SEA LEVEL RISE AND FLOOD RESILIENCY PLAN

Building Resilience and Mitigating Risks to South Florida's Water Resources

SEPTEMBER 2022

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

PROTECTOR OF THE EVERGLADES SINCE 1949

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Executive Summary

The District is strongly committed to addressing the impacts of climate change on water resources including sea-level rise, changing rainfall patterns, and evapotranspiration trends, among others. As a key part of its resiliency strategy, the District evaluates the status of its flood control infrastructure, water supply operations and ongoing ecosystem restoration efforts, and advances projects necessary to continue providing flood control, water supply, and ecosystem restoration in anticipation of future climate conditions. In coordination with the Florida Department of Environmental Protection, other State and Federal Agencies, and local governments, the District is making infrastructure adaptation investments that are needed to continue to successfully implement its mission.

This plan, which will be updated annually, is the first District initiative to compile a comprehensive list of priority resiliency projects with the goal of reducing the risks of flooding, sea level rise and other climate impacts on water resources and increasing community and ecosystem resiliency in South Florida. This goal will be achieved by updating and enhancing water management infrastructure throughout the Central & South Florida(C&SF) Flood Control System and the Big Cypress Basin and implementing effective, resilient, integrated basin-wide solutions. This list of projects was compiled based upon vulnerability assessments that have been ongoing for the past decade. These assessments utilize extensive data observations and robust technical hydrologic and hydraulic model simulations to characterize current and future conditions, and associated risks.

In dealing with flood protection, the District's Flood Protection Level of Service (FPLOS) Program has been advancing integrated modeling efforts in critical basins to aid in understanding system flood vulnerabilities and identifying cost-effective implementation strategies to assure that each basin can maintain its designated FPLOS under current and projected conditions. In addition, the District's Capital Improvement Plan (CIP) has been incorporating climate change and SLR considerations into the design of critical infrastructure projects. Both FPLOS and CIP Programs have been successful at identifying critical resiliency investments that are now being organized and expanded in this document.

The list of priority resiliency includes investments needed to increase the resiliency of the District's coastal structures part of the C&SF System and Big Cypress Basin, including structure enhancement recommendations and additional SLR adaptation needs. These projects represent urgent actions that need to address the vulnerability of the existing infrastructure. Project recommendations also comprise basin-wide flood adaptation strategies that are based upon other FPLOS recommendations, and water supply and water resources of the State protection efforts. The projects include adding "self-preservation mode" function to water control structures, construction of the South Miami-Dade Curtain Wall, L31E Levee improvements, and the Corbett Levee project. Each of these projects help to increase the functionality and capacity of the District's flood control and water supply systems and protection of the environment. The Everglades Mangrove Migration Assessment Pilot Study is being proposed to capture the adaptive foundational resilience of the coastal wetlands within the District, and to demonstrate the ability of coastal wetlands to adapt to rising sea levels via enhanced soil elevation change. Finally, critical planning projects are presented to continuously advance vulnerability assessments and scientific data and research to ensure the District's resiliency planning and projects are founded on the best available science.

RESILIENCY ACTIONS BEING PROPOSED IN THIS DOCUMENT INCLUDE BUT ARE NOT LIMITED TO THE FOLLOWING:

- Adapt infrastructure to current and future conditions
- Improve canal conveyance, drainage, and inter-basin interconnectivity
- Increase locally distributed and regional storage and infiltration options
- Build situationally appropriate infrastructure (seepage walls, flood barriers)
- Implement "self-preservation" to increase operational capacity and flexibility
- Enhance coastal wetlands and other ecosystem services
- Maximize the integration of green infrastructure and nature-based solutions
- Utilize sustainable energy sources for district facilities and projects
- Continue to expand planning efforts, including H&H modeling, data analysis, monitoring of changing observed conditions and future projections

The District seeks to implement projects that benefit the South Florida's communities and environment by working closely with state, tribal, private, and local governments and taking into consideration the needs of socially vulnerable communities and protected environmental areas. This document includes the multicriteria ranking approach that was developed to support the assessment of vulnerable areas in South Florida, including metrics that help to identify the most critical infrastructure and vulnerable areas, while also considering basin-wide resiliency needs. Cost estimates for each proposed project are also presented, as well as recommendations to incorporate sustainable sources of energy and utilize the most efficient designs, using both traditional gray infrastructure improvements and nature-based solutions.

This Plan has been updated in 2022 to include additional strategies on nature-based solutions (NBS), sustainable energy strategies, a resiliency view on ongoing ecosystem restoration efforts and associated potential carbon storage, and water supply resiliency. Additionally, the updated document contains a revised and expanded resiliency project characterization and ranking system, and the description of the new flood damage cost estimate tool (SFWMD FIAT) to support cost-benefit analysis as part of flood adaptation planning.

Among next steps for the implementation of the project recommendations included in this plan, the District is seeking for funding alternatives at the State and Federal levels. At the State level, in May 2021, Governor Ron DeSantis signed Florida Senate Bill 1954 which created the Resilient Florida Program, providing significant funding to support flooding and SLR resiliency projects throughout the State. In May 2022, Governor DeSantis approved House Bill 7053 which established further efforts towards Statewide Flooding and Sea Level Rise Resilience. At the Federal level, the District and USACE are partnering to initiate a new study, to recommend adaptation strategies to build flood resiliency in the communities served by the C&SF Systems.

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Introduction and Background

The South Florida Water Management District (District) is a regional governmental agency that manages the water resources in the southern half of the State, covering all or part of 16 counties from Orlando to the Florida Keys, and serving a population of over 9 million residents. The District's mission is to safeguard and restore South Florida's water resources and ecosystems, protect our communities from flooding, and meet the region's water supply needs while connecting with the public and stakeholders.

Since its creation in 1949, the agency has been responsible for managing the Central and Southern Florida Project (C&SF), authorized by Congress in the Flood Control Act of 1948, as well as the Big Cypress Basin. The C&SF Project consists of 2,200 miles of canals; 2,100 miles of levees/berms, 84 pump stations, 778 water control structures and weirs, and 621 culverts. This regional water management system is the primary system of canals and natural waterways that connect to community drainage districts and hundreds of smaller neighborhood systems to effectively manage floodwaters caused by heavy rainfall events, through a coordinated effort among primary, secondary, and tertiary drainage systems. The C&SF Project is a multi-purpose system that provides flood control and water supply for municipal, industrial, and agricultural uses. Additionally, the C&SF Project provides water for ecosystem restoration and protection of fish and wildlife resources as well as prevention of saltwater intrusion, with significant implications on water resources and water supply protection.

The C&SF Project is now over 70 years old and although it has been well maintained, it has not received major updates over that period. Extensive land development and population increase within the project footprint has exceeded the original design assumptions and significant changes in climate conditions, including SLR, have also impacted the project performance. Many communities in South Florida are exposed to coastal and inland flooding quite frequently. These risks and their potential impacts are multifaceted and involve flood hazards driven by storm surge, high tides, and extreme rainfall, as well as impacts to water supply, water resources and the environment.

The District is strongly committed to addressing the impacts of climate change on water resources, including rising sea-levels, changing rainfall patterns, and evapotranspiration trends, among others, and has a District Resiliency Team, working in close collaboration with various internal teams, to take on these challenges. As a key part of its resiliency strategy, the District evaluates the status of its flood control infrastructure, water supply operations and ongoing ecosystem restoration efforts, and advances projects necessary to continue providing water supply, flood protection and ecosystem restoration in South Florida, under current and future climate conditions.

In dealing with Flood Protection, the District's Flood Protection Level of Service (FPLOS) Program was established in 2015 to ensure that the regional flood control system provides the desired level of flood protection today and into the future, with consideration for land use changes, development and SLR. The FPLOS program has been advancing robust hydraulic and hydrologic modeling efforts in critical basins to aid in understanding system vulnerabilities, and to identify cost-effective implementation strategies to assure that each basin can maintain its designated FPLOS under current and projected conditions. FPLOS results are being advanced by the District, in tandem with regular operations and maintenance infrastructure investments.

The District's Capital Improvement Plan is a major responsibility of the agency that requires continually making significant investments in the C&SF Project. The District integrates resiliency related investments into its $50 Million annual CIP by incorporating climate change and SLR considerations into the design of projects and critical infrastructure. The CIP process and projects are also considered when funding dedicated to resiliency efforts is secured. In coordination with the Florida Department of Environmental Protection (FDEP) and other Local, State and Federal Agencies, the District is making infrastructure adaptation investments that are needed to successfully implement its mission.

The recommended projects described in this Plan comprise the District's comprehensive proposal to build innovative and cost-effective adaptation and mitigation solutions to the impacts of climate change on water resources. These projects were prioritized according to the District's Resiliency Vision, described in the first chapter of this document. The projects are founded on the principles of risk reduction, community wide benefits, cost effectiveness, well planned projects, full and dynamic integration of future conditions, consideration of associated water quality and ecosystem restoration objectives, leveraging partnerships with local, state, and federal Agencies, and ensuring continuous stakeholder engagement.

Given the associated uncertainties related to climate change, and adoption of projection scenarios thereof, these solutions are being proposed as part of a dynamic adaptive pathways approach, in which the timing of their implementation is prompted by pre-established warning signals or triggers. This approach supports the development of a plan that can adapt to these future uncertainties.

The FPLOS Phase I Assessments and Phase II Adaptation Studies, as detailed in Chapter 2 of this document, provide the technical foundation for the development of the adaptation triggers that will determine the need for implementation of supplemental flood mitigation strategies. The FPLOS projects included in this document represent urgent actions to be prepared for the near future. Project recommendations also comprise basin-wide flood adaptation strategies that are based upon other FPLOS recommendations, and water supply and water resources of the State protection efforts.

This Plan has been updated in 2022 to include additional strategies on sustainable energy strategies, nature-based solutions (NBS), a resiliency view on ongoing ecosystem restoration efforts and associated potential carbon storage, and water supply vulnerabilities and initial resiliency strategies, as detailed in the new chapters on sustainable energy (Chapter 3), nature-based solutions (Chapter 4), ecosystem restoration projects (Chapter 5), and water supply resiliency (Chapter 6).

Chapter 7 includes a summary of the approach developed to identify and prioritize the project recommendations included in this Plan. Critical projects were evaluated in terms of their urgency and vulnerability to SLR, storm surge and extreme rainfall risks, and their impacts to critical lifelines and the communities living in the respective project impact areas. Factors such as lower income population and pre-identified local government adaptation action areas, and their alignment with other District CIP projects were also included in the evaluation, in additional, benefits from each of the recommended projects are characterized.

Chapter 8 presents a description of each individual construction (implementation) project, their locations, completion schedule and respective cost estimates for implementing new resiliency features and modifying, and/or enhancing the District's most vulnerable infrastructures. The need to continuously evolve our understanding of climate change, SLR and flood mitigation consequences is intrinsic to the District's resiliency efforts. Chapter 9 include a list of priority planning projects. The planning projects support the

Resiliency Team's mission to coordinate scientific data and research needs to ensure the District's resiliency planning and projects are founded on the best available science. Finally, next steps and final comments are presented, including the delineation of a path forward towards the implementation of the project recommendations and funding alternatives at the State and Federal levels. At the State level, in May 2021, Governor Ron DeSantis signed Florida Senate Bill 1954 which created the Resilient Florida Program, providing significant funding to support flooding and SLR resiliency projects throughout the State. In May 2022, Governor DeSantis approved House Bill 7053 which established further efforts towards Statewide Flooding and Sea Level Rise Resilience. As part of the Resilient Florida Program implementation, the District is submitting a list of proposed projects to FDEP on an annual basis, based on the recommendations included in this plan. At the Federal level, the District and USACE are partnering to initiate a new study, to recommend adaptation strategies to build flood resiliency in the Communities served by the C&SF System.

1. Our Resiliency Vision

The District is committed to reducing the risks of flooding, sea level rise and other climate impacts on water resources and increasing community and ecosystem resiliency in South Florida, by updating and enhancing the C&SF Project infrastructure using both traditional gray infrastructure improvements and nature-based solutions. Our vision is driven by our desire to reduce risk by implementing effective, resilient solutions and anticipate future conditions, while engaging the public through various outreach activities. Our FPLOS and CIP programs ensure that projects are designed, managed, and constructed using innovative techniques. District projects will incorporate sustainable sources of energy and utilize the most efficient designs available. Our resiliency projects follow all local and Federal threatened and endangered species regulations, and we seek to restore and preserve wildlife habitat by implementing nature-based solutions. The District seeks to implement projects that benefit the South Florida's communities and environment by working closely with state, tribal, private, and local governments and taking into consideration the needs of socially vulnerable communities and protected environmental areas. Below are descriptions of each of the criteria that, when taken together, illustrate our resiliency vision and our unique role in addressing environmental, water supply and flood protection, in the context of water management operations and infrastructure risks and vulnerabilities.

Risk Reduction/ Effectiveness

The District seeks to reduce risk while maximizing the effectiveness of our projects by advancing robust hydrologic and hydraulic integrated basin wide models through the FPLOS Program. This will allow us to look at maximum stages, bank exceedances and discharge capacity of our canals as well as the flood depths and durations of overland flood inundation. Additionally, coastal structure capacity and peak stages resulting from different storm surge and SLR scenarios can be examined.

Implementation Resources

Implementation measures describe how project costs and schedules will be managed, how the project will be implemented, and how innovative techniques will be incorporated. A well-planned resiliency project includes identification of technical and project management staff and other resources needed for successful implementation. Consideration is also given to potential technical, political, and financial challenges and how they can be overcome. Additionally, project costs and schedules and pre- and post-implementation monitoring plans should be well defined.

Anticipated Future Conditions

Future conditions within each project impact area (drainage basin) are important to consider when deciding if a project is viable. It is vital to know when and where the population within a basin is projected to increase, and if land use and development are predicted to shift. Understanding demographics and changes in economic status of the community is also important. Beyond the traditional planning tools, there is a need to address future climate conditions and their impacts, including SLR, increasing groundwater elevations, rainfall extremes and other related variables. The project should be responsive to any anticipated changes, and these changes should be integrated into the planning, design, and future operation of the project. Each potential project should be informed by and/or connected to planning efforts such as Hazard Mitigation Plans, Climate Adaptation Plans, Comprehensive Plans, and others.

Vulnerable Population and Critical Infrastructure

Effective resiliency projects have community-wide benefits and should identify the populations that will be impacted, both positively and negatively. Percentage of the population that will directly benefit from the project, including the extent of the project's direct and indirect protection of community lifelines (fundamental services that allow society to function), regionally significant assets, businesses, residents, public services and natural resources are defined. Disadvantaged communities are also identified and taken into consideration. Positive impacts to vulnerable disadvantaged communities are maximized. The District strives to meet these criteria.

Levering Partnerships and Public Engagement

The District has been engaging partner agencies and the public through a series of Resiliency Public Workshops and participation in relevant public events and discussions. Outreach activities are an important way to gain public support for resiliency projects and leverage partnership with local, regional, state and Federal Agencies. In addition, FPLOS public workshops, prioritized for basins with elevated flood risk where adaptation strategies and mitigation projects need to be collaboratively developed and implemented, give stakeholders with flood control responsibilities an opportunity to share provide input and help guide the selection of projects compatible with local efforts/initiatives. Information and feedback from the public can add value to the District's planning process by introducing a real-world perspective to modeling results. The District continues to promote coordination with the public, educational institutions, stakeholders, and federal, state, and local government agencies including the USACE, FDEP Office of Resilience and Coastal Protection, FDEM, 298 Districts, planning councils, local governments, the Southeast Florida Regional Climate Change Compact, the Southwest Florida Regional Resiliency Compact, and the East Central Florida Regional Resilience Collaborative. The District is advancing integration and climate resilience strategies in the region with these partners and will be establishing a Resiliency Public Forum to promote regional collaboration, leverage technical knowledge and promoting partnership opportunities.

Ongoing Ecosystem Restoration Efforts

The District is working with USACE and other State and Federal partners to ensure ongoing ecosystem restoration efforts, and mainly the Comprehensive Everglades Restoration Plan (CERP) projects are fully implemented and operational. Restoring and preserving ecosystems is key to building and maintaining resiliency throughout South Florida. These restoration efforts have been creating and improving ecosystems, increasing ecosystem health and function, and allowing for increased water management flexibility to reduce saltwater intrusion in coastal groundwater. With improved ecosystem function, these projects have decreased the impact of flooding and SLR on South Florida's communities

Innovative Green/Nature-Based Solutions

The District is committed to seeking "green" or nature-based solutions in addition to "gray" stormwater infrastructure improvements to increase resiliency. NBS include features such as living shorelines, wetlands, artificial reefs, other urban green infrastructure features and preservation and restoration of existing natural features. Both gray and green features will be necessary to meet the challenges of climate change impacts, including SLR, along with basin-wide solutions to maximize the capacity of flood adaptation and to achieve water quality benefits. District projects will also incorporate sustainable and clean sources of energy whenever possible and utilize the most efficient designs available.

Offsetting new Energy Demands with Sustainable Sources

The District is committed to improving the energy efficiency of our operations and offsetting new energy demands through renewable energy solutions. By following the latest building codes and using state of the art materials and designs, the District builds efficient and resilient projects (Flood Resistant Design and Construction, ASCE Standard 24). With the goal of offsetting new energy demands, staff is assessing the possibility of implementing solar power for projects in areas where there is an abundance of space for solar panels and using net metering.

2. The Central and Southern Florida System

The Central and South Florida (C&SF) Project was initially authorized by the Flood Control Act of 1948, and subsequent Acts, and is a large, multipurpose water resources project designed and constructed by the United States Army Corps of Engineers (USACE) in cooperation with South Florida Water Management District – project local sponsor. It was authorized for the purposes of flood protection for urban and agricultural areas; prevention of saltwater intrusion risks to the coastal water supply sources; water level control and water conservation to ensure water supply for agricultural, municipal, industrial, and ecosystem uses; and preservation of fish and wildlife. The Project was designed to serve a population of 2 million people.

Multiple project phases throughout the years contributed to the development and expansion of the C&SF integrated water management system (hereafter referred to as the C&SF system). Today, the key structural infrastructure of the regional (primary) C&SF system includes approximately 2,200 miles of canals, 2,100 miles of levees/berms, 84 pump stations, and 778 water control structures. The regional system connects to local (secondary) and thousands of neighborhood (tertiary) drainage systems. It's one of the world's largest and most complex water management system and serves a population of approximately 9 million residents.

The C&SF system is facing significant changes which are challenging the aforementioned purposes of the system. The main drivers of change can be largely grouped into categories of population growth, increased development of land, extreme rainfall events, and sea level rise trends. A roughly tenfold increase in the study area population and consequent change in land use over time, compounded by the extreme rainfall event occurrences and an average of 6 inches of observed sea level rise, has significantly changed the performance of the C&SF system.

Despite significant infrastructure investments throughout these years, critical components of the C&SF System are showing deficiencies in performance. Coastal Structures, as the major example, control excess runoff produced by rainfall from each respective watershed to the ocean to reduce flood risk, and act as salinity intrusion barriers, operating via gravity. Currently, low-lying Coastal Structures cannot discharge during certain high tide periods or storm surge events because of insufficient upstream headwater (spillway) elevations. Gate overtopping, as a consequence of such high tailwater events, has already been documented in the lower east coast region. As part of future conditions assessments, coastal structure operations were simulated under different sea level rise scenarios, considering both upstream canal overbank risks, as well as reduction in gravity discharge capacity. Based on these advanced modeled outcomes, a number of these coastal structures were characterized as highly vulnerable to sea level rise, reaching bank-full elevation under a 25-year or less surge condition, and with 0.5 ft or less of sea level increase.

Also, within South Florida Water Management District boundaries, the Big Cypress Basin contains a network of 143.6 miles of primary canals, 35 water control structures and three back pumps providing flood control during the wet season and protecting regional water supplies and environmental resources from over-drainage during the dry season. The basin, which is facing similar conditions described above, includes Collier County and part of Monroe County.

In face of these challenges and opportunities, SFWMD is making significant infrastructure adaptation investments that are needed to successfully continue to implement its mission of safeguarding and restoring South Florida's water resources and ecosystems, protecting communities from flooding, and ensuring an adequate water supply for all of South Florida's needs. Building Resiliency and Mitigating Risks on South Florida Water Resources and enhancing the C&SF System and Big Cypress Basin are part of the District's Capital Improvement Plan (CIP). This current document outlines additional investments to be bundled with the District's CIP to ensure Building Resiliency and Mitigating Risks on South Florida Water Resources now and into the future.

SFWMD Capital Improvement Plan

The District commits to setting aside resources each year to implement the Capital Improvement Plan for repairing, refurbishing, enhancing and upgrading pump stations, canals, water control structures, levees and water storage areas to ensure the District water management infrastructure and facilities are operating at peak efficiency.

Since its creation in 1949, the District has been responsible for managing the C&SF System and Big Cypress Basin. The District has a multimillion-dollar Capital Improvement Plan already in place, with an average annual budget of $50M. All water control structures are inspected every five to seven years as part of the District's Structure Inspection Program (SIP). The purpose of the District's inspection program is to assure that the facility's equipment and instrumentation can be operated safely and reliably and to prioritize infrastructure investments into the District's CIP Program.

Inspections cover civil, structural, mechanical, electrical, and underwater components of the structure and each component is rated based on the severity of deficiencies, and on the urgency of recommended corrective actions. The individual component ratings are evaluated together to formulate an overall rating that guides prioritization of corrective actions. Figure 1 illustrates examples of the structure inspection program reports and the risk matrix utilized to calculate the overall rating. The "likelihood of failure" scoring is calculated based on the inspection of physical condition, the ability to operate and maintain the structure/facility as intended and the frequency of operation. The "consequences of failure" scoring is based on the location and size of the structure/facility, accounting for public health, safety, security & service, its financial impact on surrounding land use and upstream/downstream impacts, and its back up operational options.

The inspection reports are also used to help evaluate adaptation strategies as part of the FPLOS Program, and to prioritize resiliency investments. Structures that receive a critical rating for corrective actions are included as part of future conditions assessments and modifications for SLR and climate change impacts are recommended. This process ensures that the Resiliency Program and the regular CIP processes are integrated and improvements at each structure are coordinated. The goal is to not have to go back to the same structure twice within a short period of time.

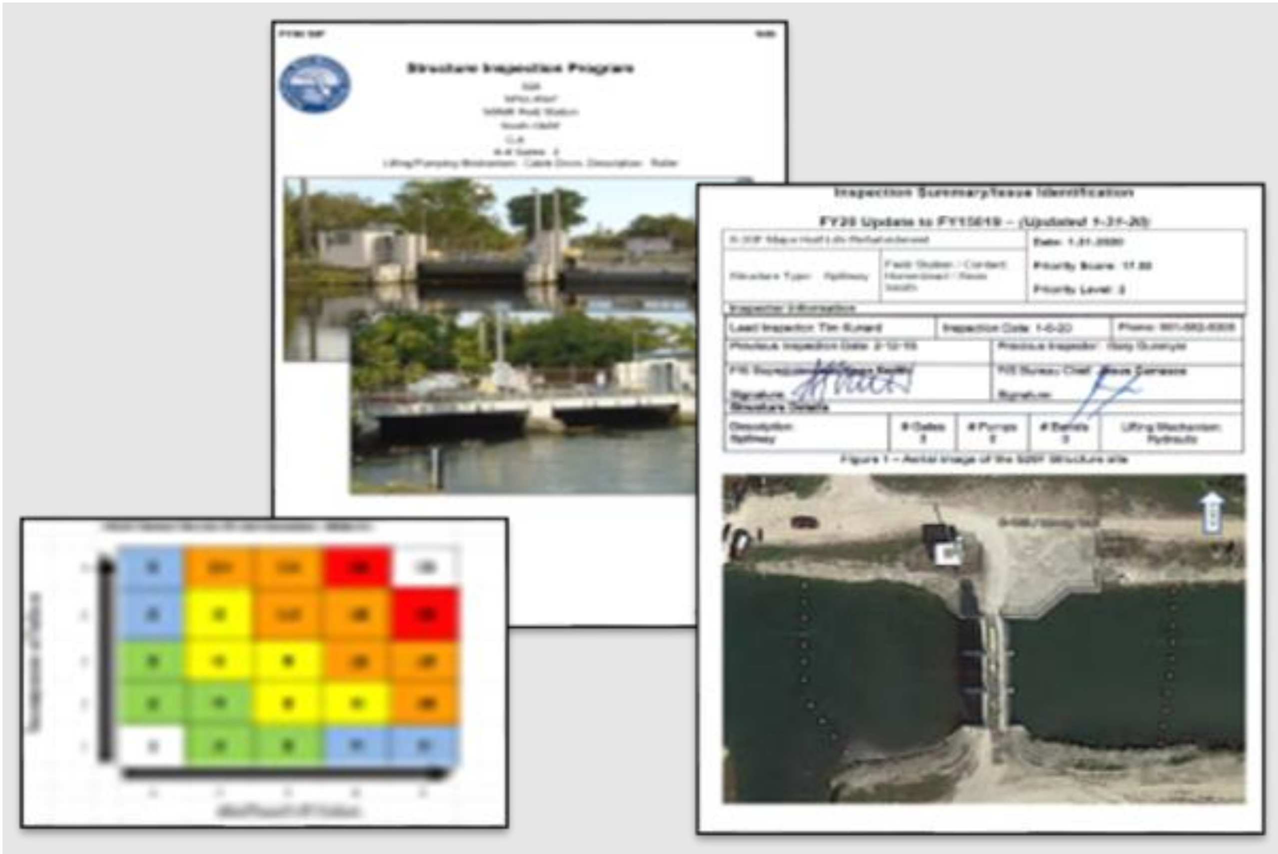


Figure 1. Examples of Structure Inspection Program Reports and the Overall Risk Rating Matrix.

The District CIP infrastructure investments are going beyond addressing needs identified into inspection reports and are enhancing water management systems with additional new components and operational capacity that is making it possible that 70+ years old system is operating today and ensuring the District mission is accomplished.

3. Assessing Flood Vulnerabilities on Water Management Systems: The Flood Protection Level of Service Program

Initiated in 2015, the District's Flood Protection Level of Service Program (FPLOS) allows the agency to evaluate the effectiveness of its flood control assets including canals, structures and pump stations to determine their ability to meet and continue to meet the flood protection needs of the region. The C&SF Project and other basins flood protection systems have many assets that are approaching end of design life, making it critical to implement this program to inform decisions on the flood control infrastructure needs of the region. The District is implementing the FPLOS program at a regional and local scale and has developed a methodology that helps to prioritize basins to study, and a suite of tools for evaluating structures and canals in selected watersheds, as well as a framework for establishing the level of service. The program incorporates input from meetings and workshops with local planning and stormwater management efforts, stakeholders, and resource managers. The FPLOS will be implemented in a phased approach in a 10-year cycle. Each basin will be evaluated, and actions taken as necessary, to ensure that the level of service is maintained. When remediation is needed, the lowest cost measures will be undertaken first, building to full replacement only when necessary. The cycle will provide opportunities to update land development and sea-level information and incorporate new technology and tools. This cyclic approach is the best use of funding and ensures that incremental, near-term measures will be incorporated into any long-term solution. The program is being executed in three stages.

Flood Vulnerability Assessment Phase (Phase I)

This stage of the program involves a periodic exploratory investigation of the primary system and related work and studies necessary to identify choke points or deficiencies in the flood control infrastructure with a focus on the primary system, and also identify flood vulnerabilities basin wide, represented by simulated overland flow inundation. These studies continue in perpetuity and each basin is revisited once every 8 to 10 years unless significant changes in the flood control system necessitate a more frequent re-assessment.

Adaptation and Mitigation Planning Phase (Phase II)

When deficiencies are identified in the system (either current or projected based on factors such as SLR and future rainfall), an Adaptation and Mitigation Planning study is triggered which executes a search for a solution within the primary system as well as the secondary and tertiary systems. These public planning projects represent collaborative efforts with operators of the secondary and tertiary systems and identifies cost effective courses of action that will, when implemented, bring the flood control system back to design specifications or desired performance for the long term.

Implementation Phase (Phase III)

The final phase includes final project design, permitting, real estate acquisition, and construction activities necessary to implement the selected adaptation strategy and course of action.

The District has taken a comprehensive and high-level approach to addressing the flood protection needs of the region. It is rigorous in its analyses using high quality integrated modeling tools, and pragmatic in its implementation. At its core, this approach is a commitment to an ongoing assessment of the state of the system to ensure that problems are identified well before they occur, providing an opportunity to plan and implement adaptations and mitigations strategies.

With a goal to reassess every basin within the District at least once every 8 to 10 years, the program initiates two assessment studies every year, starting with the most at-risk basins. This is determined based on a SLR vulnerability assessment, observed flooding, and known system limitations. These studies answer the key question: are the flood protection assets working and will they continue to work for the next 50 years? Another strength of this method is the collaborative approach in search for the appropriate solution. The District engages partners and stakeholders with responsibility for the secondary and tertiary flood control systems to identify the best course of action to mitigate any identified deficiency. The solutions are comprehensive and could range from a change in operations requiring no additional infrastructure, to major investments in infrastructure including using NNBS whenever possible. The cycle will provide opportunities to update land development and sea-level information and incorporate new technology and tools, to ensure that incremental, near-term measures will be incorporated into long-term solutions.

Figure 2 below illustrates the latest status of the FPLOS assessments and the priority basins, with consideration of existing infrastructure managed by the District. Figure 3 and Figure 4 illustrate the current and future overall flood protection level of service generally provided by existing infrastructure within each basin, as summarized in the final reports (summary and conclusions session) for the respective FPLOS Phase I (Flood Vulnerability) assessments completed for Broward and Miami Dade Counties and for Big Cypress Basin (BCB). The Flood Protection Level of Service is illustrated in these maps by the respective rainfall return frequency event that results in flooding at each basin, simulated as part of the completed FPLOS Phase I Assessments. The overall flood protection level of service assigned to each basin is a combination of the results from six performance metrics measured within each basin, for current and future conditions, and assuming that both rainfall-induced flooding and storm surge flowing flooding occurs simultaneously, as summarized in Table 1. It is important to emphasize that only portions of each basin might be showing inundation, as a result of the simulated scenarios, meaning that not the entire basin might be inundated under the given return frequency. The overall level of service assigned to each basin represent portions of that basin that will have significant overland flooding simulated under that return frequency. Detailed results, illustrating specific regions within each basin where simulated results are showing overland inundation, are provided at the final FPLOS Phase I Reports.

FPLOS Future Conditions Scenarios

The FPLOS Program assesses future conditions sea level and extreme rainfall scenarios. For the Sea Level Rise Conditions, three scenarios were defined relative to the 2015 or a more current year conditions depending on a project starting year., assumed as current sea level (2015 CSL):

- 2015 CSL +1 ft
- 2015 CSL +2 ft
- 2015 CSL +3 ft

According to Section 380.093 (5) F.S., flood vulnerability assessments should be performed accounting for at least two local sea level rise scenarios, including the NOAA intermediate-low and intermediate-high sea level rise projections, and two planning horizons for the years 2040 and 2070.

In Virginia Key, the 2022 NOAA SLR projections, relative to 2000 are detailed below. Observed change in annual MSL between 2000 and 2015 in this location is 0.073m or 0.24ft.

Intermediate Low 0.23m or 0.75ft (2040); 0.44m or 1.44ft (2070)
Intermediate High 0.27m or 0.88ft (2040); 0.79m or 2.59ft (2070)

In Key West, the 2022 NOAA SLR projections, relative to 2000 are detailed below. Observed change in annual MSL between 2000 and 2015 in this location is 0.099m or 0.325ft. The Figure below illustrates the NOAA 2022 Projections at the Key West Tidal Station.

Intermediate Low 0.24m or 0.79ft (2040); 0.44m or 1.44ft (2070)
Intermediate High 0.28m or 0.92ft (2040); 0.80m or 2.62ft (2070)

The table below summarizes the SLR projections relative to 2000, as presented by NOAA and relative to 2015, as adopted in the FPLOS Program SLR scenario formulation:

NOAA 2022 SLR Projections	Relative to 2000				Relative to 2015			
	2040 (m)	2040 (ft)	2070 (m)	2070 (ft)	2040 (m)	2040 (ft)	2070 (m)	2070 (ft)
Intermediate Low - Virginia Key	0.23	0.75	0.44	1.44	0.16	0.51	0.37	1.2
Intermediate High - Virginia Key	0.27	0.88	0.79	2.59	0.20	0.64	0.72	2.35
Intermediate Low - Key West	0.24	0.79	0.44	1.44	0.14	0.47	0.34	1.12
Intermediate High - Key West	0.28	0.92	0.80	2.62	0.18	0.60	0.70	2.30

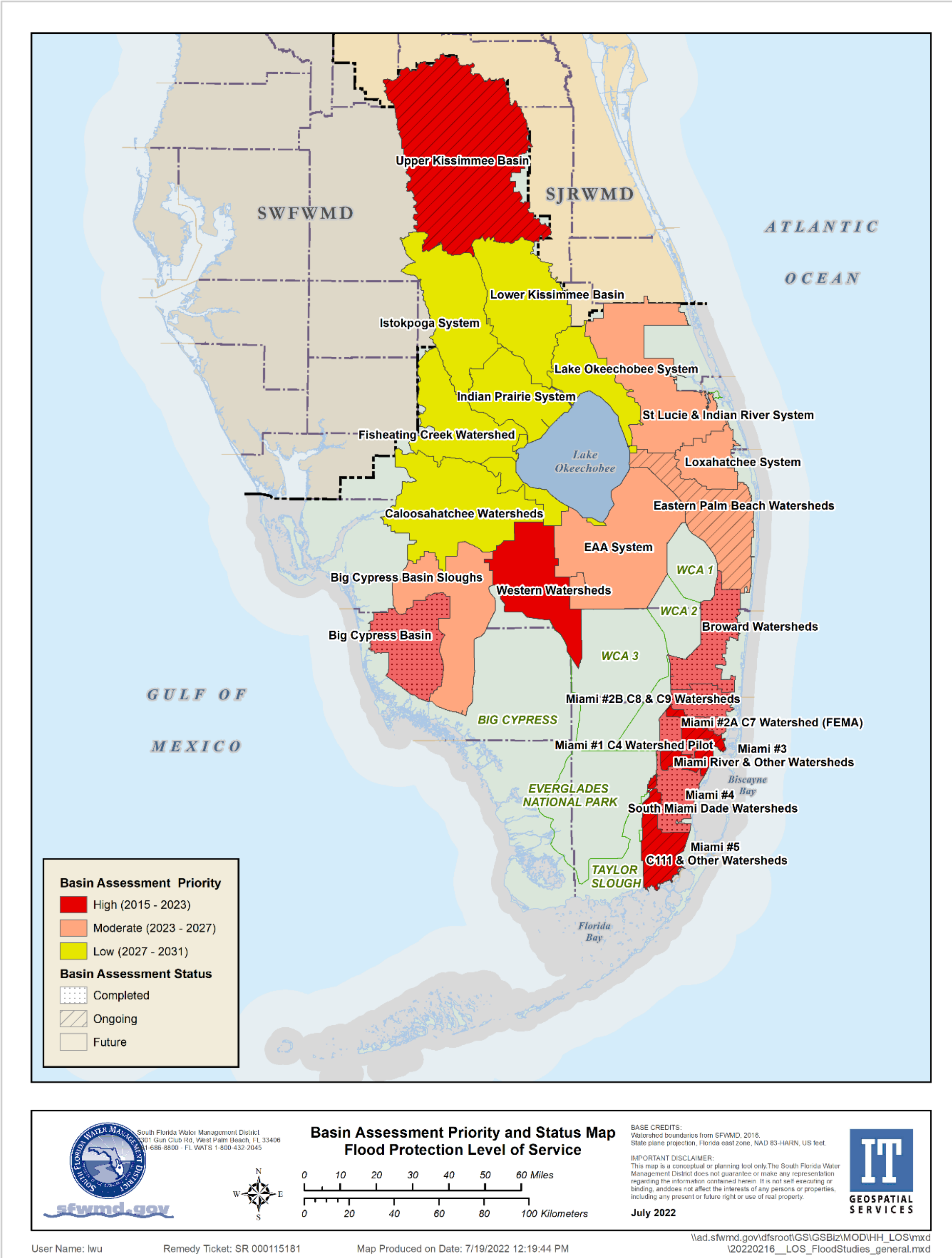


Figure 2. FPLOS Basin Assessment Priorities and Status of Implementation.

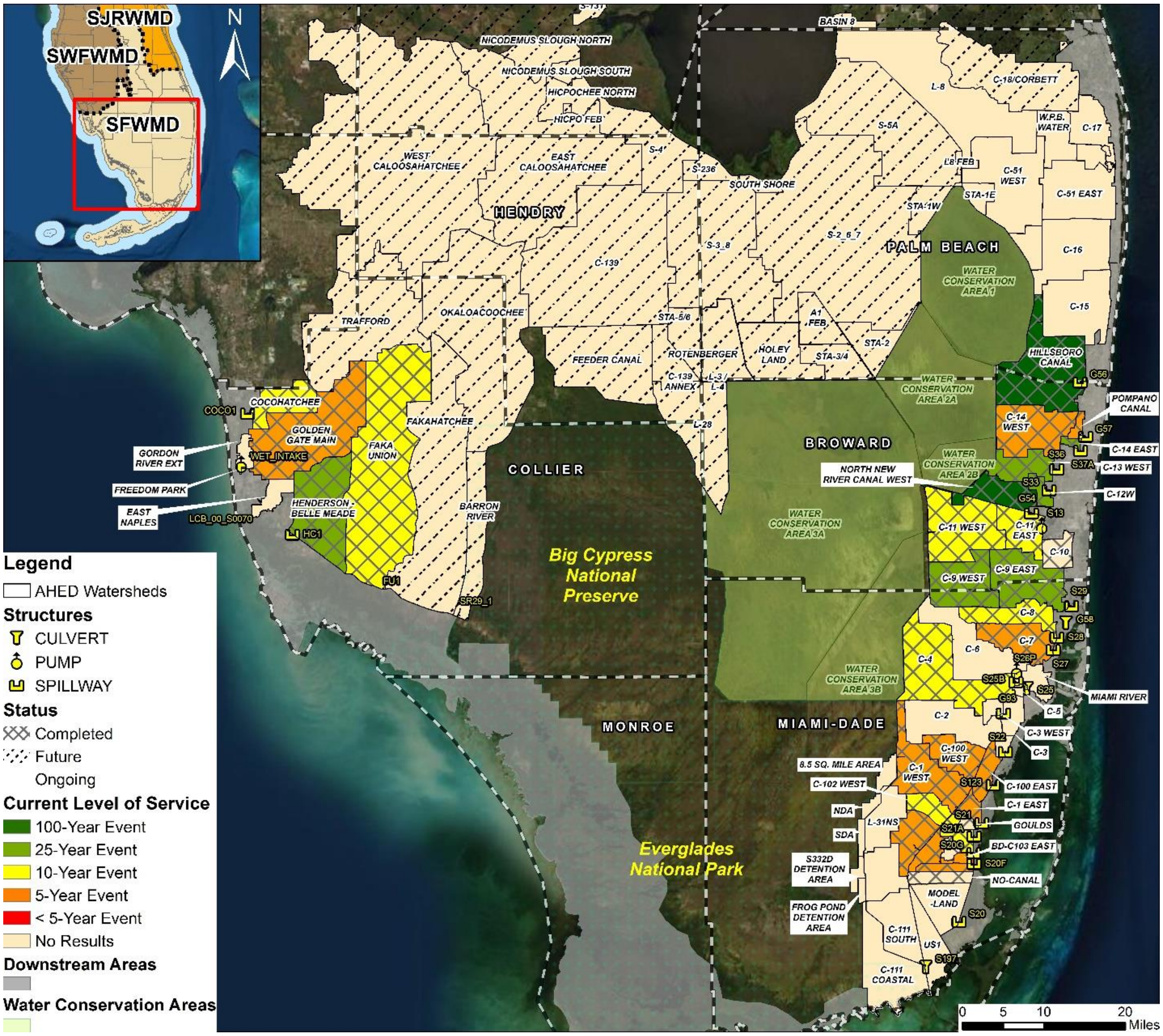


Figure 3. Current Flood Protection Level of Service generally provided by existing infrastructure in critical basins, predominantly located in Broward and Miami-Dade Counties. The Level of Service is represented by the respective rainfall frequency event that results in flooding within areas of each basin, simulated as part of completed FPLOS Phase I – Flood Vulnerability Assessments.

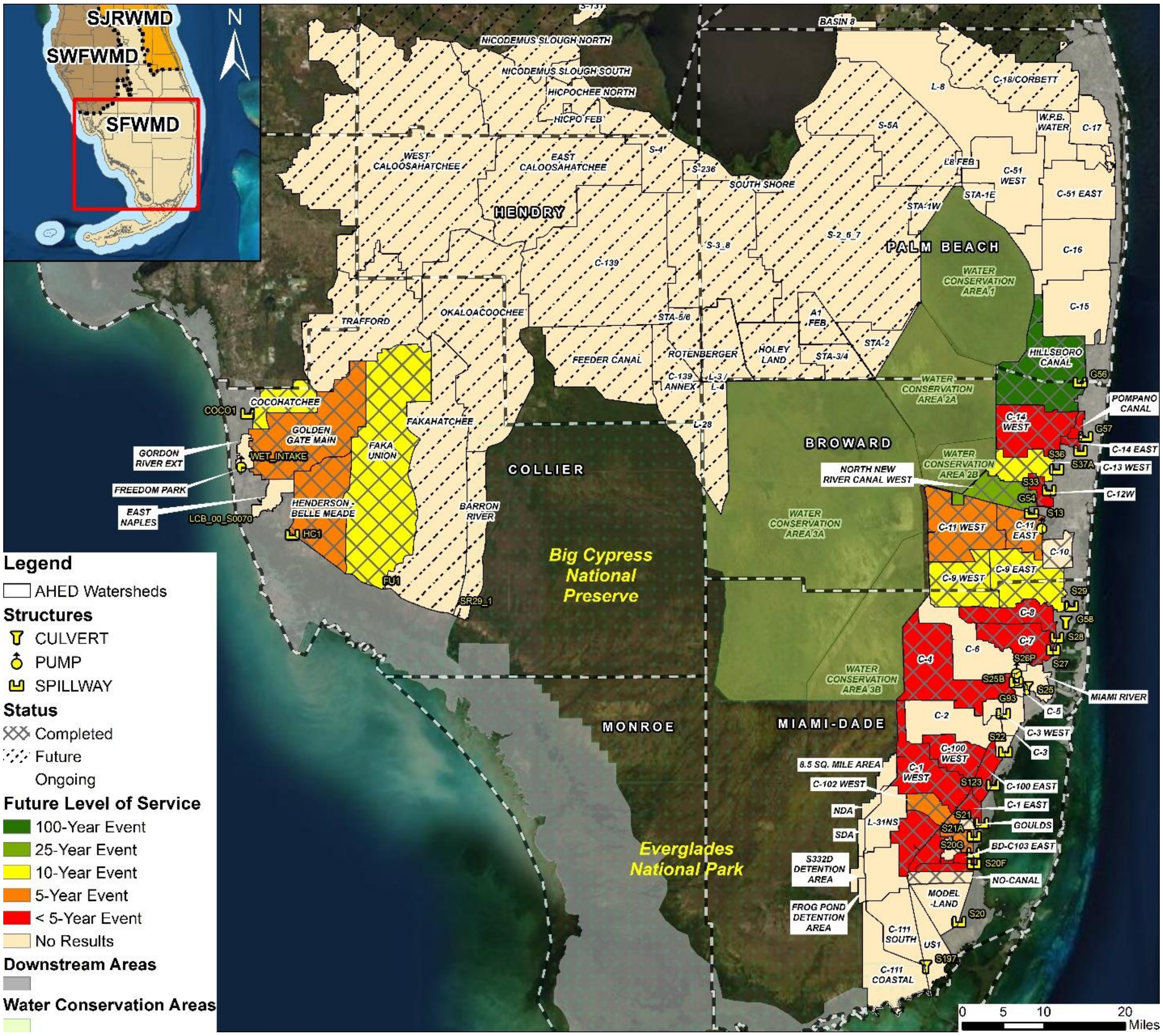


Figure 4. Future Flood Protection Level of Service generally provided by existing infrastructure in critical basins, predominantly located in Broward and Miami-Dade Counties. The Level of Service is represented by the respective rainfall frequency event that results in flooding within areas of each basin, simulated as part of completed FPLOS Phase I – Flood Vulnerability Assessments.

Table 1. Flood Protection Level of Service Summary Assessment for Maximum Stage in Primary Canals (PM1) and Frequency of Flooding (PM5) for current and future conditions.

Basins	PM1					PM5			
		Current Conditions	**Future Conditions & 1ft SLR**	**Future Conditions & 2ft SLR**	**Future Conditions & 3ft SLR**	**Current Conditions**	**Future Conditions & 1ft SLR**	**Future Conditions & 2ft SLR**	**Future Conditions & 3ft SLR**
C-8[1]		10-year	5-year	5-year	5-year	10-year	5-year*	<5-year	<5-year
C-9[1]		25-year	10-year	10-year	5-year	25-year	10-year*	10-year*	5-year*
Hillsboro[2]		100-year	100-year	100-year	100-year	100-year*	100-year*	100-year*	100-year*
C-14 West[2]		100-year	25-year	25-year	25-year	10-year*	5-year*	<5-year	<5-year*
C-14 East[2]		25-year	10-year	< 5-year	< 5-year	25-year	10-year	<5-year	<5-year
Pompano[2]		100-year	100-year	100-year	100-year	<5-year	< 5-year	< 5-year*	< 5-year*
C-13 West[2]		25-year	25-year	10-year	< 5-year	25-year	25-year	10-year	<5-year
C-12 West[2]		25-year	10-year	< 5-year	< 5-year	25-year*	5-year	< 5-year	< 5-year
North New River West[2]		100-year	100-year	25-year	10-year	100-year*	100-year*	25-year*	10-year*
C-11 West[2]		10-year	10-year	10-year	10-year	10-year*	10-year*	10-year*	10-year
C-11 East[2]		10-year	5-year	5-year	5-year	10-year*	5-year	<5-year*	<5-year*
C-4[3]		10-year	5-year	<5-year	<5-year	10-year*	5-year*	<5-year*	<5-year*
C-7[4]		<5-year	<5-year	<5-year	<5-year	<5-year*	<5-year*	<5-year*	<5-year*
C-1[5]		C1 & C1N: 5-year	5-year or less	5-year or less	5-year or less	10-year	10-year	<5-year*	<5-year
		C1N: 10-year							
C-100[5]		5-year	5-year	< 5-year	< 5-year	25-year	5-year*	< 5-year*	< 5-year
C-102[5]		10-year	10-year	5-year	5-year	5-year	5-year*	5-year*	< 5-year
C-103[5]		5-year	5-year	5-year	5-year	5-year	5-year*	5-year*	<5-year
Cocohatchee[6]		10-year	10-year	10-year	5-year	10-year**	10-year**	10-year**	5-year**
Golden Gate[6]		5-year	5-year	5-year	<5-year	5-year**	5-year**	5-year**	<5-year**
Henderson Creek[6]		25-year	25-year	25-year	10-year	25-year**	25-year**	25-year**	10-year**
Faka Union[6]		10-year	10-year	10-year	5-year	10-year**	10-year**	10-year**	5-year**

Footnotes:

* The report does not contain sufficient information to confirm the watershed LOS results. The proposed return periods were interpreted based on available information from the FPLOS study, including technical memorandums, canal profiles, flood maps and appendices; thus, the results do not reflect the SFWMD assessment on the watershed LOS as these are subject to technical interpretation and should be further reviewed by local stakeholders.

**The watershed LOS results are tightly connected with the primary canal system.

[1] C-8 and C-9 FPLOS study was completed in 2021

[2] Broward County FPLOS study was completed in 2021

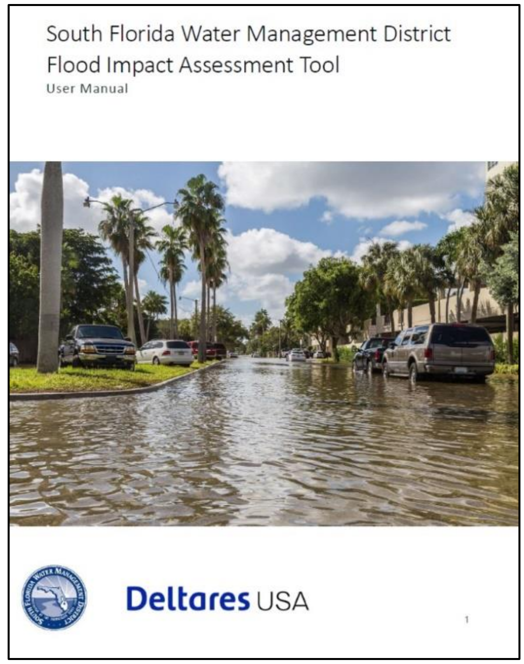
[3] C-4 FPLOS is a study produced by the H&H Bureau as a project deliverable for project 100888 (FPLOS, within the SLR projections) and completed in May 2016. The LOS design events assessed include the 5-year 72-hour, 10-year 72-hour, 25-year 72-hour, and 100-year 72-hour storm events and surge return periods, current sea level and three future sea level rises (+0.34 ft, +0.8 ft, and 2.26 ft) focused on a 50-year planning horizon. The assessment of +0.34 ft SLR scenario suggested a 10-Year LOS, +0.80 ft SLR scenario was reduced to a 5-Year LOS and +2.26 ft scenario to <5-Year LOS. These scenarios were used as reference to produce a consistent FPLOS Summary Table, as most FPLOS efforts apply SLR +1 ft, SLR+2 ft, and SLR+3 ft as sea level rise conditions. For this reason, a SLR +1 ft scenario is defined as a 5-Year LOS, while for SLR+2 ft and +3 ft a <5-Year LOS or "No Answer" may be appropriate.

[4] C-7 FPLOS is a study funded by FEMA and completed in 2017. The LOS design events assessed include the 5-year 24-hour, 10-year 24-hour, 25-year 72-hour, and 100-year 72-hour storm events and surge return periods, current sea level and three future sea level rises (+0.76 ft, +1.09 ft, and +2.21 ft). Under current condition and the three future sea level rise conditions, the assessment concluded that along downstream of the Spur Canal junction (NW 22nd Avenue), the maximum stages between NW 17th Avenue and N Miami Avenue exceed the canal bank elevations in all events and the stages exceed the canal bank elevation during the 25- and 100-year events along west of the 17th Avenue.

[5] South Miami-Dade FPLOS study was completed in 2022

[6] Big Cypress Basin FPLOS study was completed in 2017

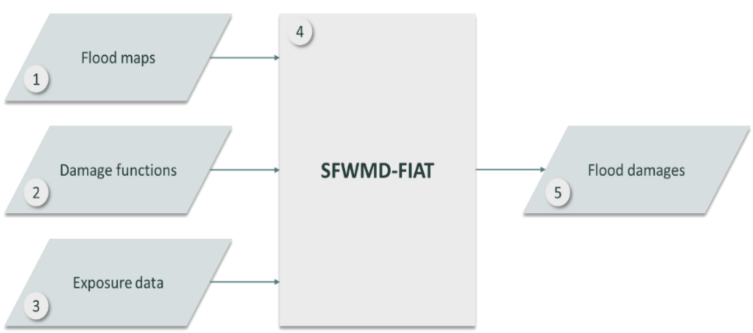
SFWMD Flood Impact Assessment Tool (SFWMD-FIAT)



The District, as part of its Resiliency and Flood Protection Level of Service initiatives, has developed a Flood Impact Assessment Tool (SFWMD-FIAT). This tool helps support recommendations for flood mitigation and adaptation measures by providing cost benefits of implementing priority infrastructure investments. These recommended strategies are supported by advanced hydrologic and hydraulic modeling tools and assessments being implemented by the District's Flood Protection Level of Service Program – Phase II (Adaptation Planning) and incorporated into this Plan. The tool provides the ability to perform future flood damage cost estimates using multiple flood elevation/inundation scenarios developed as part of future conditions modeling efforts, for various return frequencies, to calculate an expected annual flood damage estimate (Figure 5).

SFWMD-FIAT can calculate the flood damage costs for building structures and their contents – multiplied by the depreciated replacement value by square foot and by the area of the building footprint to calculate the max potential damage of the structure - as well as roads and other selected infrastructure components, for multiple flood inundation scenarios. The user can run damage calculations for multiple flood inundation scenarios and return periods using a single desktop tool. The tool is user friendly and versatile, as the economic damage curves and values of buildings can be updated anytime. The exposure data comes from the following official national data sources:

- County Supplied Building Footprints
- SFWMD Normalized Parcel and Land Use
- High Resolution Topo-Bathymetric Data
- Navteq / HERE Roads
- HAZUS Occupancy Types and Depreciated Replacement Values



1	Flood maps	Selected per damage simulation in user interface
2	Damage functions	Prepared in set-up phase, coupled to exposure types
3	Exposure data	Prepared in set-up phase, developed per area of interest
4	Desktop Damage Tool	User interface and underlying Delft-FIAT damage assessment software
5	Flood damages	Object-level + aggregated tables and (optional) shapefiles of damages

Figure 5. Block Diagram of SFWMD-FIAT tool.

The output files include post-processed summarize damages and risk in overview detail levels (Excel spreadsheet or shapefiles), including overall damage costs associated with combined structures and roads or by aggregation categories such as sub-basin, land use, tax use, census block, poverty level or critical infrastructure. The recommended projects within this Plan will have an associated cost-benefit ratio as part of the next planning round.

4. Integrating Nature-Based Solutions

The application of natural and nature-based solutions (NBS) has grown steadily over the past 20 years, supported by calls for innovation in flood risk management (FRM). The District is committed to seeking nature-based solutions (NBS) or "green and blue" in addition to "gray" infrastructure improvements. Projects that "slow the flow" by using natural processes such as retention, infiltration, and evaporation/evapotranspiration to reduce runoff will be targeted. Additionally, preservation and restoration of existing natural features will continue to be implemented as an important strategy to increase resiliency.

Different terms and definitions of NBS for risk reduction and adaptation are in use across the variety of organizations that're advancing these applications. Related terms, though not necessarily synonymous, include ecological engineering, engineering with nature, living shorelines, natural flood management, and green infrastructure, to name a few. The common element among all these terms is the focus on working with natural processes for the benefit of people and the ecosystems. For instance, Engineering With Nature (EWN®) is an initiative of the U.S. Army Corps of Engineers enabling more sustainable delivery of economic, social, and environmental benefits associated with water resources infrastructure. EWN intentionally aligns natural and engineering processes to efficiently and sustainably deliver economic, environmental, and social benefits through collaborative processes (Bridges et al. 2014 and 2021).

