindrical baffle with an inner center shaft creates an outer and inner spiraling column of flow creating residence time for pollutant travel between the inlet and outlet. Oil, trash, and other floating pollutants are captured and stored on the surface of the outer spiraling column. Low energy vortex motion then directs sediment into the protected sump region. After following the three-dimensional flow path, the treated stormwater is discharged from the outlet pipe. The unit is pre-cast, is available in several sizes for varying flow rates, and can be set up in a variety of influent connection configurations to adapt to the site piping. At the stations visited the units were working well and appeared to be capturing trash and other pollutants as intended. Operators stated that they clean the unit with a vactor truck approximately annually and they remove significant amounts of pollution from the stormwater stream.

- A second type of pollution control device in the system can be installed upstream of the larger, above ground pump stations, further out in the system. The product used by neighboriung Cities is the EcoVault™ by EcoSense International. This unit is a precast concrete stormwater treatment structure (below ground rectangular tank) that the manufacturer's literature states will remove sediment, nutrients, trash, metals, oil and grease and organics. The box is a system of in-line chambers in series with debris screens, ported baffles walls, and a fats/oil/grease (FOG) oleophilic material filter unit. The removal mechanism relies on physically slowing the flow's velocity to facilitate settling and baffles impeding forward movement of settling particles, and debris screens to remove trash and leaves out of the water to greatly reduce decomposition. These units are also serviced by a vactor trucks annually accessed through multiple top hatches.

Bar Screens

Two types of screening devices are used in the stormwater pumping systems:

- The stormwater at the submersible type stations enters a vault (or in some cases a common, split wetwell) which contains a bar screen or weir which further captures debris and trash that might damage or clog the pumps. These screens are cleaned manually and the contents properly disposed of on a regular basis. The accumulation of trash over time on the bar screens can result in clogging and head losses sufficient to result in exacerbated flooding upstream if not maintained. The bar screens are accesses by opening the at-grade hatches and have lifting hooks on them for removal by a crane if necessary.

- The larger pump stations usually have mechanical bar screens located in separate areas of the building as they are designed to remove larger heavier amounts of accumulated trash. The units installed by neighboring Cities are Infilco Degremont Climber Screens™ which operate by a large integrated rake which is mechanically lowered into the influent channel bar screen chamber by manually operating a switch at the rake control panel. The rake captures the trash against the rack, dewatering as it rises, and lifts the debris up and out of the channel into a hopper for disposal. The mechanical screening devices usually have a station influent isolation gate ahead of them to stop the flow into the station during maintenance.

Pumps

Two types of pumping units are used in stormwater pumping stations:

- The pumps in the submersible stations in neighboring Cities are generally Flygt or Ebara municipal-duty vertically configured submersible pumps and range in size depending on the station capacity being achieved. Most are mounted on an integrated rail system for removal, but some are inserted into a partially open metal can guide with a lifting hook for a crane.

- The pumps in the large stations are below-base discharge, high-flow, low-head, mixed-flow or axial pumps, each with a vertical motor. The motors are installed on pump baseplates mounted on concrete beams in the motor room and the rest of the pumps and intakes are mounted below in the drywell/wetwell.

Controls

- The (lead) pumps in all of the stations are currently activated based on a rising level of stormwater entering the station wetwell. Most have a simple float system for water level sensing and pump activation signaling. Continued rise in wetwell level activates higher mounted floats for additional (lag) pumps, and the pumps shut off in reverse sequence when the water level drops below the low-level set points. There is no supervisory reporting or remote control (SCADA) to a common control room, nor data communications at the stations, only local or manual control loops.

Station Power

- All stations operate on electrical grid primary power.

- The larger stations should have a dedicated FP&L transformer vault on the site. A standby power source (generator with fuel tank) is needed and connected to the electrical controls to allow the station to automatically operate on generated standby power during a power outage.

- The smaller stations should have a battery backup to keep the station controls operating for a while without activating the generator until the pumps are needed which avoids unnecessary starts of the generator and improves the noise emissions from the stations in the neighborhoods. Some stations can have a diesel driven pump in place as an alternate.

Forcemain, Discharge Piping, Weir Boxes, and Valves

- The pumps discharge through pressurized pipe (forcemain) to either pumped recharge wells, to free outfalls at the receiving waters (i.e., canal, lake, ICW), to a gravity pipe system, to a weir box, or to a combination. An automatic one-way valve (check valve) is installed on each pump forcemain discharge to prevent water downstream from a higher elevation at the outfall from flowing back through the pumps and flooding the station or its tributary collection area. The smaller submersible stations will have an underground valve vault with access hatches which contains the discharge appurtenances whereas the larger stations have discharge flow control gates in flow chamber boxes or inside the stations.

- The gravity outfall pipes should all be fitted with a backflow prevention device (usually manufactured by WAPRO™) which opens under normal flow out and closes under hydraulic backpressure at high tides to prevent the back flow into the system.

3.5.6 O&M Plan Creation

The SFWMD BMP Manual for South Florida Urban Stormwater Management Systems publishes empirical values that can be used to estimate "typical" O&M costs by BMP type. As each municipality is different, a more robust way to determine O&M costs is an analysis of the existing expenditures on O&M for stormwater over several years, identifying gaps and needs, and extrapolating out to the current ideal necessary budget and for the expanded future estimate.

An operation and maintenance (O&M) plan includes basic elements such as:

1. Identification of the parties responsible for maintenance
2. Maintenance schedules
3. Inspection requirements
4. Frequency of inspections
5. Easements or covenants for maintenance
6. Cost tracking
7. Equipment and tool purchase and maintenance
8. Staffing needs
9. Identification of a funding source
10. Description of basic maintenance activities:

- *Weeding, mulching, mowing, trimming of shrubs and trees, replanting*
- *Sediment, trash, and debris removal from inlets, grates, pipes, ditches, channels, and ponds – by dredging, jetting, vactoring, raking, and marine growth removal*
- *Inlet/outlet cleaning*
- *Outfall BFP cleaning*
- *Pump station maintenance – mechanical, electrical, hvac, automation, structural*
- *Gate and valve exercise*
- *Street Sweeping*
- *Swale restoration*
- *Erosion control*

3.5.7 SWMP Model Verifications to Detect Maintenance Issues

As was performed during the SWMP model verification process several times, the model should continue to be used to simulate known large rainfall events and compared with photographic data of actual flooding in the neighborhoods to disseminate between lack of required or under capacity infrastructure versus the existence of system blockages where capacity should be sufficient in the existing system. Follow-up with CCTV to pinpoint the blockages will be required in these areas.

3.6 CIP Budgetary Planning-Level Costs

The following sections describe the development of the budgetary costs and the analysis for the CIP.

3.6.1 Planning-Level Conceptual Cost Definitions

Planning-level conceptual costs are used to estimate needs for implementation fiscal planning, financing of capital improvements, and performing cost benefit analyses. At the conceptual, master-planning level, an ASCE Class 4 Estimate is appropriate for concept screening, feasibility, and study. Class 4 estimates are prepared for further detailed strategic planning, business development, project screening at more developed stages, alternative scheme analysis, confirmation of economic and/or technical feasibility, and preliminary budget approval or approval to proceed to next phases. At the SWMP 10% level of design concept completeness, the conceptual costs factor in information on system capacity through models and specific initial needs of equipment and materials and can be expected to be -30% to +50% range in variation.

CIP elements were extracted from the model alternatives, assigned to the CIP areas for accounting purposes, translated into tables of specific quantities, assigned appropriate unit costs, and totaled by CIP element type, CIP area, major drainage basin, and summed city wide. Historical design project records for past projects performed for or in the City of Hollywood by the City were reviewed and average unit costs were identified for each system component in the CIP alternatives. In addition, other public record construction estimates from recent projects within the South Florida area. Unit cost prices evaluated from previous projects were adjusted to incorporate escalation costs due to inflation and lapses in time from construction. Average unit costs from the Florida Department of Transportation (FDOT) were also evaluated and incorporated to into the estimates. A blended unit cost was estimated for each system item identified in each subbasin and applied times the total number of quantities identified per item. Each component is discussed further below.

Pump Stations

At the planning level of detail, pump stations were modeled in four discrete increasing size ranges from a small residential neighborhood station to a major metropolitan industrial facility based on need and constraints of location. Flow capacity categories were assumed by availability of electrical power, site access, land use type, and site footprint. City-owned properties, vacant lands, medians, cul-de-sacs, parks, parking lots, and other rights-of-way were used for the initial siting of the facilities in the model thus the cost estimates do not explicitly include the cost of land acquisition if necessary. **Table 3-7** provides the general characteristics of the stormwater pump station Types I through IV and the conceptual unit costs used for each size. Pump station planning level costs include items such as: influent control box, pollution control device, wetwell, pumps, motors, instrumentation and controls, connection to existing SCADA system, discharge header, valves, generator, fuel system, effluent box, sitework, and above ground structures.

Table 3-7 Standardized Stormwater Pump Station Sizes

Location / Land Use	Pump Station Type	Approx. Max Station Flow		Approx. Total Station Power	Budgetary Planning Cost
		(cfs)	(gpm)	(hp)	($)
Small SF Residential Community	I	166	81,000	400	$2.4M
Large Multi Residential Community	II	246	120,000	785	$3.5M
Larger Mixed Commercial	III	328	160,000	1,250	$4.9M
Metropolitan/Industrial	IV	410	200,000	1,800	$6.75M
Regional Canal Structure	V	660+	200,000+	2,000+	$9M

Force Mains and Pumped recharge Wells

The proposed CIPs require a network of new force mains ranging in size from 24-inch diameter to twin 72-inch diameter equivalent or larger to handle the discharge from the pump stations. The total linear footage for each diameter section of force main pipe is identified in the cost estimate tables in separate line items. A unit cost per linear foot of pipe is provided for each diameter section and was established based on reviewed of historical bid data, FDOT index pricing for South Florida, and a review of private and public projects within tri-County area. Unit cost prices evaluated from previous projects were attempted to be adjusted to incorporate escalation costs due to inflation and laps in time from construction. Excavation, backfill, and trench restoration were included within the unit cost price provided. Contingencies are added to cover fittings, appurtenances, valves, weirs, etc.

Recharge well conceptual costs were estimated for standard 24-inch casing for both inline wells (directly connection beneath the force main spaced at regular intervals along the route) and offline wells (remote clusters of wellfields located in City parks and other City lands away from the force main) drilled to an average depth of 120 feet.

Exfiltration Systems, Gravity Storm Sewer Piping, Gravity Wells, and Structures

The proposed CIPs require a network of new gravity mains ranging in size from 12-inch diameter to 96-inch diameter including elliptical and box culvert stormwater pipes of several sizes. The total linear footage for each pipe section of gravity main is identified in the conceptual cost tables in separate line items. A unit cost per linear foot of pipe for each diameter section was established based on review of historical bid data, FDOT index pricing for South Florida, as well as the review of other private and public projects within the tri-County area. Unit cost prices evaluated from previous projects were attempted to be adjusted to incorporate escalation costs due to inflation and lapse in time from construction. Excavation, backfill, and trench restoration were included within the unit cost price provided.

Gravity wells costs were estimated for a 24-inch casing to a total depth of 120 feet including the open hole section. A unit cost per feet of well depth was established utilizing the same procedure describe above.

Quantities for catch basin inlets and manholes were estimated based on the average density expected and total linear feet of gravity main using an average separation distance of 300 feet for manholes and 400 feet for inlets on both sides of the gravity mains. A uniform unit cost was assigned to each structure utilizing an extrapolation estimate for different type of structures and sizes.

Pavement and Roadway Restoration

The installation of most of the proposed stormwater drainage system components will have a significant effect on the existing roads and utilities within the rights-of -way (ROWs). The total impact on existing utilities and the potential for relocation is not fully considered by this cost estimate, since these are unknown, and are captured by contingency. The conceptual estimate considers that the full right of way to right of way existing pavement within affected work areas will have to be restored. The total area in square yards (sq. yd.) of affected roads was estimated and a general unit cost price was assigned for road restoration. The unit cost prices given above for each section of the stormwater drainage system accounts for trench restoration. The unit cost given under the section of “Pavement Restoration” accounts for the milling, resurfacing and pavement markings of all existing pavement within the work area and well as minor read base rework and minor utility adjustments.

Design, Inspection, General Conditions, and Contingency

City and Contractor general conditions allowances were added to the total cost to accommodate soft cost expenses associate with typical construction projects. At this level of estimate, general condition cost was estimated as a function of percent based on the total estimated construction cost (hard cost). Line items were added to the total cost per basin for design, mobilization, inspections, contractor’s general conditions, permit fees and internal capital improvements management fees. Finally, a 30% contingency line item was added, based on the total construction cost to account for the conceptual estimate and unknowns at this early 10% planning level.

3.6.2 Alternatives CIP Planning-Level Cost Summary

Table 3-8 provides the conceptual cost for the Primary LOS Alternative 1 and Secondary Alternative 2 by CIP Area. As shown, Alternative 2 totals in the range of $890M and is approximately half the cost of Alternative 1 at $1.9B.

Appendix A provided a graphical representation of the full CIP implementation citywide for each alternative atlas format. This atlas provides the CIP components locations as laid out within each CIP Area for a Citywide perspective, and not by individual project area which overlaps several CIP areas.

3.6.3 CIP Program Benefit-Cost Analyses

Introduction

A benefit-cost ratio (BCR) analysis is defined as the process used to measure the benefits of a decision or action subtracted from the costs associated with taking that action. BCR involves measurable financial metrics such as revenue earned, or costs saved as a result of the decision to pursue a project. As applied to a stormwater master plan, the cost of the existing conditions flood damages is compared to the predicted cost of the reduced flood damages resulting from the installation of the CIP for the chosen LOS.

Complex interconnected stormwater management systems such as the City's typically exhibit a diminishing point of return where adding more capacity or larger infrastructure begins to show less incremental reduction in flooding, and the costs become exponentially more expensive for little additional gain in the level of service. Each CIP area was optimized for the infrastructure proposed to discover the diminishing point of return and not exceed it – optimizing the total length of exfiltration systems, pump station capacities, and pipe diameters proposed.

For the City's proposed Citywide stormwater CIP Program, a BCR analysis was performed to compare the estimated potential losses from existing flooding scenarios to the cost of implementing the stormwater management infrastructure required to mitigate those losses. If the resultant cost following the installation of the improvements proves to be less than to the cost of the estimated damages of doing nothing, the project is considered economically justifiable, and the BCR will show the return on investment for every dollar spent.

Methodology

As a complement to the engineering evaluation and budgetary estimates described in the previous sections, the long-term economic loss associated with flooding in the City was analyzed. FEMA has developed a specific tool for estimating economic losses associated with natural risks including flooding. FEMA's HAZards United States (HAZUS) tool was designed to produce loss estimates for use by federal, state, regional and local governments and private enterprises in planning for risk mitigation, emergency preparedness, response and recovery. The FEMA HAZUS model was developed for major disaster analysis such as earthquakes, floods, and windstorm. By using this tool to analyze the SWMP results, the City will benefit in the coordination of future activities related to flood proofing, grant assistance, and management of repetitive loss properties.

Table 3-8 Planning-Level Cost Summary for Alternatives 1 and 2

DISTRICT	CIP AREA NAME	NEIGHBORHOOD	ALT 1 PLANNING-LEVEL COST ($)	ALT 2 PLANNING-LEVEL COST ($)
1	HE-D1-1	North Beach and South Central Beach	$35.88	$26.87
1	HE-D1-2	South Central Beach	$38.06	$25.29
1	HE-D1-3	Hollywood Lakes South	$48.80	$16.89
1	HE-D1-4	Hollywood Lakes - South Lake	$64.30	$31.06
1	HE-D1-5	Hollywood Lakes - Central	$65.35	$30.43
1	HE-D1-6	Hollywood Lakes - North Lake	$68.53	$38.33
1	HE-D1-7	Hollywood Lakes North	$50.13	$26.84
		Subtotal D1	***$371.04***	***$195.72***
2	HC-D2-6	Highland Gardens	$30.00	$3.69
2	HC-D2-1	Liberia	$42.04	$27.05
2	HE-D2-2	North Central - East	$11.61	$4.31
2	HE-D2-3	Royal Poinciana	$80.27	$34.98
2	HE-D2-4	Highland Gardens East	$41.81	$9.35
2	HE-D2-5	Parkside	$35.75	$18.32
		Subtotal D2	***$241.48***	***$97.71***
3	HC-D3-5	Hollywood Hills North	$92.77	$19.89
3	HC-D3-6	Hollywood Hills North Central	$49.31	$7.35
3	HC-D3-7	Hollywood Hills South Central	$33.27	$15.65
3	HC-D3-3, 4	Parkeast North	$73.75	$48.96
3	HC-D3-2	North Cental South	$46.28	$18.36
3	HC-D3-1	North Cental North / Parkeast	$79.52	$42.35
		Subtotal D3	***$374.90***	***$152.55***
4	HW-D4-9	Driftwood	$100.50	$58.63
4	HW-D4-8	441 Cooridor Central / Hollywood Gardens West	$43.89	$28.54
4	HW-D4-7	Playland / 441 Corridor North	$19.62	$12.73
4	HC-D4-4	Alandco	$0.00	$0.00
4	HC-D4-5	Oakridge / Mapleridge	$1.76	$1.33
4	HC-D4-6	Emerald Hills / Playland / 441 Corridor Central / Hollywood Hills	$30.17	$18.41
4	HC-D4-3	Emerald Hills / Stirling Commercial District	$33.58	$18.98
4	HC-D4-2	Emerald Hills / TY Park	$25.11	$15.56
4	HC-D4-1	Oakwood Hills	$45.02	$32.92
		Subtotal D4	***$299.66***	***$187.11***
5	HW-D5-1	Driftwood / Carriage Hills	$41.94	$20.85
5	HW-D5-2	Driftwood	$53.40	$16.82
5	HW-D5-3, 4, 5	Boulevard Heights	$257.97	$111.25
		Subtotal D5	***$353.32***	***$148.92***
6	HW-D6-6	Hollywood Gardens West / 441 Cooridor South	$8.13	$3.22
6	HW-D6-5	Beverly Park	$157.03	$48.83
6	HW-D6-4	Lawn Acres / Washington Park	$12.51	$5.72
6	HC-D6-2, 3	Hillcrest / Hollywood Hills South	$65.66	$44.67
6	HC-D6-1	Parkeast South	$16.02	$4.16
		Subtotal D6	***$259.35***	***$106.60***
			ALT 1	***ALT 2***
		CIP TOTAL CITYWIDE	**$1,899.76**	**$888.62**

There are several levels of detail for input for use of the HAZUS tool which range from typical empirical values to individual evaluations for exact local economic data. For this study, an "Advanced Level 2" HAZUS analysis was performed to determine flood hazard and measurement of exposure which means the flooding input was derived from the validated output of a detailed stormwater model developed specifically for the study area and the topographical data was supplemented with actual surveyed elevations. The HAZUS software integrates GIS technologies for displaying and manipulating inventory and displaying losses and consequences data for spreadsheets and maps. The methodology results in estimates to be made at several levels of complexity, based on the level of inventory entered for the analysis. The analysis incorporated existing available LiDAR elevations, structures, and land use data, along with the detailed engineering data on flooding elevation and extents derived from the SWMM model results.

The analyses follow a four-step HAZUS process to develop estimated loss and damage data:

1. Scenario Evaluation
2. Inundation Mapping
3. Structure Inventory
4. Economic Loss Evaluation

The analyses for the four steps are described further below.

Scenario Evaluation

A range of design storms was selected to evaluate the rainfall related flooding ranging from the 5-year to the 100-year storm, following local guidelines for storm duration ranging from 24 to 72 hours. Tides are inherently considered in the tidal stillwater boundary condition. Surge inundation has been analyzed separately by Broward County. The parameters for each of the storms including recurrence interval and probability are summarized in **Table 3-9**.

Table 3-9 HAZUS Flood Scenarios Evaluated

Flood Source							
	Rainfall				Tidal		
Recurrence Interval	5 yr	10 yr	25 yr	100 yr	1YR STILLWATER	SLR 11 INCHES	SLR 31 INCHES
Rainfall or Tidal Value	7.4 inches	9.0 inches	15.5 inches	21.2 inches	2.5 ft-NAVD	3.4 ft-NAVD	5.2 ft-NAVD
	in 24 hours	in 24 hours	in 72 hours	in 72 hours			
Existing Conditions	•	•	•	•	•	•	•
ALT 1	•	•	•	•	•	•	•
ALT 2	•	•	•	•	•	•	•

CDM Smith

Inundation Mapping

The second step of the analysis approach was to develop the extent and depth of flooding for the study area. In order to establish the extent of flooding an elevation grid was developed based on the topographic information. SWMM output was provided for each of the design rainfall storm events and was used to develop depth grids for the City. Rainfall inundation mapping several GIS data processing steps including transforming the model output files containing the modeled water surface elevation data, joining the node shapefile based on node ID, and creating a node shapefile for each storm including the modeled water surface elevation in NAVD. Using ArcGIS geoprocessing tools, polygons were created for each subbasin and the water surface elevations were assigned proximity to the modeled nodes, and a file was created representing the water surface elevation for the entire area. A Raster GRID was created using ArcGIS 3D analyst, with each grid size of 5 ft. This data along with the SWMM output was uploaded into HAZUS. HAZUS processes the data by analyzing the water surface elevation grid from the land grid resulting in a file that shows the extent of flooding and the depth of water for each location.

Structure Inventory

The third step in the analysis process was to create the structures inventory. A study region was created for the City limits including BCPA parcels and block groups. The HAZUS model creates the structure inventory from its Florida Statewide inventory which is a combination of census and property information. Appropriate first floor elevations are estimated in HAZUS internally based on structure type from FEMA data.

Shoreline Armoring Cost Accountability

As the effectiveness of the proposed CIP relies on a shoreline boundary fortification elevation of 5 ft-NAVD, an approximation of the additional cost of shoreline armoring (seawall cost) must be considered in the total costs. Using a current (2021) published marine contractor range of $800-$2,500 per linear foot for the cost of the low end of the range of seawall repair (simple concrete cap) and high end of the range (full reinforced bulkhead), a conservative middle value of $2,000 per l.f was used to calculate the City-owned, and the private- and other entity-owned costs, as some of the seawalls may be in better condition than others. Actual costs will vary depending on the actual conditions at each property. A 25% contingency was added to account for escalation, permitting, and other unknowns. Shoreline lengths for each were estimated from the GIS as shown in **Table 3-10.** A budgetary value of $186M was added to both Alternatives' CIP costs to account for the total expenditure citywide for the approximate 14 total miles of shoreline protection for the habitable areas of the City. Note, only a portion of this cost is actually the City's cost share but a Citywide cost of both a combined public, other, and private shoreline is input and used in the analysis so there is a full comparison of actual total costs to the HAZUS damages results for the cost benefit ratio.

Table 3-10 CIP Planning-Level Costs for Shoreline Improvements to 5 ft-NAVD for Habitable Areas

Parameter	Length (LF)	Length (Mile)	Avg. Unit Cost Per l.f.	Total	Comment
City Shoreline Armoring	31,046	5.9	$2,000	$62,092,800	
Contingency 25%				$15,523,200	
City Planning Budget				$77,616,000	City Planning Budget for Shoreline Armoring
Pvt/Other Shoreline Armoring	43,296	8.2	$2,000	$86,592,000	
Contingency 25%				$21,648,000	
OPCC for Other Owned				$108,240,000	
Budget Estimate for Citywide Seawall Improvements	74,342	14.1		$185,856,000	Use for Citywide HAZUS BCA

Economic Loss Evaluation

The final step to the HAZUS process was to incorporate the resultant data into a HAZUS project to establish damage and loss for each structure. For each storm event, HAZUS software compared the first-floor elevation to the peak water elevation to estimate direct physical damage. The USACE developed a series of damage curves that assign a percent damage based on flood depth. The damage curves include losses that occur at depths below grade associated with basements. Due to high ground water, table there are assumed to be no outside accessible basements in the City. The HAZUS model generates an output that consists of a damage amount in dollars that is based on the percentage of total value loss a structure incurs during the flood event. Each one of the structures has an estimated flood depth and economic loss. The results were then compiled for each one of the flooding scenarios to obtain the estimated structural loss related to both residential and non-residential structures. The HAZUS software includes tools for regional evaluations that consider indirect damages and gains related to external aid from State and Federal sources. The economic loss in this report is therefore based on structural damages to existing structures using individual assessed values.

Benefit-Cost Ratio Analysis Results

Rainfall-related flooding in Hollywood has a significant economic impact to both residential and non-residential structures. **Figure 3-12** shows the compilation of the estimated structural losses under the existing conditions for rainfall flooding by storm recurrence interval. The bars represent the flood damages in dollars for each case and the flood damage reduction is the difference between the bars in existing conditions minus the alternatives. **Figures 3-13** and **3-14** provides the predicted losses for the future SLR condition analyzed (11" and 31" above the current king tide EL of 2.5 ft NAVD). **Figure 3-14** provides the total annualized losses for current and for both SLR scenarios for comparative purposes. The rainfall flooding shows a significant exposure of multiple structures that increase with the recurrence interval. In order to mitigate the rainfall flooding effects, the SWMP identified a series of CIP projects and costs described in detail in the report for both the Primary LOS Goal and for the Secondary LOS Goal, Alternatives 1 and 2 respectively.

