Executive Summary

ES.1 Introduction and Background

On June 9, 2010, the City of Miami Beach (City) authorized CDM Smith Inc. (CDM Smith) to develop a City-wide Comprehensive Stormwater Management Master Plan (SWMMP) in order to evaluate and update its stormwater management practices, infrastructure, funding, and regulatory policies.

Miami Beach is one of 16 municipalities that entered into an Interlocal Agreement (ILA) with Miami-Dade County in 1993 (subsequently 17 additional municipalities have also entered an ILA with Miami-Dade County), authorizing Miami-Dade County to be the lead permittee in submitting a National Pollutant Discharge Elimination System (NPDES) Stormwater Permit Application, which was required by federal law. One condition of the ILA requires the City of Miami Beach to develop a SWMMP that is consistent with Miami-Dade County's Master Plan. This report is the update and expansion of the SWMMP.

The SWMMP is intended to be a guide for improving the City's stormwater management system flood control and water quality performance for the next 20 years, with considerations of potential sea level change (SLC) over 20-years of stormwater infrastructure and a 50-year planning horizon for sea wall heights. SLC, to the extent it occurs, will worsen flooding potential in the City by raising the tide levels and water table and by making it more difficult to discharge stormwater out of the area. The SWMMP provides a preliminary schedule of prioritized capital improvements necessary to allow the City's stormwater systems to:

1. meet the increasing performance and regulatory demands,
2. modernize existing systems for both flood control and water quality, and
3. maintain the City-desired flood control level of service (LOS).

The City is a highly urbanized coastal community located in southeast Florida and is a major economic resource to the region. Bounded by the Atlantic Ocean and the environmentally sensitive Biscayne Bay Aquatic Preserve, which is also an Outstanding Florida Water (OFW) requiring strict environmental protection**,** the study area covers approximately 4,200 acres. The area has relatively low-lying land that is intersected by intracoastal waterways with limited natural storage and large areas of re-development. The subtropical climate entails high-intensity rainfall and significant tidal influence. These factors all contribute to historical and potential future severe rainfall and tidal flooding.

ES.2 Program Goals and Objectives

Specific objectives of the SWMMP were defined through the initial project meetings to identify adaptable and sustainable stormwater management solutions that:

- Objective No. 1: Quantify and improve flood control LOS, that is, the degree of flood protection achieved, based on a 20-year capital improvement program;
- Objective Number 2: Quantify economic impact of flooding;
- Objective No. 3: Facilitate and prioritize operation and maintenance (O&M);

- Objective No. 4: Augment existing infrastructure for storage and treatment;
- Objective No. 5: Coordinate and guide review of projects under current design/construction and facilitate accelerated analysis of "early out" projects;
- Objective No. 6: Identify stormwater harvesting-reuse and recharge well opportunities for conservation of fresh water;
- Objective No. 7: Refine and recommend updates to the City's stormwater ordinances and assess sufficiency of the City's Stormwater Utility; and
- Objective No. 8: Provide recommendations for seawalls to mitigate the effects of sea level increases over the next 50 years.

ES.3 Methodology

As part of this SWMMP, surface water modeling was performed using the EPA Stormwater Management Model (SWMM) to estimate and evaluate existing flooding LOS and alternative solutions to meet refined LOS targets. Water quality evaluations were conducted using the CDM Smith Watershed Management Model (WMM). These tools can be used to support design and implementation.

Model development came from a multitude of resources. The following is a list of some of the data sources:

- Actual rainfall data collected from rain gages throughout the City and at Miami International Airport
- Design storms as defined by SFWMD and other methodologies (i.e. FDOT)
- South Florida Water Management District (SFWMD) and City land use plans
- Subsurface and geotechnical information obtained from the Natural Resources Conservation Service (NRCS) and projects under design by other consultants for the CIP Office
- Mean high tide elevations at Virginia Key collected by the National Ocean Service (NOS) which is a branch of the National Oceanic and Atmospheric Administration (NOAA)
- Miami-Dade County and privately sourced aerial mapping of the City
- Light Detection and Ranging (LiDAR) data from SFWMD
- LiDAR data from Miami-Dade County
- Models developed by other consultants for projects currently under construction or with construction completed for the City's CIP Office and the Florida Department of Transportation (FDOT)
- Basis of Design Reports and design plans developed by other consultants for FDOT and projects currently under construction or with construction completed for the City's CIP Office
- Construction record drawings for construction completed for the City's CIP Office

