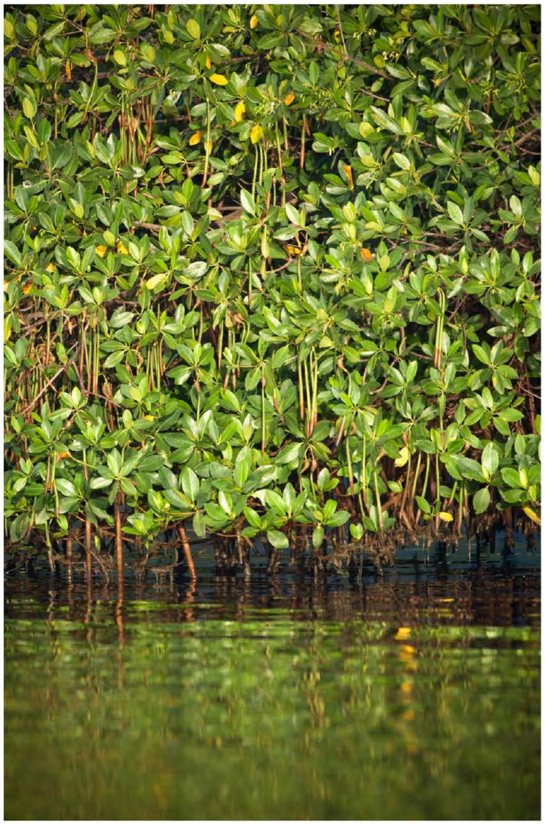
2024 SEA LEVEL RISE AND FLOOD RESILIENCY PLAN



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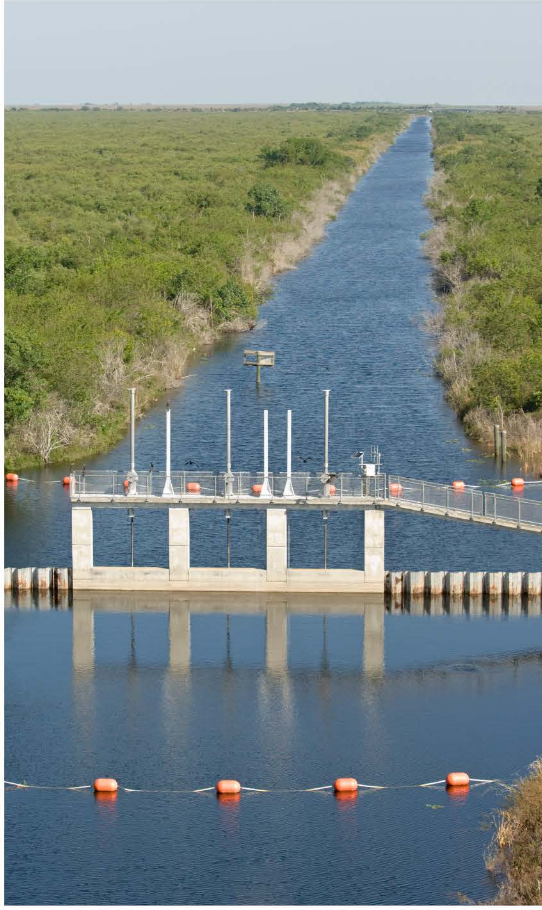

Building Resilience and Mitigating Risks to South Florida's Water Resources

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Executive Summary

Introduction

The South Florida Water Management District (District or SFWMD) is strongly committed to continuing to address the impacts of land development, population growth, and climate change – sea level rise, changing rainfall patterns – on water resources. As a regional government agency, the District manages water resources in the southern half of Florida, covering 16 counties from Orlando to the Florida Keys and serving a population of nine million residents. The District is dedicated to working with local, state, and federal partners to ensure the District provides the best available science-backed data to inform decision-making throughout South Florida. As a key part of the 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 conditions. In coordination with the Florida Department of Environmental Protection, the Florida Department of Emergency Management, other State and Federal agencies, and local governments, the District is making infrastructure adaptation investments needed to implement its mission successfully.

This SFWMD Sea Level and Flood Resiliency Plan, which is updated annually, is the first District initiative to compile a comprehensive list of priority resiliency projects to reduce the risks of flooding, sea level rise, and other climate impacts on water resources and increase 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, sustainable, integrated basin-wide solutions. This list of projects, detailed in Appendix A, was compiled based on 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 District's Flood Protection Level of Service (FPLOS) Program has been advancing integrated modeling efforts in critical basins to aid in understanding flood vulnerabilities within the C&SF System and identifying cost-effective implementation strategies to ensure that each basin can maintain its designated flood protection level of service under current and projected conditions. In addition, the District's Capital Improvement Plan (CIP) has been incorporating climate change and sea level rise considerations into the design of critical infrastructure projects. The FPLOS and CIP Programs have successfully identified critical resiliency investments organized and expanded in this document.

Priority Projects

The list of priority resiliency projects includes investments needed to increase the resiliency of the C&SF System and Big Cypress Basin flood control infrastructure. These projects represent urgent actions necessary to address the vulnerability of the existing infrastructure, including structure enhancement recommendations and other adaptations needed. Project recommendations also comprise basin-wide flood adaptation strategies that are based on other FPLOS recommendations and water supply and water resources of the State protection efforts.

Examples of these projects include enhancing canal banks, improving conveyance and discharge capacity, increasing storage, adding a "self-preservation mode" function to water control structures, hardening levees, and implementing nature-base features. Each of these projects helps to increase the functionality and capacity of the District's flood control and water supply systems and protection of the environment. Finally, critical planning projects are presented to continue to support the District Resiliency efforts.

These include vulnerability assessments and scientific data and research that will ensure the District's resiliency planning and projects are founded on the best available science.

This plan includes an updated multicriteria ranking approach developed to assess vulnerable areas in South Florida. This ranking approach includes metrics to identify the critical infrastructure and vulnerable areas while considering basin-wide resiliency needs. Cost estimates for each proposed project are presented, as well as recommendations to incorporate sustainable energy sources and utilize the most efficient designs, using both traditional gray infrastructure improvements and nature-based solutions. This plan has been updated in 2024 to include additional resiliency project priorities and new project components, reorganized into basin-wide strategies, along with high-level cost estimates.

Stakeholder Coordination

The District seeks to implement projects that benefit South Florida's communities and environment by working closely with state, tribal, private, and local governments and considering the needs of socially vulnerable communities and protected environmental areas. In its fourth iteration, this plan document includes significant contributions from our stakeholders, after meticulous consideration and incorporation of comments submitted by more than 20 partners agencies each year. In December 2022, the District began hosting quarterly South Florida Resiliency Coordination Forum meetings to promote further collaboration with local, state, federal and tribal partners on water management initiatives related to resiliency. The Forum is one of the main mechanisms for receiving input on our projects and for engaging partners in assessing the impacts of changing climate conditions and water management implications. Meeting agendas and recordings can be found on the District's Resiliency Coordination Forum web page (1).

Funding Strategies

The District continues to seek funding alternatives at the State and Federal levels to help fund the implementation of project recommendations included in this plan. 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 sea level rise resiliency projects throughout the State. In May 2022, Governor DeSantis approved House Bill 7053, establishing further efforts toward Statewide Flooding and Sea Level Rise Resilience. In January 2023, Governor DeSantis signed Executive Order 23-06 to direct funding and strategic action to continue to support the Resilient Florida Program. On June 11, 2023 Governor Ron DeSantis signed House Bill 111 on Flooding and Sea Level Rise Vulnerability Studies. and on May 10, 2024, the Governor signed HB 1557 that amends the use of Resilient Florida Grant Program funds for counties and municipalities, emphasizing flood and sea level rise preparations and enhances coordination for flood vulnerability and statewide resilience planning, including the incorporation of new data sets and assessments, among others.

As part of the Resilient Florida Program, the District and the Florida Department of Environmental Protection (FDEP) executed grant agreements for the following projects:

- Coastal Structures Enhancement and Self-Preservation Mode
- Hardening and Enhancement of S-2, S-3, S-4, S-7, S-8 Engine Control Panels
- Corbett Levee Resiliency, in partnership with Palm Beach County

Additionally, the District is currently working with FDEP to advance grant award recommendations for the following projects:

- Flood Protection Level of Service (FPLOS) Resilience Adaptation Study Phase I and II for Martin, and St. Lucie County
- Waterways Impact Protection Effort (WIPE-Out), WIPE-Out Tech Test
- Homestead Field Station Replacement

- C-8 Basin Resiliency
- S169W Structure Replacement and Trash Rake/Manatee Barrier

At the Federal level, the Federal Emergency Management Agency (FEMA) mitigation and adaptation funding is under consideration, and the District is working to finalize grant agreements with Florida Department of Emergency Management (FDEM) for the $150 million award recommendations received from FEMA Building Resilient Infrastructure and Communities (BRIC) Program for the C-7 Basin Resiliency Project, C-8 Basin Resiliency Project and C-9 Basin Resiliency Project. In addition, the District and the U.S. Army Corps of Engineers are partnering to develop the C&SF Flood Resiliency Study, and the follow up C&SF Comprehensive Study, to recommend adaptation strategies in the communities served by the C&SF Systems.

1: Resiliency Vision

Introduction

The South Florida Water Management District (SFWMD or District) is committed to ensuring the resilience of South Florida's water resources and ecosystems, today and in the future. Like many other government agencies responsible for constructing, operating, and maintaining public infrastructure, the SFWMD faces the challenge of implementing its mission while simultaneously addressing present and preparing for future impacts of a changing climate. The urbanization of South Florida, changing environmental conditions, and extreme weather greatly impact the operation and long-term performance of the District's water management infrastructure.

SFWMD's resiliency vision is one where South Florida's water resources and ecosystems are restored and safeguarded, communities are protected from flooding, and water supplies are sustainable and secure, today and in the future. In the context of SFWMD's mission and resiliency vision, resiliency is the capacity for natural and manmade systems to cope with and adapt to acute and chronic stressors as climate conditions evolve.

The District's resiliency efforts focus on

(a) assessing how sea level rise, extreme flood and rainfall events, and other evolving conditions happen today and in the future, and how they affect water resources management

(b) planning for and making infrastructure adaptation investments that are needed to successfully implement SFWMD's mission of safeguarding and restoring South Florida's water resources and ecosystems, protecting communities from flooding, and meeting the region's water needs while connecting with the public and stakeholders.

The District's resiliency projects are aimed at reducing the risks of flooding, sea level rise, and other climate impacts on water resources. The District's resiliency efforts include assessing how these risks and other evolving conditions happen today and, in the future, and how they affect water resources management. To continue to successfully implement its mission, significant infrastructure adaptation investments are needed and underway. The District is increasing community and ecosystem resiliency in South Florida by enhancing the Central and South Florida Project (C&SF Project) and Big Cypress Basin infrastructure. The strategy uses traditional gray infrastructure improvements and nature-based solutions. The current plan focuses on the most vulnerable infrastructure, recognizing that the District's entire area of operations will be covered as technical assessments and planning efforts identify additional resiliency projects and priorities each year. The District's resiliency vision is to reduce risk by implementing effective, resilient solutions and anticipating future conditions. This strategy includes public engagement through various outreach activities.

Currently, the District's Flood Protection Level of Service (FPLOS) and Capital Improvement Program (CIP) programs ensure that projects are assessed, designed, managed, and constructed using innovative techniques, incorporating sustainable sources of energy, and utilizing the most efficient designs available, with consideration of both upstream and downstream systems. Moreover, the District is developing additional vulnerability and adaptation studies. One example is the Water Supply Vulnerability Assessment, which will provide a more comprehensive overview of resiliency needs and priorities and support identifying sub-regional goals within the 16-county region served by the District.

The proposed resiliency projects follow all state and federal threatened and endangered species regulations and seek to restore and preserve wildlife habitats by integrating nature-based solutions. The District seeks to implement projects that benefit South Florida's communities and environment by working closely with state, tribal, private, and local governments and other agencies to assess and consider the needs of socially vulnerable communities and protected environmental areas.

The District's Resiliency Plan is a high-level planning document and is not intended to contain all the technical details and design specifications for each proposed project. As projects are moved into implementation, detailed plans, design specifications, and technical reviews will follow. Below are descriptions of each of the criteria that, when taken together, illustrate the District's resiliency vision and 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 projects by advancing robust hydrologic and hydraulic integrated basin-wide models through the FPLOS Program, Water Supply Plans, Ecosystem Restoration studies and additional water resources assessments. This strategy allows the District to scrutinize maximum and minimum stages, bank exceedances, discharge capacity of canals, flood depths and durations of flood inundation. Additionally, coastal structure capacity and peak stages resulting from different storm surge and sea level rise scenarios are examined as part of the FPLOS Program and other restoration studies. Water Supply vulnerability under future conditions is currently being assessed as part of the ongoing Water Supply Vulnerability Assessment (Appendix B).

Implementation Resources

Implementation resources include the recognition that project planning and management are crucial steps in implementing resiliency projects. The District uses various tools to support 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 the 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

Determining future conditions is required to identify vulnerabilities, determine adaptation solutions, and evaluate their feasibility. 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 the economic status of the community is also essential. Beyond the traditional planning tools, there is a need to address future climate conditions and their impacts. Potential impacts include the following:

- Sea level rise and saltwater intrusion
- Increased intensity of extreme rainfall and drought events
- Increase in stormwater runoff volumes

- Increasing groundwater elevations
- Other related variables

Each resiliency project should be responsive to anticipated changes. The strategy considers the potential for change and incorporates resiliency concepts in the projects' planning, design, and future operation. Each potential project will be informed by and connected to existing planning efforts such as Hazard Mitigation Plans, Climate Adaptation Plans, and Comprehensive Plans.

Underserved Population and Critical Infrastructure

To ensure formulation and implementation of equitable resiliency projects, it is necessary to develop solutions that have community-wide benefits. The 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. Underserved population within disadvantaged communities are also identified (see Chapter 8) and taken into consideration, and benefits for these communities are maximized. The District strives to meet these criteria.

Leveraging Partnerships and Public Engagement

The District has been engaging partner agencies and the public through the organization of a series of Public Workshops and participation in relevant public events and discussions. In December 2022, SFWMD hosted the first South Florida Resiliency Coordination Forum. These recurring quarterly meetings constitute a fact-finding forum to promote collaboration with local, state, federal and tribal partners on water management initiatives related to resiliency; and engage partners in assessing the impacts of changing climate conditions and water management implications. The Forum promotes regional coordination and partnership opportunities by holding proactive discussions, leveraging technical knowledge, and exchanging information. These meetings are designed to foster a constructive environment to discuss tangible asset-level solutions and support decision-making on water resource management.

Outreach activities are an important way to engage, learn and gain public support for resiliency projects and leverage partnerships with federal, state, tribal, private, and local governments and 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 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 is advancing integration and climate resilience strategies in the region through coordination with the public, educational institutions, local, state, and federal government agencies, including the U.S Army Corps of Engineers (USACE), Florida Department of Environmental Protection Office of Resilience and Coastal Protection, Florida Department of Emergency Management, Florida Department of Transportation, 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.

Ongoing Ecosystem Restoration Efforts

The District is working with USACE and other state and federal partners to ensure ongoing ecosystem restoration efforts and mainly that 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-resiliency 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 sea level rise 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. Nature-based solutions 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 sea level rise, 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 dedicated to improving the energy efficiency of its operations and offsetting new energy demands through renewable energy solutions. By following the latest local, state, and federal 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). As an initial step towards the goal of offsetting new energy demands, staff are assessing opportunities for implementing renewable energy projects as part of a variety of current projects under development.

2: The Central and Southern Florida System and Big Cypress Basin Flood Control Systems

Introduction

The purpose of this chapter is to describe the primary flood control systems that the District operates and point out current challenges due to population growth, increased land development, and changing climate impacts, including extreme rainfall events and sea level rise. A secondary purpose is to introduce the SFWMD Capital Improvement Plan (CIP) and describe how the resiliency initiatives are being integrated into the CIP and overall operations and maintenance priorities.

History

The history of water management in South Florida was driven by major flood and drought impacts and associated investments in water management infrastructure occurring after the hurricanes in the late 1920s, droughts in the 1930s, and hurricanes again in 1947. The Central and Southern Florida Project (C&SF) was initially authorized by the Flood Control Act of 1948 and subsequent Acts. It is a large, multipurpose water resources project designed and constructed by the United States Army Corps of Engineers (USACE) in partnership with what is now the South Florida Water Management (SFWMD or District), the Project's local sponsor. It was authorized for flood protection for urban and agricultural areas; prevention of saltwater intrusion risks to coastal water supply sources; water level control and 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. Today, the key structural infrastructure of the regional (primary) C&SF system includes approximately 2,175 miles of canals, 2,130 miles of levees/berms, 89 pump stations, and 915 water control structures. The regional system connects to local (secondary) and thousands of neighborhood (tertiary) drainage systems. It is one of the world's largest and most complex water management systems and currently serves approximately 9 million residents.

The Need for Resiliency

The C&SF system is facing significant changes that are challenging the performance of the system. The main drivers of change can be largely grouped into population growth, increased development of land, extreme rainfall events, drought and sea level rise trends. A roughly tenfold increase in the study area population and a consequent change in land use over time, compounded by the intensity and volume of extreme wet and dry events and an average of 6 inches of observed sea level rise, has significantly changed the operational capacity of the C&SF system.

Despite significant infrastructure investments throughout the years, critical components of the C&SF system are showing deficiencies in performance. For example, gravity-operated coastal structures convey excess runoff from each respective watershed to the ocean to reduce flood risk and act as salinity intrusion barriers. Currently, many of these low-lying coastal structures have a significant reduction in discharge capacity during high tide periods and/or storm surge events because of insufficient upstream headwater (spillway) elevations. Gate overtopping due to 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 upstream canal overbank risks and reduction in gravity discharge capacity. Based on these advanced modeled outcomes, several 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 feet or less of sea level increase.

Also, within SFWMD 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, facing similar conditions as described above, includes Collier County and part of Monroe County.

Resiliency Mission

Despite these challenges and opportunities, SFWMD is making infrastructure maintenance and adaptation investments needed to successfully 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 South Florida's needs. The District's Capital Improvement Plan (CIP) is integrated into the process of building resilient projects that mitigate risks to South Florida's water resources. This is accomplished by enhancing the C&SF and Big Cypress Basin water control systems.

The District's CIP investments go beyond addressing maintenance, repair, rehabilitation, or replacement needs identified in inspection reports. The District is also enhancing the existing water management system with new components and operational capacity. The updates allow the aging system to operate successfully today and ensure the District's mission is accomplished. This plan document outlines the additional infrastructure investments that will be bundled with the District's CIP. The additional investments help to ensure that the District constructs resilient projects to mitigate the risks to South Florida's water resources.

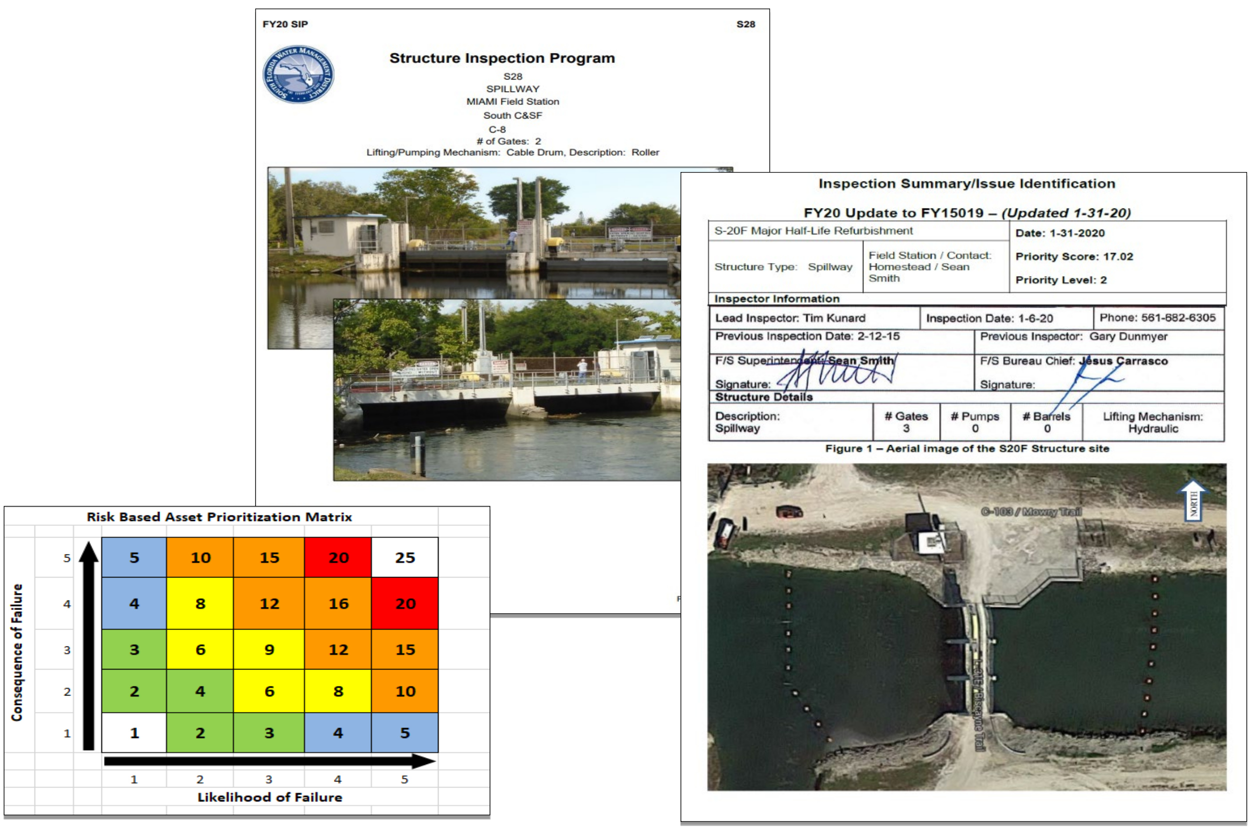


Figure 2-1: Examples of Structure Inspection Program Reports and the Overall Risk Rating Matrix

SFWMD Capital Improvement Plan

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 in place. 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 ensure that each facility's equipment and instrumentation can be operated safely and reliably and to prioritize infrastructure investments for the District's CIP Program. The District commits to setting aside resources each year to implement the CIP 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 effectively and efficiently.

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 the prioritization of corrective actions. Figure 2-1 illustrates examples of the structure inspection program reports and the risk matrix used 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 & services, its financial impact on surrounding land use, upstream/downstream impacts, and its back up operational options. The inspection reports are also used to help evaluate adaptation strategies as part of the Flood Protection Level of Service Program. Structures that receive a critical rating for corrective actions are included as part of future conditions assessments, and modifications for sea level rise and climate change impacts are recommended, in addition to addressing conditions identified in the inspection reports. 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 revisit the same structure within a short period of time. Therefore, the CIP Program informs overall resiliency planning efforts, including the Flood Protection Level of Service Program (FPLOS), which is covered in Chapter 3

3: Assessing Flood Vulnerabilities: Flood Protection Level of Service Program & C&SF Flood Resiliency Study

Flood Protection Level of Service Program

Initiated in 2015, the South Florida Water Management District's (District or SFWMD) 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 Central and Southern Florida Project (C&SF Project) and other basins flood protection systems have many assets that are approaching the 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. The program includes a methodology that helps to prioritize basins to study and a suite of tools for evaluating structures and canals in selected basins, 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 on an 8- to 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. This process is used to identify flood vulnerabilities basin-wide, represented by simulated overland flow inundation. These studies continue in perpetuity, and each basin is revisited once every eight to ten years unless significant changes in the flood control system necessitate a more frequent reassessment.

Adaptation and Mitigation Planning Phase (Phase II)

When deficiencies are identified in the system (either current or projected based on factors such as sea level rise 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 identify cost-effective courses of action that when implemented, will bring the flood control system back to design specifications or desired performance for the long term.

Implementation Phase (Phase III)

The final phase includes the integration of the recommended projects into this plan document and prioritization for follow-up 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 before they occur, providing an opportunity to plan and implement adaptations and mitigation strategies before critical conditions materialize.

With a goal to reassess every basin within the District at least once every 8 to 10 years, the program initiates two Phase I assessment studies every year, starting with the most at-risk basins. This is determined based on a sea level rise 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 of 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 identified deficiencies.

Phase II of the FPLOS program includes the assessment of projects to be implemented by SFWMD, along with projects and actions to be included by stakeholders in their implementation vehicles, such as Local Mitigation Strategies and local capital projects programs. Working with and incorporating projects planned in the secondary and tertiary system will ensure robust, regionally compatible suites of projects with broad regional support and more attractive funding to ensure effective flood control. In addition to evaluating, prioritizing, and sequencing potential solutions, the FPLOS approach addresses uncertainties related to sea level rise and other climate projections by introducing decision support and facilitation tools and techniques used for decision-making under uncertainty. These tools allow decision-makers to make informed near-term decisions with the best available information that do not inhibit the implementation of further adaptation strategies should longer-term projections change from what is currently anticipated. The solutions are comprehensive and could range from a change in operations requiring no additional infrastructure to major investments in infrastructure, including using nature-based solutions 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 3-1 illustrates the latest status of the FPLOS vulnerability assessments (Phase I) and the priority basins with existing infrastructure managed by the District.

To date, the following Phase I – Vulnerability Assessments have been completed, and the final reports are available via the link provided:

- 2016 FPLOS Phase I C-4 Basin
- 2017 FPLOS Phase I C-7, C-8, and C-9 Basins
- 2018 FPLOS Phase I Big Cypress Basin
- 2021 FPLOS Phase I Broward Basins
- 2021 FPLOS Phase I C-8 and C-9 Basins
- 2022 FPLOS Phase I C-1, C-100, C-102, and C-103 Basins
- 2023 FPLOS Phase I C-2, C-3W, C-5, and C-6 Basins Final Report
- 2024 FPLOS Phase I C-111, Model Lands, and L-31NS Basins
- 2024 FPLOS Phase I L-31NS, C-111, US1, Model Land

Over the next year and a half, Phase I – Vulnerability Assessments will also be completed for the following critical basins:

- Eastern Palm Beach County
- Upper Kissimmee Basin
- St. Lucie and Martin Counties
- Western Basins

To date, the following Phase II - Adaptation Planning Studies have been completed:

- 2023 FPLOS Phase II C-8 and C-9 Basins

Over the next year , the following, Phase II -Adaptation Planning Studies will be completed for the following critical basins:

- FPLOS Phase II C-7 Basin

Other supporting FPLOS studies, such as the Low-Lying Tidal Structure Assessment, Biscayne Bay Surge Model, and the Atlas Updates for all the FPLOS basins, also contribute to further understanding of flood vulnerabilities across the District.

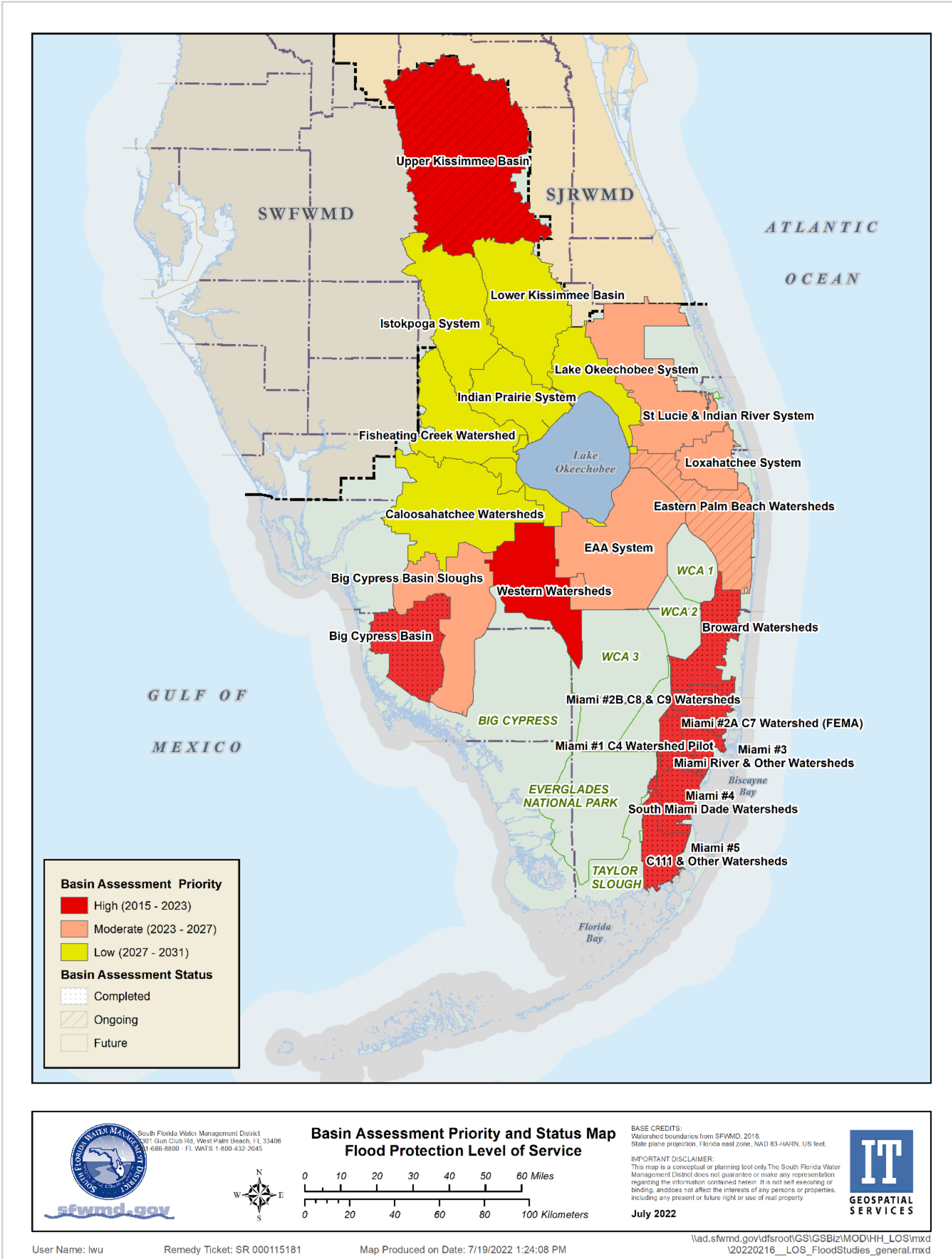


Figure 3-1: FPLOS Basin Assessment Priorities and Status of Implementation

Fully integrated and coupled hydrologic and hydraulic models have been developed and implemented as part of these studies to determine flood vulnerabilities and to support adaptation and mitigation planning. These advanced models simulate complex surface-subsurface water interactions and operational rules at each system structure, along with a range of storm surge and tidal boundary conditions, for different rainfall return frequencies and duration. Modeling outputs enhance technical understanding of the impacts caused by compound flooding drivers (rainfall, surge/tidal, and groundwater), which is critical to identify appropriate and effective resilience needs in coastal urban watersheds in South Florida. An approach for characterizing compound flooding and respective joint probabilities in transition zones is currently being validated.

Figure 3-3 and Figure 3-4 illustrate the resulting 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 section) for the respective FPLOS Phase I (Flood Vulnerability) assessments completed for Broward and Miami-Dade Counties and for Big Cypress Basin. The Flood Protection Level of Service is illustrated in these maps by the respective rainfall return frequency event that results in flooding in 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 if both rainfall-induced flooding and storm surge flooding occurs simultaneously, as summarized in Table 3-1. It is important to emphasize that only portions of each basin might be showing inundation because of the simulated scenarios, meaning that the entire basin might not be inundated under the given return frequency. The overall level of service assigned to each basin represents 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 show overland inundation are provided in the final FPLOS Phase I Reports.

A model crosswalk for the C-8 and C-9 basins and South Miami-Dade (C-1, C-100, C-102, C-103) was performed to compare the performance and results of the District's FPLOS and Miami-Dade County's modeling frameworks (MIKE SHE-MIKE Hydro and XPSWMM respectively) under current conditions and under the two-foot sea level rise scenario. Despite some differences in model assumptions and conceptualization, both models show similar results in terms of stage profiles along the canal prior to the coastal structure and similar flooding conditions when considering depths of more than one foot.

FPLOS Sea Level Rise Scenarios

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

- CSL +1 foot
- CSL +2 feet
- CSL +3 feet

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 sea level rise projections, relative to 2000, are detailed below. The observed change in annual MSL between 2000 and 2015 in this location is 0.073m or 0.24 feet.

- 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 sea level rise projections, relative to 2000, are detailed below. The observed change in annual MSL between 2000 and 2015 in this location is 0.099m or 0.325 feet. The table below illustrates the NOAA 2022 Projections at the Key West Tidal Station.

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

Table 3-1 summarizes the sea level rise projections relative to 2000, as presented by NOAA, and relative to 2015, as adopted in the FPLOS Program Sea level rise scenario formulation.

Table 3-1: See Level Rise Projections

NOAA 2022 Sea Level Rise Projections	Relative to 2000				Relative to 2015			
	2040 (m)	2040 (feet)	2070 (m)	2070 (feet)	2040 (m)	2040 (feet)	2070 (m)	2070 (feet)
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

FPLOS Future Rainfall Projections

To support the characterization of future extreme rainfall scenarios for flood resiliency planning, the SFWMD entered into a cooperative agreement with the United States Geological Survey (USGS) Caribbean–Florida Water Science Center and the FIU Sea Level Solutions Center to develop future depth-duration-frequency (DDF) curves based on available global climate model downscaled datasets (2).

The future extreme rainfall scenarios are determined by applying Change factors (CFs). CFs represent the calculated ratio of modeled future rainfall depths to historic rainfall depths for a given rainfall event and are applied to multiply the equivalent National Oceanic and Atmospheric Administration (NOAA Atlas 14) precipitation frequency estimates to determine increasing or decreasing future rainfall. Change factors greater than 1.0 (one) represent future rainfall increase, and less than 1.0 (one) represent rainfall decrease for a given event. The criteria for results selection and initial scenario formulation were based on technical consensus upon the evaluation of the available results and the best approach to represent associated uncertainty. The computed change factors are summarized in Figure 3-2 below, based on the 50% confidence interval of the model spread for a 1-day duration, 25-year rainfall frequency event and a 3-day duration, 100-year rainfall frequency event, using the ensemble of all model results for both medium-low and high future emissions scenarios compiled by 16 counties within the SFWMD boundaries.

With the goal of facilitating data accessibility, advancement of common practices, and regional consistency, spatial results are available through the SFWMD Resilience Metrics Hub's Future Extreme Rainfall Change Factors for Flood Resiliency Planning in South Florida Web Application (3). The entire set of results for each global climate model dataset and additional percentile ranges are available at the USGS ScienceBase data release portal (4).

Current Flood Protection Level of Service

The current flood protection level of service generally provided by existing infrastructure in critical basins, predominantly located in Broward and Miami-Dade Counties is shown in Figure 3-3. 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.

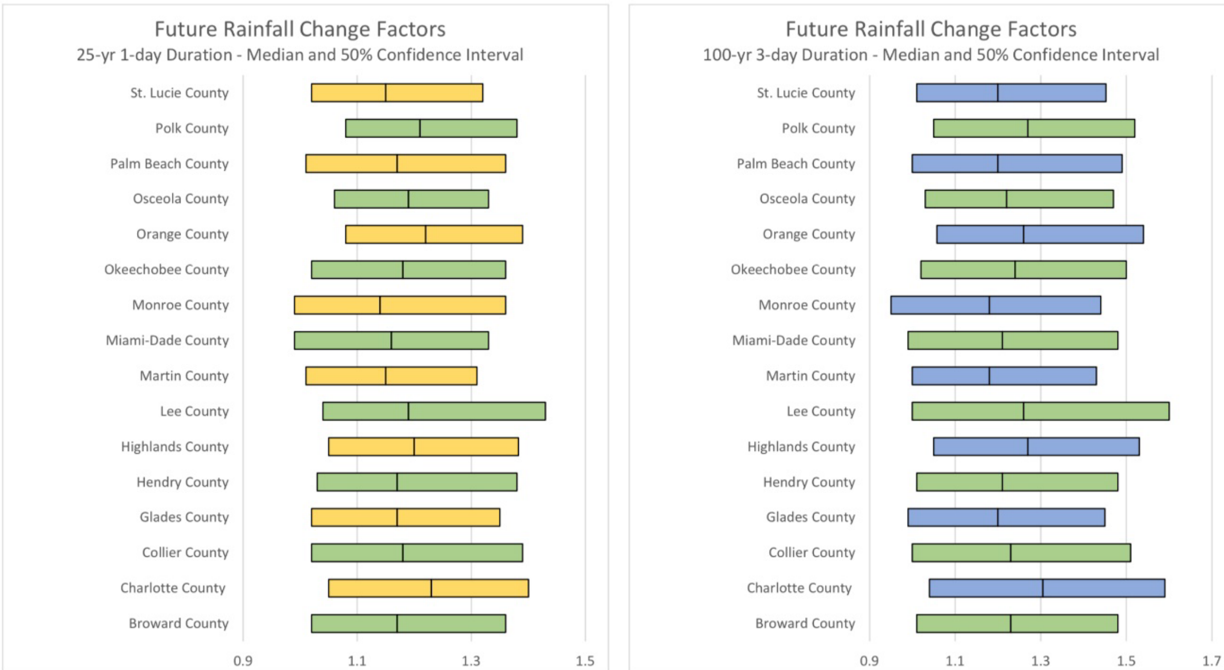


Figure 3-2: Summary of Future Rainfall Change Factors in South Florida

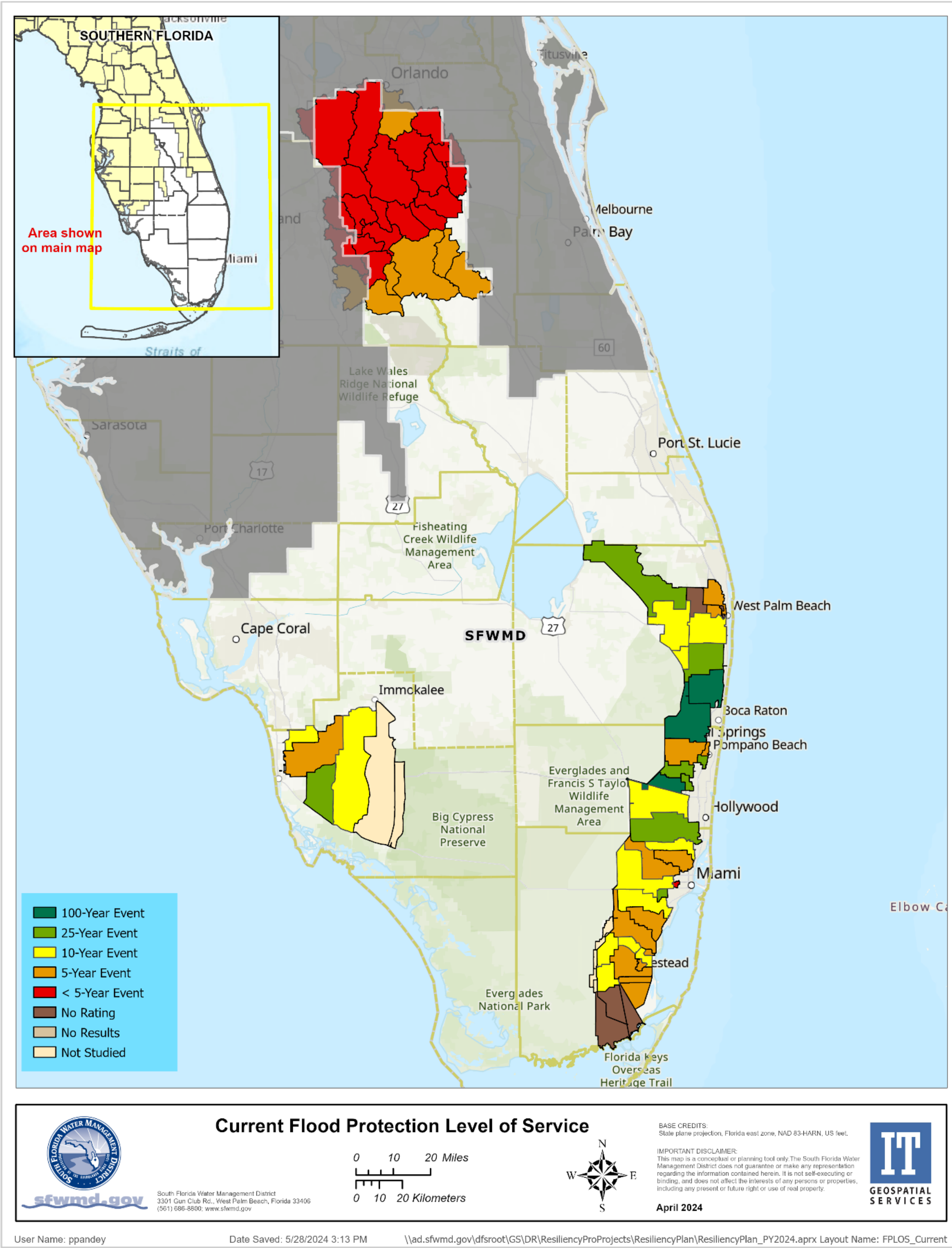


Figure 3.3: Current Flood Protection Level of Service

Future Flood Protection Level of Service

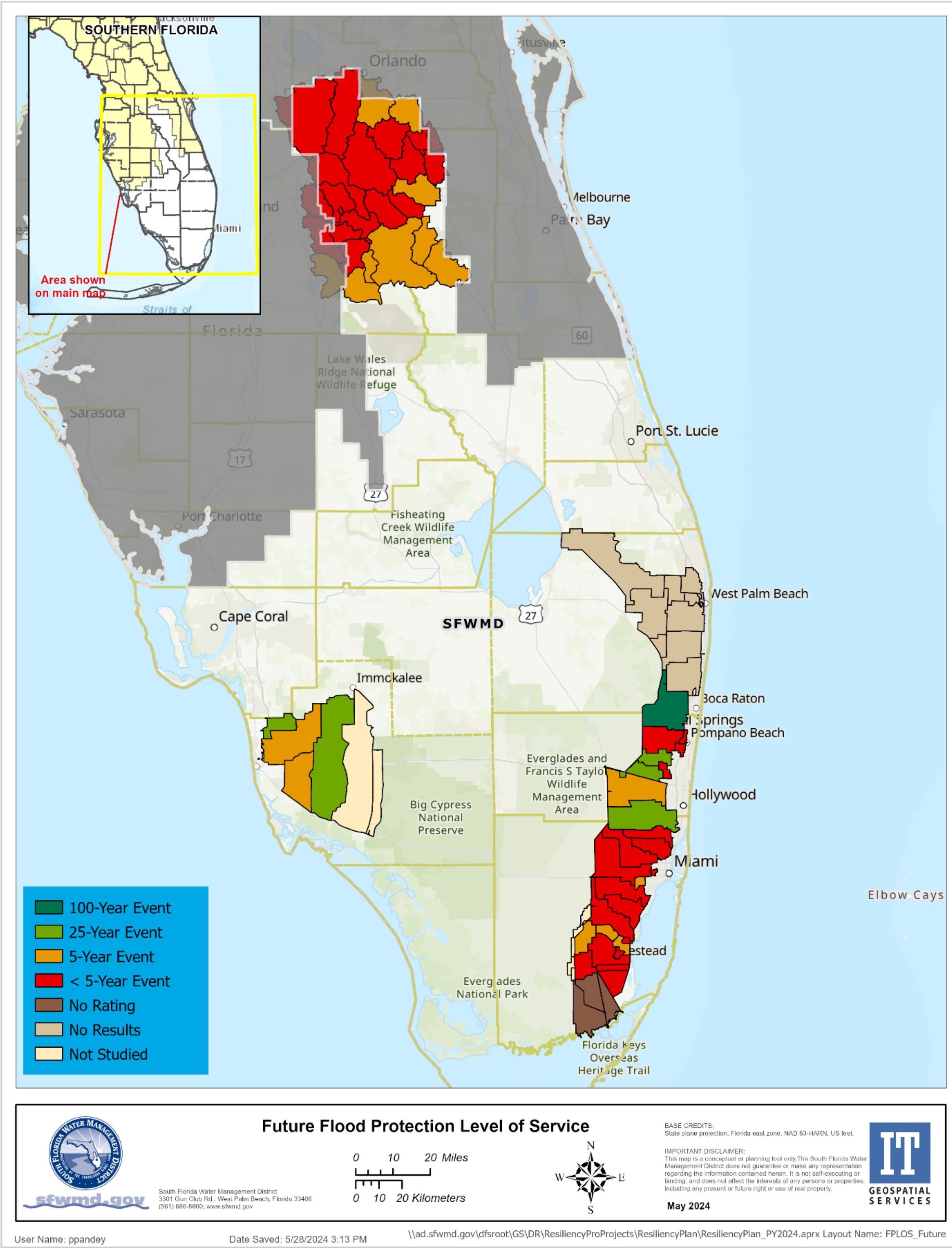


Figure 3.4: Future Flood Protection level of Service

The future flood protection level of service, under a 2-foot sea level rise scenario is shown in Figure 3-4. The figure depicts the 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 3-2: Flood Protection Level of Service Summary Assessment for Maximum Stage in Primary Canals

Basins	PM1				
	Current Conditions	Future Conditions & 1 feet SLR	Future Conditions & 2 feet SLR	Future Conditions & 3 feet SLR	Future Conditions & Rainfall Change Factors
Lake Alligator LMA[1]	< 5-Year	N/A	N/A	N/A	< 5-Year
Lake Myrtle LMA[1]	< 5-Year	N/A	N/A	N/A	< 5-Year
Lake Hart LMA[1]	< 5-Year	N/A	N/A	N/A	5-Year
Lake Gentry LMA[1]	< 5-Year	N/A	N/A	N/A	5-Year
Lake East Toho LMA[1]	25-Year	N/A	N/A	N/A	25-Year
Lake Toho LMA[1]	< 5-Year	N/A	N/A	N/A	< 5-Year
Lake Cypress LMA[1]	< 5-Year	N/A	N/A	N/A	< 5-Year
Lake Hatchineha LMA[1]	< 5-Year	N/A	N/A	N/A	< 5-Year
Lake Kissimmee LMA[1]	25-Year	N/A	N/A	N/A	100-Year
L-8[2]	100-Year				N/A
C-51 West[2]	100-Year				N/A
C-51 East[2]	10-Year				N/A
C-15[2]	100-Year				N/A
C-16[2]	25-Year				N/A
C-17[2]	5-Year				N/A
WPB Water[2]	N/A				N/A
Hillsboro[Error! Bookmark not defined.]	100-Year	100-Year	100-Year	100-Year	N/A
Pompano[Error! Bookmark not defined.]	100-Year	100-Year	100-Year	100-Year	N/A
C-14 West[Error! Bookmark not defined.]	100-Year	25-Year	25-Year	25-Year	N/A
C-14 East[Error! Bookmark not defined.]	25-Year	10-Year	< 5-Year	< 5-Year	N/A
C-13 West[Error! Bookmark not defined.]	25-Year	25-Year	10-Year	< 5-Year	N/A
C-12 West[Error! Bookmark not defined.]	25-Year	10-Year	< 5-Year	< 5-Year	N/A
North New River West[Error! Bookmark not defined.]	100-Year	100-Year	25-Year	10-Year	N/A
C-11 West[Error! Bookmark not defined.]	10-Year	10-Year	10-Year	10-Year	N/A

Table 3-2: Flood Protection Level of Service Summary Assessment for Maximum Stage in Primary Canals

Basins	PM1				
	Current Conditions	**Future Conditions & 1 feet SLR**	**Future Conditions & 2 feet SLR**	**Future Conditions & 3 feet SLR**	**Future Conditions & Rainfall Change Factors**
C-11 East[Error! Bookmark not defined.]	10-Year	5-Year	5-Year	5-Year	N/A
C-9[4]	25-Year	10-Year	10-Year	5-Year	N/A
C-8[4]	10-Year	5-Year	5-Year	5-Year	N/A
C-7[Error! Bookmark not defined.]	<5-Year	<5-Year	<5-Year	<5-Year	N/A
C-6[6]	25-Year	10-Year	5-Year	< 5-Year	N/A
C-5[6]	25-Year	10-Year	< 5-Year	< 5-Year	N/A
C-4[6]	10-Year	5-Year	<5-Year	<5-Year	N/A
C-3W[6]	25-Year	10-Year	5-Year	< 5-Year	N/A
C-2[6]	10-Year	5-Year	< 5-Year	< 5-Year	N/A
C-100[7]	5-Year	5-Year	< 5-Year	< 5-Year	N/A
C-1[7] – C-1 & C-1N	5-Year	5-Year or less	5-Year or less	5-Year or less	N/A
C-1[7] – C-1N	10-Year	5-Year or less	5-Year or less	5-Year or less	N/A
C-102[7]	10-Year	10-Year	5-Year	5-Year	N/A
C-103[7]	5-Year	5-Year	5-Year	5-Year	N/A
L-31NS (Canal L-31NS)[8]	5-Year	5-Year	5-Year	5-Year	N/A
L-31NS (C-102)[8]	10-Year	10-Year	10-Year	5-Year	N/A
L-31NS (C-103)[8]	10-Year	5-Year	<5-Year	<5-Year	N/A
C-111 AG (C-111)[8]	25-Year	10-Year	10-Year	5-Year	N/A
C-111 AG (C-113)[8]	10-Year	10-Year	10-Year	5-Year	N/A
C-111 AG (C-111E)[8]	5-Year	5-Year	<5-Year	<5-Year	N/A
C-111 SOUTH (C-111)[8]	100-Year	100-Year	100-Year	100-Year	N/A
C-111 SOUTH (C-111E)[8]	100-Year	100-Year	100-Year	100-Year	N/A
C-111 COASTAL[8]	100-Year	100-Year	100-Year	100-Year	N/A
MODEL LAND (Card Sound Rd)[8]	5-Year	<5-Year	<5-Year	<5-Year	N/A
MODEL LAND (L-31E Canal)[8]	5-Year	<5-Year	<5-Year	<5-Year	N/A
US-1[8]	N/A	N/A	N/A	N/A	N/A
Cocohatchee[9]	10-Year	10-Year	10-Year	5-Year	N/A
Golden Gate[9]	5-Year	5-Year	5-Year	<5-Year	N/A

Table 3-2: Flood Protection Level of Service Summary Assessment for Maximum Stage in Primary Canals

Basins	PM1				
	Current Conditions	Future Conditions & 1 feet SLR	Future Conditions & 2 feet SLR	Future Conditions & 3 feet SLR	Future Conditions & Rainfall Change Factors
Henderson Creek[9]	25-Year	25-Year	25-Year	10-Year	N/A
Faka Union[9]	10-Year	10-Year	10-Year	5-Year	N/A

Table 3-3: Frequency of Flooding (PM5) for current and future conditions.

Basins	PM5				
	Current Conditions	Future Conditions & 1 feet SLR	Future Conditions & 2 feet SLR	Future Conditions & 3 feet SLR	Future Conditions & Rainfall Change Factors
Lake Alligator LMA[1]	5-Year	N/A	N/A	N/A	5-Year
Lake Myrtle LMA[1]	< 5-Year	N/A	N/A	N/A	< 5-Year
Lake Hart LMA[1]	10-Year	N/A	N/A	N/A	10-Year
Lake Gentry LMA[1]	10-Year	N/A	N/A	N/A	10-Year
Lake East Toho LMA[1]	10-Year	N/A	N/A	N/A	10-Year
Lake Toho LMA[1]	10-Year	N/A	N/A	N/A	10-Year
Lake Cypress LMA[1]	10-Year	N/A	N/A	N/A	10-Year
Lake Hatchineha LMA[1]	10-Year	N/A	N/A	N/A	10-Year
Lake Kissimmee LMA[1]	5-Year	N/A	N/A	N/A	5-Year
L-8[2]	25-Year				N/A
C-51 West[2]	25-Year				N/A
C-51 East[2]	25-Year				N/A
C-15[2]	100-Year				N/A
C-16[2]	100-Year				N/A
C-17[2]	25-Year				N/A
WPB Water[2]	< 5-Year				N/A
Hillsboro**Error! Bookmark not defined.**	100-Year[10]	100-Year[10]	100-Year[10]	100-Year[10]	N/A
Pompano**Error! Bookmark not defined.**	<5-Year	< 5-Year	< 5-Year[10]	< 5-Year[10]	N/A
C-14 West**Error! Bookmark not defined.**	10-Year[10]	5-Year[10]	<5-Year	<5-Year	N/A
C-14 East**Error! Bookmark not defined.**	25-Year	10-Year	<5-Year	<5-Year	N/A
C-13 West**Error! Bookmark not defined.**	25-Year	25-Year	10-Year	< 5-Year	N/A

Table 3-3: Frequency of Flooding (PM5) for current and future conditions.

Basins	PM5				
	Current Conditions	**Future Conditions & 1 feet SLR**	**Future Conditions & 2 feet SLR**	**Future Conditions & 3 feet SLR**	**Future Conditions & Rainfall Change Factors**
C-12 West**Error! Bookmark not defined.**	25-Year[10]	5-Year	< 5-Year	< 5-Year	N/A
North New River West**Error! Bookmark not defined.**	100-Year[10]	100-Year[10]	25-Year[10]	10-Year[10]	N/A
C-11 West**Error! Bookmark not defined.**	10-Year[10]	10-Year[10]	10-Year[10]	10-Year[10]	N/A
C-11 East**Error! Bookmark not defined.**	10-Year[10]	5-Year	<5-Year[10]	<5-Year[10]	N/A
C-9**Error! Bookmark not defined.**	25-Year	10-Year[10]	10-Year[10]	5-Year	N/A
C-8[i]	10-Year	5-Year[10]	<5-Year	<5-Year	N/A
C-7[ii]	<5-Year[10]	<5-Year[10]	<5-Year[10]	<5-Year[10]	N/A
C-6	5-Year	5-Year	< 5-Year	< 5-Year	N/A
C-5	<5-Year	< 5-Year	< 5-Year	< 5-Year	N/A
C-4[iii]	10-Year[10]	5-Year[10]	<5-Year[10]	<5-Year[10]	N/A
C-3W	25-Year	10-Year	10-Year	10-Year	N/A
C-2	25-Year	25-Year	10-Year	10-Year	N/A
C-100**Error! Bookmark not defined.**	25-Year	5-Year[10]	< 5-Year[10]	< 5-Year[10]	N/A
C-1[7] – C-1 & C-1N	10-Year	10-Year	<5-Year[10]	<5-Year	N/A
C-1[7] – C-1N	10-Year	10-Year	<5-Year[10]	<5-Year	N/A
C-102[7]	5-Year	5-Year[10]	5-Year[10]	<5-Year[10]	N/A
C-103[7]	5-Year	5-Year[10]	5-Year[10]	< 5-Year[10]	N/A
L-31NS (Canal L-31NS)[8]	10-Year	10-Year	10-Year	5-Year	N/A
L-31NS (C-102)[8]	10-Year	10-Year	10-Year	5-Year	N/A
L-31NS (C-103)[8]	10-Year	10-Year	10-Year	5-Year	N/A
C-111 AG (C-111)[8]	5-Year	5-Year	5-Year	5-Year	N/A
C-111 AG (C-113)[8]	5-Year	5-Year	5-Year	5-Year	N/A
C-111 AG (C-111E)[8]	5-Year	5-Year	5-Year	5-Year	N/A
C-111 SOUTH (C-111)[8]	10-Year	10-Year	10-Year	10-Year	N/A
C-111 SOUTH (C-111E)[8]	10-Year	10-Year	10-Year	10-Year	N/A
C-111 COASTAL[8]	N/A	N/A	N/A	N/A	N/A
MODEL LAND (Card Sound Rd)[8]	10-Year	10-Year	10-Year	10-Year	N/A
MODEL LAND (L-31E Canal)[8]	10-Year	10-Year	10-Year	10-Year	N/A
US-1[8]	10-Year	10-Year	10-Year	10-Year	N/A
Cocohatchee[9]	10-Year[11]	10-Year[11]	10-Year[11]	5-Year[11]	N/A
Golden Gate[9]	5-Year[11]	5-Year[11]	5-Year[11]	< 5-Year[11]	N/A

Table 3-3: Frequency of Flooding (PM5) for current and future conditions.

Basins	PM5				
	Current Conditions	Future Conditions & 1 feet SLR	Future Conditions & 2 feet SLR	Future Conditions & 3 feet SLR	Future Conditions & Rainfall Change Factors
Henderson Creek[9]	25-Year[11]	25-Year[11]	25-Year[11]	10-Year[11]	N/A
Faka Union[9]	10-Year[11]	10-Year[11]	10-Year[11]	5-Year[11]	N/A

[i] Upper Kissimmee Basin FPLOS study is expected to be completed by fall 2024. Preliminary results.

[2] Eastern Palm Beach County FPLOS study is expected to be completed by fall 2024. Preliminary results.

[3] Broward County FPLOS study was completed in 2021.

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

[5] C-7 FPLOS study is expected to be completed by summer 2025. Preliminary results.

[6] C-2, C-3W, C-4, C-5 and C-6 FPLOS study was completed in 2024

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

[8] C-111 FPLOS study was completed in 2023.

[9] Big Cypress Basin FPLOS study was completed in 2017.

[10] The report does not contain sufficient information to confirm the 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 LOS as these are subject to technical interpretation and should be further reviewed by local stakeholders.

[11] The LOS results are tightly connected with the primary canal system.

FPLOS Next Steps

As described above, the FPLOS program is designed to allow for two new FPLOS Phase I Studies to be initiated each year. Upon completion of the key assessments, or if specific projects or actions require a more frequent reassessment, basins previously investigated will then be revisited to reassess the conditions, considering potential changes to the flood control infrastructure and more refined information on future conditions, including extreme rainfall projections. Flood vulnerability assessments for the St Lucie /Martin Counties Systems, and the Western Basins Phase I studies were initiated in 2024 as part of included in the FPLOS implementation schedule.This schedule also incorporates the initiation of at least one new Phase II study every year. The C-7 Basin Phase II study is the ongoing adaptation planning effort. Figure 3-5 shows the prioritization of basins for identifying adaptation and mitigation strategies across the District. Miami-Dade County, Broward County, Collier County, Lee County, and portions of the Upper Kissimmee Basin in Orange and Osceola Counties represent parts of the system where studies are anticipated in the near term.

Funding needs to implement the FPLOS program Phase I and Phase II studies are summarized in Chapter 10. Over the next five years, it is expected that flood vulnerability assessments will be completed for all the District's basins. Additionally, within the same timeframe, it is expected that adaptation and mitigation planning studies will be completed for 25% of the District's basins, subject to funding availability.

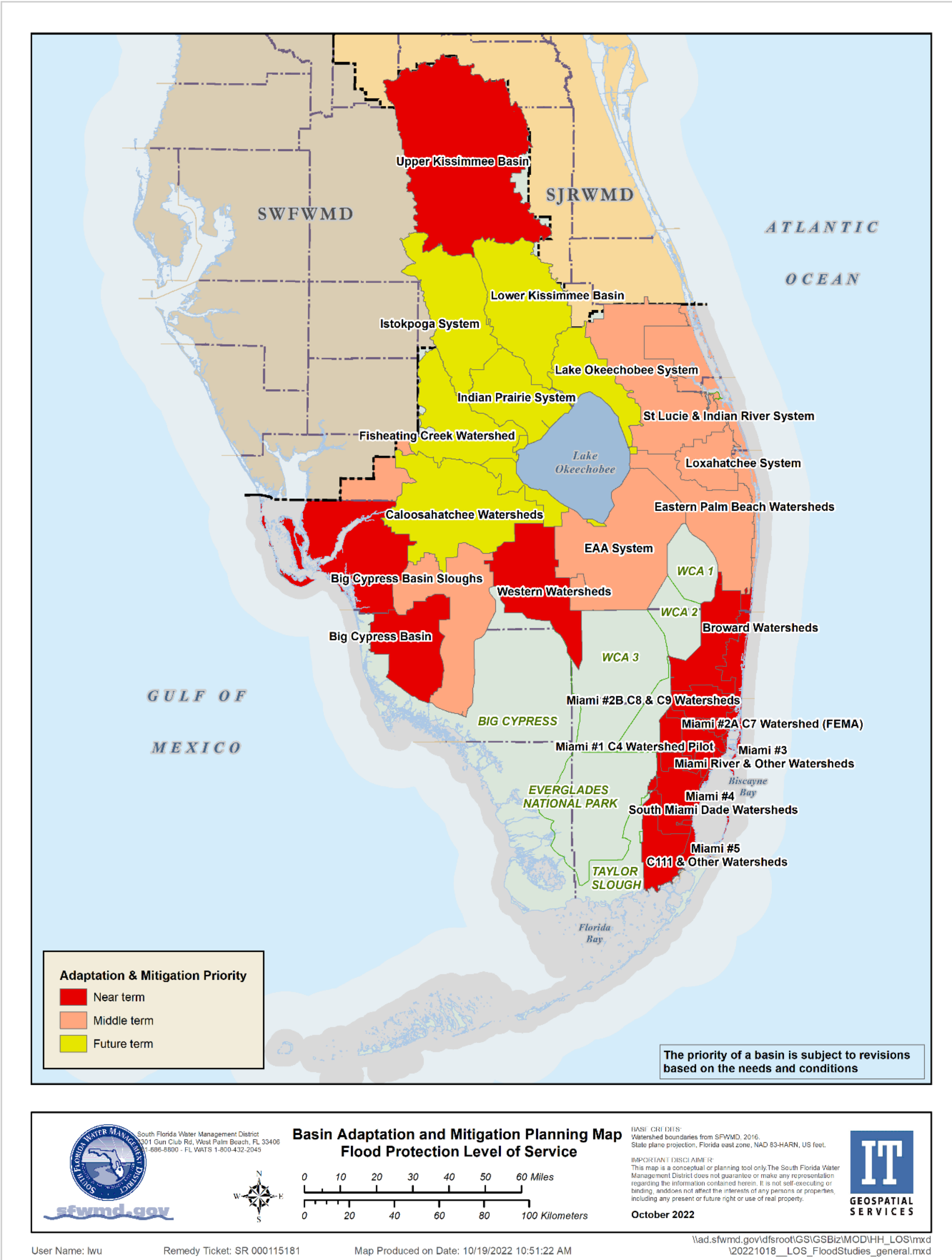
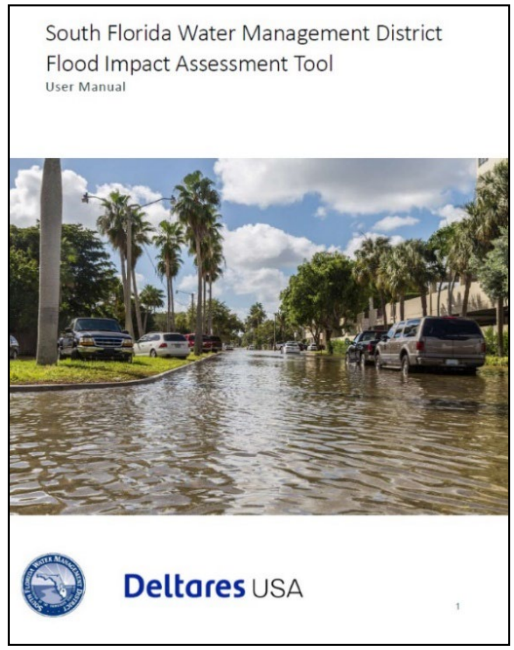


Figure 3-3: FPLOS Basin Adaptation and Mitigation Planning Map

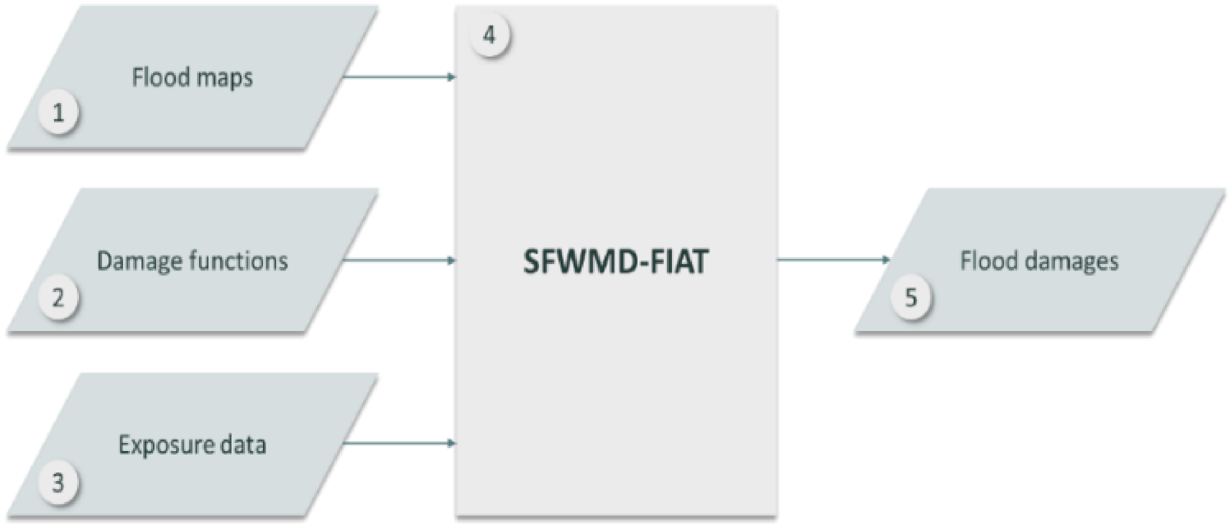
SFWMD Flood Impact Assessment Tool (SFWMD-FIAT)



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 3-6). SFWMD-FIAT can calculate the flood damage costs for building structures and their contents, multiplied by the depreciated replacement value by the 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 building values can be updated. 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 RoadsHAZUS Occupancy Types and Depreciated Replacement Values

The output files include post-processed summarized 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. The SFWMD-FIAT user manual is linked here.



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 3-4: Block Diagram of SFWMD-FIAT Tool

C&SF Flood Resiliency Study

The District, in partnership with the United States Army Corps of Engineers (USACE) – Jacksonville District (SAJ), is implementing the C&SF Flood Resiliency Study. This study is being conducted under the authority in Section 216 of the Flood Control Act of 1970, Public Law 91-611 (33 U.S.C. 549a), which authorizes the Secretary of the Army, acting through the Chief of Engineers, to review the operation of the C&SF Project due to significantly changed physical, economic or environmental conditions and to report to Congress with recommendations on the advisability of modifying the structures or their operation.

Goals and Objectives

The C&SF Flood Resiliency Study will identify technically feasible, environmentally acceptable, and economically justified project recommendations for federal participation, in collaboration with the project local sponsor - SFWMD, in a flood risk management (FRM) project to build flood resiliency, now and into the future, and reduce flood risks that affect population, property (e.g. buildings, roads), critical infrastructure (e.g. hospitals, shelters, airports, ports, utilities and other lifelines) and any other systems, in the communities served by the C&SF water management system within the lower southeast coast of Florida in Palm Beach, Broward and Miami-Dade Counties.

A feasibility level planning analysis will be conducted focused on increasing the resilience and function of vulnerable coastal structures and the conveyance of the primary inflow canals, culminating in a final

Integrated Report, which assesses potential impacts (both adverse and beneficial) in accordance with the National Environmental Policy Act (NEPA). The results of the study will allow the immediate authorization of subsequent design and construction phases. The Integrated Report will require authorization by United States Congress before proceeding with design and construction.

Current Study Status

In June 2023, the SFWMD and USACE came to an agreement on the scope of the study and the deliverable schedule. The final recommended study scope focuses on enhancing the capacity of the most vulnerable coastal water control structures and adjacent primary canals.

The target completion date for the study will align in time to be incorporated into the publication of the 2026 Water Resources Development Act, a bill that Congress authorizes every two years for new water infrastructure projects and improvements to water programs across the country.

The SFWMD and USACE are in the process of performing the recommended rounds of modeling, leveraging significant progress on flood vulnerability assessments completed by the FPLOS Program, and defining performance criteria for the selection of best alternatives to determine a Tentatively Selected Plan by April 2025.

It is important to emphasize that the FPLOS Program continues to be implemented in parallel to the development of the C&SF Flood Resiliency Study. The C&SF Flood Resiliency Study focuses on highly vulnerable infrastructure along primary C&SF system (coastal structure and canal enhancements) and will be proposing adaptation and mitigation alternatives within USACE's Flood Risk Management authority and focused mostly on flood risks resulting from rainfall driven events. The Study's performance metrics will be estimating project's benefits using USACE's National & Regional Economic Development (NED, RED), Environmental Quality (EQ), Other Social Effects (OSE) accounts. The FPLOS studies will continue to evaluate basin-wide strategies, including primary and secondary system flood protection infrastructure, and a broader selection of mitigation and adaptation alternatives, addressing compound flood drivers (surge, groundwater, tide, rainfall), inter-basin transfers and storage needs.

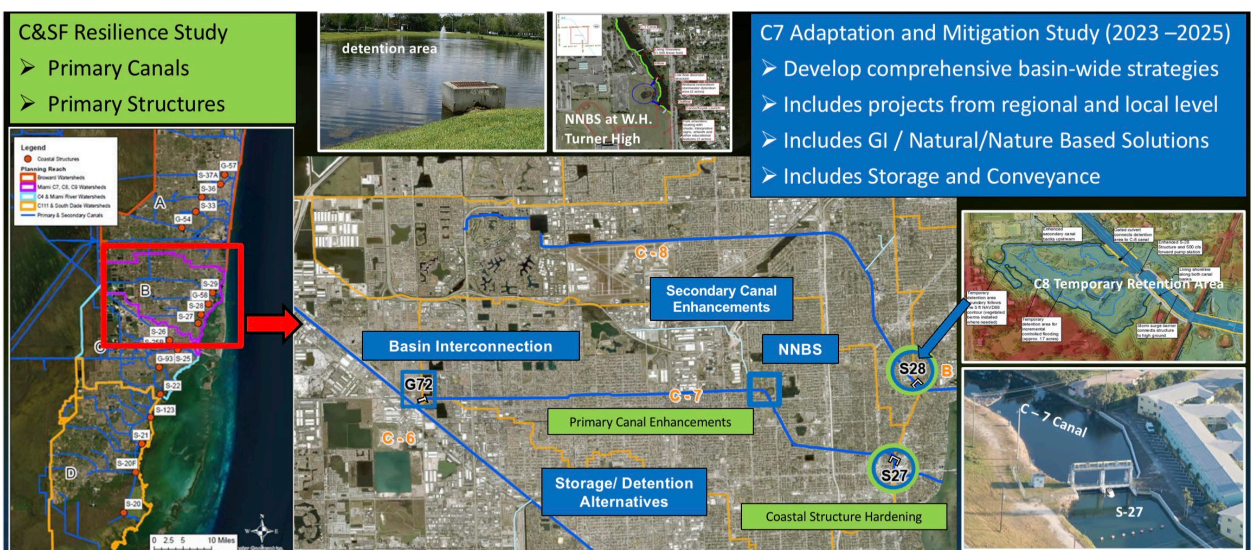
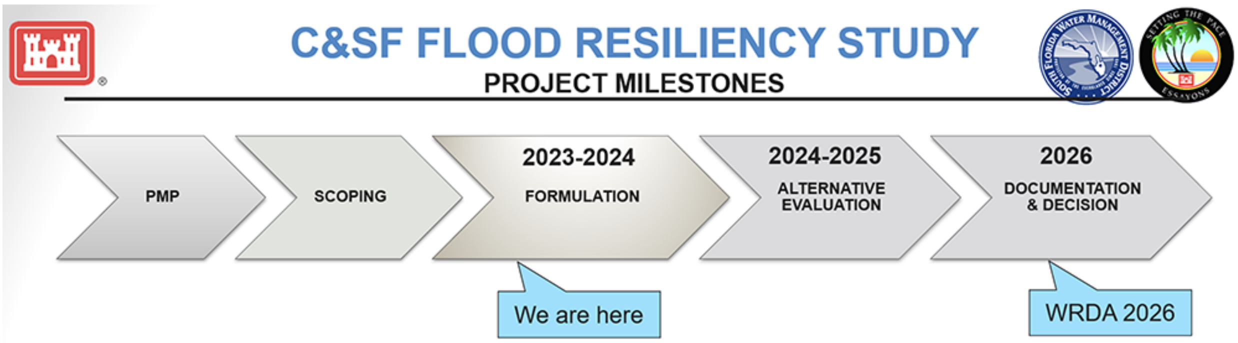


Figure 3-7: C&SF Flood Resiliency Study and FPLOS Program – examples of project alternatives being assessed within a Basin.

Next Steps and C&SF Comprehensive Study

The C&SF Flood Resiliency Study next steps are illustrated in Figure 3-8 below, aiming to submit a final report package to the USACE's vertical team by May 2026 and Signed chief's report by September 2026.



Milestone	Date
Signing of Feasibility Cost Share Agreement	September 21, 2022 [A]
Alternatives Milestone	June 20, 2023 [A]
Tentatively Selected Plan Milestone	April 2025 (S)
Draft Report Submittal to HQ	June 2025 (S)
Public Release of Draft	June 2025 (S)
Agency Decision Milestone	March 2026 (S)
Submit Final Report Package to Vertical Team	May 2026 (S)
Signed Chief's Report	September 2026 (S)

[A]=Actual/Completed (S) = scheduled

The schedule follows the USACE SMART (*Specific Measurable Attainable Risk-informed Timely*) planning process, a 3x3x3 policy waiver to extend the schedule and increase the budget has been submitted through the VTAM now at HQUSACE.

Figure 3-8: C&SF Flood Resiliency Study – Project Milestones and Schedule.

In addition, a Comprehensive C&SF Study has been authorized in WRDA 2022 as a multipurpose project to study the entire C&SF System, expanding from the single purpose FRM C&SF Flood Resiliency Study. The Comprehensive C&SF Study will identify technically feasible, environmentally acceptable, and cost-effective project recommendations justifying federal participation, in collaboration with the project local sponsors – SFWMD and St. Johns Water Management District (SJRWMD), for the purposes of flood risk management, water supply, ecosystem restoration (including preventing saltwater intrusion), recreation and related purposes. The project components and alternatives will provide an integrated regional assessment for the evaluation of the larger stormwater management system, as well as propose the best adaptation strategies to prevent flood risks from storm surge, extreme rainfall, high tides and groundwater levels, along with saltwater intrusion. Project components and alternatives not advanced as part of other ongoing or recently completed regional studies, e.g. C&SF Flood Resiliency Study, or Miami-Dade Back Bay Study within the proposed project area might be incorporated as part of project study components of the upcoming Comprehensive C&SF Study.

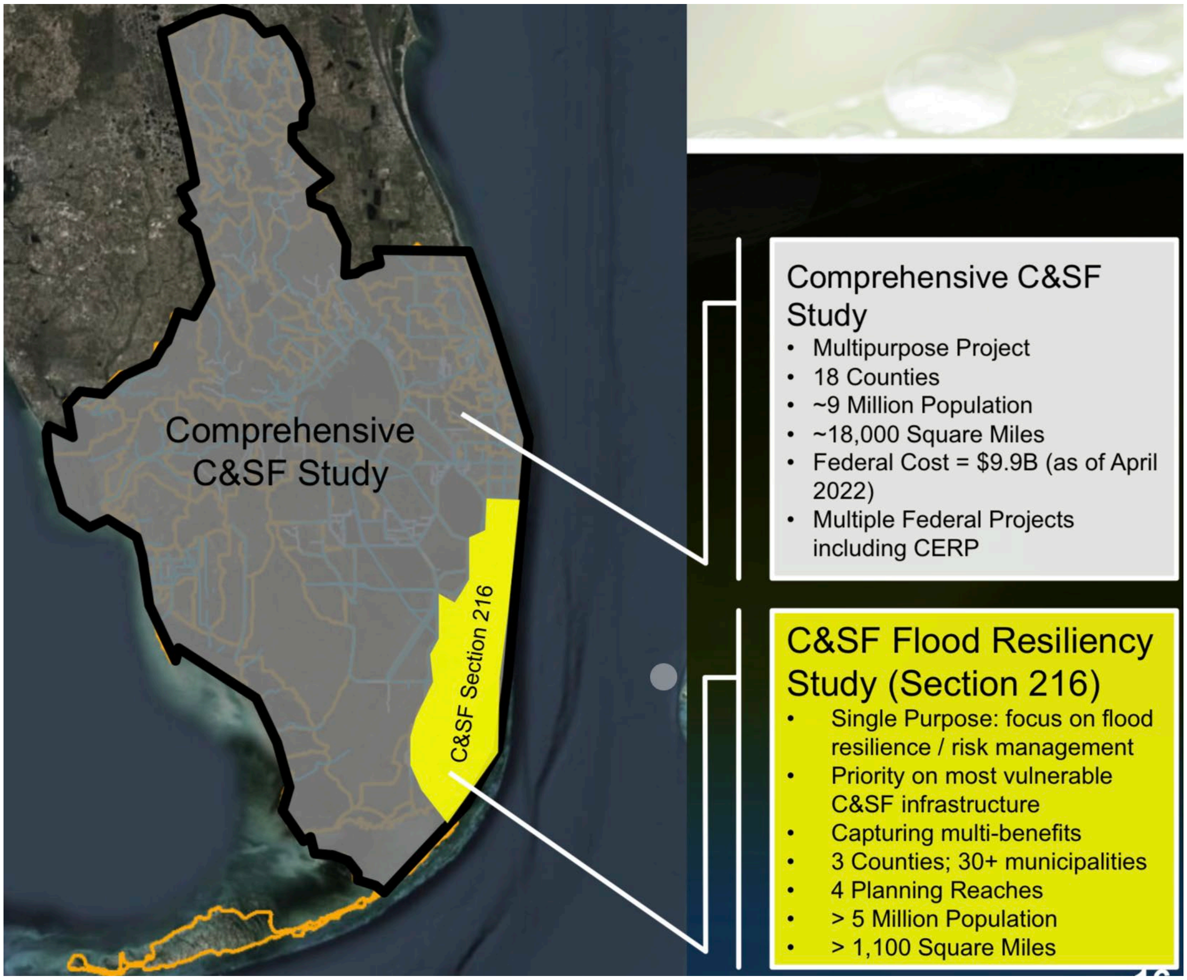


Figure 3-9: Study areas for the ongoing C&SF Flood Resiliency Study and the upcoming Comprehensive C&SF Study.

4: Nature-Based Solutions

Integrating Nature-Based Solutions

Nature-based solutions are defined as sustainable planning, design, environmental management, and engineering practices that weave natural features or processes into the built environment to build more resilient communities. These features can be used to conserve or restore ecosystem services and/or enhance natural processes that operate within engineered systems. Application of nature-based solutions 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. Nature-based solutions and green infrastructure can be used to enhance flood protection against sea level rise 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 sea level rise, along with basin-wide solutions to maximize the capacity of flood adaptation as well as achieve water quality and water supply benefits.

Nature-based solutions include features such as bioswales, rain gardens, green rooftops, living shorelines, wetlands, and artificial reefs that reduce stormwater flooding and storm surge impacts by absorbing wave energy and/or storing excess stormwater. Nature-Based features can be constructed using alternative construction materials such as concrete mixtures that enhance the ability of these features to create habitat, clean stormwater, and capture carbon. Alternative Green urban infrastructure features include green and blue features 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, nature-based solutions also provide a multitude of water resource benefits by reducing net irrigation demand for green spaces and increasing retention and infiltration of surface water, which naturally recharges aquifers and assists in preventing saltwater intrusion in coastal areas.

The use of nature-based solutions has grown steadily over the past 20 years, supported by calls for innovation in flood risk management (FRM) and resilience planning. Communities, in general, have a strong desire to integrate nature-based solutions with traditional gray stormwater infrastructure. Accordingly, major grant programs, such as FEMA BRIC and Resilient Florida, assign higher scores to proposed projects that include nature-based solutions, making them more competitive. In November 2022, the Federal government committed to ensuring that over $25B in infrastructure and climate funding can support nature-based solutions and presented a roadmap that includes unlocking funding for nature-based solutions, workforce training, and updating guidance and policies (White House Council on Environmental Quality et al. 2022) such as:

- Better accounting for nature-based options in benefit-cost analyses is required by FEMA, USACE, and other federal agencies in their regulatory and funding programs.
- Revising floodplain management requirements to consider nature-based solutions for all projects that can affect floodplains and wetlands.

The District is committed to seeking nature-based solutions in addition to and integrating into existing and planned traditional gray infrastructure improvements and leveraging significant experience from the implementation of large ecosystem restoration and water quality efforts. Projects that “slow the flow” by using natural processes such as retention, infiltration, and evaporation/evapotranspiration to reduce runoff will be targeted. Additionally, the preservation and restoration of existing natural features will continue to be implemented as an important strategy to increase resiliency.

Different terms and definitions of nature-based solutions for risk reduction and adaptation are in use across the variety of organizations that are implementing these features. 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 ecosystems. For instance, Engineering With Nature (EWN) is an initiative of the USACE enabling more sustainable delivery of economic, social, and environmental benefits associated with water resources infrastructure. The USACE EWN Program works to better integrate traditional and nature-based infrastructure approaches by aligning engineering and natural processes for greater benefit. Incorporating natural and nature-based features into project scoping, planning, design, construction, and operations, from a foundation of inclusive and collaborative engagement creates a broad array of opportunities to meaningfully strengthen community resilience into the future. On February 2023, the USACE South Atlantic Division (SAD) became an EWN Proving Ground, recognizing that "partnering with nature is vital to delivering bold solutions to combat uncertainty and achieve long-term, sustainable solutions, and meaningfully strengthen community resilience into the future. EWN proving grounds are places/projects where innovative ideas are tested on the ground, and lessons learned are documented and shared, so others can learn from experience in building sustainable water resources infrastructure and demonstrating a commitment to the broad integration of nature-base solutions. Examples of EWN principles have been extensively applied in Everglades Restoration projects.

C-9 Canal Enhancement Project

An example of a project that is proposing to use nature-based solutions combined with traditional gray infrastructure is the C-9 Canal Enhancement Project. The C-9 Canal (Snake Creek) is a fundamental component of the Central and Southern Florida Project, constructed between 1950 and 1970 by the U.S. Army Corps of Engineers, with the objective of providing flood control and managing saltwater intrusion, among other project purposes. The original design for the C&SF System did not account for intense urban development that occurred in the region, along with sea level rise, extreme rainfall, and other changing conditions.

Figure 4-1: Conceptual Plan for the C-9 Canal Enhancement Project.

The C-9 Canal Enhancement project, as defined in its initial conceptual design, includes creating a linear wetland along a six-mile section of the C-9 Canal right-of-way to increase storage capacity along canal banks and reduce out-of-bank flooding impacts. The project also provides significant co-benefits (social, environmental and water quality) along with flood risk reduction, as SFWMD's right-of-way and land ownership conditions allow. This proposed project is a component of the C-9 Basin Resiliency Project and includes the following features:

- Building berms along the outer edge of the right of way to reduce out-of-bank flooding impacts.
- Constructing distributed stormwater storage wetlands along the C-9 Canal banks, including a mosaic of ecotones (wetland, terrestrial and aquatic depending on topography).
- Constructing/modifying access roads along the banks of the C-9 Canal to improve operations and maintenance and increase the potential for public access and recreation.
- Connecting the wetland to the C-9 Canal using structural soil, low water crossings.
- Constructing structural and nature-based features at the outfalls of 8-10 secondary canals to improve water quality.

C-8 Basin Resiliency Project

Another example of a project that is proposing to use a combination of nature-based solutions and gray infrastructure is the District's C-8 Basin project in Miami-Dade County. The C-8 (Biscayne) Canal is the primary flood control feature that receives and conveys basin floodwaters by gravity through the S-28 Coastal Structure in North Miami to the sea. The objective of the project is to reduce flood risk as sea-levels rise and provide ancillary water quality benefits by restoring the basin's flood protection level of service and enhancing the quality of life in the region. The project, as defined in its initial conceptual design includes a combination of structural measures and nature-based solutions (Figure 4-2), as follows:

- Replacement of the S-28 Structure with an enhanced structure and elevated components to withstand the impacts of sea level rise and climate change.
- Installation of a 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 assist in mitigating the impacts of sea level rise, storm surge, and saltwater intrusion.
- Enhancement of secondary canal banks to improve flood control throughout the basin.
- Construction of a temporary floodwater detention area utilizing vegetated berms and other green infrastructure components 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 and provide ancillary water quality benefits.
- Installation of living shoreline along the C-8 Canal to assist in enhancing overall water quality and aquatic habitat.

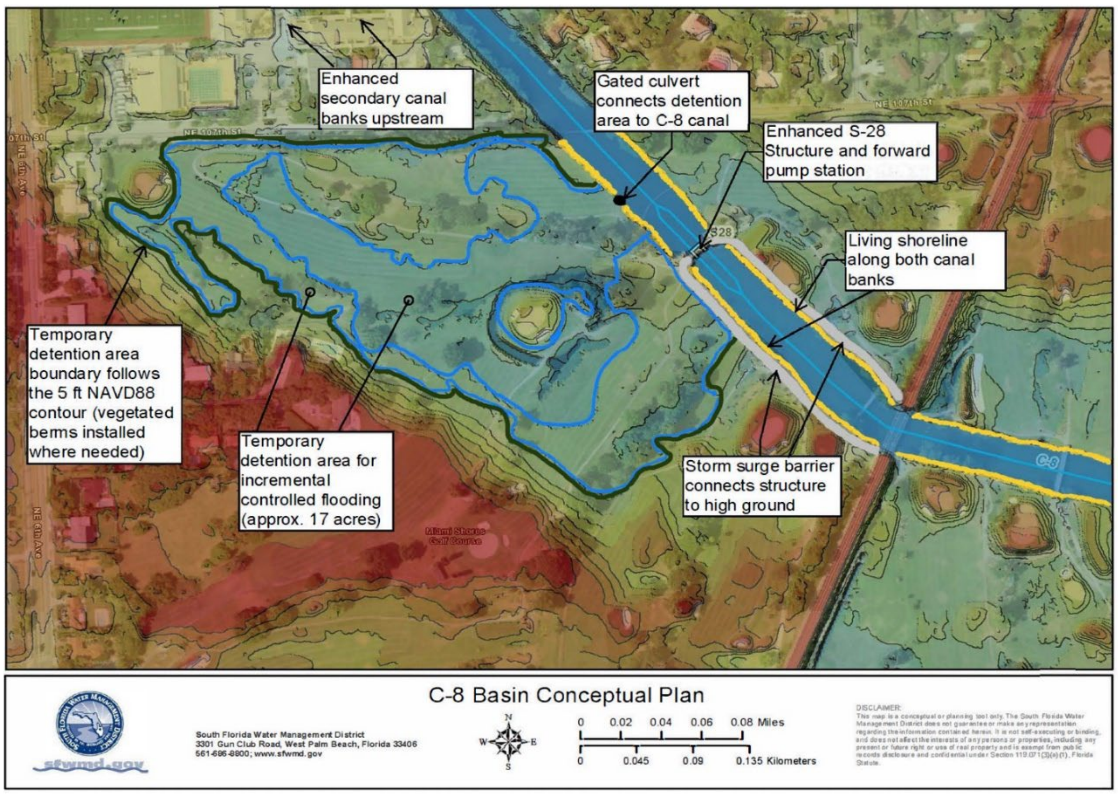


Figure 4-2: Conceptual Plan for the C-8 Basin.

The strategy to reduce peak runoff in this densely urbanized basin includes the implementation of a series of distributed storage solutions, as exemplified by the proposed project features, serving as pilot examples for the region. Ancillary benefits include improved fish and wildlife habitat, improved land value due to reduced flood risk and enhanced aesthetics, prevention of canal bank erosion, water quality benefits, and increased opportunities for recreation.

A more comprehensive list of examples of nature-based solutions that may be applied in South Florida is shown in Table 4-1 below. The table can be useful for identifying potential nature-based solutions for each water management/District mission type. The location of the proposed nature-based solutions project feature and corresponding gray infrastructure that can be either replaced or enhanced by the nature-based solutions feature are identified.

Table 4-1: Nature-Based Solutions/Green Infrastructure

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			■		
		Wastewater and stormwater reuse			■		
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/peat accretion	■	■	■		
		Constructed wetlands	■	■	■		
		Living shorelines/riparian buffers		■			

NOTES:
The table presents nature-based solution that may be applied in South Florida (5). Shaded boxes identify the location of each of the green infrastructure/nature-based solutions

Process for Assessing and Implementing Nature-Based Solutions

The initial step for assessing and implementing nature-based solutions, as proposed in this plan document, is to map available opportunities within a given basin through the analysis of land use maps (Figure 4-3) 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 more vulnerable to flooding. The map can also help to identify all lands within the basin that could potentially be used for implementing nature-based solutions. 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. During this step, vulnerable and underserved communities are also taken into account to help choose appropriate project areas.

Step two involves selecting suitable nature-based solutions that can be implemented on the parcels identified as potential sites for nature-based solutions. 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 nature-based solutions have been selected, a nature-based solutions implementation process 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 nature-based solution in providing benefits such as increased flood protection, water supply, and/or water quality improvements, as well as co-benefits such as protection from threats like heat, drought, and wildfire. Finally, if the nature-based solutions prove successful in providing significant benefits, the nature-based solutions can be upscaled and applied throughout the basin and/or regionally across basins. These seven steps are summarized below:

- Identify opportunities (such as available land)
- Select and assess nature-based solutions and related actions
- Design nature-based solutions implementation processes
- Engage stakeholders, communicate co-benefits, and establish partnerships
- Implement nature-based solutions upon funding strategy definition
- Monitor and evaluate co-benefits across all stages
- Transfer and upscale nature-based solutions

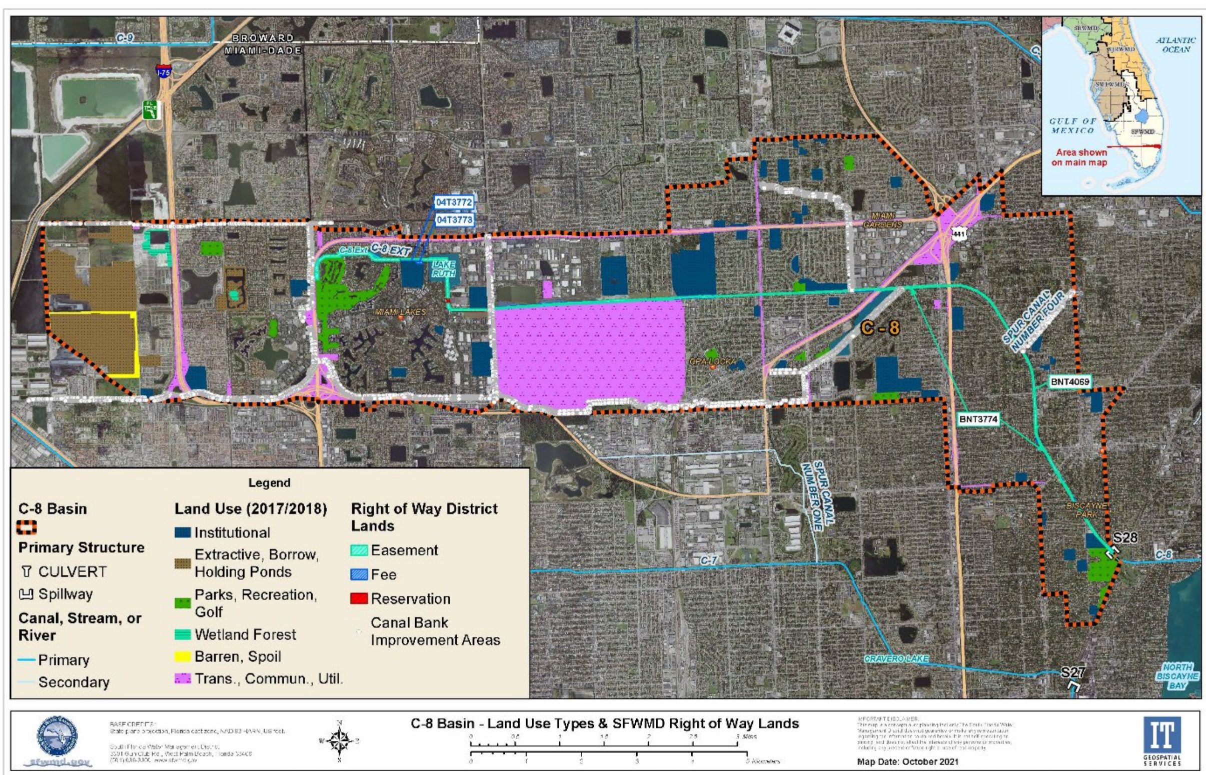


Figure 4-3: Land Use Types and SFWMD Right of Way lands within the C-8 Basin in Miami-Dade County.

Process for Evaluating Nature-Based Solutions - Estimating Direct and Indirect Benefits

The process for evaluating the benefits of the nature-based solution 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 project objectives and the primary problem(s) it is intended to solve (flood control, water supply, water quality, environmental restoration, or combination thereof). Once the assessment for the project's main intended purpose is confirmed, the project may also be evaluated relative to more comprehensive benefits related to District's missions and incorporating stakeholder projects and components. The evaluation of nature-based solutions will also include considerations of operational impacts associated with the feasibility of project implementation to maintenance activities and impacts to the regulatory classification of nature-based solutions assets relative to the project design objective in cases where nature-based solutions are paired with gray infrastructure.

This section provides a general assessment of methodologies for projects with flood control benefits. 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 and/or regional simulation model are tools that can provide a good evaluation of a large-scale storage or constructed wetland project. Standard calculations and additional modeling within the project impact area might be used to identify and implement nature-based solutions and green infrastructure. However, some nature-based solutions projects may be too small to be entered into a regional scale model capable of estimating the benefit of more localized projects. In this example, the tools selected to evaluate the flood damage reductions of the proposed project may need to be professional estimates in lieu of modeling. Examples of assessment methodologies for flood control projects are listed in Table 4-2.

Table 4-2: Examples of Assessment Methodologies for Flood Control Projects

Water Management Topic		NBS	Corresponding Gray Infrast. 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 • Professional estimates • Empirical methods
	Urban stormwater runoff	Green spaces	Urban stormwater infrastructure	• Standard engineering calculations and impact area-specific modeling • Empirical methods
		Permeable surfaces		• Standard engineering calculations and impact area-specific modeling • Empirical methods
		Green roofs		• Professional estimates • Empirical methods
	Coastal flood control	Protecting/restoring mangroves, marshes, and dunes	Artificial reefs/Sea walls/ forward pumps	• Hydraulic models for large-scale projects • Professional estimates • Empirical methods (e.g., peat accretion rates)
		Protecting/restoring reefs		

Performance Metrics for Nature-Based Solutions

Performance metrics are very useful tools for assessing a project's success, in addition to estimation of benefits. 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 the implementation of the project. They are project-specific and should be integrative of multiple aspects of the expected project result.

Performance metrics 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 feasibility and cost/benefit of the project. The second monitors the implemented project over time and compares the actual outcome to the expected outcome. The performance metrics for the two goals may be and likely will be different.

Identifying appropriate performance metrics, as summarized in Table 4-3, requires data collection both before and after project implementation and a general understanding of the inner workings of the system. For example, for the C-8 Basin project, a potential performance metric would be the turbidity of the water column. It is an integrative measure of basin runoff, erosion, and a water quality parameter that impacts aquatic habitat. Turbidity data under multiple conditions (before and after rain events), both before and after project implementation, will be needed to assess the project's success. 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:

- Estimate the direction and magnitude of change in performance metric from the current state over the expected timeframe of benefit.
- Compare current performance measure status with its desired trend and target.
- Evaluate the consistency of monitoring results with anticipated results.
- Determine if unanticipated events are indicated by the data (outliers).
- Describe how these events are affecting the desired outcome.

Table 4-3: Potential Performance Metrics

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 and Duration	Medium	Medium
Stage	High	Low
Flow	High	Low
Evapotranspiration	High	Medium
Biological Health & Biodiversity	Medium	Medium
Floodplain Connectivity	High	High
Wildlife utilization	Very low	High
Bank Stability	Low	Medium
Shoreline Change	Medium	Medium
Coastal Peat Accretion	Medium	Medium

Resiliency Projects with Nature-Based Solutions

Nature-based solutions are an important component of resiliency projects as they provide multiple benefits for both people and the environment. Projects in this plan document that include nature-based solutions are listed below and are detailed in Appendix A. As the District continues to develop priority resiliency projects, nature-based solutions will be incorporated into traditional gray infrastructure to make the water management systems more resilient. Nature-based solutions are becoming increasingly important in building resilient communities, as they offer a cost-effective and sustainable way to mitigate the impacts of climate change and improve the ability of cities to withstand and recover from natural disasters. These solutions leverage the power of nature, such as wetlands, forests, and green spaces, to provide a range of ecosystem services that enhance the resilience of communities. For example, they can reduce the risk of flooding by absorbing excess water, preventing erosion, filter pollutants, and providing shade to reduce urban heat island effects. Moreover, nature-based solutions all have co-benefits, such as improving air and water quality, supporting biodiversity, and enhancing the overall livability of urban areas. The following projects include nature-based solutions and are fully described in Appendix A.

1. S-27 Coastal Structure and C-7 Basin Resiliency
2. S-28 Coastal Structure and C-8 Basin Resiliency
3. S-29 Coastal Structure and C-9 Basin Resiliency
4. Everglades Mangrove Migration Assessment (EMMA)
5. Mangrove Experimental Manipulation Exercise (MEME)
6. Corbett Wildlife Management Area Hydrologic Restoration and Levee Resiliency

5: Ecosystem Restoration Projects and Resiliency

Ecosystem Restoration Efforts

The South Florida Water Management District (District of SFWMD) has several programs that facilitate ecosystem restoration either directly or indirectly. One of the most important, the Comprehensive Everglades Restoration Plan (CERP), 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 define 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, and other effects of climate change, monitoring is critical to identifying adaptive management opportunities and ensuring 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. Stormwater storage features are also an important aspect of CERP projects. These features help to increase resiliency by reducing flood impacts, protecting the regional water supply, and providing enhanced hydrology for environmental restoration efforts.

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 management of the STAs. Everglades STAs are large, constructed wetlands designed to maximize phosphorus removal from surface water and will total approximately 64,000 acres when Restoration Strategies is complete. STAs not only provide clean, low-nutrient water to the Everglades, but 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 the Florida Department of Environmental Protection, Florida Department of Transportation, 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.

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 resiliency to climate change.

All of these programs working system-wide, along with nature-based solutions, as introduced in the previous chapter, help restore South Florida's ecosystems, create healthy environments, and make them more resilient to climate change. Each, in its 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.

This chapter provides high-level descriptions and examples of ecosystem restoration projects in the sections below and indicates how they support overall resiliency efforts. This chapter is not intended to be the source for detailed descriptions or the status of implementation of CERP Projects and other restoration projects. Extensive restoration efforts are already part of parallel and well-established planning and implementation efforts. The District acknowledges that CERP Projects and other South Florida restoration efforts strongly support this Plan's objective 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. CERP Projects and other South Florida restoration efforts will increase the ability to balance water management for the benefit of people and the environment. Completed restoration projects will increase South Florida's ability to better manage anticipated extreme weather events and increase the ecosystem's future resilience in the face of warmer temperatures and other climate change impacts.

For the latest and most relevant information on CERP projects and the status of implementation, please refer to:

- Everglades Restoration Initiatives (6)
- Ecosystem Restoration (7)
- CERP Project Planning | South Florida Water Management District (8)
- Integrated Delivery Schedule (9)

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. These features also provide water supply flexibility during the dry seasons, increasing resiliency. 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 impacts 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, the treatment area in existing STAs will be increased through land-leveling efforts. Alongside these projects, District scientists 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 13 of 21 studies. All studies will be completed at the end of 2024.

Central and Western 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 or back to canals for water supply; CEPP North to restore flows into northwestern Water Conservation Area (WCA) 3A, move water south, and construct forested wetlands 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 sea level rise. Additionally, the Fish Habitat Assessment Program (FHAP) monitors seagrasses in Florida Bay, following trends in salinity resulting from insufficient freshwater baseflow. These projects help supply reliability for the Southeast region.

The Western Everglades Restoration Project (WERP), once approved by Congress, will re-establish ecological connectivity, reduce the severity and frequency of wildfires, and restore low nutrient conditions through alterations to existing canals and levees to allow for sheet flow. Water will move from the Western Feeder Canal towards Big Cypress National Preserve, restoring freshwater flow paths, restoring water levels, and providing connectivity for flora and fauna. The reduction in the severity and frequency of wildfires and increased water availability will assist with carbon capture and the sustainability of the ecosystem.

The Picayune Strand Restoration Project (PSRP) is removing historic roads and restoring sheet flow 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 the habitat for oysters and seagrass beds, which are critical for storm protection against erosion.

Southern Everglades

Broward County Water Preserve Areas reduce groundwater seepage from Water Conservation Areas 3A & 3B, improve water supply, and aid saltwater intrusion prevention operations. Biscayne Bay Coastal Wetlands (Phase 1; BBCW) rehydrates coastal wetlands, reduces 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,   to help protect against changes in sea-level. An Adaptive Foundational Resilience (AFR) 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 sea level rise by responding to the increased sheet flow volumes, reduced porewater salinities and improved hydroperiods predicted to occur with BBSEER restoration. There are two pilot studies needed to demonstrate how to implement the AFR throughout Florida. One is a small-scale multi-plot assessment of how mangroves will respond to a variety of drivers but with a focus on nutrients and the possible use of re-use water for restoration. This pilot is called: Mangrove Experimental Manipulation Exercise or MEME. The other pilot study is a large-scale assessment of Thin Layer Placement in Scrub Mangroves with a focus on using clean dredge material for enhanced elevation and soil accretion to enhance flood protection and foster natural adaption to sea level rise. This pilot is called: Everglades Mangrove Migration Assessment (EMMA).

Here are the questions that these two pilot studies, prescribed in 9, will address when sources of funding are identified:

- Q1: Does phosphorus or level of planting density amendment contribute to the greatest ecosystem service value (plant production, nutrient accumulation, and C sequestration) and resilience (increase in sediment elevation that exceeds the rate of SL) with shallow sediment amendments?
- Q2: Does phosphorus enhance ecosystem service value and resilience the same regardless of planting density?

- Q3: How does phosphorus and level of planting density amendment influence ecosystem service value and resilience with a moderate level of sediment amendment under different salinity conditions?
- Q4: What combinations of sediment, phosphorus, and plant density amendments confer the greatest ecosystem service value and resilience? Do these vary with salinity conditions?

To plan for a sustainable South Florida ecosystem, it is important to identify ecological vulnerabilities to sea level rise and assess how water management could be directed to minimize saltwater intrusion, peat collapse (10), and land loss. Sea level rise 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 (11) (10 pp. 277-291) (12) (13).

These demonstration-scale pilot studies are nature-based management measures to increase coastal mangrove elevation and enhance the net belowground storage of carbon. They will document the efficiency and effectiveness of Thin Layer Placement to increase the adaptive capacity of Florida's coastal wetlands and keep up with sea level rise. It will assess the value of reuse water. Results are applicable to areas throughout the Gulf and Atlantic Coasts of Florida, where direct preservation, enhancement, and restoration of mangroves and other vegetative communities will build coastal resiliency, reduce storm surge damage, and create habitat for a large variety of fish and wildlife species.

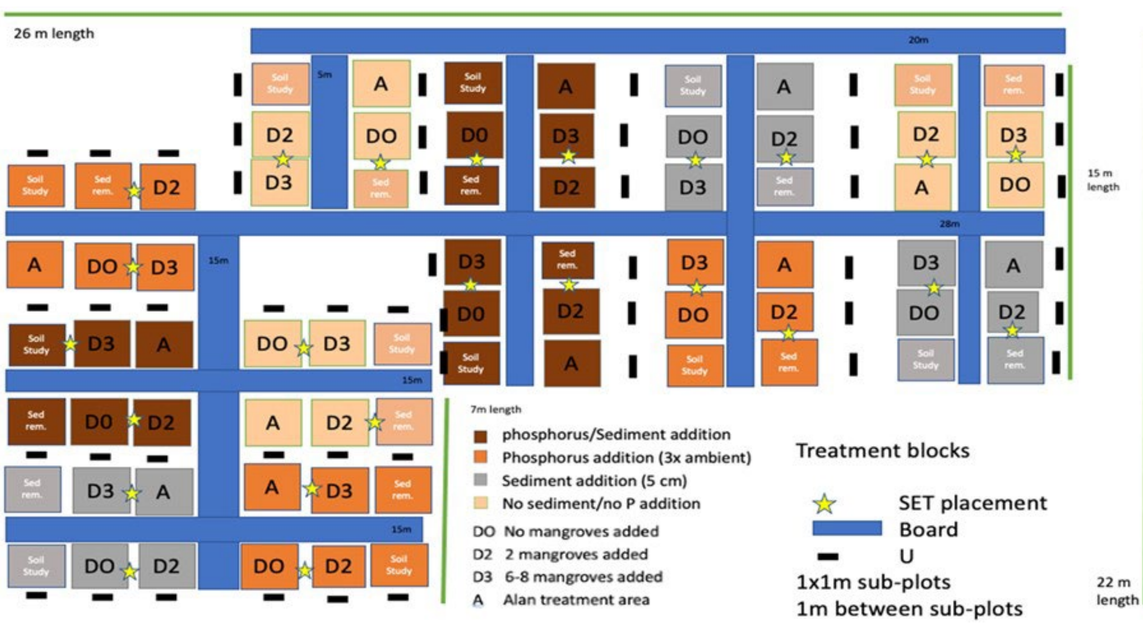


Figure 5-1: Experimental Design for the Mini-Everglades Mangrove Migration Assessment Pilot Study known as MEME (Mangrove Experimental Manipulation Exercise)

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 of 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 a Florida Department of Environmental Protection 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 the 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 stakeholder and reducing the reliance on infrastructure in natural areas through long-term restoration. The District will partner with Miami-Dade County on the S-27 Coastal Structure Resiliency project 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 Florida Department of Environmental Protection 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 nature-based solutions and Green Infrastructure, as recommended by the Biscayne Bay Task Force, create multi-faceted pathways that deliver protection to Biscayne Bay.

Ecosystem Restoration Projects Benefits and Potential Carbon Sequestration

As summarized above, comprehensive restoration efforts have been underway for the past 20-plus years by the District, in collaboration with local, state, and federal partners, to protect and restore South Florida's ecosystems. These systems are represented by four watersheds: Kissimmee River, Lake Okeechobee, Everglades, and Coastal Systems. The restoration of these vital parts of South Florida's ecosystems has 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.

Figure 5-2: Restored Section of the Kissimmee River

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, greater 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.

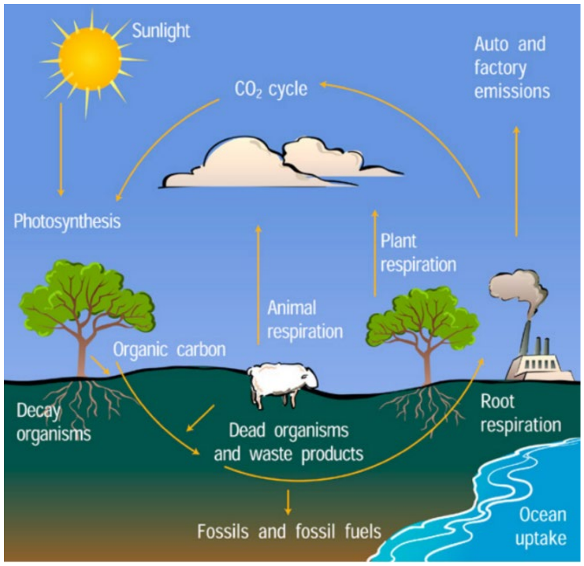
In addition to emphasizing the importance of continuing ecosystem restoration efforts and accounting for their resilience benefits, these efforts might seek to maximize the carbon uptake and storage capacity of wetlands and coastal ecosystems. The restoration and preservation of natural systems enhance 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 CERP and the creation and improvement of Everglades STAs through Restoration Strategies, has a large carbon uptake potential by mitigating 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, WCAs, mangrove forests, and submerged aquatic vegetation beds, including seagrass.

Monitoring Approach

Currently, the District does not collect carbon data as a matter of routine. This monitoring project is recommended for future funding. To provide quantitative information on 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.
- Eddy Flux Towers: An Eddy flux tower, also known as an eddy covariance tower, is a tall tower equipped with sensors that measure the exchange of gases, such as carbon dioxide, methane, and water vapor, between the atmosphere and the land surface below. The tower has an anemometer (wind speed sensor) and a sonic anemometer (which measures wind speed and direction) at the top that measures the turbulence of the air as it moves past the tower. These measurements allow scientists to calculate the vertical and horizontal movement of gases. By combining these measurements with the turbulence data, scientists can calculate the rate of exchange of these gases between the land surface and the atmosphere. This information is important for understanding the role that ecosystems play in regulating the Earth's climate. For example, the rate of carbon dioxide uptake by plants during photosynthesis can be measured using an eddy flux tower, allowing scientists to track how much carbon dioxide is removed from the atmosphere by plants.
- Remote Sensing Data: The District is actively investigating the potential for using satellite, radar, and lidar imagery to capture changes in plant biomass and land cover to determine the potential for carbon uptake. The use of satellite and radar imagery can provide a complementary approach to enhance the District's current planning projects for carbon monitoring and further improve the accuracy and efficiency of carbon monitoring.



Source: University Corporation for Atmospheric Research

Figure 5-3: Carbon Cycle

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 the District and its partners and better estimate their benefits to climate resiliency. A full description of the carbon monitoring plan can be found in Chapter 10 – Priority Planning Studies. This monitoring plan was developed in partnership with the Everglades Foundation and Florida International University.

6: Water Supply Resiliency

Understanding Vulnerabilities

The South Florida Water Management District (District or SFWMD) is implementing initial efforts to better understand the water supply vulnerabilities as they relate to sea level rise, changing rainfall patterns and drought occurrences, 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.

Water supply is one of the District's primary missions. The goal of the District's water supply plans and water use permitting program is to identify and promote the sustainable use of water supplies to meet reasonable-beneficial water needs while not causing harm to the water resources and related natural systems. Water use permitting and establishment of aquifer minimum levels protect aquifers district-wide by regulating water use withdrawals.

The SFWMD conducts water supply planning for five regions (Figure 6-1) encompassing the District: Upper Kissimmee Basin, Lower Kissimmee Basin, Upper East Coast, Lower East Coast, and Lower West Coast. Water supply plans (Plans) are developed in coordination with stakeholders and the public, 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 and projections for at least a 20-year planning horizon, water source options, water resource evaluation and protection, proposed water supply and water resource development projects, and future water supply direction. As it is related to sea level rise, these Plans and projections consider the potential for saltwater intrusion into coastal aquifers, and future plans will evaluate sea level rise scenarios in a more comprehensive manner through the development of a variable-density groundwater modeling effort (see Water Supply Vulnerability Assessment in Appendix B).

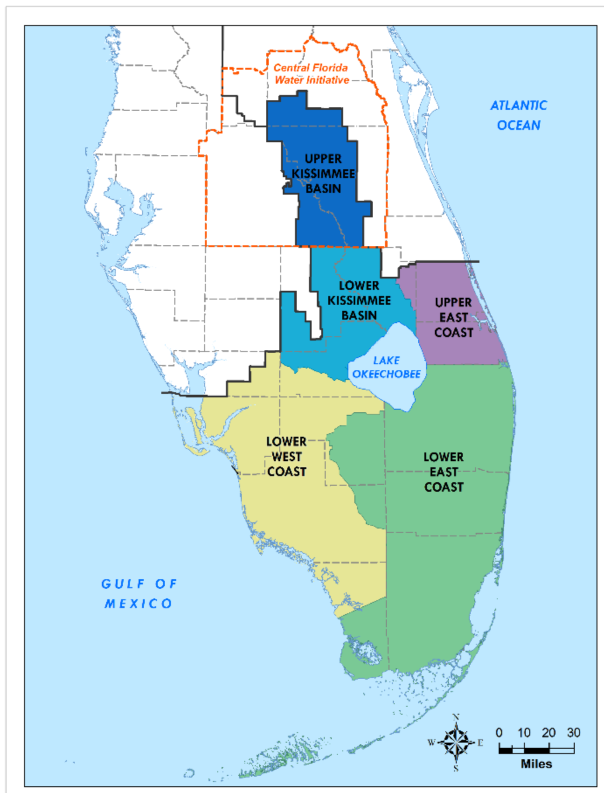


Figure 6-1: Regional Water Supply Plan Update Schedule and Respective Planning Areas

To support water supply plans and other initiatives, the District has several surface and groundwater models that simulate current and future water withdrawals, water management operations and identify potential impacts on water resources. Groundwater models are available both for traditional, fresh groundwater aquifer systems as well as the brackish Floridan Aquifer System (FAS). Single-density (freshwater) ground water system models can estimate water level drawdowns associated with those withdrawals, which can be useful in identifying areas of concern for saltwater intrusion but cannot directly simulate saltwater intrusion. The SFWMD is currently developing the East Coast Surficial Model (ECSM), which is a density-dependent groundwater model. The ECSM will be able to explicitly simulate the effects of sea level rise and potential movement of the saltwater interface and climate change on the surficial aquifer system. The ECSM includes most of the LEC planning region and the entire Upper East Coast (UEC) planning region and will be completed in 2024. In addition, the Lower West Coast (LWC) planning region is included in the District's Lower West Coast Surficial/Intermediate Aquifer Systems Model (LWCSIM) domain. In the future, following the completion of the ECSM, it is envisioned that the LWCSIM will be upgraded to be density dependent as well.

In addition, with growing dependence on the brackish FAS as a result of limitations and restrictions on increased withdrawals from traditional fresh groundwater sources, the District has developed the West Coast FAS (WCFM) and East Coast FAS (ECFM) models. These density-dependent models simulate projected groundwater withdrawals to identify potential changes in water levels and water quality on a regional basis. Moreover, the District maintains a regional FAS monitoring network to monitor and detect changes in water levels and water quality over time. One ongoing concern is the upconing of higher salinity water from lower portions of the FAS, which can increase salinity and cause harm to the resource while simultaneously increasing water treatment costs. Utilities using the FAS have experienced increasing salinity in supply wells in some areas. This information is compiled and discussed in the respective water supply plans. For assessing longer-term evolving conditions, a Water Supply Vulnerability Assessment will utilize existing surface and fresh groundwater modeling tools to evaluate the effects of sea level rise and climate change (e.g., rainfall and evapotranspiration patterns) on water supplies (See Appendix B). The outputs of the model runs will identify potential impacts on water resources and areas where the District needs to focus on identification of strategies and projects that can increase water supply resilience. The East Coast Water Supply Vulnerability Assessment was initiated in 2023, with data preparation tasks, and has a 2-year estimated duration to complete. The Water Supply Vulnerability Assessment will look beyond the traditional water supply planning efforts and 20-year planning horizon and incorporate additional climate scenarios and a longer planning horizon. This more detailed evaluation of the vulnerability of 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 water supplies.

Responding Resiliently

In parallel to assessing water supply vulnerabilities and with the goal of ensuring that South Florida has a consistent and safe water supply for current and future generations, the District has been employing three overarching project strategies: protecting existing water sources, investing in alternative water supply sources, and capturing excess water or wet-weather flows. These strategies are currently incorporated as part of water supply plan development, among other District planning efforts, as well as regulatory 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

Protection of existing water supplies is a resiliency strategy that ensures continual and safe water supply. This section highlights four of the District's protection-focused strategies: Saltwater Interface Monitoring, Salinity Control Structures and Canal Operations (Figure 6-2), Regulatory Controls, and Water Conservation and alternative water supply development.

The District develops saltwater interface maps at five-year intervals for coastal aquifers. The maps are based on salinity data from available monitor wells to determine the approximate location of the saltwater interface and any changes that may have occurred. 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 (14).

The District maintains canal and groundwater levels in the regional water management system during the wet and dry seasons to meet water supply needs from urban and agricultural demands to natural systems. Optimization of canal and groundwater levels through the operation of the District's salinity control structures minimizes further inland movement of saltwater along the coast. The existing coastal structures were designed and built in the 1950s and are operated to maintain pre-determined freshwater levels in the canals, which locally maintain water levels in the surficial aquifer, further assisting with minimizing saltwater intrusion, especially during the dry season. Enhancements to coastal structures are being proposed as an important mechanism for salinity control in water supply management. The coastal structures priority projects proposed in this plan (Appendix A.) will improve operational capacity and flexibility to continue to protect water supply sources into the future.

Regulatory control occurs through water resource protection rules such as Minimum Flows and Minimum Water Levels (MFLs), Water Reservations, and Restricted Allocation Areas (RAA). These have been adopted for several water resources in the District, including Lake Okeechobee, Kissimmee River, the Everglades, Biscayne Bay, Loxahatchee River, St. Lucie Estuary, and others. The District's regulatory programs are designed to support reasonable-beneficial uses of water while implementing criteria needed to protect water resources from harm.

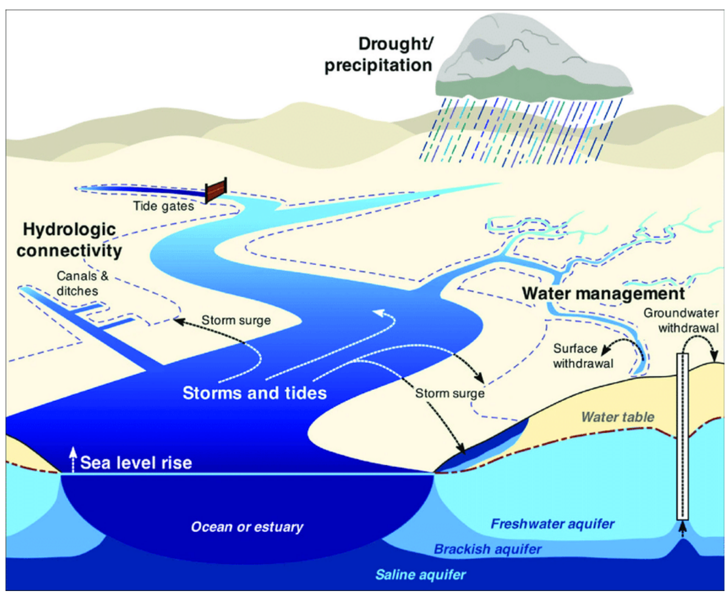


Figure 6-2: Coastal Hydrologic Cycle

MFLs are defined as the minimum flows or minimum water levels adopted by the District Governing Board pursuant to Sections 373.042 and 373.0421, Florida Statutes, at which further withdrawals would be significantly harmful to the water resources or ecology of the area. A water reservation is a legal mechanism, authorized by Section 373.223(4), Florida Statutes, to set aside water from consumptive uses for the protection of fish and wildlife or public health and safety. When a water reservation rule is in place, the volume and timing of water at specific locations are protected for the natural system. 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. An example of a Restricted Allocation Area is the Lower East Coast Regional Water Availability Rule (2007), designed to protect existing supplies and prevent further harm to natural systems. This rule is the regulatory component of the recovery strategy for the Northwest Fork of the Loxahatchee River MFL and Everglades MFL. The RAA limits the allocation of water from these waterbodies to a base condition water use as described in the Applicant's Handbook (SFWMD 2022).