Nature-based solutions are defined as project features that use or mimic natural processes to maximize benefits. These features can be used to conserve or restore ecosystem services and/or enhance natural processes in engineered systems. Application of NBS often generate social, economic, and environmental co-benefits that improve human living conditions. Green infrastructure refers to natural or semi-natural systems that provide water resource management options comparable to traditional "gray" infrastructure. Green and gray features can be combined to enhance overall system resiliency. NBS and green infrastructure can be used to enhance flood protection against sea level rise (SLR) and increased extreme rainfall caused by climate change, as well as manage water supply and improve water quality. Both gray and green infrastructure will be necessary to meet the challenges of climate change impacts, including SLR, along with basin-wide solutions to maximize the capacity of flood adaptation as well as achieve water quality and water supply benefits.

Examples of Nature-Based Solutions

Nature-based solutions include features such as bioswales, raingardens, living shorelines, wetlands and artificial reefs that reduce stormwater flooding and storm surge impacts by absorbing wave energy and/or storing excess stormwater. Green urban infrastructure features include green and blue streets that are designed to collect, store, and slow stormwater runoff. Green and blue streets have porous surfaces that help to increase infiltration and direct runoff to trees planted in porous structural soil to increase storage and evapotranspiration, as well as improve water quality. Scaled up, these features have the potential to reduce flooding by using the natural water pumping (evapotranspiration) capacity of trees and other vegetation to slow the flow and provide enhanced storage, detention, retention and infiltration options. Additionally, NBS also provides a multitude of water resources benefits by reducing net irrigation demand for green spaces, and increasing retention and infiltration of surface water, which naturally recharges aquifers and assisting in preventing saltwater instruction in coastal areas (see chapter 9).

The United States Army Core of Engineers (USACE) has developed an initiative called Engineering With Nature (EWN) which they describe as the intentional alignment of natural and engineering processes to efficiently and sustainably deliver economic, environmental, and social benefits through collaboration. .

C-8 Basin Resiliency Project

An example of a project that is proposing to use a combination of NBS and gray infrastructure is the District's C-8 Basin project in Miami-Dade County. The C-8 Canal is the central flood control feature that receives and conveys basin floodwaters by gravity through the S-28 Coastal Structure to sea.

The project will reduce flood risk under sea-level rise and provide ancillary water quality benefits, by restoring the basin's flood protection level of service and enhancing quality of life in the region. The project includes:

- Replacement of the S-28 Structure with an enhanced structure and elevated components to withstand the impacts of SLR and climate change
- Installation of a 500 cfs forward pump station adjacent to the S-28 structure to maintain basin discharge levels as sea levels rise
- Construction of a flood barrier tying the S-28 Structure to higher ground elevations to mitigate the impacts of SLR storm surge and saltwater intrusion
- Enhancement of secondary canal banks to improve flood control throughout the basin
- Construction of a temporary floodwater detention area on a portion of the Miami Shores Golf Course near the S-28 Structure to provide temporary storage of floodwaters and reduction of stormwater runoff volumes during extreme rainfall events.
- Installation of living shoreline along the C-8 Canal and vegetated flood berms to enhance flood protection

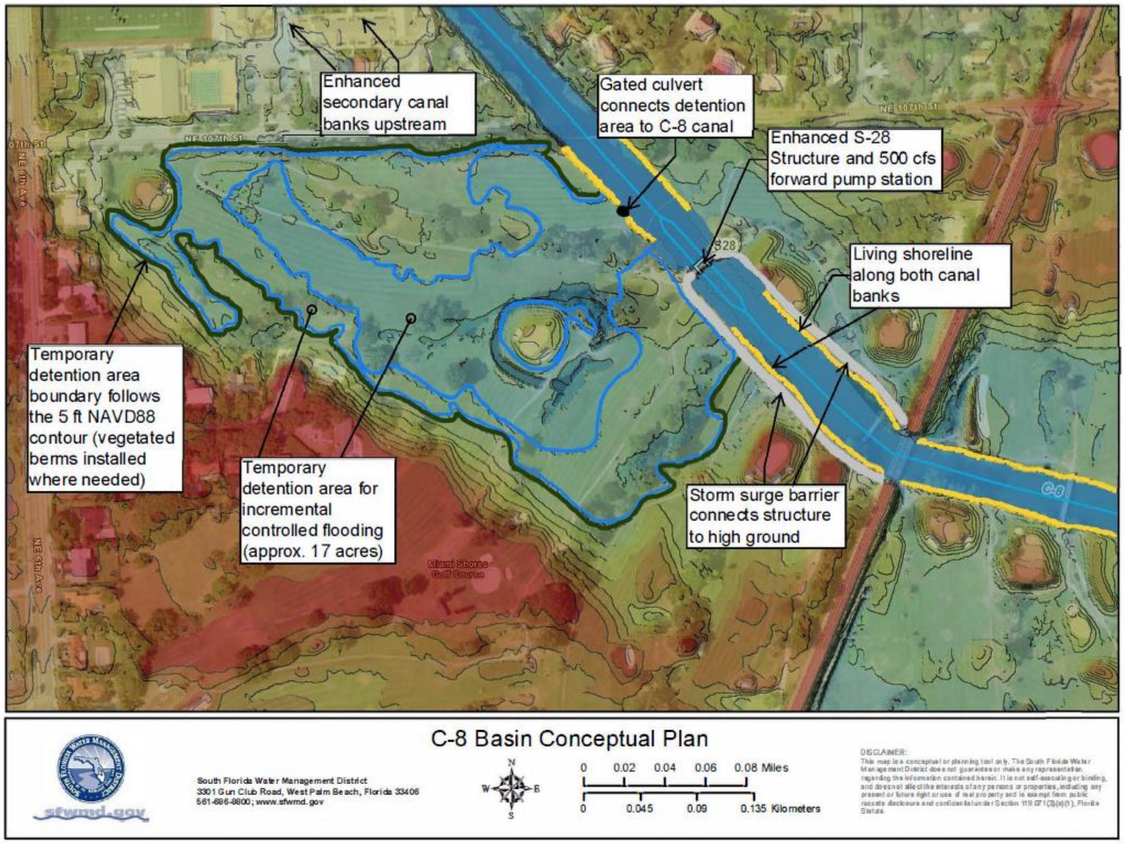


Figure 6. Conceptual plan for the C-8 Basin.

A significant aspect of this project includes using a portion of the Miami Shores Golf Course as a temporary flood water storage area during extreme rainfall and storm surge events (Figure 6). Vegetated berms and living shoreline features are also incorporated into the plan to enhance water quality and aquatic habitat. The strategy to reduce runoff in this densely urbanized basin includes implementation of a series of distributed storage solutions. These project features can serve as pilot project examples for the region. Ancillary benefits include improved fish and wildlife habitat from implementation of the living shoreline features, improved land value due to reduced flood risk and enhanced aesthetics, prevention of canal bank erosion, water quality benefits from implementation of vegetated berms and temporary flood water storage, and increased opportunities for recreation.

Additional Examples of Nature-Based Solutions

Additional examples of NBS that may be applied in South Florida are shown in Table 2 below. The table can be useful for identifying potential NBS solutions for each water management/District mission type. The location of the proposed NBS feature and corresponding gray infrastructure that can be either replaced or enhanced by the NBS feature are identified.

Table 2. Nature-Based Solutions/Green Infrastructure that may be applied in South Florida (adapted from UNEP-DHI/ICUN/TNC (2014, Table 1, p.6)

Water Management Topic/ District Mission		Green Infrastructure/Nature-Based Solution	Location: Watershed	Location: Floodplain	Location: Urban	Location: Coastal	Corresponding Gray Infrastructure (at the primary service level)
Flood control	River/canal flood control	Reconnecting rivers/canals to floodplain		■			Levees and water control structures
		Wetland restoration/conservation	■	■	■		
		Constructed wetlands	■	■	■		
		Living shorelines/riparian buffers		■			
	Urban stormwater runoff	Green spaces (bioretention and infiltration)			■		Urban stormwater infrastructure
		Detention / Storage with associated "let it grow" strategies			■		
		Enhanced Infiltration / Groundwater recharge/storage			■		
		Permeable surfaces			■		
		Green roofs			■		
	Coastal flood control	Protecting/restoring mangroves, marshes, and dunes				■	Sea walls/forward pumps
		Protecting/restoring reefs				■	
Water Supply		Reconnecting rivers/canals to floodplain		■			Impoundments, reservoirs, water distribution systems
		Wetland restoration/conservation	■	■	■		
		Constructed wetlands, other detention/storage options	■	■	■		
		Enhanced Infiltration / Groundwater recharge/storage			■		
		Green spaces (bioretention and infiltration)			■		
		Permeable surfaces			■		
Water Quality	Water purification	Reconnecting rivers/canals to floodplain		■			Water treatment plant
		Wetland restoration/conservation	■	■	■		
		Constructed wetlands	■	■	■		
		Green spaces (bioretention and infiltration)			■		
	Erosion control	Permeable surfaces			■		Reinforcement of banks/riprap
		Living shorelines/riparian buffers		■			
		Reconnecting rivers/canals to floodplain		■			
		Living shorelines/riparian buffers		■			
	Biological control	Reconnecting rivers/canals to floodplain		■			Water treatment plant
		Wetland restoration/conservation	■	■	■		
		Constructed wetlands	■	■	■		
		Living shorelines/riparian buffers		■			

Process for Assessing and Implementing Nature-Based Solutions

The process for assessing and implementing NBS can be broken down into seven steps (Raymond et al., 2017).

1. Identify problem or opportunity
2. Select and assess NBS and related actions
3. Design NBS implementation processes
4. Frequently engage stakeholders and communicate co-benefits
5. Implement NBS
6. Monitor and evaluate co-benefits across all stages
7. Transfer and upscale NBS

Problems and opportunities identified throughout South Florida that fit into the District's mission can be lumped into three categories: Flood Control, Water Supply and Water Quality. One way to identify where these problems and opportunities exist within a given basin is to create a land use map (Figure 7) for the subject basin (step 1). A modeled flood layer can be added to the map to help identify portions of the basin that are vulnerable to flooding. The map can help to identify all lands within the basin that could potentially be used for implementing NBS. These lands can include multiple types of land uses, such as institutional, extractive/borrow/holding pond areas, parks and recreation, wetlands, spoil areas, and District-owned Right-of-Way lands. Each parcel identified on the land use map can then be examined to determine ownership, size, elevation, and proximity to the flood control system.

Step two involves selecting suitable NBS that can be implemented on the parcels identified as potential sites for NBS. For example, in the case of the C-8 Basin project, a municipal golf course was selected as a potential site for a temporary detention area for low recurrence interval storm events. Once NBS have been selected, an NBS implementation processes can be designed (step 3), and all stakeholders can be engaged to negotiate partnership opportunities and land use agreements (step 4). From there, project planning, funding and ultimately implementation can proceed (step 5). Step 6 includes designing and implementing a monitoring program to evaluate the success of the NBS in providing benefits and co-benefits such as increased flood protection, water supply and/or water quality improvements. Finally, if the NBS proves successful in providing significant benefits, the NBS can be upscaled and applied throughout the basin and/or regionally across basins.

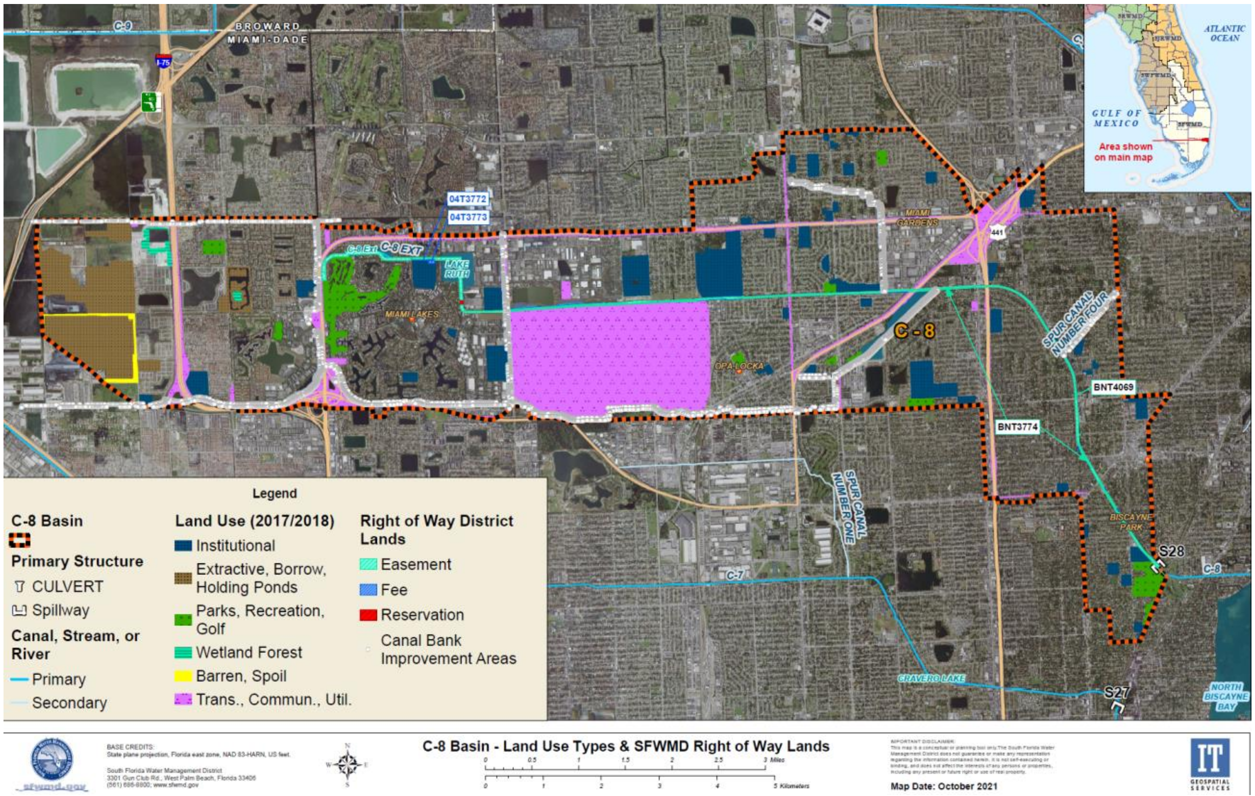


Figure 7. Land use types and SFWMD Right of Way lands within the C-8 Basin in Miami-Dade County.

Process for Evaluating NBS - Estimating Direct and Indirect Benefits

The process for evaluating the NBS and gray Infrastructure projects can use multiple tools that may include simple objective comparisons, professional estimates, standard engineering methods, empirical methods, combined hydrologic and hydraulic (H&H) models, and/or stand-alone hydraulic models. Each project, whether nature-based or gray infrastructure, should be evaluated for its ability to meet its intended purpose relative to the District's target mission and the primary problem(s) it is intended to solve (flood control, water supply, water quality, environmental restoration, or combination thereof). If the assessment for the project's intended purpose is positive, the project may also be evaluated relative to accomplishing the District's other missions and incorporating stakeholder projects and components. The evaluation of NBS will also include considerations on operational impacts associated with the feasibility of project implementation to maintenance activities and impacts to the regulatory classification of NBS assets relative to the project design objective, in cases where NBS are paired with gray infrastructure.

This section provides general assessment methodologies for the projects with flood control benefit. Evaluations and tools selected are dependent upon the 'scale' of the problem and the 'scale' of the proposed improvement project. For instance, a basin wide H&H model is a tool that will provide a good evaluation of a large-scale storage or constructed wetland project. Standard calculations and additional modeling for within project impact area will be used to identify and implement NBS and green infrastructure. However, some NBS projects may be too small to be input into the model to show the benefit of the project. In this example, the tools selected to evaluate the flood damage reductions of the proposed project may have to be calculations in lieu of modeling. Examples of assessment methodologies for flood control type of projects are listed in Table 3.

Table 3. Examples of assessment methodologies for flood control projects.

Water Management Topic		**NBS**	**Corresponding Gray Infrastructure Solution**	**Assessment Methodology Examples (scale dependent)**
Flood Control	River/canal flood control	Reconnecting rivers/canals to floodplain	Levees and water control structures	• H&H model for large scale projects • Standard engineering method to quantify additional storage
		Wetland restoration/conservation		• Standard engineering method to quantify additional storage
		Constructed wetlands/Flow Equalization Basin		• H&H model for large scale projects • Standard engineering method to quantify additional storage
		Living Shorelines/riparian buffers		• Hydraulic models for large scale projects • Educated estimates of benefit
	Urban stormwater runoff	Green spaces	Urban stormwater infrastructure	• Standard calculations and impact area specific modeling
		Permeable surfaces		• Standard calculations and impact area specific modeling
		Green roofs		• Educated estimates of benefit
	Coastal flood control	Protecting/restoring mangroves, marshes, and dunes	Sea walls/ forward pumps	• Hydraulic models for large scale projects • Educated estimates of benefit
		Protecting/restoring reefs		

Performance Metrics for NBS

Performance metrics (PMs) are very useful tools for assessing a project's success. A performance metric is an element or component of the natural system or human environment that is expected to be influenced by the project to be evaluated or monitored as representative of a class of responses to implementation of the project. They are project-specific and should be integrative of multiple aspects of the expected project result.

PMs accomplish two evaluation goals 1) evaluation of expected project performance and 2) assessment of actual project performance. The first occurs during the project planning phase to assess the viability and cost/benefit of the project. The second monitors the implemented project over time and compares actual outcome to expected outcome. The PMs for the two goals maybe and likely will be different.

Identifying appropriate PMs, as summarized in Table 4 requires data collection both before and after project implementation and a general understanding of the innerworkings of the system. For example, for the C-8 Basin project, a potential PM would be turbidity of the water column. It is an integrative measure of basin runoff, erosion, and a water quality parameter that impacts aquatic habitat. To assess the project's success, turbidity data under multiple conditions (before and after rain events) both before and after project implementation will be needed. In addition, a suite of additional parameters will need to be collected to fully assess the impact of the project. With this information the following evaluations can be made:

1. Estimate direction and magnitude of change in performance metric from current state over the expected timeframe of benefit.
2. Compare current performance measure status with its desired trend and target.
3. Evaluate consistency of monitoring results with anticipated results.
4. Determine if unanticipated events are indicated.
5. Describe how these events are affecting desired outcome.

Table 4. Potential PMs for NBS projects, likely availability of data pre-project, and the relative effort of data collection post-project.

Performance Metric	Pre-project data availability	Post-project data collection effort
Salinity	High	Low
Turbidity	Medium	Low
Chlorophyll a	Medium	Medium
Nutrients	Medium	Medium
Flooding Frequency	Medium	Medium
Stage	High	Low
Flow	High	Low
Wildlife utilization	Very low	High
Bank Stability	Low	Medium

5. Ecosystem Restoration Projects and Resiliency

Ecosystem Restoration Efforts

The District has several programs that facilitate ecosystem restoration either directly or indirectly. One of the most important, the Comprehensive Everglades Restoration Plan (CERP, or the Plan), is designed to restore, preserve, and protect the south Florida ecosystem while providing for other water-related needs of the region including water supply and flood protection. Restoration aims to achieve and sustain the essential hydrological and biological characteristics that defined the Everglades ecosystem. To ensure project objectives are met, project-level performance measures and monitoring plans, and system-wide performance measures and monitoring under the CERP's interagency Restoration, Coordination, Verification (RECOVER) program will assess ecosystem response to project implementation. With the uncertainty of impacts to these ecosystems from increases in precipitation, sea-level rise (SLR), and other effects of climate change, monitoring is critical to identifying adaptive management opportunities and to ensure the whole system is resilient in the long-term.

Each CERP project has individual components with varying objectives including wetland restoration, water storage, and water quality treatment; improved/reconnected hydrology and movement of freshwater for both environmental and human uses; and improved or restored habitat.

Another program, specific to the Everglades, is Restoration Strategies for Clean Water for the Everglades. This program's goal is to reduce phosphorus loading to the Everglades so that the historic plant and animal community may be restored. This is accomplished in two ways, by modifying and expanding existing Everglades Stormwater Treatment Areas (STAs) and by research to better understand phosphorus removal processes for improved manage of the STAs. Everglades STAs are large, constructed wetlands designed to maximize phosphorus removal from surface water and will total approximately 64,000 acres at the completion of Restoration Strategies. STAs not only provide clean, low-nutrient water to the Everglades, they also provide significant carbon sequestration through peat accumulation.

The Northern Everglades and Estuaries Protection Program (NEEPP) focuses on protecting the watersheds of Lake Okeechobee, the Caloosahatchee River and Estuary, and the St. Lucie River and Estuary. Projects focus on improved water quality and water delivery to sensitive ecosystems. This includes working closely with Florida Department of Environmental Protection and Florida Department of Agriculture and Consumer Services to implement nutrient source control measures to help meet total maximum daily loads (TMDLs) established for these water bodies.

All of these programs working system-wide, along with NBS - as introduced in the previous chapter, help restore our ecosystems, create healthy environments, and make them more resilient to climate change. Each, in their own way, provides ecosystem services that will bolster south Florida from the negative impacts of sea-level rise, changing rainfall patterns and water availability, flooding, and loss of habitat. Below are examples of specific projects that fall under these programs.

Northern Estuaries and Everglades

Along the Atlantic Coast, the Indian River Lagoon-South Project includes the C-23, C-24, C-25, and C-44 Reservoirs and STAs for water storage and treatment of St. Lucie Watershed runoff. Water quality improvement and reduction of damaging freshwater flows will provide more suitable conditions (e.g., salinity) for aquatic organisms including seagrasses and oysters, which are critical for creating buffer zones for storm surge and wave erosion. On the Gulf Coast, the C-43 Reservoir and associated projects will provide the same benefits to the Caloosahatchee River and Estuary.

North, east, and west of Lake Okeechobee are water storage and water quality improvement projects that will reduce nutrient loading and improve water delivery to the lake. Water clarity and depth are key components to a healthy submerged aquatic vegetation habitat critical for lake organisms. Lake levels also drive the amount of water sent east, west, and south, which impact the estuaries and the Everglades health. Some projects include the Nubbin Slough STA, Lower Kissimmee Basin Stormwater Treatment, and Grassy Island Flow Equalization Basin (FEB).

South of Lake Okeechobee, Restoration Strategies is improving STA performance to reduce phosphorus loading to the Everglades. At its completion in 2025, 6,500 additional acres of STA will have been built and an additional 116,000 acre-feet of water storage will be available in FEBs. In addition, effective treatment area in existing STAs will be increased through land leveling efforts. Alongside these projects, District scientist have implemented a robust Science Plan designed to evaluate the mechanisms of phosphorus removal to improve STA performance and management decision making. To date, scientists have completed eight of 21 studies. All studies will be completed at the end of 2024.

Central Everglades

The Central Everglades Planning Project (CEPP) includes the A-2 Reservoir (otherwise known as the Everglades Agricultural Area (EAA) Reservoir) and A-2 STA to store and treat Lake Okeechobee Regulatory Releases prior to sending flows to the Everglades; CEPP North to restore flows into northwestern WCA-3A, move water south, and construct tree island habitat; CEPP South to improve connectivity between WCA-3A/3B and northeast Shark River Slough; and CEPP New Water, to retain groundwater seepage from CEPP flows into northeast Shark River Slough. Providing increased hydration with low-nutrient water will result in greater peat formation, and thus carbon storage and increased marsh platform elevation to reduce impacts of SLR. Additionally, the Fish Habitat Assessment Program (FHAP) monitors seagrasses in Florida Bay, following trends in salinity resulting from insufficient freshwater baseflow.

The Picayune Strand Restoration Project (PSRP) is removing historic roads and restoring sheetflow across 55,000 acres of natural habitat, and maintaining flood protection for adjacent communities, with connections to downstream linkages to other systems e.g., Everglades National Park, Collier Seminole State Park, Ten Thousand Islands National Wildlife Refuge, and Fakahatchee Strand State Preserve. Improved freshwater delivery to estuaries such as Faka Union Bay and Pumpkin Bay will improve habitat for oysters and seagrass beds, critical for storm protection against erosion.

Southern Everglades

Broward County Water Preserve Areas reduce groundwater seepage from Water Conservation Areas 3A & 3B, improves water supply, and prevents saltwater intrusion. Biscayne Bay Coastal Wetlands (Phase 1; BBCW) rehydrates coastal wetlands, reducing freshwater point source pollution releases, and redistributes surface water into Biscayne Bay. The Biscayne Bay and Eastern Everglades Restoration (BBSEER) project is currently in the planning phase and will include the C-111 Spreader Canal West and BBCW Phase II to improve the quality, quantity, and distribution of freshwater to Biscayne Bay, improve glades habitat in the Model Lands and Southern Glades, and improve resiliency of coastal vegetation and habitat as they face changes in sea-level. An Adaptive Foundational Resilience Performance Measure is being developed as a landscape-scale, holistic evaluation of the native mangrove and coastal marsh vegetation's ability to adapt to saltwater intrusion due to SLR by responding to the increased sheetflow volumes, reduced porewater salinities and improved hydroperiods predicted to occur with BBSEER restoration. Further, a pilot study called the Everglades Mangrove Mitigation Assessment (EMMA) includes a large-scale manipulation of sediment designed to enhance the resilience of coastal mangroves in the Everglades and inform the use and success of restoration practices such as thin sediment layer placement to combat peat collapse and erosion.

Current and future projects will work in conjunction with other infrastructure projects, habitat restoration, and operational plans. These include Foundation Projects such as Kissimmee River Restoration, , Modified Water Deliveries to Everglades National Park, C-111 South Dade Project, and Tamiami Trail Next Steps. The projects restore water flow, water quality, and habitat to critical areas of the District and improve our resiliency to climate change.

Biscayne Bay

The SFMWD acknowledges the delicate and valuable ecology of Biscayne Bay and the need for short-term and long-term efforts from State, regional and local governments to address the effects from freshwater releases on water quality and ecology of the bay. The District is engaged in multiple ongoing efforts to specifically address these issues. These efforts range from assessment of flood control operation impacts on water quality of the bay to tool development through DEP funded grant with Tulane University to develop a comprehensive hydrodynamic model with water quality capability for simulating impacts of freshwater flows on quality in the bay and effect of multiple potential adaptation strategies.

The District, working with other agencies with a shared interest in addressing water quality in the Bay, is committed to identifying and implementing strategies that increase the resiliency of the entire flood control system through a coordinated effort with our partners and reducing the reliance on infrastructure in natural areas through long-term restoration. SFWMD will partner with Miami-Dade County on the S-27 Coastal Structure Resiliency to ensure that the proposed infrastructure projects adhere to the recommendations of the Biscayne Bay Task Force and prioritize Biscayne Bay health and resilience through monitoring. The District is also partnering with Miami-Dade County and FDEP to identify and pilot innovative technologies that can be implemented to target nutrient removal, ultimately protecting the health of water systems upstream and downstream of District conveyance structures. Together, these projects along with NBS and GI, as recommended by the Biscayne Bay Task Force create multi-faceted pathways that deliver protection to Biscayne Bay.

Ecosystem Restoration Projects Resiliency Benefits and Potential Carbon Sequestration

As summarized above, comprehensive restoration efforts are underway by the District, in collaboration with local, state and federal partners, for the past 20+ years, to protect and restore South Florida's ecosystems, represented by four watersheds: Kissimmee River, Lake Okeechobee, Everglades, and Coastal Systems. The restoration of these vital parts of South Florida's ecosystems have been supporting the region's overall resiliency and the District's ability to better manage water for the benefit of people and the environment, with consideration of anticipated sea level rise and extreme weather events into the future. These efforts will continue to increase the ecosystem's future resilience in the face of warmer temperatures and other climate change impacts.

In particular, the restoration of beneficial freshwater flows throughout the system slows down saltwater intrusion promoting more sustainable aquifer recharge rates, healthier estuaries and bays, more stable coastlines, reduced marsh dry outs and greater coastal resiliency. Ecosystem restoration also results in increased quantity and quality of freshwater flow to and within the Everglades, higher flexibility and storage options to address water management seasonal needs, increased wetland acreage, and increased connectivity to coastal ecosystems. These initiatives also help mitigate the effects of climate change through carbon capture and storage in peat soils.

In addition to emphasizing the importance of continuing Ecosystem Restoration efforts and account for their resilience benefits, these efforts might seek to maximize the carbon uptake and storage capacity of wetlands and coastal ecosystems. The restoration and preservation of natural systems enhances organic carbon storage by reinstating the sedimentary biogeochemical conditions and soil stability in disturbed sites and increasing the living biomass and its capacity to sequester carbon dioxide (CE Lovelock et al., 2017). Restoration of historic flows to the Everglades, as part of Comprehensive Everglades Restoration Plan (CERP) and the creation and improvement of Everglades stormwater treatment areas (STAs) through Restoration Strategies, has a large carbon uptake potential by mitigating for seagrass die-off, peat collapse, loss of ridge and slough habitat, subsidence, and restoration of agricultural lands back to wetlands. Ecosystems within the restoration project footprint that can uptake and store atmospheric carbon include STAs, water conservation areas (WCAs), mangrove forests, and submerged aquatic vegetation (SAV) beds, including seagrass.

Peat formation and chemical precipitation are the key pathways for long-term storage of carbon in the Everglades. Peat formation occurs when biomass production in greater than decomposition and leads to soil accumulation and accretion. Chemical precipitation happens in SAV/periphyton-dominated ecosystems where photosynthesis leads to the removal of carbon dioxide from the water column resulting in a changing chemical equilibrium that causes carbonate to bind with calcium and precipitate out as a floc called marl. The accumulation of peat and marl in the soil is influenced by a myriad of driving factors that are highly dependent on water management practices, local variations in geomorphology and soil processes, and above-ground and below-ground biomass allocation.

One way to assess potential carbon storage across the restoration projects is to look at carbon storage and soil accretion rates. This can be approximated using soil bulk density, loss-on-ignition (LOI) measurements, assumption of LOI to carbon conversion of 45% (Ball, 1964), and estimation of accretion rate. These variables were used to calculate a carbon storage estimate across District projects (Table 5). Based on these estimates, District projects may be sequestering close to 9 million metric tons of CO_2 per year. However, these initial estimates are based on overall assumptions and lack a more targeted monitoring and validation initiative to validate and expand these assumptions.

Currently, the District does not collect carbon data as a matter of routine. In order to dial in the carbon uptake and storage calculations, data collection efforts would need to be employed for each of the restoration projects to better represent their associated mitigation benefits and estimate resilience benefits. These include the following:

- Soil carbon characteristics: measure soil bulk density and carbon concentration at multiple depth increments to capture short-term and long-term carbon storage.
- Soil accretion: use surface elevation tables and feldspar marker horizons to measure soil surface changes and vertical accretion.
- CO_2 and CH_4 gas dynamics: measure uptake and release of carbon gasses using eddy flux towers that capture the direction (into the ecosystem or out to the atmosphere) of gas movement to determine the net uptake of carbon at the landscape scale.

Employing these measurements across District restoration projects will provide accurate assessments of carbon capture and storage associated with the different ecosystem restoration efforts currently undertaken by SFWMD and Agency partners, and better estimate their benefits to climate resiliency.

Table 5. Estimate of carbon capture among SFWMD restoration projects.

In a "Perfect" World						
REGION	Size (m2)	Affected Area (m^2)	Restoration Soil Accretion Rate (mm/yr)	Accretion $gC/m^2/yr$ (using 0.1 g/cm3 and 0.45 for %C)	Accretion (tonnes C/ha/yr)	Regional Carbon Removal Efficiency (Million tonnes CO_2/yr)
EAA	2,560,010,583	2,560,010,583	2.0	297	2.97	2.798
STA	300,000,000	300,000,000	10.0	1,485	14.85	1.639
WCA1	559,267,197	559,267,197	2.0	90	0.90	0.185
WCA2A	417,710,607	417,710,607	2.0	90	0.90	0.138
WCA2B	114,390,918	114,390,918	2.0	90	0.90	0.038
WCA3AN	721,524,946	721,524,946	2.0	90	0.90	0.239
WCA3AS	1,286,544,854	1,286,544,854	3.0	135	1.35	0.639
WCA3B	398,294,891	398,294,891	2.0	90	0.90	0.132
Ochopee Marl Marsh	381,371,694	381,371,694	1.5	68	0.68	0.095
Shark River Slough (SRS)	767,438,573	767,438,573	2.0	90	0.90	0.254
SRS Mangroves	1,083,352,500	812,514,375	7.0	410	4.10	1.224
Eastern Marls & Taylor Slough	994,032,294	994,032,294	2.0	90	0.90	0.329
Taylor Slough Mangroves	361,117,500	361,117,500	5.0	293	2.93	0.389
Florida Bay Seagrass**	5,500,000,000	4,125,000,000	-		0.46	0.692
	TOTAL	TOTAL	Average	Average	TOTAL	TOTAL
	15,445,056,557	13,799,218,432	3.27	255.12	33.62	8.792
		13,799 km2				

*Except Bulk Density of 0.33 Mg/m3 for the EAA and STA; 0.13 for mangroves.

6. Water Supply Resiliency

Understanding our Vulnerabilities

The District is implementing initial efforts to understand what our water supply vulnerabilities are as they relate to sea level rise, changing rainfall patterns and drought occurrences, increase in evapotranspiration rates and other related climate change impacts. These efforts include water supply planning, groundwater modeling, water resource protection, water conservation, alternative water supply development, regional and subregional water management, and saltwater interface mapping.

The SFWMD conducts water supply planning for five regions (Figure 8) encompassing the District: Upper Kissimmee Basin, Lower Kissimmee Basin, Upper East Coast, Lower East Coast, and Lower West Coast. Water supply plans are developed in coordination with stakeholders and the public and look at least 20 years into the future and are updated every five years to stay current with growth trends. These Plans evaluate current and future water demands and identify water sources and strategies to meet these needs while sustaining water resources and the environment. These plans help local governments and utilities in their facility and comprehensive planning efforts. Water supply plans include population and demand estimates for at least a 20-year planning horizon, water source options, water resource evaluation and protection, projects and future water supply direction. As it is related to resiliency, these plans and projections also consider saltwater intrusion, and future plans will evaluate sea level rise and climate change scenarios.

Figure 8. Regional Water Supply Plan Update Schedule and Respective Planning Areas

To support water supply plans and other initiatives, the District has several groundwater models that simulate groundwater withdrawals and identify potential impacts to water resources. Currently, fresh ground water system models can evaluate drawdowns associated with those withdrawals. The East Coast Surficial Model (ECSM) is a density-dependent groundwater model that is currently under development by the District and will allow model runs to explicitly simulate the effects of sea-level rise and some aspects of climate change on the groundwater system. The ECSM includes most of the Lower East Coast (LEC) planning region and the entire Upper East Coast (UEC) planning region. In addition, the Lower West Coast planning region is included in the District's Lower West Coast Surficial/Intermediate Aquifer Systems Model (LWCSIM). In the future, following the completion of the ECSM, it is envisioned that the LWCSIM will be upgraded to be density dependent as well.

A Water Supply Vulnerability Assessment, currently under scoping, will utilize existing surface and groundwater modeling tools to evaluate the effects of sea level rise and climate change on our water supplies (See Chapter 10). The outputs of the model runs will identify potential impacts to water resources and areas the District needs to focus identification of strategies and projects that can increase water supply resilience. The Water Supply Vulnerability Assessment will be initiated in 2023, with data preparation tasks, and has a 2-year estimated duration. The Water Supply Vulnerability Assessment will look beyond the traditional Water Supply Planning efforts and 20-year planning horizon and incorporate additional climate scenarios. This more detailed evaluation into the vulnerability of our water supply sources can help inform the development of new projects that will enhance the South Florida Region's water supply resiliency. This is part of an overall effort to help the District understand and plan around the complexities that factor into the current and future resilience of our water supplies.

Responding Resiliently

In parallel to assessing water supply vulnerabilities, and with the goal of ensuring that South Florida has consistent and safe water supply for current and future generations, the District has been employing three overarching project strategies: protecting existing water sources, creating new water supply sources, and capturing excess water. These strategies are currently incorporated as part of Water Supply Plan development among other District planning efforts.

Subsequent sections highlight existing resiliency related projects within the District boundaries. Many of the projects highlighted below achieve the goals of more than one of the above strategies. They may also have originated from within different District responsibilities, though they are highlighted here to emphasize the effect they have on making South Florida's water supply systems more resilient.

Protecting Existing Water Supply

Protecting our existing water supplies is an adaptation resiliency strategy that ensures continual and safe water supply. In this section we'll highlight two of the Districts protection focused strategies: Salinity Control Structure and Water Conservation and Regulations.

The District monitors and maintains canal and groundwater levels in the system to ensure water supply availability during the wet and dry seasons for all water supply demands, from public supply to ecosystem needs. Water resource protection rules such as Minimum Flows and Minimum Water Levels (MFL) and Restricted Allocation Areas (RAA) for several water resources in the District, including Lake Okeechobee and its tributaries, optimize canal and groundwater levels through the operation of the District’s salinity control structures minimize further inland movement of saltwater along the coast. (The Coastal Structure priority projects in Chapter 9 discuss the importance and mechanism of salinity control in water supply management.) To support this management, the District develops saltwater interface maps at five-year intervals in our coastal aquifers based on salinity data from available monitor wells. These maps are published on the District’s Website and presented in Public Workshops. The District also publishes chloride data and the saltwater interface maps on the Resilience Metrics Hub.

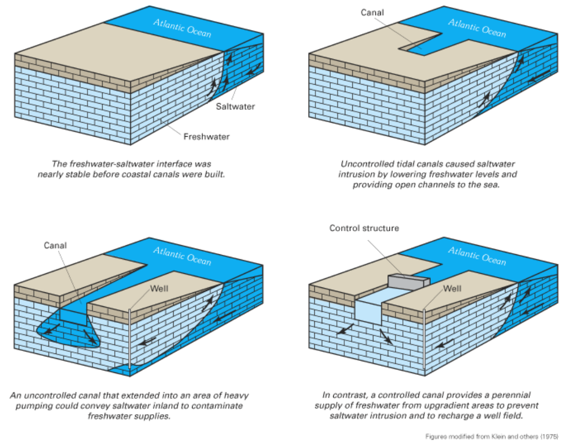


Figure 7. Diagram depicting the impact of canals and structures on saltwater intrusion.

Moreover,, the District actively promotes water conservation to incentivize efficient use of water, and recognition that conservation can extend available supplies while deferring the need for more expensive alternative water supply sources. The District’s regulatory programs are designed to support reasonable-beneficial uses of water, while recognizing the need to protect water resources from harm. Restricted Allocation Areas designated by the District are one regulatory mechanism designed to limit future uses beyond that which is already permitted to prevent harm to water resources.

Below are examples of current District projects focused on protecting existing water supplies:

- Salinity Control Structures: Coastal Structure Enhancements – The existing coastal structures were designed and built in the 1950s and are operated to maintain a pre-determined freshwater level in the canals, which locally increases the freshwater levels in the aquifer further assisting with minimizing saltwater intrusion, especially during the dry season. Enhancements to Coastal Structures, as proposed in this plan, will improve operational capacity and flexibility to further protect water supply sources into the future.

- Water Conservation: The District has many programs, partnerships, and materials dedicated to promoting water conservation across all use classes and sources. These programs range from demand-reducing strategies like Florida Friendly Landscaping to the commercially focused Florida Water Star. These and other District conservation programs incentivize users to be intentional about water consumption by providing grants, rebates, and other funding sources, as well as guidance and conservation information. Reductions in per-capita consumption have been observed in several regions in South Florida as a result of water conservation efforts being advanced by the District, utilities and local governments.

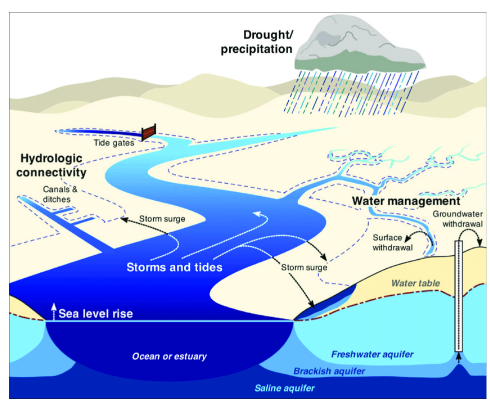


Figure 8. Diagram depicting elements of the coastal hydrologic cycle.

Creating New Water Supply Sources

In addition to protecting existing water resources, the District also encourages the development of new or alternative water sources. These solutions include the development and implementation of increased use of reclaimed water, use of brackish groundwater sources such as the Floridan Aquifer System (FAS), additional surface water storage options, and utilizing desalination of sea water or other high salinity sources. These solutions have been implemented across the District in various capacities and have been tried and proven as a sustainable resilient strategy for many communities around the world. To date, the District has provided over $248 million in cost-share grant funding for Alternative Water Supply (AWS) development.

Florida is a national leader in water reuse, reusing nearly 820 mgd of reclaimed water to conserve freshwater supplies and recharge freshwater aquifers. There are over 100 reuse facilities in the District reusing 328 mgd of reclaimed water for a beneficial purpose including irrigation of golf courses, residential lots and other green space, ground water recharge, environmental enhancement, and industrial purposes. However, there is approximately 560 mgd of potentially reusable water that is currently being disposed of through ocean discharge or deep injection wells in the District, primarily in the Lower East Coast. The biggest obstacle to further development is identification of feasible reuse options in highly urbanized areas, the cost of treatment to meet water quality requirements and related infrastructure, and funding.

There are over 40 brackish water treatment plants (reverse osmosis treatment) throughout South Florida with a combined capacity of approximately 300 mgd, treating mostly water from the FAS. Utilizing brackish water from the FAS to meet future demands reduces the stress on existing surficial aquifer system resources, thereby reducing the potential for increased saltwater intrusion. The FAS is geologically isolated in South Florida from the overlying surficial aquifer system and due to its already brackish water quality and position nearly 1,000 ft below the surface, it doesn't face the same acute climate risk from SLR as the freshwater surficial aquifer. Though brackish water sources and related treatment systems are more expensive to operate, less efficient, and produce a brine concentrate needing disposal, use of brackish water is a more sustainable water source as it has a smaller environmental impact with manageable waste streams, in addition to reducing demand on the surficial aquifer system. Utilities are planning to increase withdrawals from the FAS to meet projected growth beyond current freshwater allocations. In the past 20 years, desalination capacity in the SFWMD has increased by 480% through the addition of 28 plants including brackish treatment systems.

Finally, seawater desalination is a potential option explored by coastal communities throughout the world. Unfortunately, the cost and energy associated with seawater desalinations treatment processes reduce its utilization and increase its carbon footprint. Yet, seawater desalination remains as an option for water supply development under more critical future conditions. Additionally, desalination technology advances decrease energy demands and increase recovery efficiencies. There are two seawater desalination facilities in the District located in the Florida Keys, serving primarily as a back-up supply.

Below are examples of how the District is promoting the development of alternative water supplies:

- Reuse Facilities: Oasis Water Reclamation Facility - The District's alternative water supply funding program has contributed more than $100 Million to reclaimed water projects including the City of Pompano Beach's Oasis Water Reclamation Facility – This facility has reused over 24 billion gallons of reclaimed water over the last 3 decades.
- Brackish sources: Orlando Southeast Water Treatment Plant Lower Floridan Aquifer Wellfield Phase 1 – In 2021, the Orlando Utilities Commission received the District's latest brackish water alternative water supply development grant. The total project cost is expected to be over $95 million and is expected to provide Orlando with an additional 10 MGD.
- Seawater Desalination: Florida Keys Aqueduct Authority (FKAA) New Kermin H. Lewit RO Facility – The existing seawater desalination facility at this site will be replaced with a new facility that will double the current desalinated seawater supply to 4 MGD. Approximately 75% of the plant was funded by a hurricane disaster recovery grant and its specifications are subsequently resiliency focused.

Figure 9. Picture of reclaimed water "purple pipes".

Saving for a Non-Rainy Day

Retaining surplus water during wet conditions to use when its dry is one of the most tried and proven resiliency strategies for water supply and is another alternative water supply development strategy being supported by the District. From a regional perspective, the District primarily captures surplus water through the operation of the regional water management system. This system includes reservoirs and, WCAs development of large-scale Aquifer Storage and Recovery (ASR) which are currently being designed and tested by the District north of Lake Okeechobee, will provide another option.

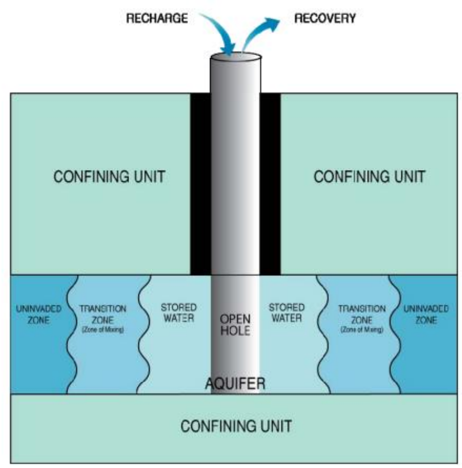


Figure 10. Graphic showing Aquifer Storage and Recharge (ASR) methodology.

The District manages both natural systems and man-made reservoirs that serve as water supply primarily for the environment and to a much lesser extent water users such as water supply utilities and agricultural irrigation, among others. Natural systems used to retain excess surface water include Water Conservations Areas (WCA) / Water Management Areas (WMA), which are large swaths of land that retain water as well as facilitate groundwater recharge. Built out reservoirs have been developed throughout the District and are often integrated into flood protection as a place for flood waters to go in addition to their water supply uses.

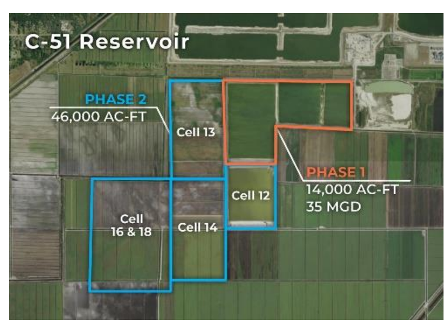


Figure 11. Plan view area of C-51 Reservoir project.

Aquifer Storage and Recovery (ASR) wells store excess water primarily during the wet season into confined aquifer systems saving it to be extracted during dry conditions. The District has a plan to construct up to 55 ASR wells north of Lake Okeechobee as part of the Comprehensive Everglades Restoration Plan (CERP). There are existing ASR wells used by utilities for water supply, such as the wells in Boynton Beach, West Palm Beach, and Marco Island. In 2015 and 2018, the District published a comprehensive ASR study that confirmed further ASR development as a feasible solution to provide beneficial water storage and availability.

Below are examples of regionally focused excess water storage projects:

- ASR: Marco Island's ASR wells – Marco Island utilizes four water supply options to meet drinking water and irrigation demands of the community: fresh surface water from Marco Lakes/Henderson Creek, brackish groundwater, reclaimed water, and excess surface water stored in ASR wells. Since 1997, Marco Island has developed seven ASR wells which store excess surface water from Marco Lakes/Henderson Creek during the rainy season for later use during the dry season. Marco Island estimates they have established a one billion gallon freshwater reserve in the brackish FAS through their ASR program. Marco Island recovers 2 to 5 mgd from the ASR wells during the dry season to meet consumer demand when surface water availability is limited.

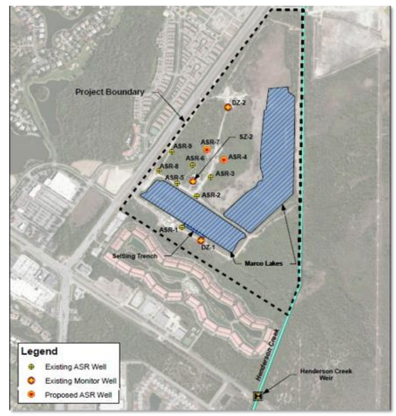


Figure 12. Map of Marco Island's ASR wellfield.

- Reservoirs: Everglades Agricultural Area Reservoir – The project includes two major features: a treatment wetland that will clean water and a reservoir that will store excess water from Lake Okeechobee. The District is responsible for constructing the 6,500-acre wetland known as a Stormwater Treatment Area (STA). The District began construction ahead of schedule in April 2020 and the project is expected to be completed in 2023. Additionally, the U.S. Army Corps of Engineers (USACE) is building the reservoir component, which will hold 240,000 acre-feet of water. The total project cost is expected be just over $2 Billion.
- New WMA/WCA: SJRWMD C-10 WMA – In 2021, the St. Johns River Water Management District (SJRWMD) received a $20 Million grant as part of FDEP Resilient Florida Program to develop the C-10 WMA. This project consists of a 1,300-acre WMA, pump station, outfall structure, 4-miles of new levee, and improvements to an existing federal levee. The project will collect water from a series of drainage canals to increase storage of water currently discharging to the Indian River Lagoon and direct flow to its historic drainage way towards the St. Johns River. The project is anticipated to provide 7.9 MGD of alternative water supply for the Upper

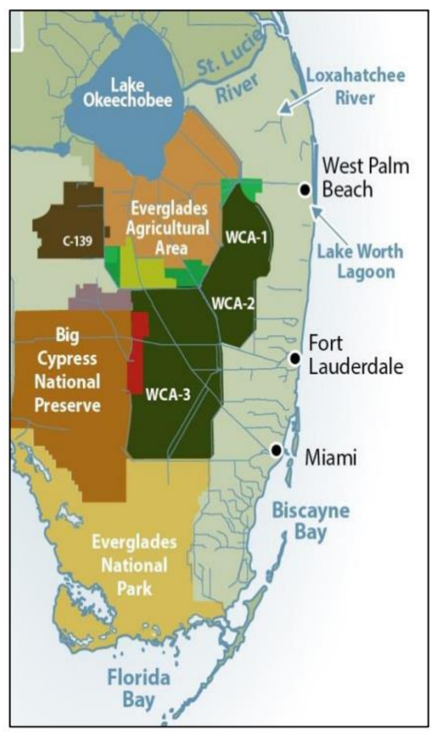


Figure 13. Water Conservation Areas (WCA) in the SFWMD.

St. Johns River. While not within SFWMD boundaries this is a recent example of the development of a new WMA for resilient water supply in Florida.

- Phase 1 C-51 Reservoir Project: – This alternative water supply project, a public-private partnership between utilities and mining industry t, is designed to store excess water from the C-51 basin before being discharged to tide and conveying this water through canals during drier periods to areas adjacent to existing public supply wellfields. The project construction is estimated at $161 million, is expected to hold 14,000 acre-feet of static storage and deliver 35 MGD in alternative water supply to offset impacts on regional canals from allocation increases. The reservoir is expected to be fully constructed in 2023.

Resiliency Path Forward

In addition to all the current projects being implemented or funded by the District there will be a process for assessing and responding to the resiliency needs of our water supplies. These needs will be better understood through vulnerability assessments and robust data collection efforts already underway as part of the Water Supply Vulnerability Assessment project. This project will help the District determine what our water supply needs are and will provide guidance on the execution of future resiliency projects like the ones featured throughout this plan. Additionally, this project will inform the integration of appropriate measures and criteria for the water allocation and serve as a benchmark evaluating the overall sustainability of the District's water resources. These projects and all additional data analysis and assessments related to the resiliency of our water supplies will be documented as part of future iterations of the SLRFRP plan.

7. Investing in Energy Efficiency and Renewable Energy

Energy Efficiency

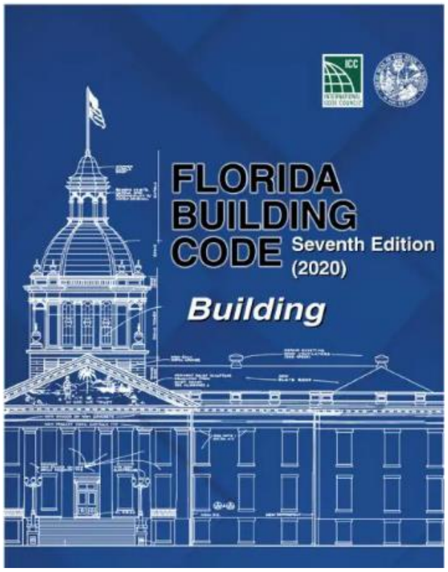
The District is committed to improving the energy efficiency of our operations and offset new energy demands through renewable energy solutions. By following the latest building codes and using state of the art materials and designs, the District builds efficient and resilient projects (Flood Resistant Design and Construction, ASCE Standard 24). Solar energy systems are already integrated into of our projects.

The District is looking into using two programs as guidance to help improve energy efficiency and promote sustainable energy in our facilities and projects. The LEED certification program and the Envision program are sustainable building design and certification programs that may be helpful in designing and implementing projects.

ACTIONS THAT THE DISTRICT TAKES TO HELP INCREASE ENERGY EFFICIENCY INCLUDE:

- AUTOMATION OF PUMP STATIONS – REDUCES RESOURCE USE, LESS FUEL AND EFFORT FOR MAINTENANCE
- DESIGN PROJECTS FOR LONGER LIFE – LESS MAINTENANCE OVER THE LIFE OF AN ASSET
- REDUCING USE OF OR SIZE OF CONTROL BUILDINGS - MOST CONTROL BUILDINGS ARE CONCRETE WITH LOW HEAT GAIN ALLOWING ALL OR MOST OF THE FACILITY TO FUNCTION APPROPRIATELY WITHOUT AIR CONDITIONING
- DIVERSIFYING THE DISTRICT'S MOTOR POOL TO INCLUDE ELECTRIC VEHICLES
- STAGGERING THE START OF MOTORS AND OTHER ELECTRICAL EQUIPMENT TO AVOID THE NEED FOR LARGER GENERATORS TO ACCOMMODATE THE INRUSH OF CURRENT
- INCLUDE SMALLER "HOUSE LOADS" GENERATOR SO THAT GENERATORS ARE SIZED APPROPRIATELY FOR THE DIFFERENT LOADS THAT ARE NEEDED DURING PUMPING AND NON-PUMPING OPERATIONS

Florida Building Code Requirements and Third-Party Programs



District project designs follow the Florida Building Code. The Code requires many of the energy efficiency related items that would be evaluated for projects seeking certification by third-party organizations such as LEED and Envision. Florida Building Code and recommendations from LEED and Envision are driving the District to develop and adopt energy efficient approaches to features such as heating, cooling, lighting and operations of motors and ancillary equipment. These state-of-the-art technologies will continue to be evaluated to improve the energy efficiency of District facilities.

LEED (Leadership in Energy and Environmental Design is an ecology-oriented building certification program run by the U.S. Green Building Council (USGBC). LEED provides a framework for healthy, efficient, carbon and cost-saving green buildings. (“LEED Rating System” U.S. Green Building Council, https://www.usgbc.org/leed)

LEED certified buildings save money, improve efficiency, lower carbon emissions, and create a healthier living environment. They are a critical part of addressing climate change and meeting Environmental, Social, and Governance goals, enhancing resilience, and supporting more equitable communities.

To achieve LEED certification, a project earns points by adhering to prerequisites and credits that address carbon, energy, water, waste, transportation, materials, health, and indoor environmental quality. Projects go through a verification and review process and are awarded points that correspond to a level of LEED certification: Certified (40-49 points), Silver (50-59 points), Gold (60-79 points) and Platinum (80+ points).