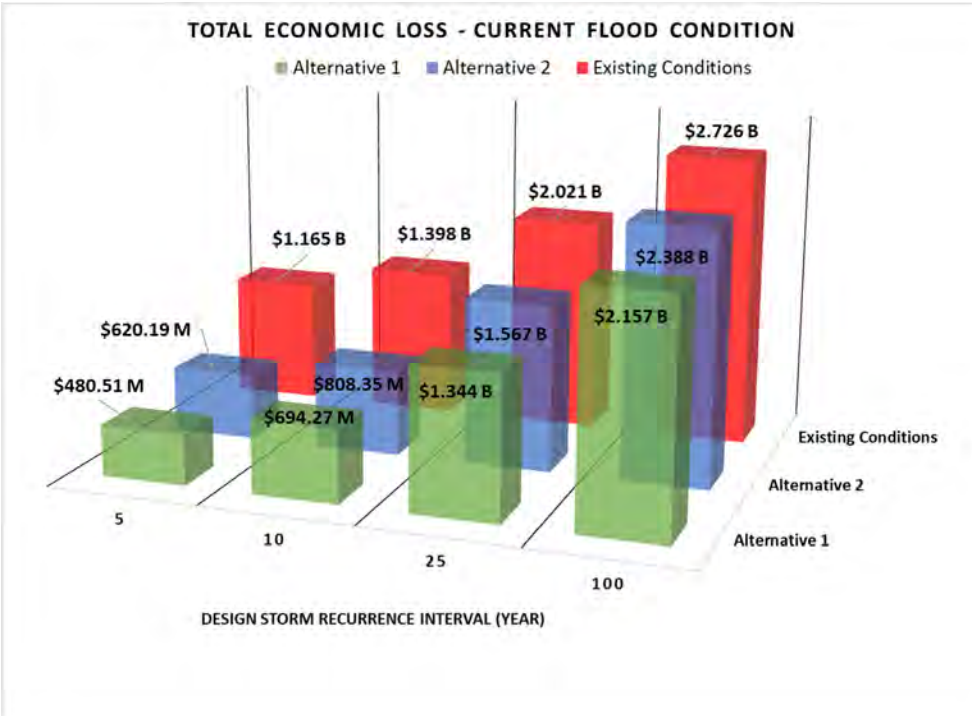


Figure 3-12 HAZUS Damages Calculated by Storm for Current Conditions (EL 2.5 ft-NAVD Sea Level)

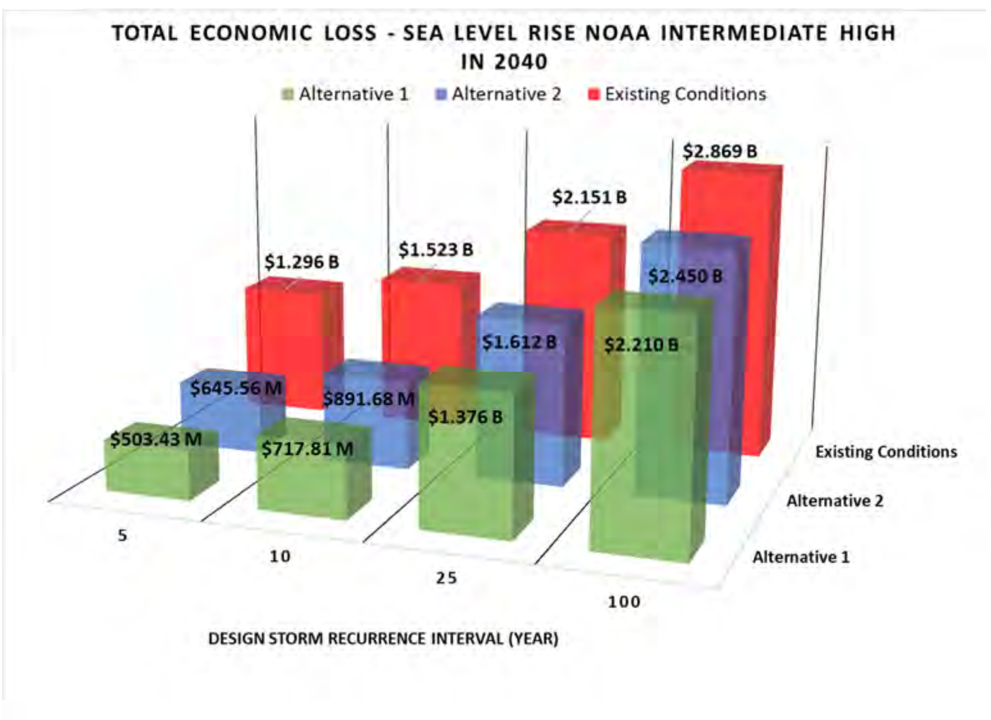


Figure 3-13 HAZUS Damages Calculated by Storm for NOAA IH 2040 SLR (EL 3.28 ft-NAVD Sea Level)

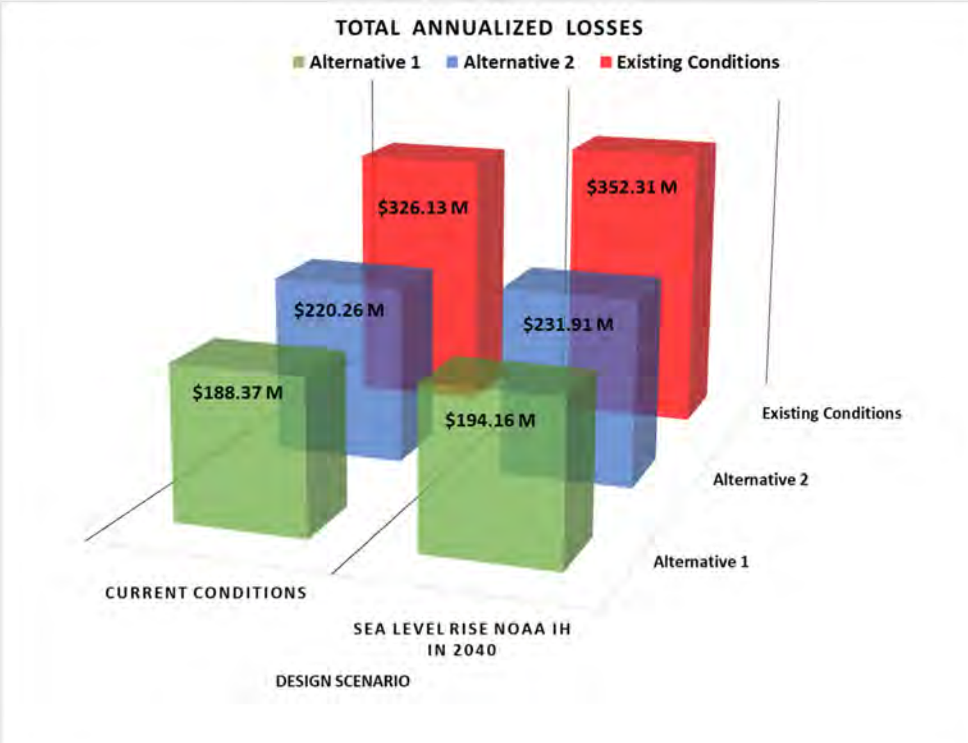


Figure 3-14 Total Annualized Losses and Damage Avoidance with CIP in Place

BCR was calculated over the FEMA 50-year design life using a 3% Real Discount Rate as 1.7:1 for Alternative 1 and 2.5:1 for Alternative 2, both positive returns in the investment as shown in **Table 3-11** (i.e., for every one dollar spent on flood mitigation, approximately two- to two-and-a-half dollars are saved in mitigated flood damage reduction). Note, the slightly lower Alternative 1 BCR also demonstrates the inherent diminishing return on investment as the desired LOS (less flooding) increases greatly the cost of the CIP required to achieve that goal, and with sea level rise, additional projected damages are mitigated even further. The Annualized Losses (net present value) for existing and SLR conditions are presented in **Table 3-12**.

Table 3-11 Summary of Benefit-Cost Ratios for CIP Scenarios

Condition	B:C ALT 1 LOS	B:C ALT 2 LOS
Current SLR Conditions	1.7	2.5
NOAA IH SLR 2040	1.9	2.9

The Annualized Losses (net present value) for both existing and the future SLR conditions under each alternative are presented in **Table 3-12**.

Table 3-12 Annualized Losses Summary Current and Future SLR

Condition	Current Sea Level (2.5 ft NAVD)	SLR NOAA IH 2040 PROJECTION
Existing	$326,128,992	$352,306,714
ALT 1	$188,368,673	$194,160,349
ALT 2	$220,259,802	$231,907,595

Benefit-Cost Analysis Conclusions

The results of this analysis can be used to determine the annual return on the CIP investment. The analysis consists of estimating the potential savings after the project implementation for individual storm events and their respective frequency. By combining the individual savings into an average yearly savings, it is possible to quantify the rate of return on the investment. Statistically this is equivalent to the area of the under the curves shown in the figures. The cumulative annualized losses and annualized flood reduction shows the net result of the avoided damages by recurrence interval storm. It should be noted that the HAZUS tool database and routines are conservative and likely slightly overestimate the number of flooded structures in the Alternative conditions due to the detail required for the flat, local Hollywood study area and thus the benefit-cost ratios may be slightly higher (better) than reported for the CIP alternatives in the HAZUS tool. The refined estimates of flooded structures from the stormwater modeling and survey under the CIP alternatives was provided in the tables CIP sections of the report. The flood damage analysis shows that the existing conditions in Hollywood have significant potential economic losses associated with flood events for both rainfall and tidal flood sources. The tidal flood sources can be mitigated with shoreline armoring including seawall, back flow preventers, and flood proofing of structures, and the rainfall flooding can be mitigated by a combination of exfiltration systems, gravity and pumped recharge wells, and pump stations.

3.7 Sea Level Rise Evaluation and Considerations

3.7.1 Introduction

Continued sea level rise will diminish the effectiveness of the City's stormwater management systems for flood control over time due to the detrimental effect of both the rising boundary condition of the ICW/Atlantic Ocean and rising groundwater levels will have on the primary system's hydraulic performance for the gravity-based systems and exfiltration.

The City's current stormwater management system and portions of the proposed system rely heavily on two main principles:

1. The ability of stormwater-generated runoff to flow from the land surfaces toward the receiving waters, and

2. The ability of stormwater generated runoff to flow from the land surfaces into the ground for treatment and recharge/disposal.

Both of these techniques require hydraulic driving head conditions favorable for the physical movement of stormwater off of the land or into the ground.

As sea levels rise as predicted to an elevation equal to or greater than the land surface being drained, the hydraulic conditions worsen and the ability to flow by gravity out to receiving waters or into the ground ceases to work. The effect is greatest on the infrastructure in the low-lying coastal areas and riverine areas, as the SLR impacts tend to diminish as it progresses further inland or away from the waterways and canals. As the groundwater levels rise with SLR, the hydraulic conditions required for their operation is jeopardized. The elements most at risk in the stormwater management system to this change are a portion of City's exfiltration systems and gravity recharge wells. To a point, additional pumped systems in the stormwater management system can be installed to overcome the hydraulic disadvantage being created by SLR at the expense of higher costs for equipment, land requirements, and operation and maintenance; however, pumped systems can only get so numerous and so large within the City's neighborhoods before their practicality, permitability, O&M requirements is diminished as well.

Backflow preventors are already installed and required at most of the City's outfalls to prevent the rising seas from flowing backward and entering the land areas through the gravity storm sewer systems. When functioning properly, these one-way valves also add hydraulic head losses to the outfall pipe system due to the additional water pressure (height of water above the valve) required to open them and can exacerbate flooding upstream. To prevent the sea from flowing onto the land during the rising tides, imminent additions for resiliency include the raising of seawalls and adding seawalls where currently none exist. This may be coupled with concurrently raising the land surface elevations and roadways in some areas. As a result, these requirements deplete existing topographical storage areas and will exacerbate stormwater flooding if compensation storage or additional flood control measures are not put in in place concurrently. Many locations do not have the available lands to accomplish this compensatory storage requirements and large pumps are required.

3.7.2 SLR Projections

SFRCC 2019 Unified SLR Projection

The Southeast Florida Regional Climate Change Compact developed the Regionally Unified Sea Level Rise Projection for Southeast Florida in 2011 with the most recent update in 2019. Prior to producing a unified projection for the region, the diversity of local sea level rise projections was a barrier to achieving regionally consistent adaptation strategies and policies, and effectively influencing supportive policies at the state and federal level. The Compact's Regionally Unified Sea Level Rise Projection and accompanying guidance report were accepted or adopted by each of the four-counties' (Monroe, Miami-Dade, Broward, Palm Beach) Boards of County Commissioners. The projection is reviewed and updated every five years, or sooner, as a result of ongoing advances in scientific knowledge and modeling via the peer-reviewed literature on global climate change. The 2019 projection is shown in **Figure 3-15**.

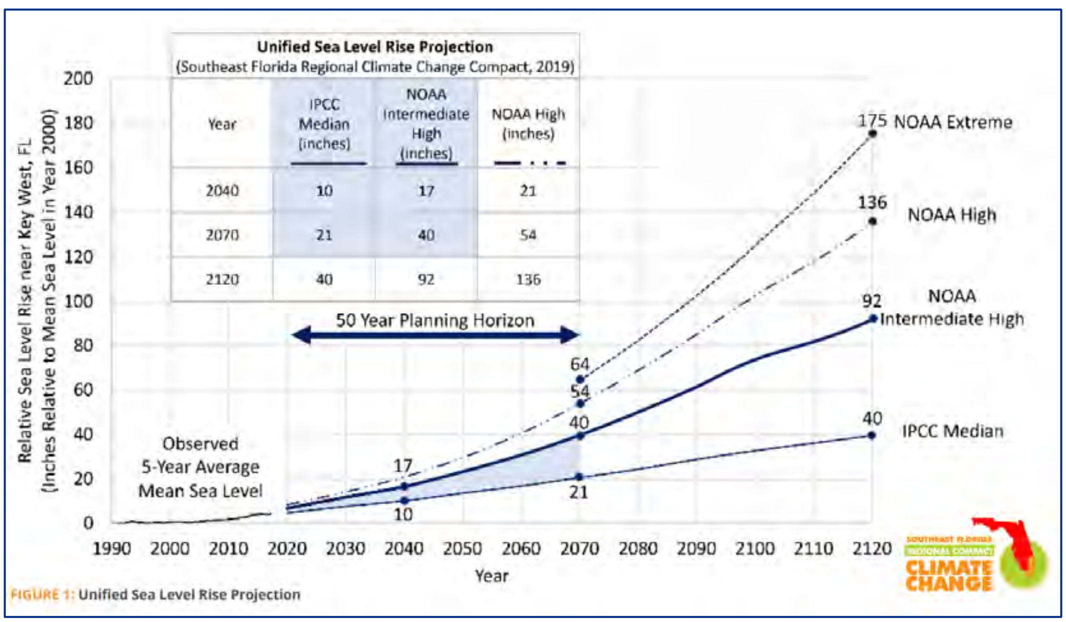
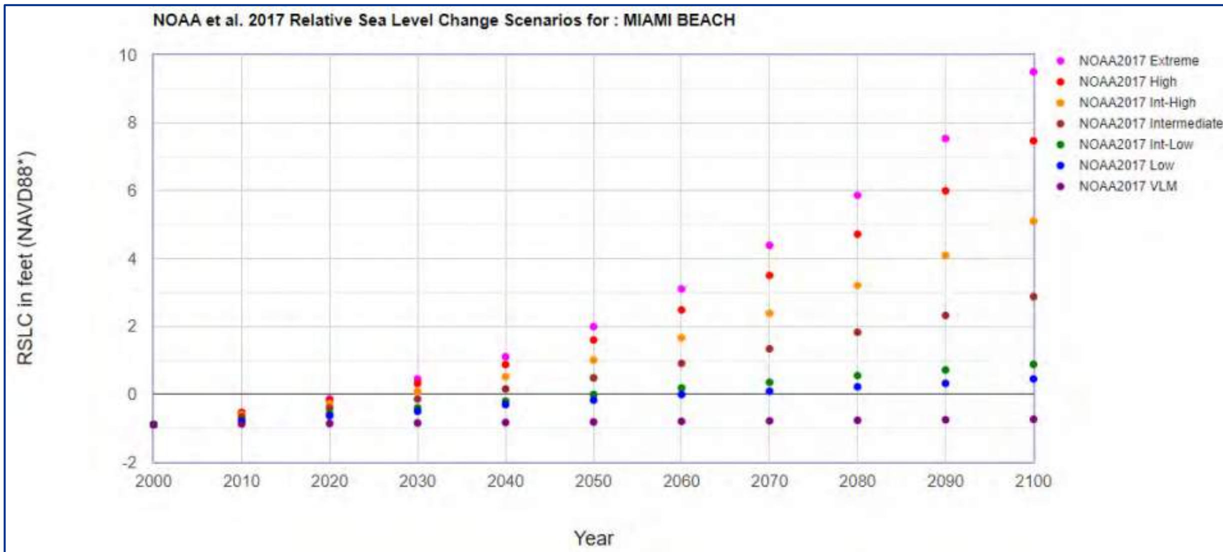


Figure 3-15 – Tri-County Compact Unified SLR Projection (2019)

CDM Smith

NOAA SLR Projections

The National Oceanic and Atmospheric Administration (NOAA) predicts that sea levels along the U.S. coastline are projected to rise, on average, 10 - 12 inches over the next 30 years (by 2050), which will be as much as the rise measured over the last 100 years (1920 - 2020). Sea level rise will vary regionally along U.S. coasts because of changes in both land and ocean height. Sea level rise will create a profound shift in coastal flooding over the next 30 years by causing tide and storm surge heights to increase and reach further inland. By 2050, “moderate” (typically damaging) flooding is expected to occur, on average, more than 10 times as often as it does today and can be intensified by local factors. The Florida Department of Environmental Protection (FDEP) requirements under recent Florida Statute 380.093, provides the sea level rise scenarios required for receiving future State Resiliency Grant Funding: NOAA 2017 Intermediate Low (IL) and Intermediate High (IH) for the years 2040 and 2070. For comparison, **Figure 3-16** provides the NOAA projections for their representative gage (Virginia Key/Miami Beach).



Scenarios for MIAMI BEACH
NOAA2017 VLM: 0.00157 feet/yr
All values are expressed in feet

Year	NOAA2017 VLM	NOAA2017 Low	NOAA2017 Int-Low	NOAA2017 Intermediate	NOAA2017 Int-High	NOAA2017 High	NOAA2017 Extreme
2000	-0.90	-0.90	-0.90	-0.90	-0.90	-0.90	-0.90
2010	-0.88	-0.80	-0.76	-0.67	-0.60	-0.53	-0.57
2020	-0.86	-0.63	-0.57	-0.40	-0.27	-0.17	-0.14
2030	-0.85	-0.50	-0.40	-0.14	0.09	0.32	0.45
2040	-0.83	-0.30	-0.21	0.15	0.52	0.88	1.11
2050	-0.82	-0.17	-0.01	0.48	1.01	1.60	1.99
2060	-0.80	-0.01	0.19	0.91	1.66	2.48	3.11
2070	-0.78	0.09	0.35	1.34	2.39	3.50	4.39
2080	-0.77	0.22	0.55	1.83	3.21	4.72	5.86
2090	-0.75	0.32	0.71	2.32	4.09	5.99	7.54
2100	-0.74	0.45	0.88	2.88	5.11	7.47	9.51

Figure 3-16 – NOAA Sea Level Rise Prediction Data

For the SWMP, the Virginia Key Gage is used as it is the closest NOAA Gage to the City of Hollywood. The next closest NOAA gage is Daytona Beach, and distance weighting the sea level rise values from Virginia Key and Daytona Beach provides nearly the same estimates as just using the Virginia Key gage, to within a hundredth of a foot. **Table 3-13** presents the base condition tailwater boundary conditions performed for this project, as well as the four sea level rise conditions.

Table 3-13 Design Storm Simulation Parameters for Sea Level Rise

Tailwater Condition	Tailwater Stage in ICW (ft-NAVD 88)				
	5-yr, 24-hr	10-yr, 24-hr	25-yr,72-hr	100-yr, 72-hr	Excess Rainfall**
Base Condition*	2.5	2.5	2.5	2.5	2.5
Base Plus 0.36 feet SLR (2040 IL)	2.86	2.86	2.86	2.86	2.86
Base Plus 0.78 feet SLR (2040 IH)	3.28	3.28	3.28	3.28	3.28
Base Plus 0.92 feet SLR (2070 IL)	3.42	3.42	3.42	3.42	3.42
Base Plus 2.65 feet SLR (2070 IH)	5.15	5.15	5.15	5.15	5.15

** Base condition is the one-year stillwater tide elevation (approx. current king tides).*

*** The Excess Rainfall Simulation is BC-Projected 13% increase.*

Both Alternatives 1 and 2 (the Primary and Secondary LOS Goal simulations) include backflow preventors and raised seawalls to provide effective flood mitigation in the low-lying areas adjacent to the Intracoastal and the Hollywood Canal. Additional simulations of the four design storms were performed for the Secondary LOS Goal (Alternative 2) with backflow preventors and all the internal CIP projects, but with existing conditions seawalls to show the limitations of adding new infrastructure without raising seawalls concurrently. These simulations were also performed with a lower tailwater (1.5. ft NAVD) to show that the CIP projects will continue to meet the LOS Goal for everyday tides, prior to SLR, but that seawall raising is critical to meeting LOS Goals for future SLR and for King Tide and small surge events.

Considerations for tidal boundary conditions and groundwater level increases are also factored into the City-wide SWMMs under these scenarios to consider impacts to flooding and proposed exfiltration and well systems. Mitigative features in the CIP to address SLR and tidal surge include the City-wide Seawall Program (target elevation 5 ft-NAVD) and backflow prevention for the outfalls to coastal waters affected by tides.

3.7.3 Analysis of SLR Impacts on the Proposed CIP

The following technical approach was undertaken for the SLR analysis on the proposed capital improvement program:

1. **Boundary Conditions: Tailwater in the Intra-Coastal Waterway**

   The boundary condition for the design storm simulations under existing conditions was set to the one-year stillwater elevation. The one-year high-tide elevation was determined based on records of tide elevations at multiple NOAA and SFWMD Structure Tide Gages, as discussed in Section 2.7 of the Model Development TM. The stillwater condition is used as a conservative approach since the timing of a storm is unknown versus the tide cycle and using a fixed stage forces stages to be a coincident high at the peak of the storm. The existing (2022) condition boundary condition uses a 2.5 ft NAVD fixed stage as the one-year stillwater. The boundary conditions for the four SLR scenarios were 2.86 ft-NAVD, 3.28 ft-NAVD, 3.42 ft-NAVD and 5.15 ft-NAVD, respectively for the 2040 NOAA IL, 2040 NOAA IH, 2070 NOAA IL, and 2070 NOAA IH SLR scenarios.

2. Boundary Conditions: Western Model

The western portion of the City uses boundary conditions developed from the South Broward Drainage District and Central Broward Water Control District models and data. As discussed in the Model Development TM, the South Broward Drainage District incorporates a Pump Station and Gated Control Structure at the south end of the District's S-1 Canal (along University Drive, outside the City of Hollywood), which represents the boundary for the southwest corner of the City of Hollywood SWMP Model. Since the gate is not expected to be operated under the base condition (because of the high tailwater condition in the SFWMD C-9 Canal), it should also not be operated under SLR scenarios. The pump station maintains water elevations upstream at 1.4 ft NAVD, which is not expected to change for the 2040 NOAA IL, 2040 NOAA IH, and 2070 NOAA IL SLR scenarios; therefore, there are no changes to the boundary condition at this location for these simulations. For the 2070 NOAA IH simulation, groundwater elevations are expected to be much higher than this trigger level (see below), so initial elevations are adjusted accordingly.

The northwest corner of the City of Hollywood SWMP Model is bounded by the CBWCD canals and FDOT pipes to those canals. In the base condition, the simulations of the CBWCD ICPR Models were performed with a boundary condition of 1.0 ft-NAVD at the SFWMD S-13 Structure in the C-11 Canal (which is also outside the City of Hollywood). The S-13 Structure is also a gated control structure with a pump station. Again, the control structure is expected to be closed during design storms and the pump station in use. Under current operating conditions, water elevations are held near 0 ft-NAVD upstream of the pump station; however, the 1.0 ft-NAVD level was chosen for the base model simulations to coincide with Broward County guidance and future expected groundwater elevations (see the Model Development TM for more details). For the 2040 NOAA IL, 2040 NOAA IH, and 2070 NOAA IL SLR scenarios, changes were made to the boundary conditions in the CBWCD, since the model already incorporates the future groundwater levels up to a 1 foot rise in elevation. For the 2070 NOAA IH SLR scenario, the CBWCD ICPR model was run with the control elevation increased to 2.65 ft NAVD to account for the SFWMD needing to account for SLR to maintain the salinity barrier.

3. Groundwater and Exfiltration Systems

The Model Development TM Section 2.5.7 discusses expected groundwater elevations in the City of Hollywood and the impacts on the stormwater model. Broward County requires the incorporation of future groundwater elevations in new CIP projects and has provided a future groundwater elevation map to coincide with this guidance. The base condition model incorporates the future groundwater levels, based on this map, for initial elevations in lakes and ponds, initial elevation of the aquifer (use in exfiltration modeling as described below), and the initial elevation of the upstream side of the SFWMD S-13 Structure in the C-11 Canal (used to develop the CBWCD boundaries conditions as described in the Model Development

TM and noted above). Based on this map, future groundwater elevations are expected to be 0.5 ft to 2.0 ft higher than year 2000 groundwater levels (based on another Broward County map). It is expected that the SFWMD will revise the operation of the S-13 Structure in the C-11 Canal from maintaining levels near 0 ft-NAVD (the boundary condition the CBWCD uses in their modeling) to near 1.0 ft NAVD, under the future Broward County groundwater levels. Note that the base (prior to SLR) condition for the existing, near-term, and two alternative corrective models are conservative, in that each already accounts for a future rise in groundwater base on the Broward County map. Therefore, lakes and ponds have less available storage at the start of the simulations than the likely initial pool elevations that occur as of this writing. Additionally, at the time of this writing, there is slightly more soil storage and more driving head in exfiltration systems than provided in the model because future levels are modeled.

For the 2040 NOAA IL, 2040 NOAA IH, and 2070 NOAA IL SLR scenarios, the 4-11 inch rise in boundary levels in the Intra-coastal Waterway/ Atlantic Ocean should cause groundwater levels to rise, but is not expected to have groundwater levels rise significantly higher than the future levels already provided by Broward County and used in the model. Therefore, for these three scenarios, no changes were made to groundwater levels compared to the base condition. Thus, the SLR scenarios for the 2040 NOAA IL, 2040 NOAA IH, and 2070 NOAA IL conditions only use changes to the boundary condition described above as modeling updates. For the 2070 NOAA IH SLR scenario, the 2.65 foot increase in sea level should have a significant impact on groundwater levels. The groundwater level near the coast will likely be at this level or slightly higher, which is an increase of over 1.5 feet from the previous "future" groundwater level provided by Broward County. However, it is expected that the groundwater levels would be flatter under this scenario, i.e. the rise would not be consistent (and additional 1.5 ft) as one moves inland. For this modeling scenario, CDM Smith used a range of groundwater elevation from 2.7 ft to 3 ft throughout the city, with lower levels near the coast and the C-10/C-11 Canals and higher levels inland. The higher groundwater levels provide normal pool levels in lakes and ponds that are not held at higher elevations by structures, reduce soil storage in the hydrologic calculations, and reduce the capacity of the modeled exfiltration (for both existing and proposed systems).

The model simulates exfiltration systems as a rating curve, where the flow rate is developed based on the depth to water table for the given system. The rating curve for the exfiltration system is based on the type of system, the system geometry, and the saturated hydraulic conductivity of the aquifer. The depth to water table is estimated using the driving head at the inlet node and an estimate of the water table elevation that is based on the volume and intensity of the precipitation. Critically, under the 2070 NOAA IH SLR condition, the initial elevation of the water table is significantly closer the land surface and the available capacity to rise prior to cutoff is lessened. The mathematical simulation of how rapidly the water table rises at or near land surface in the larger storm events is estimated based on data from monitor wells, anecdotal evidence, and local studies and experience. As the average wet season water table rises with SLR, the depth of the water table below land surface narrows and it will take less rainfall to begin to cause exfiltration systems to become limited or shut off completely. Additionally, the storage capacity in the soil that typically helps alleviate flooding after rain events is lessened, adding duration to standing water after a storm.