Moreover, the District actively promotes water conservation to incentivize the efficient use of water and recognition that conservation can extend available supplies while deferring the need for more expensive alternative water supply sources.

Investing in Water Conservation and Alternative Water Supply Sources

In addition to protecting existing water resources, the District also encourages the development of alternative water sources to reduce dependence on freshwater resources and meet growing demands for water. These solutions or sources include water conservation programs, the development and implementation of increased use of reclaimed water, the use of brackish groundwater sources such as the Floridan Aquifer System (FAS), additional surface water storage options, and utilizing sea water or other high salinity sources with desalination. 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. Since 1997, the District, in cooperation with FDEP, has provided over $243 million in state cost-share grant funding towards 530 Alternative Water Supply (AWS) projects that produced 523 million gallons of capacity per day. Additionally, the District contributed approximately $9 million toward 260 water conservation projects that have an estimated water savings of 5 billion gallons of water per year, or 13.6 million gallons of water per day, since 2003. To learn more about alternative water supply grants, access the FDEP page at: https://floridadep.gov/owper/water-policy/content/alternative-water-supply-grants.

Water conservation is a cornerstone to using water efficiently and effectively. 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, as well as guidance and conservation information. Over the last two decades, per capita water use has decreased by 30% as a result of water conservation efforts being advanced by the District, utilities, and local governments. The District continues to promote and encourage water conservation to realize additional savings. With an estimated 50% or more of residential water use being used for irrigation, there is a focus on promoting efficient irrigation. Towards this end, this District has been working with local governments to adopt year-round irrigation ordinances that limit the number of days and hours irrigation is allowed, as well as encouraging the use of advanced irrigation controllers that account for recent rainfall, rainfall forecasts, and soil moisture. Education and outreach are an integral part of promoting efficient irrigation.

Figure 6-3: Reclaimed Water System

Florida is a national leader in water reuse, reusing nearly 770 million gallons per day (MGD) of reclaimed water to conserve freshwater supplies and recharge freshwater aquifers. There are over 100 reuse facilities in the District, reusing over 250 MGD of reclaimed water for beneficial purposes, including irrigation of golf courses, residential lots and other green space, ground water recharge, environmental enhancement, and industrial purposes. However, there is approximately 475 MGD of potentially reusable water that is currently being disposed of through ocean discharge or deep injection wells in the District, primarily on the Lower East Coast. The biggest obstacle to further development is the 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 reverse osmosis water treatment plants treating brackish groundwater from the FAS throughout South Florida with a combined capacity of approximately 300 MGD. Utilizing brackish groundwater 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 depth nearly 1,000 feet below the surface, it does not face the same acute climate risk from sea level rise as the freshwater surficial aquifer system. Though brackish water sources and related treatment systems are more expensive to operate, less efficient, and produce a brine concentrate needing disposal, the use of brackish water is a 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 reverse osmosis plants, mostly brackish groundwater treatment systems.

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

Below are a couple of examples of the development of alternative water supplies in the District:

- Reuse Facilities: City of Pompano Beach 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 Groundwater: Orlando Southeast Water Treatment Plant Lower Floridan Aquifer Wellfield Phase 1 – In 2021, the Orlando Utilities Commission received a an alternative water supply development grant to construct this brackish, groundwater supply source. The total project cost is expected to be over $95 million and is expected to provide the Orlando area with an additional 10 MGD of public supply. Examples of municipalities using brackish sources along the east coast include the Town of Jupiter and City of Lake Worth Beach and Collier County Utilities and City of Cape Coral on the west coast.
- Seawater Desalination: Florida Keys Aqueduct Authority (FKAA) Kermit H. Lewin RO Facility – The existing seawater desalination facility at this site will be replaced with a new facility under construction 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 resiliency focused.

Saving for a Non-Rainy Day

Retaining wet-weather flows to use when it is 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 captures surplus water primarily through the operation of the regional water management system. This system includes major reservoirs and Water Conservation Areas (WCAs). The development of large-scale Aquifer Storage and Recovery (ASR), currently being designed and tested by the District north of Lake Okeechobee, will provide another option.

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 surface water include WCAs / Water Management Areas (WMAs), 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 used as a place for flood waters to be conveyed in addition to their water supply uses.

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.

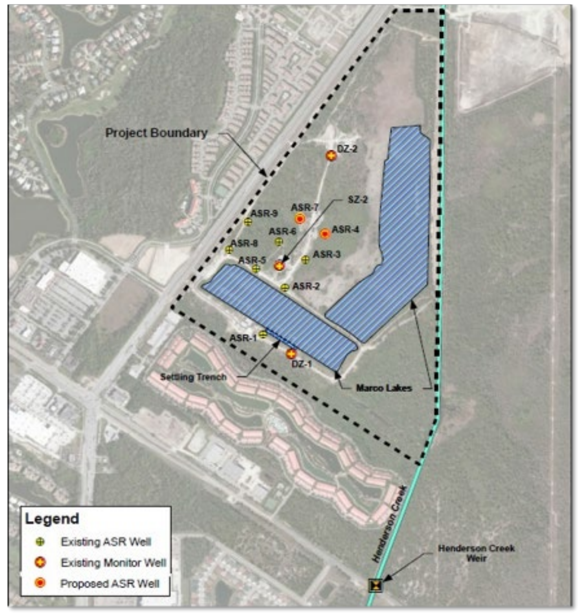


Figure 6-5: Marco Island's ASR Wellfield

Below are examples of regional and local-focused water storage projects:

Reservoirs: Everglades Agricultural Area (A-2) Reservoir and other CERP Storage Projects

The Central Everglades Planning Project's (CEPP) EAA A-2 Reservoir includes two major features: a treatment wetland that will improve water quality 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 2024. Additionally, the U.S. Army Corps of Engineers (USACE) is building the reservoir component, which will hold 240,000 acre-feet of water. The USACE began construction in 2023 and it is estimated to be completed in 2032. The total project cost for the EAA phase is expected to be $3.9 billion. Several other major storage projects are being advsnced as part of CERP, such as the C-44, C-43 resevoir projects, which also providing significant resiliency by storing water that can be avaialble to attend dry season needs.

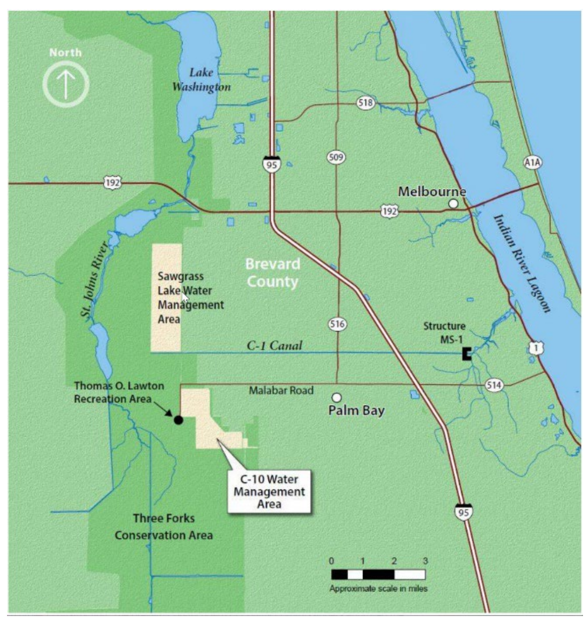


Figure 6-6: SJRWMD C-10 Water Management Area

Marco Island's ASR Wellfield

Marco Island utilizes four water supply options to meet the drinking water and irrigation demands of the community: fresh surface water from Marco Lakes/Henderson Creek, brackish groundwater, reclaimed water, and surface water stored in ASR wells. Since 1997, Marco Island has developed seven ASR wells that store 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.

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 the 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 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 the rock mining industry, 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 groundwater permit allocation increases. The reservoir construction was completed in 2024.

Town of Jupiter Groundwater Recharge System

This water storage and recharge project captures excess freshwater from the C-18 canal and conveys it through a system of existing control structures, flow-ways and salinity barriers within the Town to increase surface water storage and surficial aquifer recharge utilizing freshwater normally discharged to tide through the S-46 structure. The Town has invested over $3M in infrastructure (ditches, pump stations, conveyance systems, control structures) in the surface water recharge system in collaboration with the SFWMD.

Role of Coastal Structures in Protecting Water Supply Sources

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 barriers preventing saltwater from moving inland and impacting wellfields and other environmentally 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.

Target headwater stages at the structures are generally higher during the dry season to prevent saltwater intrusion. Conversely, target headwater stages are lowered during the wet season to allow discharges for flood protection purposes. Upstream (freshwater) operating levels are less than one foot higher than downstream tidal stages at certain coastal structure locations during high tide events. The Biscayne Aquifer MFL Prevention Strategy established that at salinity structure S-25B, an upstream canal stage of 2 feet of freshwater head needs to be maintained for more than 6 months a year to restrict movement of the saline interface without adversely affecting flood control (SFWMD 2000). Figure 6-8 shows how often the S-25B structure's tailwater level dips below the 2.5 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 climate and rainfall uncertainty increase, reducing the capability of the system to maintain freshwater minimum elevations and manage saltwater intrusion (15).

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

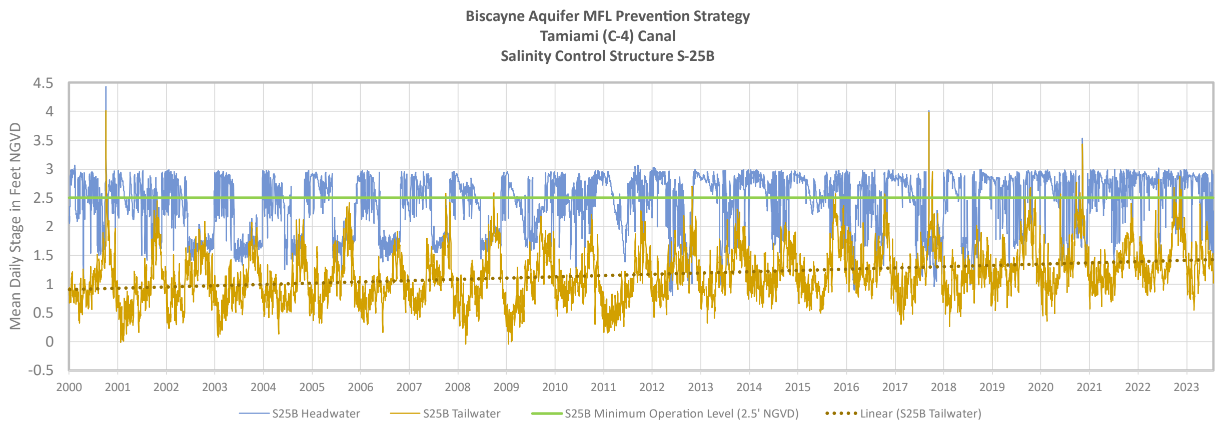


Figure 6-4: Headwater and Tailwater Stages at S-29 Structure

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 high tide events. The increased ability to maintain higher freshwater levels, especially during the dry season, reduces the potential risk of saltwater intrusion affecting freshwater supplies. Additionally, the increased control will allow operators to adjust flows. As an example, Figure 6-9 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.

In two basins where resiliency projects are currently being prioritized, risks to existing wellfields are observed by examining the position of the 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 City of North Miami Beach's Norwood-Oeffler Water Treatment Plant. This 15 MGD plant's freshwater wells are within one mile of the saltwater interface and coastal structure. In the C-7 basin, the saltwater interface is 7 city blocks away from the freshwater wells for the City of North Miami's Winson Water Treatment Plant. Since 2009, the saltwater interface has gradually been moving westward (see Figure 6-10). Since 2000, 25 public supply wells have been lost along South Florida's coastline due to saltwater intrusion.

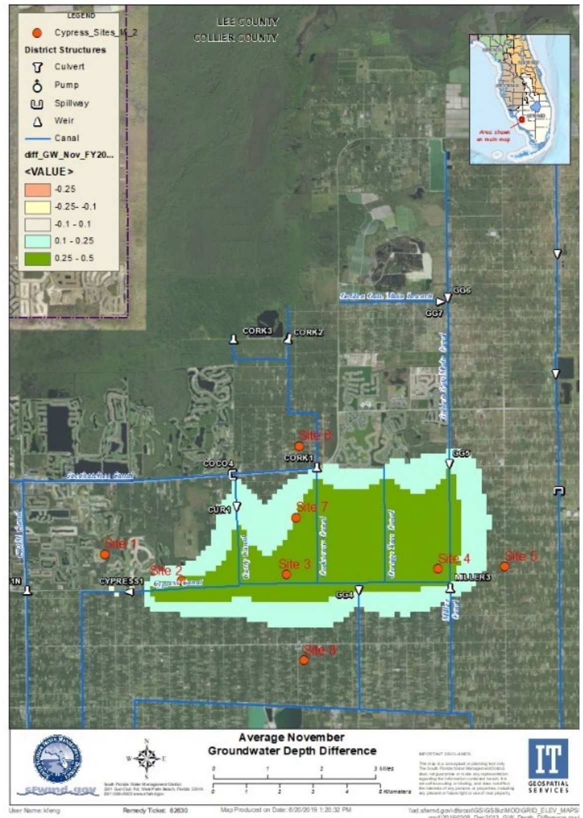


Figure 6-5: Average November Positive Groundwater Depth Difference Due to Optimized Structure Operations

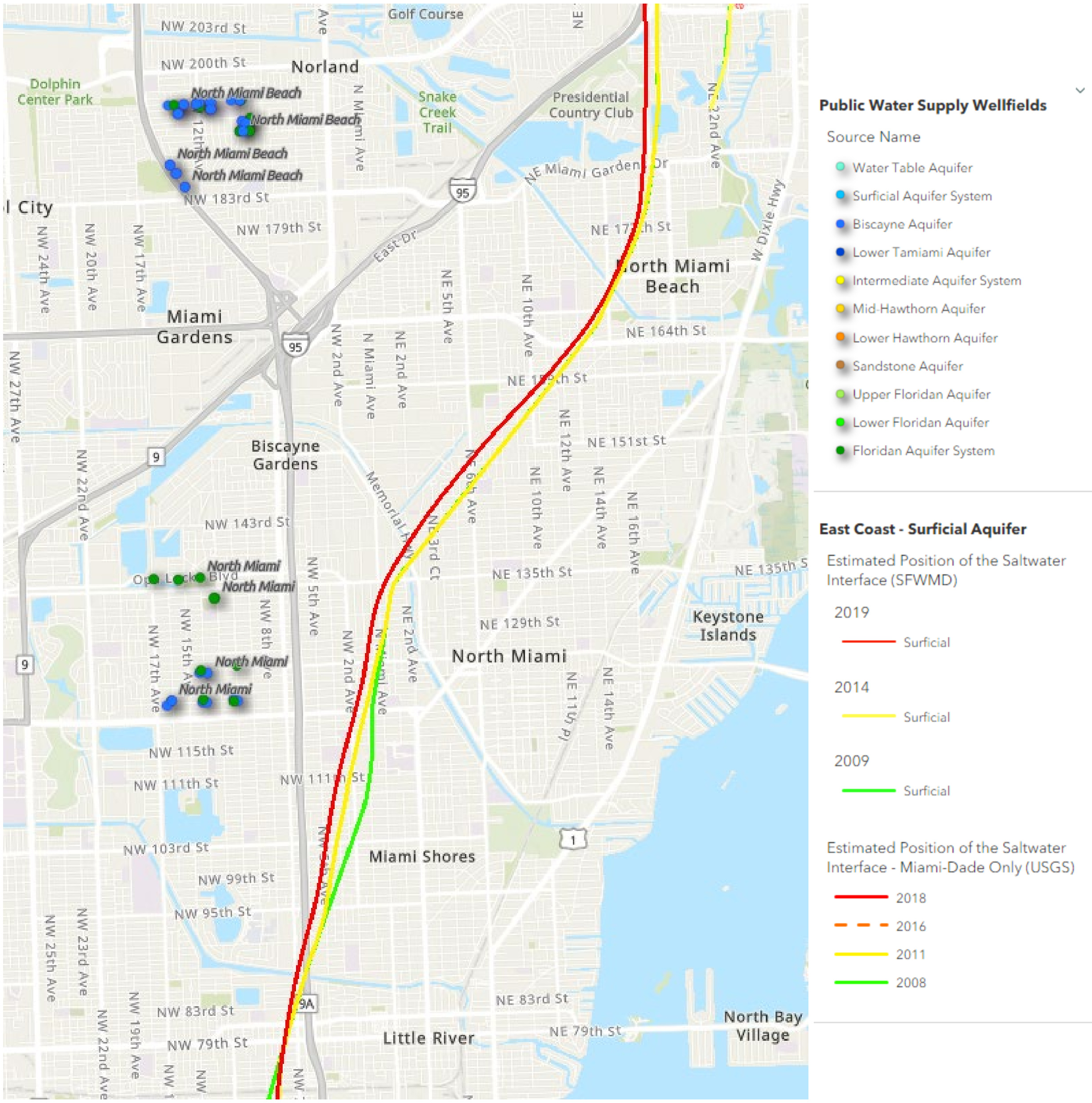


Figure 6-6: Saltwater Interface Line in S-27, S-28, and S-29 Structures.

*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.

Resiliency Path Forward

In addition to all the current projects being implemented or funded by the District and its partners, there will be a process for assessing and responding to the resiliency needs of water suppliers. These needs will be better understood through vulnerability assessments and robust data collection efforts already underway as part of the District's Water Supply Vulnerability Assessment project. The Water Supply Vulnerability Assessment (Appendix B) project will help the District determine what the 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 water allocation and serve as a benchmark for evaluating the overall sustainability of the District's water resources. These projects and all additional data analysis and assessments related to the resiliency of water supplies will be documented as part of future iterations of the Resiliency Plan.

7: Energy Efficiency and Renewable Energy

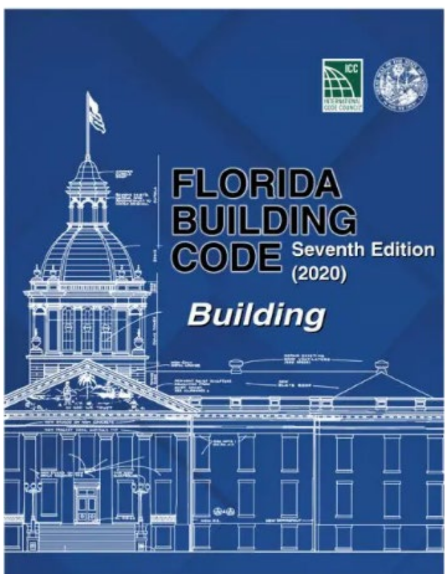
Energy Efficiency

The South Florida Water Management District (District or SFWMD) is committed to improving the energy efficiency of operations and to 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, American Society of Civil Engineers Standard 24).

Energy efficiency is crucial because it helps to reduce the District's overall energy consumption, which in turn might reduce the reliance on fossil fuels and other non-renewable sources of energy. By investing in energy-efficiency and renewable energy projects, the District can significantly reduce the amount of energy consumed and reduce the District's carbon footprint. Overall, a combination of renewable energy and energy efficiency measures is essential for a sustainable future.

The District is looking into using two programs as guidance to help improve energy efficiency and promote sustainable energy in facilities and projects. The Leadership in Energy and Environmental Design (LEED) certification program and the Envision program are sustainable building design and certification programs that may be helpful in designing and implementing projects. With regards to renewable energy, solar energy systems are already integrated into some of the District's projects, as detailed below.

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.

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 reduce the maximum electrical service needed.

Include smaller "house loads" generator so that generators are sized appropriately for the different loads that are needed during pumping and non-pumping operations.

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

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).
- It does this via a bidirectional electric meter that is installed along with the solar panels.

Renewable Energy

Florida receives abundant sunshine throughout the year, which makes it an ideal location for solar power generation. Additionally, solar power can help to reduce energy costs over the long term as a renewable source of 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 large-demand projects are complex to implement in urban environments due to the lack of larger open space. However, the District owns 1.5 million acres of land, some of which are available and suitable for solar arrays.

The District is considering one pilot project to explore the use of floating solar panels in applications where wind damage to the solar infrastructure would not increase the risk to the flood control system, in addition to looking for traditional opportunities, like using solar on rooftops. This proposed pilot project would be implemented on Lake Freddy at the District headquarters in West Palm Beach. In addition, a

Figure 7-1: Lake Freddy Floating Solar Array Pilot Project.

solar canopy for District fleet vehicles in the parking lot at headquarters is also being evaluated to address a portion of existing energy demands.

In addressing larger energy needs, and with the goal of offsetting new energy demands, the District is assessing the possibility of implementing solar power for projects in areas where there is an abundance of open land for solar panels. Currently, the District is investigating opportunities to install solar arrays on District lands near the C-43 and C-44 Reservoir projects, with the goals of reducing energy costs at these facilities, as well as offsetting carbon emissions from existing and new proposed structures that rely at least partially on fossil fuel generated power.

The District is also exploring the possibility of purchasing and installing solar arrays near specific project locations. These potential projects would use smaller (approximately 2 megawatts) arrays that would provide power directly to District facilities. These installations would be connected to the electrical grid and use net-metering to track solar power generation and consumption, as described below.

8: Characterizing and Ranking Resiliency Projects

Introduction

The South Florida Water Management District (District or SFWMD) is initially focusing its resiliency infrastructure investment priorities to address coastal water control structure's vulnerability to sea level rise. This is a no-regret strategy (these structures would need to be altered under any future scenario), as recommended by the District's Flood Protection Level of Service (FPLOS) Phase I Flood Vulnerability Assessments and validated by FPLOS Phase II Adaptation Planning Studies. The results of these FPLOS studies demonstrate current limitations on the operational capacity of and the need for adaptation to restore original design capacities at these structures.

The District has a number of projects underway that increase overall water management resiliency. These include CERP, NEEP, AWS, among others. This prioritization and ranking of projects does not include porject that we put of these programs as they have an independent prioritization process. Much of the emphasis of this plan focuses on increasing flood control resileincy and therefore, the ranking presented below includes several proejcts that are derived from FPLOS and other similar studies.

During the initial stages of already observed sea level rise 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 will be required to maintain headwater stages at structures and to prevent saltwater intrusion and flooding impacts. Enhancing existing structures 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.

Figure 8-1: Central & Southern Florida Project

Adaptation to sea level rise and storm surge involves large-scale projects that integrate floodwalls, gates, and forward pumps to properly manage surface and groundwater within the area. In addition, long-term sea level rise 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, sea level rise, 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. These improvements will be made in increments until the original design capacity is fully restored. Figure 8-2 illustrates the relative percent of the time that gate closures were needed during the King Tide season (September through November) 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 King Tide events, with a significant increase of up to 15 hours per day during the peak of the 2020 King 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 Central & Southern Florida (C&SF) forward pump implementation strategies; b) the assumption that other local flood mitigation strategies will be constructed in the basin in combination with the local forward pump solutions; c) the consideration of downstream capacity; and d) best professional judgment.

The C-8/C-9 Basin FPLOS Phase II Adaptation Planning Study has recently recommended more specific pump capacities for S-28 and S-29 Coastal Structures, as detailed in Appendix A. As the design is evolving for these and other coastal structures, final pump capacities will be determined. Figures 8-3 and 8-4 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 II Studies, which includes the assessment of local and larger regional forward pump strategies. No harm to downstream conveyance capacity or increasing flooding risks will result from the proposed forward pumping projects. Appropriate operational criteria and mitigation measures will be planned and designed, as adequate, during the final feasibility and implementation phases.

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 upstream water levels (headwater) were lowered consistently at structures with gravity flow and a forward pump. At the S-25B and S-26 coastal structures, upstream 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 upstream water levels increased with gravity flow alone. These observations, as illustrated in Figure 8-4, demonstrate the existing limitations and associated challenges in maintaining or reducing upstream 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 the 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 resulting from pumping at the S-25B 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, the City of Miami, and the City of West Miami.

Levee and canal bank enhancements are other examples 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. Enhancement of L-31 and the Corbett Levee are being proposed to address vulnerability to sea level rise, storm surge, and increasing stormwater volumes as a result of more extreme rainfall events. Future modeling efforts will determine additional resiliency needs at other levee structures.

All the proposed projects include resiliency strategies to reduce the vulnerability of communities and environmentally sensitive areas downstream and upstream of these structures.

The District is also committed to seeking nature-based solutions in addition to gray infrastructure improvements to increase resiliency, as described in Chapter 4. Gray infrastructure examples and nature-based features will be necessary to meet the challenges of land development and climate change impacts, including sea level rise, 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 move forward as part of the FPLOS Phase II dynamic adaptive pathway approach. This approach and additional considerations were applied in the Pilot Phase II 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

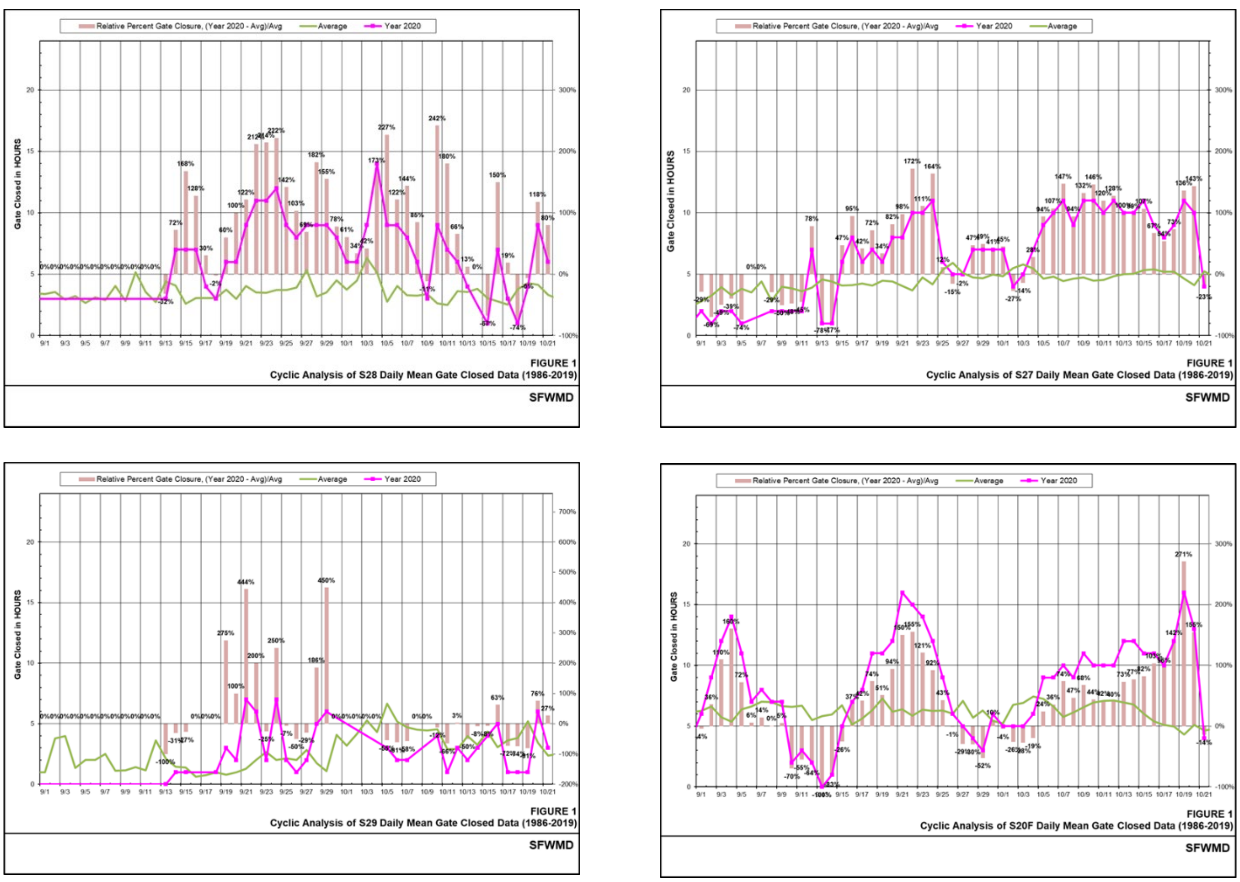
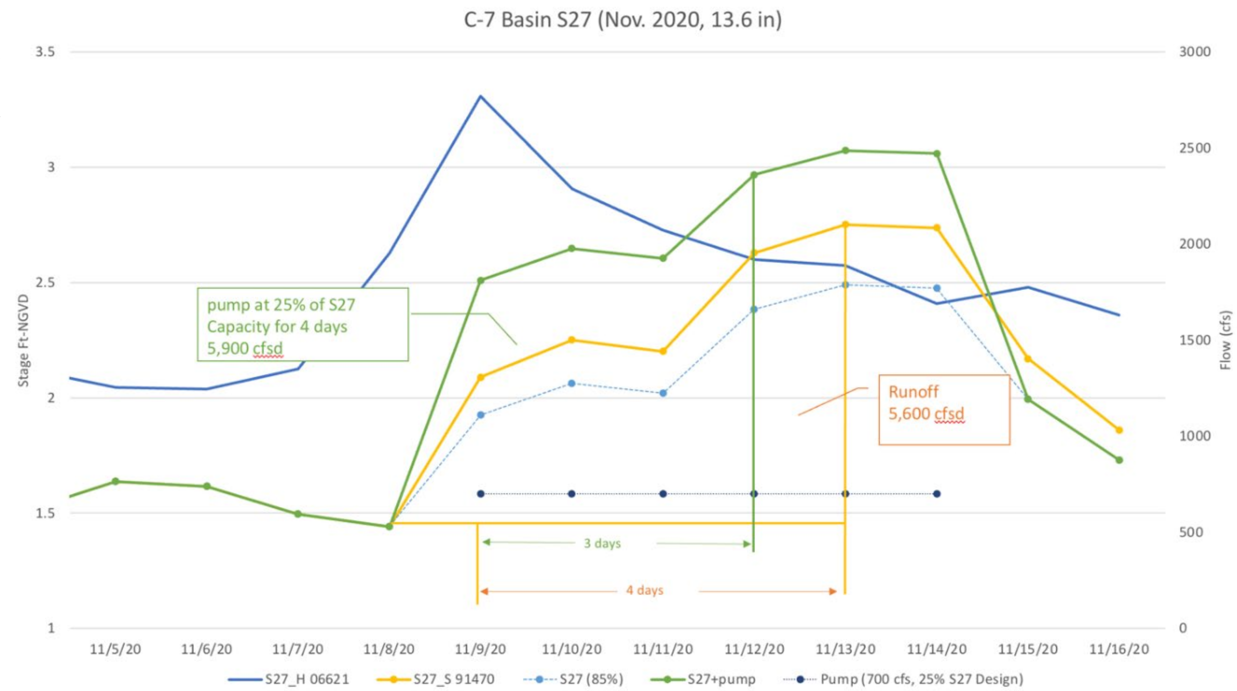


Figure 8-2: Relative Percent Gate Closure Times during the 2020 High Tide Season.

Strategy (LMS). The project had two elements: 1) a technical assessment of the FPLOS for the existing infrastructure under current and future sea level rise 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 combinations of mitigation strategies) that can be explored to facilitate the implementation of different alternatives. Once an individual flood mitigation alternative is no longer able to achieve the specified target of the performance, additional or other mitigation strategies



Potential amount of time needed to remove the cumulative flows at S-27 (5,600 cfs/day 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 8-3: Potential amount of time need to remove cumulative flows at S-27.

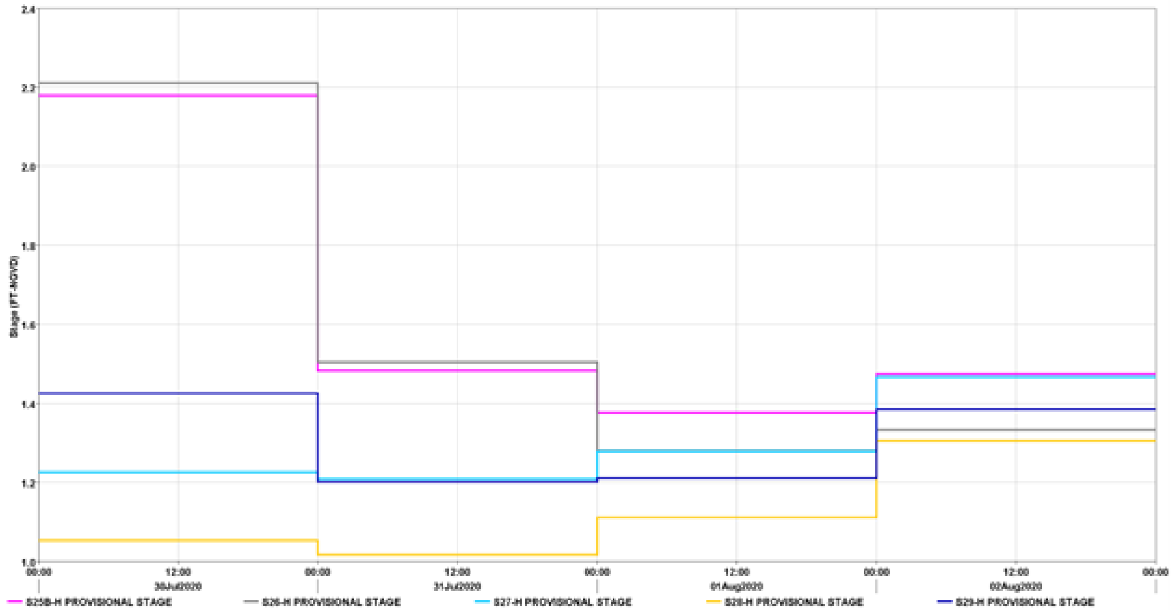


Figure 8-4. Observed Headwater Stages during Hurricane Isaias at Coastal Structures with forward pumps (S-25B and S-26) vs. Coastal Structures with gravity discharge only (S-27, S-28, S-29).

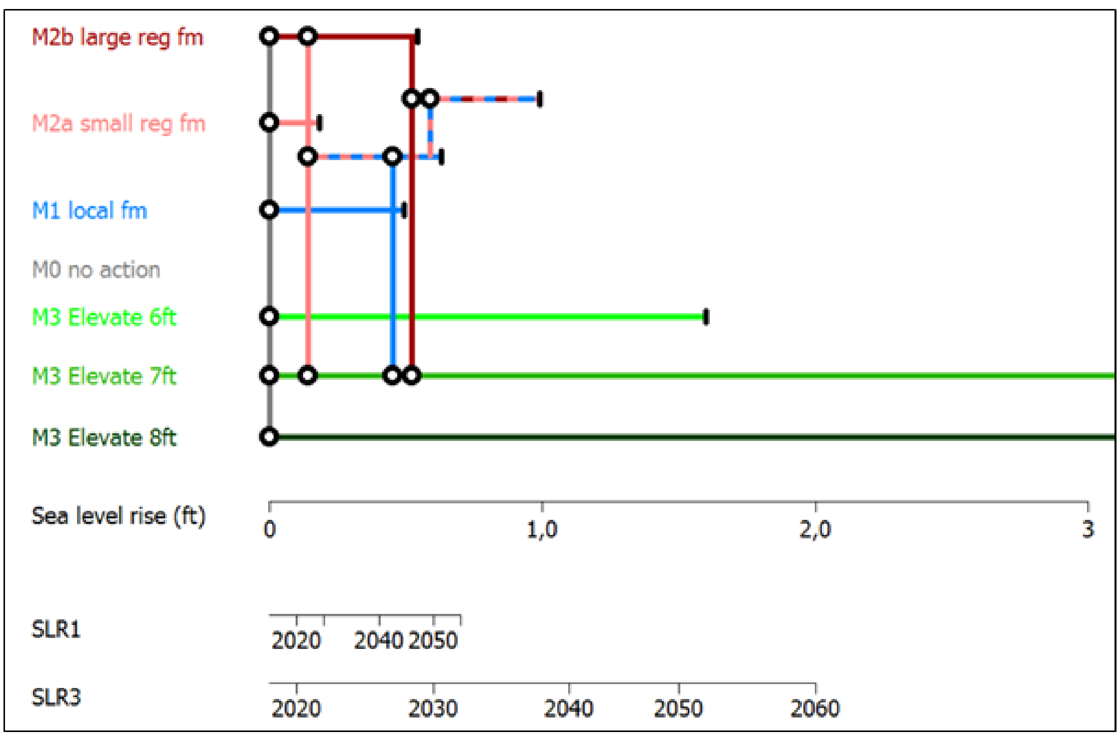


Figure 8-5: Illustrative Adaptation Pathways map for the C-7 Basin.

Updated Federal Emergency Management Agency Coastal Zone A Maps, the U.S. Army Corps of Engineers (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 ongoing Section 216 C&SF Flood Resiliency Study. Figure 8-6 below summarizes how these combinations of solutions can be developed 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 8-5 describes the Illustrative Adaptation Pathways map for the C-7 Basin based on the simulated expected annual damage for the current sea level and the two possible future sea level rise scenarios. Each alternative has a horizontal line representing its effectiveness as sea level rise increases over time. Circles represent decision points, beginning with the selection of which alternative to start implementation (along the vertical gray line). New alternatives are available (new vertical lines) as a new decision point (circle representing a performance threshold) is reached along the horizontal implementation pathways. Figure 8-6 (Source: USACE, modeled from https://ewn.el.ercd.dren.mil/nnbf/other/5-ERDC-NNBF_Brochure.pdf) describes the potential flood mitigation measures to improve resiliency and sustainability.

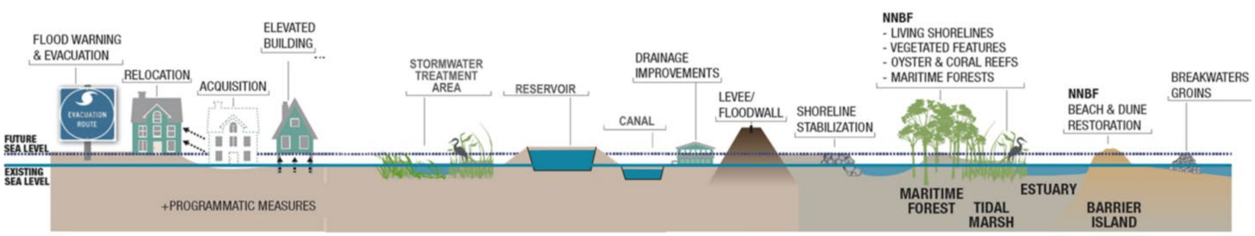


Figure 8-6: Potential Flood Mitigation Measures to improve resilience and sustainability.

Underserved Communities

The District serves diverse communities throughout its area of operations, each experiencing unique and varied impacts resulting from climate change and other evolving conditions, including population increase and land development. The timing, extent, and types of impacts South Florida's communities face vary based on factors like location (coastal or inland) and socioeconomic circumstances (demographics and economics). The SFWMD recognizes the disproportionate vulnerability of minority and financially disadvantaged communities, who are more adversely affected by the impacts of climate change, and incorporates this awareness into its resiliency planning to ensure equitable benefits for all communities.

SFWMD aims to provide equal protection from adverse impacts, equitable access to the benefits provided by resiliency projects, and equal opportunities for participation in the planning and decision-making processes for all affected communities. To effectively plan resiliency projects that align with SFWMD's mission and resiliency vision and serve South Florida's communities, the District follows guiding principles that prioritize social considerations. These guiding principles ensure that resiliency projects provide equal protection against climate change-driven environmental impacts, enhance the quality of life for all community members, and facilitate equal access to the planning and decision-making processes through stakeholder engagement and coordination with the local governments and impacted communities.

SFWMD's Resiliency Planning Guiding Principles for Social Considerations:

- **Do no harm:** SFWMD resiliency projects are designed to avoid further harm to disadvantaged communities.
- **Prioritize and value prevention:** SFWMD focuses on preparing South Florida's communities for anticipated changing conditions, ensuring the water management system can withstand acute and chronic stressors of evolving climate conditions and recover quickly from disruptions.
- **Prioritize vulnerable communities:** SFWMD prioritizes investments in projects that benefit disadvantaged communities and enhance the quality of life for all community members.
- **Proactive engagement and leadership** – SFWMD involves community experts and leaders from impacted community groups, seeking their insights and feedback to shape equitable projects.
- **Meaningful community engagement** – SFWMD actively seeks input and ideas from community members, ensuring projects are informed by their perspectives.
- **Responsive and continued engagement** – SFWMD remains responsive and accountable to community concerns, prioritizing follow-up actions and ongoing discussion.
- **Transparency in developing and executing resiliency work**: SFWMD fosters ongoing engagement, communication, trust, and collaboration by being transparent in its development and execution of resiliency projects.

The SFWMD utilizes a range of resources to determine socioeconomic vulnerability, identify disadvantaged communities, and highlight locations that may be candidates for further review both at a regional scale and within project impact areas. These data are included in project ranking criteria and utilized for grant applications. The District relies on reputable sources, including the Center for Disease Control (CDC) Agency for Toxic Substances and Disease Registry (ATSDR) Social Vulnerability Index (SVI), the Council on Environmental Quality (CEQ), Climate and Economic Justice Screening Tool (CEJST), the Environmental Protection Agency (EPA) Environmental Justice screening and mapping tool (EJScreen), and the Federal Emergency Management Agency (FEMA) National Risk Index (NRI).

These resources are driven by diverse federal datasets and consider socioeconomic status either in isolation or in conjunction with various other factors like access to resources, environmental quality, and exposure to natural hazards, as outlined in tables 8-1 through 8-4. By utilizing these robust datasets, the District gains a more comprehensive understanding of the intricate relationship between the socioeconomic status of communities, their environment, and the risks they face. Figures 8-7 through 8-10 show the areas where socially vulnerable and disadvantaged communities were identified within the SFWMD region.

Incorporating these socioeconomic, environmental, and risk indicators as part of the project ranking process ensures regional support to local communities. This facilitates the identification and implementation of solutions that alleviate environmental and climate impacts, increase community resilience to hazards, and improve quality of life where it is most needed. The prioritized resiliency projects are expected to result in reduced flood risks, increase the resilience of water supply systems, preserve and enhance natural areas, heighten civic engagement, and improve the quality of life for all residents of these communities.

Centers for Disease Control/Agency for Toxic Substances and Disease Registry Social Vulnerability Index

The CDC's Agency for Toxic Substances and Disease Registry (ATSDR) Social Vulnerability Index (SVI) utilizes U.S. Census data to assess the social vulnerability of communities in each census tract. Census tracts are geographical subdivisions within counties where statistical data is collected by the Census. The CDC/ATSDR SVI evaluates each tract based on 16 social factors, which are grouped into four themes (Table 8-1). Each tract receives a separate ranking for each of the four themes and an overall ranking. The ranking scale ranges from Very Low (0.0-0.19) to Low (0.20-0.39), Moderate (0.40-0.59), High (0.60-0.79), and Very High (0.8-1.0).

The SFWMD uses the overall SVI ranking equal to or greater than the intermediate range to identify socially vulnerable communities both at the regional level (as depicted in figure 8-7) and within project impact areas. Figure 8-7 highlights the locations where socially vulnerable communities have been identified within the SFWMD region.

Table 8-1: CDC/ATSDR SVI Themes and Corresponding Social Factors

Socioeconomic Status	Household Characteristics	Racial and Ethnic Minority Status	Housing Type & Transportation
• below 150% poverty • unemployed • housing cost burden • no high school diploma • no health insurance	• aged 65 or older • aged 17 or younger • civilian with a disability • single-parent households • English language proficiency	• Hispanic or Latino (of any race), Black and African American (not Hispanic or Latino), American Indian and Alaska Native (not Hispanic or Latino), Asian (not Hispanic or Latino), Native Hawaiian and Other Pacific Islander (not Hispanic or Latino), Two or More Races (not Hispanic or Latino), Other Races (not	• multi-unit structures • mobile homes • crowding • no vehicle • group quarters

Table 8-1: CDC/ATSDR SVI Themes and Corresponding Social Factors

Socioeconomic Status	Household Characteristics	Racial and Ethnic Minority Status	Housing Type & Transportation
		Hispanic or Latino)	

*Source: CDC/ATSDR Social Vulnerability Index (SVI).

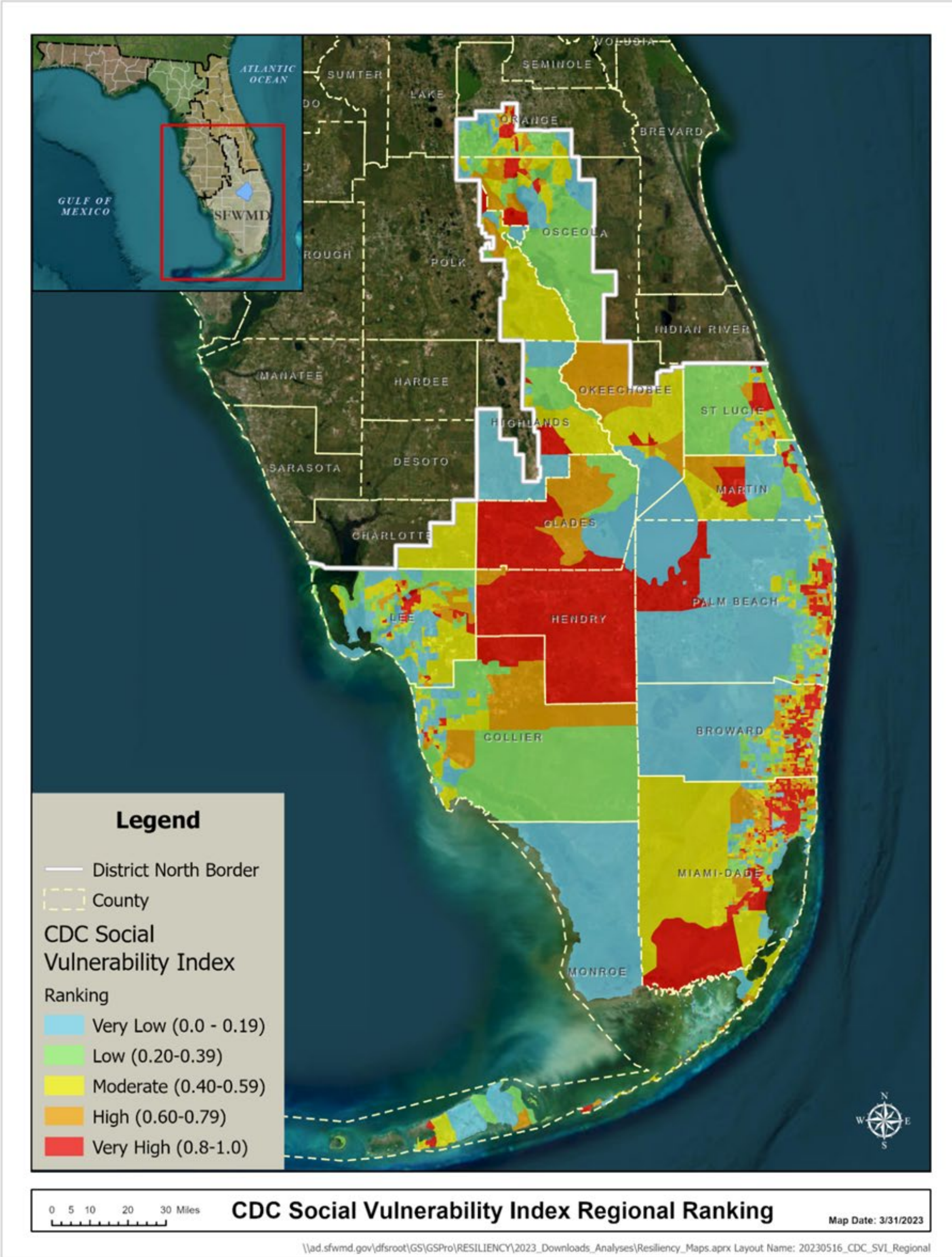


Figure 8-7: Communities identified as socially vulnerable based on the CDC/ATSDR SVI overall ranking for census tracts within the SFWMD region.

CEQ CEJST

The Council on Environmental Quality's (CEQ) Climate and Economic Justice Screening Tool (CEJST) utilizes various data sources to identify disadvantaged communities with consideration for environmental quality, including:

- U.S. Census's American Community Survey, the Federal Emergency Management Agency's (FEMA) National Risk Index,
- First Street Foundation's Climate Risk Data,
- Department of Energy (DOE)'s Low-Income Energy Affordability Data (LEAD) Tool,
- Environmental Protection Agency's (EPA) Office of Air and Radiation (OAR) Environmental Justice Screening and Mapping Tool (EJScreen),
- Centers for Disease Control and Prevention's (CDC) PLACES and U.S. Small-area Life Expectancy Estimates Project (USALEEP) data,
- National Community Reinvestment Coalition's (NCRC) dataset of formerly redlined areas,
- Department of Housing and Urban Development's (HUD) Comprehensive Housing Affordability Strategy (CHAD),
- Multi-Resolution Land Characteristics (MRLC) consortium by the Trust for Public Lands and American Forests' Percent Developed Imperviousness (CONUS) data,
- Department of the Interior's (DOI) Abandoned Mine Land Inventory System (e-AMLIS),
- U.S. Army Corps of Engineers' Formerly Used Defense Sites data,
- EPA's Resource Conservation and Recovery Act (RCRA) database for Treatment, Storage, and Disposal Facilities (TSDF) data compiled by EJScreen,
- EPA's Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) database compiled by EJScreen,
- EPA's Risk Management Plan (RMP) facilities data compiled by EJScreen,
- EPA's National Air Toxics Assessment (NATA),
- Department of Transportation's (DOT) transportation access disadvantage data and traffic data compiled by EJScreen,
- EPA's Underground Storage Tanks (USTs) data,
- EPA's Risk-Screening Environmental Indicators (RSEI) compiled by EJScreen, and
- Bureau of Indian Affairs' (BIA) Land Area Representation (LAR) dataset.

The CEJST uses these data as indicators of burdens and organizes them into eight categories. The eight categories are climate change, energy, health, housing, legacy pollution, transportation, water and wastewater, and workforce development (table 8-2). A community is identified as disadvantaged in the CEJST if it meets two criteria: (1) the census tract is at or above the threshold for one or more environmental, climate, or other burdens, and (2) the census tract is at or above the threshold for an associated socioeconomic burden. Additionally, a census tract surrounded by disadvantaged communities and with a low-income percentile at or above 50% is also considered disadvantaged.

SFWMD utilizes these eight categories to identify disadvantaged communities both at the regional level (as depicted in figures 8-8 and 8-9) and within project impact areas. Figures 8-8 and 8-9 illustrate communities identified as disadvantaged in the eight categories within the SFWMD region.

Table 8-2: The CEQ CEJST categories and corresponding factors.

Climate Change	Energy	Health	Housing
ARE (1) at or above the 90th percentile for expected agriculture loss rate OR expected building loss rate OR expected population loss rate OR projected flood risk OR projected wildfire risk AND (2) are at or above the 65th percentile for low income	ARE (1) at or above the 90th percentile for energy cost OR PM2.5 in the air AND (2) are at or above the 65th percentile for low income	ARE (1) at or above the 90th percentile for asthma OR diabetes OR heart disease OR low life expectancy AND (2) are at or above the 65th percentile for low income	(1) Experienced historic underinvestment OR are at or above the 90th percentile for housing cost OR lack of green space OR lack of indoor plumbing OR lead paint AND (2) are at or above the 65th percentile for low income

Legacy pollution	Transportation	Water and wastewater	Workforce Development
(1) Have at least one abandoned mine land OR Formerly Used Defense Sites OR are at or above the 90th percentile for proximity to hazardous waste facilities OR proximity to Superfund sites (National Priorities List (NPL)) OR proximity to Risk Management Plan (RMP) facilities AND (2) are at or above the 65th percentile for low income	ARE (1) at or above the 90th percentile for diesel particulate matter exposure OR transportation barriers OR traffic proximity and volume AND (2) are at or above the 65th percentile for low income	ARE (1) at or above the 90th percentile for underground storage tanks and releases OR wastewater discharge AND (2) are at or above the 65th percentile for low income	ARE (1) at or above the 90th percentile for linguistic isolation OR low median income OR poverty OR unemployment AND (2) fewer than 10% of people ages 25 or older have a high school education (i.e., graduated with a high school diploma)

*Source: Methodology & data - Climate & Economic Justice Screening Tool (geoplatform.gov).

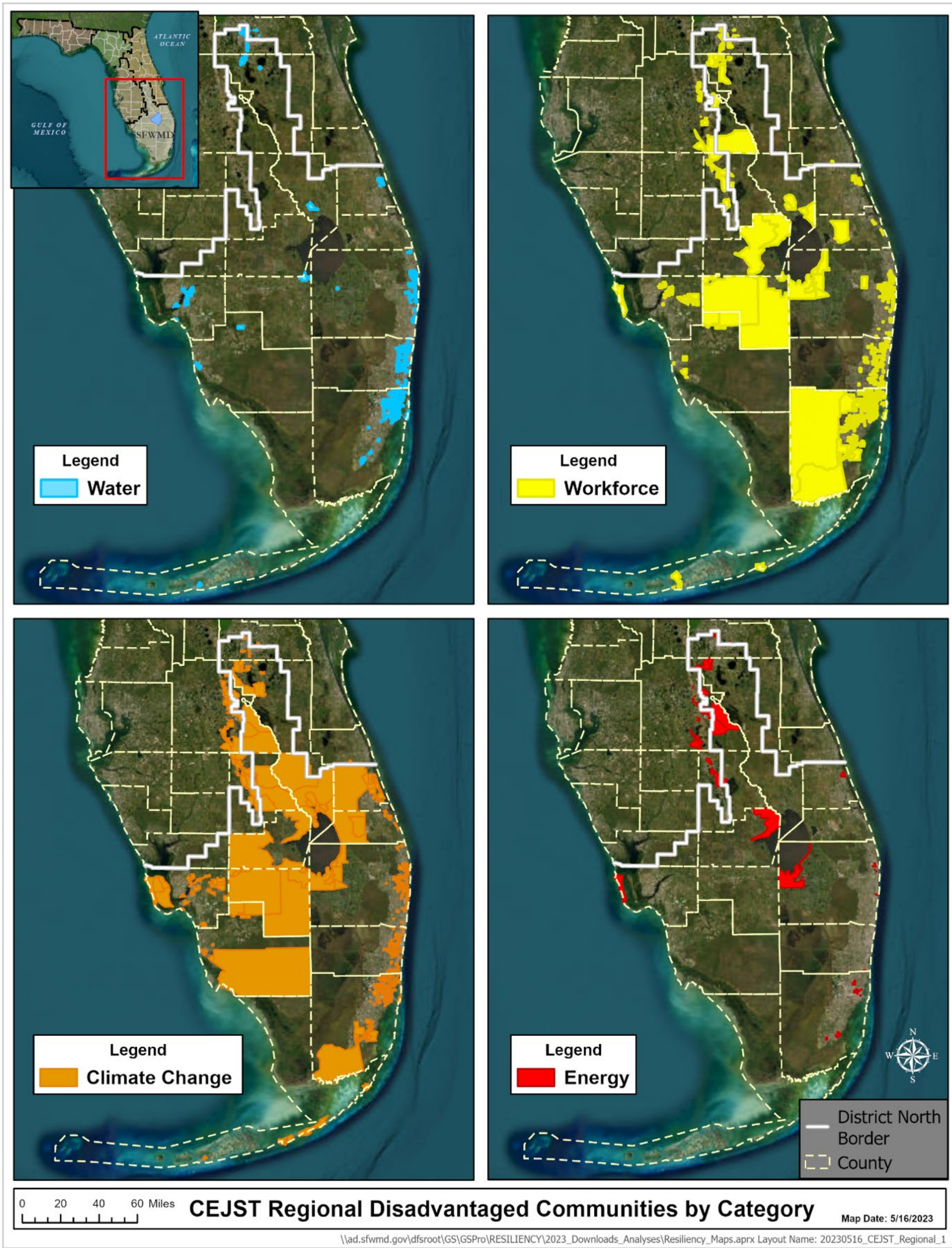


Figure 8-8: Communities identified as disadvantaged based on the CEQ CEJST for the water and wastewater, climate change, workforce, and energy burden categories.

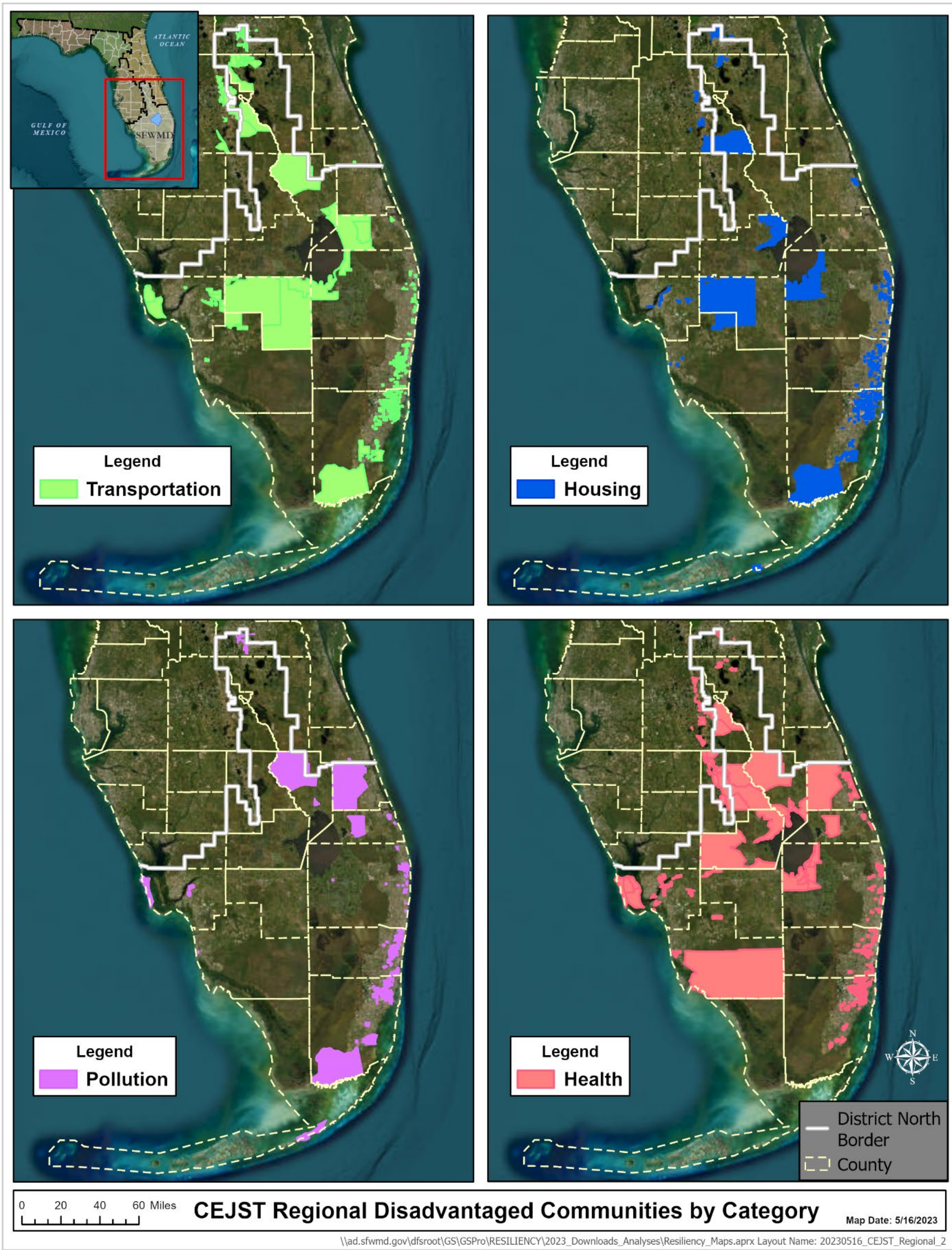


Figure 8-9: Communities identified as disadvantaged based on the CEQ CEJST for the transportation, housing, pollution, and health burden categories.

EPA EJScreen

The Environmental Protection Agency (EPA) Environmental Justice screening and mapping tool (EJScreen) conducts a preliminary assessment of communities most affected by environmental harms and risks in a selected location. EJScreen incorporates data from various sources, including:

- EPA, Office of Air and Radiation (OAR) Fusion of Model and Monitor Data
- EPA, Office of Air Quality Planning and Standards, Air and Toxics Data Update
- U.S. Department of Transportation traffic data
- U.S. Census's American Community Survey
    - Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) database, National Priorities List, and Superfund Alternative Approach sites
- EPA, Risk Management Plan (RMP) database, facility data
- EPA, Resource Conservation and Recovery Act (RCRA) database (RCRAInf)
    - EPA, Risk-Screening Environmental Indicators (RSEI) Model, Toxics Release Inventory (TRI) data

These data serve as environmental indicators and socioeconomic factors for calculating environmental justice (EJ) and supplemental indexes. EJScreen comprises twelve EJ indexes and twelve supplemental indexes in EJScreen, each representing twelve environmental indicators and either the demographic index (which includes the average of two socioeconomic factors) or the supplemental demographic index (which includes the average of five socioeconomic factors) (Table 8-3). Each environmental indicator and demographic index has its own separate EJ or supplemental index; there is no cumulative score or single EJ index.

The supplemental indexes provide a more comprehensive analysis. To calculate a specific EJ index, EJScreen applies a formula that combines an environmental indicator with the demographic index (EJ Index = the Environmental Indicator Percentile for a Block Group X the Demographic Index for a Block Group). Similarly, a formula is applied that combines a single environmental factor with the supplemental demographic indicator to calculate a single supplemental index (Supplemental Index = the Environmental Indicator Percentile for Block Group X Supplemental Demographic Index for Block Group). The smallest geographic unit for which census data is published is called a block, while a block group is a cluster of blocks that form a subdivision of a census tract.

The SFWMD utilizes the CDC SVI and CEQ CEJST to identify vulnerable and disadvantaged communities and rank projects both regionally (as depicted in Figures 8-7 through 8-9) and within project impact areas. EJScreen does not classify communities in an area as socially vulnerable or disadvantaged. Instead, it calculates environmental justice indexes to identify areas that may require further review, analysis, or outreach as the EPA and planners develop programs, policies, and other activities. The EJScreen Supplemental Indexes greater than or equal to the state and national 40th percentile serve as additional guides for SFWMD to leverage local knowledge of resiliency concerns and additional information to enhance socioeconomic and demographic considerations in resiliency planning.

Table 8-3: EPA EJScreen and supplemental indexes and corresponding indicators.

Environmental Justice (EJ) Index	Demographic Index	Supplemental Demographic Index
• Particulate Matter 2.5 • Ozone • Diesel Particulate Matter • Air Toxics Cancer Risk • Air Toxics Respiratory Hazard Index • Traffic Proximity • Lead Paint • RMP Facility Proximity • Hazardous Waste Proximity • Superfund Proximity • Underground Storage Tanks • Wastewater Discharge	• % low income • % people of color	• % low income • % unemployed • % limited English speaking • % less than high school education • low life expectancy

* Sources: Understanding EJScreen Results | US EPA.

FEMA NRI

In addition to examining the social vulnerability and disadvantaged communities' datasets in isolation, there is merit in considering them alongside hazard exposure data. This is not primarily aimed at pinpointing vulnerable and disadvantaged communities. Instead, it offers an alternative approach to comprehending the unequal environmental hazards these communities are exposed to and the potential consequences of natural risk factors.

While the Federal Emergency Management Agency (FEMA) National Risk Index (NRI) doesn't introduce for identifying a new dataset for identifying socially vulnerable and disadvantaged communities, it aids in examining their relative risk concerning natural hazards and the potential impacts they could expect during or after a disaster. The FEMA NRI evaluates risk by evaluating three components, one for eighteen natural hazards and two for community risks (as detailed below and in Table 8-4).

Expected Annual Loss (EAL): This is the natural hazards component of the NRI. It represents the projected average economic loss in dollars due to annual natural hazards. EAL serves as a metric for estimating the impacts of natural hazards on communities. The hazards included in the risk index were selected based on State Hazard Mitigation Plans from January 2016. Data sources for these hazards vary (depending on the hazard type) and include the National Weather Service (NWS), the National Oceanographic and Atmospheric Association (NOAA), the U.S. Geological Survey (USGS), the U.S. Army corps of Engineers (USACE), the Smithsonian databases, and the U.S. Department of Agriculture (USDA), among others.

Social Vulnerability: This is one of the two Community Risk Adjustment factors of the NRI. It utilizes the CDC/ATSDR SVI discussed earlier as the basis for characterizing potential impacts on vulnerable communities.

Community Resilience: This is the second of two Community Risk Adjustment factors of the NRI. It utilizes data on community resilience from the Hazards Vulnerability & Resilience Institute (HVRI) Baseline Resilience Indicators for Communities (BRIC) Index and includes a set of 49 indicators that represent six types of resilience as the basis for distinguishing the relative capacity of a community to effectively respond to and recover from the impacts of natural disasters.

Together, Social Vulnerability and Community Resilience constitute Community Risk Adjustment factors. These factors scale the EAL and ultimately amplify and reduce the NRI and the characterization of potential risks to communities from natural hazards. The adjustment increases the NRI with higher Social Vulnerably and decreases the NRI with greater Community Resilience. This dynamic adjustment translates to higher Social Vulnerability results leading to elevated Risk Index values, while higher Community Resilience results lead to lowered Risk Index values. In essence, Social Vulnerability (drawn from CDC SVI data) and Community Resilience (derived from HVRI BRIC data) act as elements that amplify and counteract the potential impacts of the set of natural hazards. The following equation illustrates how the scores for the three components are combined to adjust the EAL through the application of the Community Risk Adjustment factors to calculate the NRI scores: Risk Index = Expected Annual Loss × (Social Vulnerability ÷ Community Resilience).

The Risk Index scores are clustered using an algorithm that groups similar communities within each cluster while maximizing differentiation between clusters. This approach leverages the available source data for natural hazards (EALs) and community risk factors (social vulnerability and community resilience) to establish a relative baseline risk measurement for each U.S. county (or county-equivalent) and Census tract, indicating a community’s national ranking in risk compared to others for a given component (individual or overall natural hazards) and level (county or census tract). Scores are presented as composite and individual scores for the eighteen hazard types.

The SFWMD utilizes the CDC SVI and CEQ CEJST to identify vulnerable and disadvantaged communities and rank projects both regionally (as depicted in Figures 8-7 through 8-9) and within project impact areas. The NRI ranking, falling in the moderate range or higher, serves as an additional resource for understanding the correlation between socioeconomic status and community risk. Figure 8-10 highlights locations within the SFWMD region where communities susceptible to natural hazards have been identified.

Table 8-4: FEMA NRI components.

Expected Annual Loss	Social Vulnerability	Community Resilience
• Avalanche • Coastal Flooding • Cold Wave • Drought • Earthquake • Hail • Heat Wave • Hurricane • Ice Storm • Landslide • Lightning • Riverine Flooding • Strong Wind • Tornado • Tsunami • Volcanic Activity • Wildfire • Winter Weather	• Below 150% Poverty • Unemployed • Housing Cost Burden • No High School Diploma • No Health Insurance • Aged 65 & Older • Aged 17 & Younger • Civilians with a Disability • Racial & Ethnic Minority Status • Multi-Unit Structures • Mobile Homes • Crowding • No Vehicle • Group Quarters • Single-Parent Households • English Language Proficiency	• Social • Economic • Community capital • Institutional capacity • Housing/infrastructure • Environmental

* Source: Data and Methods | National Risk Index (fema.gov).

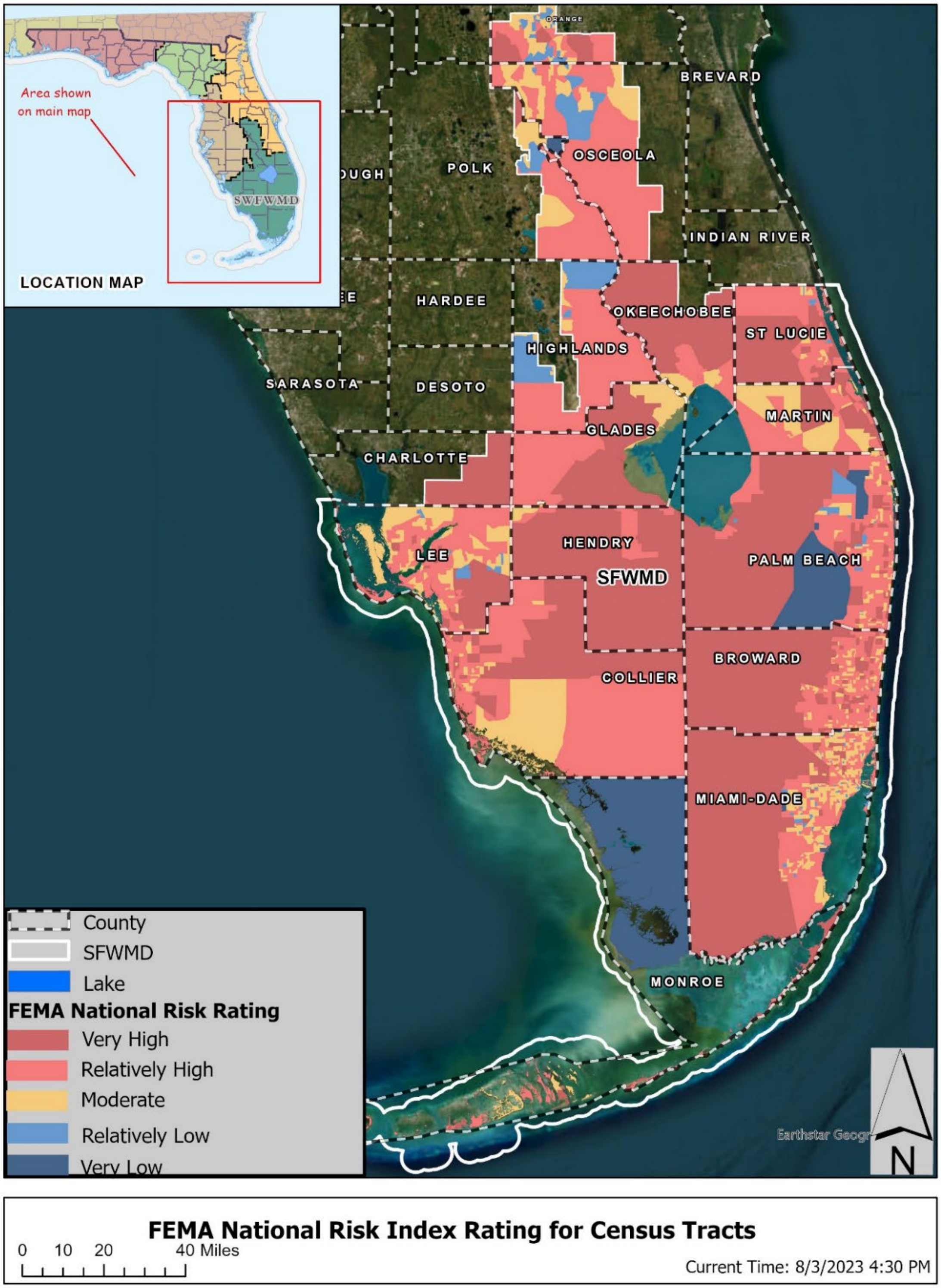


Figure 8-10: Relative natural hazard risk based on the FEMA NRI composite score for census tracts within the SFWMD region.

Proposed Ranking Criteria

A multi-criteria approach was developed to support the characterization and ranking of resiliency projects, including metrics that help to identify the most critical infrastructure associated with the most vulnerable areas. It is important to note that this ranking process is designed to= help determine project needs and priorities in terms of advancing projects in the most vulnerable areas. There are additional factors and opportunities that might determine project funding.

The selection of criteria was based on the Resilient Florida Program, as detailed below. This program is administered by the Florida Department of Environmental Protection (FDEP), and it allows water management districts to submit a list of proposed projects that mitigate the risks of flooding or sea level rise 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:

- Tier 1 must account for 40 percent of the total score and consist of all of the following criteria:
    - 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%)
    - The degree to which the project addresses risks to regionally significant assets. (10%)
    - The degree to which the project reduces risks to areas with an overall higher percentage of vulnerable critical assets. (10%)
    - 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%)

- Tier 2 must account for 30 percent of the total score and consist of all of the following criteria:
    - The degree to which flooding and erosion currently affect the condition of the project area (7.5%)
    - 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%)
    - 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%)
    - The cost-effectiveness of the project. (7.5%)

- Tier 3 must account for 20 percent of the total score and consist of all of the following criteria:
    - The availability of local, state, and federal matching funds, considering the status of the funding award, and federal authorization, if applicable. (6.5%)
    - 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%)
    - The exceedance of the flood-resistant construction requirements of the Florida Building Code and applicable floodplain management regulations. (7%)

- Tier 4 must account for 10 percent of the total score and consist of all the following criteria:
  - The proposed innovative technologies are designed to reduce project costs and provide regional collaboration. (5%)
  - 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 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.

Note: When FPLOS Phase I Assessment Results are not yet available within the area of influence of a project, but significant flooding events have been recently reported (as detailed below), all points will be awarded to the proposed project.

Known Chronic and Nuisance Flooding Report

Flood Prone Area layer documented using the observed historical flooding events with evidence collected by agencies/universities/media/citizens. The flood prone area is available as a feature layer in district geospatial server.

No Alternatives / Backup to Mitigate Worst Case Scenario

The respective structure does not have an alternative operational routing or no system backup to mitigate potential limitations in operation or the worst-case scenario of structure failure under extreme event conditions.

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 an 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; the 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. The 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)

The project impact area is within FEMA Flood Zone A, AH, AE, and 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 the project will lower flood risks (reduce inundated areas).

Criteria Set 2: Consequence of System Deficiencies

Critical Assets/Lifelines Density

The total number of Critical Assets from the recently released FDEP Statewide Critical Assets Dataset (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.

The 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. FDEP developed and updated Critical Assets dataset that have relevant information that has been used to classify Regional Significant Assets from Critical Assets.

Impact Area Across Administrative Boundaries

The number of administrative and County boundaries across the area of influence characterizes different levels of regional significance for the respective projects.

Social Vulnerability

CDC SVI: Percent of the communities within the proposed project's impact area are identified as socially disadvantaged based on datasets available from the Center for Disease Control (CDC) Agency for Toxic Substances and Disease Registry (ATSDR) Social Vulnerability Index (SVI) that consider economic status, household characteristics, ethnicity and race, and access to transportation to determine socioeconomic burden and vulnerability in a changing climate.

CEQ CEJST: Communities within the proposed project's impact area that are identified as socially disadvantaged and vulnerable based on one of the eight datasets available from the Council on Environmental Quality's (CEQ) Climate and Economic Justice Screening Tool (CEJST) that consider economic status, household characteristics, ethnicity and race, illness, air, land, and water pollution, transportation and traffic, green spaces, and workforce development to determine socioeconomic burden and vulnerability in a changing climate.

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. Conservation Areas from FDEP Statewide Critical Datasets Layers provides the detailed Protectd Areas in the sate and has been used for the analysis.

Total Population

Total number of people residing within the project impact area of the proposed project based on 2023 estimates.

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 the proposed project influences saltwater interface – dual purposes, e.g., coastal structures).

Adaptation Action Areas

The 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." Equivalent priority planning areas, as recommended by counties, were also identified within project impact areas.

Criteria Set 3: Benefits from System Enhancements

Nature-based Solutions

The project includes nature-based solutions or green infrastructure in addition to "gray" infrastructure improvements to increase resiliency (Natural or semi-natural systems that provide water quality/ecosystem benefits and environmental habitat enhancement).

Ecosystem Restoration

The project included natural enhancements of the environment by restoring the lands and waters that benefit wildlife.

Cost Benefit Analysis

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

Previous State Commitment / Involvement

The project received previous state funding for its previous phases, including pre-construction activities, design, permitting, or Phase I Construction.

Available Match

The 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

The 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-

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

Capital Improvement Program (CIP) Status

Project Status as part of the District's 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.

Process for Applying Criteria

To apply the criteria sets detailed above, project impact areas were established for each project, as illustrated in the examples shown in Figure 8-14 below. Figures 8-15 through 8-18 summarize the ranking point assignment distribution, overall assumptions, and adopted weighting for each of the four 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, sea level rise and saltwater intrusion studies, environmental restoration and impact assessments, existing conditions reports, local engineering expertise and discussions with District’s staff. Assumptions include the project’s ability to protect the 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 August 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, 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 area and established weights. Projects with the highest combination of points become the highest priority projects. Table 8-9 below lists the infrastructure projects and presents the total points obtained for each criteria subset and overall points. Figures 8-16 through 8-23 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 Resiliency Plan updates and as vulnerability assessment results and additional information becomes available. The new criteria established in this current plan differ 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 the 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.

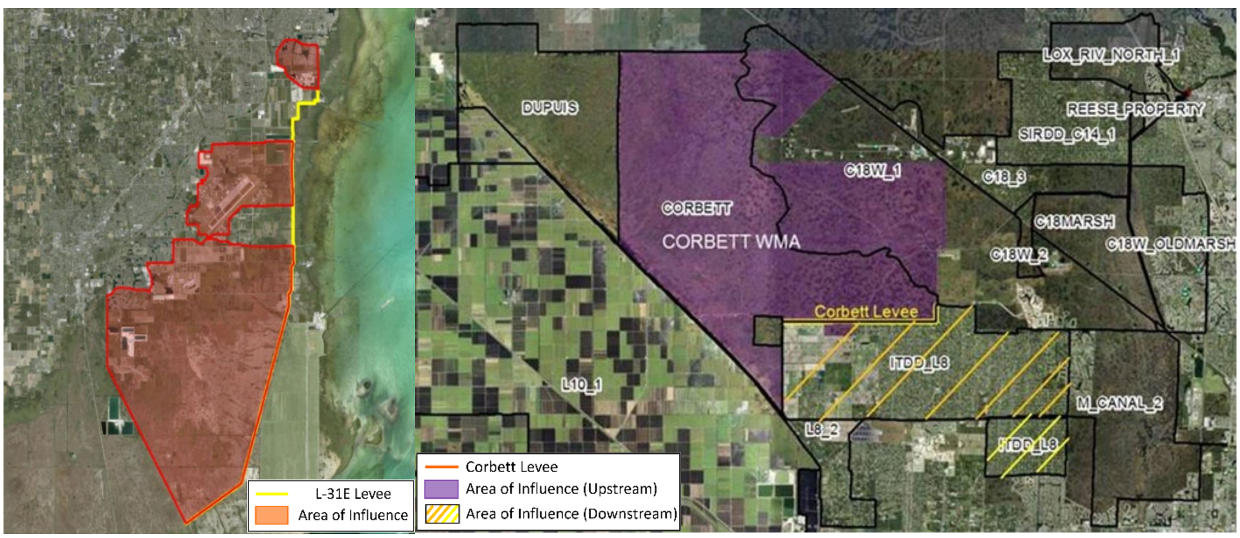


Figure 8-11: Examples of Project Impact Areas from the Proposed L-31E Levee Project (left) and the Corbett Levee (right).

				Low Probability				High Probability
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)	15%	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)	13%					Yes, flooded more than three times within the last five years or is experiencing ongoing erosion.
	1.3	No Alternatives/Backup to Mitigate Worst Case Scenario	3%			Partial		Yes
	1.4	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
	1.5	Sea Level Resulting in Overbank Flooding		>3 ft	2 ft to 3 ft	1 ft to 2 ft	0.5 to 1 ft	0.5 ft or less
	1.6	Exceedance of Canal Normal Operating Range (OR)			Less than or Equal to 1 ft	More than 1 ft	> 2.5 ft	> 3.5 ft
	1.7	Finished Floor Elevation < Base Flood Elevation	3%			FFE < BFE + 1'	FFE < BFE + 2' (or 1' inland)	FFE < BFE + 3' (or 2' inland)
	1.8	FEMA Flood Zone Exposure						Yes
	1.9	Storm Surge Inundation Exposure				Yes, under Cat 3	Yes, under Cat 4	Yes, under Cat 5

Figure 8-12: Summary and Scoring System utilized for characterizing Criteria Set 1 "Likelihood of System Deficiency"

				Low Probability				High Probability
Criteria	**ID**	**Category**	**Weighting**	**1**	**2**	**3**	**4**	**5**
Consequence of System Deficiency	**2.1**	Critical Assets / Lifelines	6%			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
			6%			1 or more RS Critical Assets	3 or more RS Critical Assets	5 or more RS Critical Assets
	2.2	Impact Area Across Administrative Boundaries	2.5%	1 County		1 County & 2 Administrative Boundaries		> 2 Counties & > 2 Administrative Boundaries
	2.3	Social Vulnerability (CDC SVI)	5.0%				0.4 - 0.6	> 0.6
		Social Vulnerability (CEQ CEJST)						Yes
	2.4	Environmental Protected Areas	3.5%	Lower Density		Average		Higher Density
	2.5	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
	2.6	Public Water Supply Wellfields	5%	Lower Density		Average		Higher Density
	2.7	Adaptation Action Areas	1%	Does not Intersect Adaptation Action Area				Intersect Adaptation Action Area

Figure 8-13: Summary and Scoring System utilized for characterizing Criteria Set 2 "Consequence of System Deficiency"

				Low Probability				High Probability
Criteria	**ID**	**Category**	**Weighting**	**1**	**2**	**3**	**4**	**5**
Benefits from System Enhancement	**3.1**	Nature-based Solutions	5%					Yes
	3.2	Ecosystem Restoration						Yes
	3.3	Cost Benefit Analysis	2.5%					BCA Larger than 1
	3.4	Previous State Funding	2.5%		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 Match	2.5%			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	2.5%					Yes
	3.7	Innovative Technologies	5%					Yes

Figure 8-14: Summary and Scoring System utilized for characterizing Criteria Set 3 "Benefits from System Enhancement"

				Low Probability				High Probability
Criteria	**ID**	**Category**	**Weighting**	**1**	**2**	**3**	**4**	**5**
Project Status (SIP / CIP Programs)	**4.1**	SIP Overall Rating	5%			Overall C-3 or N/A	Overall C-4	Overall C-5
	4.2	Capital Improvement Program (CIP) Status	5%	Issue ID & Risk Ranking	PDR Approved / Project Kick-off Meeting and/or Suvey & Geotech Commenced	Partial Design	Design Complete / Permit Application Submitted	Initiated Construction

Figure 8-15: Summary and Scoring System utilized for characterizing Criteria Set 4 "Project Status (SIP/CIP Programs)"

Table 8-5: Ranking of Coastal Structure Projects (top) and Priority Projects (bottom)

Projects	Likelihood of System Deficiency	Consequence of System Deficiency	Benefits from System Enhancement	Project Status	Total Points
C-9 Basin Resiliency and S-29 Coastal Structure	33.50	20.70	18.50	5.00	**77.70**
C-14 Basin Resiliency	39.50	19.30	16.50	1.00	**76.30**
C-12 West Basin Resiliency	39.50	18.90	16.50	1.00	**75.90**
C-7 Basin Resiliency and S-27 Coastal Structure	35.30	16.30	18.50	5.00	**75.10**
C-6 Basin Resiliency	38.30	15.30	20.00	1.00	**74.60**
C-8 Basin Resiliency and S-28 Coastal Structure	35.30	16.10	18.50	4.00	**73.90**
C-11 Basin Resiliency	36.50	19.30	16.50	1.00	**73.30**
MODEL-LAND Basin Resiliency	37.10	13.50	16.50	6.00	**73.10**
C-2 Basin Resiliency	39.50	15.30	16.50	1.00	**72.30**
Pompano Canal and C-14 West Basin Resiliency	35.50	19.30	16.50	1.00	**72.30**
C-100 Basin Resiliency	38.50	15.10	16.50	1.00	**71.10**
C-111 AG Basin Resiliency	34.90	13.50	16.50	6.00	**70.90**
HARB Basin Resiliency	39.50	13.50	16.50	1.00	**70.50**
North New River Canal West Basin Resiliency	33.50	19.10	16.50	1.00	**70.10**
Henderson-Belle Meade Basin Resiliency	33.50	18.90	16.50	1.00	**69.90**
C-102 and C-102N Basin Resiliency	35.50	13.50	16.50	4.00	**69.50**
C-5 Basin Resiliency	38.30	13.50	16.50	1.00	**69.30**
C-103 and C-103N Basin Resiliency	34.60	13.90	16.50	4.00	**69.00**
C-1 Basin Resiliency	35.80	14.10	16.50	1.00	**67.40**
GOULDS Basin Resiliency	35.90	13.50	16.50	1.00	**66.90**
C-4 Basin Resiliency	31.60	15.10	18.50	1.00	**66.20**
C-3 and C-3 West Basin Resiliency	33.50	15.10	16.50	1.00	**66.10**
C-13 West Basin Resiliency	31.10	17.10	16.50	1.00	**65.70**
L-31NS Basin Resiliency	31.90	13.50	16.50	1.00	**62.90**
Hillsboro Canal Basin Resiliency	24.50	20.50	16.50	1.00	**62.50**
North Biscayne Bay Basin Resiliency	23.30	14.50	16.50	1.00	**55.30**
C-111 SOUTH Basin Resiliency	20.90	12.90	16.50	1.00	**51.30**
US1 Basin Resiliency	20.90	12.90	16.50	1.00	**51.30**

Projects	Likelihood of System Deficiency	Consequence of System Deficiency	Benefits from System Enhancement	Project Status	Total Points
Hardening of S-2, S-3, S-4, S-7, S-8 Engine Control Panels	35.50	24.50	17.50	6.00	**83.50**
Coastal Structures Enhancement and Self Preservation Mode	39.50	21.70	18.50	1.00	**80.70**
Big Cypress Basin Microwave Tower	38.50	23.30	17.50	1.00	**80.30**
C-29, C-29A, C-29B, and C-29C Canal Conveyance Improvement	38.50	19.50	16.50	5.00	**79.50**
S-58 Structure Enhancement and Temporary Pump	39.50	19.50	16.50	2.00	**77.50**
L8 FEB / G539 PS - Resiliency Upgrades	34.30	18.50	17.50	7.00	**77.30**
S-61 Spillway Enhancement and Erosion Control	35.50	23.50	16.50	1.00	**76.50**
S-59 Structure Enhancement and C-31 Canal Conveyance Improvements	38.50	19.50	16.50	1.00	**75.50**
South Miami-Dade Curtain Wall	37.00	15.30	18.50	1.00	**71.80**
L-31E Levee Improvements	38.50	15.10	16.50	1.00	**71.10**
Corbett Levee Water Control Structures	19.90	19.70	17.50	1.00	**58.10**
JW Corbett Wildlife Management Area Hydrologic Restoration and Levee Resiliency	20.90	17.30	18.50	1.00	**57.70**
Everglades Mangrove Migration Assessment (EMMA)	22.90	12.90	19.00	1.00	**55.80**

Legend

Priority Levels

Blue	Lower
Green	Medium
Yellow	Medium High
Orange	High

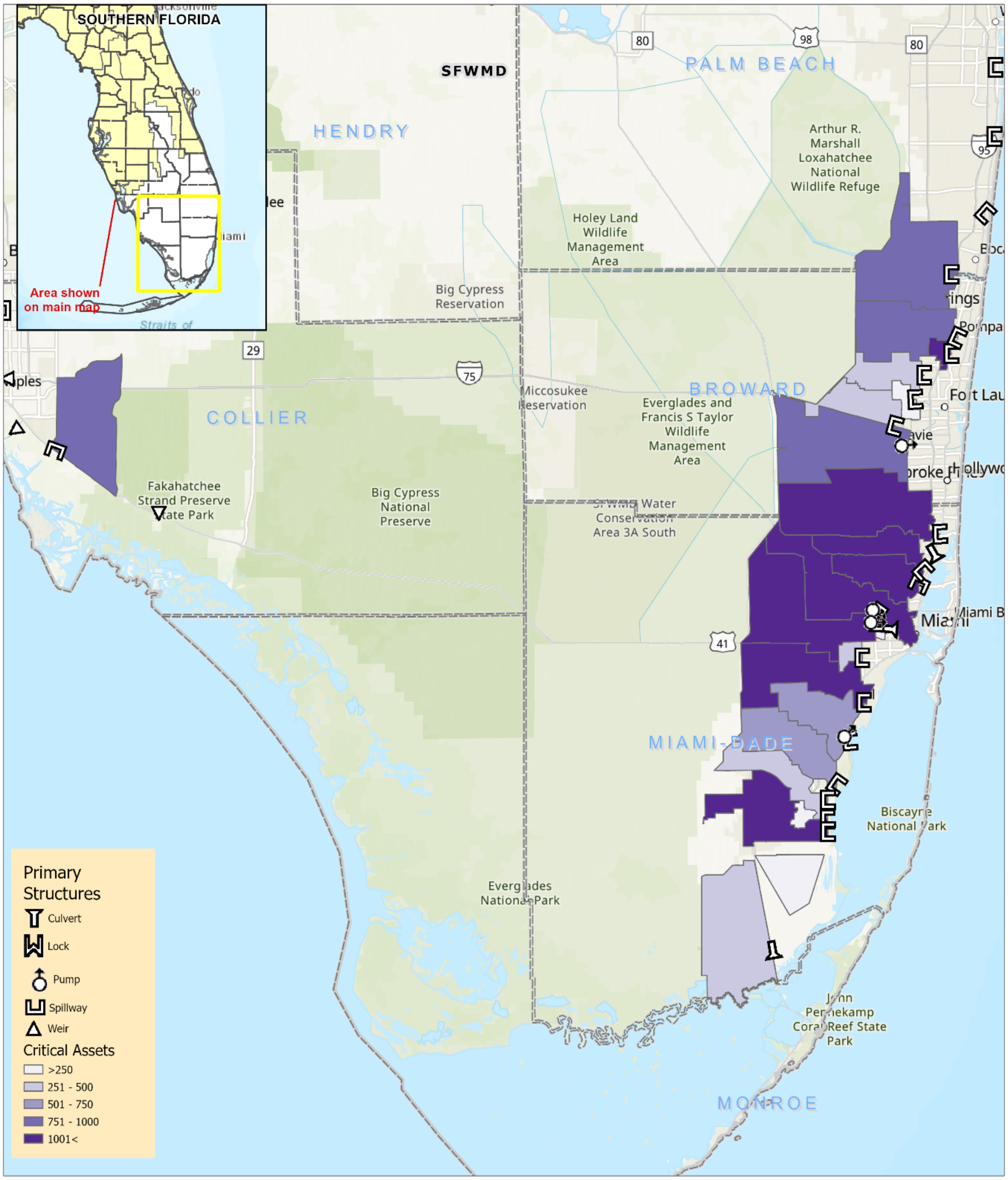


Figure 8-16: Critical Assets (Lifelines) per Coastal Structures Resiliency Project Impact Areas, utilized as part of the Resiliency Projects Ranking Criteria Set 2

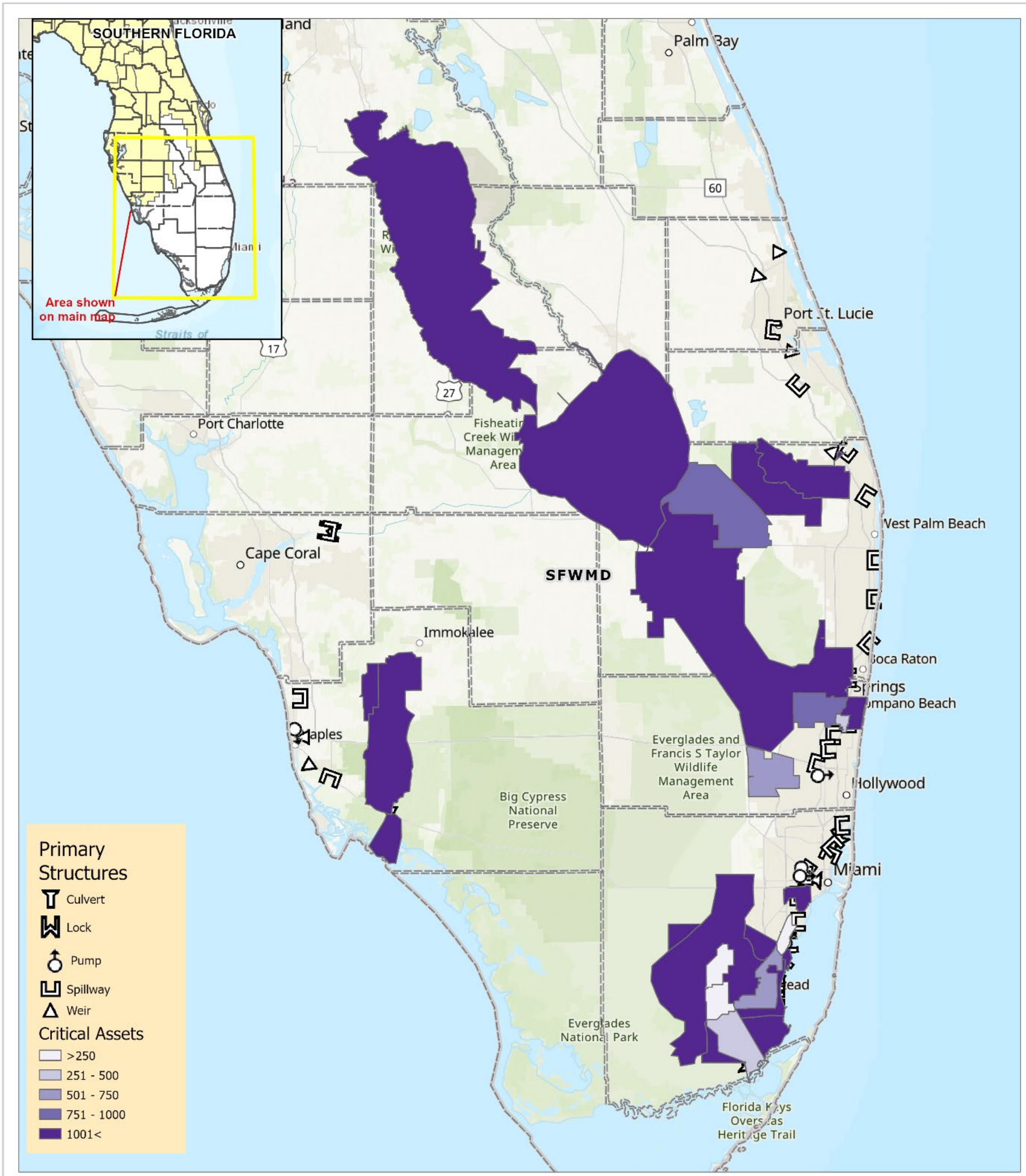


Figure 8-17: Critical Assets (Lifelines) per Other Priority Project Impact Areas, utilized as part of the Resiliency Projects Ranking Criteria Set 2

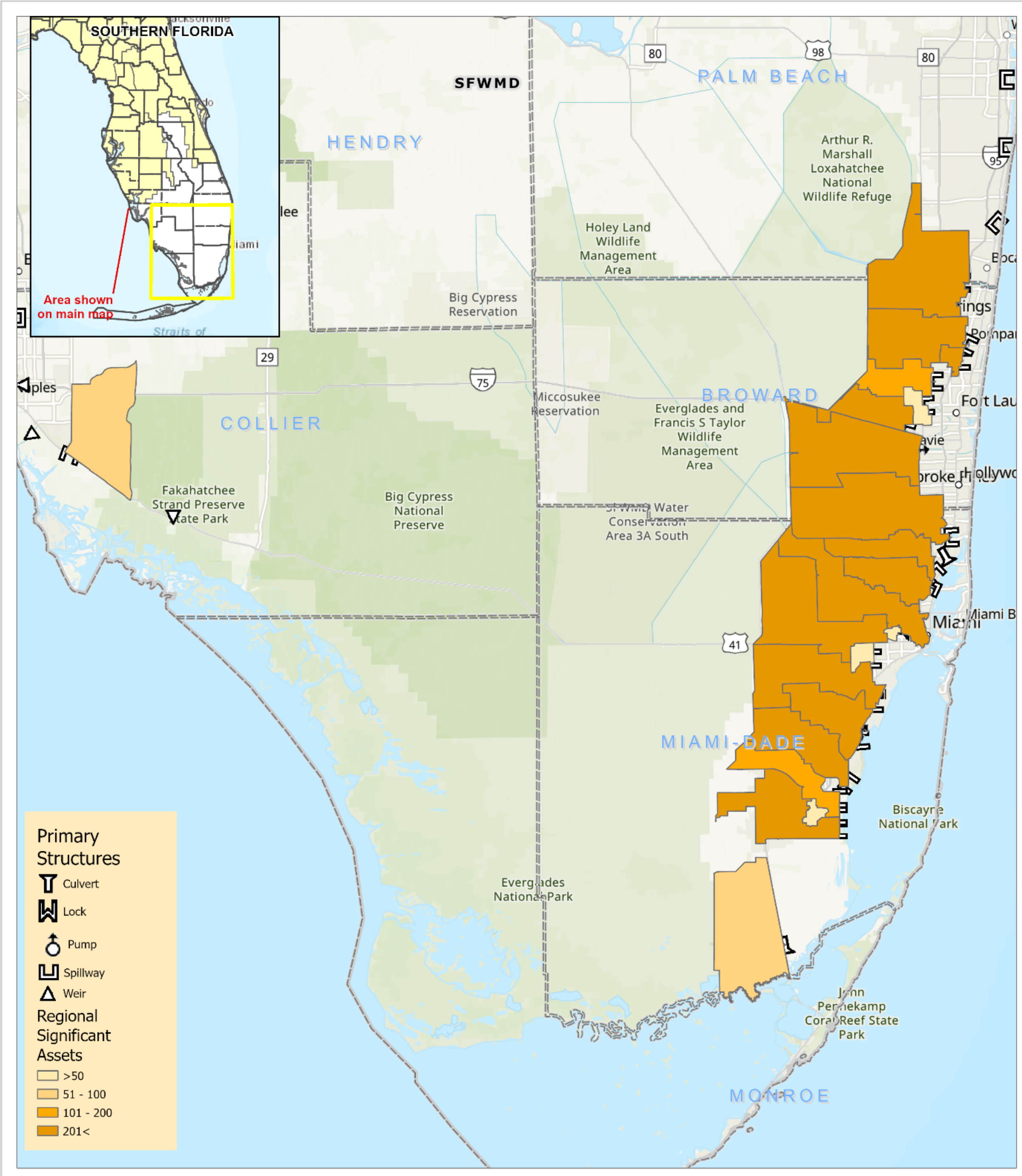


Figure 8-18: Regional Significant Assets per Coastal Structures Resiliency Project Impact Areas, utilized as part of the Resiliency Projects Ranking Criteria Set 2

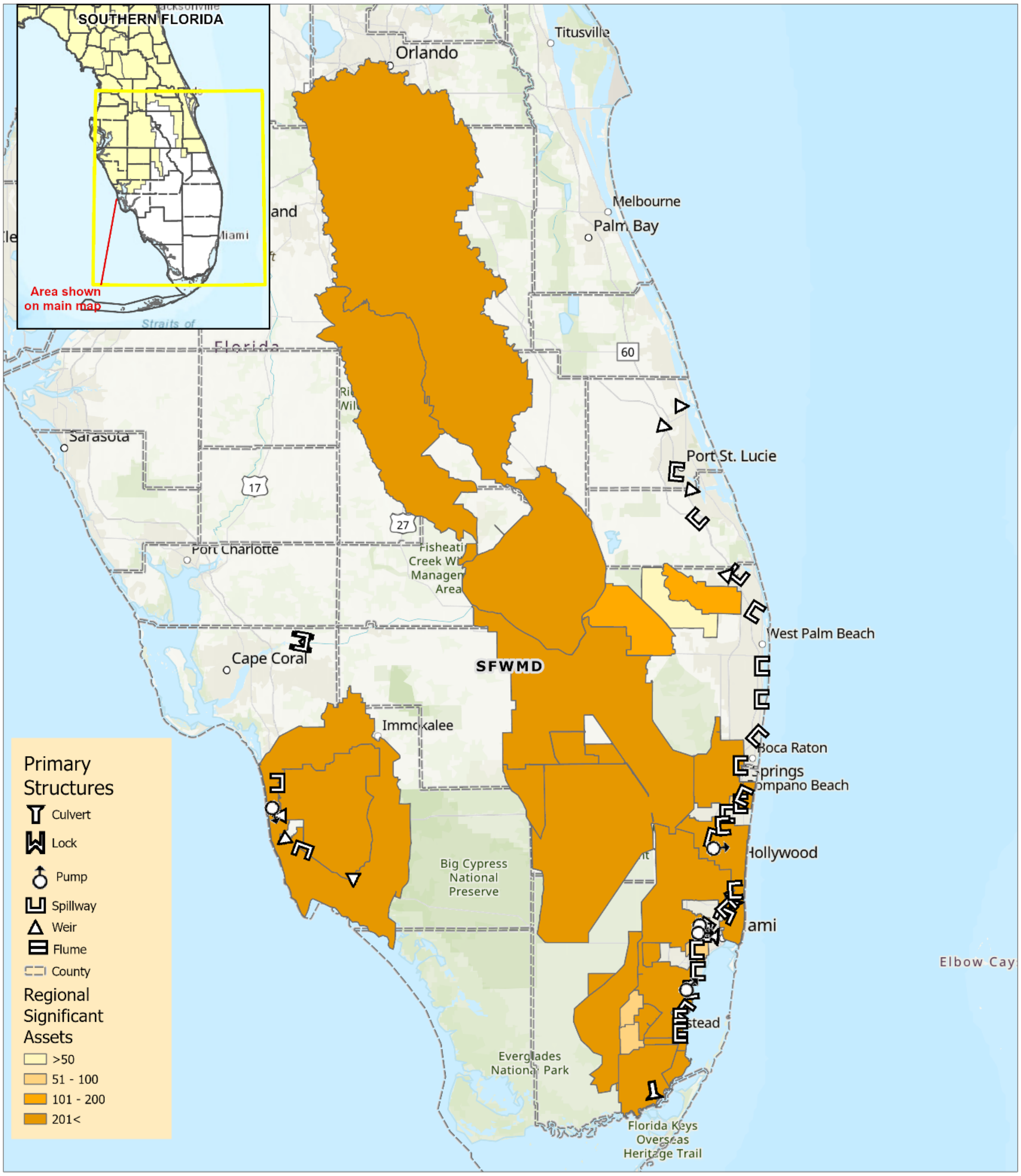


Figure 8-19: Regional Significant Assets per Other Project Impact Areas, utilized as part of the Resiliency Projects Ranking Criteria Set 2

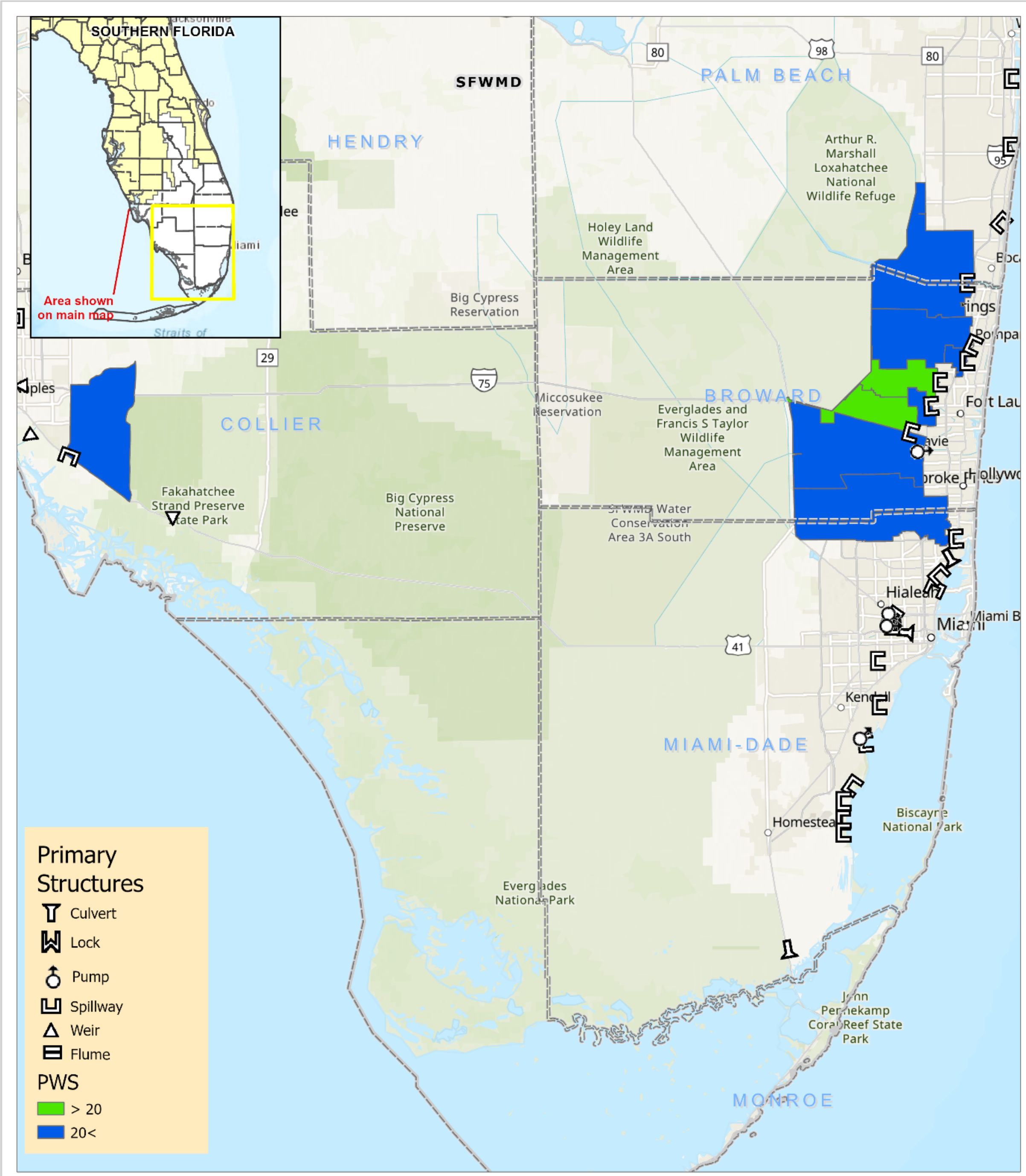


Figure 8-20: Public Supply Wellfields within 20000 ft of the Saltwater interface line per Coastal Structures Resiliency Project Impact Areas, utilized as part of the Resiliency Projects Ranking Criteria Set 2

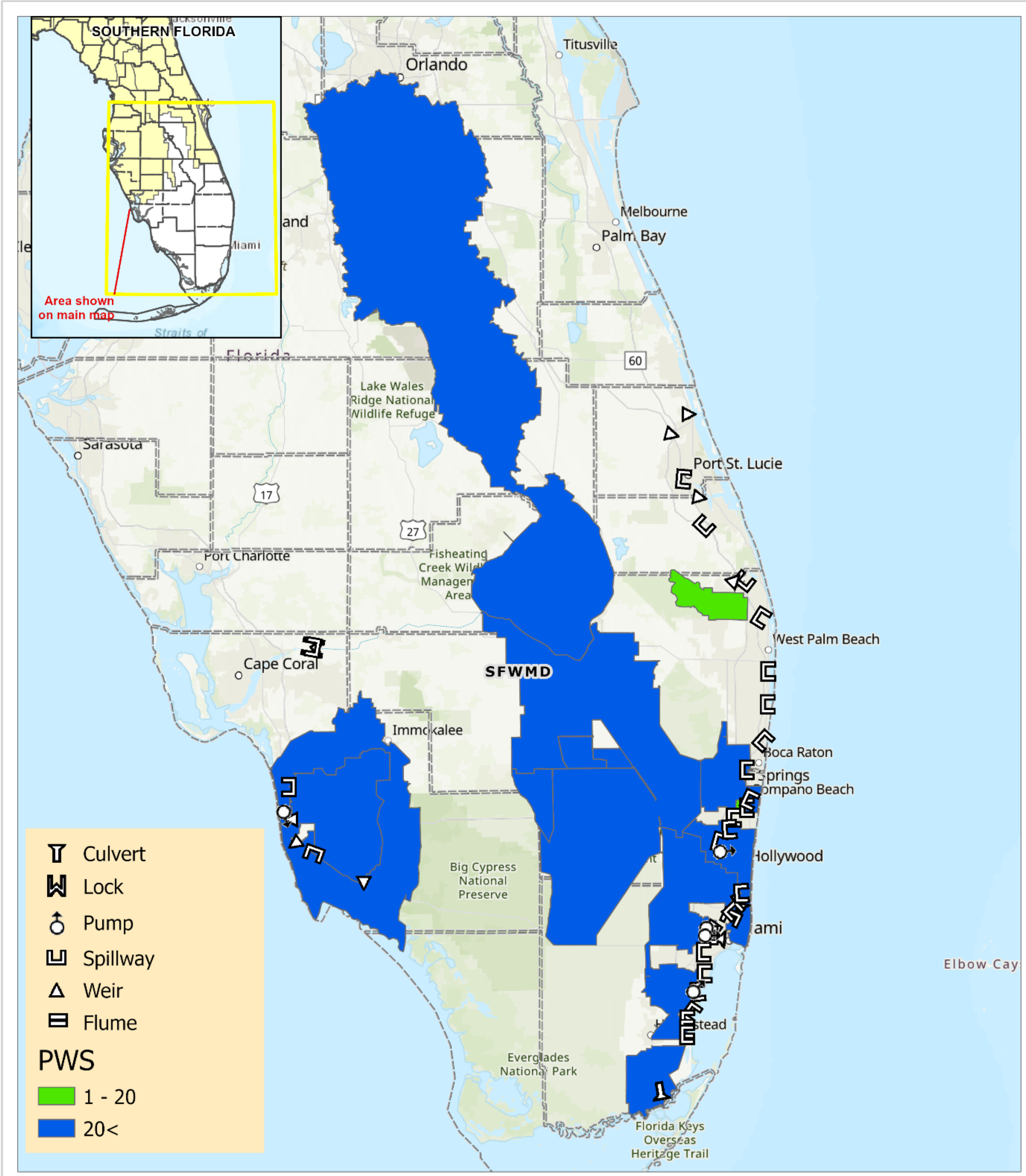


Figure 8-21: Public Supply Wellfields within 20000 ft of the Saltwater Interface line per Other Project Impact Areas utilized as part of the Resiliency Projects Ranking Criteria Set 2

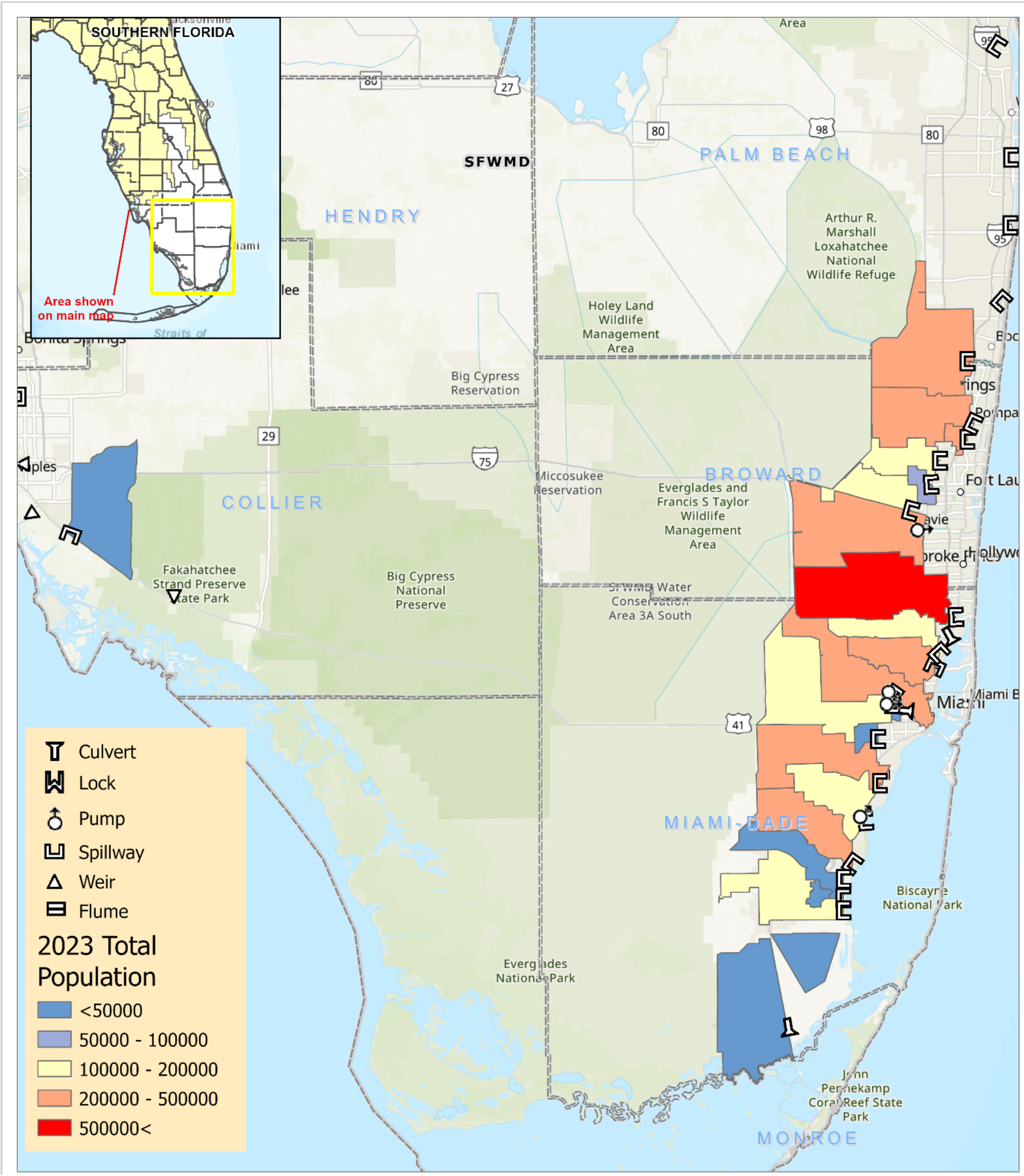


Figure 8-22: Total Population per Coastal Structures Resiliency Project Impact Areas, utilized as part of the Resiliency Projects Ranking Criteria Set 2

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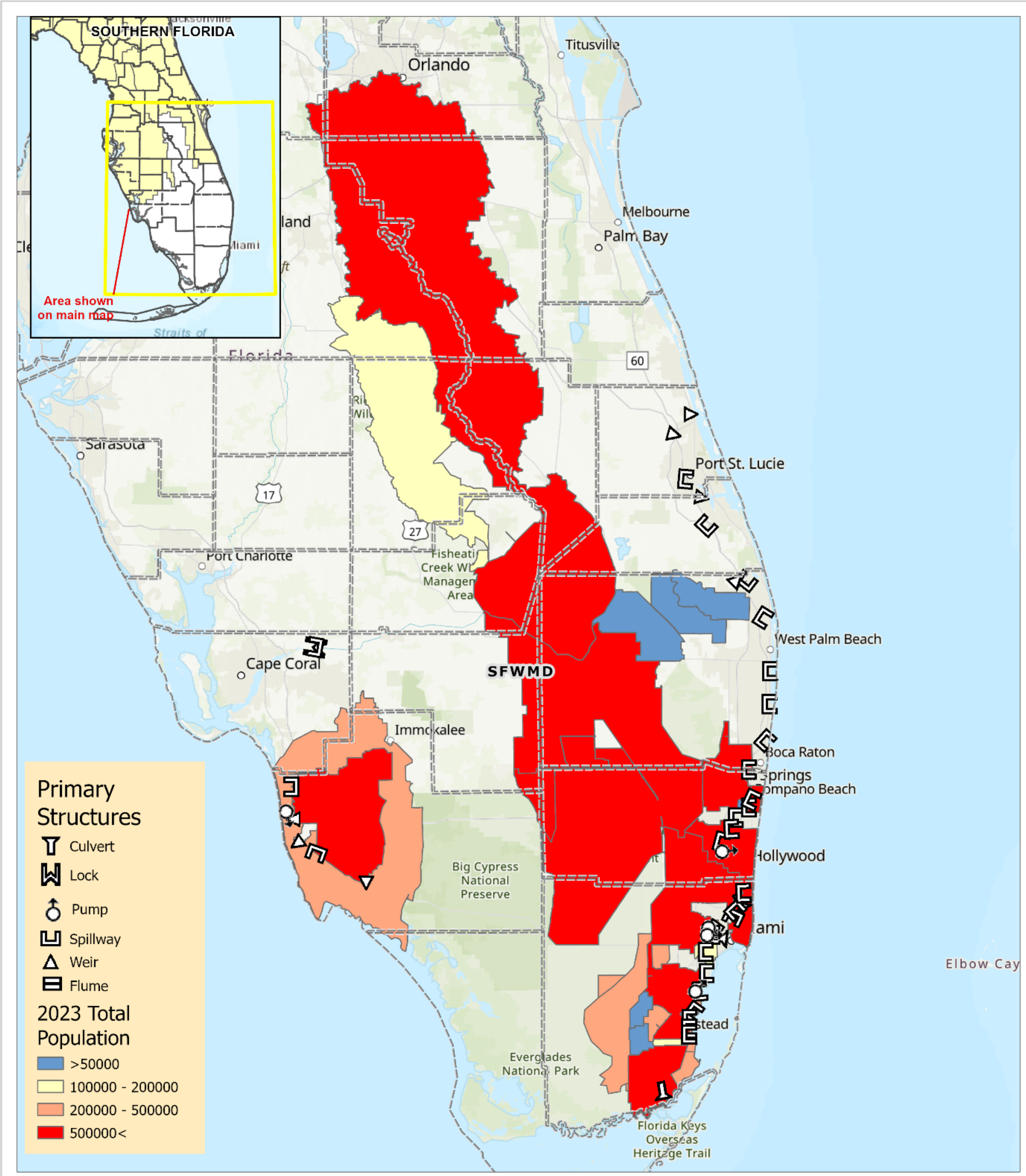

Figure 8-23: Total Population per Other Project Impact Areas utilized as part of the Resiliency Projects Ranking Criteria Set 2

9: Enhancing our Water Management Systems: Priority Resiliency Implementation Projects

The list of priority resiliency implementation projects is presented in Appendix A, illustrated in Figure 9-1 and summarized below (Table 9-1), showing the status of funding and how each project is linked to the District's mission. In this 2024 Plan Update document, additional project components in each priority basin have been detailed and integrated into a basin-wide main project. The organization of all project components into a main project by basin (or equivalent project influence area) allows for easier identification of project components being proposed in each basin, with a clearer indication of joint and complementary strategies. The organization of project components by basin allows for further coordination among various stakeholders, including local governments, water management districts, and community organizations. This will lead to increased effectiveness and efficiency, as investments and interventions are summarized by drainage basin or project influence area boundaries, and will clearly show initial strategies being proposed for areas with the higher risk. It also allows for facilitated community engagement and participation, as local stakeholders have a better understanding of the specific challenges and opportunities within each basin, allowing for more meaningful input into the planning process.