The goal of LEED is to create buildings that:

- Reduce contribution to global climate change
- Enhance individual human health
- Protect and restore water resources
- Protect and enhance biodiversity and ecosystem services
- Promote sustainable and regenerative material cycles
- Enhance community quality of life

Envision is another holistic sustainability framework and rating system run by the Institute for Sustainable Infrastructure that enables a thorough examination of the sustainability and resiliency of all types of civil infrastructure. It can be used to assist the District in delivering civil infrastructure that tackles climate change, addresses public health needs, cultivates environmental justice, creates jobs, and spurs economic recovery. (“Envision: The Blueprint for a Sustainable Future” Institute for Sustainable Infrastructure, https://sustainableinfrastructure.org/envision/overview-of-envision/)

Envision consists of:

- A guidance manual that includes 64 sustainability and resiliency criteria
- Project assessment tools
- Third-party project verification
- Professional training and credentialing

Renewable Solar Energy

The District is currently using renewable solar energy solutions to power much of its environmental monitoring network and to assist in powering certain components of District facilities, such as lighting and gate operation. Solar panels take up a considerable amount of space and are difficult to implement in urban environments due to lack of open space. However, the District owns 1.5 million acres of land, some of which is available and suitable for solar arrays.

With the goal of offsetting new energy demands, staff is assessing the possibility of implementing solar power for projects in areas where there is an abundance of open land for solar panels. Two pilot projects are currently being considered. One project would explore the use of floating solar panels in applications where wind damage to the solar infrastructure would not increase risk to the flood control system. The second pilot project would include a solar canopy for District fleet vehicles in the parking lot at headquarters.

In addition, the District is initiating coordination with FP&L to install solar panels at the C-43 and C-44 Reservoir adjacent lands, depending on funding availability, with the goals of reducing energy costs at these facilities as well as offsetting carbon emissions from existing and new proposed pump stations that rely at least partially on fossil fuel generated power. These installations would use net-metering to track solar power generation and consumption as described below.

NET-METERING FOR SOLAR POWER SYSTEMS

- When a solar power system generates more electricity than the customer can use, the customer receives a credit for the excess kilowatt-hours (kWh) sent to the grid.
- If less electricity than needed is produced via solar, the customer must buy electricity from the utility to make up the difference.
- The customer pays for the "net" amount of electricity used (kWh purchased minus credit for kWh exported).

8. Characterizing and Ranking Our Resiliency Projects

The District is initially focusing its resiliency infrastructure investment priorities looking at coastal structures adaptation needs to SLR as a non-regret strategy being recommended at FPLOS Phase I Flood Vulnerability Assessments. During the initial stages of observed SLR impacts, the District is continuing to operate structures through operational changes, by investing in extending the top of gates, and implementing targeted structure enhancement measures. As sea levels increase, additional measures are required to maintain headwater stages at structures and to prevent saltwater intrusion and flooding impacts. Enhancing existing structure can substantially improve their functionality and performance by reducing the vulnerability of systems and equipment to flooding and maintaining their ability to protect against saltwater intrusion. Adaptation to SLR and storm surge involve large scale projects that integrate floodwalls, gates, and forward pumps to properly manage surface and groundwater within the area. In addition, long-term SLR may also involve seepage barriers to avoid saltwater intrusion and control the long-term rise in groundwater levels. Some of these efforts are beginning to be advanced in the region, to address storm surge and other coastal hazards.

Many of the District's coastal structures were constructed over 70 years ago and are no longer capable of conveying their design discharge due to changes within the watershed, SLR, and climate change. The District is proposing to restore the original design discharge at these structures by installing forward pump stations that can continue to discharge to tide when gravity discharge ceases (during storm surge or extreme high tide events) and to augment gravity discharge at critical times. Figure 9 below illustrates the relative percent of time that gate closures were needed during the High Tide Season in 2020 at four different locations. As observed in these charts, these gates were closed for about 3-5 hours on average, per day during high tide events, and with a significant increase up to 15 hours per day during the peak of the 2020 high tide season.

To determine pumping capacity needs at the coastal structures, pump sizes at the most immediate priority structures have been initially estimated using one half of the design discharge capacity of the structure. For instance, a structure with a design discharge capacity of 1,000 cubic feet per second (cfs) would need a 500 cfs pump station. Structures ranked as intermediate in terms of priority, are being augmented with one quarter of the design discharge capacity for initial pump sizing. Structures ranked in the long-term need category would not have pump cost estimates until they move from long-term to intermediate need. Initial pump sizing is based on: a) existing C&SF forward pump implementation strategies; b) the assumption that other local flood mitigation strategies will be advanced in the basin in combination with the local forward pump solutions; c) the consideration of downstream capacity; and d) best professional judgement. As design is evolving for these coastal structures, final pump capacities will be determined. Figures 10 and 11 below illustrate a comparison between the amount of time needed to remove the cumulative flows (or the total runoff to bring the stages back to normal operating ranges) for the scenarios with forward pumps sized at 25% and 50% of the spillway design capacity, relative to the no pump scenario. The design of forward pump stations will be adaptable and will include the ability to add additional pumps in the future as environmental conditions change. The precise nature of improvements at each structure, including consideration of replacement needs, additional flooding barriers, and forward pump sizing, will be determined during the feasibility and design phases for each structure, and as part of the more detailed and comprehensive FPLOS adaptation planning phase, which includes the assessment of local and larger regional forward pump strategies.

The effectiveness of using forward pumps to reduce flood risk and restore the original level of service can be demonstrated by the operational results of existing forward pumps at the S-25B and S-26 coastal structures. During Hurricane Isaias, between July 20 and August 2, 2020, the average daily landside water levels (headwater) were lowered consistently at structures with gravity flow and a forward pump. At the S-25B and S-26 coastal structures, landside water levels were reduced significantly with the combination of gravity flow and forward pumping. During the same storm event at S-27, S-28 and S-29, the average daily landside water levels increased with gravity flow alone. These observations, as illustrated in Figure 12, demonstrate the existing limitations and associated challenges in maintaining or reducing landside water levels by relying solely upon gravity flow.

Another flood mitigation alternative is the utilization of emergency storage options. One example is the C-4 Emergency Detention Basin (C-4 EDB) in Miami-Dade County. When the C-4 Canal can't handle the water volume necessary to prevent flooding, the C-4 EDB is employed to receive and store the excess water. The forward pump station at the mouth of C-4 Canal is the first component of the C-4 EBD that is used, when needed, in addition to gravity flow. The S-26 Pump Station at the mouth of the Miami River Canal in the C-6 basin was built to ensure the higher tailwater as a result of the S-25B pumping does not impact C-6 upstream of S-26. These stations pump to the Miami River and are used first for flood control. The EDB is used for larger rain events when stages continue to rise, and additional flood mitigation is needed. The C-4 EDB provides improved flood protection for the City of Sweetwater, Miami-Dade County, City of Miami, and City of West Miami.

Levee and canal bank enhancements are an additional example of project recommendations included in this plan to provide additional flood protection and prevent the impacts of sea level rise on water resources and the environment. L-31 and Corbett Levees are being proposed to address vulnerability to SLR, storm surge and increasing stormwater volumes, as a result of more intense extreme rainfall events. The projects include resiliency strategies to reduce vulnerability of communities and environmental areas downstream and upstream of these structures. Future modeling efforts will determine additional resiliency needs at other levee structures.

The District is also committed to seeking "green" or nature-based solutions in addition to "gray" infrastructure improvements to increase resiliency, as described in Chapter 4. Both gray infrastructure examples and green features will be necessary to meet the challenges of land development and climate change impacts, including SLR, along with basin-wide solutions to maximize the capacity of flood adaptation.

The restoration of design discharge capacities will need to be combined with additional upstream and downstream solutions, to be advanced as part of the FPLOS Phase II dynamic adaptive pathway approach. This approach and considerations were applied in the FPLOS Assessment for the C-7 Basin: Identification and Mitigation of Sea Level Rise Impacts (2015 FEMA PDM Study). The main objective of this study was to reduce the potential for loss of life and property by recommending alternative mitigation strategies to be updated in the Miami-Dade County Local Mitigation Strategy (LMS). The project had two elements: 1) a technical assessment of the FPLOS for the existing infrastructure under current and future SLR scenarios; and 2) a strategic assessment of alternative mitigation strategies intended for incorporation into the Miami-Dade LMS. The study evaluated a series of mitigation alternatives for the basin involving local hydraulic measures (M1), a regional forward pump (M2) and elevating buildings (M3) and associated benefits to be implemented by multiple agencies. The results show various pathways (sequences and combination of mitigation strategies) can be explored. If an individual flood mitigation alternative is not able to achieve the specified target of the performance criteria, additional or other mitigation strategies are needed. Adaptation pathways were assessed for the entire C-7 Basin, as summarized in Figure 13 below, showing how multiple strategies can be combined over time. A similar strategy is currently being finalized as part of the C8/C9 Basins FPLOS Phase II Adaptation Planning Studies. Project Status and recommended strategies are being updated at: http://www.buildcommunityresilience.com/SFWMD/FPLOS/c8c9/.

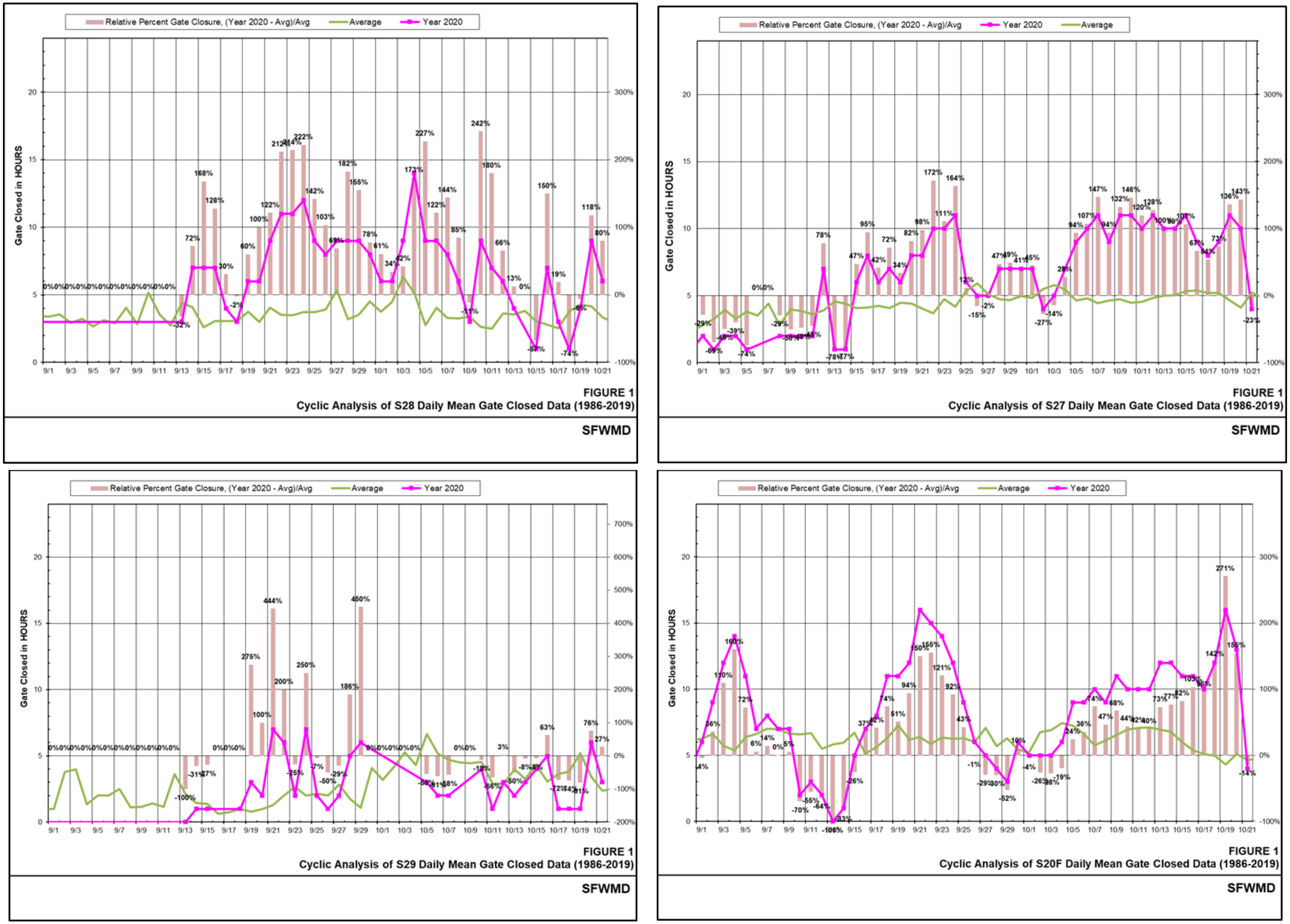


Figure 9. Relative Percent Gate Closure Times during the 2020 High Tide Season

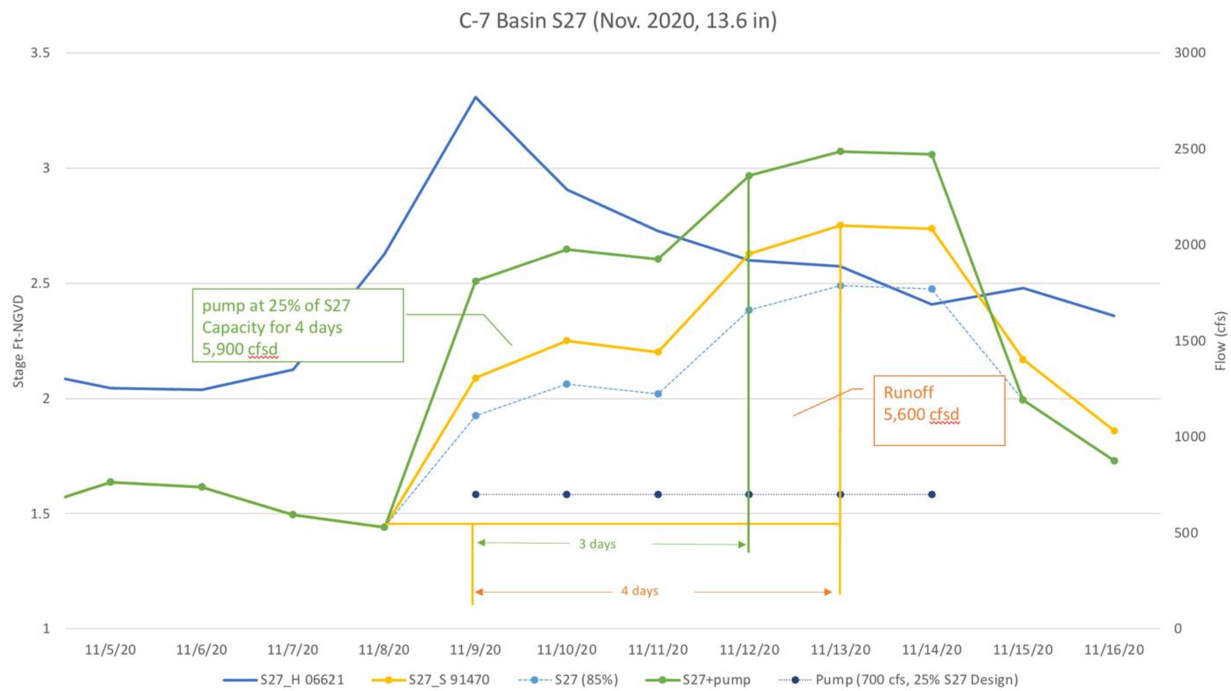


Figure 10. Potential amount of time needed to remove the cumulative flows at S-27 (5600 cfsd total runoff to bring the stages back to normal operating ranges during Tropical Storm Eta in November 2020) for the scenario with forward pumps sized at 25% of the spillway design capacity (3 days) relative to the no pump scenario (4 days)

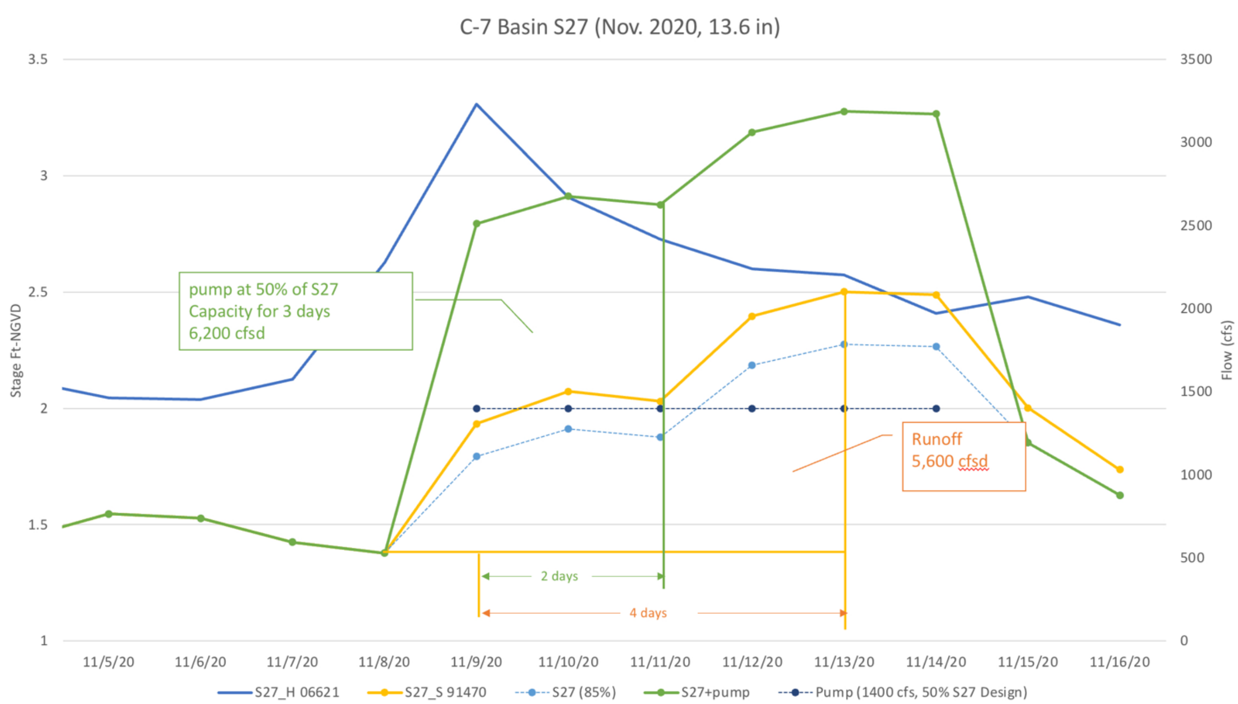


Figure 11. Potential amount of time needed to remove the cumulative flows at S-27 (5600 cfsd total runoff to bring the stages back to normal operating ranges during Tropical Storm Eta in November 2020) for the

scenario with forward pumps sized at 50% of the spillway design capacity (2 days) relative to the no pump scenario (4 days)

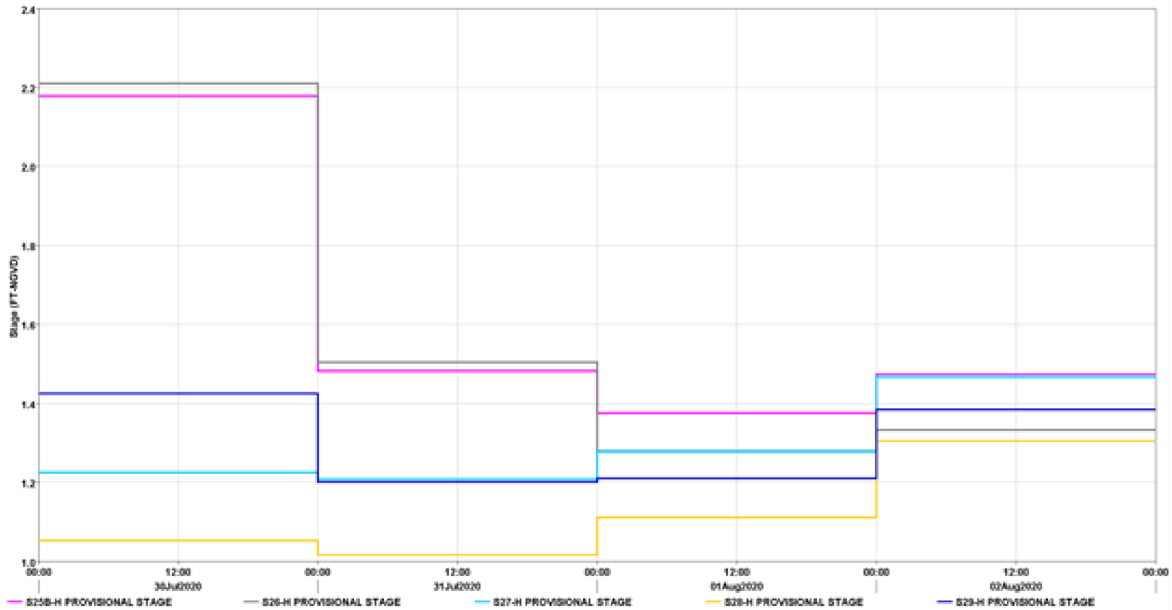


Figure 12. *Observed Headwater Stages during Hurricane Isaias, in July/August 2020, at Coastal Structures with forward pump (S-25B and S-26) vs. Coastal Structures with gravity discharge only (S-27, S-28, S-29)*

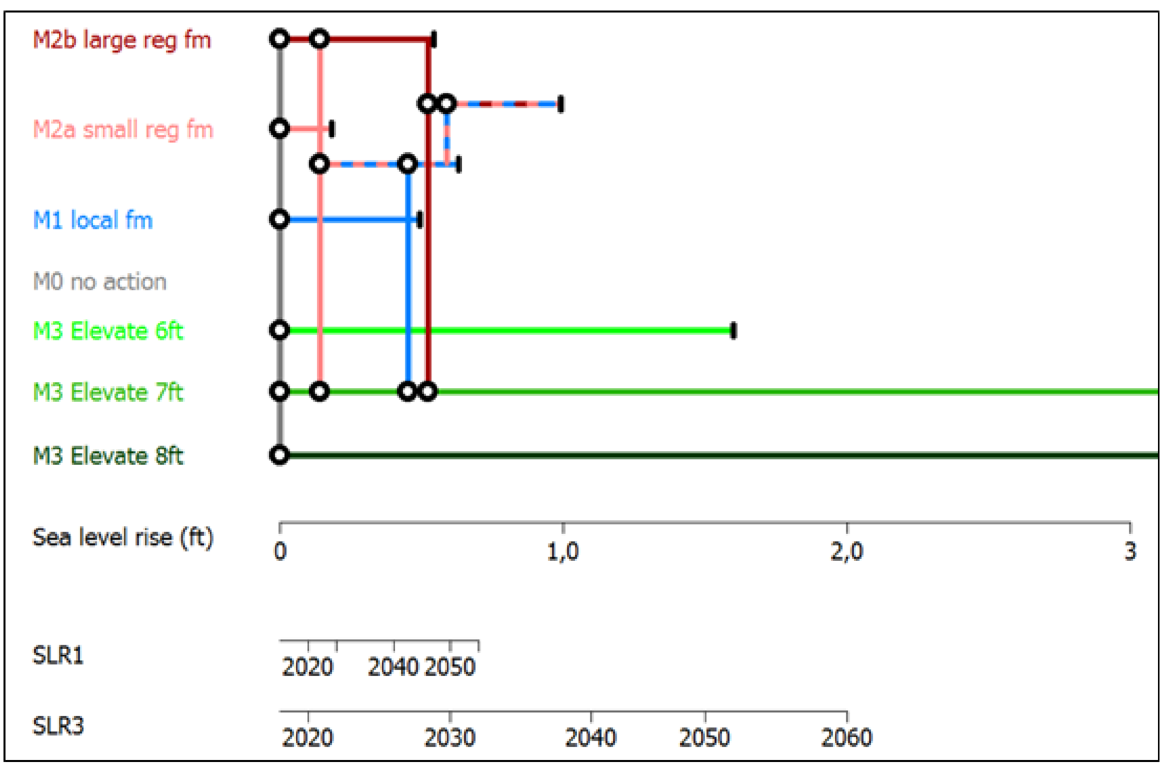


Figure 13. *Adaptation Pathways map for the entire basin, based on the simulated expected annual damage for the current sea-level and the two possible future sea level rise scenarios.*

Updated FEMA Coastal Zone A Maps, the USACE South Atlantic Coastal Study and Back Bay Feasibility Studies, including the Miami Dade, Collier County and the Florida Keys – Monroe County Coastal Storm Risk Management Studies were recently released in response to coastal storm risks and flood protection needs. These studies were developed focusing on storm surge flood inundation risks. The District is working closely with these Federal Agencies to coordinate the implementation of coastal adaptation strategies such as beach and dune restoration, shoreline stabilization, flood walls and nature and natural base solutions, including living shorelines, oyster and coral reefs, marshes, etc, along with the upcoming Section 216 C&SF Flood Resiliency Study. Figure 14 below summarizes how these combinations of solutions can be advanced, through cooperation among local, state, regional and Federal Agencies. The figure is meant to highlight many of the mitigation strategies that are available for use either by themselves or together when the site allows.

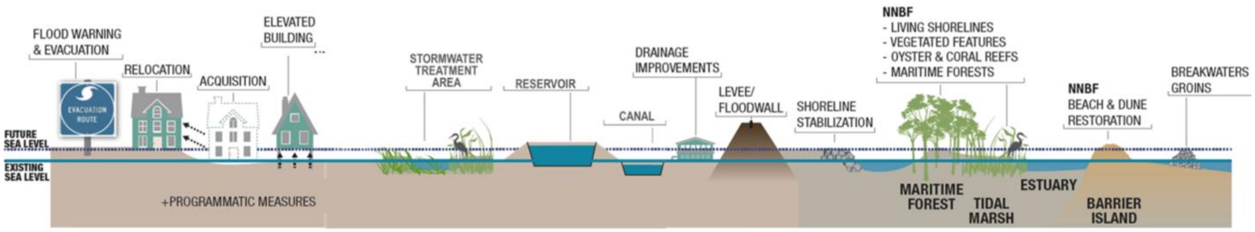


Figure 14. Potential Flood Mitigation Measures to improve resilience and sustainability (Source: USACE, modeled from https://ewn.el.ercd.dren.mil/nnbf/other/5-ERDC-NNBF_Brochure.pdf)

Socially Disadvantaged Communities

The communities we serve across SFWMD are diverse and all our communities are experiencing varied impacts of climate change and other changing conditions, such as population increase and land development. The timing, extent, and kinds of impacts our communities experience vary, depending on their location, such as coastal or inland communities, and their socioeconomic circumstances. The SFWMD considers the fact that minority and financially disadvantaged communities can be more adversely affected, as part of its resiliency planning efforts, to ensure equitable community wide benefits. Ensuring equitable community wide benefits means providing equal protection, equal access to the benefits of resiliency projects, and equal opportunity to participate in the planning and decision-making process for all members of our region's communities.

To effectively plan resiliency projects to meet our mission, resiliency vision, and serve our communities, we look to a set of guiding principles for social considerations. Following these guiding principles ensures SFWMD resiliency projects provide an equal degree of protection from the environmental impacts and associated quality of life to all members of the communities across project basins and provides equal access to the planning and decision-making process through stakeholder engagement and coordination with the local governments and impacted communities.

Resiliency Planning Guiding Principles for Social Considerations:

- Do no harm – SFWMD resiliency projects do not further harm vulnerable communities.
- Prioritize and value prevention – SFWMD resiliency projects are aimed at preparing our communities for the anticipated changing conditions, so the systems we rely on can withstand natural hazards and recover rapidly from disruptions.

- Prioritize vulnerable communities – SFWMD prioritizes investing in projects that benefit disadvantage communities and improve quality of life for all communities.
- Meaningful community engagement – SFWMD is proactive in soliciting input and ideas on actions so that projects are informed by member of our communities. SFWMD prioritizes transparency in developing and executing resiliency work to ensure continued engagement, communication, trust, and collaboration.
- Proactive engagement and leadership – SFWMD reach out to community experts and leaders in impacted community groups for ideas and feedback to inform equitable projects.
- Responsive and continued engagement – SFWMD is responsive and accountable to community concerns when addressed, prioritizing follow-up and continued discussion.

To identify disadvantaged communities within project impact areas, as part of project ranking criteria and grant applications, SFWMD uses a variety of resources that include data from the U.S. Census, the Council's on Environmental Quality (CEQ) Climate and Economic Justice Screening Tool (CEJST), the Center's for Disease Control and Prevention (CDC) Social Vulnerability Index (SVI). These resources for identifying where disadvantaged communities are most vulnerable is driven by various federal datasets such as the American Community Survey (ACS) and FEMA's National Risk Index, among many others. SFWMD also considers the percentage of financially disadvantaged population within project impact areas living in low lying areas (under 6FT elevation) because of South Florida's unique geology, characterized by flat and low topography.

The map below (Figure 15) shows the areas where disadvantaged communities were identified within the current resiliency project impact areas included in this plan, based on the CEJST for the climate change category. This category consider data from two sources: the U.S. Census (2015-2020 American Community Survey) and FEMA (2014-2021 National Risk Index). More information about the CEJST is available on the tool's data and methodologies page.

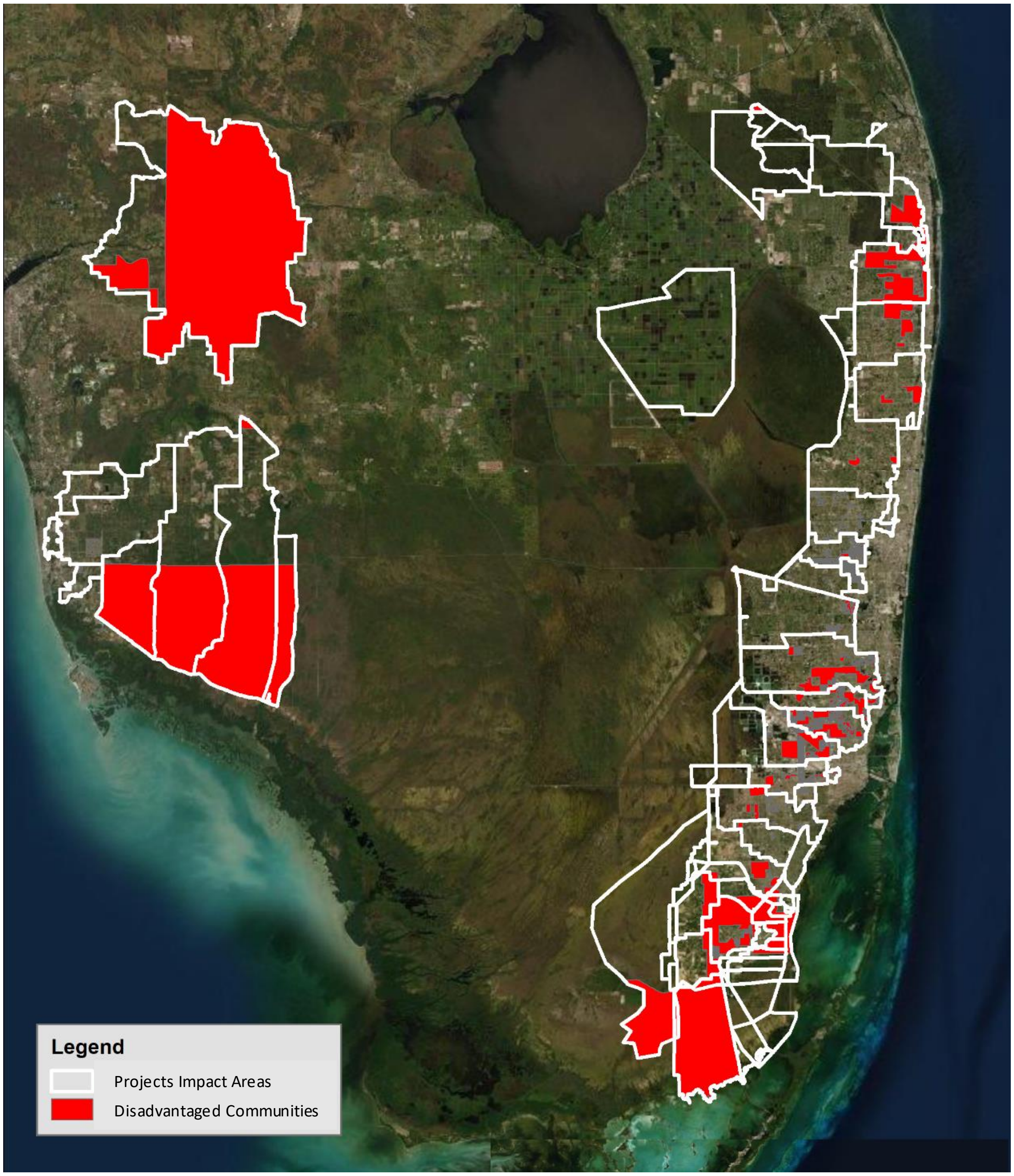


Figure 15. Map of socially disadvantaged communities within each project impact area.

Including these socioeconomic indicators as part of our project ranking process provides regional support to local communities for finding and aligning solutions that alleviate the environmental impacts and increase quality of life where it is needed most, in disadvantaged vulnerable communities. The outcomes of the prioritized resiliency projects are expected to be accompanied by a decline flood risks, reductions in water supply vulneraries, the enhancement of natural areas, an increase in civic engagement and an improved quality of life for all residents of these communities.

Proposed Ranking Criteria

A multicriteria approach was developed to support the characterization and ranking of resiliency projects, including metrics that help to identify the most critical infrastructure associated with most vulnerable areas. The selection of criteria were based on the Resilient Florida Program, as detailed below. This program is administered by the FDEP and it allows water management districts to submit a list of proposed projects that mitigate the risks of flooding or SLR on water supplies or water resources of the state by September 1, annually. Each project submitted to the program must contain a description of the project, project location, completion schedule, cost estimate, and the cost share percentage available with a minimum of 50%. The legislation requires FDEP to implement a scoring system for assessing each project. The scoring system will include the following tiers and criteria:

1) Tier 1 must account for 40 percent of the total score and consist of all of the following criteria:
   a) The degree to which the project addresses the risks posed by flooding and sea level rise identified in the local government vulnerability assessments or the comprehensive statewide flood vulnerability and sea level rise assessment, as applicable. (10%)
   b) The degree to which the project addresses risks to regionally significant assets. (10%)
   c) The degree to which the project reduces risks to areas with an overall higher percentage of vulnerable critical assets. (10%)
   d) The degree to which the project contributes to existing flooding mitigation projects that reduce upland damage costs by incorporating new or enhanced structures or restoration and revegetation projects. (10%)

2) Tier 2 must account for 30 percent of the total score and consist of all of the following criteria:
   a) The degree to which flooding, and erosion currently affect the condition of the project area (7.5%)
   b) The overall readiness of the project to proceed in a timely manner, considering the project's readiness for the construction phase of development, the status of required permits, the status of any needed easement acquisition, and the availability of local funding sources.(7.5%)
   c) The environmental habitat enhancement or inclusion of nature-based options for resilience, with priority given to state or federal critical habitat areas for threatened or endangered species. (7.5%)
   d) The cost-effectiveness of the project. (7.5%)

3) Tier 3 must account for 20 percent of the total score and consist of all of the following criteria:
   a) The availability of local, state, and federal matching funds, considering the status of the funding award, and federal authorization, if applicable. (6.5%)
   b) Previous state commitment and involvement in the project, considering previously funded phases, the total amount of previous state funding, and previous partial appropriations for the proposed project. (6.5%)
   c) The exceedance of the flood-resistant construction requirements of the Florida Building Code and applicable floodplain management regulations. (7%)

4) Tier 4 must account for 10 percent of the total score and consist of all the following criteria:
   a) The proposed innovative technologies designed to reduce project costs and provide regional collaboration. (5%)
   b) The extent to which the project assists financially disadvantaged communities. (5%)

Following the overall Resiliency Florida scoring system, and incorporating additional criteria that are relevant to characterize and to prioritize the most critical project needs in this Plan, the following criteria set has been implemented:

Criteria Set 1: Likelihood of System Deficiencies

- FPLOS Phase I Assessment Results (Current and /or Future Conditions)

Basin wide flood vulnerabilities, as part of FPLOS Phase I Assessment Results (or equivalent assessment): vulnerability of the drainage system within the project impact area to manage flood risks to adjacent developed or partially developed land under current and future conditions represented by the FPLOS overall flood protection level of service (i.e., 5-YR, 10-YR, 25-YR), as summarized in Phase I FPLOS Reports – Flood Vulnerability Assessments.

- Known chronic and nuisance flooding report

Observed flooding events, with documentation by agencies/universities/media/citizens providing evidence of flooding events in the project impact area in the past 5 years.

- Return Period of Overbank Flooding

Infrastructure Performance Under Sea Level Scenarios or Extreme Rainfall Events (higher water levels exceeding infrastructure design capacity): Frequency that canal overbank flooding and/or other infrastructure bypass is observed onto the adjacent developed or partially developed floodplain (riverine flooding) as a result of peak stage profile at any point along the canal system being higher than canal bank / levee elevation (vulnerability of the drainage / flood protection system within the project impact area of the proposed project). Excludes overbank flooding of non-saline water that results primarily in inundation of wetlands or other natural areas

- Sea Level Resulting in Overbank Flooding

Infrastructure Performance Under Sea Level Scenarios or Extreme Rainfall Events (higher water levels exceeding infrastructure design capacity): Increase of sea levels that result in canal overbank flooding and/or other infrastructure bypass resulting in increase in flood risks to developed or partially developed adjacent land and water supplies (vulnerability of the drainage / flood protection / salinity barrier system within the project impact area of the proposed project; proposed project will reduce in inundated areas).

- Exceedance of Canal Normal Operating Range

Infrastructure Performance Under Sea Level Scenarios or Extreme Rainfall Events (higher water levels exceeding infrastructure design capacity): Maximum peak stage profile levels along the primary canal system exceeding normal operational range stages (canal performance), which reduces discharges from secondary systems, increasing flood risks further inland. Project will lower canal stages (reduce inundated areas).

- FFE < BFE

Infrastructure Finish Floor Elevation Exposure: Comparison between Infrastructure Finish Floor Elevation (FFE) and FEMA Base Flood Elevation (BFE), when applicable

- FEMA Flood Zone (benefits set or likelihood set of criteria)

Project impact area is within FEMA Flood Zone A, AH, AE, V and will lower flood risks (reduction of inundated areas)

- Storm Surge Inundation Exposure

Project Impact Area (or Finished Floor Elevation, for infrastructure enhancement projects) is within specific Hurricane Categories - Storm Surge event inundated area, when applicable, and project will lower flood risks (reduce inundated areas).

Criteria Set 2: Consequence of System Deficiencies

- Critical Assets/Lifelines Density

Total number of Critical Assets (Lifelines: Water, Resource Facilities, Regional Medical Centers, Emergency, Operations Centers, Regional Utilities, Major Transportation Hubs and Corridors, Airports and Seaports) located within the project impact area of the proposed project.

Total number of Regional Significant Assets (Lifelines: Water, Resource Facilities, Regional Medical Centers, Emergency, Operations Centers, Regional Utilities, Major Transportation Hubs and Corridors, Airports and Seaports) located within the project impact area of the proposed project.

- Social Vulnerability

Percentage of financially disadvantaged population within the project impact area of the proposed project, representing number of households within a characterized social vulnerability index per Basin Drainage Area / project impact area. Percentage of financially disadvantaged population within the project impact area within low lying areas (under 6FT elevation).

- Environmental Protected Areas

Vulnerable environmental protected areas - state or federal critical habitat for threatened or endangered species- within the project impact area of the proposed project, and that can be impacted by flooding events.

- Total Population

Total number of people residing within the project impact area of the proposed project

- Public Water Supply Wellfields

Vulnerable public water supply wellfields within 20,000ft of the 2018/2019 Saltwater Interface and within the project impact area of the proposed project (when applicable – if proposed project influence saltwater interface – dual purposes, e.g., coastal structures)

- Adaptation Action Areas

Project impact area is within an established “Adaptation Action Area” or “Adaptation Area”. Section 163.3164(1), Florida Statutes defines AAA as "a designation in the coastal management element of a local government’s comprehensive plan which identifies one or more areas that experience coastal flooding due to extreme high tides and storm surge, and that are vulnerable to the related impacts of rising sea levels for the purpose of prioritizing funding for infrastructure needs and adaptation planning."

Criteria Set 3: Benefits from System Enhancements

- Nature-based Solutions

Project includes NBS or “green” infrastructure in addition to “gray” infrastructure improvements to increase resiliency (Natural or semi-natural systems that provide water quality / ecosystem benefits, environmental habitat enhancement)

- Ecosystem Restoration

Project included natural enhancements of the environment by restoring the lands and waters that benefit wildlife

- Cost Benefit Analysis

Cost-effectiveness of the project estimated as larger than one, estimated based on avoided economic loss.

- Previous State Commitment / Involvement

Project received previous state funding into its previous phases, including pre-construction activities, design, permitting or Phase I Construction.

- Available Match

Project includes documentation that 50% cost share is available, or funds will be available but have not been appropriated or released.

- Florida Building Code Design Criteria

Exceedance of the flood-resistant requirements in the Florida Building Codes Act, as adopted by the State of Florida pursuant to Part IV, Chapter 553, F.S. or local floodplain management ordinances.

- Innovative Technologies

Project proposal includes innovative technologies to optimize project benefits, protect communities and the environment, reduce project costs and provide regional collaboration.

Criteria Set 4: Project Status (SIP/CIP Programs)

- SIP Overall Rating-

Performance level used to define the ability of the structure to perform intended function under current conditions, as reported as part of SFWMD Structure Inspection Program Report (Final Category)

- Capital Improvement Program (CIP) Status

Project Status as part of the District fiscally constrained expenditure plan that lays out anticipated infrastructure investments over the next five years. Project indication about Design or Pre-Design is stated in the CIP.

In order to apply the criteria sets detailed above, project impact areas were established for each project, as illustrated in the examples shown in Figure 16 below. Figures 17-20 summarize the ranking point assignment distribution, overall assumptions and adopted weighting for each of the 4 categories of criteria. The project impact areas were determined based on potential benefits to the communities and the environment that the proposed infrastructure is expected to provide upstream and downstream of each project location. A wide range of information was considered to delineate the project impact areas, including, but not limited to H&H modeling, design technical manuals, storm surge inundation scenarios, SLR and saltwater intrusion studies, environmental restoration and impact assessments, existing conditions reports, local engineering expertise and discussions with District's staff. Assumptions include the projects' ability to protect water supply and water resources of the state, increase the resilience levels of agricultural, natural and urban areas to flood conditions as well as improvement of wildlife corridors, habitat connectivity, salinity reduction, and water quality.

According to the Resilient Florida final rule language for Florida Rules Chapter 62S-8 Statewide Flooding and Sea Level Rise Resilience Plan, effective 8/22/2022, “Project impact area” means the discrete area the project encompasses as well as the delineated area that will be directly benefitted by a mitigation project (such as a watershed or hydrologic basin for flood mitigation projects, a service or sub-service area for a utility, a neighborhood, a natural area, or a shoreline).

All infrastructure projects receive a certain number of points for each of the evaluated criteria according to the evaluation of each respective project impact areas and established weights. Projects with the highest combination of points, become the highest priority projects. Table 6 below lists all the infrastructure projects and presents the total points obtained for each criteria subset, and overall points. Figures 21-25 illustrate some of these adopted criteria, and how values vary spatially at each project impact area.

This ranking process will be updated continuously as part of future Plan updates and as vulnerability assessment results and additional information becomes available. The new criteria established in this current plan differs from the criteria established in the 2021 Sea Level Rise and Flood Resiliency Plan, mainly because of the adoption of overall criteria and weights determined in the Resilient Florida final rule language for Chapter 62S-8 Statewide Flooding and Sea Level Rise Resilience Plan. Shifts in project priorities, relative to last planning cycle were observed and will be evaluated, individually, as part of the next planning cycle. A higher weight, in comparison to Chapter 62S-8, was assigned to the Likelihood of System Deficiency subset, and notably the criteria relative to FPLOS Flood Vulnerability Assessment results, which characterizes the degree of flooding risks at each assessed basin, utilizing the latest and greatest input data and most advanced modeling tools, coupling rainfall, storm surge and groundwater compound flooding risks.

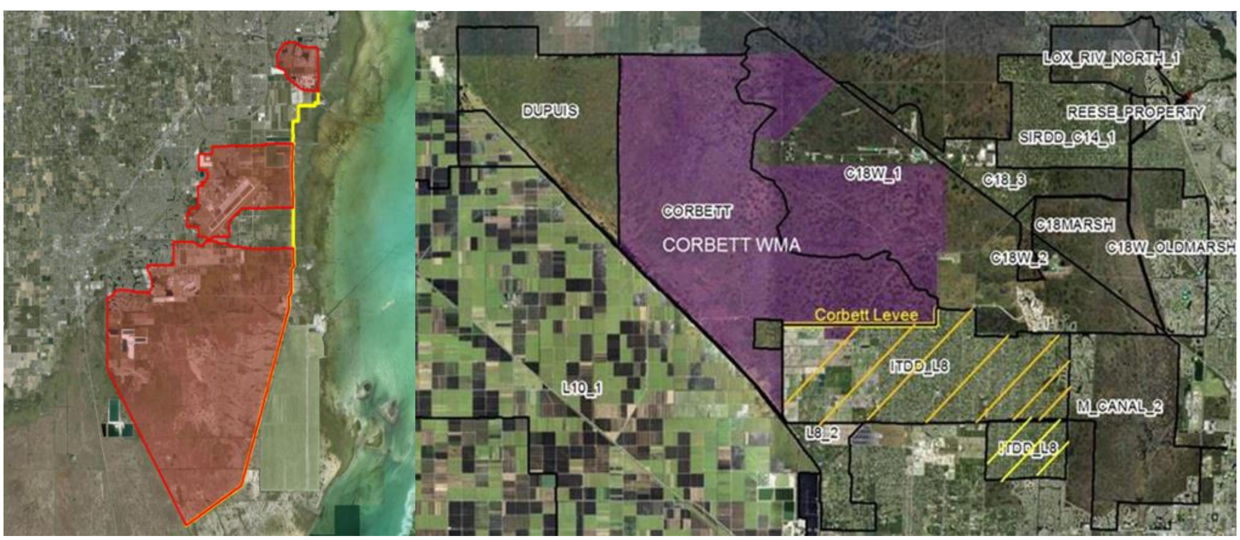


Figure 16. Examples of Project Impact Areas from the Proposed L31 Levee Project (left) and the Corbett Levee (right),

Criteria	ID	Category	Weighting	1	2	3	4	5
Likelihood of System Deficiency	1.1	FPLOS Phase I Assessment Results (Current and /or Future Conditions)	17%	Future Conditions Less than 25-Year	Future Conditions 10-YR or less	Future Conditions 5-Yr or less	Current Conditions 10-YR or less	Current Conditions 5-YR or less
	1.2	Known chronic and nuisance flooding report (OR)	14%					Yes, flooded more than three times within the last five years or is experiencing ongoing erosion.
	1.3	Return Period of Overbank Flooding	6%	More than 100-yr	100-yr or less	50-yr or less	25-yr or less	5-yr or less
	1.4	Sea Level Resulting in Overbank Flooding		>3 ft	2 ft to 3ft	1 ft to 2 ft	0.5 to 1 ft	0.5 ft or less
	1.5	Exceedance of Canal Normal Operating Range (OR)			Less than or Equal to 1 ft	More than 1 ft	> 2.5 ft	> 3.5 ft
	1.6	Finished Flood Elevation < Base Flood Elevation	3%			FFE < BFE + 1'	FFE < BFE + 2' (or 1' inland)	FFE < BFE + 3' (or 2' inland)
	1.7	FEMA Flood Zone Exposure						Yes
	1.8	Storm Surge Inundation Exposure				Yes, under Cat 3	Yes, under Cat 4	Yes, under Cat 5

Figure 147. Summary and Scoring System utilized for characterizing Criteria Set 1 "Likelihood of System Deficiency".

Criteria	ID	Category	Weighting	1	2	3	4	5
Consequence of System Deficiency	2.1	Critical Assets / Lifelines	5%			0-25% of Critical Assets are within areas lower than 6FT or within inundated areas from FPLOS	25-50% of Critical Assets are within areas lower than 6FT or within inundated areas from FPLOS	More than 50% of Critical Assets are within areas lower than 6FT or within inundated areas from FPLOS
			5%			1 or more RS Critical Assets	3 or more RS Critical Assets	5 or more RS Critical Assets
	2.2	Social Vulnerability	2.5%	Lower Density		Average		Higher Density
			2.5%	Lower Density		Average		Higher Density
	2.3	Environmental Protected Areas	3.5%	Lower Density		Average		Higher Density
	2.4	Total Population	1%	Up to 50,000 people	Up to 100,000 people	Up to 200,000 people	Up to 500,000 people	More than 500,000 people
	2.5	Public Water Supply Wellfields	5%	Lower Density		Average		Higher Density
	2.6	Adaptation Action Areas	1%	Does not Intersect Adaptation Action Area				Intersect Adaptation Action Area

Figure 18. Summary and Scoring System utilized for characterizing Criteria Set 2 "Consequence of System Deficiency"

Criteria	ID	Category	Weighting	1	2	3	4	5
Benefits from System Enhancement	3.1	Nature-based Solutions	6.25%					Yes
	3.2	Ecosystem Restoration						Yes
	3.3	Cost Benefit Analysis	3.75%					BCA Larger than 1
	3.4	Previous State Funding	3.75%		Previous State Funding utilized in Preconstruction activities	Previous State Funding utilized in Design	Previous State Funding utilized in Permitting	Previous State Funding utilized in Construction
	3.5	Available Mach	3.75%			Specifically identified local, state, or federal cost share, but the funds have not been appropriated or released at the time the applicant submits its proposal to the FDEP		Approved and adopted capital improvement plan
	3.6	Florida Building Code Design Criteria	3.75%					Yes
	3.7	Innovative Technologies	2.5%					Yes

Figure 19. Summary and Scoring System utilized for characterizing Criteria Set 3 "Benefits from System Enhancement".

Criteria	ID	Category	Weighting	1	2	3	4	5
Project Status (SIP/CIP Programs)	4.1	SIP Overall Rating	3.0%			Overall C-3	Overall C-4	Overall C-5
	4.2	Capital Improvement Program (CIP) Status	4.0%	Issue ID & Risk Ranking	Survey & Geotech Commenced	Partial Design	Permit Application Submitted	Design Complete

Figure 20. Summary and Scoring System utilized for characterizing Criteria Set 4 "Project Status (SIP/CIP Programs)".

Table 6. Ranking of Coastal Structure Projects (top) and Other Priority Projects (bottom) according to the pre-established criteria sets, and total summarized points.

Projects	Likelihood of System Deficiency	Consequence of System Deficiency	Benefits from System Enhancement	Project Status	Total Points
S27	40.00	18.24	18.13	5.98	**82.34**
S26/S26PS	40.00	16.91	18.13	0.00	**75.03**
G57	38.80	15.26	18.13	0.00	**72.18**
S22	36.60	15.26	18.13	1.98	**71.96**
S25	36.60	15.26	18.13	1.98	**71.96**
S21	40.00	13.56	18.13	0.00	**71.68**
S28	36.60	14.36	18.13	1.98	**71.06**
S25B/S25BPS	36.60	15.06	18.13	0.00	**69.78**
S29	32.00	15.46	18.13	4.00	**69.58**
S37A	33.20	15.26	18.13	1.98	**68.56**
S13/S13PS	33.00	15.26	18.13	0.00	**66.38**
S36	28.60	15.06	18.13	0.00	**61.78**
G54	26.40	15.06	18.13	1.98	**61.56**
S123	26.00	15.06	18.13	1.98	**61.16**
G56	25.20	15.26	18.13	1.98	**60.56**
S20F	26.00	15.06	18.13	0.00	**59.18**
G93	26.40	11.31	18.13	1.98	**57.81**
S197	25.20	10.33	18.13	1.98	**55.63**
S20G	22.60	12.93	18.13	0.00	**53.66**
S33	18.00	14.86	18.13	1.98	**52.96**
S21A	22.60	7.96	18.13	3.00	**51.68**
S20	12.40	8.65	18.13	1.98	**41.16**
G58	12.40	9.78	18.13	0.00	**40.31**

Projects	Likelihood of System Deficiency	Consequence of System Deficiency	Benefits from System Enhancement	Project Status	Total Points
S2, S3, S4, S7, S8	18.50	21.79	22.50	0.00	**62.79**
CURTAIN_WALL	20.40	15.26	21.88	0.00	**57.53**
CORBETT_LEVEE	23.40	10.30	19.38	4.00	**57.08**
L8 FEB/G539	18.50	15.59	22.50	0.00	**56.59**
EMMA	26.40	8.65	20.94	0.00	**55.99**
L-31E	6.40	14.11	15.63	0.00	**36.14**

Legend

Priority Levels

Blue	Lower
Green	Medium
Yellow	Medium High
Orange	High

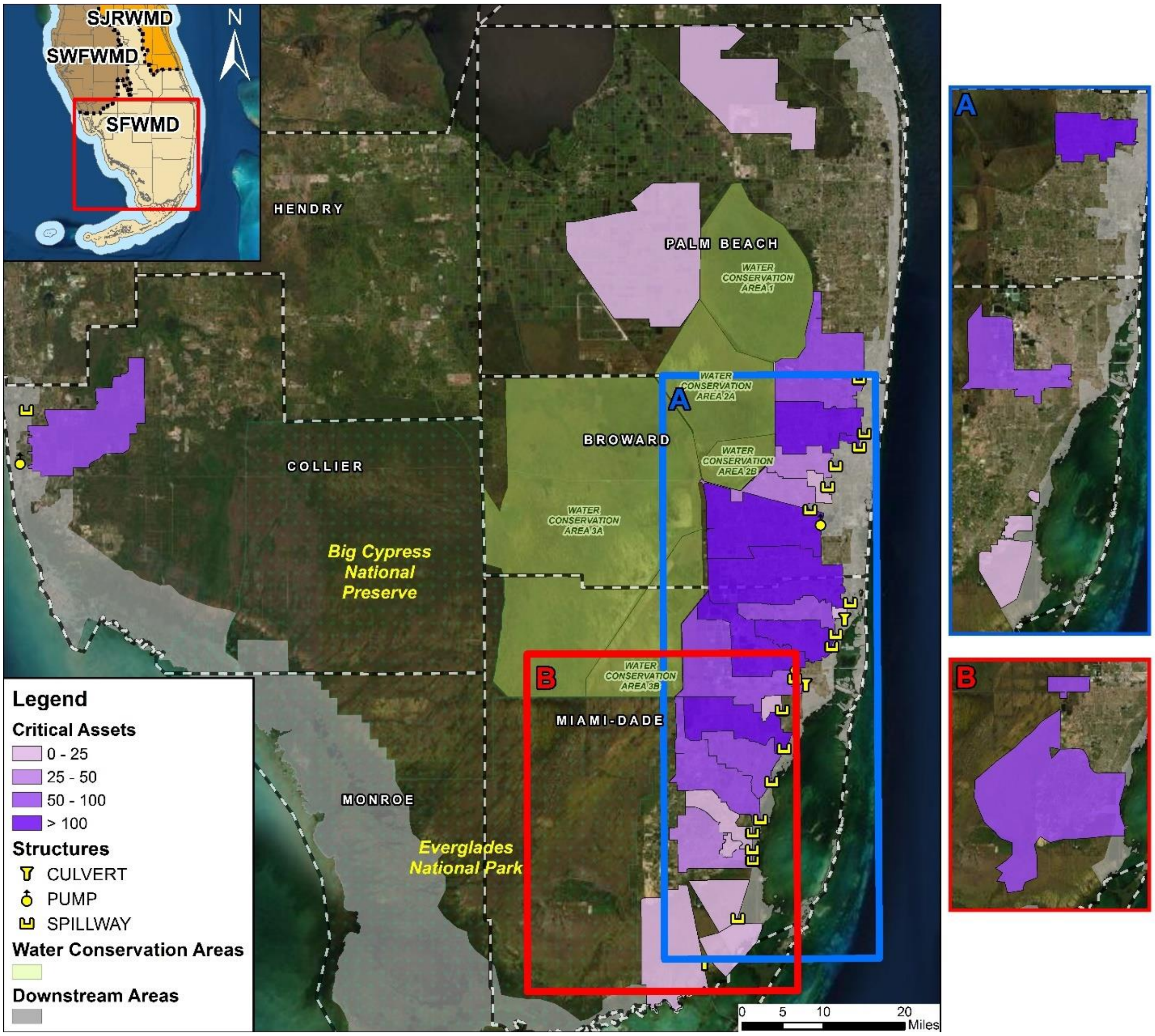


Figure 21. Critical Assets (Lifelines) per Project Impact Areas, utilized as part of the Resiliency Projects Ranking Criteria Set 2. Two sample locations (right panels) are included to avoid overlapping multiple areas of influence. Panel A displays G57 (top), S25B/S25BPS (middle) and L-31E (bottom), while Panel B only displays the Curtain Wall area of influence.