3.7.3.1 Inundation Analysis of LOS Alternatives for SLR

The proposed Alternative 1 CIP developed a solution for meeting the City's primary LOS goal of no more than 3-inches of flooding over the road crowns in the 10-year recurrence interval design storm for major roadways and evacuation routes, no more than 3-inches of flooding over the road crowns in the 5-year recurrence interval design storm for local streets, and minimizing building inundation to the extent practicable in the 100-year storm. Alternative 2 developed a solution for meeting the City's secondary LOS goal of no more than 6-inches of short (typically less than one hour) duration flooding over the road crowns in the 10-year recurrence interval design storm for major roadways and evacuation routes and no more than 6-inches of short duration flooding over the road crowns in the 5-year recurrence interval design storm for local streets. Scenarios for the two LOS Alternative models were then simulated under the four SLR conditions described above. For a visual comparison, the flood inundation maps for the 100-year design storms for both alternatives under the SLR scenarios are presented in **Appendix C**. The flooding reduction summary for existing conditions, Alternatives Nos. 1 and 2 CIP scenarios at the existing 1-year stillwater boundary condition and Alternative Nos. 1 and 2 CIP scenarios under the four SLR scenarios is provided in **Appendix D**.

3.7.3.2 FS 380.093 Resiliency Analysis and Reporting

The City performed a Vulnerability Analysis in 2023 in parallel with the SWMP to comply with the State (FDEP) administered requirements for eligibility for future Resiliency Grant Funding. The analysis includes a Peril of Flood Analysis under various conditions of future sea level rise and rainfalls. The City's SWMP model was used to perform the required scenarios technical analyses and the results of the study are provided as a standalone Technical Memorandum in Appendix D**.** The report provides the Citywide 10-year design storm inundation maps for the Alternatives 1 and 2 CIP with the 2040 NOAA IL, 2040 NOAA IH, 2070 NOAA IL, and 2070 NOAA IH SLR scenarios and with 1.5-ft SLR and 2.5-ft SLR the 2040 NOAA IL, 2040 NOAA IH, 2070 NOAA IL, and 2070 NOAA IH SLR scenarios plus rainfall events and a statistical analysis of recurrence.

3.7.4 Resiliency Scenario Analysis and Results

An analysis of the effects of sea level rise (and associated higher groundwater levels), coupled with trends toward increasing intensity storms and the impact of the potential of climate change on the proposed CIP is important to perform and understand for future resiliency of the City.

3.7.4.1 Shoreline Armoring Impact Analysis

Shoreline armoring is critical to resiliency, vulnerability reduction, and the performance of the stormwater CIP, as it is designed only to convey stormwater runoff to achieve the desired LOS. Encroachment of seawater into the stormwater system reduces the effectiveness of the system's ability to meet the LOS by consuming the capacity of the pipes and equipment meant for the collection and transport of stormwater, resulting in flooding. Currently, many low-lying areas exist along the City's shoreline allowing "sunny day" tidal flooding to encroach into the City's streets. If this situation occurs during a rainfall event, the flooding is exacerbated, and roadways can become impassable until the tide recedes. By ordinance, all seawalls in the City will need to be raised to EL 4 ft NAVD by 2035 and EL 5 ft NAVD by 2050 creating a seamless barrier to the rising tides toward the end of this century, and coupled with backflow prevention and pipe lining protecting from infiltration into the tidal outfalls. Accordingly, the Alternative 1 and 2 scenarios assume the seawalls are in place at the 5 ft NAVD elevation. As part of the SWMP, a special purpose LiDAR survey was flown to refine the accuracy of the existing shoreline boundary conditions for modeling purposes and was provided as a GIS layer to the City for analysis purposes to identify low and problematic spots along the City's coastline.

Tidal Flooding Simulations

A model simulation was performed to simulate the potential situation of the proposed stormwater CIP installed but without the associated continuous raised seawalls to the minimum ordinance height. The results showed that as the tide reaches an elevation of 2.5 ft NAVD or higher, the proposed CIP cannot keep up with the additional inflow of the tide and severe flooding again occurs in the low-lying areas of the City. A second model simulation was performed to analyze the near-term condition in the Hollywood Lakes area where the City is embarking on an aggressive shoreline armoring plan which includes three phases of seawalls and berms at EL 5 ft NAVD for the City-owned coastal shoreline property, to be installed by 2027. The results of this simulation show the City's seawalls are effective in providing a barrier to tidal flooding, however there are a few private properties that will need to have their shoreline raised in conjunction, as these few low gaps allow enough tidal inflow through their properties to enter the roadways and impact the proposed CIP, resulting in flooding and impacting the design LOS. Results show the CIP is not effective and cannot keep up with the required capacity when simultaneously pumping out the sea.

The model also shows how concurrent rainfall greater the 25-yr storm exacerbates flooding in the neighborhoods as the new seawall traps the water that flowed overland prior to the armoring. A recommendation to provide operable water release gates/openings in the seawalls in the interim to let water out in the larger storms until the future CIP can be installed was provided to the City to incorporate into the seawall projects.

Other areas requiring seawall/shoreline improvements (outside of the Lakes area) on tidally influenced waterways which were discovered during modeling and are listed in each CIP area narrative. Some of these include - Calle Largo Drive at the north perimeter of the Orangebrook GC, existing berm to be raised to EL 6 ft NAVD due to future stages (CIP area D6-1), CIP Area D1-7 Westlake, C-10 Canal finger islands North Central, Parkeast CIP Area D3-1, N 46th Ave CS-22 Canal Structure and others.

3.7.4.2 Analysis of Potential Future Rainfall Intensity (Climate Change)

Whether due to natural or man-made causes, USEPA Climate Change Indicator data has reported that the Florida peninsula has warmed more than one degree (F) during the last century. It is postulated that the global effect may be resulting in sea level rise and a climate-related trend toward heavier rainstorms becoming more frequent or severe, and resultant increases in storm damages. Since 1958, the amount of precipitation during heavy rainstorms has increased by 27 percent in the Southeast (EPA 430-F-16-011), and the trend toward increasingly heavy rainstorms may continue with a warmer climate fueling the storms. More intense rainstorms can increase flooding as there is a fixed capacity in the existing canals and rivers, and more water will accumulate in low-lying areas that drain slowly. EPA climate change bulletins also generally indicate that tropical storm and hurricane activity have been becoming more intense during the past 20 years. Although warming oceans provide these storms with more energy, climate scientists are not sure whether the recent intensification reflects a long-term trend. Coastal, low-lying cities, roads, railways, ports, and water supplies in Florida are all vulnerable to the impacts of storms and sea level rise. Potentially greater wind speeds and the resulting damages can make insurance for wind damage more expensive or difficult to obtain. Whether or not storms become more intense, coastal homes and infrastructure will flood more often if sea levels rise, storm surges will become higher as well, and as a result, a potential increase in flood insurance premiums for the City is likely.

In June of 2021, the Broward County Board of County Commissioners adopted the Broward Future Conditions 100-year Flood Map, now established in the Broward County Code of Ordinances. Along with the Future Conditions Groundwater Table Map. That modeling effort accounted for the predicted increase in rainfall intensity showing a 13% increase in the rainfall estimates used in the 100-year rainstorm based on the Broward County DDF Change Factor Ensemble Analysis (Yin, Li, & Urich, 2019). Accordingly, the 100-yr 72-hr design storm 5-minute interval time series (inches/hr) was multiplied by 1.13 at each time step. This resulted in an event-based volumetric increase of 2.8 inches of rainfall with a total rainfall depth range of 23.94-24.28 inches and a peak rate of 1.15 – 1.16 inches/hr across the city. The near-term, Alternative 1 and Alternative 2 100-yr 72-hr plus 13% model output was used to calculate the increase in flood stages above the 100-yr 72-hr model runs. Tabular results were parsed spatially into the West, Central, East and Beach model domains. Data was limited to high flood prone areas previously identified. Additionally, detention/retention ponds and depressional natural areas were not reported unless inundation encroached on streets or buildings.

Near-term

West: The flood prone areas increase in peak stage ranged between approximately 1.5 – 2.5 inches. The largest increase occurred in the 441 Corridor between 441 and the turnpike, and North of Taft Street .

Central: The flood prone areas increase in peak stage ranged between approximately 2 – 3.5 inches. The largest increase occurred in the Emerald Hills, Oakridge and the Stirling Commercial neighborhoods.

East: The flood prone areas increase in peak stage ranged between approximately 1 – 2.5 inches. The largest increase occurred in the Hollywood Lakes neighborhood, specifically West of N 14th Ave. and North of Taft St. The areas in the immediate vicinity of North and South Lake only showed an increase of 1-1.5 inches. While this area is low and receives runoff from uphill contributing areas, the flood stage increase is less significant due to overtopping of the existing seawalls. This would not be the case if seawalls were raised to the 2035 and 2050 mandated elevations.

Hollywood Beach: The flood prone areas increase in f peak stage ranged between approximately 0–1 inch. Hollywood beach showed negligible increase in flood stages except for the area bounded by Azalea Ter, Hollywood Beach Blvd, and S. Ocean Dr. This area showed a 1” increase.

Alternative 1

West: The flood prone areas increase in peak stage ranged between approximately 1.5–3 inches. The largest increase occurred in the Driftwood and Carriage Hills neighborhoods.

Central: The flood prone areas increase in peak stage ranged between approximately 2.5–7.5 inches. The largest increase occurred in the Park East and North Central Neighborhoods. The localized North Central region bounded by I95, N 28th Ave., Johnson St., and Peirce St. shows an 8 inch increase in flood stages. Additionally, the finger islands in North Central, west of the Hollywood Canal and east of I-95, show a stage increase larger than 18 inches. The reason for this increase is that the adjacent Hollywood canal has a peak stage of 5.28' NAVD which breaches the 5' NAVD seawalls modelled. As has been noted previously in this report the 100-yr 72-hr Alternative 1 simulation shows the canal stage reaching but not breaching the 5' NAVD seawalls.

East: The flood prone areas increase in peak stage ranged between approximately 2–8 inches. The largest increase occurred in the Hollywood Lakes neighborhood, specifically between North Lake and South Lake north of Hollywood Blvd, and east of N 10th Ave. While there is disparity of a 4-inch increase in flood stage between the lakes, the entire area is inundated to approximately 2.5' NAVD, indicating the proposed pumps cannot keep up with the increased volume from rainfall and contributing runoff.

Hollywood Beach: The flood prone areas increase in peak stage ranged between approximately 2-3 inches. Increased flooding was relatively consistent throughout Hollywood Beach.

Alternative 2

West: The flood prone areas increase in f peak stage ranged between approximately 1.5 – 2.5 inches. The increase in flood stage was relatively consistent in all flood-prone neighborhoods.

Central: The flood prone areas increase in peak stage ranged between approximately 1.5 – 5 inches. The largest increase occurred in the Park East, Stirling Commercial, Hollywood Hills and North Central neighborhoods. The localized North Central region bounded by I95, N 28th Ave., Johnson St., and Peirce St. shows a 6 inch increase in flood stages. As in the alternative 1 analysis, the finger islands in North Central, west of the Hollywood Canal and east of I95, show a stage increase larger than 18 inches. The reason for this increase is that the adjacent Hollywood canal has a peak stage of 5.28 feet NAVD which breaches the 5' NAVD seawalls modelled. As has been noted previously in this report the 100-yr 72-hr Alternative 2 simulation shows the canal stage reaching but not breaching the 5' NAVD seawalls.

East: The flood prone areas increase in peak stage ranged between approximately 1.5 – 4.5 inches. The largest increase occurred in the Hollywood Lakes neighborhood.

Hollywood Beach: The flood prone areas increase in peak stage ranged between approximately 1.5 – 3 inches. Increased flooding was relatively consistent throughout Hollywood Beach.

Table 3-14 provides the approximate range in the flood prone area stage compared to the 100-yr 72-hr design storm.

Table 3-14 Flood-prone Area Stage Ranges Compared to 100 yr Storm

Area	Near-term Fld. Stage Increase (inches)	Alternative 1 Fld. Stage Increase (inch)	Alternative 2 Fld. Stage Increase (inch)
Beach	0 - 1	2 - 3	1.5 - 3
East	1 - 2.5	2 - 8	1.5 - 4.5
Central	2 - 3.5	2.5 - 6.5	1.5 - 5
West	1.5 - 2.5	1.5 - 3	1.5 - 2.5

Section 4

SWMP Summary and Recommendations

This section provides guidance for use of the SWMP as a guideline for the City's stormwater capital program.

4.1 SWMP as a Living Document

This SWMP is intended to be a flexible, living document to be used as the City's guide to the future resilience of the City. As projects are built, the GIS and SWMM model should be updated with the as-built information, the models re-run, and the latest output files made accessible to project designers as existing baseline conditions. Accelerated projects or deviations from the ideal sequencing due to funding limitations, coordination with other work, or other influencing factors for prioritization should be tested for effectiveness and impact in the model and a determination made for the potential necessary inclusion of parallel projects to make the stormwater management system work as intended and not potentially worsen conditions in other locations.

4.2 SWMP Elements Implementation

The SWMP implementation requires coordination of several areas of practice including CIP design, permitting, and construction; resiliency initiatives such as building code, design standards updates, and potential land use changes; ordinance enforcement for shoreline armoring; joint project agreements with neighboring municipalities and government agencies; funding sustainability and financial planning; and initiation of discussions for regional solutions and policy changes.

The following sections discuss the implementation of the various SWMP elements.

4.2.1 CIP Construction Permitting Process

An Environmental Resource Permit (ERP) is required for development or construction activities to prevent flooding, protect the water quality of Florida's lakes and streams from stormwater pollution, and protect wetlands and other surface waters. The SFWMD has delegated the process to Broward County through the Surface Water Licensing Division to regulate these activities. Projects developed or implemented conceptually in phases (such as the Citywide SWMP) will be required to have an approved (i.e., commission adopted) overall master plan showing the applicant's contiguous land holdings and providing assurance that a funding mechanism is in place. The primary concerns of the regulatory agencies are to ensure continuity between phases and satisfactory completion and operation of individual phases if the overall project is not completed as planned for water quality and demonstration of no post-CIP impact on the existing flows and stages which could result in flooding in other areas, as well as other regulated environmental issues and water quality.

For multi-phased programs in the SWMP, the regulators typically encourage the submittal of a "Conceptual ERP". Issuance of a conceptual approval permit is a regulatory determination that the conceptual plan is, within the extent of detail provided in the application, consistent with applicable rules at the time of issuance. The conceptual approval permit then provides the permit holder (City) with a "rebuttable presumption that, during the duration of the conceptual approval permit, the design and environmental concepts upon which the conceptual approval permit is based will meet applicable rule criteria for issuance of permits for subsequent phases of the project, barring any significant deviations".

The purpose of obtaining the conceptual permit is to be able to expedite and reduce the information required for individual project construction permits as they are designed and constructed in accordance with the approved master plan conceptual ERP. If individual project permits were pursued by each designer without the Citywide Conceptual permit in place, there would likely come a point in the process where the regulators would halt any new permitting and require an analysis of how all of the projects come together, which would result in delays and potentially be beyond the knowledge of any particular designer working on a small piece of the full citywide CIP. This SWMP has been designed to be the support documentation required for the conceptual permit application.

4.2.2 BMP Treatment Train Concept for Stormwater Quality

A stormwater Best Management Practice (BMP) is a method or combination of methods found to be the most effective and feasible means of preventing or reducing the amount of pollution generated by nonpoint sources to a level compatible with water quality goals or requirements.

BMPs are classified as either:

- Prevention - avoiding the generation of pollutants.
- Reduction - reducing or redirecting of pollutants.
- Treatment - capturing and treating pollutants.

Methods for controlling pollutants in stormwater runoff are further categorized as non-structural or structural BMPs and are often used in concert to control pollution in stormwater runoff.

- *Nonstructural BMPs* are practices that improve water quality by reducing the accumulation and generation of potential pollutants at or near their source and do not require physical construction of a facility but provide for the development of pollution control programs that include prevention, operations and maintenance, education, and regulation.
- *Structural BMPs* involve design and construction a facility for controlling quantity and quality of urban runoff. These structures treat runoff at either the point of generation or the point of discharge and require routine maintenance such as retention/detention system, aquifer recharge systems, oil water separators, trash screens, and grit chambers.

The effective combination of both types of BMPs is known as a BMP treatment train.

4.2.3 Stormwater Management and Septic Systems

Septic systems for residential sanitary waste disposal are still in use throughout Broward County. A septic system is a buried tank attached to the waste drains of a dwelling to capture and partially treat raw domestic sanitary wastewater and are usually used in more remote or limited-access areas where public municipal sewer service is not practical or available. The septic system's drainfield requires that the groundwater elevation be lower than it to function properly and not backup into the house or flood the ground with sewage. Recent maps from the Florida Department of Health, which oversees septic tanks in the state, show more than 50,000 parcels in Broward County that could still be on septic and within Hollywood, approximately half the City's households are estimated to be without sewer lines due to the high cost of conversion. A large portion of the proposed stormwater infrastructure CIP relies on exfiltration and disposal of stormwater into the underground aquifer due to the constraints on new or direct discharge to the protected the receiving waterways. If septic systems are nearby these stormwater BMPs, there is the potential for movement of known areas of septic system bacteria – how far, at what concentration, or to where, is not known without further study. Close coordination of the City's SWMP CIP and the City/State/County's initiatives to eliminate remaining septic tanks should be undertaken for potential coordination of projects and accelerated their scheduling in stormwater improvement neighborhoods.

4.2.4 FEMA Flood Zones

The Federal Emergency Management Agency's (FEMA) flood hazard maps reflect current flood risks for metropolitan areas. FEMA flood maps divide the City into flood zones ranging from Moderate to High Flooding risk. According to FEMA data, approximately 45% of the homes in Hollywood are built upon floodplains and are considered within flood-risk zones. Flood Insurance Rate Maps (FIRMs) illustrate flood hazards throughout the City on a course scale and are used for determining flood insurance policy rates. Structures determined to lie in a flood zone usually obtain an Elevation Certificate that can be used to gage how high a structure's lowest floor elevation was built in relation to that flood zone's recurrent flood stage. Certificates are now required for all new construction, as well as for construction projects that involve making substantial improvements to a structure and are used to determine flood loss claims. Broward County has kept records of these Certificates on file since it began participating in the Community Rating System (CRS).

The current flood Zone map of the City is maintained by Broward County and can be found at: https://www.broward.org/Environment/FloodZoneMaps/Documents/FEMA_Current_FloodZone_%208_18_2014_ADA.pdf

4.2.5 Current NFIP-CRS Review

As a part of the FEMA National Flood Insurance Program (NFIP), the Community Rating System (CRS) is a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum program requirements. Congress established the NFIP with the passage of the National Flood Insurance Act of 1968. As a result, flood insurance premium rates are discounted to reflect the reduced flood risk resulting from the community actions meeting the three goals of the Community Rating System:

1. Reduce flood damage to insurable property.
2. Strengthen and support the insurance aspects of the National Flood Insurance Program.
3. Encourage a comprehensive approach to floodplain management.

4. Community Rating System to provide incentive to municipalities to improve using flood insurance premium discounts to residents.

For National Flood Insurance Program Community Rating System participating communities, flood insurance premium rates are discounted in increments of 5 percent. Assignment of a Class 10 means the community is not participating in the Community Rating System and receives no discount, a Class 9 community would receive a 5 percent discount, up to a Class 1 community which would receive a 45 percent premium discount.

The Community Rating System Classes for local communities are based on 19 creditable activities which fall under four categories: Public Information, Mapping and Regulations, Flood Damage Reduction, Flood Preparedness. The elements of the comprehensive citywide Stormwater Master Plan and CIP implementation should allow an increase in the NFIP Community Class and discount for the City's residents.

The **Table 4-1** below shows the credit points earned, classification awarded, and premium reductions given for the City under the NFIP CRS.

Table 4-1 City of Hollywood Current (2021) NFIP-CRS Rating

Community No.	125113
Current Effective Date	5/1/2012
Current Class	6
% Discount for SFHA*	20
% Discount for non-SFHA	10
Status	C

Source: FEMA CRS Eligible Communities Table effective October 1, 2021

*Special Flood Hazard Area (SFHA)

Figure 4-1 shows the current CRS classes, where the City scores today, and the City's goal. An analysis of the City's CRS rating was performed as part of the SWMP. The City will need the following to continue to improve its rating:

- 486+ points to attain the next highest CRS Class 5
- 986+ points to attain a CRS Class 4 (City Goal)

The Class 4 Prerequisites are:

- Meet all Class 5 & 6 prerequisites.
- Receive and maintain a classification of 4/4 or better under the (Building Code Effectiveness Grading Schedule (BCEGS)
- Minimize increases in future flooding.
- Activity 330 – Public Outreach
- Activity 420 – Open Space Preservation
- Activity 430 – Higher Regulatory Standards

- Activity 450 – Stormwater Management

Figure 4-1 NFIP-CRS Requirements *(Current 2023 Class Circled)*

Table 110-1. CRS classes, credit points, and premium discounts.

CRS Class	Credit Points (cT)	Premium Reduction	
		In SFHA	Outside SFHA
1	4,500+	45%	10%
2	4,000–4,499	40%	10%
3	3,500–3,999	35%	10%
4	3,000–3,499	30%	10%
5	2,500–2,999	25%	10%
6	2,000–2,499	20%	10%
7	1,500–1,999	15%	5%
8	1,000–1,499	10%	5%
9	500–999	5%	5%
10	0–499	0	0

SFHA: Zones A, AE, A1–A30, V, V1–V30, AO, and AH

Outside the SFHA: Zones X, B, C, A99, AR, and D

Preferred Risk Policies are not eligible for CRS premium discounts because they already have premiums lower than other policies. Preferred Risk Policies are available only in B, C, and X Zones for properties that are shown to have a minimal risk of flood damage.

Some minus-rated policies may not be eligible for CRS premium discounts.

Premium discounts are subject to change.

4.2.6 CIP Projects Design and Permitting Using the SWMP

The initial order of future CIP Area projects will be driven by future available budgets, and logical groupings of next-phase projects will be driven by influencing factors that will continuously re-prioritize the projects as the CIP program progresses.

For individual CIP projects, designers will use the published SWMP input, output, and data showing the chosen alternative's:

- Infrastructure components, sizes, lengths, inverts
- Intended equivalent capacities
- Upstream and downstream peak stage elevations
- Sub-catchment areas contributing to the runoff and imperviousness
- Pipe peak flows and velocities for the design storms at the connection points (model nodes) on the PSMS
- Time series for flows and stages for creating local site models for individual project boundary conditions

The designers will provide the final layout and design and confirm the recommended:

1. PSMS routes from the SWMP CIP (transmission pipes, weirs, outfalls),
2. Exfiltration trench systems and gravity wells from required local hydrogeologic testing,
3. SSMS collector systems (local catch basins/inlets, connecting pipes, manholes) and attachment points to the PSMS
4. Stub-outs and future connections to other SWMP CIP elements
5. Roadway re-grading
6. Location, layout, and design of pump stations, force mains, valving, and pumped recharge wells at the recommended capacities, easement requirements, and local architectural neighborhood design reviews board approvals
7. Perform the project-specific water quality calculations demonstrating compliance with the SWMP values and obtain the BC SWLD permit using BC design standards and permit applications will be compared by regulatory agencies to the approved conceptual ERP for conformance to the Stormwater Master Plan.
8. Similarly, shared-system modifications by FDOT or Broward County (or neighboring municipalities) also should be entered into the SWMP when planned and final installed for impact analysis on the City's LOS and coordination of any potential shared project re-sizing.

The SWMP CIP elements are to be considered planning-level equivalent sizes and capacities, thus designers have significant leeway to split or combine culverts, pipes, exfiltration systems, channels, swales, recharge wells, pump stations and force mains as land acquisition and route analysis, connectivity, and/or available rights-of-way (ROWs) dictate.

Projects CIP areas can be split further into smaller phases where for example the exfiltration trenches and gravity wells are installed for some immediate relief, and the associated pump stations and force mains (which are significantly more expensive, have a longer lead time for components to design and permit and construct) are deferred to a later date. These areas of partial installation should be modeled in detail to gauge the impact on flood stages of the components being chosen for installation before the full system can go in. The City should perform an independent review of each of the designs for conformance to the SWMP recommendations by quickly analyzing any deviations for impacts directly in the model.

Contractors should be required to provide their as-built systems in a both a City standard record drawing format and in a GIS file to be entered into the City's GIS and subsequently the SWMM model to keep both current. The EC model should be kept current and updated and re-run frequently with the partial, on-going improvements in place to have an up-to-date accounting of flows and stages during the phased implementation where peripheral influences will re-prioritize the planned implementation sequencing.

4.2.7 Near-Term Resiliency Planning and Actions

Resiliency is affected by economic, social, spatial, and physical factors and its planning involves a wide range of stakeholders. Resiliency planning can include:

- Vulnerability analyses and critical structure hardening
- Updating land use codes, zoning, development standards
- Building code modifications for more resilient construction (higher finished floor elevations, capturing more stormwater on-site, green measures, shoreline protection requirements)
- Incentive programs and other plans or policies to better prepare for likely shocks and stresses while also developing measures that allow for action in the face of uncertainty or unexpected events.

Understanding where and how the City is vulnerable to loss from coastal hazards and adapting planning and development practices to compensate for these vulnerabilities will ultimately result in lives and dollars saved, and a stronger City for the future.

"Coastal" Resilience as defined by NOAA is building-in the ability for a community to "bounce back" after hazardous events such as hurricanes, coastal storms, and flooding – rather than simply reacting to impacts afterward. In summary, a more resilient city is one in which governance is able to quickly restore basic services and resume social, institutional and economic activity after a disastrous event.

Near-term resiliency (20- to 40-year planning horizon) measures include both structural and non-structural actions, many of which are currently in place or in progress in the City:

- <u>Risk Assessments, Vulnerability Assessments, and Strategic Action Plans</u> – Planning studies such as this comprehensive Stormwater Master Plan which define the highest risk areas of the City can assist local governments in identifying and assessing the risks that climate change poses to their current and planned assets, operations and services as well as to help prioritize risks that require further action as a basis for decision-making and adaptation planning and funding solutions. Risk assessments aim to ensure that municipal systems will be resilient and analyze the risks posed by extreme weather and sea level rise and help develop holistic strategies for addressing them. The Stormwater Master Plan analyses show the areas of weakness and the improvements required to the stormwater management system both under current conditions and under the detrimental effect future sea level rise on the City's critical infrastructure and evacuation routes.

- <u>Raising or Hardening of Critical Infrastructure –</u> Using the predicted peak stages for the masterplan tables, the City's critical infrastructure can be raised to the appropriate resiliency height chosen. This can be performed by relocation and building new, constructing watertight berms or containment walls and stairs at entrances, or adding new stories and relocating from the first floor. City public works infrastructure and be heightened by adding new concrete pads and slabs, watertight hatches, and raising electrical equipment. It is important to note that it is usually more cost effective to flood proof individual buildings and raise electrical equipment than try to lower flood stages in an entire basin for the protection of critical assets, as long as the stormwater infrastructure is sufficient to allow safe access and evacuation during flooding conditions.