An integrated basin wide strategy ensures that all relevant factors are considered, minimizing vulnerabilities and maximizing the effectiveness of water management strategies. Each basin has or will eventually have comprehensive project components to reduce flood risks, as FPLOS Phase II studies are completed. For example, The C-8 Basin Resiliency Project includes flood risk adaptations at the S-28 Coastal Structure and addition of a forward pump station as its main project component, along with tie-back levee, canal bank improvements, additional storage, and nature-based features. Appendix A includes a description of each of these project components that integrate with the Basin Resiliency Projects, along with initial high-level cost estimates. Please refer to the figure 9-1 and table 9-1 for the list of Priority Resiliency Implementation Projects.

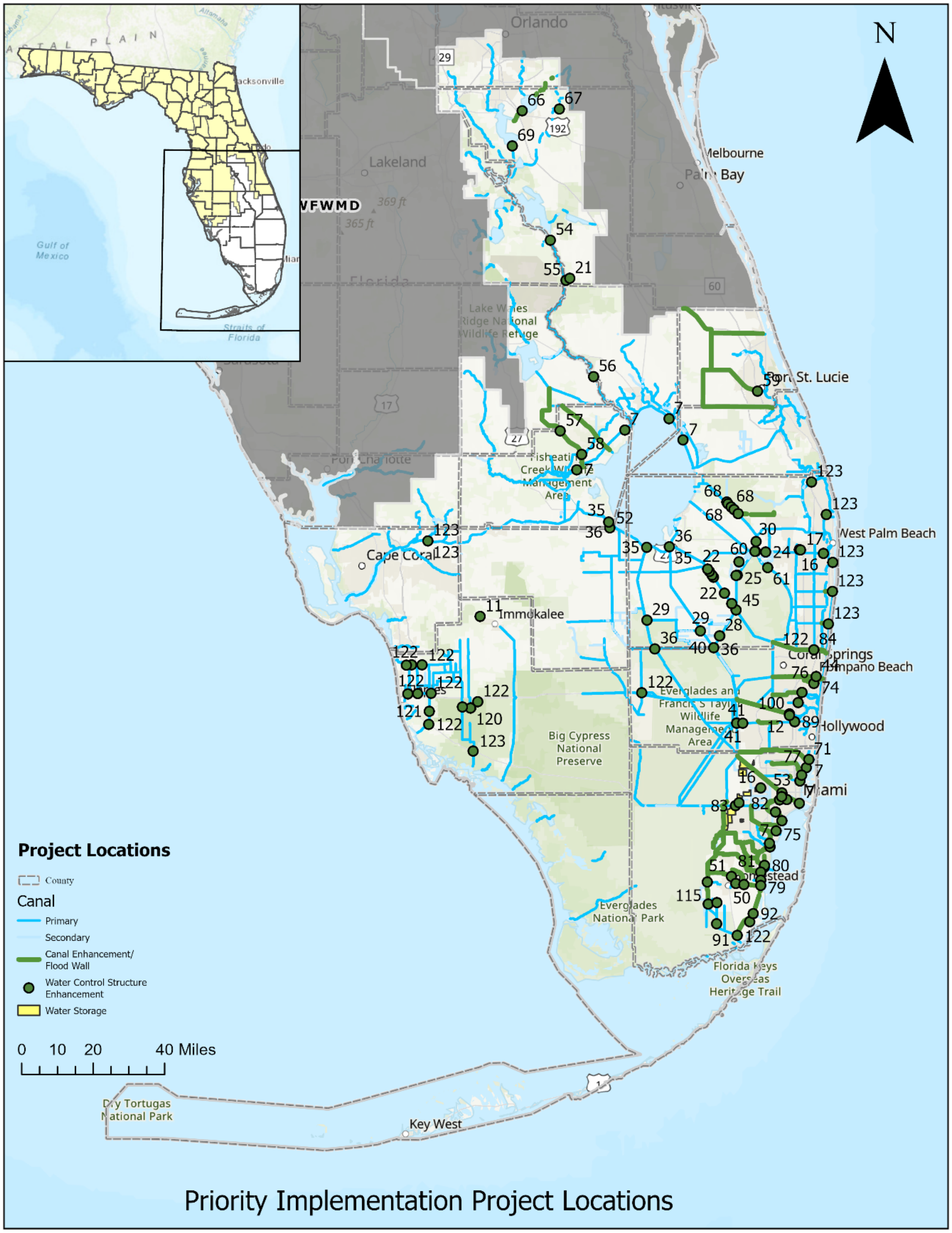

Figure 9-1: Project locations for the Priority Resiliency Implementation Projects

Table 9-1: List of Resiliency Priority Projects showing how the project is linked to the District's mission as well as implementation and funding status.

Project Name	Mission	Source	Status of Implementation	Status of Funding
C-8 Basin Resiliency and S-28 Coastal Structures	Flood Control, Water Supply, Ecosystem Restoration	FPLOS Phase II	Ongoing Design	Partially funded $50M FEMA BRIC +$28M FDEP Resilient Florida, SFWMD & MDC Match
C-9 Basin Resiliency and S-29 Coastal Structure	Flood Control, Water Supply, Ecosystem Restoration	FPLOS Phase II	Ongoing Design	Partially funded $50M FEMA BRIC + SFWMD & MDC & SBDD Match
C-7 Basin Resiliency and S-27 Coastal Structure	Flood Control, Water Supply, Ecosystem Restoration	FPLOS Phase II (Pilot)	Ongoing Design	Partially funded $50M FEMA BRIC + SFWMD Match
Hillsboro Canal Basin Resiliency	Flood Control, Water Supply	FPLOS Phase I	Not Started	Not yet funded
C-14 Basin Resiliency	Flood Control, Water Supply	FPLOS Phase I	Not Started	Not yet funded
C-14 West Basin Resiliency	Flood Control, Water Supply	FPLOS Phase I	Not Started	Not yet funded
C-14 East Basin Resiliency	Flood Control, Water Supply	FPLOS Phase I	Not Started	Noth yet funded
Pompano Canal Basin Resiliency	Flood Control, Water Supply	FPLOS Phase I	Not Started	Not yet funded
C-13 West Basin Resiliency	Flood Control, Water Supply	FPLOS Phase I	Not Started	Not yet funded
C-12 West Basin Resiliency	Flood Control, Water Supply	FPLOS Phase I	Not Started	Not yet funded
North New River Canal West Basin Resiliency	Flood Control, Water Supply	FPLOS Phase I	Not Started	Not yet funded
C-11 Basin Resiliency	Flood Control, Water Supply	FPLOS Phase I	Not Started	Not yet funded
C-11 West Basin Resiliency	Flood Control, Water Supply	FPLOS Phase I	Not Started	Not yet funded
North Biscayne Bay Basin Resiliency	Flood Control, Water Supply	FPLOS Phase I	Not Started	Not yet funded

Project Name	Mission	Source	Status of Implementation	Status of Funding
Miami River and C-6 Basin Resiliency	Flood Control, Water Supply	FPLOS Phase I	Not Started	Not yet funded
C-6 Basin Resiliency	Flood Control, Water Supply	FPLOS Phase I	Not Started	Not yet funded
C-5 and C-4 Basin Resiliency	Flood Control, Water Supply	FPLOS Phase I	Not Started	Not yet funded
C-5 Basin Resiliency	Flood Control, Water Supply	FPLOS Phase I	Not Started	Not yet funded
C-4 Basin Resiliency	Flood Control, Water Supply	FPLOS Phase I	Not Started	Not yet funded
C-3 West Basin Resiliency	Flood Control, Water Supply	FPLOS Phase I	Not Started	Not yet funded
C-2 Basin Resiliency	Flood Control, Water Supply	FPLOS Phase I	Not Started	Not yet funded
C-100 Basin Resiliency	Flood Control, Water Supply	FPLOS Phase I	Not Started	Not yet funded
C-100 East Basin Resiliency	Flood Control, Water Supply	FPLOS Phase I	Not Started	Not yet funded
C-1 Basin Resiliency	Flood Control, Water Supply	FPLOS Phase I	Not Started	Not yet funded
Goulds Canal Basin Resiliency	Flood Control Water Supply	FPLOS Phase I	Not Started	Not yet funded
HARB Basin Resiliency	Flood Control Water Supply	FPLOS Phase I	Not Started	Not yet funded
C-102 / C-102N Basin Resiliency	Flood Control, Water Supply	FPLOS Phase I	Not Started	Not yet funded
C-103 / C-103N Basin Resiliency	Flood Control, Water Supply	FPLOS Phase I	Not Started	Not yet funded
L-31NS Basin Resiliency	Flood Control, Water Supply	FPLOS Phase I	Not Started	Not yet funded
C-111 AG Basin Resiliency	Flood Control, Water Supply	FPLOS Phase I	Not Started	Not yet funded

Project Name	Mission	Source	Status of Implementation	Status of Funding
C-111 South and C-111 Coastal Basin Resiliency	Flood Control, Water Supply	FPLOS Phase I	Not Started	Not yet funded
US1 Basin Resiliency	Flood Control, Water Supply	FPLOS Phase I	Not Started	Not yet funded
Model Land Basin Resiliency	Flood Control, Water Supply	FPLOS Phase I	Not Started	Not yet funded
Remaining Water Control Structures Resiliency	Flood Control, Water Supply	FPLOS Phase I (not yet completed)	Not Started	Not yet funded
Coastal Structures Enhancement and Self-Preservation Mode	Flood Control, Water Supply	CIP/Post Storm	Ongoing Design and Construction	Fully Funded $6.3M FDEP Resilient Florida + SFWMD Match
L8 FEB / G-539 Pump Resiliency Upgrades	Flood Control, Water Supply	CIP	Ongoing Design	Not yet funded h
Hardening Of S-2, S-3, S-4, S-7, S-8 Engine Control Panels	Flood Control, Water Supply	CIP	Construction Started	Fully Funded $8.5M FDEP Resilient Florida + SFWMD Match
JW Corbett WMA Hydrologic Restoration and Levee Resiliency	Flood Control, Water Supply, Environmental Restoration	Post Storm / Event Response	Construction Started	Fully Funded $9.7M y FDEP Relient Florida, $2M Palm Beach County + SFWMD Match,
C-29, C-29A, C-29B and C29C Canal Conveyance Improvements	Flood Control	Post Storm / Event Response	Not Started	Not yet funded
S-59 Structure Enhancement and C-31 Canal Conveyance Improvements	Flood Control	Post Storm / Event Response	Not Started	Not yet funded
S-58 Structure Enhancement and Temporary Pump	Flood Control	Post Storm / Event Response	Not Started	Not yet funded
S-61 Spillway Enhancement and Erosion Control	Flood Control	Post Storm / Event Response	Not Started	Not yet funded
Corbett Levee Water Control Structures	Flood Control	Post Storm / Event Response	Not Started	Not yet funded
Big Cypress Basin Microwave Tower	Flood Control, Water Supply	Post Storm / Event Response	Not Started	Not yet funded
Henderson Creek Improvements	Flood Control, Water Supply	Post Storm / Event Response	Not Started	Not yet Funded

Project Name	Mission	Source	Status of Implementation	Status of Funding
L-31E Levee Improvements	Flood Control, Water Supply	FPLOS Phase I	Not Started	Not yet funded
Everglades Mangrove Migration Assessment (EMMA)	Flood Control, Water Supply, Environmental Restoration	Innovative Projects	Not Started (Conceptual Design Completed)	Not yet funded
Mangrove Experimental Manipulation Exercise (MEME)	Flood Control, Water Supply, Environmental Restoration	Innovative Projects	Not Started (Conceptual Design Completed)	Partially funded (SFWMD)
South Miami-Dade Curtain Wall	Flood Control, Water Supply, Environmental Restoration	Innovative Projects	Not Started	Not yet funded
Renewable Energy Projects	Flood Control, Water Supply, Environmental Restoration	Innovative Projects	Not Started	Not yet funded

SFWMD Mission and Resiliency Implementation Projects

As we detail and prioritize implementation projects in this Plan, it is important to reinforce SFWMD's mission elements and how resiliency is embedded in each of these elements. The District's mission is to safeguard and restore South Florida's water resources and ecosystems, protect communities from flooding, and meet the region's water needs while connecting with the public and stakeholders.

Flood Control

Flood Control has been part of the District's mission since its creation as the Central and Southern Florida Flood Control District in 1949. Operations and Maintenance staff operate and oversee approximately 2,175 miles of canals and 2,130 miles of levees/berms, 89 pump stations, 915 water control structures, and weirs, and 621 project culverts. As part of this responsibility, the District has been implementing its Capital Improvement Program (CIP) to ensure investment in the maintenance of the flood control assets, a Structure Inspection Program (SIP) to routinely inspect and assess the structural integrity and operation of the flood control assets and, more recently, the Flood Protection Level of Service (FPLOS) program to comprehensively assess the system's ability to meet and continue to meet the flood protection needs of the region into the future. These programs are critical to keeping South Florida habitable and its primary flood control system functioning as designed today and into the future and their recommendations are incorporated into this Plan.

Water Supply Planning

Water supply planning is essential to meet the growing demands of 9 million residents, millions of visitors, businesses, and the environment. Section 373.790 F.S. requires the District to develop and update regional water supply plans approximately every five years with a planning horizon of 20 years to ensure that the available water resources in the region are sufficient to meet future water needs. These plans also identify measures to achieve demands where deficiencies are found, including promoting water conservation and the use of alternative water supplies. The District has taken steps to include sea level rise and climate change impacts in water supply planning efforts and maintains a Saltwater Interface Monitoring and Mapping Program to determine the approximate location of the saltwater interface since

2009, with updated maps every five years. Future conditions saltwater intrusion scenario projections are being simulated as part of the upcoming Lower East Coast Water Supply Plan and will be further characterized as part of the ongoing water supply vulnerability assessment. Upon the completion of this assessment, and the formulation of adaptation strategies, project recommendations will be incorporated into this Plan.

Ecosystem Restoration

Numerous ecosystem restoration projects are being planned, built, and operated to protect and preserve South Florida's unique ecosystems, including the Everglades, the Kissimmee River, Lake Okeechobee, and a diverse array of coastal watersheds, as detailed in Chapter 5. The most prominent of these efforts is the Comprehensive Everglades Restoration Plan (CERP), a cost-share partnership between the State of Florida and the Federal government to restore, protect and preserve the greater Everglades. Ecosystem Restoration supports the District's efforts to address the effects of climate change and sea level rise by building systemwide resiliency. More recently, restoration studies are integrating sea level rise as part of future conditions assessments, such as the Biscayne Bay Southeastern Everglades Ecosystem (BBSEER) study. Completed CERP projects increase the District's ability to better manage anticipated extreme weather events. 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, and reduced occurrence of marsh dry outs. Even though all these programs help restore South Florida's ecosystems, create healthy environments, and make them more resilient to climate change, Ecosystem Restoration projects are not incorporated into this Plan, as they have their own planning mechanisms, notably CERP.

This Resiliency Plan document, and particularly the list of priority implementation projects included in this chapter and detailed in Appendix A, reflects the status of resiliency incorporation into each of the District's mission elements, summarized above. As demonstrated throughout the document and in the list and figure below (Figure 9-2), long-term resiliency strategies in support of the District's water supply mission are still in a relatively emerging stage, when typical efforts are characterized by vulnerability assessments and exploratory studies, with more short-term and localized adaptation strategies being prioritized and part of Water Supply Plans and not incorporated into this plan. The flood protection mission is in a more advanced and transforming stage, with resiliency strategies that include adaptation, supported by robust technical assessments in place for over a decade through the FPLOS Program. Therefore, the flood resiliency projects included in this chapter are supported by detailed technical analysis with consideration for how these projects are sized to address current and future evolving conditions. Similarly, work in support of ecosystem restoration, including model development, analyses, implementation of projects, and assessment of project performance, is substantive and has been implementing resiliency projects in South Florida for over two decades, as summarized above and in Chapter 5.. The goal over the next decade is to move each of the mission areas to mature stages as adaptation strategies become clearer and more comprehensive for building resiliency in South Florida.

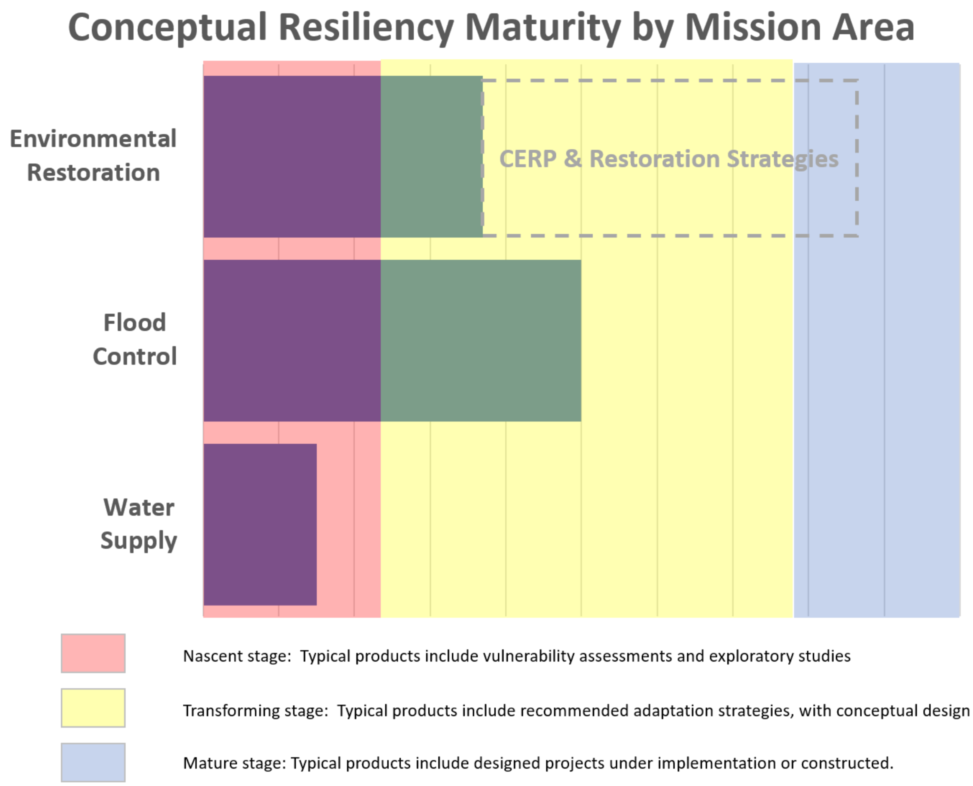

Figure 9-2: Conceptual Resiliency Maturity by Mission Area

Resiliency Priority Implementation Projects - Primary Sources

This plan incorporates resiliency strategies that include robust adaptation solutions supported by integrated technical assessments, detailed analyses, and projects designed to address current and future conditions. The primary sources of projects formulated for this plan are detailed in Figure 9-3 and include FPLOS Phase II Studies, FPLOS Phase I Studies, Post Storm/Event Response, CIP, and Innovative Projects. Recommendations with the strongest technical support are listed first. These are the projects that have been validated with the most advanced modeling and future scenario assessments.

FPLOS Phase II project recommendations are the result of robust, comprehensive feasibility studies that evaluate a set of alternative adaptation strategies throughout the system (including primary, secondary, and tertiary systems). These studies assess the potential effects of implementing the project and the quantified benefits for flood risk reduction basin-wide, which will inform the basis for design as the following step. FPLSO Phase II recommendations also include project sequencing so that planning is adaptable to evolving conditions and projects are implemented as needed and based on the determination of thresholds established to maintain an appropriate flood protection level of service.

FPLOS Phase I project recommendations are projects identified based on the results of flood vulnerability assessments, not yet validated through adaptation planning modeling. They include no-regret strategies such as enhancing coastal structures, building forward pump stations, storage options, and flood barriers at coastal structures. Post Storm or Event response recommendations are developed based on the characterized impacts and pre-identified response actions to extreme events such as hurricanes and extreme rainfall events. During and after extreme events, the District water managers operate the system in the most efficient manner and might adjust how the system is operated to help relieve flooding, as needed. Event response project recommendations aim to build upon what is learned from pre-, during- and post-storm operations, along with observed limitations to the water management system, and develop best response strategies for system enhancement. Capital Improvement Plan project recommendations are projects that are based on CIP and Operations and Maintenance regular needs. These projects are driven by the need to replace, repair, and/or enhance aging or damaged flood control infrastructure and are aligned with resiliency goals. Innovative Project Recommendations are new and innovative ideas that may need to be further assessed before they are fully developed. They can include project features such as nature-based solutions and/or renewable energy project features. Project features that are the result of grant funding requirements often fall under this category as well.

It is important to note that only FPLOS project recommendations that fall within the SFWMD's authority to implement are included in this Plan. Any projects located within secondary systems or downstream of our area of operations are not presented in this document and will be implemented in partnership with local governments, following a parallel implementation strategy.

The list of priority resiliency implementation projects presented in this plan includes investments needed to increase the resiliency of the District's main primary system, such as canals and structures enhancement and additional adaptation needs. These projects represent urgent actions to address the vulnerability of the existing flood protection infrastructure within the C&SF system. Additional projects comprise basin-wide flood adaptation strategies that further protect the water supply and water resources of the State. Examples of these projects include adding "self-preservation mode" functionality to water control structures, construction of the South Miami-Dade Curtain Wall, L31E Levee improvements, the J.W. Corbett Wildlife Management Area Hydrologic Restoration and Levee Resiliency project, and the Everglades Mangrove Migration Assessment project (EMMA). Each of these projects helps to increase the functionality and capacity of the District's flood control system and protection of the environment.

Among the projects described in this plan are the forward pump stations to coastal water control structures to restore the original flood protection level of service. These projects might have downstream impacts, which are being assessed and mitigated, as needed, as part of each respective implementation phase. In addition, as part of the ongoing C&SF Flood Resiliency Study, USACE's and SFWMD's project teams will have the opportunity to assess the conditions downstream of the coastal structures and establish not only current conveyance challenges but also the impacts of sea level rise and potential mitigation flood risk management strategies. Nature-based features are being included as part of recommended strategies to provide ancillary water quality benefits.

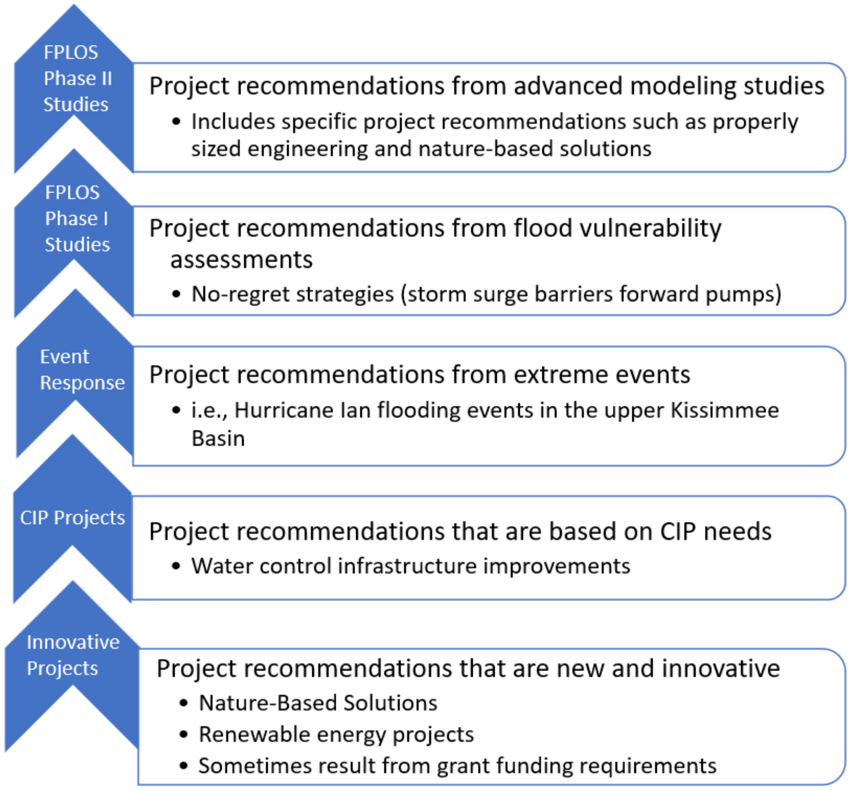

Figure 9-3: Diagram describing how projects are formulated and entered into this plan.

Cost Estimates

The high-level cost estimates for the projects included in this plan were prepared using the District's current understanding of construction costs in the marketplace and historical costs from projects of similar scope. Additionally, the District followed cost-estimating procedures such as those employed by the U.S. Army Corps of Engineers. The initial sizing of each project component is based on the recent FPLOS study results. Appendix A presents the proposed projects descriptions and cost estimates. The number of project components varies by basin due to factors such as topography, hydrology, canal network, existing infrastructure, land use and flood vulnerabilities.

The proposed cost estimates are based on the USACE Civil Works Cost Engineering guideline ER 1110-2-1302 Class 4 and 5 (Planning Level), providing ballpark figures based on high-level cost assumptions and very limited technical information. These estimates commonly referred to as "Rough Order of Magnitude" serve as a starting point for understanding overall costs without delving into specifics. Despite heavily relying on the best historical data and engineering judgment, these estimates are subject to change due to various factors such as cost book information, assumptions, material prices, inflation, indirect costs, and contingencies. For more precise costings, a formal in-depth cost estimate analysis is required if the project progresses to Phase II or III.

The high-level cost estimates for the different projects and project components were calculated by a Professional Engineer certified in the State of Florida. The cost estimates for each forward pump station were calculated based on the range of pumping capacity of the pump station (Table 9-2). For example, a 250 cfs pump station would cost $17,187,500 as the cost per unit of discharge for the "up to 250 cfs range" is $68,750. The cost for canal bank elevations was calculated based on a range of canal bank proposed elevation and average cost per linear feet of $83.33. Dredging costs was based on the dredging volume (cubic yards) from $60 to $160, depending on the location. Canal length, average dredging width and dredging depth are used to calculate the dredging volume. For example, a dredging project in the North New River Canal located in Central Broward has a cost $120 per cubic yard for a total of 35,000 cubic yards is $4,200,000. Raising canal banks is based on the cumulative length in need of raising. For example, a 24,000-foot embankment improvement of an average height of 2 feet would cost $4,008,000, as the cost per square feet raised for 2 ft is $167. Spillways costs are determined by their dimensions and capacity in cubic feet per second (cfs). For instance, a two-gate spillway measuring 20'x 8.4' with a capacity of 3,250 cfs has an estimated cost of $19,819,792, including $16,244,091 for the spillway replacement and $3,575,700 for demolition and removal work.

Culvert costs are calculated based on their capacity and number of barrels. For example, an 8'x 10' gated box culvert with a capacity of 400 cfs and one barrel has total cost of $2,965,191, with $2,578,427 allocated for replacement with automation and $386,764 demolition and removal.

The cost for distributed storage projects includes three components: distributed storage at $15,000 per acre-foot, earthwork based on embankment improvement assumptions (if needed), and design and construction management at 15% of costs excluding real estate. For example, an area requiring 20 acre-feet of storage without embankment improvement is estimated to cost $300,000, with an additional 15% ($45,000) for design and construction management, resulting in a total cost of $345,000.

All estimated costs include backup generators, as appropriate, and the schedules for implementation of the major project components are estimated at an average of 1.5 years for design and 2.5 years for construction. Schedules will be adjusted based on confirmation of project implementation. No Engineering during construction or construction management costs were included. An initial estimate for real estate costs, as well as $2M for tying the structure back to a higher elevation, was 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. Follow up feasibility studies, conducted as part of FPLOS Phase II efforts, will confirm the size and the need for forward pumps. All cost estimates have been updated for 2024 according to SFWMD Engineering and Construction recommendations, based on the building structure cost index adjustment from May 2023 to May 2024 of 7% higher than the 2023 estimates. For pump stations and related items, an increase of 25% was used. According to recent references from USACE and the SFWMD Principal Cost Estimator, Pumps and pump station construction costs have increased significantly over the last year. The 25% increase in these costs represents the District's best professional judgment and are based on the latest engineering and construction cost estimation data.

All newly 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 9-2: Summary of Cost Assumptions

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

Forward Pump Cost Estimates		
Cubic Feet per Second	**Threshold**	**Cost per Unit Discharge**
Up to 250	250	$68,750
250-500	500	$66,250
500-750	750	$63,750
750-1000	1000	$62,500
>1000	Other	$60,000

Canal Widening / Canal Re-Alignment Cost Estimates	
Canal Widening (ft)	**Average Cost (Per linear feet)**
20	$462
50	$920
75	$1,302
100	$1,684

Canal Bank Elevation Cost Estimates	
Canal Banks Height (ft)	**Average Cost (Per linear feet)**
0.5	$42
1.0	$83
1.5	$125
2.0	$167
2.5*	$208
5.0**	$416
7.0***	$583
Note * - Adjustment factor of 25% for heights between 2.5 to 5.0 ft Note ** - Adjustment factor of 50% for heights between 5.0 to 7.0 ft Note *** - Adjustment factor of 75% for heights above 7.0 ft	

Dredging Cost Estimates	
Location	**Cost per Cubic Yard**
North Broward	$60 to 80
Central Broward	$120
Miami	$140
Homestead	$160
Note: Adjustment factor of 22% for dredging depths above 2.5ft	

Material Dredging Cost Estimates	
Material	**Cost per Cubic Yard**
No Limestone	$20 to 25
Limestone	$60 to 75

Hauling	$20 to 25

Distributed Storage Cost Estimates	
Distributed Storage	$15,000 per Ac-Ft (includes culvert, pump, etc. price here)
Earthwork (Raise berms by x ft)	Use canal bank elevation assumptions
Design and Construction Management	15% of costs excluding real estate

Storage Areas Cost Estimates	
Storage Areas	$15,000 per Ac-Ft
Curtain Wall (if needed)	$50 per ft^2

Habitat Replacement/Restoration	$15,000 to 20,000 per acre

Spillway Cost Estimates				
Spillway Gate Dimension	Capacity (cfs)	Number of Gates	Replacement with Automation	Demo & Removal
16′ x 9.2′	800	1	$11,208,423	$2,144,220
22.7′ x 8.5′	945			
14′ x 12′	975			
29′ x 17′	1,230	1	$14,640,420	$2,465,853
29′ x 15′	1,350			
20′ x 8.4′	3,250	2	$16,244,091	$3,575,700
18′ x 11′	2,000	2	$18,992,050	$3,573,700
20.7′ x 4.4′	2,070			
20′ x 8.4′	3,080			
25′ x 13′	2,300	2	$21,680,710	$4,109,755
21′ x 12′	2,330			
28′ x 15′	2,800			
28′ x 18′	3,220			
26′ x 7′	3,390			
26′ x 14′	3,470			
20.7′ x 8′	3,420	3	$36,871,000	$5,360,550 - $5,678,134
22′ x 12.5′	3,670			
22′ x 11.7′	4,800			
25.8′ x 7.7′	4,800			
22 ‵ x 10′	5,900			
26′ x 11′	6,800			
28′ x 18′	7,440			
29′ x 17′	1,800	4	$42,488,182	$7,147,400
23′ x 15′	4,780			
28′ x 14′	28,000	5	$48,610,228	$8,934,250
28′ x 14′	26,000	6	$54,732,273	$10,721,100
Note: This table serves as reference based on size and configuration of existing spillways				

Culvert Cost Estimates				
Box Culvert Dimensions	Capacity (cfs)	Number of Barrels	Replacement with Automation	Demo & Removal
6′x6′ Gated Box	105	1	$676,837	$101,526
7′x7′ Gated Box	282	1	$1,817,791	$272,669
8′x10′ Gated Box	282	1	$2,140,800	$321,120
8′x8′ with Auto Slide Gate	287	1	$1,850,021	$277,503
10′x5′ Gated Box	300	1	$1,611,517	$128,921
6′x10′ OR 8′x8′ Gated Box	300	1	$1,933,820	$290,073

Culvert Cost Estimates				
Box Culvert Dimensions	Capacity (cfs)	Number of Barrels	Replacement with Automation	Demo & Removal
8′x8′ with Auto Slide Gate	304	1	$1,959,605	$293,941
8′x8′ with Auto Slide Gate	308	1	$1,985,389	$297,808
8′x8′ with Auto Slide Gate	316	1	$2,036,957	$305,544
8′x8′ with Auto Slide Gate	334	1	$2,152,987	$322,948
8′x10′ Gated Box	362	1	$2,333,477	$350,021
9′x10′ Gated Box	396	1	$2,552,643	$382,896
10′x10′ Gated Box	396	1	$2,948,590	$442,289
8′x10′ Gated Box	400	1	$2,578,427	$386,764
8′x8′ with Auto Slide Gate	410	1	$2,642,888	$396,433
8′x8′ with Auto Slide Gate	430	1	$2,771,809	$415,771
9′x10′ Gated Box	450	1	$2,900,731	$435,110
9′x10′ Gated Box	900	2	$5,801,461	$435,110
10′x10′ Gated Box	986	2	$6,355,823	$953,373
9′x10′ Gated Box	2,000	2	$7,735,281	$1,160,292
8′x8′ with Auto Slide Gate	480	3	$3,094,113	$464,117
10′x5′ Gated Box	1,800	6	$11,602,922	$1,740,438
Note: This table serves as reference based on size and configuration of existing culverts				

Real Estate Costs – Placeholder Average Costs	$8,750,000

Forward Pump Backup Generator	10% of forward pump costs
Tie-back (flood barriers around coastal structure)	$2,500,000

Real Estate Needs

Early Real Estate investigation efforts play a vital role in ensuring project implementation success by identifying and addressing key considerations related to land availability and acquisition. It helps to evaluate the land interests needed for the project, including factors such as location, size, ownership, and cost. Without these considerations early on, there may risks in acquiring necessary project land.

In addition, real estate costs can represent a significant portion of project budgets. Early real estate investigation assists with cost estimation and budget planning, reducing the risk of cost overruns during project execution. The overall goals and objectives of each project are enhanced through coordination with real estate interests. This includes identifying potential challenges early, optimizing resource allocation, and facilitating effective communication with landowners and collaboration among project partners and the execution process. Some of the key steps in Real Estate efforts include:

1. Research real estate needs for priority projects. At this stage, a preliminary project footprint is created as part of conceptual design plans, and any potential real estate needs are identified.
2. Upon confirmation of real estate needs, a title search is initiated, which informs the process design process.
3. Upon the refinement / confirmation or project footprint, an appraisal is requested, along with necessary legal descriptions to support land negotiations.
4. Upon completion of appraisal, landowners are contacted to begin negotiations.

5. Once all required lands have been acquired the project is ready for construction.

A summary of ongoing real estate efforts current being advanced for the priority projects included in this plan is presented below, in Table 9-3.

Table 9-3: Summary of Ongoing Real Estate Efforts

Project Name	Priority	Location	Real Estate Status	Ownership
C-7 Basin Resiliency (S-27)	High	Miami-Dade	Real Estate Negotiations initiated	Private
C-8 Basin Resiliency (S-28)	High	Miami-Dade	Title research in progress	Public
C-9 Basin Resiliency (S-29)	High	Miami-Dade	Real Estate Negotiations initiated (Draft MOU)	Public
C-6 Basin Resiliency (S-25B)	High	Miami-Dade	Title research in progress	TBD
C-6 Basin Resiliency (S-26)	High	Miami-Dade	Title research in progress	TBD
C-14 Basin Resiliency (G-57)	High	Broward	Title research in progress	TBD
C-2 Basin Resiliency (S-22)	High	Miami-Dade	Title research in progress	TBD
C-12 Basin Resiliency (S-33)	High	Broward	Title research in progress	TBD

Land Resources Needs

Coordination with Land Resources follows a similar process to the Real Estate. Once a project footprint has been identified and project features are chosen, Land Resources can identify and plan for future land management and recreational needs for the project.

Capital Improvement Plan – Priority Projects

Priority resiliency implementation projects were evaluated to confirm that an integrated strategy for implementation is being used. An analysis was completed to identify how each individual CIP project is related to this plan's recommended resiliency projects. The analysis identified projects that have common objectives or overlapping impact areas and that can optimize benefits and continue to ensure that the water management system is operating at peak efficiency.

The District CIP infrastructure investments have been making system improvements beyond the needs identified in Operations and Maintenance inspection reports. These investments are enhancing District's water management systems with additional components and operational capacity, making it possible for the 70-plus-year-old system to function and ensuring the District's flood control mission is accomplished. These ongoing resiliency investments, along with proposed enhancements that account for future conditions, are being implemented through a bundling strategy. Table 9-4 presents a list of CIP projects that will continue to enhance the Central and Southern Florida (C&SF) System and Big Cypress Basin. More information about these projects can be found in the District's CIP.

Table 9-4: List of CIP priority projects.

Category	Project Names
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 Canal Package 3 L8 Tieback – Boil Repair/Dupuis Canal Backfill BCB Canal Improvements (Green, I-75, & Faka Union Canals)
Communication/Control and Telemetry Upgrades and Replacement	Manatee Gate Control Panel Replacements Picayune Command & Control Center SCADA Stilling Well/Platform(C&SF) SCADA Stilling Well/Platform (STA) Tower Repair Program S5A Tower Replacement Faka Union Tower Replacement BCB SCADA Additions & Replacements BCB Communication Tower (Lake Trafford)
Field Facilities Construction Upgrades and Replacement	Fort Lauderdale Field Station Modifications Homestead Field Station Replacement Miami Field Station Modifications and Replacements Gate Overhauls: 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 – MS 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: S362, S127, G420, Picayune Command & Control G251 Dewatering Provision G310 Trash Rake Refurb/Replacement G310/G335 Pump Overhaul G335 Trash Rake Refurb/Replacement G370/372 Concrete Repairs G370/G372 Pump Refurbishments L8 FEB / G539 PS – Resiliency Upgrades S-25B & S-26 Forward Pump Stations pump and generator replacements Pump/Engine Overhauls (C&SF) Grant

Category	Project Names
	Pump/Engine Overhauls (STA) S2, S3, S4 Pump Refurbishments S2, S3, S4, S7, S8 Engine Control Panel Hardening S6 Pump Refurbishment G6A New Pump Station S7 Pump Refurbishment S9/S9A Trash Rakes & Refurbishment S332B Pump Station Replacement and Discharge Channel North Shore Lake Okeechobee Pump Station Expansions G409 Pump Station Replacement Pump Station Modification/Repair Staff Support
Structure Upgrades and Replacement	Fall Protection G57 Wingwall Replacement & G16 G93 IT Shelter and Structure Refurbishment Gate/Hydro Cylinder Overhauls (C&SF) Gate/Hydro Cylinder Overhauls (STA) Generator Replacement Program Hoist Conversion Project S179 & future conversions S167 Wingwall Replacement S169W Trash Rake S26 Major Refurbishment S65 Spillway Replacement S65A Spillway Replacement S65D Spillway Replacement S70 Replacement S71 Replacement S49 Replacement STA1W Structure Refurbishments & Replacements STA1WE1 Outflow Structures Generator Additions G150 & G151W Automation and G136 Culvert Replacement Structure/Bridge Modification/Repair Staff Support Corkscrew Canal Headwater Improvement I-75 Weir 1 & 2 Removal & Replacement Upper Faka Union Replacements (FU5, FU6, FU7 Golden Gate #5 Replacement Henderson Creek Structure Replacements (HC1 & HC1A) Golden Gate #5 Replacement Gordon River #1 Replacement Palm River #1 Replacement

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 supplement the District Resiliency mission by advanced scientific data and research needs to ensure the projects are founded on the best available science. These projects include FPLOS studies, Water Supply Vulnerability Assessment, various monitoring and data collection projects, climate projection, tidal predictions, flood observation data collection, to name a few. The full list of Resiliency Planning Studies, along with project descriptions, is presented in Appendix A and summarized in Table 9-5.

Hydrometeorological 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 are important to characterize observed 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 needs. Hydrometeorological data such as seawater level, air temperature, incoming solar radiation, rainfall, and evapotranspiration rate can provide trends that can help with the prediction of climate change and overall future conditions. Therefore, monitoring stations must be of high quality and structurally stable to minimize environmental disturbances to the station. In this context, the District is implementing a set of water and climate resilience metrics to track and document shifts and trends in District-managed water and climate data. These efforts support the assessment of current and future climate condition scenarios and District resiliency investment priorities. As part of the District's communication and public engagement, the effort will provide information to stakeholders, and public and partner agencies, while supporting local resiliency strategies.

In addition to observed and projected data analysis and monitoring processes, hydraulic and hydrologic modeling efforts are fundamental in evaluating flood risks and 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 Flood Protection Level of Service (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 sea-level rise (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 are detailed in Appendix A.

Table 9-5: List of Resiliency Priority Planning Studies.

1. FPLOS Adaptation and Mitigation Planning (Phase II Studies)
2. FPLOS Assessment (Phase I Studies)
3. Comprehensive C&SF Flood Resiliency Study
4. Water Supply Vulnerability Assessment
5. Water and Climate Resiliency Metrics – Phase I: Web Tool Implementation and Phase II: Enhanced Analyses
6. Hydrometeorological Data Monitoring
7. Statewide Regional Climate Projections
8. Enhancing Tidal Predictions
9. Flooding Observation Survey and Notification System
10. Evaluating the Performance of the SFINCS Hazard Model to Support and Accelerate the FPLOS and SEFL Regional Adaptation Planning Efforts
11. Green Infrastructure Flood Mitigation Strategies - Associating Water Quality Benefits in the Little River Watershed
12. Waterways Impact Protection Effort (Project WIPE-Out)
13. Future Conditions District Internal Resources for Regulation
14. Designing Wetland Habitat Enhancement and Flooding Improvements for Charlotte Harbor Flatwoods Project
15. Corkscrew Watershed Initiative
16. Carbon Storage Monitoring and Reporting
17. A Surface Elevation Table Network To Monitor Accretion

11: 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, SLR, and other climate impacts on water resources and increasing community and ecosystem resiliency in South Florida. This list of projects was compiled based on 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 projects includes investments needed to increase the resiliency of the District's coastal structures, including structure enhancement recommendations and additional 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 and advanced technical analyses.

Through collaboration with local municipalities, Counties, Regional Climate Compacts, and 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, flood-proofing, road elevations, relocation, other local drainage improvements, shoreline stabilization, living shorelines, beach restoration, ecosystem restoration, water resources protection, and others.

Among the next steps for the implementation of the project recommendations included in this plan, the District continues to seek 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 toward Statewide Flooding and Sea Level Rise Resilience. In January 2023, Governor DeSantis signed Executive Order 23-06 to direct funding and strategic action to continue to support the Resilient Florida Program. On June 11, 2023, Governor Ron DeSantis signed House Bill 111 on Flooding and Sea Level Rise Vulnerability Studies. and on May 10, 2024, the Governor signed HB 1557 that amends the use of Resilient Florida Grant Program funds for counties and municipalities, emphasizing flood and sea level rise preparations and enhances coordination for flood vulnerability and statewide resilience planning, including the incorporation of new data sets and assessments, among others. The District received around $70 million in grant award recommendation from this program to support project implementation.

At the Federal level, Federal Emergency Management Agency (FEMA) mitigation and adaptation funding is under consideration, and the District is working to finalize grant agreements with FDEM for the $150 million award recommendations received from FEMA Building Resilient Infrastructure and Communities (BRIC) Program for the C-7 Basin Resiliency Project, C-8 Basin Resiliency Project and C-9 Basin Resiliency Project.

In addition, the District and USACE initiated the C&SF Flood Resiliency Study to recommend adaptation strategies to build flood resiliency in the Communities served by the C&SF Systems. This study was initiated in the Fall of 2022 under the existing authority of the Flood Control Act of 1970 – Section 216 and is currently leveraging advanced hydrologic, hydraulic, and/or hydrodynamic models, representing surface water systems 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 (17). The Section 216 Study focuses 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 is being conducted in coordination with stakeholders, Federal agencies, State, Tribal, and local officials. USACE and the SFWMD are 50/50 cost-sharing partners. The results of this study will allow the immediate authorization of subsequent design and construction phases, and the Final Chief's Report is estimated to be finalized by September 2026.

Finally, the District is committed to continue promoting regional coordination and partnership opportunities by holding proactive discussions, leveraging technical knowledge, and exchanging information. The SFWMD Resiliency Public Forum was kicked off in December 2022 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, which meets quarterly, will continue to foster a constructive environment to discuss tangible asset-level solutions and support decision-making on water resource management.

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Glossary of Terms

Term	Definition
BRIC	Baseline Resilience Indicators for Communities
C&SF	Central & Southern Florida
CEJST	Climate and Economic Justice Screening Tool
CEQ	Council on Environmental Quality
CIP	Capital Improvement Plan
CIP	Capital Improvement Program
District	South Florida Water Management District
EAL	Expected Annual Loss
EJ	Environmental Justice
EMMA	Everglades Mangrove Migration Assessment
FAS	Floridan Aquifer System
FEMA	Federal Emergency Management Agency
FIAT	Flood Impact Assessment Tool
FPLOS	Flood Protection Level of Service
HVRI	Hazards Vulnerability & Resilience Institute
MH	Marker Horizons
NOAA	National Oceanographic and Atmospheric Association
NRI	National Risk Index
NWS	National Weather Service
RSMAS	Rosenstiel School of Marine and Atmospheric Science
SETs	Surface Elevation Tables
SFWMD	South Florida Water Management District
SIP	Structure Inspection Program
SJRWMD	St. Johns River Water Management District
SLR	Sea Level Rise
STAs	Stormwater Treatment Areas
TMDLs	Total Maximum Daily Loads
UM	University of Miami
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
WCA	Water Conservation Area

APPENDIX A – FPLOS PHASE I – INITIAL PROJECT RECOMMENDATIONS

APPENDIX B WATER SUPPLY VULNERABILITY ASSESSMENT APPROACH

South Florida Water Management District

Water Supply Vulnerability Assessment Approach

Planning Assumptions and Scenario Recommendations for the Lower East Coast Planning Region

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Abbreviations

AFSIRS	Agricultural Field Scale Irrigation Requirements Simulation
AG	Agricultural (Demand)
ASR	Aquifer Storage and Recovery
BEBR	Bureau of Economic and Business Research
C&SF	Central and Southern Florida
CERP	Comprehensive Everglades Restoration Plan
DSS	Domestic Self Supply (Demand)
ECFM	East Coast Floridan Aquifer System Model
ECSM	East Coast Surficial Groundwater Model
ET	Evapotranspiration
FDACS	Florida Department of Agriculture and Consumer Service
FEB	Flow Equalization Basin
FIU	Florida International University
FPLOS	Flood Protection Level of Service
FSAID	Florida Statewide Agricultural Irrigation Demand
GCM	Global Circulation Model
GW	Groundwater
ICI	Institutional, Commercial, and Industrial (Demand)
LEC	Lower East Coast
LOSOM	Lake Okeechobee System Operating Manual
MGD	Million Gallons per Day
NOAA	National Oceanic and Atmospheric Administration
PCUR	Per-Capita Use Rate
PWR	Power (Demand)
PWS	Public Water Supply (Demand)
RAA	Regional Allocation Areas
REC	Recreation and Landscape (Demand)
RSM	Regional Simulation Model
SFWMM	South Florida Water Management Model
SLR	Sea Level Rise
STA	Stormwater Treatment Areas
SW	Surface Water
SWM	Surface Water Management
TAZ	Traffic Analysis Zones
USGS	United States Geological Survey
WCA	Water Conservation Area
WSP	Water Supply Plan

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Executive Summary

The South Florida Water Management District (SFWMD or District) is conducting a Water Supply Vulnerability Assessment (WSVA) for the District's Lower East Coast aimed at understanding how future development and climate conditions impact our regional water supply. SFWMD is developing a density-dependent groundwater model – the East Coast Surficial Model (ECSM) – which will initially be run with Sea Level Rise (SLR) scenarios. Additionally, SFWMD is developing future conditions rainfall, evapotranspiration (ET), and temperature datasets to support climate change scenario formulation for follow up ECSM simulations and other regional modeling.

The District created an internal workgroup with representation from various organizational units to develop an approach for identifying and assessing vulnerabilities. Initial scenarios, modeling assumptions, input data selection and limitations, scope, time, and cost were considered in the development of the proposed approach. Table 1 summarizes the majority of the initial recommendations and assumptions that are being integrated into the proposed approach.

To properly analyze the effects of climate change, including SLR, water demand and climate projections will be estimated, and each of the water availability sources will be analyzed as independent "buckets", using selected metrics to assess vulnerability. Initial scenario formulation includes less and more conservative estimate ranges, with degrees of warming, dryness, and sea level rise, along with 2045 and 2075 growth scenario ranges. The outputs of these scenario runs should allow for SFWMD to understand how future conditions may impact overall water resources availability. Future iterations beyond this WSVA may include the analysis of adaptation strategies and their effects.

The WSVA will be build on the 2023-2024 Lower East Coast Water Supply Plan (WSP) update, and other upcoming WSP efforts. Scenario runs A through C are planned to be included in the 2023-2024 LEC Plan Update while the other scenario runs will be conducted after the 2023-2024 LEC Plan Update as part of the WSVA. The assessment will be based on WSP methodologies by independently analyzing the effects of future climate conditions on growth rates, withdrawal rates, and availability of water supply sources. Public supply and domestic self-supply's 20-year BEBR growth rates will be extrapolated to 50 years and their withdrawal rates will be

Table 1. Summary of recommendations in the report.

WS Vulnerability Assessment Future Conditions Recommendations		
Water Demand Projections		
Water Use Category	**Growth Rate**	**Withdrawal Rate**
Public Supply	Extrapolate BEBR Med growth to 2075	PCUR at 50 years
Agriculture	LEC WSP 2045 Rate	AFSIRS with Climate Change Datasets
Landscape and Recreation	Proportional to Population Growth	Use rate at 50 years
Domestic Self Supply	Proportional to Population Growth	PCUR at 50 years
Institutional, Commercial, and Industrial	LEC 2045 WSP Rate	LEC 2045 WSP Rate
Power	LEC 2045 WSP Rate	LEC 2045 WSP Rate
Climate Projections		
Climate Conditions	**Rainfall, Temperature, Evapotranspiration**	**Sea Level Rise**
Datasets	Downscaled GCMs	2022 NOAA Inter Low, Inter High
Existing Availability Source Segmentation		
Availaibility Sources	**Metrics**	**Assumptions**
Surficial Aquifer	GW Levels, TDS, Flow Vectors, Zone Budgets	Canal Stages, Flows from RSM, Tidal
Shallow Impoundment	Storage, Water Depth, Overland Flow	
Unsaturated Zones	Storage	
Canals	Storage, Stages	Conveyance, Quality, Structure Operations
Lakes	Storage, Inflows/Stages	
Reservoirs	Storage	Seepage, Level of Service
Scenario Formulation		
Scenario Run	**Growth Variable**	**Climate Variable**
A (LEC WSP)	Base Condition	Current Climate
B (LEC WSP)	BEBR Med 2045	Current Climate
C (LEC WSP)	BEBR Med 2045	SLR1
D (WS Vuln)	BEBR Med 2045	Warmer and Drier
E (WS Vuln)	BEBR Med 2045	Warmer, Drier, & SLR1
F (WS Vuln)	BEBR Med 2045	Hot, Driest, & SLR2
G (WS Vuln)	BEBR Med 2075	Current Climate
H (WS Vuln)	BEBR Med 2075	SLR1
I (WS Vuln)	BEBR Med 2075	Warmer and Drier
J (WS Vuln)	BEBR Med 2075	Warmer, Drier, & SLR1
K (WS Vuln)	BEBR Med 2075	Hot, Driest, & SLR2

calculated using the WSP per capita use rate. Agriculture, landscape, and recreational withdrawal rates will include projected temperature, rainfall, and ET rates at 50 years in the future. The ECSM will incorporate SLR as a boundary condition, and future temperature, rainfall, and ET conditions.

Water Supply Vulnerability Assessment Approach

Introduction and Background

The South Florida Water Management District (SFWMD or District) is conducting a Water Supply Vulnerability Assessment (WSVA) aimed at understanding how future development and climate change, including sea level rise, impact regional water supply, and how improvements to water management, water allocation rules, and to the regional system infrastructure can be prioritized to increase resilience.

The purpose of this report is to provide a summary of planning assumptions and scenario recommendations to serve as guidance to the WSVA implementation process for the LEC Planning Area, establishing an internally agreed upon approach, and assessment intention. The report is also intended to serve as a documented process for developing a vulnerability assessment that can be replicated in other planning regions and also by other agencies and stakeholders.

The report is structured into four main sections based on the proposed assessment approach: Water Use Category Growth and Withdrawal Rates, Future Climate Conditions, Availability Sources, and Scenario Formulation. The appendix contains additional details to support understanding of the thought process behind the summarized assumptions and recommendations.

Global and Local Context

Changing climate conditions impact water supply and demand across the region, at micro and macro scales. The District has incorporated qualitative summaries of the potential effects of climate change and future conditions on water supply as part of its Water Supply Plans (WSP) and other related initiatives to provide sustainable water supply for reasonable-beneficial water users while not causing harm to water resources and related natural systems. To improve upon these efforts, the District will be conducting a WSVA that will use advanced modeling to analyze the water supply vulnerability as a result of future climate conditions, including sea level rise (SLR) and increasing demands on those systems beyond the current WSP 20-year planning horizon.

The first WSVA will incorporate the SFWMD’s Lower East Coast (LEC) water supply planning area, which includes Palm Beach, Broward and Miami-Dade counties and portions of Monroe, Collier, and Hendry counties.

The WSVA will look at how changes to temperature, rainfall, evapotranspiration (ET), SLR, and growth projections affect availability of various water sources for human uses while not harming water resources and related natural systems. The proposed assessment will help the District make informed decisions on its many water management responsibilities and support partner agencies in their planning needs.

South Florida’s unique hydrogeologic, meteorological, and supply/demand system requires a dedicated vulnerability analysis to properly plan for future conditions. However, there are many interdependent complexities between management practices, stakeholder needs, and current and future physical conditions that present challenges to the completion of a comprehensive vulnerability assessment. Therefore, as a preliminary approach, the proposed assessment is intentionally limited in scope and purpose to allow for future iterations based on lessons learned.

This is the first time that a dedicated South Florida water supply assessment will look at the combined effects of SLR, climate change variables and future growth in demands. Hence, there are no best practices or standardized procedures to rely upon. Additionally, due to the complexity and requirements of the models initially identified to conduct the proposed assessment, the criteria for success, as well as the modeling approach, were carefully considered in the assessment planning process. This report summarizes initial recommendations for the above-mentioned considerations and will serve as the basis for the concurrent assessment scoping. These considerations and recommendations are a result of eight months of internal workgroup discussions, with representation from Water Supply, Water Use Permitting, Office of Counsel, Resiliency, and Hydrology & Hydraulics bureaus.

What follows is documentation on processes as well as the initial workgroup recommendations regarding approaches for assumptions for growth rates, withdrawal rates, climate variables, water availability, and model scenarios and plan for assessment execution.

The Need for an Assessment

Florida statutes requires that WSPs be based on at least a 20-year planning horizon and updated at least every five years. WSP provide a roadmap on how projected water demands can be met without causing harm to the water resources within the planning horizon. While 20-year planning periods serve as an adequate planning horizon to provide guidance to various water use studies, such as utility master planning, regional water resources development and natural resource protection studies, the 20-year planning horizon is not sufficient to evaluate the longer-term effects of climate change and SLR and anticipated potential adaptation and mitigation needs. WSPs consider climate change and SLR possible impacts, but are not formulated yet to adapt to the impacts of longer-term projected climate and growth.

The current WSP 5-year updates being developed by the District have a planning horizon of 2045. WSP, in general, base their emphasis and technical process on the paradigm of how water users can meet current and future demands for at least a 20 year planning horizon. For example, WSP use historic data and observations with 20-year demand projections in their scenarios. Consequentially, this categorizes availability of sources as entities to meet demands based on existing conditions rather than as systems with vulnerabilities that have evolving characteristics over longer time periods. As a result, there is a need for the development of an assessment outside of the WSP process that takes a dedicated look at each source's inherent vulnerabilities and understand the nature of and effects caused by each source's vulnerability characteristics as they change over longer time periods.

The proposed WSVA will look at the vulnerabilities inherent within each source as a function of its interactions with the hydrological system and using its features, demands, and climate parameters as inputs. This allows the District to assess vulnerability as an independent parameter, which can then be addressed through targeted adaptation and mitigation strategies that can increase the relevant source's resilience. Furthermore, the concept of water supply resiliency is best approached from a regional perspective, beyond the distinction of boundary lines -- either agency, permittees, or otherwise. The WSVA, like the WSPs, can provide an integrated systems perspective to vulnerability and resiliency.

Lastly, it's important to note that the assessment will be designed around usefulness for water supply planners, managers, and water users. For instance, given that infrastructure investments and their engineering designs are typically based on a 50-year lifespans as part of future planning efforts; a 50-year time horizon is being recommended.

Internal Workgroup

To incorporate input from the many organizational units within the District, an internal workgroup was created with representation from Resiliency, Water Supply, Water Use Permitting, Office of Counsel, and Hydrology & Hydraulics bureaus to develop the approach, decision variables, scope, and recommendations that will be used in the assessment. This group was selected and identified to ensure that all relevant business areas were represented, and their inputs were included in initial considerations for the proposed assessment. As part of these discussions, in-depth research was conducted, and the latest science and methodologies used by industry, academia, and similar agencies were presented. The workgroup met for a period of eight months to finalize its initial recommendations and discuss major assumptions.

The discussions were segmented into the following categories: Water Use Category Growth Rates and Withdrawal Rates, Climate Change Variables, and Sources of Water Availability. These categories were intentionally selected to match those referenced in the WSP to leverage existing modeling demands and assumptions and to serve as a supplement to the analysis conducted to support the WSP. However, these categories differ from the WSP in that they were discussed in relation to climate change. For instance, the workgroup discussed how the growth of Public Supply might be affected by climate change in a way that is not already captured using current WSP methodology.

Every additional changing variable introduces the need for further comparative model runs, which requires additional resources and scoping. Therefore, when possible and appropriate, the option of no change from WSP procedures was selected as the recommendation. It should be noted that all the variables discussed for this initial iteration of the WSVA are based on and applicable to the LEC planning area. Future iterations of a WSVA may necessitate different assumptions.

Figure 1 presents a schematic that highlights the overall approach taken by the District to incorporate climate change effects such as SLR and changing rainfall and ET patterns, and future growth conditions in the WSVA for the LEC planning area. The details of the discussions, the research presented, and the explanation for the recommendations that were made are documented below. The following sections are intentionally written as a documentation of the technical discussion process and initial proposed recommendations rather than conclusive suggestions. The process will adapt based on best available information and the knowledge gained as the WSVA progresses.

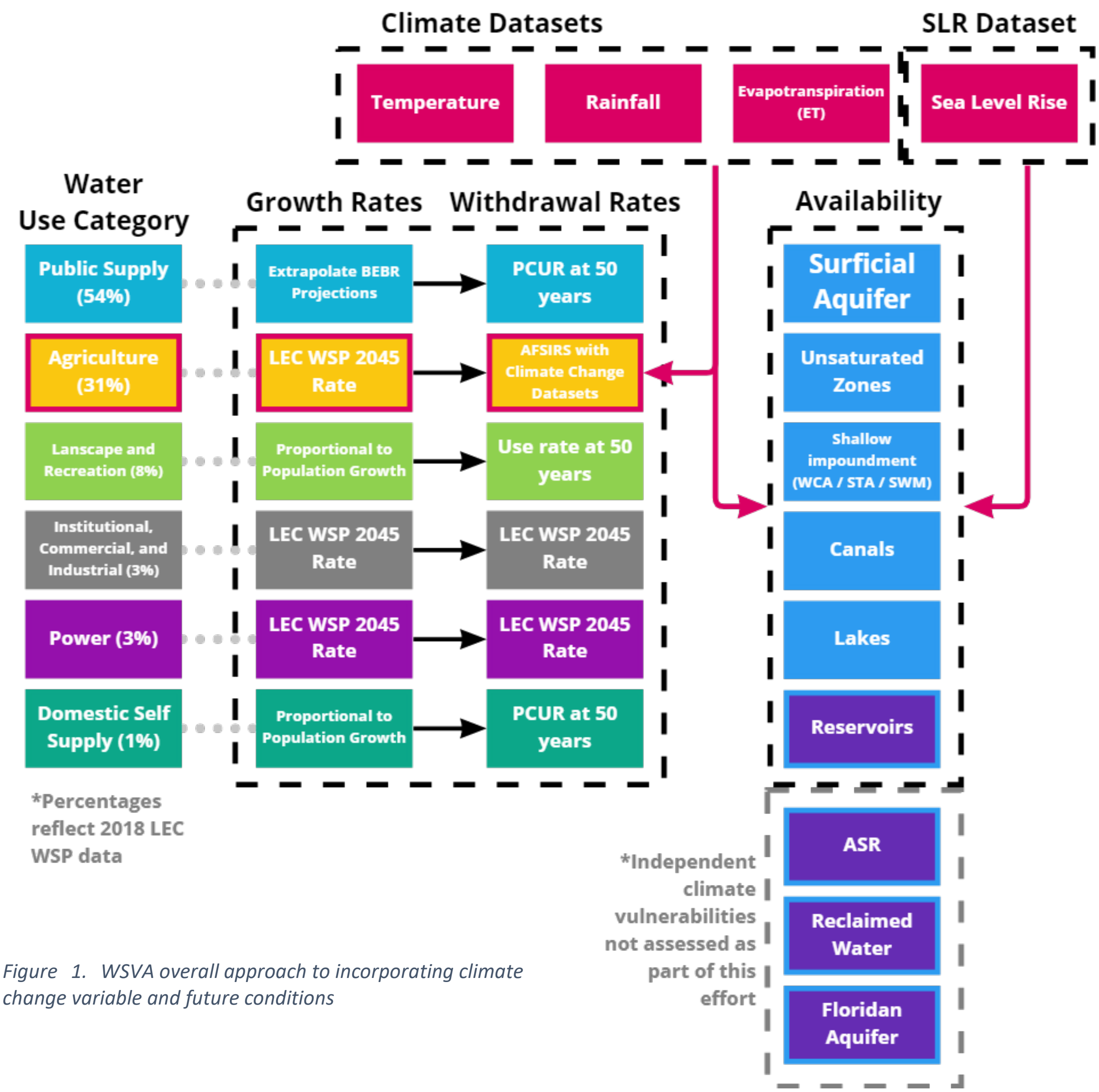


Figure 1. WSVA overall approach to incorporating climate change variable and future conditions

Water Use Category Growth and Withdrawal Rates

Projected water use demands are determined as a function of each water use category's projected growth rate and their projected per unit withdrawal rates. The recommended approaches to project future growth and withdrawal rates for each of the water use categories - Public Supply, Agricultural, Landscape and Recreation, Institutional, Commercial, and Industrial, Power, and Domestic Self Supply – are summarized below. These water use categories, and overall proposed approach to estimate demands, leverage the methodology developed for the LEC WSP. See Appendix A: Water Use Category Growth and Withdrawal Rates for detailed workgroup discussion, relevant research, and major assumptions used in developing the approach for each water use category.

Public Supply Demand

Public Supply (PS) is defined as potable water supplied by water treatment plants with average gross (raw) pumpage of 0.10 million gallons per day (mgd) or greater. In the LEC, PS accounted for 49% of total demands in 2016, of which 94% came from fresh surface water and groundwater sources. In the LEC WSP, population growth and distribution is derived from multiple sources of information, including county-level data from the University of Florida Bureau of Economic and Business Research (BEBR), sub-county data from traffic analysis zones, local data from local government comprehensive plans, and United States census data. This population is further divided into utility service area by using utility service area GIS coverages.

The PS withdrawal rate is calculated by applying a utility-specific per-capita use rate (PCUR), which is calculated in the LEC WSP by taking the monthly and yearly utility-specific finished water data reported to Florida Department of Environmental Protection (FDEP) and dividing it by the utility's estimated population (permanent residents) utility-served service area population. The most recent 5 years PCURs are averaged to develop an average utility-based PCUR, which is then applied to the utility-served population projections to calculate the projected demand at five-year increments for a 20-year planning horizon.

For the PS water demand estimation in the proposed WSVA, it is recommended that BEBR's 20-year county level Medium projection be extrapolated out to 2075 to account for population growth, and that the PS withdrawal rate methodology adopted in the current WSP approach, as summarized above, is replicated for the 2075 estimated growth.

Agricultural Demand

Agricultural demand (AG) is defined in the LEC WSP as self-supplied water used for commercial crop irrigation, greenhouses, nurseries, livestock watering, pasture, and aquaculture. In the LEC, AG accounts for 37% of total demands in 2016 of which approximately 99% comes from sources considered in the proposed WSVA.

The WSP methodology for projecting agricultural growth is based on the irrigated agriculture growth maps generated by Florida Department of Agriculture and Consumer Services (FDACS) in the Florida Statewide Agricultural Irrigation Demand (FSAID) report. These reports are generated annually and contain parcel level polygons of statewide agricultural lands (ALG) and agricultural irrigated lands (ILG) including crop type projected out to 25 years.

The AG water withdrawal rate is determined in the WSP using the Agricultural Field Scale Irrigation Requirements Simulation (AFSIRS) model (Smajstrla 1990). The FDACS irrigated crop acres, soil types, growing seasons, and irrigation methods are used as input data for the AFSIRS model. AG withdrawal rate estimates and projections are based on the typical commercially grown crop categories developed by the FDEP and water management districts for use in water supply plans. The demands of these crops are then calculated for an average rainfall year and a 1-in-10-year drought.

For the AG water demand estimation in the proposed WSVP, it is recommended that the AG growth rate adopts the current LEC WSP approach and utilizes the same estimated acreage. Although it is likely that these acreages will change as a result of climate change, there isn't an established process for projecting that change beyond the 25 years developed in FSAID. For the AG withdrawal rates, it is recommended that the AFSIRS approach adopted in the LEC WSP is applied with the simulation of future climate conditions.

Landscape and Recreational Demand

Landscape and Recreation demand (REC) is defined in the LEC WSP as self-supplied and reclaimed water used to irrigate golf courses, sports fields, parks, cemeteries, and large common areas such as land managed by homeowners' associations and commercial developments. In the LEC, REC accounts for 8% of total demands in 2016 of which approximately 71% comes from sources considered in the proposed WSVA assessment.

In the LEC WSP, growth in REC demands were increased proportionally with population growth. However, because golf is a unique use case that accounts for a significant portion of REC demand and is influenced by different parameters than other recreation and landscape uses, its growth is segmented from other REC demands and increases/decreases are done on a case-by-cases basis based on local best-available information.

While in the past REC withdrawal rates have been calculated using AFSIRS, the 2023 update to the LEC WSP will use water use data from the District's Estimated Annual Water Use Report. This methodology will likely follow a similar approach to PCUR developed for PS noted above.

For the REC water demand estimation in the proposed WSVP, it is recommended that the REC growth rate adopts the current LEC WSP approach and utilizes the same projected REC withdrawal rates.

Institutional, Commercial, and Industrial and Power Demands

Industrial, Commercial, and Institutional (ICI) demand is defined in the LEC WSP as self-supplied water associated with the production of goods or provision of services by industrial, commercial, or institutional establishments. In the LEC, ICI accounts for 3% of total demands in 2016 of which approximately 65% comes from sources evaluated in the proposed WSVA assessment.

Power Generation (PWR) demand is defined in the LEC WSP as self-supplied and reclaimed water used for cooling, potable, and process water by power generation facilities. In the LEC, PWR accounts for 2% of total demands in 2016 of which approximately 0% comes from sources considered in the proposed WSVA assessment (2018 LEC WSP). Power Generation facilities primarily use seawater, brackish groundwater, and reclaimed water to meet 100% of the demands.

ICI growth is captured on a case-by-case basis with the addition of known permits and population projections while PWR growth is captured exclusively on a case-by-case basis in consulation with power utilities, principally Florida Power and Light. Withdrawal rates are captured by WUP annual reports and not projected for WSPs.

For the ICI and PWR water demand estimation in the proposed WSVP, it is recommended that the ICI and PWR growth rate adopts the current LEC WSP approach and utilizes the same projected ICI and PWR withdrawal rates.

Domestic Self Supply Demands

Domestic Self Supply (DSS) demand is defined in the LEC WSP as potable water used by households served by small utilities (less than 0.10 mgd) or self-supplied by private household wells. In the LEC, DSS accounts for 1% of total demands in 2016 of which 100% comes from sources evaluated in the proposed assessment. It is assumed that approximately 50% of DSS wells are also used for irrigation. DSS projections are developed simultaneously with PS population estimates and projections and uses the same PCUR as

PS.

For the DSS water demand estimation in the proposed WSVA, it is recommended that the DSS growth rate adopts the current LEC WSP approach and utilizes the same projected DSS withdrawal rates.

Future Climate Conditions

50-year Time Horizon

As stated above, the purpose of the WSVA is to understand how climate change may affect water supplies. The gradual nature of climate change makes it difficult to see its effects in the short term and at the same time it is in the short term that the most effective mitigation can take place. The proposed assessment is therefore looking beyond the typical 20-year planning horizon and modeling a water future that exists when the expected consequences will likely be felt and measurable. For this reason, the proposed WSVA will look at conditions in 50 years, or 30 years beyond that reviewed in the LEC WSP.

Similarly, adaptation and mitigation strategies that may be simulated as part of long-term modeling should not be evaluated beyond 50 years due to high levels of uncertainty. Infrastructure lifespans are usually 50 years and outputs of the model runs will be informative and helpful to infrastructure planners. Furthermore, regional water supply projects, such as the C-51 reservoir, required permit applicants to submit 50-year demand estimates, which were required to financially justifying the development of the reservoir.

Sea Level Rise

Sea Level Rise (SLR) will likely be one of the most critical effects of climate change on the region. While the effects of SLR on flooding are being studied as part of the District's Flood Protection Level of Service (FPLOS) program, the effects of SLR on water supply in South Florida have yet to be modeled and analyzed. To investigate these effects, the ECSM – a density-dependent groundwater model of the Surficial Aquifer System (SAS) is being developed, which will allow us to explicitly simulate saltwater movement, including that associated with SLR. The SLR projections will be included into the model application for the 50-year scenario.

There are many SLR projections based on different methodologies, data, and potential application. Section 380.093.(3).(d).3.b., F.S. associated with the Resilient Florida Program and the FDEP Sea Level Impact Projections (SLIP) assessments state, at a minimum, assessments should include the NOAA 2017 Intermediate High and Intermediate Low curves. In February 2022, NOAA published their latest update to the Sea Level Rise Scenario projections (NOAA Technical Report NOS 01), which is based on updated data and the latest methodologies. Table 2 and Figure 2 shows a comparison of the two projections, highlighting the 2022 projections lower ranges of uncertainty.

Table 2. The difference in the SLR projected height for Virginia Key, FL between NOAA 2017 and 2022 projections.

NOAA Curve/SLR (ft)	2017 (2040)	2022 (2040)	2017 (2060)	2022 (2060)	2017 (2080)	2022 (2080)
Intermediate Low	0.69	0.36	1.08	1.21	1.44	1.67
Intermediate	1.05	0.82	1.8	1.44	2.72	2.36
Intermediate High	1.41	0.92	2.56	1.87	4.1	3.38
High	1.77	1.02	3.38	2.3	5.61	4.46

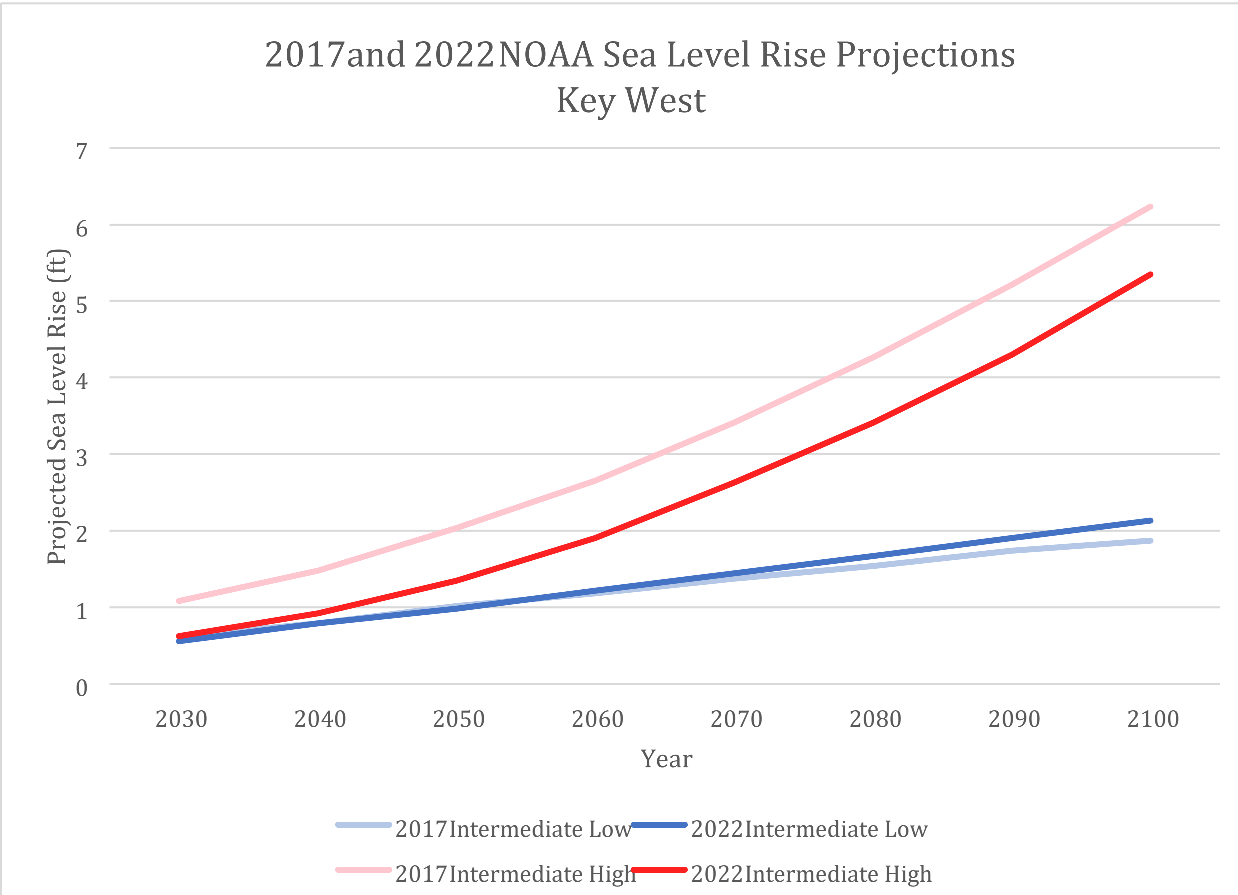


Figure 2. 2017 and 2022 Intermediate Low and High NOAA Sea Level Rise Projections for Key West.

Based on the updated 2022 NOAA projections, this vulnerability assessment will use the 2022 NOAA Intermediate Low and Intermediate High curves as the initial projected SLR scenario. The Florida Flood Hub, in coordination with FDEP Resilient Florida Program, is currently coordinating and leading a scientist workgroup in charge of proposing statewide SLR projections. To maintain approach consistency, the District will adopt Resilient Florida statewide recommendations, as applicable.

To incorporate SLR in the ECSM boundary conditions, a future conditions tidal dataset with daily maximum, minimum, and average elevations will be developed based on an observation dataset, offset per the selected 2022 NOAA curves. Figure 3 shows an example of how a tidal observation dataset may be offset to account for future SLR. The future conditions tidal dataset is currently under development and will undergo a thorough statistical analysis and review process before being incorporated into the WSVA modeling.

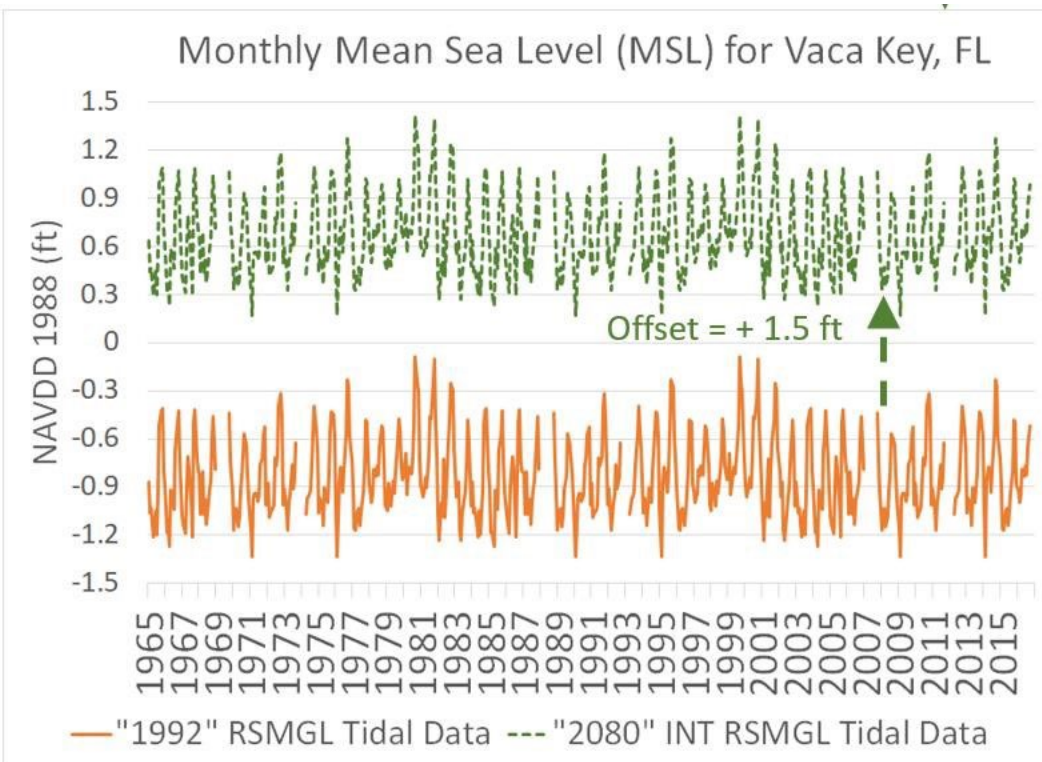


Figure 3. Example tidal observational dataset offset for future SLR.

Temperature, Rainfall and Evapotranspiration

Temperature changes and their effects on rainfall and evapotranspiration will likely have a major effect on water supply. In anticipation of this and other District resiliency efforts, the United States Geological Survey (USGS) and Florida International University (FIU) are partnering with the District to assess and develop suites of rainfall and ET datasets to be used for regional and subregional planning.

These datasets are designed around the premise that climate conditions are non-stationary and therefore incorporate evolving conditions. The non-stationary conditions use Global Circulation Models (GCM), which include empirical and physics-based models that incorporate elements of dynamics, chemistry, and biology of the atmosphere, biosphere, and the oceans as well as greenhouse gas emissions. These GCM have large scales (100km-250km) and therefore need to be downscaled to regional and subregional levels.

The preliminary projection ranges produced by FIU and USGS used statistically and dynamically downscaled datasets. Each of these downscaled datasets were statically analyzed and compared to each other and to observational data. The top ten best performing models with the highest correlation, low root means square error, and a Climate Performance Index (MCI) < 0 and a Model Variability Index (MVI) < 0 for each climate region were selected for the determination of scenario ranges. Figure 4 summarizes the approach used to develop the future climate datasets.

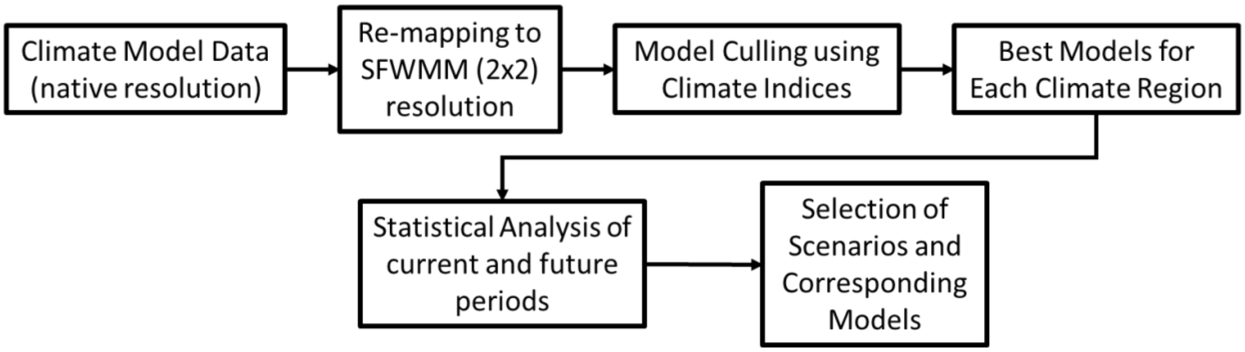


Figure 4. Summary of the adopted approach to modeling future climate scenarios.

While full ET projections require additional climatic variables such as wind speed and relative humidity, temperature is one of the primary drivers and an output of the produced datasets. Figure 5 shows that the average daily maximum temperature is expected to increase considerably. Higher temperatures especially at night result in greater water losses and therefore increased demands.

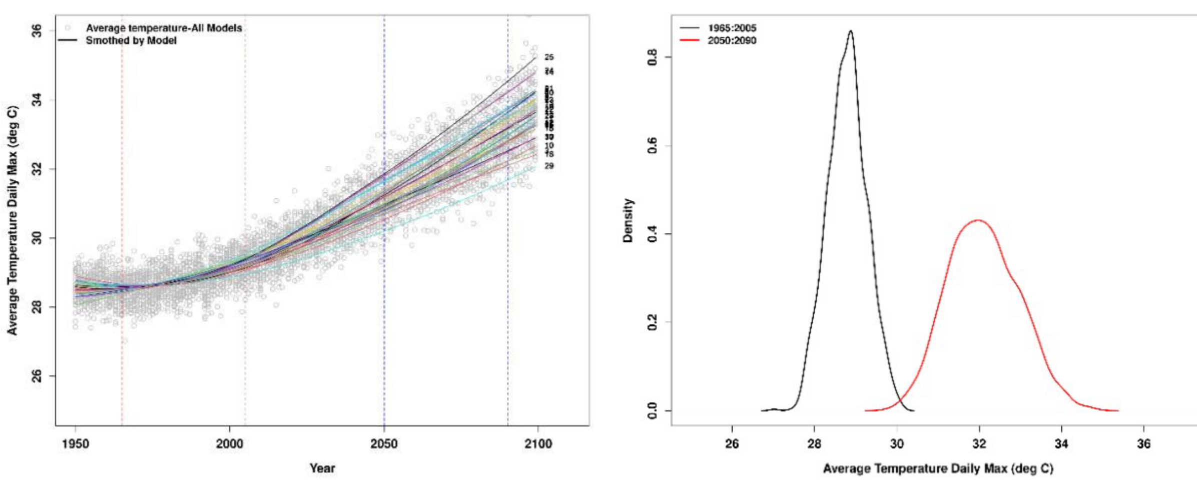


Figure 5. Time Series of gridded average tasmax for all climate models in the LOCA dataset, (b) Kernel Density Functions of tasmax for base and future periods.

Additionally, an overall decrease in annual total precipitation is initially predicted as shown in Figure 6 below.

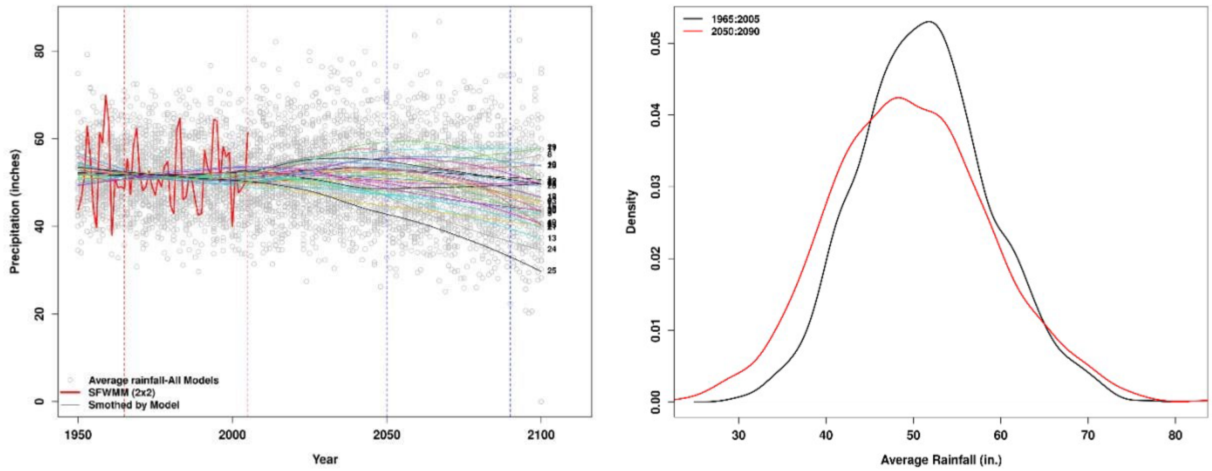


Figure 6. Time Series of gridded average rainfall for all climate models in the LOCA dataset. Also shown is the SFWMM (2x2) average rainfall and smoothed PRCPTOT for each model.

There will be further development and evaluations of the above summarized approach and their eventual datasets based on the model input needs. This development will likely result in future climate datasets that can be used throughout the District's modeling efforts and will follow a thorough internal review process. Additional regional future conditions temperature, rainfall, and ET projections may be developed to fully address future climate scenario uncertainty and will depend on the regional groundwater and surface water model's needs and outputs. The results will be updated and shared as they are developed.

Water Availability

System Overview

When assessing the vulnerability of water supplies due to climate change, there are many assumptions and simplifications that must be considered. By using the models and frameworks represented in the LEC WSP as a starting point, we can create an approach for how model outputs may be interpreted and used to understand system vulnerability. At the same time, we can analyze each element in the system as an independent entity with vulnerabilities related to its inputs, outputs, demands, management systems, and additional inherent characteristics.

The Block Diagram in Figure 7 shows how the interactions between the hydrologic system are modeled in the South Florida Water Management Model (SFWMM). For the proposed assessment, a similar simplified diagram was developed below to highlight the intricate hydrology of South Florida and how the influence of future climate conditions and demands will be analyzed and understood from a systematic vulnerability point of view. The System Vulnerability Block Diagram in Figure 9 and its legend in Figure 8 is based on segmentation of the hydrologic characteristics as they are described in the LEC WSP. It should be noted that major assumptions regarding

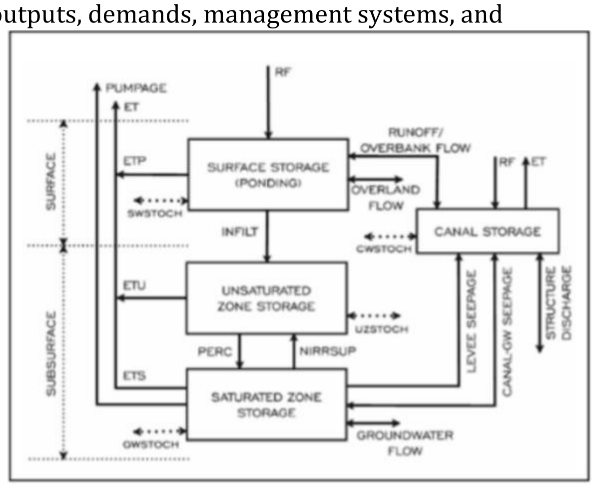


Figure 7. SFWMM Block Diagram.

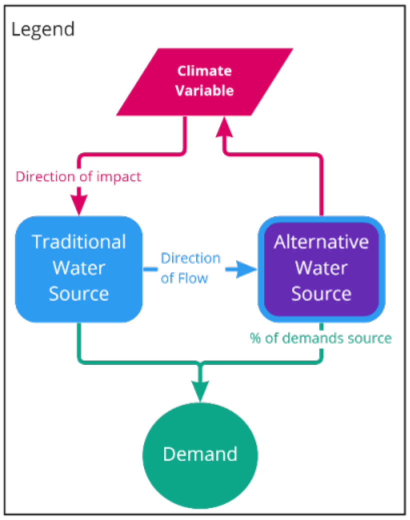


Figure 8. System Vulnerability Block Diagram Legend.

ecosystem demands and flood protection management are included in model development but not shown below.

The parallelograms represent the climate vulnerability variables that will be changing in the proposed assessment. The rectangles with the rounded edges represent water sources with blue fill representing traditional water sources and purple fill representing alternative water sources. The circles represent demands, and each color corresponds to a different demand use case. The connections with arrows indicate flow of water with blue representing regular water flows, red representing climate variable, and multi-color demands representing each source of demand with the associated percentage from source as indicated in the 2018 LEC WSP Demands.

Note: Shallow impoundments, unsaturated zones, canals, lakes, and reservoirs are combined as surface water for simplification of demand allocation. Additionally, SLR may have numerous cascading impacts; however, we are still unsure of its effect on the overall supply and demand. SLR will be incorporated as boundary conditions and therefore doesn't have an arrow indicated direction of flow or impact.

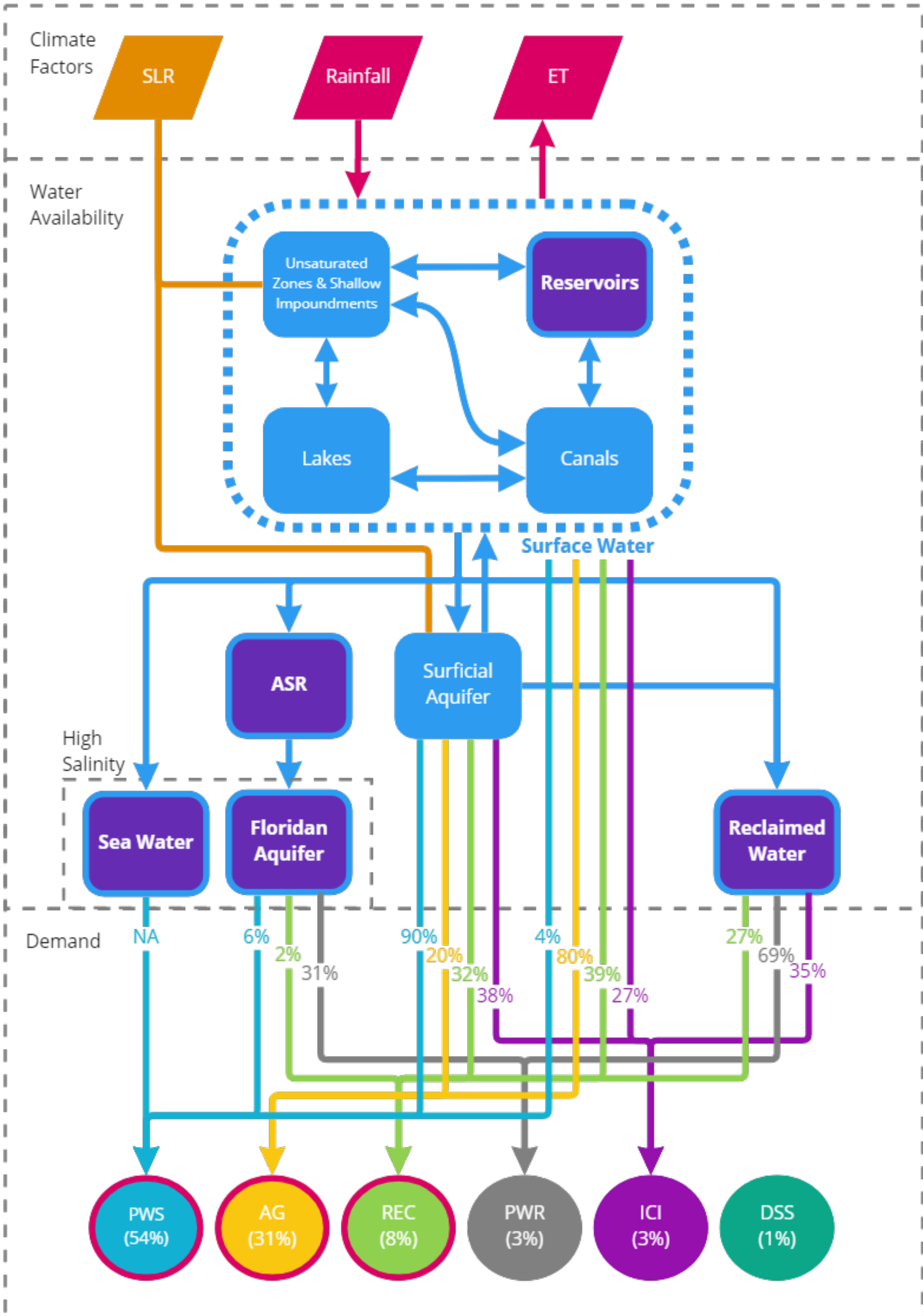


Figure 9. Vulnerability Block Diagram highlighting climate influences, supply sources, and demand.

Models

In the LEC, there are three major surface and groundwater water models to support the assessment of the regional water resources system: the East Coast Surficial Model (ECSM), the Regional Simulation Model (RSM), and the South Florida Water Management Model (SFWMM or 2-by-2). The ECSM, RSM, and SFWMM are all being recommended for the WSVA as they model different components of the system that need to complement each other to get comprehensive and accurate scenario runs. Various water sources and sinks, boundary conditions, and management systems may be captured in one model but not the other and so connections between them have to be established. As model simulations are developed, they need to be continuously checked and equilibrated. This iteration between models is a complex, time consuming, resource intensive, and essential process that ensures results are comprehensive and valid.

The ECSM is a regional model extending north to south from Vero Beach to Marathon and east to west from the Atlantic Coast to the L-2 Canal. While the ECSM is the primary model to be used for the WSVA, the RSM and SFWMM runs will be used to develop the boundary conditions for the ECSM including those related to structure operations and flows from Lake Okeechobee. The ECSM is a 5-layer model that uses daily stress periods with a 1,000 ft x 1,000 ft cell size grid to provide information on daily water levels, monthly total dissolved solids (TDS) concentrations, and 30-day average structure flows. The ECSM code is based on SEAWAT v 4.0 and uses specialized District packages among which are the wetland, routing, and data management packages. After calibration and peer review, ECSM will be used to simulate demands for the 2024 LEC WSP Update and then the WSVA.

The RSM simulates the coupled movement and distribution of groundwater and surface water in conjunction with the coordinated operation of canals and water control structures in South Florida. The RSM has two principal components, the Hydrologic Simulation Engine (HSE) and the Management Simulation Engine (MSE). These components allow for the simulation of management actions and their hydrologic responses. The HSE simulates natural hydrology, water control features, water conveyance systems and water control bodies. The HSE component solves the governing equations of water flow through both the natural hydrologic system and the man-made structures. The MSE component provides a wide range of operational and management capabilities to the RSM by implementing water control structure rules, canal stage maintenance levels and reservoir operating guidelines. Since there is not a single unique way that operations can be executed, the MSE is designed to provide a flexible, extensible expression of management simulation and optimization targets employing a suite of modern control algorithms.

The SFWMM is a regional-scale model that simulates the hydrology and the management of the water resources system from Lake Okeechobee to Florida Bay. It covers an area of 7,600 square miles using a mesh of 2x2 mile cells. In addition, the model includes inflows from the Kissimmee River, and runoff and demands in the Caloosahatchee River and St. Lucie Canal basins. The model simulates the major components of the hydrologic cycle in south Florida including rainfall, evapotranspiration, infiltration, overland and groundwater flow, canal flow, canal groundwater seepage, levee seepage and groundwater pumping. It incorporates current or proposed water management control structures and current or proposed operational rules. The ability to simulate water shortage policies affecting urban and agricultural water uses, and environmental needs in South Florida is a major strength of this model. The SFWMM simulates hydrology daily using observational climatic data periods which includes droughts and wet periods.

There are many other District models some of which are used for water supply purposes like the East Coast Floridan Aquifer System Model (ECFM). However, these models are not highlighted in this report as they will likely not be used to conduct the assessment.

Defining and Measuring Vulnerability

Defining and measuring water supply vulnerability are independent yet connected resiliency concepts. For this assessment, they are combined in that we are only able to measure the parameters that the models can capture, and therefore vulnerability is defined based on model output metrics. As the WSVA models are run, the assessment will further define the thresholds and perhaps additional metrics for each output. These thresholds will likely depend on various factors such as location, hydrologic context and impact, demand dependencies, or even the ease of a implementing a particular adaptation or mitigation strategy. These vulnerability definitions and thresholds will be based on model outputs and were initially considered as part of workgroup selection of relevant recommended metrics.

To develop recommendations for analyzing source vulnerabilities, the workgroup segmented each of availability sources into "buckets" based on their hydrologic similarities, management systems, and modeling capabilities and to highlight the temporal and spatial stressors and stresses characteristic to each type of source. For example, the recommended outputs for the bucket representing canals are storage and stage. These are recommended based on the ability for the models to compute those metrics, their usefulness to water managers and planners, and their potential for assessing future demand and climate impacts among other considerations (see Canals). IDEF0 diagrams were developed for each source to facilitate workgroup discussion and their input assumptions and output recommendations are discussed below.

Figure 10 depicts how each bucket's variables are defined. Blue arrows represent the flow of water and red arrows represent climate variables potentially impacting the respective source as part of the proposed assessment. Orange lines represent how each bucket is modeled and therefore potentially what its input requirements and output limitations are. Black lines represent District management systems that may be impacted as part of the vulnerability assessment. Lastly, the top right box contains the recommended output metrics that will be used to measure relative vulnerability and the bottom right box contains major model input assumptions identified by the workgroup.

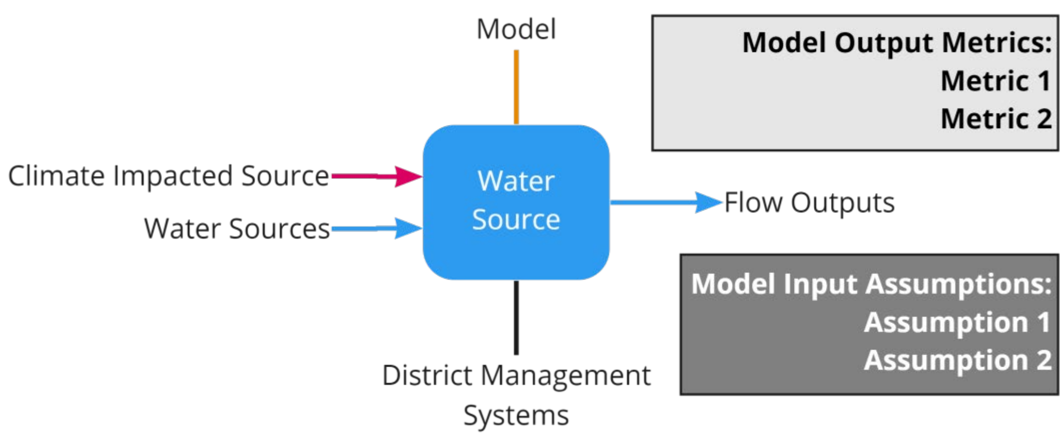


Figure 10. IDEF0 diagram legend for water availability sources.

Availability Sources

It is recommended that for the WSVA the following be analyzed as independent and combined availability sources: shallow impoundments, unsaturated groundwater, canals, lakes, reservoirs, and the surficial aquifer. Future assessments may include analyzing the Floridan Aquifer, reclaimed water, seawater, and Aquifer Storage and Recovery (ASR).

Note: Environmental (ENV) water needs including supply to Everglades National Park and other water conservation areas are met via different assumptions and related management strategies such as Minimum Flows and Minimum Levels (MFL) and Restricted Allocation Areas (RAAs). These assumptions may not be called out specifically; however, they are incorporated as the assumptions carried over from adopting WSP methodologies. Additionally, all approved future Comprehensive Everglades Restoration Plan (CERP) projects that are part of the Integrated Delivery Schedule and are currently being modeled as part of the CERP Update effort, are suggested to be included as future condition simulation assumptions.

Shallow Impoundments

Shallow impoundments are all confined and unconfined surface water accumulation that is not otherwise segmented in the block diagram in Figure 9. This category includes vast swatches of wetlands, such as the Everglades National Park and Water Conservation Area or the Arthur R. Marshall Loxahatchee National Wildlife Refuge, as well as dispersed water management projects. These features will be represented in the ECSM layer 1 and likely simulated through the Wetlands Package.

The major features included in shallow impoundments are Water Conservation Areas (WCA), Stormwater Treatment Areas (STA), and Surface Water Management Areas (SWM). This bucket is currently modeled primarily by the SFWMM and the RSM. The District regulates this bucket as part of MFL and Water Use Permits (WUP) for some AG and REC demands. In addition to precipitation, water flows into shallow impoundments via urban and rural surface runoff, as well as from groundwater, canals, lakes, and reservoirs. Water flows out of shallow impoundments to canals to AG and REC Demand and to the Surficial Aquifer via recharge into the unsaturated and saturated zones of groundwater. Shallow impoundments do have associated losses via ET. The climatically impacted input parameters are SLR, rainfall, ET and AG and REC demands. The effects of SLR on shallow impoundments may be a result of SLR effects on higher groundwater elevations however this bucket will likely not have a SLR component beyond the indirect effects of SLR boundary conditions in the various models. Figure 11 shows an overview of the bucket representing shallow impoundments.

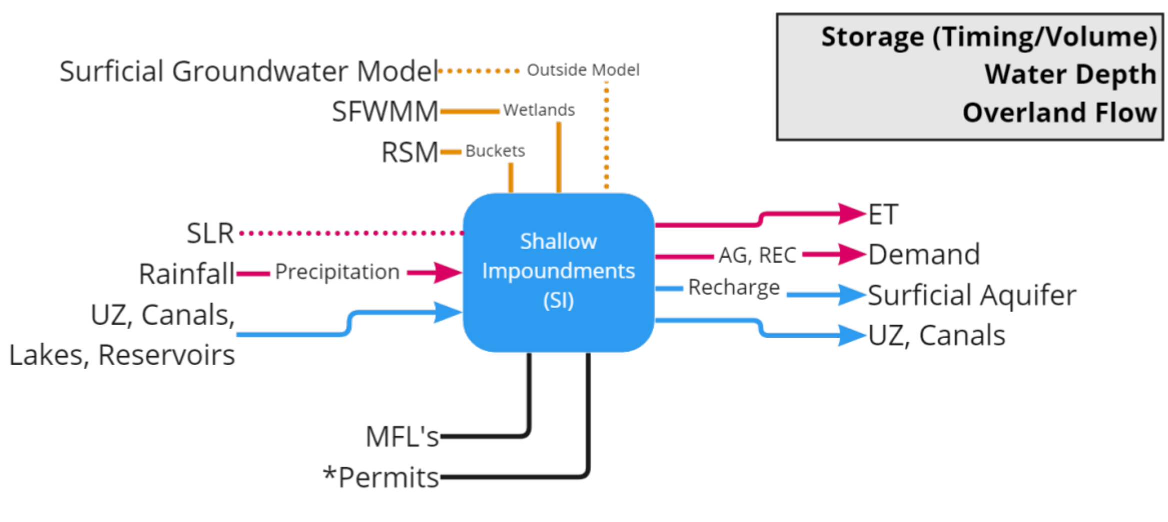


Figure 11. Shallow Impoundment IDEF0 Diagram.

Based on the above-mentioned inflows, outflows, and model constraints, and with a focus on how a vulnerability assessment may be used to assist with MFL and Permits, the following metrics were identified as model output variables: Storage, Water Depth, and Overland Flow rates. Storage will be assessed based on timing and volume and measuring what are the impacts of climate and demand input conditions. Pre-established threshold values will assist in determining vulnerability. Water depth and overland flow are related to volume but as they relate to MFL triggers require their own independent analysis. The proposed assessment will aim to answer the question of if and when might a given climate change future condition trigger an MFL violation and/or a pre-determined vulnerability condition in addition to other questions.

Unsaturated Zones

The unsaturated zone (UZ) is characterized by many parameters that will likely have climate effects not featured in the proposed assessment such as changes in soil capacity and transmissivity. Included in the unsaturated zones are Lake Flirt Marl, Pamlico Sand, Miami Limestone, Fort Thompson Formation, and Key Largo Formation among others that will be represented in the ECSM layers 1, 2, and 3.

Unsaturated zones are currently modeled by the SFWMM and RSM. The District indirectly regulates the unsaturated zone mostly through withdrawal permits for some PWS, AG, REC, and DSS. The majority of PWS, AG, and REC demand is permitted through the saturated zones represented as the Surficial Aquifer however there is a close relationship between both zones. In addition to rainfall, water flows into the unsaturated zones via urban and rural surface runoff infiltration, and as direct infiltration from ponded water sources including shallow impoundments, canals, lakes, and reservoirs. Water flows out of the unsaturated zones to PWS, AG, REC, and DSS demand to the Surficial Aquifer via recharge and as losses via ET. The climatically impacted parameters are SLR, precipitation, ET and AG and REC demand. The effects of SLR on the unsaturated zones will be analyzed through the models. Rainfall and ET will be incorporated as through the above-mentioned datasets directly incorporated into the model, along with AFSIRS input withdrawal rates. Figure 12 shows an overview of the unsaturated zones bucket.

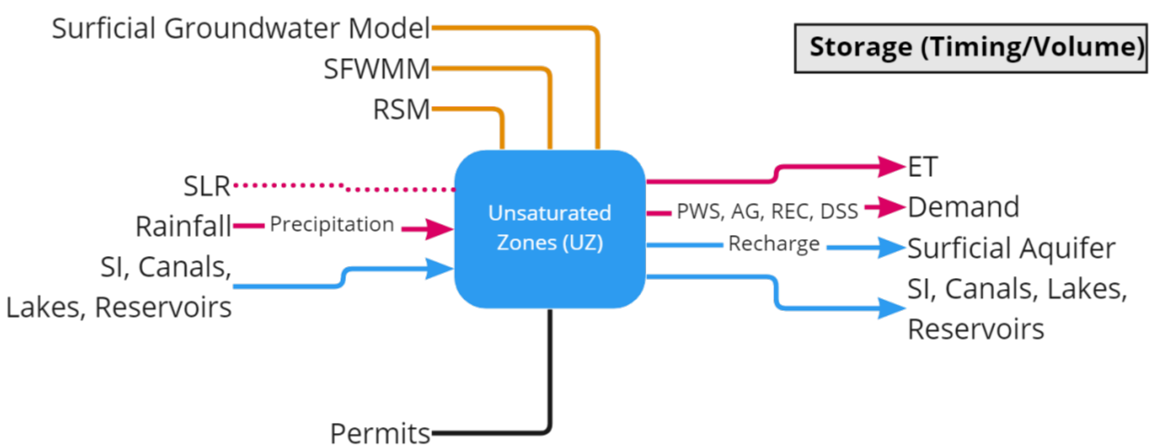


Figure 12. Unsaturated Zone IDEF0 Diagram.

Changes in storage, timing and volume were identified as model output variables based on the abovementioned inflows, outflows, and model constraints and with a focus on how a vulnerability assessment may be used to support permitting. It should be noted that soil capacity changes both in terms of storage potential and through porosity recharge rates will likely be affected by climate change: however, due to the lack of scientific consensus, uncertainty in approach, and modeling difficulty this change factor will not be incorporated into the proposed assessment. There is an additional planning project highlighted in the 2022 Resiliency Plan that may look at the climate change effects on those parameters.

Canals

South Florida's canals were primarily developed for flood protection and prevention of saltwater intrusion in 1948, as part of the Central and Southern Florida Project (C&SF Project) and act a major conduit of the regions' fresh water. Canal operations are tied to water management operation goals, established in specific operation manuals.

Canals are currently modeled by the ECSM, SFWMM, and RSM as part of WSP and many other District modeling efforts such as CERP and FPLOS. Water levels in the canals are impacted by structures operation, RAAs, MFLs, and a few AG withdrawal permits. In addition to rainfall, water flows into the canals via urban and rural surface runoff, infiltration from groundwater, and flows from shallow impoundments, secondary canals, lakes, and reservoirs. Water flows out of canals to tide, AG demand, to the Surficial Aquifer via recharge, as losses via ET, and into lakes and reservoirs. Figure 13 shows an overview of the unsaturated zones bucket.

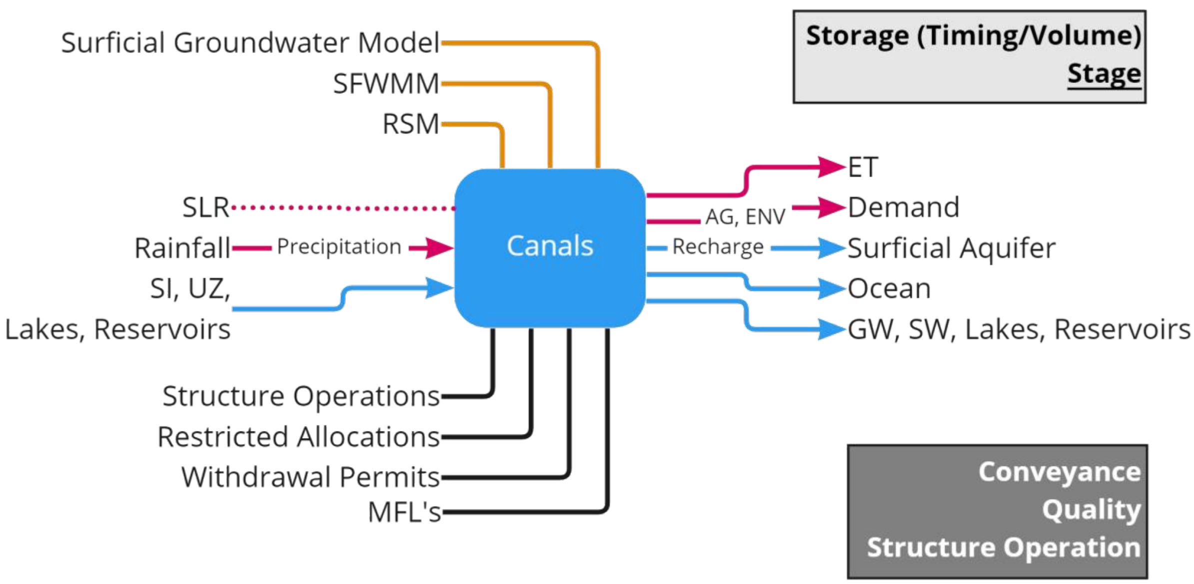


Figure 13. Canals IDEF0 Diagram.

The climatically impacted parameters are SLR, precipitation, ET, and AG demands and ENV needs. The effects of SLR on the canals is very important to consider as their stages are triggers from MFL and RAA. Additionally, they are used as withdraw limitation assumptions in the ECSM model runs. The effects of SLR will likely result in operational changes and structure enhancements first, which might have greater impacts than purely increasing or decreasing demand. Although unlikely, operations may also change because of water quality conditions to prevent downstream negative ecological affects. Furthermore, the canals are operated to prevent saltwater intrusion in addition to its primary flood protection objectives, as such their conveyance characteristics take precedent over storage and quality considerations. Therefore, maintaining conveyance and assumptions regarding quality and other structure operational decisions will be modeled as inputs rather than outputs.

To support decision making for operations, permits, and other regulatory procedures managed by the district, the stage of water in the canals as well as storage in terms of volume and timing are the expected vulnerability outputs. These outputs may take the form of time to trigger a particular structure operation, MFL, or RAAs.

Lakes

Small lakes and shallow impoundments may have similar functional and modeling characteristics, however, there are significant source demand differences such as the City of West Palm Beach's water supply from Lake Magnolia and Clear Lake, when compared to shallow impoundments, that are not a direct sources of water supply. Similarly, Lake Okeechobee's cubic mile of water is the heart of the surface water system in South Florida and its tributaries and distributaries are the supply and source for much of the regions fresh water. Many assumptions and modeling inputs are based on Lake Okeechobee's regulatory and hydrologic conditions.

Lakes, such as stormwater management lakes, are currently modeled by the ECSM, SFWMM, and RSM. Lake levels are impacted by operations of inflow and outflow structures, MFL, WUP and ERPs. Water flows into lakes via rainfall, urban and rural surface runoff, infiltration from groundwater, and through canals and outfalls. Water flows out of lakes via operation of outflow structures. For Lake Okeechobee, these operations will be simulated according to the 2023 Lake Okeechobee System Operating Manual (LOSOM) schedule, which includes sending water to Everglades National Park, estuaries, and other environmental and regional demands. Lakes additionally have components of PWS, AG, and REC demands. Water also flows to the Surficial Aquifer via recharge, as losses via ET, and into groundwater via infiltration. Figure 14 shows an overview of the bucket representing lakes.

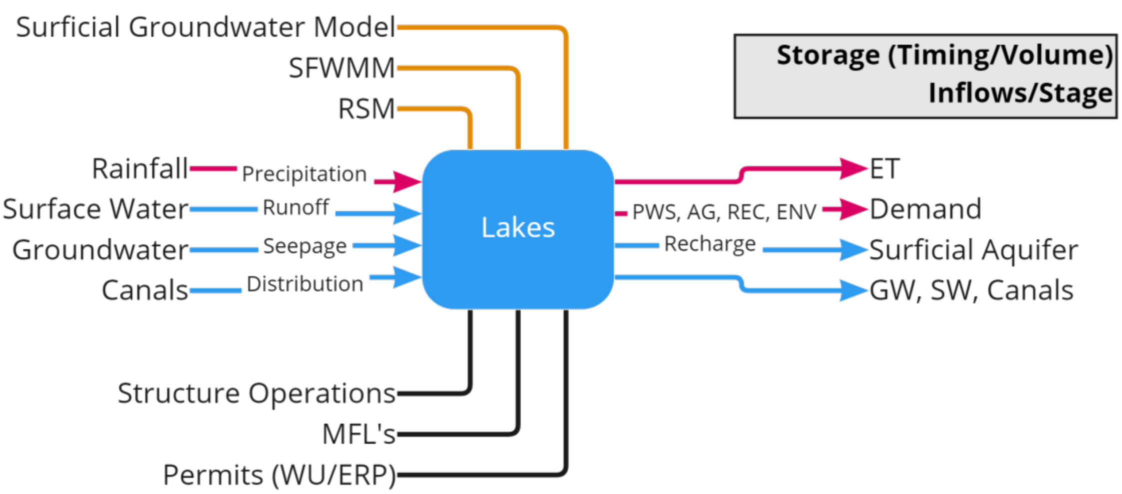


Figure 14. Lakes IDEF0 Diagram.

The effect of climate change on lake conditions will likely be cause by changes in rainfall, ET, and ecosystem and consumer demand. SLR's impact is expected to occur because of drainage and canal conveyance from downstream conditions. The major output metrics associated with lakes are the storage and inflow/outflow rates. MFL triggers and their timing will also likely be a threshold of interest just as they are with canals.

Reservoirs

Reservoirs in the region server multiple purposes including flood protection and ecosystem water supply needs. The C-51 is a recent example of a reservoir developed for consumer water supply needs which, upon completion, will be operated and managed by the District and serve as supplemental water supply to eight local water utilities. Additionally, Flow Equalization Basins (FEB) whose primary design is for storm water management purposes also serve as reservoirs.

Reservoirs are currently modeled by the ECSM, SFWMM, and RSM as well as individual and independent specific modeling for future reservoir development and other operational objectives like ecosystem restoration and flood protection. The District manages reservoirs through operations of structures, WUP, ERP (where District is the permitee), and Dam Safety permits. Water flows into reservoirs via urban and rural surface runoff, infiltration from groundwater, and pumped in via canals. Water flows out of reservoirs to PWS, AG, and PWR demand, to the Surficial Aquifer via recharge, as losses via ET, and into other sources via pumping from canals. Figure 15 shows an overview of the unsaturated zones bucket.

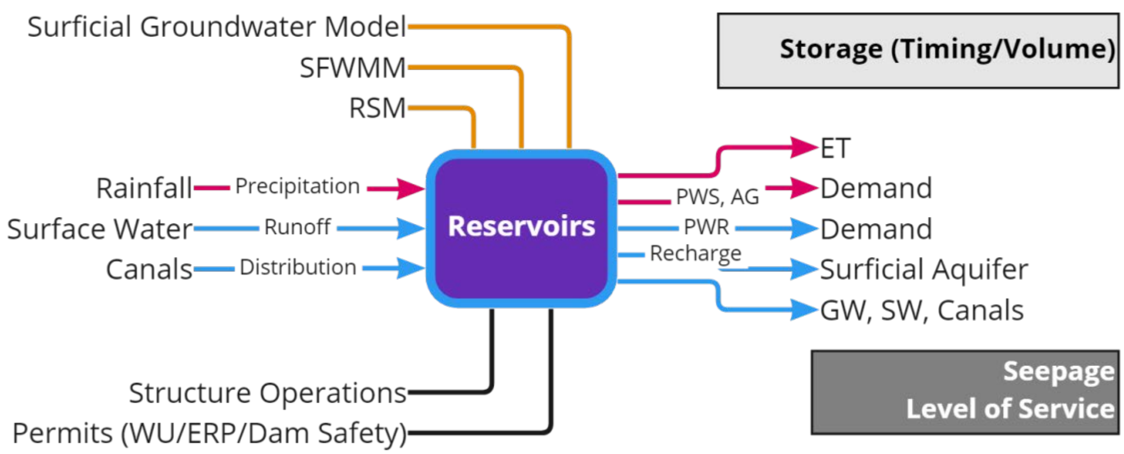


Figure 15. Reservoirs IDEF0 Diagram.

While reservoirs are intended to store water, they aren't fully impervious and therefore do contribute to groundwater via seepage which will be incorporated as a model assumption. Additionally, reservoirs act as storm water buffers and their flood protection level of service assumptions take precedent over storage and as such will be model input assumptions. Storage in terms of volume and timing will be the assessed vulnerability metric and threshold.