- Survey data collected by the CDM Smith team's topographic surveyor, Hadonne
- Neighborhood surveys developed by the City
- Geographic Information System (GIS) coverages of the City, which are maintained by the City's Information Management System (IMS)

CDM Smith used the United States Army Corps of Engineers (USACE) guidance document (Engineering Circular 1165-2-212: Sea-Level Change Consideration for Civil Works Programs) for incorporating the direct and indirect effects of projected future sea level change (SLC) across a projected 20-year project life cycle for stormwater improvements and a projected 50-year cycle for seawalls. The USACE guidance document presents an approach for planning studies and engineering design for evaluating a range of possible future rates of SLC, represented as three equation-based scenarios (or curves): low, intermediate and high.

CDM Smith performed sensitivity analysis by evaluating the three scenarios to maximize the benefits of the recommendations under varied degrees of potential future SLC. Evaluation of LOS performance and adaptability of the SWMMP-recommended system are based on the intermediate scenario (curve), which based on the 20-year life cycle is projected to have a tidal mean high water condition of approximately 0.67 ft. NAVD. However, adjustment calculations have been performed for the high projections (0.84 ft. NAVD) in the instance that SLC accelerates (**Figure 1**). This SLC sensitivity analysis included a variety of mean high tide elevation predictions over the next 20 years in combination with SFWMD defined design storm events.

For the next 50 year planning period, a minimum seawall elevation recommendation was established based on statistical analysis of Federal Emergency Management Agency's (FEMA) 1-year tidal stillwater elevation. Per FEMA, the stillwater elevation is the maximum storm induced water surface elevation, primarily a combination of the normal astronomic tide and the storm surge. Stillwater elevations do not include the effect of waves. To obtain the 1-year tidal elevation, regression analysis was completed the stillwater elevations published in the FEMA Flood Insurance Study (FIS) issued in September 2009. The statistical analysis determined the 1-year tidal stillwater elevation as 2.2 ft NAVD. CDM Smith developed a recommendation of a minimum seawall height of 1 foot above the 1-year tidal stillwater (1.0 + 2.2 ft NAVD = 3.2 ft NAVD).

Since the 1-year stillwater is based on statistical analysis rather than tidal data from the Virginia Key gage, CDM Smith correlated the recommended minimum sea wall height to the mean higher high water (MHHW) information used in the evaluation of the stormwater recommendations. The USACE-based sensitivity analysis was applied to determine where the current MHHW tide conditions relate to the recommended seawall height over the next 50-years. (**Figure 2**).

The MHHW tide conditions normally observed in Miami Beach during the months of April and October (spring tides) relate to the annualized MHHW data recorded from the Virginia Key gage. The current, Year 2009, annualized MHHW elevation is 1.6 ft NAVD. For consistency in the analysis of SLC, CDM Smith recommends that projections be referenced to the same data source, in this instance, tidal records from Virginia Key.

This analysis considers the establishment of seawall elevations to protect against normal tidal conditions. The recommended minimum height does not provide protection against extreme tidal events, which may coincide with hurricanes and other natural disasters.