- Emergency Operations Center – The City's division of emergency management and emergency operations center is well established and includes officials from City government, police, fire rescue, disaster specialists, and public information officers. The City is also a member of the Broward County local mitigation strategy workgroups which provide updates and information on mitigation topics, maintains and updates the Local Mitigation Strategy Plan that is approved by the Federal Emergency Management Agency (FEMA), maintains a list of projects that may become eligible for mitigation or other grant funding, coordinates with local communities that participate in the Community Rating System program to save people money on flood insurance, and coordinates with the State and FEMA after a disaster to get federal funding to help communities rebuild stronger.

- Tidal Flooding Prediction Tool – The SWMP model can be converted to a tidal flooding prediction tool by varying the boundary condition (tide elevation) and calibrating to the NOAA tide charts observed data and visual sunny day flooding. The LiDAR topography DEM in the model is accurate enough to predict the water depth in all areas of the City. By opening the outfalls to simulate a "leaking" BFP or breached seawall, areas of tidal inundation can be predicted ahead of king tide events to alert first responders and residents to area that should be avoided. Superimposing predicted rainfall and wind effects can provide flood maps of the predicted flood water depth Citywide to prepare for these types of events. the tool can also be used to demonstrate areas where BFPs and pipes are leaking for repair.

- Building Code Strategies – Risk mitigation requires a citywide response using adaptation strategies, starting with revisions and updates to building and land development codes, focusing on evaluating minimum structure finish-floor elevations compared to predicted water surface elevations, and piled or stilted structures to consider future sea level rise (which is only effective if roadways and building access are raised as well). The Florida Building Code (FBC) includes flood provisions that are consistent with the NFIP requirements for buildings and structures and the City is required to enforce the FBC or higher standard. Incentives or requirements for adding new green infrastructure and low-impact development features such as bioswales, porous pavers, cisterns, green roofs, on-site runoff storage and reuse for irrigation and water quality treatment, less impervious surfaces, all will reduce individual contributions of runoff to the primary system and can synergistically compound to make an impact on the total urban runoff quantity and water quality. Land use code changes are considered fiscally practical in low lying areas where the capital cost of the installation of flood reduction measures outweighs the cost of buyouts/relocations and repurposing the land for dedicated stormwater management. Several areas of the City demonstrated how adding additional or larger stormwater infrastructure in the models gained little additional flooding reduction. There are sociopolitical and economic challenges with buyouts and relocations that will make this decision more difficult for City leaders.

- Insurance - The National Flood Protection Insurance Program (NFIP) allows property owners in participating communities to buy insurance to protect against flood losses. Participating communities are required to establish management regulations in order to reduce future flood damages. This is intended to be furnished as an insurance alternative to disaster assistance and reduces the rising costs of repairing damage to buildings and their contents caused by flood. The more NFIP/CRS measures the City has in place, the better the discounted rate will be for the residents.

- Dedicated Sources of Financing – Implementation of specific financing instruments designed to create diversified, scaled pools for investment tailored to a targeted class of measures that share a similar risk-reward profile such as portfolio-based loans, catastrophe bonds, re-insurance, securitization, or other structured finance instruments, which can provide much larger private capital flows sourced for adaptation and other kinds of disaster risk reduction.

- Public Awareness – Public awareness campaigns to understand adaptation policy and its benefits to the City are crucial to gain the trust, buy-in, and engagement of residents and developers/investors into the resiliency programs. Access to information and advertisement of updates on the progress of stormwater capital improvements around the City will show a pro-active program and keep positive public support. It is important for transparency that the public know the intended result of individual CIPs. A phased project will not solve all flooding immediately and will be only partially effective until the other related phases are connected and in place. Confidence in the program can be lost if the effect of the installation of partial improvements are overstated and flooding still occurs after installation.

- Preserving or Creating Natural Coastal Wetlands – Several published reports have shown the benefit of "nature-based" coastal defenses such as mangroves and wetlands abilities to reduce inland property damage from surge flooding during storms. Creating, protecting, and strengthening natural infrastructure living shorelines such as coral reefs, oyster reefs, and marshes are the first lines of defense. The primary natural shoreline protection mechanism is their inherent ability to dissipate wave energy and block surge flow similar to the effect of artificial defenses such as seawalls. By comparison, natural or nature-based coastal defenses can be cost-effective, self-maintaining, and adaptable to changing conditions including sea level rise, and work in harmony with the natural environment. Southeast Florida's coral reefs, beaches, dunes, wetlands and coastal forests provide a habitat for indigenous wildlife and are understood to be an integral part of the diverse mix of attractions that anchors the region's tourism and real estate-driven economy and are part of the goals of the Southeast Florida Climate Compact.

- Shoreline Armoring – Shoreline armoring is the practice of using physical structures to protect shorelines from wave action, coastal erosion, and block the onset of storm surge. Armoring also includes "green infrastructure" such as the creation and conversion of shoreline areas to seaside parks with natural coastal protection features and berms. Traditional "grey infrastructure" such as seawalls and breakwaters are common along the City's shorelines and canals but are lacking in many areas – some seawall areas have fallen into dis-repair, some are at too low an elevation to be effective, and several areas have no protection. The shoreline armoring is only as strong as its weakest link as encroaching waters will find the low spot or break in the armor and flooding will occur, which is why it is critically important, for the expense that will be required, to pay careful attention to the continuity and seamlessness of the shoreline system, including enforcement of private properties, to seal the barrier and prevent the onset flooding. Grey infrastructure has some drawbacks including aesthetics, potential negative impacts on the natural environment, high initial construction costs, and significant replacement costs. Creating multi-level shoreline barriers which incorporate pedestrian walkways, marine activities, and shoreline recreation allows for continued mixed use of the shoreline under varying tide scenarios and allows for adaptable measures storm surge and for future sea level rise. Extending the barriers offshore with natural nature-scape can lessen the aesthetic issues but complicates environmental permitting.

It should be noted that:

- In some areas of the City, this will require the extension of the seamless connected seawalls into neighboring municipalities.
- The recommended seawalls are not restricted to just the coastal neighborhoods. Several inland areas along the tidally influenced canals will require raised seawalls as well as noted in the CIP Area summaries.
- Areas of seawalls will trap stormwater runoff inside the wall and exacerbate existing flooding if the SWMP CIP is not installed concurrently.

- <u>Updated Evacuation Routes Design Standards</u> – The occurrence and severity of flooding can have an impact on evacuation routes, restrict access to homes, schools, hospitals, and businesses, and can affect the public transit infrastructure. The major evacuation routes for the City are the larger County and State Roads. Although technically the responsibility of the roadway owners, the City can do its part to address flooding in local streets and areas along these routes allowing for safe access to the roadways.
- <u>Backflow Prevention</u> – The City's stormwater systems typically have open outfall pipes into the receiving waters that are vulnerable to water freely flowing back onto the land as the receiving water level rises, resulting in non-rainfall related flooding in low lying areas at high tides. Backflow prevention devices are used to provide a one-way valve in the pipes allowing flow only out toward the receiving water, and they seal shut when conditions would result in flow in the opposite direction in toward the land. Backflow preventers also add headloss to the hydraulic system requiring additional energy to open that and adding to the flood stage height that must be compensated for in the design in order to not exacerbate flooding at street level due to the restriction caused by the valves. Backflow preventers also require diligent, regular maintenance to keep them operational due the corrosive and living marine environment. The City is currently in the process of standardizing and retrofitting its most vulnerable tidal flooding area outfalls with backflow prevention devices and all new outfalls added to the City's system in the CIP will require backflow prevention devices. Additionally, interconnections with other stormwater systems that do not have backflow prevention (FDOT and BC) will require in-system back flow prevention at the system connections as noted in the CIP Area summaries.
- <u>Use of Gravity Driven Drainage Systems</u> – The use of positive gravity drainage systems wherever hydraulically possible (i.e., flow from relatively higher to lower areas) requires no external power sources or controls and is automatically engaged when needed, so currently, it is inherently resilient. Exfiltration systems, gravity drainage wells, and storm

sewer collection piping to the outfalls all fall under this gravity-driven system category. These systems must be maintained and kept free of debris and clogging to function properly. In the terms of Hollywood's long-term outlook, over time, as sea levels rise and the available driving head lessens, many of these systems will eventually become less and less effective and, if population remains in these areas, the pipes will need to be replaced with powered, positive drainage systems such as large pump stations for water movement and pumped recharge wells for disposal.

- Emergency Standby Power Systems for Critical Infrastructure - Power outages result from electrical system failures at the grid, local, or facility level and are frequent in South Florida. Typical strong convective thunderstorms and tropical systems can down powerlines, produce lightning which causes electrical power surges and transients affecting sensitive electronics, and floodwaters can inundate and short electrical equipment. If severe weather events become more frequent or extreme, the likelihood of power failures, and pump shutdown events increase, resulting in loss of investment in infrastructure and ineffective flood control. As the City's current and proposed stormwater management systems rely on a network of pump stations working in concert to keep flood waters at the desired LOS, having a dedicated, maintained standby power system at all critical stormwater pump stations in the system is key for resiliency to keeping flooding events at a minimum. The power delivery side of the generator should be monitored by telemetered SCADA so the operations staff in the main control operations room can know the station generators are not only operating but are delivering the power to the station, and a sufficient reserve supply of fuel on site is required. A fleet of portable generators can sometimes be substituted due to their reduced costs and ability to share resources where they are needed, however deploying, connecting, and maintaining operation of the equipment in storm conditions is often challenging when flood waters are rising and time is of the essence, and fuel storage and distribution may become an issue as well. For this situation, the pump stations will need a ramped, elevated slab or platform to park and secure the portable generators and keep them above flood heights. In addition, an inventory of portable, high-capacity, low-head stand-by diesel driven stormwater pumps can also be dispatched to known flood areas where permanent pump station facilities are not practical or are not yet installed and there exists a safe setup area at the low point for collection, a route for the safe arrangement of the discharge hose/pipe, and a nearby, acceptable discharge point. This can be City-owned and maintained or contracted out on an as-needed, stand-by basis. It is noted that even the largest portable engine driven pumps are not of sufficient size to provide the capacity required to lower existing flood levels even in a typical smaller storm, but can help to dissipate standing water post-storm, especially at higher-tide conditions in gravity outfall neighborhoods.

- Flood Stage Gauge Network – A dry-land and canal stage monitor network can report real-time flooding city wide and assist emergency managers in providing public safety information in flood-prone areas. The monitors can also provide historical water surface elevation data correlated with rainfall to see real time stormwater systems response, CIP effectiveness, and aid in locating future improvements or trouble areas where clogging may be occurring and maintenance is required. The monitors will also pick up trends over time for areas where sea level rise is beginning to diminish the effectiveness of the stormwater systems.

- Planning Studies for Relocation of At-Risk Population and Infrastructure – Over time, as the City implements the CIP and adapts to rising seas, it may be appropriate to consider relocation for the repetitive loss structures and areas, converting to stormwater management lands use rather than attempting to add more costly infrastructure. The SWMP model and HAZUS tools can be used to further assess the benefits vs costs for the flood risks and protection of public safety and the environment.

- Discussions for Regional Solutions – The City should continue to engage discussions with its neighboring municipalities and entities (Cities, County, SFWMD, USACE) for co-operative larger-scale regional solutions to assist with runoff flows entering the City from off site, shared projects for flood mitigation, and sea level rise solutions County-wide and basin wide for flood mitigation coordination.

4.2.8 Long-Term Resiliency Planning and Sea Level Rise Adaptation of the SWMP

Long-term resiliency (i.e., end of the century) measures also include both structural and non-structural activities. Most long-term measures are conceptual in nature because they require funding and policy decisions beyond what the City can realistically generate or implement today, significantly affect the entire South Florida population, its way of life, and the local and regional economy, and requires coordination and agreement amongst multiple stakeholders. Often, the long-term solutions also directly compete with environmental protection initiatives. Considering standard engineering solutions, it is likely that at a certain point in the future, the energy required to continually pump water out of the City (if the pumped option is even affordable) might exceed the City's capability for pumping, and in terms of fossil-fuel emissions, may have a carbon footprint beyond local climate change initiatives.

Because climate change cycles occur over such a long period of time, in general it is sometimes hard for officials and regulators to begin to commit funding, adopt, or enforce long-term solutions now, as there are many competing interests for the funding for more pressing current issues. It is speculated that future bank mortgage and development lending risk, flood insurance rates and availability, long-term municipal land leasing, and the real estate market will ultimately drive the urgency for actually implementing long-term resiliency actions in South Florida, or the population will begin to relocate to higher ground.

Although it is beyond the scope of this stormwater master plan project to specifically model potential changes in groundwater flows with SLR, it is expected from the results of other specific studies, that low-lying areas close to the coast will need to be raised due to groundwater seepage under the proposed seawalls, especially at future higher SLR elevations. The Biscayne Aquifer is useful for stormwater discharge and recharge because it is highly permeable, but that same high permeability will result in seepage under seawalls as sea levels rise, as is seen now during the sunny day flood events of King Tides where standing water is also observed rising from the ground on the "landside" of newly raised seawalls, where the ground elevation was not raised concurrently. If future sea levels continue to rise (beyond the design life of this CIP) to 6 ft or potentially 10 ft above the recorded 1990 levels as projected toward the end of this century, the aquifer disposal design elements of this SWMP CIP are not expected to continue to be able to perform in many areas, as groundwater will also seep under the seawalls at rates potentially beyond the capacity of the pump stations' ability to handle the flows, exfiltration and gravity wells will become hydraulically unfeasible, and the "living with water" measures discussed previously will need to be firmly in place.

Coastal Flood Barrier

In 2020, the U.S. Army Corps of Engineers recommended a coastal flood wall, operable roadway and canal gates, and other natural barriers be built to protect the South Florida coastline against large storm surge events, the exact location of which is still to be finally determined at the time of this report. Although not explicitly part of that study, to remain effective later in the century and prevent waters from also rising up through the ground under future SLR conditions, if the ground surface elevation is not raised in conjunction, the City's seawalls including the regional flood wall will need to be accompanied by underground impermeable cutoff walls (or curtains) extending through the bottom of the Biscayne Aquifer, likely comprised of impervious bentonite (clay) which may need to be up to 200 feet deep. For this concept to be effective, both the flood protection walls and the additional bentonite curtain into the aquifer must extend seamlessly and continuously well beyond the City limits - to the northern and southern extents of the aquifer, likely from northern Broward County through Homestead in Southern Miami-Dade County, to be effective, so there are no locations for water to seep through. There are many potential issues with placing seawalls/floodwalls at the edge of the municipal areas including the aesthetics and environmental concerns of a high barrier, economic issues limiting recreational access and impacting commercial traffic inland. There are many permitting, social, and economic issues and options to overcome and resolve with the "common ocean berm" defense against SLR and large surge events. The enormous cost issue of such an undertaking is likely even beyond that which most collective municipalities can afford, however many other studies have concluded that the "do nothing" option is likely to cost even more. Between the loss of property value, the loss of tourism for the state, and the mass movement of the population of Southeast Florida to elsewhere, the "do nothing" costs would be staggering, before the loss of such an iconic Cities as currently exist along the coastline is factored in.

Current Prototype Floodwall Protection Systems

Two notable types of mechanical flood protection systems in low-lying areas are currently in operation in the Netherlands and in New Orleans, LA. The primary difference between the way the Netherlands and the City of New Orleans have protected their low-lying areas is that the Netherlands uses a perimeter defense with canals at ground level even if ground level is well below sea level and large pumps at the perimeter end of the canals; whereas New Orleans pumps up to raised canals from the center of the city (to take advantage of the "bottom of the bowl" collection system) and then uses the elevated canals at sea level height with high floodwalls extending into the city for protection. The floodwalls extending into the city were found to be vulnerable during Hurricane Katrina. A future plan for New Orleans is likely to eventually move to a perimeter defense where there is one large protective berm surrounding the city, with pumps at the edge.

Adaptation Considerations

Another long-term option for the City would be to adapt and live with the rising water and over time, raising the lowest-lying elevations in the City. This would likely require the eventual phased reconstruction or jacking of foundations of all structures Countywide currently below approximately elevation 10 ft NAVD to start, filling-in all parcels along the way, and elevating the roadways to match the new grade as the previous stage-storage is depleted. The lowest-lying areas would be excavated creating large, dedicated storage areas for stormwater and potentially providing fill for some of the remaining areas. Forward-thinking, resiliency analyses and studies in conjunction with preparations for co-existing with stormwater flooding and adaptation to future sea level rise consider modifying the basic design of the City considering building code changes, Low Impact Development/Green Infrastructure (LID/GI) requirements, and exploring the possibility of conceptual measures such as future elevated pile roadway networks, elevated pile houses, floating neighborhoods and platform communities in low-lying areas over the created water catchments, sealing underground utilities, conversion of low-lying streets to an interconnected canal system for transportation and flood control, back pumping to dedicated stormwater management lands, conversion of flood prone lands to stormwater management lands, elevating all critical infrastructure, in conjunction with relocation, and adding dikes, locks, floodwalls, and large pumping systems for future sea level rise conditions.

Components of the CIP program proposed in this SWMP for stormwater management infrastructure will be beyond their design life by the time regional options are significantly accepted and in place. If groundwater levels can be maintained close to existing levels or lower, either with a local floodwall/curtain or a perimeter floodwall/curtain and pumping systems, the installed exfiltration and pumped recharge into the Biscayne Aquifer should still provide flood relief for large rainfall events and the large gravity systems and pump stations should be able to continue to move floodwaters from flood prone areas to the waterways and out to sea.

4.2.9 Stormwater Design Criteria Recommendations and Development Guidelines

The following recommendations are made:

1. Design Criteria – Design of new stormwater systems should be in accordance with the SWMP CIP recommendations and meet BC SWLD requirements for water quality and pre-post demonstration of no impact. Designers should use the single source, official City-published values for the applicable LOS and appropriate design storm for the design tailwater conditions at the attachment point to the PSMS from the SWMP output data (as updated in the living model). New development should maintain the new water quality requirements treatment storage for the protection of receiving waters and maintain the historic flood plain storage on-site and retain historic flow paths.

2. Seawall Heights - The City has adopted the Broward County recommended seawall ordinance which includes minimum seawall heights proposed to be raised, or installed in phases, up to 5 ft-NAVD. The City needs to enter discussions with neighboring municipalities where seawalls need to be extended in several areas past the City's jurisdictional limits to prevent flooding from offsite into the City. Stormwater CIP infrastructure should be installed concurrently in areas where new seawall is replacing historic overland sheet flow off the land.

3. Finished Floor Elevations (FFEs) – The SWMP established peak flood stages across the City for the 100-year, 72-hour SFWMD design storm using NOAA Atlas 14 rainfall data (approximately 17 inches) under existing high tide conditions and future sea level rise conditions. The City should consider new building finished floor elevations be constructed at least 1 foot above the target future sea level rise flood elevation for the structure's design year based on the City-adopted latest SF Climate Compact projections, FS 380 requirements, or above the FEMA flood elevation whichever is greater in that location. Additionally, Building Code modifications should begin to consider the structure's ground floors to be designed to be adaptable to future inundation (i.e., sacrificial as sea levels rise) where not practical to raise to the required height now.

4. Backflow Preventers – Backflow preventers are necessary to be installed in all City and private outfalls to manage tidal backflow (existing and new outfalls). It is recommended that designers use the City-approved devices and that are resistant to the corrosive tidal and brackish conditions along the coast and account for the additional headloss in their hydraulic calculations. The City will need to engage a regular maintenance program to service each of these devices so that they do not fail and exacerbate flooding due to maintenance issues.

5. Recharge Wells – Both gravity and pumped recharge wells are recommended as part of the CIP in areas where the hydraulics are favorable and underground pumped recharge regulation allows. Pretreatment should be provided as required by FDEP and BC SWLD as these well tend to clod rapidly due to the sand and debris in the South Florida Stormwater and need to be maintained regularly to maintain their design capacity.

6. Exfiltration Systems – exfiltration systems are recommended as a major component of the SWMP. It is recommended that exfiltration be constructed in areas where the street inlets are above 6 ft-NAVD and that the perforated pipes be a minimum 36-inches in diameter or larger as necessary for hydraulic conveyance. New exfiltration trenches should be 8-feet wide by a minimum of 8-feet deep and that the perforated pipe and rock trench be wrapped in filter fabric. Maintenance access structures should be no more than 400 feet apart for cleaning access. New private development exfiltration trenches should be designed in accordance with the most current SFWMD regulatory criteria. The City should enforce the Broward County future GWEL requirement for the wet season water table elevation to account for future higher groundwater conditions due to sea level rise. This increase modifies the H_2, D_S, and D_U parameters in the SFWMD exfiltration equation in Permit Information Manual Volume IV, which in turn will increase the design length of the trench system. Retrofit exfiltration for the CIP projects in the City rights-of-way should follow the SWMP recommendations for the lengths provided which are already optimized for the area LOS and in most areas use the maximum available area. If additional area is available and the hydraulics are favorable, an additional 10% of length can be required on a case-by-case basis to account for sea level rise.

7. Stormwater Design Standards Manual – A standalone stormwater design standards manual for all City stormwater projects should be developed in electronic format to provide to designers as single-source checklist issued by the City to follow for consistent and acceptable submittals for planning, design, and permitting. The manual should provide the necessary information and a step-by-step procedure for consistency and conformance with the SWMP. The document should provide live links to pertinent internal and external data and other

required information for the design and permitting submittals from the SWMP. The electronic design standards manual will greatly streamline the City's review process by providing a single standard format for submittals and compliance with the master plan. A layout for a standard small, medium, and large stormwater pump station with preferred standardized equipment and acceptable manufacturers should be developed for consistency of maintenance and minimizing of warehoused equipment.

4.2.10 Operations and Maintenance Program Expansion

As the stormwater system assets expand rapidly as part of the CIP implementation, the associated operational and maintenance costs (O&M) will increase accordingly. Maintaining a clean, operable system free of clogging and breaks is paramount to flood control and meeting imposed water quality requirements. USEPA, FDEP, FSA, and SFWMD all have published recommended guidelines, tools, and procedures for stormwater maintenance best practices, controls, maintenance schedules, fact sheets, cost estimating tools, and inspection forms. Considering the cost of the City's investment in stormwater CIP infrastructure, an enhanced operation and maintenance program and budget is required in parallel to ensure the investment meets the desired LOS and functions as designed when needed. Whether performed in-house or contracted out to vendors, the O&M funding sources can be supplemented by enhancing the City's stormwater utility or impact fees.

Preventative maintenance involves the regular inspection and testing, and proactive replacement and repair of stormwater management system assets and equipment. Typical stormwater system O&M activities include recurrent:

- Street sweeping
- Pump station maintenance – pumps, controls, electrical gear, instrumentation, standby power, fuel systems
- Outfall clearing
- Collection and transmission pipe jetting, cleaning, and debris removal
- Catch basin clearing
- Manhole clearing
- Structural repairs and erosion control
- Back flow preventer maintenance
- Exfiltration system and drainage well cleaning
- Conveyance swale, ditch, and pond clearing and mowing and restoration
- Canal dredging
- Pollution control device maintenance
- Control gate and weir maintenance
- Permeable pavement and grass paver maintenance
- Bioswale maintenance

- Construction and Operations SWPPP inspection and enforcement

All these activities should be tracked, recorded, and linked to the new stormwater GIS that was created for this project to provide visual dashboards, O&M planning, and asset management protocols. All O&M spot repairs which alter the system connectivity should be updated within the GIS from the field record drawings and updated in the SWMP models and the O&M data should be trended over time to discover patterns in maintenance efforts to better understand hotspots and root causes. The GIS created for the City allows for live or batch modifications and updates using tablets or other hand-held smart devices to streamline the process.

To create a baseline for operational costs, existing stormwater system O&M expenditures are totaled and level of maintenance / level of service are evaluated and graded, a needs analysis is developed, and a budget is established. By dividing by key assets (number of SWPS, miles of pipe or trench, acres of dry detention, etc.) unit cost metrics applicable to Hollywood can be derived and projected out into the future as new CIP is installed, and the portion of the stormwater utility fund can be reserved.

4.2.11 CIP Program Management Considerations

Several factors will shape how the CIP will be implemented including the City's funding capacity over time and the bonding capacity of the contractors able to perform the work. Whether internal or external, the City will need engage program oversight and have a management team and the proper support staffing to administer and coordinate the CIP including: project managers, construction managers, design consultant managers, permit managers, design standards and quality control managers, joint project agreement coordinators, construction inspectors, money managers, and schedulers.

For a simplified perspective, for the desired 20-year CIP, assuming an average project size of $50 million, a $2 billion program (Alternative 1 LOS) will require 2-3 projects to be let annually for approximately 45 total program projects. Using a 2.5% City administrative fee, this equates to a dedicated staff of between 15-20 people. Note, it is more likely that the "average" $50M project will be split into four (or more) smaller phases during actual implementation as budget allows.

This program will also result in construction on City streets as its associated disruption throughout the City on a continuous basis for the next 25-30 years. For large programs with similar work areas and specialties as this (i.e., stormwater components), it is recommended that the City pre-qualify a rotating pool of qualified contractors and set unit prices with escalation to streamline the procurement process. Projects can then be assigned based on contractor specialty and availability, and the next assignments of work can be based on an annual review of performance and the contractors' capacity for new work. Simple projects such as exfiltration systems can be let as design build to cut costs and accelerate the schedule.

For budgetary planning, simple linear annual expenditure for three program lengths of 20, 25, and 30 years is provided in **Table 4-2**.