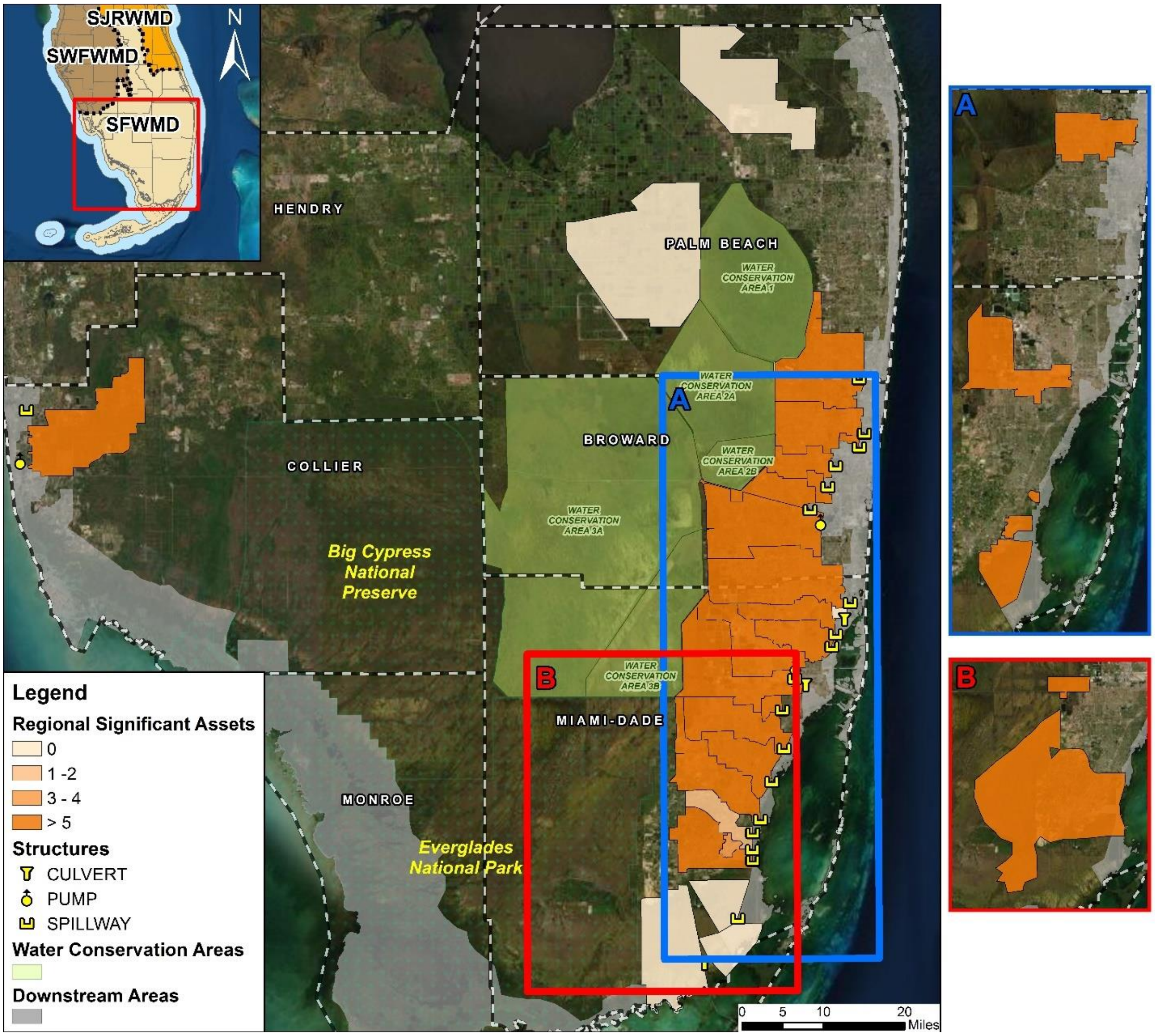


Figure 22. Regional Significant Assets per Project Impact Areas, utilized as part of the Resiliency Projects Ranking Criteria Set 2. Two sample locations (right panels) are included to avoid overlapping multiple areas of influence. Panel A displays G57 (top), S25B/S25BPS (middle) and L-31E (bottom), while Panel B only displays the Curtain Wall area of influence.

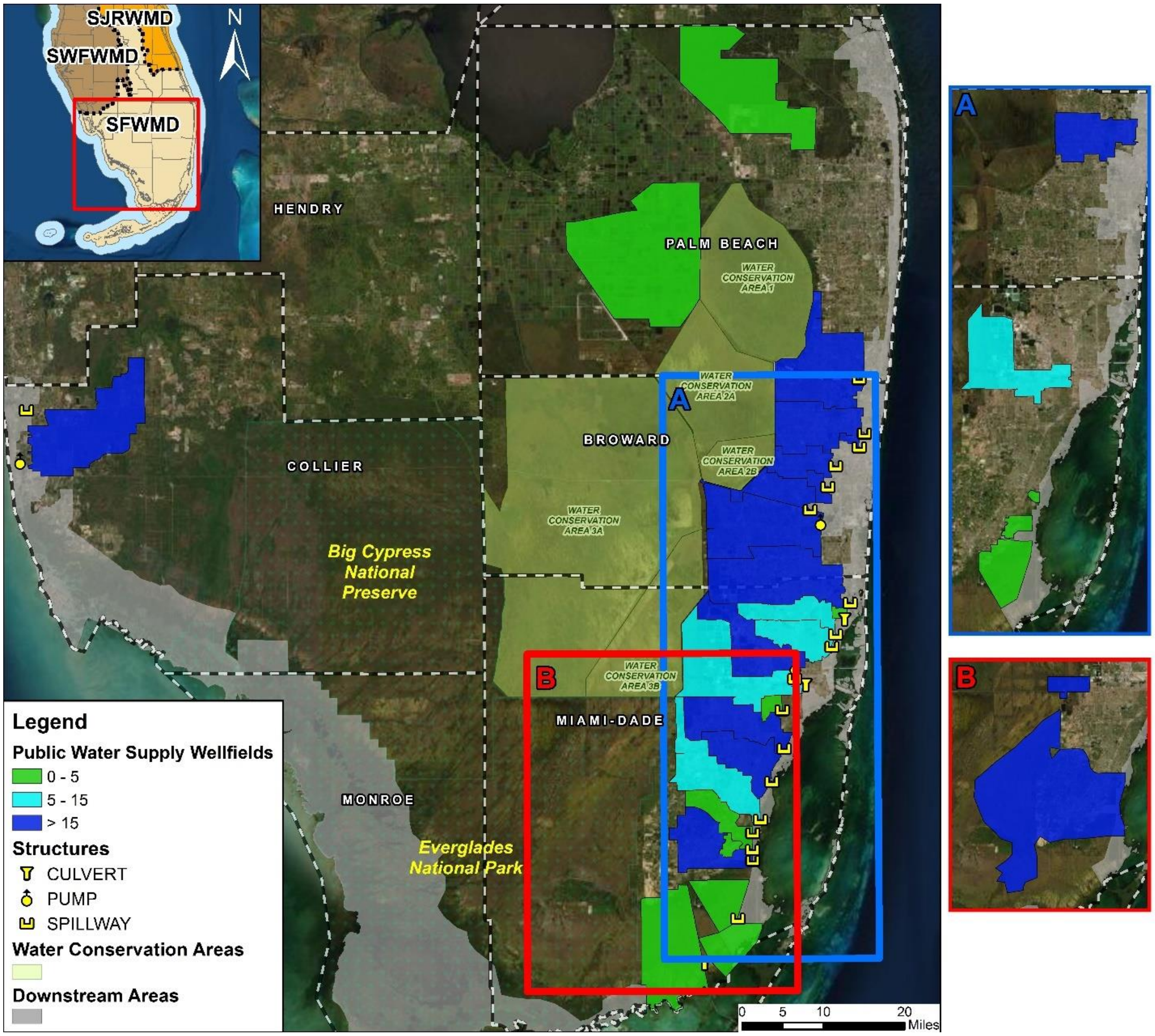


Figure 23. Public Water Supply Wellfields per Project Impact Areas utilized as part of the Resiliency Projects Ranking Criteria Set 2. Two sample locations (right panels) are included to avoid overlapping multiple areas of influence. Panel A displays G57 (top), S25B/S25BPS (middle) and L-31E (bottom), while Panel B only displays the Curtain Wall area of influence.

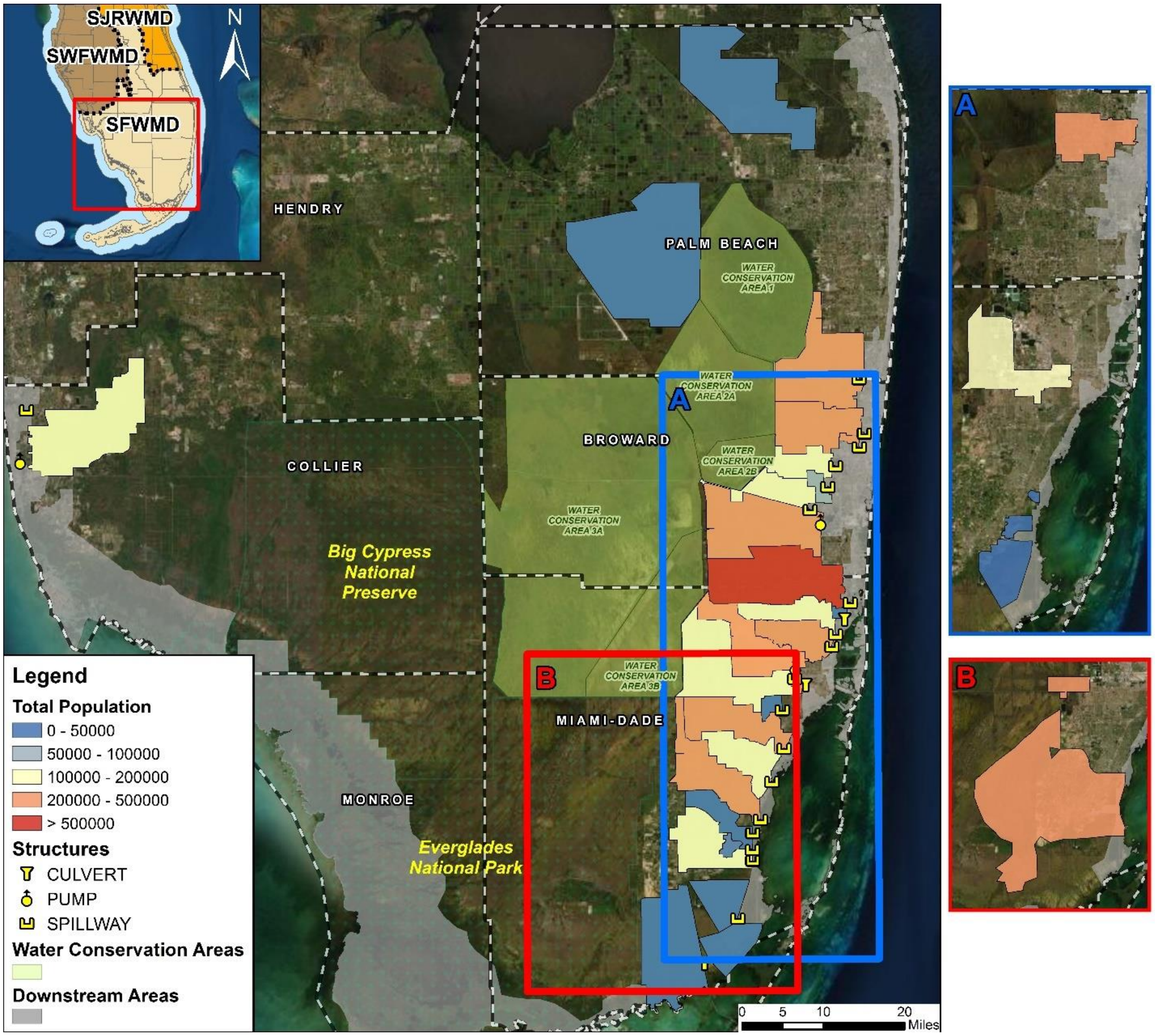


Figure 24. Total Population per Project Impact Areas utilized as part of the Resiliency Projects Ranking Criteria Set 2. Two sample locations (right panels) are included to avoid overlapping multiple areas of influence. Panel A displays G57 (top), S25B/S25BPS (middle) and L-31E (bottom), while Panel B only displays the Curtain Wall area of influence.

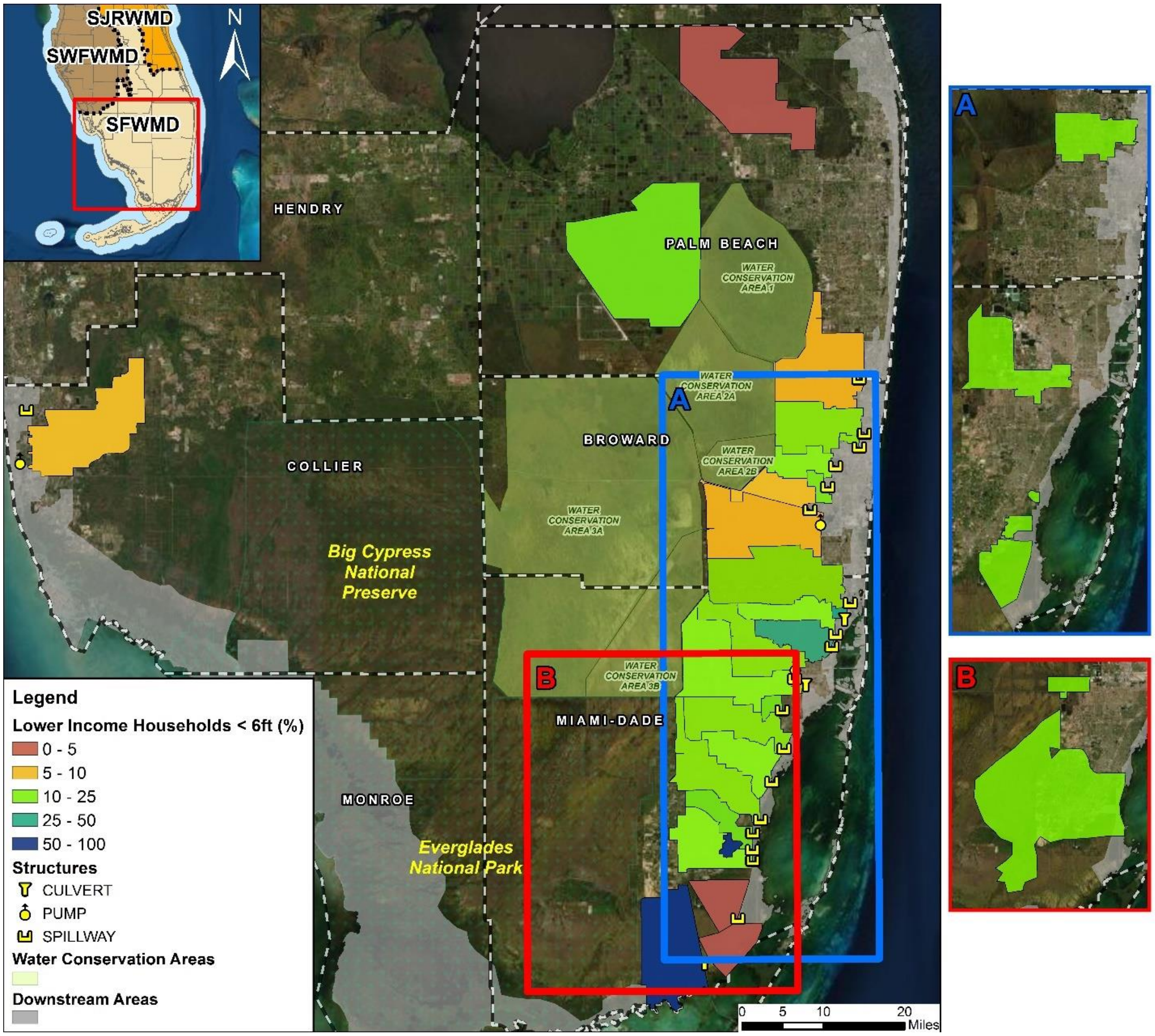


Figure 25. Percentage of Lower Income Households Under 6ft per Project Impact Areas, utilized as part of the Resiliency Projects Ranking Criteria Set 2. Two sample locations (right panels) are included to avoid overlapping multiple areas of influence. Panel A displays G57 (top), S25B/S25BPS (middle) and L-31E (bottom), while Panel B only displays the Curtain Wall area of influence.

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9. Enhancing our Water Management Systems: Priority Projects

Resiliency Implementation Priority Projects – Cost Estimates

The list of priority resiliency implementation projects includes investments needed to increase the resiliency of the District's coastal structures, such as structure enhancement recommendations and additional SLR adaptation needs. These projects represent urgent actions to address the vulnerability of the existing flood protection infrastructure. Project recommendations comprise basin-wide flood adaptation strategies that are based upon other FPLOS recommendations, all of which represent water supply and water resources of the State protection efforts. These additional projects are: adding "self-preservation mode" function to water control structures, construction of the South Miami-Dade Curtain Wall, L31E Levee improvements, and the Corbett Levee project. Each of these projects help to increase the functionality and capacity of the District's flood control system and protection of the environment. The Everglades Mangrove Migration Demonstration Project is being proposed to capture the adaptive foundational resilience of the coastal wetlands within the District, and to demonstrate the ability of coastal wetlands to adapt to rising sea levels via enhanced soil elevation change.

The cost estimates for structure improvements were prepared using the District's current understanding of construction cost in the marketplace and historical costs from projects of similar scope. Additionally, the District followed cost estimating procedures like those employed by the U.S. Army Corps of Engineers. The initial sizing of each proposed pump station is based upon the recent FPLOS study results. Pump station discharge capacity was calculated using half of one quart of the design discharge capacity of the structure (see justification in Resiliency Approach section above). For instance, a structure with a discharge capacity of 1000 cfs would need a 250 cfs pump station. The pump station cost estimates were calculated by a Professional Engineer certified in the State of Florida. Estimates were based upon the District's record of pump station costs from 2006 to present and adjusted for coastal conditions in Miami-Dade County. The cost estimates for each forward pump station were calculated based upon the range of pumping capacity of the pump station (Table 7). For example, a 250 cfs pump station would cost $13,750,000 as the cost per unit of discharge for the "up to 250 cfs range" is $55,000. All estimated costs include backup generators, as appropriate, and the schedules for implementation of the Coastal Structure Refurbishment and Forward Pump Projects is estimated at an average of 1.5 years for design and 2.5 years for construction. Schedules will be adjusted based upon confirmation of project implementation. Real Estate costs were determined for the S-27 and S-29 Coastal Structures and range from $8M - $16M depending on the project footprint and the land use within the areas surrounding the project. An initial placeholder of $7M for real estate costs, as well as $2M for tying the structure back to higher elevation were included in all the structure cost estimates and will be refined during the pre-design stage. Cost estimates for forward pumps and respective backup generators (at 10% of pump total costs) are also included, but forward pumps may not be recommended for all the structures. Feasibility studies, conducted as part of FPLOS Phase II efforts, will confirm the need for forward pumps. All cost estimates have been updated to reflect 2022 inflation increases according to SFWMD Engineering and Construction recommendations, based on the building structure cost index increase from January 2021 to June 2022 of 22.15%.

All new developed structures and components will exceed existing and expected future flood related codes. The State of Florida Building code established the minimum floor elevation by determining the

Baseline Flood Elevation (100-year flood line) per ASCE 24-14, plus 1 (one) foot. The Miami-Dade County Code (Chapter 11C) is at regulatory flood elevation (100 year flood).

Table 7. Summary of Cost Assumptions

Pump Capacity % (from Design Discharge)	
Medium High and High Impact Structures	50%
Medium, Medium Low and Low Impact	25%

Forward Pump Cost Estimates		
Cubic Feet Per Second	**Threshold**	**Cost per Unit of Discharge**
Up to 250	250	$ 68,750.00
250-500	500	$ 66,250.00
500-750	750	$ 63,750.00
750-1000	1000	$ 62,500.00
> 1000	other	$ 60,000.00

Real Estate Costs - Placeholder Average Cos	$ 8,750,000.00

Forward Pump Backup Generator	10% of forward pump costs

Tie Back (flood barriers around Coastal Stru	$ 2,500,000.00

5-year District's Capital Improvement Plan – Priority Projects

As part of evaluating priority resiliency implementation projects, and with the goal of ensuring an integrated strategy to implement projects at the District, an analysis was accomplished to identify how each individual Capital Improvement Plan project is related to this plan's recommended resiliency projects, have common objectives or overlapping impact areas, and can optimize benefits and continue to operate the water management system at peak efficiency.

The District CIP infrastructure investments have been implementing system improvements beyond the needs identified into O&M inspection reports and enhancing District's water management systems with additional components and operational capacity that is making it possible that 70+ years old system functions today and ensuring the District mission is accomplished. These continuous resiliency investments, along with new proposed enhancements that account for future conditions, should be implemented throught a bundling strategy.

Table 8 presents a list of CPI projects that will continue to enhance the C&SF System and Big Cypress Basin and are being evaluated jointly with the resiliency priority projects for an integrated implementation strategy, as the District continues to successfully achieve its mission. More information about these projects can be found at the District Capital Improvement Plan.

Table 8. List of CPI priority projects.

Canal and Levee Conveyance	C-100A Tree Removal & Bank Stabilization C25 Canal Bank Repairs (Hurricane Irma) Canals C16, G16, C14, C41, C1W, C1N, C15 C40, C23, C24, C25 Dredge/Bank Stabilization Hillsboro Package 3 L8 Tieback - Boil Repair/Dupuis Canal Backfill LD1 Bank Stabilization (Uncle Joes)
Communication/Control and Telemetry Upgrades and Replacement	Manatee Gate Control Panel Replacements District-wide Microwave Tower Backbone Radio Upgrades Picayune Command & Control Center S-285/290 SCADA Retrofit SCADA Stilling Well/Platform(C&SF) SCADA Stilling Well/Platform (STA) Tower Repair Program
Field Facilities Construction Upgrades and Replacement	Fort Lauderdale Field Station Modifications Homestead Field Station Replacement Miami Field Station Modifications and Replacements Gate Overhauls: Paint Shop, Sandblast, Air Compressor Facilities Underground Storage Tank Replacements West Palm Beach Field Station Modifications O&M Facility Construction/Improvements Staff Support

Project Culvert Replacement	Large Project Culvert Replacements – Multiple Sites PC Culvert Project Replacements & Removals - Multiple Sites PC Replacements ~ STCL FS PC to Bridge conversion PC Replacements ~ WPB FS Area, 6 Sites on L15
Pump Station Upgrades and Replacement	Arc Flash Program Automation Upgrades: G310, G335, S319, S362 G-251 Dewatering Provision G310 Trash Rake Refurb/Replac G-310/G-335 Pump Overhaul G335 Trash Rake Refurb/Replac G370/372 Trash Rake, Fuel Farm & Structural L8 FEB / G539 PS - Resiliency Upgrades L8 FEB Flap Gate Purchase / Retrofit Pump/Engine Overhauls (C&SF) Pump/Engine Overhauls (C&SF) Grant Pump/Engine Overhauls (STA) S2, S3, S4 Pump Refurbishments S2, S3, S4, S7, S8 Engine Control Panel Hardening S-331 Command & Control Center Comm (Multiple Sites) S6 Package 1 S6 Pump Refurbishment S7 Pump Refurbishment S-9/S-9A Trash Rakes & Refurbishment Pump Station Modification/Repair Staff Support
Structure Upgrades and Replacement	Fall Protection G57 Wingwall Replacement & G16 G6A/S6 Access Bridge G93 IT Shelter and Structure Refurbishment Gate/Hydo Cylinder Overhauls (C&SF) Gate/Hydo Cylinder Overhauls (STA) Generator Replacement Program Hoist Conversion Project (S176 & S179) & future conversions S167 Wingwall Replacement S169W Relocation and Trash Rake S26 Major Refurbishment S65 Spillway Replacement S65A Spillway Replacement S65D Spillway Replacement S70 Replacement STA1E Outflow Structure Generator Addition STA1WE1 Outflow Structures Generator Additions Structure/Bridge Modification/Repair Staff Support

Relevance of Advancing Recommended Projects for Mitigating Risks on South Florida Water Resources

As detailed earlier in this Document, this resiliency plan seeks to build resiliency and mitigate the risks of flooding and sea level rise on water resources. The District's canals and coastal structures are an integral part of water resources management. Among other purposes, the coastal structures act as barrier preventing saltwater intrusion from moving inland and impacting wellfield protection zones and other environmental protected areas. They do this by maintaining freshwater elevations upstream of the structure higher than ocean/saltwater levels, especially during the dry season, and provide recharge to the Surficial/Biscayne Aquifer.

The canals operate under normal and dry/wet season conditions which set the necessary water stages in the canal and therefore the subsequent operations of the canal's structures. These operational conditions are relative to and therefore limited by the difference in elevation between the head and tail waters. Upstream (freshwater) operating levels are less than one foot higher than downstream tidal stages at certain coastal structure locations during . The Biscayne Aquifer MFL Prevention Strategy established that 2 feet of freshwater head needs to be maintained for more than 6 months a year, to prevent salt water from encroaching into the Biscayne Aquifer. Figure 26 shows how often the S-29 structure's tailwater level dips below the 2 feet minimum as well as how the tailwater and headwater are converging, which translates to less head difference in this gravity structure during extended periods of time. This reduced control is further exacerbated as the structures age, sea levels rise, and as climate and rainfall uncertainty increase, reducing the capability of the system to maintain freshwater minimum elevations and manage saltwater intrusion.

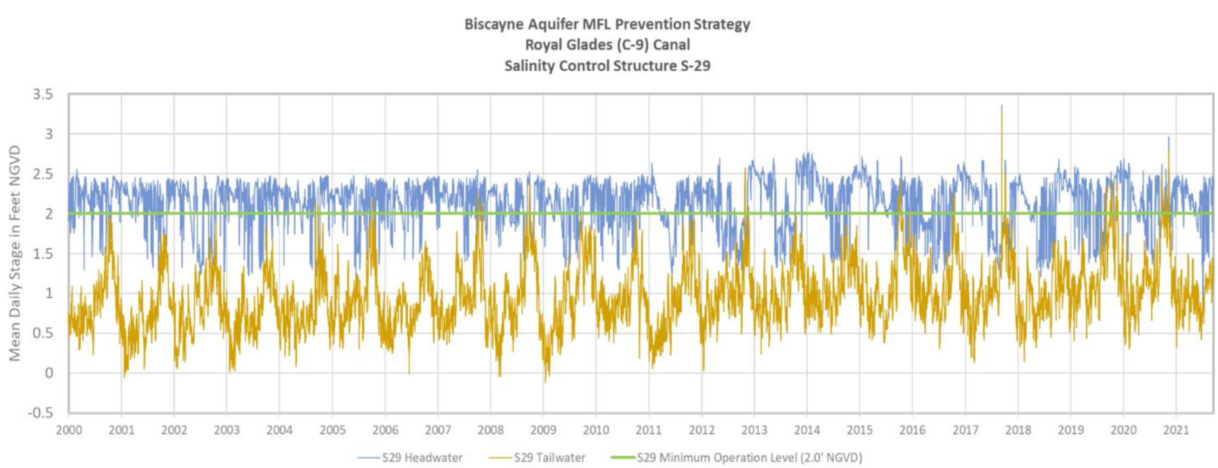

Figure 26. Headwater and Tailwater stages at S-29 structure.

The rehabilitation and replacement of lift gates and the installation of a new pump station will allow, beyond flood protection, for increased control of upstream fresh water by giving operators flexibility in discharge capacity, precise flow rate control, and optimization via integrated basin wide freshwater management, reducing unnecessary or earlier drawdowns as a result of the existing limitations in discharge capacity during higher tide events. The increased ability to maintain higher freshwater levels, especially during the dry season, significantly reduces the potential risk of saltwater intrusion effecting fresh water supplies. Additionally, the increased control will allow operators to adjust flows for. As an example, Figure 27 shows the benefit to subregional groundwater water levels as the result of maintaining higher canal levels near the end of the wet season in Collier County.

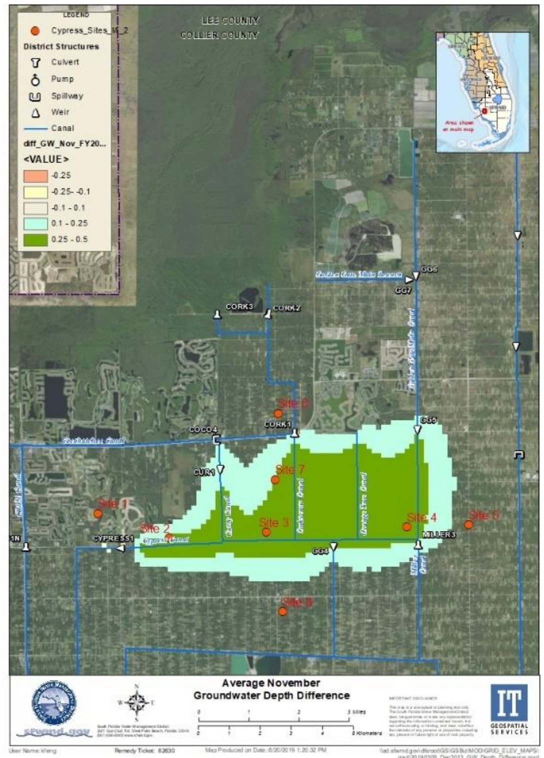

Figure 27. Average November positive groundwater depth difference due to optimized structure operations.

In two basins where resiliency projects are being prioritized currently, we can observe risks to existing wellfield protection zones by the advance of saltwater interface. In the C-9 basin example, the risk to water supplies is particularly acute as the majority of North Miami's water is serviced by the Norwood-Oeffler Water Treatment Plant. This 15 MGD plant's freshwater wells are within one mile of the saltwater intrusion line and coastal structure. In the C-7 basin, the saltwater intrusion line is 7 city blocks away from the freshwater wells for the Winson Water Treatment Plant. Since 2009, the saltwater interface has gradually been moving westward (see Figure 28). Since 2000, 25 water supply wells have been lost along South Florida's coastline due to saltwater intrusion.

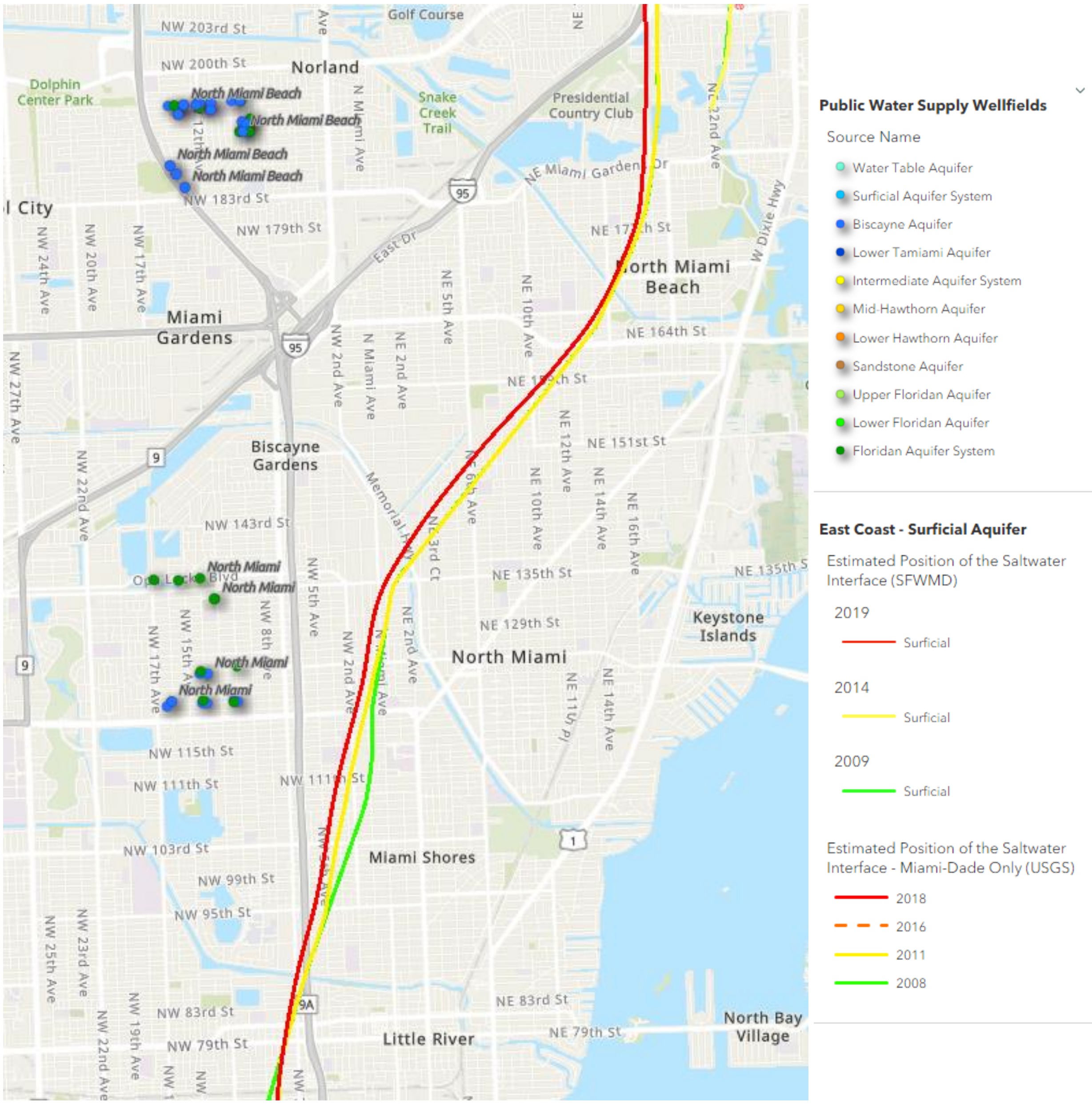

Figure 28. Saltwater interface line in S-27, S-28, and S-29 structures.

*Detailed information on Water Supply Management and saltwater intrusion is documented in the Lower East Coast Water Supply Plan and Saltwater Interface Monitoring and Mapping Program Technical Publication WS-58.

S-27 Coastal Structure and C-7 Basin Resiliency

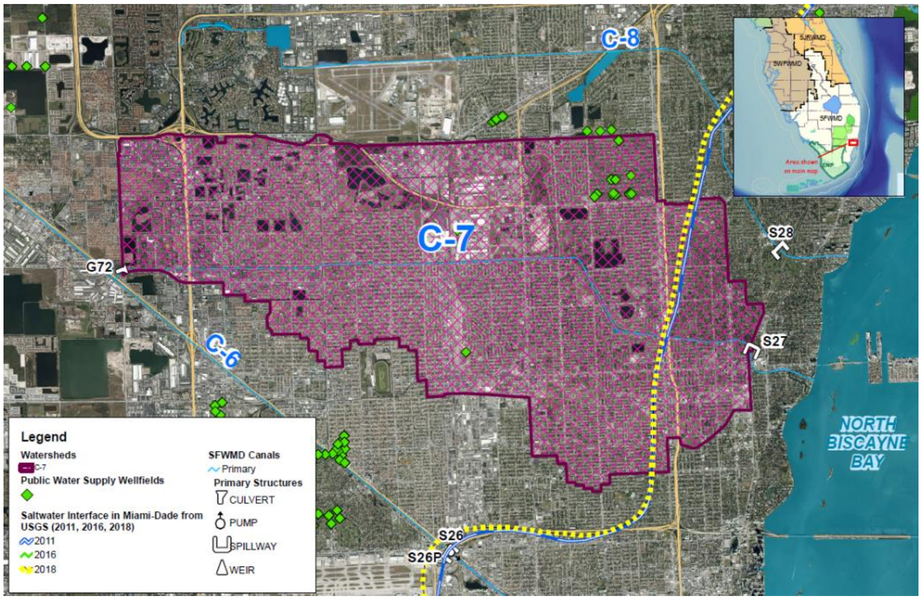

Figure 29. Map of C-7 Basin.

S-27 is a reinforced concrete, gated spillway, with discharge controlled by two vertical lift gates with a discharge capacity of 2,800 cfs. Operation of the gates is automatically controlled. The structure is in the City of Miami near the mouth of C-7 Canal about 700 feet from the shore of Biscayne Bay. The C-7 Basin has a population of about 270,000 people within 32 square miles, in the northeastern portion of Miami-Dade County (Figure 29). The area drained by the C-7 Canal is fully developed with primarily residential and commercial uses. The C-7 Canal is the central flood control feature that receives and conveys basin flood waters by gravity through the S-27 Coastal Structure to sea. This structure maintains optimum water control stages upstream in C-7 (Little River Canal); it passes the design flood (75 percent of the Standard Project Flood) without exceeding upstream flood design stage and restricts downstream flood stages and discharge velocities to non-damaging levels; and it prevents saltwater intrusion during periods of high tides.

As evidenced during the recent Tropical Storm Eta in November 2020, SLR is limiting the ability of these central flood control features to convey flood waters. Serious flooding events occurred in the C-7 Basin, with near 100-year rainfall volumes, and higher sea levels impeding the S-27 Coastal Structure's ability to deliver those volumes to tide (Figure 30).

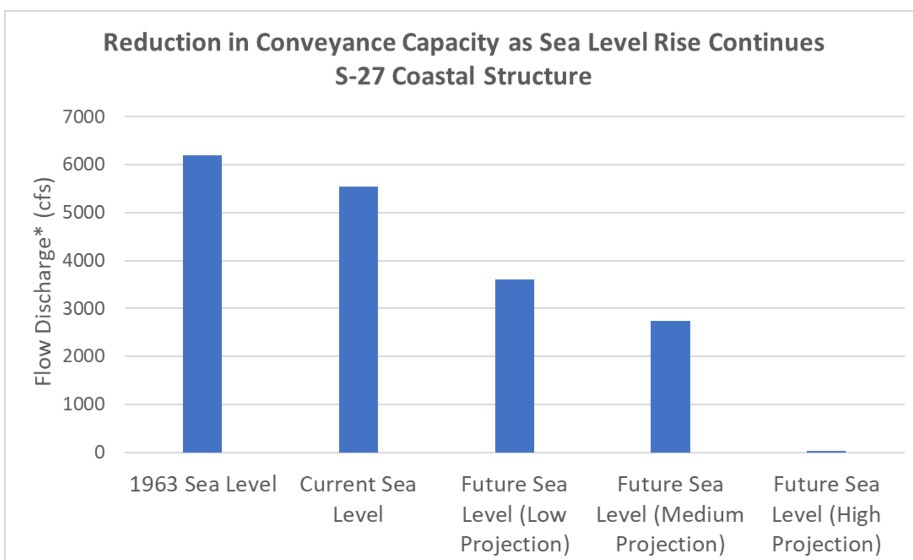

Figure 30. Reduction in conveyance capacity at S-27 as SLR continues.

The FPLOS Program is developing water management models to evaluate system operations under changed current and future conditions and recommending priority infrastructure investments in critical locations. Recent observations and FPLOS model results show the S-27 Structure is in urgent need of modifications. The C-7 Basin FPLOS was evaluated under the current sea level conditions and three projected future sea level rise scenarios. The current sea level (CSL) and design storm surge were evaluated under future sea level rise scenarios. The existing level of service under current sea level and future sea level was established using a calibrated XP-SWMM Hydrologic & Hydraulic (H&H) model of the C-7 Basin. A total of 16 simulations were developed for four design storms, using the District's 5-year and 10-year, 24-hour duration and 25- and 100-year, 72-hour duration, and four sea level conditions (CSL, 1-foot SLR, 2-foot SLR and 3-foot SLR). The output of the 16 simulations were quantified and analyzed based on the established FPLOS performance metrics. The flood protection level of service in the C-7 Basin is currently equivalent to a five-year flood/rainfall event recurrence interval, compared to the 25-year event minimum design criteria, and is further reduced under future sea level rise scenarios.

Additional evaluation of the hydraulic capacity of S-27 under various sea level and storm surge conditions in comparison with the design conditions was performed by Zhang (2017). The model simulation results indicate that the discharge capacity of S-27 is sensitive to sea level and storm surge. Decreases in capacity due to rising sea level and storm surge are highly salient for both current and projected future sea levels. Moreover, under current sea level conditions, the results of the analysis suggest that S-27 will not be able to pass any flow during the peak of a storm surge with a recurrence interval of 5 years or greater. Under projected future sea level conditions, it was found that the structure will have no capacity during the peak of any storm surge with a recurrence interval of two years or more.

These technical studies reveal that gravity discharge alone through traditional gated spillways may no longer be a reliable means of conveying inland flood waters to tide during high tides and storm surge events. Enhancing the S-27 Structure is urgent, so flood conveyance can be maintained despite high tide events and SLR. The District proposes installation of a 1,400 cubic feet per second forward pump and backup generator facility to maintain basin discharge capacity as sea levels rise, enhancing the structure against SLR impacts (increasing the height of its gates and service bridge to prevent overtopping), and enhancing the S-27 tieback levee (flood barrier). A significant associated benefit of the proposed project is the protection of water supply sources (including the Biscayne Aquifer – a sole source aquifer) by enhancing the S-27 Structure to prevent sea water from overtopping the gates. This work will reduce saltwater intrusion vulnerability.

A total of 192 Community Lifeline facilities would be protected by implementation of the S-27 Resiliency Project. These include two (2) airports, eighty (80) faith-based facilities, three (3) fire stations, five (5) hazardous waste transporter facilities, two (2) hazardous waste transfers/storers/disposers, one (1) heliport, twelve (12) hospitals/medical facilities, eleven (11) law enforcement centers and seventy-six (76) public schools.

SFWMD will partner with Miami Dade County to ensure that the proposed infrastructure projects adhere to the recommendations of the Biscayne Bay Task Force and prioritize Biscayne Bay health and resilience. The Task Force report also recommends accelerating green infrastructure solutions for flooding, resiliency and water quality that include a review of watershed habitat restoration opportunities in repetitive loss areas and future flood hazard areas; and evaluating and allocating cost savings of Community Rating Systems (CRS) benefits into the Biscayne Bay watershed water quality restoration plan. A request for innovation is being proposed to advance water quality pilot technology at Little River Basin, to be associated with the proposed project components and incorporated as part of ongoing project design, upon identification of a feasible technology. This project component, known as Project WIPE-Out, is also detailed in as part of the District's resiliency planning projects (Chapter 9).

A total cost estimate to enhance the S-27 Coastal Structure, to address flooding, SLR and other related risks to vulnerable communities in the C-7 Basin is presented below. The estimate includes modifications to the existing structure and control building, as well as an additional forward pump. The supplementary pumping capacity will extend the conveyance performance for additional years as sea levels rise, delay out of bank flooding, and reduce canal peak stages. Additional funds to purchase real estate for the project are included and negotiations with private property owners for land purchase will initiate upon funding confirmation. An integrated basin-wide strategy to reduce peak stages and increase resiliency of the C7 Basin proposes to leverage the construction additional storage options and interbasin connections.

S-27 Cost Estimate

Structure Enhancement	$	5,642,523
Forward Pump (1400 cfs)	$	67,200,000
Forward Pump Backup Generator Facility	$	6,720,000
Structure Tie Back (Flood Barrier)	$	2,000,000
Design & Construction Management	$	12,234,378
Water Quality Pilot Technology RFI	$	500,000
Real Estate	$	10,000,000
Total	**$**	**104,296,902**
2022 Adjusted Cost	**$**	**126,460,496.22**

S-29 Coastal Structure and C-9 Basin Resiliency

The S-29 Coastal structure is a reinforced concrete, gated spillway, with discharge controlled by four cable operated, vertical lift gates with a discharge capacity of 4,780 cfs. Operation of the gates is automatically controlled so that the gates open or close in accordance with the seasonal operational criteria. The structure is in the City of North Miami Beach near the mouth of the C-9 (Snake Creek Canal) and about 500 feet from the shore of Lake Maule. The C-9 Basin is a region of about 450,000 people within100 square miles(Figure 31), in the southern portion of Broward County and northeastern portion of Miami-Dade County. The area drained by the C-9 Canal is fully developed with primarily residential and commercial uses. The C-9 Canal is the central flood control feature which receives and conveys basin flood waters by gravity through the S-29 Coastal Structure to sea. This structure maintains optimum water control stages upstream in C-9; it passes the design flood (100 percent of the Standard Project Flood) without exceeding upstream flood design stage and restricts downstream flood stages and discharge velocities to non-damaging levels; and it prevents saltwater intrusion during periods of extreme high tides.

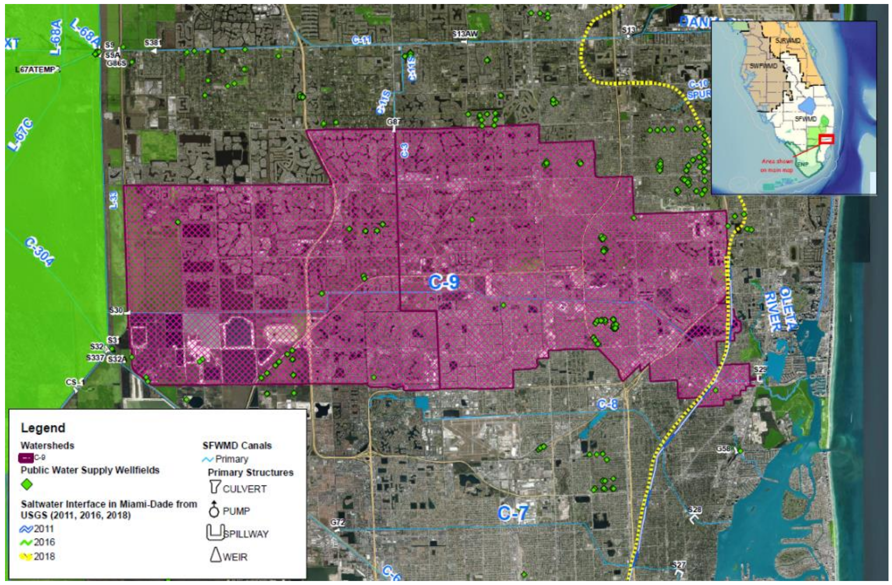

Figure 3115. Map of C-9 Basin.

As evidenced during the recent Tropical Storm Eta, SLR is limiting the ability of these central flood control features to convey flood water. Serious flooding events occurred in the C-9 Basin, with greater than 100-year rainfall volumes, and higher sea level impeding the S-29 Coastal Structure's ability to deliver those volumes to tide (Figure 32).

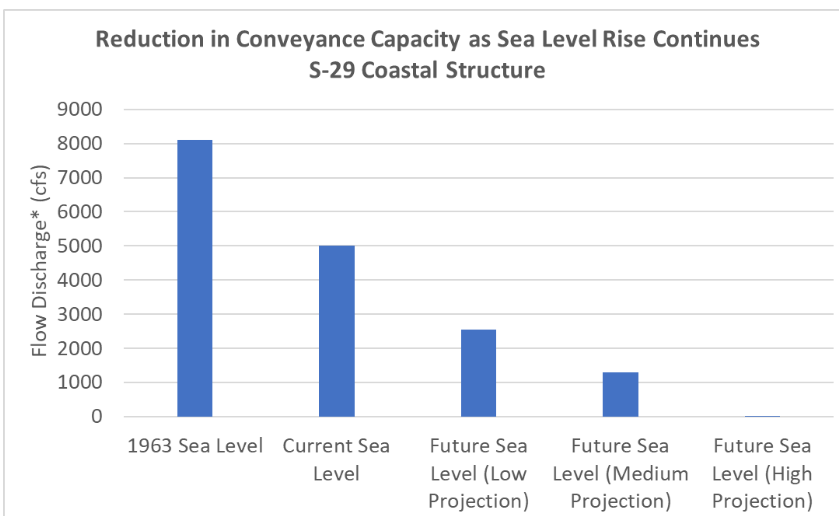

Figure 32. Reduction in conveyance capacity at S-29 as SLR continues

The FPLOS Program is developing water management models to evaluate system operations under changed current and future conditions and recommending priority infrastructure investments in critical locations. Recent observations and FPLOS model results show the S-29 Structure is in urgent need of modifications. The flood protection level of service in the C-9 Basin is currently equivalent to a twenty five-year rainfall/flood event recurrence interval. Level of service is reduced to a five-year event under a two-foot sea level rise scenario. The proposed project will provide 20-40 years of protection against sea level rise depending on the scenario (INOAA Intermediate Low or NOAA Intermediate High). Peak canal stage can be reduced by 15% for each 500cfs increase in pump capacity.

The purpose of this project is to restore the design discharge of the S-29 Structure and decrease flood impacts within the C-9 Basin due to sea level rise, climate change and land use changes in the basin. Conceptual design is complete and final design is underway. Final design will be based upon a simulation of the combined regional and local hydraulic measures in the C-9 Basin. The design of a forward pump station will be adaptable and will include the ability to easily add additional pumps in the future as environmental conditions change. The current design includes pumping capacity of 2000 cfs. The S-29 structure will also be enhanced and hardened by raising the bridge, converting the gate opening system to a more robust mechanism, replacing the existing gates with corrosion resistant stainless-steel gates, replacing the control building with a hardened and elevated control building, and adding a corrosion control system to the structure.

A total cost estimate to harden the S-29 Coastal Structure, to address flooding, SLR and other related risks to vulnerable communities in the C-9 Basin is presented below. The estimate includes modifications to the existing structure and control building, addition of a forward pump and construction of flood barriers. The additional pumping capacity will extend the conveyance performance for additional years as sea levels rise, delay out of bank flooding, and reduce canal peak stages. Additional funds to purchase real estate for the project are included and negotiations with Miami Dade County for land purchase will initiate upon funding confirmation. The project is located within an existing Miami-Dade County park and the county can only convey an easement, which will reduce real estate costs. The current location of major equipment in the deck of the structure might trigger a need for replacement instead of enhancement, which will be confirmed during Design. An integrated basin-wide strategy to reduce peak stages and increase resiliency of the C-9 Basin proposes to leverage the construction of CERP Water Preserve Areas (C-9 and C-11 Impoundment) for additional storage.

S-29 Cost Estimate

Structure Enhancement	$10,452,319
Forward Pump (2000cfs)	$97,915,774
Forward Pump Backup Generator Facility	$10,448,077
Structure Tie Back (Flood Barrier)	$ 2,769,122
Design, Implementation & Construction Management	$18,237,794
Real Estate**	$ 16,800,000
Total*	**$156,623,087**
2022 Adjusted Cost	**$191,578,859**

*May need to be replaced rather than refurbished, costs may be higher.

** Public Land, with potential to be included as cost-matching

S-28 Coastal Structure and C-8 Basin Resiliency

An example of a project that is proposing to use a combination of NBS and gray infrastructure is the District's C-8 Basin project in Miami-Dade County. The District is requesting FEMA grant funding to advance flood risk reduction measures in the C-8 Basin, a region of about 270,000 people that covers 28 square miles, in the northeastern portion of Miami Dade County. We estimate an additional 70,000 workers, travelers, and visitors are using the area for employment, transportation, and recreation. In addition, 96 critical assets would be protected under the proposed project. These include Airports (1), Faith Based Facilities (38), Fire Stations (6), Hazardous Waste Transport Facilities (3), Heliports (1), Hospitals/Medical Facilities (6), Law Enforcement Centers (6), and Public Schools (33). Overall flood protection levels of service will improve and water supply protection from saltwater intrusion will increase. This means that 13% of the most populous county in Florida will benefit from an increased level of flood protection. The area drained by the C-8 Canal is fully developed with primarily residential and commercial uses. The C-8 Canal is the central flood control feature that receives and conveys basin floodwaters by gravity through the S-28 Coastal Structure to sea.

S-28 is a reinforced concrete, gated spillway, with discharge controlled by two cable operated, vertical lift gates that are 17.5 feet high by 27.8 feet wide. The structure has a discharge capacity of 3,220 cfs. S-28 is in the City of Miami near the mouth of C-8 about a mile from the shore of Biscayne Bay. Operation of the gates is automatically controlled so that the gate hydraulic operating system opens or closes the gates in accordance with the operational criteria. This structure maintains optimum water control stages upstream in C-8; it passes the design flood (100 percent of the Standard Project Flood) without exceeding upstream flood design stage and restricts downstream flood stages and discharge velocities to non-damaging levels; and it prevents saltwater intrusion during periods of extreme high flood tides. The impacts of sea level rise at S-28 Coastal Structures are illustrated in Figure 33, demonstrating the risks of saltwater overtopping the gates and minimum freeboard requirements as early as 2040.