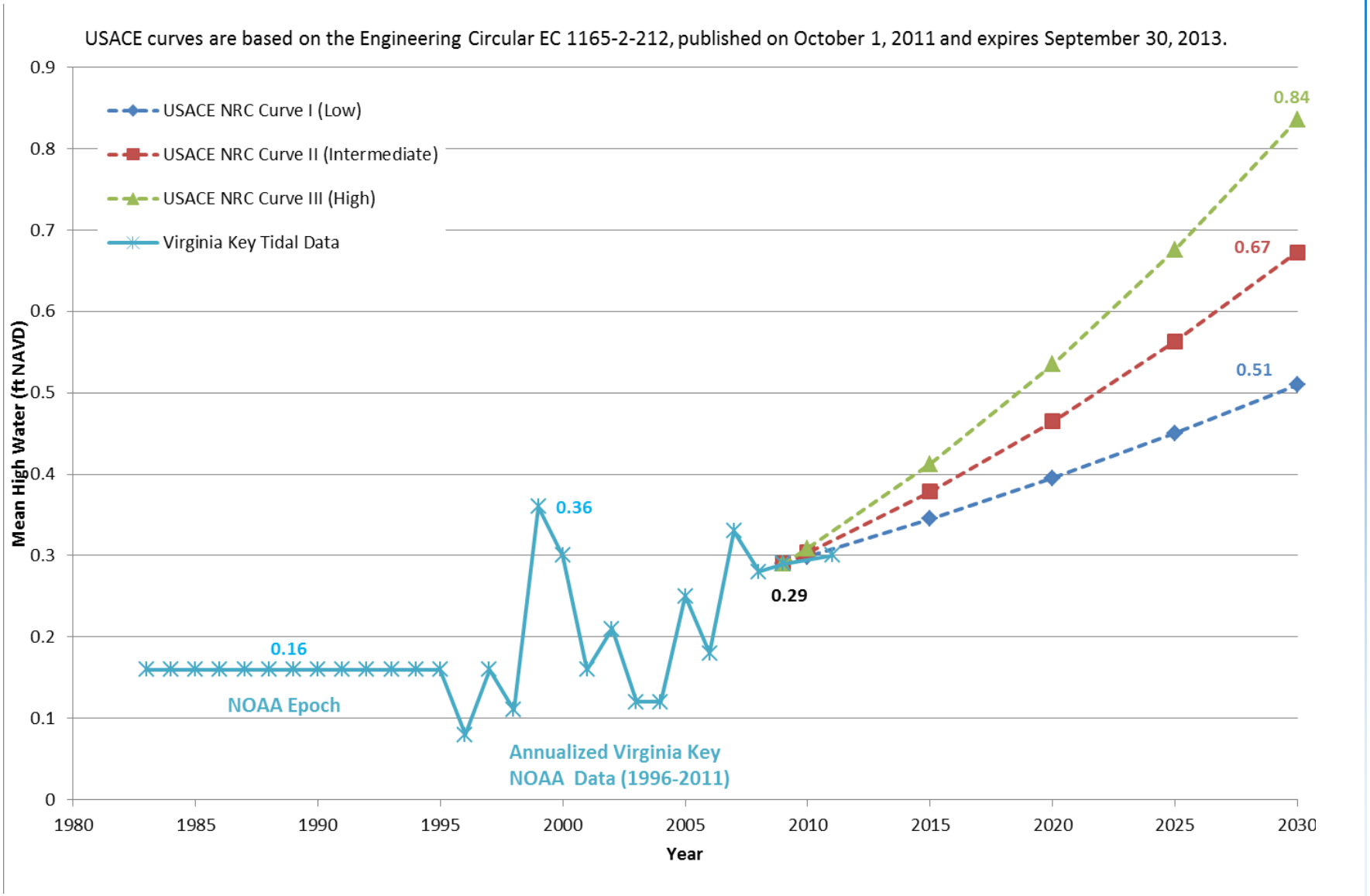

Figure 1
Historic and Projected Mean High Water Levels at Virginia Key

USACE curves are based on the Engineering Circular EC 1165-2-212, published on October 1, 2011 and expires September 30, 2013