Table 4-2 CIP Annual Planning Cost Expenditure by Alternative (2022 US Dollars, No escalation)

LOS	PROGRAM CIP COST	PROGRAM YRS - ANNUAL EXPENDITURE		
		20	25	30
ALT 1	$1,900,000,000	$95,000,000	$76,000,000	$63,333,333
ALT 2	$890,000,000	$44,500,000	$35,600,000	$29,666,667

4.2.12 Public Information Program Continuation

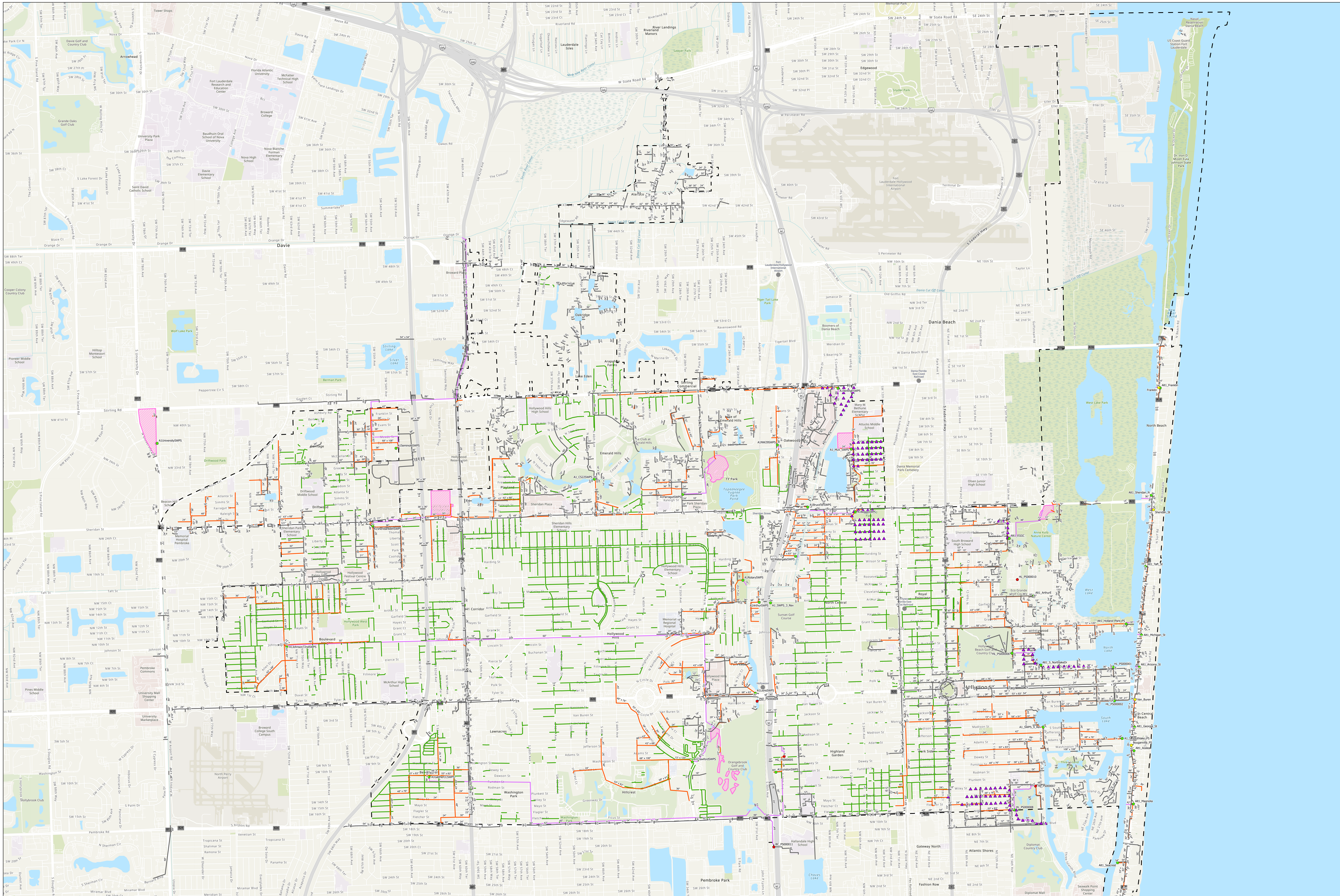
The residents of Hollywood are an essential component of the resiliency of the community and an important part of the stormwater system maintenance and operations. Crowd-sourced data solicitation and encouraging residents to stay informed about the key services stormwater systems provide will help to build long lasting support for the management of these critical systems. As part of the Stormwater Master Plan Update for the City, an educational campaign about stormwater, water quality, and sea level rise was developed. This educational campaign was the start of an informative, prolonged educational campaign. There is a need for consistent and continued education, especially on complex topics like stormwater and sea level rise, and other topics such as water quality which requires a constant reminder of good practices and the consequences of non-compliance. The City has a role in educating its residents for assisting in the reduction of pollutants that end up in the coastal water bodies. The provided materials, and future campaigns, should be easily understandable, graphical, and in multiple languages to ensure inclusivity for all members of Hollywood's diverse community. The City's existing and proposed new stormwater system are an essential component of the health of the receiving waterways and lakes and the comprehensive flood protection of the City. The overall plan of continued education through social media, newsletters, and other City communications should be maintained and the City should continue to promote the Stormwater Master Plan as the foundation of a strong resilience and education program for the community. Simple and straightforward opportunities to further educate the people of Hollywood and remind them about the importance of the stormwater system, such as using utility bills or community engagement workshops as an opportunity to educate residents on stormwater, resiliency issues, and the 311 or other reporting systems should be considered to be continued. As the City embarks on an ambitious capital improvement program, the SWMP document should be referred to often as successes are realized. This will build credibility in the community for the Master Plan, and with the City's improvement program.

4.3 Future SWMP Updates

As the CIP program progresses and new infrastructure is installed, the EC model should be updated to reflect the changes provided in the record drawing information. The first selected CIP projects (or partial phases of projects) will likely be completed and on-line within 5 years. Due to the comprehensive and detailed model and plan, unless there are significant deviations in the overall master plan approach or land use (such as raising of land areas, elevation of roadways, conversion of urban lands to create dedicated stormwater management areas, or the installation of large regional stormwater management projects by the County, USACE, or State/SFWMD), the individual CIP areas can be updated in the models as they are completed, and a brief technical memorandum created annually to show the progress and effects of the phased installation of the CIP over time. This update document in conjunction with the approved conceptual ERP can also be used for the FEMA 5-year update cycle and the MS4 cycle throughout the 20-year CIP program.

Appendix A

Citywide SWMP Proposed CIP for Alternatives 1 and 2



Citywide Proposed CIP for Alternative 1

CDM Smith

City of Hollywood Florida

N

0 2,000 4,000 8,000 Feet

Legend

Hollywood City Limits

Model Pump Stations

- Existing SWPS
- Near Term SWPS
- Alt 1 SWPS

Alt 1 Injection Wells

Existing Gravity Pipes

Alt 1 Gravity Pipes

Alt 1 Exfiltration Pipes

Alt 1 Forcemains

Existing Forcemains

Alt 1 Detention Pond

City of Hollywood Stormwater Master Plan
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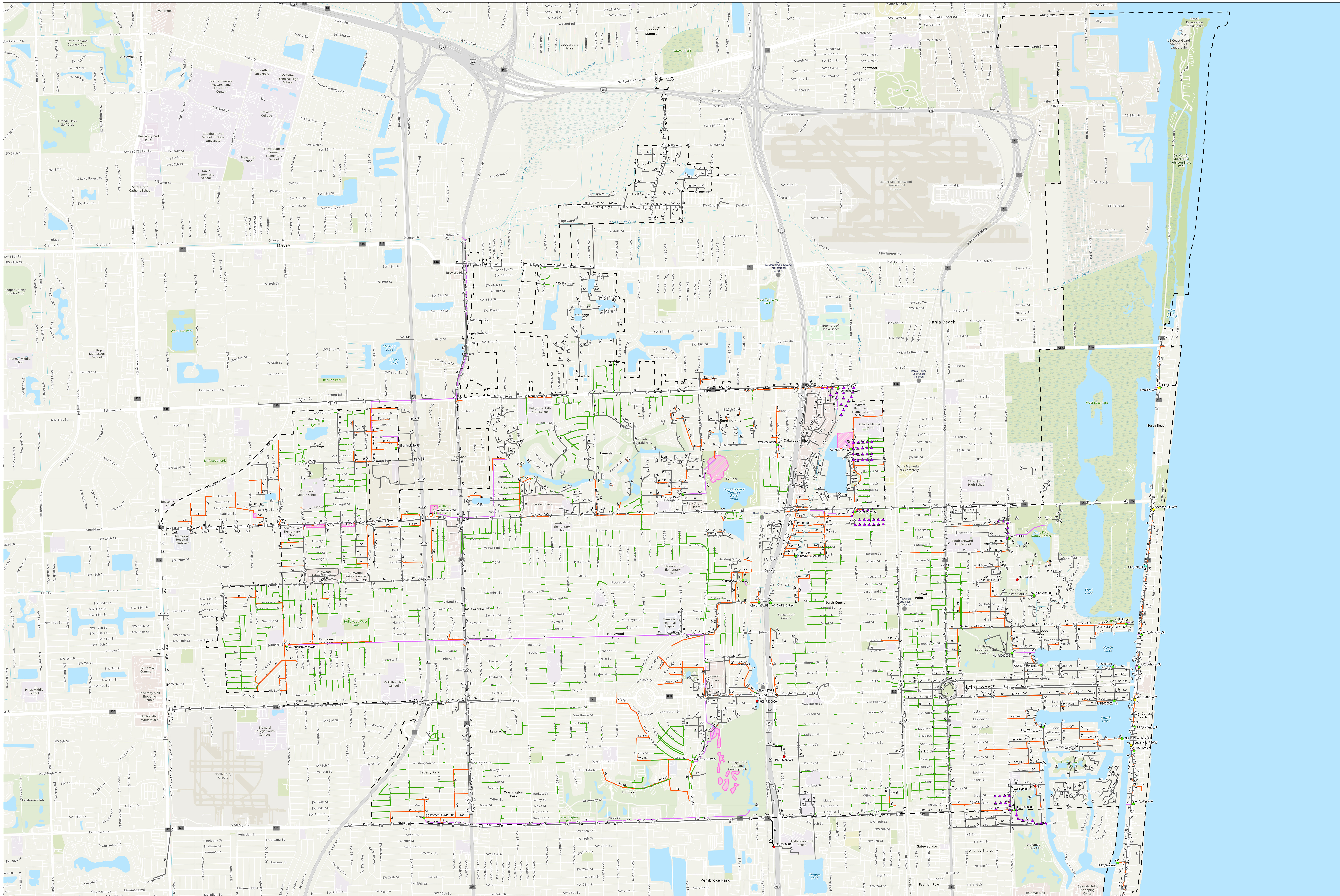

Citywide Proposed CIP for Alternative 2

CDM Smith

City of Hollywood Florida

N

0 2,000 4,000 8,000 Feet

Legend

Hollywood City Limits

Model Pump Stations

- Existing SWPS
- Near Term SWPS
- Alt 2 SWPS

Alt 2 Injection Wells

Alt 2 Gravity Pipes

Existing Gravity Pipes

Alt 2 Exfiltration Pipe

Alt 2 Forcemains

Existing Forcemains

Alt 2 Detention Pond

City of Hollywood Stormwater Master Plan
Appendix A
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Appendix B

Land Acquisition and Easements List

CITY OF HOLLYWOOD SWMP
LAND ACQUISITION LISTING (ALTERNATIVE 1 LOS)

Item	CIP Area	Proposed Facility	SWMP CIP Use	Parcel ID	Owner* (*2022 BCPA Tax Roll)	Address	Purchase Land Value*	Tributary Area (Acres)	SWPS Capacity (cfs)	Flow (cfs/acre)	Comment
1	HW-D5-1	University Dr Detention Pond and SWPS	Purchase SWM Land	514104010011	WALDREP ENTERPRISES LLLP	STIRLING RD & University Ave DAVIE FL 33024	$7,064,790	580	180	0.31	
2	HW-D5-2	Sheridan66 SWPS	SWPS Easement	514111180300	CITY OF HOLLYWOOD DEPT OF COMMUNITY & ECONOMIC DEV	N 65 WAY HOLLYWOOD FL 33024	N/A	198	176	0.89	
3	HW-D5-2	Williams Park Dry Detention	SW Detention Easement	514101000262	CITY OF HOLLYWOOD DEPT OF COMMUNITY & ECONOMIC DEV	6101 SHERIDAN ST HOLLYWOOD FL 33024	N/A				
4	HW-D5-3/4/5	Johnson72 SWPS	SWPS Easement	514114070010	CITY OF PEMBROKE PINES	7190 JOHNSON ST HOLLYWOOD FL 33024	N/A	350	200	0.57	
5	HW-D4-9	Seminole SWPS	SWPS Easement	514102211310	SCHOOL BOARD OF BROWARD COUNTY ATTN	6401 CHARLESTON ST HOLLYWOOD FL 33024	N/A	230	220	0.96	
6	HW-D6-5	GaitherCC SWPS	SWPS Easement	514124142820	CITY OF HOLLYWOOD DEPT OF COMMUNITY & ECONOMIC DEV	6291 FUNSTON ST HOLLYWOOD FL 33023	N/A	330	150	0.45	
7	HC-D4-6	CS-22 Structure and SWPS	SWPS Easement	514206084880	FIRST EAGLE MANAGEMENT LLC	GREENS RD HOLLYWOOD FL 33021	N/A	1179	600	0.51	
8	HC-D4-2	Farragut SWPS	SWPS Easement		ROW	ROW	N/A	170	140	0.82	
9	HC-D4-2	TY Park Detention	SW Detention Easement	514205000360	BROWARD COUNTY BOARD OF COUNTY COMMISSIONERS	3301 N PARK RD HOLLYWOOD FL 33021					
10	HC-D4-1	StirlingE SWPS	SWPS Easement	514204000112	CF & A HILL FAMILY LTD	STIRLING RD HOLLYWOOD FL 33020	N/A	56	100	1.79	IWs to meet the permit limit
11	HC-D4-1	NW29 SWPS	SWPS Easement	514204040071	3600 HOLLYWOOD LLC	3600 N 29 AVE HOLLYWOOD FL 33020	N/A	72	220	3.06	does not meet permit constraint limit
12	HC-D4-1	BruceTer SWPS	SWPS Easement	514209160560	FLORIDA DEPT OF TRANSPORTATION OFFICE OF RIGHT OF WAY	ACCESS RD HOLLYWOOD FL 33020	N/A	15	100	6.7	does not meet permit constraint limit
13	HC-D6-3	Crawford SWPS	SWPS Easement	514220060041	CITY OF HOLLYWOOD DEPT OF COMMUNITY & ECONOMIC DEV	WASHINGTON ST HOLLYWOOD FL 3302	N/A	636	360	0.6	
14	HC-D3-4	Rotary SWPS	SWPS Easement	514208000022	CITY OF HOLLYWOOD DEPT OF COMMUNITY & ECONOMIC DEV	3102-3150 TAFT ST HOLLYWOOD FL 33021	N/A	493	270	0.5	
15	HC-D3-4	Rotary Influent FM from Lake	SWFM Easement	514208170011	LAKE DELRAY INVESTORS LP	3081 TAFT ST HOLLYWOOD FL 33021	N/A				
16	HC-D3-4	Rotary Influent FM from Lake	SWFM Easement	514208160020	HEICO AEROSPACE CORPORATION	3069 TAFT ST HOLLYWOOD FL 33021	N/A				
17	HC-D3-4	Arthur SWPS	SWPS Easement	N/A	CITY OF HOLLYWOOD DEPT OF COMMUNITY & ECONOMIC DEV	ROW OF ARTHUR ST AT N 30TH CT	N/A	23.5	10	0.4	
18	HC-D3-4	Lions SWPS	SWPS Easement	514217022490	CITY OF HOLLYWOOD DEPT OF COMMUNITY & ECONOMIC DEV	TYLER ST HOLLYWOOD FL 33021	N/A	228	270	1.2	
19	HC-D6-1	Orangebrook GC Detention Improvements	Coordinate with GC Improvements	514217050010	CITY OF HOLLYWOOD DEPT OF COMMUNITY & ECONOMIC DEV	400 ENTRADA DR HOLLYWOOD FL 33021	N/A	2528			
20	HC-D2-6	Funston SWPS	SWPS Easement	N/A	CITY OF HOLLYWOOD DEPT OF COMMUNITY & ECONOMIC DEV	2923 FUNSTON ST HOLLYWOOD FL 330205	N/A	259	100	0.4	
21	HC-D3-1	Watergate SWPS	SWPS Easement	N/A	CITY OF HOLLYWOOD DEPT OF COMMUNITY & ECONOMIC DEV	HARDING ST HOLLYWOOD FL 33020	N/A	69	140	2.0	does not meet permit constraint limit
22	HC-D3-1	Boggs SWPS	SWPS Easement	N/A	CITY OF HOLLYWOOD DEPT OF COMMUNITY & ECONOMIC DEV	2402 SHERIDAN ST HOLLYWOOD FL 33020	N/A	212	240	1.1	IWs to meet the permit limit
23	HC-D2-1	MLKCC	SWPS Easement	514204014720	CITY OF HOLLYWOOD DEPT OF COMMUNITY & ECONOMIC DEV	2400 CHARLESTON ST HOLLYWOOD FL 33020	N/A	347	240	0.7	
24	HC-D2-1	Liberia Detention Area 1 (N)	Purchase SWM Land	514204000190	CHARLES N LEIBNITZER LIV REV TR LEIBNITZER,CHARLES N TRSTEE	N 24 AVE HOLLYWOOD FL 33020	$52,450				
25	HC-D2-1	Liberia Detention Area 2 (S)	Purchase SWM Land	514204000200	DANIA ECONOMIC DEVELOPMENT CORP	N 24 AVE HOLLYWOOD FL 33020	$114,440				
26	HE-D1-1	Franklin SWPS	SWPS Easement	514201026130	TIITF/DNR DIV REC & PARKS NORTH BEACH STATE REC AREA	N SURF RD HOLLYWOOD FL 33019	N/A	73	145	2.0	
27	HE-D1-1	Taft SWPS	SWPS Easement	514212020040	BELLAIR DEVELOPMENT LLC	N OCEAN DR HOLLYWOOD FL 33019	N/A	40.7	175	4.3	
28	HE-D1-1	Michigan SWPS	SWPS Easement	514213010810	KRYSTAL CITY LLC	337 MICHIGAN ST HOLLYWOOD FL 33019	N/A	40.6	200	4.9	
29	HE-D1-1	Arizona SWPS	SWPS Easement	514213011970	FLORIDA DEPT OF TRANSPORTATION OFFICE OF RIGHT OF WAY	N OCEAN DR HOLLYWOOD FL 33019	N/A	26.6	120	4.5	
30	HE-D1-2	Georgia SWPS	SWPS Easement	514213013760	HOLLYWOOD MOON DEVELOPMENT LLC	901 S OCEAN DR HOLLYWOOD FL 33019	N/A	47.3	190	4.0	
31	HE-D1-2	Azalea SWPS	SWPS Easement	514213013760	CITY OF HOLLYWOOD DEPT OF COMMUNITY & ECONOMIC DEV	1301 S OCEAN DR HOLLYWOOD FL 33019	N/A	34.1	100	2.9	
32	HE-D1-2	Magnolia SWPS	SWPS Easement	514224010381	CITY OF HOLLYWOOD DEPT OF COMMUNITY & ECONOMIC DEV	301 MAGNOLIA TER HOLLYWOOD FL 33019	N/A	47	200	4.3	
33	HE-D1-2	Seacrest SWPS	SWPS Easement	514223170030	DIPLOMAT LANDINGS OWNER LLC % THAYER LODGING GROUP LLC	3451-3690 S OCEAN DR HOLLYWOOD FL 33019	N/A	67.7	185	2.7	
34	HE-D1-3	SW08 Upgrade SWPS	SWFM Easement Enlargement	514223080460	MALTESE DIPLOMAT OWNER LLC	WILEY ST HOLLYWOOD FL 33009	N/A	378	475	1.3	IWs to meet the permit limit
35	HE-D1-3	Diplomat GC FM	SWFM Easement	514226110501	MALTESE DIPLOMAT OWNER LLC	ATLANTIC SHORES BLVD HALLANDALE BEACH FL 33009	N/A				FM through GC & IWs
36	HE-D1-3	Diplomat FM Hallandale ROW	SWFM Easement	514222132810	CITY OF HALLANDALE BEACH	ATLANTIC SHORES BLVD HALLANDALE BEACH FL 33009	N/A				Outfalls
37	HE-D1-4	SW04 SWPS Upgrade	SWPS Easement	N/A	RIGHT OF WAY	RIGHT OF WAY	N/A	441	400	0.9	
38	HE-D1-4	SSouthLake SWPS	SWPS Easement	N/A	RIGHT OF WAY	RIGHT OF WAY	N/A	69.7	100	1.4	
39	HE-D1-5	SW01 SWPS Upgrade	Existing SWPS Easement	514214024070	CITY OF HOLLYWOOD DEPT OF COMMUNITY & ECONOMIC DEV	698 LINCOLN ST HOLLYWOOD FL 33019	N/A	78.2	408	5.2	Direct ICW
40	HE-D1-5	SW02 SWPS Upgrade	Existing SWPS Easement	N/A	RIGHT OF WAY	RIGHT OF WAY	N/A	133	309	2.3	Direct ICW
41	HE-D1-5	SNorthLake SWPS	SWPS Easement	N/A	RIGHT OF WAY	RIGHT OF WAY	N/A	171	250	1.5	Direct ICW
42	HE-D1-6	SW06 Upgrade	Existing SWPS Easement	514215027670	CITY OF HOLLYWOOD DEPT OF COMMUNITY & ECONOMIC DEV	1645 POLK ST HOLLYWOOD FL 33020	N/A	401	192	0.5	
43	HE-D1-6	HollandPk	SWPS Easement	N/A	CITY OF HOLLYWOOD DEPT OF COMMUNITY & ECONOMIC DEV	801 JOHNSON ST HOLLYWOOD FL 33019	N/A	107	355	3.3	Direct ICW
44	HE-D1-7	ArthurE SWPS	SWPS Easement	N/A	RIGHT OF WAY	RIGHT OF WAY	N/A	107	90	0.8	
45	HE-D1-7	EcoGC SWPS	SWPS Easement	N/A	CITY OF HOLLYWOOD DEPT OF COMMUNITY & ECONOMIC DEV	1451 TAFT ST HOLLYWOOD FL 33019	N/A	521	290	0.6	
46	HE-D1-7	Westlake Detention Pond	Permission for shared- use of detention land or shared pond	514211000010	BROWARD COUNTY BOARD OF COUNTY COMMISSIONERS	1200 SHERIDAN ST HOLLYWOOD FL 33019	N/A				

CITY OF HOLLYWOOD SWMP
LAND ACQUISITION LISTING (ALTERNATIVE 2 LOS)