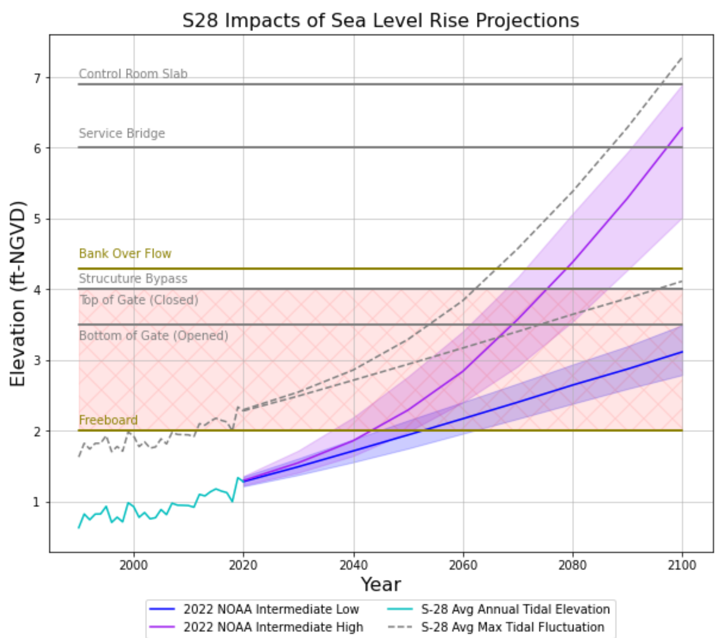

Figure 33. S-28 Impacts of Sea Level Rise Projections.

This project will reduce flood risk under sea-level rise and provide ancillary water quality benefits, by restoring the basin's flood protection level of service and enhancing quality of life in the region. The project includes:

- Replacement of the S-28 Structure with an enhanced structure and elevated components to withstand the impacts of SLR and climate change

- Installation of a 500 cfs forward pump station adjacent to the S-28 structure to maintain basin discharge levels as sea levels rise
- Construction of a flood barrier tying the S-28 Structure to higher ground elevations to mitigate the impacts of SLR storm surge and saltwater intrusion
- Enhancement of secondary canal banks to improve flood control throughout the basin
- Construction of a temporary floodwater detention area on a portion of the Miami Shores Golf Course near the S-28 Structure to provide temporary storage of floodwaters and reduction of stormwater runoff volumes during extreme rainfall events.
- Installation of living shoreline along the C-8 Canal and vegetated flood berms to enhance flood protection

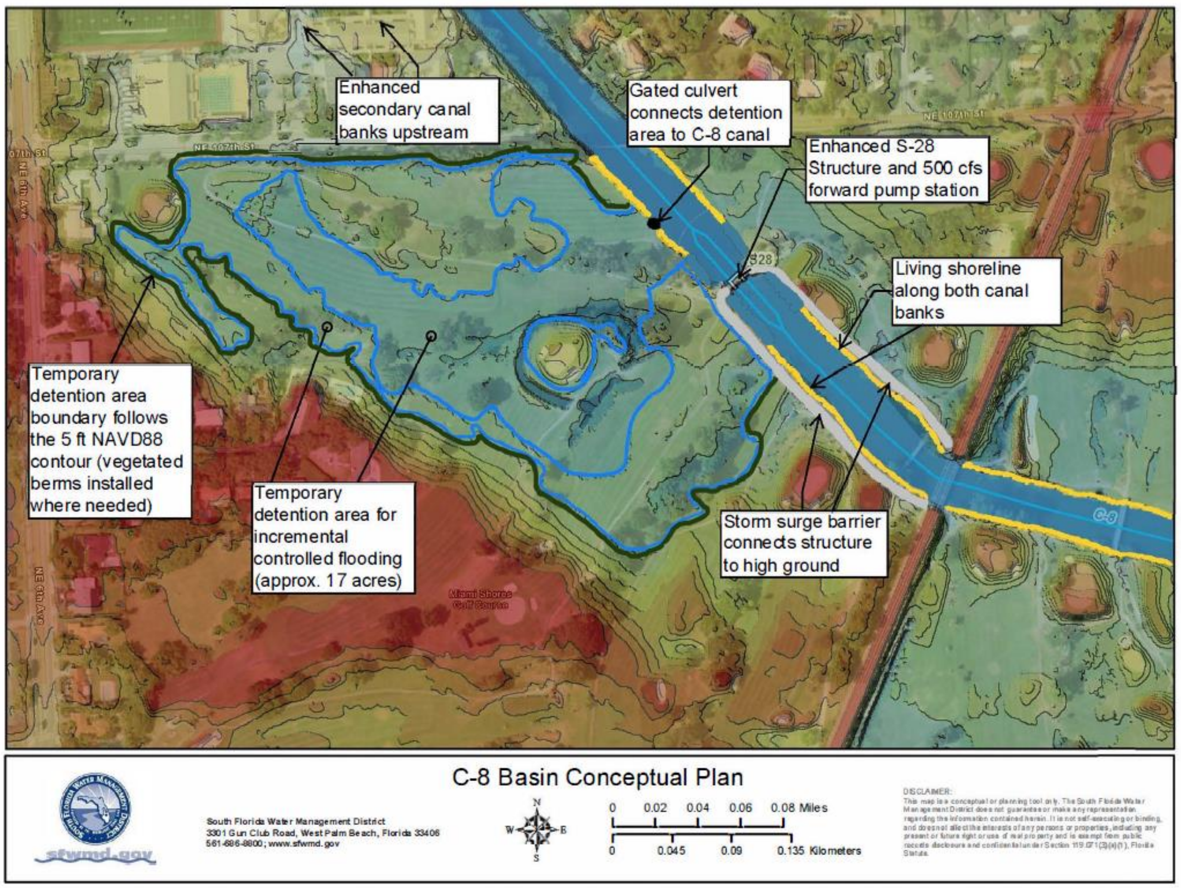

Figure 34. Conceptual plan for the C-8 Basin.

A significant aspect of this project includes using a portion of the Miami Shores Golf Course as a temporary flood water storage area during extreme rainfall and storm surge events (Figure 34 above). Vegetated berms and living shoreline features are also incorporated into the plan to enhance water quality and aquatic habitat. The strategy to reduce runoff in this densely urbanized basin includes implementation of a series of distributed storage solutions. These project features can serve as pilot project examples for the region. Ancillary benefits include improved fish and wildlife habitat from implementation of the living shoreline features, improved land value due to reduced flood risk and enhanced aesthetics, prevention of canal bank erosion, water quality benefits from implementation of vegetated berms and temporary flood water storage and increased opportunities for recreation.

A total cost estimate to harden the S-28 Coastal Structure, to address flooding, SLR and other related risks to vulnerable communities in the C-8 Basin is presented below and it includes modifications to the existing structure and control building, addition of a forward pump and construction of flood barriers. The additional pumping capacity will extend the conveyance performance for additional years as sea level rises, delay out of bank flooding, and reduce canal peak stages. Additional potential funds to purchase real estate for the project are included and negotiations with landowner will initiate upon funding confirmation.

S-28 Cost Estimate

Structure Replacement	$13,510,594
Forward Pump (1500cfs)	$79,639,466
Forward Pump Backup Generator Facility	$ 8,750,314
Structure Tie Back (Flood Barrier)	$ 2,987,463
Design, Implementation & Construction Management	$15,733,176
Real Estate	$ 1,803,384
Nature Based Solutions	$1,500,000
Total	**$123,924,398**
Adjusted 2022 Cost	**$ 154,079,651**

S-26 Coastal Structure Resiliency

S-26 is a two-bay, reinforced concrete gated spillway located in the City of Miami at the NW 36th Street crossing of the Miami (C-6) Canal, between NW North River Drive and NW South River Drive, northeast of the Miami International Airport. The structure consists of two 14.1 feet high by 26.0 feet wide gates with a discharge capacity of 3,470 cfs. The discharge from the structure is controlled by two hydraulically driven cable operated vertical lift gate mechanisms. The gates can either be remotely operated from the District Control Room or controlled on-site. To maintain flood protection for the C-6 basin, a 600 cfs pump station was added to the S-26 spillway as part of the Miami Dade County Flood Mitigation Program. The S-26 is the outlet to tide for the C-6 basin. The structure maintains optimum water control stages upstream in the C-6 Canal. It was designed to pass 100% of the Standard Project Flood (SPF) without exceeding upstream flood design stage and restricts downstream flood stages and discharge velocities to non-damaging levels, and it prevents saltwater intrusion during periods of extreme high tides. The structure is maintained by the Miami Field Station.

The purpose of this project is to build resiliency, restore the design discharge of the S-26 Structure and decrease flood impacts within the C-6 Basin due to sea level rise, climate change and land use changes in the basin. Project conceptual design is finalized. Final design will be based upon simulation of the combined regional and local hydraulic measures in the C-6 Basin. The S-26 structure will be enhanced by raising the bridge, converting the gate opening system to a more robust mechanism, replacing the existing gates with taller corrosion resistant stainless-steel gates and replacing the control building with an elevated control building, and adding a corrosion control system to the structure. Flood barriers will be constructed around the coastal structure to tie it back to higher land. The design of a forward pump station will be adaptable and will include the ability to easily add additional pumps in the future as environmental conditions change. The current design includes a pumping capacity of 1735 cfs.

The entire population currently living in the C-6 Basin, estimated at 223,766, will directly or indirectly benefit from this project. The total number of critical assets vulnerable to flooding under current and future conditions in the C-6 Basin are 226. These include airports, faith-based facilities, fire stations, waste management facilities, hospitals and medical facilities, law enforcement centers, and schools. The state's public schools have a vital role in our communities during emergency storm evacuations and post-storm recovery efforts, serving as shelters for displaced residents and emergency response staging areas. Overall flood protection levels of service are expected to increase in the entire basin with project implementation, as well as water supply protection from saltwater intrusion.

The project will provide 20-40 years of protection against SLR, depending on the scenario (Intermediate Low or NOAA Intermediate High). Peak canal stage can be reduced by 15% with each 500 cfs increase in forward pumping capacity. The pump station facility will have a useful life of approximately 50 years.

A total cost estimate to harden this Coastal Structure, to address flooding, SLR and other related risks to vulnerable communities in the Basin is presented below.

S-26 Cost Estimate

Structure Enhancement	$ 7,101,519
Forward Pump (1735 cfs)	$83,280,000
Forward Pump Backup Generator Facility	$ 8,328,000
Structure Tie Back (Flood Barrier)	$ 2,000,000
Design, Implementation & Construction Management	$15,106,428
Real Estate	$ 2,404,512
Total	**$118,220,458**
2022 Adjusted Cost	**$ 147,174,44**

G-57 Coastal Structure Resiliency

G-57 is a reinforced concrete, gated spillway with discharge controlled by two stem-operated, vertical lift gates measuring 6 ft. high by 14 ft. wide. Discharge capacity at G-57 is 375 cfs. Operation of the gates is automatically controlled so that the gate operating system opens or closes the gates in accordance with the operational criteria. The structure is located on the Old Pompano Canal just east of Cypress Road. This structure maintains upstream water control stages in Old Pompano Canal. It passes the design flood without exceeding the upstream flood design stage and restricts downstream flood stages and channel velocities to non-damaging levels; and it prevents saline intrusion. G-57 is serviced by the Fort Lauderdale Field Station.

The SFWMD FPLOS developed advanced H&H models to evaluate system operations under changed current and future conditions and recommended infrastructure investments in critical locations. Recent observations and FPLOS model results show that the G-57 Structure needs adaptation. The FPLOS results and recent observations show the G-57 Coastal Structure is no longer providing the design level of service, which impacts the overall flood protection level of service in the C-14 Basin. The flood protection level of service in the C-14 Basin is currently equivalent to a five-year rainfall/flood event recurrence interval. Level of service is reduced to a less than five-year event under a two-foot sea level rise scenario.

The entire population currently living in the C-14 Basin, estimated at 302,629, will directly or indirectly benefit from this project. The number of critical assets vulnerable to flooding under current and future conditions at C-14 Basin are 57. These include faith-based facilities, fire stations, hospitals and medical facilities, law enforcement centers, recreational facilities and schools. The state's public schools have a vital role in our communities during emergency storm evacuations and post-storm recovery efforts, serving as shelters for displaced residents and emergency response staging areas. Overall flood protection levels of service are expected to increase in the entire basin, as well as water supply protection from saltwater intrusion contamination with project implementation.

Enhancing the G-57 structure will restore discharge capacity by adding a forward pump to convey flood waters when the downstream water elevations preclude gravity flow. These modifications will protect flood prone areas within the C-14 Basin. The proposed project will provide 20-40 years of protection against sea level rise depending on the scenario (NOAA Intermediate Low or NOAA Intermediate High). Peak canal stage can be reduced by 15% by for each 500 cfs increase in pump capacity.

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The purpose of this project is to build resiliency, restore the design discharge of the G-57 Structure and decrease flood impacts within the C-14 Basin due to sea level rise, climate change and land use changes in the basin. Project conceptual design is finalized. Final design will be based upon simulation of the combined regional and local hydraulic measures in the C-14 Basin. The G-57 structure will be enhanced and hardened by raising the bridge, converting the gate opening system to a more robust mechanism, replacing the existing gates with corrosion resistant stainless-steel gates and increased height, replacing the control building with a hardened and elevated control building, and adding a corrosion control system to the structure. Flood barriers will be constructed around the coastal structure to tie it back to higher land. The design of a forward pump station will be adaptable and will include the ability to easily add additional pumps in the future as environmental conditions change.

The design life for the facility is 50 years with consideration for mechanical equipment being rehabilitated or replace over the design life. The engines may require at least one major overhaul during the design life while the pump materials will be designed to provide long service life. The structural and architectural design of the pump stations will include elements that will require minimum maintenance and repair over the design life.

A total cost estimate to harden this Coastal Structure, to address flooding, SLR and other related risks to vulnerable communities in the Basin is presented below. The estimate includes modifications to the existing structure and control building, as well as an additional forward pump. The supplementary pumping capacity will extend the conveyance performance for additional years as sea levels rise, delay out of bank flooding, and reduce canal peak stages. Placeholder funds to tie the structure to higher land elevations and to purchase real estate for the project are included. Negotiations with private property owners for land purchase will initiate upon funding confirmation.

G-57 Cost Estimate

Structure Enhancement	$ 5,316,285
Forward Pump (200cfs)	$10,312,500
Forward Pump Backup Generator Facility	$ 1,031,250
Structure Tie Back (Flood Barrier)	$ 2,000,000
Design, Implementation & Construction Management	$ 2,799,005
Real Estate	$ 7,000,000
Total	**$28,459,040**
Adjusted 2022 Cost	**$ 33,823,800.36**

S-22 Coastal Structure Resiliency

S-22 is a two-bay, reinforced concrete gated spillway located in C-2 (Snapper Creek) Canal, about 7,000 feet from the mouth of Biscayne Bay and about ten miles southwest of downtown Miami. The C-2 Canal has as an open channel connection with the C-4 Canal, west of intersection of Turnpike and Miami SW 8th Street. The structure has two (2) 15.0 feet high by 17.7 feet wide gates and a discharge capacity of 1905 cfs. The gates are operated by an electric driven cable drum. The gates can either be remotely operated from the District Control Room or controlled on-site. The purpose of S-22 is to permit release of flood runoff from the tributary basin, prevent over-drainage, and prevent saltwater intrusion during periods of extreme high tides. The structure maintains optimum stages upstream in the C-2 Canal. The structure is maintained by the Miami Field Station.

The project consists of enhancing the S-22 Coastal Structure and installing forward pumps to increase its resiliency and maintain basin discharge levels while sea levels rise. The SFWMD has developed advanced H&H models to evaluate system operations under changed current and future conditions and recommended infrastructure investments in critical locations. Recent observations and model results show that the S-22 Structure needs adaptation.

The FPLOS Assessment for the C-2 Basin will be available in 2023. A similar study to assess the impacts of SLR at tidal structures was conducted. The Low-lying Tidal Structure Assessment Susceptibility to Sea Level Rise and Storm Surge report models show the level of service of the S-22 structure is equivalent to a 100-year event recurrence interval under current (sea level) conditions. The structure does not meet the design level of service under a 0.5-foot SLR scenario beyond a ten-year event and would not meet the design level of service under a one-foot SLR scenario for all return periods (2yr, 5yr, 10yr, 25yr, 50yr, 100yr).

Enhancing the S-22 Structure will restore discharge capacity by adding a forward pump to convey flood waters when downstream water elevations preclude gravity flow. These modifications will protect flood prone areas within the C-2 Basin (population 289,878). The project will provide 20-40 years of protection against SLR depending on the scenario (NOAA Intermediate Low or NOAA Intermediate High). Peak canal stage can be reduced by 15% by for each 500cfs increase in pump capacity.

The purpose of this project is to build resiliency, restore the design discharge of the S-22 Structure and decrease flood impacts within the C-2 Basin due to sea level rise, climate change and land use changes in the basin. Project conceptual design is finalized. Final design will be based upon simulation of the combined regional and local hydraulic measures in the C-2 Basin. The S-22 structure will be enhanced and hardened by raising the bridge, converting the gate opening system to a more robust mechanism, replacing the existing gates with corrosion resistant stainless-steel gates and increased height, replacing the control building with a hardened and elevated control building, and adding a corrosion control system to the structure. Flood barriers will be constructed around the coastal structure to tie it back to higher land. The design of a forward pump station will be adaptable and will include the ability to easily add additional pumps in the future as environmental conditions change. The proposed design includes pumping capacity of 1000 cfs.

The design life for the facility is 50 years with consideration for mechanical equipment being rehabilitated or replace over the design life. The engines may require at least one major overhaul during the design life while the pump materials will be designed to provide long service life. The structural and architectural design of the pump stations will include elements that will require minimum maintenance and repair over the design life.

The entire population currently living in the C-2 Basin, estimated at 289,878, will directly or indirectly benefit from this project. The number of critical assets vulnerable to flooding under current and future conditions at C-2 Basin are 300. These include faith-based facilities, fire stations, hospitals and medical facilities, law enforcement centers, recreational facilities, and schools. The state's public schools have a vital role in our communities during emergency storm evacuations and post-storm recovery efforts, serving as shelters for displaced residents and emergency response staging areas. Overall flood protection levels of service are expected to increase in the entire basin, as well as water supply protection from saltwater intrusion contamination.

A total cost estimate to harden this Coastal Structure, to address flooding, SLR and other related risks to vulnerable communities in the Basin is presented below. The estimate includes modifications to the existing structure and control building, as well as an additional forward pump. The supplementary pumping capacity will extend the conveyance performance for additional years as sea levels rise, delay out of bank flooding, and reduce canal peak stages. Placeholder funds to tie the structure to higher land elevations and to purchase real estate for the project are included. Negotiations with private property owners for land purchase will initiate upon funding confirmation.

S-22 Cost Estimate

Structure Enhancement	$ 5,997,785
Forward Pump (1000cfs)	$47,625,000
Forward Pump Backup Generator Facility	$ 4,762,500
Structure Tie Back (Flood Barrier)	$ 2,000,000
Design, Implementation & Construction Management	$ 9,057,792
Real Estate	$ 7,000,000
Total	**$76,443,077***
Adjusted 2022 Cost	**$93,803,847**

*May need to be replaced rather than refurbished, costs may be higher.

S-37A Coastal Structure Resiliency

This structure is a reinforced concrete, gated spillway with discharge controlled by two stem-operated, vertical lift gates. The structure has a discharge capacity of 3,890 cfs. Operation of the gates is automatically controlled so that the gate operating system opens or closes the gates in accordance with the operational criteria. The structure is located on C-14, 150 feet east of Dixie Highway and just east of the F.E.C. Railroad. This structure maintains optimum upstream water control stages in C-14; it passes the design flood (40% and 60% of the Standard Project Flood from the western and eastern portions of the drainage basin, respectively) without exceeding the upstream flood design stage, and restricts downstream flood stages and channel velocities to non-damaging levels; and it prevents saltwater intrusion during periods of extreme high tides. S-37A is maintained by the Fort Lauderdale Field Station. A total cost estimate to harden this Coastal Structure, to address flooding, SLR and other related risks to vulnerable communities in the Basin is presented below. The estimate includes modifications to the existing structure and control building, as well as an additional forward pump. The supplementary pumping capacity will extend the conveyance performance for additional years as sea levels rise, delay out of bank flooding, and reduce canal peak stages. Placeholder funds to tie the structure to higher land elevations and to purchase real estate for the project are included. Negotiations with private property owners for land purchase will initiate upon funding confirmation.

S-37A Cost Estimate

Structure Enhancement		$ 6,240,444
Forward Pump (2000 cfs)		$81,761,744.58
Forward Pump Backup Generator Facility		$ 10,453,117
Structure Tie Back (Flood Barrier)		$ 2,000,000
Design, Implementation & Construction Management		$ 15,068,300
Real Estate		$7,000,000
	Total	**$122,523,637**
	Adjusted 2022 Cost	**$ 151,404,547**

G-58 Coastal Structure Resiliency

G-58 is a four-barrel corrugated metal pipe culvert located on Arch Creek immediately downstream from the Florida East Coast Railroad bridge. Features include one 60-inch culvert and three 72-inch culverts. The discharge capacity of this structure is 300 cfs. This structure maintains optimum upstream water control stages in Arch Creek; it passes the design flood (60% of the Standard Project Flood) without exceeding upstream flood design stage; and restricts downstream flood stages and discharge velocities to non-damaging levels; and it prevents saltwater intrusion during periods of extreme high tides. G-58 is serviced by the Miami Field Station.

A total cost estimate to harden this Coastal Structure, to address flooding, SLR and other related risks to vulnerable communities in the Basin is presented below. The estimate includes modifications to the existing structure and control building, as well as an additional forward pump. The supplementary pumping capacity will extend the conveyance performance for additional years as sea levels rise, delay out of bank flooding, and reduce canal peak stages. Placeholder funds to tie the structure to higher land elevations and to purchase real estate for the project are included. Adjacent lands are owned by the State of Florida, which will result in reduced real estate costs.

G-58 Cost Estimate

Structure Enhancement	$ 6,136,884
Forward Pump (75cfs)	$ 4,125,000
Forward Pump Backup Generator Facility	$ 412,500
Structure Tie Back (Flood Barrier)	$ 2,000,000
Design, Implementation & Construction Management	$ 1,901,157
Real Estate	$ 3,000,000
Total	**$17,575,542**
Adjusted 2022 cost	**$21,219,428**

S-123 Coastal Structure Resiliency

S-123 is a fixed crest, reinforced concrete, gated spillway, with discharge controlled by two cable operated, vertical lift gates measuring 12.7 ft. high by 25.0 ft. wide. Discharge capacity at this structure is 2,300 cfs. Operation of the gates is automatically controlled so that the gate hydraulic operating system opens or closes the gates in accordance with the operational criteria. The structure is located near the mouth of C-100 below the junction of C-100, C100A and C-100B and about 600 feet from the shore of Biscayne Bay. This structure maintains optimum water control stages upstream in Canals C-100, C-100A, and C-100B; it passes the design flood (40 percent of the Standard Project Flood) without exceeding upstream flood design stage, and restricts downstream flood stages and discharge velocities to non-damaging levels; and it prevents saltwater intrusion during periods of extreme high tides. The structure is maintained by Miami Field Station.

A total cost estimate to harden this Coastal Structure, to address flooding, SLR and other related risks to vulnerable communities in the Basin is presented below. The estimate includes modifications to the existing structure and control building, as well as an additional forward pump. The supplementary pumping capacity will extend the conveyance performance for additional years as sea levels rise, delay out of bank flooding, and reduce canal peak stages. Placeholder funds to tie the structure to higher land elevations and to purchase real estate for the project are included. Adjacent lands are owned by the State of Florida, which will result in reduced real estate costs.

S-123 Cost Estimate

Structure Enhancement	$ 6,533,070
Forward Pump (1150 cfs)	$55,200,000
Forward Pump Backup Generator Facility	$ 5,520,000
Structure Tie Back (Flood Barrier)	$ 2,000,000
Design, Implementation & Construction Management	$10,387,960
Real Estate	$ 7,000,000
Total	**$86,641,030**
Adjusted 2022 Costs	**$ 106,551,289**

S-20F Coastal Structure Resiliency

Inspection Summary/Issue Identification

FY20 Update to FY15019 – *(Updated 1-31-20)*

S-20F Major Half-Life Refurbishment		**Date: 1-31-2020**
Structure Type: Spillway	Field Station / Contact: Homestead / Sean Smith	**Priority Score: 17.02** **Priority Level: 2**

Inspector Information

Lead Inspector: Tim Kunard	Inspection Date: 1-6-20	Phone: 561-682-6305
Previous Inspection Date: 2-12-15	Previous Inspector: Gary Dunmyer	
F/S Superintendent: Sean Smith Signature:	F/S Bureau Chief: Jesus Carrasco Signature:	

Structure Details

Description:	# Gates	# Pumps	# Barrels	Lifting Mechanism:
Spillway	3	0	0	Hydraulic

Figure 1 – Aerial image of the S20F Structure site

S-20F is a three-bay, reinforced concrete gated spillway, located on the L-31E Levee at its junction with C-103 (Mowry) Canal, about 2,000 feet from the shore of Biscayne Bay and 190 feet east of SW 320th Street, approximately 8.7 miles southeast of the City of Princeton in eastern Miami-Dade County. The structure consists of three 13.0 feet high by 25.0 feet wide gates and has a discharge capacity of 2,900 cfs. Discharge from the structure is controlled by three hydraulically driven cable operated vertical lift gates. The gates can either be remotely operated from the District Control Room or controlled on-site. The S-20F Structure maintains optimum stages upstream along the C-103 Canal. The structure restricts downstream flood stages and discharge velocities to non-damaging levels and prevents saltwater intrusion during periods of extreme high tides. The structure is maintained by the Homestead Field Station.

A total cost estimate to harden this Coastal Structure, to address flooding, SLR and other related risks to vulnerable communities in the Basin is presented below. The estimate includes modifications to the existing structure and control building, as well as an additional forward pump. The supplementary pumping capacity will extend the conveyance performance for additional years as sea levels rise, delay out of bank flooding, and reduce canal peak stages. Placeholder funds to tie the structure to higher land elevations and to purchase real estate for the project are included. Adjacent lands are owned by the United States of America and are part of Biscayne National Park, which will result in reduced real estate costs.

S-20F Cost Estimate

Structure Enhancement	$ 7,312,238
Forward Pump (725 cfs)	$36,975,000
Forward Pump Backup Generator Facility	$ 3,697,500
Structure Tie Back (Flood Barrier)	$ 2,000,000
Design, Implementation & Construction Management	$ 7,497,710
Real Estate	$ 7,000,000
Total	**$64,482,448**
Adjusted 2022 Cost	**$78,853,061**

S-21 Coastal Structure Resiliency

S-21 is a reinforced concrete gated spillway with three cable operated vertical lift gates, located near the mouth of C1 at its junction with L31E and about 3,500 feet from the shore of Biscayne Bay. Each gate measures 10.7 feet high by 27.8 feet wide. The discharge capacity of S-21 is 2,560 cfs. Operation of the gates is automatically controlled so that the hydraulic operating system opens or closes the gates in accordance with the operational criteria. This structure maintains optimum water control stages upstream in C1 and restricts downstream flood stages and discharge velocities to non-damaging levels; and it prevents saltwater intrusion during periods of extreme high tides. The gates can be remotely controlled by either the on-site controls or from the SFWMD Control Room. Operation of the gate is automatically controlled so that the gate opens or closes in accordance with the operational criteria.

A total cost estimate to harden this Coastal Structure, to address flooding, SLR and other related risks to vulnerable communities in the Basin is presented below. The estimate includes modifications to the existing structure and control building, as well as an additional forward pump. The supplementary pumping capacity will extend the conveyance performance for additional years as sea levels rise, delay out of bank flooding, and reduce canal peak stages. Placeholder funds to tie the structure to higher land elevations and to purchase real estate for the project are included. Adjacent lands are owned by Miami-Dade County and are part of a county park, which will result in reduced real estate costs.

S-21 Cost Estimate

Structure Enhancement	$ 7,328,487
Forward Pump (640 cfs)	$32,640,000
Forward Pump Backup Generator Facility	$ 3,264,000
Structure Tie Back (Flood Barrier)	$ 2,000,000
Design, Implementation & Construction Management	$ 6,784,873
Real Estate	$ 7,000,000
Total	**$59,017,360**
Adjusted 2022 Cost	**$72,021,700**

S-21A Coastal Structure Resiliency

S-21A is a reinforced concrete, two-bay, gated spillway located near the mouth of C-102 canal (Princeton) at its junction with the L-31E Levee, about a mile from the shore of Biscayne Bay and immediately east of SW 97th Avenue. The structure consists of two 11.8 feet high by 20.8 feet wide gates and has a discharge capacity of 1300 cfs. The discharge from the structure is controlled by two hydraulically driven cable operated vertical lift gates. The gates can be remotely controlled by either the on-site controls or from the SFWMD Control Room. Operation of the gate is automatically controlled so that the gate opens or closes in accordance with the operational criteria. Upstream of S-21A, the C-102 canal has an open junction with the L-31E canal on its north bank. The southern junction is controlled by a gated project culvert. A new pump station (S-705) is scheduled to be constructed in this junction as part of the Biscayne Bay Coastal Wetlands Project. The structure is maintained by Homestead Field Station.

A total cost estimate to harden this Coastal Structure, to address flooding, SLR and other related risks to vulnerable communities in the Basin is presented below. The estimate includes modifications to the existing structure and control building, as well as an additional forward pump. The supplementary pumping capacity will extend the conveyance performance for additional years as sea levels rise, delay out of bank flooding, and reduce canal peak stages. Placeholder funds to tie the structure to higher land elevations and to purchase real estate for the project are included. Adjacent lands are owned by Miami-Dade County, which will result in reduced real estate costs.

S-21A Cost Estimate

Structure Enhancement	$ 6,288,289
Forward Pump (650 cfs)	$33,150,000
Forward Pump Backup Generator Facility	$ 3,315,000
Structure Tie Back (Flood Barrier)	$ 2,000,000
Design, Implementation & Construction Management	$ 6,712,993
Real Estate	$ 7,000,000
Total	**$58,466,282**
Adjusted 2022 Cost	**$ 71,332,853**

G-93 Coastal Structure Resiliency

G-93 is a two-bay, reinforced concrete gated spillway with two single stem vertical lift gates measuring 5.0 feet high by 10.0 feet wide on the C-3 (Coral Gables) Canal, west of Southwest 57th Ave (Red Road or SR959) in the City of Coral Gables. This structure has a discharge capacity of 640 cfs. The C-3 Canal has an open connection to the C-4 Canal just east of the Palmetto Expressway and continues about 4.1 miles downstream of G-93 through highly urbanized South Miami areas before discharging to Biscayne Bay at Sunrise Harbor. The original structure, G-97, was replaced in January 1990 by G-93. The structure maintains optimum upstream water control stages; it was designed to pass 40% of the Standard Project Flood (SPF) plus a small discharge from the C-4 basin without exceeding upstream flood design stage and restricts downstream flood stages and discharge velocities to non-damaging levels; and it prevents saltwater intrusion during periods of high tides. The structure is maintained by Miami Field Station.

A total cost estimate to harden this Coastal Structure, to address flooding, SLR and other related risks to vulnerable communities in the Basin is presented below. The estimate includes modifications to the existing structure and control building, as well as an additional forward pump. The supplementary pumping capacity will extend the conveyance performance for additional years as sea levels rise, delay out of bank flooding, and reduce canal peak stages. Placeholder funds to tie the structure to higher land elevations and to purchase real estate for the project are included. Adjacent lands are owned by Miami-Dade County and are part of Coral Gables Wayside Park, which will result in reduced real estate costs.

G-93 Cost Estimate

Structure Enhancement	$ 4,231,301
Forward Pump (320 cfs)	$16,960,000
Forward Pump Backup Generator Facility	$ 1,696,000
Structure Tie Back (Flood Barrier)	$ 2,000,000
Design, Implementation & Construction Management	$ 3,733,095
Real Estate	$ 7,000,000
Total	**$35,620,396**
Adjusted 2022 Cost	**$ 42,775,496**

S-25B Coastal Structure Resiliency

S-25B is a two-bay, reinforced concrete gated spillway located in the City of Miami immediately east of the Northwest 42nd Avenue (Le Jeune Road) crossing of the C-4 (Tamiami) Canal, east of Miami International Airport. The structure consists of two 11.9 feet high by 22.8 feet wide gates with a discharge capacity of 2000 cfs. The gates are controlled by two hydraulically driven cable operated vertical lift gate mechanisms. The gates can either be remotely operated from the District Control Room or controlled on-site. Structure S-25B controls flow from the C-4 canal to the Miami Canal downstream of S-26. The structure maintains optimum stages upstream in the C-4 Canal. It was designed to pass 100% of the Standard Project Flood (SPF) for the eastern portion of the C-4 basin without exceeding upstream flood design stage and restricts downstream flood stages and discharge velocities to non-damaging levels; and it prevents saltwater intrusion from the Miami Canal during periods of extreme high tides. This structure also includes a forward pump station. The S-25B Forward Pump station is a reinforced concrete, electric pump station, with discharge controlled by three 200 cfs pumps. These pumps were added to the gravity structure S-25B in 2002 to maintain discharges from the land side to the seaside of the structure when gravity capacity is limited, or the gates need to be closed due to the threat of saltwater intrusion. The pumped water flows into the 120-foot box culvert that runs under and along the edge of a golf course south of the S-25B spillway and discharges downstream (east) of S-25B into the C-4 Canal. The culvert is 10 feet high by 8 feet wide and consists of segmental sections with bell and spigot type connections. The pumps can either be remotely operated from the District Control Room or controlled on-site. This structure is operated in coordination with the adjacent S-25B spillway. The structure is maintained by Miami Field Station.

A total cost estimate to harden this Coastal Structure, to address flooding, SLR and other related risks to vulnerable communities in the Basin is presented below. The estimate includes modifications to the existing structure and control building, as well as an additional forward pump. The supplementary pumping capacity will extend the conveyance performance for additional years as sea levels rise, delay out of bank flooding, and reduce canal peak stages. Placeholder funds to tie the structure to higher land elevations and to purchase real estate for the project are included. Adjacent lands are owned by Miami-Dade County, which will result in reduced real estate costs.

25B Cost Estimate

Structure Enhancement	$ 6,465,811
Forward Pump (1000 cfs)	$48,000,000
Forward Pump Backup Generator Facility	$ 4,800,000
Structure Tie Back (Flood Barrier)	$ 2,000,000
Design, Implementation & Construction Management	$ 9,189,872
Real Estate	$ 7,000,000
Total	**$77,455,683**
Adjusted 2022 Cost	**$ 77,455,683**

G56 Coastal Structure Resiliency

G-56 is a reinforced concrete gated spillway, with discharge controlled by three cable operated, vertical lift gates. This structure has a discharge capacity of 3,760 cfs. The gates are operated on-site or remotely from the District Control Room. The new structure was completed in 1991 to replace the old Deerfield Lock Structure. The structure is located near the mouth of the Hillsboro Canal, about two miles west of Deerfield Beach. This structure maintains optimum water control stages in the Hillsboro Canal. It passes flood flows while limiting the upstream stage, downstream stage and channel velocity. G56 is serviced by the Fort Lauderdale Field Station.

A total cost estimate to harden this Coastal Structure, to address flooding, SLR and other related risks to vulnerable communities in the Basin is presented below. The estimate includes modifications to the existing structure and control building, as well as an additional forward pump. The supplementary pumping capacity will extend the conveyance performance for additional years as sea levels rise, delay out of bank flooding, and reduce canal peak stages. Placeholder funds to tie the structure to higher land elevations and to purchase real estate for the project are included. Negotiations with private property owners for land purchase will initiate upon funding confirmation.

G-56

Structure Enhancement	$ 8,859,342
Forward Pump (1880 cfs)	$90,240,000
Forward Pump Backup Generator Facility	$ 9,024,000
Structure Tie Back (Flood Barrier)	$ 2,000,000
Design, Implementation & Construction Management	$16,518,501
Real Estate	$ 7,000,000
Total	**$133,641,843**
Adjusted 2022 Cost	**$165,302,305**

G-54 Coastal Structure Resiliency

G-54 is a reinforced concrete gated spillway, located on the North New River Canal about 0.9 mile west of the intersection of I-595 and Florida's Turnpike, west of Ft. Lauderdale. The structure consists of three 9.5 feet high by 16 feet wide gates with a discharge capacity of 1,600 cfs. The discharge from this structure is controlled by hydraulically driven cable operated vertical lift gates. The gates can either be remotely operated from the District Control Room or controlled on-site. Construction of G-54 was completed in 1992 to replace the old Sewell Lock Structure. This structure maintains optimum water control stages in the North New River canal. It passes watershed flows or regulatory releases from Water Conservation Area (WCA)-2 while limiting the upstream stage, and channel velocity. G-54 is serviced by the Fort Lauderdale Field Station.

A total cost estimate to harden this Coastal Structure, to address flooding, SLR and other related risks to vulnerable communities in the Basin is presented below. The estimate includes modifications to the existing structure and control building, as well as an additional forward pump. The supplementary pumping capacity will extend the conveyance performance for additional years as sea levels rise, delay out of bank flooding, and reduce canal peak stages. Placeholder funds to tie the structure to higher land elevations and to purchase real estate for the project are included. Negotiations with private property owners for land purchase will initiate upon funding confirmation.

G-54 Cost Estimate

Structure Enhancement	$ 8,023,036
Forward Pump (800 cfs)	$40,000,000
Forward Pump Backup Generator Facility	$ 4,000,000
Structure Tie Back (Flood Barrier)	$ 2,000,000
Design, Implementation & Construction Management	$ 8,103,455
Real Estate	$7,000,000
Total	**$ 69,126,491**
Adjusted 2022 Cost	**$ 84,658,115**

S-25 Coastal Structure Resiliency

S-25 is a single barrel, corrugated metal pipe culvert with a reinforced-concrete headwall and operating platform on the upstream (west) side. The structure is in the C-5 (Comfort) Canal, at the exit ramp from the East-West Dolphin Expressway (SR 836) and the crossing of Northwest 27th Avenue in the City of Miami. The structure consists of one 9.1 feet high by 8.3 feet wide gate with a discharge capacity of 320 cfs. S-25 can either be remotely operated from the District Control Room or controlled on-site. S-25 maintains an optimum upstream stage in C-5 Canal; it was designed to pass 1-in-10 flood without exceeding upstream flood design stage and restricts downstream flood stages and discharge velocities to non-damaging levels; and it prevents saltwater intrusion during periods of extreme high tides. The structure is maintained by Miami Field Station.

A total cost estimate to harden this Coastal Structure, to address flooding, SLR and other related risks to vulnerable communities in the Basin is presented below. The estimate includes modifications to the existing structure and control building, as well as an additional forward pump. The supplementary pumping capacity will extend the conveyance performance for additional years as sea levels rise, delay out of bank flooding, and reduce canal peak stages. Placeholder funds to tie the structure to higher land elevations and to purchase real estate for the project are included. Negotiations with private property owners for land purchase will initiate upon funding confirmation. A portion of the needed property is owned by the Florida Department of Transportation, which may reduce land acquisition costs.

S-25 Cost Estimate

Structure Enhancement	$ 3,695,351
Forward Pump (160 cfs)	$ 8,800,000
Forward Pump Backup Generator Facility	$ 880,000
Structure Tie Back (Flood Barrier)	$ 2,000,000
Design, Implementation & Construction Management	$ 2,306,302
Real Estate	$ 7,000,000
Total	**$24,681,653**
Adjusted 2022 Cost	**$ 29,102,068**

S-33 Coastal Structure Resiliency

S-33 is a reinforced concrete, gated spillway with discharge controlled by a cable operated, vertical lift gate that is 9.0 feet high by 20.0 feet wide. The structure has a discharge capacity of 920 cfs. The gates can be remotely controlled by either the on-site controls or from the SFWMD Control Room. Operation of the gate is automatically controlled so that the gate opens or closes in accordance with the operational criteria. The structure is located on C-12 about 1/2 mile east of State Road 7. This structure maintains optimum upstream water control stages in C-12; it passes the design flood (50% of the Standard Project Flood) without exceeding the upstream flood design stage and restricts downstream flood stages and channel velocities to non-damaging levels, and it prevents saltwater intrusion into the area west of the structure. S-33 is maintained by the Fort Lauderdale Field Station.

A total cost estimate to harden this Coastal Structure, to address flooding, SLR and other related risks to vulnerable communities in the Basin is presented below. The estimate includes modifications to the existing structure and control building, as well as an additional forward pump. The supplementary pumping capacity will extend the conveyance performance for additional years as sea levels rise, delay out of bank flooding, and reduce canal peak stages. Placeholder funds to tie the structure to higher land elevations and to purchase real estate for the project are included. Negotiations with private property owners for land purchase will initiate upon funding confirmation.

S-33 Cost Estimate

Structure Enhancement	$ 4,237,616
Forward Pump (230 cfs)	$12,650,000
Forward Pump Backup Generator Facility	$ 1,265,000
Structure Tie Back (Flood Barrier)	$ 2,000,000
Design, Implementation & Construction Management	$ 3,022,892
Real Estate	$ 7,000,000
Total	**$30,175,508**
Additional 2022 Cost	**$ 35,969,386**

S-20G Coastal Structure Resiliency

S-20G is a reinforced concrete gated spillway located near the mouth of the Military Canal at its junction with the L-31E Levee, about 2,300 feet from the shore of Biscayne Bay. The structure is located immediately north of SW 301 Street, approximately 8 miles east of the City of Homestead in eastern Miami-Dade County. The structure consists of one 12.3 feet high by 25.8 feet wide gate. The discharge capacity of S-20G is 900 cfs. The structure is controlled by a hydraulically driven cable operated vertical lift gate. The gate can either be remotely operated from the District Control Room or controlled on-site. Operation of the gate is automatically controlled so that the hydraulic operating system opens or closes the gate in accordance with the operational criteria. Upstream of S-20G, the Military Canal does not have open junctions with the L-31E levee and both junctions are controlled by gated (flashboard riser) project culverts (L-31E PC-17&18). The northern junction is controlled by Project Culvert L-31E PC-17, which controls flow between the C-102 (S-21A) basin and the Military Canal (S-20G) basin. The southern junction is controlled by Project Culvert L-31E PC-18, which controls flow between the C-103 (S-20F) basin and the Military Canal (S-20G) basin. The structure maintains optimum stages upstream in the Military Canal and restricts downstream flood stages and discharge velocities to non-damaging levels; and it prevents saltwater intrusion during periods of extreme high tides. S-20G is maintained by Homestead Field Station.

A total cost estimate to harden this Coastal Structure, to address flooding, SLR and other related risks to vulnerable communities in the Basin is presented below. The estimate includes modifications to the existing structure and control building, as well as an additional forward pump. The supplementary pumping capacity will extend the conveyance performance for additional years as sea levels rise, delay out of bank flooding, and reduce canal peak stages. The District owns all the adjacent lands, which will eliminate real estate acquisition costs.

S-20G Cost Estimate

Structure Enhancement	$ 4,084,409
Forward Pump (225 cfs)	$12,375,000
Forward Pump Backup Generator Facility	$ 1,237,500
Structure Tie Back (Flood Barrier)	$ 2,000,000
Design, Implementation & Construction Management	$ 2,954,536
Real Estate	$ 7,000,000
Total	**$29,651,445***
Adjusted 2022 Cost	**$35,314,307.76**

*May need to be replaced rather than refurbished, costs may be higher.

S-13 Coastal Structure Resiliency

S-13 is a pump station with a gated spillway that can control flow that bypasses the pumps. The structure is in C-11 (South New River Canal) about 300 feet west of U.S. Highway 441 and 5.5 miles southwest of Fort Lauderdale. It is a reinforced concrete structure with a concrete block superstructure. The pump station has a capacity of 540cfs at a 4-foot static head and is powered by a diesel engine. The gated spillway features a 16-foot wide by 11-foot high vertical lift gate which is raised or lowered by means of stem hoists. Operation of the gate is normally controlled automatically but may be controlled manually during emergencies or for servicing. Other equipment includes a 5-ton manually operated overhead bridge crane for general maintenance. The purpose of the structure is to release flood runoff from, prevent over drainage of, and saltwater intrusion into the agricultural area served by C-11 (South New River Canal) west of the structure. The purpose of the pump station is to pump surplus water through C-11 from the agricultural area west of the structure at a rate of 3/4 inch per day to keep water levels in the canal west of the structure at an optimum water control stages upstream in C-11 East. This structure is maintained by the Fort Lauderdale Field Station.

A total cost estimate to harden this Coastal Structure, to address flooding, SLR and other related risks to vulnerable communities in the Basin is presented below. The estimate includes modifications to the existing structure and control building. The current site contains 3.5 acres. There is no additional room to expand, which will eliminate land acquisition costs.

S-13 Cost Estimate

Structure Enhancement		$32,269,673
Forward Pump	$	-
Forward Pump Backup Generator Facility	$	-
Structure Tie Back (Flood Barrier)		$ 2,000,000
Design, Implementation & Construction Management		$ 5,140,451
Real Estate	$	-
Total		**$39,410,124**
Adjusted 2022 Cost		**$49,262,655**

S-36 Coastal Structure Resiliency

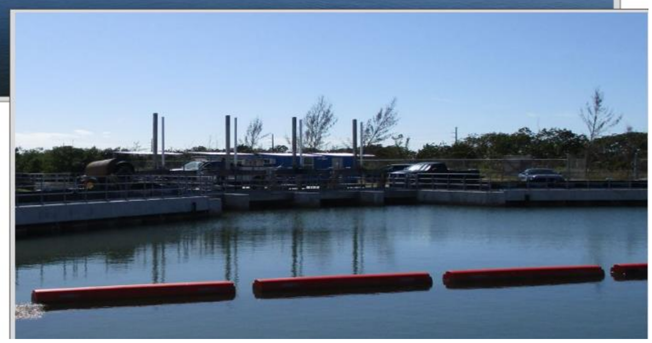
S-36 is a reinforced concrete, gated spillway with discharge controlled by a cable operated, vertical lift gate that is 14.0 ft. high by 25.0 ft. wide. The structure has a discharge capacity of 1,090 cfs. Operation of the gate is automatically controlled so that the gate electric motor opens or closes the gate in accordance with the seasonal operational criteria. The structure is located on C-13 west of Oakland Park. This structure maintains optimum water control stages upstream in C-13; it passes the design flood (50 percent of the Standard Project Flood) without exceeding upstream flood design stage and restricts downstream flood stages and discharge velocities to non-damaging levels; and it prevents saltwater intrusion during periods of extreme high tides. S-36 is maintained by the Fort Lauderdale Field Station.

A total cost estimate to harden this Coastal Structure, to address flooding, SLR and other related risks to vulnerable communities in the Basin is presented below. The estimate includes modifications to the existing structure and control building, as well as an additional forward pump. The supplementary pumping capacity will extend the conveyance performance for additional years as sea levels rise, delay out of bank flooding, and reduce canal peak stages. Placeholder funds to tie the structure to higher land elevations and to purchase real estate for the project are included. Can only expand south into property owned by the City of Oakland Park, which will reduce acquisition costs.

S-36 Cost Estimate

Structure Enhancement	$ 4,619,722
Forward Pump (275 cfs)	$14,442,500
Forward Pump Backup Generator Facility	$ 1,444,250
Structure Tie Back (Flood Barrier)	$ 2,000,000
Design, Implementation & Construction Management	$ 3,375,970
Real Estate	$ 7,000,000
Total	**$32,882,442**
Adjusted 2022 Cost	**$ 39,353,053**

S-197 Coastal Structure Resiliency



S-197 is a four-barrel cast-in-place concrete box culvert with four vertical slide gates measuring 10.0 ft x 10.0 ft. The structure has a discharge capacity of 2,400 cfs. S-197 is located upstream of the mouth of the C-111 about three miles from the shore of Manatee Bay and 750 ft east of U.S. Highway 1. The gates are manually operated by the field station. Real time stage data are available through telemetry. The S-197 maintains optimum water control stages upstream in the C-111 Canal, prevents saltwater intrusion during high tides and blocks reverse flow during storm surges. This structure usually remains closed to divert discharges from S-18C overland to the panhandle of the Everglades National Park. S-197 is opened for flood control when the overland flow capacity, with S-197 closed, is insufficient. This structure is maintained by the Miami Field Station.

A total cost estimate to harden this Coastal Structure, to address flooding, SLR and other related risks to vulnerable communities in the Basin is presented below. The estimate includes modifications to the existing structure and control building, as well as an additional forward pump. The supplementary pumping capacity will extend the conveyance performance for additional years as sea levels rise, delay out of bank flooding, and reduce canal peak stages. Placeholder funds to tie the structure to higher land elevations and to purchase real estate for the project are included. Adjacent lands are owned by the District and Miami-Dade County, which will reduce land acquisition costs.

S-197 Cost Estimate

Structure Enhancement	$ 6,358,509
Forward Pump (600 cfs)	$30,600,000
Forward Pump Backup Generator Facility	$ 3,060,000
Structure Tie Back (Flood Barrier)	$ 2,000,000
Design, Implementation & Construction Management	$ 6,302,776
Real Estate	$ 7,000,000
Total	**$55,321,285**
Adjusted 2022 Cost	**$ 67,401,607**

S-20 Coastal Structure Resiliency

S-20 is a reinforced concrete, gated spillway located on L-31E about three miles from the shore of Biscayne Bay. The structure has a discharge capacity of 450 cfs, with discharge controlled by a cable operated, vertical lift gate that is 11.4 feet high by 16.8 feet long. Operation of the gate is automatically controlled so that the gate's hydraulic operating system opens or closes the gate in accordance with the seasonal operational criteria. This structure maintains optimum water stages in the upstream agricultural area. The structure passes the design flood (40 percent of the Standard Project Flood) without exceeding upstream flood design stage and restricts downstream flood stages and discharge velocities to non-damaging levels. S-20 also prevents saltwater intrusion during periods of extreme high tides. The structure is maintained by the Homestead Field Station.

A total cost estimate to harden this Coastal Structure, to address flooding, SLR and other related risks to vulnerable communities in the Basin is presented below. The estimate includes modifications to the existing structure and control building, as well as an additional forward pump. The supplementary pumping capacity will extend the conveyance performance for additional years as sea levels rise, delay out of bank flooding, and reduce canal peak stages. Placeholder funds to tie the structure to higher land elevations and to purchase real estate for the project are included. Adjacent lands are owned by the District and Florida Power& Light, which may reduce land acquisition costs.

S-20 Cost Estimate

Structure Enhancement	$4,198,152
Forward Pump	$6,187,500
Forward Pump Backup Generator Facility	$618,750
Structure Tie Back (Flood Barrier)	$2,000,000
Design, Implementation & Construction Management	$1,950,660
Real Estate	$7,000,000
Total	**$21,955,062***
Adjusted 2022 Cost	**$ 25,693,828**

*May need to be replaced rather than refurbished, costs may be higher.

Remaining Water Control Structures Resiliency

Additional water control structures are vulnerable to SRL and other changing conditions. As estimated projections are realized into the future, there will be the need to enhance the remaining structures not detailed in this Plan, to increase their resiliency, and maintain operational performance. Figure 35 below illustrate four sea level rise scenarios and inundation levels expected to occur by the end of this century, and the location of critical water control structures that integrate the C&SF System and Big Cypress Basin, in relation to these scenarios.

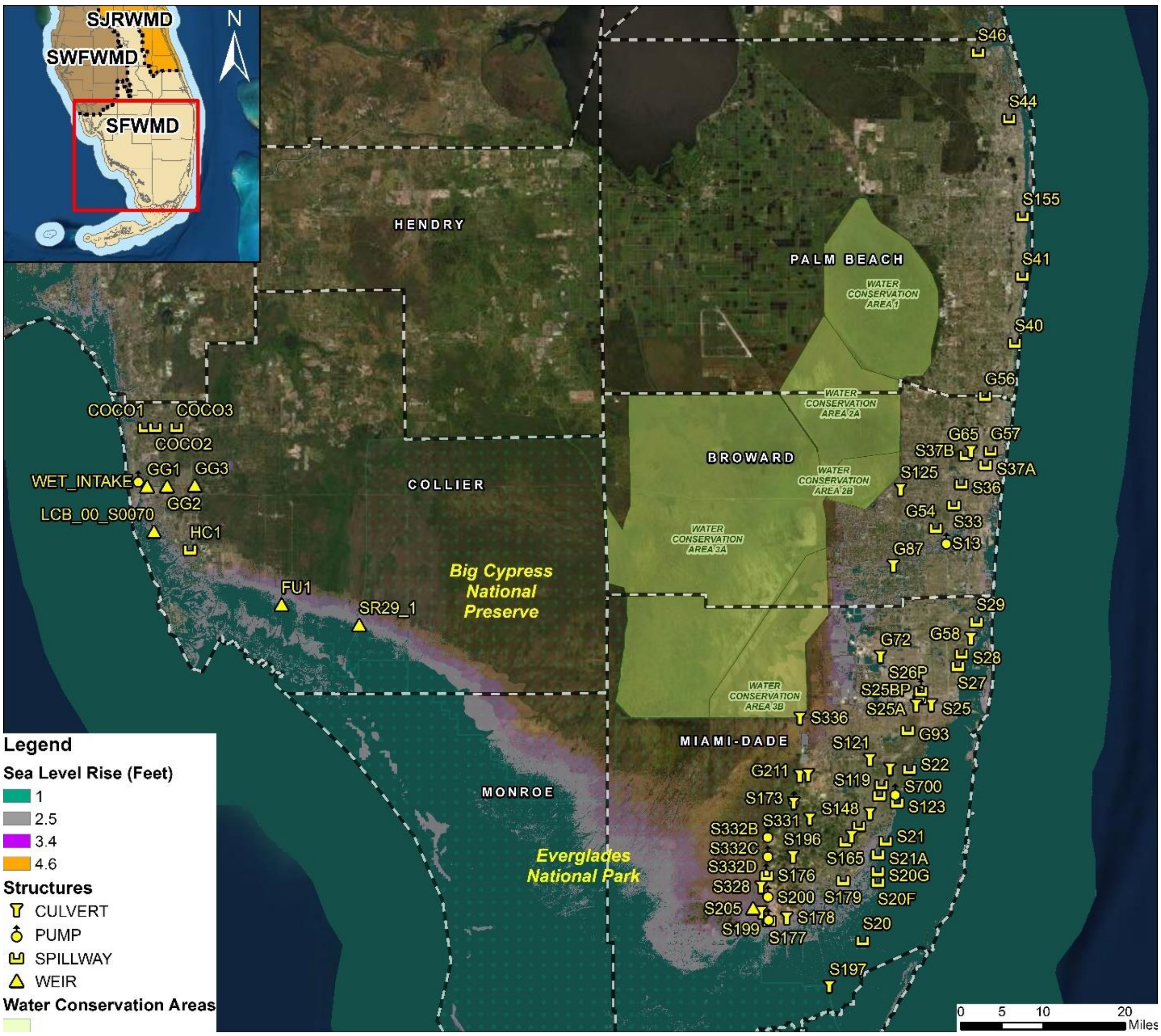


Figure35. Potential impacts of rising sea levels in South Florida to water control structures.