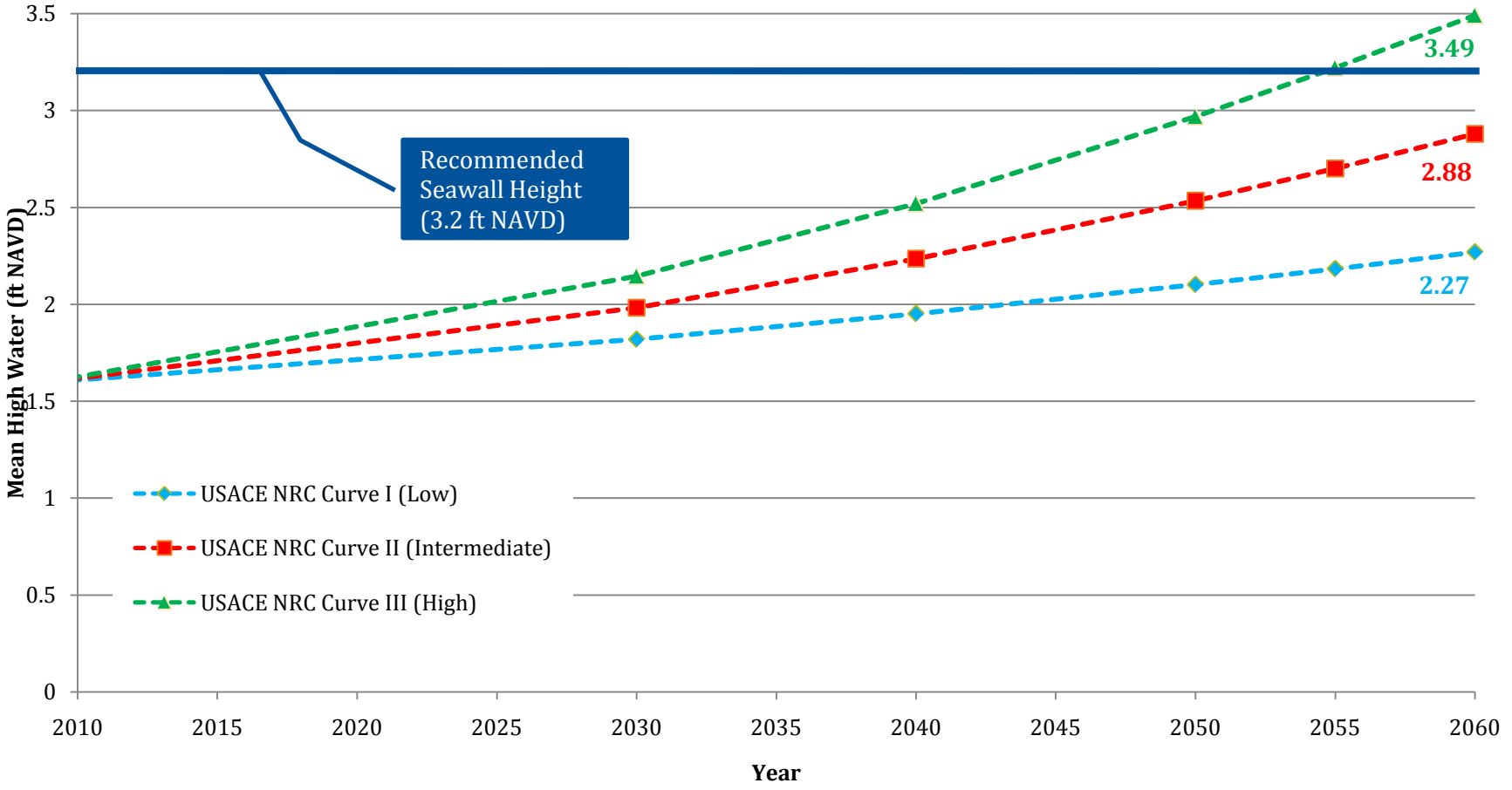

Figure 2
Projected Mean Higher High Water Levels at Virginia Key

As a complement to the engineering evaluation, CDM Smith utilized the FEMA's Hazards United States (HAZUS) tool designed to estimate hazard-induced losses for use by federal, state, regional and local governments, and private enterprises in planning for risk mitigation, emergency preparedness, response and recovery. By using a standard FEMA tool, the City will benefit in the coordination of future activities related to flood proofing, grant assistance, and management of repetitive loss properties. The analysis, which was performed for South Beach, incorporated existing elevations, structure and land use data along with information from the detailed flood model (SWMM). 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 a flood event, like the statistically calculated once-in-5-year storm (5.9 inches of rainfall in 24 hours).

ES.4 Level of Service

The primary purposes of LOS criteria are to protect public safety and property. Program goals are to maintain passable roads for emergency and evacuation traffic during 5.9 inches of rainfall in 24 hours and to keep flood stages below the first floors of homes and buildings. The LOS criteria were first used to identify and define potential problem areas using the stormwater model developed for this study. The LOS criteria were then used to evaluate the effectiveness of contemplated improvements. LOS achievement decisions directly affected the size and cost of proposed improvement alternatives.