Surficial Aquifer

The surficial aquifer is the primary focus of the proposed assessment as it supplies 90% of PWS, 20% of AG, 32% of REC, and 38% of ICI, totaling 55% of the LEC water demands in addition to the portion of water that is later reclaimed. The surficial aquifer is fully encompassed in the ECSM model.

The surficial aquifer is currently modeled by the ECSM, SFWMM, and RSM. The District manages withdrawals from the surficial aquifer through WUPs, RAA, and storm water disposal. Water flows into the surficial aquifer via recharge from all surface water sources during the wet season. Water flows out of the surficial aquifer to PWS, AG, REC, ICI, and DSS demand, back to surface water sources, as losses via ET, and out to tide through the regional canal network. Figure 16 shows an overview of the surficial aquifer bucket.

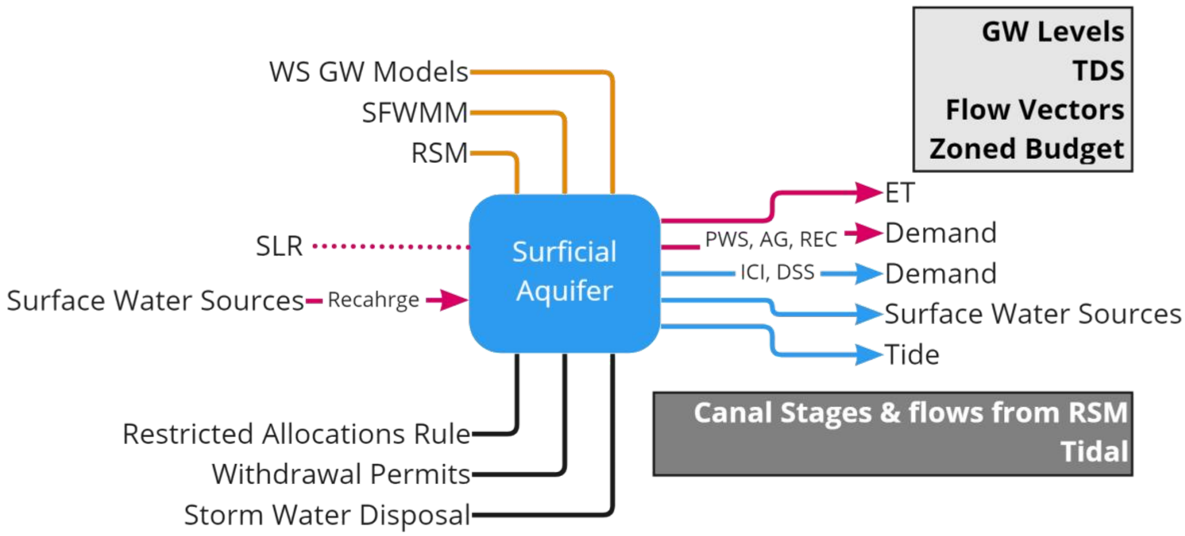


Figure 16. Surficial Aquifer IDEF0 Diagram.

The surficial aquifer is connected to all surface water sources and the effects of demand through surficial aquifer withdrawals cascade throughout other sources in the system. For instance, an inland PS well cone of depression can cause water levels to drop in nearby canal which can trigger an MFL violation related to Lake Okeechobee, especially in drier conditions. Similarly, PWS wellfield withdrawals and their future growth are limited by the RAAs in the LEC. Coastal wellfields will further be evaluated, as part of this assessment, to characterize vulnerability related to the migration of saline water/saltwater intrusion. Modeling and optimizing the responses to potential further demand restrictions will be included as assumptions, inputs, and rules and adaptation responses.

Additionally, an assumption is placed on the limits of PS demands as maximum withdraws and the proposed assessment will help us understand what future conditions cause us to reach those limits and when. There are also assumptions made from flows done in the RSM that are inputs to the ECSM as boundary conditions. Lastly, as the ECSM is a density-dependent model, SLR will be modeled as tidal boundary condition that will likely not change with time throughout the model run.

The density-dependent ECSM allows for a more robust analysis of groundwater. Based on its capabilities, the vulnerability output will include groundwater levels, salinity concentrations via Total Dissolved Solids (TDS), flow vectors (direction and magnitude of flow), and zoned budget analysis i.e., how much volume, inflow, and outflow a particular area has. TDS concentrations output will allow for water quality degradation to be analyzed spatially. The flow vectors can show what is the cause various flows of water i.e., is withdrawal the cause for lower canal levels or is it the drier regional conditions. This can help planners and regulatory staff identify potential mitigation strategies or begin the process of updated guidelines based on what works and what drives vulnerability. The zoned budget analysis can provide agencies and planners with an understanding of what their future condition and supply may look like in terms of volume and provide them with guidance on how to plan and regulate accordingly.

Figure 17 contains the combined model input assumptions and model output metrics for each availability source that are initially suggested to go in the development of the assessment and model runs.

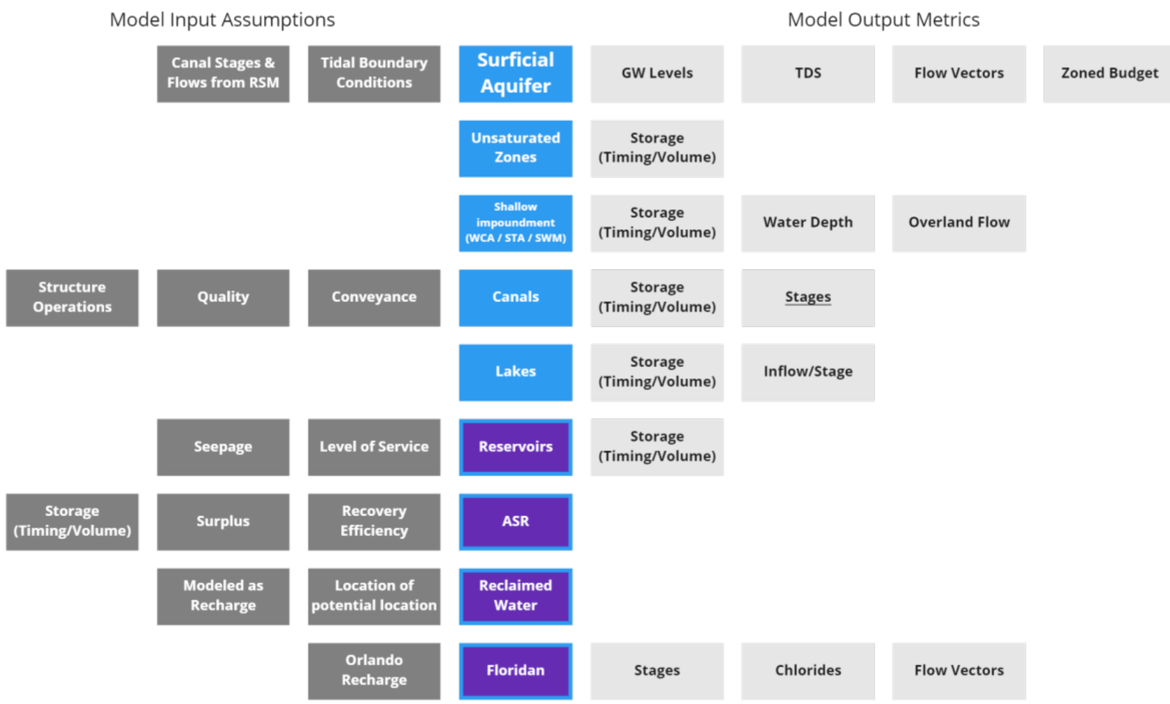


Figure 17. Diagram of the availability metrics and assumptions.

Scenario Formulation

Based on the above research and discussion and approaches identified by the workgroup, the scenario model runs were recommended based on less and more conservative climate change conditions and on a range of growth scenarios within the determined 50-year planning horizon. Selected individual runs are recommended to isolate effects independent of each other. Table 3 defines each of the independent variables that will change with each model run.

Table 3. Independent model variables and their definitions.

Name	Definition	Dataset
Current Climate	Observational data	1985 – 2016 (POR)
2020 Growth Scenario	Base Condition	1985 – 2016 (POR)
2045 Growth Scenario	20-year planning horizon	BEBR Median 2045
2075 Growth Scenario	50-year planning horizon	BEBR Median 2075
Sea Level Rise 1 (SLR1)	NOAA Intermediate Low	NOAA 2022 Update
Sea Level Rise 2 (SLR2)	NOAA Intermediate High	NOAA 2022 Update
Climate Change 1	Warm and Drier	FIU/USGS Future Conditions
Climate Change 2	Hot and Driest	FIU/USGS Future Conditions
Less Conservative	Warm, Drier, & SLR1	Combined
More Conservative	Hot, Driest, & SLR2	Combined

Growth will be evaluated as 2020 Growth Scenario, 2045 Growth Scenario, and 2075 Growth Scenario. 2020 Growth Scenario is defined as the current population at the time of the of the model run. 2045 Growth Scenario is defined as the population growth up to the end of the LEC WSP time horizon (2045) which is based on BEBR Median growth projections. 2075 Growth Scenario is defined as the extrapolation of BEBR Median growth projections out to the end of the 50-year time horizon (centered around 2075).

Sea Level Rise 1 (SLR1) is defined as the 2022 NOAA Intermediate-Low curve as the tidal boundary conditions which reflects the 17^{th} percentile of the projected ranges. Sea Level Rise 2 (SLR2) is defined as the 2022 NOAA Intermediate-High curve as the tidal boundary conditions which reflects the 83^{rd} percentile of the projected ranges.

Climate change will be evaluated on a scale of temperature and moisture (hotter and drier) conditions based on future temperature, rainfall, and ET models and datasets. The runs will be classified into four categories, Climate Change 1 & 2, and Less and More Conservative estimates. Climate Change 1 is defined as warmer and drier conditions which will reflect the respective percentile future condition (around 5-25 percentile: lower bottom of ranges) for temperature, rainfall, and ET in 50 years (centered around 2075). Climate Change 2 is defined as the respective percentile future condition (75-95 percentile: upper bottom of ranges) for temperature, rainfall, and ET in 50 years. Less Conservative is defined as Climate Change 1 with SLR 1, and More Conservative is defined at Climate Change 2 with SLR 2.

The first scenarios will be developed for the 2023 Update to the LEC WSP. These include the 2020 base condition (Current Climate and 2020 Growth Scenario), the 2045 future demand condition (Current Climate and 2045 Growth Scenario), and the 2045 Sea Level Rise Condition (SLR1 and 2045 Growth Scenario). These runs, designated A, B, and G in Figure 18 will serve as the basis for the information contained in the WSP. The climate period of record will use 1985 to 2016 and the SLR boundary conditions will be based on existing tidal conditions for A and B, and SLR 1 for C.

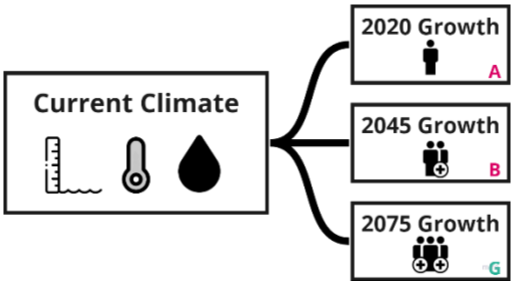


Figure 18. Current climate scenario diagram.

Following the initial LEC WSP scenarios, the first vulnerability scenarios to run will be the 2045 Growth with Climate Change 1, Less Conservative, and More Conservative conditions, designated as D, E, and F. These runs will build on run C by adding climate variables to previous runs and then comparing the effects. The second round of the vulnerability assessment runs are 2075 Growth with No Change, SLR1, Climate Change 1, Less Conservative, and More Conservative conditions, designated as G, H, I, J, and K. These runs represent the total future condition as they combine 2075 growth conditions with 50-year climate and SLR conditions. Figure 19 and Table 4 represent the vulnerability assessment scenario runs.

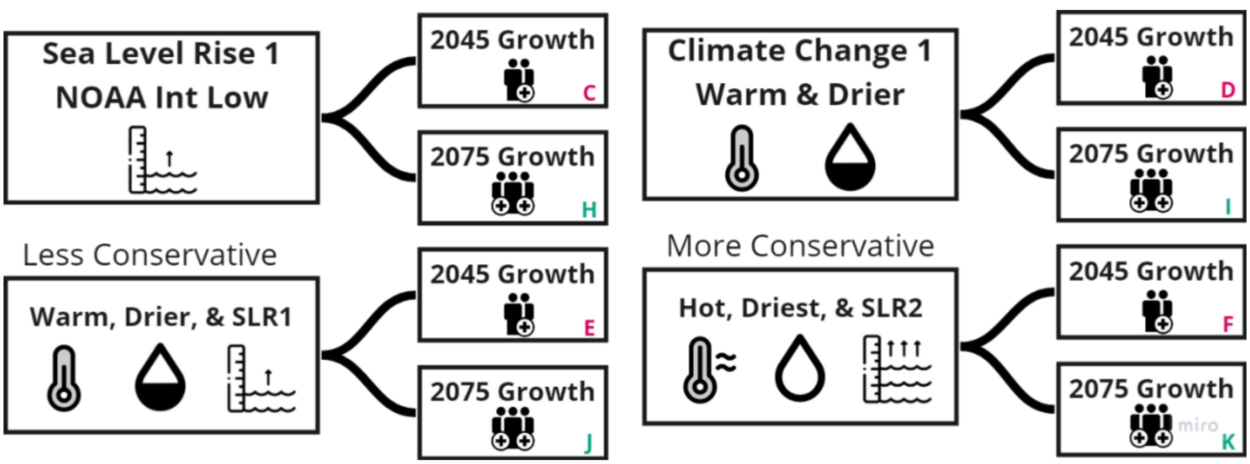


Figure 19. SLR1, Climate Change 1, Less Conservative, and More Conservative scenario diagram.

Table 4. Model run designation and associated independent variables.

Scenario Run	Growth Variable	Climate Variable
A (LEC WSP)	Base Conditions	Current Climate
B (LEC WSP)	BEBR Med 2045	Current Climate
C (LEC WSP)	BEBR Med 2045	SLR1
D (WS Vuln)	BEBR Med 2045	Warmer and Drier
E (WS Vuln)	BEBR Med 2045	Warmer, Drier, & SLR1
F (WS Vuln)	BEBR Med 2045	Hot, Driest, & SLR2
G (WS Vuln)	BEBR Med 2075	Current Climate
H (WS Vuln)	BEBR Med 2075	SLR1
I (WS Vuln)	BEBR Med 2075	Warmer and Drier
J (WS Vuln)	BEBR Med 2075	Warmer, Drier, & SLR1
K (WS Vuln)	BEBR Med 2075	Hot, Driest, & SLR2

Expected Outcomes

Based on the above scenarios and the availability thresholds and metrics discussed above, outputs can be used to determine how a particular sources availability behaves over time. This source behavior can be depicted in a variety of different outputs from geographic maps, tables, and graphs which can then be used to assist management and planning processes accordingly. For example, Figure 20 depicts an illustrative example output comparing a theoretical source volume and demand in model runs A, E, and F, No Change and No Growth and Low Growth with Less and More Conservative conditions. The source volume is shown in purple and grey and is plotted against its low growth demand in gold and green no growth demand in blue. This graph shows us when demand may exceed supply and how the timeline need to enact management practice changes with different conditions. (Note: This output is for illustrative purposes and is not representative of any source, condition, or actual expected outcome.)

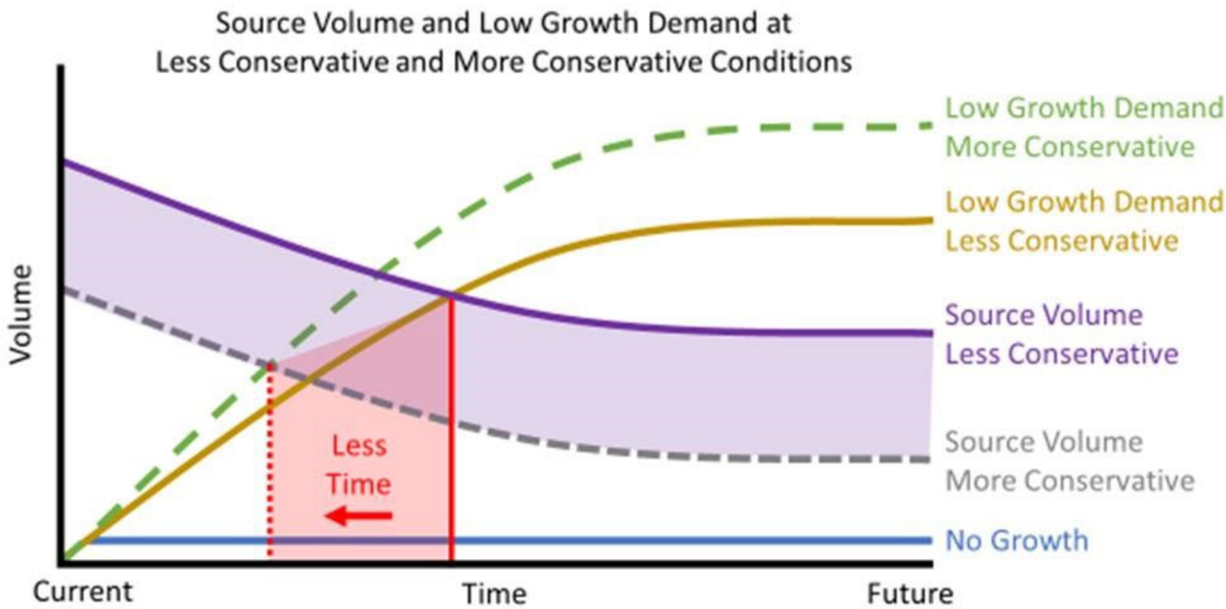


Figure 20. Example assessment output comparing a theoretical source volume and demand for model runs A, E, and F.

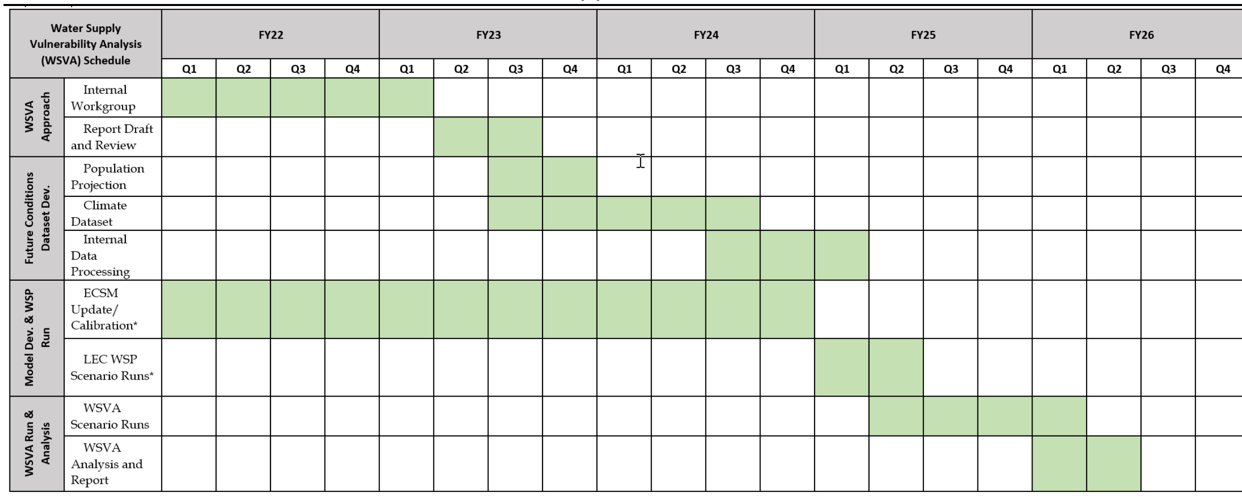
In addition to supporting planning efforts the outputs can be used to identify and define risk thresholds. For instance, a system or source can be defined as "at risk" when it's within a certain timeframe from reaching a variable threshold. This can support various mitigation efforts such as grant applications to allow development of alternative water supplies or rule-making to further restrict use from at risk sources.

Scenario Limitations and Timeline

The time it takes to set up, troubleshoot, and run each model places limitations on the scope of the study. Once the ECSM has been calibrated, additional time is needed to set up the new scenario runs and execute these modeling runs. These challenges are compounded with the longer time horizon and the novelty of incorporating new elements such as density dependence, in addition to the above-mentioned need of equilibrating multiple models.

New datasets such as future temperature, rainfall, and ET and future growth projections will be developed as model inputs. The development of these datasets will require additional parallel efforts and increased costs. In anticipation of these and other model requirements the scoping of necessary parallel efforts will begin immediately. Table 5 shows the anticipated timeline for the future condition development, model development, model runs, and analysis, leveraging the model development advanced as part of the LEC WSP.

Table 5. Anticipated timeline of the WSVA.



* the LEC WSP model development, calibration and scenario runs are illustrated here for planning purposes only and are not dependent on any of the described WSVA tasks.

Future Work

"An ounce of prevention is worth a pound of cure" – Benjamin Franklin

In addition to the initial recommendations described above, which are being prioritized as part of the initial study recommendations, future efforts, as detailed below, were identified by the Workgroup, and will be further developed as part of future study phases. It is important to note that the first phase of the WSVA is to develop a series of base climate conditions on which to apply various mitigation and adaptation strategies. Like the FPLOS program, base conditions are first developed, which inform the appropriate mitigation and adaptation strategies to then be modeled.

Future Scenarios

Future scenarios should include the incorporation of alternative mitigation strategies into modeling. These mitigation strategies can help managers understand the resiliency strategies that may be attained to reduce vulnerabilities. While there are many potential mitigation strategies, Figure 21 shows a few potential mitigation strategies that might be organized as part of additional scenario runs roped in Mitigation Strategies Scenarios.

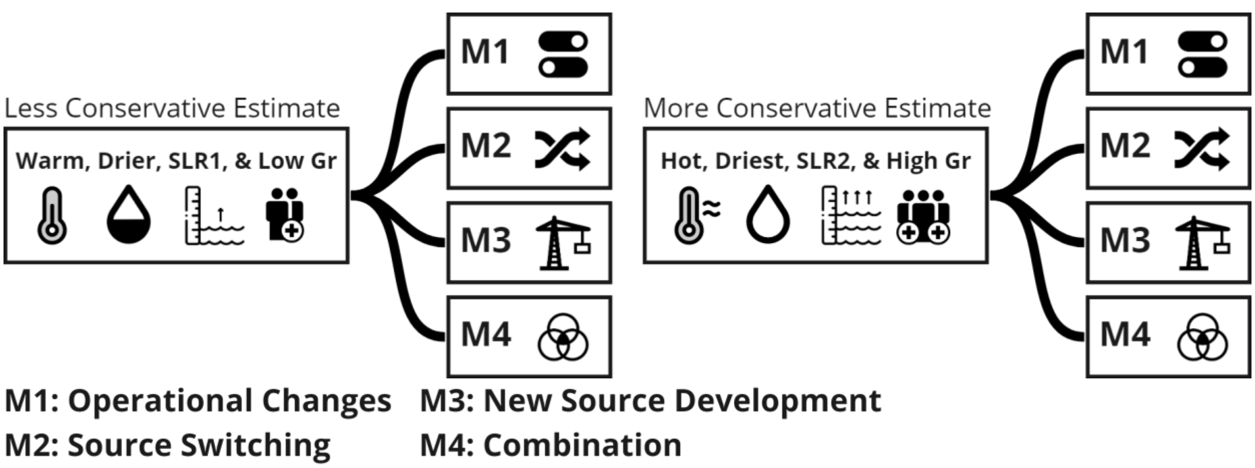


Figure 21. Mitigation scenarios runs.

M1 corresponds to operational change which in the above scenarios are input assumptions. These assumptions can be optimized with a given climate condition and requires no additional infrastructure investment. However, there are many objectives that determine the operational procedures of various structures which can compete with one another and have complex interdependent regulatory constraints. Therefore, modeling this mitigation strategy is not trivial and will require additional discussion. M2 corresponds to source switch which assumes that demands will be met with different sources throughout the model time frames. The scenarios above discuss the assumption that demand will be capped at the RAA limitation. M2 analyses would evaluate if some of the demands were met by sources like reclaimed water or via distribution from other utilities. M3 corresponds to the development of new sources such as additional Floridan aquifer or seawater. Historically, development of new sources has been a popular management practice for utilities who are approaching their RAA limitations or at risk of saltwater intrusion. M4 corresponds to a combination of all the above-mentioned strategies and may include projections for increased conservation.

These strategies can be combined with outputs mentioned previously and can assist with the identification of water supply priority resiliency investments. Figure 22 shows an illustrative potential output that shows the effect of M3 on source volume and highlights how that may increase the timeline for mitigation or adaptation to climate change. Similarly, it can also help define vulnerabilities based on the time it takes to implement various mitigation strategies, their likelihood of success, and potential impact. For instance, new source development may temporarily solve a supply shortage but may also be the only available mitigation strategy so that a particular source or location is therefore “at risk”.

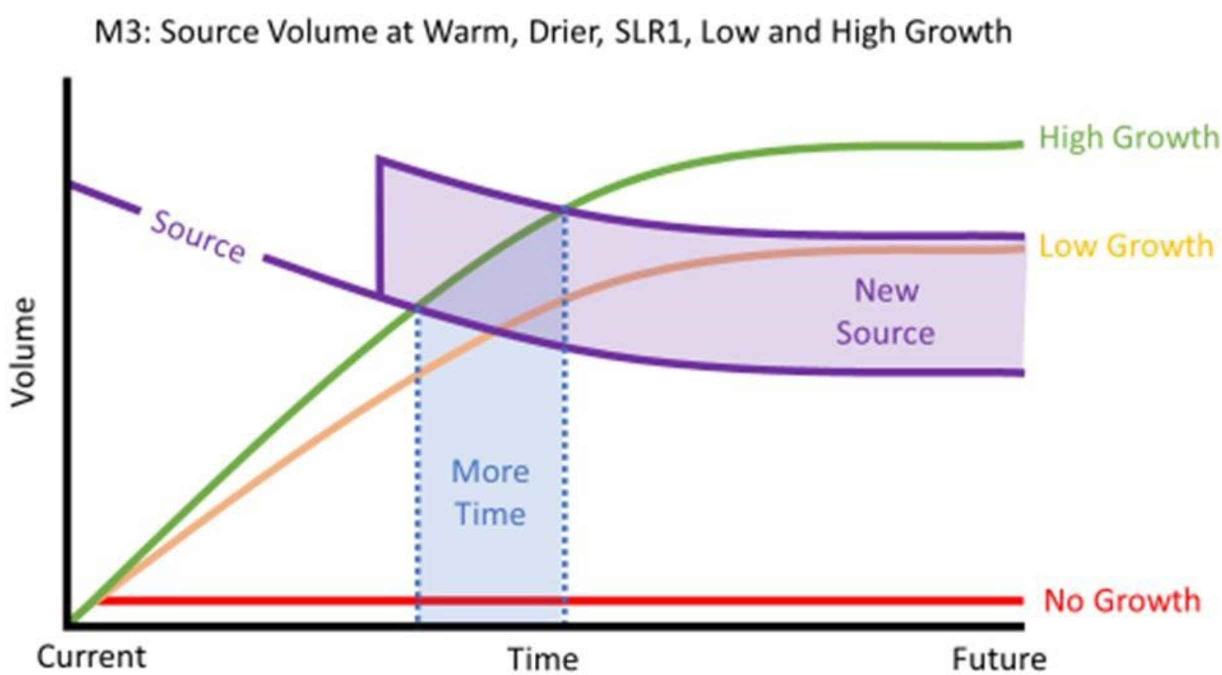


Figure 22. Example mitigation scenario output highlighting the effect of new supply sources.

Not Assessed Availability Sources

Reclaimed water, ASR and the Floridan Aquifer are sources whose vulnerability are not being recommended to be directly analyzed as part of the initial phases of the proposed assessment. While these sources play an essential role in the LEC water supply system, in the case of ASR and Reclaimed Water, they are potential mitigation and adaptation strategies, and in the case of the Floridan Aquifer are likely more affected by future demand conditions rather than the climate change conditions featured in the proposed assessment (SLR, temperature, rainfall, and ET). Future analysis may independently look at the climate vulnerabilities associated with each of these sources.

Appendix A: Water Use Category Growth and Withdrawal Rates Workgroup Discussion

How a particular water use category demand change over time is combination of its growth rate and withdrawal rate. The growth rate is a function of the projected growth of that industry such population increases, irrigated acreage increase/decrease or the square footage of industrial or commercial space. The withdrawal rate is the estimate water use per unit to calculate the overall demand for that water use category. Water use per unit can include per capita water use for public supply and domestic self-supply, water needs per acre of crop for agriculture, or water needs per acre of landscape or golf course. Changing climate can impact the water use per unit, especially for water use categories that include irrigation.

For the proposed assessment, growth rates are separated from withdrawal rates to allow for the application of an independent climate focused methodology where applicable and feasible. Each of these rate's variables may have important climate change components but their relationships and model inputs would have to be sufficiently established to be incorporated into the WSVA which may is beyond the scope of the proposed assessment especially for growth rates. Alternatively, the approach to apply the effects of climate change on withdrawal rates have a clearer methodology and the process of applying them is relatively straight forward.

The use categories follow the 2018 LEC WSP methodology and are segmented as Public Supply (PS), Agriculture (AG), Landscape and Recreation (REC), Institutional, Commercial, and Industrial (ICI), Power (PWR) and Domestic Self Supply (DSS). Below are the explanations, discussions, and research for the above use category growth rates. For each water use category, a series of boxes are presented showing options considered by the workgroup with the light green box indicating the option the workgroup suggests adopting.

A.1: Water Use Category Growth Rates

Public Supply Growth Rates

Figure 23 shows options presented to the workgroup based on research of the latest scientific methodology and strategies implemented by similar agencies.

Figure 23. Public Supply growth rate options.

In the WSP, PS growth is derived from multiple sources of information, including county-level data from the University of Florida Bureau of Economic and Business Research (BEBR), sub-county data from Traffic Analysis Zones (TAZ), and local data from local government comprehensive plans and United States census. BEBR 20-year projections are conducted at the county level. These county-level projections are distributed by District staff via TAZ and census data to utility service areas whose boundaries are updated annually. The BEBR projection serves as the control for the county-wide projection when combining individual utility service area populations. Estimates of DDS population within the utility service area is subtracted from the utility service area population to estimate the utility-served population. In addition, local government plans for providing utility service in current DSS areas are incorporated in the projections.

When projecting growth rates in PS, factors to consider include the projection methodology underlying the rates themselves and how they will be distributed spatially within utility service areas. While these are connected, climate influences may have different impacts on each aspect. For instance, increased coastal flooding due to climate change can change how population growth gets distributed within service areas and between utilities but may not have as consequential an effect on overall growth rates.

While there are uncertainties with population growth rates and distribution methodology even at 20 years, PS must be assessed with future conditions as it's the demand category that has the largest demands associated with assessed sources. Based on this need, similar scientifically or legally verified methodologies were researched that can either extrapolate BEBR projections or be applied to conduct independent projections for a 40-50 planning horizon.

As an example, the C-51 reservoir project required permittees to conduct long-term demand projections. While the methodology used in the permittees' projections varied across utilities based on their internal demand segmentation and fee-rate projection procedures, the overall approach was to extrapolate population growth rates through a moving average percent difference. This percent difference is then applied to future years until the end of the assessment period.

For the proposed WSVA, a similar extrapolation methodology is suggested to be applied to county populations and then spatially distributed according to current WSP methodology.

PS Growth Rate Assumptions

There are several assumptions and uncertainties embedded within the projections and methodologies, some of which are:

All the assumptions and uncertainties within BEBR's projection methodologies are carried over into our extrapolation. BEBR's methodology is simplified as follows: Pt = (Ht x PPHt) + GQt, where Pt is the population at time t, Ht is the number of occupied housing units at time t, PPHt is the average number of persons per household at time t, and GQt is the group quarters population at time t. Notably, seasonal residents and undocumented persons are not formally incorporated as part of the permanent population (however their withdrawal rates are likely captured in percapita use rate). Additionally, birth rates, death rates, national and international migration rates, and other persons factors are simplified within the PPHt term.

Spatial distribution of BEBR projections to utility boundary lines are accurate.

The effects of Covid-19 have intruded additional uncertainties and growth rate extrapolations will not be modified accordingly.

The significance factor and variability of each of the parameters with BEBR projections carry over to extrapolated numbers.

The plateau effect of the population projection implies a leveling off of future growth.

Climate change effects were not incorporated into projection methodologies or distribution.

PS Growth Rate Research

Below are relevant highlights from research conducted to supplement the workgroup's decision-making process.

BEBR has conducted long-term population projections for the Florida 2070 project.

Miami-Dade County conducted long-term projections for sewer flows.

C-51 Reservoir Permit required long-term projections. Methodologies documented were Dania Beach Utilities, Hallandale Beach Utilities, The City of Sunrise, City of Margate, City of Ft Lauderdale, City of Pompano Beach, Miami-Dade Water and Sewer Department. and Broward County.

State of Oregon conducted long-term projects and found population to be more influential than changes in use types.

Washington State conducted long-term linear projections.

Seattle Utilities did population forecast until 2040 and then a linear extrapolation until 2060.

Thames Water used a cohort-component "industry standard" incorporating population, housing, and occupancy in long-term component and applied a percentage growth rate from government population data.

Agricultural Growth Rates

Figure 24 shows the options presented to the workgroup based on research of the latest scientific methodology and strategies implemented by similar agencies.

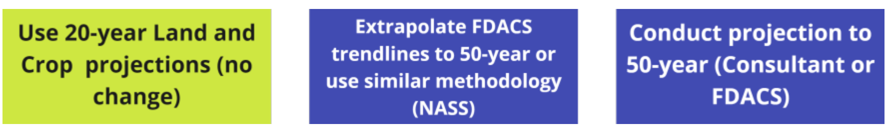


Figure 24. Agricultural growth rate options.

The WSP methodology for projecting agricultural growth is based on the irrigated agriculture growth maps generated by Florida Department of Agriculture and Consumer Services (FDACS) in the Florida Statewide Agricultural Irrigation Demand (FSAID) report. These reports are generated annually and contain parcellevel polygons of statewide agricultural lands (ALG) and agricultural irrigated lands (ILG) including crop type projected out to 25 years. These projections are based on USDA National Agricultural Statistics Service (NASS) using standard trend analysis with data from 1987-2017. County-level trends used an autoregressive procedure where the best functional fit was selected from logarithmic, linear, exponential, and power forms. Crop-type projections and their subsequent withdrawal rates are discussed in the Withdrawal Rates section.

Based on the current use of FSAID AG acreage projections in WSPs, the workgroup recommended use of 20-year growth rate projections rather than extrapolate FSAID trendlines using similar methodology conducted by FDACS to develop future land projections or to conduct new projections with a new methodology. The FSAID growth rates are tied to crop types and acreages and developing new procedures or attempting to project spatially distributed crop types extrapolated from the FSAID report is beyond the scope of the proposed assessment due to high uncertainty. These uncertainties while climatically relevant include elements such as long-term land use changes and future crop type demand which are unreasonable to assume at 50 years.

AG Growth Rate Assumptions

There are several assumptions and uncertainties embedded within projecting Agricultural growth rates using FDACS's FSAID data, some of which are:

FSAID geographic land use changes don't consider climate change factors such as the effects of increased drought or the shift from agricultural land to housing due to increased inland migration

NASS statistics use census and survey information of which data is often voluntary and therefore incomplete.

Land use change plans rarely exceed 10 – 20 years and therefore projection of potential land use changes beyond even up to 20 years is uncertain.

Trendlines using various regressions rather than model-based approaches don't capture the reasons behind various changes and can therefore be less encompassing of future changes.

The Coronavirus pandemic caused various changes that affected land use such as increased Florida migration and lower demand of restaurant produce. Incorporating these and other Covid19 impacts may change future predictions.

AG Growth Rate Research

Below are relevant highlights from research conducted to supplement the workgroup's decision-making process.

Oregon used acreages by land use by county, distribution by crop by county, crop specific irrigation demands. Did not project land use changes.

Landscape and Recreation Growth Rates

Figure 25 and Figure 26 shows the options presented to the workgroup based on research of the latest scientific methodology and strategies implemented by similar agencies.

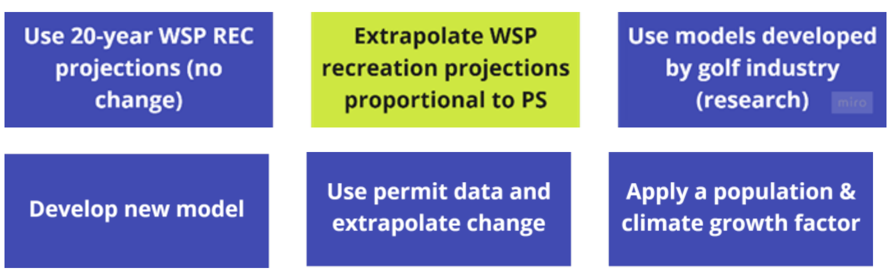


Figure 25. Recreational growth rate options.

Figure 26. Landscape growth rate options.

In the LEC WSP, growth in REC demands were increased proportionally with population growth. However, because golf is a unique use case that accounts for a significant portion of REC demand and is influenced by different parameters than other recreation and landscape uses its growth is segmented from other REC demands and is added on a case-by-cases basis.

Golf growth rates have been minimal or declining in the past decade. As a result, increases in golf are added to a WSP on case-by-case basis where there are water use permits and/or planned growth documenting increases in golf but not projected. The golf industry had been seeing a steady decline until Covid-19 where the trend reversed; however, projecting future growth rates is too uncertain. To allow for the comparison to WSP -- and to balance scope with the additional uncertainties -- it is suggested that the proposed assessment maintain the same 20-year acreages and growth rates determined in the WSP.

REC Growth Rate Assumptions

There are several assumptions and uncertainties embedded in using the WSP current Landscape and Recreational growth rate methodologies, some of which are:

Landscape growth within the PS utility service area is accounted for with the PS population growth rate, which implies irrigated landscape grows at the same rate as population. This is conservative but unlikely as the average household size in the LEC is increasing and there have been considerably more construction of apartments and multifamily homes then single-family homes, which translates to less lawns per capita.

The projections are limited to known upcoming water use permits and only 10 years of expected land use changes.

All parks and other recreation are assumed to grow proportionally to population.

The effects of climate change will not be incorporated into REC growth. WSP use WUP and known new development to determine new REC locations and manually update associated demands on the WSP 5-year update schedule.

REC Growth Rate Research

Below are relevant highlights from research conducted to supplement the workgroup's decision-making process.

ASCE found that different plot types (single, multifamily, commercial) have a considerable effect on predictive demand because of increased lawns.

Municipal and industrial demand growth is most closely associated with population growth.

Golf courses were on the decline and land use was often switching to housing development but picked back up during the Coronavirus Pandemic so future growth is more uncertain.

Industrial, Commercial, and Institutional Growth Rates

Figure 27 shows the options presented to the workgroup based on research of the latest scientific methodology and strategies implemented by similar agencies.

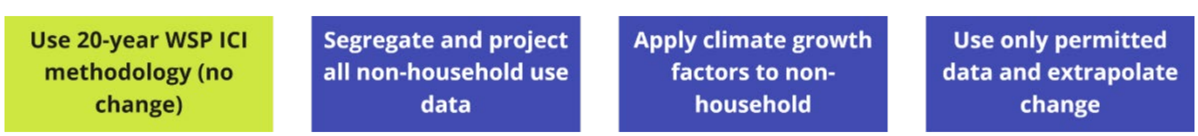


Figure 27. Industrial, Commercial, and Institutional growth rates options.

ICI is primarily differentiated from other business use cases by it being self-supplied and not sourced from a utility (PS). The largest ICI use cases are from agricultural produce processing and mining and the majority of

ICI growth is associated with mining for increased population. Currently, ICI growth is captured with the addition of known permits and population projections.

If both utility and self-supply Industrial, Commercial, and Institutional users could be segmented then independent growth variables could be associated with each segment and their impact and contribution to withdrawal rates could be more accurately planned. However, due to current data limitations from utilities, segmentation of users is not viable, and creating new data requirements is beyond the scope of this exercise. Additionally, extrapolating the growth rates of self-supplied ICI and applying climate dependent coefficients would likely introduce uncertainty. Therefore, maintaining the existing WSP methodology is suggested for the proposed WSVA assessment.

ICI Growth Rate Assumptions

There are several assumptions and uncertainties embedded within the WSP current ICI growth rate methodologies, some of which are:

Various ICI uses and growth rates are embedded in PS and are therefore assumed to grow relative to population.

WSP ICI additions are only done on a case-by-case basis and therefore not projected.

Climate change considerations and industry influences are not incorporated; however, may have an effect especially as agriculture processing technology improves.

ICI Growth Rate Research

Below are relevant highlights from research conducted to supplement the workgroup's decision-making process.

A District economist found a correlation between water supply growth with the mining industry and population growth. This is likely related to the needs for construction materials as population increases.

London segments water demand and growth rates by business sector and assigns a Gross Value Added as an informant factor in their modeling. This modeling uses individual growth rate coefficients per business sector.

Power Growth Rate

Figure 28 shows the options presented to the workgroup based on research of the latest scientific methodology and strategies implemented by similar agencies.

Figure 28. Power Generation growth options.

Current WSP methodologies incorporate PWR growth in an additive stepwise fashion as PWR demand is primarily associated with cooling requirements for power generating facilities. Additional growth is only incorporated with the development of new power facilities as defined and projected by those facilities in the utility's 10-year work plans, principally Florida Power & Light. Furthermore, future demand is at least partially expected to be met by renewable energy such as solar which has few to no water demand requirements.

There is a correlation between increased temperature and household cooling needs which may translate to increased demand on power producing facilities; however, the associated uncertainty is too high.

PWR Growth Rate Assumptions

There are several assumptions and uncertainties embedded within using the WSP current PWR growth methodologies, some of which are:

Power growth is not projected in the WSP, unless provided by the utility's 10-year work plans.

Power growth does include climate related factors.

PWR Growth Rate Research

Below are relevant highlights from research conducted to supplement the workgroup's decision-making process.

Many studies show an increase in power consumption needs as the climate warms. This is particularly acute (increase in 25%) for warm tropical climates with cooling needs.

A study found an increase of 11% in residential air conditioning cooling demand.

A study found that increased temperatures of cooling water reduce cooling efficiency and thus requires more water. Additionally, increased salinity concentration limits the ability of cooling water to be re-used and may therefore increase water needs.

Domestic Self Supply Growth Rate

Figure 29 shows the options presented to the workgroup based on research of the latest scientific methodology and strategies implemented by similar agencies.

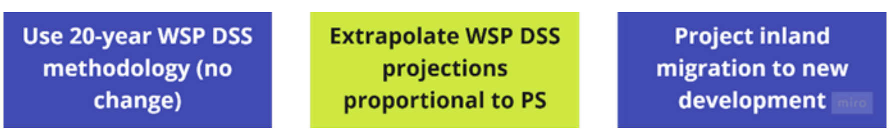


Figure 29. Domestic Self Supply growth options.

DSS projections are developed simultaneously with PS population estimates and projections. Although DSS is defined as self-supplied, often DSS users are within utility boundaries as it may be cheaper for the user to maintain an existing well or drill a new well rather than connecting to the utility. The WSP applies BEBR population growth to DSS. All permanent residents outside of PS utility service area boundaries are considered DSS population. Estimates of DDS population within the utility service area is subtracted from the utility service area population to estimate the utility-served population. In addition, local government plans for providing utility service in current DSS areas are incorporated in the projections, which result in decreases in DSS.

The increase in population is mostly closely associated with urban growth which is supplied by PS; therefore, the growth rates theoretically do not have to be proportional as DSS users may not necessarily be growing at that rate. However, even though the increase in demand may be due to additional urban growth, perhaps the lower cost to develop new DSS and its higher demand rates will end up being proportional to overall demands caused by population growth. Because of these considerations, maintaining the population trendline increase applied to PS was recommended.

DSS Growth Rate Assumptions

There are several assumptions and uncertainties embedded within the WSP current DSS growth methodologies, some of which are as follows:

Trends in land use changes are not incorporated

Population served by PS grows at the rate as DSS

DSS will not grow or shrink because of climate change impacts (such as drought and potentially lower water tables)

A.2: Water Demands and Withdrawal Rates

The following sections will discuss projecting future water needs as they relate to the growth recommendations highlighted earlier allocating these demands amongst sources. For instance, PS will incorporate an additional 30 years of population projections in its growth rate, and how demand will be distributed to each water source. The term "demand" throughout this section will refer to the withdrawal rate applied to the growth rate for each water use category.

Public Supply Withdrawal Rate

Figure 30 shows the options presented to the workgroup based on research of the latest scientific methodology and strategies implemented by similar agencies.

Figure 30. Public Supply withdrawal rate options.

In the 2018 LEC WSP, existing PS demands were met by the Surficial Aquifer (90%), the Floridan Aquifer (6%) and surface water sources (4%). The utility-specific PCUR is calculated in the WSP by taking the monthly and yearly utility-specific finished water data reported to Florida Department of Environmental Protection (FDEP) and dividing it by the utility's reported utility-served service area population. The most recent 5 years PCURs are averaged to develop an average utility-based PCUR which is then applied to the utility-served population projections to calculate the projected demand at five-year increments for a 20year horizon. This is also referred to as the net (finished) demands. Gross (raw) water withdrawals are the volumes needed from the water source(s) to produce the required net (finished) water volumes, considering water treatment process losses. Water use permit allocations for PS utilities are based on the gross (raw) water volume to meet service area demands. To determine gross (raw) water demand for each PS utility, net (finished) water projections were multiplied by raw-to-finished ratios, which are based on the treatment efficiency of each PS water treatment plant. For example, if a typical membrane softening treatment facility withdraws a gross (raw) volume of 10.00 mgd and produces 9.00 mgd of net (finished) water, its treatment losses are 10%. Therefore, its raw-to-finished ratio would be 1.11 (10 mgd divided by 9 mgd).

Florida Statute specifies that the level of certainty planning goal associated with identifying demands shall be based upon meeting demands during a 1-in-10-year drought event (Section 373.709(2)(a)1., F.S. The increased PS demands during 1-in-10-year drought conditions are calculated using the method described in the Districtwide Water Supply Assessment (SFWMD 1998), which considers the increased demands on the irrigation portion of PS during droughts. The drought demand factors are 1.17 for Martin County, 1.09 for St. Lucie County, and 1.17 for northeastern Okeechobee County (within the UEC Planning Area) and 1.10 for Palm Beach and Broward counties, 1.07 for Miami-Dade County, 1.03 for Monroe County and 1.06 for Hendry County. Average water demands were multiplied by the drought demand factor to calculate demands during 1-in-10-year drought conditions. This demand is modeled with both an average rainfall year and a 1-in-10-year drought.

The average rainfall year is defined as a year having rainfall with a 50 percent probability of being exceeded in any other year and a 1-in-10-year drought is defined as a year in which below normal rainfall occurs with a 90 percent probability of being exceeded in any other year; expected return frequency of once in 10 years.

There are many variables that affect the uncertainties in future drought conditions which are mostly encapsulated in temperature, rainfall, and ET and as such it is suggested that drought be represented in the climate variables rather than as change in the withdrawal rate.

A potential consequence of applying a more conservative modeling approach is increases in water needs may be needed to ensure water supply in drying conditions than current needs, i.e., increased allocations and potentially more frequent water shortage restrictions. This can perhaps be explained by the local and regional nature of drought and the extreme hydrologic differences between various planning scenarios. It is therefore not suggested that for the purpose of the proposed assessment the definition of drought in terms of withdrawal rates be altered without regional consensus or state direction. Additionally, the SFWMD's permitting threshold and planning goal are both established with a 1-in-10-year level of certainty.

PCUR are defined essentially as moving averages and an option to apply an extrapolated version of PCUR is based on the similar extrapolation suggested for PS population growth rates. However, utility based PCUR are affected by many variables whose uncertainties would make it difficult to isolate their trends from their causes. For instance, a decreasing PCUR may be the result of plant treatment or distribution efficiency, increased water conservation, or distributed growth to housing with lower demands, all of which have may have a different management response. Additionally, there exists gaps with current utility service boundary and use rate data. Making additional assumptions and their subsequent uncertainties would not be accurately captured without first developing new utility data standardization procedures which is beyond the scope of this effort. This is further emphasized given that many utilities conduct existing standard conservation plans rather than goal-based plans and may not be looking at or have different methodologies for understanding the causes, effects, and trends of different use categories. As a result, it is not suggested that trends in PCUR be extended beyond the WSP methodology.

Segmenting out climate affected use cases such as landscape irrigation that uses water from a PS utility or various climate affected business sectors can make the vulnerability assessment more robust. This segmentation would introduce the necessity for data that may not already exist; it would require the development of a new PCUR procedure and may not even have an applicable management consequence beyond the existing additional development of alternative water supplies or increased conservation. For instance, in certain areas, utility permit holders are intentionally limited by their withdrawal's ecological impacts and their ability to provide water for their customers as discussed in Restricted Allocation Area rules

(RAA) and WSPs while others are limited by their projected demands. Because of source restrictions (RAAs), many utilities have developed or are planning to develop alternative water supplies beyond their current fresh groundwater allocations and are not planning an increase in permitted surficial aquifer or surface water withdrawals. Conservation is therefore incentivized by the utility to meet the demands limited by existing withdrawal limitations such as the increased costs associated with alternative water supply development or the changing of water supply treatment methodologies to more expensive desalination. Further incentive for alternative water supply development is encouraged through cost-share opportunities and longer permit allocations; for example, most wells using the surficial aquifer must renew their permits every 10 years unless they meet the conditions of assurance, in which case it can be as long as 20 years. As an additional incentive to switch to alternative water sources, wells on the Floridan aquifer must renew their permits at a maximum of every 30 years. However, beyond the incentive and implementation challenges, segmenting out climate use cases may inform the redevelopment of existing rules to ensure continual supply. Due to a lack of comprehensive data, the need for developing new procedures, and the existing limitations already incentivizing resiliency, it is not suggested that climate related use cases in PWS be segmented.

Withdrawal rates would need be altered to reflect a potential reduction in treatment efficiencies due to climate change. For instance, if modeling shows sea level rise exacerbating saltwater intrusion, then the treatment efficiencies of coastal utility may decrease, which may result in increased demand on the system. This, however, is not suggested to be included in the proposed assessment as there is not enough research nor clear methodology to adequately predict efficiency decline. Furthermore, utility responses to decreased efficiencies may result in the development of alternative water supply or other management actions that are difficult to model.

Lastly, a regional withdrawal rate could potentially be applied rather than through associated utility withdrawal rates. This idea was based on the concept of understanding vulnerability from a macro perspective with demand needs allocated as decision variables. However, this perspective ignores the reality of the demands caused by existing infrastructure, is extremely difficulty to develop, introduces new uncertainties, and removes the ability to provide localized and therefore meaningful outputs. It is therefore not suggested that a regional withdrawal rate be utilized as part of the proposed assessment.

Based on the above discussion it is suggested that the proposed assessment utilize the current WSP approach of applying averaged PCUR determined for the 20/25-year WSP and then applying them to increased growth associated with future conditions. Additionally, utilizing the current approach would require fewer additional model runs and less time needed to analyze and develop a new methodology. Additionally, drought uncertainties would not be ignored but rather included in changing temperature, rainfall, and ET patterns.

PS Withdrawal Rate Assumptions

There are several assumptions and uncertainties embedded within using the WSP current PS withdrawal rate, some of which are as follows:

PCUR includes households, landscape, and business uses in addition to losses and distributions efficiency. Many of these categories contain various climate affected use cases which are all included in the PCUR, increasing it uncertainty.

Drought conditions are captured in 1-in-10 scenario runs. Increased drought uncertainties due to climate change are incorporated in temperature, rainfall, and ET changes.

Future demand beyond RAA limits is assumed to be met by alternative water supply or conservation i.e., modeling will limit demands at RAA withdrawal limits.

There are no econometric variables associated with growth or demand beyond those included in population projections.

PS Withdrawal Rate Research

Below are relevant research highlights.

Seattle public withdrawal rates used price and other econometric variables.

Washington State used and extrapolated per capita consumption withdrawal rate to 2075.

Oregon uses a standardized data collection from providers and segments and applies different methodologies to various zones based on their expected growth.

See research highlighted in PWS Growth Rate

Agricultural Withdrawal Rate

Figure 31 shows the options presented to the workgroup based on research of the latest scientific methodology and strategies implemented by similar agencies.

Figure 31. Agricultural demand options.

In the 2018 LEC WSP, existing Agricultural (AG) demands were met by surface water sources (80%) and the Surficial Aquifer (20%). The AG water withdrawal rate is determined in the WSP using the Agricultural Field Scale Irrigation Requirements Simulation (AFSIRS) model (Smajstrla 1990). The FDACS irrigated crop acres, soil types, growing seasons, and irrigation methods are used as input data for the AFSIRS model. AG withdrawal rate estimates and projections are based on the typical commercially grown crop categories developed by the FDEP and water management districts for use in water supply plans. The demands of these crops are then calculated for an average rainfall year and a 1-in-10-year drought. AFSIRS considers the parameters featured in the Figure 32 and illustrated in Figure 33.

Climate	Crop Data	Irrigation Efficiency	Soil Data	Land Use Data	Runoff
Daily Rainfall (NEXRAD)	Crop types [16 perennial (sugarcane, citrus, turf, etc) and 44 annual (vegetables)]	10 irrigation systems	773 detailed soil types by SCS (SSURGO)	Based on the ILG parcels	Runoff Curve Number *(TR55, USDA)*
Reference ET (RET) *(USGS)*	Crop coefficients (standard)	Percent irrigation efficiency	7 Generic Hydrologic Soil Groups (HSG)	Florida Land Use Cover Classification System (FLUCCS) Codes	
	Extinction depth/root zone depths (standard, crop based)	Percent area of soil surface irrigated	Infiltration: A – High, B – Moderate, C – Slow, D – Very Slow	Conversion table from FSAID ILG to AFSIRS detailed level crop codes	
	Growing seasons (for annual crops)	Percent fraction of ET from irrigated portion of crop root zone		at general use code level the categories crosswalk is direct 1 to 1	

Figure 32. AFSIRS parameters and data sources.

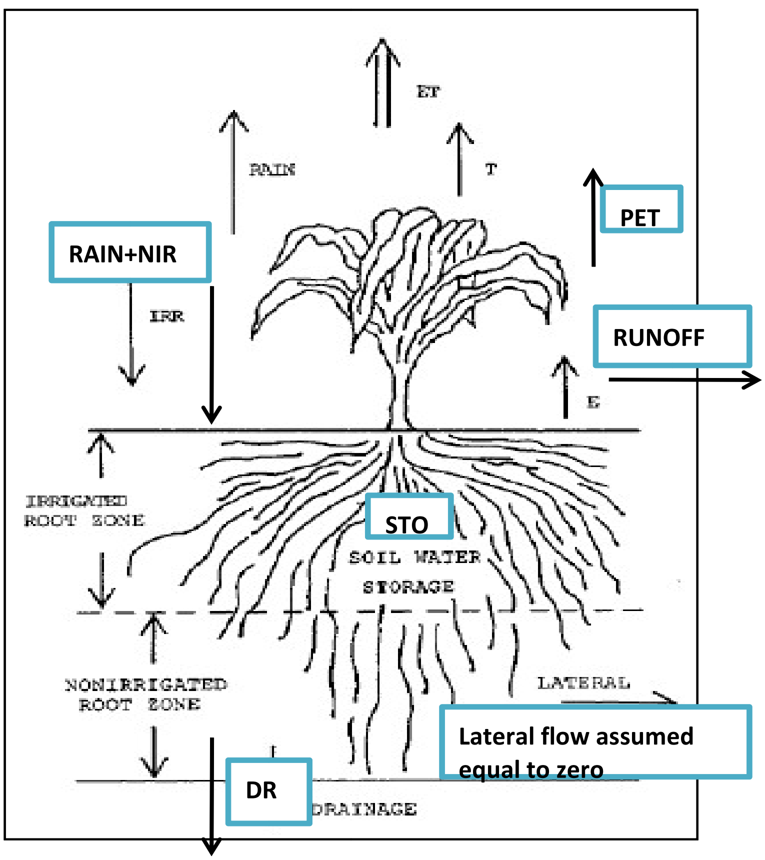


Figure 33. Illustration of parameters reflected in AFSIRS.

Within AFSIRS there are many parameters (beyond the growth rate parameters) that will be affected by climate change. For instance, climate change may cause soil to dry out, which can affect its storativity, transmissivity, and discharge characteristics. This change has a very influential effect both in practice and in modeling on the infiltration and recharge and will therefore the effect the demand and supply of availability sources. However, these effects and consequences of these changes are hard to anticipate. For example, if soils dry out then as infiltration rates increase so too does the irrigation demand, which can increase the agricultural production costs and may result in a change of crop type. Therefore, it is not suggested that new models or additional parameter changes be applied to the proposed assessment due to the increased response uncertainty.

The FSAID 7, 8, and 9 reports highlight a few of the potential effects of how climate change may impact agricultural demand; however, these effects are not included in the final estimates and are therefore not suggested to be applied to the proposed assessment.

It is suggested that 50-year temperature, rainfall, and ET conditions at be applied to AFSIRS (See red boxes in Figure 32) and applied to 20-year acreages and expected crop types provided by FDACS. This reduces the need for additional model runs, eliminates the time needed to develop a new methodology, and provides a means for comparison to WSP model runs.

AG Withdrawal Rate Assumptions

There are several assumptions and uncertainties embedded within using AFSIRS as the AG withdrawal rate, some of which are as follows:

All the assumptions represented in AFSIRS model and FDAC acreage and crop type are embedded.

Climate change will not be reflected in the following AFSIRS input categories: crop data, Irrigation efficiency, soil data, land use data and runoff curve numbers.

Climate changes will only be reflected in temperature, rainfall, and ET rates.

AG Demand Research

Below are relevant highlights from research conducted to supplement the workgroup's decision-making process.

FSAID 7, 8, and 9 reports conducted future demand with climate change scenarios of Representative Concentration Pathway 4.5 and 8.5 and looked at the following: changes in ETo, rainfall, temperature, warm night (effects ET), frost freezes, intensification of hydrologic cycle, shorter cold season.

Oregon's major demand assumption are the following: not to project crop differences, crops are irrigated properly, <u>existing and future shortages were not considered</u>, losses are in efficiency rate at 80% conveyance and 66% in application. Important conclusion factors: Early spring may affect specific crops, higher ET means higher consumption and demand, increased demands are expected to outpace increase precipitation even in wetter scenarios.

Irrigation withdrawal is likely to increase because of climate change effects on agriculture produced in Middle America. This withdrawal is associated with increase temperature and will outpace the expected increase in precipitation.

Ghait et al. does a thorough review of various ET models that can be applied to crops. Additionally, there are several alternate withdrawal rate methodologies that can be applied.

Landscape and Recreation Withdrawal Rate

Figure 34 shows the options presented to the workgroup based on research of the latest scientific methodology and strategies implemented by similar agencies.

Figure 34. Landscape and Recreation demand options.

In the 2018 LEC WSP, existing Landscape and Recreation (REC) demands were met by various surface water sources (39%), the Surficial Aquifer (32%), Reclaimed Water (27%), and the Floridan Aquifer (2%). REC demands are calculated only for areas with water use permits issued by the SFWMD. In 2018 REC withdrawal rates were calculated using AFSIRS for areas supplied by surface water sources, and the Surficial and Floridan Aquifers and using quantities submitted to the FDEP for areas supplied by reclaimed water. The 2023 withdrawal rates will use rates determined from annual water use reports. The exact methodology is still under development but will likely follow a similar approach to PS.

There are three types of irrigated landscaped areas outside of those permitted by the SFWMD that are excluded from the REC demands. The first type includes landscaped areas irrigated with potable water provided by PS utilities, which are accounted for under PS estimates and projections. The second type is irrigated single-family or duplex residential landscaped areas served by individual residential wells permitted by rule [Rule 40E-2.061, F.A.C.] or local stormwater pond, ditch, or canal rather than with an individual water use permit. Demands associated with these small, residential wells and surface water withdrawals are not quantified as part of the WSPs due to the lack of water use and acreage data. The third type of irrigated landscaped areas are those served with reclaimed water that do not require a water use permit. This usually occurs where reclaimed water is used directly from a pressurized pipeline or delivered into a lined or unlined lakes.

The vulnerability assessment will be conducted using only what can be incorporated into and simulated with the groundwater model. Therefore, it is suggested that future climate conditions be applied to the spatial data from REC acreages in WUPs. It should be noted that these demands will have growth rates based on the population growth rates.

REC Demand Assumptions

There are several assumptions and uncertainties embedded with using AFSIRS on spatially distributed REC demands, some of which are as follows:

Irrigation demands embedded within PS PCUR don’t incorporate climate change withdrawal rate changes.

Irrigation demands without spatial components will not be included and may account for a significant portion of the total demand.

Irrigation demands associated with small residential wells and those supported by reclaimed water will not be included as they are not directly incorporated into the groundwater model. Application of reclaimed water will be incorporated in the model simulations.

Locations associated with a WUP will be based on population growth rates to 2075.

REC Demand Research

Below are relevant highlights from research conducted to supplement the workgroup's decision-making process.

ASCE found that different plot types (single, multifamily, commercial) have a considerable effect on predictive demand because of increased lawns.

"The effect of climate change on municipal and industrial water demand could be estimated through the evaluation of how the range of potential future climates would affect outdoor demands."

"Results show that groundwater pumping and recharge both will increase and that the effects of groundwater pumping will overshadow those from natural fluctuations. Groundwater levels will decline more in areas with irrigation-driven decreasing trends in the baseline."

Industrial, Commercial, and Institutional Withdrawal Rate

Figure 35 shows the options presented to the workgroup based on research of the latest scientific methodology and strategies implemented by similar agencies.

Figure 35. Industrial, Commercial, and Institutional demand options.

In the 2018 LEC WSP, existing ICI demands were met by the surficial aquifer (38%), reclaimed water (35%), and various surface water sources (27%). Recirculated water used in closed-loop geothermal heating and cooling systems is not included in demand calculations. ICI projections assume demands for average rainfall years and 1-in-10-year drought conditions are the same and withdrawal demand is equal to user demand (no losses are assumed). The withdrawal rate for mining is connected to population growth and future demands are calculated accordingly.

Agriculturally focused ICI withdrawal rates such as those related to fruit cleaning will likely have impacts because of climate change; however, those impacts are too unpredictable and uncertain. For example, changes in withdrawal rates based on increasing processing efficiency will likely be inconsequential compared to those based on crop changes because of climate. Additionally, given that no additional business use cases are suggested to be segmented out and that drought conditions are accounted for in future climate conditions, it is suggested that the proposed assessment not deviate from the current WSP methodology.

ICI Withdrawal Rate Assumptions

There are several assumptions and uncertainties embedded within using existing WSP ICI withdrawal rate methodology, some of which are as follows:

ICI withdrawal rate will not change because of climate change

Demand rate associated with agricultural processing of different crop types and reductions to crop yield are not incorporated

ICI demands include only those defined by the WSP and not business use cases incorporated into PS

Future improvements to processing efficiency will not be incorporated

ICI mining withdrawal rates will be applied to future population growth

Power Withdrawal Rate

Figure 36 shows the options presented to the workgroup based on research of the latest scientific methodology and strategies implemented by similar agencies.

Figure 36. Power withdrawal rate options.

In the 2018 LEC WSP, existing Power (PWR) demands were met by Reclaimed Water (69%) and the Floridan Aquifer (31%). PWR demands do not include the use of brackish surface water and cooling water returned to its withdrawal source, or seawater. Demands under average rainfall and 1-in-10-year drought conditions are assumed to be equal for the PWR category, and no distinction is made between net and gross water demands. Baseline demands are estimated using utility-required reported water use. Additional demands are added on a case-by-case basis and projecting future demand based on climate change is not feasible. Additionally, increased power generation will likely be the result of renewables that require less demand such as solar power. Therefore, it is suggested that the proposed assessment apply existing WSP methodologies.

- Power water supply withdrawal rates will not include the effects of climate change

Domestic Self Supply Withdrawal Rate

Figure 37 shows the options presented to the workgroup based on research of the latest scientific methodology and strategies implemented by similar agencies.

Figure 37. Domestic Self Supply withdrawal rate options.

Domestic Self Supply (DSS) demand accounts for 1% of total water supply demands in the LEC. It is delineated in the WSP as potable water used by households served by small utilities (less than 0.10 mgd) or self-supplied by private wells. The WSP applied the same PCUR to both PS and DSS. It is suggested that the same methodology used in WSP be applied to DSS in the proposed assessment. (See discussion in PS Growth Rate and Withdrawal Rate and DSS Growth Rate)

All PS PCUR assumptions apply.

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Appendix A. Priority Implementation and Planning Project Descriptions and Cost Estimates

PRIORITY IMPLEMENTATION PROJECT DESCRIPTIONS AND COST ESTIMATES

C-8 Basin Resiliency and S-28 Coastal Structure

This resiliency project is mainly tied to the District's mission to provide flood control, water supply protection, and ecosystem restoration. An example of a project that is proposing to use a combination of nature-based solutions and gray infrastructure is the District's C-8 Basin project in Miami-Dade County. The District has been awarded 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. It is estimated that 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), Public Schools (33). The 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. S-28 is a gravity structure, and the designed discharge capacity is achieved when the gradient between the head and tailwater is sufficient to pass the flow. The 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 S-28 Structure was designed to 1) maintain optimum water control stages upstream in C-8, 2) release the design flood (100 percent of the Standard Project Flood) without exceeding the upstream flood design stage, 3) restrict downstream flood stages and discharge velocities to non-damaging levels, and 4) prevent saltwater intrusion during periods of extreme high flood tides The impacts of sea level rise at S-28 Coastal Structures are illustrated in Figure 1, demonstrating the risks of saltwater overtopping the gates and minimum freeboard requirements as early as 2040.

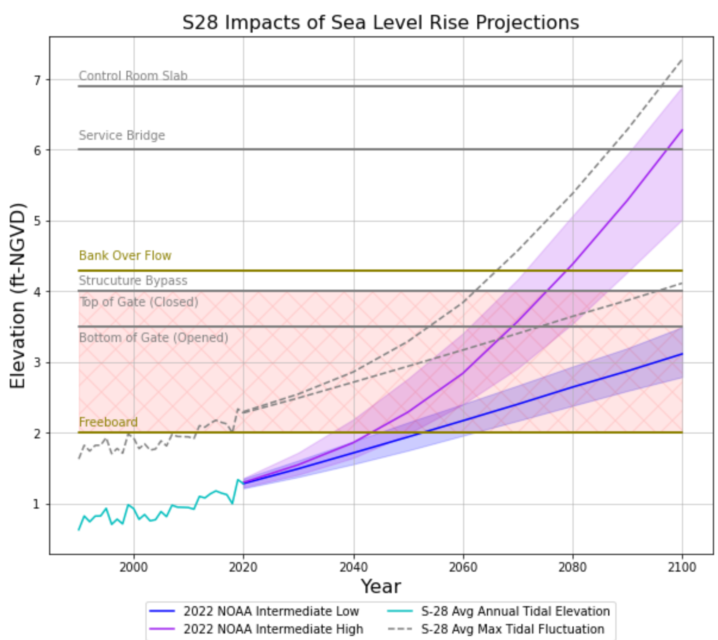


Figure 1: S-28 Impacts of Sea Level Rise Projections.

Percent of Population Impacted

One hundred percent of the population currently living in the C-8 basin, estimated at 270,000 people, will either directly or indirectly benefit from this project. It is estimated that an additional 70,000 workers, travelers, and visitors using the area for employment, transportation, and recreation. This means that 13% of the most populous county in Florida will benefit from an increased level of protection.

Community-Wide Benefits

Miami-Dade County has been shifting to incorporate a wider range of co-benefits (social, environmental, operational) into their projects to consider equity community-wide. In the context of the proposed project, “community-wide” refers to the historical, cultural, and recreational values that South Florida residents share. This project is aligned with the County’s goals of promoting resilience in a way that goes beyond environmental sustainability (https://www.miamidade.gov/global/management/strategic-plan/home.page). The County encourages jurisdictions to take a holistic approach to resilience efforts across four broad dimensions: Leadership and Strategy, Economy and Society, Health and Wellbeing, and Infrastructure and Environment. Their vision is “Delivering excellent service today and tomorrow.” The SFWMD works closely with the County and local jurisdictions to instill these values, particularly with respect to preparing for disasters and extreme events.

Impacts to Lifelines

This project will reduce direct and cascading flood impacts on Community Lifelines, residents, businesses, public services, infrastructure, and natural systems through three key lifelines: Food, Water, Shelter, Transportation, and Energy. Food, Water, Shelter - The proposed project significantly reduces the threat to property. Under the lifeline subcategory of shelter, the project increases the level of protection for over 200,000 primary homes across the area (and nearly 16,000 commercial, industrial, government, education, and religion buildings). Without the project, it would take months for residents whose homes may be significantly damaged to stabilize their living situation. Given the level of damage expected, residents would be displaced while repairs to homes occurred. All of the Village of Miami Shore's single-family homes are on septic tank systems. The septic tank systems east of NE 12th Avenue are particularly vulnerable to sea level rise. In recent years, several properties in the Village have had to retrofit their septic system due to system failure. Alleviation of flooding would minimize future failures.

Transportation

The golf course is bordered by Biscayne Blvd (U.S. Highway 1) to the east. This road is a key evacuation route and connector for the region. The project would alleviate flooding and allow this main artery to flow during extreme events.

Safety and Security

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). The overall flood protection levels of service will improve, and water supply protection from saltwater intrusion will increase. The proposed project removes a portion of utility infrastructure from the floodplain.

Impacts to Disadvantaged Communities

According to ACS Census, approximately 19% of the population living in the C-8 basin is considered financially disadvantaged. The CDC Social Vulnerability Index shows the census tracts to the north of the project area are in the highest vulnerability ranking. The proposed project has positive direct and indirect (ancillary) impacts related to risk reduction, which will benefit these vulnerable communities. The project will improve existing open space amenities, provide regional flood resilience, and leverage public investment in ongoing resiliency efforts through coordination with local partners. Ancillary impacts of the proposed green infrastructure will improve water quality, air quality, habitat creation, economic opportunity, reduced social vulnerability, cultural resources, public health, and mental health. These benefits are mainly related to flood risk reduction measures, environmental benefits, and the opportunities created for recreation and development.

Project Scope

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 the quality of life in the region. The project includes:

FPLOS Phase II Recommendations:

- S-28 Costal Structure Replacement: replacing major components of the S-28 Structure with a new elevated, gated, water control structure. 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.
- Forward Pump: building a new 2550 cfs forward pump station that will convey flood waters to tide when downstream water elevations are too high to allow gravity flow. The design of the proposed forward pump station will be adaptable and will include the ability to add additional pumps in the future as conditions continue to change.
- Tie Back Levee: Constructing a tie-back levee to provide flood and storm surge protection and supporting the required function of the spillway gates and pump during a 100-year event with a three-foot sea level rise.
- Canal Improvements: including improving geometry, widening, elevating, and enhancing canal banks throughout the basin, including the S-28 Coastal Structure immediate of C-8 Canal, as well as the most vulnerable locations along the secondary system (Marco Canal, NW 17 AVE Canal, Red Road/NW 57 AVE Canal, Spur #4 Canal, Spur Canal, Upper Rio Vista Canal), in partnership with Miami-Dade county.
- Storage: Adding approximately 250-acre feet of distributed storage in the C-8 Basin.
- Additional stormwater green infrastructure project components:
- Building vegetated berms and constructing a temporary impoundment to reduce runoff, therefore reducing peak flood elevations by storing water on the Miami Shores Golf Course during extreme events until canal elevations subside, allowing the impoundment to drain slowly and including a gated culvert to connect the detention area to the C-8 Canal. Beneficial reuse of excavated sediments from ditches/ponds to build levees and berms.
- Installing living shoreline features to assist in reducing bank erosion and improve aesthetics and storm resiliency. Ancillary benefits include the creation of aquatic habitat and water quality benefits, which will increase recreational value in the project area (kayaking, canoeing, wildlife observation, and fishing).

Adaptation and Mitigation Study for the C-8 Basin

The proposed C-8 Basin Resiliency Project was advanced following the completion of flood vulnerability assessments and findings of a need for a major refurbishment of the S-28 Structure through the Structure Inspection Program. The project, a no-regret strategy at the time of its inception, is currently in design. The recently completed comprehensive study of the C-8 basin (FPLOS Phase II Studies in the C-8 and C-9 Basins, 2023) confirmed the C-8 Basin project elements, evaluated the potential downstream impacts and water quality impacts to Biscayne Bay, and identified additional adaptations necessary to achieve flood risk reduction and resiliency within the C-8 Basin. The study, completed in collaboration with water managers of the secondary and tertiary flood control system, identified and recommended sequencing for the implementation of the project. The M2B implementation strategy is being recommended for near-term implementation, and M2C for longer-term implementation, addressing flood risks resulting from more than 2 feet of sea level rise. Table 1 illustrates which project components were recommended as part of each implementation strategy. The M2C features, once implemented, will achieve a level of service equal to or greater than the existing conditions under the 25-year SLR0 event for the 25-year SLR3 scenario. In addition to these regional project features, there are local projects that will be developed in partnership with local partners – at secondary and tertiary systems. The project recommendations from FPLOS Phase II Study for the C-8 Basin are not fully incorporate in this plan and will be detailed in future plan updates.

Table 1: FPLOS Phase II project component recommendations for the C-8 Basin

FPLOS Recommendation	M2A	M2B	M2C
• Forward pump station at S-28 Structure location	**1550 cfs**	**2550 cfs**	**3550 cfs**
• Tidal structure improvements and tieback levees/floodwalls	x	x	x
▪ Canal improvements (raised bank elevations)		x	x
▪ Canal improvements (Improved canal geometry)		x	x
▪ Canal improvements (Canal widening)			x
▪ 250 acre-feet of distributed storage		x	x

Reducing Risk and to What Level

The proposed project consists of local and regional flood mitigation strategies that reduce flood risk and enhance resiliency. These mitigation strategies will increase the effective resilience of the entire C-8 Basin. A range of critical assets, including fire stations, emergency shelters, and medical facilities, support several Community Lifelines and a variety of cultural, historical, and environmental resources in the basin. Additionally, the County has a high Building Code Effectiveness Grading Schedule (BCEGS) score of 2, which shows a commitment to reducing risk through strong building code adoption and enforcement activities. Extensive land development and population increases within the basin have already exceeded the original design assumptions of the C-8 Canal and S-28 Structure. Significant changes in climate conditions and sea level rise have also impacted the project and are limiting flood protection operations. These risks and their potential impacts are multifaceted and involve flood hazards driven by storm surges, high tides, and extreme rainfall.

Increase Resilience

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 rain and storm surge events. Vegetated berms and living shoreline features are also incorporated into the conceptual plan to enhance water quality and aquatic habitat. The strategy to reduce runoff in this densely urbanized basin includes the implementation of a series of distributed storage solutions. These project features can serve as a pilot example regionally, as nearby jurisdictions are looking to implement similar measures.

Ancillary Benefits

Ancillary benefits include improved fish and wildlife habitat from the 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 the implementation of vegetated berms and temporary flood water storage on the golf course and increased opportunities for recreation. SFWMD aims to improve the C-8 Basin's water quality and ecological functions beyond enhancing the flood protection level of service while maximizing the risk reduction benefits and co-benefits of natural and nature-based solutions, such as short- and long-term environmental, economic, and social advantages that improve a community's quality of life and make it more attractive to new residents and businesses.

Leveraging Innovation

This project will introduce green infrastructure features that have not been used previously in this area. While Miami-Dade County is eager to pilot linear parks, living shorelines, and expand Greenways and Blueways, this project will be the first opportunity in this basin. The County conducted stakeholder engagement to share the approaches and gather feedback. The community most enthusiastically supported the green infrastructure approaches.

Outreach Activities

A comprehensive public outreach process is embedded in the SFWMD Sea Level Rise and Flood Resiliency Plan – Annual Update and the Flood Protection Level of Service Program (FPLOS), along with the and the Miami-Dade Sea Level Rise Strategy, to ensure equal opportunity for South Florida communities to participate in the planning and decision-making process. The FPLOS Phase II Studies' initial round of workshops and meetings are designed to obtain local project data and information about community needs, promoting coordination and collaboration with partner agencies and local communities. The closing workshops and outreach efforts are designed to provide stakeholders with helpful planning tools and cost-effective courses of action for prioritizing and designing projects in the secondary and tertiary systems and inform the community about the impacts of flooding and the benefits of the adaptation and mitigation projects identified. This process was recently completed at the C-8 Basin, and the project site (http://www.buildcommunityresilience.com/SFWMD/FPLOS/c8c9/) was used as a tool to collect information and feedback from community partners and make outreach materials available.

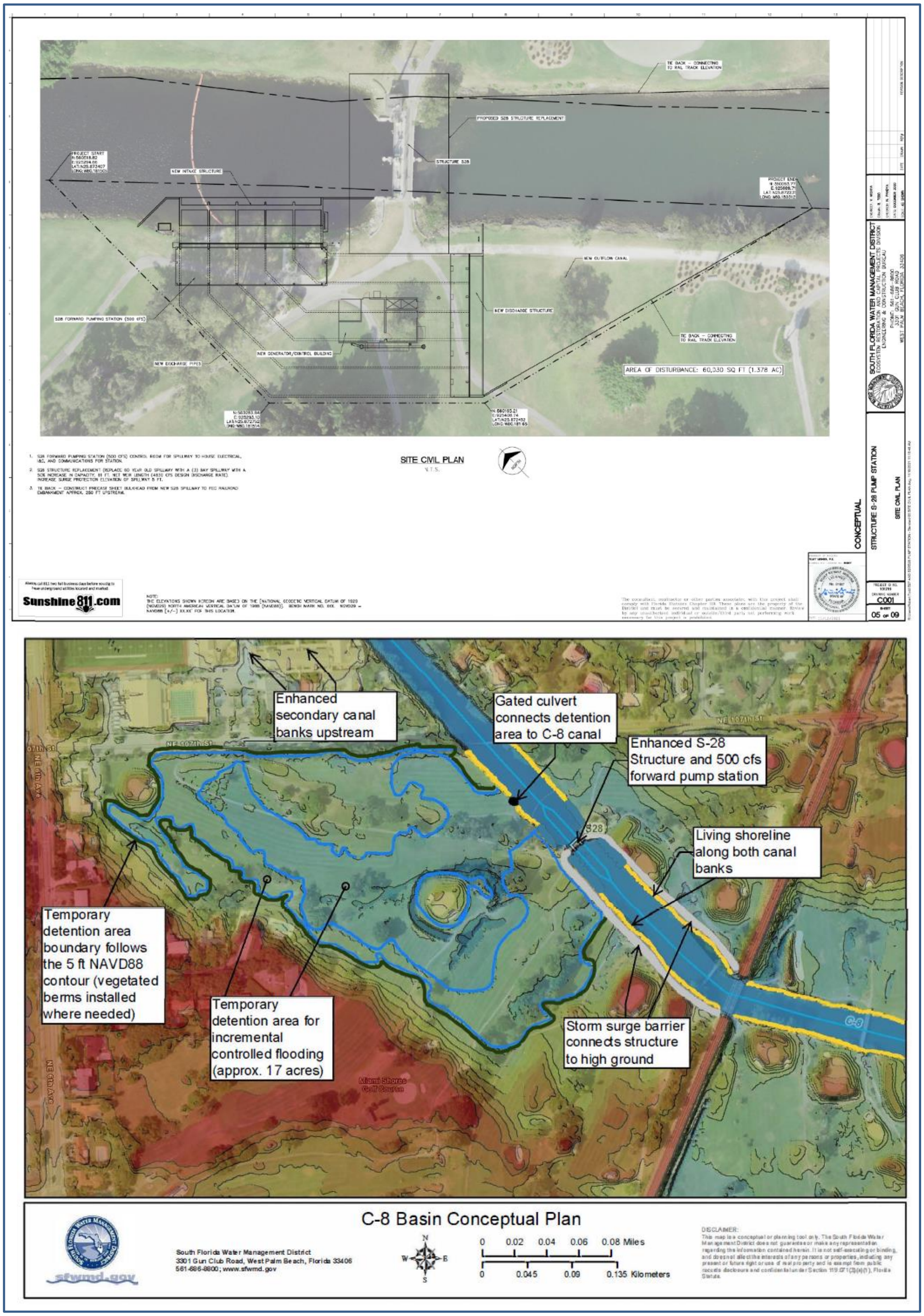


Figure 2: Site plan for S-28 Structure features and conceptual plan for the C-8 Basin.

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 2 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 the 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 the 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 the 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, sea level rise, 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, the 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 the landowner will initiate upon funding confirmation.

C-8 Basin Cost Estimate

Structure Enhancement and Pump Station (M2B)	
S-28 Structure Replacement	$20,772,538
Forward Pump (2550 cfs)	$133,752,500
Forward Pump Backup Generator Facility	$14,300,000
Structure Tie Back (Flood Barrier)	$3,733,750
Design & Construction Management	$25,883,818
Real Estate	NA
Total Pump Station Cost	**$198,442,607**
Storage (M2B)	
Distributed Storage (~250 Acre-Ft)	$38,860,000
Design & Construction Management	$5,829,000
Total Storage Cost	**$44,689,000**
Canal Improvements (M2C)	
Raise Canal Banks (to 7.5 feet NGVD29)	$13,281,910
Widen Canal (approx. 20,000 linear feet by 100 feet)	$33,832,330
Design & Construction Management	$7,067,136
Total Canal Improvements Cost	**$54,181,376**
Stormwater Green Infrastructure / nature-based solutions (BRIC Application)	
Temporary Impoundment, Vegetative Berms, and Living Shoreline	**$1,605,000**
Total Cost Estimate for C-8 Basin	**$298,917,983**

Note: The cost assumptions for the FPLOS Phase II M2 Alternatives are planning level estimates and will be refined as the project designs advance.

C-9 Basin Resiliency and S-29 Coastal Structure

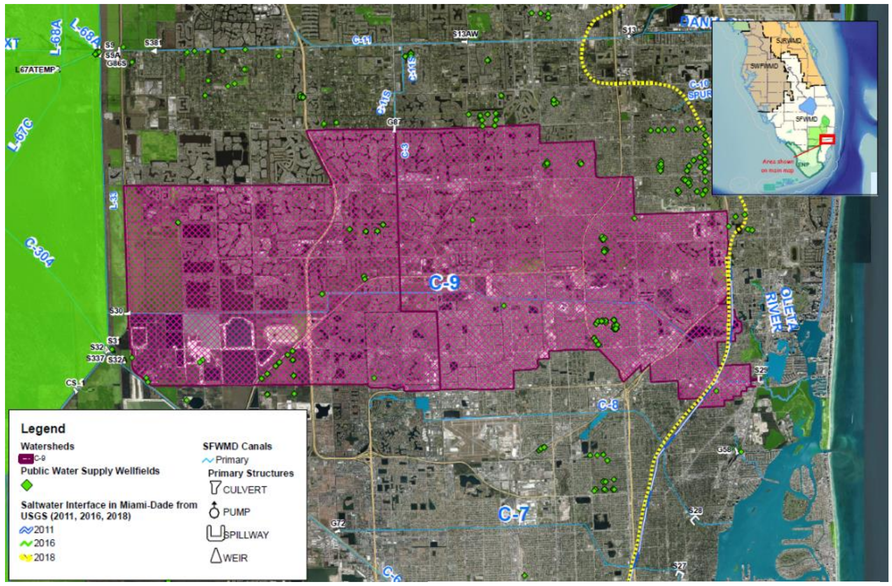


Figure 3: Map of C-9 Basin

This resiliency project is mainly tied to the District's mission to provide flood control, water supply protection, and ecosystem restoration. This project proposes flood risk reduction measures for the C-9 Basin, a region of about 549,964 people (Census Tracts, 2022), encompassing 100 square miles, located in the southern portion of Broward County and northeastern portion of Miami-Dade County (Figure 3). The basin area is fully developed with primarily residential and commercial uses. The C-9 Canal and the S-29 Coastal Structure are the primary flood control features of this basin. The C-9 Canal receives and conveys flood waters by gravity through the S-29 Coastal Structure to the Oleta River (tide). 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. The S-29 Structure is located near the mouth of the C-9 Canal, in an urbanized area of North Miami Beach east of Biscayne Boulevard and just north of Northeast 165th Terrace. The structure controls fresh water flows out of the C-9 Canal into the Oleta River and drains the C-9 East and C-9 West watersheds. The C-9 Canal extends approximately 19.5 miles east from the L-33 Canal adjacent to Water Conservation Area 3B and the lake belt region before traversing the densely populated area between Miramar to the north and Miami Gardens to the south. The canal drainage area is developed with a mixture of commercial structures along Biscayne Boulevard, high-rise residences immediately to the east, and a public park to the north. The S-29 Structure was originally designed by the U.S. Army Corps of Engineers (USACE) as part of the Central and Southern Florida (C&SF) Project with the objective of providing flood control and preventing saltwater intrusion. The C&SF Project was authorized in 1948 and was constructed by the USACE between 1950 and 1970. S-29 is a gravity structure, and the designed discharge capacity is achieved when the gradient between the head and tailwater is sufficient to pass the flow. Operation of the gates is automatically controlled so that the gates open or close in accordance with the seasonal operational

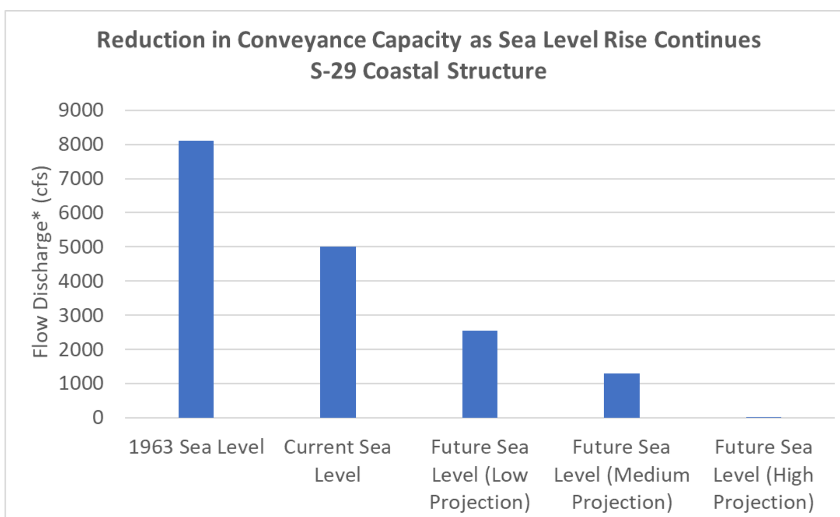


Figure 4: Reduction in conveyance capacity at S-29 as SLR continues.

criteria. The structure's original design did not account for the sea level rise of the magnitudes that are being experienced today along the coastline of South Florida. Figure 4 illustrates the impacts of sea level rise on conveyance capacity at the S-29 structure over time.

Percent of Population Impacted

One hundred percent of the population currently living in the C-9 basin, estimated at 549,964 people (2022 Census), will either directly or indirectly benefit from this project. The overall flood protection levels of service and water supply protection from saltwater intrusion are expected to improve. Flood modeling results from the C-9 Basin Flood Protection Level of Service Study, as detailed here, demonstrate basin-wide benefits.

Community-Wide Benefits

SFWMD, Broward, and Miami-Dade County have been shifting to incorporate a wider range of co-benefits (social, environmental, operational) into their projects to consider equity community-wide. In the context of the proposed project, "community-wide" refers to the historical, cultural, and recreational values that South Florida residents share. This project is aligned with Miami-Dade County's goals of promoting resilience in a way that goes beyond environmental sustainability.

Miami-Dade County encourages jurisdictions to take a holistic approach to resilience efforts across four broad dimensions: Leadership and Strategy, Economy and Society, Health and Wellbeing, and Infrastructure and Environment. Their vision is "Delivering excellent service today and tomorrow." The SFWMD, as the agency responsible for the primary water control system, works closely with the County and local jurisdictions to instill these values, particularly with respect to preparing for disasters and extreme events.

Impacts to Lifelines

This project will reduce direct and cascading flood impacts on Community Lifelines, residents, businesses, public services, infrastructure, and natural systems through three key lifelines: Food, Water, Shelter, Transportation, and Energy. Food, Water, Shelter. The proposed project significantly reduces the threat to property. Under the lifeline subcategory of shelter, the project increases the level of protection for over 177,621 primary homes across the area. Without the project, it would take months for residents whose homes may be significantly damaged to stabilize their living situation. Given the level of damage expected, residents would be displaced while repairs to homes occurred. Many of the basin's single-family homes are on septic tank systems. The septic tank systems east of I95 are particularly vulnerable to sea level rise. In recent years, several properties in this basin have had to retrofit their septic system due to system failure. Alleviation of flooding would minimize future failures.

Transportation

The S-29 Structure is bordered by Highway U.S.1 to the west and SR826 to the south. These roads are key evacuation routes and connectors for the region. The project would alleviate flooding and allow these main arteries to function and be more easily accessible during extreme events.

Safety and Security

In addition, 162 critical assets would be protected under the proposed project. These include Airports (5), Fire Stations (19), Hazardous Waste Transport Facilities (2), Heliports (3), Hospitals/Medical Facilities (17), Law Enforcement Centers (6), and Public Schools (110). The overall flood protection levels of service will improve, and water supply protection from saltwater intrusion will increase. The proposed project removes a portion of utility infrastructure from the floodplain.

Impacts to Disadvantaged Communities

To ensure forty percent (40%) of the overall project benefits flow to disadvantaged communities that are marginalized, underserved, and overburdened by environmental stressors, the District relies on data available through the Climate and Economic Justice Screening Tool (CEJST) and the Centers for Disease Control and Prevention (CDC) Agency for Toxic Substances and Disease Registry (ATSDR) Social Vulnerability Index (SVI). Based on these data, fifty-seven percent (57%) of the population within the project impact area were identified as socioeconomically disadvantaged and will receive equal access to community-wide benefits from the implementation of this resiliency project. These benefits are mainly related to flood risk reduction measures, environmental benefits, and the opportunities created for education, recreation, and development.

The CEJST identifies twenty-five percent (25%) of the population within the project impact as disadvantaged under the Climate Change category. The climate change category quantifies and considers the percent low-income population and higher education non-enrollment as well as expected population, building, and agricultural loss rates above pre-determined thresholds.

The CDC identifies twenty-seven percent (27%) of the population within the project impact areas as having an SVI greater than 0.8 or higher, the highest vulnerability ranking, and thirty percent (30%) of the population within the project impact area as having an SVI between 0.6 and 0.8, the second highest vulnerability ranking. The CDC/ATSDR SVI ranks each census tract on 16 social factors, including poverty, lack of vehicle access, and crowded housing, and groups them into four related themes.

Project Scope

The proposed project consists of flood mitigation and enhancement strategies at the C-9 Basin to build flood resiliency and increase protection against saltwater intrusion. Specifically, the project includes:

FPLOS Phase II Recommendations:

- S-29 Coastal Structure Enhancement: converting the gate opening system to a more robust mechanism, upgrading the existing gates to elevated, corrosion-resistant stainless-steel gates and enhancing, elevating, and hardening the control building, and adding a corrosion control system to the structure.
- Forward Pump: building a new 2550cfs forward pump station that will convey flood waters to tide when downstream water elevations are too high to allow gravity flow. The design of the proposed forward pump station will be adaptable and will include the ability to add additional pumps in the future as conditions continue to change.
- Tie Back Levee: Construct a tie-back levee/salinity barrier to provide flood and storm surge protection and support the required function of the spillway gates and pump during a 100-year event with a three-foot sea level rise.
- Canal Improvements: raising canal bank elevations, improving geometry, and widening. A portion of approximately 7 miles of the C-9 Canal is being widened to include nature-based solutions enhancement along canal banks (more details provided in the subsection below)
- Storage: Adding approximately 250-acre feet of distributed storage in the C-9 Basin
- Additional stormwater green infrastructure project components: Enhancing an approximately 16-acre flow-through wetland/stormwater detention area at Pickwick Lake (Figure 5), which is owned by the City of North Miami Beach, to reduce local runoff in the area. The stormwater detention area will incorporate Biosorption Activated Media (BAM), an innovative stormwater best management practice in South Florida that has been deployed across agencies and in varied use cases and has consistently reduced harmful nutrients such as nitrogen and phosphorus, and other contaminants in stormwater.

- Installing 1,850 linear feet of living shoreline to assist in reducing bank erosion and improve aesthetics and storm resiliency. In addition, a shaded gathering area, educational signage, and other amenities to help increase community engagement and public use will be incorporated into the project.

Adaptation and Mitigation Study for the C-9 Basin

The proposed C-9 Basin Resiliency Project was advanced following the completion of flood vulnerability assessments and findings of a need for a major refurbishment of the S-29 Structure through the Structure Inspection Program. The project, a no-regret strategy at the time of its inception, is currently in design. The recently completed comprehensive study of the C-9 basin (FPLOS Phase II Studies in the C-8 and C-9 Basins, 2023) confirmed the C-9 Basin project elements, evaluated the potential downstream impacts and water quality impacts to Biscayne Bay, and identified additional adaptations necessary to achieve flood risk reduction and resiliency within the C-9 Basin. The study, completed in collaboration with water managers of the secondary and tertiary flood control system, identified and recommended sequencing for implementation of the project. The M2B implementation strategy is being recommended for near-term implementation, and M2C for longer-term implementation, addressing flood risks resulting from more than 2 feet of sea level rise. Table 2 illustrates which project components were recommended as part of each implementation strategy. The study recommended that features of the M2C scenario, such as the canal widening, be opportunistically implemented to deliver immediate water quality and other social benefits along with flood risk reduction. The M2C features, once implemented, will achieve a level of service equal to or greater than the existing conditions under the 25-year SLR0 event for the 25-year SLR3 scenario. In addition to these regional project features, there are local projects that will be developed in partnership with local partners – at secondary and tertiary systems.The project recommendations from FPLOS Phase II Study for the C-9 Basin are not fully incorporate in this plan and will be detailed in future plan updates.

Table 2: FPLOS Phase II project component recommendations for the C-9 Basin.

FPLOS Recommendation	M2A	M2B	M2C
• Forward pump station at S-29 Structure location	**1550 cfs**	**2550 cfs**	**3550 cfs**
• Tidal structure improvements and tieback levees/floodwalls	x	x	x
▪ Canal improvements (raised bank elevations)		x	x
▪ Canal improvements (Improved canal geometry)		x	x
▪ Canal improvements (Canal widening)			x
▪ 250 acre-feet of distributed storage		x	x

Figure 5: Pickwick Lake wetland restoration/stormwater detention area features.

Reducing Risk and to What Level

Extensive land development and population increases within the basin have already exceeded the original design assumptions of the C-9 Canal and S-29 Structure. Significant changes in climate conditions and sea level rise have also impacted the area and are limiting flood protection operations. These risks and their potential impacts are multifaceted and involve flood hazards driven by storm surges, high tides, and extreme rainfall. This project will reduce flooding risk by reducing peak canal stages, bank exceedances, and overland flood inundation throughout the C-9 Basin for the 5-year, 10-yr, 25-yr, and 100-yr extreme storm events and under 1ft, 2ft, and 3ft sea level rise scenarios, as demonstrated by hydrology and hydraulics model simulations. The project consists of local and regional flood mitigation strategies that reduce flood risk and enhance resiliency. These mitigation strategies will increase the resilience of the entire C-9 Basin. A range of critical assets, including fire stations, emergency shelters, and medical facilities, support several Community Lifelines and a variety of cultural, historical, and environmental resources in the basin. Additionally, the County has a high Building Code Effectiveness Grading Schedule (BCEGS) score of 2, which shows a commitment to reducing risk through strong building code adoption and enforcement activities.

Increase Resilience

The project components to increase resilience include enhancements to the S-29 Structure and the addition of a forward pump and a tie-back levee. The pump will maintain basin discharge capacity while sea levels rise. The new levee and increased elevation of the flood control gates and service bridge will help prevent overtopping and reduce saltwater intrusion risk. A significant aspect of this project includes the construction of demonstration-level nature-based features at Pickwick Lake in partnership with the City of North Miami Beach. These proposed components include enhancing a 16-acre flow-through wetland/stormwater detention area and installing a living shoreline to reduce bank erosion, and indirectly enhancing water quality and aquatic habitat. The overall strategy to reduce runoff in this densely urbanized basin includes the implementation of a series of distributed storage solutions. This project can serve as an example regionally, as nearby jurisdictions are looking to implement similar measures. Elevation of secondary canal banks and construction of sluice gates with green retaining walls will also help to reduce flooding impacts and increase resilience in the basin.

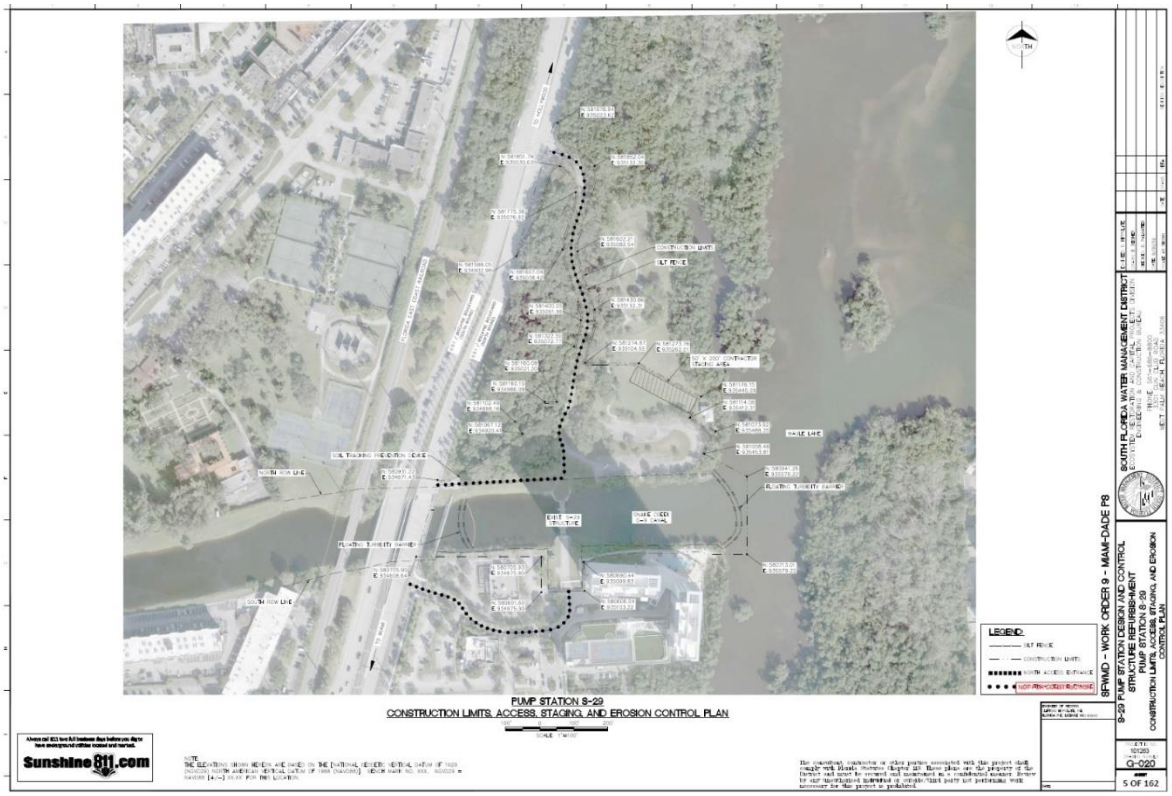


Figure 6: Site plan at S-29 Structure.

Ancillary Benefits

Beyond enhancing the flood protection level of service, the project aims to maximize the risk reduction benefits and co-benefits of nature-based solutions and improve the C-9 Basin's water quality and ecological functions. Benefits include short and long-term environmental, economic, and social advantages that improve a community's quality of life, emphasize community engagement, and increase recreational value in the project area (kayaking, canoeing, wildlife observation, and fishing). Ancillary benefits also include improved fish and wildlife habitat from the 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 the implementation of the flow-through wetland/stormwater detention area and increased opportunities for recreation.

Leveraging Innovation

This project will introduce green infrastructure features that have not been used previously in this area. While Miami-Dade County is eager to pilot linear parks, living shorelines, and expand Greenways and Blueways, this project will be the first opportunity in this basin. The County conducted stakeholder engagement to share the approaches and gather feedback. The community most enthusiastically supported the green infrastructure approaches.

Outreach Activities

A comprehensive public outreach process is embedded in the SFWMD Sea Level Rise and Flood Resiliency Plan – Annual Update and the Flood Protection Level of Service Program (FPLOS), along with the and the Miami-Dade Sea Level Rise Strategy, to ensure equal opportunity for all members of South Florida communities to participate in the planning and decision-making process. The FPLOS Phase II Studies' initial The initial round of workshops and meetings are designed to obtain local project data and information about community needs, promoting coordination and collaboration with partner agencies and local communities. The closing workshops and outreach efforts are designed to provide stakeholders with helpful planning tools and cost-effective courses of action for prioritizing and designing projects in the secondary and tertiary systems and inform the community about the impacts of flooding and the benefits of the adaptation and mitigation projects identified. This process was recently completed at the C-9 Basin, and the project site (17) was used as a tool to collect information and feedback from community partners and make outreach materials available.

C-9 Basin Cost Estimate

Structure Enhancement and Pump Station (M2B)	
S-29 Structure Refurbishment	$12,856,352
Forward Pump (2550 cfs)	$111,669,000
Forward Pump Backup Generator Facility	$11,919,000
Structure Tie Back (Flood Barrier)	$2,769,000
Design & Construction Management	$21,812,000
Total Pump Station Cost	**$177,025,352**
Storage (M2B)	
Distributed Storage (~250 Acre-feet)	$38,860,000
Design & Construction Management	$5,829,000
Total Storage Cost	**$44,689,000**
Canal Improvements (M2C)	
Raise Canal Banks (to 7.5 feet NGVD29)	$7,119,000
Widen Canal (approx. 40,000 linear feet by ~40-50 feet, with nature-based solutions enhancements along the canal bank)	$53,860,000
Widen Canal (approx. 40,000 linear feet by 75 feet)	$53,860,000
Design & Construction Management	$17,227,000
Total Canal Improvements Cost	**$132,066,000**
Stormwater Green Infrastructure / nature-based solutions (BRIC Proposal)	
Pickwick Lake and Living Shoreline	$1,500,000
Total Cost Estimate for C-9 Basin	**$355,280,352**

Note: The cost assumptions for the FPLOS Phase II M2 Alternatives are planning level estimates and will be refined as the project's designs advance. The latest 30% design for this project is recommending a cost estimate of about $140M for the 2500cfs forward pump and S-29 structure enhancement.

C-9 Canal Enhancement with Nature-Based Features

The C-9 Canal Enhancement project includes creating a linear wetland along a six-mile section of the C-9 Canal right-of-way to increase storage capacity along canal banks and reduce out-of-bank flooding impacts. The project also provides significant co-benefits (social, environmental and water quality) along with flood risk reduction, as SFWMD's right-of-way and land ownership conditions allow. This proposed project is a component of the C-9 Basin Resiliency Project and includes the following features:

- Building berms along the outer edge of the right of way to reduce out-of-bank flooding impacts.
- Constructing distributed stormwater storage wetlands along the C-9 Canal banks, including a mosaic of ecotones (wetland, terrestrial and aquatic depending on topography).
- Constructing/modifying access roads along the banks of the C-9 Canal to improve operations and maintenance and increase the potential for public access and recreation.
- Connecting the wetland to the C-9 Canal using structural soil and low water crossings. This will increase floodplain connectivity, increase the ability to store water, and indirectly improve water quality, including dissolved oxygen levels and improve fish and wildlife habitat.
- Constructing structural and nature-based features at the outfalls of 8-10 secondary canals to improve water quality.
- Constructing temporary pump pads at secondary canal outfalls. The pads would make it easier to deploy temporary pumps during and after extreme events, as needed.

Figure 7: Rendering of the C-9 Canal Enhancement project.

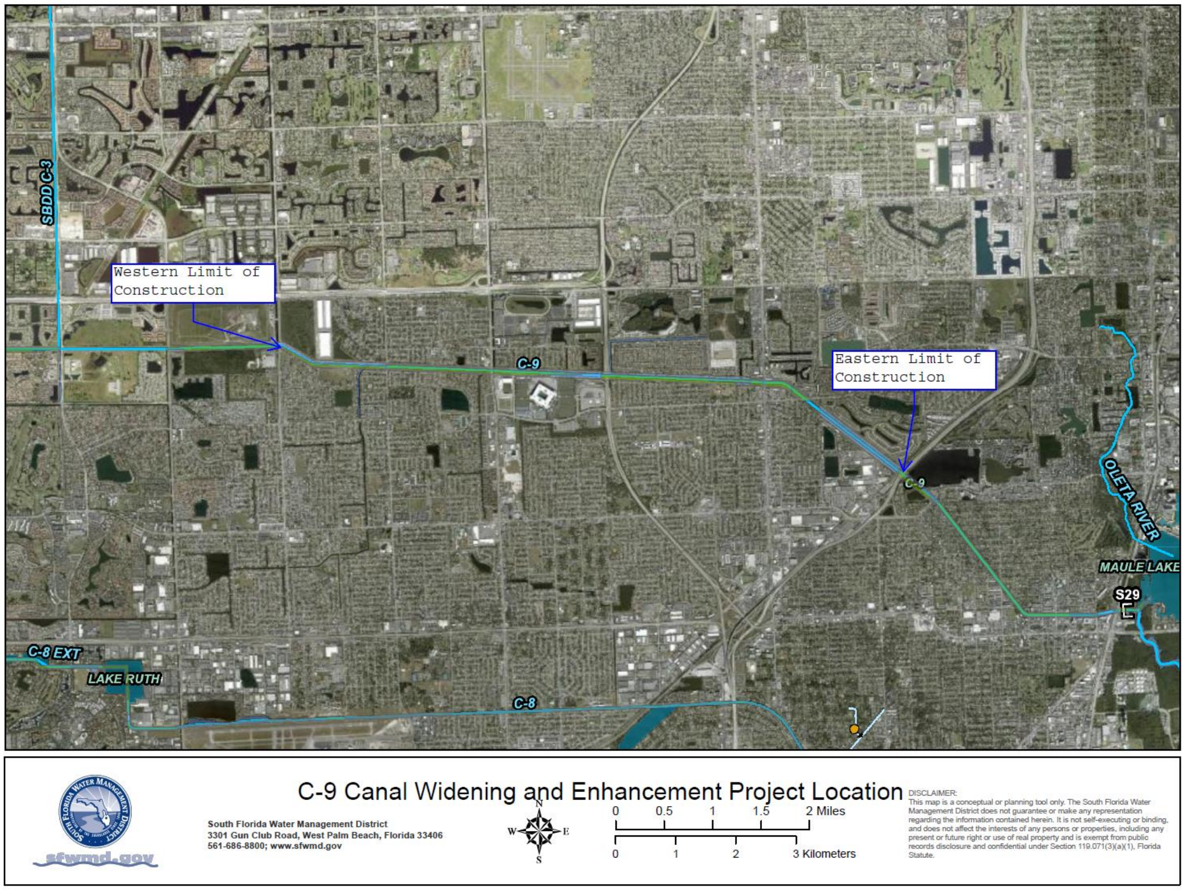


Figure 8: Potential project footprint for C-9 Enhancement project.

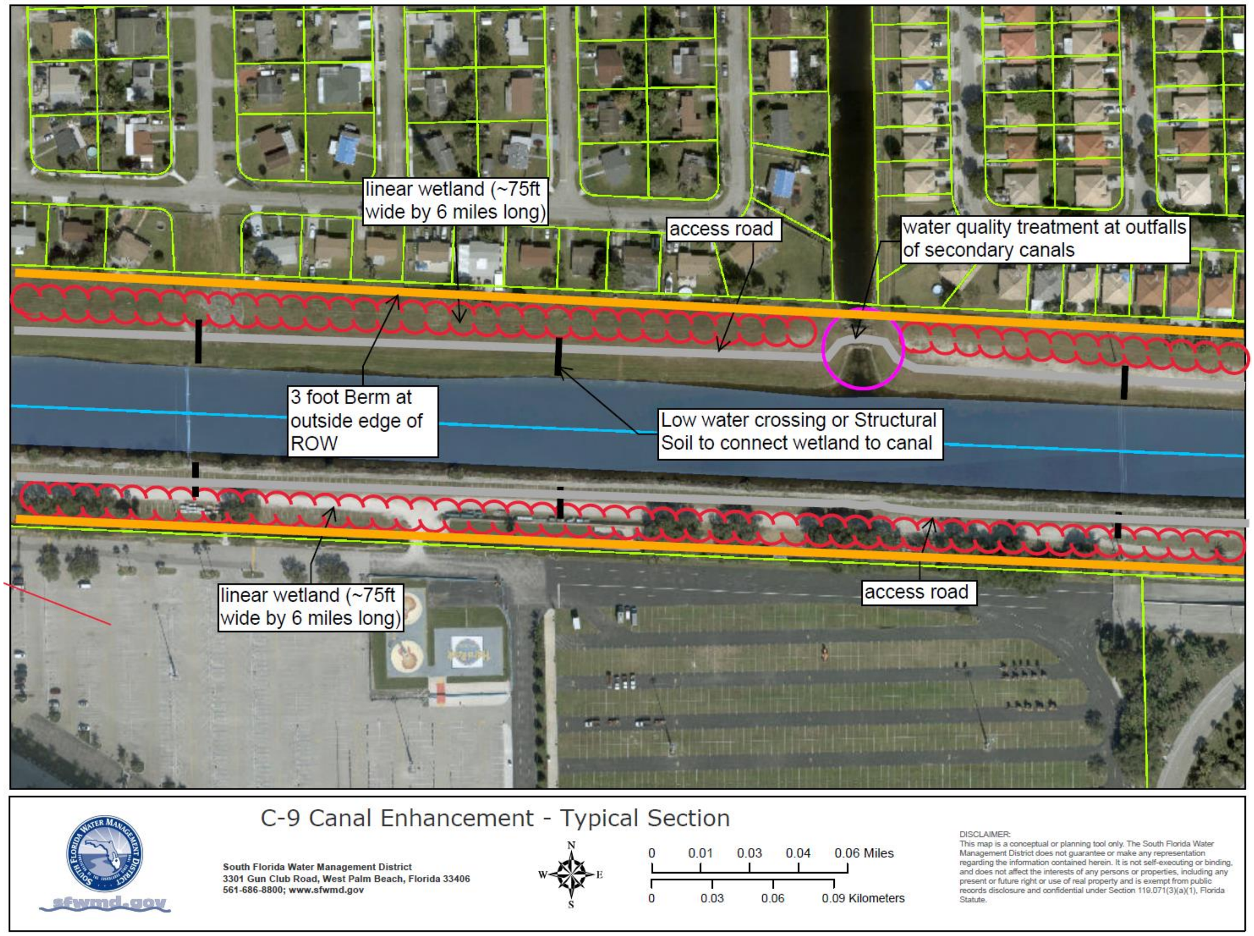


Figure 9: Typical section of the C-9 Canal Enhancement project showing potential project features.

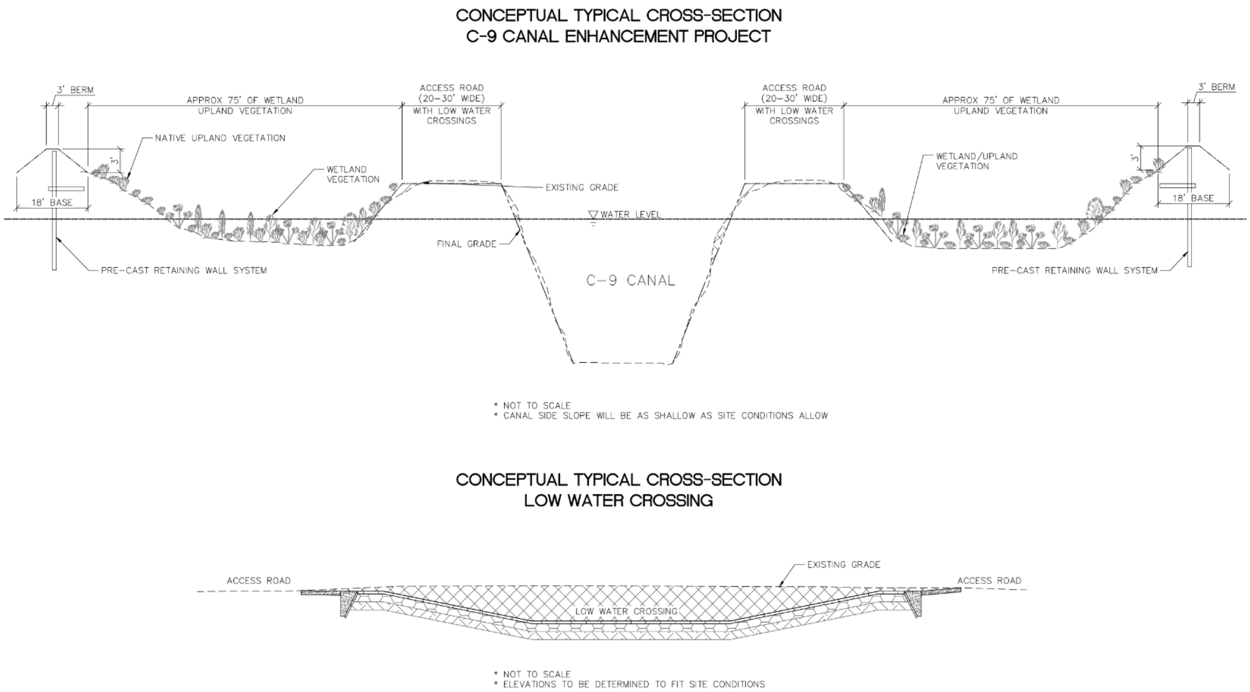


Figure 10: Typical cross-section of the C-9 Canal Enhancement project showing potential project features.

C-7 Basin Resiliency and S-27 Coastal Structure

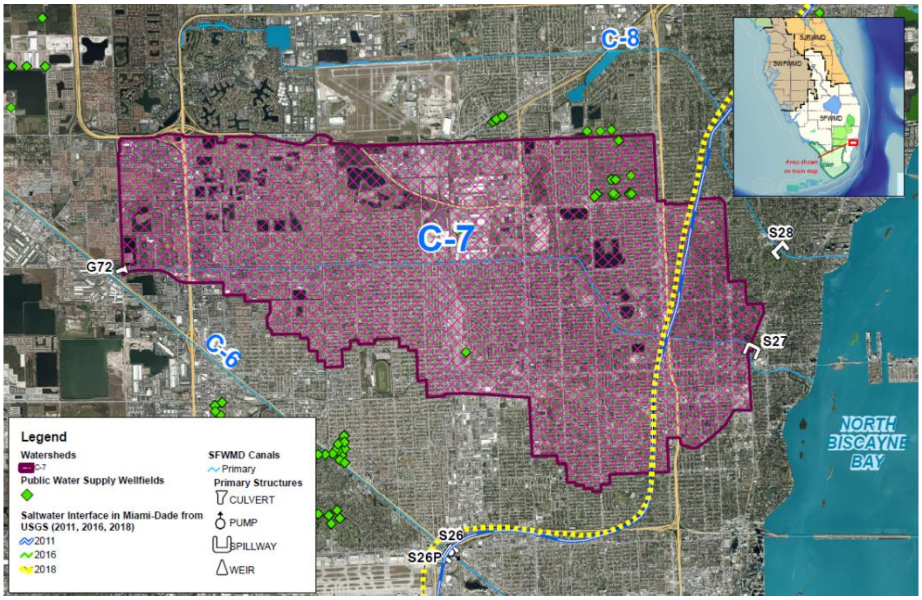


Figure 11: Map of C-7 Basin.

This resiliency project is mainly tied to the District's mission to provide flood control, water supply protection, and ecosystem restoration. S-27 is a reinforced concrete, gated spillway, with discharge controlled by two vertical lift gates with a discharge capacity of 2,800 cfs. S-27 is a gravity structure, and the designed discharge capacity is achieved when the gradient between the head and tailwater is sufficient to pass the flow. The operation of the gates is automatically controlled. The structure is in the City of Miami near the mouth of the 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 11). 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 was designed to 1) maintain optimum water control stages upstream in C-7 (Little River Canal), 2) release the design flood (75 percent of the Standard Project Flood) without exceeding the upstream flood design stage, 3) restrict downstream flood stages and discharge velocities to non- damaging levels, and 4) prevent saltwater intrusion during periods of high tides.

Percent of Population Impacted

One hundred percent of the population currently living in the C-7 basin, estimated at 254,000 people (2020 Census), will either directly or indirectly benefit from this project. The overall flood protection levels of service and water supply protection from saltwater intrusion are expected to improve. Flood modeling results from the C-7 Basin Flood Protection Level of Service Study, as detailed in this proposal, demonstrate basin-wide benefits.

Community-Wide Benefits

SFWMD and Miami-Dade County have been shifting to incorporate a wider range of co-benefits (social, environmental, operational) into their projects to consider equity community-wide. In the context of the proposed project, "community-wide" refers to the historical, cultural, and recreational values that South Florida residents share. This project is aligned with the SFWMD Sea Level Rise and Flood Resiliency Plan and Miami-Dade County's goals of promoting resilience in a way that goes beyond environmental sustainability (https://www.miamidade.gov/global/management/strategic-plan/home.page) The County encourages jurisdictions to take a holistic approach for resilience efforts across four broad dimensions: Leadership and Strategy, Economy and Society, Health and Wellbeing, and Infrastructure and Environment. Their vision is "Delivering excellent service today and tomorrow." The SFWMD, as the agency responsible for the primary control system, works closely with the County and local jurisdictions to instill these values, particularly with respect to preparing for disasters and extreme events.

Impacts to Lifelines

This project will reduce direct and indirect flood impacts on Community Lifelines, residents, businesses, public services, infrastructure, and natural systems through three key lifelines: Food, Water, Shelter, Transportation, and Energy. Food, Water, Shelter - The proposed project significantly reduces the threat to property. Under the lifeline subcategory of shelter, the project increases the level of protection for over 80,527 primary homes across the area. Without the project, it would take months for residents whose homes may be significantly damaged to stabilize their living situation. Given the level of damage expected, residents would be displaced while repairs to homes occurred. Many of the basin's single-family homes are on septic tank systems. The septic tank systems east of I95 are particularly vulnerable to sea level rise. In recent years, several properties in this basin have had to retrofit their septic system due to system failure. Alleviation of flooding would minimize future failures.