An initial placeholder costs are being proposed for structures identified to be within the inundation scenarios illustrated in the figure above. These structures have not yet been assessed through H&H Models, and it will be refined during future modeling efforts and pre-design stages. The proposed costs are estimated to enhance Coastal Structures identified in Table 9, to address flooding and other related *risks to vulnerable communities at the respective basin level due to land development and changed climate conditions, including sea-level rise. The enhanced structures capacity will extend their performance for additional years as seas rise, delay out of bank flooding, and reduce canal peak stages. These investments will need to be combined with additional upstream and downstream solutions to be characterized as part of FPLOS Phase II Adaptation Strategies, and detailed as part of future design phases.*

Table 9. Remaining Coastal Structures and placeholder costs.

Coastal Structures	Basin Name	Area (Acres)	Structure Enhancement Overall Estimated Costs (Placeholder)
G211	8.5 SQ. MILE AREA	4764.33	$ 34,376,000.00
S119	C-100 WEST	16660.17	$ 34,376,000.00
S148	C-1 WEST	32624.60	$ 34,376,000.00
S155	C-51 EAST	47012.34	$ 34,376,000.00
S165	C-102 WEST	8405.92	$ 34,376,000.00
S178	C-111 AG	17563.47	$ 34,376,000.00
S179	BD-C103 CENTRAL/WEST	22685.71	$ 34,376,000.00
S200	FROG POND DETENTION AREA	1727.37	$ 34,376,000.00
S331	L-31NS	16838.66	$ 34,376,000.00
S332B	NDA	2788.98	$ 34,376,000.00
S332C	SDA	2473.26	$ 34,376,000.00
S332D	S332D DETENTION AREA	3155.06	$ 34,376,000.00
S37B	C-14 WEST	32246.98	$ 34,376,000.00
S40	C-15	39423.02	$ 34,376,000.00
S41	C-16	39812.66	$ 34,376,000.00
S44	C-17	22357.07	$ 34,376,000.00
S46	C-18 / CORBETT	65735.53	$ 34,376,000.00
			$ 34,376,000.00
COCO1	COCOHATCHEE	17628.52919	$ 34,376,000.00
COCO2	COCOHATCHEE	17628.52919	$ 34,376,000.00
COCO3	COCOHATCHEE	17628.52919	$ 34,376,000.00
FU1	BIG CYPRESS BASIN	135740.3529	$ 34,376,000.00
G65	C-14 EAST / C-14 WEST, POMPANO CANAL	36493.85798	$ 34,376,000.00
G72	C-7 / C-6	54651.027	$ 34,376,000.00
G737	FROG POND	1727.365874	$ 34,376,000.00
G87	C-11 EAST / WEST, C-9 EAST / WEST	122772.61089	$ 34,376,000.00
GG1	GOLDEN GATE MAIN	71253.58016	$ 34,376,000.00
GG2	GOLDEN GATE MAIN	71253.58016	$ 34,376,000.00
GG3	GOLDEN GATE MAIN	71253.58016	$ 34,376,000.00
HC1	HENDERSON - BELLE MEADE	47538.70388	$ 34,376,000.00
LCB_00_S0070	EAST NAPLES	7390.151115	$ 34,376,000.00

Coastal Structures	Basin Name	Area (Acres)	Structure Enhancement Overall Estimated Costs (Placeholder)
S118	C-100 WEST	16660.16722	$ 34,376,000.00
S120	C-100 WEST	16660.16722	$ 34,376,000.00
S700	C-100 EAST/ C-100 WEST	25085.83454	$ 34,376,000.00
S125	C-13 WEST, NORTH NEW RIVER CANAL WEST	33206.587	$ 34,376,000.00
S149	C-1 WEST	32624.5955	$ 34,376,000.00
			$ 34,376,000.00
S195	C-102 WEST	8405.921685	$ 34,376,000.00
S173	L-31NS, L-31 N CC	16923.28842	$ 34,376,000.00
S176	L-31NS	16838.65942	$ 34,376,000.00
S177	C-111 AG	17563.46884	$ 34,376,000.00
S199	C-111 AG	17563.46884	$ 34,376,000.00
S194	C-31NS, C-102 EAST / C-102 WEST	31884.239	$ 34,376,000.00
S196	L-31NS, BD-C103 CENTRAL / WEST, BD-C103 EAST, NO-CANAL	46488.84507	$ 34,376,000.00
S121	C-2	33654.88486	$ 34,376,000.00
S205	S332D DETENTION AREA	3155.062	$ 34,376,000.00
S328	S332D DETENTION AREA	3155.061629	$ 34,376,000.00
S205	S332D DETENTION AREA	3155.061629	$ 34,376,000.00
S33	C-12W	4780.585242	$ 34,376,000.00
S173	L-31N CC	84.628584	$ 34,376,000.00
S336	L-29 CC	225.026396	$ 34,376,000.00
S338	L-29 CC, C-1 EAST / C-1 WEST	38089.795396	$ 34,376,000.00
S125	C-13 WEST	15322.8794	$ 34,376,000.00
S700	C-100 EAST / C-100 WEST	25085.83454	$ 34,376,000.00
S79, S79_LOCK	WEST CALOOSAHATCHEE	349589.7829	$ 34,376,000.00
SR29_1	BARRON RIVER	29690.7493	$ 34,376,000.00
		TOTAL	**$ 1,890,680,000.00**

Additional projects costs detailed below were estimated for project recommendations from FPLOS Phase I Studies, as summarized in Appendix A.

Self-Preservation Mode at Critical Structures, Coastal Structures Enhancement and Storm Surge Protection

Implementation of self-preservation mode at water control structures means building or retrofitting structures with systems that make the structure and is operation more resilient. A self-preservation mode system includes a backup system that can be programed to operate the structure appropriately and independently, without the direct control of water managers. Adding self-preservation mode capabilities to critical water control structures will allow water managers to manage the system for flood control, water supply, environmental restoration, and saltwater intrusion prevention even when communication with the structure is lost due to weather or other circumstances.

Currently, in advance of storm onslaught, storm surge modeling predictions are compared to the finished floor elevations of the coastal structures to determine which finished floor elevations are below the predicted surge elevation. District staff then disable the power and back-up generator with the structure gates fully open to avoid permanent damage to the electrical system which could occur if the structure were energized during the predicted storm surge event. This so-called “structure lockout” is performed with the gates open to reduce the risk of damage to the structure and so that storm generated runoff can pass through the structure even if the gates are no longer operational. However, this procedure also allows smaller storm surge events to pass through the structure and propagate upstream when it could have potentially been blocked by closing the gates.

Manually operated structures require that decisions to release water be made long before storm impacts affect a given area. Water releases from non-automated structures must be done while it is safe for staff to visit the site to implement pre-storm operations. Automated structures allow water managers to delay water releases until they are warranted, which can help to avoid over-draining the area upstream, particularly when storm conditions do not occur as originally predicted. Structures with self-preservation mode capabilities can mitigate the consequences of a change in a storm’s path because they allow more flexible operational strategies. Structures with self-preservation mode capabilities can preserve environmentally sensitive lands and prevent damage to stormwater treatment areas, caused by over-draining the area unnecessarily. Structures with self-preservation mode capabilities can also help avoid prolonged drought conditions that can occur when water is released late in the wet season in anticipation of a storm that does not materialize.

Once self-preservation features are added to critical structures, gates will continue to be operable during the initial onslaught of the storm, well after it is no longer safe for personnel to travel to the site to manually disable the power and backup generator. Additionally, adding an independent system override to the gate controls and/or a pre-hurricane-initiated program to the local Remote Terminal Unit (RTU) and/or Backup Controller (BUC) so that the structure will operate as desired even if communications are lost. For example, if tailwater stage reaches a specific pre-determined high elevation, the structure will shut itself off by going into a lockdown mode that first opens all gates and then shuts off commercial power and disables the generator.

SELF-PRESERVATION MODE FOR COMBATTING STORM SURGE DAMAGES AND SALTWATER INTRUSION AT COASTAL WATER CONTROL STRUCTURES

- MAXIMIZING THE OPERATIONAL CAPACITY AT CRITICAL WATER CONTROL STRUCTURES
- DETERMINATION OF ELEVATION TO EXTEND GATES TO PREVENT REVERSE FLOW DURING A NON-STORM RELATED EXTREME HIGH TIDE OR MINOR STORM
- OPTIMIZING THE TIME TO OPEN AND CLOSE GATES BEFORE STORM SURGE INUNDATES CRITICAL EQUIPMENT AND/OR CAUSES THE STRUCTURE TO FAIL
- AVOIDING UNNECESSARY LOCKOUTS

The coastal structures were originally intended to provide a barrier to reduce saltwater intrusion without increasing flood risk from rainfall in the basin. They were not designed to provide robust storm surge protection; however, some surge protection can be achieved during less significant events. Therefore, the ability to operate structure gates for an extended period into a storm event is desirable. In many cases, the tops of structure gates can be extended to maximize the ability to protect against storm surge. The elevation for self-preservation mode to begin the lockdown procedure should be higher than a non-storm related extreme high tide which may already result in reverse flow over the closed gates, but low enough to allow time for all gates to open fully before the storm surge inundates critical equipment that could fail due to pressure on closed gates. The infrastructure to accomplish this must be hardened such that it is not susceptible to damage from windblown debris and/or storm surge. The lockdown would be lifted manually by District staff sent to the site to evaluate any damage to the mechanical and electrical systems after the all-clear has been issued after a storm event. Like the current pre-storm lockdown, after the storm has passed, if damage has occurred the gates would remain open or be operated by alternate means (portable generator, crane, other temporary measures) until repairs have been completed.

The District will prioritize the implementation of a self-preservation mode system that will enhance electrical components and sensors in critical coastal structures to maximize our operational capacity and minimize the time gates need to be locked in the open position, given anticipated storm surge scenarios.

Considering recently observed and projected increases in frequent storm surge/ high tailwater conditions, maximizing operational flexibility of coastal structures is necessary for optimal flood control and prevention of saltwater intrusion. Implementing self-preservation mode infrastructure is a relatively inexpensive investment that can pay dividends. The majority of District controlled structures already have backup generators (the most expensive component) and therefore they only need automation components such as hardened sensors, communication equipment and computer systems added.

Other strategies that the District considers to be related to the self-preservation concept include maximizing the operation of secondary flood control system, increasing the ability to transfer water between basins and also optimizing the operation of stormwater treatment areas (STAs) and enhancing automation so that drawdowns can be avoided when not necessary.

STAs depend on certain hydrologic conditions (water levels) to optimize nutrient removal, because aquatic plants require a certain water level range to grow and thrive. When the water level in an STA is kept within the optimal range, the STA can operate most efficiently. Drastic changes in water level can severely impact the efficiency of an STA and can even cause aquatic vegetation to die, thus turning an STA into a nutrient source instead of a nutrient sink. Adding remote control and automation to the pump stations that control water levels in STAs helps to ensure that water levels are kept at their optimal range even when a power failure occurs at the pump station and avoid unnecessary drawdown operations when storm prediction is highly uncertain.

Maximizing the operation of secondary flood control system is another way to increase the resiliency of the C&SF System. For instance, the primary system (C&SF Project) may be operating at maximum efficiency, but if a secondary water control structure is clogged with debris or has suffered a power outage, flooding upstream of the secondary structure can occur. The District is committed to partnering with the entities that operate secondary water control systems to make modifications to the secondary systems that increase resiliency of the entire flood control system.

Another strategy that is promising for making the C&SF Project more resilient is increasing connectivity between basins. Having the ability to move water from a flooded basin to an adjacent basin that can handle additional water could be a very effective tool that does not require discharging to tide. With increased connectivity between basins, water managers could have powerful additional tools for operating the system to optimize flood control efforts.

Table 10 summarizes the self-preservation actions needed, at each prioritized C&SF structure, and initial estimated costs to implement additional programming costs, and backup controller instrument and platform; install backup controller and other automation features; modify gates for added high tide protection against reverse flow, according to the number of gates in each selected coastal structure; modify structure by adding seals and additional needs.

Table 10. Modifications and costs needed to harden coastal structures

ID	Name	Additional Programming; Storm Resilient Back Up Controller instrument and platform	Install Backup Controller and other automation features	Modify gates for added high tide protection against reverse flow	Modify Structure by adding seals*	Control Panel Upgrades / Hardening
1	S-123 (2)	$150,000.00		$100,000.00	$50,000.00	
2	S-22 (2)	$150,000.00		$100,000.00		
3	S-27 (2)	$150,000.00		*4		
4	S-28 (2)	$150,000.00		*4		
5	S-21 (3)	$150,000.00		$150,000.00	$75,000.00	
6	S-25 (1)	$150,000.00		$50,000.00		
7	S-20 (1)	$150,000.00		$50,000.00		
8	S-20F (3)	$150,000.00		$150,000.00		
9	S-20G (1)	$150,000.00		$50,000.00		
10	S-21A (2)	$150,000.00		$100,000.00		
11	S-25B (2)	$150,000.00		$100,000.00		
12	S-26 (2)	$150,000.00		$100,000.00		
13	S-29 (2)	$150,000.00		*4		
14	S-197 (4)	$25,000.00				
15	G-56 (3)	$150,000.00		$150,000.00		
16	COCO1		$175,000.00			
17	GG-1		$175,000.00			
18	HC1		$175,000.00			
19	COCO2		$175,000.00			
20	GG2		$175,000.00			
21	COCO3		$175,000.00			
22	GG3		$175,000.00			
23	S487, S486, S488					$3,050,000.00
24	G-420					$600,000.00
25	G-57, S-381					$300,000.00
26	Manatee Gates*2					$5,000,000.00
27	S140, S7					$1,000,000.00
28	S-179*3					$500,000.00

** This option will replace the need for raising the heights*

*2 G-36, S-127, S-131, S-33, G-93, S-123, S-22, S-25, S-25B, S-26, S-27, S-28, S-29, S-20F, S-20G, S-21, S-21A

*3 *Gate Hoist Conversion*

*4 *Gates modifications are included in the major refurbishment proposals for these Coastal Structures*

JW Corbett Wildlife Management Area Hydrologic Restoration and Levee Resiliency

Background

In August of 2012, Tropical Storm Isaac brought unprecedented rainfall to areas of central Palm Beach County resulting in widespread flooding in the area. As part of the State's response to the Storm, the Indian Trail Improvement District's (ITID) Corbett Levee was identified as an area of critical concern for berm failure due to localized slope failures, excessive seepage, and the formation of boils (seepage pathways). In September 2012, the SFWMD was directed by the Governor's Office to immediately convene a multi-agency working group to develop a plan for strengthening the Corbett Levee to meet current USACE and South Florida Water Management District standards and to increase the level of flood protection in the area for over 40,000 residents. The project was designed and constructed by the District following the latest engineering and construction technologies. The first phase of the project included building 2.6 miles of levee to the east of the ITID Reservoir. However, the eastern section of levee remains unfinished due to lack of funding. Therefore, the project is currently not meeting its full flood protection and habitat enhancement potential.

Corbett Wildlife Management Area

Corbett Wildlife Management Area (Corbett WMA), upstream of the Levee, consists of approximately 60,000 acres of cypress swamp, pine flatwoods, sawgrass marsh, and hardwood hammocks adjacent to the L-8 canal and upstream of the C-51 canal. The Corbett WMA is home many wildlife species, including deer, turkey, and feral hogs that draw hunters as well as threatened and endangered species like the red-cockaded woodpecker, Everglade snail kite, gopher tortoise, and indigo snake. Other notable species that are frequently encountered include bobcat, sandhill crane and numerous wading birds and waterfowl.

The Corbett WMA has been held at artificially low water levels for years, resulting in fish and wildlife habitat loss. Additionally, holding water levels at lower elevations requires increased discharge of stormwater into the regional system, thereby diminishing the capacity for flood control in areas adjacent to and downstream of the Corbett WMA. Completion of construction of the Corbett Levee would allow water managers to restore a more natural hydroperiod and therefore improve wildlife habitat within the Corbett WMA while simultaneously increasing the resilience, storage capacity and functionality of the flood control system. This is particularly beneficial to create wildlife corridors and habitat connectivity within the C-18 Basin and nearby areas close to lake Okeechobee.

Loxahatchee River Watershed Restoration Project

The Loxahatchee River Watershed Restoration Project (LRWRP) will restore 10,000 acres of existing disturbed wetlands in the J.W. Corbett Wildlife Management Area (WMA), Loxahatchee Slough, Pal-Mar East, Cypress Creek Natural Area and Kitching Creek. Specifically, the LRWRP will restore 1,642 acres of wetlands within the J.W. Corbett WMA.

Completion of the Corbett Levee will provide flood protection to adjacent residential communities and ecological benefits that are consistent with the planning objectives of the LRWRP. The planning objectives include restoring water flows to the National Wild and Scenic Northwest Fork of the Loxahatchee River, increasing the natural area extent of wetlands within the watershed, restoring connections between natural areas to improve hydrology and natural storage, and restoring native plant and animal abundance and diversity within the natural areas of the Loxahatchee River Watershed.

The Corbett Levee will retain additional freshwater within the J.W. Corbett WMA that can be used to supplement the C-18W Reservoir and ASR well system to provide additional flow to the Loxahatchee River. The Corbett Levee will also enhance storage capacity in J.W. Corbett WMA, which will improve hydroperiods for wetland communities. An improved hydroperiod will benefit wetland habitat and function, which further strengthens the connectivity between adjacent natural areas within the LRWRP.

Flood Protection

In addition, the completion of this project will address excess flooding due to the impacts of climate change such as an increase in the number and intensity of tropical cyclones. The urban areas adjacent to the Corbett Levee highly rely on the ability of the inner canal system to drain water to the M-O canal. Flooding conditions as a result of channel overbank flow diminish the drainage capacity of the system, exacerbating flood inundation depth and extent across the basin. For instance, rainfall impacts from Tropical Storm Isaac were well beyond the design capacity of the berm that existed prior to the construction of the Corbett Levee. Finishing this project would increase the District's operational flexibility and therefore improve the system's resiliency to flooding.

The proposed final section of levee is approximately three miles long. In addition, the project proposes the concurrent construction of a 0.6 N/S levee portion, that is part of the CERP Loxahatchee Project - C18-W Impoundment Project (L-101W, 0.6 mile segment from the east end of ITID's M-O Canal to 100th Ln North) to allow full operational change to JW Corbett WMA. Total project costs below include the 0.6 mile segment, which will be built as a separate project. Without the north south segment the operational changes to Southeast JW Corbett WMA will be limited.

Bahiagrass Pilot Study

Landscape turf represents a major draw on Florida's water resources, and it requires intensive maintenance such as mowing and fertilization. Bahiagrass requires very little supplemental irrigation and fertilization. This proposed pilot study would be located on the Corbett Levee. The goals of the study are:

- Retain the persistence and resilient nature of bahiagrass
- Improve color and density of bahiagrass to increase its utilization in landscapes and therefore reduce the need for fertilization and irrigation
- Increased seed yield during fewer months of the year to increase seed production and reduce the price of seed
- Reduce the rate of leaf elongation to reduce the need for mowing
- Produce seed heads only in June, July, and August to concentrate seed production times and reduce the need for mowing

To accomplish these goals, both traditional methods of plant breeding and more advanced genetic technologies/gene editing would be used.

Amount	Description of Annual Activity
$13,000,000	Construction

L-31E Levee Improvements

The proposed strategy consists of enhancement of the L-31E Levee. Addressing coastal structures vulnerability to SLR and storm surge is a high priority in South Florida. Funding will be used harden L-31E Levee, a component of the 72-year-old Central and Southern Florida Project, to address storm surge risks and SLR vulnerability. The L-31E Levee is one of the priority projects on the District's CIP list.

Funds are needed to advance resiliency strategies to reduce vulnerability of communities upstream of the L-31E Levee. Future modeling efforts will determine additional resiliency needs at other levee structures, based on the determination of what cross sectional change that a vulnerable levee would need to provide more protection from storm surge and SLR.

L-31E Levee Storm Surge Study

A storm surge study was performed on the L-31E Levee to determine the level of resiliency of the levee as it currently exists as well as to determine the levee crest elevation required to effectively counteract sea level rise and storm surge. The study was performed using a combination of ADCRIC/SWAN and Delft3D models of Biscayne Bay, information from previous studies, and using the FEMA/Taylor Engineering study of 391 synthetic storms. The L-31E Levee has six concrete spillway structures and twelve culverts. The following modeling scenarios were run as part of the storm surge study:

- No Levee and Present-day sea level
- Existing Levee Crest with open gates and present-day sea level
- Existing levee crest with closed gates and present-day sea level
- Non-overtopping levee with closed gates and present-day sea level
- Non-overtopping levee with closed gates and Sea Level Rise (SLR) + 1 foot
- Non-overtopping levee with closed gates and Sea Level Rise (SLR) + 2 foot
- Non-overtopping levee with closed gates and Sea Level Rise (SLR) + 3 foot

The study recommendations are summarized as follows:

1) Start planning and define goals for the levee, integrated with additional efforts being advanced in the region, including:
    a. Return period, time horizon, sea level
2) Start design considerations using the following:
    a. 100-year surge elevation
    b. Non-overtopping levee simulation
    c. Present-day and Future sea level scenarios, starting at a 2ft increase
    d. Add freeboard according to FEMA and USACE guidance

3) Gate opening has negligible impact on crest elevation
4) Edge effects need to be evaluated
5) Take in consideration wave overtopping, and inland drainage

The next steps will be to draft a Project Definition Report (PDR) and Work Order Scope of Work (SOW) to request the design of an increased levee crest elevation to at least four feet along the entire levee based on the chart in figure 36. The 100-year return period will be the target plus an additional two feet per FEMA to get the levee certified. The current FEMA maps underpredict surge because the L-31E levee was neglected: the L-31E Levee adds approximately two feet to the 25-year surge and more than one foot to the 100-year surge. The L-31E Levee as-builts suggest that the levee was built with an average crest elevation of 7.5ft NGVD 29. We are proposing to raise the levee two feet from current average elevation and another two feet per FEMA requirements above the 100-year return period. A rough estimate projected that approximately between $39M to $45M will achieve this design goal. Final design plans will provide the final recommended elevation, which might differ from the recent Study recommendation, as well as additional project features. A PDR will be developed with collaboration between the Engineering and Construction Bureau and the Resiliency Team to determine the most effective scope of work to bring the levee to a robust resiliency level for future generations. The remaining studies and the design of the levee crest elevation will be performed by a consultant.

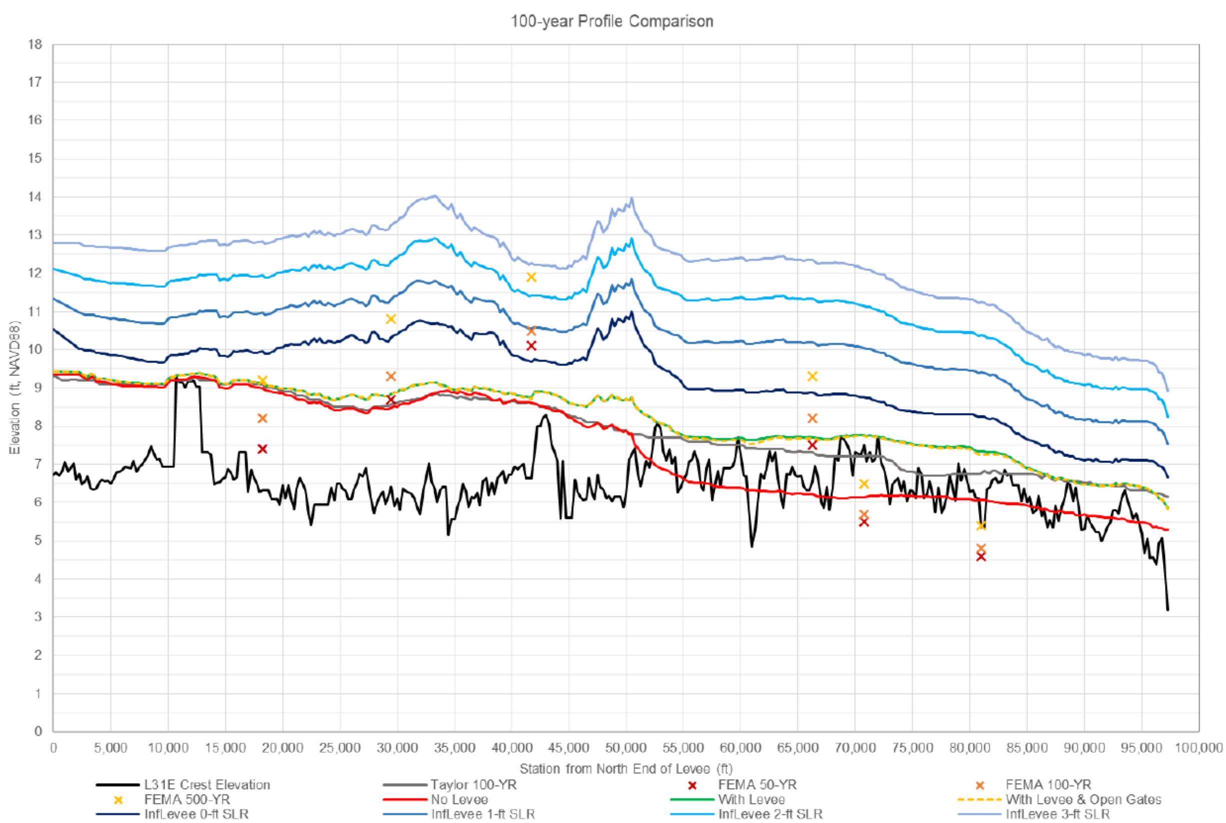


Figure36. 100-Year Profile for Levee Crest Elevation Consideration.

Areas of Influence

The area of influence on the south and west side of the levee is agricultural land that will need protection during storm surge and sea level rise. Going north along the levee, the Homestead Air Reserve Base is an area of influence that will need protection during storm surge and sea level rise. Further North is mostly residential areas and they also will need protection, however, in that area of influence the impact will be major when it comes to raising the levee crest elevation as the levee elevation coincides with the actual road. One possible solution might be to decommission two to four miles of the levee in that area. These areas of influence are depicted with the red diamonds in Figure 37 below. The following canals will also be affected by the levee under sea level rise: C-103, G95, C102 and C-1 since they drain the inland areas west of the levee. All these areas of influence will need to be examined closely in the additional modeling that will need to be performed to successfully design a levee crest elevation increase.

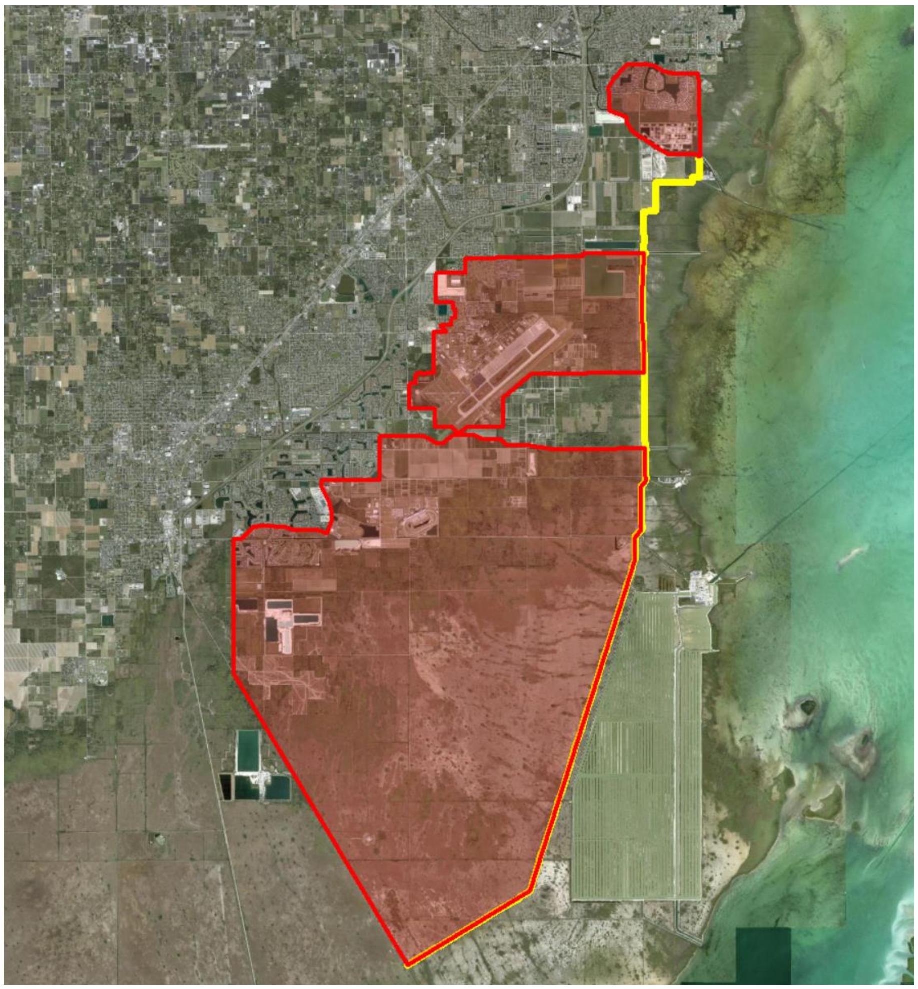


Figure 16. Location of L31E Levee (yellow) and area of influence (red).

Amount	Description of Annual Activity
$39M - $45M	Design, Permitting and Construction

Everglades Mangrove Migration Assessment (EMMA) Pilot Study: Directing Coastal Resilience

EMMA is designed to capture the adaptive foundational resilience of the coastal wetlands within the SFWMD, with an emphasis on nutrient depleted mangroves. By adaptive we mean that this resiliency project will demonstrate the ability of coastal wetlands to adapt to rising sea levels via enhanced soil elevation change. This pilot study will evaluate and implement the ability of coastal communities to shift to foundational plant communities that are more resilient to higher water depths and salinities, which in turn, are able to accrete more peat, capture more sediments, sequester more carbon and keep up with SLR. This is a foundational project because it is focused on the plant communities such as mangrove swamps and sawgrass plains, that are endemic to the historic and extant ecology of Florida. Resilience is the ability of the foundational communities to shift rates of productivity, community structure and spatial extent, in the face of SLR, to minimize wetland conversion to open water habitats and maximize shoreline retention. EMMA is focused upon the hydrologic attributes needed to enhance, restore and preserve wetland function and extent, and as such, has direct relevance to water management, hydrological models, planning and decision making.

EMMA is a large-scale, landscape field manipulation of sediment and dredge material, with the potential to be incorporated into the USACE Beneficial Use Program (The Role of the Federal Standard in the Beneficial Use of Dredged Material from U.S. Army Corps of Engineers New and Maintenance Navigation Projects (PDF)), in the scrub mangrove ecosystem of the Model Lands, which is owned by Miami Dade County, and is not subject to the WQ or soil nutrient constraints associated with the Everglades Forever Act. Results of EMMA will have implications for and application to all coastal wetlands of Florida that are vulnerable to SLR.

EMMA would take advantage of the new Thin Layer Placement (TLP) technology associated with distributing dredge spoil across an existing wetland to add elevation and, when needed, additional soil phosphorus (Berkowitz et al. 2019, VanZomeren et al. 2018). Beneficial uses of dredged material such as TLP will build landscape resiliency by improving soil aeration in the root zone, thereby increasing redox potentials (Eh), plant productivity, soil accretion, and by supplying a medium for greater carbon sequestration, which allows coastal wetlands to keep pace with SLR (DeLaune et al 1990, Baustian et al 2015).

Goals and Objectives

Changes in water management in concert with SLR, has caused coastal wetlands to subside, tidal creeks to fill in (Meeder et al 2018)), peat to collapse (Wilson et al 2019), and plant communities to shift to slow growing, transgressive, open water habitats (Meeder et al, 2018)). Peat collapse causes rapid declines in soil surface elevation (Chambers et al. 2019), converting wetlands in a vegetated state to an open water state (Cahoon et al. 2003; McKee et al. 2011; Baustian et al. 2012; Voss et al. 2013; Wilson 2018). In South Florida, peat collapse has been observed in sawgrass (*Cladium jamaicense*) peat marshes and coastal mangroves, which are highly organic (>85%), and depend on inputs of organic material to maintain and raise soil elevation, as they receive little inorganic sediment input (Rejmankova and Macek 2008, Chambers et al 2019). Since changes in soil surface elevation in mangrove and sawgrass peat marshes is largely a function of primary productivity, there is growing concern that saltwater intrusion will increase coastal marsh degradation.

Without intervention, the current trajectory of SLR will result in significant land loss and loss of stormwater protection. Intervention that promotes accretion rates that act to maintain or outpace SLR in key coastal communities (e.g. those adjacent to historic tidal creeks) will result in a myriad of ecosystem and socio-economic benefits. The goal of this Pilot is to advance our understanding of biological vs. physical controls on the capacity of coastal wetlands to persist under increased SLR. Our objectives are to:

1. Develop demonstration scale evidence that supports managed wetland transgression to include sediment augmentation via a TLP strategy.
2. Evaluate the adaptive resilience of coastal mangroves to phosphorus enrichment in combination with enhanced soil elevations.

Study Design

The study will consist of three assessment locations (Figure 38) – the Charly Site located on the southeastern tip of the C-111 canal, the Pocket Site located along the C-111 just west of the S-197 structure, and the Baby EMMA Site located just west of US-1 and north of the C-111 canal. Peat accumulation and mangrove plant growth will be measured along transects that have been elevated by TLP in comparison to mangroves that have been locally spiked with elevated phosphorus. The multifactorial design (Figures 39-41) will divide each transect into control transects and TLP treatment transects to document costs and benefits of TLP and help establish the protocols for effective beneficial use of dredge materials in coastal habitats. Project implementation monitoring, as detailed below, will be conducted to measure changes in soil surface elevation, quantify belowground and aboveground biomass production, and track observable changes in water quality and exchange fluxes between surface water and groundwater in the spaces between sediments – inside and outside of the study area. It should be noted that all EMMA sites will have special sediment capture fences in place to retain sediments and prevent downstream turbidity plumes.

Figure 38. EMMA Assessment Locations (From left to right: Charly Site, Pocket Site, and Baby EMMA Site)

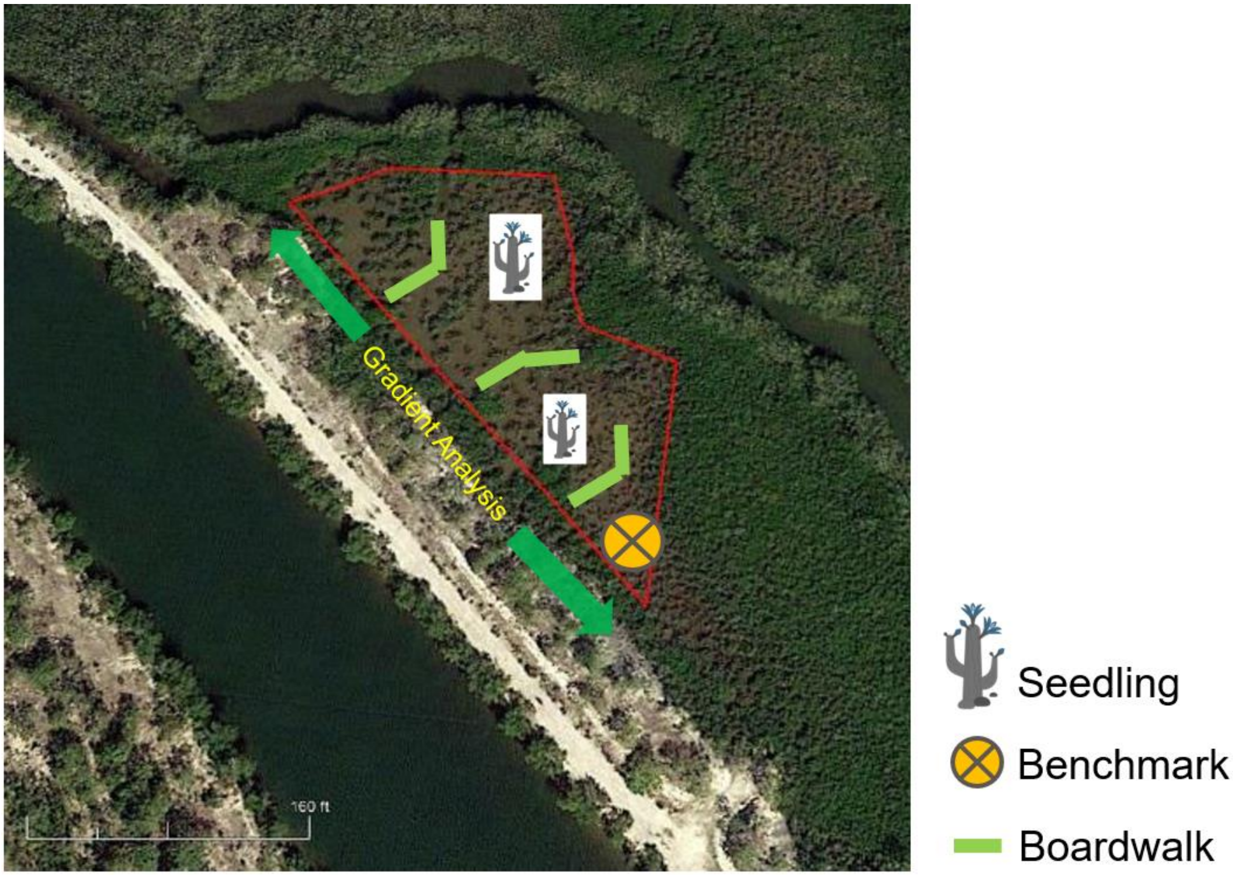


Figure 39. Pocket Site study desing.

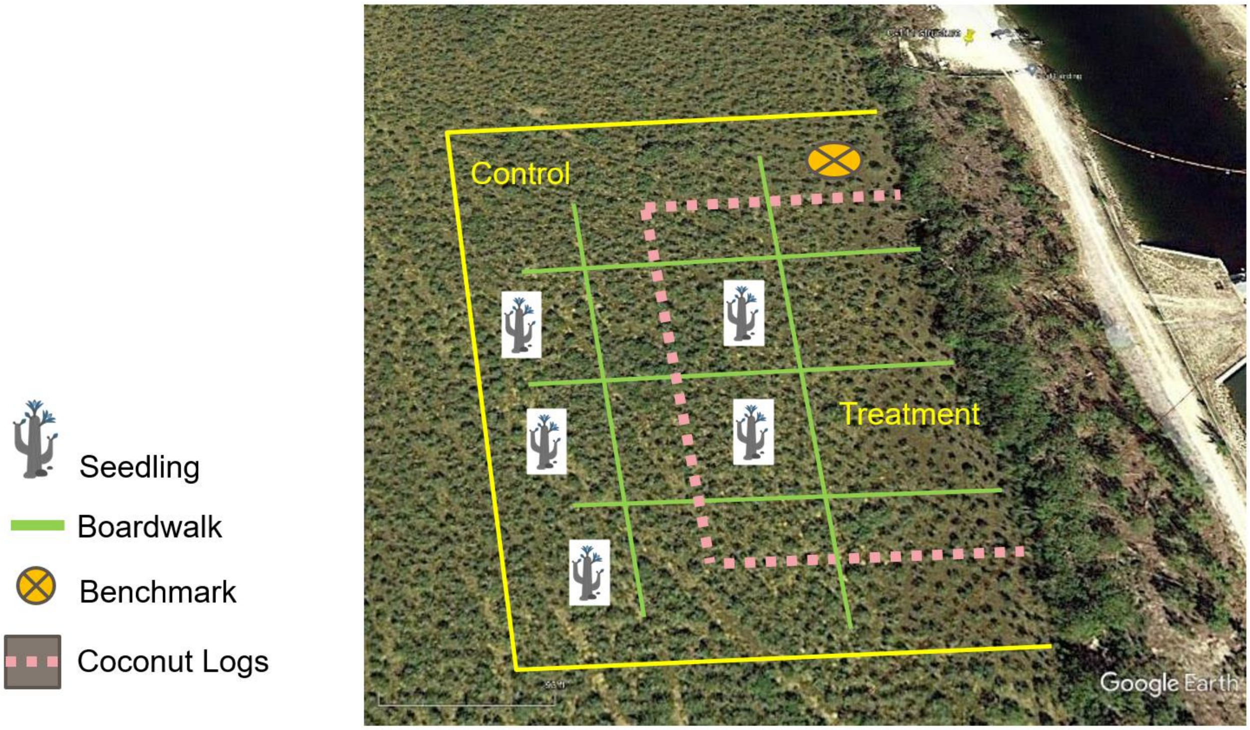


Figure 40. Pocket Site study design.

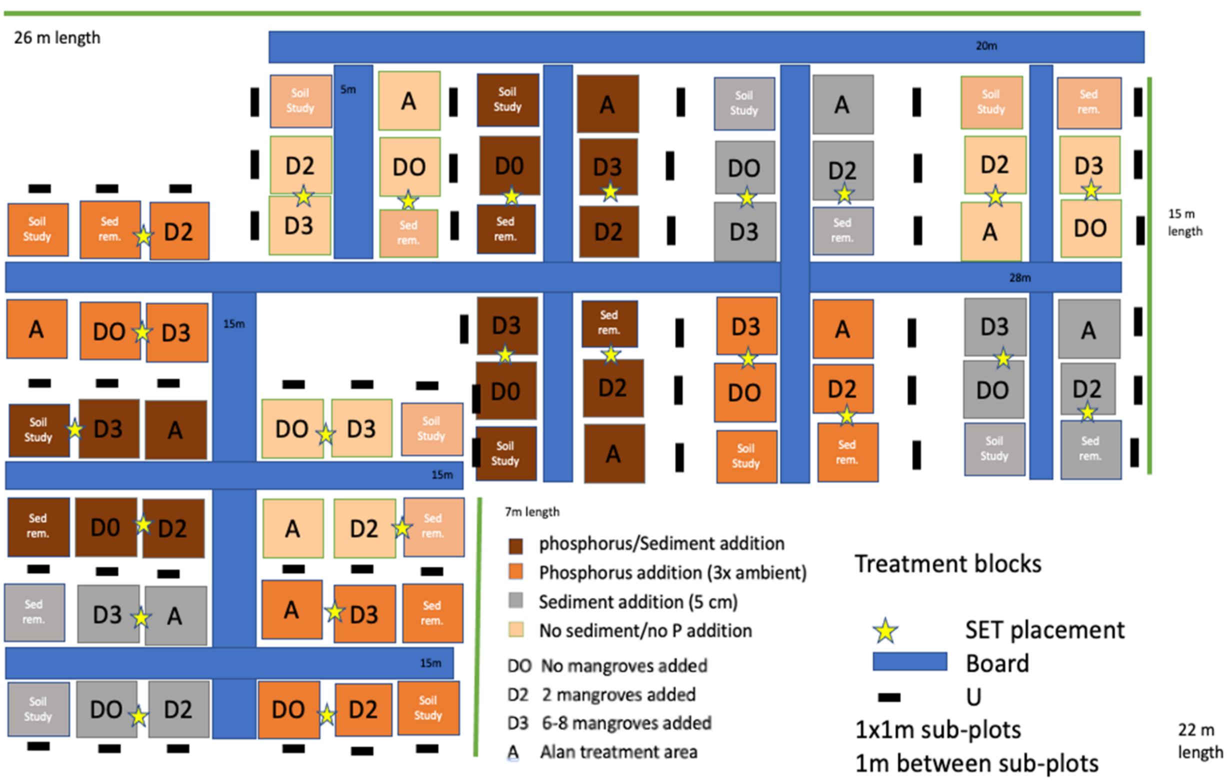


Figure 41 Baby EMMA study design.

Permanent Benchmarks and Soil Elevation Surveys

Permanent benchmarks will need to be installed in and around the study area to preserve relevance to SL and SLR. Six Class "B" (Stainless Steel rod driven to refusal) NGS stability standard monuments will be established. The work will include, but not limited to, processing the data, Quality Assurance, describing, typing, and reconnaissance. If no published NGVD 29 elevations were available at the site, NGVD 29 elevations will be derived from the NAVD 88 elevations by means of applying a site-wide, uniform datum shift, or offset value, of -0.456 meter (-1.496 feet). The sense of the algebraic sign of this value is NAVD 88 elevation minus NGVD 29 elevation. This value will be obtained from the NGS VERTCON model and was computed by both the NGS VERTCON Online web site (*http://www.ngs.noaa.gov/TOOLS/Vertcon/vertcon.html*, accessed May 2007, version 2.0) and by means of the software CORPSCON version 6.0.1 (which itself uses the NGS-developed VERTCON software).

The horizontal datum for this survey will be the North American Datum of 1983 (NAD 83). Soil Elevation surveys will be conducted using real-time kinematics referenced to the 1988 North American Vertical Datum (NAVD88) with Trimble R8 global navigation satellite system receiver equipment (Trimble Inc., Sunnyvale, CA, USA) with a horizontal accuracy of ± 1 cm and a vertical accuracy of ± 2 cm. Soil elevations will be set out with respect to the North American Vertical Datum of 1988 (NAVD 88) and the National Geodetic Vertical Datum of 1929 (NGVD 29). NAVD 88 elevations will be determined by differential leveling from benchmarks.

Sediment Elevation Table (SET)

The SET is an extremely accurate and precise leveling device designed to sit on a permanent benchmark pipe or rod and measure changes in elevations in inter-tidal and sub-tidal wetlands (Boumans and Day 1993, Cahoon 1995). Once installed on the benchmark, the SET establishes a constant reference plane with respect to the benchmark, allowing for repeated measurements of the sediment surface (Cahoon et al. 2002). Changes in the elevation of the soil surface over time will be measured using the surface elevation table–marker horizon (SET–MH) methodology, which has been widely used and recommended for monitoring intertidal surface-elevation trajectories in coastal wetlands (Cahoon 1995).

Biotic Monitoring: Above and belowground biomass. Mangroves are considered 'bottom heavy plants' as they invest much of their biomass into their root system (Komiyama et al., 2008, 2000). Mangroves have two kinds of root systems adapted to the anoxic and saline conditions of mangrove habitats: aerial roots that grow above the soil surface, and belowground roots. Belowground root biomass in mangroves generally contributes up to 60% of the total tree biomass (Khan et al., 2009; Komiyama et al., 1987; Tamooh et al., 2008). It is critical that we understand the belowground processes in this pilot study. At each plot, duplicate root cores (that is, sampling units; 0–45 cm depth; shallow root zone) will be randomly collected using a PVC coring device (10.2 cm diameter 9 45 cm length. Roots will be sorted into diameter size classes of less than 2 mm, 2–5 mm, and greater than 5 mm (fine, small, and coarse roots, respectively). Each root sample will be oven-dried at 60 °C to a constant mass and weighed.

Composition, tree density, and basal area in tall and scrub mangroves will be quantified through measurements of the species and diameter at 1.3 m height (DBH) of all trees rooted within a designated study plot, which will be 154 m2 (radius of 7 m). Similarly, due to the lower density of the scrub mangroves, tree density and biomass will be measured in six 2 m radius plots. The diameter of trees of *R.*

mangle will be measured at the main branch, above the highest prop root. In scrub mangroves, the diameter of the main branch of the tree will be measured at 30 cm from the ground (D30).

Soil carbon and nutrients. At each plot, soil samples for bulk density and nutrient concentration will be collected using a peat auger consisting of a semi-cylindrical chamber of 6.4 cm radius attached to a cross handle. Soil cores will be systematically divided into depth intervals of 0–15 cm, 15–30 cm, 30–50 cm, 50–100 cm. Root and soil samples will be analyzed for Total Carbon, Total Nitrogen and Total Phosphorus.

Interstitial chemistry. Porewater turbidity and salinity, and soil chemistry, may change during this study and may accretion rates as they relate to belowground and aboveground biological production . Interstitial chemistry and physical properties will be analyzed by extracting water from the ground at 30 cm using a syringe and an acrylic tube. The syringe is rinsed twice before obtaining a clear water sample from which salinity was measured using an YSI-30 multiprobe sensor.

Surface water chemistry. To monitor possible impacts to water quality downstream from TLP, surface water samples will be analyzed to identify any changes to physical and chemical properties over time.

Schedule and Costs: Total costs, shown below, do not reflect the current efforts to integrate this pilot study with (1) funding from the USACE Regional Sediment Management (RSM) Division to locate and distribute TLP spoil materials or (2) funding from the National Science Foundation, given to FIU for its Long-Term Ecological Research (LTER) to address the dynamics of ecosystem change in South Florida due to climate change. The exact amounts of the USACE and the FIU LTER combined contributions to EMMA and the creation of an adaptive foundational resilience protocol is not yet known and will need to be negotiated.

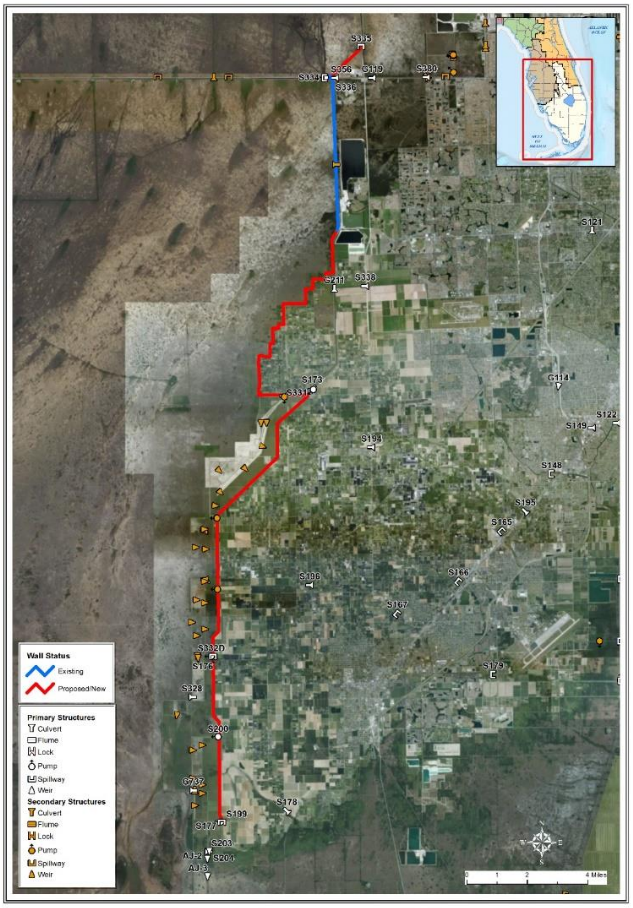
Summary

To plan for a sustainable South Florida ecosystem, it is important to identify ecological vulnerabilities to sea-level rise (SLR) and ask how we might direct water management to minimize saltwater intrusion, peat collapse (Sklar et al, 2019) and land loss. SLR projections for the next 50 years will threaten the structure and function of coastal wetlands in South Florida and there is agreement among coastal scientists that sea level is rising at rates that will inundate most lowlands distributed along the coasts (Ross et al 2000; Sweet et al, 2017, Sklar et al, 2019; Sklar et al, 2021).

This demonstration-scale pilot study is a nature-based management measure to increase coastal mangrove elevation and enhance net belowground storage of carbon. It will document the efficiency and effectiveness of TLP to increase the adaptive capacity of Florida's coastal wetlands and keep up with SLR. Results are applicable to areas throughout the Gulf and Atlantic Coasts of Florida, where direct preservation, enhancement, and restoration of mangrove and other vegetative communities, will build coastal resiliency, reduce storm surge damage, and create habitat for a large variety of fish and wildlife species.

Amount	Description of Annual Activity
$2,760,000	Final Design, Permitting, Construction and Planting, Monitoring, Reporting

South Miami Dade Curtain Wall



The South Miami Dade Curtain Wall Project is being implemented by the District in the southern part of its water management system, adjacent to southwest Miami-Dade County developed areas and Everglades National Park. Curtain Walls are in-ground groundwater and seepage barriers that help to limit water flow in South Florida's porous aquifer. The South Miami-Dade Curtain Wall Project will increase the District's ability to manage water levels in Water Conservation Area 3A in Everglades National Park. Benefits associated with these established engineering features include flood protection, water supply maintenance, saltwater intrusion prevention, and ecosystem restoration, by improving water flow to Florida Bay and other estuaries. More specifically, this project will help prevent seepage of water from Everglades National Park while keeping the water in the park to support restoration goals and promote flow south toward Florida Bay, instead of seeping eastwards towards developed areas of South Dade where such seepage contributes to a reduction in flood protection level of service.

Extensive hydrologic and hydraulic modeling efforts allowed the District to evaluate the most effective alternatives in terms of the alignment, depth and extension of these proposed barriers, and associated impacts. Feasibility Assessments developed since this project was first conceptualized, describe project alternatives in combination with the current and future condition operations of the C&SF water management features and CERP projects in the region. This project has been positively received in many of the public meetings that have been held and is of interest to private, public, local, state and federal stakeholders in the region.

The recent modelling effort completed by the District in 2018 demonstrated the benefit of the curtain wall for both restoration and flood control. Several curtain wall configurations were examined. Figure 30 illustrates three different scenarios; a 27-mile South a 19-mile scenario, from Structure S-331 to Structure S-177, including a portion of the 8.5 Square Mile Area (Las Palmas Community) in unincorporated Miami Dade County; a 19-mile North scenario, from Structure S-335 including all of the 8.5 Square Mile area; and a 31-mile Full Extent scenario from Structure S-335 to Structure S-177. The 27-mile South scenario, with gaps in the curtain wall, was recommended for more detailed study and implementation because it provided the best outcome for restoration and flood control while mitigating impacts to Biscayne Bay, Taylor Slough and water supply.

The results of the H&H modeling, illustrated in Figure below, demonstrate the flood control and restoration improvements resulting from the 27-mile South scenario. Wetter conditions were observed in Everglades National Park and drier conditions were observed in the eastern developed areas and in the South Dade agricultural areas demonstrating improved restoration and flood protection conditions, respectively.