ES.5 Basis of Proposed Improvements and Recommendations

CDM Smith developed recommendations and proposed modifications to language included in the City's Public Works Manual, City ordinances, and policy documents. Implementation of these modifications should be coordinated with the various City Departments including Public Works, CIP, Planning, City Attorney, Finance, Budget and Performance Improvement, and the City Manager's Office. Recommendations were made based on the following major categories:

- Data Management
- Stormwater Models and Future Condition Analysis
  - In recognition of SLC, tidal conditions for future modeling efforts should utilize tidal boundary conditions as defined by the latest version of the SWMMP. This version of the SWMMP recommends a tidal boundary condition of 0.67 ft. NAVD. It is based on USACE guidance intermediate scenario projections for SLC based on a current day (Year 2009) mean high water elevation at 0.29 ft. NAVD and a projected Year 2030 mean high water elevation at 0.67 ft. NAVD (See Figure 1).
- Stormwater Harvesting and Reuse
- Sea-Level Rise Considerations
  - The SWMMP recommends the City monitor SLC phenomena and possibly participate with local and regional climate change advisory committees regarding regional recommendations related to SLC.

- Seawall Height Considerations
  - In recognition of SLC, statistical analysis of the 1-year stillwater elevation, and spring tides of 1.6 ft. NAVD (Year 2009), the SWMMP recommends based on the USACE guidance intermediate scenario, the establishment of a minimum seawall height of 3.2 ft. NAVD, which provides greater than 50 years of sea wall protection against future MHHW tidal elevations.
- Pump Station O&M
- Storage Facility Standards and O&M
- Outfalls/Backflow Preventer Standards and O&M
- Recharge Well Standards and O&M
- Swales O&M
- Exfiltration Trench O&M
- 100-Year Floodplain Storage
- Stormwater Design Standards

ES.6 Proposed Improvements and Project Coordination

Evaluations were performed for project areas to determine the level of infrastructure improvements necessary to meet the LOS for the statistically calculated once-in-5-year storm LOS. A tiered Best Management Practice (BMP) treatment train approach was used to identify the most effective solutions for each project area and to identify opportunities for flood control, water quality, aquifer recharge, and stormwater harvesting and irrigation use. The tiered approaches were incrementally formulated from the simplest tier 1 (e.g., back flow preventers) through the most complex and costly tier 4 (e.g., underground storage), and bundled together to determine the economic feasibility of proposed infrastructure improvements. Due to the anticipated significant capital investment and stringent permitting to discharge into Biscayne Bay, the tiered approach will allow the City to proceed with specific elements of the BMP treatment train as economic conditions permit. This would allow for future addition of tiers to ultimately meet the full 5-year LOS while monitoring and adjusting to sea-level rise conditions.

ES.7 Project Ranking and Recommendations

The results of the flood damage analysis using the FEMA HAZUS tool showed that the existing topographic conditions in Miami Beach have significant potential economic losses associated with flood events, for both rainfall-induced and tidally-induced events with the implementation of a Capital Improvement Program (CIP).

A prioritized stormwater CIP list based on the ongoing projects and problem areas identified in the SWMMP was developed. In addition, CDM Smith provided recommendations regarding overall stormwater management needs to achieve better O&M, policies, and standards for existing and future conditions.

Three project categories have been identified:

- Early Out (Near-Term Implementation) Projects and Currently Scheduled CIP Projects;
- Concurrency-Reviewed (Review of Projects Currently Under Final Design and Construction) CIP Projects; and
- SWMMP- Identified Projects.

CDM Smith recommends approximately $196 million in capital improvements (based on 0.5 ft NAVD (low scenario) to 0.67 NAVD (intermediate scenario) mean high water tidal conditions) proposed for the City's primary stormwater management system. CDM Smith has incorporated an additional sea-level rise adjustment of approximately $10 million to account for the potential phenomena of accelerated sea-level rise (up to 0.84 ft NAVD mean high tidal conditions) (high scenario), and subsequent additional stormwater facility needs. CDM Smith also reviewed O&M costs associated within these identified capital projects. **Table ES-1** shows the locations, timeframes and capital costs of the proposed projects.