Item	CIP Area	Proposed Facility	SWMP CIP Use	Parcel ID	Owner* (*2022 BCPA Tax Roll)	Address	Purchase Land Value*	Tributary Area (Acres)	SWPS Capacity (cfs)	Flow (cfs/acre)	Comment
1	HW-D5-1	Bicentenial Park Dry Detention	SW Detention Easement	514103320010	CITY OF HOLLYWOOD DEPT OF COMMUNITY & ECONOMIC DEV	7350 FARRAGUT ST HOLLYWOOD FL 33024	N/A				
2	HW-D5-2	Sheridan Swale70	SW Detention Easement	514111112690	PUBLIC LAND % CITY OF HOLLYWOOD OFFICE OF BUSINESS & INTL TRA	N 69 WAY HOLLYWOOD FL 33024	N/A				
3	HW-D5-2	Sheridan Swale68	SW Detention Easement	514111090360	PUBLIC LAND % CITY OF HOLLYWOOD OFFICE OF BUSINESS & INTL TRA	N 67 TER HOLLYWOOD FL 33024	N/A				
4	HW-D5-3/4/5	Johnson72 SWPS	SWPS Easement	514114070010	CITY OF PEMBROKE PINES	7190 JOHNSON ST HOLLYWOOD FL 33024	N/A	350	160	0.46	
5	HW-D4-9	Seminole SWPS	SWPS Easement	514102211310	SCHOOL BOARD OF BROWARD COUNTY ATTN	6401 CHARLESTON ST HOLLYWOOD FL 33024	N/A	230	160	0.70	
6	HW-D6-5	Fletcher63 SWPS	SWPS Easement	14124051700	MEDICAL PROPERTY HOLDINGS LLC	6300 FLETCHER ST HOLLYWOOD FL 33023	N/A	178	100	0.56	
7	HW-D4-8	WilliamsPk SWPS	SWPS Easement	514101000262	CITY OF HOLLYWOOD DEPT OF COMMUNITY & ECONOMIC DEV	6101 SHERIDAN ST HOLLYWOOD FL 33024	N/A	140	25	0.18	
8	HW-D4-8	Williams Park Dry Detention	SW Detention Easement	514101000262	CITY OF HOLLYWOOD DEPT OF COMMUNITY & ECONOMIC DEV	6102 SHERIDAN ST HOLLYWOOD FL 33024	N/A				
9	HC-D4-6	CS-22 Structure	SW Structure Easement	514206084880	FIRST EAGLE MANAGEMENT LLC	GREENS RD HOLLYWOOD FL 33021	N/A	1179	600	0.51	
10	HC-D4-2	Farragut SWPS	SWPS Easement	N/A	ROW	ROW	N/A	170	140	0.82	
11	HC-D4-2	TY Park Dry Detention	SW Detention Easement	514205000360	BROWARD COUNTY BOARD OF COUNTY COMMISSIONERS	3300 N PARK RD HOLLYWOOD FL 33021	N/A	170	120	0.71	
12	HC-D4-1	StirlingE SWPS	SWPS Easement	514204000112	CF & A HILL FAMILY LTD	STIRLING RD HOLLYWOOD FL 33020	N/A	56	80	1.43	IWs to meet the permit limit
13	HC-D4-1	NW29 SWPS	SWPS Easement	514204040071	3600 HOLLYWOOD LLC	3600 N 29 AVE HOLLYWOOD FL 33020	N/A	72	180	2.50	does not meet permit constraint limit
14	HC-D6-3	Crawford SWPS	SWPS Easement	514220060041	CITY OF HOLLYWOOD DEPT OF COMMUNITY & ECONOMIC DEV	WASHINGTON ST HOLLYWOOD FL 3302	N/A	636	270	0.4	
15	HC-D3-4	Rotary SWPS	SWPS Easement	514208000022	CITY OF HOLLYWOOD DEPT OF COMMUNITY & ECONOMIC DEV	3102-3150 TAFT ST HOLLYWOOD FL 33021	N/A	493	220	0.4	
16	HC-D3-4	Rotary Influent FM from Lake	SWFM Easement	514208170011	LAKE DELRAY INVESTORS LP	3081 TAFT ST HOLLYWOOD FL 33021	N/A				
17	HC-D3-4	Rotary Influent FM from Lake	SWFM Easement	514208160020	HEICO AEROSPACE CORPORATION	3069 TAFT ST HOLLYWOOD FL 33021	N/A				
18	HC-D3-4	Arthur SWPS	SWPS Easement	N/A	CITY OF HOLLYWOOD DEPT OF COMMUNITY & ECONOMIC DEV	ROW OF ARTHUR ST AT N 30TH CT	N/A	23.5	5	0.2	
19	HC-D3-4	Lions SWPS	SWPS Easement	514217022490	CITY OF HOLLYWOOD DEPT OF COMMUNITY & ECONOMIC DEV	TYLER ST HOLLYWOOD FL 33021	N/A	228	220	1.0	
20	HC-D6-1	Orangebrook GC Berm Improvements	Coordinate with GC Improvements	514217050010	CITY OF HOLLYWOOD DEPT OF COMMUNITY & ECONOMIC DEV	400 ENTRADA DR HOLLYWOOD FL 33021	N/A	2528			
21	HC-D3-1	Watergate SWPS	SWPS Easement	N/A	CITY OF HOLLYWOOD DEPT OF COMMUNITY & ECONOMIC DEV	HARDING ST HOLLYWOOD FL 33020	N/A	82	80	1.0	does not meet permit constraint limit
22	HC-D3-1	Boggs SWPS	SWPS Easement	N/A	CITY OF HOLLYWOOD DEPT OF COMMUNITY & ECONOMIC DEV	2402 SHERIDAN ST HOLLYWOOD FL 33020	N/A	212	90	0.4	IWs to meet the permit limit
23	HC-D2-1	MLKCC	SWPS Easement	514204014720	CITY OF HOLLYWOOD DEPT OF COMMUNITY & ECONOMIC DEV	2400 CHARLESTON ST HOLLYWOOD FL 33020	N/A	347	160	0.5	
24	HC-D2-1	Liberia Detention Area 1 (N)	Purchase SWM Land	514204000190	CHARLES N LEIBNITZER LIV REV TR LEIBNITZER,CHARLES N TRSTEE	N 24 AVE HOLLYWOOD FL 33020	$52,450				
25	HC-D2-1	Liberia Detention Area 2 (S)	Purchase SWM Land	514204000200	DANIA ECONOMIC DEVELOPMENT CORP	N 24 AVE HOLLYWOOD FL 33020	$114,440				
26	HE-D1-1	Franklin SWPS	SWPS Easement	514201026130	TIITF/DNR DIV REC & PARKS NORTH BEACH STATE REC AREA	N SURF RD HOLLYWOOD FL 33019	N/A	73	110	1.5	
27	HE-D1-1	Taft SWPS	SWPS Easement	514212020040	BELLAIR DEVELOPMENT LLC	N OCEAN DR HOLLYWOOD FL 33019	N/A	40.7	145	3.6	
28	HE-D1-1	Michigan SWPS	SWPS Easement	514213010810	KRYSTAL CITY LLC	337 MICHIGAN ST HOLLYWOOD FL 33019	N/A	40.6	160	3.9	
29	HE-D1-1	Arizona SWPS	SWPS Easement	514213011970	FLORIDA DEPT OF TRANSPORTATION OFFICE OF RIGHT OF WAY	N OCEAN DR HOLLYWOOD FL 33019	N/A	26.6	100	3.8	
30	HE-D1-2	Georgia SWPS	SWPS Easement	514213013760	HOLLYWOOD MOON DEVELOPMENT LLC	901 S OCEAN DR HOLLYWOOD FL 33019	N/A	47.3	105	2.2	
31	HE-D1-2	Azalea SWPS	SWPS Easement	514213013760	CITY OF HOLLYWOOD DEPT OF COMMUNITY & ECONOMIC DEV	1301 S OCEAN DR HOLLYWOOD FL 33019	N/A	34.1	80	2.3	
32	HE-D1-2	Magnolia SWPS	SWPS Easement	514224010381	CITY OF HOLLYWOOD DEPT OF COMMUNITY & ECONOMIC DEV	301 MAGNOLIA TER HOLLYWOOD FL 33019	N/A	47	135	2.9	
33	HE-D1-2	Seacrest SWPS	SWPS Easement	514223170030	DIPLOMAT LANDINGS OWNER LLC % THAYER LODGING GROUP LLC	3451-3690 S OCEAN DR HOLLYWOOD FL 33019	N/A	67.7	135	2.0	
34	HE-D1-3	SW08 Upgrade SWPS	SWFM Easement Enlargement	514223080460	MALTESE DIPLOMAT OWNER LLC	WILEY ST HOLLYWOOD FL 33009	N/A	378	220	0.6	
35	HE-D1-3	Diplomat GC FM	SWFM Easement	514226110501	MALTESE DIPLOMAT OWNER LLC	ATLANTIC SHORES BLVD HALLANDALE BEACH FL 33009	N/A				FM through GC & IWs
36	HE-D1-3	Diplomat FM Hallandale ROW	SWFM Easement	514222132810	CITY OF HALLANDALE BEACH	ATLANTIC SHORES BLVD HALLANDALE BEACH FL 33009	N/A				Outfalls
37	HE-D1-4	SW09 SWPS Upgrade	SWPS Easement	N/A	RIGHT OF WAY	RIGHT OF WAY	N/A	441	325	0.7	
38	HE-D1-4	SSouthLake SWPS	SWPS Easement	N/A	RIGHT OF WAY	RIGHT OF WAY	N/A	69.7	105	1.5	
39	HE-D1-5	SW01 SWPS Upgrade	Existing SWPS Easement	514214024070	CITY OF HOLLYWOOD DEPT OF COMMUNITY & ECONOMIC DEV	698 LINCOLN ST HOLLYWOOD FL 33019	N/A	78.2	183	2.3	Direct ICW
40	HE-D1-5	SW02 SWPS Upgrade	Existing SWPS Easement	N/A	RIGHT OF WAY	RIGHT OF WAY	N/A	133	229	1.7	Direct ICW
41	HE-D1-5	SNorthLake SWPS	SWPS Easement	N/A	RIGHT OF WAY	RIGHT OF WAY	N/A	171	80	0.5	Direct ICW
42	HE-D1-6	SW06 Upgrade	Existing SWPS Easement	514215027670	CITY OF HOLLYWOOD DEPT OF COMMUNITY & ECONOMIC DEV	1645 POLK ST HOLLYWOOD FL 33020	N/A	401	125	0.3	
43	HE-D1-6	HollandPk	SWPS Easement	N/A	CITY OF HOLLYWOOD DEPT OF COMMUNITY & ECONOMIC DEV	801 JOHNSON ST HOLLYWOOD FL 33019	N/A	107	355	3.3	Direct ICW
44	HE-D1-7	ArthurE SWPS	SWPS Easement	N/A	RIGHT OF WAY	RIGHT OF WAY	N/A	107	55	0.5	
45	HE-D1-7	EcoGC SWPS	SWPS Easement	N/A	CITY OF HOLLYWOOD DEPT OF COMMUNITY & ECONOMIC DEV	1451 TAFT ST HOLLYWOOD FL 33019	N/A	521	50	0.1	
46	HE-D1-7	Westlake FM Easement	SW FM FM Easement	514211000010	BROWARD COUNTY BOARD OF COUNTY COMMISSIONERS	1200 SHERIDAN ST HOLLYWOOD FL 33019	N/A				

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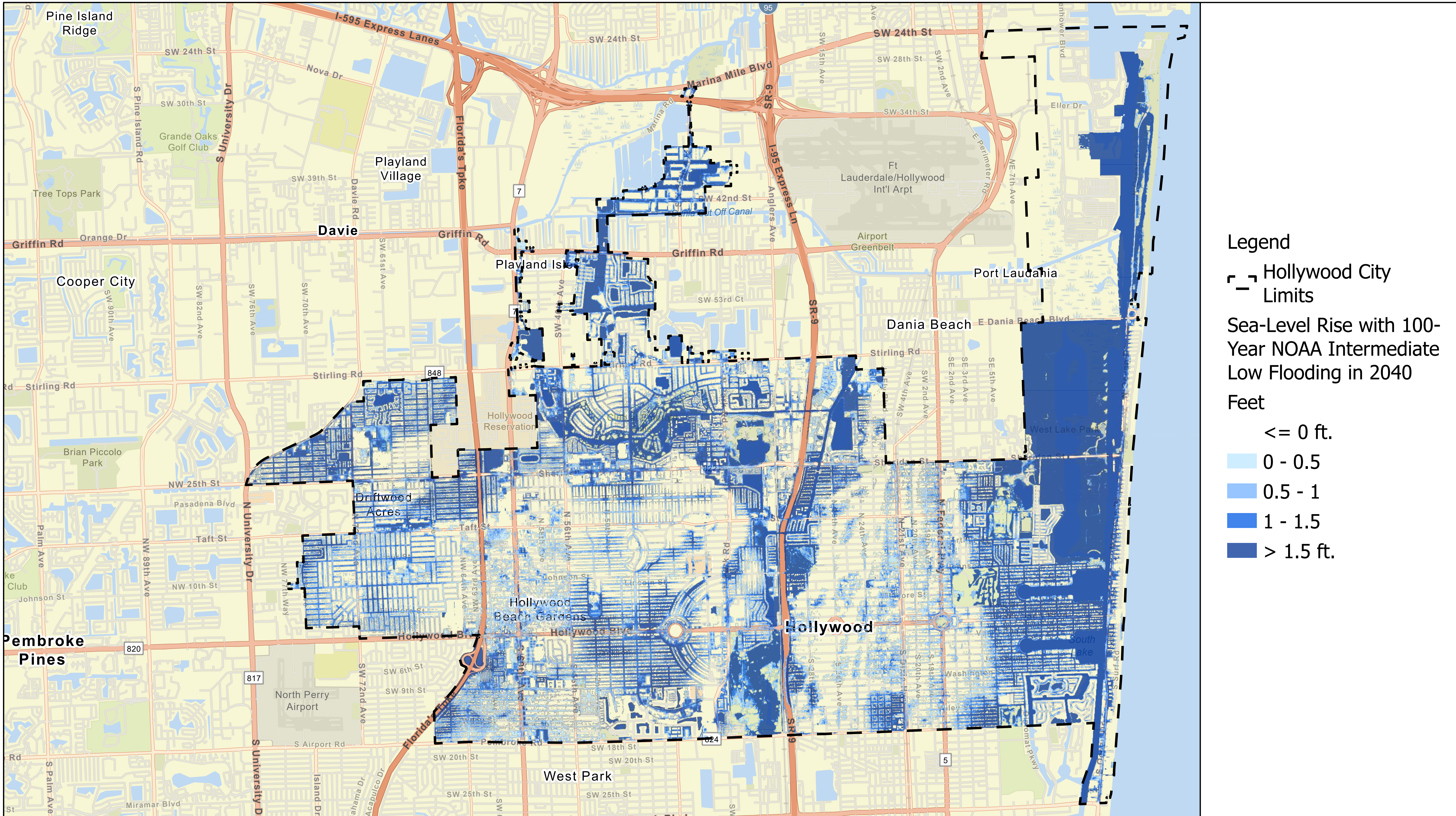
Appendix C

100 Year Storm Event with Sea Level Rise for CIP Alternatives



Projected Sea-Level Rise Scenario for 100-Year Storm
NOAA Intermediate Low Flooding in 2040

0 2,000 4,000 8,000 Feet
1:53,000

City of Hollywood Stormwater Master Plan
Appendix
8/4/2023

CDM Smith
City of Hollywood Florida

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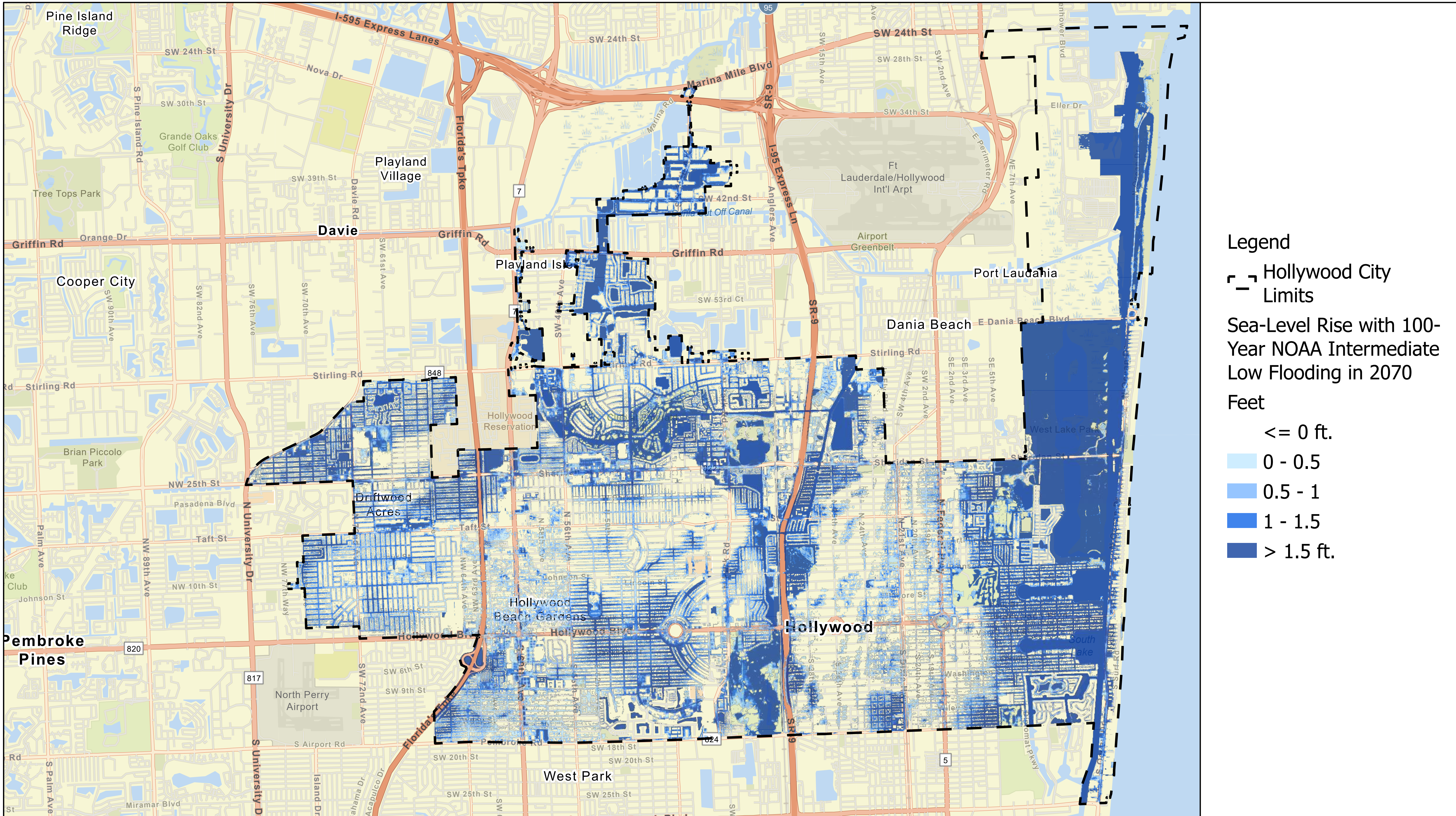

Projected Sea-Level Rise Scenario for 100-Year Storm
NOAA Intermediate Low Flooding in 2070

0 2,000 4,000 8,000 Feet
1:53,000

City of Hollywood Stormwater Master Plan
Appendix
8/4/2023

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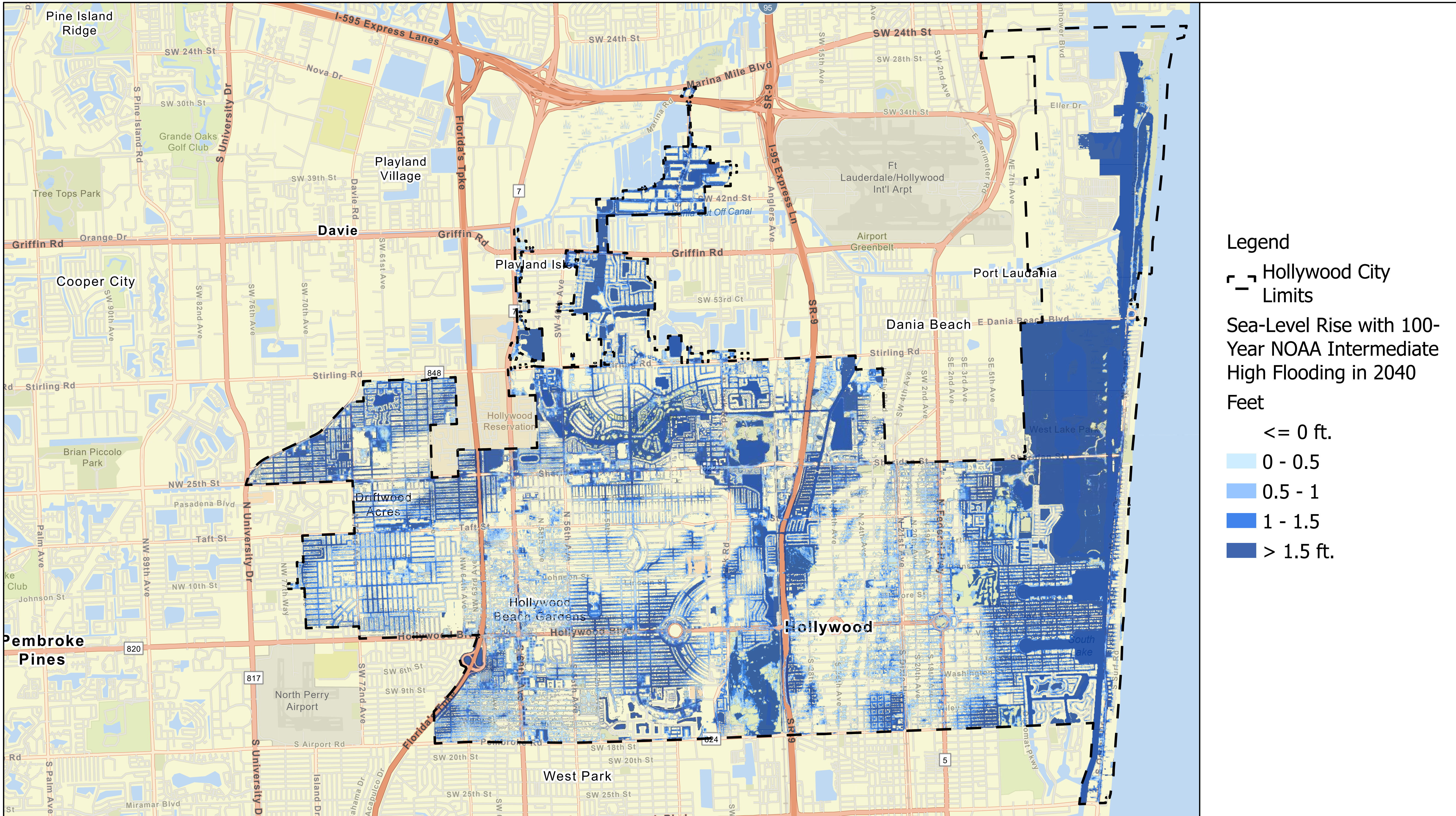

Projected Sea-Level Rise Scenario for 100-Year Storm
NOAA Intermediate High Flooding in 2040

0 2,000 4,000 8,000 Feet
1:53,000

City of Hollywood Stormwater Master Plan
Appendix
8/4/2023

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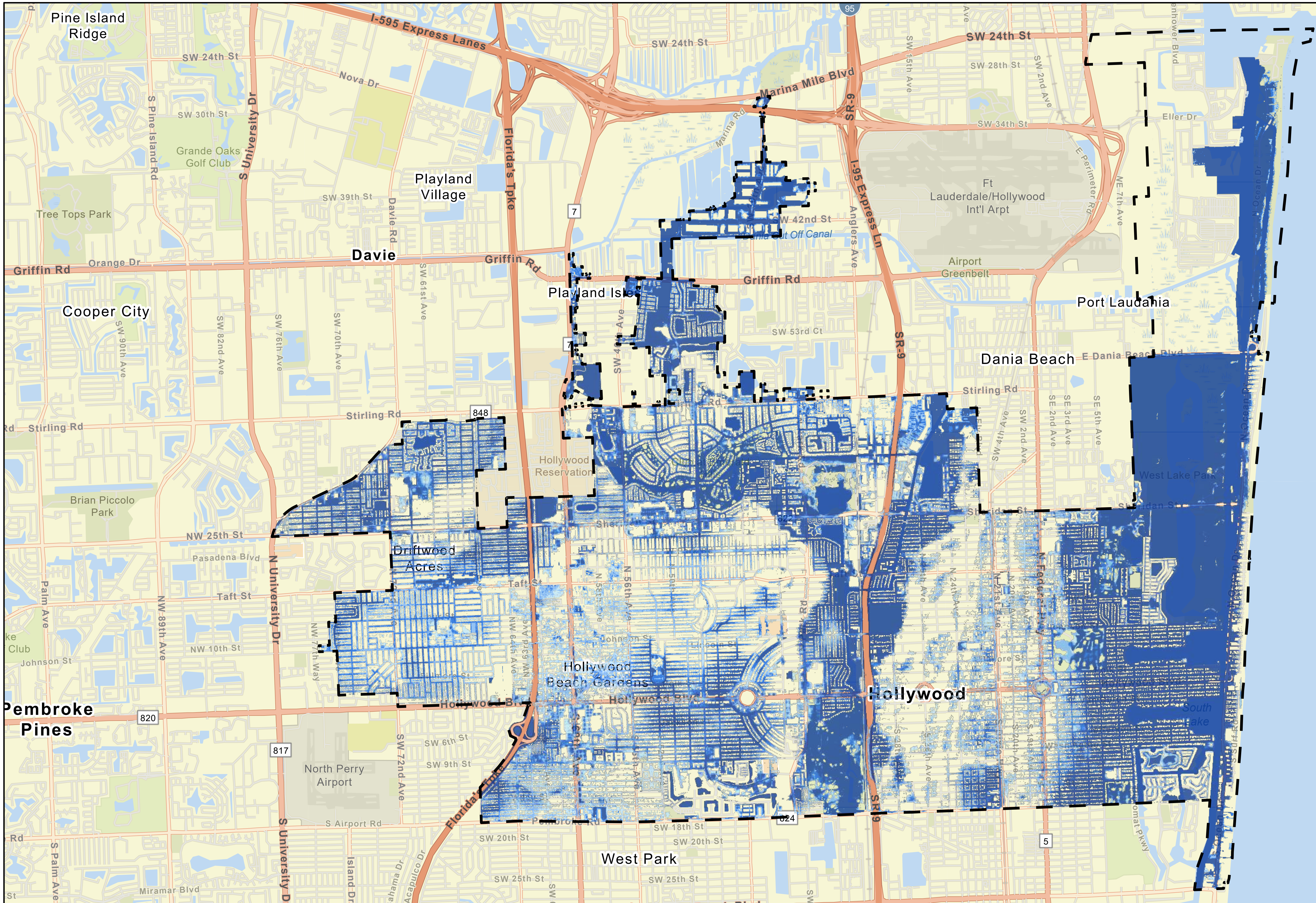

Legend

Hollywood City Limits

Sea-Level Rise with 100-Year NOAA Intermediate High Flooding in 2070

Feet

- <= 0 ft.
- 0 - 0.5
- 0.5 - 1
- 1 - 1.5
- > 1.5 ft.

CDM Smith

City of Hollywood Florida

Projected Sea-Level Rise Scenario for 100-Year Storm
NOAA Intermediate High Flooding in 2070

0 2,000 4,000 8,000 Feet

1:53,000

City of Hollywood Stormwater Master Plan

Appendix

8/4/2023

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Appendix D

FS 380.093 Resiliency Analysis and Reporting TM

TECHNICAL MEMORANDUM

City of Hollywood
Vulnerability Assessment

FS380.093 Requirements Analysis and Reporting

Prepared for Tetratech

State of Florida DEP Agreement No.: 22PLN44

August 2023

Section 1 – Introduction

This Technical Memorandum describes the methodology and results of the engineering and technical analyses performed in accordance with the requirements of FS380.093 reporting requirements to accompany the City of Hollywood Vulnerability Assessment.

1.1 FS 380.093 and Resilient Florida Grant Program Overview

Under Title XXVII Natural Resources, Conservation; Reclamation and Use, Chapter 380 – Land and Water Management. Section 093 - Resilient Florida Grant Program - comprehensive statewide flood vulnerability and sea level rise data set and assessment; Statewide Flooding and Sea Level Rise Resilience Plan; regional resilience entities; the Florida Legislature recognized that "*…the State is particularly vulnerable to adverse impacts from flooding resulting from increases in frequency and duration of rainfall events, storm surge from more frequent and severe weather systems, and sea level rise, and that such adverse impacts pose economic, social, environmental, and public health and safety challenges to the State.*" The Legislature further recognized that the adverse impacts of flooding and sea level rise affect coastal and inland communities across the state and, consequently, a coordinated approach is necessary to maximize the benefit of efforts to address such impacts and to improve the State's resilience to flooding and sea level rise.

Accordingly, to most effectively address these challenges, State funding is being allocated in a manner that prioritizes addressing some of the most significant risks and *"…to effectively and efficiently address and prepare for the adverse impacts of flooding and sea level rise in the state, the State has deemed it necessary to conduct a comprehensive statewide assessment of the specific risks posed to the state by flooding and sea level rise and develop a statewide coordinated approach to addressing such risks."* Subject to appropriation, the Florida Department of Environmental Protection (FDEP, "the Department") is providing grants based on need to counties municipalities such as the City of Hollywood to fund the costs of community resilience planning and necessary data collection for such planning, including:

- Comprehensive plan amendments and necessary corresponding analyses that address the requirements of s. 163.3178(2)(f);
- Vulnerability assessments that identify or address risks of flooding and sea level rise;
- The development of projects, plans, and policies that allows communities to prepare for threats from flooding and sea level rise; and
- Projects to adapt critical assets to the effects of flooding and sea level rise.

The vulnerability assessment (VA) conducted pursuant to paragraph (b) must encompass the entire county or municipality; include all critical assets owned or maintained by the grant applicant; and use the most recent publicly available Digital Elevation Model (DEM) and generally accepted analysis and modeling techniques. An assessment may encompass a smaller geographic area or include only a portion of the critical assets owned or maintained by the grant applicant with appropriate rationale and upon approval by the Department.

By July 1, 2023, the Department shall have completed a comprehensive statewide flood vulnerability and sea level rise assessment that identifies inland and coastal infrastructure, geographic areas, and communities in the state that are vulnerable to flooding and sea level rise and the associated risks. Every September 1st (since 2021), counties and municipalities may submit to the Department a list of proposed projects that address risks of flooding or sea level rise identified in vulnerability assessments that meet the requirements for grant funding for competitive award and cost matching.

Appendix E provides the full text of FS 380.093.

Section 2 – Background

The City of Hollywood is currently in the process of proactively addressing upcoming multiple reporting requirements of Florida Statutes Section 380.093 - Statewide Flooding and Sea Level Rise Resilience Plan (added by 2021 Fla. Laws, ch.28,s 1, eff. 5/12/2021).

The City has entered a grant agreement in 2023 with the State of Florida (No. 22PLN44) for an updated, compliant Vulnerability Assessment (VA) which will comply with the Peril of Flood statute, develop an Adaptation Plan, and incorporate the City's new Stormwater Master Plan.

The VA will include, among other items, submitting a report or documentation detailing the findings of "*…vulnerability assessments that identify or address risks of flooding and sea level rise; the development of projects, plans, and policies that allow communities to prepare for threats from flooding and sea level rise; and projects to adapt critical assets to the effects of flooding and sea level rise...*" for projects requesting the use of State grant funding.

The assessment reporting will be used by the State as part of the consideration for future grant funding assistance applications for applicable projects. The Citywide Comprehensive Stormwater Master Plan (Draft SWMP, 12/2022), as a standalone document, provides a portion of the background support information required to apply for the grant funding, and also can be used as the basis to perform the other technical requirements for the VA and other grant submittals. The models and portions of the previous analyses from the Citywide SWMP were used as the basis for the additional specific FS 380.093 analyses performed in this deliverable.