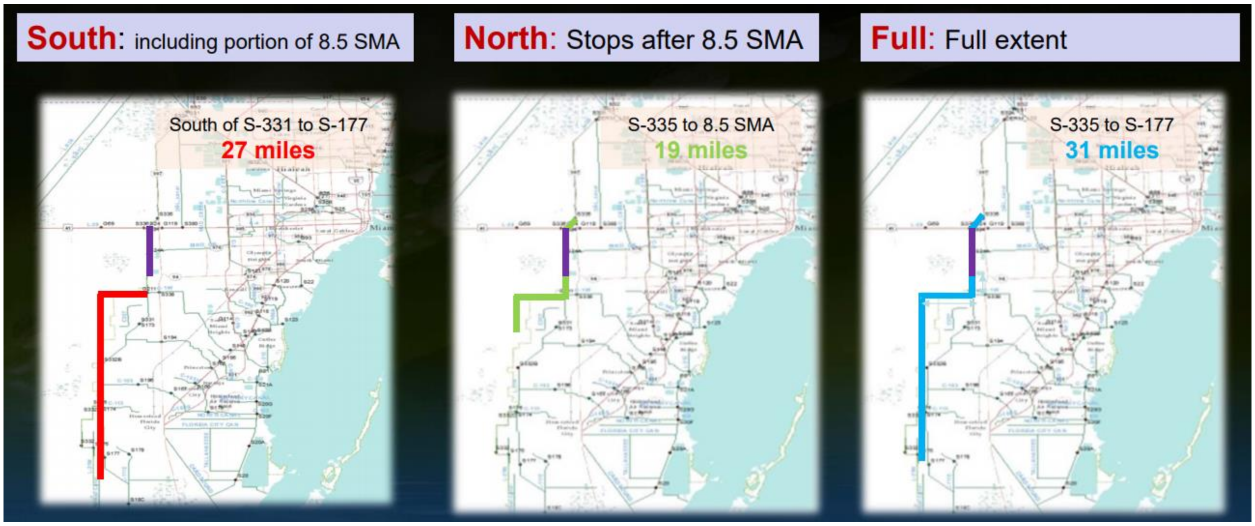


Figure 42. *Location and extension of three curtain wall configuration scenarios examined in 2018*.

Results of all three scenarios also show increased average annual overland flows to Shark River Slough, during wet and dry seasons, compared to the No Wall scenario, as illustrated in Figure 43 and Table 11 below. Flows to Taylor Slough also improved with the Full and South wall scenarios. Successfully intercepting and redirecting flows back into Everglades National Park reduces the availability of regional water to Biscayne Bay, therefore, ongoing studies and future opportunities to ensure flows to Biscayne Bay are maintained or enhanced are being advanced as part of parallel efforts. The Biscayne Bay Southeastern Everglades Ecosystem Restoration Project (BBSEER) is being advanced in collaboration with the USACE with the goals of making progress towards restoration of depth and duration of freshwater at Biscayne Bay, as well as ecosystem structure and function with improved native plant and animal abundances and diversity. The study recommended additional data collection and more rigorous modeling which was authorized and funded by the Governing Board in 2020. The project, public planning process that engages stakeholders and partner agencies is ongoing.

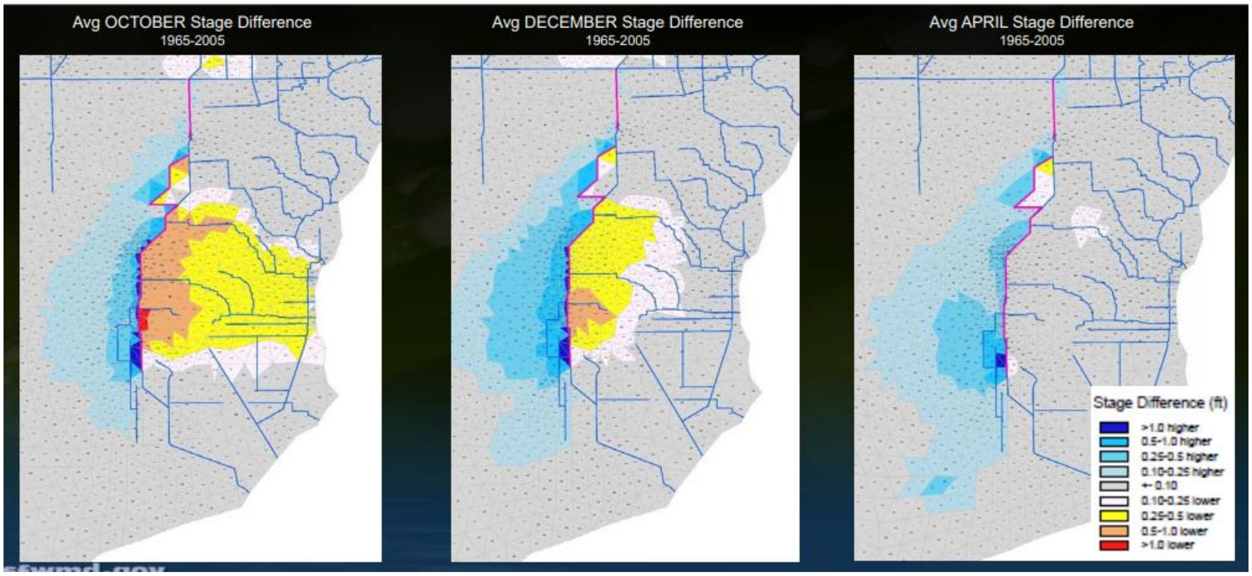


Figure 17. H&H modeling results illustrating the average water stage difference with and without the full extent curtain wall scenario.

Table 11. Average Annual Overland Flows to Shark River Slough during wet and dry seasons for three curtain wall scenarios compared to the no wall scenario.

	No Wall	South Wall	North Wall	Full Wall
Shark River Slough	833	890	873	884
Wet Season (Jun-Oct)	466	501	486	491
Dry Season (Nov-May)	367	389	387	393
Taylor Slough	85	109	82	99
Wet Season (Jun-Oct)	61	74	59	69
Dry Season (Nov-May)	24	35	23	30
Biscayne Bay	927	874	897	889
North Bay	561	534	571	570
Central Bay	120	114	121	121
South Bay	246	226	205	198

In March 2021, the SFWMD Governing Board approved the construction of the initial phase of the South Miami Dade Curtain Wall Project / Seepage Cut-off wall, which consists of a 2.3-mile-long, 26-inch wide curtain wall along the 8.5 Square Mile Area (Las Palmas Community) in unincorporated Miami Dade County, along the C-358 Canal and the L-357W Levee. The 8.5 Square Mile Area Curtain Wall is nearing completion. The total costs for the initial 2.3 miles - $15M is fully funded with State Funds in a multiyear project. The project was bid on a per unit length basis to allow continuation of the wall subject to additional funding.

In August 2002, the SFWMD Governing Board approved the construction of additional 4.9 miles of seepage cut-off wall along the L-357W Levee from the end of the 2.3-mile segment to the junction with the L-31N Levee, as part of the Central Everglades Planning Project (CEPP). This additional project continues to minimize seepage from Everglades National Park (ENP) and mitigate regional flooding in urbanized areas downstream.

Additional new funding will facilitate construction of incremental curtain wall sections, increasing the ability of water managers to address high water events in Water Conservation Areas and the Central Everglades, promote flows to Florida Bay, and better utilize assets built for achieving restoration goals and providing flood mitigation.

The cost estimates below propose to incrementally build the curtain wall assuming five to ten miles every three to five years at an average cost of $8M-$10M per mile escalated for inflation for the out years. The final design of the full wall will be established at the end of the public planning process and may exceed the total miles recommended in the initial study. Additional project refinement and confirmation of the final extension of the seepage wall will be defined based on further model analyses and monitoring efforts.

Implementation Timing	Amount*	Incremental Strategy
Immediate Needs (FY22-FY25)	$75,000,000	Construction of 5-10 Miles
Near Term (FY25-FY28)	$75,000,000	Construction of 5-10 Miles
Intermediate Term (FY28-FY31)	$75,000,000	Construction of 5-10 Miles
Long Term (FY31-FY34)	$75,000,000	Construction of 5-10 Miles

*Cost in 2020 dollars will be adjusted for future years, assuming 7.5 Miles

Renewable Energy Projects

Among renewable energy projects, the District is proposing the installation of a solar canopy in the District Headquarters parking lot. Fleet vehicles could be parked under the canopy to keep them protected from the elements. The solar canopy would use net-metering to offset a portion of the energy usage and carbon footprint at District Headquarters. Electric vehicle charging stations could also be installed to utilize power generated by the solar canopy.

Floating Solar Panel Pilot Project

A floating solar panel pilot project on Lake Freddy at District Headquarters would help to offset energy costs. Floating solar panels have a lifespan of 25+ years and are designed to withstand hurricane-force wind conditions. Additional benefits include Increased energy production due to cooling effect of water (in some cases 10+%), neutral or positive environmental impact, improves water quality and reduces algal blooms due to shading of the water column.

Total Amount of Funding Request	Duration
$ 885,674	1 year

Solar Panel Installations at C-43 and C-44

In addition, the District is initiating coordination with FP&L to install solar panels at the C-43 and C-44 Reservoir adjacent lands with the goals of reducing energy costs at these facilities as well as offsetting carbon emissions from existing and new proposed pump stations that rely at least partially on fossil fuel generated power.

Total Amount of Funding Request	Duration
C-43 Solar Panel Installation: $8,000,000 – 10,000,000	1 year
C-43 Solar Panel Installation: $8,000,000 – 10,000,000	1 year

10. Priority Planning Studies

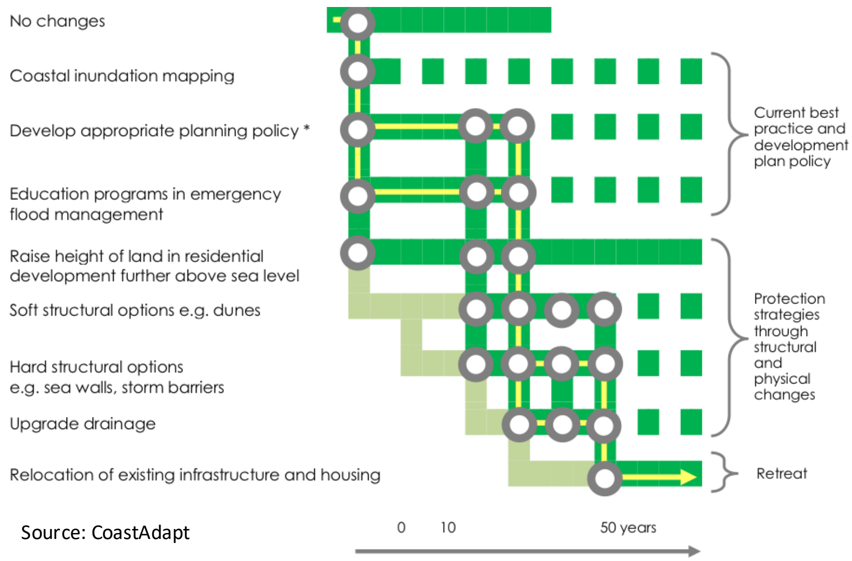
Various planning projects and efforts are being prioritized as part of the District's Resiliency Program. These studies are an integral part of providing South Florida with a robust and resilient flood infrastructure, now and in the future. Planning projects help support the District's Resiliency mission, by coordinating scientific data and research needs to ensure the projects are founded on the best available science.

Hydro-meteorological monitoring has played an important role in managing the water control system in South Florida. Through its DBHYDRO tool, the District stores and makes hydrologic, water quality, and hydrogeologic data available to the public and partner agencies. Continuing efforts to enhance monitoring become are important to combat a changing climate and increasing sea levels. Science and data are required to build a resilient water management system and infrastructure that addresses current and future impacts. Hydro-meteorological data such as seawater level, air temperature, incoming solar radiation, rainfall, and evapotranspiration rate can provide trends that can help with prediction of climate change. Due to the slow process of climate change, monitoring stations must be high quality and stable to minimize environmental disturbances to the station. In this context, the District is implementing a set of water and climate resilience metrics with the goal of tracking and documenting shifts and trends in District-managed water and climate data. These efforts support the assessment of current and future climate conditions scenarios and District resiliency investment priorities. As part of the District's communication and public engagement priorities, the effort will provide information to stakeholders, and public and partner agencies, while supporting local resiliency strategies. Five key planning projects are detailed below, to support the continued monitoring and metrics development efforts, including: a web tool implementation to support real time trend analysis of the Water and Climate Resilience Metrics, enhancement of the District's saltwater interface mapping and monitoring, hydrometeorological data monitoring, flooding events database tool and the development of regional climate rainfall projections.

In addition to observed and projected data analysis and monitoring processes, hydraulic and hydrologic modeling efforts are fundamental in evaluating the effectiveness of the District's flood control assets which include canals, structures, and pump stations. Modeling efforts help to determine if the flood control system meets and will continue to meet flood protection needs. The FPLOS Program is being implemented at a regional and local scale using a suite of tools and performance indicators for evaluating structures and canals in selected watersheds, as well as a framework for establishing the level of service at each basin. The program incorporates input from meetings and workshops with local planning and stormwater management efforts, stakeholders, and resource managers. The results provide support for local flood vulnerability assessments, based on the latest modeling tools and most advanced dynamic H&H models, simulating existing drainage infrastructure to determine flood inundation scenarios, the necessary integration between surface and groundwater systems, and tidal/storm surge and rainfall scenarios for current and future conditions. Modeling efforts also include future conditions groundwater modeling to evaluate SLR, the saltwater intrusion monitoring network, and climate change impacts that may influence future water use vulnerability.

Recurring funding needs to continue to advance Phase I - Assessments and Phase II Adaptation Studies in priority basins, annually, as well as groundwater modeling efforts, are detailed below.

FPLOS Adaptation and Mitigation Planning (Phase II Studies)



Source: CoastAdapt

FPLOS Phase II studies will advance previously developed FPLOS Phase I water management (H&H) models to identify feasible flood adaptation and mitigation solutions in critical basins. Results of these studies will help develop recommendations for regional and local integrated strategies and priority infrastructure investments and operational changes that may be required to ensure continued long-term performance of the at-risk parts of the system. When the FPLOS assessment (Phase I Studies) identifies a deficiency in the flood control system, a detailed public planning study is initiated to identify appropriate resilient adaptation strategies. This public planning approach ensures the agency, in collaboration with partners and stakeholders, determines the best local and regional solutions that are not limited to the primary system. The comprehensively evaluated and coordinated course of action, based on robust technical assessments, will ensure that the District's flood protection systems maintain their level of service, in response to population growth, land development, SLR and climate change.

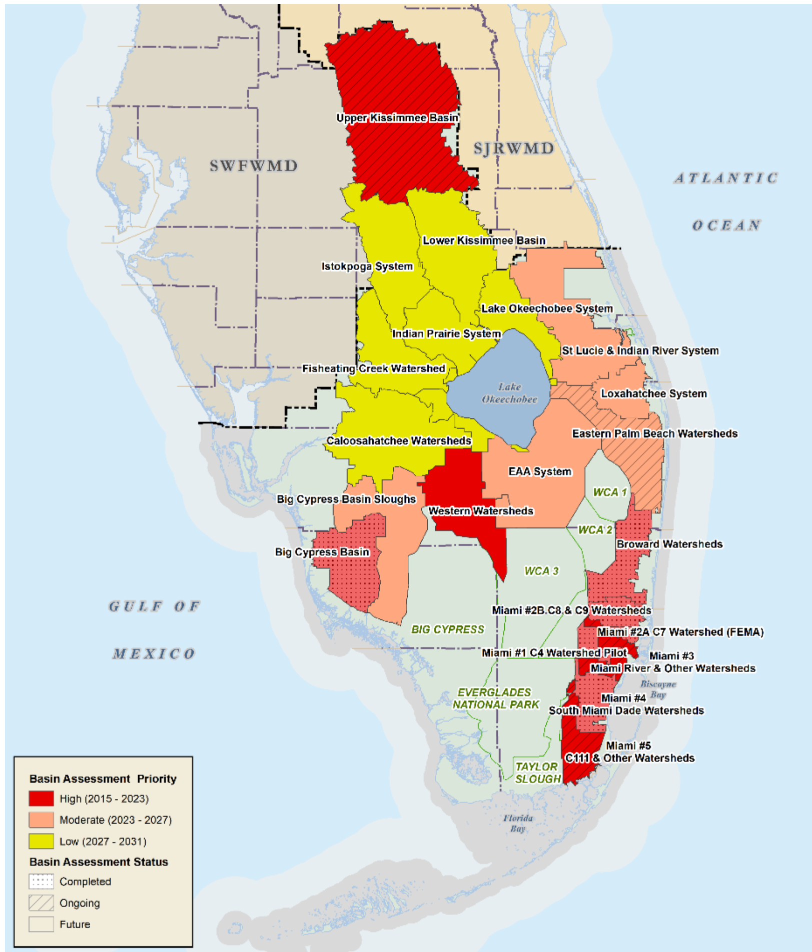
It is crucial that this phase of the FPLOS program be properly and well-funded, preferably with recurring funds, because it identifies projects that are ready to design and build, both for the District and for local stakeholders that are responsible for secondary and tertiary flood control assets. Results from this phase may (on a project by project basis) provide recommendations for cost-share opportunities with federal, state or local partners. A constant stream of properly, regionally evaluated project features across the three tiers of the flood control system will position the region well to compete for state and federal funds for flood control and flood resilience infrastructure.

An adaptation pathway approach is incorporated into the Phase II studies to support the definition of an implementation strategy for the recommended projects (sequences and combinations of flood adaptation and mitigation strategies). If an individual flood mitigation alternative is not able to achieve the specified target of a pre-determined performance criteria, additional mitigation strategies are triggered, setting up a plan on how multiple strategies can be implemented over time.

In FY21, Phase II Studies were kicked off in the C-9 and C-8 Basins in Broward and Miami-Dade Counties. Completion of the C-7 Pilot Phase II Study is expected to be initiated in FY22. The Program annual budget is $2M with at least one new start every year. Design costs are not included as part of this phase and will be completed upon funding confirmation for each individual recommended flood adaptation project.

Total Amount of Funding Request	Duration
$8,000,000	Four years - recurring

FPLOS Assessment (Phase I Studies)



FPLOS Phase I Studies have been ongoing for the past 6 years. These studies identify and prioritize long-term infrastructure improvement needs, in response to population growth, land development, SLR and climate change. Requested funding will be used to advance the development of water management (H&H) models to evaluate the flood protection system operations under changed current and future conditions. This phase identifies issues in the flood control system in 8 to 10-year cycles through a comprehensive, regional approach to addressing flood risks, intensified by sea-level rise. Phase I studies also properly characterize flood vulnerability, risks to critical assets, and potential co-benefits of integrated solutions. This effort is integrated into the District's Capital Improvement Program to ensure its structures, pumps, and canals are functioning as designed, and will remain operational under future climate conditions.

This request is for full funding, which will allow the FPLOS program to meet its planed schedule of two new assessments each year, to meet the goal of cycling through all District basins every 8 to 10 years. All FPLOS H&H models, input data and output results developed as part of assessment and adaptation planning efforts are being and will continue to be stored in the statewide model management system (https://apps.sfwmd.gov/smmsviewer/).

Total Amount of Funding Request	Duration
$4,000,000	Four years - recurring

Water Supply Vulnerability Assessment

The South Florida Water Management District (SFWMD) is conducting a Water Supply Vulnerability Assessment aimed at understanding how future development and climate conditions impacts our regional water supply. As an initial effort, SFWMD is developing the East Coast Surficial Groundwater Model (ECSM) to be density dependent allowing for Sea Level Rise (SLR) scenarios to be incorporated into the model simulations. Additionally, SFWMD has contracted FIU and the USGS to develop future conditions rainfall, evapotranspiration (ET), and temperature datasets to support scenario formulation for the ECSM model runs and other regional modeling.

SFWMD created an internal workgroup with representation from various bureaus to develop an approach for identifying and assessing vulnerabilities. Initial scenarios, modeling assumptions, input data selection and limitations, research, scope, time, and cost were considered in the development of the proposed approach. The following illustrations summarize a subset of initial recommendations and assumptions that are being integrated into the proposed approach. More detailed information on the approach, and next steps will be described in the upcoming report: Water Supply Vulnerability Assessment – Scoping.

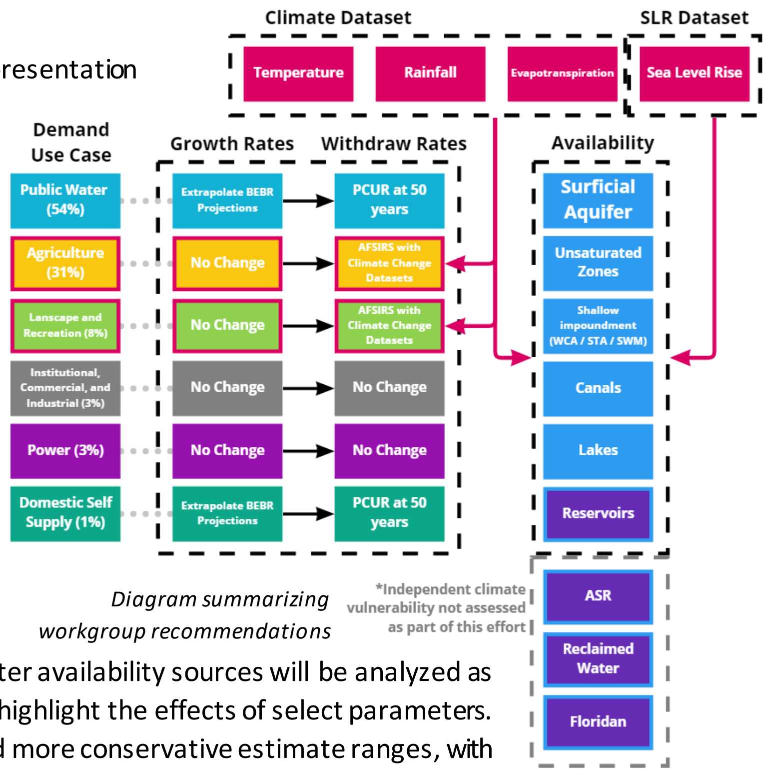


Diagram summarizing workgroup recommendations

To properly analyze the effects of climate change, including sea level rise, each of the water availability sources will be analyzed as independent "buckets" and model outputs will highlight the effects of select parameters. Initial scenario formulation is proposing less and more conservative estimate ranges, with degrees of warming, dryness, and sea level rise, along with growth scenario ranges. The outputs of these scenario runs should allow for SFWMD to understand how future conditions may impact source characteristics, water management operations, and overall water availability. Future iterations may include the analysis of water management strategies and their effects.

The vulnerability assessment will be in addition to the 2023 Lower East Coast Water Supply Plan Update, and other upcoming WSP efforts. The assessment will therefore be based on WSP methodologies by independently analyzing climate effects on growth rates, withdraw rates, and availability water supply sources. Public water supply and domestic self-supply's 20-year BEBR growth rates will be extrapolated to 50 years and their withdrawal rates will be calculated using the 20-year per capita use rate. Agriculture, landscape, and recreational withdrawal rates will include projected temperature, rainfall, and ET rates at 50 years. The surficial aquifer and other fresh water sources will incorporate SLR in its boundary conditions and all surface water and unconfined groundwater will incorporate future temperature, rainfall, and ET conditions.

Total Amount of Funding Request	Duration
$1,200,000	Four Years – One time

Water and Climate Resiliency Metrics - Web Tool Implementation

As part of a series of resiliency initiatives to address changing conditions, the District has established an initial set of water and climate resilience metrics districtwide. These science-based metrics were developed with the goal of tracking and documenting shifts and trends in District-managed water and climate data. The metrics support the assessment of current and future climate condition scenarios and related operational decisions that inform District resiliency investment priorities. As part of the District's communication and public engagement priorities, this effort informs stakeholders, the public, and partner agencies about the District's resilience efforts, while supporting local resiliency strategies.

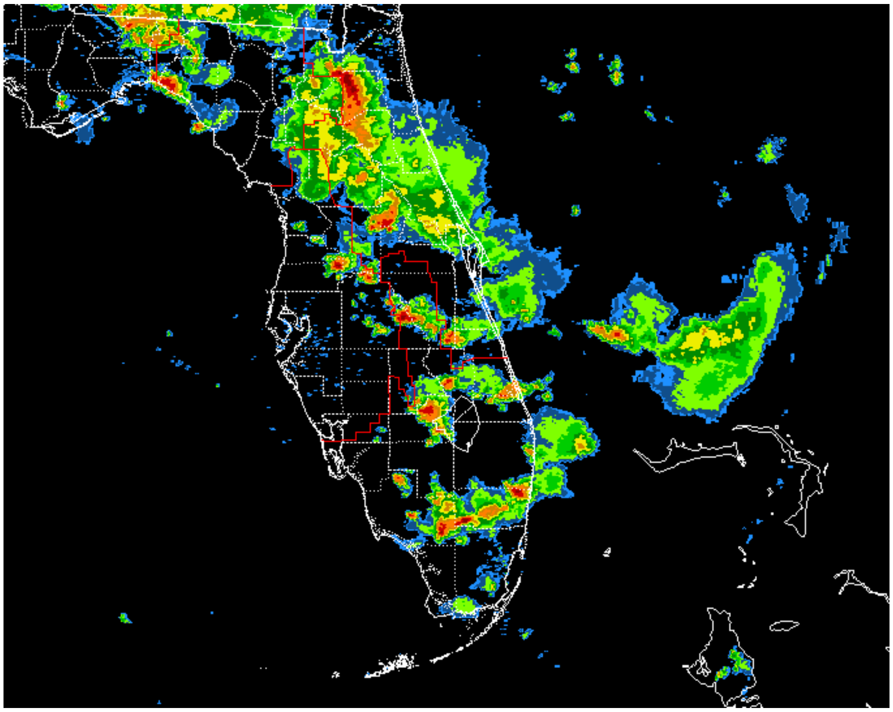
The Water and Climate Resilience Metrics are an important step towards planning for the future with consideration of long-term observed trends and their impacts on the District mission. The initial set of selected water and climate resiliency metrics are currently being automated for publication through an interactive web portal, providing navigation to different locations districtwide and access to real time data. The portal will generate alternative mapping, chart, and graph options to display and communicate trend results, supported by a story map.

This webtool will provide real time updates of observed data and automated trend analyses, for the fifteen prioritized Water and Climate Resiliency Metrics. Real time automation will minimize rework and reprocessing of trend analysis for the selected metrics, based on the best available data and will be integrated into the District's existing database tools, DBHydro.

This funding request will be utilized to incorporate new metrics, as recommended by the stakeholder and technical review processes. In addition, funding will support continued integration between DBHydro and the Esri based Resilience Metrics Hub featuring story maps and web tools for analyzing and sharing data, as well as the development of the Water and Climate Resiliency Metrics Phase II – Development of Future Projections.

Total Amount of Funding Request	Duration
$900,000	Three Years – One Time

Hydrometeorological Data Monitoring



This recurring funding request for Hydrometeorological monitoring will be used for establishing key baseline monitoring stations, and evapotranspiration monitoring for Lake Okeechobee and the rainfall monitoring network, focusing on specific resiliency needs. Future additional data needs will be identified and validated through the Water and Climate Resiliency Metrics Project.

Hydrometeorological monitoring has played an important role in managing water control systems in South Florida. Stage, flow and rainfall data are used daily in SFWMD's Operations and Control Center. District weather stations, Florida Agricultural Weather Network's stations, and National Oceanic and Atmospheric Administration stations, have been used to calibrate/verify the Geostationary Operational Environmental Satellite estimate of incoming solar radiation. Incoming solar radiation is the most important factor that drives evapotranspiration, and therefore is vital for generation of reference evapotranspiration and potential evapotranspiration estimates for all of Florida at the resolution of 2-km by 2-km grids.

With proper support from the Resiliency program, rainfall analyses, such as temporal and spatial distribution, and trend analysis, can be strengthened and conducted at a more frequent interval. Rain gauge stations can be added to the network to address the coverage disparity identified by the Rain Gauge Network Optimization study. A properly distributed rain gauge network will benefit radar rainfall estimates, and climate change trend analysis. Additionally, the National Hurricane Center in Miami has been using the meteorological data from the District's weather stations for hurricane prediction. More accurate data would benefit these efforts as well.

Building resilient water management systems and infrastructure requires science and data. Time series hydro-meteorological data such as seawater level, air temperature, incoming solar radiation, rainfall, and evapotranspiration rate can provide input for trend analyses used for the prediction of climate change.

Total Amount of Funding Request	Duration
$300,000	Four Years – One Time

Statewide Regional Climate Projections

Statewide Regional Climate Projections will be developed in coordination with the Florida Flood Hub, FDEP, USGS, Academia, Water Management Districts, Regional Planning Councils and other partner agencies to capture conditions/mechanisms of rainfall, and other related climate variables. Determination of future extreme rainfall conditions (both wet and dry conditions) is key for evaluating potential impacts from climate change to operation of District infrastructure and mission implementation. There is specific interest in determination of future rainfall scenarios as part of FPLOS Phase I Assessments.

The District, the U.S. Geological Survey, Florida International University (FIU) and local governments have been working over the past five plus years at evaluating global and regional climate models to estimate future extreme rainfall conditions. In May 2019, the District and FIU organized a Workshop to define a strategy for the development of uniform rainfall scenarios in Florida. As part of the short-term workshop recommendations, the District is assessing best available downscaled climate datasets and identifying a subset of best performing model datasets that are relevant to inform the extreme rainfall scenarios. A separate long-term effort should be conducted as recommended in the 2019 Workshop, because the use of available climate datasets for estimating future rainfall in Florida show biases in extreme rainfall, which are relatively large when comparing past observation with climate model's historic data. A Florida Regional Climate Projections modeling effort would be better suited to capture conditions/mechanisms of rainfall occurrences in our State, including contributions from tropical storms and sea breeze, as well as Florida shelf and ocean dynamics, and other important climatic processes. Advancing a statewide regional climate projections model would reduce future rainfall uncertainty estimates in Florida. Project costs and proposed schedule is summarized below. Costs include estimated match from USGS of $150K per year (not added to the total amount of funding request)

- Year 1: $750K - Scientist & Stakeholder Workshops to finalize modeling approach; initial testing / pre-evaluation of AOGCMs and regional models for boundary conditions
- Year 2: $750K - Initial reanalysis, coupled Ocean Atmosphere & WRF model development
- Year 3: $750K - Run of 2-km WRF / 10-km Ocean Atmosphere Regional Climate Models; historic and climate projections for multiple scenarios

- Year 4: $750K - Development and validation of Depth-duration-frequency curves and additional rainfall frequency results (average/season/extreme dry); web tool for results dissemination; public presentations; final report

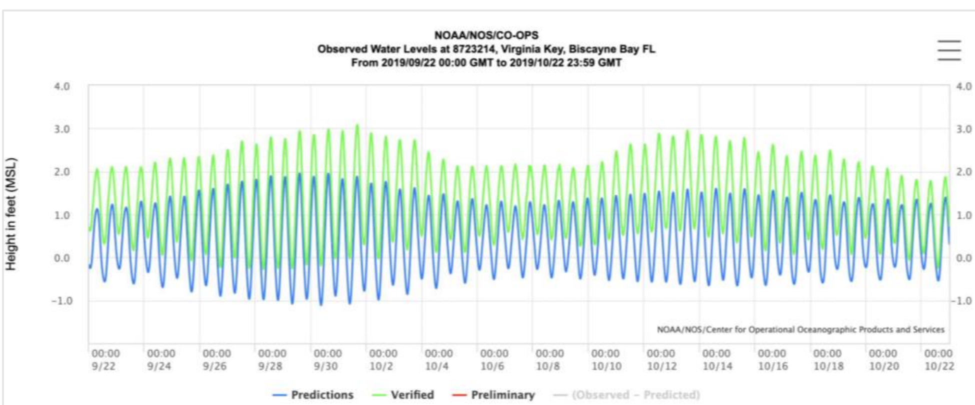
Total Amount of Funding Request	Duration
$2,400,000	Four Years – One Time

Enhancing Tidal Predictions (SFWMD, University of Miami Rosenstiel School of Marine and Atmospheric Science)

Local near-future tidal predictions will be developed in partnership with the University of Miami (UM) Rosenstiel School of Marine and Atmospheric Science (RSMAS) to capture tidal conditions influenced by global and local variables. Establishing accurate near-future tidal conditions is key for evaluating potential impacts due to sea level rise to operation of the District's coastal structures and mission implementation. Accurate tidal predictions will improve water management response and response timing, ultimately reducing flood disaster risks and benefiting communities in South Florida.

NOAA tidal predictions, which are available for any particular site well into the future, are limited by current model inputs. These tidal predictions use sea-level information from 1983-2001, a historical period that does not account for the roughly six-inch rise in sea level observed in South Florida in the last 20 years. Furthermore, these tidal predictions are produced using a course seasonal average of tides and lack inputs representing current weather or oceanic conditions.

In 2020, UM began working to improve current tidal predictions by accounting for more recent changes in sea-level rise and including adjustments for surface pressure forecasts (weather elements such temperature, wind velocity and direction, humidity, rainfall, cloud formation, sunshine, thunder and lightning over a geographic area) to address the limitations of current tidal predictions. Moreover, the improved prediction model includes a multiple linear regression that accounts for various additional relevant parameters, such as oceanic waves. The updated model is currently being run and tested for NOAA's Virginia Key Tide Station (and its U.S. global weather model (GFS) output is available for up to 10 days in the future.



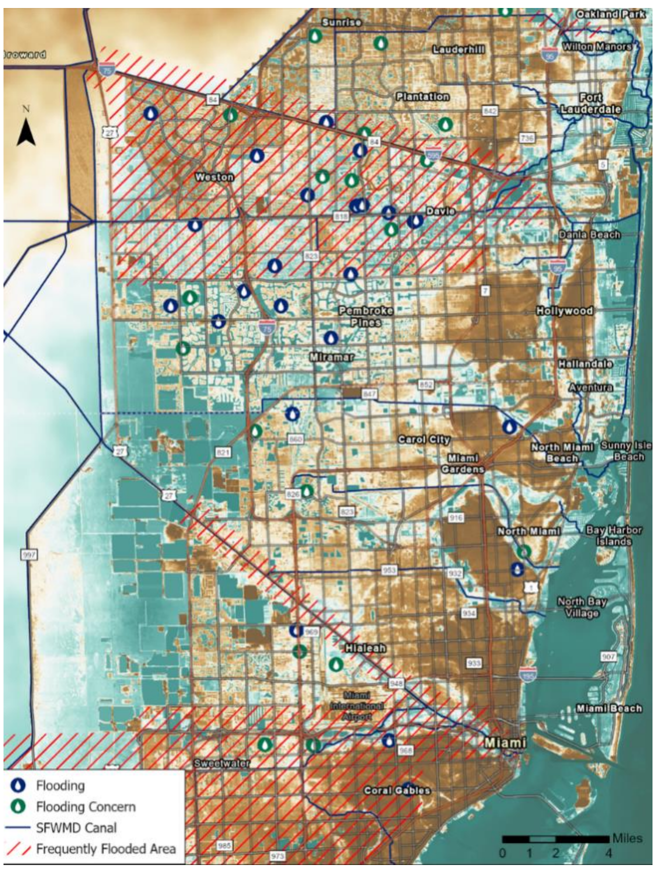
The District is seeking funding to partner with UM RSMAS to build on current efforts and refine the model for use at additional tide stations along South Florida's east coast: Port Everglades, Lake Worth, Key West, Vaca Key and Naples. Near-future tidal predictions based on the latest available data and best available science would provide water managers at the SFWMD and local agencies more accurate and necessary information to respond to variable weather conditions now and in the future.

Total Amount of Funding Request	Duration
$ 300,000	2 Years – One time

Flooding Observation Survey and Notification System

Identification and documentation of highwater marks is critical to understanding flood depth and extent and provides observations necessary to validate simulation models attempting to replicate flood occurrence. Identifying where to record and measure highwater marks is a challenge. Flood observations during events can be used to inform highwater mark collection as well as provide an early warning of emerging issues that require investigation to mitigate during an event.

Compilation of flood distribution, depth, and extent over time will inform understanding of trends in flood occurrence and effectiveness of mitigation efforts. Although there are local initiatives to collect such information, there are no regional or statewide tools that can be leveraged at the local level to assist in early notification or inform high water mark collection. A statewide system of collection and notification would provide local tools to assist local agencies in responding to and documenting flood occurrence within their jurisdiction. It would provide a repository for evaluating flood occurrence over time and could be leveraged to model and develop mitigation measures to address increasing flood occurrence. At a regional level, such tools can be used to assess regional trends and better inform understanding of the response of regional and local systems to rainfall and mitigation measures.



Development of a regional / statewide flood observation and notification system is proposed as a means to standardize and centralize flood observation information. Once established, this repository can serve as the basis for development of other regional and statewide tools to assist in the compilation and standardization of flood evaluation and be used to validate local and regional modeling tools for design and implementation and mitigation measures.

Although regional monitoring networks provide critical information for the evaluation of hydrologic trends, a repository of ground observations are needed to understand how these trends impact the effectiveness of local and regional storm water management systems and how mitigation measures are improving those conditions. This proposal is to establish cloud based regional tools and a repository for the standardization flood observation and highwater mark data to evaluate flood occurrence over time and mitigation measure effectiveness.

Total Amount of Funding Request	Duration
$1,000,000	Four Years – One Time

Evaluating the performance of the SFINCS hazard model to support and accelerate the FPLOS and SE-FL regional adaptation planning efforts

Following the recently finalized collaborative development of the SFWMD-FIAT tool and partnership meetings between the District, Miami Dade County, Broward County, and Deltares, this project description summarizes regional modeling challenges and proposes an evaluation of a new tool to address these challenges.

The FPLOS and regional adaptation planning efforts experience various modeling challenges: Firstly, integration of coastal and inland flood modeling is currently lacking. As a result, the studies do not consider compound flooding. Secondly, the comprehensive Mike flood models used by the District and Broward County yield reliable and high-resolution results, but this comes at an expense: run times for individual scenarios amount to nine hours. As a result, detailed probabilistic flood hazard modeling is not feasible. As an alternative, the District and Broward County work with a representative set of scenarios/conditions, using a deterministic approach. As an additional consequence, the studies can model only a relatively small subset of the many identified scenarios, introducing decision-making uncertainties. Finally, only model experts can use the modeling tools, and the tools miss an adequate translation to support planning. Herein, Miami Dade County relies on the modeling work of the District to inform and support its planning efforts.

The USGS and Deltares recently improved and applied the Coastal Storm Modeling System, COSMOS, to the SE Atlantic coast, including South Florida, as part of their coop. The improvement included setting up and validating the compound flood model SFINCS (Super Fast Inundation of Coastal Systems), a physics-based, reduced complexity model with typical runtimes of seconds to a couple of minutes for individual hydro-meteorological events depending on the spatial scales.

The SFINCS flood hazard model is also part of the Community Flood Resilience Support System (CFRSS), recently developed by Deltares in partnership with the Department of Homeland Security. The CFRSS helps address all the above-listed challenges and supports the DHS in its mission to accelerate climate adaptation nationwide. The system application to Charleston, the pilot community, is promising.

The SFINCS and the CFRSS tool could, e.g., support the FPLOS program as quick scan tools to evaluate all scenarios of interest quantitatively. Then, based on the results, scenarios for detailed assessments using the comprehensive Mike models can be selected and implemented, reducing uncertainty in decision-making. However, this use requires an additional performance evaluation of the SFINCS model. For instance, validation of the available SFINCS model in the Cosmos modeling system for South Florida focused on the near-shore water levels. Therefore, the proposal is to more thoroughly assess the performance of SFINCS in simulating regional flood extents and water depths by comparing the model inputs, outputs, and computational times with the Mike basin models and readily available field observations used to calibrate and verify the Mike models. The costs for this in-depth performance evaluation approximate $75,000, and includes updating the SFINCS model application as needed and possible within the scope and available budget. The latter will be determined in collaboration with the District.

Total Amount of Funding Request	Duration
$75,000	1 Year

Green Infrastructure Flood Mitigation Strategies - Associating Water Quality Benefits in the Little River Watershed

In partnership with Miami-Dade County and Florida International University, this project proposed the integration of scientific research and coastal water management challenges to develop actionable information for resilience of coastal environments in the face of climate change, SLR, and land-use development. The overall goal is to identify nature-based features that can be evaluated for flood protection and water quality benefits in consultation with stakeholders to improve watershed restoration planning.

To enhance regional adaptive capacity for addressing the increasing challenges of flood and water quality protection, a more comprehensive approach to watershed management is needed. In this project, we propose to address the overarching question: What are the flood mitigation and water quality benefits of cumulative “green elements” of the Community Rating System (CRS) program and other nature-based features with and without gray flood mitigation approaches? By planning for restoration and enhancement of natural functions that can improve flood protection and water quality benefits within the watershed in a coordinated effort across agencies, supported by expertise of local academic and NGO collaborators, we strive to enhance socio-ecological resilience in the face of SLR and land-use change.

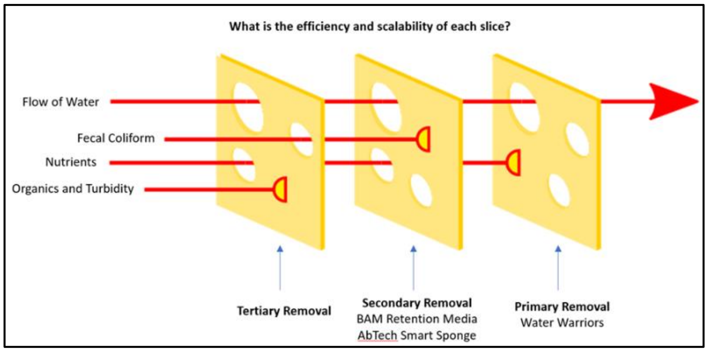
Quantifying flood mitigation and water quality benefits through comprehensive watershed restoration planning is a key outcome of the project. Comparing FPLOS performance metrics, water quality benefits (specifically, TP, TN, and TSS load reductions), and averted economic damage (Bouwer et al. 2017) across the diverse set of watershed restoration scenarios will support flood protection planning with quantifiable environmental, societal, and economic benefits assessed by this project. It is expected that future funding opportunities will result in construction of immediately feasible CRS/Low Impact Development features and zoning/code changes to enable more transformational CRS/Low Impact Development features to be constructed across the C-7 and other basins in South Florida.

Total Amount of Funding Request	Duration
$450,000	Three Years – One Time

Waterways Impact Protection Effort (Project WIPE-Out)

The project is to assist the District in finding and piloting innovative technologies that can protect the health of water systems upstream and downstream of District conveyance structures. Currently, our waterways and canals act as a channel which collects and moves contamination that flows in from our basins. This contamination ranges from dissolved nutrients to large debris and eventually makes its way into our water bodies such as the Biscayne Bay and the ocean and their natural inhabitants.

These water bodies are an essential part of the South Florida and global ecosystem. Protecting the health of these unique and fragile ecosystems will require testing different strategies and configurations until a suite of solutions is identified to be scaled across the region, as the District advanced the implementation of priority resiliency projects.



The WIPE-Out project is part of an overall protection strategy that utilizes a swiss-cheese model of hazard and risk management. This model is used across industries from aviation to healthcare and follows the principle of layered defenses, where each layer can block risks ultimately prevents hazards from taking place. To manage nutrient loads and eutrophication, the proposed multi layered approach takes the form of multiple locations and technologies of nutrient removal with the goal of eventually scaling appropriate solutions until contaminants are contained within the ideal limits. Future iterations may look at the reductive effects of incorporating NBS.

Project WIPE-Out will be implemented in partnership with Miami Dade County and target nutrient removal via two strategies: The WIPE-Out Tech Test and the WIPE-Out Incubator.

Trash build-up in the C-7 Canal.

The WIPE-Out Tech Test will identify a selection of promising technologies with scaling potential to pilot in The Little River (C-7 Canal), a culturally and ecologically important canal that has been called ground zero for the challenge of removing contaminates. Every year the District removes more than 200 tons of trash from the Little River which costs the District over $100,000.

The WIPE-Out Incubator will be multi-year effort that is focused on creating local capacity through developing nutrient removal ideas in partnerships with various agencies, university, and business partners. The incubator will assist in launching new startups and potentially scalable treatment technologies by providing them with a real-world location to test their technology, free monitoring, venture building courses and programming, and access to non-dilutive seed capital, potential investors, and clients.

Total Amount of Funding Request	Duration
$3M to $4M	1.5 – 3 years -One Time

Future Conditions District Internal Guidance for Regulation

As a first step in advancing of District's initiatives related to enhancing regulation standards to account for future changing climate conditions and building resiliency, the District Regulation team is proposing the development of an internal guidance tool to have quick access to critical information relevant to both ERP and Water Use permitting analysis. Criteria currently utilized by the Regulation Team in evaluating permits, such as rainfall and groundwater levels, are subject to changes as a result of non-stationary climate conditions, as being documented on observed trends and future projections. This information is currently being incorporated into the Water and Climate Resilience Metrics Hub (Resiliency Metrics Hub (arcgis.com)) with the goal of grouping some of the key parameters that will serve this purpose. The development of a tool or guidance document to serve the purposes of the regulation team and providing the latest references and quick access to information that is relevant to their permitting analysis, is needed.

Total Amount of Funding Request	Duration
$ 450,000	3 Years – One time

Carbon Storage Monitoring and Reporting

With the goal of establishing a routine reporting on carbon uptake and storage totals, associated with ecosystem restoration efforts, data collection efforts would need to be employed for individual restoration projects to better represent their associated mitigation benefits and estimate resilience benefits. These include the following:

- Soil carbon characteristics: measure soil bulk density and carbon concentration at multiple depth increments to capture short-term and long-term carbon storage.
- Soil accretion: use surface elevation tables and feldspar marker horizons to measure soil surface changes and vertical accretion.
- CO_2 and CH_4 gas dynamics: measure uptake and release of carbon gasses using eddy flux towers that capture the direction (into the ecosystem or out to the atmosphere) of gas movement to determine the net uptake of carbon at the landscape scale.

Employing these measurements across District restoration projects will provide accurate assessments of carbon capture and storage associated with the different ecosystem restoration efforts currently undertaken by SFWMD and Agency partners, and better estimate their benefits to climate resiliency.

The objectives of this proposed project is to establish ongoing monitoring and reporting mechanism to highlight carbon uptake potential associated with District's restoration efforts.

Total Amount of Funding Request	Duration
$ 450,000	3 Years – One time

Designing Wetland Habitat Enhancement and Flooding Improvements for Charlotte Harbor Flatwoods Project

The Designing Wetland Habitat Enhancement and Flooding Improvements for Charlotte Harbor Flatwoods project is a Florida Fish and Wildlife Conservation Commission proposal supported by the District coordinated Charlotte Harbor Flatwoods Initiative (CHFI) and part of the South Florida Water Management District's (District) priority projects included in the 2021 Sea Level Rise and Flood Resiliency Plan.

The CHFI is a multi-agency and community partnership which has been planning and implementing projects for the hydrological restoration of 85,000 acres in the Charlotte Harbor Flatwoods region since 2010. Partners include Florida Department of Environmental Protection (FDEP), Southwest and South Florida Water Management Districts, Florida Fish and Wildlife Conservation Commission (FWC), U.S. Fish and Wildlife Service, Florida Department of Transportation, Lee and Charlotte counties, City of Cape Coral, Coastal and Heartland National Estuary Partnership, and other community stakeholders. More on the CHFI is available at:

https://chnep.wateratlas.usf.edu/charlotte-harbor-flatwoods-initiative/

BENEFITS

- reduced erosion and regional flooding,
- minimized saltwater intrusion by rehydrating the land to increase groundwater recharge,
- increased wetland water storage, depths and duration for habitat enhancement,
- improved flows to Charlotte Harbor's tidal creeks, mangroves, and seagrass beds, and
- decreased nutrient runoff pulses to the estuary, reducing harmful algal blooms and protecting fisheries resources.

The project area includes Yucca Pens Wildlife Management Area (WMA), part of the largest remaining hydric pine flatwoods in southwest Florida and its tidal creeks that flow into Charlotte Harbor. The WMA's coastal wetlands are within northern Lee and southern Charlotte Counties. The proposed project will deliver the final design and permitting for a large-scale restoration that will improve the hydrology of >8,000 acres of wetlands increasing the coastal resiliency of Cape Coral and substantially improving habitat for protected species. The design will build upon a preliminary conceptual model prioritized by Florida's Deepwater Horizon Program and funded in 2019 through Natural Resource Damage Assessment. that simulates appropriate timing and quantity of water flows required to improve wetland habitat conditions, minimize erosion and offsite flooding, improve groundwater recharge, and reduce the risk of wildfires. Additional modeling using future land use data, predicted population increase, climate change impacts, and sea level rise, as well as confirmed and potential future land acquisition and restoration projects will be finalized July 2022.

Specifically, ditch blocks in smaller ditches would increase storage and surface water hydrology. The reestablishment of connections to several tidal creeks to the west of Yucca Pens, would be accomplished with low water fords installed through existing off-highway vehicle ruts and ditches in Yucca Pens. This will restore flows from Yucca Pens to Charlotte Harbor at several locations rather than as point source from the City of Cape Coral's man-made Gator Slough Canal. An approximately 4.5-mile-long groundwater seepage barrier at the southern boundary of Yucca Pens along Gator Slough Canal will reduce wet season surface water drawdowns and raise groundwater levels in Yucca Pens. All would protect aquifer recharge and reduce the potential for saltwater intrusion with sea level rise.

The total project costs are around $550,000 and a full proposal will be submitted to the National Fish & Wildlife Foundation National Coastal Resilience Fund late June 2022 and may include matching funds from FDEP and FWC.

Total Amount of Funding Request	Duration
$550,000	1 Year

Final Comments and Next Steps

In coordination with the Florida Department of Environmental Protection, other State and Federal Agencies, and local governments, the District is making infrastructure adaptation investments that are needed to continue to successfully implement its mission. This plan presents a comprehensive list of priority resiliency projects with the goal of reducing the risks of flooding, sea level rise and other climate impacts on water resources and increasing community and ecosystem resiliency in South Florida. This list of projects was compiled based upon vulnerability assessments that have been ongoing for the past decade. These assessments utilize extensive data observations and robust technical hydrologic and hydraulic model simulations to characterize current and future conditions, and associated risks.

The list of priority resiliency includes investments needed to increase the resiliency of the District's coastal structures, including structure enhancement recommendations and additional SLR adaptation needs. These projects represent urgent actions to address the vulnerability of the existing flood protection infrastructure. Project recommendations also comprise basin-wide flood adaptation strategies that are based upon other FPLOS recommendations, and water supply and water resources of the State protection efforts. Important planning projects are also presented to continuously advance vulnerability assessments and scientific data and research to ensure the District's resiliency planning and projects are founded on the best available science.

Through collaboration with local municipalities, Counties, Regional Climate Compacts, State and Federal Agencies, the projects being proposed in this Plan are discussed and integrated into regional strategies to promote resiliency, which include other structural and non-structural adaptation and mitigation measures, such as flood proofing, road elevations, relocation, other local drainage improvements, shoreline stabilization, living shorelines, beach restoration, and others.

Among next steps for the implementation of the project recommendations included in this plan, the District is seeking for funding alternatives at the State and Federal levels. At the State level, in May 2021, Governor Ron DeSantis signed Florida Senate Bill 1954 which created the Resilient Florida Program, providing significant funding to support flooding and SLR resiliency projects throughout the State. In May 2022, Governor DeSantis approved House Bill 7053 which established further efforts towards Statewide Flooding and Sea Level Rise Resilience. At the Federal level, FEMA mitigation and adaptation funding is under consideration. In addition, the District and USACE are partnering to advance the C&SF Flood Risk Management and Resiliency Study, to recommend adaptation strategies to build flood resiliency in the Communities served by the C&SF Systems. This Study will be initiated in the Fall 2022 under the existing authority of the Flood Control Act of 1970 – Section 216 and will leverage advanced hydrologic, hydraulic and/or hydrodynamic models, representing surface water system and associated operational rules, as well as groundwater and ocean/coastal water interaction developed under the South Florida Water Management District's Flood Protection Level of Service (FPLOS) Program and USACE's South Atlantic Coastal Study (SACS, https://www.sad.usace.army.mil/SACS/). The Section 216 Study will focus on the highly vulnerable infrastructure that can reduce the most immediate flood risk to changing hydrodynamic and climate conditions, and the resilience aspects of such infrastructure, and will be conducted in coordination with stakeholders, Federal agencies, State, Tribal and local officials. USACE and the SFWMD would be 50/50 cost-sharing partners for a 3x3x3 compliant study- that's $3M budget and 3-tiers concurrent reviews over 3-years. The results of the Section 216 Study will allow the immediate authorization of subsequent design and construction phases.

Finally, the District is committed to continue promoting regional coordination and partnership opportunities by holding proactive discussions, leveraging technical knowledge and exchanging information. The South Florida Water Management District's (SFWMD) Resiliency Public Forum is being established to promote collaboration on water management initiatives related to resiliency, and further engage partners on the impacts of changing climate conditions and water management implications, now and into the future. This forum will foster a constructive environment to discuss tangible asset-level solutions and support decision making on water resource management

References

SFWMD, Aquifer Storage and Recovery Regional Study Fact Sheet, 2018
https://usace.contentdm.oclc.org/utils/getfile/collection/p16021coll11/id/3905

SFWMD, Aquifer Storage and Recovery Regional Study, 2015

https://www.sfwmd.gov/sites/default/files/documents/ASR_Regional_Study_Main_Report_Final_2015.pdf

SFWMD, Aquifer Storage and Recovery Program Update, 2008

https://www.sfwmd.gov/sites/default/files/documents/ASR_Interim_Report_2008.pdf

SFWMD, Alternative Water Supply Pilot Project Designation Request – C-51 Reservoir Phase 1

https://www.sfwmd.gov/sites/default/files/documents/C-51%20Reservoir%20Ph%201.pdf

SFWMD, Central Everglades Planning Project Post Authorization Change Report, 2018

https://www.sfwmd.gov/sites/default/files/documents/cepp_pacr_main_report.pdf

https://pandj.com/c-51-reservoir-construction/

SFWMD, Managing South Florida's Water Conservation Areas Fact Sheet

https://www.sfwmd.gov/sites/default/files/documents/fyi_wca_management.pdf

SFWMD, Saltwater Interface Monitoring and Mapping Program Technical Publication WS-58, 2020

https://www.sfwmd.gov/sites/default/files/documents/ws-58_swi_mapping_report_final.pdf

USGS, Origins and Delineation of Saltwater Intrusion in the Biscayne Aquifer and Changes in the Distribution of Saltwater in Miami-Dade County, Florida, 2014

https://pubs.usgs.gov/sir/2014/5025/pdf/sir2014-5025.pdf

https://www.sfwmd.gov/recreation-site/stormwater-treatment-area-1-west-sta-1w

https://www.sfwmd.gov/community-residents/florida-friendly-landscaping-guide

https://floridawaterstar.com/

SFWMD, Water Reuse: A safe and effective way to save water.

https://www.sfwmd.gov/sites/default/files/documents/bts_reuse.pdf

OASIS, Water Consumer Confidence Report, 2021

https://cdn.pompanobeachfl.gov/city/pages/utilities/City-of-Pompano-OASIS_CCR-web.pdf

SFWMD, Alternative Water Supply Approved Projects List, 2022

https://www.sfwmd.gov/sites/default/files/FY97-present_AWS_ApprovedPrjts_4-11-2022.pdf

SFWMD, Growth of Desalination within the South Florida Water Management District, 2020

https://www.sfwmd.gov/sites/default/files/Growth_of_Desalination_Facilities_Within_the_SFWMD.pdf

FKAA, Environmental Assessment of New Kermit H. Lewin Reverse Osmosis Facility, 2021

https://www.fkaa.com/DocumentCenter/View/486/New-Kermit-H-Lewin-Reverse-Osmosis-Facility-EA-51521

CE Lovelock et al., Assessing the risk of carbon dioxide emissions from blue carbon ecosystems. Front Ecol Environ 2017;15(5):257-265.