Transportation

The S-27 Structure is bordered by U.S. 1 to the east and SR934 to the south. These roads are key evacuation routes and connectors for the region. The project would alleviate flooding and allow these main arteries to function and be more easily accessible during extreme events.

Safety and Security

In addition, 118 critical assets would be protected under the proposed project. These include Airports (2), Fire Stations (9), Hazardous Waste Transport Facilities (7), Heliports (1), Hospitals/Medical Facilities (12), Law Enforcement Centers (11), and Public Schools (76). The proposed project removes a portion of utility infrastructure from the floodplain.

Impacts to Disadvantaged Communities

To ensure forty percent (40%) of the overall project benefits flow to disadvantaged communities that are marginalized, underserved, and overburdened by environmental stressors, the District used data available through the Climate and Economic Justice Screening Tool (CEJST) and the Centers for Disease Control and Prevention (CDC) Agency for Toxic Substances and Disease Registry (ATSDR) Social Vulnerability Index (SVI). Based on these data, ninety-four percent (94%) of the population within the project impact area were identified as socioeconomically disadvantaged and will receive equal access to community-wide benefits from the implementation of this resiliency project. These benefits are mainly related to flood risk reduction measures, environmental benefits, and the opportunities created for education, recreation, and development. The CEJST identifies forty-six percent (46%) of the population within the project impact as disadvantaged under the Climate Change category. The climate change category quantifies and considers the percent low-income population and higher education non-enrollment as well as expected population, building, and agricultural loss rates above pre-determined thresholds. The CDC identifies sixty-seven percent (67%) of the population within the project impact areas as having an SVI greater than 0.8 or higher, the highest vulnerability ranking, and twenty-seven percent (27%) of the population within the project impact area as having an SVI between 0.6 and 0.8, the second highest vulnerability ranking. The CDC/ATSDR SVI ranks each census tract on 16 social factors, including poverty, lack of vehicle access, and crowded housing, and groups them into four related themes.

Project Scope

The proposed project consists of flood mitigation and enhancement strategies at C-7 Basin, known as Litter River, in Miami-Dade County, to build flood resiliency and increase protection against saltwater intrusion. Specifically, the project includes:

- Enhancing major components of the S-27 Structure and converting the gate opening system to a more robust mechanism, upgrading the existing gates with elevated, corrosion-resistant stainless-steel gates, enhancing and elevating the control building, and adding a corrosion control system to the structure.

- Building a new forward pump station that will convey flood waters to tide when downstream water elevations are too high to allow gravity flow. The design of the proposed forward pump station will be adaptable and will include the ability to easily add additional pump capacity in the future as conditions continue to change.
- Constructing a tie-back levee/salinity barrier to provide flood and storm surge protection and supporting the required function of the spillway gates and pump for the selected scenario of a 100-year event with a three-foot sea level rise.
- Building an approximately 2-acre flow-through wetland/stormwater detention area to reduce local runoff on the W.H. Turner High School property (owned by Miami-Dade County Public Schools). This project feature will increase the ability to leverage partners and enhance outreach activities and emphasize community engagement. This stormwater detention area will be incorporating Biosorption Activated Media (BAM), an innovative stormwater best management practice in South Florida that has been deployed across agencies and in varied use cases and has consistently reduced harmful nutrients such as Nitrogen, Phosphorus, and other contaminants in stormwater. BAM is a patented unique combination of recycled tire crumb, silt, clay, and sand that is optimized for inert filtration and reactive filtration and to provide an ideal habitat for microbes to facilitate biosorption & biological uptake.
- Installing 1,500 linear feet of living shoreline along the C-7 Canal Bank to assist in reducing bank erosion and improve aesthetics and storm resiliency. The flow-through wetland/stormwater detention area and living shoreline features will be incorporated into the W.H. Turner High School curriculum for environmental science students. In addition, a shaded gathering area, a community garden, educational signage, and outdoor classroom amenities for public use and to increase community engagement will be incorporated into the project.

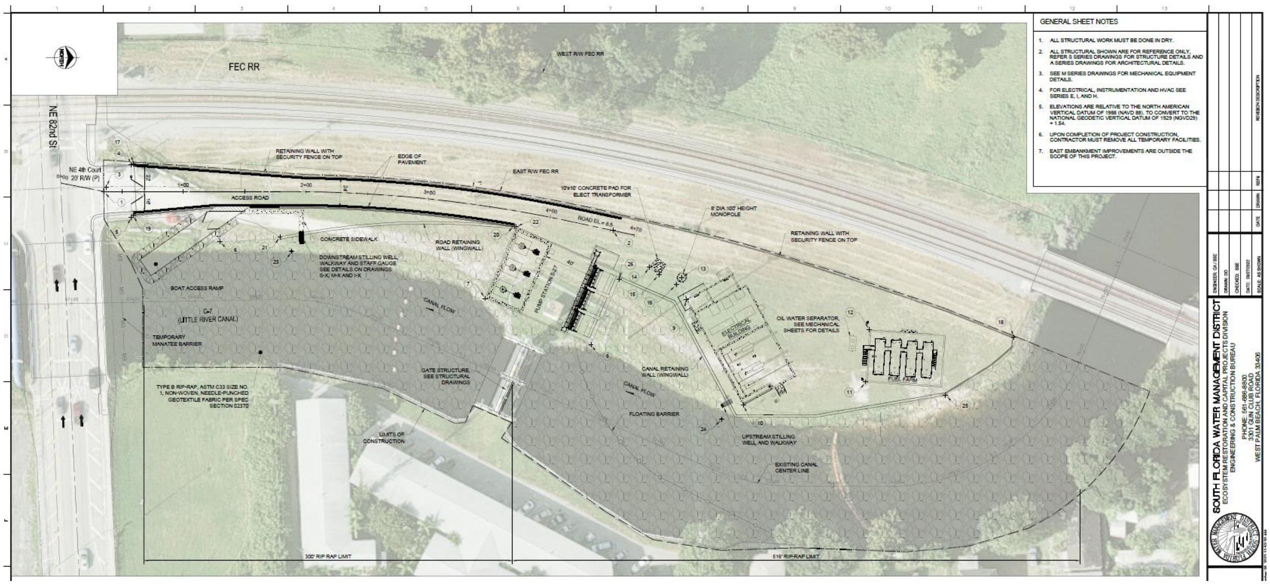


Figure 12: Site plan at S-27 Structure.

Reducing Risk and to What Level

Extensive land development and population increases within the basin have already exceeded the original design assumptions of the C-7 Canal and S-27 Structure. Significant changes in climate conditions and sea level rise have also impacted the area and are limiting flood protection operations. These risks and their potential impacts are multifaceted and involve flood hazards driven by storm surges, high tides, and extreme rainfall. This project will reduce flooding risk by reducing peak canal stages, bank exceedances, and overland flood inundation throughout the C-7 Basin for the 5-year, 10-yr, 25-yr, and 100-yr storm events and under different sea level rise scenarios, as demonstrated by hydrology and hydraulics model simulations. The project consists of local and regional flood mitigation strategies that reduce flood risk and enhance resiliency. These mitigation strategies will increase the resilience of the entire C-7 Basin. A range of critical assets, including fire stations, emergency shelters, and medical facilities, support several Community Lifelines and a variety of cultural, historical, and environmental resources in the basin. Additionally, the County has a high Building Code Effectiveness Grading Schedule (BCEGS) score of 2, which shows a commitment to reducing risk through strong building code adoption and enforcement activities.

Increase Resilience

The project components to increase resilience include enhancements to the S-27 Structure and the addition of a forward pump and a tie-back levee. The pump will maintain basin discharge capacity while sea levels rise. The new levee and increased elevation of the flood control gates and service bridge will help prevent overtopping and reduce saltwater intrusion risk. A significant aspect of this project includes the construction of demonstration project-level nature-based features at W.H. Turner Technical High School in partnership with Miami-Dade County Public Schools. The proposed components include building a flow-through wetland/stormwater detention area and installing a living shoreline to reduce bank erosion and indirectly enhance water quality and aquatic habitat. The overall strategy to reduce runoff in this densely urbanized basin includes the implementation of a series of distributed storage solutions. This project can serve as an example regionally, as nearby jurisdictions are looking to implement similar measures. The project will also be incorporated into the school curriculum for environmental science students, adding an important educational component.

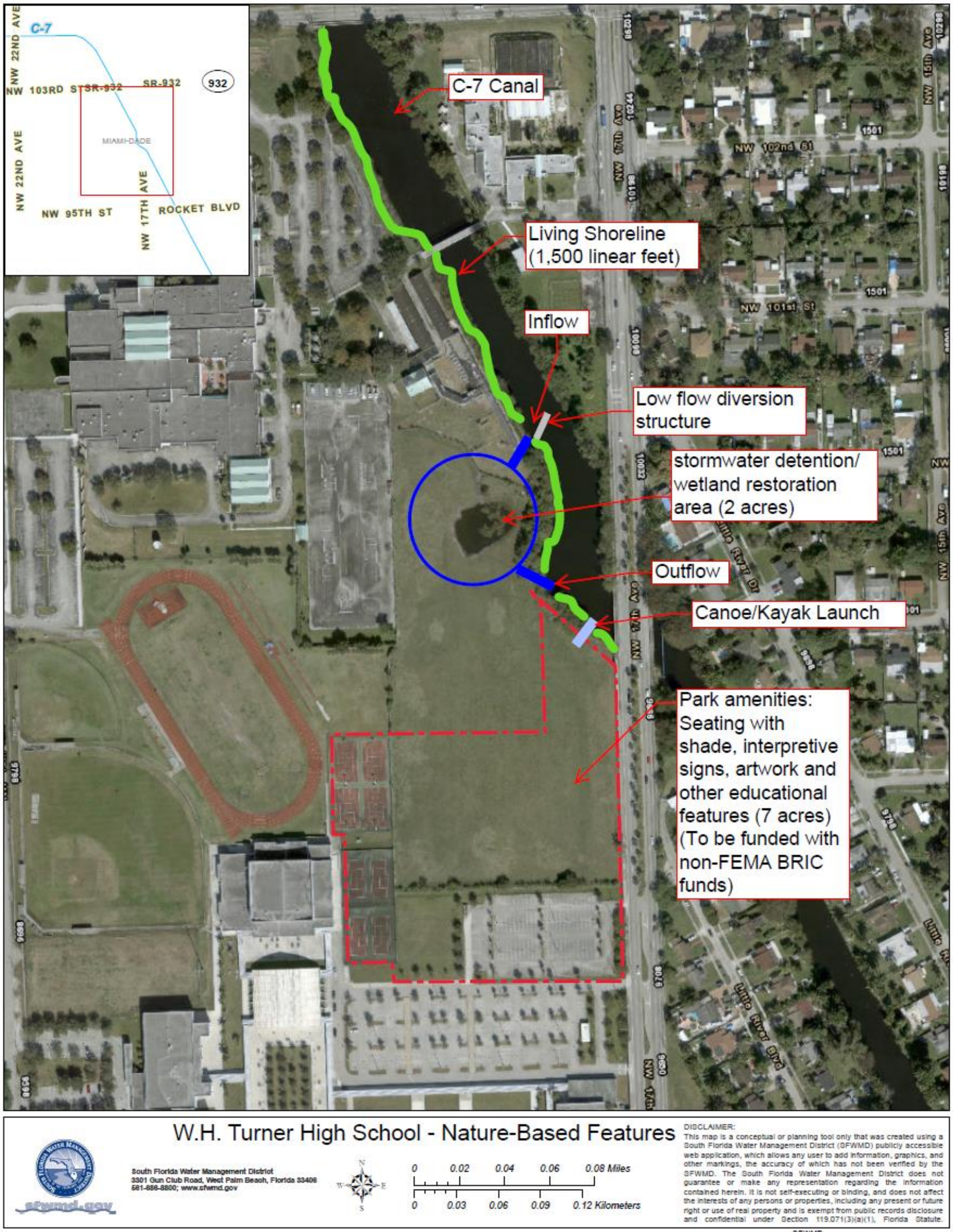


Figure 13: Nature-based features at W.H. Turner High School

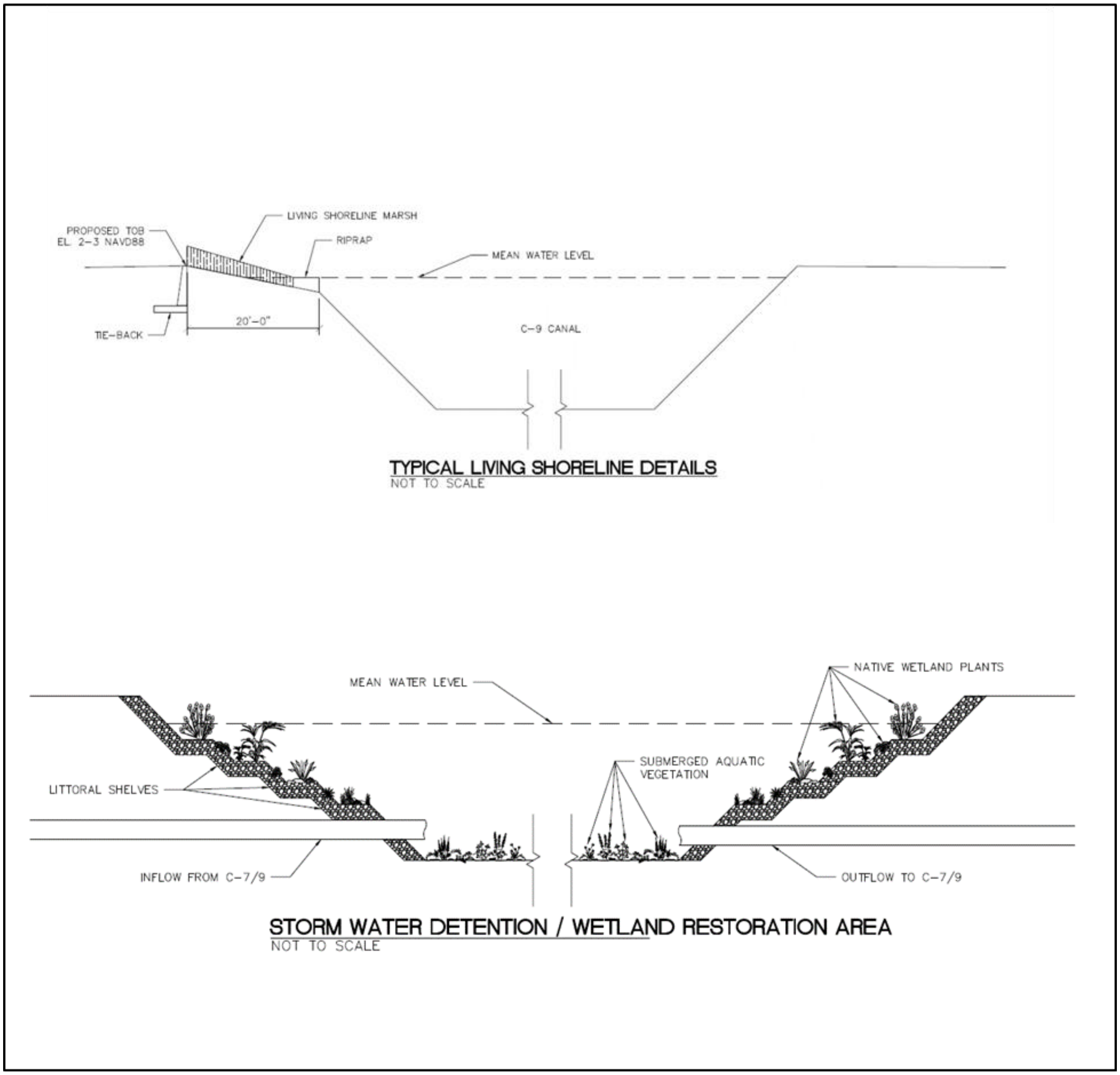


Figure 14: Typical living shoreline detail and stormwater detention area/wetland restoration area

Ancillary Benefits

Beyond enhancing the flood protection level of service, the project aims to maximize the risk reduction benefits and co-benefits of nature-based solutions and improve the C-7 Basin's water quality and ecological functions. Benefits include short and long-term environmental, economic, and social advantages that improve a community's quality of life, emphasize community engagement, and increase recreational value in the project area (kayaking, canoeing, wildlife observation, and fishing). Ancillary benefits also include improved fish and wildlife habitat from the 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 the implementation of the flow-through wetland/stormwater detention area and increased opportunities for education and recreation (outdoor classroom activities).

Leveraging Innovation

This project will introduce green infrastructure features that have not been used previously in this area. While Miami-Dade County is eager to pilot linear parks, living shorelines, and expand Greenways and

Blueways, this project will be one of the first opportunities in this basin. The County conducted stakeholder engagement to share the approaches and gather feedback. The community most enthusiastically supported the green infrastructure approaches.

Outreach Activities

A comprehensive public outreach process is embedded in the SFWMD Sea Level Rise and Flood Resiliency Plan – Annual Update and the Flood Protection Level of Service Program (FPLOS), along with the and the Miami-Dade Sea Level Rise Strategy, to ensure equal opportunity for all members of South Florida communities to participate in the planning and decision-making process The public and key stakeholders contributed to informing the identification of priority adaptation strategies through several workshops and public comments.

C-7 Basin Cost Estimate

Structure Hardening*	$5,642,523
Construction of 1400 cfs Forward Pump at S-27 Structure*	$67,200,000
Forward Pump Backup Generator	$6,720,000
Structure Tieback Levee	$2,000,000
Design & Construction Management	$12,234,378
Real Estate	$10,000,000
Total Cost for S-27	$103,796,902
Adjusted 2023 Cost	$125,370,188
Design and Permitting of Green Infrastructure	$200,000
Construction of Green Infrastructure	$1,300,000
Total Cost with Green Infrastructure	**$126,870,189**

*The latest 30% design for this project is recommending a cost estimate of about $120M for the 1400cfs forward pump and structure enhancement

Hillsboro Canal Basin Resiliency

G-56 Coastal Structure Resiliency

This resiliency project is mainly tied to the District's mission to provide flood control and water supply protection. 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, sea level rise, 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.

Cost Estimate

Structure Enhancement	$13,621,239
Forward Pump (1880 cfs)	$138,744,000
Forward Pump Backup Generator Facility	$13,874,400
Structure Tie Back (Flood Barrier)	$3,075,000
Design, Implementation & Construction Management	$25,397,196
Real Estate	$4,312,500
Adjusted 2024 Cost	**$199,024,335**

C-14 Basin Resiliency

S-37A Coastal Structure Resiliency

This resiliency project is mainly tied to the District's mission to provide flood control and water supply protection. 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. The 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. The S-37A Structure was designed to 1) maintain optimum upstream water control stages in C-14; 2) release 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, 3)restricts downstream flood stages and channel velocities to non-damaging levels; and 4) prevent 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, sea level rise, 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.

Cost Estimate

Structure Enhancement	$9,594,684
Forward Pump (2000 cfs)	$125,708,728
Forward Pump Backup Generator Facility	$16,071,669
Structure Tie Back (Flood Barrier)	$3,075,000
Design, Implementation & Construction Management	$23,167,512
Real Estate	$4,312,500
Adjusted 2024 Cost Total	**$181,930,093**

C-14 West Basin Canal Dredging Resiliency

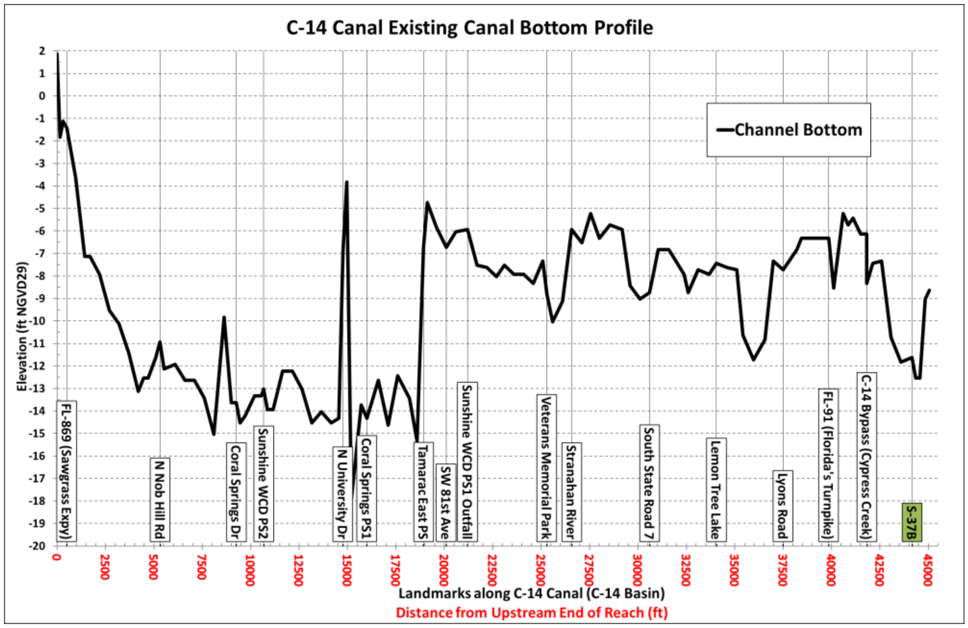


Figure 15: C-14 Canal Existing Bottom Profile

This resiliency project links to the District's mission to provide flood control. As part of the phase 1 FPLOS preliminary mitigation project identification, it was suggested that one potential way to reduce peak stages in the C-14 Canal would be to dredge the canal in areas with significant head loss, specifically due to sediment accumulation. These areas could be identified by comparing the bottom profile to the designed canal bottom. It is also possible that the existing canal bottom is deeper than the designed canal bottom due to years of scour and/or previous dredging as part of canal maintenance.

Detailed bathymetry of the C-14 canal bottom exists in the form of surveyed cross sections. The eastern half of the C-14 Canal is several feet shallower than the western half, which could mean that the canal's conveyance capacity is currently lower than it was designed to be. It is likely that dredging the western half would increase the overall conveyance capacity of the system, but if it would have enough impact to reduce canal stages is unknown. For the purposes of this cost estimate, it is assumed that the eastern segment of the canal downstream of Tamarac East Pump Station (chainage 18,925) to Structure S-37B will be dredged by 5 ft in depth as part of the resiliency strategy, which could be bring the canal back closer to design conditions or deepen it beyond design conditions, depending on how the existing canal bottom compares with the original designed bottom. It is also assumed that, on average, the eastern portion of the C-14 Canal would be dredged across an average width of 75 feet, which was approximated from the bottom width of multiple cross sections.

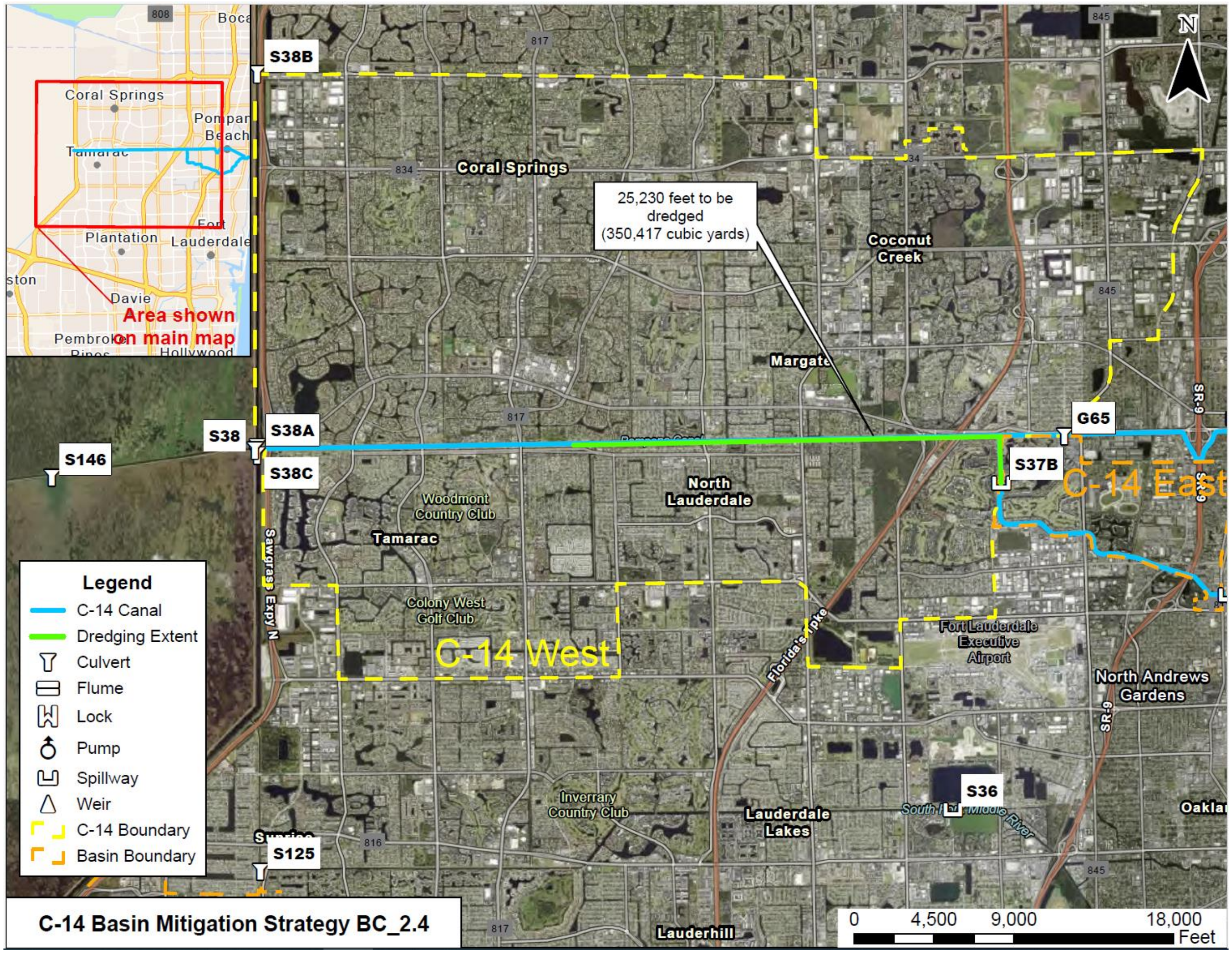
Following the aforementioned assumptions, the C-14 Canal has a total proposed dredging volume of approximately 350,417 cubic yards (cy). The existing canal bottom based on limited survey and interpolated cross section data is shown in Figure 15.

The purpose of this project is to build resiliency and decrease flood impacts within the C-14 West Basin due to extreme rainfall events, sea level rise, climate change, and land use changes in the basin, which contribute to higher canal elevations and bank exceedances. It is possible that restoring or deepening the canal bottom through dredging could reduce the head loss or increase the conveyance capacity of the canal, which may lead to lower peak water levels. This project will directly or indirectly benefit the entire C-14 West Basin, although the magnitude of that benefit is unknown. It is important to note that any changes to the downstream tidal outfall structures such as the addition of pump stations at S-37B or S-37A could significantly change the dredging requirements, especially if the required conveyance capacity of the canal increases to support the pump station.

A total cost estimate to dredge the C-14 Canal is presented in the table below.

Cost Estimate

Canal Dredging	$29,995,666.67
Adjusted 2024 Cost Total	**$29,995,667**



C-14 West Basin Canal Embankment Resiliency

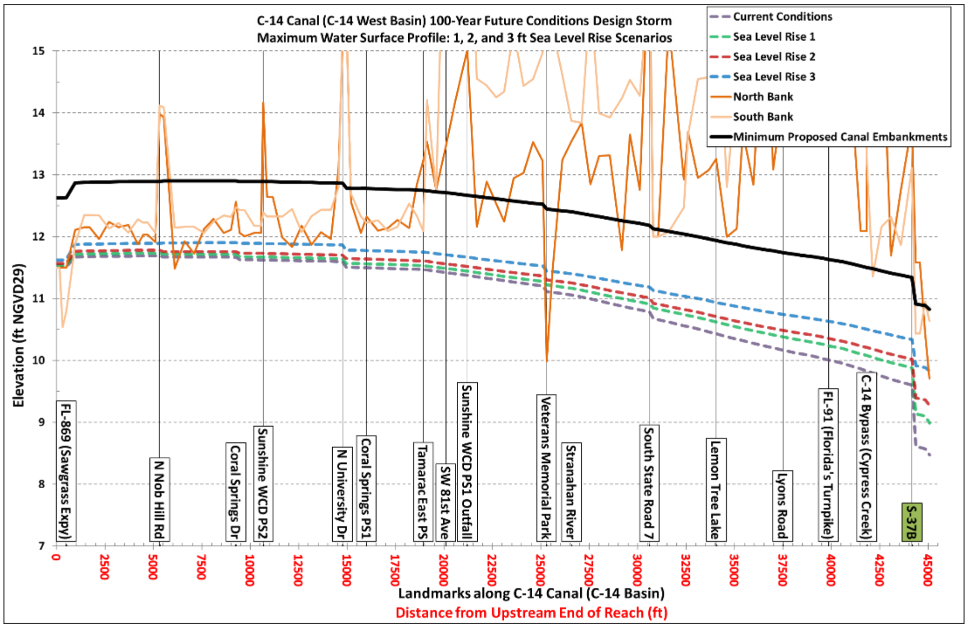


Figure 16: FPLOS PM1 Maximum Water Surface Profile with Existing and Proposed Minimum Canal Embankments

This resiliency project links to the District's mission to provide flood control. As part of the PM #1 analysis of the Flood Protection Level of Service study, the C-14 West Basin's existing canal bank elevations were compared with simulated peak stages from the interconnected surface water / ground-water MIKE SHE / MIKE HYDRO model of Broward County. Although the C-14 Canal is predicted to mostly contain the 100-year return period design storm with three feet of sea level rise within its canal embankments, there are a few localized locations that are predicted to have exceedance. As part of this cost estimate, it is assumed that any canal segment that has a simulated 100-year SLR3 peak stage that is higher or within 1.0 ft elevation of the top of the embankments, will be subject to canal embankment improvements as part of the resiliency strategy.

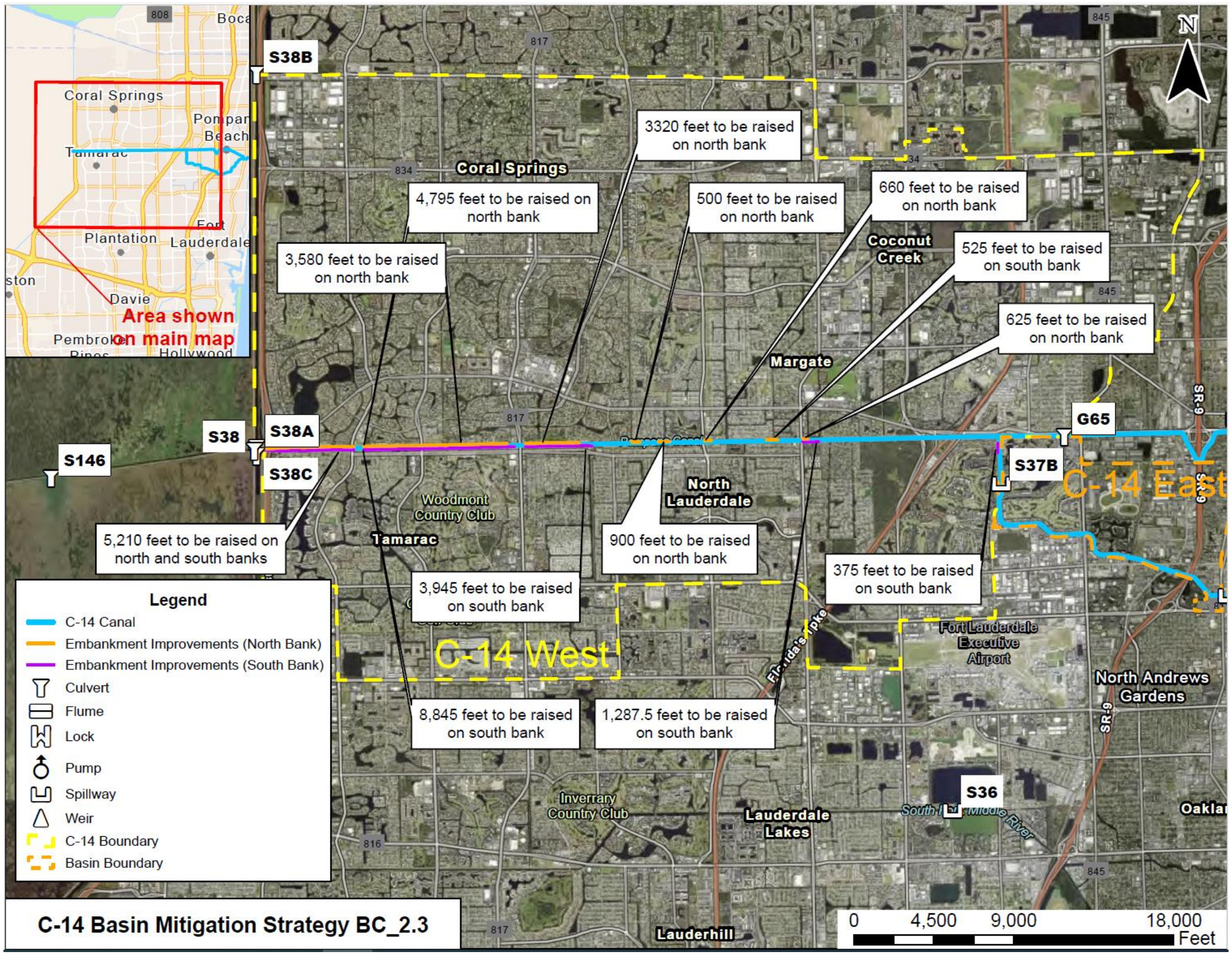
Following the aforementioned assumptions, the C-14 West Basin has a total proposed embankment improvement length of approximately 39,778 feet, approximately 20,115 feet along the north side of the canal and approximately 19,663 feet along the south side of the canal. The proposed minimum embankment profile is shown as the black line in Figure 16.

The purpose of this project is to build resiliency and decrease flood impacts within the C-14 West Basin due to extreme rainfall events, sea level rise, climate change, and land use changes in the basin, which contribute to higher canal elevations and bank exceedances. Although the majority of the C-14 Canal was not predicted to exceed the existing bank elevations, that study did not consider future increase in rainfall totals, which will likely result in increased maximum water stages in the C-14 Canal. Therefore, as part of future resiliency planning, this cost estimate represents a larger increase in canal improvements than indicated by the FPLOS Phase 1 study, to ensure adequate freeboard as well as additional uncertainty.

This project is predicted to provide additional protection up to and likely beyond the 100-year 3-feet sea level rise storm event. This project will directly and indirectly benefit the C-14 West Basin, with a direct benefit in the immediate area of the bank improvements and an indirect benefit elsewhere. It is important to note that any changes to the downstream tidal outfall structures such as the addition of pump stations at S-37B or S-37A could make the proposed canal bank improvements unnecessary. A total cost estimate to raise the C-14 Canal embankments is presented in the table below.

Cost Estimate

North Bank Raising	$4,483,969
South Bank Raising	$4,383,098
Adjusted 2024 Cost Total	**$8,867,068**



C-14 East Basin Canal Dredging Resiliency

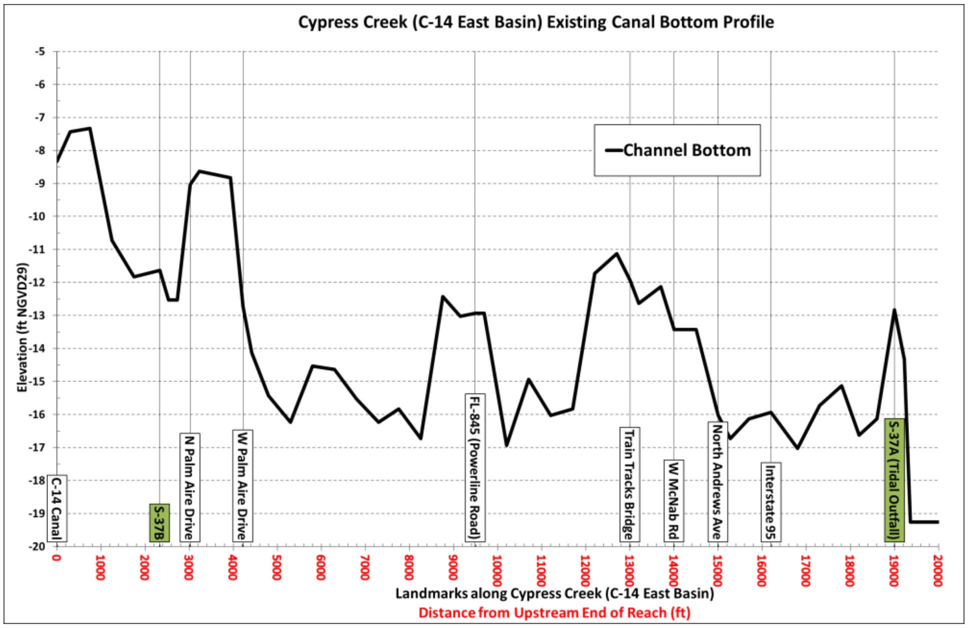


Figure 17: Cypress Creek Canal Existing Bottom Profile

This resiliency project links to the District's mission to provide flood control. As part of the phase 1 FPLOS preliminary mitigation project identification, it was suggested that one potential way to reduce peak stages in the Cypress Creek Canal (C-14 East) would be to dredge the canal in areas with significant head loss, specifically due to sediment accumulation. These areas could be identified by comparing the bottom profile to the designed canal bottom. It is also possible that the existing canal bottom is deeper than the designed canal bottom due to years of scour and/or previous dredging as part of canal maintenance.

Detailed bathymetry of the Cypress Creek Canal bottom exists in the form of surveyed cross sections. For the purposes of this cost estimate, it is assumed that the entire canal will be dredged by an average of 1 ft in depth as part of the resiliency strategy, which could bring the canal back closer to design conditions or deepen it beyond design conditions, depending on how the existing canal bottom compares with the original designed bottom. It is also assumed that, on average, the Cypress Creek Canal would be dredged across an average width of 60 feet, which was approximated from the bottom width of multiple cross sections.

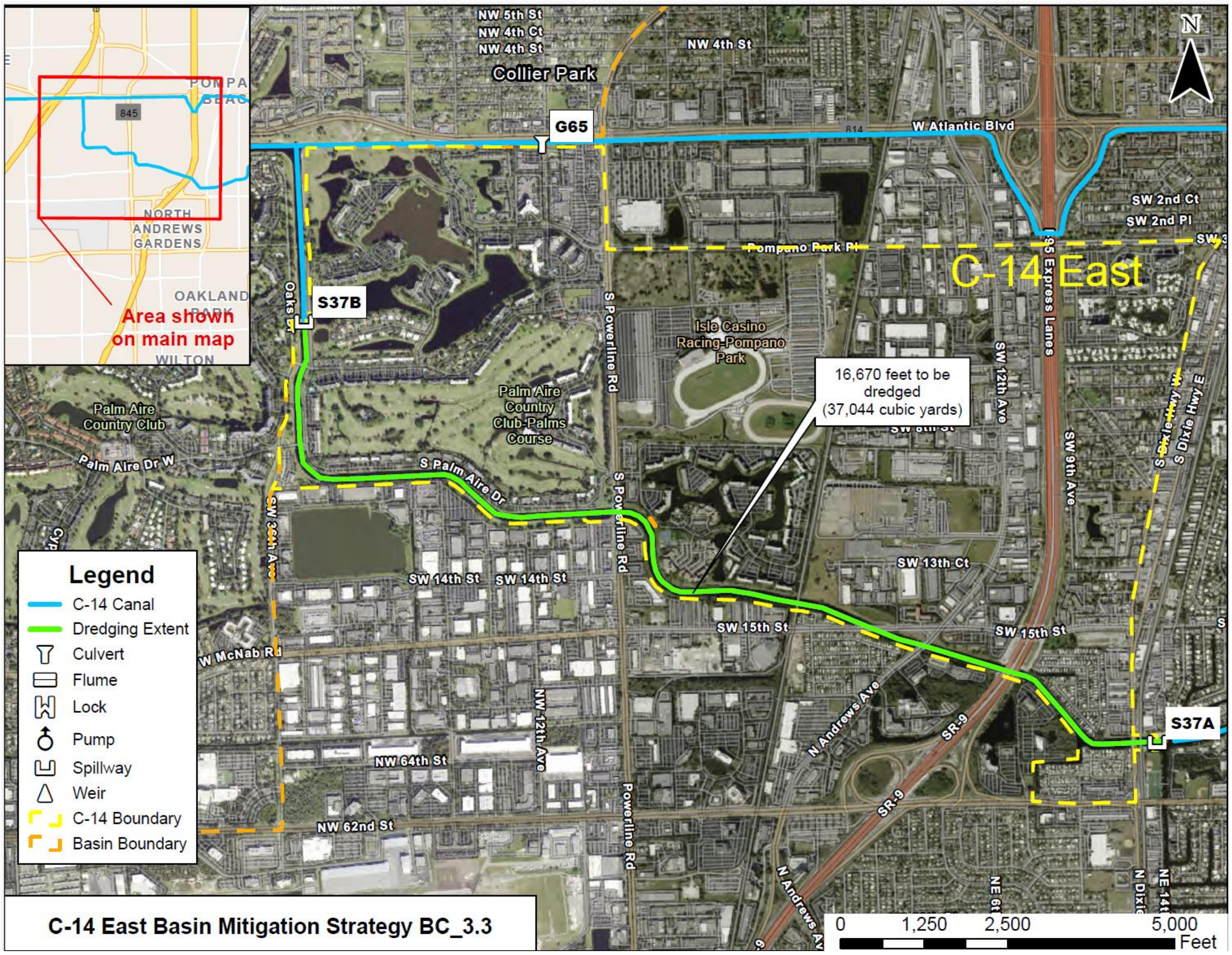
Following the aforementioned assumptions, the Cypress Creek Canal has a total proposed dredging volume of approximately 37,044 cubic yards (cy). The existing canal bottom based on survey data is shown in Figure 17.

The purpose of this project is to build resiliency and decrease flood impacts within the C-14 East Basin due to extreme rainfall events, sea level rise, climate change, and land use changes in the basin, which contribute to higher canal elevations and bank exceedances. It is possible that restoring or deepening the canal bottom through dredging could reduce the head loss or increase the conveyance capacity of the canal, which may lead to lower peak water levels. This project will directly or indirectly benefit the entire C-14 East Basin, although the magnitude of that benefit is unknown. It is important to note that any changes to the downstream tidal outfall structure such as the addition of pump station at S-37A, or the addition of a pump station upstream at S-37B could significantly change the dredging requirements, especially if the required conveyance capacity of the canal increases to support the pump station(s).

A total cost estimate to dredge the Cypress Creek Canal is presented in the table below.

Cost Estimate

Canal Dredging	$3,171,004
Adjusted 2024 Cost Total	**$3,171,004**



C-14 East Basin Canal Embankment Resiliency

This resiliency project links to the District's mission to provide flood control. As part of the PM #1 analysis of the Flood Protection Level of Service study, the Cypress Creek Canal (C-13 East) bank elevations were compared with simulated peak stages from the inter-connected surface water / ground-water MIKE SHE / MIKE HYDRO model of Broward County. The Cypress Creek Canal is predicted to have extreme levels of bank exceedance across a majority of the canal length for the 100-year return period design storm with three feet of sea level rise. As part of this cost estimate, it is assumed that any canal segment that has a simulated 100-year SLR3 peak stage that is higher or within 1.0 ft elevation of the top of the embankments, will be subject to canal embankment improvements (rising) as part of the resiliency strategy.

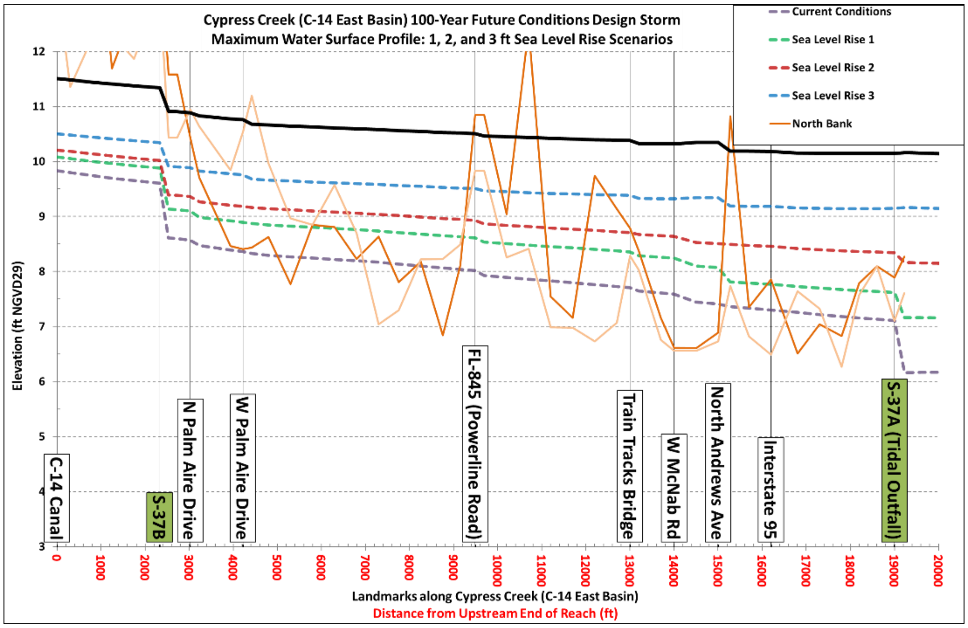


Figure 18: FPLOS PM1 Maximum Water Surface Profiles with Existing and Proposed Minimum Canal Embankments

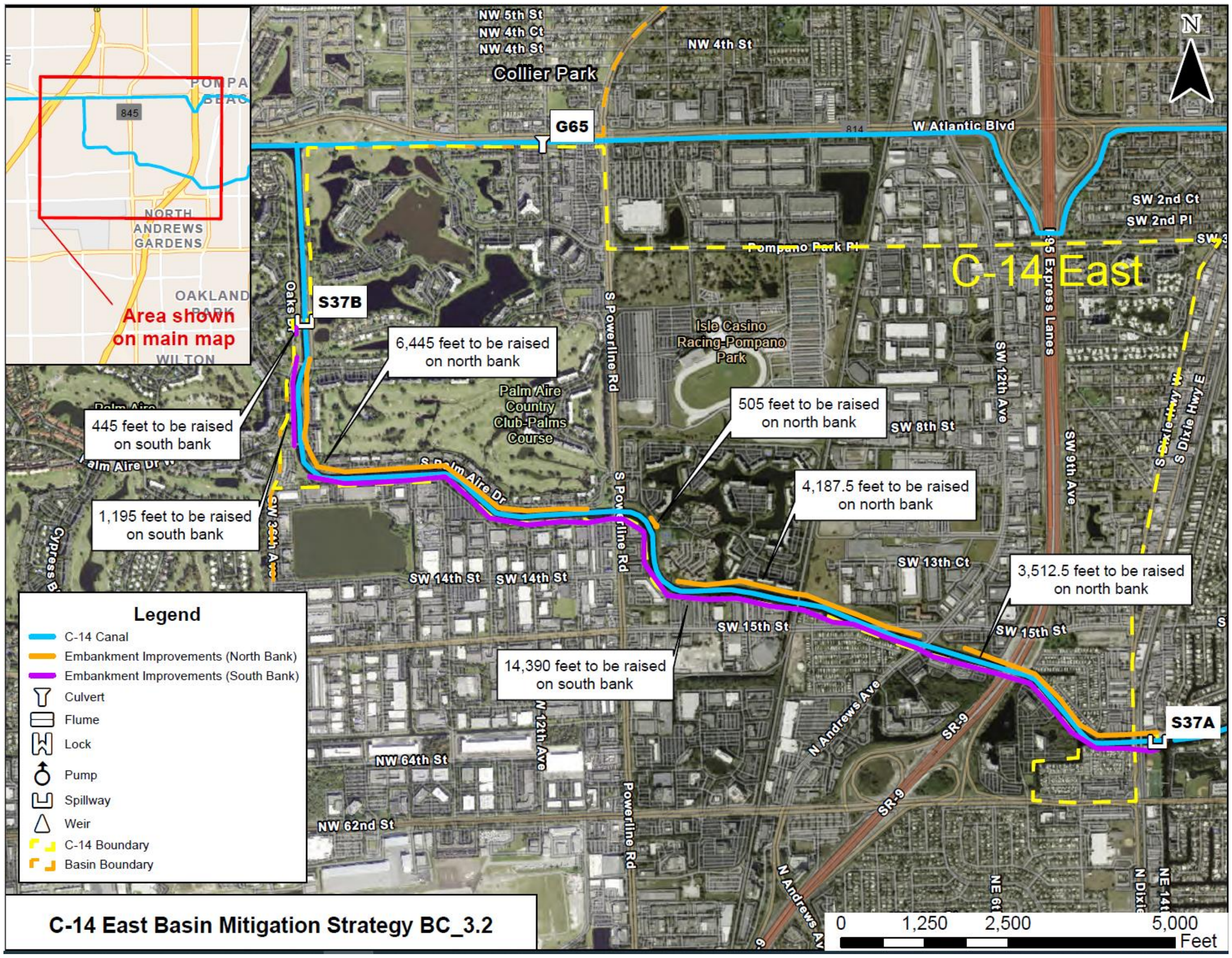
Following the aforementioned assumptions, the C-14 East Basin has a total proposed embankment improvement length of approximately 30,680 feet, approximately 14,650 feet along the north side of the canal (average of 3 ft height) and approximately 16,030 feet along the south side of the canal (average of 2.5 ft height). The proposed minimum embankment profile is shown as the black line in Figure 18.

The purpose of this project is to build resiliency and decrease flood impacts within the C-14 East Basin due to extreme rainfall events, sea level rise, climate change, and land use changes in the basin, which contribute to higher canal elevations and bank exceedances. The majority of the Cypress Creek Canal was predicted to have bank exceedances and that study did not consider future increase in rainfall totals, which would likely result in even higher increased maximum water stages in the Cypress Creek Canal. Therefore, as part of future resiliency planning, this cost estimate represents a larger increase in canal improvements than indicated by the FPLOS Phase 1 study, to ensure adequate freeboard as well as to protect against additional uncertainty.

This project is predicted to provide additional protection up to and likely beyond the 100-year 3-feet sea level rise storm event. This project will directly and indirectly benefit the C-14 East Basin, with a direct benefit in the immediate area of the bank improvements and an indirect benefit elsewhere. It is important to note that any changes to the downstream tidal outfall structure such as the addition of pump station at S-37A could make the proposed canal bank improvements unnecessary, or the addition of a pump station upstream at S-37B could make these improvements less effective if S-37A isn't also improved by the addition of a pump station. A total cost estimate to raise the Cypress Creek Canal embankments is presented in the table below. Cypress Creek Canal Embankment Cost Estimate.

Cost Estimate

North Bank Raising	$4,478,647
South Bank Raising	$3,573,354
Adjusted 2024 Cost Total	**$8,052,001**



Pompano Canal Basin Resiliency

G-57 Coastal Structure Resiliency

This resiliency project is mainly tied to the District’s mission to provide flood control and water supply protection. G-57 is a reinforced concrete, gated spillway with discharge controlled by two stem-operated, vertical lift gates measuring 6 feet high by 14 feet wide. The discharge capacity at G-57 is 375 cfs. The 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. The G-57 Structure was designed to 1) release the design flood without exceeding the upstream flood design stage, 2) restrict downstream flood stages and channel velocities to non-damaging levels, and 3) prevent 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. The 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 is 57. These include faith-based facilities, fire stations, hospitals and medical facilities, law enforcement centers, recreational facilities, and schools. Public schools have a vital 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). The peak canal stage can be reduced by 15% for each 500 cfs increase in pump capacity.

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. The project's conceptual design is finalized. The final design will be based on a 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 replaced 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, sea level rise, 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.

Cost Estimate

Structure Enhancement	$8,173,788
Forward Pump (200cfs)	$15,855,469
Forward Pump Backup Generator Facility	$1,585,547
Structure Tie Back (Flood Barrier)	$3,075,000
Design, Implementation & Construction Management	$4,303,471
Real Estate	$2,103,948
Adjusted 2024 Cost	**$35,097,222**

C-13 Basin Resiliency

S-36 Coastal Structure Resiliency

This resiliency project is mainly tied to the District's mission to provide flood control and water supply protection. S-36 is a reinforced concrete, gated spillway with discharge controlled by a cable-operated, vertical lift gate that is 14.0 feet high by 25.0 feet 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. The S-36 Structure was designed to 1) maintain optimum water control stages upstream in C-13, 2) release the design flood (50 percent of the Standard Project Flood) without exceeding the upstream flood design stage, 3) restrict downstream flood stages and discharge velocities to non-damaging levels, and 4) prevent 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, sea level rise, 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. It can only expand south into property owned by the City of Oakland Park, which will reduce acquisition costs.

Cost Estimate

Structure Enhancement	$7,102,823
Forward Pump (275 cfs)	$22,205,344
Forward Pump Backup Generator Facility	$2,220,534
Structure Tie Back (Flood Barrier)	$3,075,000
Design, Implementation & Construction Management	$5,190,555
Real Estate	$143,750
Adjusted 2024 Total	**$39,938,006**

C-13 Basin Canal Embankment Resiliency

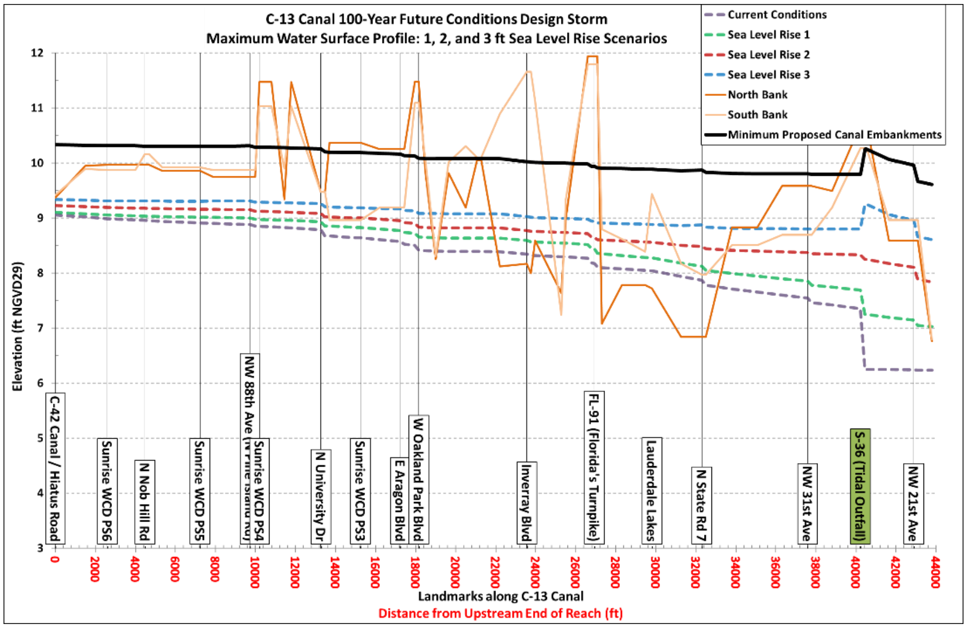


Figure 19: FPLOS PM1 Maximum Water Surface Profiles with Existing and Proposed Minimum Canal Embankments

This resiliency project links to the District's mission to provide flood control. As part of the PM #1 analysis of the Flood Protection Level of Service study, the C-13 West Basin's existing canal bank elevations were compared with simulated peak stages from the interconnected surface water / ground-water MIKE SHE / MIKE HYDRO model of Broward County. The C-13 Canal is predicted to have several instances of bank exceedance across its length for the 100-year return period design storm with three feet of sea level rise. As part of this cost estimate, it is assumed that any canal segment that has a simulated 100-year SLR3 peak stage that is higher or within 1.0 ft elevation of the top of the embankments, will be subject to canal embankment improvements (raising) as part of the resiliency strategy.

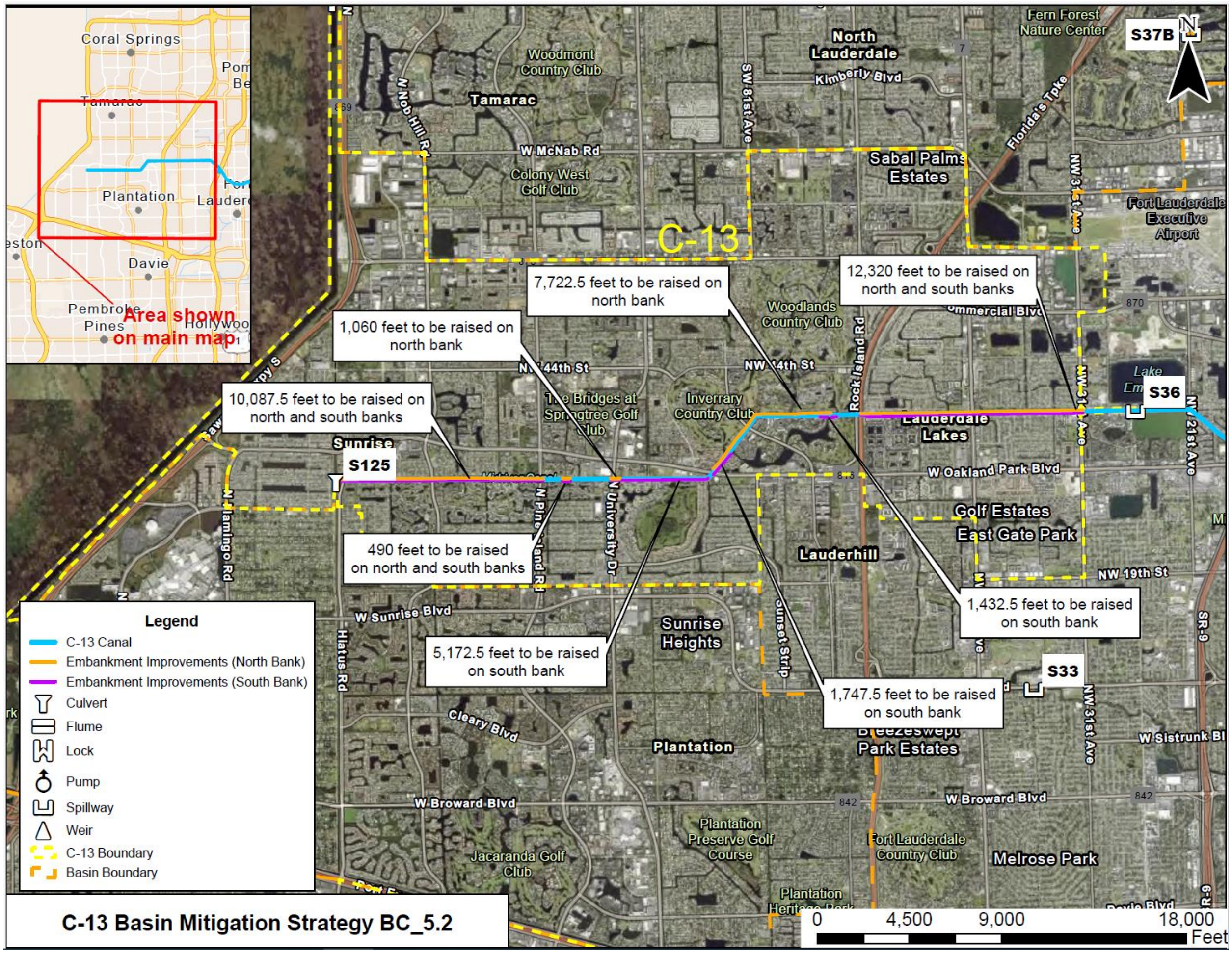
Following the aforementioned assumptions, the C-13 West Basin has a total proposed embankment improvement length of approximately 62,930 feet, approximately 31,680 feet along the north side of the canal and approximately 31,250 feet along the south side of the canal. The proposed minimum embankment profile is shown as the black line in Figure 19.

The purpose of this project is to build resiliency and decrease flood impacts within the C-13 West Basin due to extreme rainfall events, sea level rise, climate change, and land use changes in the basin, which contribute to higher canal elevations and bank exceedances. Although many parts of the C-13 Canal were not predicted to have bank exceedances, that study did not consider future increase in rainfall totals, which would likely result in even higher increased maximum water stages in the C-13 Canal. Therefore, as part of future resiliency planning, this cost estimate represents a larger increase in canal improvements than indicated by the FPLOS Phase 1 study, to ensure adequate freeboard as well as to protect against additional uncertainty.

This project is predicted to provide additional protection up to and likely beyond the 100-year 3-feet sea level rise storm event. This project will directly and indirectly benefit the C-13 West Basin, with a direct benefit in the immediate area of the bank improvements and an indirect benefit elsewhere. It is important to note that any changes to the downstream tidal outfall structure such as the addition of a pump station at S-36 could make parts of the proposed canal bank improvements unnecessary. A total cost estimate to raise the C-13 Canal embankments is presented in the table below.

Cost Estimate

North Bank Raising	$7,062,000
South Bank Raising	$6,966,146
Adjusted 2024 Cost Total	**$14,028,146**



C-12 Basin Resiliency

S-33 Coastal Structure Resiliency

This resiliency project is mainly tied to the District's mission to provide flood control and water supply protection. 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. The 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, sea level rise, 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.

Cost Estimate

Structure Enhancement	$6,515,335
Forward Pump (230 cfs)	$19,449,375
Forward Pump Backup Generator Facility	$1,944,938
Structure Tie Back (Flood Barrier)	$3,075,000
Design, Implementation & Construction Management	$4,647,697
Real Estate	$2,300,000
Adjusted 2024 Cost	**$37,932,345**

North New River Basin Resiliency

G-54 Coastal Structure Resiliency

This resiliency project is mainly tied to the District's mission to provide flood control and water supply protection. G-54 is a reinforced concrete gated spillway located on the North New River Canal about 0.9 miles west of the intersection of I-595 and Florida's Turnpike, west of Fort 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, sea level rise, 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 be initiated upon funding confirmation.

Cost Estimate

Structure Enhancement	$12,335,418
Forward Pump (800 cfs)	$61,500,000
Forward Pump Backup Generator Facility	$6,150,000
Structure Tie Back (Flood Barrier)	$3,075,000
Design, Implementation & Construction Management	$12,459,063
Real Estate	$7,187,500
Adjusted 2024 Cost	**$102,706,981**

North New River Canal West Basin Canal Dredging Resiliency

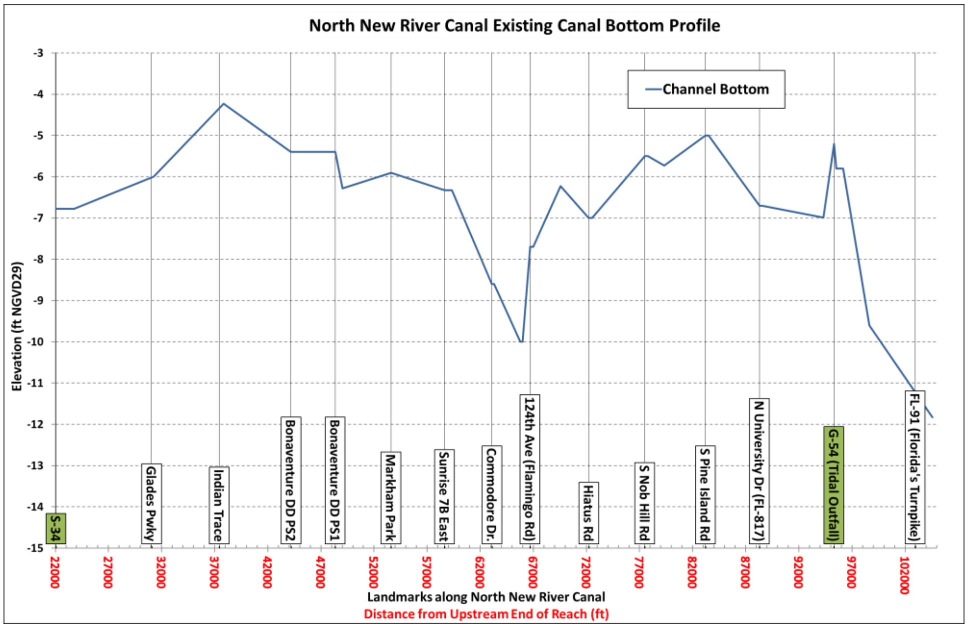


Figure 20: North New River Canal Existing Bottom Profile

This resiliency project links to the District's mission to provide flood control. As part of the phase 1 FPLOS preliminary mitigation project identification, it was suggested that one potential way to reduce peak stages in the North New River Canal would be to dredge the canal in areas with significant head loss, specifically due to sediment accumulation. These areas could be identified by comparing the bottom profile to the designed canal bottom. It is also possible that the existing canal bottom is deeper than the designed canal bottom due to years of scour and/or previous dredging as part of canal maintenance.

As detailed bathymetry of the canal bottom does not exist and the surveyed data is spread out relatively far apart, there is not enough detail to make a strong case for or against dredging as a "mitigation" project, rather it should be part of maintenance (to prevent degradation rather than to improve the system). However, for the purposes of this cost estimate, it is assumed that the entire canal will be dredged by 1 ft in depth as part of the resiliency strategy, which could be bring the canal back closer to design conditions or deepen it beyond design conditions, depending on how the existing canal bottom compares with the original designed bottom. It is also assumed that, on average, the North New River Canal would be dredged across an average width of 60 feet, which was approximated from the bottom width of multiple cross sections.

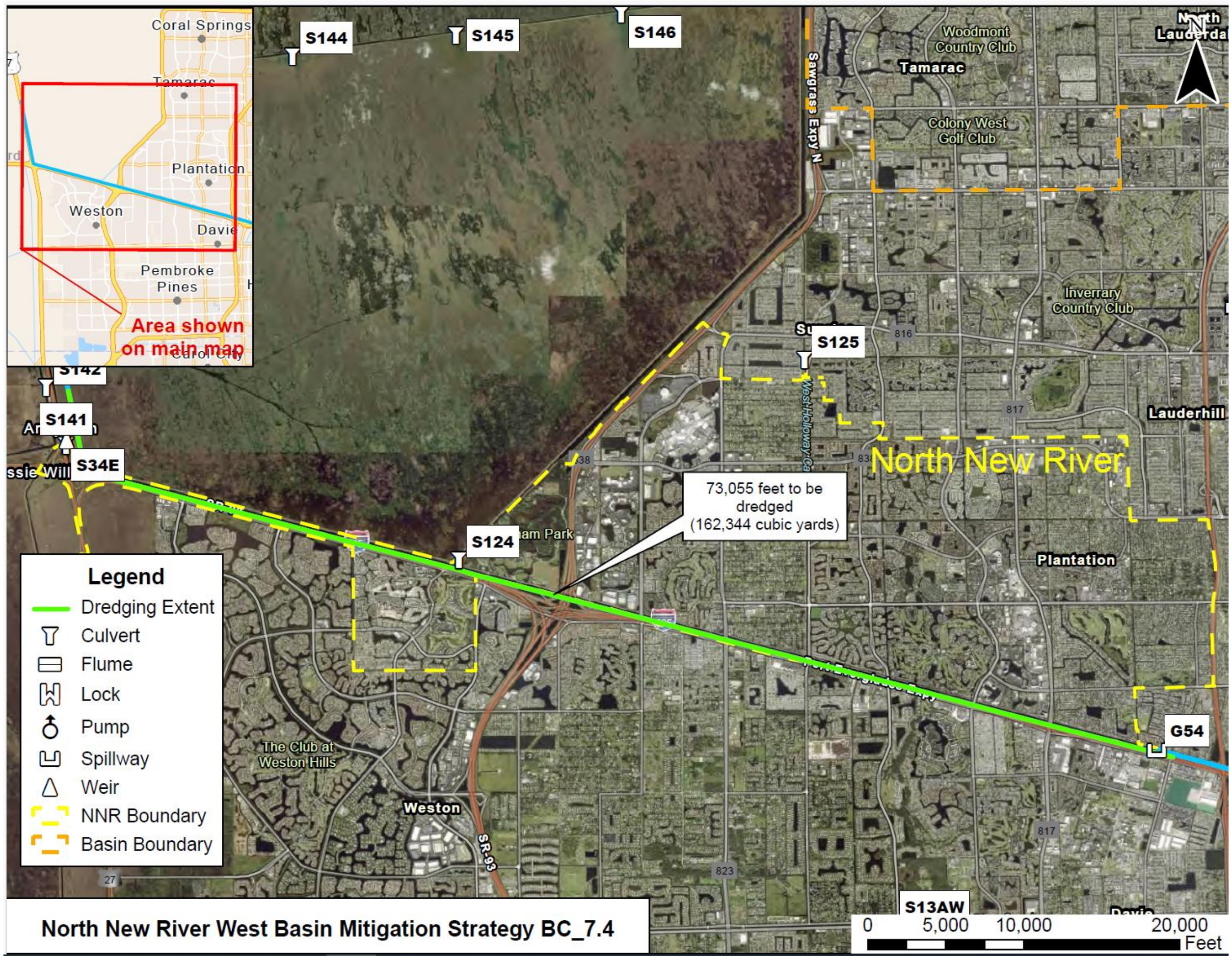
Following the aforementioned assumptions, the North New River Canal has a total proposed dredging volume of approximately 162,344 cubic yards (cy). The existing canal bottom based on limited survey and interpolated cross section data is shown in Figure 20.

The purpose of this project is to build resiliency and decrease flood impacts within the North New River West Basin due to extreme rainfall events, sea level rise, climate change, and land use changes in the basin, which contribute to higher canal elevations and bank exceedances. It is possible that restoring or deepening the canal bottom through dredging could reduce the head loss or increase the conveyance capacity of the canal, which may lead to lower peak water levels. This project will directly or indirectly benefit the entire North New River West Basin, although the magnitude of that benefit is unknown. It is important to note that any changes to the downstream tidal outfall structure such as the addition of a pump station at G-54 could significantly change the dredging requirements, especially if the required conveyance capacity of the canal increases to support the pump station.

A total cost estimate to dredge the North New River Canal is presented in the table below.

Cost Estimate

Canal Dredging	$20,845,027
Adjusted 2024 Cost Total	**$20,845,027**



North New River West Basin Canal Embankment Resiliency

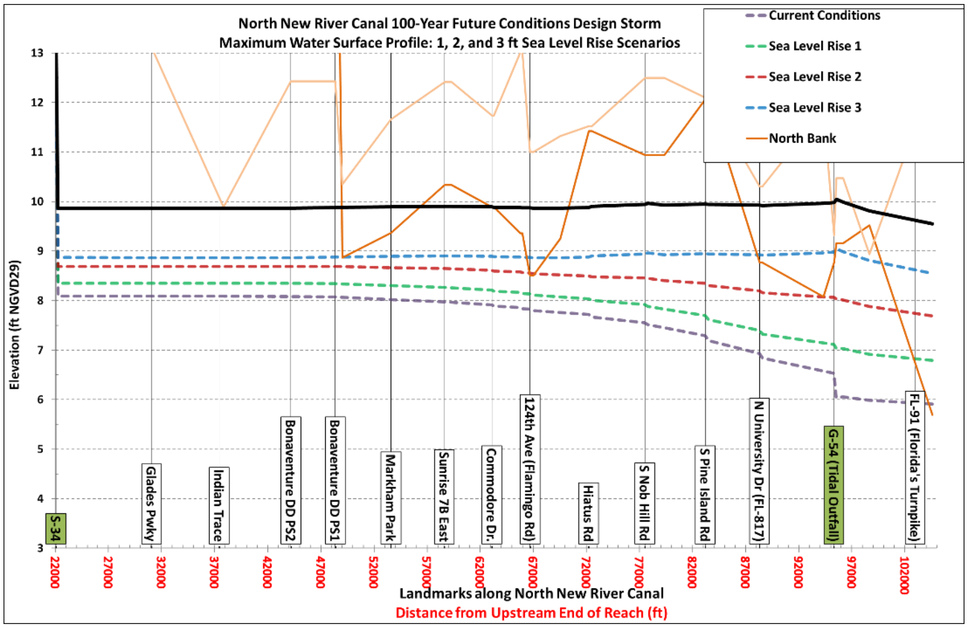


Figure 21: FPLOS PM1 Maximum Water Surface Profiles with Existing and Proposed Minimum Canal Embankments

This resiliency project links to the District's mission to provide flood control. As part of the PM #1 analysis of the Flood Protection Level of Service study, the North New River West Basin's existing canal bank elevations were compared with simulated peak stages from the interconnected surface water / ground-water MIKE SHE / MIKE HYDRO model of Broward County. The North New River Canal is predicted to have just a few instances of bank exceedance for the 100-year return period design storm with three feet of sea level rise. As part of this cost estimate, it is assumed that any canal segment that has a simulated 100-year SLR3 peak stage that is higher or within 1.0 ft elevation of the top of the embankments, will be subject to canal embankment improvements (raising) as part of the resiliency strategy.

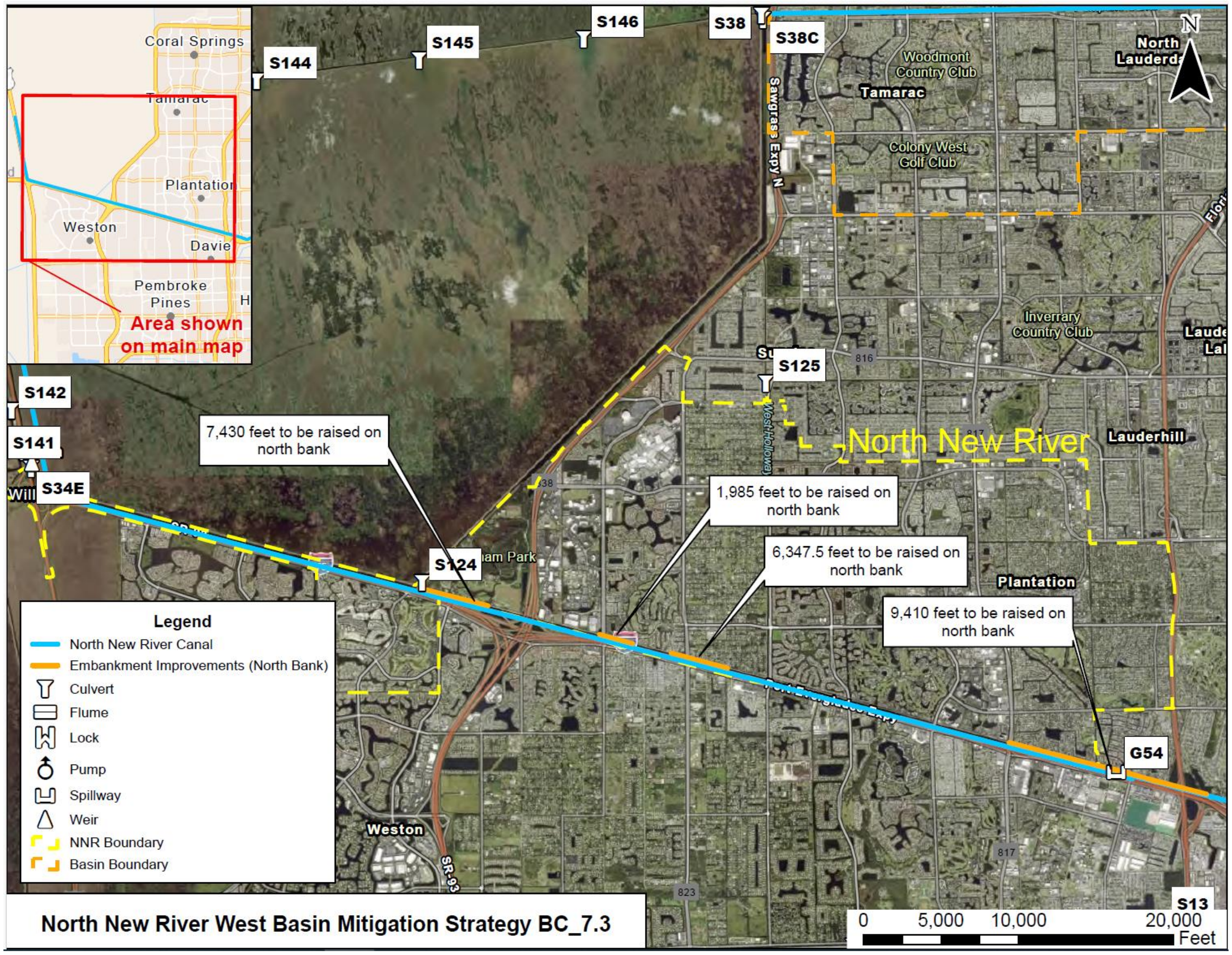
Following the aforementioned assumptions, the North New River West Basin has a total proposed embankment improvement length of approximately 25,173 feet along the north side of the canal. The proposed minimum embankment profile is shown as the black line in Figure 21**.**

The purpose of this project is to build resiliency and decrease flood impacts within the North New River West Basin due to extreme rainfall events, sea level rise, climate change, and land use changes in the basin, which contribute to higher canal elevations and bank exceedances. Although many parts of the North New River Canal were not predicted to have bank exceedances, that study did not consider future increase in rainfall totals, which would likely result in even higher increased maximum water stages in the North New River Canal. Therefore, as part of future resiliency planning, this cost estimate represents a larger increase in canal improvements than indicated by the FPLOS Phase 1 study, to ensure adequate freeboard as well as to protect against additional uncertainty.

This project is predicted to provide additional protection up to and likely beyond the 100-year 3-feet sea level rise storm event. This project will directly and indirectly benefit the North New River West Basin, with a direct benefit in the immediate area of the bank improvements and an indirect benefit elsewhere. It is important to note that any changes to the downstream tidal outfall structure such as the addition of a pump station at G-54 could make parts of the proposed canal bank improvements unnecessary. A total cost estimate to raise the North New River West Basin Canal embankments is presented in the table below.

Cost Estimate

North Bank Raising	$5,611,370
South Bank Raising	$0
Adjusted 2024 Cost Total	**$5,611,370**



C-11 Basin Resiliency

S-13 Coastal Structure Resiliency

Figure 22: Structure S-13 – Upstream View (Photo by SFWMD)

This resiliency project links to the District's mission to provide flood control. S-13 is a two-bay, reinforced concrete gated spillway located in the Town of Davie at the intersection of SR-7 and Orange Drive, about 2.7 miles west of the Fort Lauderdale Airport. The structure consists of one 11.5 feet high by 16.6 feet wide gate with a discharge capacity of 540 cfs. The discharge from the structure is controlled by one electric driven cable drum operated vertical lift gate mechanism. The gates can either be remotely operated from the District Control Room or controlled on-site. The discharge from the structure is also controlled by three 180 cfs diesel driven pumps. The S-13 structure is the outlet to tide for the C-11 East basin. The structure maintains optimum water control stages upstream in the C-11 Canal.

As part of the phase 1 FPLOS preliminary mitigation project identification, it was suggested that one potential way to reduce flooding and increase the flood protection level of service in the C-11 East Basin is to increase the pumping capacity of the structure. With sea level rise, the S-13 tailwater stage will often exceed the headwater stage, which will force the underflow gate to remain closed, which will significantly reduce the discharge capacity of the structure. Therefore, supplemental discharge capacity is required in the form of pump capacity. S-13 is not predicted to be overtopped by the 100-year SLR3 storm surge event, although it is predicted to be within just hundredths of a foot. Therefore, the top of the structure could be extended vertically by attaching metal plates, with negligible costs compared to the addition of the added pump capacity.

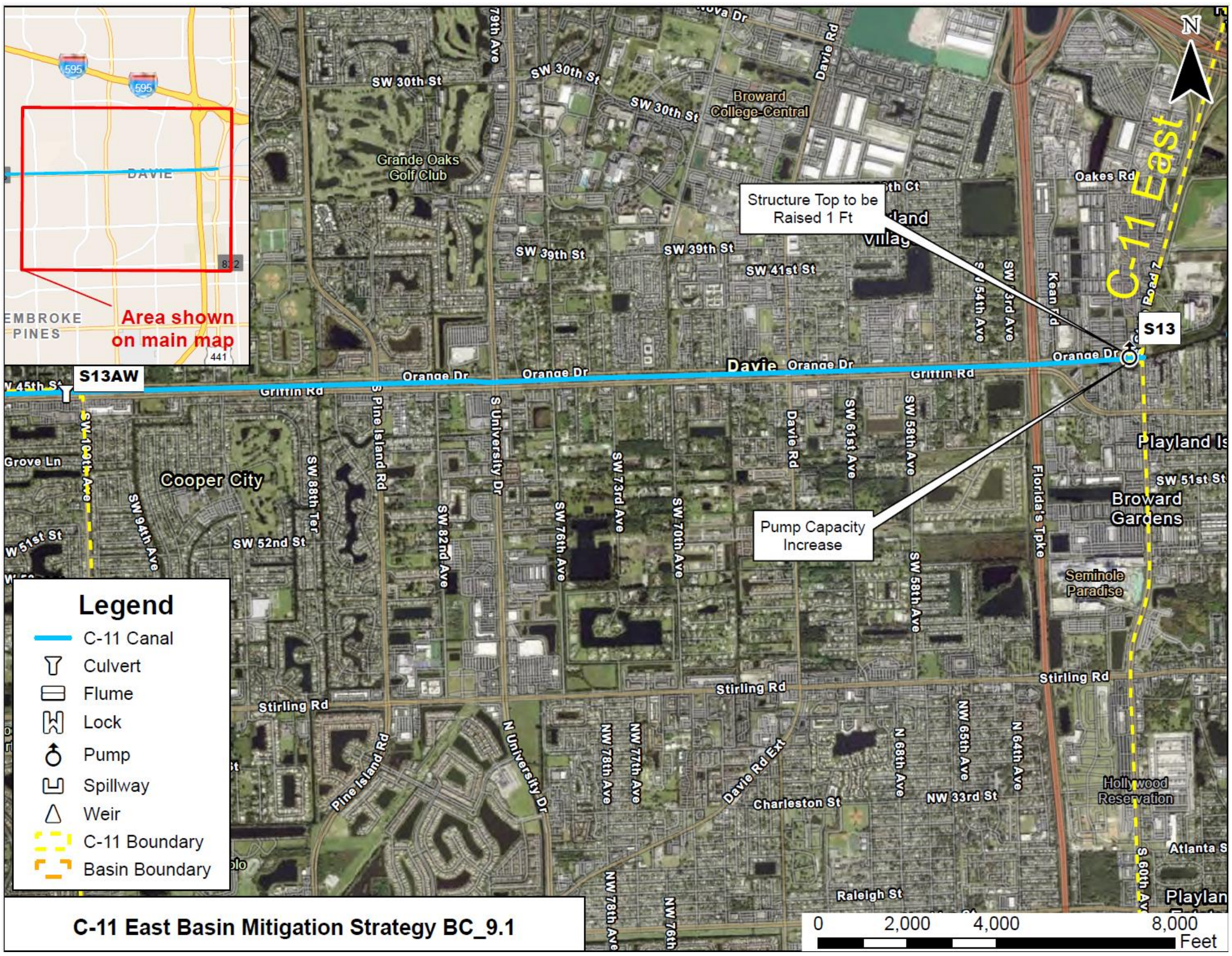
As part of this cost estimate, it is assumed that an additional 500 cfs or 1,000 cfs will be added to the S-13 structure in order to provide supplemental discharge capacity during times where the underflow gate is unable to operate due to downstream conditions.

The purpose of this project is to build resiliency and decrease flood impacts within the C-11 East Basin due to extreme rainfall events, sea level rise, climate change, and land use changes in the basin, which contribute to higher canal elevations and bank exceedances. It is very likely that adding additional pump capacity could reduce flooding in terms of both depth and duration in the C-11 East Basin. This project will directly and indirectly benefit the entire C-11 East Basin, although the magnitude of that benefit is unknown.

A total cost estimate to increase the pump capacity of Structure S-13 on the C-11 Canal is presented in the table below.

Cost Estimate

Forward Pump Cost (500 cfs Option 1)	$35,443,750
Adjusted 2024 Cost Option 1 Total	**$35,443,750**
Forward Pump Cost (1,000 cfs Option 2)	$70,887,500
Adjusted 2024 Cost Option 2 Total	**$70,887,500**



C-11 West Basin Canal Dredging Resiliency

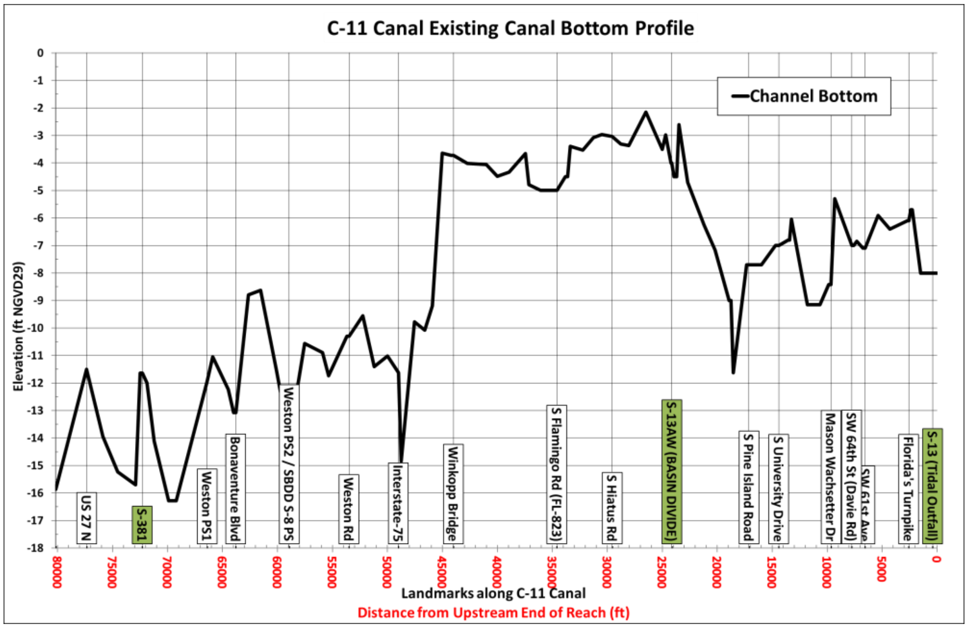


Figure 23: C-11 Canal Existing Bottom Profile

This resiliency project links to the District's mission to provide flood control. As part of the phase 1 FPLOS preliminary mitigation project identification, it was suggested that one potential way to reduce the duration of flooding in the C-11 West Basin would be to increase the conveyance capacity of the C-11 Canal, so that the pump has less "down-time".

Simulation results from the interconnected surface water / ground-water MIKE SHE / MIKE HYDRO Model indicate that the S-9/S9A Pump Station is unable to discharge at full capacity at all times during the storm event as it draws the canal water level down and has to re-establish a minimum pool. One way to potentially increase the conveyance capacity of the canal would be to dredge the canal in areas with significant head loss, specifically due to sediment accumulation. These areas could be identified by comparing the bottom profile to the designed canal bottom. It is also possible that the existing canal bottom is deeper than the designed canal bottom due to years of scour and/or previous dredging as part of canal maintenance.

As detailed bathymetry of the canal bottom does not exist and the surveyed data is spread out far apart, there is not enough detail to make a strong case for or against dredging to restore design conditions as a "mitigation" project, rather it should be part of maintenance (to prevent degradation rather than to improve the system). However, for the purpose of increasing conveyance capacity, this cost estimate assumes that, on average, the upstream portion of the C-11 Canal in the C-11 West Basin (between Interstate 75 and Structure S-13AW) will be dredged by 5 ft in depth. It is also assumed that, on average, the upstream portion of the C-11 Canal in the C-11 West Basin will be dredged across an average width of 75 feet, which was approximated from the bottom width of multiple cross sections.

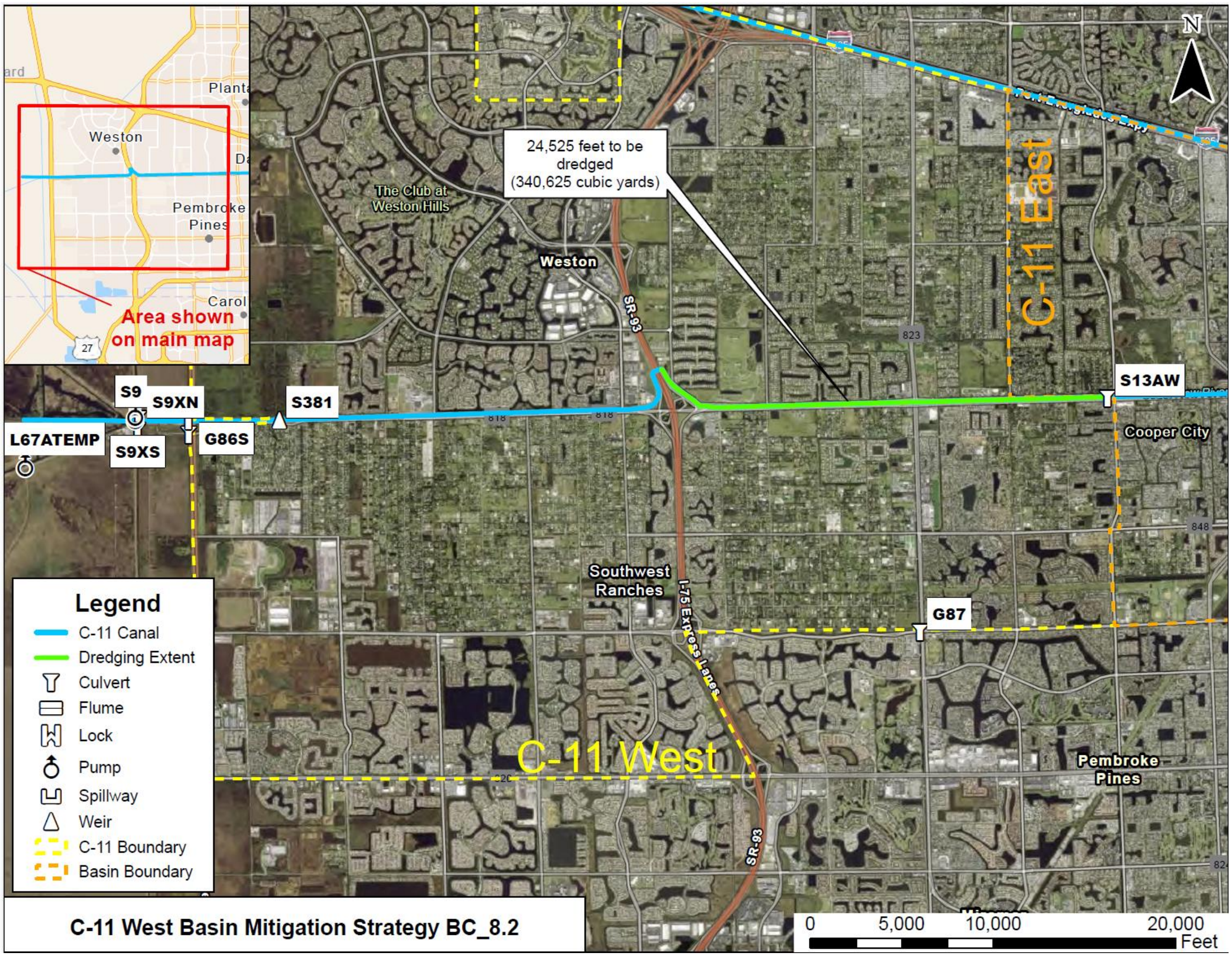
Following these assumptions, the C-11 Canal has a total proposed dredging volume of approximately 340,625 cubic yards (cy). The existing canal bottom based on survey data is shown in Figure 22.

The purpose of this project is to build resiliency and decrease flood impacts within the C-11 West Basin due to extreme rainfall events, sea level rise, climate change, and land use changes in the basin, which contribute to higher canal elevations and bank exceedances. It is possible deepening the canal bottom through dredging could reduce the head loss or increase the conveyance capacity of the canal enough to ensure the S-9/S-9A pump stations can discharge at full capacity throughout a storm event, which could reduce the duration of flooding in this basin. This project will directly or indirectly benefit the entire C-11 West Basin, although the magnitude of that benefit is unknown. It is important to note that any changes to the downstream outfall structure such as an increase in discharge capacity could significantly change the dredging requirements.

A total cost estimate to dredge the C-11 Canal in the C-11 West Basin is presented in the table below.

Cost Estimate

C-11 Dredging	$43,736,250
Adjusted 2024 Cost Total	**$43,736,250**



North Biscayne Bay Basin Resiliency

G-58 Coastal Structure Resiliency

This resiliency project is mainly tied to the District's mission to provide flood control and water supply protection. 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. The G-58 Structure was designed to maintain optimum upstream water control stages in Arch Creek, 2) release the design flood (60% of the Standard Project Flood) without exceeding the upstream flood design stage, 3) restrict downstream flood stages and discharge velocities to non-damaging levels, and 4) prevent 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, sea level rise, 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.

Cost Estimate

Structure Enhancement	$9,435,460
Forward Pump (75cfs)	$6,342,188
Forward Pump Backup Generator Facility	$634,219
Structure Tie Back (Flood Barrier)	$3,075,000
Design, Implementation & Construction Management	$2,923,030
Real Estate	$3,000,000
Adjusted 2024 cost	**$25,409,897**

C-6 Basin (Miami River) Resiliency

S-26 Coastal Structure Resiliency

This resiliency project is mainly tied to the District's mission to provide flood control and water supply protection. 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 the upstream flood design stage and 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 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. The project's conceptual design is finalized. The final design will be based on a 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. There is an urgent need to identify and purchase lands in this area to accommodate future structure modifications and pump station sizing.

In 2023, the District is replacing existing pumps at this location as part of the normal operations and maintenance program. The pump capacity will not be increased as part of this maintenance because the existing control building and structure cannot support increasing the pump size. One important consideration at this site is that the system needs to be fully operational during construction.

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 is 226. These include airports, faith-based facilities, fire stations, waste management facilities, hospitals and medical facilities, law enforcement centers, and schools. Public schools have a vital role 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.

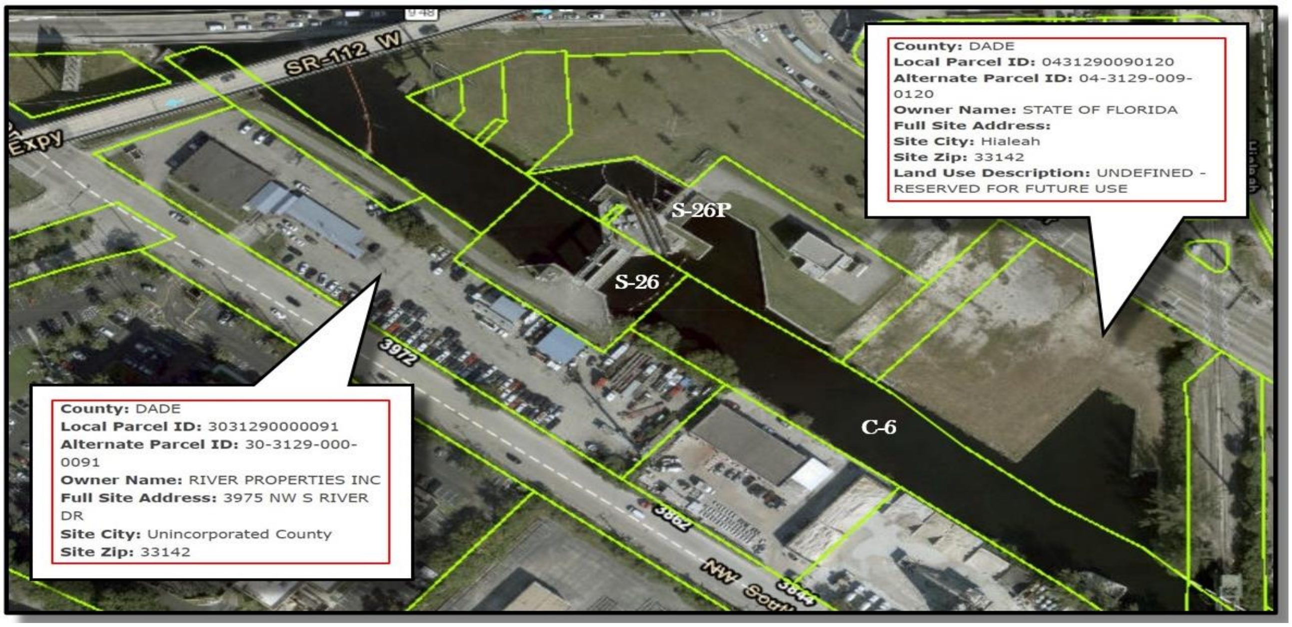


Figure 24: Land Needs for S-26 Structure Enhancements

The project will provide 20-40 years of protection against sea level rise, depending on the scenario (Intermediate Low or NOAA Intermediate High). The 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, sea level rise, and other related risks to vulnerable communities in the Basin is presented below.

Cost Estimate

Structure Enhancement	$10,918,585
Forward Pump (1735 cfs)	$128,043,000
Forward Pump Backup Generator Facility	$12,804,300
Structure Tie Back (Flood Barrier)	$3,075,000
Design, Implementation & Construction Management	$23,226,133
Real Estate	$2,404,512
2024 Adjusted Cost	**$180,471,530**

C-6 Canal Embankment Resiliency

The C-6 Watershed consists of areas draining to the C-6 Canal (Miami Canal or Miami River) from the L30 Levee southeast to Airport Expressway. The primary discharge canal is the Miami River (C-6 Canal) from the S-31 water control structure to the S-26 water control structure, which is approximately 14.5 miles long. The purpose of this project is to build resiliency and decrease flood impacts within the C-6 Watershed due to canal overbank flow, which is exacerbated by storm surge and sea level rise.

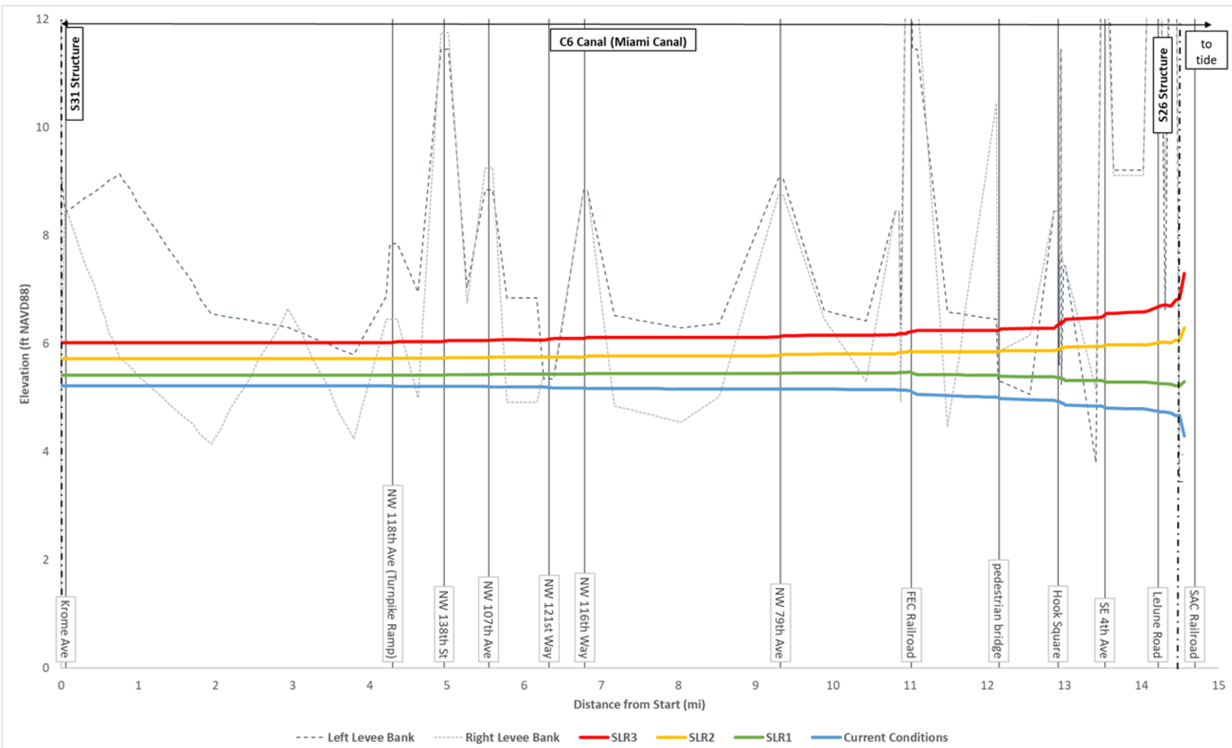


Figure 25: Maximum stage profile for the Miami River in the C-6 Watershed for the 100-year design storm taken from the C-2 through C-6 FPLOS Study (2023).

Based on the FPLOS Assessment for the C-6 Watershed, there are several locations along the Miami River where the canal top of bank is exceeded, even during current conditions design storm simulations (see Figure 27). The neighborhoods of Hialeah Gardens and Medley are directly impacted by canal overtopping, under some conditions. Raising the elevation of the canal banks will help reduce overtopping of embankments from the canals to the overland elevations during the peak of storm events.

For the C-6 Watershed there are several locations where raising the embankments can provide immediate relief during extreme rainfall and surge events with high canal stages. To review the deficiency of these embankment heights, a comparison was made with the 2022 Miami-Dade County Flood Criteria map, which is based on a 10-year, 24-hour storm event, 2060 scenario with SLR. It is proposed that stretches of the canal with bank elevations lower than the Miami-Dade County Flood Criteria map (which varies spatially) be raised to this level. For the purposes of this study, canal embankments east of the Florida's Turnpike will be considered for improvements, as the canal to the west of the Turnpike primarily serves natural areas or mine lakes.

The embankment improvements consider all embankments along the Miami River, east of Florida's Turnpike, within the C-6 and Miami River Watersheds that are deficient from the flood criteria. It is assumed that for areas with sufficient right-of-way the embankment improvements can be achieved with stabilized earthen embankments, for areas with minimal right of way it is assumed that structural improvements will be required such as sheet pile bulkheads.

The total length of proposed embankment improvements is approximately 11 miles, 5.5 miles on the right embankment and about 5.5 miles on the left embankment. While 28% (16,159 ft) of these embankments will be able to build a levee at the lower cost, 72% (41,609 ft) will require a flood wall due to limited space. Survey will need to be conducted to determine the exact extent of embankment deficiency.

A conceptual cost estimate to raise canal embankments in the Miami River is presented below.

Cost Estimate

Line Item	Cost
Embankment Construction	$3,602,031
Flood Wall Construction	$11,130,573
Design, Implementation & Construction Management	$2,209,891
Real Estate	TBD
Adjusted 2024 Cost Total*	**$16,942,494**

*Excludes Real Estate Costs to be determined by SFWMD

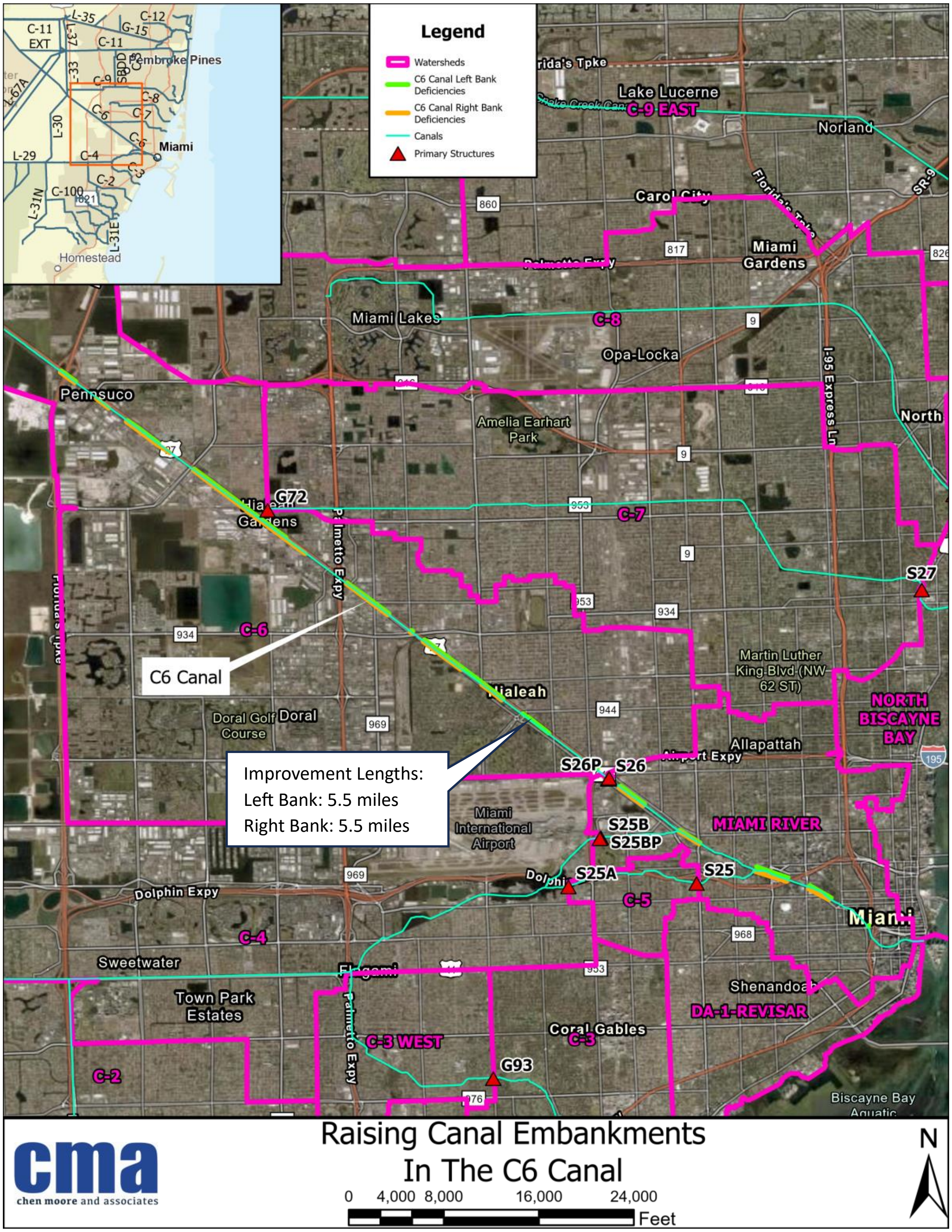


Figure 26: Proposed embankment improvements in the Miami River.

C-6 Canal Widening and Dredging Resiliency

The C-6 Watershed consists of areas draining to the C-6 Canal from the L30 Levee southeast to Airport Expressway. The primary discharge canal is the Miami River (C-6 Canal), which spans 14.5 miles from the S31 water control structure to the S-26 water control structure. The S-26 water control structure is a two-bay reinforced concrete gated spillway that serves as the outlet to tide for the C-6 Basin. The structure maintains optimum water control stages upstream in 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 high tides.

Figure 27: View of the Miami River.

According to the Canal Conveyance Capacity Project: C-6 Canal Study, the current Miami River conditions are significantly different than the design conditions, with most of the design cross sections assumed by the C&SF Project never being implemented. Due to the urbanization and development in this area, it is no longer possible to implement the design conditions at present time. The current canal cross sections have smaller depths and bottom widths (at some stations), leading to smaller cross section areas compared to the C&SF design. The C-6 Canal Study found that the original design flows could not be conveyed through S-26 while satisfying the water surface elevation criteria set by the original C&SF project[1]. This study also saw that increasing canal cross sections in the undeveloped area upstream in the Miami River helped decrease water surface elevations to meet the design guidelines.

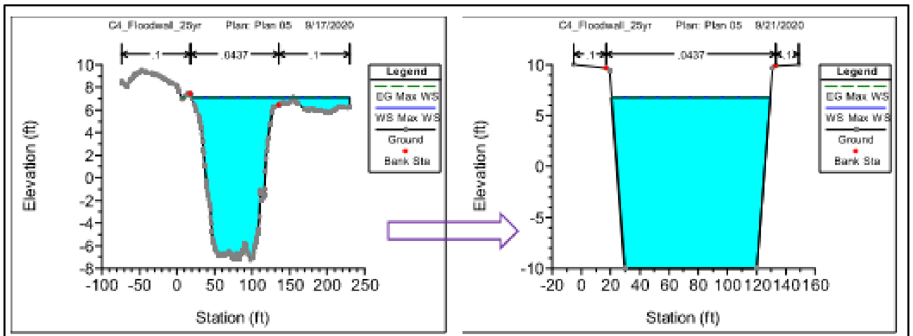


Figure 53 – Water Surface profile comparison at various XS in C-6 Canal for 25-year using hypothetical cross section

Figure 28: Example of a hypothetical cross section used in the C-6 Canal Study to see the effect of dredging and widening the C-6 Canal on the overall water surface elevations[2].

The purpose of this project is to improve the canal capacity and bank overtopping with modifications to target channel cross sections by dredging and widening, where possible. The project will evaluate the length of the Miami Canal from the S-31 to S-26 structures, or approximately 13 miles, via survey and bathymetric analysis. The sections that are below the designed standard carrying capacity will then be dredged and/or widened. From the original C-6 Canal Study, dredging the portion of the canal upstream of the F.E.C. Railway helped to provide additional canal capacity and meet the design guidelines. Figure 30Figure 29 shows the proposed dredged section of the C-6 Canal and the peak water surface elevation for a 25 yr/ 3day design storm simulation. The initial estimate of the amount of dredging and widening that would be needed is around 11 miles based on this study; however, additional analysis will be performed to provide a more accurate estimate. Final design will be based upon simulation of the combined regional and local hydraulic measures in the C-6 Watershed.

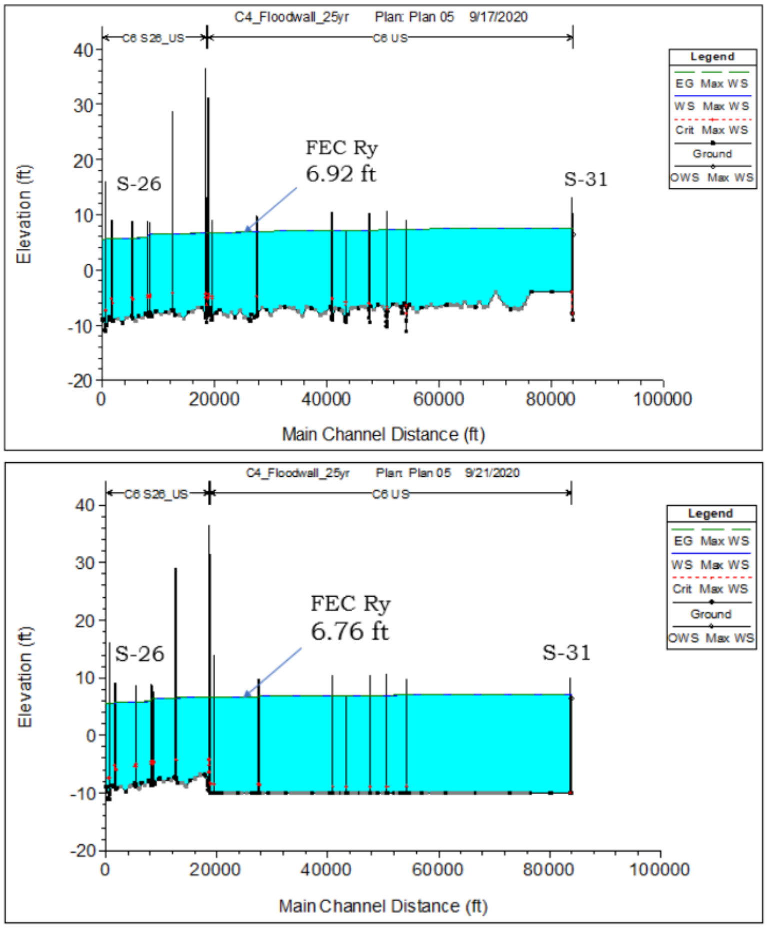


Figure 29: Proposed dredged section of the C-6 Canal from the Canal Conveyance Capacity Project for the C-6 Canal.

A conceptual cost estimate to increase the conveyance capacity in the Miami River is presented below. Figure provides a schematic of the proposed improvements.

Cost Estimate

Line Item	Cost
Canal Dredging/Widening	$128,894,578
Design, Implementation & Construction Management	$19,334,187
Real Estate	TBD
Adjusted 2024 Cost Total*	**$148,228,764**

*Excludes Real Estate Costs to be determined by SFWMD

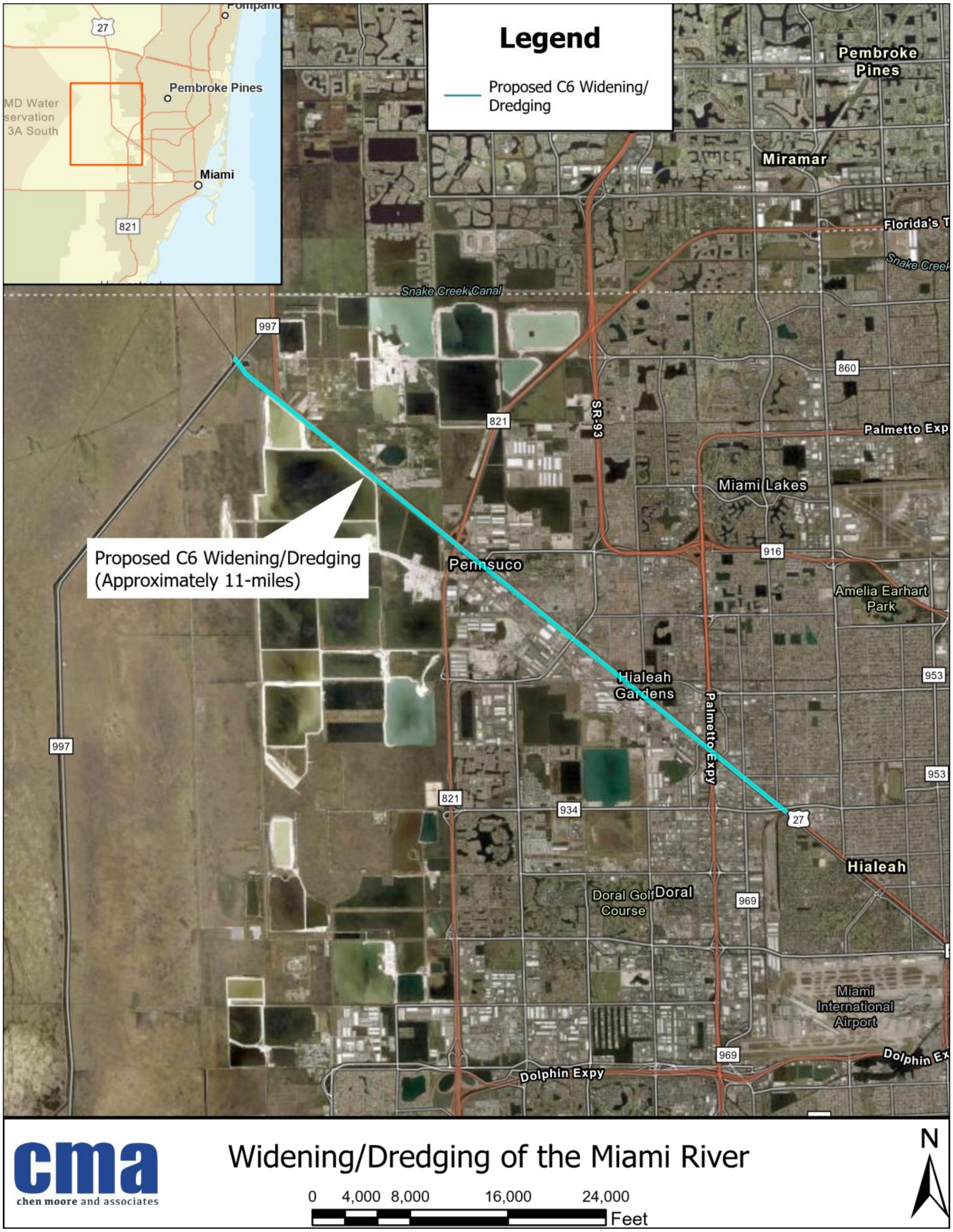


Figure 30: Proposed location of widening/dredging the Miami River.

Temporary Storage – Two Potential Sites

To provide additional storage within the C-6 watershed, open spaces such as Miami-Dade County parks, municipal parks, or golf courses can potentially be used as emergency temporary storage. Most of these areas are at lower elevations compare to the average grade for buildings. Green infrastructure can be implemented at these parks to allow for recreational use during dry periods while providing storage during storm events. The C-6 Watershed has a few non-urban areas and recreational areas that may be considered for use as temporary storage during extreme rainfall events.

One pre-identified area along the primary canal could accommodate an approximately 6.5-acre flow-through stormwater detention area. This additional storage will provide flood protection during extreme rainfall events by helping reduce the peak stages in the canal. The recommended improvements for implementing this potential temporary storage include:

- Levee (4-ft height) – 2,700 ft
- Pump Station – One 50 cfs Inflow Pump Station
- Passive Gravity Control Structures
    - 1 Outflow Structure – overflow weir to control 2 ft of storage

The volume of storage provided by this potential project is estimated to be 13 ac-ft, based on 2 feet of storage over the 6.5-acre storage area.

A second potential area for temporary storage was also identified along the secondary canal. This area may already have naturally lower embankments that likely provide some floodplain storage, and could be divided into two sections: One that can be re-graded to allow the canal to overflow onto the natural areas and utilize the water hazards temporarily, and another for offline storage that can be enhanced to provide additional dry detention. Extensive earthwork would be required to re-grade the green spaces for storage to make this option functional.

The recommended improvements for implementing the second potential temporary storage option include:

- Excavation Earthwork – 130 ac-ft
- Area Retrofit – 625 acres
- Active Gravity Control Structures
    - Gated Culvert

The volume of storage is estimated to be 130 ac-ft.

The purpose of these projects is to build resiliency and decrease flood impacts within the C-6 Watershed due to canal overbank flow, which is exacerbated by storm surge and sea level rise. The final design and location of these projects will be based upon simulation of the combined regional and local hydraulic measures in the C-6 Watershed. Overall flood protection levels of service are expected to increase in the entire watershed with project implementation.

A conceptual cost estimate to implement this strategy below.