Table ES-1 City of Miami Beach Stormwater Management Master Plan Capital Costs (in Million $)

	0-5 Years	5-10 Years	10-15 Years	15-20 Years	Total
Biscayne Point				11	11
North Shore		7			7
North Shore (72nd Street)			10		10
Normandy Isle			20		20
Upper La Gorce*		11		1	12
Lower La Gorce*	12			2	14
La Gorce Island/Allison Island		9			9
Oceanfront			0.3		0.3
Nautilus				4	4
Sunset Island 3 and 4*	3				3
Flamingo/West Avenue	47			59	106
Subtotal	**62**	**27**	**30.3**	**55**	**196.3**
Adjustment for higher sea-level rise		2	4	4	10
Total	**62**	**29**	**34.3**	**81**	**206.3**

*Under design

The CIP was also evaluated both technically (SLC) and financially (capital cost) based on a 30-year planning horizon. However, given the design life of the pumping components and CDM Smith's experience in the development of other SWMMP, it was concluded that a 20-year planning cycle was appropriate with continued monitoring of SLC in shorter time increments.

The financial analysis of the City's Stormwater Utility shows that it will require additional funding to finance the construction of recommended CIP projects and to operate and maintain the system over the next 20 years.

ES.8 Conclusions

The submitted SWMMP provides comprehensive recommendations for improving the City's stormwater management system performance for the next 20 years. Appropriate consideration has been given to potential rainfall related flooding, sea-level rise, water quality of Biscayne Bay, and O&M of an expanded system. The presented capital improvements allow the City's stormwater systems to be flexible and adaptable in meeting the increasing LOS performance targets and regulatory demands.

Specific objectives were defined through the initial project meetings, including the following; the means by which the SWMMP addresses them are also noted.

- Objective Number 1: Quantify and improve flood control LOS based on a 20-year capital improvement program;
  - SWMMP Solution: A comprehensive 20-year CIP was developed quantifying improvements to flood control LOS with flexibility to adapt to varying degrees of SLC. The $196 million CIP quantifies the economic requirements to meet LOS and water quality requirements. Increasing the CIP to $206 million provides a financial adjustment to accommodate higher SLC projections over the 20-year time frame;
- Objective Number 2: Quantify economic impact of flooding;
  - SWMMP Solution: FEMA HAZUS evaluation documents the economic impact of flooding on the region of the City that generates the majority of the City's tourism revenue. The $196 million CIP quantifies the economic requirements to meet LOS. Increasing the CIP to $206 million provides a financial adjustment to accommodate higher SLC projections;
- Objective Number 3: Facilitate and prioritize O&M;
  - SWMMP Solution: Refinements and expansion of current O&M practices have been evaluated with a projected cost as part of the development of recommendations. These considerations are included in projected future funding of the City's Stormwater Utility;
- Objective Number 4: Augment existing infrastructure for storage and treatment;
  - SWMMP solution: The BMP Treatment train tiered solutions augment the existing infrastructure with storage and treatment solutions to manage flooding, protect and improve water quality, increase recharge, and provide potential water for irrigation;
- Objective Number 5: Coordinate and guide review of projects under current design/construction and facilitate accelerated analysis of "early out" projects;
  - SWMMP solution: Early out projects have been developed and concurrency reviews have been performed to guide the development of stormwater solutions under construction that are consistent with the SWMMP;

- Objective Number 6: Identify stormwater harvesting-reuse and recharge well opportunities for conservation of fresh water;
  - SWMMP solution: Tier 1 through Tier 4 BMP Treatment Train recommendations recharge the Biscayne Aquifer under the City while developing storage solutions that promote irrigation and reuse of treated stormwater;
- Objective Number 7: Refine and recommend updates to the City's stormwater ordinances and assess sufficiency of the City's Stormwater Utility;
  - SWMMP Solution: Recommendations to refine ordinances and policies including those related to SLC are proposed while identifying the long-term revenue sufficiency of the Stormwater Utility;
- Objective Number 8: Provide recommendations for seawalls to mitigate the effects of sea level increases over the 50 years;
  - SWMMP Solution: Preliminary inspection and elevation standards for seawalls have been made with consideration of SLC, based on USACE guidance documents. A recommendation of a minimum seawall height of 3.2 ft NAVD provides a means to protect against projected spring tidal conditions over the next 50 years, based on intermediate SLC projections.

The presented SWMMP addresses the objectives defined at the initiation of the project. The developed solutions are consistent with the project statement defined at the project kickoff meeting: "Proposed solutions are needed that are accurate, timely, effective, and defensible."