Jerath et al. 2016. The role of economic, policy and ecological factors in estimating value of carbon stocks in Everglades mangrove forest, south Florida, USA. Environmental Science and Policy.

Modernizing Building Codes

https://www.whitehouse.gov/briefing-room/statements-releases/2022/06/01/fact-sheet-biden-harris-administration-launches-initiative-to-modernize-building-codes-improve-climate-resilience-and-reduce-energy-costs/

Bridges, T. S., J. Lillycrop, J. Wilson, T. Fredette, B. Suedel, C. Banks, and E. Russo. 2014. Engineering with nature promotes triple-win outcomes. *Terra et Aqua* 135: 17-23.

Bridges, T. S., J. K. King, J. D. Simm, M. W. Beck, G. Collins, Q. Lodder, and R. K. Mohan, eds. 2021. *International Guidelines on Natural and NatureBased Features for Flood Risk Management*. Vicksburg, MS: U.S. Army Engineer Research and Development Center.

Raymond, Christopher & Frantzeskaki, Niki & Kabisch, Nadja & Berry, P. & Breil, Margaretha & Nita, Mihai & Geneletti, Davide & Calfapietra, Carlo. (2017). A framework for assessing and implementing the co-benefits of nature-based solutions in urban areas. Environmental Science & Policy. 77. 15-24. 10.1016/j.envsci.2017.07.008.

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Appendix A: FPLOS Phase I – Initial Project Recommendations and High-Level Estimated Costs

Project Name	Basin	Sub-Basin	Sub-Basin Current FPLOS Condition	Mitigation Strategy ID	Total Cost	Comment
Canal Conveyance Improvements	C-8	N/A	N/A	C8_1	$ 8,762,351	Conveyance improvements within the eastern segment of C8, downstream of its confluence with Marco Canal could help improve the current conditions FPLOS. As noted in the recent FPLOS report (Taylor, 2020), this canal segment has a number of bank exceedances, even for the more frequent (e.g., 10-year) design storm events. Dredging the C8 Canal to deepen and/or widen the cross section could reduce flood elevations and thus the frequency of bank exceedances. Although the effectiveness of this strategy would tend to diminish with increasing SLR and higher storm surge elevations, this strategy could be implemented in conjunction with mitigation strategy #2 to improve FPLOS in future SLR scenarios, which would serve to maintain manageable headwater elevations at S28.

Project Name	Basin	Sub-Basin	Sub-Basin Current FPLOS Condition	Mitigation Strategy ID	Total Cost	Comment
Flood Walls and Storm Surge Barrier Downstream of S28	C-8	N/A	N/A	C8_3		Mitigation strategy #3 is somewhat similar to Mitigation strategy #2 but would be more comprehensive and could potentially provide a higher level of flood protection under the more extreme SLR and storm surge scenarios. This strategy would involve construction of a storm surge barrier (i.e., a miter gate or sector gate) downstream of S28 in the vicinity of U.S Highway 1 (Biscayne Blvd), along with a flood wall to tie the surge barrier back into high ground. According to the USACE Back Bay Study (USACE, 2020), the associated flood wall would have to be continuous with a flood wall and storm surge barrier in the C7 Watershed. In order to be effective under the more extreme SLR scenarios, levees and/or flood walls may have to incorporate seepage barriers due to the extremely high permeability of the underlying Biscayne Aquifer. Without such barriers, the porous limestone of the Biscayne could provide a subsurface pathway for tidal waters to flow underground, seeping into the canals upstream of the floodwalls and surge barriers whenever the tides are higher than canal stages. Assessing the feasibility of seepage barriers will require a detailed analysis of the site(s) geology. Seepage barriers are expected to be costly in this environment. Due to the limestone geology, sheet pile walls may not be feasible. Seepage cut-off walls could possibly be constructed using a sequence of drilled shafts or specialized bedrock-cutting equipment similar to that currently employed in the rehabilitation of the Herbert Hoover Dike (Bruce, 2009). Furthermore, this strategy may require additional seepage management infrastructure (seepage collection canals and pumps) on the inland side of the seepage barriers in order to collect and discharge fresh groundwater to tide. Another possible refinement to this strategy would involve co-locating the surge barrier with the gated control structure (S28) and/or a forward pump station. The current plan presented in the USACE Back Bay study calls for a

Project Name	Basin	Sub-Basin	Sub-Basin Current FPLOS Condition	Mitigation Strategy ID	Total Cost	Comment
						separate surge barrier some distance downstream of S28. If the surge barrier, rebuilt S28, and forward pump station could all be co-located, there may be opportunities to improve the operational flexibility of the system over the current plan, such as having the ability to pump down C-8 when the surge barrier is closed. Thus the structure could serve dual purposes of conveying rainfall-induced runoff while protecting against storm surge.

Project Name	Basin	Sub-Basin	Sub-Basin Current FPLOS Condition	Mitigation Strategy ID	Total Cost	Comment
Raise levees along C-8 canal and add gates / pumps on the secondary branches	C-8	N/A	N/A	C8_4	$248,791,563	If, in the future SLR scenarios, it is no longer feasible or cost effective to maintain stages in the primary canals at acceptable levels, it may be necessary to consider raising the levees along the primary canals and constructing new gated structures and/or pumps on the secondary canals to achieve an acceptable level of flood protection. The FPLOS report shows the flood depth differences for the 25-year event with no mitigation measures (3-foot SLR minus current conditions), along with conceptual locations of potential new gated structures and pump stations on existing secondary canals at their confluence with the primary canals. Also shown on this report are areas that currently drain directly to the primary canals. Because these areas would not be protected by improvements on secondary branches, they would require modifications to the stormwater collection system to either (a) re-route the drainage to a nearby secondary branch, or (b) re-route the drainage to new municipal pump stations (not shown). Although the extensive drainage modifications this would require may render this strategy infeasible basin-wide, this option was included for completeness or as an option to be considered for targeted areas. Initial Cost estimates include adding pump stations for the Miami-Dade Co. tributary canals to the C8 Canal
Connect Western Mine Pits South of C9 Canal to the C9 Canal	C-9	N/A	N/A	C9_1	$92,401,883	Connect Western Mine Pits South of C9 Canal to the C9 Canal. Construction of a 1000 cfs immediately west of SW 173rd Ave. Construct backup generator power for C9 Lake Belt forward Pump Station
Oleta River Storm Surge Barrier	C-9	N/A	N/A	C9_2	$14,576,015	This strategy would include a surge barrier on the Oleta River to the north of S29. The Oleta River barrier would cut off a potential pathway for storm surge to bypass the S29 and enter the C9 basin from the north and west through a swath of urbanized lowlands. A more comprehensive (and more costly) version of this strategy that would provide a higher level of flood protection could also be considered for the C9 Basin. This would be similar to the strategy of flood walls and surge barriers discussed as Mitigation Strategy #3 for the C8 Basin.

Project Name	Basin	Sub-Basin	Sub-Basin Current FPLOS Condition	Mitigation Strategy ID	Total Cost	Comment
Raise levees along C-9 Canal and add gates / pumps on the secondary branches	C-9	N/A	N/A	C9_3	$322,493,438	This strategy is similar to mitigation strategy #4 in the C-8 basin. If, in the future SLR scenarios, it is no longer feasible or cost effective to maintain stages in the primary canals at acceptable levels, it may be necessary to consider raising the levees along the primary canals and constructing new gated structures and/or pumps on the secondary canals to achieve an acceptable level of flood protection. Conceptual locations of potential new gated structures and pump stations on existing secondary canals at their confluence with C-9. As in C-8, areas draining directly to C-9 would not be protected by improvements on secondary branches, and would require additional modifications to the stormwater collection systems to either (a) re-route the drainage to a nearby secondary branch, or (b) re-route the drainage to new municipal pump stations (not shown). Although the extensive drainage modifications this would require may render this strategy infeasible basin-wide, this option was included for completeness or as an option to be considered for targeted areas. Initial cost Estimates include only new pumps to secondary brances (Station estimate based on $50k/cfs incls all dewatering, structure const, site work, elec., I&C, and mechanical.) and not raising canal banks.
Increase Connectivity Between C-9 and C-11	C-9	N/A	N/A	C9_4		This strategy was identified by the South Broward Drainage District (SBDD) as a way to increase operational flexibility. In particular, enlarging the Silver Lake Control Structure would facilitate the movement of water into C-11 Basin from SBDD S5 Basin or vice versa depending on relative water levels within the two canals.

Project Name	Basin	Sub-Basin	Sub-Basin Current FPLOS Condition	Mitigation Strategy ID	Total Cost	Comment
Structure S-37B improvements	Broward County	C-14 Basin	The C-14 West Basin has been assigned a 5-year FPLOS rating for SLR1 and less than 5-year FPLOS rating for SLR2 and SLR3. For all return period design storm and sea level rise scenarios simulated, the first FPLOS deficiency that is predicted to occur is flooding of a gravity-drained area that has topographic elevation lower than the peak stage in the C-14 Canal. As return period and sea level rise increases, other deficiencies are predicted to occur such as bank exceedance. Much of the C-14 West Basin is drained by pumps or is	BC_2.1		Although Structure S-37B is not a tidal structure, it is expected to be impacted by sea level rise. As storm surge and sea level rise propagate upstream of Structure S-37A, higher tailwater levels will be seen at Structure S-37B. Higher tailwater levels at Structure S-37B result in decreased discharge and higher stages in the C-14 Canal. One possible improvement to S-37B is the addition of a pump station. However, this addition would only be feasible with major modifications to Structure S-37A also, otherwise it would worsen downstream flooding between S-37B and S-37A. Structural or operational modifications to structure S-37B alone would not be beneficial as Structure S-37B is not predicted to be overtopped and maintains positive head differential during the simulated sea level rise scenarios. Structure improvements at S-37B may be avoidable with a combination of modifications to Structure S-37A, which will be needed anyway, and secondary system improvements, which later studies may determine to be more cost effective as the FPLOS deficiencies are very localized and not widespread.

Project Name	Basin	Sub-Basin	Sub-Basin Current FPLOS Condition	Mitigation Strategy ID	Total Cost	Comment
Add gates / pumps on the secondary system	Broward County		protected by the embankments along the C-14 Canal.	BC_2.2	$129,800,461	As part of the PM #5 analysis presented in Deliverable 4.2A, Taylor Engineering compared peak canal stages with land surface topography elevations. A significant area of the C-14 West Basin has topographic elevations that are lower than the simulated peak canal stages, however, much of it is drained by pumps (areas such as Coral Springs and Tamarac). Areas drained by pumps can continue to discharge when downstream water levels are higher (unless required by permit to stop when the downstream stages exceed a threshold stage), so they are of less significance for the purposes of the PM #5 evaluation. However, areas that are drained by gravity are unable to drain whenever downstream water levels are higher than the land surface elevation. In the C-14 West Basin, one area in particular was identified as being drained by gravity and having land surface elevations lower than the peak stage where it drains to the C-14 Canal. This area, mainly roads in North Lauderdale, between N University Dr and S State Road 7 (Hwy 441), would benefit from the addition of operable structure(s), whether it be to actively drain when downstream water levels are elevated or to prevent the elevated C-14 Canal from backing up into secondary system. The FPLOS report shows conceptual locations of potential new gated structures or pump stations on existing secondary canals at their confluence with the primary canals. Cost estimates include: Replace the existing control structure for flows into the WCA-2 with a 2000 cfs gated spillway amd Construction of a 2000 cfs immediately east of the Sawgrass Expy, including backup generator

Project Name	Basin	Sub-Basin	Sub-Basin Current FPLOS Condition	Mitigation Strategy ID	Total Cost	Comment
Raise levees at selected locations on the C-14 Canal	Broward County			BC_2.3		As part of the PM #1 analysis presented in Deliverable 4.2A, Taylor Engineering compared peak canal stages with canal bank elevations. Although the C-14 Canal is predicted to mostly contain the 100-year return period design storm within its banks for all three sea level rise scenarios simulated, there are a few localized locations of exceedance. Of the three locations with significant bank exceedance levels, only one is predicted to directly result in inundation of developed lands, which was the metric used to identify deficiencies in this study. The FPLOS Report shows the location proposed for canal bank improvements. The proposed bank improvement would involve raising about 1200 linear ft of the 1700 ft section shown on the north side of the canal to form a more elevated continuous embankment.
Canal dredging in areas with significant head loss	Broward County			BC_2.4		One potential way to reduce stages in the C-14 Canal would be to dredge the canal in areas with significant head loss. The canal bottom profile can be compared to the canal design bottom elevation to identify areas with sediment accumulation. Based on the 25-year design storm simulation results, there is a predicted head loss of about 0.60 ft to 0.74 ft (decreasing as SLR increases) over the 9400 ft stretch of canal between the Sunshine WCD PS1 outfall and South State Road 7, and 1.0 ft to 1.23 ft (decreasing as SLR increases) over the 13500 ft stretch of canal between South State Road 7 and Structure S-37B. These areas could benefit from dredging if the existing canal conditions have deteriorated compared to the design conditions. Regardless of whether the existing canal conditions in these areas have deteriorated compared to design, it is possible that deepening the canal to improve conveyance could reduce peak canal stages.

Project Name	Basin	Sub-Basin	Sub-Basin Current FPLOS Condition	Mitigation Strategy ID	Total Cost	Comment
Raise levees on the Cypress Creek Canal	Broward County	C-14 East Basin	The C-14 East Basin has been assigned a 10-year FPLOS rating for SLR1 and less than 5-year FPLOS rating for SLR2 and SLR3. Under SLR1 scenario, the 25-year design storm is predicted to produce peak canal stages that exceed bank elevations and inhibit gravity-driven drainage. Under SLR2 and SLR3 scenarios, the 5-year design storm is predicted to produce peak canal stages that exceed bank elevations and inhibit gravity-driven drainage. As return period and sea level rise increases, so does the predicted occurrences of bank exceedance as well as the area and duration of flooding. The C-14 East Basin is drained by gravity and is therefore sensitive to stage in the Cypress Creek Canal. To reduce flooding and increase the level of service provided for the C-14 East Basin, Taylor Engineering recommends evaluation of the following two potential flood mitigation projects:	BC_3.2		If, in the future SLR scenarios, it is no longer feasible or cost effective to maintain stages in the primary canals at acceptable levels, it may be necessary to consider raising the levees along the primary canal to reduce overland flooding as a result of bank exceedance. However, this strategy alone would not reduce flooding as a result of elevated stages in the primary canal inhibiting gravity-driven discharge from the secondary system. Therefore, this mitigation strategy could be implemented as necessary in select locations that would still experience bank exceedance after Structure S-37A Improvements (mitigation strategy 1) have been implemented, which can be determined through future model simulations.
Canal dredging in areas with significant head loss	Broward County			BC_3.3		One potential way to reduce stages in the Cypress Creek Canal would be to dredge the canal in areas with significant head loss. The canal bottom profile can be compared to the canal design bottom elevation to identify areas with sediment accumulation. Based on the 10-year design storm simulation results, there is a predicted head loss of about 0.3 ft over the 1 mile stretch of canal between W Palm Aire Drive and FL-845 (Powerline Road) and 0.2 ft over the 3500 ft stretch of canal between FL-845 and the Train Tracks Bridge.

Project Name	Basin	Sub-Basin	Sub-Basin Current FPLOS Condition	Mitigation Strategy ID	Total Cost	Comment
Culvert Modification	Broward County	POMPANO BASIN	The Pompano Basin has been assigned a less than 5-year FPLOS rating for all SLR scenarios simulated. The Pompano Canal is predicted to contain the 100-year SLR3 design storm event within its banks with no instances of bank exceedance. However, the canal stage resulting from even the 5-year SLR1 scenario is predicted to result in water backing up and spilling out of the secondary system, as well as inhibiting gravity-driven drainage of developed areas in some localized areas. The Pompano Basin is drained by gravity and model simulations indicate that it would be sensitive to extremely sensitive to sea level rise. As return period and sea level rise increases, so does the overland flood depth and duration in many areas. To reduce flooding and increase the level of service provided for the Pompano Basin, Taylor Engineering recommends evaluation of the following three potential flood mitigation projects: • Culvert modification: Increase the conveyance capacity / decrease the head loss through the culvert immediately upstream of	BC_4.1		The results of the future conditions FPLOS assessment indicate that the culvert immediately upstream of G-57 is at least partially responsible for the elevated stages in the Pompano Canal. This 10 ft diameter culvert, which is approximately 1450 ft in length, is predicted to have approximately 1.5 to 4.0 ft of head loss depending on the specific return period and sea level rise scenario. Depending on the specific scenario, this head loss is more significant than the effects of sea level rise. Therefore, although Structure G-57 experiences overtopping / bypass, improving the conveyance capacity of this section of the canal may prove to have more impact than G-57 improvements alone. However, to maximize flood protection improvement, modification of this culvert could be done in conjunction with Structure G-57 improvements.
Divert Water Through C-14 West / C-14 East Basin	Broward County			BC_4.3		If, in the future SLR scenarios, it is no longer feasible or cost effective to maintain stages in the primary canal at acceptable levels, it may be necessary to consider diverting water from the Pompano Basin to the C-14 West Basin, which will ultimately pass through the C-14 East Basin to tide. However, as the C-14 West Basin and the C-14 East Basin are predicted to be affected by sea level rise, diverting water to them would likely only be feasible after structure improvements at S-37B and S-37A are implemented. It may be more effective to divert water through Structure S-37B and Structure S-37A, which will both likely need improvements anyway to protect the large area they serve, than to perform some level of improvement at Structure G-57 and the culvert immediately upstream in addition to the C-14 Basin projects. These potential strategies should be further investigated and analyzed in future studies.

Project Name	Basin	Sub-Basin	Sub-Basin Current FPLOS Condition	Mitigation Strategy ID	Total Cost	Comment
			Structure G-57 • Structure G-57 improvements • Divert water through C-14 West / C-14 East Basin			
Raise levees along the C-13 Canal and add gates / pumps on secondary branches	Broward County	C-13 WEST BASIN	The C-13 West Basin has been assigned a 25-year FPLOS rating for SLR1, 10-year rating for the SLR2, and less than 5-year rating for SLR3. Under SLR1 scenario, the 100-year design storm is predicted to produce peak canal stages that exceed bank elevations and inhibit gravity-driven drainage. Under SLR2, the 25-year design storm is predicted to produce peak canal stages that exceed bank elevations and inhibit gravity-driven drainage. Under SLR3, the 5-year design storm is predicted to produce peak canal stages near the tidal structure that are higher than larger return periods storms under smaller sea level rise, which highlights the C-13 West Basin's sensitivity to sea level rise.	BC_5.2		If, in the future SLR scenarios, it is no longer feasible or cost effective to maintain stages in the primary canals at acceptable levels, it may be necessary to consider raising the levees along the C-13 Canal and constructing new gated structures and/or pumps on the secondary canals to achieve an acceptable level of flood protection. The FPLOS report presents conceptual locations of potential new gated structures and pump stations on existing secondary canals at their confluence with the primary canals. Gravity structures such as gated culverts, sluice gates, or flap gates are different types of structures that could be considered to prevent flood water from propagating upstream.

Project Name	Basin	Sub-Basin	Sub-Basin Current FPLOS Condition	Mitigation Strategy ID	Total Cost	Comment
			Per District operational criteria, the S-36 tidal structure closes whenever the tailwater elevation comes within 0.1 ft of the headwater elevation. Due to the increased tailwater elevation associated with sea level rise, the S-36 structure is predicted to close often to prevent storm surge from propagating upstream. Although this prevents storm surge from propagating upstream, it does not completely prevent increased stages upstream, as the C-13 Canal stage will increase due to being unable to discharge to tide when the Structure S-36 is closed.			
Structure Operation Modification	Broward County	NORTH NEW RIVER WEST BASIN	The North New River West Basin has been assigned a 100-year FPLOS rating for SLR1, 25-year for SLR2, and 10-year for SLR3. North New River is predicted to contain the 100-year SLR1, 25-year SLR2, and 10-year SLR3 storm events within its banks with no instances of bank exceedance and little to no overland flooding resulting directly from the elevated canal stages. The 100-year SLR2 and 25-year SLR3 design storms are almost completely contained within bank, however, there is one localized area where	BC_7.1		Based on District-provided structure operations (SFWMD H&H Bureau, 2020), Structure G-54 opens when the headwater elevation exceeds 4.5 ft NGVD29 and does not close until the headwater falls below 3.5 ft NGVD29. As such, once the structure is opened, it remains open when downstream water levels are higher than upstream water levels as long as the upstream water levels have not fallen below 3.5 ft NGVD29, which only occurs for the SLR1 scenarios. It is possible that peak upstream canal stages can be reduced by changing the standard operating criteria. One potential modification that should be further analyzed is closing the gate whenever the downstream elevation is within 0.1 ft of the headwater elevation, as is done with other District tidal outfall structures in Broward County. This operation or a similar set of operating criteria relating to closing the structure if tailwater exceeds headwater would be necessary if a pump station is added, as discussed in Section 8.2. In addition, if structure operations are modified so that the structure closes, the

Project Name	Basin	Sub-Basin	Sub-Basin Current FPLOS Condition	Mitigation Strategy ID	Total Cost	Comment
			even the small exceedance would contribute to overland flooding of developed areas. Per District operational criteria listed in the Water Control Operations Atlas for Eastern Broward County (SFWMD H&H Bureau, 2020), the G-54 tidal structure opens whenever the headwater elevation is greater than 4.5 ft NGVD29 and does not close when the downstream water level is elevated. This simulated operation results in elevated upstream water levels and instances of flow reversal. It is possible that closing the structure when downstream levels are within 0.1 ft of the headwater elevation would have similar results to current conclusions as storm surge would overtop Structure G-54, but it should be further analyzed.			gated structure would need modification, which is also discussed in Section 8.2.
Raise Levees at Select Location(s)	Broward County			BC_7.3		If, in the future SLR scenarios, it is no longer feasible or cost effective to maintain stages in the primary canal at acceptable levels, it may be necessary to consider raising the canal levees to reduce overland flooding as a result of bank exceedance. For the North New River Canal, only one instance of bank exceedance was predicted during the future condition simulations (upstream and downstream 124th Ave (N Flamingo Rd)), which was the primary deficiency that impacts the assigned flood protection level of service. Raising the segment of canal embankment identified in Deliverable 4.2B would increase the level of service and is likely a very feasible project to implement. The proposed bank improvement would involve raising about 2800 linear ft of the 3600 ft section shown on the north side of the canal to form a more elevated continuous embankment. It is possible that this strategy would not be required if Structure G-54 follows salinity control operations discussed in Section 8.1, which future modeling simulations can address.

Project Name	Basin	Sub-Basin	Sub-Basin Current FPLOS Condition	Mitigation Strategy ID	Total Cost	Comment
Canal dredging in areas with significant head loss	Broward County			BC_7.4		One potential way to reduce stages in the North New River Canal would be to dredge the canal in areas with significant head loss. The canal bottom profile can be compared to the canal design bottom elevation to identify areas with sediment accumulation. Based on the 25-year design storm simulation results, there is a predicted head loss of about 0.3 ft to 0.83 ft (decreasing as SLR increases) over the 3 mile stretch of canal between Hiatus Rd and N University Dr (FL-817), and 0.14 to 0.46 ft (decreasing as SLR increases) over the 7000 ft stretch of canal between N University Dr and Structure G-54. These areas could benefit from dredging if the existing canal conditions have deteriorated compared to the design conditions. The head loss through the North New River Canal should be analyzed again after the salinity control operations discussed in Section 8.1 have been included in future model simulations. Dredging in areas with significant head loss may eliminate the need to raise the embankment, which could be analyzed in the next phase of this FPLOS study.
Lower water control elevation of primary canal	Broward County	C-11 WEST BASIN	The C-11 West Basin has been assigned a 10-year FPLOS rating for all SLR scenarios. Although the C-11 Canal is expected to contain the 100-year storm event within its banks with no instances of bank exceedance, the elevated canal stage would decrease the gravity drainage ability of the secondary system, contributing to flooding of	BC_8.1		The C-11 West Basin is controlled at a water elevation of 4.0 ft NGVD29. Lowering the control water level in the western segment of the C-11 Canal (upstream / west of Structure S-13AW) may help buffer the peak rainfall and result in overall lower stages in the primary system. As this basin is drained by pumps at the western end of the C-11 Canal, lowering the control elevation would need to be implemented with modification to the standard operating procedure, otherwise the primary canal system would fill back up prior to peak rainfall. However, lowering the control elevation and maintaining the lower stages pre-storm with the pumps may reduce flooding to some extent.

Project Name	Basin	Sub-Basin	Sub-Basin Current FPLOS Condition	Mitigation Strategy ID	Total Cost	Comment
Improve C-11 conveyance capacity / operation modification	Broward County		developed areas. To reduce flooding and increase the level of service provided for the C-11 West Basin, Taylor Engineering recommends evaluation of the following four potential flood mitigation projects: • Lower water control elevation of primary canal • Improve C-11 conveyance capacity / operation modification • Add gates / pumps to the secondary system • Use the existing inter-basin connection with C-11 East Although there is a large pump station already draining the C-11 West Basin, it is already at maximum capacity in accordance with the non-Everglades Construction Project permit (SFWMD H&H Bureau, 2020). Therefore, instead of increasing the capacity of the pump station, a potential flood mitigation project would be to provide it more opportunity to discharge at its maximum capacity, either by improving channel conveyance capacity or by modifying the	BC_8.2		One potential way to reduce the duration of flooding is to increase the conveyance capacity of the C-11 Canal so that the pump has less “down-time”. Based on standard operating criteria, the S-9/S-9A Pump Station reduces discharge when the headwater drops below 1.0 ft NGVD29 and may turn off completely if the water elevation drops below 0.0 ft NGVD29 until the minimum pool elevation is re-established. Increasing channel conveyance capacity could increase the water level upstream of the pumps which would allow them to stay at peak discharge longer, as well as reducing upstream water levels. One potential way of improving canal conveyance is to dredge the primary canal (back to design condition in areas with significant head loss of sediment deposition) or deepen the canal beyond design conditions. Based on the future condition simulations, this strategy would not likely reduce peak flood depths as the pumps are at peak capacity during those times. However, it could reduce the duration that the primary canal is elevated, ultimately reducing the duration of flooding.
Add gates / pumps to the secondary system	Broward County			BC_8.3		If, in the future SLR scenarios, it is no longer feasible or cost effective to maintain stages in the primary canals at acceptable levels, it may be necessary to consider constructing new gated structures and/or pumps on the secondary canals to achieve an acceptable level of flood protection. Due to the large number of connection points between the primary and secondary system, it is likely not feasible to add a pump station to each one. However, it is possible that some strategic combination of gates and pumps could be implemented to reduce flooding and increase the level of service. Adding gates to the secondary canals at their confluence with the primary canals would prevent water from backing up into the secondary system during times of peak stage and pump stations placed on secondary canals with the most connectivity could actively drain the secondary system.

Project Name	Basin	Sub-Basin	Sub-Basin Current FPLOS Condition	Mitigation Strategy ID	Total Cost	Comment
Use the existing inter-basin connection with C-11 East	Broward County		standard operation criteria. These are further discussed in Section 9.2.	BC_8.4		Between the C-11 West Basin and the C-11 East Basin exists Structure S-13AW, which is an inter-basin connection. For the purposes of the FPLOS design storms, this structure remained closed. The intended purpose of this structure is to discharge excess water from the C-11 West Basin to tide when capacity is available in the C-11 East Basin. One potential way to reduce flooding in the C-11 West Basin is to divert some flood water to tide through the C-11 East Basin. However, this would only be feasible if structure modifications were implemented to increase the discharge potential of the C-11 East Basin tidal structure. As the maximum discharge capacity of the S-9/S-9A pump station is limited, the most obvious way to remove flood water from the C-11 West Basin is to discharge it to tide by increasing the maximum capacity of the S-13 tidal structure. However, modifications to the S-13 structure alone may not be sufficient enough and the primary canal conveyance may need to be improved through dredging (back to design condition) or deepening in some sections. Improvements to the S-13 structure are further discussed in Section 10.2.

Project Name	Basin	Sub-Basin	Sub-Basin Current FPLOS Condition	Mitigation Strategy ID	Total Cost	Comment
Structure S-13 Improvements Option 1	Broward County	C-11 EAST BASIN	The C-11 East Basin has been assigned a 5-year FPLOS rating for all SLR scenarios. Although the C-11 Canal is expected to contain the 100-year storm event within its banks with no instances of bank exceedance, the elevated canal stage would decrease the gravity drainage ability of the secondary system, contributing to flooding of developed areas.	BC_9.1		Structure S-13 is the tidal outfall structure for the C-11 East Basin and is composed of a pump station and an underflow gate. Regardless of gate position, water will bypass this structure at an elevation of 8.0 ft NGVD29 (SFWMD H&H Bureau, 2020), which was not predicted to occur based on District-provided storm surge data. However, the S-13 peak tailwater used for the 100-year SLR3 scenario is within 0.04 ft of bypassing/overtopping the structure. The S-13 underflow gate closes whenever the tailwater elevation gets within 0.1 ft of the headwater elevation. Under future condition sea level rise, the S-13 tailwater stage will often exceed the headwater stage, which forces the underflow gate to remain closed, which significantly reduces the discharge. Structure improvements would involve re-building or modifying the S-13 structure to include more (or larger) forward pumps and increase the heights of the platform to reduce the potential for overtopping/bypass. Due to the low elevation of the C-11 East Basin, sea level rise will likely make a gravity structure such as the S-13 underflow gate impractical. Although the gate is still able to discharge at times during the simulated sea level rise design storms, it does so with upstream water level elevations that cause flooding. Therefore, to reduce flooding and increase FPLOS, increased pump capacity is required.
Structure S-13 Improvements Option 2	Broward County			BC_9.2		Structure S-13 improvement option 1 involves sizing the upgraded/modified pump station to handle the needs of the C-11 East Basin alone. S-13 improvement option 2 involves sizing the upgraded/modified pump station to handle not just the needs of the C-11 East Basin, but also some needs of the C-11 West Basin. The discharge out of the C-11 West Basin through the S-9/S-9A pump station is limited based on the non-Everglades Construction Project permit. However, discharge to tide is only limited to what the infrastructure can handle. As modifying Structure S-13 is likely required to protect the C-11 East Basin from sea level rise, it may be possible to also increase the level of service for the C-11 West Basin at the same time with one project.

Project Name	Basin	Sub-Basin	Sub-Basin Current FPLOS Condition	Mitigation Strategy ID	Total Cost	Comment
Add Gates / Pumps to the Secondary System	Broward County			BC_9.3		If, in the future SLR scenarios, it is no longer feasible or cost effective to maintain stages in the primary canals at acceptable levels, it may be necessary to consider constructing new gated structures and/or pumps on the secondary canals to achieve an acceptable level of flood protection. Due to the large number of connection points between the primary and secondary system, it is likely not feasible to add a pump station to each one. However, it is possible that some strategic combination of gates and pumps could be implemented to reduce flooding and increase the level of service. Adding gates to the secondary canals at their confluence with the primary canals would prevent water from backing up into the secondary system during times of peak stage and pump stations places on secondary canals with the most connectivity could actively drain the secondary system. In the C-11 East Basin, the secondary system is mostly composed of north/south drainage canals and does not have many east/west canals connecting them. Therefore, increased connectivity and conveyance between the secondary system would be needed to minimize the number of secondary system pump stations.

Project Name	Basin	Sub-Basin	Sub-Basin Current FPLOS Condition	Mitigation Strategy ID	Total Cost	Comment
Improvements in Primary Canals C-1W and C-1	South Miami-Dade	Watershed C-1	The C-1 Watershed has been assigned a 10-year FPLOS rating for SLR0 and SLR1 and 5-year FPLOS rating for SLR2 and SLR3. The primary reason for rating the watershed as a 10-yr and 5-yr LOS is due to canal bank exceedance. The following infrastructure projects are suggested to maintain and improve the LOS of watershed C-1: 1. Improvements in Primary Canals C-1W and C-1. 2. Upgrades of coastal structure S21 and potential new tidal structure at the Goulds Canal outfall to Biscayne Bay. 3. Upgrades of inland structures S148 and S149. 4. Installation of backflow prevention measures and devices. 5. Installation of control structure at the crossing of Cutler Wetland C-1 Flow Way and the eastern levee. 6. Improvements to elevation requirements of levees at the eastern boundary of the C-1 watershed. 7. Development of local flood mitigation projects in collaboration with Miami-Dade County. The numerical model can be	SMD_2.1		The improvements in Primary Canals C-1W and C-1 may include maintenance and dredging to provide an even bottom gradient from the west to the east and an upgrade of canal bank top elevations to eliminate overtopping. An example of the canal profiles and the deficiencies along the canals for 25-yr design event and SLR 0, 1, 2 and 3 is provided in the Report. The canal profiles show exceedance of canal banks on multiple locations for design events with a return period greater than 5-yr and 10-yr and an increase of SLR. In addition, the report shows that there is a water divide in canal C-1W at approximate chainage 5.5 which suggests that the cross sections of the C-1W may require widening to allow flow to the west (to canal L-31N). Structure S-338 closes depending on the flooding conditions downstream in the C-1 basin. Opening of the structure may cause additional flooding. Any changes for flood operations to this structure will be dependent on downstream flood conditions, therefore additional analysis is recommended to provide a better understanding of effects of redirecting flow to the west. Improvements in Canals C-1W and C-1 will involve: • Increase of canal bank elevation above the stage of the 25-yr 3-day design event within the Urban Development Boundary and at locations where flooding damages may occur as result of overtopping of the canal banks. • Maintenance of canals C-1W and C-1, and potential dredging to improve the canal bottom gradient and minimize hydraulic losses Considering that dredging and changing the elevations of the original canal bottom profiles could be prohibitively expensive for the entire canal, additional hydrographic surveys of the C-1N and C-1 canals and cross sections are recommended (C-1W canal already has a detailed cross section survey which has been implemented in the model). The new hydrographic surveys will be used to update the model cross sections, and additional simulation are suggested to determine locations where the canal bottom profile or cross section configurations may cause head

Project Name	Basin	Sub-Basin	Sub-Basin Current FPLOS Condition	Mitigation Strategy ID	Total Cost	Comment
			extended to provide analysis of the suggested projects and evaluate the effect of each project on the LOS for current and future conditions.			losses due to constriction or sedimentation and determine canal sections that may require deepening or widening.
New tidal structure at the Goulds Canal outfall to Biscayne Bay	South Miami-Dade	Watershed C-1		SMD_2.3	$14,140,467	Additional consideration should be given to future urbanization of the agricultural areas which are in the vicinity of Goulds Canal. Future land use which is marked as Agriculture. If the agricultural areas become developed, significant runoff contribution will be expected into Goulds Canal, which may additionally require a tidal structure to accommodate discharges from urbanized areas.

Project Name	Basin	Sub-Basin	Sub-Basin Current FPLOS Condition	Mitigation Strategy ID	Total Cost	Comment
Upgrades of inland structures S148 and S149	South Miami-Dade	Watershed C-1		SMD_2.4		The inland structures will require: • Increase of conveyance capacity of Canal C-1N by increasing the capacity of Structure S149 (currently 400 cfs), considering that flooding and canal overtopping has been observed upstream of S149 in canal C-1N. • Upgrade heights of the S149 platform and gates. Currently stages of 7.5 NGVD 29 (6.0 ft NAVD) can by-bypass the structure. • Upgrade heights of the S148 platform and gates. Currently stages of 9.0 NGVD 29 (7.5 ft NAVD) can by-bypass the structure.
Installation of backflow prevention measures and devices		Watershed C-1		SMD_2.5		Installation of backflow prevention devices to protect the secondary and tertiary system from backflow from the primary canal system particularly for increased SLR and storm surge conditions which can create high stages in the primary canals.
Installation of control structure at the crossing of Cutler Wetland C-1 Flow Way and the eastern levee.	South Miami-Dade	Watershed C-1		SMD_2.6		The planned Cutler Wetland C-1 Flow Way will require a control structure to avoid backflow during storm surge as discussed in the analysis of Future Conditions (Task 5.2, Section 3.1.4). Proposed structures may include a set of gated box culverts with parameters which will be based on additional analysis of flow rates and stages determined from selected design events and SLR scenario.
Improvements to elevation requirements of levees at the eastern boundary of the C-1 watershed.		Watershed C-1		SMD_2.7		Levee overtopping caused by storm surge can result in significant backflow in the C-1 watershed and increased upstream flood potential. Therefore, raising the top of the levees up to the 25-yr 3-day design event storm elevation at locations on the C-1 Watershed Canal within the Urban Development Boundary would be necessary. Elevation improvements of all levees at the eastern boundary of the C-1 watershed to 7.5 ft (NAVD 88) plus the necessary freeboard would be required. For example, near Goulds Canal, the levee will require an upgrade with a recommended top of the levee of 7.5 ft. (NAVD 88) plus required freeboard (based on the peak stages for the 100-yr event and +3 ft SLR).

Project Name	Basin	Sub-Basin	Sub-Basin Current FPLOS Condition	Mitigation Strategy ID	Total Cost	Comment
Development of local flood mitigation projects in collaboration with Miami-Dade County.	South Miami-Dade	Watershed C-1		SMD_2.8		The proposed mitigation areas are based on the flood depth greater than 1.0 ft for the 25-yr 3-day design event and flood depth greater than 2.5 ft for the 25-yr 3-day design event. Based on the Flood Extent and Duration Maps (PM5 and PM6) for the 25-yr 3-day storm event and +3 ft SLR, the C-1 Watershed areas within the Urban Boundary Line will require flood mitigation. To analyze the impacts of SLR on the urban drainage, the difference of the flood rasters for SLR 3 and SLR 0 were used to determine the greatest impact of SLR within the watershed. The SLR 0 depth raster depth was subtracted from the SLR 3 depth raster and differences were classified into 3 categories: i) less than 1 ft SLR impact, ii) SLR impact between 1 and 2 feet and SLR impact greater than 2 feet. The FPLOS report shows the areas impacted by SLR change from +0 to +3 ft. The major impacts are within the wetland areas which are interconnected within the drainage system and more specifically the primary canals. The figure shows that the SLR impacts for most of the urban areas (except for the areas highlighted with yellow and red colors) is not expected to be significant for a SLR change from 0 to 3. The FPLOS Report additionally shows the locations within watershed C-1 which will experience increased flooding with SLR and will require drainage improvements.

Project Name	**Basin**	**Sub-Basin**	**Sub-Basin Current FPLOS Condition**	**Mitigation Strategy ID**	**Total Cost**	**Comment**
Improvements in Primary Canals C-100, C-100A, C-100B.		Watershed C-100	The C-100 Watershed has been assigned a 5-year FPLOS rating for SLR0 and SLR1 and less than 5-year FPLOS rating for SLR2 and SLR3. The primary reason for these ratings is due to canal bank exceedance along several locations along the C-100 Canal. The following projects are recommended for evaluation as potential flood mitigation projects: 1. Improvements in Primary Canals C-100, C-100A, C-100B. 2. Upgrades of coastal Structure S123. 3. Backflow prevention. 4. Increase in elevation of all levees at the eastern boundary of the C-100 watershed. 5. Development of local	SMD_3.1		Considering that changing the original canal bottom profile design could be prohibitively expensive for the entire canal, additional hydrographic surveys of the cross sections are recommended. The hydrographic surveys can be used to update the model cross sections, and additional simulation are suggested to determine locations where the canal bottom profile may cause head losses due to constriction or sedimentation. Improvements in Canals C-100, C-100A and C-100B involve: • Increase of C-100B canal bank elevation above the peak stage of the 25-yr 3-day design event within the Urban Development Boundary and at locations where flooding damages may occur as result of overtopping of the canal banks. • Maintenance and dredging of canals C-100A and C-100B for selected locations to improve the canal bottom gradient at locations which potentially have negative bottom gradient or higher hydraulic losses than average • An example of the canal profiles is provided in the report. The canal profiles show exceedance of canal banks on multiple locations of canal banks of C-100A and C-100B within the Urban Development Boundary of Miami-Dade County.

Project Name	Basin	Sub-Basin	Sub-Basin Current FPLOS Condition	Mitigation Strategy ID	Total Cost	Comment
Upgrades of coastal Structure S123.	South Miami-Dade	Watershed C-100	flood mitigation projects in collaboration with Miami-Dade County. The numerical model can be extended to provide an analysis of the suggested projects and evaluate the effects of each project on the LOS for the current and future conditions. The improvements in Primary Canals C-100, C-100A, C-100B may include maintenance and dredging to provide an even bottom gradient from west to east and an increase of the canal bank elevations to eliminate overtopping.	SMD_3.2		Structure S123 is a two-gate spillway structure with a design flow of 2,300 cfs at 40% SPF, for a 0.5 ft head differential and a tailwater at 1.5 ft (0.0 ft NAVD 88). The major deficiency of this structure for SLR and storm surge conditions is the low by-pass level which is listed as 8.0 ft NGVD 29 (approximately 6.5 NAVD 88). For example, the structure will be by-passed for the 25-yr and 100-yr Storm events for SLR 2 and 3. Figure 17 shows the computed headwater elevations at Structure S123 for the 25-yr and 100-yr events and SLR 0, 1, 2 and 3 ft. Figure 18 illustrates the locations of the C-100 canal banks which have an elevation deficiency and will allow overtopping of the canal. The structure is rated at 5,000 cfs at 100% SPF with head differential of 0.8 ft at tailwater of 2.0 ft NGVD 29 (0.5 NAVD 88) and may require increased peak flow capacity for future SLR and storm surge conditions, and to maintain the peak headwater to design conditions (1.3 ft NAVD). The upgrades of structure S123 include: • Installation of a new pump facility which will require additional analysis to optimize flow rates, pump location, downstream effects, funding, local conditions, selected return period of design events, criteria for SLR, freeboard and storm surge elevations. • Increase the heights of the platform and gates above 7.5 ft NAVD plus freeboard. • Improvements to the levees north and south of the structure to be above 7.5 ft (currently the lowest points are 6.03 ft. (NAVD) and potential overtopping can occur).
Backflow prevention.		Watershed C-100		SMD_3.3		Installation of backflow prevention devices are necessary to protect the secondary and tertiary system from backflow from the primary canal system, particularly for increased SLR and storm surge conditions, which can create high stages in the primary canals.

Project Name	Basin	Sub-Basin	Sub-Basin Current FPLOS Condition	Mitigation Strategy ID	Total Cost	Comment
Development of local flood mitigation projects in collaboration with Miami-Dade County.	South Miami-Dade	Watershed C-100		SMD_3.4		Based on the Flood Extent and Duration Maps, the C-100 Watershed areas within the Urban Boundary Line which will require flood mitigation, based on the flood depth greater than 1.0 ft and 2.5 ft for the 25-yr 3-day design event, are depicted in the yellow colored areas. Additionally, the difference of the flood rasters for SLR 3 and SLR 0 were used to determine the greatest impact of SLR within the watershed. The SLR 0 depth raster depth was subtracted from the SLR 3 depth raster.The differences were classified into 3 categories: i) less than 1 ft impact, ii) impact between 1 and 2 feet and iii) impact greater than 2 feet. The FPLOS repot also shows that the SLR impacts for most of the urban areas (except for the areas highlighted with yellow and red colors) is not expected to be significant for SLR change from 0 to 3. The locations within watershed C-100 which will experience increased flooding with increasing SLR and will require drainage improvements are detailed in the report.
Improvements in Primary Canals C-102 and C-102N		Watershed C-102	The C-102 Watershed has been assigned a 5-year FPLOS rating for SLR0 and SLR1 and less than 5-year FPLOS rating for SLR2 and SLR3. The primary reason for rating the watershed as 5-yr and less than 5-yr is due to canal bank exceedance. The following projects are recommended for evaluation as potential flood mitigation projects: 1. Improvements in Primary Canals C-102 and C-102N. 2. Upgrades of coastal structure S21A. 3. Backflow prevention devices. 4. Installation of a control	SMD_4.1		Improvements in Primary Canals C-102 and C-102N may require maintenance and dredging to provide an even bottom gradient from west to east and an increase of canal bank elevations to eliminate overtopping. Considering that changing the original canal bottom profile design could be prohibitively expensive for the entire canal, additional hydrographic surveys of the cross sections are recommended. The hydrographic surveys can be used to update the model cross sections, and additional simulations are suggested to determine locations where canal bottom profile may cause head losses due to constriction or sedimentation. Improvements in Canals C-102 and C-102N involve: • Increase of canal bank elevation above the stage of the 25-yr 3-day design event within the Urban Development Boundary and at locations where flooding damages may occur as a result of overtopping of the canal banks. • Maintenance of Canals C-102 and C-102N to ensure a consistent canal bottom gradient which will minimize the hydraulic losses.

Project Name	Basin	Sub-Basin	Sub-Basin Current FPLOS Condition	Mitigation Strategy ID	Total Cost	Comment
			structure at the eastern levee crossing of conveyances. 5. Improved elevation of all levees at the eastern boundary of the C-102 watershed. 6. Development of local flood mitigation projects in collaboration with Miami-Dade County. The numerical model can be extended to provide an analysis of the suggested projects and evaluate the effects of each project on the LOS for current and future conditions.			An example of the canal profiles and the deficiencies along the canals C-102 and C-102N is provided in the report.
Backflow Prevention	South Miami-Dade	Watershed C-102		SMD_4.3		Installation of backflow prevention devices will be necessary to protect the secondary and tertiary system from backflow from the primary canal system particularly for increased SLR and storm surge conditions which can create high stages in the primary canals.
Installation of control structures at Levee L31E	South Miami-Dade	Watershed C-102		SMD_4.4		Information from SFWMD suggests that 10 culverts and 5 pump stations will be constructed on Levee L-31E for future planned water deliveries to the wetlands east of the levee. All culverts will require controlled gates to prevent backflow from Biscayne Bay during tidal and storm surge events.

Project Name	Basin	Sub-Basin	Sub-Basin Current FPLOS Condition	Mitigation Strategy ID	Total Cost	Comment
Retrofitting Levees		Watershed C-102		SMD_4.5		The top elevation of the L-31E levee between Structures S20G and S21A. The profile shows that the levee elevation can be overtopped at multiple locations for peak stages greater than 5.5-6.0 ft. Overtopping of Levee L-31E can result in significant backflow in the C-102 watershed, increased flooding potential upstream and considerably slower drainage of the flooded areas. Therefore, upgrading the levee to 7.5 ft NAVD plus required freeboard is recommended (7.5 ft NAVD is based on the headwater peak stages for the 100-yr design event and SLR +3.0 ft).
Local Mitigation projects	South Miami-Dade	Watershed C-102		SMD_4.6		Based on the Flood Extent and Duration Maps (reported in PM5 and PM6), the C-102 Watershed areas within the Urban Boundary Line which will require flood mitigation, based on the flood depth greater than 1.0 ft for the 25-yr 3-day design event and flood depth greater than 2.5 ft for the 25-yr 3-day design event. Additionally, the difference of the flood depth rasters for SLR +3 and SLR +0 were used to determine the greatest impact of SLR within the watershed. The SLR 0 depth raster depth was subtracted from the SLR 3 depth raster and differences were classified into 3 categories: i) less than 1 ft SLR impact, ii) SLR impact between 1 and 2 feet and SLR impact greater than 2 feet. The report shows the areas impacted by SLR from 0 to 3 ft. The major impacts are within the wetland areas which are interconnected with the drainage system. The FPLOS report shows that the SLR impacts on the urban areas is not expected to be significant for SLR from 0 to 3, however there are multiple locations within the watershed which experience flooding and which will require mitigation such as conveyance improvements, coastal structure upgrades, and backflow prevention. FPLOS report shows the locations within watershed C-102 which will experience increased flooding with increasing SLR and will require drainage improvements.

Project Name	Basin	Sub-Basin	Sub-Basin Current FPLOS Condition	Mitigation Strategy ID	Total Cost	Comment
Improvements in Primary Canals C-103 and C-103N		Watershed C-103	The C-103 Watershed has been assigned a 5-year FPLOS rating for SLR0 and SLR1 and less than 5-year FPLOS rating for SLR2 and SLR3. The primary reason for rating the watershed as 5-yr and less than 5-yr is due to canal bank exceedance. The following projects are recommended for evaluation as potential flood mitigation projects: 1. Improvements in Primary Canals C-103 and C103N. 2. Upgrades of coastal structures S20F and S20G. 3. Backflow prevention devices. 4. Installation of a control structure at levee L-31E. 5. Improved elevation of all levees at the eastern boundary of the C-103 watershed. 6. Development of local flood mitigation projects in collaboration with Miami-Dade County. The numerical model can be extended to provide an analysis of the suggested projects and evaluate the effect of each project on the	SMD_5.1		The improvements in Primary Canals C-103 and C-103N considers improved maintenance and dredging at locations with high head losses to provide an even bottom gradient from west to east, and upgrades of the canal banks to eliminate overtopping. • An increase of C-103 canal bank elevation above the stage of the 25-yr 3-day design event, within the Urban Development Boundary and at locations where flooding damages may occur as a result of overtopping of the canal banks. • Maintenance of canals C-103 and C-103N to ensure consistent canal bottom gradient which will minimize the hydraulic losses. • An example of the canal profiles is provided in the FPLOS report Considering that dredging of the original canal bottom profile design could be prohibitively expensive for the entire canal, additional hydrographic surveys of the cross sections are recommended. The hydrographic surveys can be used to update the model cross sections, and additional simulation are suggested to determine locations where the canal bottom profile may cause head losses due to constriction or sedimentation
Backflow Prevention	South Miami-Dade	Watershed C-103		SMD_5.3		Installation of backflow prevention devices are necessary to protect the secondary and tertiary system from backflow from the primary canal system particularly for increased SLR and storm surge conditions which can create high stages in the primary canals.
Installation of Control Structures at Levee L31E		Watershed C-103		SMD_5.4		Information from SFWMD suggests that 10 culverts and 5 pump stations will be constructed on Levee L-31E for future planned water deliveries to the wetlands east of the levee. All culverts will require controlled gates to prevent backflow from Biscayne Bay during tidal and storm surge events.

Project Name	Basin	Sub-Basin	Sub-Basin Current FPLOS Condition	Mitigation Strategy ID	Total Cost	Comment
Retrofitting Levees	South Miami-Dade	Watershed C-103	LOS for current and future conditions.	SMD_5.5		Overtopping of the levee can result in significant backflow in the C-103 watershed which will also result in considerably slower drainage and increased upstream flood potential. Therefore, upgrading the levee to 7.5 ft NAVD plus required freeboard are recommended. The top elevation of the L-31E levee between structure S20G and Florida City Canal. The profile shows that the levee elevation can be overtopped at multiple locations for peak stages greater than 5.0-6.0 ft.
Local Mitigation projects		Watershed C-103		SMD_5.6		Based on the Flood Extent and Duration Maps (reported in PM5 and PM6), the C-103 Watershed areas within the Urban Boundary Line which will require flood mitigation based on the flood depth greater than 1.0 ft for the 25-yr 3-day design event and flood depth greater than 2.5 ft for the 25-yr 3-day design event. There are multiple locations within the watershed which experience flooding and which will require mitigation such as conveyance improvements, coastal structure upgrades and backflow prevention. Additionally, the difference of the flood depth rasters for SLR +3 and SLR +0 were used to determine the greatest impact of SLR within the watershed. The SLR 0 depth raster depth was subtracted from the SLR 3 depth raster and differences were classified into 3 categories: i) less than 1 ft SLR impact, ii) SLR impact between 1 and 2 feet and iii) SLR impact greater than 2 feet. FPLOS Report shows the areas impacted by SLR from 0 to 3 ft and the locations within watershed C-103 which will experience increased flooding with increasing SLR and will require drainage improvements.

Project Name	Basin	Sub-Basin	Sub-Basin Current FPLOS Condition	Mitigation Strategy ID	Total Cost	Comment
Downstream C-7 Basin OBS: These projects were detailed back in 2018 and associated cost estimates are now outdated.	C-7	N/A	N/A	C7_1		Measures include the following: ID; Measure; Unit Cost; Dimensiones M1; Total Costs; Remarks A- Flood walls; $1500 per linear foot; 36568 feet; $54,852,000; Assuming 30 feet depth B- Exfiltration trenches; $1500 per linear foot; 170,293 feet; $25,543,950 C- Backflow preventers; $70,000 per piece; 16 pieces; $1,120,000; Range of $10,000 to $100,000 D- Pumps; $30,000 per cfs; 3,300 cfs; $99,000,000; Range of 3>0 to 30,000 per CFS Total: $180,515,950 Note: For the M1 scenario, it was assumed that 3,300 cfs pump capacity would be needed. In practice this was less, as about 3,137 cfs maximum capacity was simulated. However, the 3,300 cfs was used for the cost calculation. Only construction costs are considered; operation and maintenance costs for the pumps are not included.
Elevation to 6 feet (NGDV29) for all buildings and roads OBS: These projects were detailed back in 2018 and associated cost estimates are now outdated.	C-7	N/A	N/A	C7_3.1		ID; Unit Costs of Elevation; Dimensions; Total Costs A- Buildings; $50,000 per building; 736; $36,800,000 B- Roads; $500 per linear foot elevation; 240,156; $120,078,206 Total: $156,878,206
Elevation to 7 feet for all buildings and roads OBS: These projects were detailed back in 2018 and associated cost	C-7	N/A	N/A	C7_3.2		ID; Unit Costs of Elevation; Dimensions; Total Costs A- Buildings; $50,000 per building; 1,730; $86,500,000 B- Roads; $500 per linear foot elevation; 367,964; $183,982,245 Total: $270,482,245

Project Name	Basin	Sub-Basin	Sub-Basin Current FPLOS Condition	Mitigation Strategy ID	Total Cost	Comment
estimates are now outdated.						
Elevation to 8 feet for all buildings and roads OBS: These projects were detailed back in 2018 and associated cost estimates are now outdated.	C-7	N/A	N/A	C7_3.3		ID; Unit Costs of Elevation; Dimensions; Total Costs A- Buildings; $50,000 per building; 3,432; $171,600,000 B- Roads; $500 per linear foot elevation; 474,458; $237,229,000 Total: $408,829,000
All buildings elevated to the maximum 100-year flood levels under scenario SLR3, and all roads to the 10-year flood level under scenario SLR3 (scenario M3(x)). OBS: These projects were detailed back in 2018 and associated cost estimates are now outdated.	C-7	N/A	N/A	C7_3.4		ID; Unit Costs of Elevation; Dimensions; Total Costs A- Buildings; $50,000 per building; 2,932; $146,600,000 B- Roads; $500 per linear foot elevation; 284,197; $142,098,530 Total: $288,698,530

SEA LEVEL RISE AND FLOOD RESILIENCY PLAN

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