Cost Estimate

Line Item	Potential Site 1	Potential Site 2
Distributed Storage*	$208,650	$2,086,500
Levee	$963,000	
Earthwork		$22,441,420
Design, Implementation & Construction Management	$175,748	$3,679,188
Real Estate	TBD	TBD
Adjusted 2024 Cost Total*	**$1,347,398**	**$28,207,108**

*Based on storage volume and includes cost of culverts, pumps, etc.
**Excludes Real Estate Costs to be determined by SFWMD

Additional Potential CERP Storage

A project to provide more storage in the C-6 Watershed is to connect and utilize the mining lakes west of the Turnpike as storage and emergency detention. Within the C-6 Watershed, there are over 2,500 acres of existing mine lakes that have completed their operations and are currently serving no additional purpose. These open pits could be utilized as additional storage by constructing embankments and seepage walls to contain additional flood waters pumped in from adjacent canals such as the C-6 Canal and Grahams Dairy Canal.

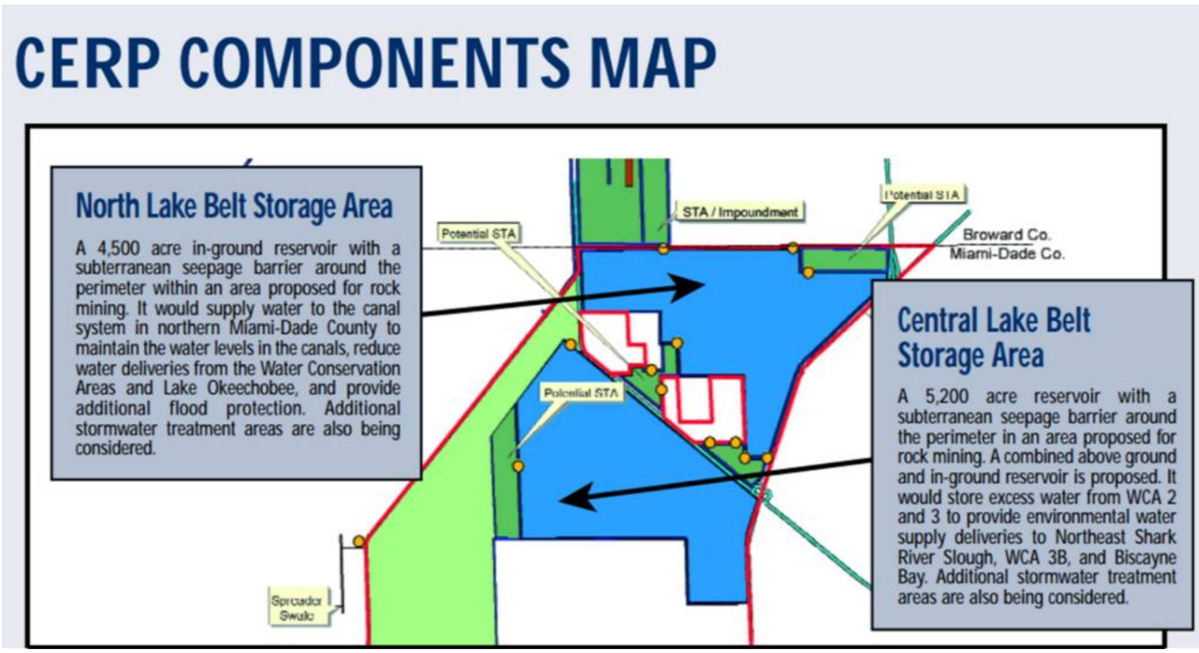


Figure 31: Central Everglades Components Map including the proposed North Lake Belt Storage Area and the proposed Central Lake Belt Storage Area[3].

Another option is to connect the mining pits west of the Turnpike and south of the C-6 Canal to the C-6 Canal. This project was identified by the SFWMD and USACE as a CERP project, referred to as the North Lake Belt Storage Area (see Figure 32). As mentioned in the CERP plan, this would require seepage barriers to prevent horizontal losses to the groundwater. It should be considered that vertical losses through the bottom could be a major problem if the seepage walls around the proposed storage area do not penetrate low enough into a confining layer.

In addition to the complication of controlling groundwater seepage out of the mine lakes, the lakes would also require building up the existing levees to store additional water. Any additional storage in these mine lakes would require much larger levees designed for water levels above the water table elevation.

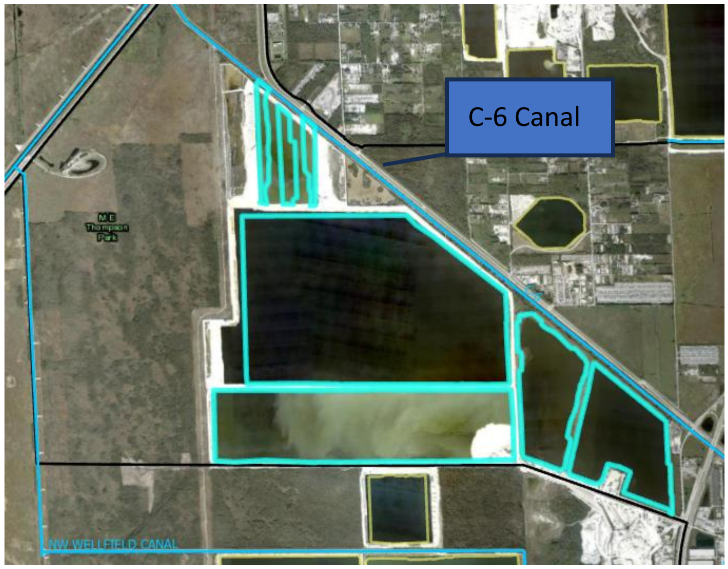


Figure 32: Location of proposed additional storage area south of the C-6 Canal.

There are approximately 2,500 acres of open mine lakes south of the C-6 Canal that could be used to provide offline emergency detention during extreme storm events. A pump station located along the C-6 Canal would pull water from the canal during storm events to reduce peak stages in the C-6 Canal and protect the communities downstream. The open lakes that would be used for this storage area and will require purchase, additional embankment development, pump station and spillway design.

The recommended improvements to implement Option A include the following elements:

- Levee (6-ft height) – 72,300 ft
- Pump Station – One 1,000 cfs Inflow Pump Station
- Gravity Control Structures
    - 3 Gated Culvert Locations – each location has four (4) 5x10 ft box culvert with gate
    - 1 Outflow Structure – 5x20 ft gated spillway

The volume of storage provided by Option A is estimated to be 5,000 ac-ft based on 2 feet of storage over the 2,500-acre lake area.

Another alternative (Option B) consist of approximately 209 acres of open mine that could be used to provide offline emergency detention during extreme storm events. This project will require additional embankment development, pump station and spillway design, and a combination of in-situ seepage barriers and seepage canals.

The recommended improvements to implement Option B include the following elements:

- Levee (6-ft height) – 17,410 ft
- Seepage Canal – 6,410 ft
- In-Situ Seepage Barrier – 1,925 ft
- Flow Way – 5,118 ft

- Pump Station –
  - One 300 cfs Inflow Pump Station
  - Two 50 cfs Seepage Canal Pump Stations
- Gravity Control Structures
  - 1 Gated Culvert – 5x10 ft box culvert with gate
  - 1 Inflow/Outflow Structure – 5x20 ft gated spillway

The volume of storage provided by Option B is estimated to be 400 ac-ft.

A conceptual cost estimate to implement these offline storage options, to address flooding, SLR and other related risks to vulnerable communities in the C-6 Watershed are presented below. Figure 33 provides schematics of the proposed improvements for Option A and Option B, respectively.

Cost Estimate

Line Item	Option A	Option B
Levee Construction	$38,680,500	$9,314,350
Seepage Canals	--	$2,921,298
In-situ Seepage Barriers	--	$3,089,625
Pump Stations	$66,875,000	$28,622,500
Spillways	$11,993,013	$11,993,013
Gated Culverts	$24,830,253	$1,724,323
New Flow-way	--	$7,605,917
Design, Implementation & Construction Management	$21,356,815	$9,790,654
Real Estate	TBD	TBD
Adjusted 2024 Cost Total*	**$163,735,581**	**$75,061,679**

*Excludes Real Estate Costs to be determined by SFWMD

C-5 Basin Resiliency

S-25 Coastal Structure Resiliency

This resiliency project is mainly tied to the District's mission to provide flood control and water supply protection. 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 the 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, sea level rise, 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 be initiated upon funding confirmation. A portion of the needed property is owned by the Florida Department of Transportation, which may reduce land acquisition costs.

Cost Estimate

Structure Enhancement	$5,681,603
Forward Pump (160 cfs)	$13,530,000
Forward Pump Backup Generator Facility	$1,353,000
Structure Tie Back (Flood Barrier)	$3,075,000
Design, Implementation & Construction Management	$3,545,940
Real Estate	$11,500,000
Adjusted 2024 Cost	**$38,685,544**

S-25A Coastal Structure Resiliency

Currently, the S-25A structure is a single-barreled, manually operated, gated culvert located at NW 45th (Figure 36). This structure is kept closed during the wet season and is opened in the dry season when water levels in Comfort Canal recede to 1.5 ft NGVD29, in an effort to control salinity intrusion. Analysis of future conditions has shown that overtopping of NW 45th Ave (7.5 ft NGVD29) occurs during peak storm conditions, as the C-5 Watershed is not able to discharge and is impacted by storm surge and SLR backflowing at S-25.

Figure 33: Current S-25A structure.

Analysis has shown that the effects of pumping into the C-4 Impoundment can have far-reaching impacts throughout the primary canal system. Flows have been shown to temporarily reverse direction from the C-2 Watershed at Snapper Creek and SW 132nd Ave, as well as in the C-3W Watershed at the connection between the Tamiami Canal and Coral Gables Canal. This effect on the system may increase with additional stormwater storage projects that may be implemented in the future in both the C-4 and C-2 Watersheds, for example adding back pumping at S-380 or creating new stormwater storage in the western mine lakes.

Allowing the connection with the C-5 Watershed to open under certain conditions may alleviate some of the higher stages in the canal that are impacting the low-lying basins of Little Havana and Grapeland Heights. This project would require the creation of a uni-directional flap gate that can be utilized to reduce operational procedures and keep the flow direction out of the C-5 Watershed.

This project will include the construction of a flap gate structure, which will only allow flow from east to west, but can be held open in the dry season to maintain its existing function. Modeling analysis will be required to size the culvert appropriately; however, the initial assumption will be to retrofit the existing 54” CMP culvert.

While raising the roadbed or adding a levee to prevent overtopping would be helpful if the gate remains closed, the surrounding community (e.g. Little Havana and Grapeland Heights) is far below the existing overtopping elevation, and therefore preventative measures to keep the stream elevation low are of critical importance and the immediate concern.

The recommended improvements to structure S-25A include the following elements:

- Tie-back Levees – 450 ft
- Passive Gravity Control Structures – Retrofit of S-25A with Flap Gate and adjustable counterweight

This project would provide direct benefits to the population living in the low-lying areas of the C-5 Watershed. In addition, since upgrades to the S-25 structure may be more extensive and require a longer period of development and construction, immediate retrofits to the S-25A structure would provide interim relief to the C-5 watershed in the event of extreme storm surge and rainfall.

A conceptual cost estimate to upgrade the S-25A structure, to address flooding due to storm surge and SLR within the C-5 Watershed is presented below. Figure 36 provides a schematic of the proposed improvements.

Cost Estimate

Line Item	Cost
Retrofit of Existing Structure	$132,081
Demolition	$296,928
Tie Back Levees	$40,125
Design, Implementation & Construction Management	$70,370
Real Estate	TBD
Adjusted 2024 Cost Total*	**$539,504**

*Excludes Real Estate Costs to be determined by SFWMD

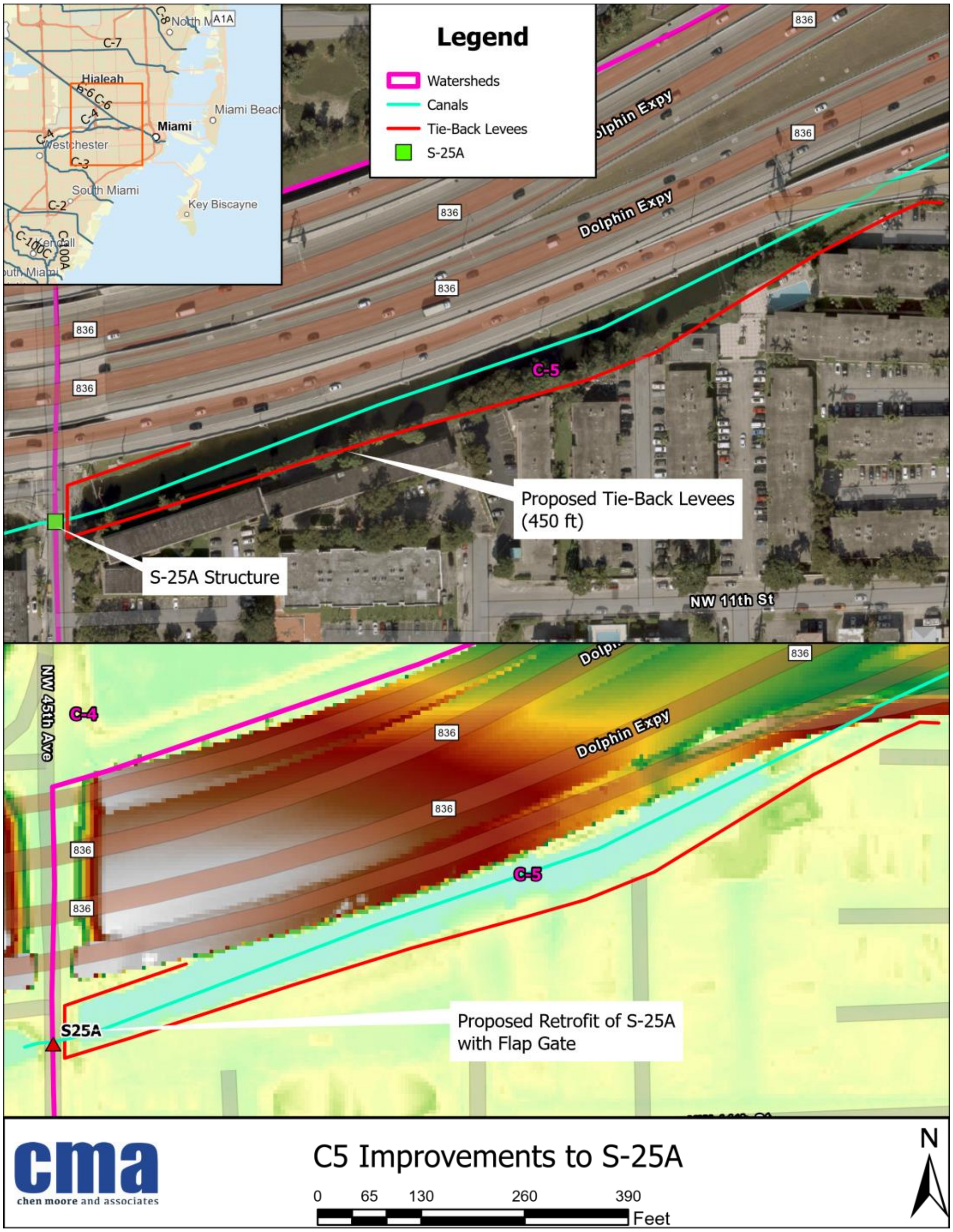


Figure 34: Proposed improvements to S-25A and the Comfort Canal adjacent to S-25A.

Comfort Canal Embankment Resiliency

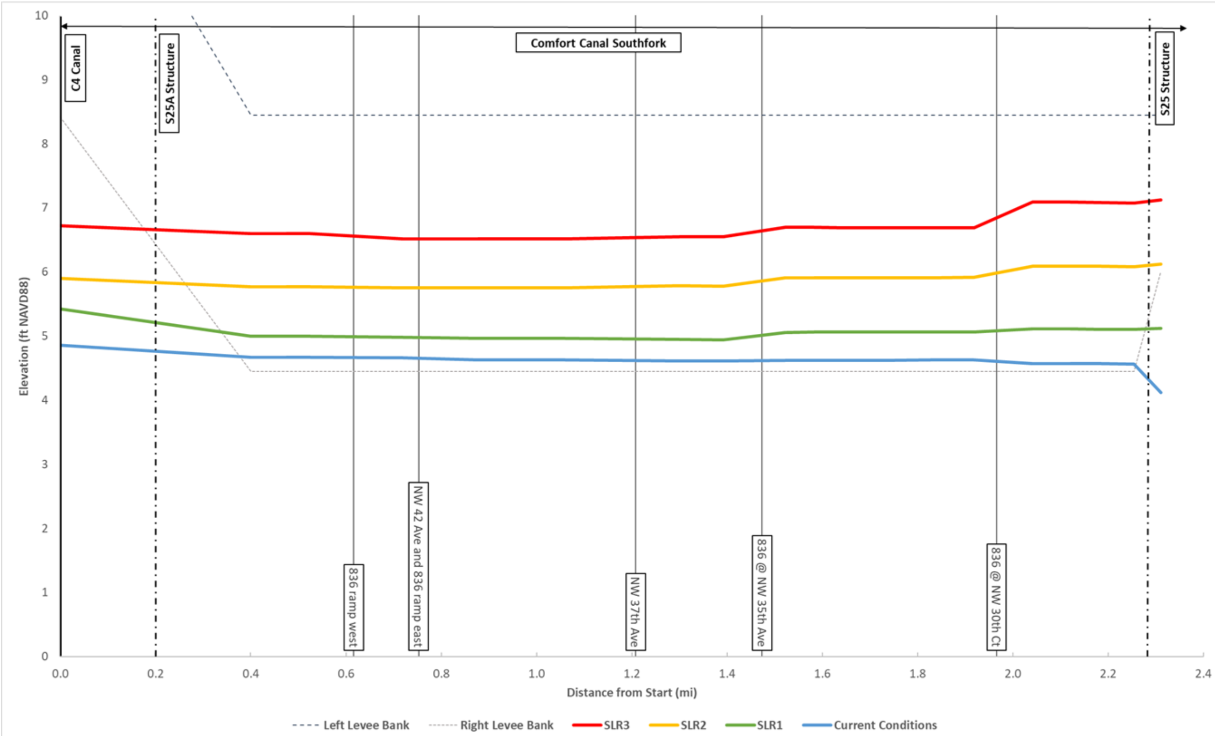


Figure 35: Maximum stage profile for the Comfort Canal in the C-5 Watershed for the 100-year design storm taken from the C-2 through C-6 FPLOS Study (2023).

The C-5 Watershed is a relatively small watershed that consists of areas north of SW 8th St, west of NW 27th Ave, east of Red Road, and south of NW 16th St. The primary discharge canal is the Comfort Canal (C-5 Canal) from the S-25A water control structure to the S-25 water control structure, which is approximately 2 miles long. The purpose of this project is to build resiliency and decrease flood impacts within the C-5 Watershed due to canal overbank flow, which is exacerbated by storm surge and sea level rise.

Based on the FPLOS Assessment for the C-5 Basin, a majority of the canal top of bank is exceeded, even during current conditions simulations (Figure 34). Neighborhoods of concern include Little Havana and Grapeland Heights. Raising the elevation of the canal banks will help reduce overtopping of embankments from the canals to the overland elevations during the peak of storm events.

For the C-5 Watershed, there are several locations where raising the embankments can provide immediate relief during extreme rainfall and surge events with high canal stages, including Little Havana and Grapeland Heights. To review the deficiency of embankment heights, a comparison was made with the 2022 Miami-Dade County Flood Criteria map, which is based on a 10-year, 24-hour storm event, 2060 scenario with SLR. It is proposed that stretches of the canal with bank elevations lower than the Miami-Dade County Flood Criteria map (which varies spatially) be raised to this level.

Survey will need to be conducted to determine the exact extent of embankment deficiency. An estimated 11,000 ft (2.1 miles) of embankment will be improved to reduce overtopping of the canal into the low-lying regions of the C-5 Watershed. It is estimated that approximately 100% of the Comfort

Canal is built up directly adjacent to the canal and there would be insufficient easement to build a levee. As an alternative to levees, sheet pile floodwalls with a concrete cap can be implemented over stretches of the canal that lack easements. These floodwalls would tie into the levees, matching the height and providing the same level of flood protection.

A conceptual cost estimate to raise canal embankments in the Comfort Canal is presented in below. Figure 34 provides a schematic of the proposed improvements.

Cost Estimate

Line Item	Cost
Flood Wall Construction	$2,958,550
Design, Implementation & Construction Management	$443,783
Real Estate	TBD
Adjusted 2024 Cost Total*	**$3,402,333**

*Excludes Real Estate Costs to be determined by SFWMD

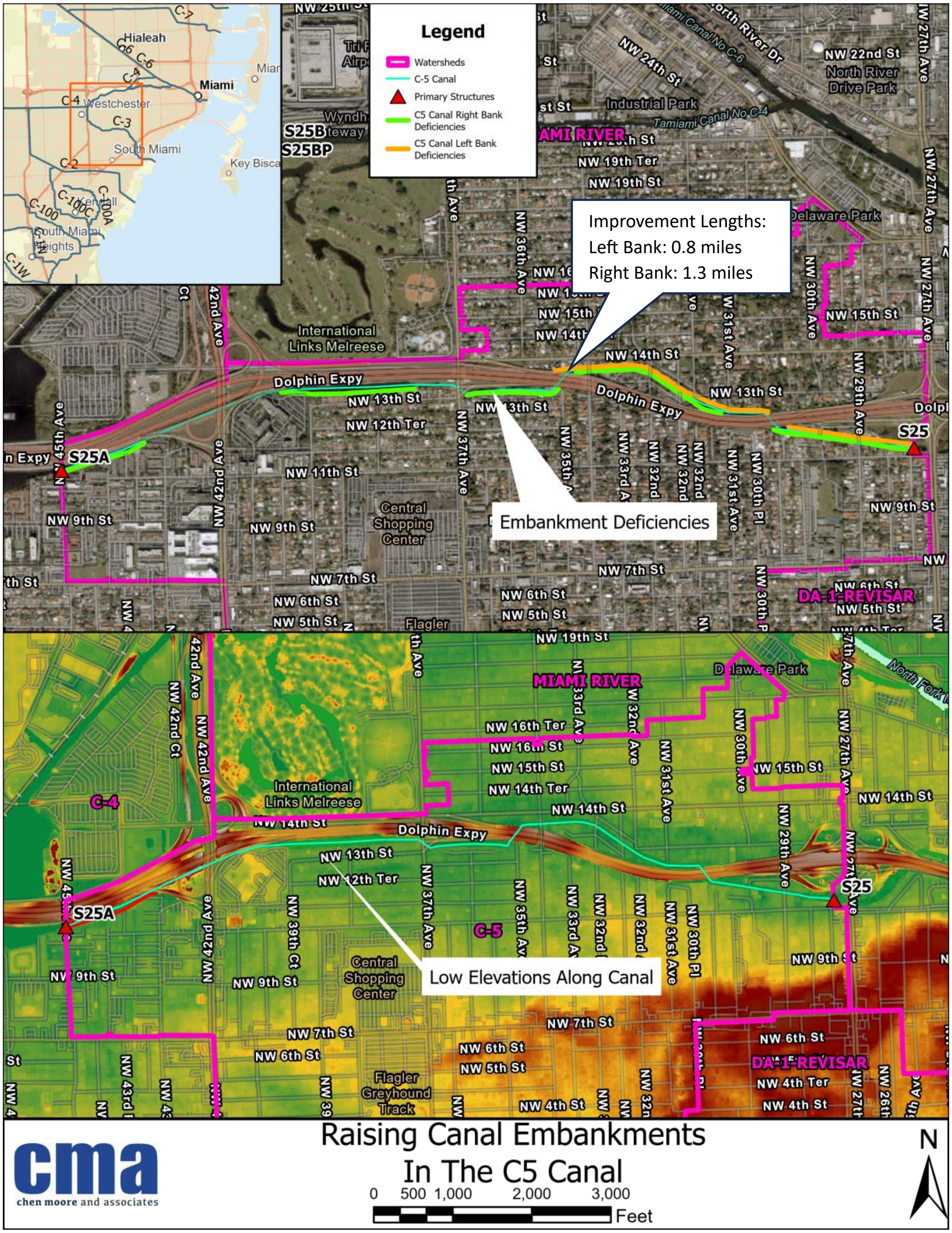


Figure 36: Proposed embankment improvements in the Comfort Canal (top) and topography showing the low elevations along the Comfort Canal (bottom).

C-4 Basin Resiliency

S-25B Coastal Structure Resiliency

This resiliency project is mainly tied to the District's mission to provide flood control and water supply protection. S-25B is a two-bay, reinforced concrete gated spillway located in the (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 the 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, sea level rise, 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.

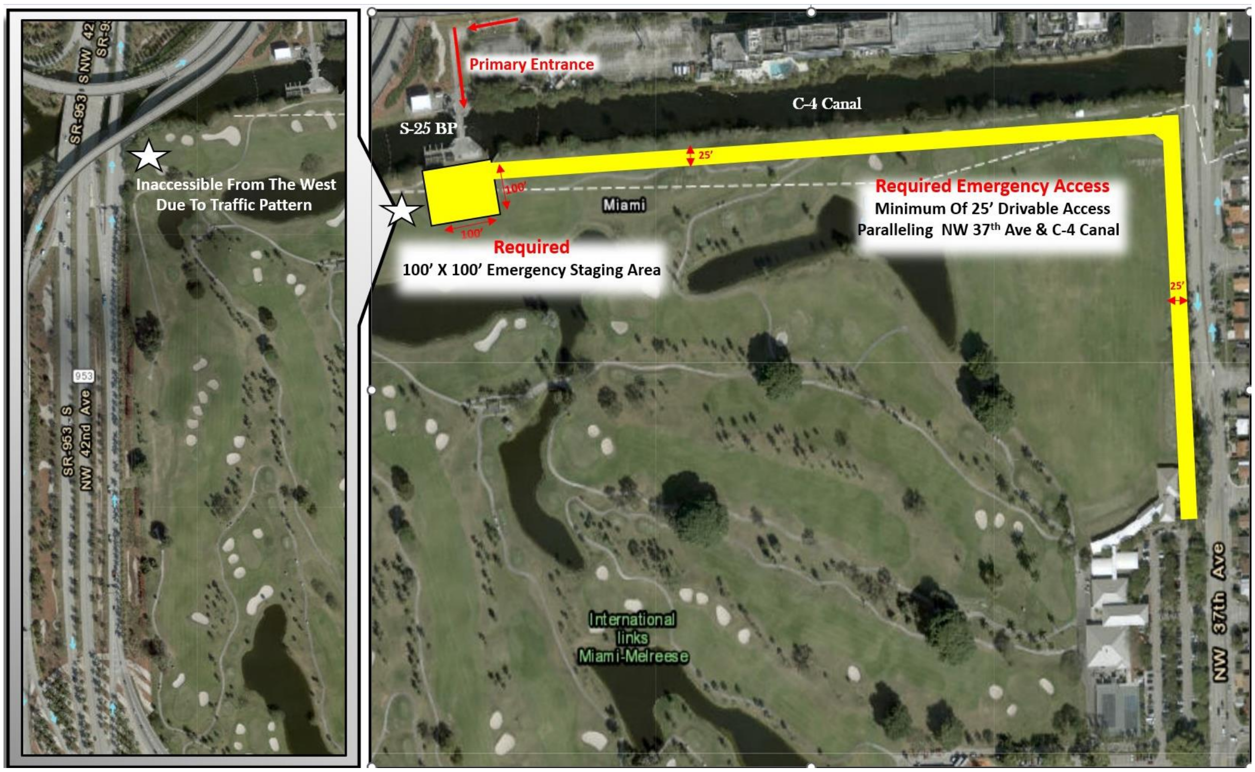


Figure 37: Real Estate Needs for S-25.

Cost Estimate

Structure Enhancement	$9,941,185
Forward Pump (1000 cfs)	$73,800,000
Forward Pump Backup Generator Facility	$7,380,000
Structure Tie Back (Flood Barrier)	$3,075,000
Design, Implementation & Construction Management	$14,129,428
Real Estate	$143,750
Adjusted 2023 Cost	**$108,469,363**

S-380 Structure Resiliency

S-380 is a five-barrel culvert located in the C-4 (Tamiami) Canal (Figure 44). Flow through the structure is controlled by single stem sluice gates mounted on a frame on the upstream side (west end of the structure). The purpose of S-380 is to maintain stages to create and preserve nearby wetlands as well as enhance water supply by providing aquifer recharge. Additional water could be stored west of the structure for flood control purposes prior to and during a storm event. The following recommendations should be considered:

1) Adjusting the operations of the S-380 gates to remain open if the C-4 Emergency Detention Basin (EDB) is not pumping and there is not a positive head differential across the S-380 structure, and closed if the C-4 Detention Basin is pumping and there is a positive differential across the S-380 structure.

2) Potential upgrades for this purpose include installing a backflow pump and raising the structure elevation. In addition, the northern levee along the C-4 Canal within the Pennsuco wetlands region could be degraded to be below the top of the S-380 structure to provide additional overflow to the wetlands area with increasing normal discharge from the wetlands to the C-4 Canal.

Figure 38: Current S-380 structure.

S-380 has a design capacity of 400 cfs. Control is affected by single stem sluice gates that are remotely operated from the SFWMD Operation Control Center or controlled on-site. S-380 is equipped with L.P. gas driven generator as emergency back-up power.

S-380 typically remains open during the wet season effectively maintaining the control of this reach of canal at G-119. When the stage at the T5W stage monitoring station reaches an elevation of 4.80 feet NGVD29, S-380 will be partially closed to limit discharges through only one culvert barrel. Therefore, 4 of the 5 culvert gates will be closed completely. Should the stage at T5W increase to 6.5 feet NGVD29 all gates at S-380 will be closed until the stage at T5W recedes to 6.0 feet NGVD29. Once the EDB has been emptied, the S-380 structure may be fully opened to drain the area west of S-380 down to a stage of 4.0 feet NGVD29.

Modeling analysis will be performed to evaluate the effects of simply changing the protocol for closing the gate to rely solely on the head differential at S-380 and whether the pumps are on in the C-4 EDB. This could provide more canal storage west of the structure during extreme conditions in the C-4 Canal, and would likely be more effective when SLR is higher and the C-4 EDB storage capacity is maximized.

In addition, by adding backward pumps to the structure, additional canal storage could be realized in the wetlands to the west of the structure. This may require either raising canal embankments in the C-4 Canal from S-336 to S-380 or adding one-directional gated culverts to those embankments to utilize the Pennsuco wetlands as storage. Backward pumps will not be able to operate when the C-4 EDB pumps are operating, as there is currently too much localized drawdown caused by the C-4 EDB pumps. However, the Miami-Dade 2021 Water Control Map shows a future planned canal connecting the C-4 Canal to the Bird Drive Extension Canal along the SW 157th Ave (Figure 45). Connecting this planned canal to the C-4 Canal just downstream of the S-380 structure would provide additional capacity and flow to the back pump at S-380. In addition, the backward pump at S-380 would be able to operate prior to a storm event to provide pre-storm drawdown in the canals.

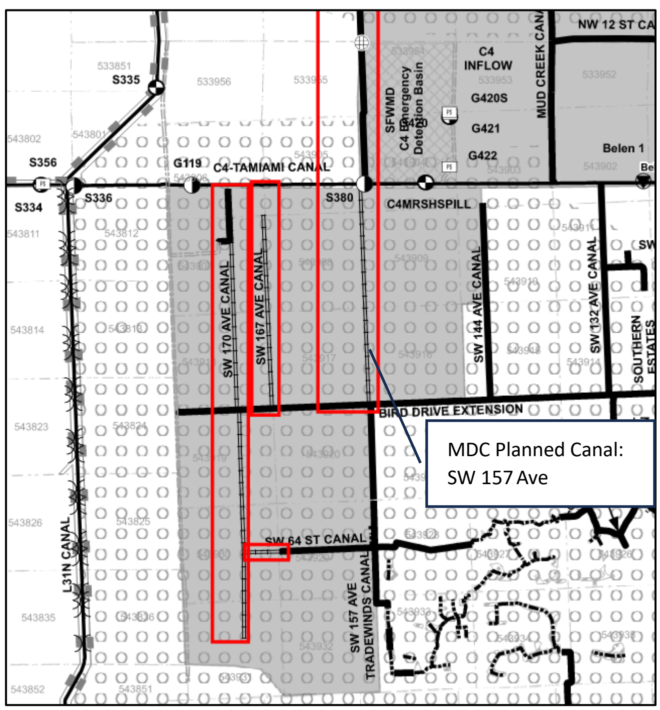


Figure 39: Portion of the Miami-Dade 2021 Water Control Map showing future planned canals.

This project will be presented as two separate options. The project with Option A will include adjusting the operational protocol for the structure, adding a backward pump to increase the storage capacity west of the structure, and increasing the northern levee to approximately 8 ft NAVD88. The volume of storage provided by Option A would be approximately 77 ac-ft based on an additional 2 feet of storage in the canal. Option B will include adjusting the operational protocol, adding flap gated culverts along the northern levee to allow the canal stages to overflow into the wetlands to the north, and adding a backward pump to increase the storage capacity west of the structure. The volume of storage provided by Option B could be over 77 ac-ft based on an additional 2 feet of storage in the canal and northern wetlands.

The recommended improvements to implement Option A include the following elements:

- Modeling to Optimize Protocol to raise operational range
- Pump Station – Backward Pump at 200 cfs
- Raising Canal Embankments – 24,000 ft

The recommended improvements to implement Option B include the following elements:

- Modeling to Optimize Protocol to raise operational range
- Passive Gravity Structures – 6 x Culverts with Flap Gates
- Pump Station – Backward Pump at 200 cfs

This project could provide flood protection for the population living within the C-4 Watershed. With the MDC future planned canal along SW 157th Ave, the project could impact the population living within the C-4 and C-2 Watersheds by pulling and storing from both the watersheds.

A conceptual cost estimate to update this structure and the segment of the C-4 Canal between S-336 and S-380, to address flooding and other related risks to vulnerable communities in the Watershed is presented **Error! Reference source not found.**. Figure 45 provides a schematic of the proposed improvements.

Cost Estimates

Line Item	Option A	Option B
Gated Culverts	--	$546,984
Back Pump (200 cfs)	$14,712,500	$14,712,500
Raising Canal Embankments	$4,280,000	--
Design, Implementation & Construction Management	$2,848,875	$2,288,923
Adjusted 2024 Cost Total*	**$21,841,375**	**$17,548,407**

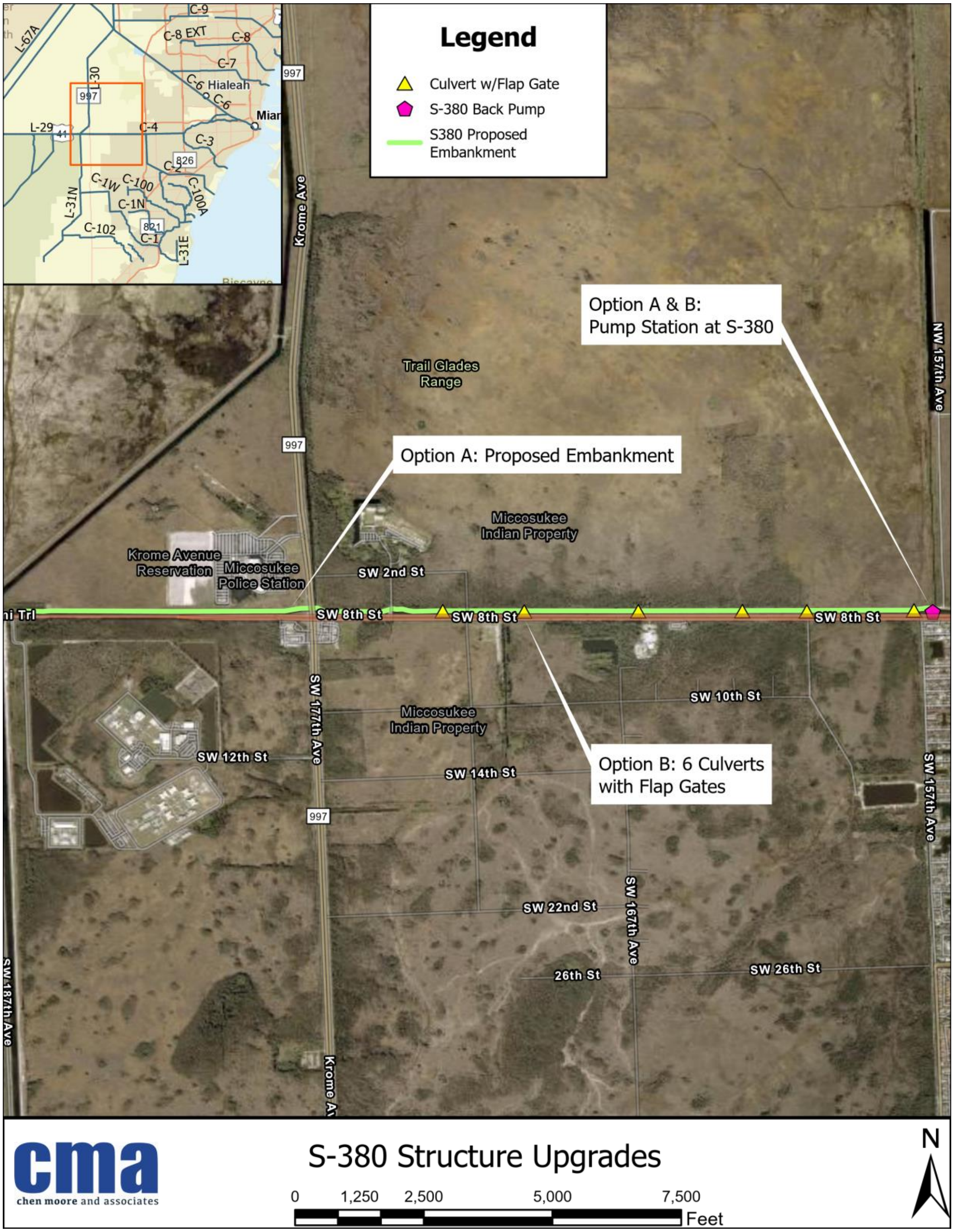


Figure 40: Proposed C-4 Canal and S-380 structure upgrades.

C-4 Canal Embankment Resiliency

The C-4 Watershed consists of areas draining to the Tamiami, or C-4 Canal, from the western wetland regions, the Central Mining Lake Belt region, and the urban developed regions east of NW 137th Ave to NW 42nd Ave. The primary discharge canal is the C-4 Canal from the S-336 water control structure to the S-25B water control structure, which is approximately 15 miles long. The purpose of this project is to build resiliency and decrease flood impacts within the C-4 Basin due to canal overbank flow, which is exacerbated by storm surge and sea level rise.

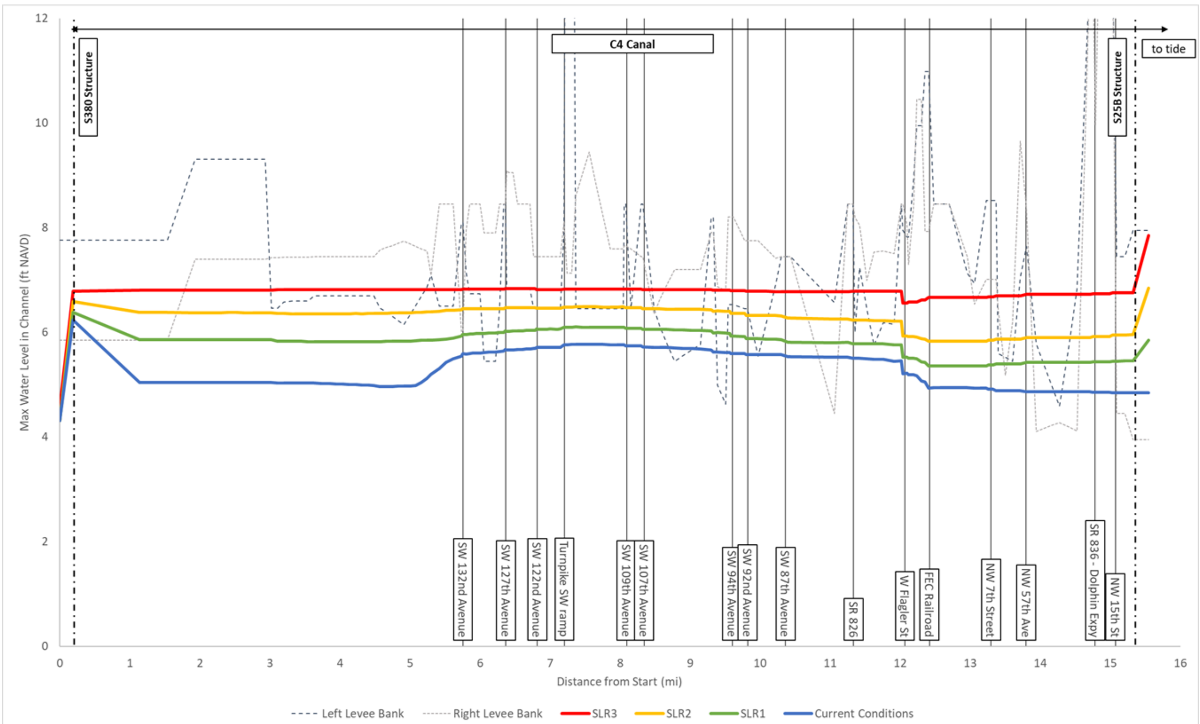


Figure 41: Maximum stage profile for the Tamiami Canal in the C-4 Watershed for the 100-year design storm taken from the C-2 through C-6 FPLOS Study (2023).

Based on the FPLOS Assessment for the C-4 Watershed, there are several locations along the Tamiami Canal where the canal top of bank is exceeded, even during current conditions design storm simulations (see Figure 39). Raising the elevation of the canal banks will help reduce overtopping of embankments from the canals to the adjacent communities during the peak of the storm events. For the C-4 Watershed there are several locations where raising the embankments or installing flood walls can provide immediate relief during extreme rainfall and surge events with high canal stages.

The District implemented the Tamiami Canal Flood Protection Project in response to local flooding from Hurricane Irene in 1999 and the "No Name Storm" in 2000. As part of this project, the District constructed flood protection walls and earthen berms along the canal in sections of unincorporated Miami-Dade County and the City of Sweetwater. In several phases, the District constructed these flood protection measures from west of the Palmetto Expressway to 132nd Ave.

Figure 42: Location of canal bank improvements included in the Tamiami Canal (C-4) Flood Protection Project.

For the purpose of this exercise, the total length that will be considered for additional flood protection measures will not include the length of the Tamiami Canal that was already addressed in the Tamiami Canal Flood Protection Project (i.e. this project will only consider areas east of the Palmetto Expressway).

To review the deficiency of these embankment heights, a comparison was made with the 2022 Miami-Dade County Flood Criteria map, which is based on a 10-year, 24-hour storm event, 2060 scenario with SLR. It is proposed that stretches of the canal with bank elevations lower than the Miami-Dade County Flood Criteria map (which varies spatially) be raised to this level.

This project considers all embankments, east of the Palmetto Expressway, within the Tamiami Canal that are deficient from the flood criteria. This portion of the canal is bounded by development and may lack sufficient easement in some areas to build a levee with the appropriate dimensions. Therefore, some regions will require flood walls, built with sheet piling and concrete caps, instead of levees to provide flood protection from the canal within a limited space. It is estimated that the total length of the canal embankments that require improvements is approximately 43,510 ft (or 8.2 miles). While 40% (17,210 ft) of these embankments will be able to build a levee at the lower cost, 60% (26,300 ft) will require a flood wall due to limited space. Survey will need to be conducted to determine the exact extent of embankment deficiency.

A conceptual cost estimate to improve canal embankments along the Tamiami Canal to prevent direct flooding from canal overbank flow into the communities adjacent to Tamiami Canal, is presented below. Figure 40 provides a schematic of the proposed improvements.

Cost Estimates

Line Item	Cost
Embankment Construction	$4,473,046
Flood Wall Construction	$7,035,250
Design, Implementation & Construction Management	$1,726,244
Real Estate	TBD
Adjusted 2024 Cost Total*	$13,234,540

*Excludes Real Estate Costs to be determined by SFWMD

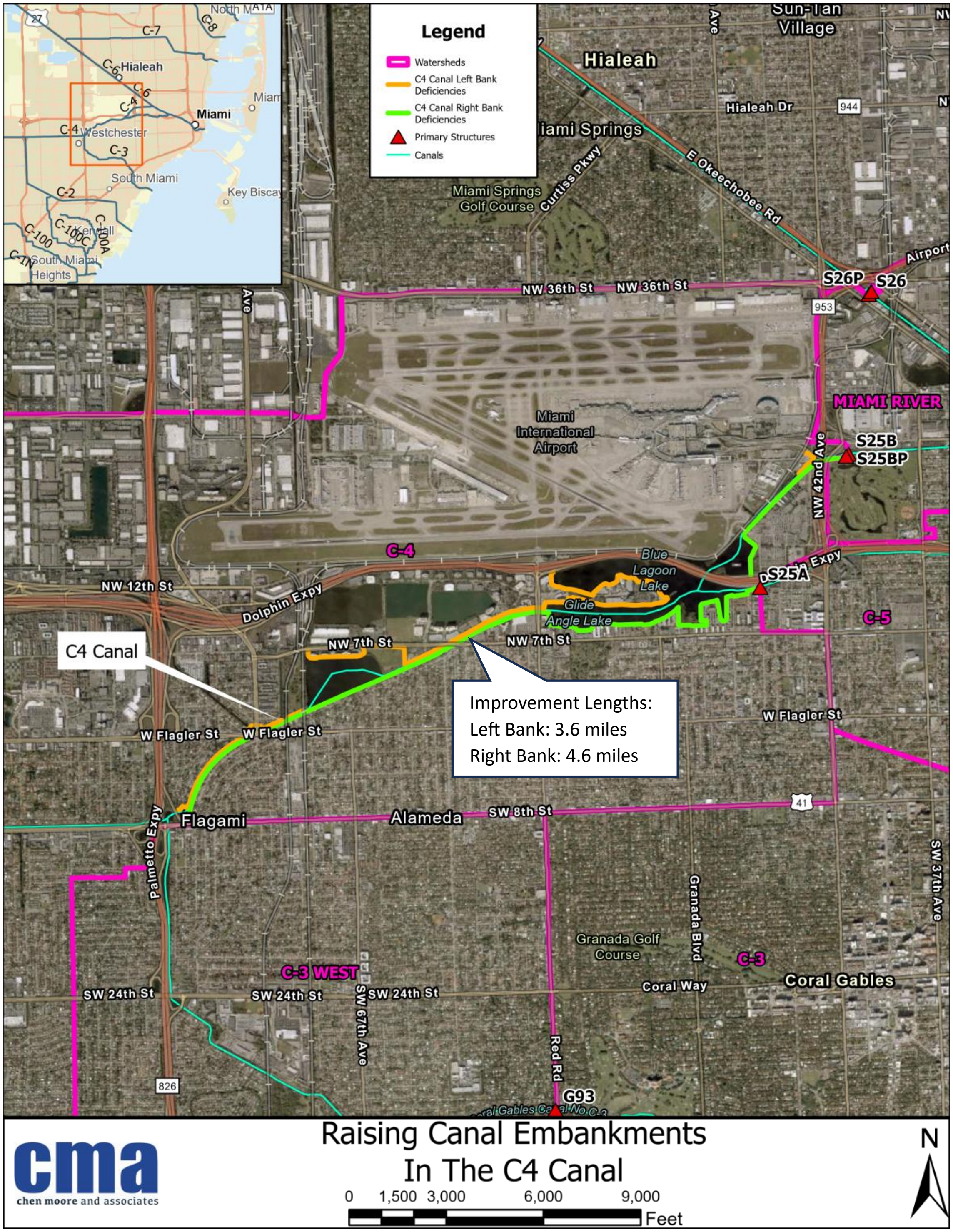


Figure 43. Proposed embankment improvements in the Tamiami Canal.

Expansion of the C-4 Emergency Detention Basin

One option to provide more storage in the C-4 Watershed is to expand the C-4 Emergency Detention Basin (EDB). As part of the Tamiami (C-4) Canal Flood Protection Project that was launched in response to local flooding from Hurricane Irene in 1999 and the "No Name Storm" in 2000, a 900-acre Emergency Detention Basin was constructed north of 8th Street, in the C-4 Watershed. As part of the FPLOS study of the C2-C-6 Watersheds, it was determined that during the 100-year/72-hour current condition simulation the detention basin reaches capacity (i.e. max water level of 8.44 ft-NAVD88 or 10 ft-NGVD29), and during the 25-year/72-hour the detention basin reaches capacity for the future SLR conditions, as shown in **Error! Reference source not found.**2. Once the basin reaches capacity, no additional flood relief can be achieved with this facility alone; therefore, additional storage options will be required for providing additional stormwater detention.

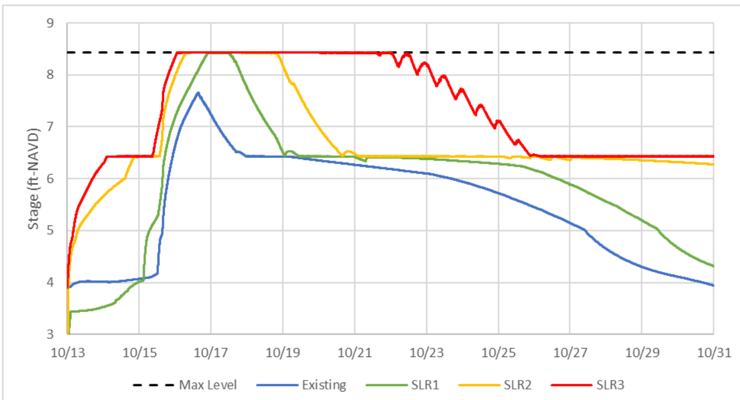


Figure 44: Water surface elevation during the 100-year/72-hour storm with respect to the maximum storage elevation in the C-4 Emergency Detention Basin (EDB).

The expansion of the emergency detention basin could increase the size and capacity of the detention basin, as well as provide flexibility for other watersheds, such as the C-2 and C-3W, to use the C-4 EDB for emergency storage and would add up to 740 acres of storage area (potentially 2,960 ac-ft of storage volume at maximum capacity).

This project would also require development of surrounding levees to protect existing communities and businesses. In addition, an existing pump station should be demolished and converted to a gated box culvert. A seepage canal would be constructed on the eastern side of the proposed expansion, a north to south culvert, as well as an outflow spillway for slow release after the storm recedes.

The recommended improvements to implement an Expansion of the C-4 EDB include the following elements:

- Levee (4-ft height) – 30,300 ft
- Demolition of pump station
- Seepage Canal – 3,950 ft
- Gravity Control Structures
    - 1 Inflow Structure – six 5 x 10 ft box culverts with vertical lift gates

- 1 North to South Connection Weir – overflow weir to control 2ft of storage
- 1 Outflow Structure – one 4x 20 ft spillway with vertical lift gates

The volume of storage provided by this proposed project is estimated to be 2,960 ac-ft, based on 2 ft of storage.

A conceptual cost estimate to implement this C-4 EDB expansion, to address flooding, SLR and other related risks to vulnerable communities in the C-4 Watershed is presented below. Figure 41 provides a schematic of the proposed improvements.

Cost Estimates

Line Item	Option A
Levee Construction	$10,807,000
Seepage Canal	$1,800,176
Overflow Weir	$11,993,013
Gated Structures	$24,408,139
Demolition	$107,000
Design, Implementation & Construction Management	$7,367,299
Real Estate	TBD
Adjusted 2024 Cost Total*	$56,482,627

*Excludes Real Estate Costs to be determined by SFWMD

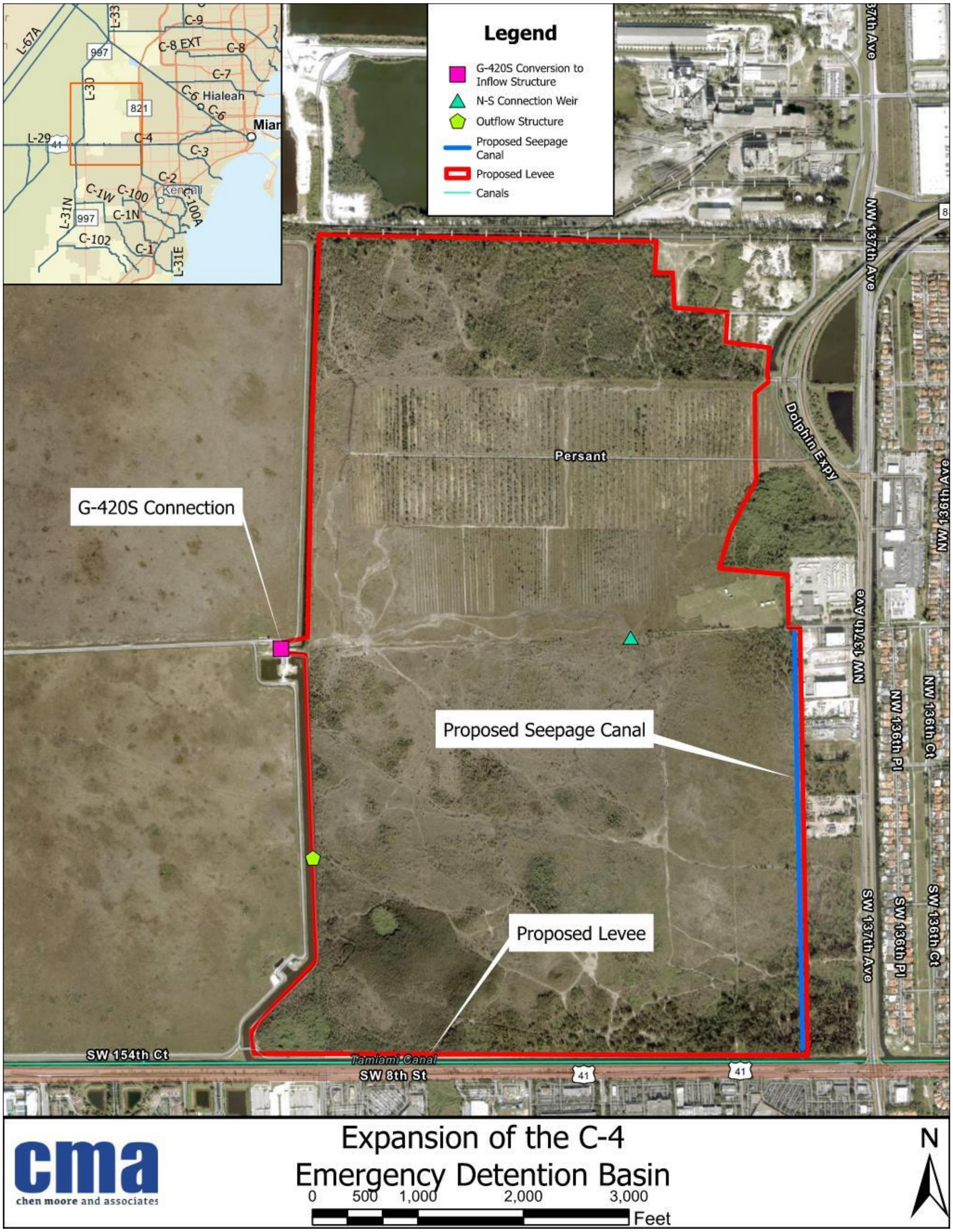


Figure 45: Location of proposed expansion of the C-4 Emergency Detention Basin and additional improvements.

Off-Line Lakes Storage

The C-4 Watershed consists of areas draining to the Tamiami, or C-4 Canal, from the western wetland regions, the Central Mining Lake Belt region, and the urban developed regions east of NW 137th Ave to NW 42nd Ave. The primary discharge canal is the C-4 Canal, which spans approximately 15 miles from the S-336 water control structure to the S-25B water control structure.

In previous FPLOS studies, separating the main conveyance canal from a larger storage area adjacent to the canal was evaluated as a potential mitigation strategy to help reduce peak flows and stages in the primary canals. In the C-4 watershed, several large lakes branch off from the C-4 Canal, just south of the Miami International Airport, upstream of the S-25B structure. Separating the C-4 Canal from these off-line storage areas to the north via a weir structure could potentially increase storage and decrease peak stages and flows. However, embankments and seepage may need to be considered along with the weir structures to maximize the impacts of the off-line storage areas.

Some lakes that appear to be better contained and separated from the primary canal may have the most potential for storage, while requiring the least amount of improvements as can be utilized during extreme rainfall and/or storm surge events, to reduce the peak stages within the C-4 Canal by storing within the lakes. The total storage area of three (3) lakes is approximately 113 acres.

Groundwater/surface water modeling of this area will be required to determine what the appropriate storage depths are of this system such that adjacent communities are not impacted, however, for the purposes of this cost estimate it is assumed that 2 feet of storage depth will be achieved.

The development of lakes as potential emergency offline storage would require survey, land acquisition, levees that protect the surrounding commercial areas, and connecting canal(s) with one lake. A multi-purpose water control structure is proposed at the connection canal with Lake Mahar, which will serve as both overflow during high stages in the C-4 Canal, as well as a slow-release spillway to reduce the stages in the lakes once the C-4 Canal stages have receded.

The recommended improvements to implement this lake storage project include the following elements:

- Flood Walls to elevation 5.5 ft NAVD88 – 9,855 ft
- Pump Station – One 600 cfs Backflow Pump Station
- Passive Gravity Control Structures
    - 2 Equalization Culverts with Gates
    - 1 Outflow Structure – gated box culvert

The volume of storage provided by this project is estimated to be approximately 226 ac-ft based on 2 feet of storage over 113 acres of lakes.

A conceptual cost estimate to implement the proposed off-line lake storage is presented below. Figure 38 provides a schematic of the proposed improvements.

Cost Estimate

Line Item	Cost
Flood Walls	$2,636,213
Backward Pump (600 cfs)	$40,927,500
Equalization Culverts	$4,138,376
Gated Box Culvert	$2,965,836
Design, Implementation & Construction Management	$7,600,189
Real Estate	TBD
Adjusted 2024 Cost Total*	$58,268,112

*Excludes Real Estate Costs to be determined by SFWMD

Temporary Storage – Two Potential Sites

To provide additional storage within the C-4 Watershed, open spaces, parks or golf courses can potentially be used as emergency temporary storage for extreme rainfall events. Several municipal and county parks have been identified as having potential for emergency storage. Green infrastructure can be implemented at these parks to allow for recreational use during dry periods while also being able to provide storage during storm events. A majority of these parks are at lower elevations than average grade.

This potential project would require interagency cooperation with Miami Dade County which manages Ludlam Trail to the east of an existing campground. The existing levees to the east and west of the campground would serve as a levee for the proposed system, with one additional levee required on the southern boundary with the Canal. The additional storage provided by this campground will provide flood protection during extreme rainfall events as well as water quality treatment. This project could also provide ecosystem services by improving riparian ecology.

The recommended improvements to implement this potential project to provide a volume of storage estimated to be 34.8 ac-ft include the following elements:

- Levee (4-ft height) – 560 ft
- Pump Station – One 80 cfs Inflow Pump Station
- Passive Gravity Control Structures
    - 1 Outflow Structure – overflow weir to control 2ft of storage

Another park already has naturally lower elevations that could be utilized for dry detention or offline storage to reduce peak stages in the Tamiami Canal during extreme rainfall events. It is proposed to develop this park into an offline dry detention area. Implementation of this system would require infrastructure such as an inflow gated culvert/weir at the C-4 Canal; equalization culverts; and embankments to protect the adjacent communities.

The recommended improvements to implement this potential project to provide a volume of storage estimated to be 30 ac-ft include the following elements:

- Levee (at elevation 7-ft NAVD88) – 8,300 ft
- Pump Station – One 50 cfs Inflow Pump Station
- Passive Gravity Control Structures
    - 3 x 2ft Diameter Equalization Culverts
    - 1 Outflow Structure – overflow weir to control 2ft of storage

The purpose of this project is to build resiliency and decrease flood impacts within the C-4 Watershed due to canal bank overflow, which is exacerbated by storm surge and sea level rise. The final design of this project will be based upon simulation of the combined regional and local hydraulic measures in the C-4 Watershed. A total cost estimate to implement temporary storage in the basin is presented below **Error! Reference source not found.**.

Cost Estimates

Line Item	Potential Site 1	Potential site 2
Distributed Storage*	$558,540	$481,500
Levee	$199,733	$1,850,208
Design, Implementation & Construction Management	$113,741	$349,756
Real Estate	TBD	TBD
Adjusted 2024 Cost Total*	$872,014	$2,681,465

*Based on storage volume and includes cost of culverts, pumps, etc.
**Excludes Real Estate Costs to be determined by SFWMD

Additional Potential CERP Storage

A project to provide more storage in the C-4 Watershed is to connect and utilize the mining lakes west of the Turnpike as storage and emergency detention. Within the C-4 Watershed, there are over 6,000 acres of existing mine lakes that have completed their operations and are currently serving no additional purpose. These open pits could be utilized as additional storage by constructing embankments and seepage walls to contain additional flood waters pumped in from adjacent canals such as Mud Creek Canal, Snapper Creek Extension Canal, and the Northwest Wellfield Canal.

Central Lake Belt Storage Area was identified by the SFWMD and USACE as a CERP project (Figure 47). This project includes a combined above and in-ground 5,200 acre reservoir. The initial purpose of this reservoir is for water supply but it could also be used for storage during the wet season. An STA is also proposed on the western side of the storage area. During storm events, water can be routed to the Central Lake Belt Storage Area, that will be kept at low levels during the wet season, and can be managed to include pre-storm drawdown. Following the storm event, water from the storage area can be routed through the STA to increase the water quality prior to discharge to WCA3 or Biscayne Bay. This can work in coordination with the current structures located along the Northwest Wellfield Canal, or additional structures can be considered along the Snapper Creek Extension Canal that runs parallel to the Turnpike. As mentioned in the CERP plan, this would require seepage barriers to prevent horizontal losses to the groundwater. It should be considered that vertical losses through the bottom could be a major problem if the seepage walls around the proposed storage area do not penetrate low enough into a confining layer.

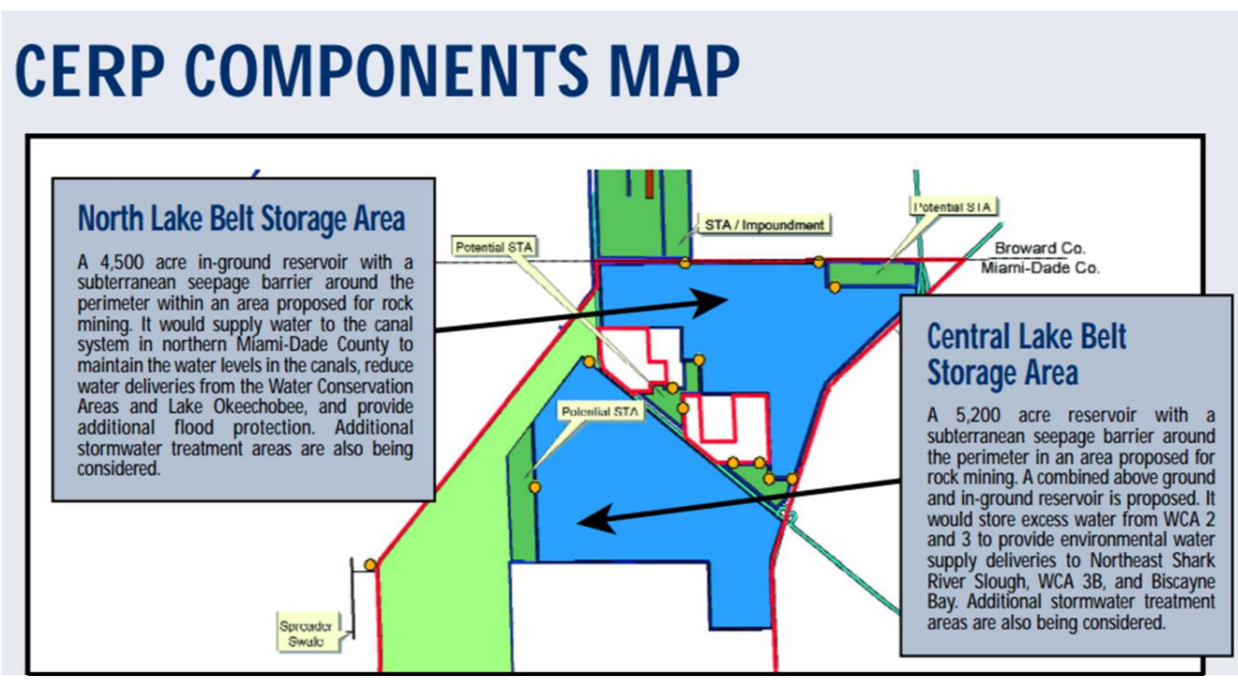


Figure 46: Central Everglades Components Map including the proposed North Lake Belt Storage Area and the proposed Central Lake Belt Storage Area[3].

In addition to the complication of controlling groundwater seepage out of the mine lakes, the lakes would also require building up the existing levees, as these were designed to maintain a 25-year storm event without off-site flows. Any additional storage in these mine lakes would require much larger levees designed for water levels above the water table elevation.

There are approximately 886 acres north of the C-4 Emergency Detention that could be used to extend the emergency storage capacity of the EDB during extreme storm events that may be exacerbated by SLR. These open lakes will require additional embankment development, pump station and spillway design, and a seepage canal. These lakes would be designed to hold 2 ft above the wet season water table.

The recommended improvements to implement Option A include the following elements:

- Levee (6-ft height) – 42,500 ft
- Seepage Canal – 6,440 ft
- Pump Station – One 700 cfs Inflow Pump Station
- Seepage Return Pump Station – 100 cfs
- Gravity Control Structures
    - 5 Gated Culvert Locations – each location has three (3) 5x10 ft box culvert with gate
    - 1 Outflow Structure – 5x20 ft gated spillway

The volume of storage provided by Option A is estimated to be 1,772 ac-ft.

It should be noted that there are approximately 1,280 acres of current open ponds that are directly adjacent to or could connect with the Northline Canal or the Snapper Creek Extension Canal via additional structures to provide offline detention storage during the peak of a storm event. Leaving several mines as open lakes to the northwest would provide a buffer between the detention storage system and the Northwest Wellfield.

The proposed detention storage area consists of open lakes that will require additional embankment development, pump station and spillway design. An existing canal should be re-configured for use as a seepage canal along the southern boundary.

The recommended improvements to implement Option B include the following elements:

- Levee (6-ft height) – 47,650 ft
- Seepage Canal – 9,425 ft
- Pump Station –
    - One 800 cfs Inflow Pump Station
    - One 100 cfs Seepage Canal Pump Station
- Gravity Control Structures
    - 3 Gated Culverts Locations – each location has three (3) 5x10 ft box culvert with gate
    - 1 Outflow Structure – 5x20 ft gated spillway

The volume of storage provided by Option B is estimated to be 2,400 ac-ft.

Another component is that there are approximately 1,720 acres of current open ponds that are directly adjacent to or could connect with the Northwest Wellfield Canal or the Snapper Creek Extension Canal via additional structures to provide offline detention storage during the peak of a storm event. Leaving several mines as open lakes to the south would provide a buffer between the detention storage system and the Northwest Wellfield.

The proposed detention storage area consists of open lakes that will require additional embankment development, pump station and spillway design.

The recommended improvements to implement Option C include the following elements:

- Levee (6-ft height) – 52,870 ft
- Pump Station
  - One 800 cfs Inflow Pump Station
- Gravity Control Structures
  - 3 Gated Culvert Locations – each location has three (3) 5x10 ft box culvert with gate
  - 1 Outflow Structure – 5x20 ft gated spillway

The volume of storage provided by Option C is estimated to be 2,400 ac-ft.

A conceptual cost estimate to implement these offline storage options, to address flooding, SLR and other related risks to vulnerable communities in the C-4 Watershed are presented below. Figure 46, provides schematics of the proposed improvements for Option A, Option B, and Option C, respectively.

Cost Estimate

Line Item	Option A	Option B	Option C
Levee Construction	$22,737,500	$25,492,750	$28,285,450
Seepage Canal	$2,934,970	$4,295,356	--
Pump Stations	$55,105,000	$60,856,250	$53,500,000
Gated Culverts	$43,030,829	$30,615,702	$30,615,702
Design, Implementation & Construction Management	$18,571,245	$18,189,009	$16,860,173
Real Estate	TBD	TBD	TBD
Adjusted 2024 Cost Total*	$142,379,544	$139,449,068	$129,261,325

*Excludes Real Estate Costs to be determined by SFWMD

C-3 Basin Resiliency

G-93 Coastal Structure Resiliency

This resiliency project is mainly tied to the District's mission to provide flood control and water supply protection. 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 the 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, sea level rise, 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.

Cost Estimate

Structure Enhancement	$6,505,626
Forward Pump (320 cfs)	$26,076,000
Forward Pump Backup Generator Facility	$2,607,600
Structure Tie Back (Flood Barrier)	$3,075,000
Design, Implementation & Construction Management	$5,739,634
Real Estate	$10,350,000
Adjusted 2024 Cost	**$54,353,860**

Additional Salinity Structure or Storm Surge/Tidal Barrier at the end of the C-3 Canal

The G-93 salinity structure is located over 4.1 miles upstream of the mouth of the Coral Gables Canal at Biscayne Bay. The segment of canal that is unprotected from the effects of storm surge includes highly urbanized South Miami and Coral Gables, serving residents and the Biltmore and Riviera Country Clubs, the University of Miami campus, and Baptist Health Doctors Hospital. These communities and institutions within the C-3 Watershed are currently unprotected from the effects of storm surge and rising sea levels. In addition, any additional discharge relief efforts for the C-3W Watershed, such as forward pumping at the G-93 structure, may increase stages in the 4.1 mile stretch to the Bay, creating a limitation in flood protection upstream of G-93.

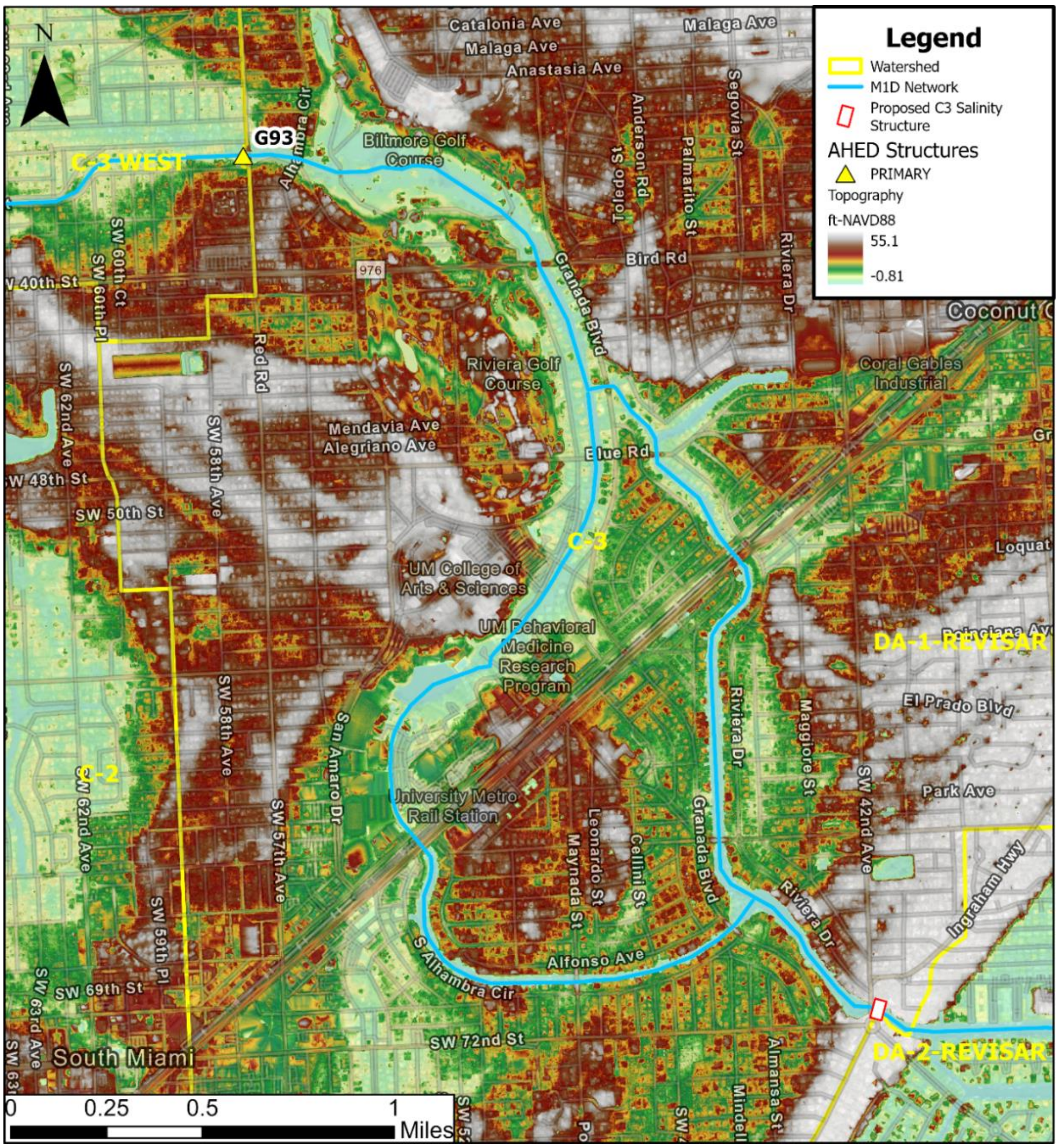


Figure 47: Location of proposed additional salinity structure in the Coral Gables Canal.

An additional salinity structure could be added closer to Biscayne Bay to limit the effect of storm surge and SLR on the C-3 and C-3W Basins, while also providing more discharge capacity for the G-93 structure by maintaining a positive head differential. A potential location for this structure is the area around Cocoplum Circle, near Ingraham Park, as shown in Figure 48. This location is located along the Miami Rock Ridge, a high topographic ridge running parallel to the coast, which would provide a natural levee. There is an existing Cocoplum Road Pedestrian Bridge that could tie-in with the design and capabilities of a new salinity structure.

This structure could significantly reduce impacts from SLR and storm surge in Coral Gables from Biscayne Bay all the way to Red Road. However, a standard sluice gate implemented at this location would eliminate recreational and commercial navigation upstream. In addition, the existing ecology of the canal would be impacted by a sluice gate or other permanent structure, as the segment of canal that is currently brackish and used by manatees and fish would likely become less brackish and would impede wildlife accessibility. However, implementation of a miter gate would maintain the canal as navigable and brackish until the gates are closed during extreme tides and storm surge events. Miter gates consist of a pair of gates, anchored to reinforced concrete abutments at either riverbank, that swing out and meet at an angle pointing toward the upstream direction. Because of this design, the gate would only be operable when the tides are higher than the canal levels (as indicated at G-93_T) and could not be used to control flows out of the system. A miter gate would also limit the impacts to wildlife that currently use the channel, as it would only be used under extreme conditions for short periods of time.

In addition, a forward pump can be added to the gate to relieve rainfall runoff from both the C-3 Watershed and discharge from G-93.

The purpose of this project is to build resiliency and reduce the impacts of storm surge and sea level rise. Secondarily, this project would increase the discharge capacity of G-93 by reducing the tailwater stages during peak events. Final design will be based upon simulation of the combined regional and local hydraulic measures in the C-3W and C-3 Watersheds. Depending on the specific location of the salinity control structure, the salinity structure and it’s casing would span 130 ft to 275 ft across the Coral Gables Canal.

This project is presented as two options, depending on the needs of the system as a whole, whether other improvements will be made at G-93 and within the C-3W Watershed in general, modeling results, and depending on the price point and projected impact from SLR. Option A would implement a typical gated structure that can be operated remotely by SFWMD and that would effectively stop navigation upstream of the structure. Option B would implement a miter gate with double sliding doors that would remain open during normal operations and would close via remote operations in preparation of a surge or extreme tide event. Both options include a forward pump station at the gate to pump runoff out of the watershed while the gates are closed.

The recommended improvements to implement Option A include the following elements:

- Forward Pump Station – 480 cfs pump with backup generator
- Active Gravity Control Structures – Spillway with two (2) 10W x 20H ft gates

The recommended improvements to implement Option B include the following elements:

- Forward Pump Station – 480 cfs pump with backup generator

- Active Gravity Control Structures – Miter Gate with Double Sliding Doors

The project will provide protection against the effects of even the most severe surge events and SLR, due to the location along the Miami Rock Ridge, which provides a high elevation barrier with which the salinity control structure can tie into. Therefore, the life cycle of this proposed project is limited to the fatigue life of the miter gate itself, which can be 80+ years depending on design.

A conceptual cost estimate to construct this new salinity structure, to address storm surge and SLR related flooding is presented in below. Figure 48 provides a schematic of the proposed improvements.

Cost Estimate

Line Item	Option A	Option B
Structure Construction	$20,321,494	$15,515,000
Forward Pump (480 cfs)	$34,026,000	$34,026,000
Forward Pump Backup Generator Facility	$3,402,600	$3,402,600
Design, Implementation & Construction Management	$8,662,514	$7,941,540
Real Estate	TBD	TBD
Adjusted 2024 Cost Total*	$66,412,608	$60,885,140

*Excludes Real Estate Costs to be determined by SFWMD

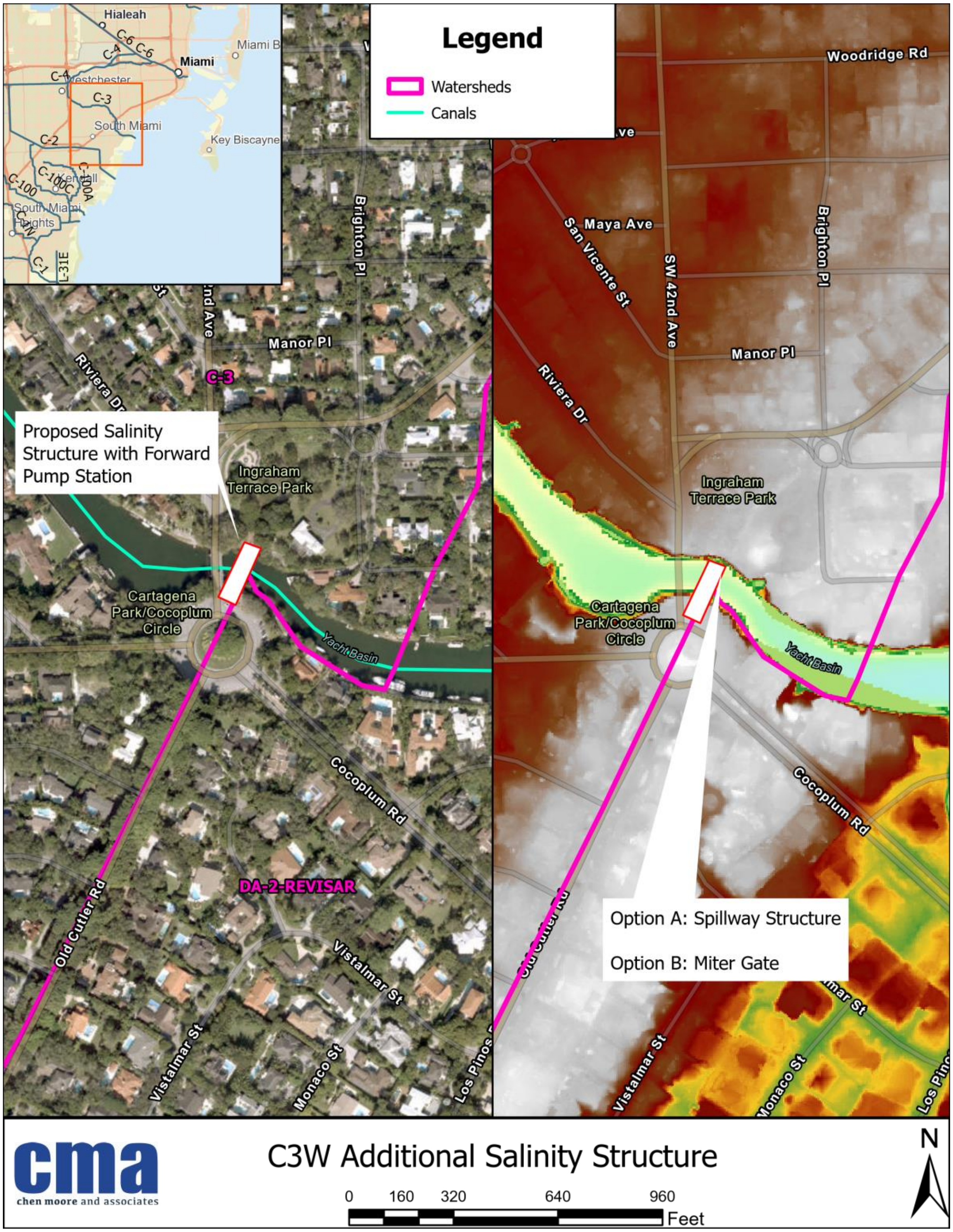


Figure 48: Location of proposed additional salinity structure (Option A) or storm surge/tidal barrier (Option B) at the end of the C-3 Canal with aerial (left) and topography (right).

Coral Gables Canal Embankment Resiliency

The C-3W and C-3 Watersheds consist of areas south of SW 8th Street and east of SW 82nd Avenue. The primary discharge canal is the Coral Gables Canal, which extends from the intersection with the Tamiami Canal (C-4 Canal) to the G-93 water control structure, approximately 3.4 miles downstream. The C-3 Watershed consists of areas draining to the portion of the Coral Gables Canal downstream of the G-93 structure, and is influenced by tides. The purpose of this project is to build resiliency and decrease flood impacts within the C-3W and C-3 Watersheds due to canal bank overflow, which is exacerbated by storm surge and sea level rise.

Based on the FPLOS Assessment for the C-3W Watershed, there are some locations along the Coral Gables Canal where the canal top of bank is exceeded, primarily adjacent to the intersection with the C-4 Canal and just upstream of G-93 (**Error! Reference source not found.**). Raising the elevation of the canal banks in these areas will help reduce overtopping of embankments from the canals to the overland elevations during the peak of storm events.

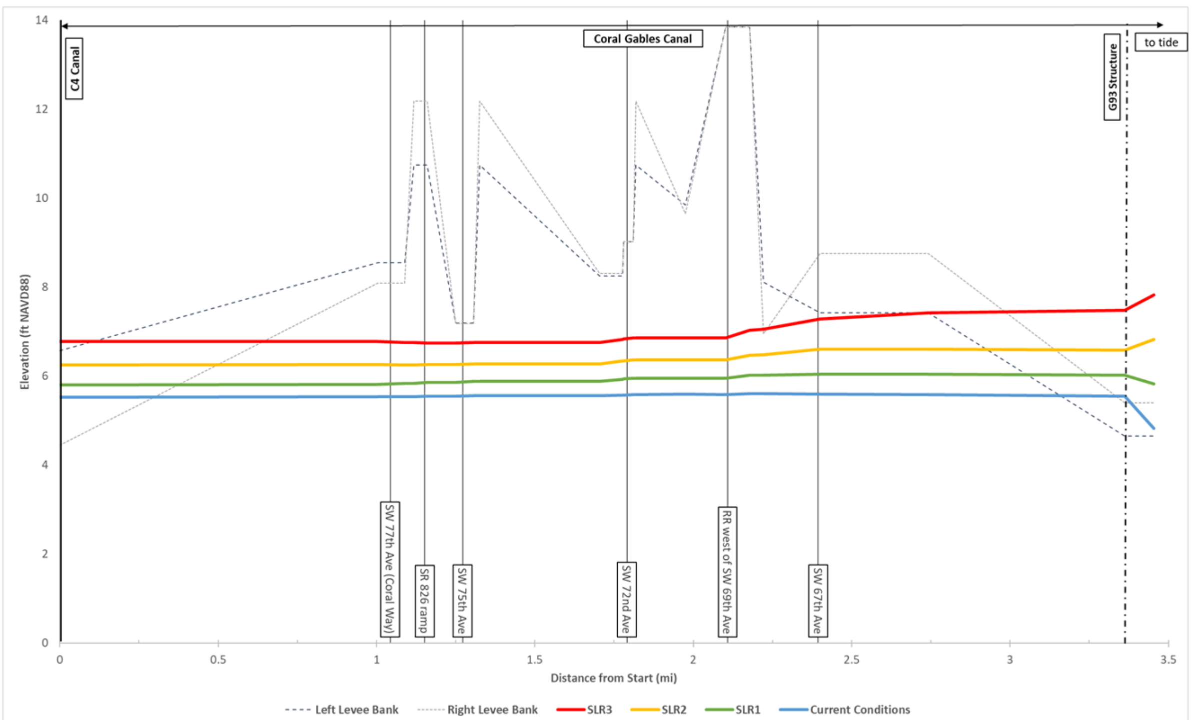


Figure 49: Maximum stage profile for the Coral Gables Canal in the C-3W Watershed for the 100-year design storm taken from the C-2 through C-6 FPLOS Study (2023).

To review the deficiency of embankment heights, a comparison was made with the 2022 Miami-Dade County Flood Criteria map, which is based on a 10-year, 24-hour storm event, 2060 scenario with SLR. It is proposed that stretches of the canal with bank elevations lower than the Miami-Dade County Flood Criteria map (which varies spatially) be raised to this level. For the C-3W Watershed, there are two primary locations where raising the embankments can provide immediate relief during extreme rainfall and surge events with high canal stages: 1) Intersection with the C4 Canal and 2) Upstream of G-93 structure. Within the C-3 Watershed, there are some residential areas that may benefit from increased protections from the canal embankments.

This project would raise all the canal embankments within the Coral Gables Canal that are deficient from the Miami-Dade County Flood Criteria. Survey will need to be conducted to determine the exact extent of embankment deficiency. For the Coral Gables Canal, this total length of canal that is deficient is approximately 3.4 miles (17,900 ft). However, some stretches of the canal do not have sufficient easement to build or raise the levee, and therefore flood walls would be used at these locations. The flood walls would be constructed with sheet piling and would have a concrete cap matching the Miami-Dade Flood Criteria elevation. It is estimated that approximately 69% of these deficient embankments, 2.4 miles (12,440 ft) of the Coral Gables Canal, particularly the areas downstream of the G-93 structure, have residential and commercial buildings directly adjacent to the canal and would require flood walls, rather than embankments, to contain the higher stages in the canal.

A conceptual cost estimate to raise canal embankments in the Coral Gables Canal is presented below**Error! Reference source not found.**. **Error! Reference source not found.** Figure 49 provides a schematic of the proposed improvements.

Cost Estimate

Line Item	Cost
Embankment Construction	$1,218,916
Flood Wall Construction	$3,326,504
Design, Implementation & Construction Management	$681,813
Real Estate	TBD
Adjusted 2024 Cost Total*	$5,227,232

*Excludes Real Estate Costs to be determined by SFWMD

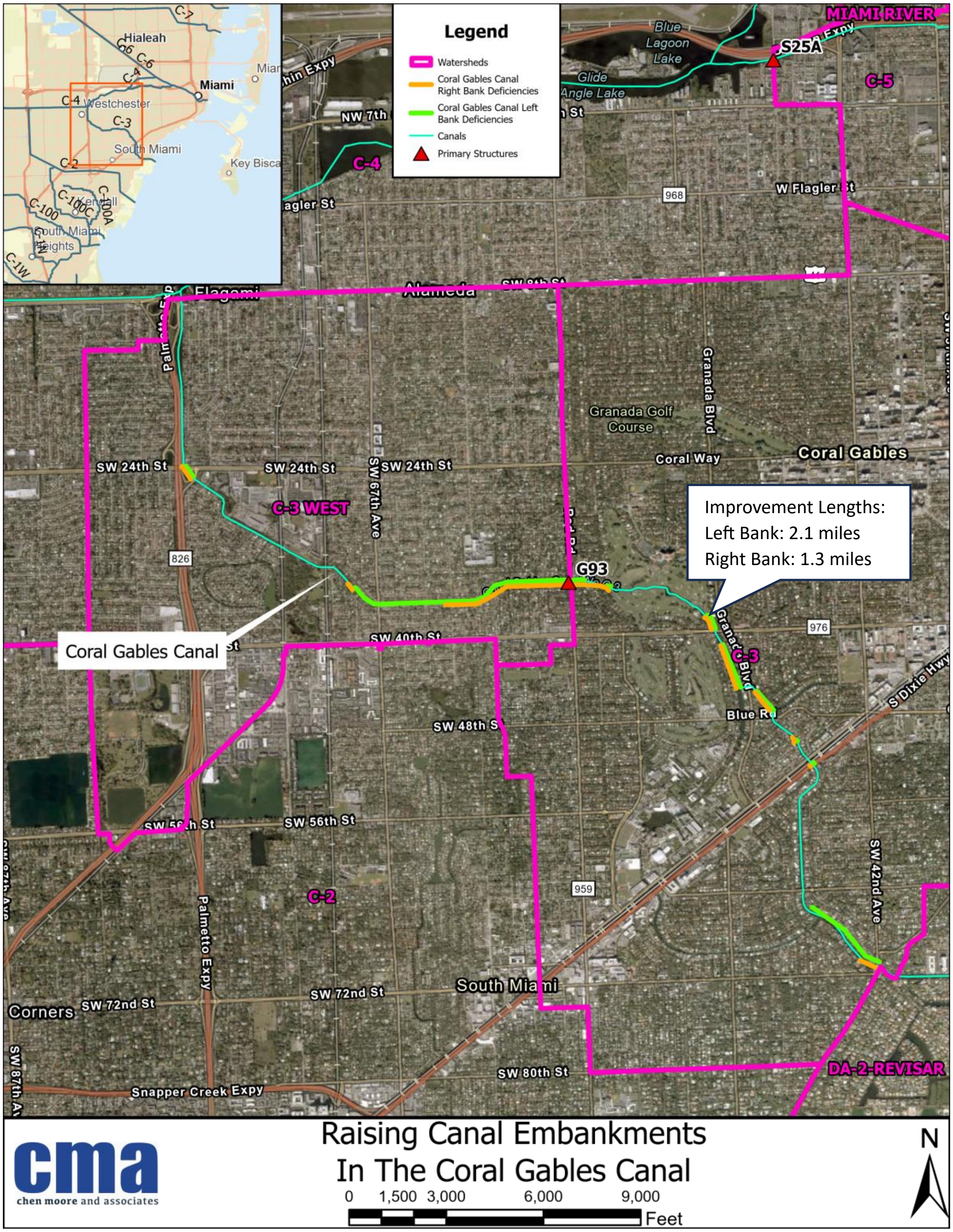


Figure 50. Proposed embankment improvements in the Coral Gables Canal.

Temporary Storage – Two Potential Sites

The C-3 Basin is entirely within the eastern and highly urbanized portion of Miami-Dade County, and therefore there is no land readily available for regional storage. To provide additional storage within this basin, parks or golf courses can potentially be used as emergency temporary storage. A majority of these parks are at lower elevations. Green infrastructure can be implemented at these parks to allow for recreational use during dry periods while also being able to provide storage during storm events.

There is one park located upstream of G-93**Error! Reference source not found.** that could potentially be used for temporary storage to limit the amount of water coming out of the basin during a storm event. This is critical for the C-3W Watershed as there is a significant amount of urbanized area downstream of G-93 and discharging too much water from the watershed in a short amount of time can contribute to flooding in the C-3 Watershed. It is proposed to utilize the park during high-stage events in the C-3 Canal as a 56-acre dry/wet detention, flow-through facility. Since this park has some of the higher ground elevations in Miami-Dade County, extensive earthwork may be required to be able to store water below the height of the levee. This project would require coordination with Miami-Dade County, which currently manages the park. In addition, construction will include regrading the park in certain areas, constructing a levee, and an inflow/outflow weir.

The recommended improvements to implement this potential temporary storage project include the following elements:

- Levee (4-ft height) – 7,450 ft
- Excavation Earthwork– 50 ac-ft
- Active Gravity Control Structures – one gated Inflow/Outflow Weir
- Pump Station – one 100 cfs pump

The volume of storage provided is estimated to be 112 ac-ft based on 2 ft of storage.

Another location downstream of the G-93 structure provides an essential floodplain service with low embankments along the primary canal and low topography that is exceeded in some areas by both the 100 year and 25 year 3-day design storms, providing approx. 5 ac-ft and 2.5 ac-ft of storage, respectively. It is proposed that this storage is expanded by re-grading the area by 2 ft and providing additional floodplain storage in areas that would not impact infrastructure to help decrease peak stages in the canal.

Topography in these golf courses or parks must be reviewed to ensure that new connections to the canal floodplain do not create new paths to structures or residences nearby. Some park facilities may require protective levees or berms to control the flooding extent.

The recommended improvements to implement this potential temporary storage project include the following elements:

- Excavation Earthwork – 26 ac-ft
- Levee/Berm (up to 10 ft NAVD88) – 5,000 ft

The volume of storage provided is estimated to be approximately 13 ac-ft during a 100 year/3day storm event under current sea level conditions. The total storage could be up to 28.5 ac-ft during a 100 year/3 day storm event under +3 feet of sea level rise.

The purpose of these projects is to build resiliency and decrease flood impacts within the C-3 Basin due to canal overbank flooding, which is exacerbated by storm surge and sea level rise. The final design will be based upon simulation of the combined regional and local hydraulic measures in the C-Basin. A conceptual cost estimate to implement these strategies is presented below.

Cost Estimate

Line Item	Potential Site 1	Potential Site 2
Distributed Storage*	$1,797,600	$457,425
Excavation Earthwork	$4,315,658	$4,488,284
Levees/Berms	$2,657,167	$1,114,583
Design, Implementation & Construction Management	$1,315,564	$909,044
Adjusted 2024 Cost Total*	$10,085,988	$6,969,336

*Based on storage volume and includes cost of culverts, pumps, etc.

C-2 Basin Resiliency

S-22 Coastal Structure Resiliency

This resiliency project is mainly tied to the District's mission to provide flood control and water supply protection. 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 an open channel connection with the C-4 Canal, west of the 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 the 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 sea level rise 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 sea level rise scenario beyond a ten-year event and would not meet the design level of service under a one-foot sea level rise 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 sea level rise depending on the scenario (NOAA Intermediate Low or NOAA Intermediate High). The peak canal stage can be reduced by 15% 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. The project's conceptual design is finalized. The final design will be based on a 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 a pumping capacity of 1000 cfs.

The design life for the facility is 50 years, with consideration for mechanical equipment being rehabilitated or replaced 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 is 300. These include faith-based facilities, fire stations, hospitals and medical facilities, law enforcement centers, recreational facilities, and schools. Public schools have a vital role 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, sea level rise, 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.

Cost Estimate

Structure Enhancement	$9,221,595
Forward Pump (1000cfs)	$73,223,438
Forward Pump Backup Generator Facility	$7,322,344
Structure Tie Back (Flood Barrier)	$3,075,000
Design, Implementation & Construction Management	$13,926,356
Real Estate	$7,000,000
Adjusted 2024 Cost	**$113,768,733**

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

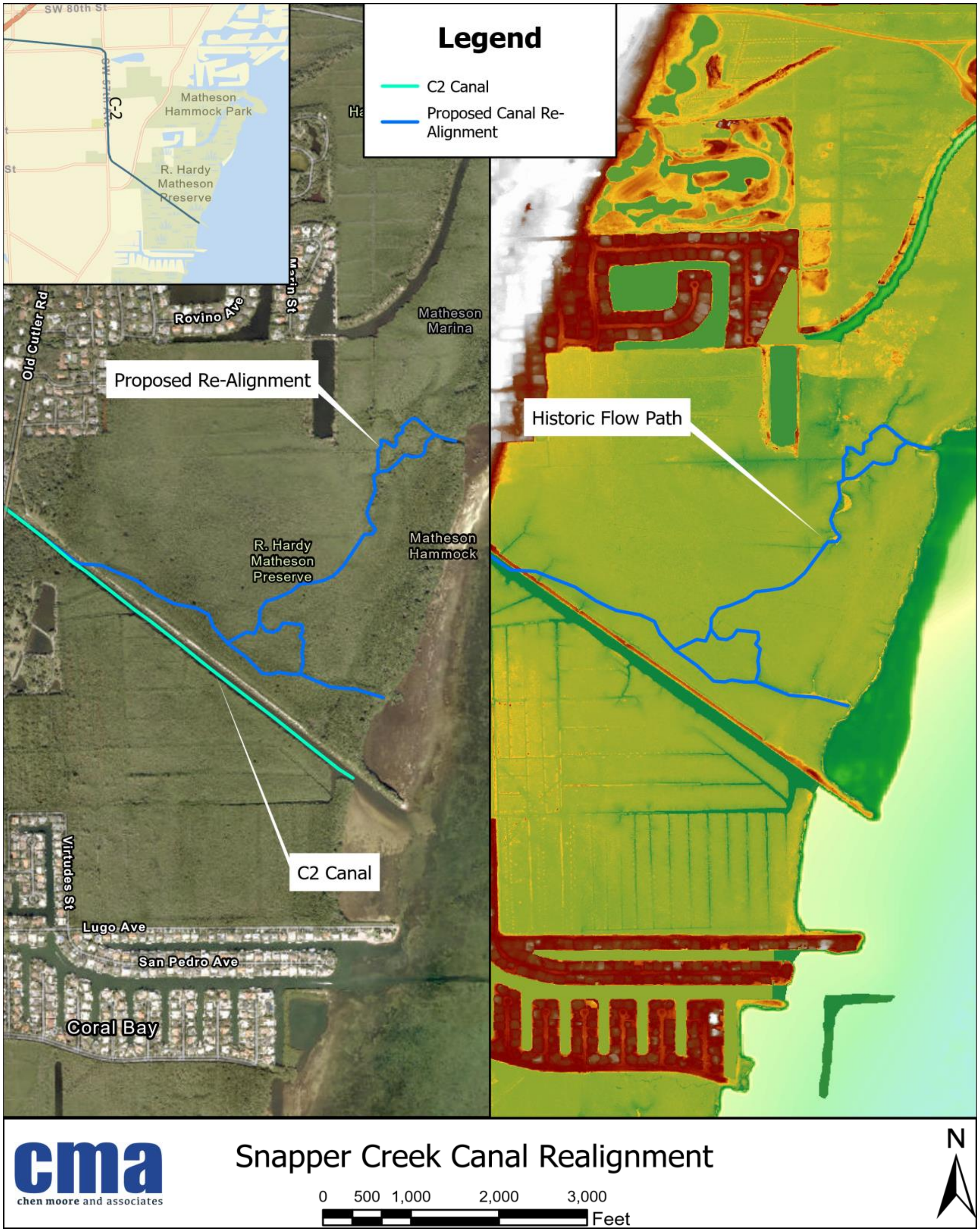


Figure 51: Snapper Creek Canal proposed realignment with aerial (left) and topography (right).

C-2 Canal Embankment Resiliency

The C-2 Watershed consists of the area south of the C-4 Canal and east of the L31N Canal. The primary canal is the Snapper Creek Canal (or C-2 Canal) which is approximately 13 miles long and extends from the confluence with the C-4 Canal to Biscayne Bay. The purpose of this project is to build resiliency and decrease flood impacts within the C-2 Watershed due to canal overbank flow, which are exacerbated by storm surge and sea level rise.

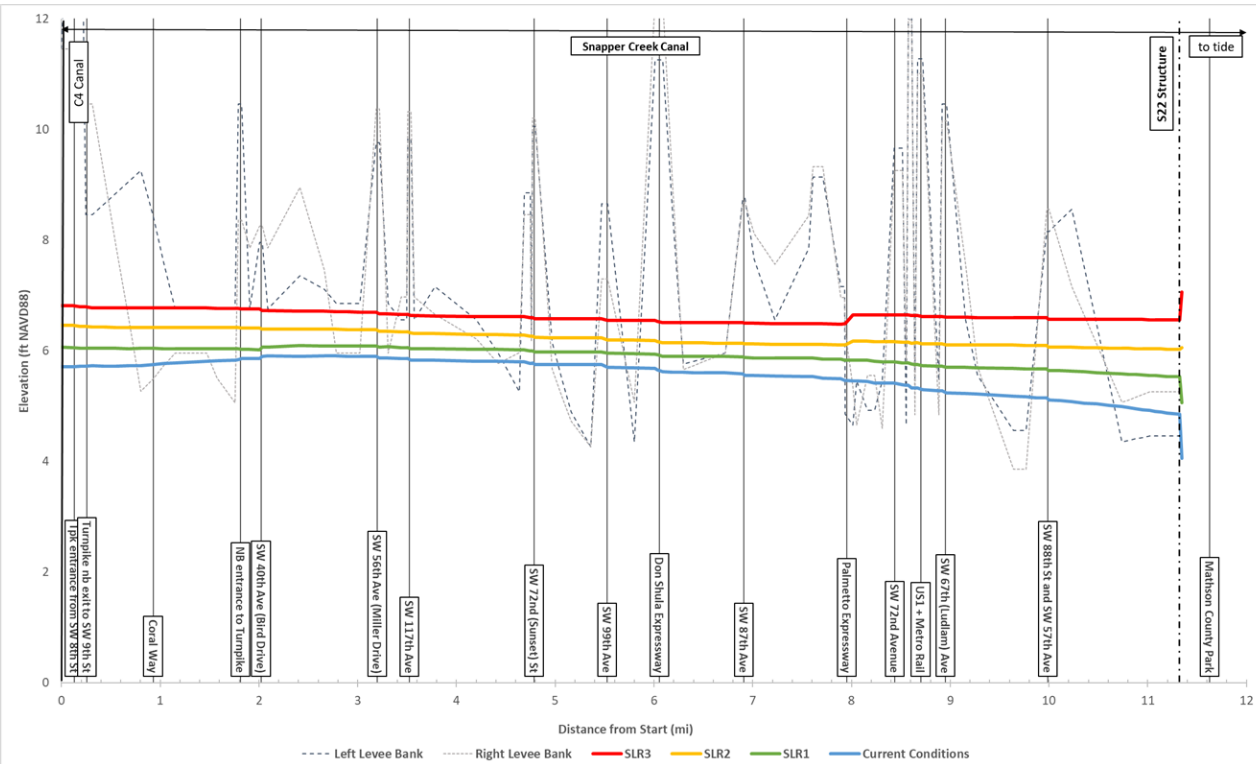


Figure 52. Maximum stage profile for the Snapper Creek Canal in the C-2 Watershed for the 100-year design storm for current conditions, +1ft, +2ft, and +3ft of SLR. Graphic taken from the C-2 through C-6 FPLOS Study (2023).

Based on the FPLOS Assessment for the C-2 Watershed, there are several locations along the Snapper Creek Canal where the canal top of bank is exceeded, even during current conditions design storm simulations (see Figure 54). Raising the elevation of the canal banks will help reduce overtopping of embankments from the canals to the adjacent communities during the peak of the storm events. For the C-2 Watershed there are several locations where raising the embankments can provide immediate relief during extreme rainfall and surge events with high canal stages. Adjacent communities that are impacted by peak stages in the Snapper Creek Canal include Westwood Lakes, Sunset, and the Dadeland area. To review the deficiency of these embankment heights, a comparison was made with the 2022 Miami-Dade County Flood Criteria map, which is based on a 10-year, 24-hour storm event, 2060 scenario with SLR. It is proposed that stretches of the canal with bank elevations lower than the Miami-Dade County Flood Criteria map (which varies spatially) be raised to this level.

The embankment improvements consider all embankments along the Snapper Creek Canal within the C-2 Watershed that are deficient from the flood criteria. The total length of the proposed embankment improvements is approximately 14 miles, or about 7 miles on each side of the canal. Survey will need to be conducted to determine the exact extent of embankment deficiency.

It is assumed that for areas with sufficient right-of-way the embankment improvements can be achieved with stabilized earthen embankments which are less costly, for areas with minimal right of way it is assumed that structural improvements will be required such as sheet pile bulkheads which are more costly. It is estimated that approximately 5,000 ft of the Snapper Creek Canal lacks sufficient easement to build an embankment and this portion would be built up using sheet pile flood walls with a concrete cap.

A conceptual cost estimate to raise canal embankments along the Snapper Creek Canal to prevent flooding into the communities adjacent to Snapper Creek Canal from canal overbank flow, is presented below. Figure 53 provides a schematic of the proposed improvements.

Cost Estimate

Line Item	Cost
Embankment Construction	$14,283,179
Flood Wall Construction	$1,330,263
Design, Implementation & Construction Management	$2,342,016
Real Estate	TBD
Adjusted 2024 Cost Total*	$17,955,458

*Excludes Real Estate Costs to be determined by SFWMD

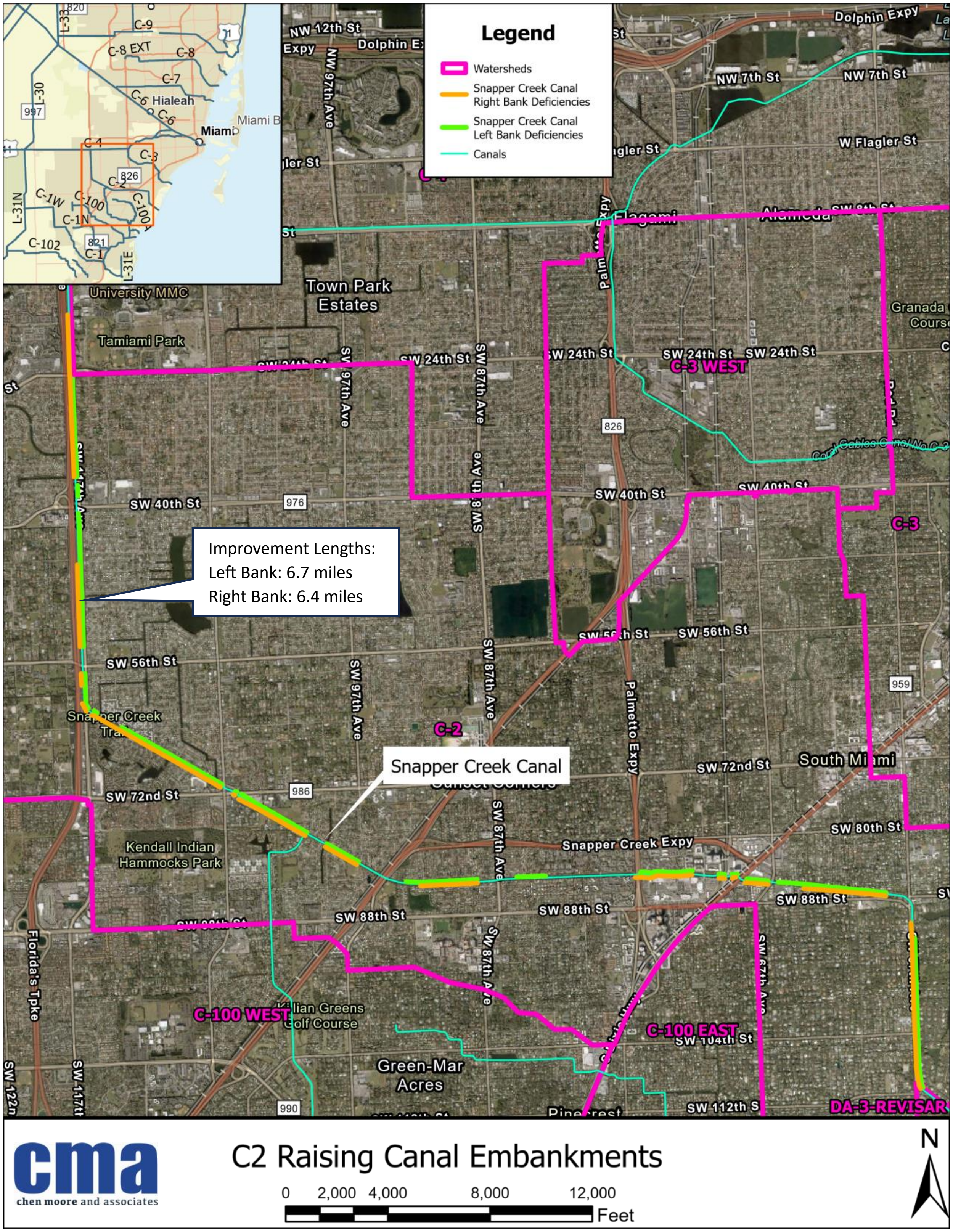


Figure 53: Proposed embankment improvements in the Snapper Creek Canal.

Temporary Storage – Three Potential Sites

To provide additional storage within the C-2 Watershed, open spaces, parks, or golf courses can potentially be used as emergency temporary storage. Green infrastructure can be implemented at these parks, which are typically left at a lower elevation than the developed areas, to allow for recreational use during dry periods while also being able to provide storage during storm events. The C-2 Watershed has a few non-urban areas and recreational areas that may be considered for use as temporary storage areas during extreme rainfall events.

A large open parcel could add an approximately 8-acre flow-through stormwater detention area on this property. This additional storage will provide flood protection during extreme rainfall events by allowing overflow from the canal to spill into the detention area. This project will require embankments, weir/gated culvert, dredging, and riparian landscaping. The recommended improvements to implement this potential temporary storage project include the following elements:

- Levee (4-ft height) – 2,600 ft
- Excavation Earthwork– 20.5 ac-ft
- Passive Gravity Control Structures
    - 1 Inflow Structure – culvert with flap gate (approx. 300 cfs)
    - 1 Outflow Structure – overflow weir to control 2ft of storage

The volume of storage provided is estimated to be 16 ac-ft, based on 2 feet of storage over the 8-acre area.It is proposed that this area could be enhanced to provide additional dry detention, and/or regraded to allow the canal to overflow onto the natural areas during extreme events. The recommended improvements to implement this potential temporary storage project include the following elements:

- Excavation Earthwork– 61 ac-ft
- Area Retrofit – 213 acres

The volume of storage is estimated to be around 400 ac-ft.

Upstream of S-22, there is a natural area that may provide additional storage due to its low topography. This area has large regions below 3 ft NAVD88, which is lower than the peak of the 100yr/3day and 25yr/3day design storm events upstream of S-22; however, the embankment along the primary canal prevents water from the canal from entering this low area.

By adding an inflow point along the embankment of the primary canal and surrounding the area with a levee, this would add an approximately 22-acre wetlands/flow-through stormwater detention area on this property.

The recommended improvements to implement this potential temporary storage project include the following elements:

- Levee (4-ft height) – 4,300 ft
- Active Gravity Structures – Inflow/Outflow Weir 6-ft wide with Underflow Gate

- Passive Gravity Control Structures – 2 x 48” culverts with one-directional flap gates in northeast corner

The volume of storage provided is estimated to be 8.3 ac-ft based on topography below the 100yr/3day design storm.

These proposed storage sites are designed with the goal of building resiliency and decreasing flood impacts within the C-2 Watershed due to canal overbank flow, which are exacerbated by storm surge and sea level rise. The final design of this project will be based upon modeling simulations of the combined regional and local hydraulic measures in the C-2 Watershed, the coordination with private and public organizations, and engineering design. A conceptual cost estimate to implement this strategy is presented below.

Cost Estimate

Line Item	Potential Site 1	Potential Site 2	Potential Site 3
Distributed Storage*	$256,800	$6,420,000	$133,215
Levee	$927,333	$0	$1,533,667
Earthwork	$1,769,420	$10,530,205	--
Design, Implementation & Construction Management	$443,033	$2,542,531	$250,032
Real Estate	TBD	TBD	TBD
Adjusted 2024 Cost Total**	$3,396,586	$19,492,736	$1,916,914

*Based on storage volume and includes cost of culverts, pumps, etc.
**Excludes Real Estate Costs to be determined by SFWMD

Additional Potential CERP Storage

As part of the Central Everglades Restoration Plan (CERP), an area in the western C-2 Watershed was proposed to be an above-ground impounded recharge area of 2,877 acres, providing 11,500 ac-ft of storage. The goals were to:

1. Reduce seepage from Everglades National Park,
2. Recharge groundwater east of Krome Avenue,
3. Increase C-4 Canal peak flood attenuation,
4. Allow water supply deliveries to the South Dade Conveyance System, and
5. Increase spatial extent of wetlands.

This project, known as the Bird Drive Recharge Area, was deemed to be not feasible as envisioned in the Yellow Book due to the low cost/benefit ratio[9]. In terms of flood control, it was stated that the flood attenuation benefits were diminished due to the C-4 Emergency Detention Basin (EDB). However, the FPLOS scenario analysis demonstrated that the C-4 EDB reaches capacity during the 100-year/72-hour rainfall event current sea level conditions (i.e. max water level of 8.44 ft-NAVD88 or 10 ft-NGVD29), and during the 25-year/72-hour the EDB reaches capacity for the future SLR conditions. Therefore, based on the results of FPLOS, the capacity of the EDB as envisioned in 2011 may be overwhelmed especially with SLR conditions reducing the discharge capacity of tidal structures.

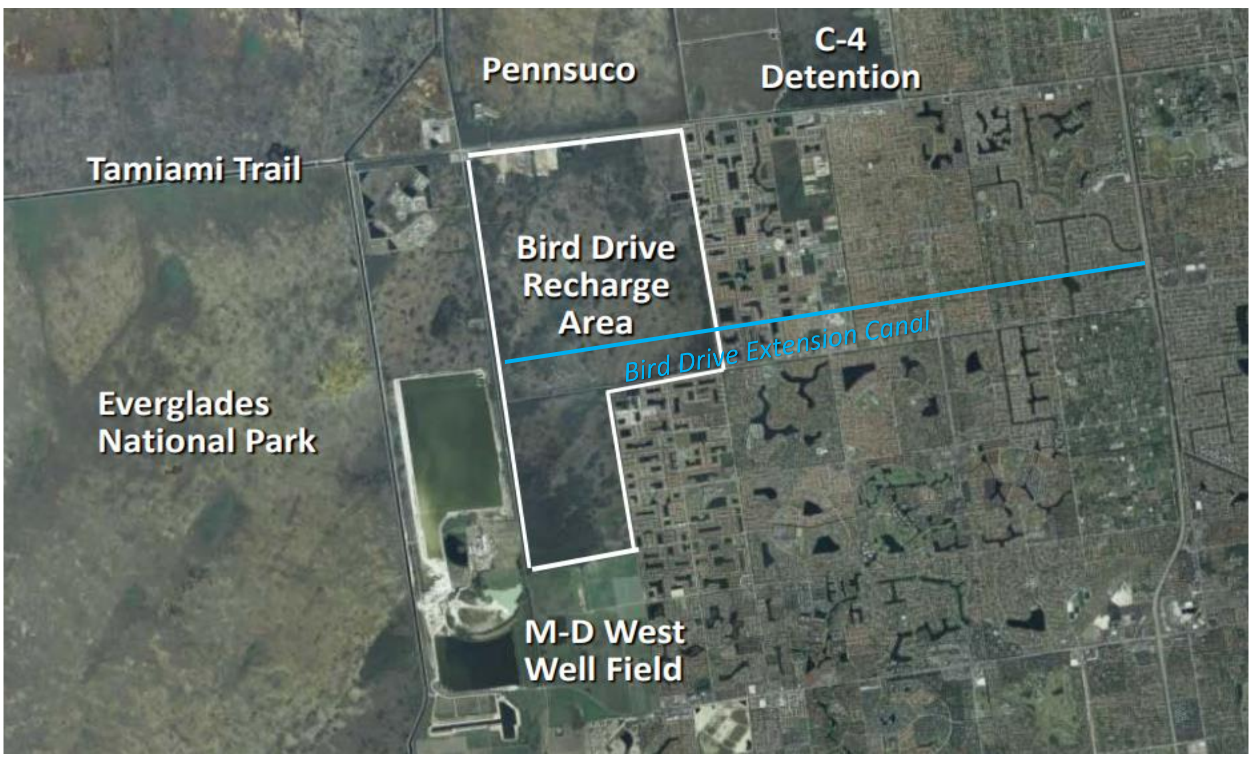


Figure 54: Potential western storage areas in the C-2 Basin, including the Bird Drive Recharge Area and Western Mine Lakes.

There are two potential alternatives for a storage area project. Option A could provide flood relief for multiple basins such as the C-2, C-3W, C-4, and C-5 watershed, as the impact of pumping activities has shown to have an impact in downstream watersheds during peak storm surge and runoff. This area should be reevaluated as a flood control option, similar to the C-4 Emergency Detention Basin. This area is directly adjacent to the Bird Drive Extension Canal (Figure 56). Additional structures are recommended to be added to the Bird Drive Extension Canal to provide operational flexibility. This area consists of approximately 1,886 parcels with various owners, including private entities, the SFWMD, the Miami Dade Expressway Authority, and the Miccosukee Tribe; therefore, the complete acquisition of these parcels may be a challenge. The total acreage owned by parties other than SFWMD that would have to be acquired is approximately 3,900 acres. However, considering this area is outside of the Urban Development Boundary the land should be less costly than areas further to the west. The recommended improvements to implement Option A include the following elements:

- Levee (10-ft height) – 77,000 ft
- Seepage canal– 23,000 ft along western boundary
- Active Gravity Structures – 2 – 5x20 ft gated spillway
- Pump Station Capacity
  - 1 pump station at 700 cfs for northern recharge area,
  - 1 pump station at 500 cfs for southern recharge area,
  - 2 Seepage pump stations at approx. 100 cfs each

The volume of storage provided by Option A is estimated to be 15,600 ac-ft based on 4 feet of storage over the 3,900 acres.

Option B focus on mine lakes that may be used for stormwater storage by enhancing the existing embankments, constructing appropriate structures and pumps to move water quickly into the storage areas and release water when stages recede in the Bird Drive Extension Canal, and considering groundwater seepage walls. The mine lakes in this region are particularly well suited for storage as the existing L31N and seepage wall would provide a western seepage barrier when the stages in the mine lakes are raised. However, seepage to the east may be considerable, and seepage barriers may be required. The recommended improvements to implement the 2,500 acre mine lake storage Option B include the following elements:

- Levee (10-ft in height) – 63,200 ft
- Seepage cutoff wall (30-ft in depth) – 11,000 ft
- Active Gravity Structures –
  - Primary outfall with 2 – 5x20 ft gated spillway
  - Optional secondary outfall with 1 – 14x12 ft gated spillway
  - 1 equalizer structure with two (2) 9x10 ft gated box culverts
- Pump Station Capacity - 1000 cfs

The volume of storage provided by Option B is estimated to be 20,000 ac-ft.

A conceptual cost estimate to acquire and connect storage in the western C-2 Watershed to the Bird Drive Extension to create stormwater detention to relieve the C-2 Watershed during periods of extreme rainfall runoff is presented below.