Section 3 – Technical Approach

3.1 FS 380.093 Analysis Requirements

The following analyses were performed for the FS 380.093 reporting elements:

1. Depth and locations of flooding from tides and number of expected days annually,
2. Depth and location of flooding for published storm surge,
3. Depth and location of rainfall induced flooding including SLR and high tide,
4. Depth and location of tidal and rainfall compounded flooding with future SLR.

The Citywide comprehensive hydrology and hydraulic (H&H) models were developed in the United States Environmental Protection Agency (EPA) Stormwater Management Model SWMM Version 5 for the Primary Stormwater Management System (PSMS), which is generally pipes and channels 18 inches and larger. The SWMP dynamic models and the data that were previously developed for the City's Stormwater Master Plan were modified for the particular requirements of these analyses to provide the items listed below as excerpted from the FS 380.093 reporting requirements (at this time):

[Provide the calculated/estimated] depth of:

1. *Tidal flooding, including future high tide flooding, which must use thresholds published and provided by the department. To the extent practicable, the analysis should also geographically display the number of tidal flood days expected for each scenario and planning horizon.*

2. *Current and future storm surge flooding using publicly available NOAA or FEMA storm surge data. The initial storm surge event used must equal or exceed the current 100-year flood event. Higher frequency storm events may be analyzed to understand the exposure of a critical asset.*

3. *To the extent practicable, rainfall-induced flooding using spatiotemporal analysis or existing hydrologic and hydraulic modeling results. Future boundary conditions should be modified to consider sea level rise and high tide conditions.*

4. *To the extent practicable, compound flooding or the combination of tidal, storm surge, and rainfall-induced flooding for the following scenarios and standards.*

The required sea level rise scenarios and planning horizons are:

- *At least two local sea level rise scenarios, which must include the 2017 NOAA Intermediate-Low, NOAA and Intermediate-High, Sea Level Rise projections.*

- *At least two planning horizons that include planning horizons for the years 2040 and 2070.*

The requirements further note: *Local sea level data may be taken from one such gauge if the gauge has higher mean sea level. Data taken from an alternate gauge may be used with appropriate rationale and department approval, as long as it is publicly available or submitted to the department.*

3.2 Local Sea Level Rise Data Analysis

For this reporting analysis, local sea level rise tidal data are necessary. Local sea level data has been interpolated between the two closest NOAA tide gauges. The City of Hollywood is situated between the Virginia Key and Daytona Beach NOAA Tide Gauges; however, the Virginia Key Gauge is significantly closer and the interpolated data matches the Virginia Key data to the hundredth of a foot. There is also a Miami Beach gage south of the City of Hollywood, but the Virginia Key gage is slightly higher at the 2020 time period and is therefore used in this analysis. The sea level rise increments for these two gauges are nearly identical to the hundredths of a foot, indicating that either gauge may be used with similar results.

The NOAA 2017 projection for the intermediate high and intermediate low scenarios, for existing conditions (2020), and two future planning horizons in 2040 and 2070 were extracted from the U.S. Army Corps of Engineers Sea-Level Change Curve Calculator Version 2021.12 (https://cwbi-app.sec.usace.army.mil/rccslc/slcc_calc.html) in "feet" and "North American Vertical Datum 1988 (NAVD88)."

Table 3-1 presents these data and highlights the sea-level changes between 2040 and 2070 and the 2020 base condition for the highlighted/bold font projections.

Table 3-1. NOAA 2017 Sea Level Rise Projections

Scenarios for VIRGINIA KEY							
NOAA2017 VLM: 0.00157 feet/yr							
All values are expressed in feet							
Year	NOAA2017 VLM	NOAA2017 Low	NOAA2017 Int-Low	NOAA2017 Intermediate	NOAA2017 Int-High	NOAA2017 High	NOAA2017 Extreme
2000	-0.84	-0.84	-0.84	-0.84	-0.84	-0.84	-0.84
2010	-0.82	-0.74	-0.7	-0.61	-0.54	-0.48	-0.51
2020	-0.8	-0.57	**-0.51**	-0.34	**-0.21**	-0.11	-0.08
2030	-0.79	-0.44	-0.34	-0.08	0.15	0.38	0.51
2040	-0.77	-0.28	**-0.15**	0.21	**0.57**	0.94	1.17
2050	-0.76	-0.11	0.05	0.54	1.07	1.66	2.05
2060	-0.74	0.05	0.25	0.97	1.72	2.54	3.17
2070	-0.73	0.15	**0.41**	1.39	**2.44**	3.56	4.45
2080	-0.71	0.28	0.61	1.89	3.26	4.77	5.92

2090	-0.69	0.38	0.77	2.38	4.15	6.05	7.6
2100	-0.68	0.51	0.94	2.94	5.17	7.53	9.53

The 2021 City of Hollywood Stormwater Master Plan uses a 1-year tidal stillwater as the base "existing" boundary condition for all South Florida Water Management District (SFWMD) design rainstorm simulations. The 1-year stillwater was used to consider a coincident rainfall and tidal flood condition. A value of 2.5 ft-NAVD was used for the 1-year stillwater elevation, which is approximately equal to a relatively high current 2023 "King Tide" elevation. This boundary condition was developed at Port Everglades, located near the opening of the Intracoastal Waterway and the Atlantic Ocean. The 1-year recurrence was used to acknowledge that rainfall events in South Florida often are concurrent with some surge, but that a 10-year surge combined with a 10-year rainfall event would be more infrequent than a 10-year event. The SWMP includes validation of the stormwater model for historic flood events (December 2019, Eta, April 2023) and the actual tides for those events were used in those validations.

Note that the 1-year still-water is significantly higher than the mean tide values in Table 3-1; however, it is the "differences" in elevations that are critical to the four FS 380 reporting items in this analysis, and not the "absolute" mean tide value.

The following sections describe the analysis of each of the four analysis items in detail. For ease of extraction/reproduction for use in other submittals, most figures have been provided as standalone pages in the **Appendices**.

Section 4 – Tidal Flooding Analysis (Item 1)

The depth of tidal flooding for FS 380.093 Reporting Item 1 is presented as "sunny day" flooding, i.e., flooding that occurs due to rising tide with no accompanying precipitation. The flooding can either breach the shoreline protection elevation or it enters into the low lying land surfaces through stormwater piping connected to the tidally influenced waterways and exits as flooding through the at-grade grates.

The figures presented herein show the depth of flooding expected throughout the City of Hollywood for existing conditions, and for the four sea level rise scenarios (NOAA 2017 Intermediate-Low in 2040, NOAA 2017 Intermediate-Low in 2070, NOAA 2017 Intermediate-High in 2040, and NOAA 2017 Intermediate-High in 2070). The depth of flooding for the existing condition is based on a boundary condition using the 1-year still-water as described in Section 3, and the detailed analyses City of Hollywood SWMP (2023).

The four sea level rise scenarios add to the base boundary conditions based on the difference between the 2020 mean sea level value for the given SLR condition and the 2040 and 2070 values, as presented above in Table 3-1.

4.1 Tidal Inundation Vulnerable Areas Mapping

For the first part of FS 380.093 Item 1, the flood-depth maps for tidal inundation were developed with the City of Hollywood SWMP SWMM models using the latest Broward County LiDAR DEM (2020), City seawall DEM (2021), and no precipitation, using the following caveats:

- The installation of backflow preventors throughout the City's is completed at all of their at-risk low stormwater outfalls.
- Broward County and Florida Department of Transportation (FDOT) system outfalls also have the required backflow prevention in place.
- Private seawalls are at existing condition elevations (from the 2021 specific-purpose shoreline survey).
- City of Hollywood (public) seawalls raised in accordance with the in-progress City of Hollywood, GO Bond funded, Shoreline Protection Program, scheduled to be completed in 2026.

The City of Hollywood has recently provided backflow protection to all City outfalls with upstream inlets at grate elevations less than the one-year still-water used as the boundary condition for existing condition models. FDOT has installed backflow prevention or has plans to install backflow prevention in the "near" future for all FDOT outfalls on Hollywood Beach. The City of Hollywood Stormwater Master Plan includes backflow prevention for all City, County and

FDOT outfalls that impact the City of Hollywood. It is expected that as sea levels rise, these outfalls will be fitted with backflow prevention, even if much of the rest of the SWMP does not get implemented.

This analysis determines seawall vulnerability, though potentially more roads are at risk for sunny day flooding if outfalls or other shoreline protection beyond the City's control are not also raised or fitted with backflow prevention. This analysis does not take into account leaking or damaged backflow devices or seawalls which can allow significant tidal flooding to encroach on to the land surface significantly, as these must be corrected as part of continual shoreline protection maintenance as they are discovered.

4.2 Tidal Inundation Days Mapping

The second part of FS 380.093 Item 1 is to geographically display the number of days tidal flooding is projected for each of the projections and time horizons. To satisfy this condition, observed tidal data at Port Everglades, the Intracoastal Waterway in northern Biscayne Bay (the SFWMD S-29 Structure), and the Intracoastal Waterway at the S-40 Structure (Boca Raton) were used to determine the number of days different seawall elevations may be breached under existing conditions and the four sea level rise scenarios. Ten years of observed data were examined for the structures north and south of the City of Hollywood and then compared to the available 5-year record from the Port Everglades tidal gage.

To provide the required geographical representation of this, the City was subdivided into nineteen areas that were either topographically contiguous or interconnected by common infrastructure at a neighborhood level of detail along the floodplains of the Intracoastal Waterway, the C-11 Canal, the C-10 Canal, and the C-10 Spur Canal. The areas were analyzed using the DEM and stormwater infrastructure GIS, and either combined or neighborhood boundaries were slightly edited to match locations with similar seawall elevations and/or to combine neighborhoods using a connected stormwater management system. The critical (low) seawall elevation was found for each of the nineteen areas from the City shoreline survey, and then the number of days that the critical elevation was projected to be overtopped was calculated for existing conditions and the four sea level rise scenarios. Generally, overtopping or discontinuities in the seawall are expected to affect a significant portion of the coastal neighborhoods.

The following guidelines were used to develop the critical elevations:

- For locations where the seawalls were very low, or there were no seawalls at all, the low point in the ground elevation between the edge of water and the City roadways were used for the critical elevation. The City of Hollywood SWMP models and the merged topo/shoreline DEMs were used to find these data. The north side of South Lake is a good example of this, as the seawall invert is overtopped at 1.9 ft NAVD into a backyard, but the topographic elevations between the backyard and the street is 2.12 ft NAVD which is used as the data point.

- If the low seawall only affected a contained area on a dead-end side street or cul-de-sac, the neighboring (higher) seawall elevation was selected.

Figure 4-1 presents the recent 10-year (June 2013 through May 2023) daily maximum observed stage data for Port Everglades Gauge. The availability of data was limited to 2/1/2018 to present, therefore analysis was performed comparing the available data to the next closest gauges: Virginia Key (VK) Gauge to the south and the SFWMD S-40 gauge to the North. VK data was consistently lower with a root mean square error (RMSE) of 0.52.

Conversely, the S-40 gauge was consistently higher with an RMSE of 0.48. The direct average of the Virginia Key and S-40 Max daily stage data compared to the Port Everglades data produced an RMSE of 0.1 ft.

Based on this analysis, the average of S-40 and VK data was appended to the Port Everglades timeseries from 6/1/2013 to 1/31/2018 resulting in a 10-year dataset.

There are seven days higher than 2.5 ft NAVD in the record:

- EL 3.49 ft NAVD on 9/10/2017 during Hurricane Irma,
- EL 2.64 ft NAVD on 10/1/2019 and 11/9/2022, and
- 4 additional days between EL 2.5 and 2.6 ft NAVD (11/10/2022, 9/21/2020, 10/19/2020, 9/3/2019).

It is noted that this gauge location is somewhat sheltered from wave action. Coastal wind driven actual stages in the Northlake and Southlake Neighborhoods for example, were likely higher than the peak observed recorded stage; however, this Item 1 analysis addresses tidal flooding, not storm surge and wind-wave action flooding (see Section 5, Item 2).

Figure 4-1. Daily Maximum Tide Stages for the City of Hollywood

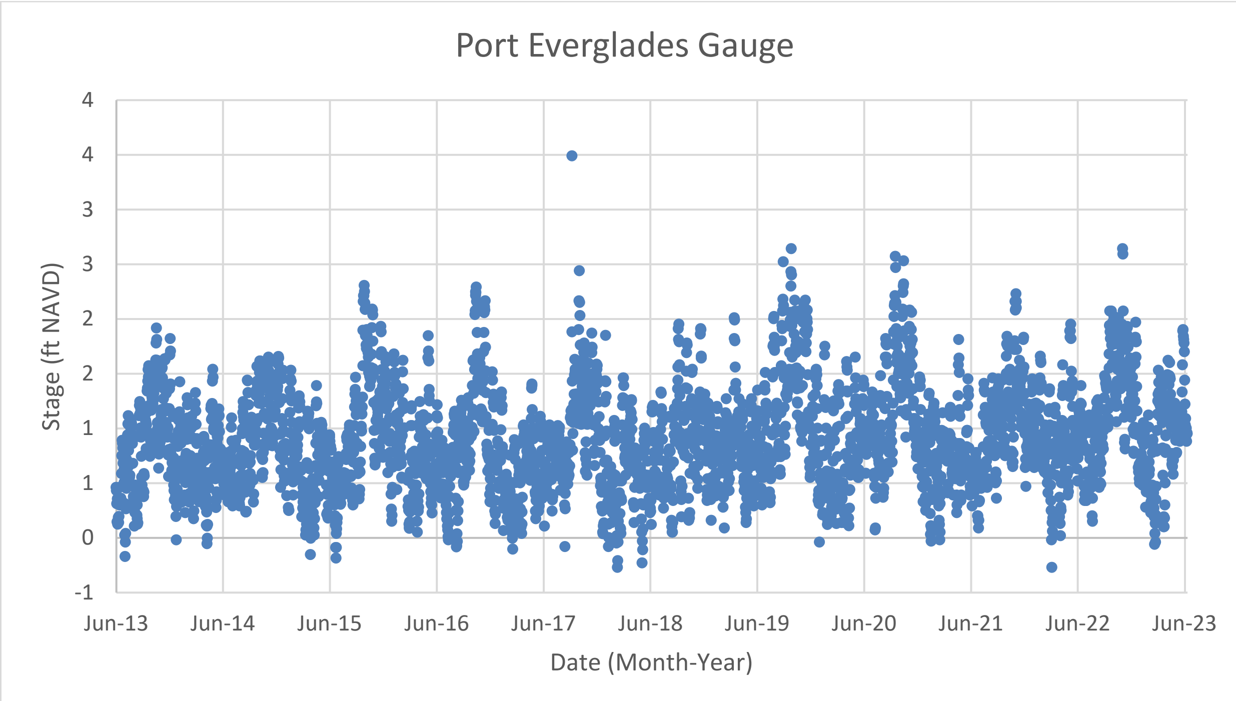


Table 4-1 presents the number of days each neighborhood's Critical Elevation (CE) is topped in the 10-year record, normalized to a single year.

Table 4-1. Annualized Days of Tidal Flooding per Neighborhood

Neighborhood	ID	CE (ft NAVD)	Annualized Days Exceeded for 10 yr Time Series (6/1/2013-5/31/2023)				
			Exist (2020)	2040_IL (+0.36 ft)	2040_IH (+0.78 ft)	2070_IL (+0.92 ft)	2070_IH (+0.2.65 ft)
North Beach	1-1	1.55	31.7	84.5	200.9	244.5	365.3
South Central Beach	1-2	2.69	0.1	1.1	10.7	18.1	356.1
Hollywood Lakes South	1-3	3.90	0.0	0.0	0.1	0.1	72.8
Hollywood Lakes - South Lake	1-4	2.40	1.0	7.1	26.7	39.8	365.1
Hollywood Lakes - Central	1-5	1.90	11.2	32.5	99.3	135.9	365.3
Hollywood Lakes - North Lake	1-6	2.55	0.5	2.5	18.1	26.3	364.2
Hollywood Lakes North	1-7	2.55	0.5	2.5	18.1	26.3	364.2
Liberia	2-1	2.90	0.1	0.5	3.9	8.7	337.4
North Central North	3-1	3.90	0.0	0.0	0.1	0.1	72.8
North Central South	3-2	4.10	0.0	0.0	0.1	0.1	43.7
Parkeast North	3-4	3.00	0.1	0.1	2.1	5.0	320.9
Oakwood Hills	4-1	4.20	0.0	0.0	0.1	0.1	31.7
Emerald Hills / TY Park	4-2	4.30	0.0	0.0	0.0	0.1	24.5
Emerald Hills Central	4-3	4.25	0.0	0.0	0.1	0.1	28.1
Alandco	4-4	3.45	0.1	0.1	0.1	0.5	191.3
Emerald Hills West	4-6	4.25	0.0	0.0	0.1	0.1	28.1
Playland / 441 Corridor	4-7	4.50	0.0	0.0	0.0	0.0	13.8
Parkeast	6-1	4.10	0.0	0.0	0.1	0.1	43.7
North Central Finger Islands	3-1	2.80	0.1	0.8	7.4	12.3	347.4

- Under the existing conditions, the lowest critical elevation (1.55 ft NAVD) is exceeded on 317 different days in the 10-year record. This results in an annualized value of 31.7 days per year.

- For the NOAA Intermediate High projection in 2070 (IH 2070), the value is exceeded every day in the record, including leap days, resulting in an annualized value of 365.3 days per year.

These results are geographically displayed on **Figures 4-2 through 4-6**, respectively, for the existing condition and the four Sea-Level Rise projections/time horizons (NOAA 2017 Intermediate-Low in 2040, NOAA 2017 Intermediate-Low in 2070, NOAA 2017 Intermediate-High in 2040, and NOAA 2017 Intermediate-High in 2070).

Section 5 – Storm Surge Flooding Analysis (Item 2)

The predicted depth of flooding for FS 380.093 Item 2 is taken directly from the Special Flood Hazard Areas subject to inundation by the 1% annual chance of flood designated by FEMA for use in production of their Flood Insurance Risk Map (FIRM) products. The National Flood Hazard Layer (NFHL) geospatial database for the City of Hollywood was downloaded directly from https://msc.fema.gov/portal/advanceSearch#searchresultsanchor. The NFHL has a latest study effective date of 09/11/2009 and contains flood zone information consistent with changes based on Letters of Map Revision (LOMR) sent to communities. The latest LOMR effective date incorporated is 12/27/2021.

The FEMA flood zones and corresponding Base Flood Elevations (BFE) present within the City of Hollywood model domain consist of zones AE, AH, VE, and X. The extent of the FEMA flood zones has been clipped to match the extent of the City of Hollywood SWMP Model area, displayed on **Figure 5-1.**

- Zone AE – 1% annual chance BFE determined.
- Zone AH – Flood depths of 1-3 feet (usually areas of ponding); 1% annual chance BFE determined.
- Zone VE – Coastal flood zone with velocity hazard (wave action); 1% annual chance BFE determined.
- Zone X – Areas of 0.2% annual chance flood; areas of 1% chance of flood with average depths < 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance of flood; No BFE is determined.

A 1% annual chance of flood inundation map was created using the NHFL flood zones and the City of Hollywood DEM dated 2017 and modified with updated LiDAR topography from 2019 and is geographically displayed on **Figure 5-2.**

Additionally, the FEMA flood zone BFEs within the City of Hollywood were modified with the addition of four sea level rise scenarios. The following sea level rise projected increases were extracted from the projection data as required to be used for the analysis:

1. 0.36 (NOAA Intermediate-Low 2040)
2. 0.92 (NOAA Intermediate-Low 2070)
3. 0.78 (NOAA Intermediate-High 2040)
4. 2.65 ft (NOAA Intermediate-High 2070)

Projection/time horizon pairs were added to each flood zone BFE connected to the receiving waterbodies (i.e., canals, Intracoastal Waterway, etc.). The resulting flood depths were then interpolated using the City of Hollywood DEM to project the increase in the flood zone extents inland to a point where the ground surface elevation met the flood elevation. The resulting sea level rise inundation maps are geospatially represented on **Figures 5-3 to 5-6**.

It should be noted that as of the writing of this report, FEMA has preliminary special flood hazard area maps in process with their latest study due to be published. Upon the official issuance of the data as the “Effective Products,” new FEMA based sea level rise flood inundation maps should be available and these should be compared to the current maps being used in this analysis for any required modifications to the results.

Section 6 – Rainfall-Induced Flood Analysis (Item 3)

The depth of rainfall flooding for FS 380.093 Item 3 was developed from the City of Hollywood SWMP SWMM models. The SWMP includes existing condition models with a 1-year stillwater boundary condition of 2.5 ft NAVD as described above over a range of precipitation events. The SWMP models have been revised to provide the same backflow protection and near-term public seawall construction as the models in Item 1 (Section 4).

For this task, the sea level rise analysis from the SWMP was conducted with the same specific increases of 0.36, 0.92, 0.78, and 2.65 feet, respectively, for the NOAA Intermediate-Low/Yr 2040, Intermediate-Low/Yr 2070, Intermediate-High/Yr 2040, and Intermediate-High/Yr 2070 projection/time horizon pairs. The models were simulated for the 10-year, 24-hour design storm to match the City of Hollywood's desired flood control Level of Service Goal (LOS) design storm, and for the 100-year, 72-hour design storm for a more severe case. The SFWMD 24-hour and 72-hour design storm hyetographs were used for this analysis. Precipitation volumes vary slightly across the City for each storm, with volumes extracted from the 2022 NOAA Atlas 14.

Flood depth maps under existing conditions, for the 10-year and 100-year, 72-hour design storms respectively are presented as **Figures 6-1 and 6-2**.

Figures 6-3 through 6-6 show the flood depth maps for the projected sea level rise scenario/time horizon pairs for the 10-year storm. **Figures 6-7 through 6-10** show the flood depth maps for the projected sea level rise scenario/ time horizon pairs for the 100-year storm.

Section 7 – Compound Flooding Analysis (Item 4)

The depth of flooding for FS 380.093 Item 4 is a combination of a precipitation flood event and a tidal surge event. Item 2 (Section 5) provided the flood inundation due to surge based on FEMA maps. The flood elevations vary across the City based on flood zone; however, the elevation in the Intracoastal Waterway in the AE zone typically ranged between EL 6-8 ft-NAVD.

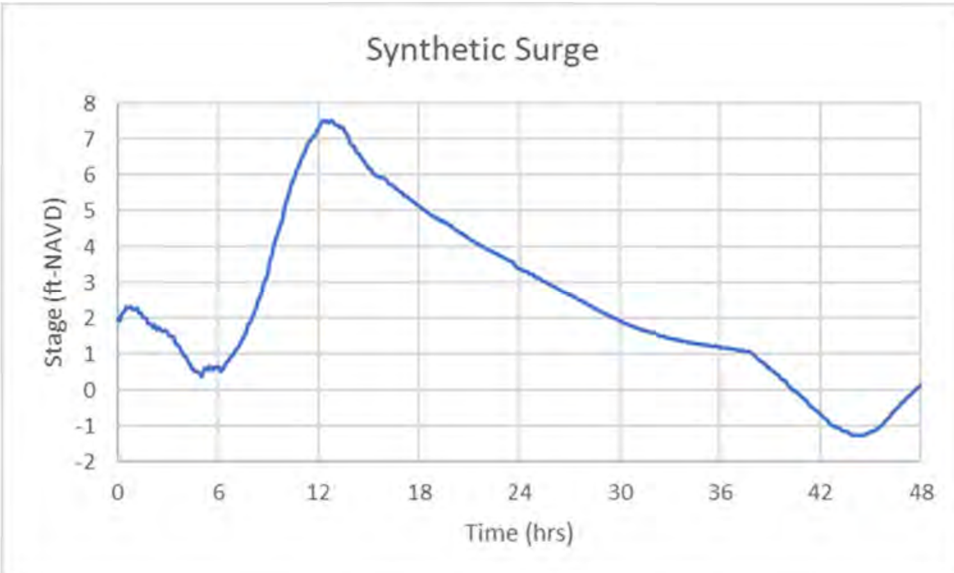
Except for the model Validation Storms (used to calibrate input parameters and verify results to actual conditions experienced for historic storm and boundary condition data), the City of Hollywood SWMP uses fixed stage boundary conditions in the Intracoastal Waterway. For example, the present conditions base scenario (prior to sea level rise) used a fixed 2.5 ft-NAVD boundary condition representing the one-year stillwater condition (i.e., the annual high tide), based on the historical statistics of nearby stage gages. This tidal stage is generally a high King Tide which lasts for only a few hours. The modeling is conservative by using a fixed stage boundary because the peak flow will always occurs at the high tide, which is the worst-case condition for flooding, and as condition that may happen, was desired by the City.

For this compound surge and rainfall analysis using a fixed stage boundary condition is not a viable option because the extreme stages can bypass control structures, seawalls, and lower natural ridges, and then flow into the City through the stormwater PSMS. The model can replicate and perform this process, but the unpredictable length of time that the surge remains high becomes a factor in how far inland the flows can go (i.e., variability between slower versus faster moving storms). Therefore, the observed surge for two representative closest recent South Florida storm events, Hurricane Ian in Fort Myers Florida and Hurricane Irma in Miami Florida were used to develop a synthetic surge boundary condition for the Intracoastal Waterway at the boundary of the City of Hollywood. While the Gulf and Atlantic sides have different approach bathymetry, both areas do have similar characteristics to Hollywood of open water then channeling into a series of metropolitan areas with inland controlled canals and lakes for predicting typical surge height timing.

Figure 7-1 presents the developed synthetic time series boundary condition used in the base condition compound model in the Intracoastal Waterway. The data matches the observed stages in the Caloosahatchee River near downtown Fort Myers during Hurricane Ian from approximately hour 6 though hour 38. The rest of the data was extracted from Hurricane Irma data from the Virginia Key gage near downtown Miami. Hurricane Irma produced multiple tide cycles above normal prior to the storm, while Ian actually reduced stages in the river for the day prior to the storm. Though it likely does not affect the final results, the model is more conservative with the higher starting condition.

The timing of the surge was adjusted such that the peak stage (7.5 ft-NAVD) occurs just after the peak of the rainfall (hour 12) for the 24-hour design storm. This allows much of the peak runoff to align with the peak boundary stage, though the timing of peak runoff varies throughout the system.

Figure 7-1. Synthetic Surge Time Series for the City of Hollywood



The SWMP models were then revised to provide the same backflow protection and near-term public seawall construction as the models in Item 1 (Section 4). As with the SWMP models and the models from previous sections, to account for offsite flows and stages, boundary conditions for the western portions of the City were developed from SFWMD and SBDD Structure operations, the CBWCD operational models, and a joint Fort Lauderdale-Hollywood model to determine flows in the South Fork of the New River and its interaction the Dania Cutoff Canal under the extreme tailwater condition.