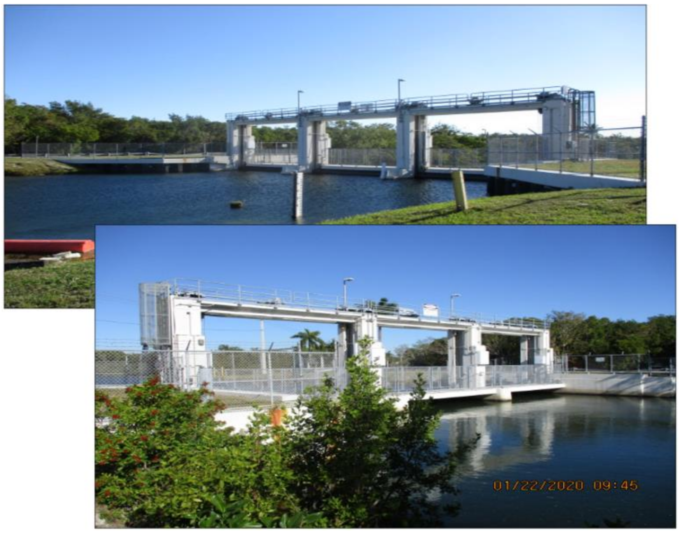
Cost Estimate

Line Item	Option A	Option B
Levee Construction	$68,658,333	$56,353,333
Inflow Pumps	$83,192,500	$66,875,000
Seepage Pumps	$14,712,500	--
Seepage Canal	$10,482,037	--
Seepage Wall	--	$10,593,000
Outflow Gravity Structures	$20,321,494	$38,522,069
Design, Implementation & Construction Management	$29,605,030	$25,851,510
Real Estate	TBD	TBD
Adjusted 2024 Cost Total*	$226,971,893	$198,194,913

*Excludes Real Estate Costs to be determined by SFWMD

C-1 Basin Resiliency

S-21 Coastal Structure Resiliency



This resiliency project is mainly tied to the District's mission to provide flood control and water supply protection. 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. The operation of the gates is automatically controlled so that the hydraulic operating system opens or closes the gates in accordance with the operational criteria. The S21 Structure was designed to 1) maintain optimum water control stages upstream in C1, 2) restrict downstream flood stages and discharge velocities to non-damaging levels, and 3) prevent 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. The 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, sea level rise, 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.

Cost Estimate

Structure Enhancement	$11,267,550
Forward Pump (640 cfs)	$50,184,000
Forward Pump Backup Generator Facility	$5,018,400
Structure Tie Back (Flood Barrier)	$3,075,000
Design, Implementation & Construction Management	$10,431,742
Real Estate	$7,000,000
Adjusted 2024 Cost	**$86,976,692**

C-1W and C-1 Canal Embankment Resiliency

Canal bank elevation improvements of the C-1W and C-1 Canals are proposed to help achieve the District's mission of providing flood control and protection. This project is intended to raise the current level of service (LOS) rating of the canals from 5-yr at 0 feet of Sea Level Rise (SLR) to a 25-yr LOS rating at 3.0 feet of SLR.

This project will include raising portions of the existing canal bank elevations of both sides of the C-1W and the C-1 Canals to the anticipated storm surge elevation of a 25-yr 3-day storm event with 3 feet of SLR plus freeboard along a total of 26.6 miles of canal banks. 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. Figure 1 provides the existing canal embankments for C-1W from the Flood Protection LOS Performance Metric (PM) 1. The proposed canal embankments are assumed 3 feet above the canal water profile for SLR3.

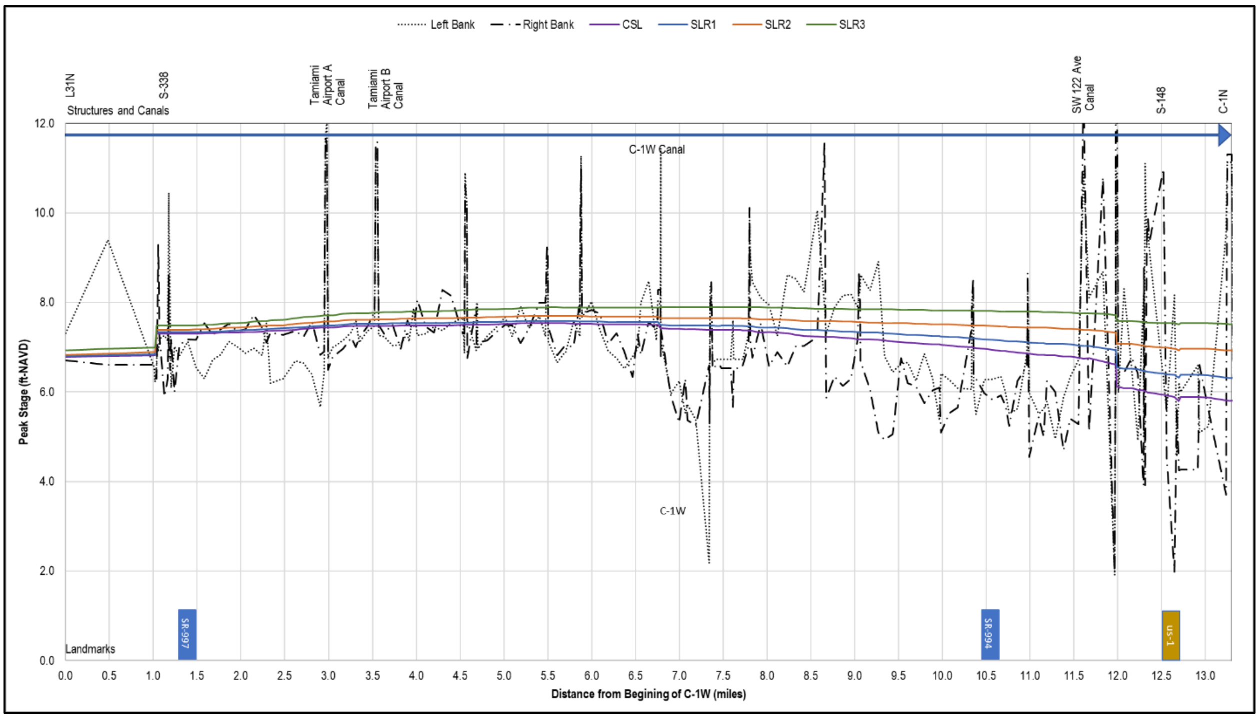


Figure 55: C-1W Canal Banks and Surface Water Profiles of Peak Stages for the 25-yr Design Storm with 3 feet SLR

The canal banks will be a 3:1 slope on both sides of the canal banks. The proposed increases in canal bank elevations vary from 0 to 5 feet depending on the existing canal elevation with an average increase of 3 feet over the left and right bank of the canal. The elevation improvements will eliminate the potential of canal bank overtopping and flooding of the adjacent areas.

The proposed improvements would provide flood protection for approximately 59.1 square miles. These projects will benefit approximately 235,000 people located in the jurisdiction of Miami-Dade and Cutler Bay municipalities. The canals are primarily located near residential areas, however they do pass critical infrastructure such as: South Dixie Highway, the Kendall-Tamiami airport, the Miami-Dade police station, the Miami-Dade Landfill, and the South District Wastewater Treatment Plant.

The C-1W and C-1 Canals are located in Watershed C-1. Canal C-1W begins at the District's gated culvert G-211 and ends directly upstream of the S-148 Structure and spans a total length of approximately 12 miles. The C-1 Canal is approximately 7 miles long, beginning at the S-148 Structure and discharging into the Biscayne Bay through the District's S-21 Structure. The proposed improvements will cover the portions of the canals which fail under 3feet of SLR. Each bank of the improvement area is approximately 13.3 miles long on each side of the canals for a total of 26.6 miles of canal bank improvements. Based on the analysis of Figure 63, approximately 98% of the left canal bank and 95% on the right canal bank have deficient heights and will require upgrades on both sides of the canal.

The C-1W and C-1 Canals serve several functions within the C-1 Watershed. The C-1 and C-1W canals are also the primary canals in the C-1 Watershed. These canals provide services such as flood protection, drainage, irrigation, and maintaining the groundwater table at elevations adequate to prevent saltwater intrusion.

The purpose of the proposed work is to provide increased flood protection for areas adjacent to the canals due to rising sea levels and future land use changes within the basin that are increasing runoff volumes. As a result of these changing conditions within the basin, the current canal elevations no longer adequately protect surrounding areas to the desired LOS. By increasing the height of the canal bank elevations within this watershed, it is less likely there will be overtopping and flooding in these adjacent areas within the watershed. These elevation improvements will be completed in conjunction with dredging and maintenance in the proposed canals. The canal bank elevations will be improved by using either suitable dredged material from the adjacent canal and/or imported fill, or a combination of material as needed.

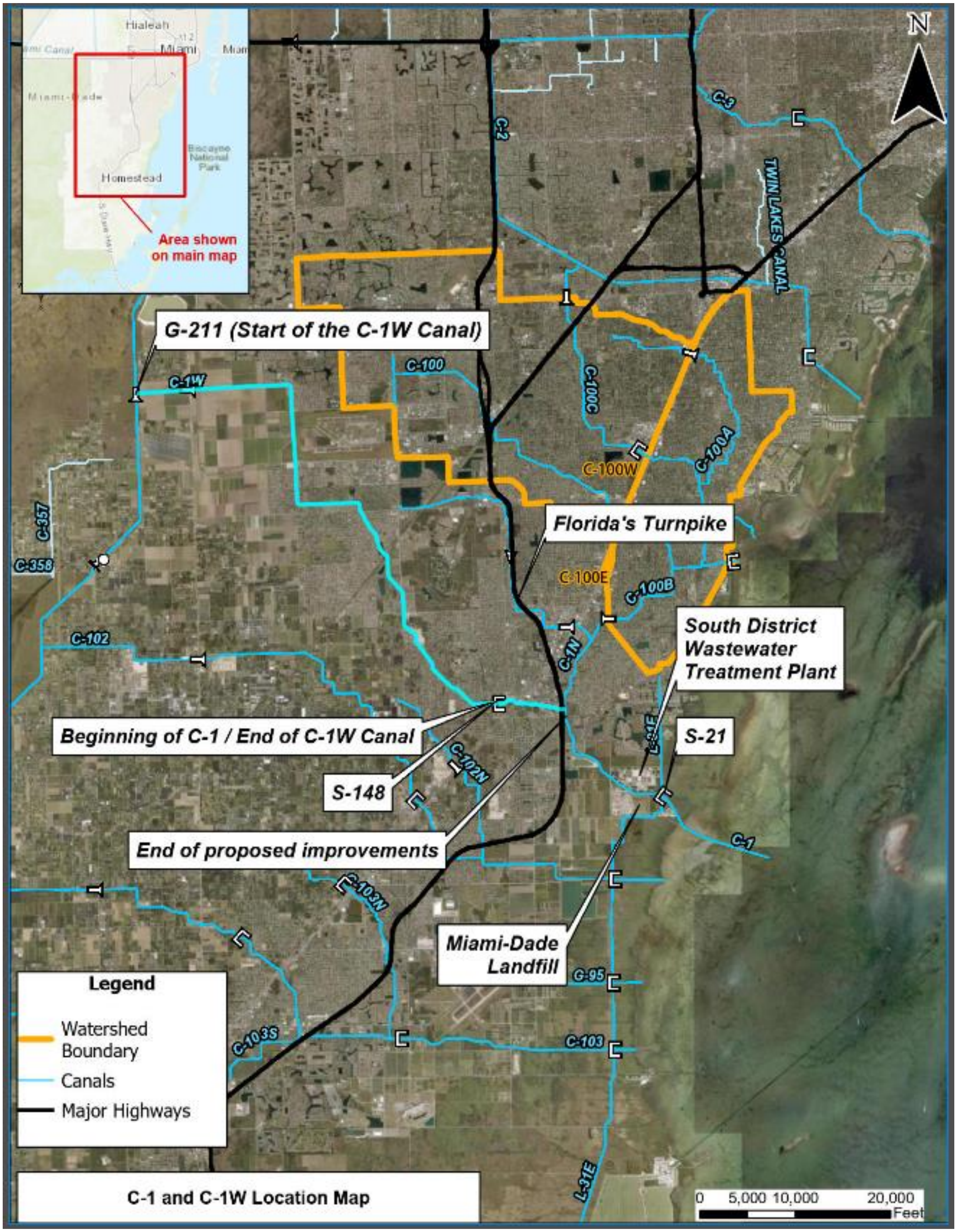


Figure 56: C-1W and C-1 Location Map

Cost Estimate

The cost estimate for the proposed improvements is presented in the below cost summary table. The cost estimate is a high-level cost estimate based on a conceptual design and assumption listed below. The cost summary table also includes construction costs, design and construction management costs, and real estate costs. The methodology for developing the costs includes performing quantity takeoffs, and applying historical unit cost data from the District database.

Item	Cost
Left Bank Canal Elevation Improvements	$21,896,454.15
Right Bank Canal Elevation Improvements	$24,225,596.38
Design, Implementation & CMS at 15%	$6,918,307.58
Real Estate	--
Adjusted 2024 Cost Total	**$53,040,358.11**

Assumptions

- Left and right top of bank would be raised to three feet above the SLR 3 profile. See Figure 65 for the proposed canal bank elevations.
- Left and right banks would be a minimum of 14 feet wide at the top with 3H:1V side slopes.
- Unit cost based on interpolation of District reference costs for average embankment height of 2.8ft for the left embankment and 3.1ft for the right embankment. Costs were provided per linear feet of embankment in 0.5ft height increments from 0.5ft to 2.5ft.

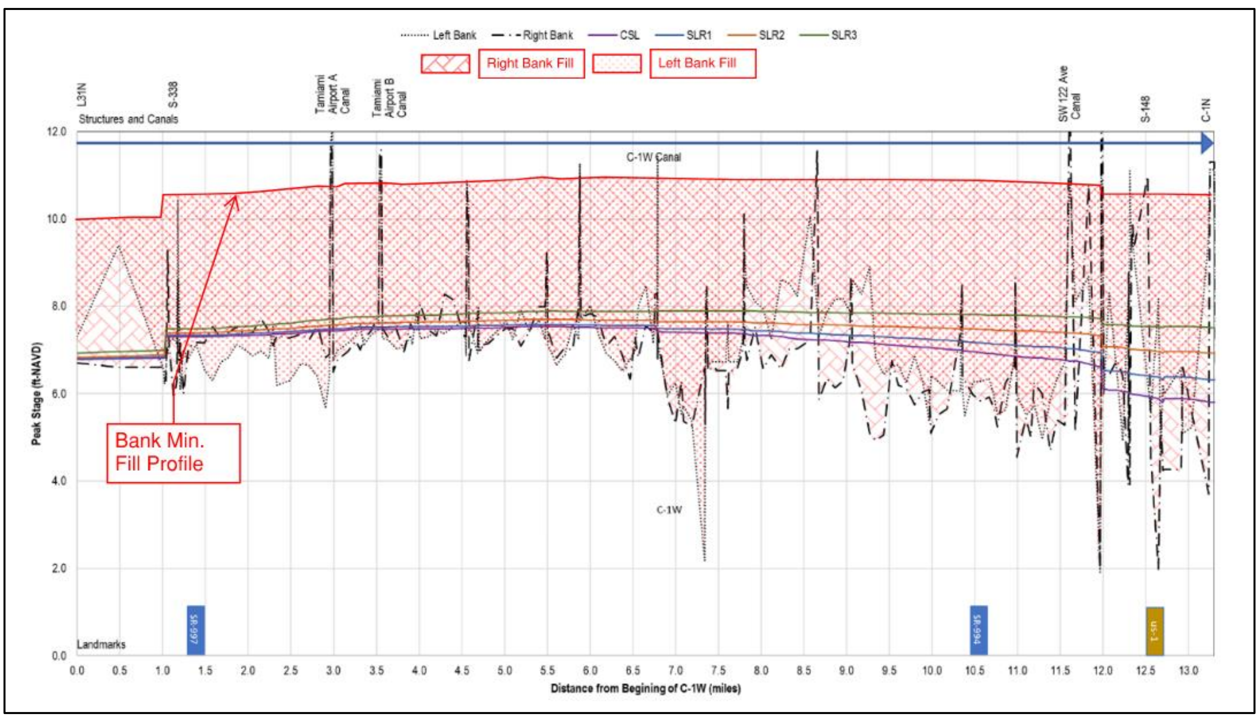


Figure 57: Recommended Fill for Canal Banks and Surface Water Profiles of Peak Stages for the 25-yr Design Storm with 3 feet SLR

C-1W and C-1 Canal Dredging Resiliency

Dredging of the C-1W and C-1 Canals is proposed to help achieve the District's mission of providing the required level of flood control and protection. This project will include dredging the bottom of the C-1W and C-1 Canals from their current elevations to their originally designed as built elevation. Figure 66 shows the profile of the C-1W Canal bottom elevation.

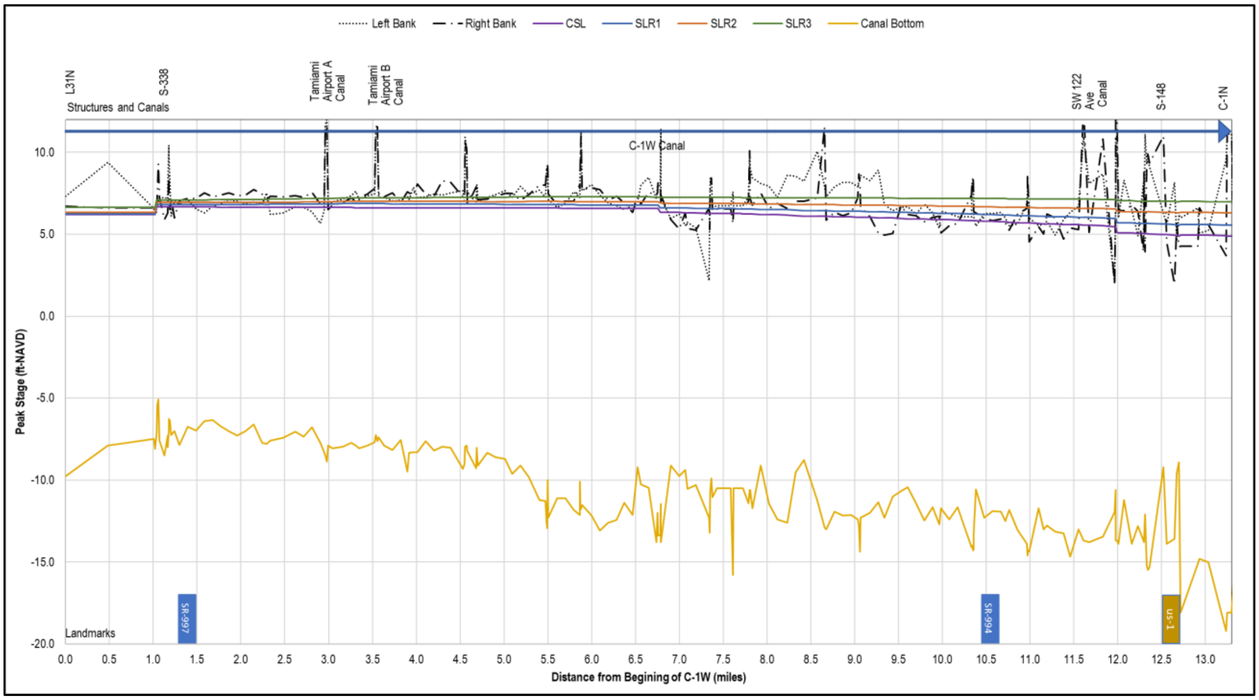


Figure 58: C-1W Canal Banks and Surface Water Profiles of Peak Stages for the 25-yr Design Storm

This project is intended to raise the current level of service (LOS) rating of the canals from 5-yr at 0 feet of Sea Level Rise (SLR) to a 25-yr LOS rating at 3.0 feet of SLR.

The purpose of the proposed work is to provide increased flood protection and LOS for areas adjacent to the canals due to rising sea levels. Over time these drainage canals experience sediment accumulation due to storm events with higher velocities which can transport upstream sediments and erode canal bank slopes into the canal bottoms. As a result of these changing conditions and variation in storm intensity and flow velocity, the canal depths have become silted in and shallower than the original design and therefore, no longer provides the same conveyance capacities as originally designed and can't protect the surrounding areas and drainage watershed to the desired LOS. By dredging out these accumulated sediments it will provide more water storage and canal conveyance capacity within the canal, as it was originally intended, and will have less overtopping and flooding in adjacent areas. Dredging of the canal bottom will also create a smooth gradient across the entire length of the canal which will reduce hydraulic losses. Dredging will be completed in conjunction with the proposed canal bank elevation increases and maintenance in the proposed canals. If suitable, the dredged material can be used in the Canal Bank improvements project within the C-1 Watershed.

To determine the depth of dredging for the canals, the project will include additional bathymetric and cross sectional survey information to better quantify total dredge depths and volumes. Refer to the list of assumptions made in the cost estimate section of this report regarding the proposed improvements for an estimate of the dredged depth and average canal widths. Based on model data, the approximate dredging depth is illustrated in the profile depicted in Figure 66.

The proposed improvements would provide flood protection for approximately 59.1 square miles, benefitting approximately 235,000 people located in the jurisdiction of Miami-Dade and Cutler Bay municipalities. The canals are primarily located near residential areas, however they do pass critical infrastructure such as: the Florida Turnpike, South Dixie Highway, the Kendall-Tamiami Airport, the Miami-Dade Police Station, the Miami-Dade Landfill, and the Miami Dade's South District Wastewater Treatment Plant.

The C-1W and C-1 Canals are located in Watershed C-1. Canal C-1W begins at gated culvert G-211 and ends directly upstream of the Districts S-148 Structure, spanning a total length of approximately 13 miles. The C-1 Canal is approximately 7 miles long, beginning at Spillway S-148 and discharging into Biscayne Bay through the District's S-21 Structure. The total length of the improvement area is approximately 13.3 miles. The C-1W and C-1 Canals have a total proposed dredging volume of approximately 463,141 cubic yards (cy).

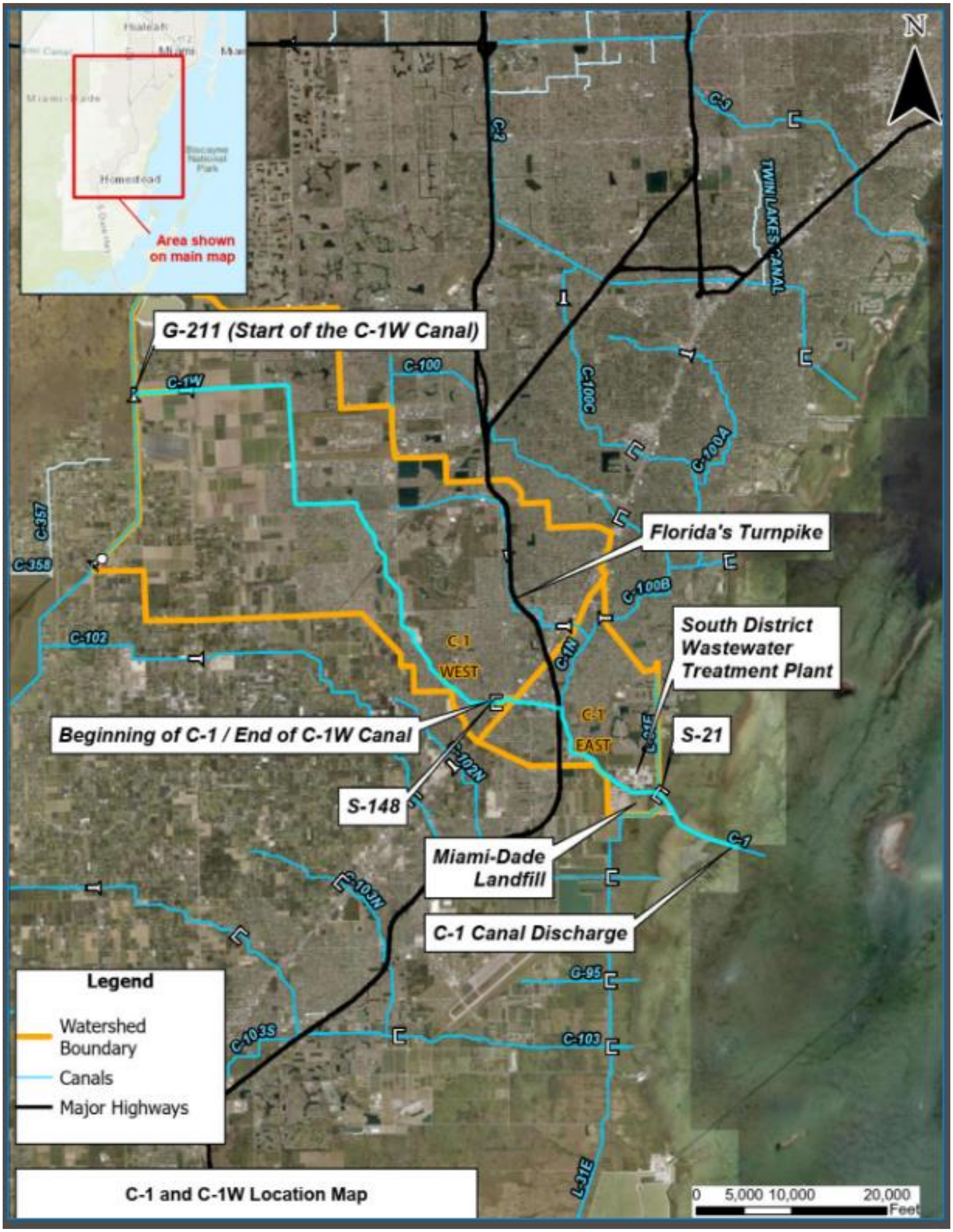


Figure 59: C-1W and C-1 Location Map

Cost Estimate

The cost estimate for the proposed improvements is presented in the below cost summary table. The cost estimate is a high-level cost estimate based on a conceptual design and assumption listed below. The cost summary table also includes construction costs, design and construction management costs, and real estate costs. The methodology for developing the costs includes performing quantity takeoffs, and applying historical unit cost data from the District database.

Item	Cost
Dredge Canal	$84,245,348
Design, Implementation & CMS at 15%	$12,636,802
Real Estate	--
Adjusted 2024 Cost Total	$96,882,150

Assumptions

- The dredge profile would be a consistent slope to remove sediments. See Figure 68 below for the proposed bottom of canal profile.
- Canal bottom width at 55 feet wide with 1H:1V side slopes.
- Proposed Canal Profile assumed based on providing a uniform grade to provide an overall result that will maintain current conveyance capacity, considering sea level rise conditions that will reduce hydraulic gradient.
- Unit cost based on District reference costs per cubic yard in Miami.

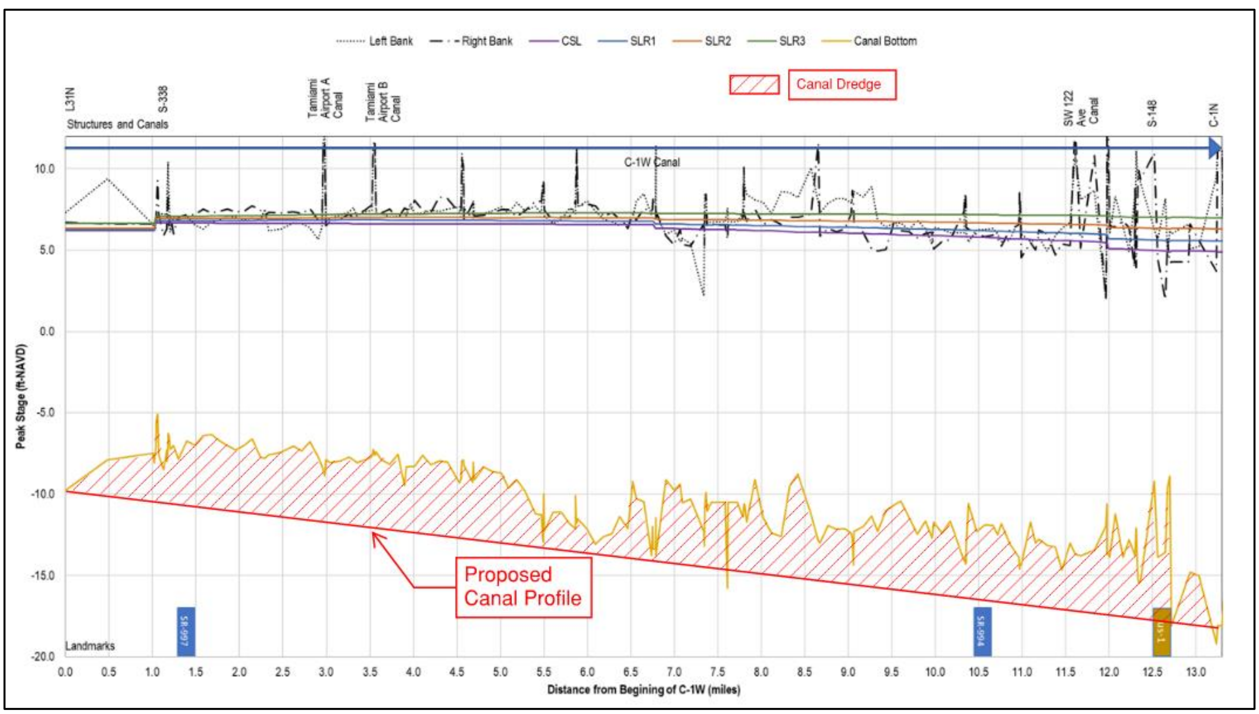


Figure 60: Proposed Canal Profile

C-100 Basin Resiliency

S-123 Coastal Structure Resiliency

This resiliency project is mainly tied to the District's mission to provide flood control and water supply protection. S-123 is a fixed crest, reinforced concrete, gated spillway, with discharge controlled by two cable-operated, vertical lift gates measuring 12.7 feet high by 25.0 feet wide. The discharge capacity at this structure is 2,300 cfs. The 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. The S-123 Structure was designed to 1) maintain optimum water control stages upstream in Canals C-100, C-100A, and C-100B, 2) release the design flood (40 percent of the Standard Project Flood) without exceeding the upstream flood design stage, 3) restrict downstream flood stages and discharge velocities to non-damaging levels, and 4) prevent saltwater intrusion during periods of extreme, high tides. The structure is maintained by Miami Field Station.

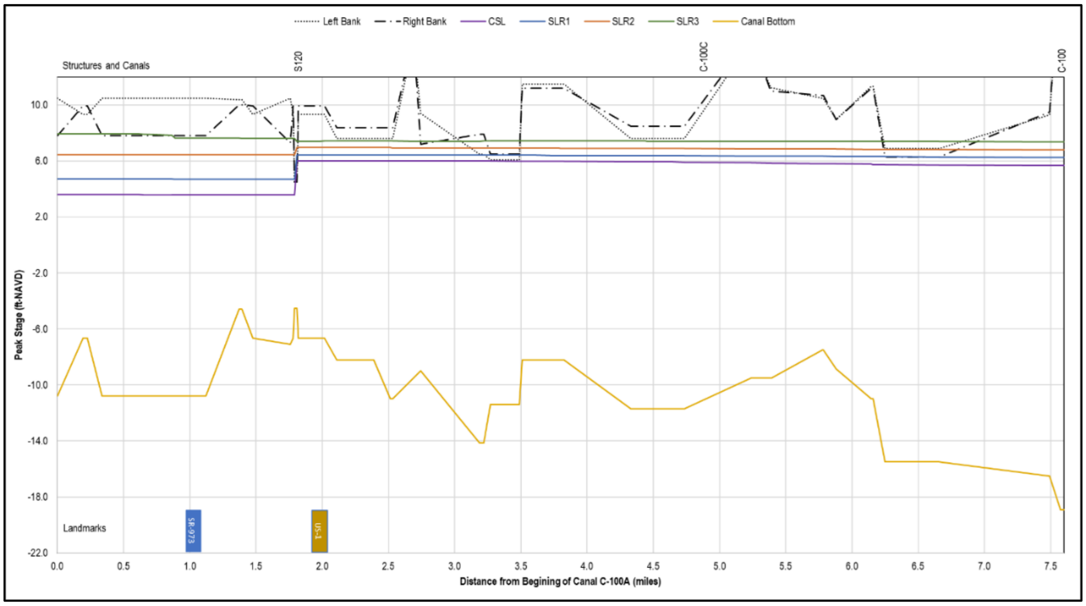
A total cost estimate to harden this Coastal Structure to address flooding, sea level rise, and other related risks to vulnerable communities in the Basin is presented below. The estimate includes modifications to the existing structure and control building, as well as an additional forward pump. The 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.

Cost Estimate

Structure Enhancement	$10,044,597
Forward Pump (1150 cfs)	$84,870,000
Forward Pump Backup Generator Facility	$8,487,000
Structure Tie Back (Flood Barrier)	$3,075,000
Design, Implementation & Construction Management	$15,971,489
Real Estate	$7,000,000
Adjusted 2024 Costs	**$129,448,086**

C-100A and C-100B Canal Dredging Resiliency

Dredging of the C-100A and C-100B Canals is proposed in order to help achieve the District's mission of providing the required level of flood control and protection. This project will include dredging the bottom of the C-100A and C-100B canals.



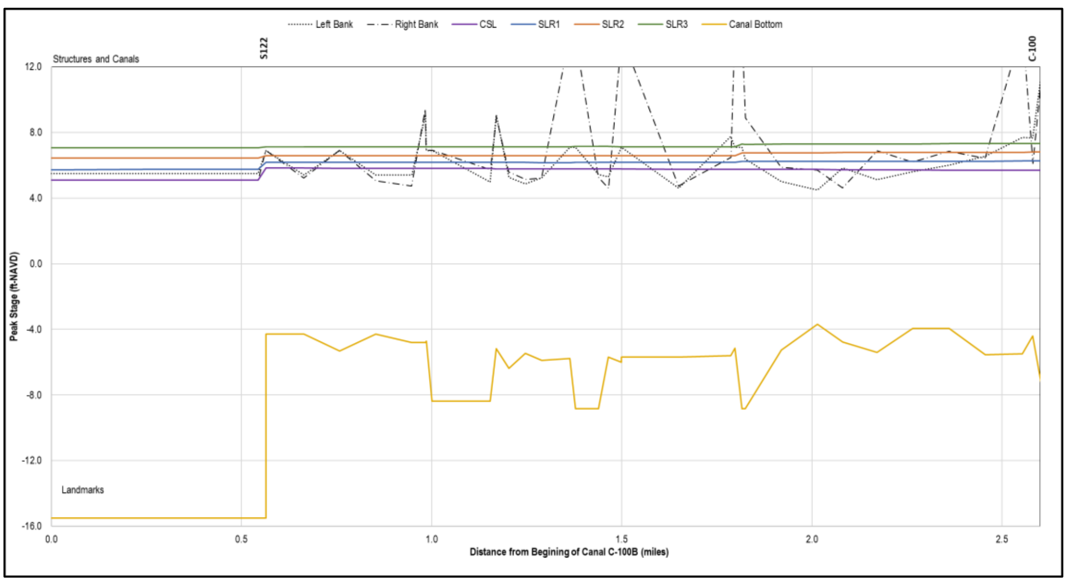


Figure 61: C-100A and C-100B Canal Banks and Surface Water Profiles of Peak Stages for the 25-yr Design Storm

The purpose of this dredging is to create a smooth gradient across the entire length of the canal as well as remove sediments which have accumulated over time. In order to determine the depth of dredging the canals this project will require additional bathymetric and cross sectional survey information to further refine the depths and volumes of the dredge material. Refer to the list of assumptions made in the cost estimate section of this report regarding the proposed improvements for an estimate of the dredged depth and average canal widths.

The proposed improvements provide flood protection for approximately 39.2 square miles. These projects will benefit approximately 250,000 people located in the jurisdictions of Miami-Dade, Palmetto Bay, and Cutler Bay municipalities. The project will benefit the homeowners adjacent to the canal by increasing their flood protection and protecting their property. Additionally, there are several pieces of critical infrastructure that will benefit from the project including the Florida Turnpike and South Dixie Highway.

The C-100A and C-100B Canals are located in Watershed C-100 (See Figure 58). Canal C-100A begins near the intersection of SW 100th Street and SW 93rd Avenue and flows into the C-100B Canal, spanning a total length of approximately 9.2 miles. Canal C-100B is located between the C-100A Canal and the District's culvert S-122 structure spanning a total length of approximately 2.6 miles The total length of the improvement area is approximately 11.8 miles. C-100A and C-100B Canals have a total proposed dredging volume of approximately 130,000 cubic yards (cy). C-100A and C-100B primarily pass through residential areas, however the canals do cross under two major highways, the South Dixie Highway and the Florida Turnpike.

The purpose of the proposed work is to provide increased flood protection Level of Service (LOS) to accommodate a 25-yr 3-day storm event under conditions of 3.0 feet of Sea Level Rise (SLR) and providing for an improved flood protection and LOS for areas adjacent to the canals due to rising sea levels. Over time these drainage canals experience sediment accumulation due to storm events with higher velocities which can transport upstream sediments and erode canal bank slopes into the canal bottoms. As a result of these changing conditions and variation in storm intensity and flow velocity, the canal depths have become silted in and shallower than the original design and therefore, no longer provides the same conveyance capacities as originally designed and can't protect the surrounding areas and drainage watershed to the desired LOS. By dredging out these accumulated sediments it will provide more water storage and canal conveyance capacity within the canal, as it was originally intended, and will have less overtopping and flooding in adjacent areas. Dredging will be completed in conjunction with the proposed canal bank elevation increases and maintenance in the proposed canals. If suitable, the dredged material can be used in the canal bank improvements project within the C-100 Watershed.

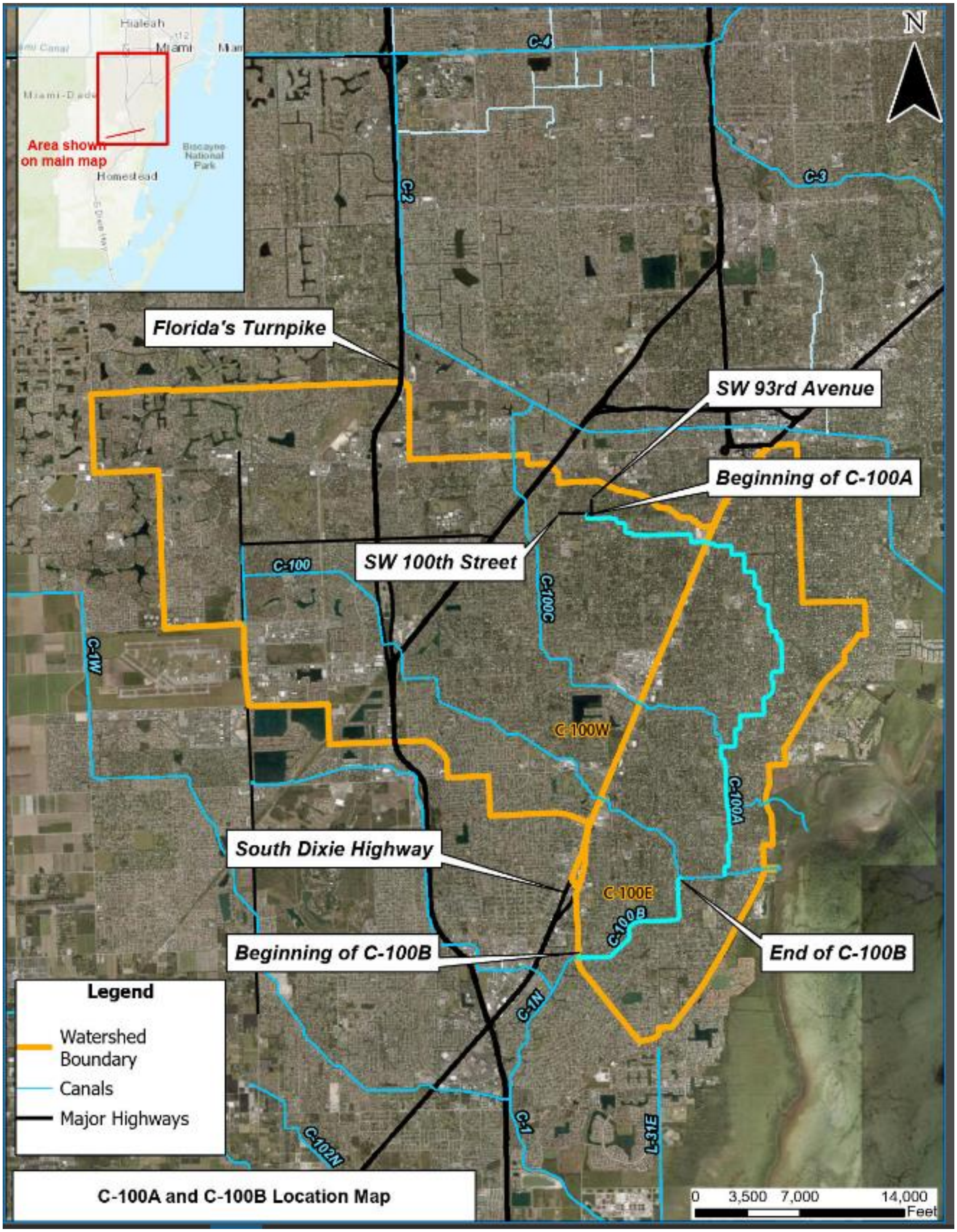


Figure 62: Location Map

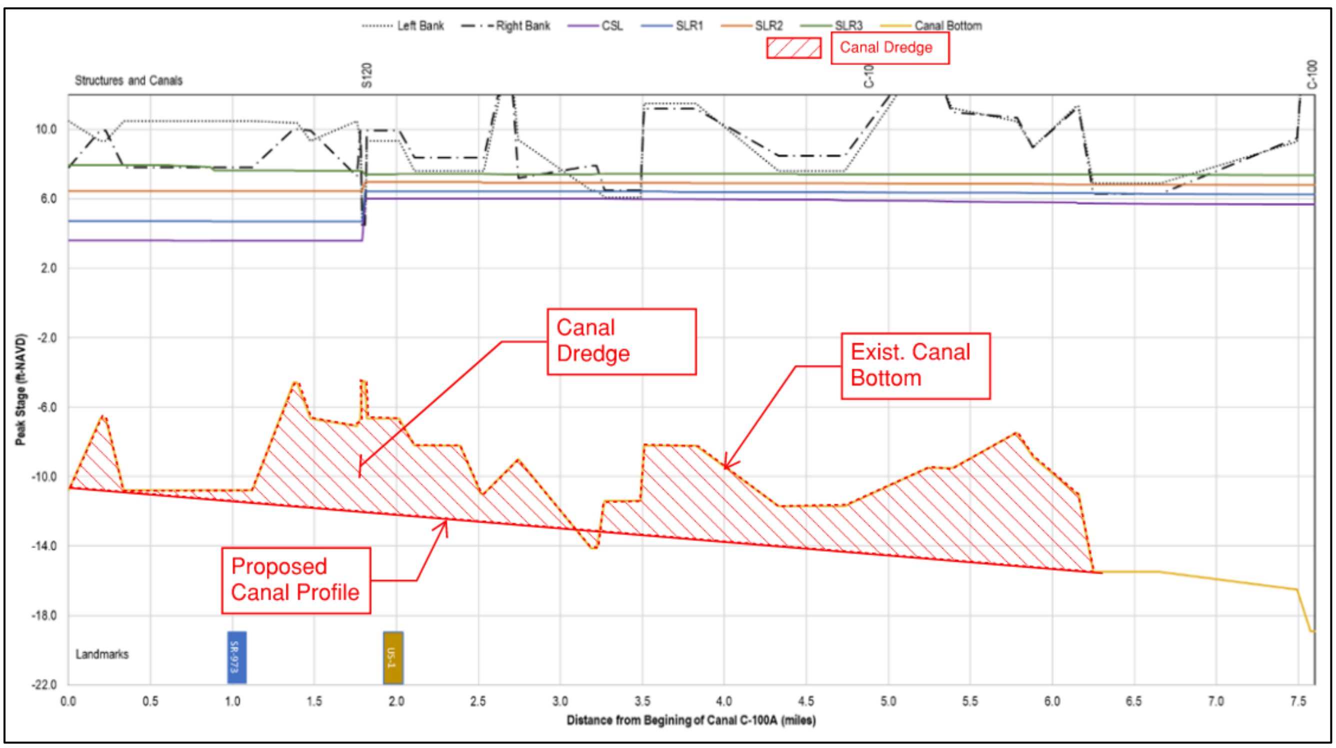
Cost Estimate

The cost estimate for the proposed improvements is presented in the below cost summary table. The cost estimate is a high-level cost estimate based on a conceptual design and assumption listed below. The cost summary table also includes construction costs, design and construction management costs, and real estate costs. The methodology for developing the costs includes performing quantity takeoffs, and applying historical unit cost data from the District database.

Item	Cost
Dredge Canal C-100A	$19,209,367.60
Dredge Canal C-100B	$3,605,536.20
Design, Implementation & CMS at 15%	$3,422,235.57
Real Estate	--
Adjusted 2024 Cost Total	**$26,237,139.37**

Assumptions

- The dredge profile would be a consistent slope to remove impediments. See Figure 59 below for the proposed bottom of canal profile.
- Canal bottom width at 15 feet wide with 1H:1V side slopes.
- Proposed Canal Profile assumed based on providing a uniform grade to provide an overall result that will maintain current conveyance capacity, considering sea level rise conditions that will reduce hydraulic gradient.
- Unit cost based on District reference costs per cubic yard in Miami.



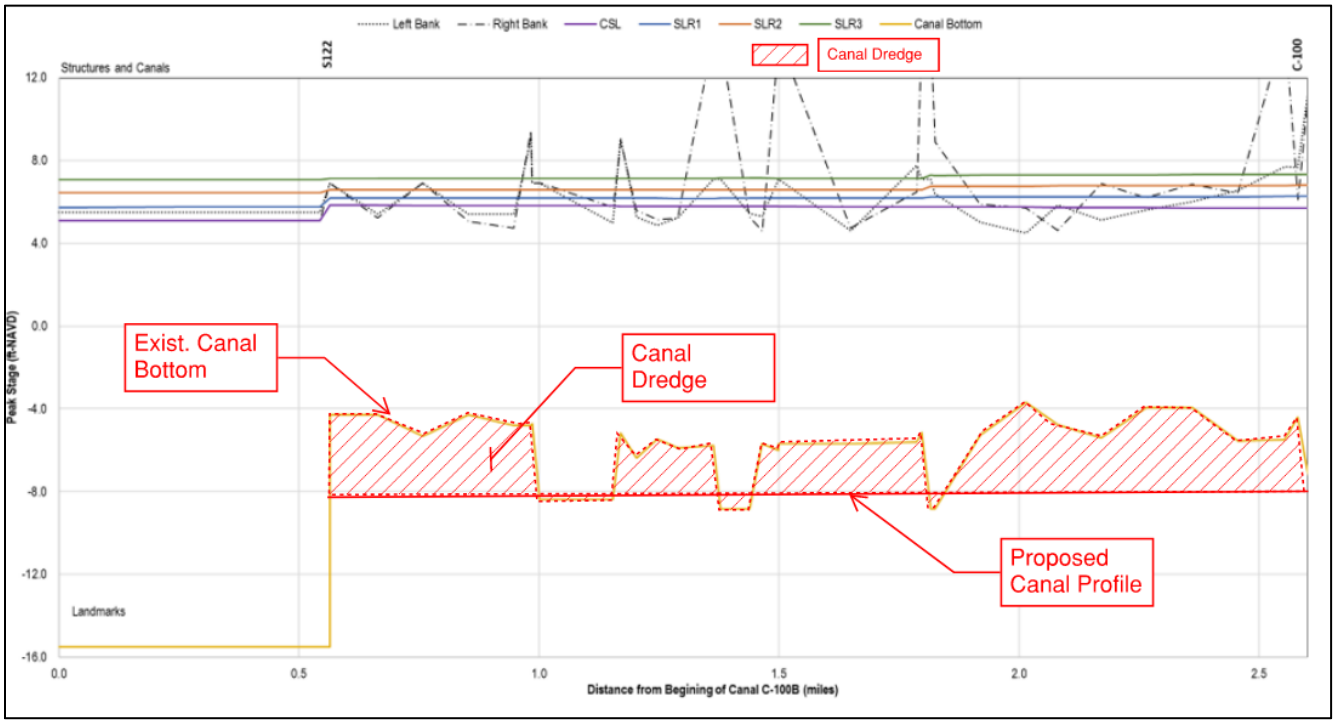


Figure 63: Proposed C-100A AND C-100B Canal Profiles

C-100B Canal Embankment Resiliency

Canal bank elevation improvements for the C-100B canal are proposed in order to help achieve the District's mission of providing flood control and protection.

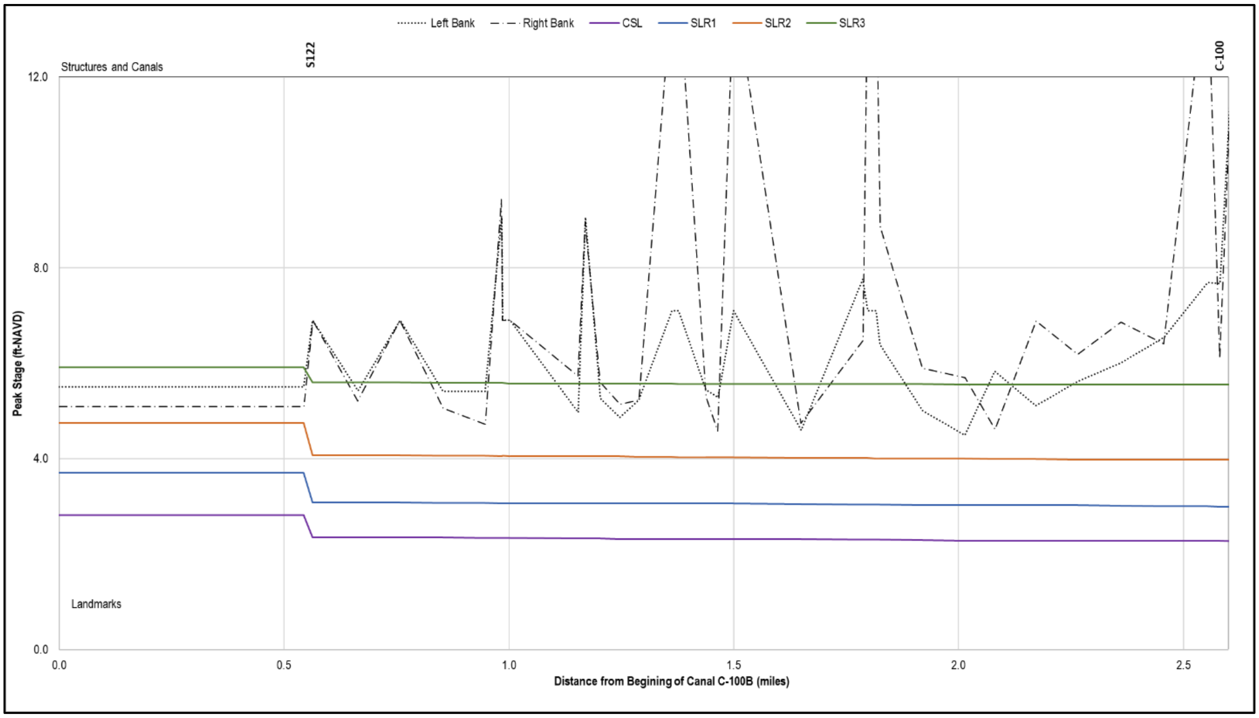


Figure 64: C-100B Canal Banks and Surface Water Profiles of Peak Stages for the 25-yr Design Storm

This project will include raising the existing canal bank elevations to the storm surge elevation for a 25-yr 3-day storm event plus 3 feet of sea level rise (SLR) and freeboard along 2.6 miles of canal at a 3:1 slope on both sides of the canal banks. Multiple locations are overtopped for the 3 feet SLR as depicted in Figure 60 above. Proposed elevation increases vary from 0 to 5 feet depending on the existing canal bank elevations and conditions, with an average fill height of 3.9 feet on the left bank and 3.4 feet on the right bank. Refer to Figure 61 below for the minimum bank fill profile based on 3 feet of freeboard and the SLR3 profile.

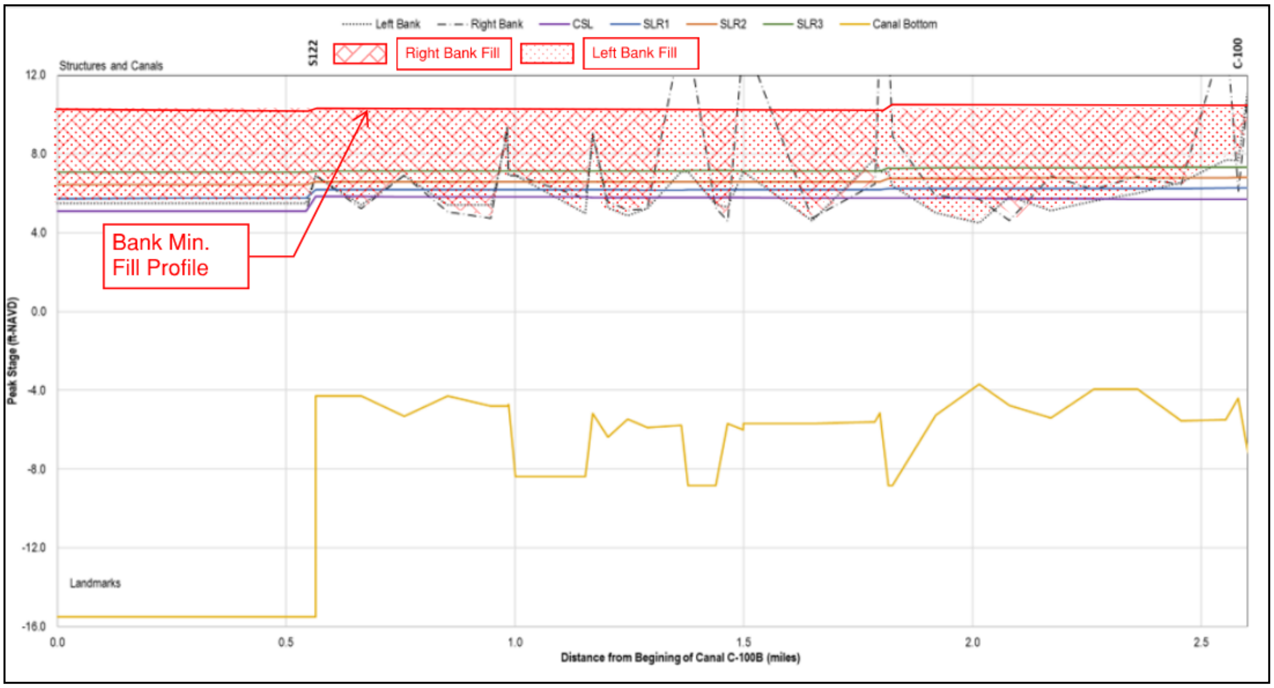


Figure 65: Recommended Fill for Canal Banks and Surface Water Profiles of Peak Stages for the 25-yr Design Storm with 3 feet SLR

The elevation improvements will eliminate the potential of canal bank overtopping and flooding of the adjacent areas. The proposed improvements would provide flood protection for approximately 39.2 square miles. This project will benefit approximately 232,000 people located in the jurisdiction of Miami-Dade and Cutler Bay municipalities.

The C-100B Canal is located in Watershed C-100. Canal C-100B is located between the C-100 Canal and the District's culvert S-122 spanning a total length of approximately 2.6 miles. Therefore, the total length of the improvement area for both sides of the canal banks is approximately 5.2 miles with approximately 99% of the left bank and 89% of the right bank of the total length that has deficient height in comparison to the SLR3 25-yr water profile plus 3 feet of freeboard.

The C-100B Canal serves several functions within the C-100 Watershed. The C-100B Canal connects Watershed C-1 with Watershed C-100 through structure S-122. This canal also provides services such as flood protection, drainage, irrigation, and maintaining the groundwater table at elevations adequate to prevent saltwater intrusion.

This project is intended to raise the current level of service (LOS) rating of the canal from 5-yr at 0 feet of SLR to a 25-yr LOS rating at 3.0 feet of SLR. As a result of these changing conditions within the basin, the current canal bank elevations no longer adequately protect surrounding areas. By increasing the height of the canal bank elevations, it is less likely there will be overtopping and flooding in adjacent areas within this watershed. The project will benefit the homeowners adjacent to the canal by increasing flood protection for their property.

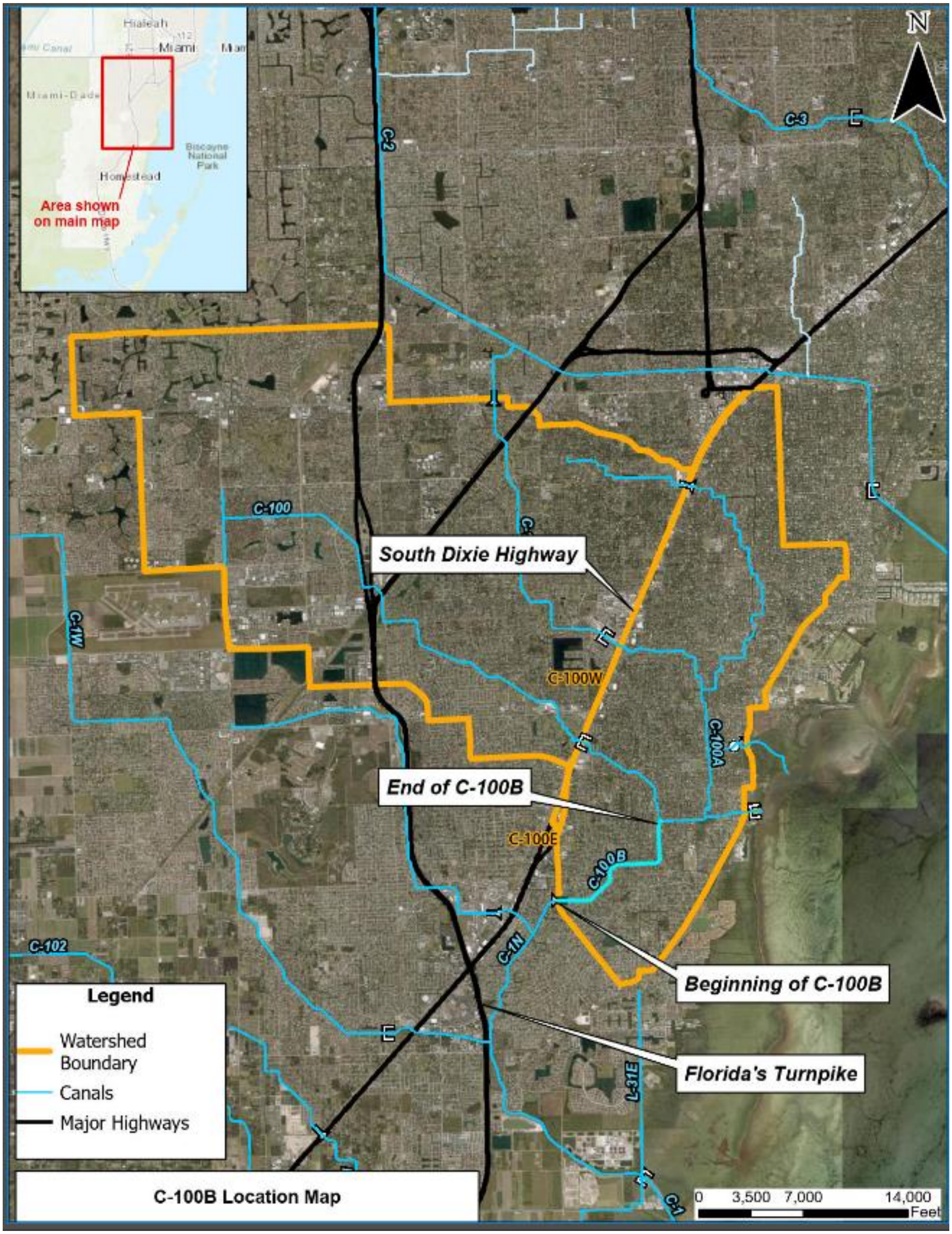


Figure 66: C-100B Location Map

Cost Estimate

The cost estimate for the proposed improvements is presented in the below cost summary table. The cost estimate is a high-level cost estimate based on a conceptual design and assumption listed below. The cost summary table also includes construction costs, design and construction management costs, and real estate costs. The methodology for developing the costs includes performing quantity takeoffs, and applying historical unit cost data from the District database.

Item	Cost
Left Bank Canal Elevation Improvements	$27,339,007.92
Right Bank Canal Elevation Improvements	$29,535,990.94
Design, Implementation & CMS at 15%	$8,531,249.83
Real Estate	--
Adjusted 2024 Cost Total	$65,406,248.69

Assumptions

- Left and right top of bank would be raised to three feet above the SLR 3 profile. See Figure 60 for the proposed canal bank elevations.
- Left and right banks would be a minimum of 14 feet wide at the top with 3H:1V side slopes.
- Unit cost based on interpolation of District reference costs for average embankment height of 3.9ft for the left embankment and 3.4ft for the right embankment. Costs were provided per linear feet of embankment in 0.5ft height increments from 0.5ft to 2.5ft.

Goulds Canal Basin Resiliency

Goulds Canal Structure Resiliency

Goulds Canal is approximately 2.3 miles long and flows adjacent to SW 248th Street and currently has a road crossing the canal that prevents positive discharge to Biscayne Bay. Beyond the canal crossing is another canal that discharges directly to Biscayne Bay just south of the Miami-Dade Landfill. Historically, the Goulds Canal had a positive outfall, however, it was disconnected when the road crossing of the canal was built.

For this project, a new gated water control structure and pump station are being proposed near the location of the Goulds Canal Crossing. This new structure and pump station will provide for upstream watershed discharge into Biscayne Bay to provide the required level of flood control and protection. The proposed improvements will provide protection for a 25-yr 3-day storm event assuming 3.0 feet of Sea Level Rise (SLR) and future land use changes and urbanization within the watershed's drainage basin. This project will include the design and construction of a 500 cubic feet per second (cfs) drainage pump station and a 500 cfs gravity gated control structure (2 gated spillway) at the outfall of the Goulds Canal as well as the removal of an existing canal plug crossing. The construction of the new gravity spillway and pump station will reduce the potential of canal bank overtopping and flooding of the adjacent areas, particularly the upstream urban areas. Gravity flow will be used when the head conditions within the Goulds Canal allow for gravity flow. However, due to rising tidal tailwater elevations it will likely increase requiring the use of a pump station to maintain optimal water levels within the canal. The approximate location of the proposed structure is shown in Figure 69.

The proposed improvements would provide flood protection for approximately 59.1 square miles. This project will benefit approximately 235,000 people located in the jurisdiction of Miami-Dade and Cutler Bay municipalities. The Goulds Canal is also adjacent to residential areas as well as two pieces of critical infrastructure, the Florida Turnpike, and the Miami-Dade Landfill.

This project is intended to raise the current flood protection LOS rating of the watershed from 5-yr at 0 feet of SLR to a 25-yr LOS rating at 3.0 feet of SLR. The proposed work will also provide increased water control to mitigate future land use changes. The surrounding land use is currently primarily agricultural; however, future urban development is expected. As a result of these expected changing conditions, the canal no longer adequately protects surrounding areas, and a control structure is required to maintain optimal water levels within the canal for drainage, irrigation, and the prevention of saltwater intrusion. Through the construction of a combined spillway and pump station, additional tidal changes due to anticipated SLR and additional basin runoff due to future land use changes can be mitigated.

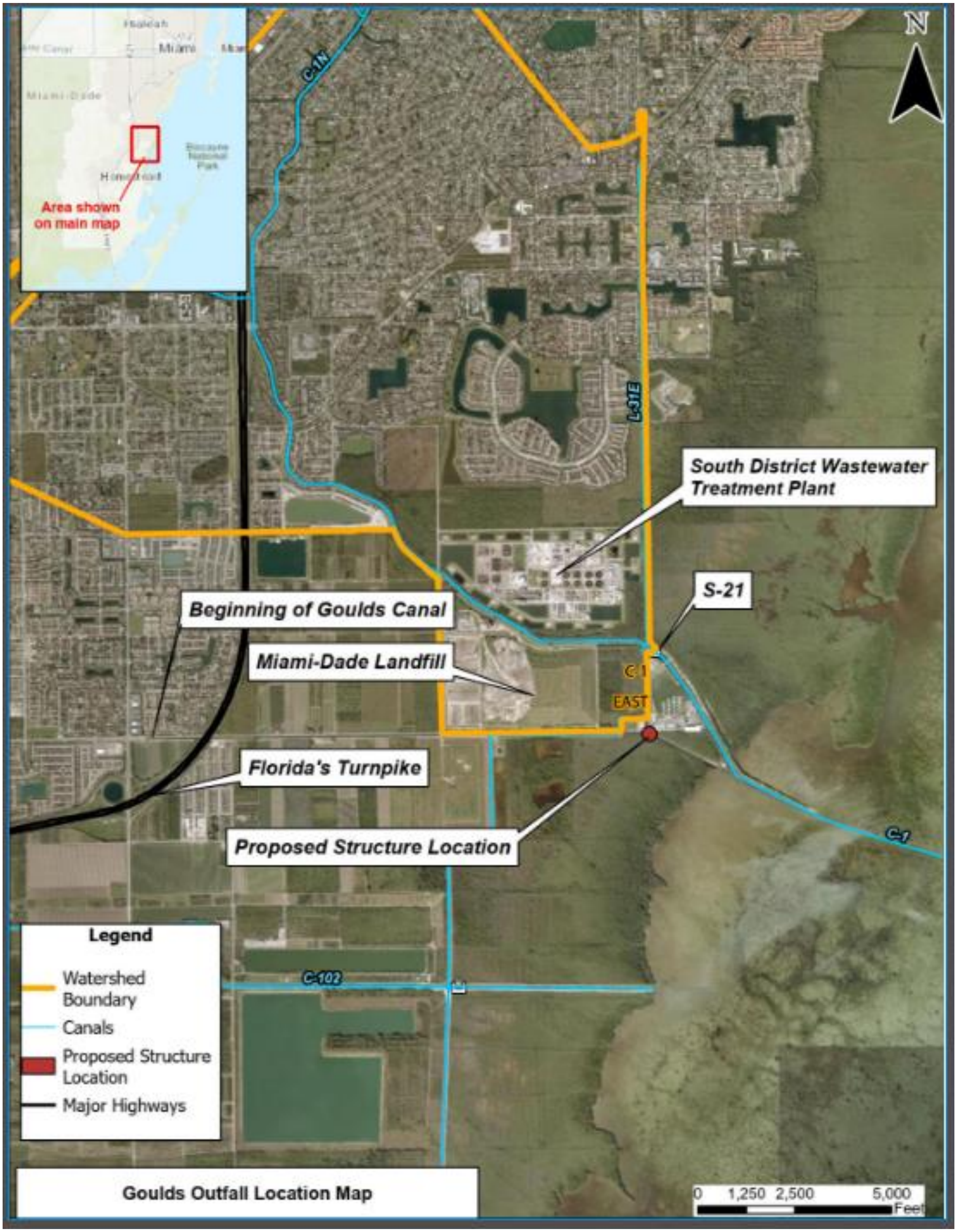


Figure 67: Goulds Canal Proposed Structure Location

The proposed pump station and gravity spillway control structure will be located in the C-1 Basin on the Goulds Canal just west of the Black Point Marina. There is currently a canal crossing at this location which would be demolished as part of the project. The location of the proposed structure and plug removal can be seen in Figure 70. The proposed location for the new infrastructure would be located within an 8.89 acre parcel. This parcel is currently owned by SFWMD so land acquisition will likely not be required for this project.

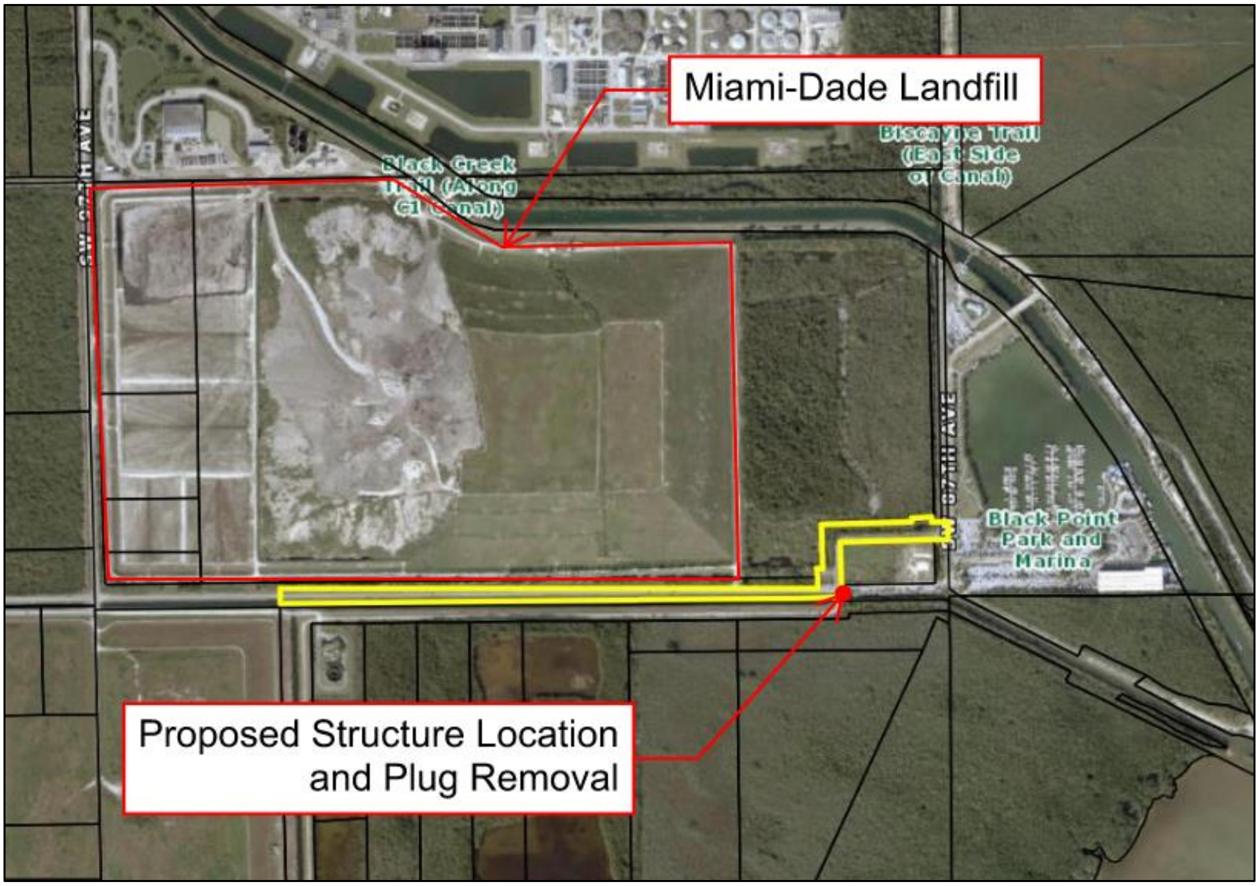


Figure 68: Proposed Parcel Acquisition

Cost Estimate

The cost estimate for the proposed improvements is presented in the below cost summary table. The cost estimate is a high-level cost estimate based on a conceptual design and assumption listed below. The cost summary table also includes construction costs, design and construction management costs, and real estate costs. The methodology for developing the costs includes performing quantity takeoffs, and applying historical unit cost data from the District database.

Item	Cost
Canal Crossing Removal	$465,568
Spillway Construction	$12,532,200
Pump Station Construction	$35,443,750
Generator Building	$1,418,553
Design, Implementation & CMS at 15%	$7,479,010
Real Estate	--
Adjusted 2024 Cost Total	**$57,339,080**

Assumptions

- Canal Crossing Removal based on demolition and removal costs from the G-343N District Database table.
- Spillway construction costs are based on 80% of the S334 Spillway, with the assumption that general site costs are covered under other features such as the pump station cost.
- Pump Station cost are based on the unit cost from the District database for 500 cfs pump station.
- Generator building costs are based on Pump Station S-701 pump station project.
- Design Implementation & Construction Management Service

HARB Basin Resiliency

S-20G Coastal Structure Resiliency

This resiliency project is mainly tied to the District's mission to provide flood control and water supply protection. 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 a 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. The 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 Structure to address flooding, sea level rise, 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 peak stages. The District owns adjacent lands, which will eliminate real estate acquisition costs.

S-20G Cost Estimate

Structure Enhancement	$6,279,780
Forward Pump (225 cfs)	$19,026,563
Forward Pump Backup Generator Facility	$1,902,656
Structure Tie Back (Flood Barrier)	$3,075,000
Design, Implementation & Construction Management	$4,542,600
Real Estate	$7,000,000
Adjusted 2024 Cost	*** $41,826,599**

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

C-102 and C-102N Basin Resiliency

S-21A Coastal Structure Resiliency

This resiliency project is mainly tied to the District's mission to provide flood control and water supply protection. S-21A is a reinforced concrete, two-bay, gated spillway located near the mouth of the 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. The 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 at 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, sea level rise, 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.

Cost Estimate

Structure Enhancement	$9,668,244
Forward Pump (650 cfs)	$50,968,125
Forward Pump Backup Generator Facility	$5,096,813
Structure Tie Back (Flood Barrier)	$3,075,000
Design, Implementation & Construction Management	$10,321,227
Real Estate	$7,000,000
Adjusted 2024 Cost	**$86,129,409**

C-102 and C-102N Canal Embankment Resiliency

Canal bank elevation improvements of the C-102 and C-102N Canals are proposed in order to help achieve the District's mission of providing flood control and protection.

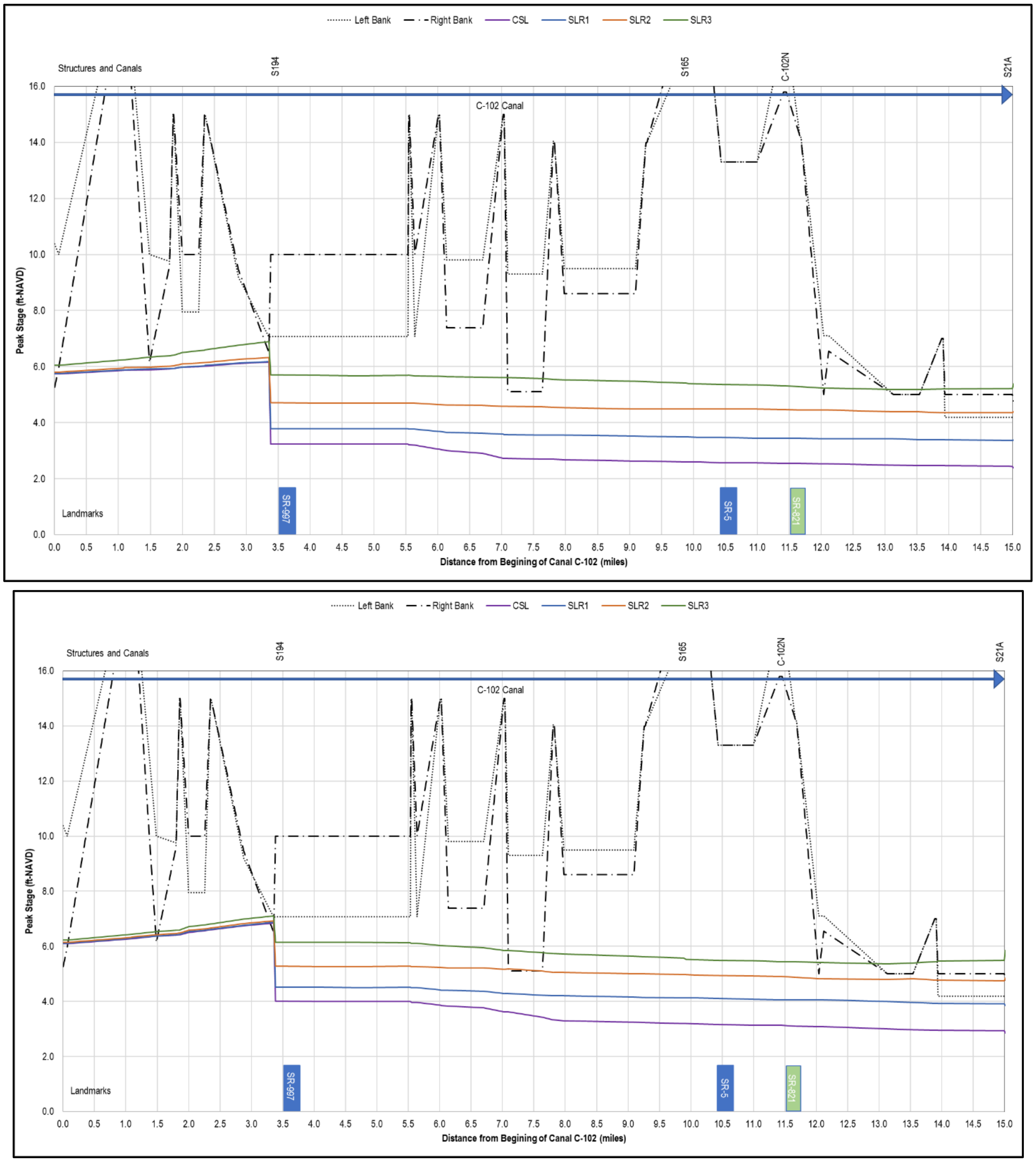


Figure 69: C-102 and C-102N Canal Banks and Surface Water Profiles of Peak Stages for the 25-yr Design Storm

Multiple locations are overtopped for the 3-feet Sea Level Rise (SLR) scenario.

This project is intended to raise the current level of service (LOS) rating of the canals from 5-yr at 0 feet of SLR to a 25-yr LOS rating at 3.0 feet of SLR. This project will include raising the existing canal bank elevations to the storm surge elevation for a 25-yr 3-day storm event plus 3 feet of sea level rise and freeboard along 20 miles at a 3:1 slope on both sides of the canal banks. The proposed elevation increases vary from 0 to 5.5 feet depending on the existing canal bank elevation and conditions, with an average fill height of 1.5 feet on both the left and right bank. Refer to Figure 71 for the minimum bank fill profile based on 3 feet of freeboard atop the SLR3 profile.

The elevation improvements will eliminate the potential of canal bank overtopping and flooding of the adjacent areas. The proposed improvements would provide flood protection for approximately 23.5 square miles. The purpose of the proposed work is to provide increased flood protection, for areas adjacent to the canals, due to rising sea levels and future land use changes within the basin. As a result of these changing conditions within the basin, the current canal elevations no longer provide the desired LOS to the surrounding areas. By increasing the height of the canal bank elevations within these canals, it is less likely there will be overtopping and flooding in adjacent areas. These projects will benefit approximately 192,000 people located in the jurisdictions of Miami-Dade, Homestead, and Cutler Bay municipalities. The project will benefit the landowners adjacent to the canal by increasing flood protection for their property.

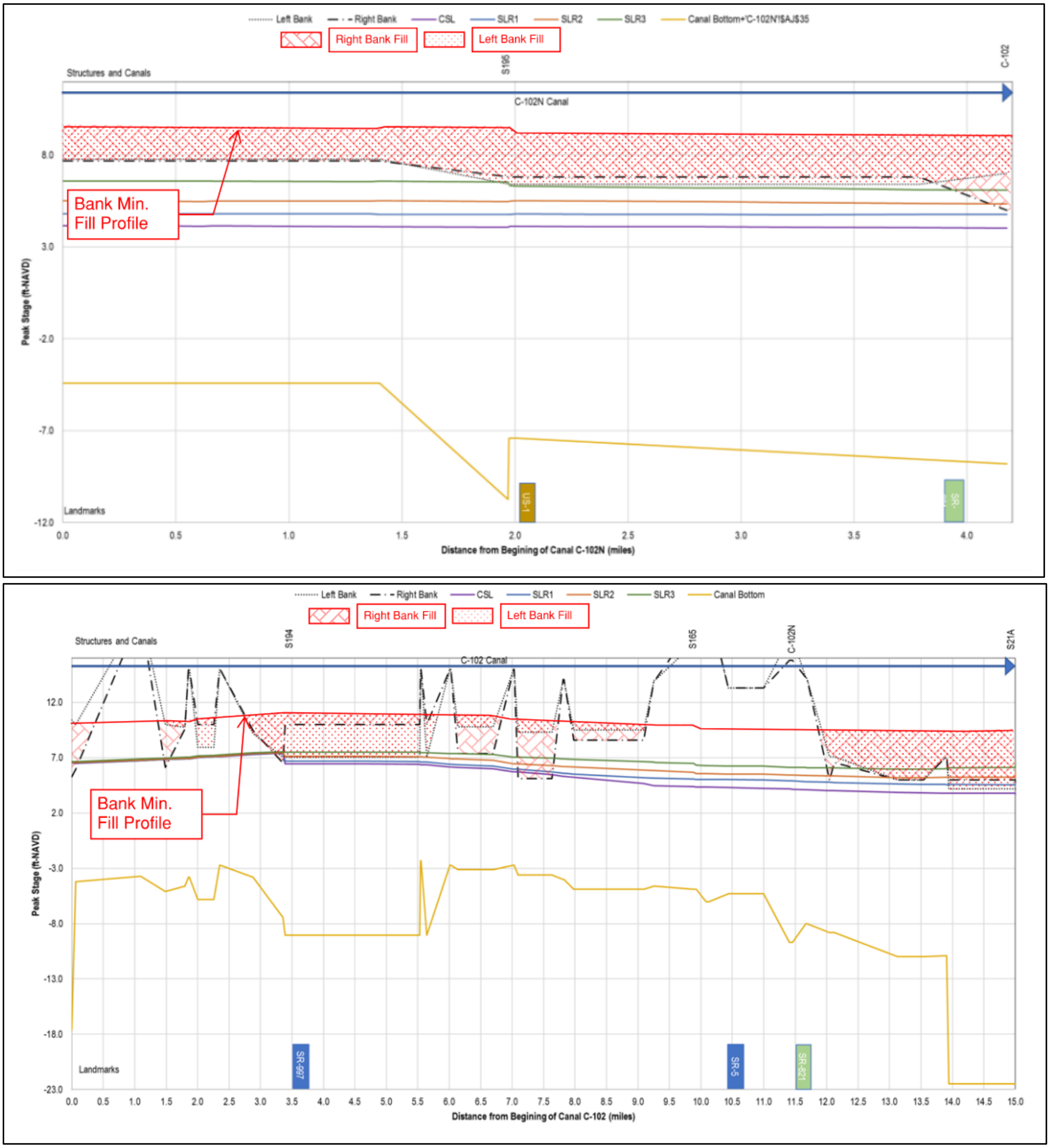


Figure 70: Recommended Fill for Canal Banks and Surface Water Profiles of Peak Stages for the 25-yr Design Storm with 3 feet SLR

The C-102 and C-102N Canals are located in Watershed C-102 (Figure 73). C-102 begins at the intersection of L-31N (along SW 208th Street) and SW 192nd Street and is approximately 15 miles long. C-

102N is approximately 4.2 miles long and discharges into the C-102 Canal just south of the Florida Turnpike. The total length of the proposed bank improvements is approximately 30 miles for the left and right bank of the C-102 canal and 8.4 miles for the left and right bank of the C-102N canal. Approximately 70% of the C-102 banks and 100% of the C-102N banks has deficient height in comparison to the SLR3 25-yr water profile plus 3 feet of freeboard. These canals are located mostly in residential areas; however, they do cross two major highways, the South Dixie Highway and the Florida Turnpike.

The C-102 and C-102N Canals serve several functions, and they also serve as the primary canals in the C-102 Watershed. These canals provide services such as flood protection, drainage, irrigation, and maintaining the groundwater table at elevations adequate to prevent saltwater intrusion.

These elevation improvements will be completed in conjunction with dredging and maintenance in the proposed canals. The canal bank elevations will be improved by using either suitable dredged material from the adjacent canal and/or imported fill, or a combination of material as needed. Additional proposed work includes hydrographic surveys of the canals to determine which sections would have the most hydraulic benefit most from proposed improvements.

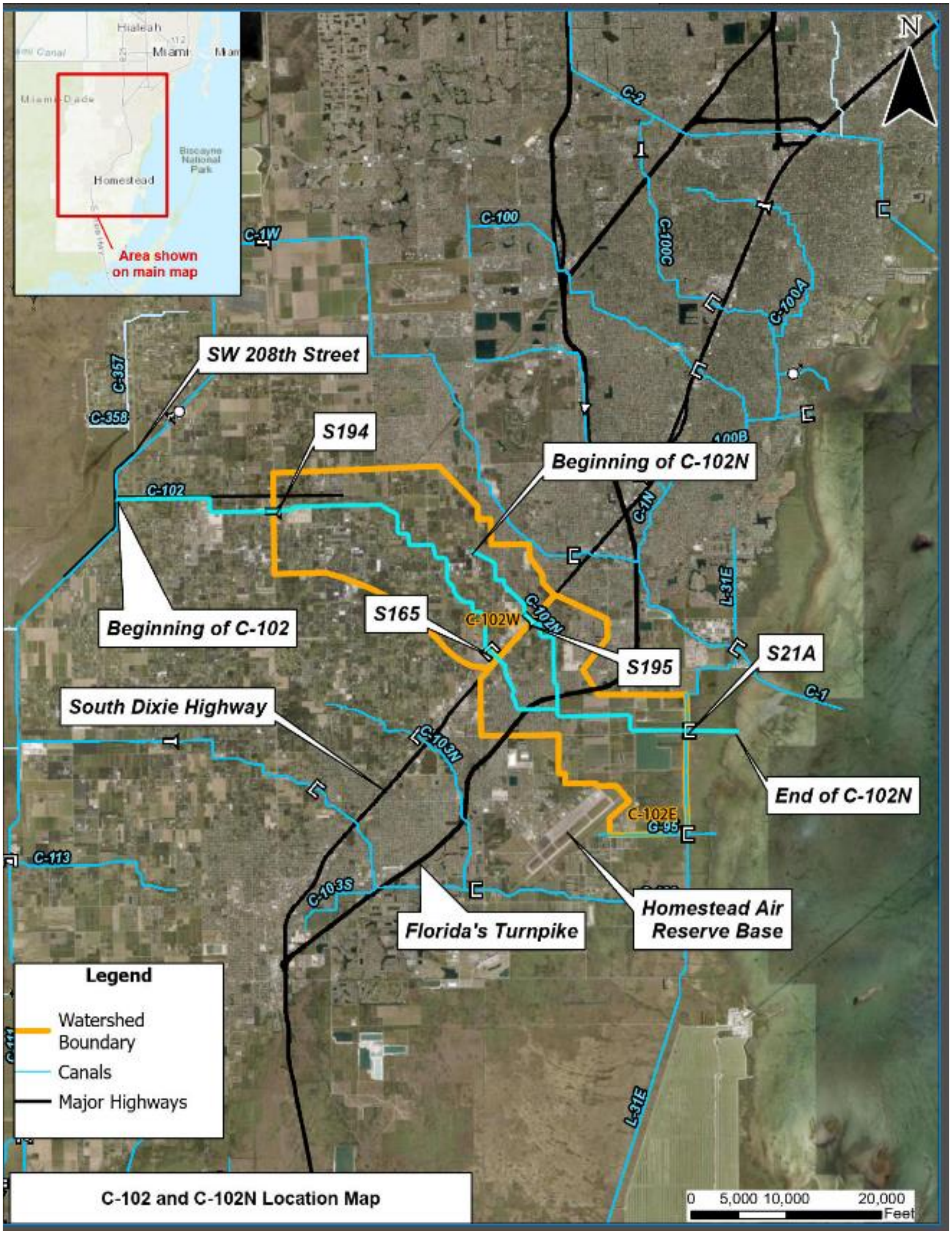


Figure 71: C-102 and C-102N Location Map

Cost Estimate

The cost estimate for the proposed improvements is presented in the below cost summary table. The cost estimate is a high-level cost estimate based on a conceptual design and assumption listed below. The cost summary table also includes construction costs, design and construction management costs, and real estate costs. The methodology for developing the costs includes performing quantity takeoffs, and applying historical unit cost data from the District database.

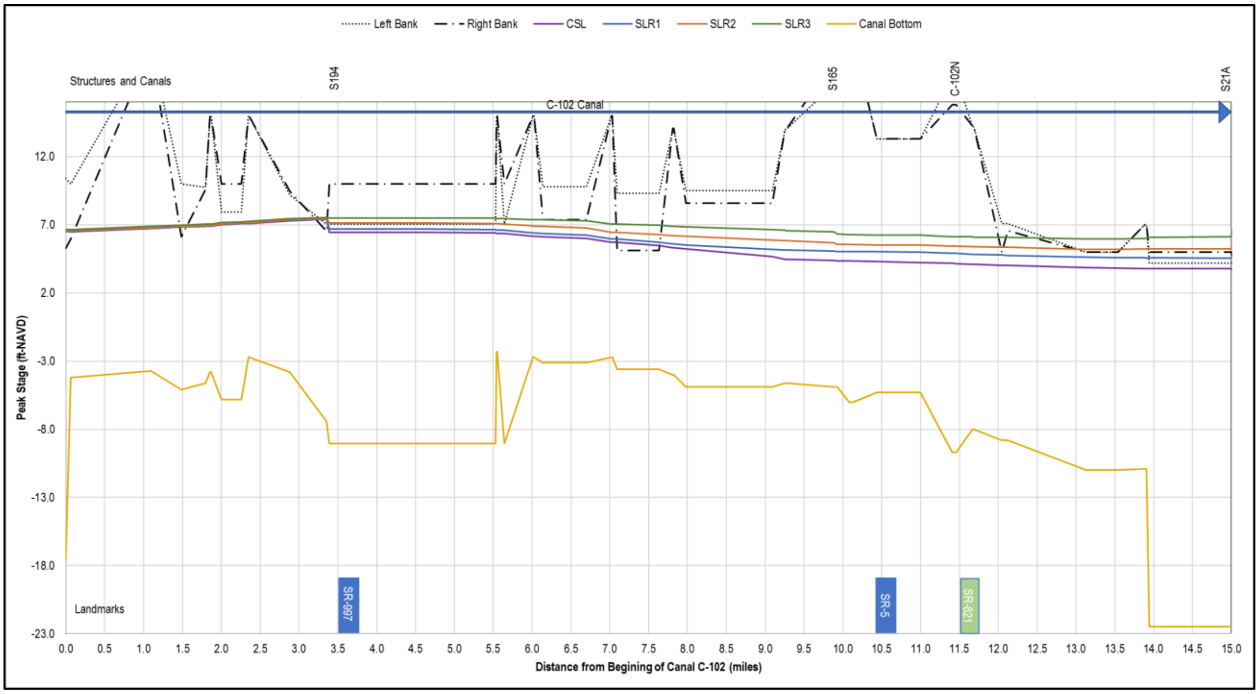
Item	Cost
Raise Left Embankment C-102	$19,071,011
Raise Right Embankment C-102	$18,782,245
Raise Left Embankment C-102N	$5,701,151
Raise Right Embankment C-102N	$5,211,818
Design, Implementation & CMS at 15%	$7,314,934
Real Estate	--
Adjusted 2024 Cost Total	**$56,081,159**

Assumptions

- Left and right top of bank would be raised to three feet above the SLR 3 profile.
- Left and right banks would be a minimum of 14 feet wide at the top with 3H:1V side slopes.
- Unit cost based on interpolation of District reference costs for average embankment height of 1.5ft for the left and right embankment of C-102, 2.2ft for the C-102N left embankment, and 2.1ft for the C-102N right embankment. Costs were provided per linear feet of embankment in 0.5ft height increments from 0.5ft to 2.5ft.

C-102 and C-102N Canal Dredging Resiliency

Dredging of the C-102 and C-102N Canals is proposed in order to help achieve the District's mission of providing flood control and protection.



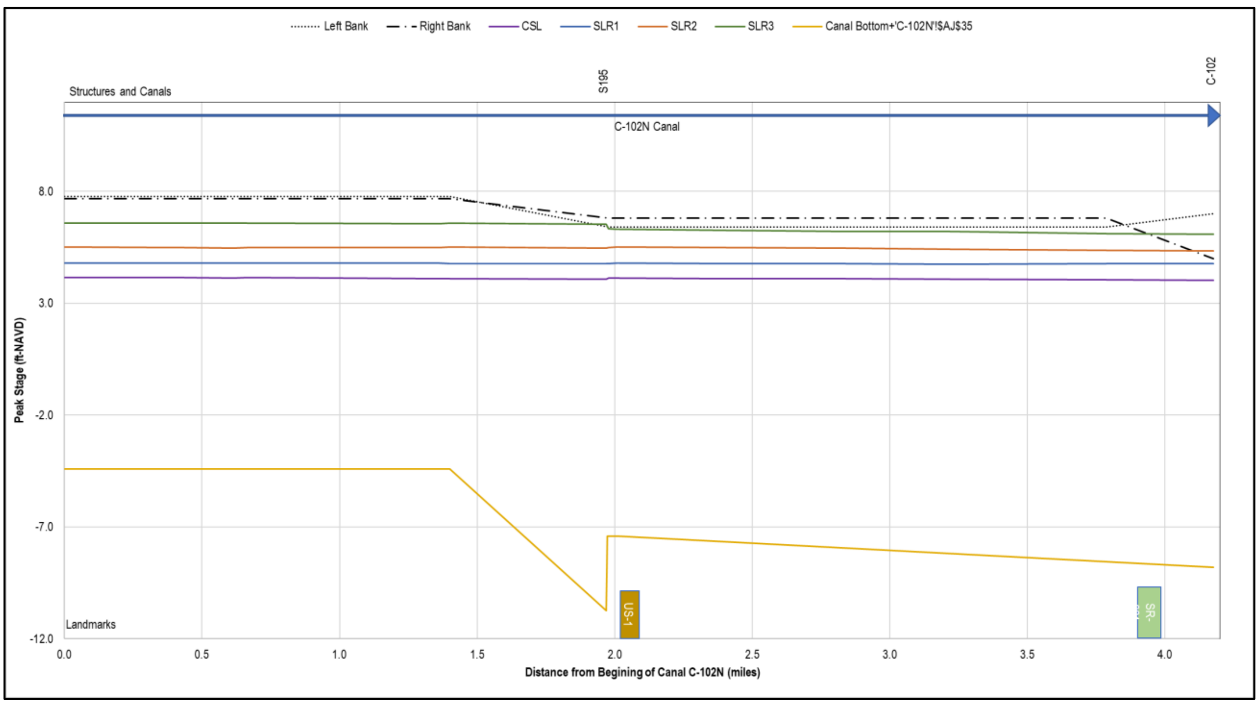


Figure 72: C-102 and C-102N Canal Banks and Surface Water Profiles of Peak Stages for the 25-yr Design Storm with 3 feet SLR

This project will include dredging the bottom of the C-102 and C-102N Canals from their current elevations to their originally designed as built elevation. The purpose of this dredging is to create a smooth gradient across the entire length of the canal as well as remove sediments which have accumulated over time. In order to determine the depth of dredging the canals the project will require some additional bathymetric and cross sectional survey information to further define the dredge depths and excavated volumes of material. Refer to the list of assumptions made in the cost estimate section of this report regarding the proposed improvements for an estimate of the dredged depth and average canal widths.

The proposed improvements would provide flood protection for approximately 23.5 square miles. These projects will benefit approximately 192,000 people located in the jurisdictions of Miami-Dade, Homestead, and Cutler Bay municipalities. These canals are located mostly in residential areas; however, they do flow under two major highways, the South Dixie Highway and the Florida Turnpike.

The C-102 and C-102N Canals are located in Watershed C-102. C-102 begins at the intersection of L-31N (along SW 208th Street and SW 192nd Street) and is approximately 15 miles long. C-102N is approximately 4.2 miles long and discharges into the C-102 just south of the Turnpike. The proposed improvements do not span the full length of the canals. The total length of the improvement area is approximately 15.1 miles. C-102 and C-102N Canals have a total proposed dredging volume of approximately 131,000 cubic yards (cy).

The purpose of the proposed work is to provide increased flood protection Level of Service (LOS) to accommodate a 25-yr 3-day storm event under conditions of 3.0 feet of Sea Level Rise (SLR) providing for an improved flood protection and LOS for areas adjacent to the canals due to rising sea levels. Over time these drainage canals experience sediment accumulation due to storm events with higher velocities which can transport upstream sediments and erode canal bank slopes into the canal bottoms. As a result of these changing conditions and variation in storm intensity and flow velocity, the canal depths have become silted in and shallower than the original design and therefore, no longer provides the same conveyance capacities as originally designed and can't protect the surrounding areas and drainage watershed to the desired LOS. By dredging out these accumulated sediments it will provide more water storage and canal conveyance capacity within the canal, as it was originally intended, and will have less overtopping and flooding in adjacent areas. Dredging will be completed in conjunction with the proposed canal bank elevation increases and maintenance in the proposed canals. If suitable, the dredged material can be used in the Canal Bank improvements project within the C-102 Watershed.

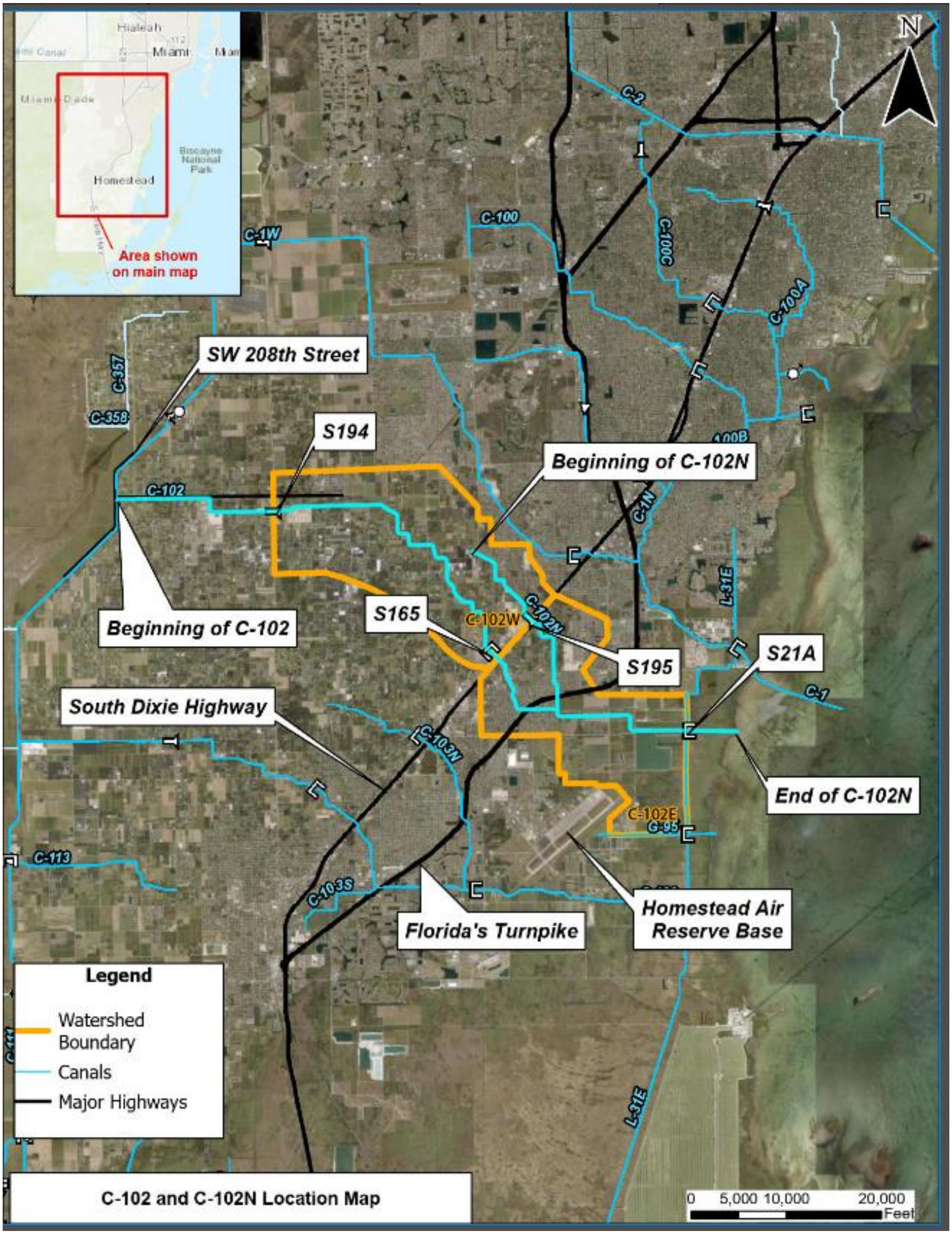


Figure 73: Location Map

Cost Estimate

The cost estimate for the proposed improvements is presented in the below cost summary table. The cost estimate is a high-level cost estimate based on a conceptual design and assumption listed below. The cost summary table also includes construction costs, design and construction management costs, and real estate costs. The methodology for developing the costs includes performing quantity takeoffs, and applying historical unit cost data from the District database.

Item	Cost
Dredge Canal C-102	$28,162,999
Dredge Canal C-102N	$859,103
Design, Implementation & CMS at 15%	$4,353,315
Real Estate	--
Adjusted 2024 Cost Total	$33,375,418

Assumptions

- The dredge profile would be a consistent slope to remove impediments.
- Canal bottom width for the C-102 Canal at 25 feet wide, and for the C-102N Canal 10 feet wide, with 1H:1V side slopes.
- Proposed Canal Profile assumed based on providing a uniform grade to provide an overall result that will maintain current conveyance capacity, considering sea level rise conditions that will reduce hydraulic gradient.
- Unit cost based on District reference costs per cubic yard in Miami.

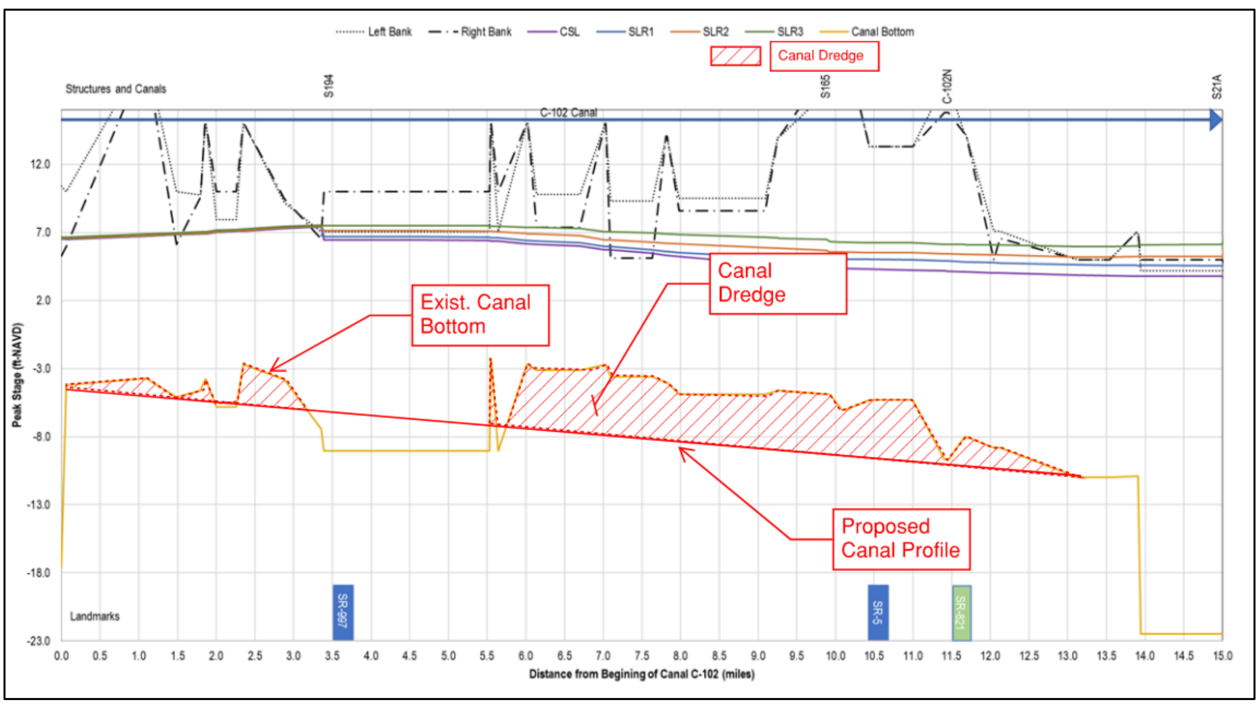


Figure 74a: C102 Proposed Canal Profiles

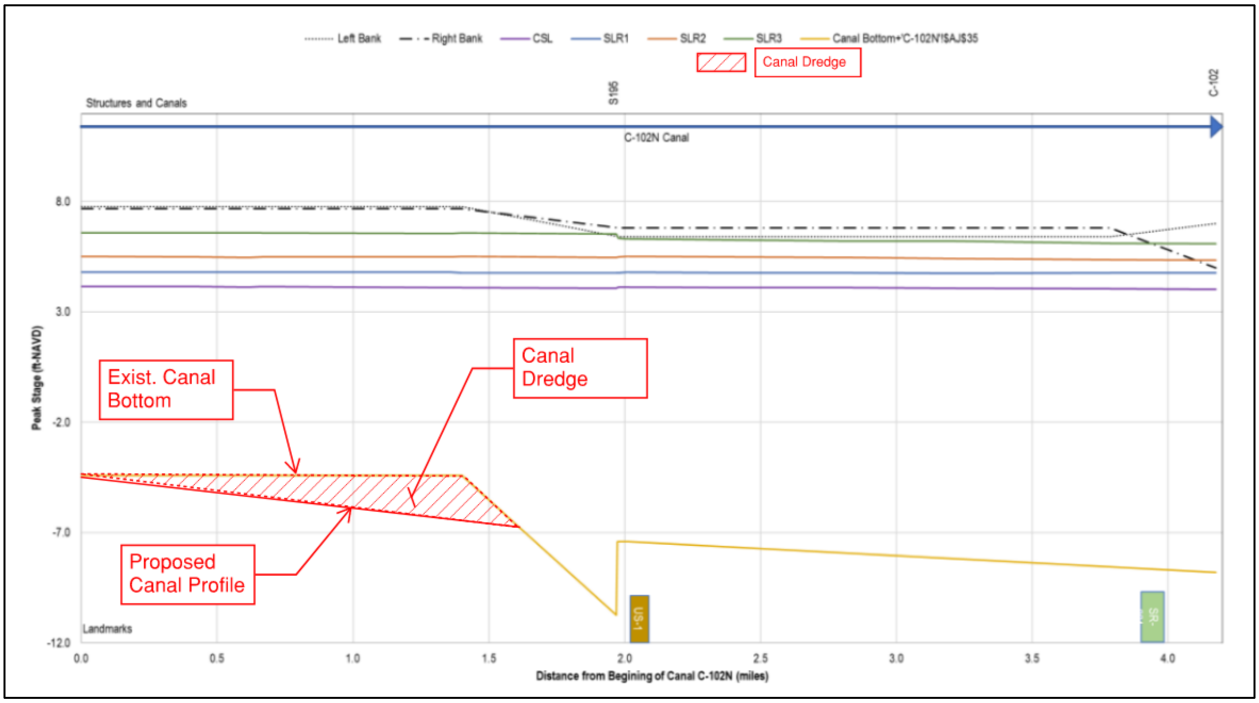


Figure 74b: C-102N Proposed Canal Profiles

C-103 and C-103N Basin Resiliency

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

Figure 1 – Aerial image of the S20F Structure site

This resiliency project is mainly tied to the District's mission to provide flood control and water supply protection. 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 was designed to 1) maintain optimum stages upstream along the C-103 Canal, 2) restrict downstream flood stages and discharge velocities to non-damaging levels, and 3) prevent 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, sea level rise, 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.

Cost Estimate

Structure Enhancement	$11,242,567
Forward Pump (725 cfs)	$56,849,063
Forward Pump Backup Generator Facility	$5,684,906
Structure Tie Back (Flood Barrier)	$3,075,000
Design, Implementation & Construction Management	$11,527,730
Real Estate	$7,000,000
Adjusted 2024 Cost	**$95,379,266**

C-103 and C-103N Canal Embankment Resiliency

Canal bank elevation improvements for the C-103 and C-103N Canals are proposed in order to help achieve the District's mission of providing flood control and protection.

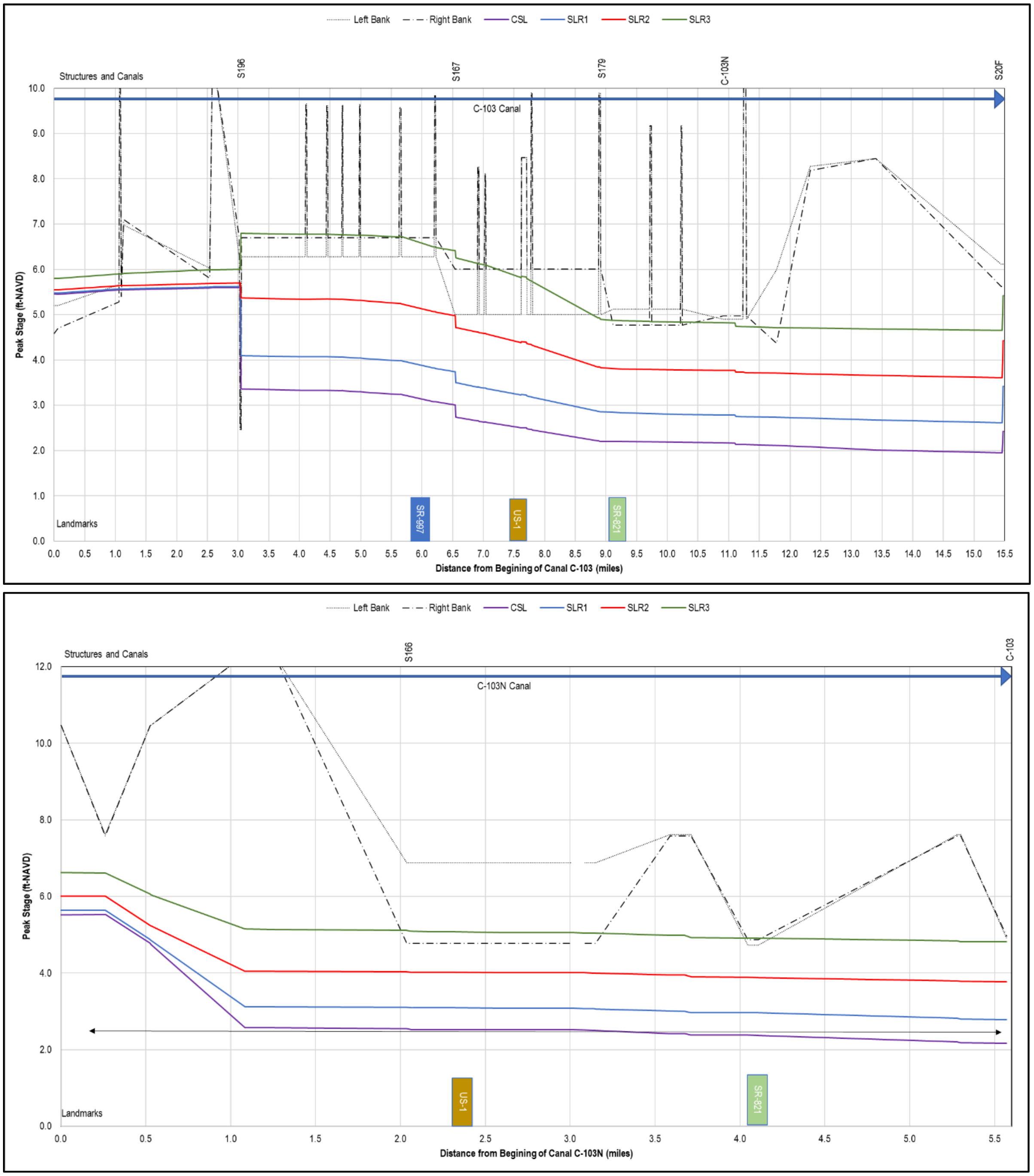


Figure 75: C-103 and C-103N Canal Banks and Surface Water Profiles of Peak Stages for the 25-yr Design Storm with 3 feet SLR

The canal banks are overtopped for 3 feet SLR as depicted in Figure 77.

This project is intended to raise the current level of service (LOS) rating of the canals from 5-yr at 0 feet of Sea Level Rise (SLR) to a 25-yr LOS rating at 3.0 feet of SLR. This project will include raising the existing canal bank elevations to the storm surge elevation for a 25-yr 3-day storm event plus 3 feet of sea level rise and freeboard along 22 miles of canal at a 3:1 slope on both sides of the canal banks. The proposed elevation increases vary from 0 to 5 feet depending on the existing canal elevations and conditions, with an average fill height of 2.5 feet on both the left and right bank for the C-103 and the C-103N Canal. Refer to Figures 78 and 79for the minimum bank fill profile based on 3 feet of freeboard atop the SLR3 profile. The elevation improvements will eliminate the potential of canal bank overtopping and flooding of the adjacent areas.

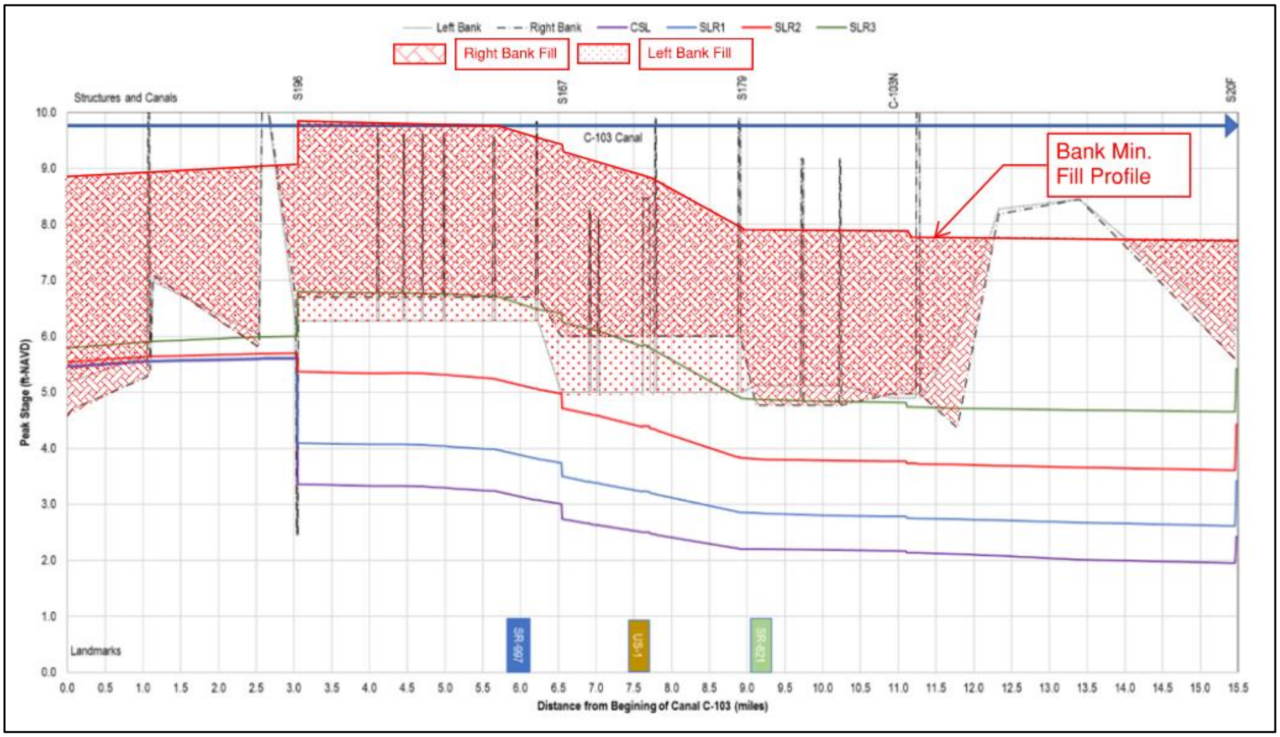


Figure 76: Recommended Fill for Canal Banks and Surface Water Profiles of Peak Stages for the 25-yr Design Storm with 3 feet SLR

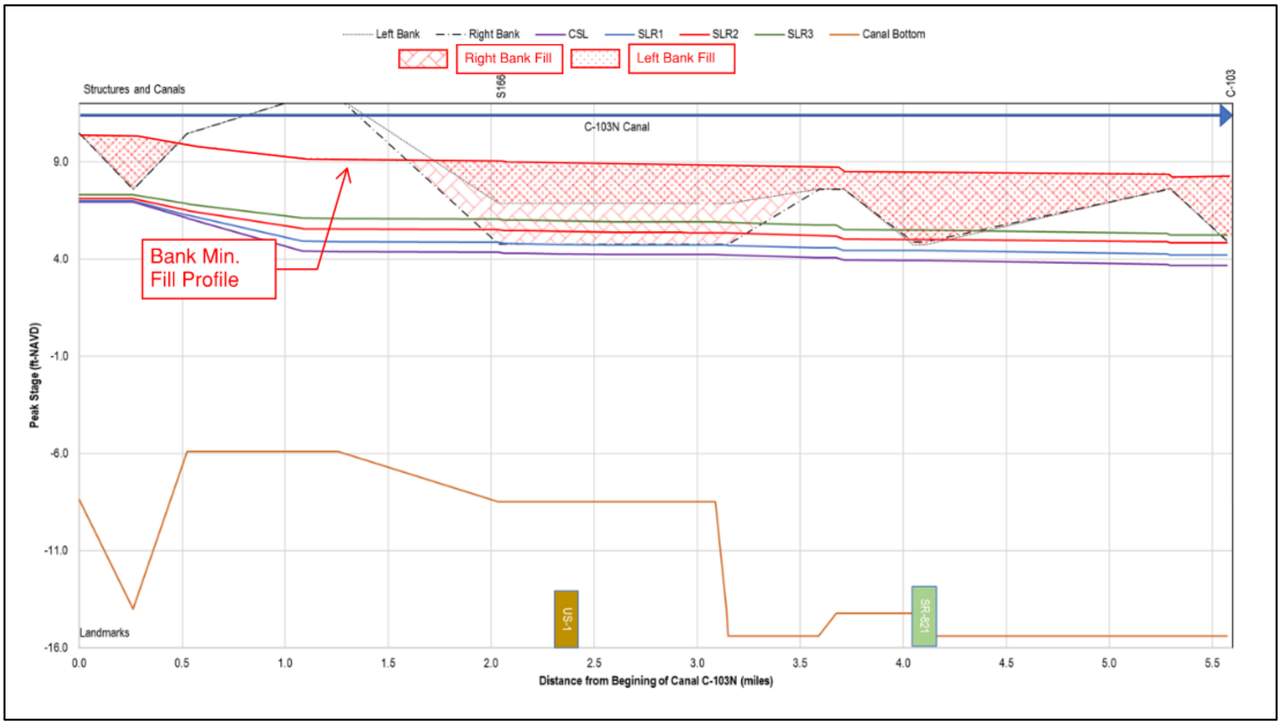


Figure 77: Recommended Fill for Canal Banks and Surface Water Profiles of Peak Stages for the 25-yr Design Storm with 3 feet SLR

The C-103 and C-103N Canals are located in Watershed C-103 (Figure 80). C-103 begins at the intersection of L-31N and SW 266th Street and is approximately 15.5 miles long. C-103N is approximately 5.6 miles long and begins south of the intersection of SW167th Avenue and SW 256th Street. The total length of the proposed bank improvements is approximately 31 miles for the left and right bank of the C-103 Canal and 11.2 miles for the left and right bank of the C-103N Canal. Approximately 88% of the C-103 banks and 82% of the C-103N banks have deficient heights in comparison to the SLR3 25-yr water profile plus 3 feet of freeboard.