The compound flooding analysis models were then simulated for the 10-year, 24-hour design storm to match the City of Hollywood's desired flood control LOS design storm. **Figure 7-2** presents the depth of flooding map for the City of Hollywood under this scenario.

For the FS 380 Item 4 analysis, the four sea level rise projection / time horizon increments (0.36, 0.92, 0.78, and 2.65 ft respectively for the required NOAA Intermediate-Low/2040, Intermediate-Low/2070, Intermediate-High/2040, and Intermediate-High/2070 scenarios) were added to the synthetic surge time series as constant increases.

The models were then re-simulated with these increased time-series boundary conditions. **Figures 7-3 through 7-6** present the depth of flooding maps for the City of Hollywood for each required SLR scenario respectively.

Section 8 – Analysis Summary

The inundation maps and tables presented herein directly address the four required items currently listed in FS380.093 for the required vulnerability assessment analyzed citywide for the City of Hollywood. The exhibits show the supporting information demonstrating predicting flooding inundation under the four required different scenarios Citywide and support the need for resiliency projects in the at risk areas.

The City is currently addressing sea level rise with its shoreline protection initiative for its tidally exposed seawalls. The City has also adopted the Broward County Regional Resiliency Standard *Policy 2.21.7 Article XXV – Resiliency Standards for Tidal Flood Protection* adding the requirement for all private seawalls to be raised to the target higher elevations in the near future. In addition, the comprehensive Citywide Stormwater Master Plan (Draft, December 2022) has identified a multiyear phased capital improvements program and best management practices to reduce flooding to the City-desired level of service and continue to meet the water quality of the receiving waters.

This analysis, and/or its exhibits, can be attached to City stormwater and resiliency project State grant funding applications to demonstrate compliance with the requirements of the statute (in addition to other requirements in the applications). The VA will further also need to identify and submit the locations and elevations of “critical assets/critical infrastructure” as defined by the statute.

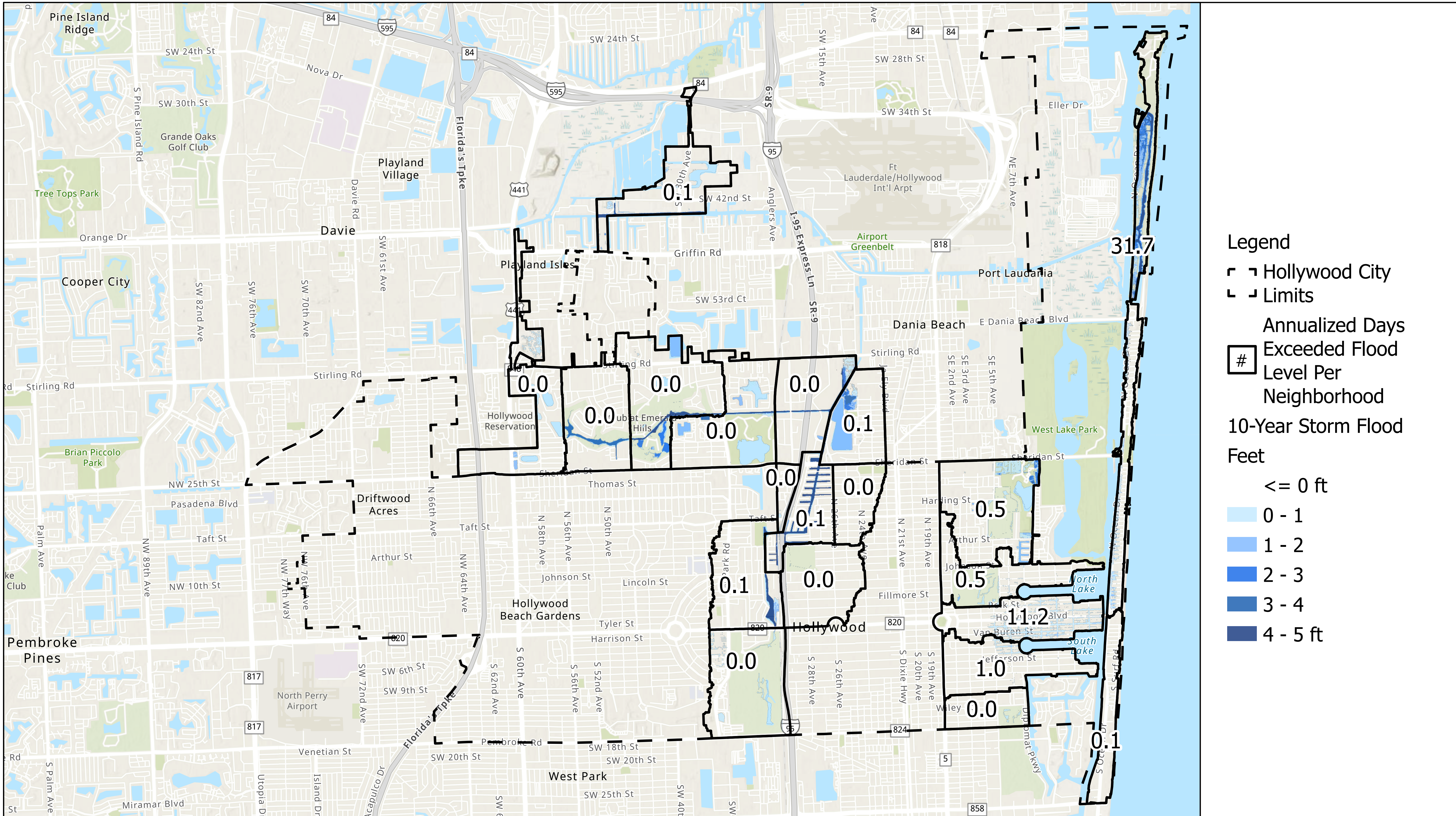
Additional published information can be found at https://floridadep.gov/rcp/florida-resilient-coastlines-program/content/resilience-and-coastal-protection-rules-development

Finally, if applicable, the City must submit Peril of Flood comprehensive plan amendment language that addresses the requirements of s. 163.3178(2)(f), if the municipality is subject to such requirements and has not yet complied with such requirements as determined by the Department of Economic Opportunity.

APPENDIX A

TIDAL FLOODING ANALYSIS RESULTS

SECTION 4 (ITEM 1) FIGURES



Annualized Days Exceeded
(last decade, Port Everglades Gauge)
Existing Conditions Flood Extent

0 2,000 4,000 8,000 Feet
1:53,000

City of Hollywood FS 380.093 Reporting
Figure 4-2
7/31/2023

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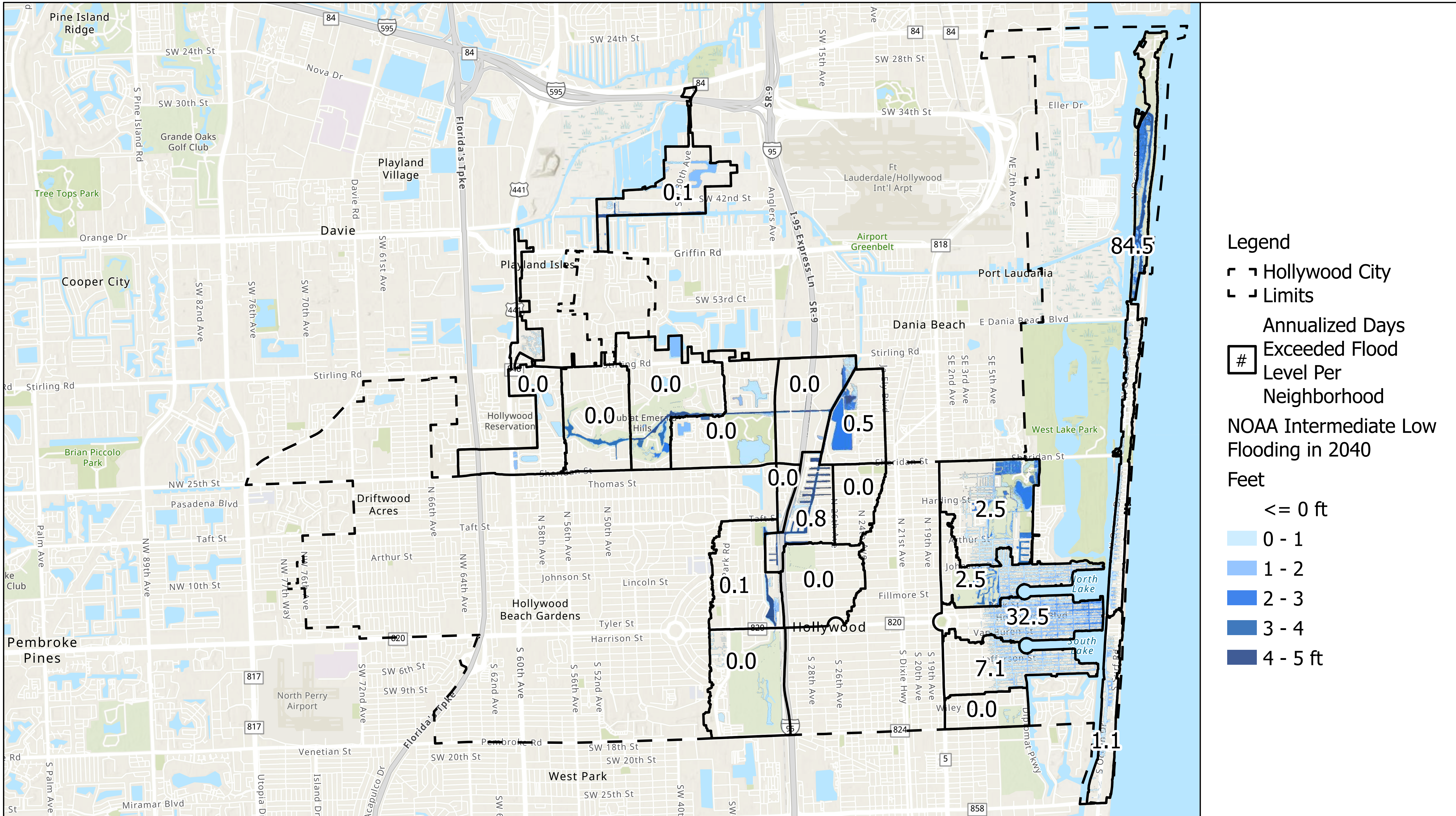

0 2,000 4,000 8,000 Feet
1:53,000

Annualized Days Exceeded
(last decade, Port Everglades Gauge)
NOAA Intermediate Low 2040 Flood Extent

City of Hollywood FS 380.093 Reporting
Figure 4-3
7/31/2023

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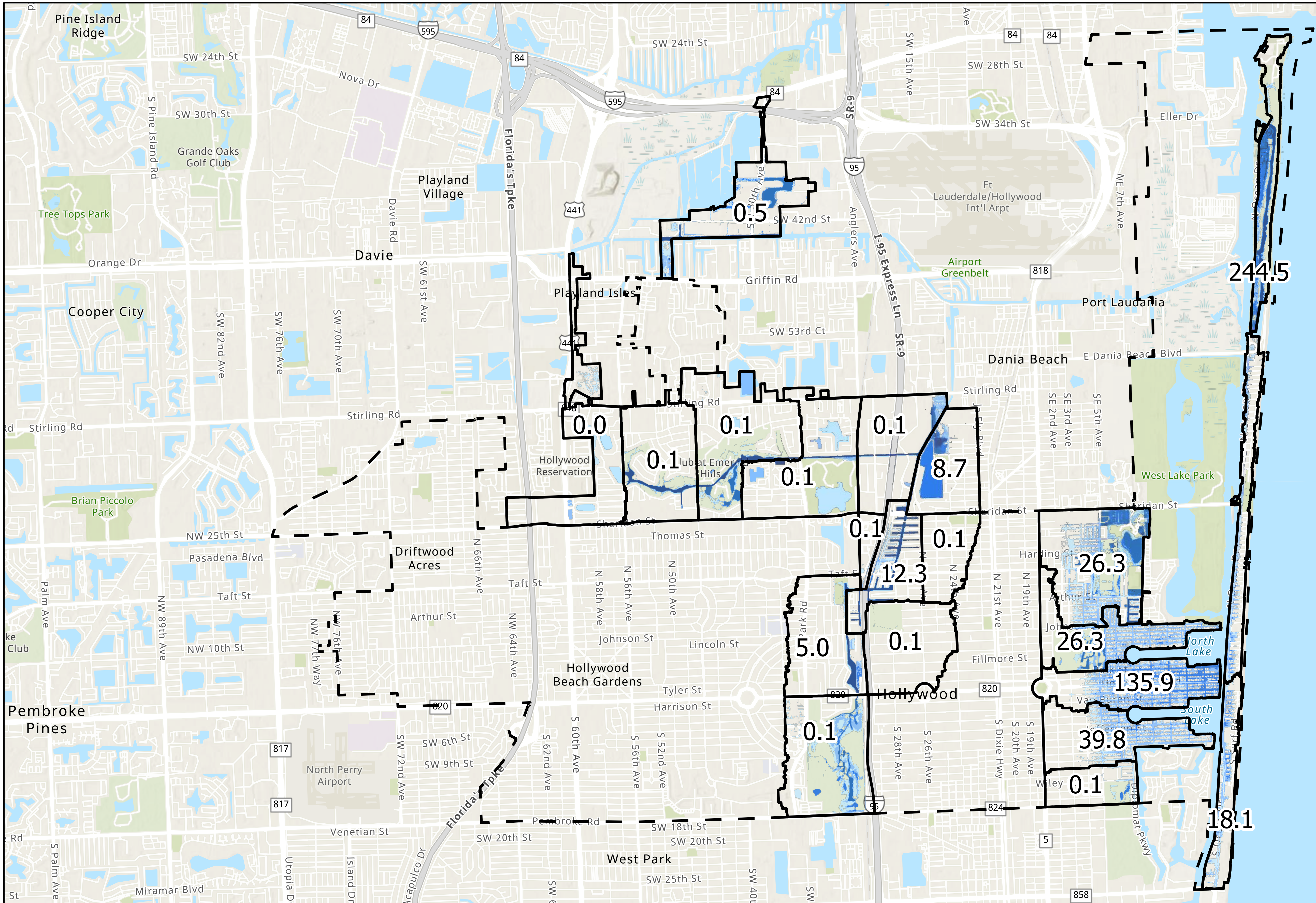


Legend

Hollywood City Limits

Annualized Days Exceeded Flood Level Per Neighborhood

NOAA Intermediate Low Flooding in 2070

Feet

<= 0 ft
0 - 1
1 - 2
2 - 3
3 - 4
4 - 5 ft

CDM Smith

City of Hollywood Florida

Annualized Days Exceeded (last decade, Port Everglades Gauge) NOAA Intermediate Low 2070 Flood Extent

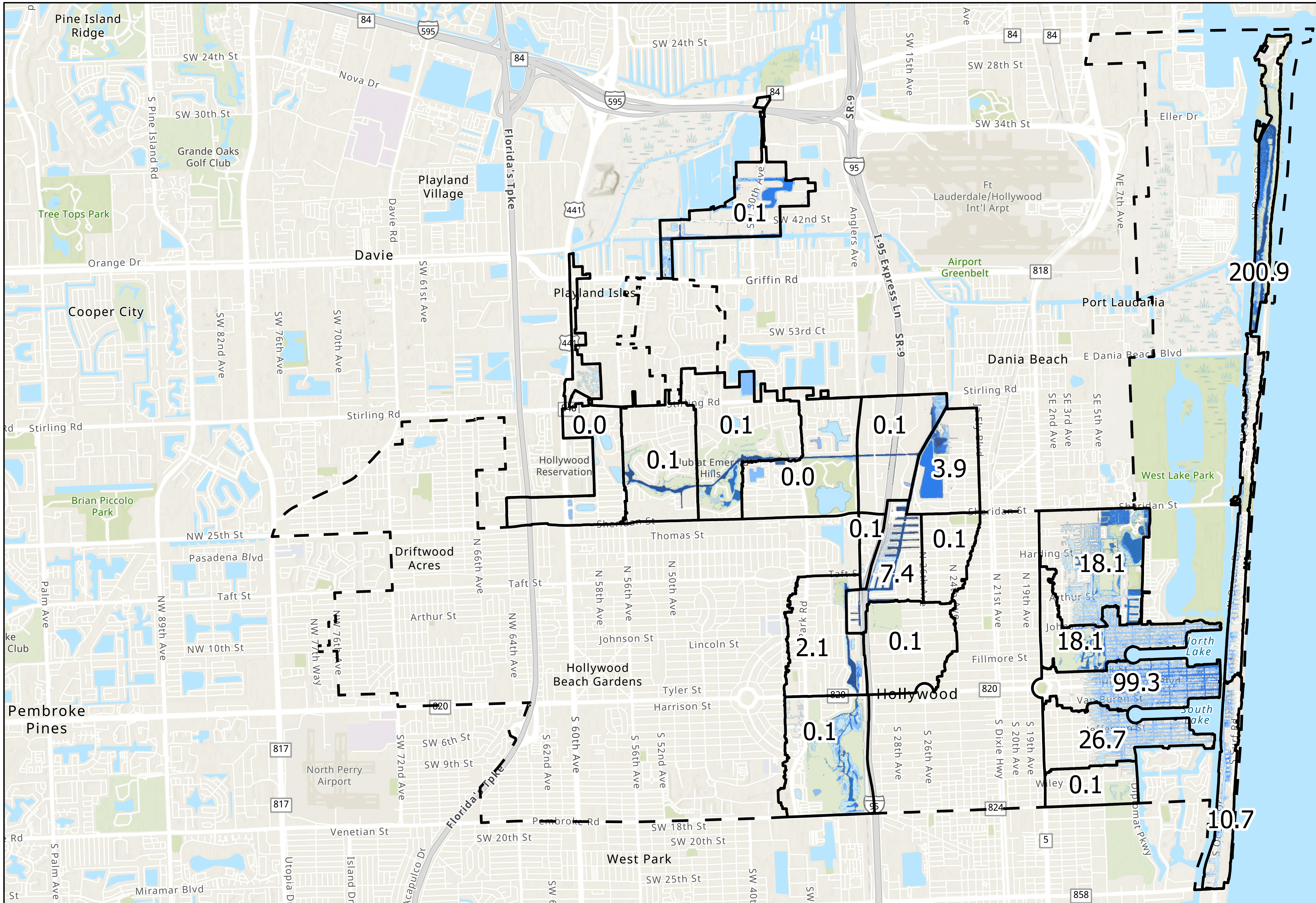
0 2,000 4,000 8,000 Feet

1:53,000

City of Hollywood FS 380.093 Reporting

Figure 4-4

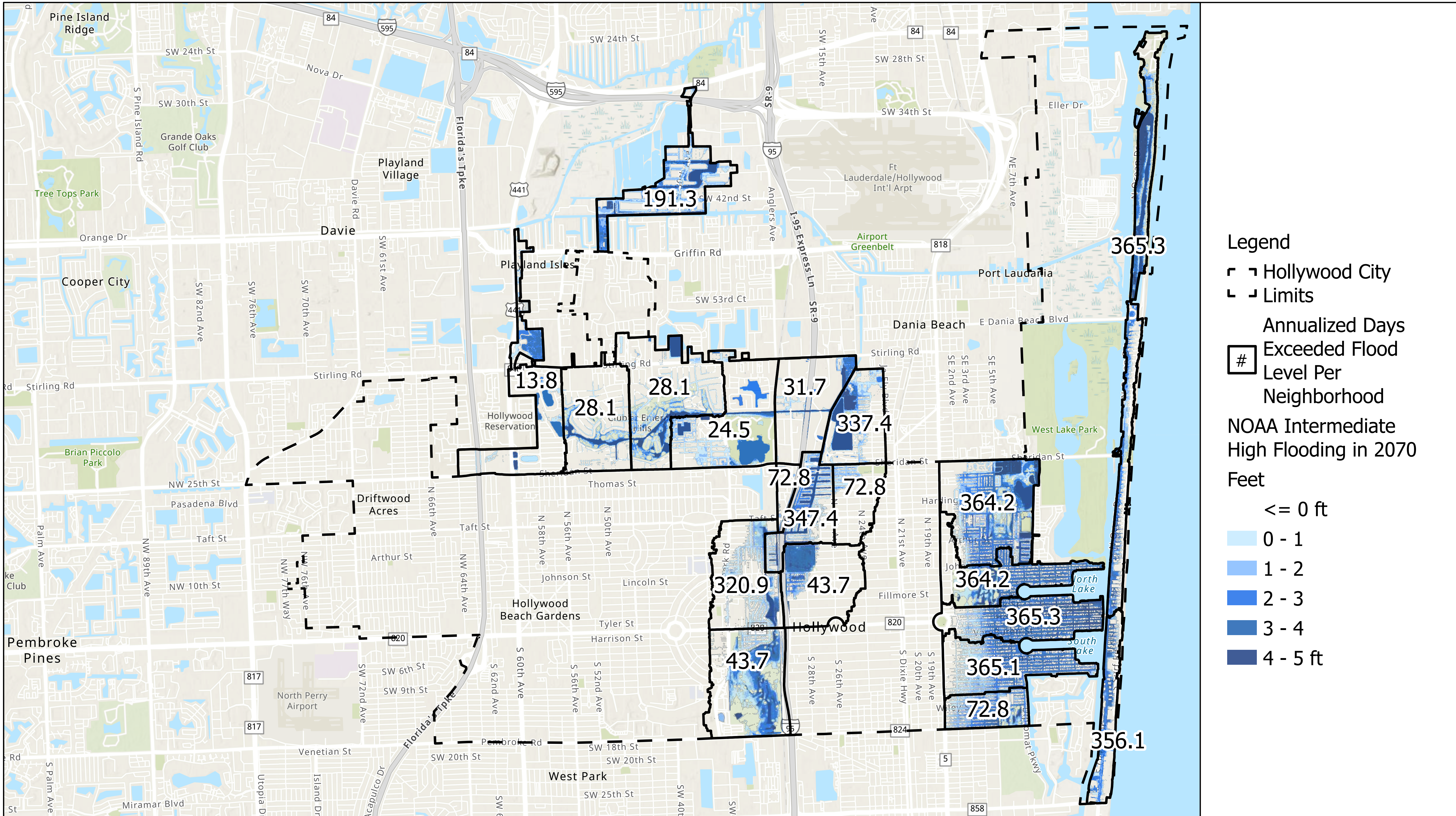
7/31/2023



Annualized Days Exceeded
(last decade, Port Everglades Gauge)
NOAA Intermediate High 2040 Flood Extent

0 2,000 4,000 8,000 Feet
1:53,000

City of Hollywood FS 380.093 Reporting
Figure 4-5
7/31/2023



Annualized Days Exceeded
(last decade, Port Everglades Gauge)
NOAA Intermediate High 2070 Flood Extent

CDM Smith

City of Hollywood Florida

City of Hollywood FS 380.093 Reporting
Figure 4-6
7/31/2023

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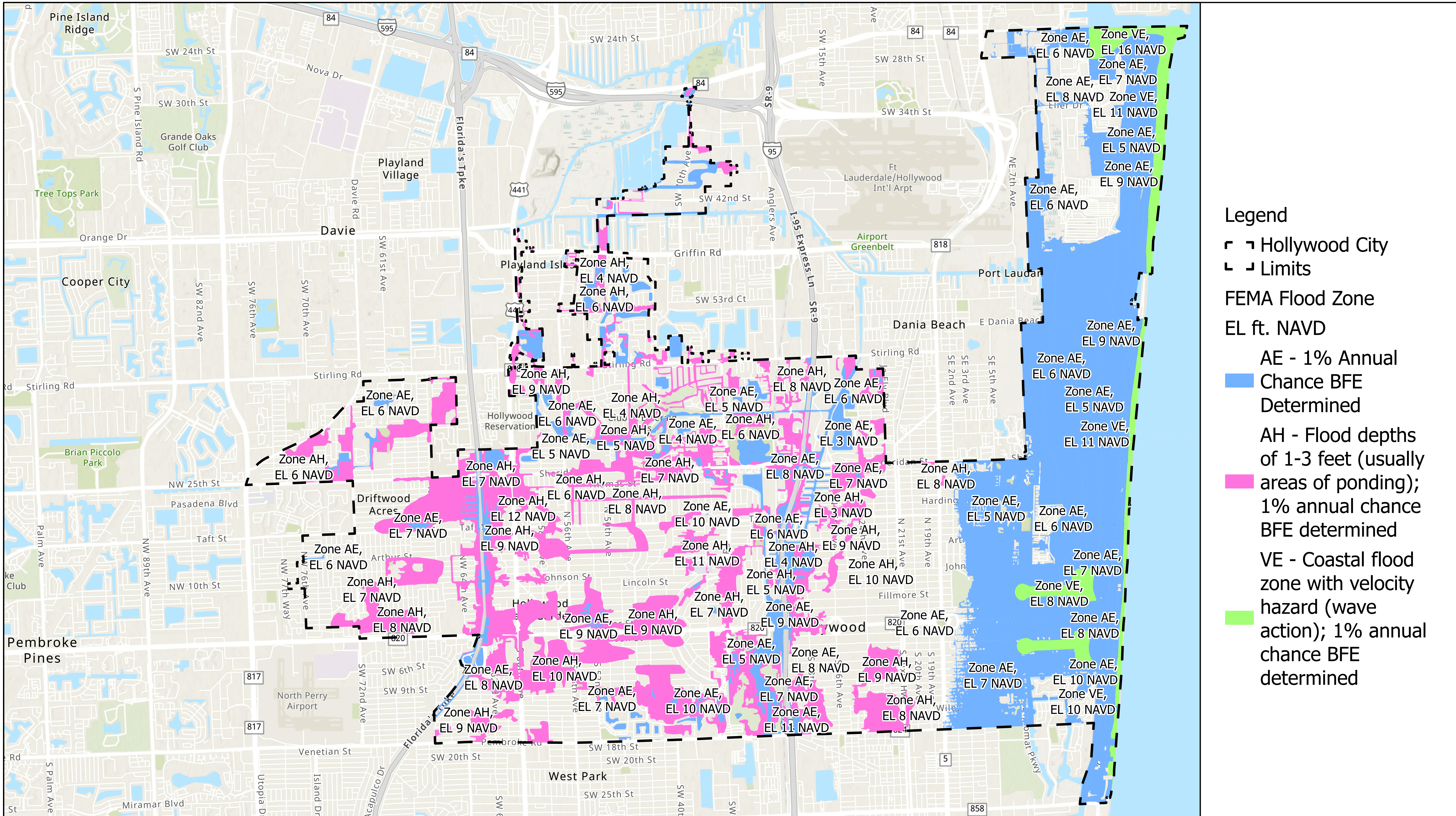
APPENDIX B

STORM SURGE FLOODING ANALYSIS RESULTS

SECTION 5 (ITEM 2) FIGURES



FEMA Flood Zones Map

City of Hollywood FS 380.093 Reporting

Figure 5-1

7/31/2023

0 2,000 4,000 8,000 Feet

1:53,000