The C-103 and C-103N Canals serve several functions within the C-103 Watershed. The C-103 and C-103N Canals are also the primary canals in the C-103 Watershed. They provide services such as flood protection, drainage, irrigation, and maintaining the groundwater table at elevations adequate to prevent saltwater intrusion. This project is intended to raise the current LOS rating of the canals from 5-yr at 0 feet of SLR to a 25-yr LOS rating at 3.0 feet of SLR. The purpose of the proposed work is to provide increased flood protection for areas adjacent to the canals due to rising sea levels and future land use changes within the basin. As a result of these changing conditions within the basin, the current canal elevations no longer adequately protect surrounding areas. By increasing the height of the canal bank elevations, it is less likely there will be overtopping and flooding in adjacent areas. The proposed improvements will provide improved flood protection for approximately 62.3 square miles. These projects will benefit approximately 180,000 people located in the jurisdictions of the Miami-Dade and Homestead municipalities. These canals are located mostly in residential areas, however, they do cross two major highways, the South Dixie Highway and the Florida Turnpike.

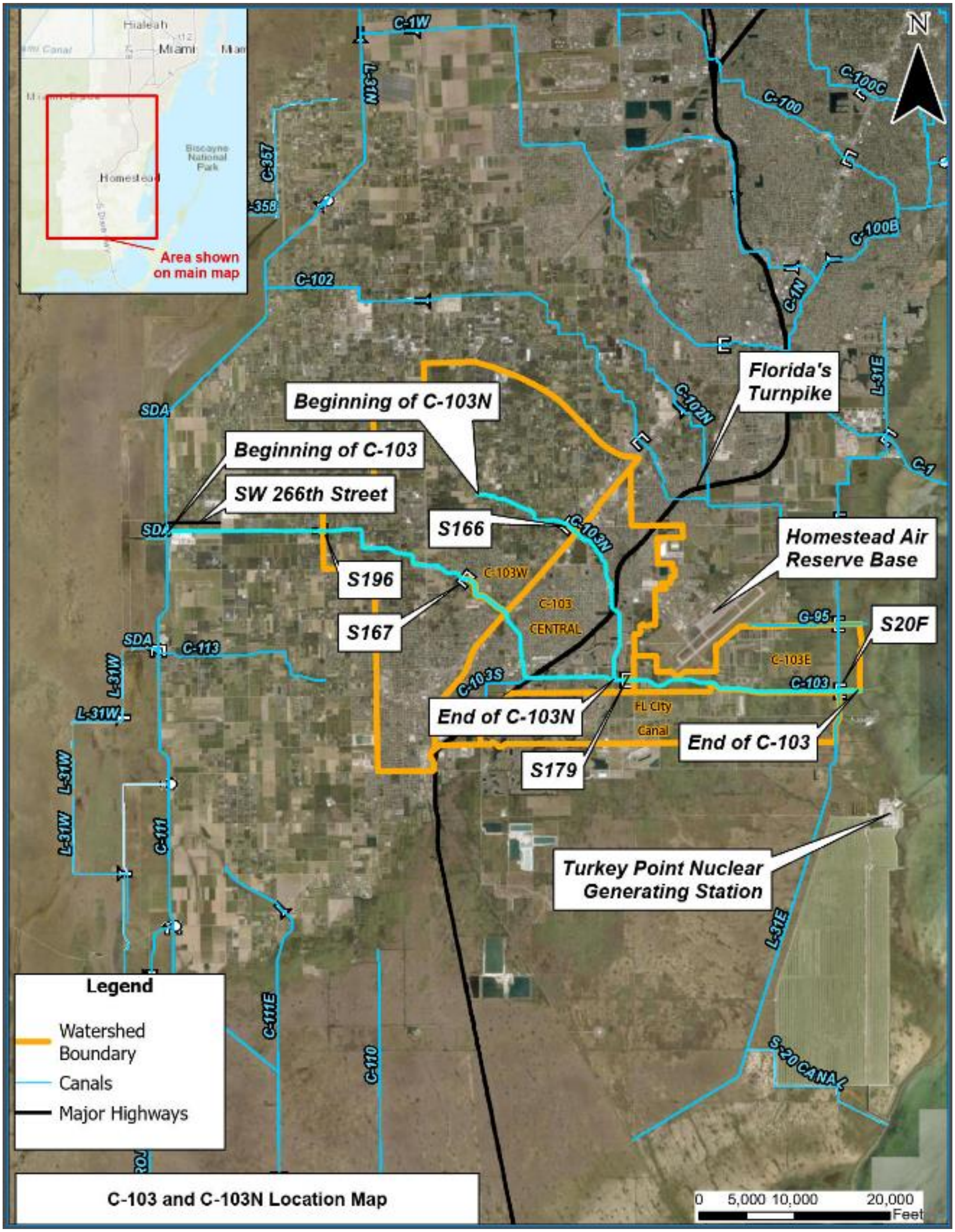


Figure 78: C-103 and C-103N Location Map

Cost Estimate

The cost estimate for the proposed improvements is presented in the below cost summary table. The cost estimate is a high-level cost estimate based on a conceptual design and assumption listed below. The cost summary table also includes construction costs, design and construction management costs, and real estate costs. The methodology for developing the costs includes performing quantity takeoffs, and applying historical unit cost data from the District database.

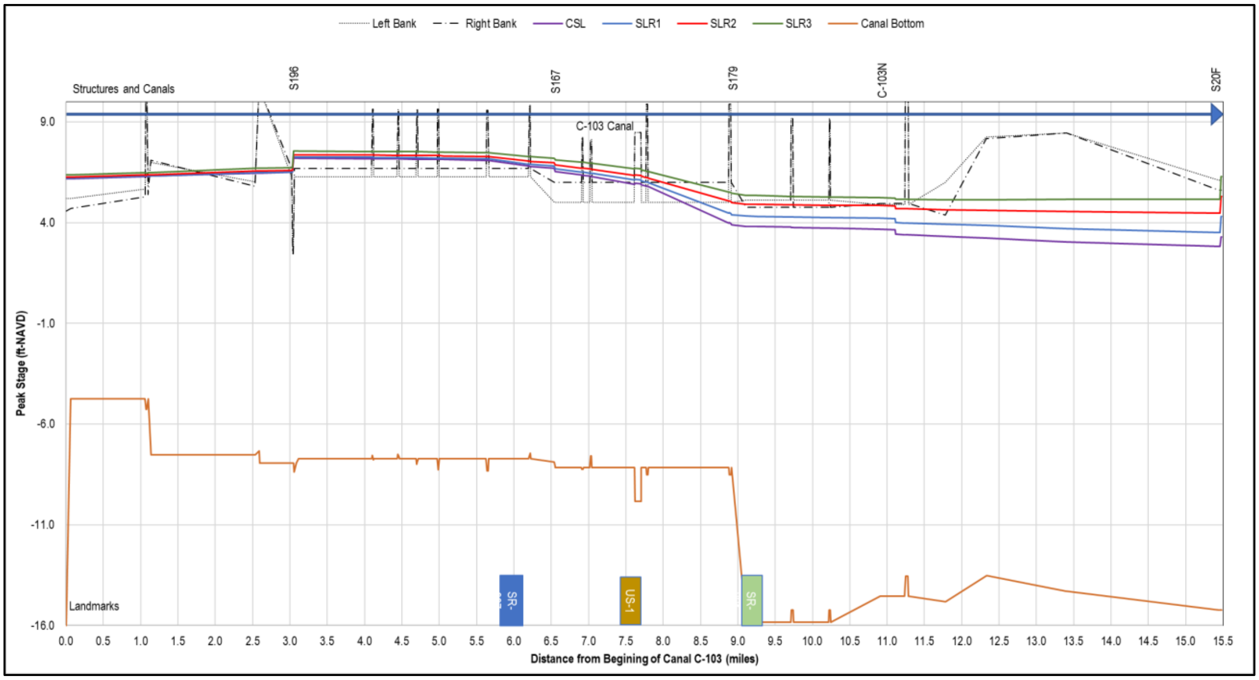
Item	Cost
Raise Left Embankment C-103	$81,858,565
Raise Right Embankment C-103	$75,321,222
Raise Left Embankment C-103N	$6,427,194
Raise Right Embankment C-103N	$22,764,530
Design, Implementation & CMS at 15%	$27,955,727
Real Estate	--
Adjusted 2024 Cost Total	$214,327,237

Assumptions

- Left and right top of bank would be raised to three feet above the SLR 3 profile.
- Left and right banks would be a minimum of 14 feet wide at the top with 3H:1V side slopes.
- Unit cost based on interpolation of District reference costs for average embankment height of 2.6ft for the left embankment and 2.5ft for the right embankment for the C-103 Canal. For the C-103N Canal the average embankment height is 1.7ft for the left embankment and 2.8ft for the right embankment. Costs were provided per linear feet of embankment in 0.5ft height increments from 0.5ft to 2.5ft.

C-103 and C-103N Canal Dredging Resiliency

Dredging of the C-103 and C-103N Canals is proposed in order to help achieve the District's mission of providing flood control and protection.



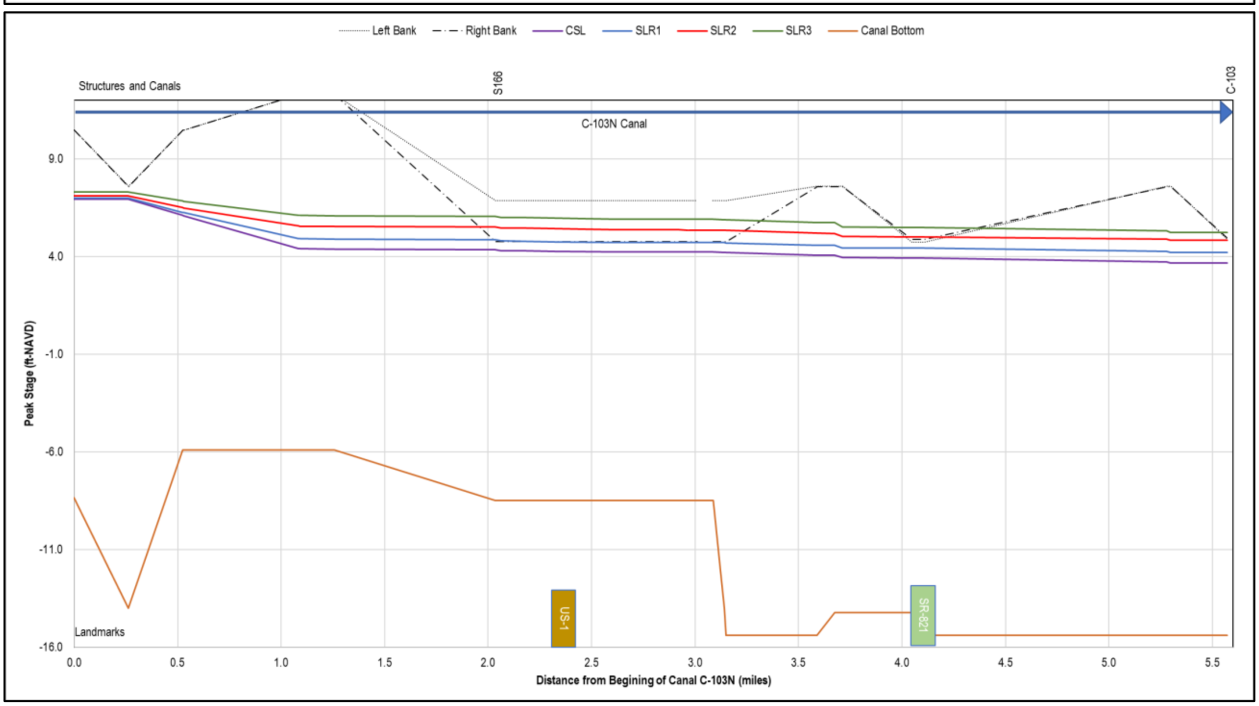


Figure 79: C-103 and C-103N Canal Banks and Surface Water Profiles of Peak Stages for the 25-yr Design Storm with 3 feet SLR

This project will include dredging the bottom of the C-103 and C-103N from their current elevations to their originally designed as built elevation. The purpose of this dredging is to create a smooth gradient across the entire length of the canal as well as remove sediments which have accumulated over time. In order to determine the depth of dredging the canals the project will require additional bathymetric and cross sectional survey information to further define the dredge depth and excavated volume of material information. Refer to the list of assumptions made in the cost estimate section of this report regarding the proposed improvements for an estimate of the dredged depth and average canal widths.

The C-103 and C-103N Canals are located in Watershed C-103 (Figure 82). C-103 begins at the intersection of L-31N and SW 266nd Street and is approximately 15.5 miles long. C-103N is approximately 5.6 miles long and begins south of the intersection of SW167th Avenue and SW 256th Street. C-103 and C-103N Canals have a total proposed dredging volume of approximately 55,000 cubic yards (cy).

The proposed improvements would provide flood protection for approximately 62.3 square miles. These projects will benefit approximately 180,000 people located in the jurisdictions of the Miami-Dade and Homestead municipalities. Additionally, there are several pieces of critical infrastructure that will benefit from the project including the Florida Turnpike, South Dixie Highway, the Kendall-Tamiami Airport, the Miami-Dade Police Station, the Miami-Dade Landfill, and the South District Wastewater Treatment Plant.

The purpose of the proposed work is to provide increased flood protection level of service (LOS) to accommodate a 25-yr 3-day storm under conditions of 3.0 feet of Sea Level Rise (SLR). These improvements will provide protection for areas adjacent to the canals due to rising sea levels and sediment accumulation within the canals. As a result of these changing conditions within the basin, the current canal depth is shallower than the original design and no longer adequately protects surrounding areas. By dredging out accumulated sediments within the canals more water storage can be provided, and it is less likely there will be overtopping and flooding in adjacent areas. Dredging will be completed in conjunction with canal bank elevation increases and maintenance in the proposed canals. Additional proposed work includes hydrographic surveys of the canals to determine which sections would have the most hydraulic benefit most from proposed improvements.

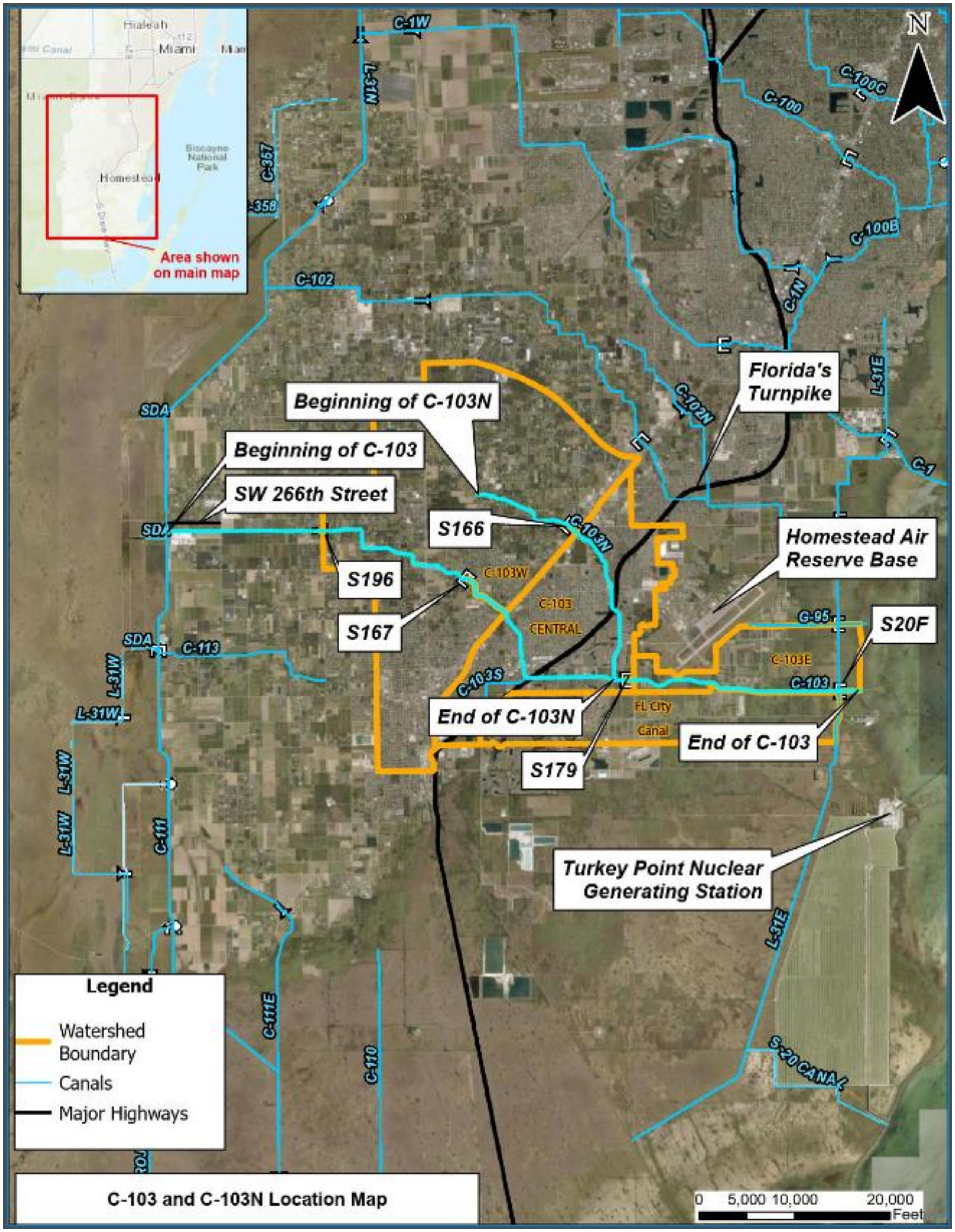


Figure 80: Location Map

Cost Estimate

The cost estimate for the proposed improvements is presented in the below cost summary table. The cost estimate is a high-level cost estimate based on a conceptual design and assumption listed below. The cost summary table also includes construction costs, design and construction management costs, and real estate costs. The methodology for developing the costs includes performing quantity takeoffs, and applying historical unit cost data from the District database.

Item	Cost
Dredge Canal C-103	$5,757,113.60
Dredge Canal C-103N	$2,396,350.60
Design, Implementation & CMS at 15%	$1,223,019.63
Real Estate	--
Adjusted 2024 Cost Total	**$9,376,483.83**

Assumptions

- The dredge profile would be a consistent slope to remove impediments.
- Canal bottom width for the C-103 Canal at 31 feet wide, and for the C-103N Canal 30 feet wide, with 1H:1V side slopes.
- Proposed Canal Profile assumed based on providing a uniform grade to provide an overall result that will maintain current conveyance capacity, considering sea level rise conditions that will reduce hydraulic gradient.
- Unit cost based on District reference costs per cubic yard in Miami.

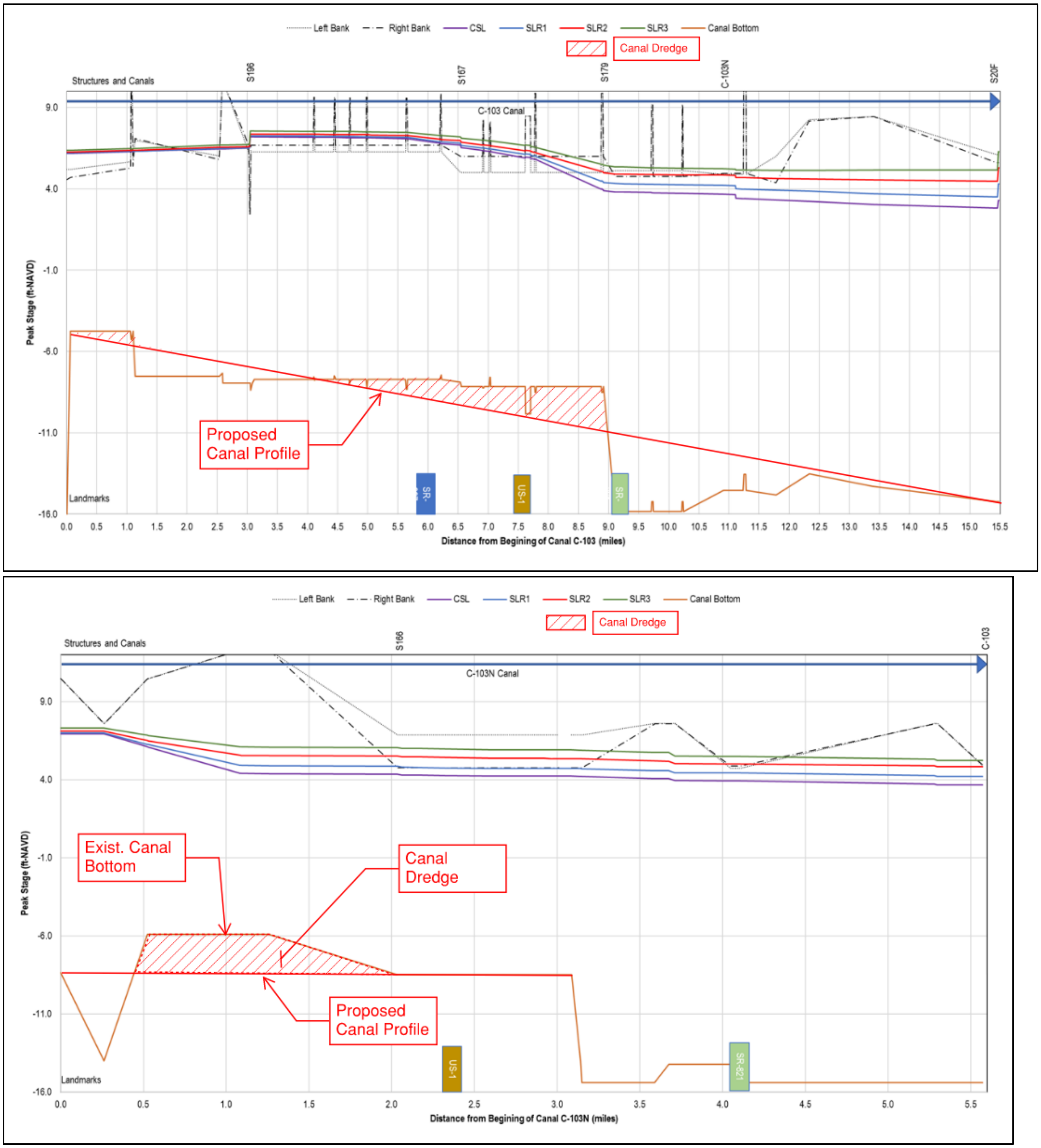


Figure 81: C103 and C103N Proposed Canal Profiles

L-31NS Basin Resiliency

S-176 Structure Resiliency

S-176 is a one-bay, reinforced concrete gated spillway at the boundary between watersheds L-31NS and C111-AG, and located on the divide between the L-31 Canal and the C-111 Canal between S-331 and S-177, about 5 miles west of Homestead. The structure has one (1) 8.0 feet high by 20.8 feet wide gates with a sill elevation of -1.0 feet NGVD29.

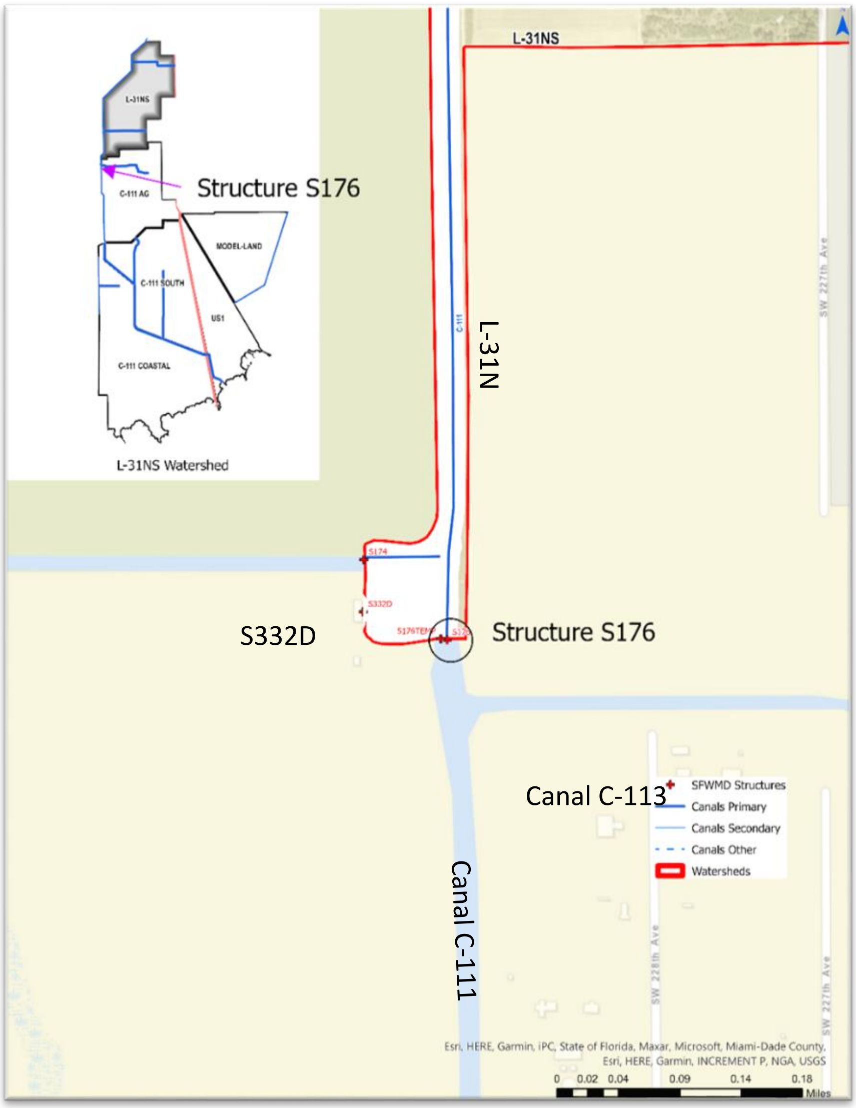


Figure 82: Location of Pump Construction in Watershed L-31NS to Supplement Discharges in Structure S176

The discharge from this structure is controlled by an electric cable drum operated vertical lift gate. The gate can either be remotely operated from the SFWMD Operation Control Center or controlled on-site. The structure was completed in 1967 and is currently maintained by the Homestead Field Station.

This structure maintains optimum upstream stages in the L-31N Canal. It was designed to pass 40% of the Standard Project Flood (SPF) without exceeding upstream flood design stage and restricts downstream flood stages and discharge velocities to non-damaging levels The structure has a design capacity of 630 cfs and a normal headwater operating range from 2.95 ft to 3.45 ft NAVD 88 (4.5 ft NGVD to 5.0 ft NGVD). Analysis of structure S176 was conducted for PM2, PM 3 and PM 4 and this structure was reviewed for potential issues, and the need to increase discharge capacity for future SLR conditions and changes of hydrology.
The service bridge elevation 9.45 feet NVD, water levels which can bypass the structures are 9.45 ft NAVD. A review of the headwater showed that the structure will not be overtopped for the 100-yr event with 3 ft of SLR considering that for the 100-yr event with 3 ft SLR the peak head water elevation is 6.45 ft NAVD. The design discharge (630 cfs) is exceeded for the CSL and for the 25-yr event and is approximately equal to the SPF discharge for the CSL event and is below the SPF discharge for future events which also indicates reduced capacity for increased SLR. It is proposed to double the capacity of S176 by installing a pump station with a capacity of 630 cfs.

As part of the Flood Protection Level of Service (FPLOS) preliminary mitigation project identification, a suggested approach to mitigate flooding and enhance flood protection in the L-31N Watershed involves increasing the pumping capacity of the structure. Due to sea level rise, the S176 tailwater stage is anticipated to frequently surpass the headwater stage, causing the underflow gate to remain closed and significantly reducing the structure's discharge capacity. Consequently, additional pump capacity is deemed necessary. While the 100-year sea level rise (SLR) storm surge for current conditions is not expected to overtop S176, it is projected to reduce the structure discharge capacity because of reduced hydraulic gradient for future conditions for SLR greater than 2 and 3 ft.

The primary considerations for cost analysis include engineering and design costs, encompassing studies and plans to integrate the pump station with the existing gravity structure effectively. Material costs involve the selection and procurement of equipment and materials necessary for pump station construction. Construction costs encompass labor, specialized equipment, and the execution of tasks such as excavation, foundation work, and the installation of pumping equipment. Electrical and mechanical components required for the pump station's operation contribute to overall costs. Environmental considerations, including potential impacts on local ecosystems, may necessitate additional measures and costs for compliance. Permitting and regulatory compliance costs are factored in for obtaining necessary approvals and ensuring adherence to relevant regulations. Contingency budgets are included to address unforeseen challenges during construction. Additionally, operational and maintenance costs over the pump station's lifecycle are considered in the overall estimation. These cost assumptions provide a foundational framework for budgeting, emphasizing the need for detailed assessments for accurate and project-specific estimations. The total cost was estimated assuming $66,250/cfs.

Cost Estimate

Item	Pump Costs	Proposed Discharge (cfs)	Adjusted 2024 Cost Total
Pump Station Construction	$66,250/cfs	630	$ 44,659,125

Project Benefits: The proposed pump station installation aims to enhance flood protection for approximately 7.02 square miles, primarily consisting of agricultural lands within watershed L-31NS. Within the 3.5 square miles of the Urban Area, an estimated 4,200 people residing in Unincorporated Miami-Dade County stand to benefit from this enhancement. The strategic implementation of pumps within upstream watersheds emerges as a crucial enhancement to resilience against sea level rise impacts. By integrating pumps into the canal infrastructure, the diminishing hydraulic gradient resulting from sea level rise and storm events is addressed, thereby bolstering the conveyance efficiency of the canals. This improvement in conveyance not only counteracts the challenges posed by rising sea levels but also plays a pivotal role in mitigating potential flooding in the agricultural and the residential areas upstream structure S176. The incorporation of pumps enables the controlled and efficient movement of water within the canal system, effectively counterbalancing the hydraulic challenges brought about by sea level rise and fortifying the resilience of agricultural lands against inundation. Additionally, the heightened conveyance capacity minimizes the risk of sea intrusion, securing vital ecosystems and preventing salinity issues that could adversely impact agricultural productivity. The enhanced conveyance facilitated by strategically placed pumps acts as a proactive measure against storm surge impacts.

L-31N Canal Embankment Resiliency

The L-31N canal originates at the convergence point of canals C-4, L-30, and L-29, extending towards structure S176, which serves as the division between canals L-31N and C-111. The L-31N Canal separates the drainage in south Miami-Dade County into easterly and westerly flows. The L-31N Canal Levee plays a crucial role in preventing overflow from Everglades National Park (ENP) into the predominantly agricultural development in the southern part of Miami-Dade County. Recent studies conducted as part of the Florida Resilient Coastlines Project (FPLOS) in 2023 revealed potential vulnerabilities, indicating that the canal banks of L-31N could be overtopped, leading to flooding impacts on the agricultural areas.

Retrofitting and increasing the eastern canal bank elevation of L-31NS can provide reduction of flood extent and duration within the agricultural areas of the watershed and increase of the FPLOS rating to greater than the watershed 5-yr rating. The results of Phase I of FPLOS project showed that the SLR does not significantly increase the flood extent, however, the flood duration increased with both SLR, and rainfall return period. Development of local flood mitigation projects and installation of secondary canals were suggested along with local drainage improvements to reduce flood duration, and the addition of ditches and local pumps to L-31NS Canal.

This project will include raising portions of the existing canal bank elevations of on the left side (looking downstream in the direction of flow in canal L-31N) anticipated canal elevation of a 25-yr 3-day storm event with 3 feet of SLR plus freeboard along a total of 10 miles of canal banks. 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. Figure 84 illustrates the existing canal embankments for L-31N from the Flood Protection LOS Performance Metric PM1 of the C-111 FPLOS. The L-31N Canal has a total proposed left embankment improvement length of approximately 10.2 miles, resulting in an average elevation of 2.66 ft, average cross section deficiency 625 ft^2 and a total volume of infill required for 10.2 miles is 201,800 cubic yards. The proposed canal embankments are assumed 3 feet above the canal water profile for SLR.

Figure 83. Profile of Peak Stages in Canal L-31N from Pump Station S331 to Structure S176 for 25-yr Design Event and Proposed Top of Left Canal Bank Elevation. Data from the Flood Protection LOS Performance Metric PM1 of the C-111 FPLOS

By increasing the height of the canal bank elevations within this watershed, it is less likely there will be overtopping and flooding in these adjacent areas within the watershed. The canal bank elevations will be improved by using either suitable dredged material from the adjacent canal and/or imported fill, or a combination of material as needed.

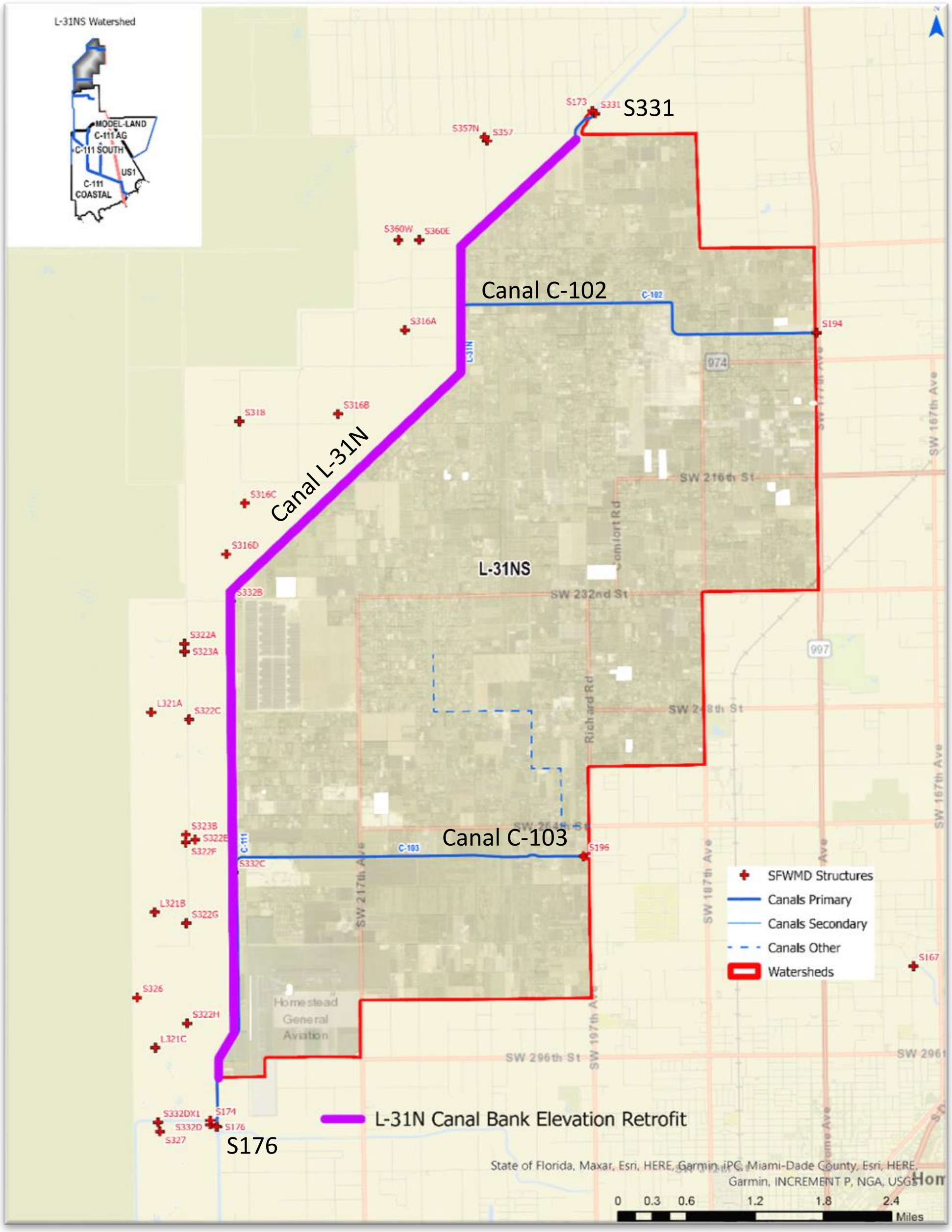


Figure 84: Location of Canal L-31N Upgrades of the Eastern Canal Bank Elevation

This document outlines the conceptual methodology for estimating costs related to elevating the L-31N top left canal bank to address improved resiliency and decrease of flood impacts within the L-31NS watershed due to extreme rainfall events, sea level rise, climate change, and land use changes in the basin, which contribute to higher canal elevations and bank exceedances.

Estimating conceptual costs for increasing canal bank and levee elevations involves a comprehensive assessment of various factors influencing the construction and modification processes which include conducting studies to evaluate existing conditions and designing elevation changes in adherence to safety standards and regulatory requirements.

The choice of materials significantly impacts costs, with options ranging from traditional soil and clay to more engineered solutions such as geotextiles or geomembranes. Construction costs encompass labor, equipment, and the execution of tasks like excavation, grading, and material placement. Specialized equipment may be necessary depending on project complexity. Environmental considerations, particularly in ecologically sensitive areas, may introduce additional measures and costs to protect the surroundings. Permitting and regulatory compliance expenses are also factors, encompassing fees and assessments for adherence to local, state, and federal regulations. Including a contingency budget is common to address unforeseen circumstances or changes in project scope, and risk management costs may be factored in for potential challenges during construction. Surveying and geotechnical investigations are integral for understanding existing conditions and soil properties, contributing to overall project accuracy. These conceptual costs provide an initial framework for budgeting, emphasizing the need for detailed site assessments and collaboration with engineering and construction professionals for precise estimations tailored to specific project requirements.

Left and right banks would be a minimum of 18 feet wide at the top with 3H:1V side slopes. The Embankment fill project will be separate from the canal dredging project, resulting in additional cost items for General, Clearing, Erosion Control, and Finish Grade & Sod. The basis of the costs was assumed $60/cubic yard.

The analysis of topography along the canal locations, current elevations top of the banks the deficiency of canal infill was calculated and determined that L-31N Canal has a total proposed left embankment improvement length of approximately 10.2 miles, resulting in an average elevation of 2.66 ft, average cross section deficiency 625 ft^2 and a total volume of infill required for 10.2 miles is 201,800 cubic yards.

Cost Estimate

Item	Quantity, cubic yard	Cost $/cuy	Adjusted 2024 Cost Total
Embankment Fill	201,800.00	$60/cuy	$ 12,955,560

Project Benefits: The proposed canal bank retrofit aims to enhance flood protection for approximately 7.02 square miles, primarily consisting of agricultural lands. Within the 3.5 square miles of the Urban Area, an estimated 4,200 people residing in Unincorporated Miami-Dade County stand to benefit from this enhancement. Ensuring the robust protection of canal banks against overtopping due to sea level rise is a critical measure aimed at mitigating potential flooding in both agricultural and residential areas. As sea levels continue to rise, the risk of inundation amplifies, posing a direct threat to vulnerable communities. By fortifying canal banks, the resulting barrier that not only safeguards against overtopping but also acts as a shield against sea intrusion. This proactive approach not only protects valuable agricultural lands from submersion but also ensures the integrity of residential areas, shielding homes and infrastructure from the devastating consequences of flooding. Moreover, fortified canal banks play a pivotal role in minimizing the impacts of storm surge events, acting as a primary defense line during extreme weather conditions.

C-111 AG Basin Resiliency

S-177 Structure Resiliency

S-177 is a reinforced concrete, gated spillway located in the C-111 Canal just downstream from SR 9336 (Ingraham Highway), southwest of Florida City in the Miami-Dade County at the downstream boundary of Watershed C-111 Ag, controlling discharges to Watershed C-111 South. S-177 is located about 5.5 miles south/downstream of S-176. The structure consists of one 12.6 feet high and 22.8 feet wide gate with a sill elevation of -7.1 feet NGVD29.

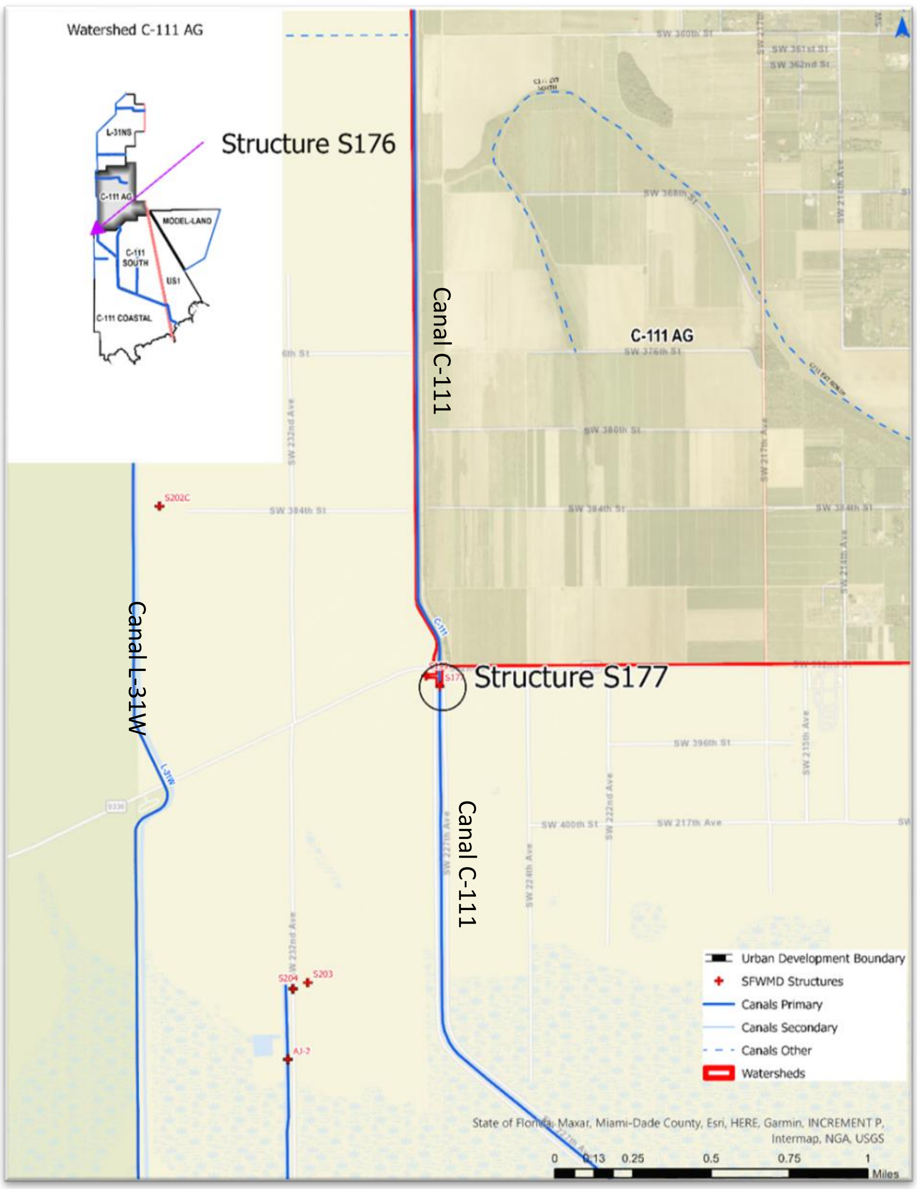


Figure 85: Location of Structure S176

The discharge from the structure is controlled by a hydraulically driven cable operated vertical lift gate. The gates can either be remotely operated from the SFWMD Operation Control Center or controlled on-site. The structure is currently maintained by Homestead Field Station. S-177 was initially constructed to maintain optimum stages in the C-111 Spreader Canal. It was designed to pass 40% of the Standard Project Flood (SPF) without exceeding upstream flood design stage and restricts downstream flood stages and discharge velocities to non-damaging levels.

During moderately dry conditions, S-177 can pass sufficient flow to maintain stages downstream within a half-foot of the water supply levels. With a design capacity of 1,400 cfs, S177 is positioned south of S176. The service bridge elevation is 7.45 feet NVD, and the water levels capable of bypassing the structure are 7.45 ft NAVD. After reviewing the headwater, it was determined that the structure does not experience overtopping during the 100-year event with 3 ft of SLR. This conclusion is based on the peak headwater elevation of 6.45 ft NAVD for the 100-year event with 3 ft SLR. An upgrade of the structure is proposed by addition of pump station with capacity of 400 cfs based on the results from modeling for SLR 3 which showed that the structure cumulative discharges declined for increased Sea Level Rise.

An upgrade of the structure is proposed by 400 cfs based on the results from modeling SLR 3, which showed that the structure cumulative values decline for SLR3.

As part of the Flood Protection Level of Service (FPLOS) preliminary mitigation project identification, a suggested approach to mitigate flooding and enhance flood protection in the C-111 Ag Watershed involves increasing the pumping capacity of the structure. Due to sea level rise, the S177 tailwater stage is anticipated to frequently surpass the headwater stage, causing the underflow gate to remain closed and significantly reducing the structure's discharge capacity. Consequently, additional pump capacity is deemed necessary. While the 100-year sea level rise (SLR) storm surge for current conditions is not expected to overtop S177, it is projected to reduce the structure discharge capacity because of reduced hydraulic gradient for future conditions for SLR greater than 2 and 3 ft.

The primary considerations for cost analysis include engineering and design costs, encompassing studies and plans to integrate the pump station with the existing gravity structure effectively. Material costs involve the selection and procurement of equipment and materials necessary for pump station construction. Construction costs encompass labor, specialized equipment, and the execution of tasks such as excavation, foundation work, and the installation of pumping equipment. Electrical and mechanical components required for the pump station's operation contribute to overall costs. Environmental considerations, including potential impacts on local ecosystems, may necessitate additional measures and costs for compliance. Permitting and regulatory compliance costs are factored in for obtaining necessary approvals and ensuring adherence to relevant regulations. Contingency budgets are included to address unforeseen challenges during construction. Additionally, operational and maintenance costs over the pump station's lifecycle are considered in the overall estimation. These cost assumptions provide a foundational framework for budgeting, emphasizing the need for detailed assessments for accurate and project-specific estimations. The total cost was estimated assuming $66,250/cfs.

Cost Estimate

Item	Pump Costs per cfs	Proposed Discharge	Adjusted 2024 Cost Total
Pump Station Construction	$66250/cfs	400 cfs	$ 28,355,000

Project Benefits: The proposed pump station installation aims to enhance flood protection for approximately 18.75 square miles, primarily consisting of agricultural lands. Within the 5.6 square miles of the Urban Area, an estimated 2,800 people residing in Unincorporated Miami-Dade County stand to benefit from this enhancement. The strategic implementation of pumps within upstream watersheds emerges as a crucial enhancement to resilience against sea level rise impacts. By integrating pumps into the canal infrastructure, the diminishing hydraulic gradient resulting from sea level rise and storm events is addressed, thereby bolstering the conveyance efficiency of the canals. This improvement in conveyance not only counteracts the challenges posed by rising sea levels but also plays a pivotal role in mitigating potential flooding in the agricultural and residential areas upstream structure S176. The incorporation of pumps enables the controlled and efficient movement of water within the canal system, effectively counterbalancing the hydraulic challenges brought about by sea level rise and fortifying the resilience of agricultural lands against inundation. Additionally, the heightened conveyance capacity minimizes the risk of sea intrusion, securing vital ecosystems and preventing salinity issues that could adversely impact agricultural productivity. The enhanced conveyance facilitated by strategically placed pumps acts as a proactive measure against storm surge impacts.

S-178 Structure Resiliency

S-178 is a compound structure, located at the north end of C-111E Canal at Ingraham Highway (State Road 9336), about 5 miles southwest of Homestead in Miami-Dade County and manages the discharge from C-111 AG to Watershed C-111 SOUTH. The structure is at the outlet of C-111E basin lowland slough, where seasonal agriculture and residential properties are located.

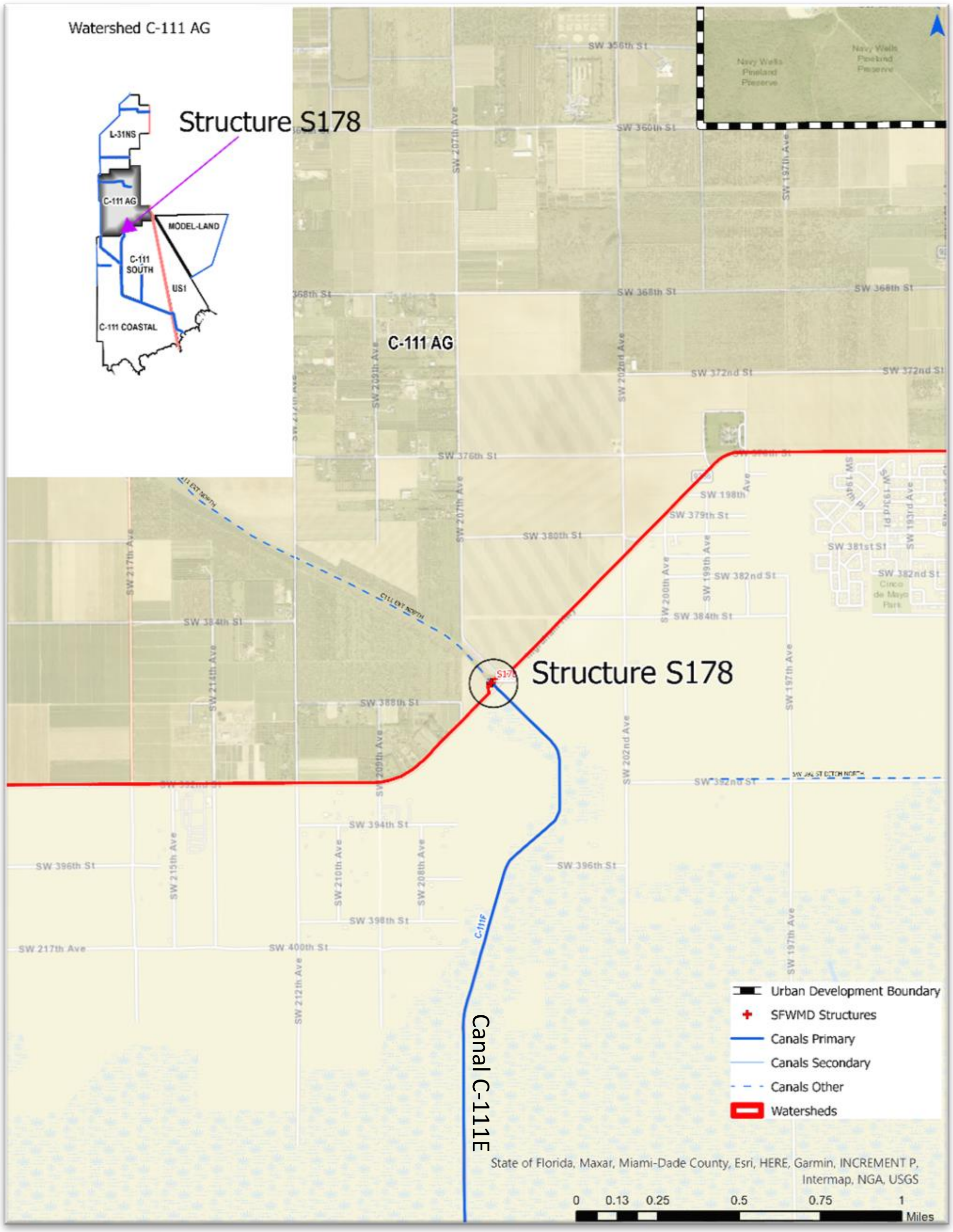


Figure 86: Location of Structure S178

The slough is a very shallow swale which is maintained by the adjacent property owners. A minor rain event will cause flooding within the slough to the groves. Theoretically, flow can be controlled by two (2) 8.0 feet high by 8.0 feet manually operated vertical sluice gate with sill elevations of -3.0 feet NGVD29, a weir at 6.5 feet NGVD29, and a reinforced concrete box culvert of 12.0 feet high by 10.0 feet wide. The structure was built in 1966 by the USACE and is currently maintained by the Homestead Field Station. S-178 releases water from the C-111E to the C-111 Canal, upstream of S-18C. This structure was originally designed to maintain optimum upstream water control stages in C-111E Canal; It was designed to pass 40% of the Standard Project Flood (SPF) (or up to the amount which will reach the structure) without exceeding the upstream flood design stage and restricts downstream flood stages and channel velocities to non-damaging levels.

Structure S178 has a design capacity of 500 cfs and is responsible for releasing water from C-111E to the C-111 upstream of S18C. The service bridge elevation is 13.95 feet NVD, and the water levels capable of bypassing the structure are 4.45 ft NAVD. A review of the headwater indicated that the structure would be subject to overtopping during the 100-year event with 3 ft of SLR. This assessment is based on the peak headwater elevation exceeding 5.45 ft NAVD for this particular event.

As part of the Flood Protection Level of Service (FPLOS) preliminary mitigation project identification, a suggested approach to mitigate flooding and enhance flood protection in the C-111 Ag Watershed involves increasing the pumping capacity of the structure. Due to sea level rise, the S178 tailwater stage is anticipated to frequently surpass the headwater stage, causing the underflow gate to remain closed and significantly reducing the structure's discharge capacity. Consequently, additional pump capacity is deemed necessary. While the 100-year sea level rise (SLR) storm surge for current conditions is not expected to overtop S178, it is projected to reduce the structure discharge capacity because of reduced hydraulic gradient for future conditions for SLR greater than 2 and 3 ft. An upgrade of the structure is proposed by 250 cfs based on the results from modeling SLR 3, which showed that the structure cumulative values decline for SLR3.

The primary considerations for cost analysis include engineering and design costs, encompassing studies and plans to integrate the pump station with the existing gravity structure effectively. Material costs involve the selection and procurement of equipment and materials necessary for pump station construction. Construction costs encompass labor, specialized equipment, and the execution of tasks such as excavation, foundation work, and the installation of pumping equipment. Electrical and mechanical components required for the pump station's operation contribute to overall costs. Environmental considerations, including potential impacts on local ecosystems, may necessitate additional measures and costs for compliance. Permitting and regulatory compliance costs are factored in for obtaining necessary approvals and ensuring adherence to relevant regulations. Contingency budgets are included to address unforeseen challenges during construction. Additionally, operational and maintenance costs over the pump station's lifecycle are considered in the overall estimation. These cost assumptions provide a foundational framework for budgeting, emphasizing the need for detailed assessments for accurate and project-specific estimations. The total cost was estimated assuming $68,750/cfs.

Cost Estimate

Item	Pump Costs per cfs	Proposed Discharge	Adjusted 2024 Cost Total
Pump Station Construction	$68750/cfs	200 cfs	$ 14,712,500

Project Benefits: The proposed pump station installation aims to enhance flood protection for approximately 18.75 square miles, primarily consisting of agricultural lands. Within the 5.6 square miles of the Urban Area, an estimated 1,800 people residing in Unincorporated Miami-Dade County stand to benefit from this enhancement. The strategic implementation of pumps within upstream watersheds emerges as a crucial enhancement to resilience against sea level rise impacts. By integrating pumps into the canal infrastructure, the diminishing hydraulic gradient resulting from sea level rise and storm events is addressed, thereby bolstering the conveyance efficiency of the canals. This improvement in conveyance not only counteracts the challenges posed by rising sea levels but also plays a pivotal role in mitigating potential flooding in the agricultural and residential areas upstream structure S176. The incorporation of pumps enables the controlled and efficient movement of water within the canal system, effectively counterbalancing the hydraulic challenges brought about by sea level rise and fortifying the resilience of agricultural lands against inundation. Additionally, the heightened conveyance capacity minimizes the risk of sea intrusion, securing vital ecosystems and preventing salinity issues that could adversely impact agricultural productivity. The enhanced conveyance facilitated by strategically placed pumps acts as a proactive measure against storm surge impacts.

C-111 Canal Embankment Resiliency

C-111 Canal begins downstream of the SFWMD S332D and S176 structures (approximately even with S.W. 304th Street, 1-mile north of Mowery Drive and immediately north of the confluence with the C-113 Canal) and continues southward to approximately 1.1 miles south of S177 where C-111 turns southeast to the intersection of C-111E, approximately 2.7 miles. The C-111 then continues due south 3.0 miles; then southeast to the S197 Structure, approximately 5.5 miles. The canal continues south of S197 discharging into Manatee Bay.

Retrofitting and increasing the eastern canal bank elevation of C-111 can provide reduction of flood extent and duration within the agricultural areas of the watershed and increase of the FPLOS rating to greater than the watershed 10-yr rating for current conditions and 5-yr for future SLR. The results of Phase I of FPLOS project showed that the SLR does not significantly increase the flood extent, however, the flood duration increased with both SLR, and rainfall return period. Development of local flood mitigation projects and installation of secondary canals were suggested along with local drainage improvements to reduce flood duration, and the addition of ditches and local pumps to C-111 Canal.

This project will include raising portions of the existing canal bank elevations of on the left side (looking downstream in the direction of flow in canal C-111) anticipated canal elevation of a 25-yr 3-day storm event with 3 feet of SLR plus freeboard along a total of 1.5 miles of canal banks. 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.

Figure 8787 illustrates the existing canal embankments for L-31N from the Flood Protection LOS Performance Metric PM1 of the C-111 FPLOS.

By increasing the height of the canal bank elevations within this watershed, it is less likely there will be overtopping and flooding in these adjacent areas within the watershed. The canal bank elevations will be improved by using either suitable dredged material from the adjacent canal and/or imported fill, or a combination of material as needed.

Estimating conceptual costs for increasing canal bank and levee elevations involves a comprehensive assessment of various factors influencing the construction and modification processes which include conducting studies to evaluate existing conditions and designing elevation changes in adherence to safety standards and regulatory requirements.

Left and right banks would be a minimum of 18 feet wide at the top with 3H:1V side slopes. Embankment fill project will be separate from the canal dredging project, resulting in separate cost items for General, Clearing, Erosion Control, and Finish Grade & Sod.

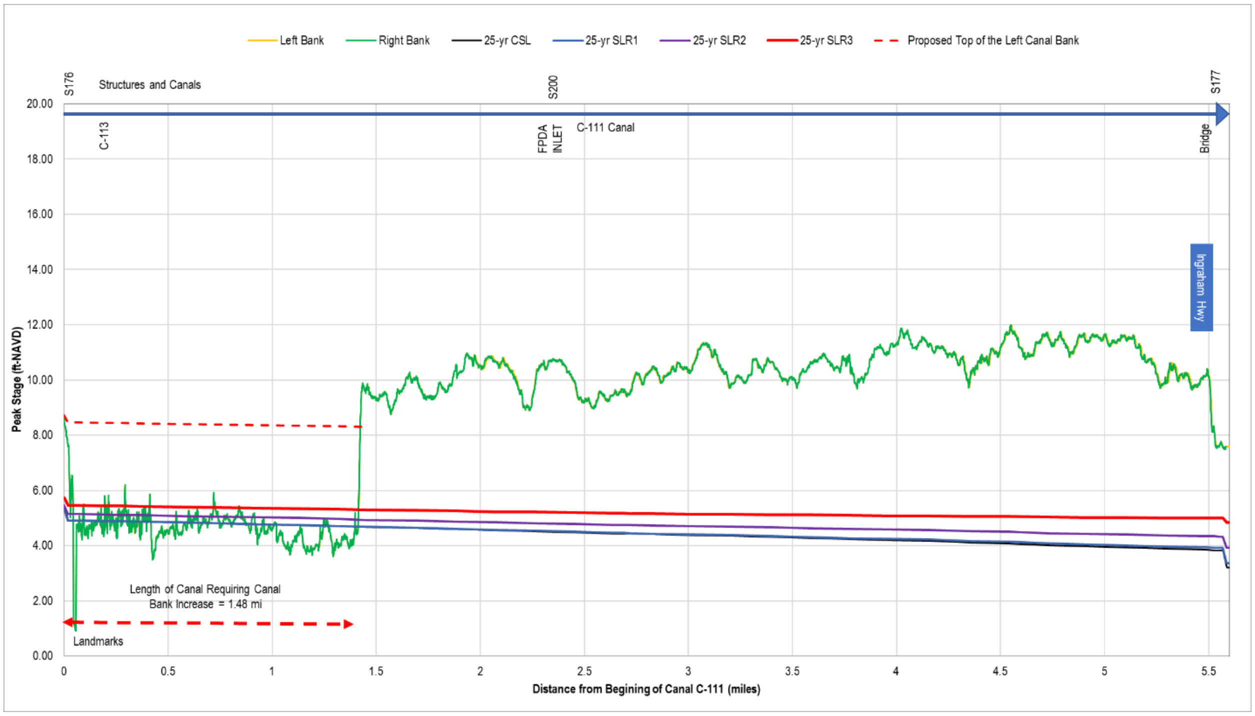


Figure 87: Profile of Peak Stages in Canal C-111 from Structure S176 to Structure S177 for 25-yr Design Event and Proposed Top of Left Canal Bank Elevation

The choice of materials significantly impacts costs, with options ranging from traditional soil and clay to more engineered solutions such as geotextiles or geomembranes. Construction costs encompass labor, equipment, and the execution of tasks like excavation, grading, and material placement. Specialized equipment may be necessary depending on project complexity. Environmental considerations, particularly in ecologically sensitive areas, may introduce additional measures and costs to protect the surroundings. Permitting and regulatory compliance expenses are also factors, encompassing fees and assessments for adherence to local, state, and federal regulations. Including a contingency budget is common to address unforeseen circumstances or changes in project scope, and risk management costs may be factored in for potential challenges during construction. Surveying and geotechnical investigations are integral for understanding existing conditions and soil properties, contributing to overall project accuracy. These conceptual costs provide an initial framework for budgeting, emphasizing the need for detailed site assessments and collaboration with engineering and construction professionals for precise estimations tailored to specific project requirements.:

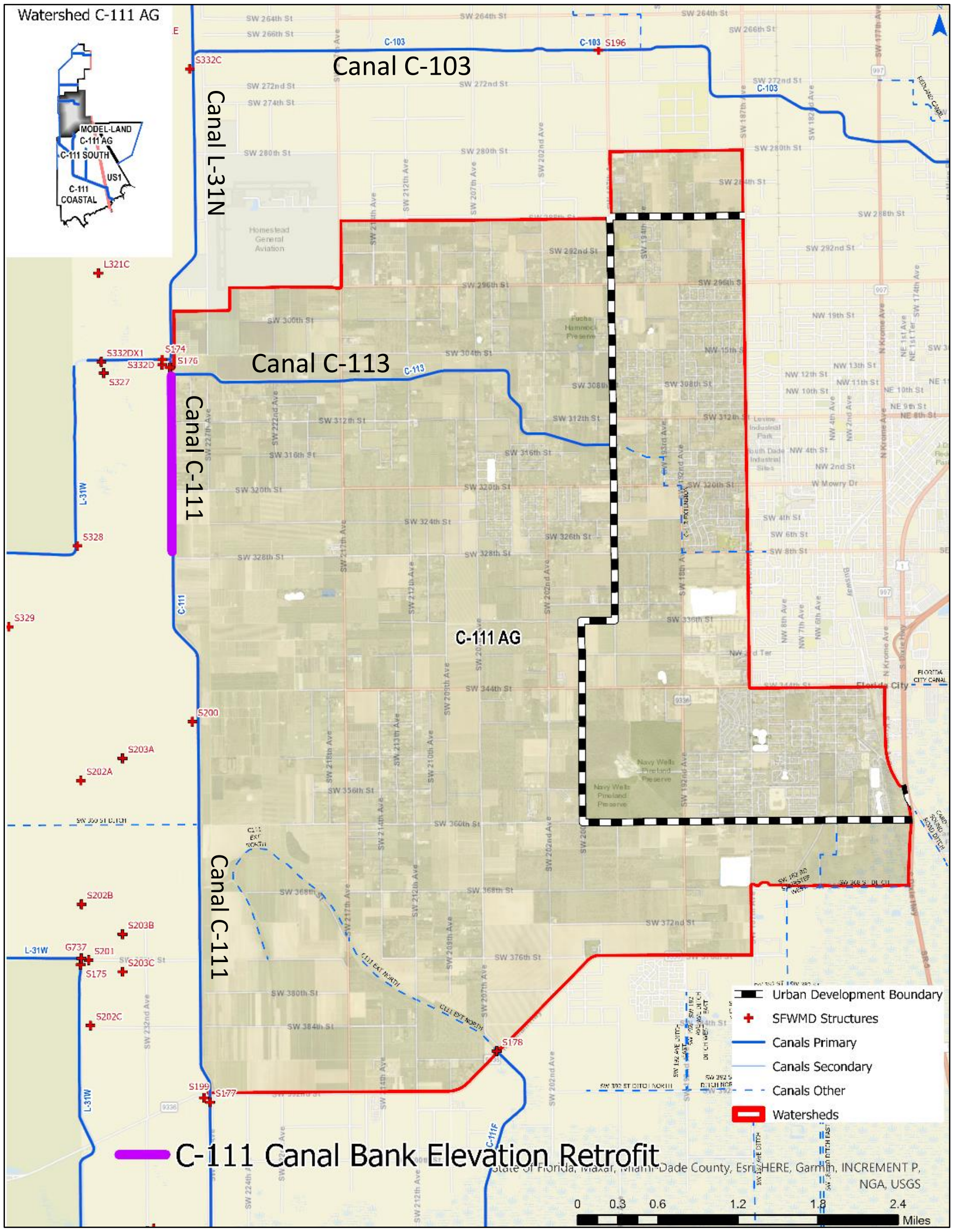


Figure 88: Implementation Costs for Watershed L-31NS Canal Bank Elevation Retrofit

The C-111 Canal has a total proposed left embankment improvement length of approximately 1.48 miles, resulting in an average elevation of 3.11 ft, average cross section deficiency 476 ft^2 and a total volume of infill required for 1.48 miles is 27,510 cubic yards. The proposed canal embankments are assumed 3 feet above the canal water profile for SLR. This includes only the top of the left canal bank (eastern side of levee C-111 Canal between structures S176, and S177 for a total length of 1.48 miles).

Left and right banks would be a minimum of 18 feet wide at the top with 3H:1V side slopes. The Embankment fill project will be separate from the canal dredging project, resulting in additional cost items for General, Clearing, Erosion Control, and Finish Grade & Sod. The basis of the costs was assumed $60/cubic yard.

Cost Estimate

Item	Quantity, cubic yards	Cost	Adjusted 2024 Cost Total
Embankment Fill	27,510	$75/cuy	2,207,677.50

Project Benefits: The proposed pump station installation aims to enhance flood protection for approximately 4.5 square miles, primarily consisting of agricultural lands. Within the 5.6 square miles of the Urban Area, an estimated 1,200 people residing in Unincorporated Miami-Dade County stand to benefit from this enhancement. Ensuring the robust protection of canal banks against overtopping due to sea level rise is a critical measure aimed at mitigating potential flooding in both agricultural and residential areas. As sea levels continue to rise, the risk of inundation amplifies, posing a direct threat to vulnerable communities. By fortifying canal banks, the resulting barrier that not only safeguards against overtopping but also acts as a shield against sea intrusion. This proactive approach not only protects valuable agricultural lands from submersion but also ensures the integrity of residential areas, shielding homes and infrastructure from the devastating consequences of flooding. Moreover, fortified canal banks play a pivotal role in minimizing the impacts of storm surge events, acting as a primary defense line during extreme weather conditions.

C-111 South and C-111 Coastal Basin Resiliency

S-197 Coastal Structure Resiliency

This resiliency project is mainly tied to the District's mission to provide flood control and water supply protection. S-197 is a four-barrel cast-in-place concrete box culvert with four vertical slide gates measuring 10.0 feet x 10.0 feet 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 feet 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, sea level rise, 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.

The Biscayne Bay and Southeastern Everglades Ecosystem Restoration (BBSEER) Project is formulating plans to restore parts of the South Florida ecosystem in freshwater wetlands of the Southern Glades and Model Lands, the coastal wetlands and subtidal areas, including mangrove and seagrass areas, of Biscayne Bay, Biscayne National Park, Manatee Bay, Card Sound, and Barnes Sound. As part of project formulation, management measures being proposed as part of modeling alternatives under discussion include the removal of the S-197 Coastal and backfilling of the lower C-111 canal from S18-C to S-197. As final alternatives are formulated, the flood protection level of service in the project influence area will be maintained.

Cost Estimate

Structure Enhancement	$9,776,209
Forward Pump (600 cfs)	$47,047,500
Forward Pump Backup Generator Facility	$4,704,750
Structure Tie Back (Flood Barrier)	$3,075,000
Design, Implementation & Construction Management	$9,690,519
Real Estate	$7,000,000
Adjusted 2024 Cost	**$81,293,978**

S-18C Structure Resiliency

S-18C is a two-bay, reinforced concrete gated spillway located on C-111 Spreader Canal, southeast of the City of Homestead in southeastern Miami-Dade County. S18C controls stages in C-111 upstream to S177 and in C-111E, and it regulates discharges from the middle reach of C-111 to the lower reach.

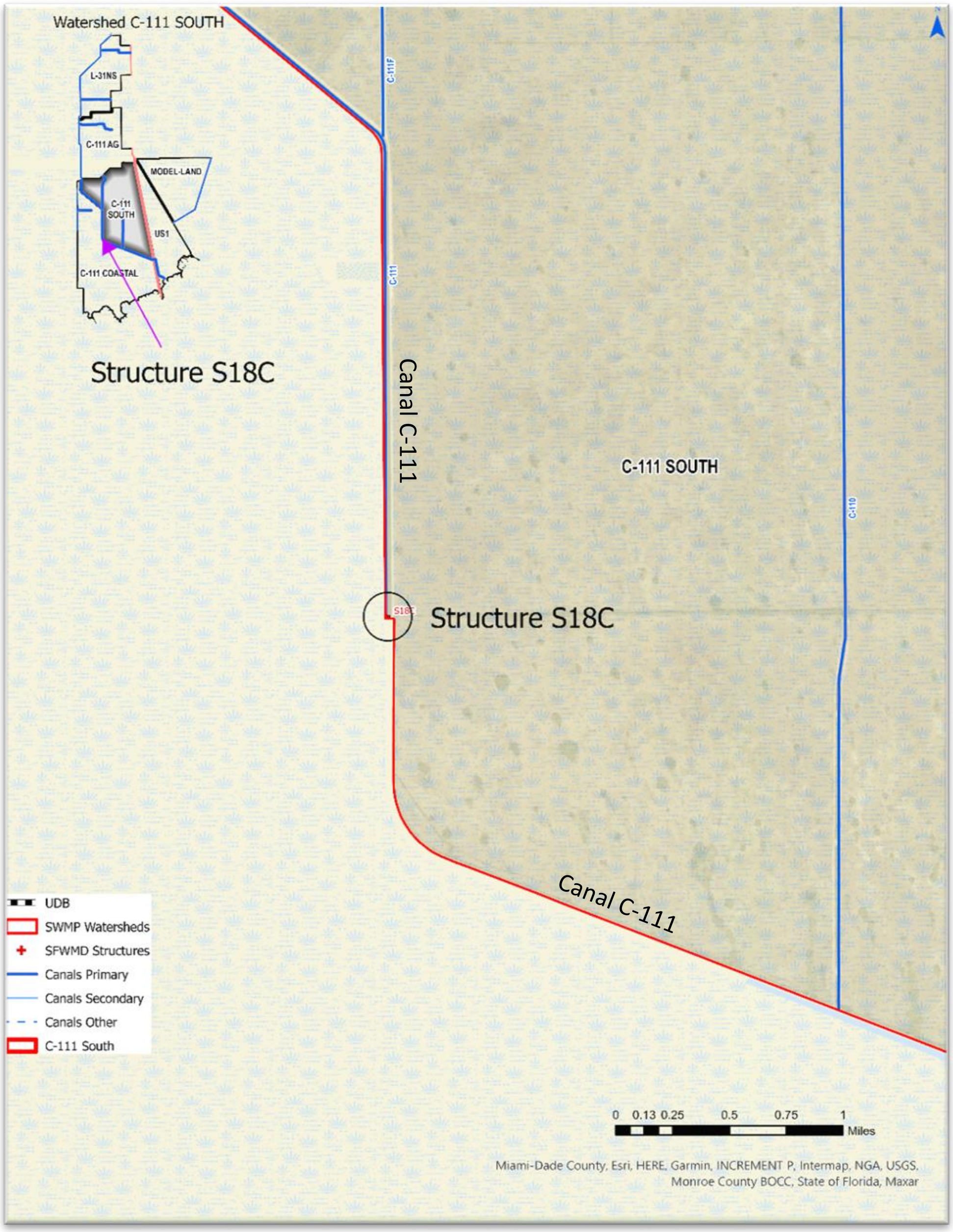


Figure 89: Implementation Costs for Watershed L-31NS Pumps at Structure S18C

The structure is located about 6.5 miles upstream of S-197 culvert. The structure consists of two (2) 11.0 feet high by 22.8 feet wide gates with sill elevations of -7.0 feet NGVD29. The discharge from the structure is controlled by a hydraulically driven cable operated vertical lift gates. The gates can be remotely controlled by either the on-site control or from the SFWMD control room. The structure is currently maintained by Homestead Field Station.

S-18C was designed to maintain optimum water control stages in C-111 Spreader Canal. It was also designed to pass 40% 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 assists in preventing saltwater intrusion. It also makes discharges to the eastern panhandle of the Everglades National Park (ENP). Material on the southern side of the C-111 Canal between S-18C and S-197 was removed to improve sheet flow of freshwater from S-18C to ENP and Florida Bay as well as to moderate the frequency of S-197 gate openings.

The discharge capacity of the structure is reduced for increasing SLR and analysis of forward pumping is proposed. The analysis should be performed for all three structures S176, S177 and S18C to determine if a single forward pump can be sufficient at one of the structures or possibly two pumps can provide a greater benefit. Increase of pumping capacity by 700 cfs is proposed.

As part of the Flood Protection Level of Service (FPLOS) preliminary mitigation project identification, a suggested approach to mitigate flooding and enhance flood protection in the C-111 South Watershed involves increasing the pumping capacity of the structure. Due to sea level rise, the S18C tailwater stage is anticipated to frequently surpass the headwater stage, causing the underflow gate to remain closed and significantly reducing the structure's discharge capacity. Consequently, additional pump capacity is deemed necessary. While the 100-year sea level rise (SLR) storm surge for current conditions is not expected to overtop S18C, it is projected to reduce the structure discharge capacity because of reduced hydraulic gradient for future conditions for SLR greater than 2 and 3 ft. The discharge capacity of the structure is reduced for increasing SLR and analysis of forward pumping is proposed. Increase of pumping capacity by 720 cfs is proposed.

The primary considerations for cost analysis include engineering and design costs, encompassing studies and plans to integrate the pump station with the existing gravity structure effectively. Material costs involve the selection and procurement of equipment and materials necessary for pump station construction. Construction costs encompass labor, specialized equipment, and the execution of tasks such as excavation, foundation work, and the installation of pumping equipment. Electrical and mechanical components required for the pump station's operation contribute to overall costs. Environmental considerations, including potential impacts on local ecosystems, may necessitate additional measures and costs for compliance. Permitting and regulatory compliance costs are factored in for obtaining necessary approvals and ensuring adherence to relevant regulations. Contingency budgets are included to address unforeseen challenges during construction. Additionally, operational and maintenance costs over the pump station's lifecycle are considered in the overall estimation. These cost assumptions provide a foundational framework for budgeting, emphasizing the need for detailed assessments for accurate and project-specific estimations. The total cost was estimated assuming $66,250/cfs.

Cost Estimate

Item	Pump Costs per cfs	Proposed Rate	Adjusted 2024 Cost Total
Pump Station Construction	$66250/cfs	720 cfs	$ 51,039,000

Project Benefits: The proposed pump station installation aims to enhance flood protection for approximately 5.78 square miles, primarily consisting of agricultural lands. Within the 0.6 square miles of the Urban Area, an estimated 1,100 people residing in Unincorporated Miami-Dade County stand to benefit from this enhancement. The strategic implementation of pumps within upstream watersheds emerges as a crucial enhancement to resilience against sea level rise impacts. By integrating pumps into the canal infrastructure, the diminishing hydraulic gradient resulting from sea level rise and storm events is addressed, thereby bolstering the conveyance efficiency of the canals. This improvement in conveyance not only counteracts the challenges posed by rising sea levels but also plays a pivotal role in mitigating potential flooding in the agricultural and residential areas upstream structure S176. The incorporation of pumps enables the controlled and efficient movement of water within the canal system, effectively counterbalancing the hydraulic challenges brought about by sea level rise and fortifying the resilience of agricultural lands against inundation. Additionally, the heightened conveyance capacity minimizes the risk of sea intrusion, securing vital ecosystems and preventing salinity issues that could adversely impact agricultural productivity. The enhanced conveyance facilitated by strategically placed pumps acts as a proactive measure against storm surge impacts.

US1 Basin Resiliency

Levee/Flood Barrier Resiliency

The US1 Watershed has been assigned a no FPLOS rating considering that the watershed is unprotected from the south and there are no agricultural areas, and the urban areas small fraction (35 acres from total of 16,803 acres, mostly located on high ground). However, during storm surge, watershed US 1 is unprotected from the coast and the storm surge propagates considerably north thus creating potential flooding of Card Sound Road. Therefore, a potential extension of Levee L-31E from the junction with Card Sound Road to the boundary between watershed US 1 and C-111 South is proposed for analysis to determine protection from storm surge events and overtopping during high tide for future conditions of SLR.

Watershed US 1 discharges into Barnes Sound which is part of Florida Bay. Florida Bay is a large shallow estuary located on the southern tip of the Florida mainland, between the Florida Keys and the mainland. Barnes Sound is one of the interconnected bodies of water within Florida Bay, situated on the northeastern side of the bay. It is known for its diverse marine ecosystems and serves as a habitat for various marine species. Therefore, installing a levee which may interfere with the outflows to Barnes Sound will require investigation of impacts on the ecosystem.

In the current conditions, the outflows to Barnes Sound play a vital role in sustaining the ecosystem and supporting life within the area. These outflows bring essential freshwater, nutrients, and sediments that contribute to the health and diversity of the ecosystem. However, with projected sea level rise (SLR) in the future, the availability of fresh outflows may become limited, posing challenges for the long-term sustainability of the ecosystem.

To address this issue and ensure the continued ecological functioning of the area while protecting against the impacts of SLR, installing a levee with culverts and backflow prevention measures can provide an effective solution. By incorporating culverts, which are pipes or channels that allow water to pass through, it is possible to maintain the essential outflow of freshwater while preventing saltwater intrusion.

Estimating conceptual costs for increasing canal bank and levee elevations involves a comprehensive assessment of various factors influencing the construction and modification processes which include conducting studies to evaluate existing conditions and designing elevation changes in adherence to safety standards and regulatory requirements.

The choice of materials significantly impacts costs, with options ranging from traditional soil and clay to more engineered solutions such as geotextiles or geomembranes. Construction costs encompass labor, equipment, and the execution of tasks like excavation, grading, and material placement. Specialized equipment may be necessary depending on project complexity. Environmental considerations, particularly in ecologically sensitive areas, may introduce additional measures and costs to protect the surroundings.

Permitting and regulatory compliance expenses are also factors, encompassing fees and assessments for adherence to local, state, and federal regulations. Including a contingency budget is common to address unforeseen circumstances or changes in project scope, and risk management costs may be factored in for potential challenges during construction. Surveying and geotechnical investigations are integral for understanding existing conditions and soil properties, contributing to overall project accuracy. These conceptual costs provide an initial framework for budgeting, emphasizing the need for detailed site assessments and collaboration with engineering and construction professionals for precise estimations tailored to specific project requirements.

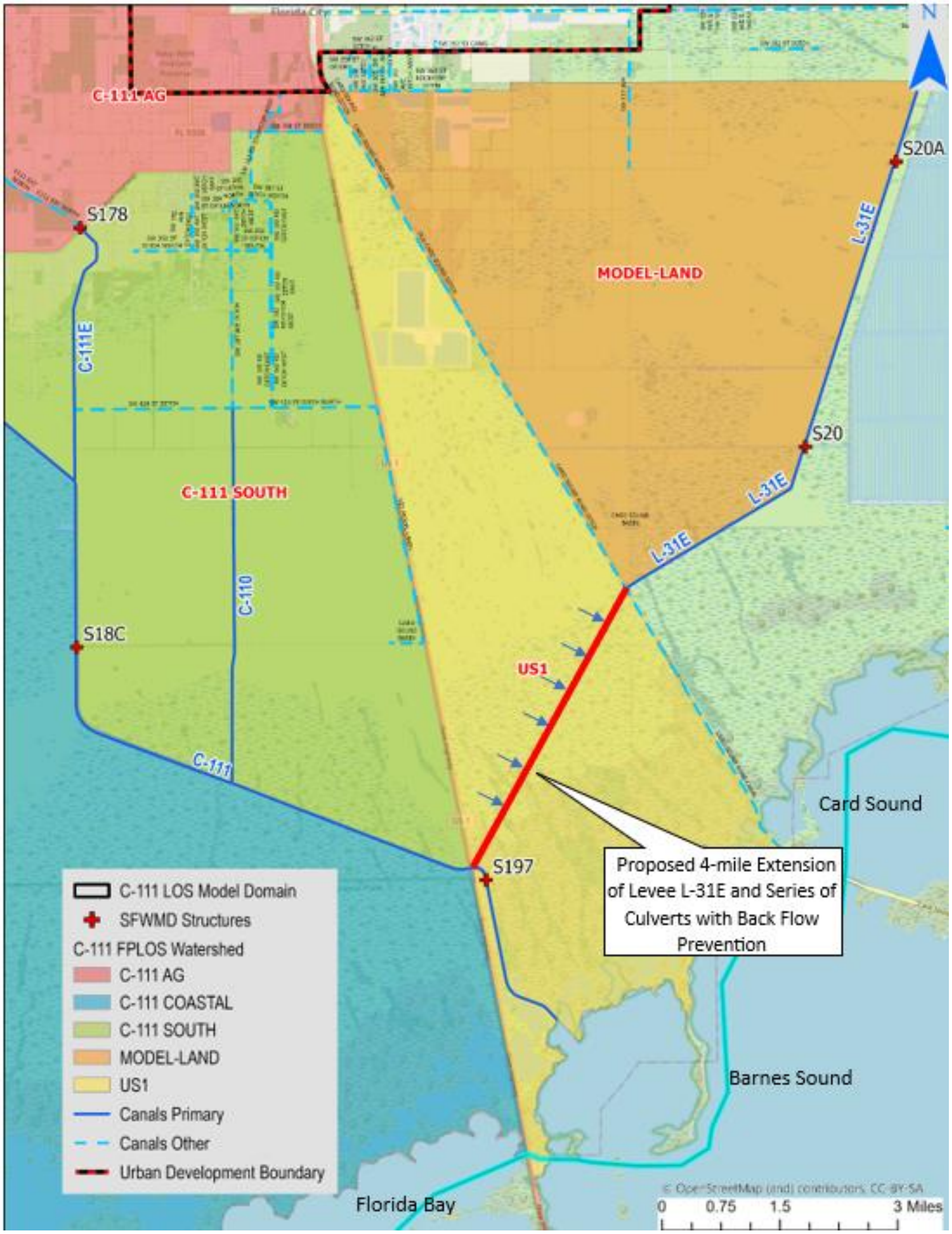


Figure 90: Extension of Levee L-31E SW (From Card Sound Road and L-31E to S197)

The analysis of topography along the canal locations, current elevations top of the banks the deficiency of canal infill was determined. Topography at the location of proposed levee varies between -0.25 and +0.3 ft NAVD (average assumed -0.025 ft NAVD). The average elevation is 3.11 ft (based on the flood elevations of the 25-yr 3-day event with SLR3 of 5.1 ft at the junction with Card Sound Road and 5.05 ft NAVD upstream S197 or average of 5.075 ft NAVD. Based on the topography and proposed top of the levee, the average cross section 168 ft^2 and the total volume of infill required for 4.0 miles is 132,000 cubic yards.

Left and right banks would be a minimum of 18 feet wide at the top with 3H:1V side slopes. The Embankment fill project will be separate from the canal dredging project, resulting in additional cost items for General, Clearing, Erosion Control, and Finish Grade & Sod. The basis of the costs was assumed $60/cubic yard.

Cost Estimate

Item	Quantity, cubic yard	Cost	Adjusted 2024 Cost Total
Embankment Fill	132,000	$75	$ 10,593,000

Project Benefits: The envisioned levee holds a crucial role in safeguarding southeastern Miami-Dade County from sea encroachment, especially amidst rising sea levels and storm surges. This system integrates a sturdy levee and strategically positioned culverts. The levee serves as a barrier against extreme tides and storm surges, while the one-directional culverts efficiently channel drainage from inland areas towards the coastal zones. These culverts act as a preventive measure against seawater intrusion into the underlying aquifer. The proposed infrastructure aims to mitigate increased canal water levels and the augmented risk of coastal flooding. The construction of this levee is essential not only for preserving the critical benefits of storm surge protection but also for minimizing the impact of sea level rise on the southern section of Miami-Dade County.

MODEL LAND Basin Resiliency

S-20 Coastal Structure Resiliency

This resiliency project is mainly tied to the District's mission to provide flood control and water supply protection. 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. The S-20 Structure was designed to 1) maintain optimum water stages in the upstream agricultural area, 2) release the design flood (40 percent of the Standard Project Flood) without exceeding the upstream flood design stage, 3) restrict downstream flood stages and discharge velocities to non-damaging levels, and 4) 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, sea level rise, 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.

Cost Estimate

Structure Enhancement	$6,454,659
Forward Pump	$9,513,281
Forward Pump Backup Generator Facility	$951,328
Structure Tie Back (Flood Barrier)	$3,075,000
Design, Implementation & Construction Management	$2,999,140
Real Estate	$35,000
Adjusted 2024 Cost	*** $23,028,408**

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

Levee/Flood Barrier Resiliency

The L-31E is a vital component of the Central and Southern Florida Flood Control Project, constructed in the 1960s to provide flood protection, water supply, and support economic development in South Florida. Positioned along Biscayne Bay, the L-31E comprises a levee and a canal safeguarding southeastern Miami-Dade County from sea encroachment. The levee prevents extreme tides and storm surge, exemplified during Hurricane Irma in 2017. The canal serves as a hydraulic barrier, preventing seawater intrusion into the aquifer below. Water control structures regulate canal levels, and runoff is discharged into Biscayne Bay. However, rising sea levels since construction pose challenges, causing higher canal water levels and increasing the risk of coastal flooding.

Retrofitting and increasing the eastern canal bank elevation of levee L-31E can provide reduction of flood extent and duration within watershed Model Land and increase of the FPLOS rating to greater than the watershed 5-yr rating. The results of Phase I of FPLOS project showed that the SLR does not significantly increase the flood extent, however, the flood duration increased with both SLR, and rainfall return period. Development of local flood mitigation projects and installation of secondary canals were suggested along with local drainage improvements to reduce flood duration, and the addition of ditches and local pumps to L-31E Canal.

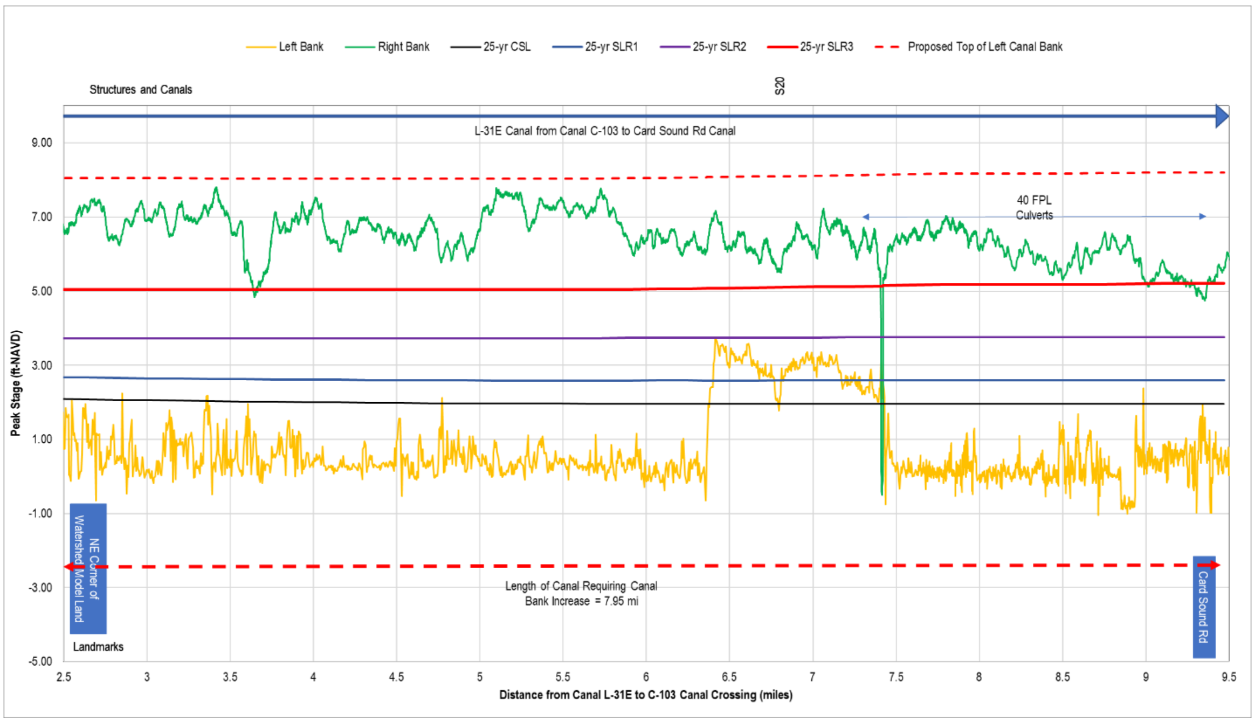


Figure 91: Profile of Peak Stages in L-31E Canal to Card Sound Rd for 25-yr Design Event and Proposed Top of Levee L-31E

This project will include raising portions of the existing canal bank elevations of on the left side (looking downstream in the direction of flow in canal L-31E from the junction with C-103 to the intersection of L-31E with Card Sound Road) anticipated canal elevation of a 25-yr 3-day storm event with 3 feet of SLR plus freeboard along a total of 10 miles of canal banks. 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.

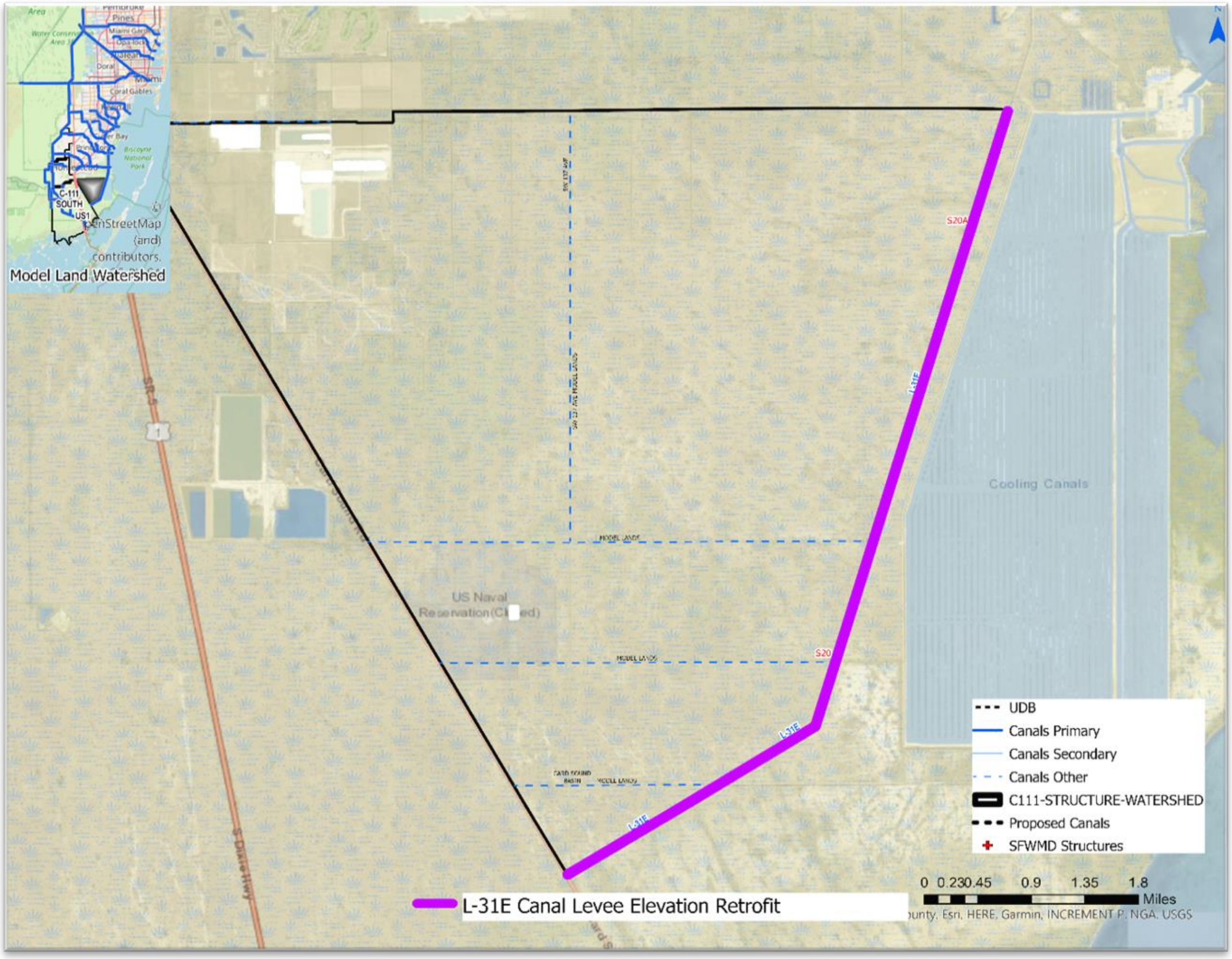


Figure 92:. Levee/Flood Barrier Retrofit in Watershed Model Land

By increasing the height of the canal bank elevations within this watershed, it is less likely there will be overtopping and flooding in these adjacent areas within the watershed. The canal bank elevations will be improved by using either suitable dredged material from the adjacent canal and/or imported fill, or a combination of material as needed.

This document outlines the conceptual methodology for estimating costs related to elevating the L-31N top left canal bank to address improved resiliency and decrease of flood impacts within the L-31NS watershed due to extreme rainfall events, sea level rise, climate change, and land use changes in the basin, which contribute to higher canal elevations and bank exceedances.

Estimating conceptual costs for increasing canal bank and levee elevations involves a comprehensive assessment of various factors influencing the construction and modification processes which include conducting studies to evaluate existing conditions and designing elevation changes in adherence to safety standards and regulatory requirements.

The choice of materials significantly impacts costs, with options ranging from traditional soil and clay to more engineered solutions such as geotextiles or geomembranes. Construction costs encompass labor, equipment, and the execution of tasks like excavation, grading, and material placement. Specialized equipment may be necessary depending on project complexity. Environmental considerations, particularly in ecologically sensitive areas, may introduce additional measures and costs to protect the surroundings. Permitting and regulatory compliance expenses are also factors, encompassing fees and assessments for adherence to local, state, and federal regulations. Including a contingency budget is common to address unforeseen circumstances or changes in project scope, and risk management costs may be factored in for potential challenges during construction. Surveying and geotechnical investigations are integral for understanding existing conditions and soil properties, contributing to overall project accuracy. These conceptual costs provide an initial framework for budgeting, emphasizing the need for detailed site assessments and collaboration with engineering and construction professionals for precise estimations tailored to specific project requirements.

Left and right banks would be a minimum of 18 feet wide at the top with 3H:1V side slopes. Embankment fill project will be separate from the canal dredging project, resulting in separate cost items for General, Clearing, Erosion Control, and Finish Grade & Sod.

The analysis of topography along the canal locations, current elevations top of the banks the deficiency of canal infill requires average increase of levee elevation by 0.62 ft. The average cross section deficiency is 1,544 ft^2 and the total volume of infill required for 7.8 miles is 134,600 cubic yards. Costs are calculated based on $60/cuy.

Cost Estimate

Item	Quantity, cubic yard	Cost	Adjusted 2024 Cost Total
Embankment Fill	134,600.00	$60	$8,641,320

Project Benefits: The L-31E infrastructure along Biscayne Bay plays a crucial role in safeguarding southeastern Miami-Dade County from sea encroachment. The effectiveness of this protection is notably demonstrated during extreme events like Hurricane Irma in 2017, where the levee successfully prevented inundation from storm surges. The integrated system comprises a levee and a canal, with the levee acting as a vital barrier against extreme tides and storm surge, while the canal serves as a hydraulic barrier, preventing the intrusion of seawater into the underlying aquifer. Water control structures along the canal help regulate water levels, and excess runoff is discharged into Biscayne Bay. Despite the success of this system, the rising sea levels since its construction present challenges, leading to elevated canal water levels and an increased risk of coastal flooding. Therefore, enhancing the levee protection becomes imperative for preserving the multifaceted benefits provided by this critical infrastructure for the southern section of Miami-Dade County.

L-31E Levee Improvements

This resiliency project is mainly tied to the District’s mission to provide flood control and water supply protection. The proposed strategy consists of the enhancement of the L-31E Levee. Addressing coastal structures' vulnerability to sea level rise and storm surge is a high priority in South Florida. Funding will be used to harden L-31E Levee, a component of the 72-year-old Central and Southern Florida Project, to address storm surge risks and sea level rise 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 the 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 a vulnerable levee would need to provide more protection from storm surges and sea level rise.

L-31E Levee Elevation Improvements

Elevation improvements of the L-31E Levee are proposed in order to help achieve the District's mission of providing flood control and protection. This project will include raising the existing levee elevations to the 100-yr storm surge elevation including 3 feet of sea level rise (SLR) plus freeboard at a 3:1 slope.

The L-31E Levee is partially located in Watershed C-1 (Figure 99). This project is part of a larger effort to retrofit the L-31E Levee, however this portion of the project is located within the C-1 Watershed. The section of the L-31E within the C-1 drainage basin begins near the intersection of SW 204th Street and SW 87th Avenue and connects to the C-1 Canal near the S-21 Control Structure. The total length of proposed improvements for the section of the levee within the C-1 Basin is approximately 0.7 miles on each bank, 1.4 miles total. According to record drawings the average height of the levee is 7.5 feet NGVD.

To provide flood protection for 3 feet of SLR during a 100-yr storm event, the levee height will need to be raised. Proposed elevation increases vary from 1 to 10 feet depending on the existing canal bank elevations and conditions, with an average fill height of 5.5 feet on the left and right including 3 feet of freeboard. The additional freeboard will be needed for the levee to be certified by the Federal Emergency Management Agency (FEMA). The total length of the proposed bank improvements is approximately 1.4 miles total for both the left and right bank of the L-31 Levee. 100% of the L-31 Levee banks have deficient height in comparison to the SLR3 100-yr water profile.

District levees serve a similar function to canal banks, however, levees have the additional purpose of providing a salinity barrier from inundation associated with tidal flooding. Levees are primarily used as a barrier to prevent flood waters from entering the areas it is designed to protect. The canal adjacent to most levees can usually be classified as a borrow canal. A borrow canal's primary purpose is to provide fill for the levee. This differs from primary and secondary canals which are mainly used for water storage and drainage conveyance.

The purpose of the proposed work is to provide increased flood protection for areas on the interior of the levee due to rising sea levels and land use changes within the C-1 Watershed drainage basin. This project is intended to raise the current Level of Service (LOS) rating of the canals from 5-yr at 0 feet of Sea Level Rise (SLR) to a 100-yr LOS rating at 3.0 feet of SLR. As a result of these changing conditions within the basin, the current levee elevations no longer adequately protect surrounding areas. By increasing the height of the levee, it is less likely there will be overtopping and flooding in adjacent areas.

In storm surges, the L-31E Levee provides protection to residents and property owners by reducing upstream flood potential. The project will benefit the property owner's interior to the levee by increasing their flood protection LOS to the 100-yr plus 3 feet of SLR. This project will benefit approximately 235,000 people located in the jurisdiction of Miami-Dade and Cutler Bay municipalities. In addition, there are also pieces of critical infrastructure that will benefit from the project such as the Miami Dade South District Wastewater Treatment Plant.

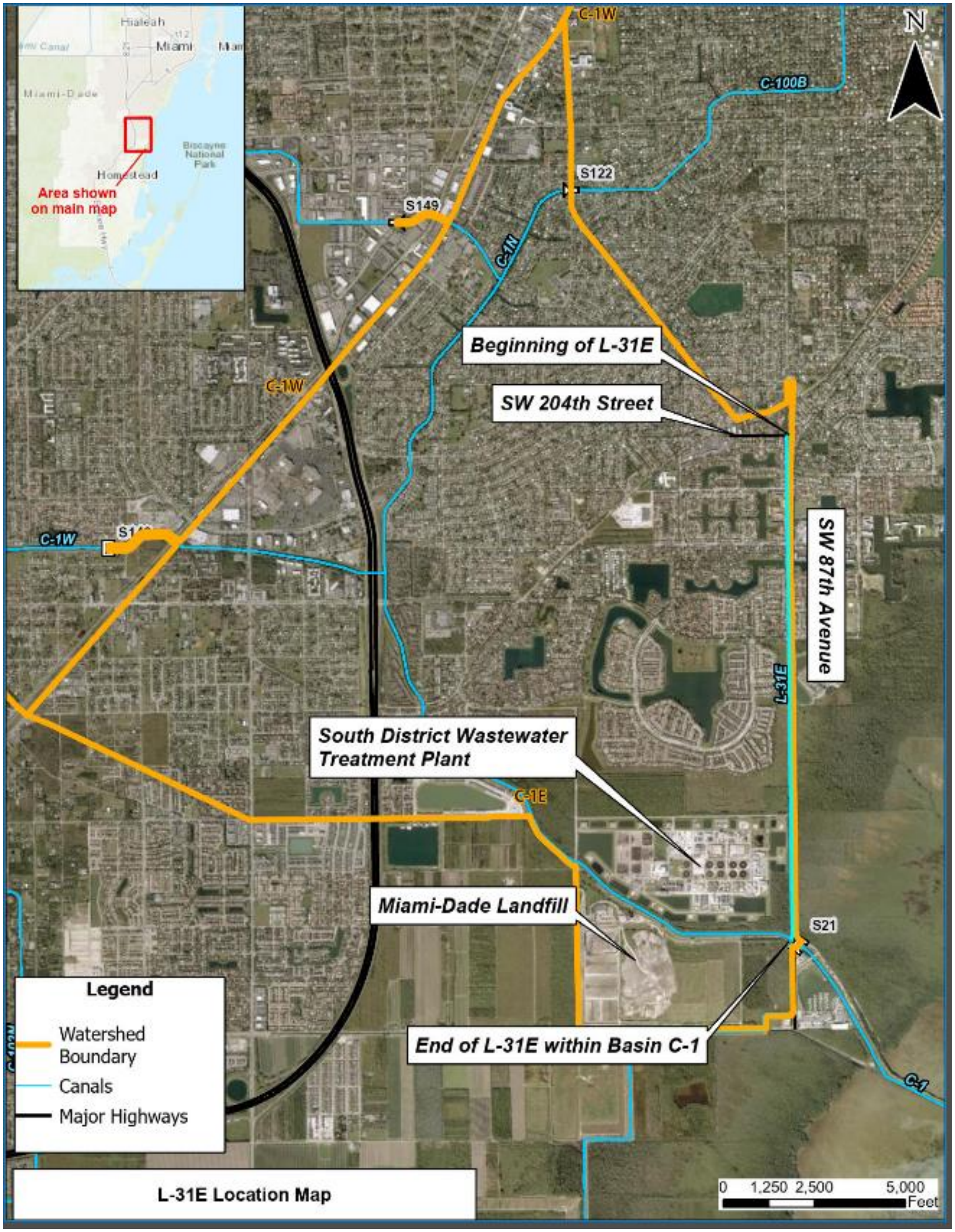


Figure 93: Location Map

SFWMD is currently planning additional work on the L-31E Levee which includes 10 culverts and 5 pump stations along the L-31E Levee. The purpose of these projects is to control water deliveries to wetlands east of the L-31 Levee. The proposed culverts will be gate controlled to prevent backflow from Biscayne Bay during storm events.

Cost Estimate

The cost estimate for the proposed improvements is presented in the below cost summary table. The cost estimate is a high-level cost estimate based on a conceptual design and assumption listed below. The cost summary table also includes construction costs, design and construction management costs, and real estate costs. The methodology for developing the costs includes performing quantity takeoffs and applying historical unit cost data from the District database.

Item	Cost
Left Bank Canal Elevation Improvements	$2,657,833
Right Bank Canal Elevation Improvements	$2,657,833
Design, Implementation & CMS at 15%	$797,350
Real Estate	--
Adjusted 2024 Cost Total	**$6,113,016**

Assumptions

- Left and right top of bank would be raised to three feet above the SLR 3 profile.
- Left and right banks would be a minimum of 14 feet wide at the top with 3H:1V side slopes.
  Unit cost based on interpolation of District reference costs for average embankment height of 5.4ft for the left and right embankment. Costs were provided per linear feet of embankment in 0.5ft height increments from 0.5ft to 2.5ft.

L-31E Levee Retrofit from S-20G to S-21A

Proposed levee elevation improvements of the L-31E Levee are proposed in order to help achieve the District's mission of providing flood control and protection. This project will include raising the existing levee elevations to the 100-yr storm surge elevation (including 3 feet of sea level rise) plus freeboard at a 3:1 slope. The proposed improvements would provide flood protection for approximately 23.5 square miles.

The L-31E Levee is partially located in Watershed C-102. This project is part of a larger effort to retrofit the L-31E Levee, this portion of the project is located within the C-102 Watershed. The section of L-31E within the C-102 drainage basin begins near the intersection of the C-102 Canal and SW 97th Ave. The section ends around SW 300th street where it continues south into the C-103 Basin. The total length of this section of the levee is approximately 2.1 miles. L-31E Levee passes through primarily agricultural areas.

To provide flood protection for 3 feet of SLR during a 100-yr storm event, the levee height will need to be raised. Proposed elevation increases vary from 2 to 7 feet depending on the existing canal bank elevations and conditions, with an average fill height of 3.6 feet on the left bank and 5.7 feet on the right bank including 3 feet of freeboard. The total length of the proposed bank improvements is approximately 2.1 miles for the left and right bank of the L-31 Levee. The L-31 Levee banks have 100%

deficient height in comparison to the SLR3 100-yr water profile. Refer to Figure 102 for the minimum bank fill profile based on 3 feet of freeboard atop the SLR3 profile.

District levees serve a similar function to canal banks however, levees have the additional purpose of providing a salinity barrier from inundation associated with tidal flooding. Levees are primarily used as a barrier to prevent flood waters from entering the areas it is designed to protect. The canal adjacent to most levees can usually be classified as a borrow canal. Borrow canal's primary purpose is to provide fill for the levee whereas a traditional canal is primarily used for water storage and conveyance.

The purpose of the proposed work is to provide increased flood protection for areas on the interior of the levee due to rising sea levels and land use changes within the watershed drainage basin. This project is intended to raise the current Level of Service (LOS) rating of the canals from 5-yr at 0 feet of Sea Level Rise (SLR) to a 100-yr LOS rating at 3.0 feet of SLR. As a result of these changing conditions within the basin, the current levee elevations no longer adequately protect surrounding areas. By increasing the height of the levee, it is less likely there will be overtopping and flooding in adjacent areas. This project will benefit approximately 10,000 people located in the jurisdiction of the Unincorporated Miami-Dade municipality. In storm surges, the L-31E Levee provides protection to residents and property owners by reducing upstream flood potential. The project will benefit the property owner's interior to the levee by increasing their flood protection LOS to the 100-yr plus 3 feet of SLR.

This project is a component of a larger effort to retrofit the L-31E Levee. SFWMD is currently planning additional work on the L-31E including 10 culverts and 5 pump stations along the L-31E levee. The purpose of these projects is to control water deliveries to wetlands east of the levee. The proposed culverts will be gate controlled to prevent backflow from Biscayne Bay during storm events.

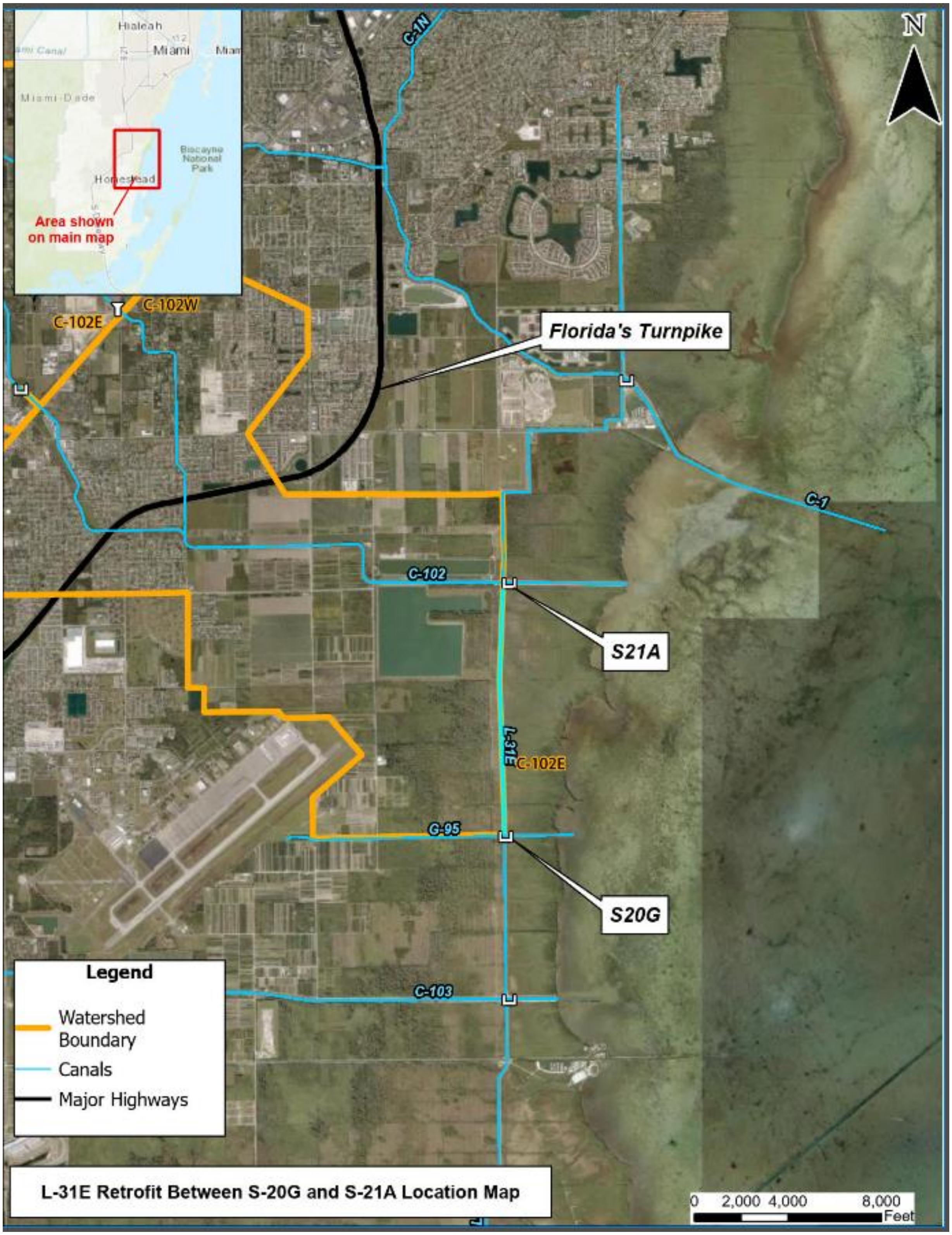


Figure 94: Location Map

Cost Estimate

The cost estimate for the proposed improvements is presented in the below cost summary table. The cost estimate is a high-level cost estimate based on a conceptual design and assumption listed below. The cost summary table also includes construction costs, design and construction management costs, and real estate costs. The methodology for developing the costs includes performing quantity takeoffs and applying historical unit cost data from the District database.

Item	Cost
Left Bank Canal Elevation Improvements	$4,438,026
Right Bank Canal Elevation Improvements	$8,414,810
Design, Implementation & CMS at 15%	$1,927,925
Real Estate	--
Adjusted 2024 Cost Total	**$14,780,761**

Assumptions

- Left and right top of bank would be raised to three feet above the SLR 3 profile.
- Left and right banks would be a minimum of 14 feet wide at the top with 3H:1V side slopes.
- Unit cost based on interpolation of District reference costs for average embankment height of 3.6ft for the left embankment and 5.7ft for the right embankment. Costs were provided per linear feet of embankment in 0.5ft height increments from 0.5ft to 2.5ft.

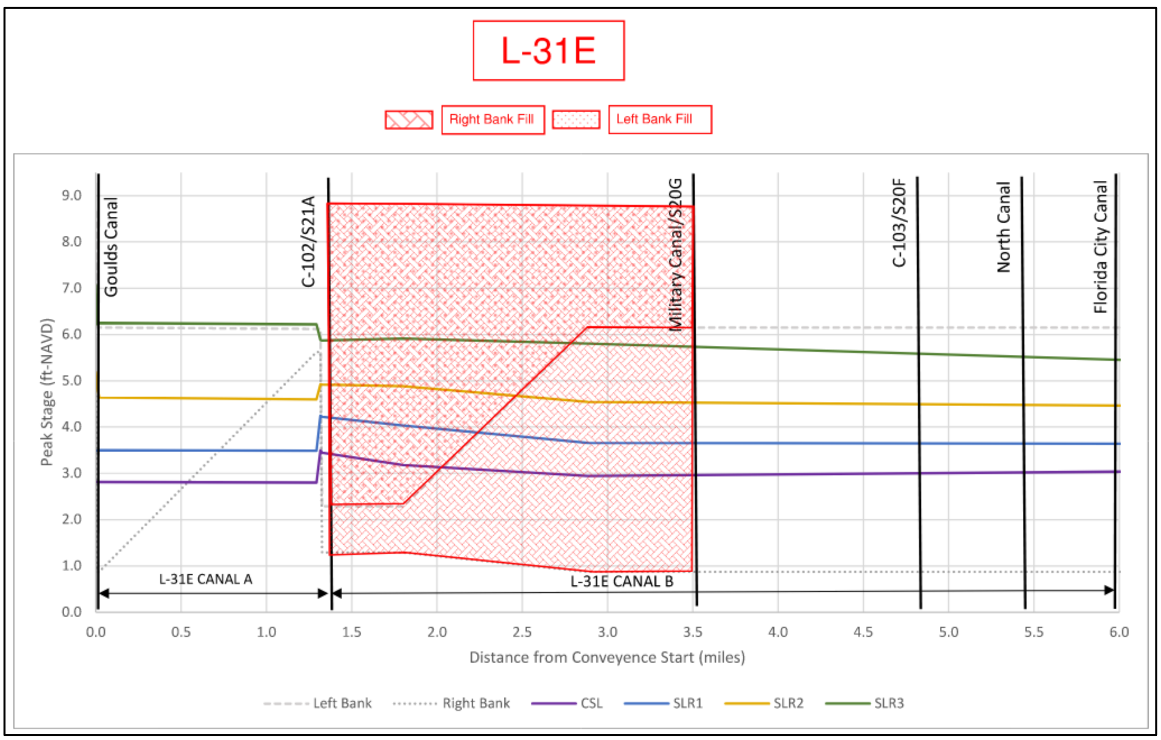


Figure 95: Recommended Fill for Canal Banks and Surface Water Profiles of Peak Stages for the 100-yr Design Storm with 3 feet SLR

L-31E Retrofit from S-20G to the Florida City Canal

Levee elevation improvements of the L-31E Canal and Levee are proposed in order to help achieve the District's mission of providing flood control and protection This project is part of a larger effort to retrofit the L-31E Levee, this portion of the L-31E project is located within the C-103 Watershed. This project will include raising the existing levee elevations to the 100-yr storm surge elevation including 3 feet of sea level rise (SLR) plus freeboard at a 3:1 slope.

L-31E is partially located in Watershed C-103 (See Figure 110). This project is part of a larger effort to retrofit the L-31E Levee. The section of L-31E within the C-103 basin begins at S-20G near the intersection of SW 97th street and SW 300th street and connects to the Florida City Canal at the intersection of SW 344th and Biscayne Trail.

In storm surges, L-31E protects residents and property owners by reducing upstream flood potential. The project will benefit the property owner's interior to the levee by increasing their level of service for flood protection. The proposed improvements would provide flood protection for approximately 62.3 square miles. This project will benefit approximately 15,000 people located in the jurisdiction of the Unincorporated Miami-Dade municipality. The total length of this section of the levee is approximately 2.3 miles. L-31E passes primarily agricultural areas but is located near critical infrastructure such as the Turkey Point Nuclear Station.

To provide flood protection for 3 feet of SLR during a 100-yr storm event, the levee height will need to be raised. Proposed elevation increases vary from 3 to 8 feet depending on the existing canal bank elevations and conditions, with an average fill height of 3 feet on the left bank and 8 feet on the right bank including 3 feet of freeboard. The total length of the proposed bank improvements is approximately 2.3 miles for the left and right bank of the L-31E Levee. 100% of the L-31 Levee banks have deficient height in comparison to the SLR3 100-yr water profile. Refer to Figure 111 for the minimum bank fill profile based on 3 feet of freeboard atop the SLR3 profile.

District levees serve a similar function to canal banks however, levees have the additional purpose of providing a salinity barrier from inundation associated with tidal flooding. Levees are primarily used as a barrier to prevent flood waters from entering the areas it is designed to protect. The canal adjacent to most levees can usually be classified as a borrow canal. The primary purpose of a borrow canal is to provide fill for the levee whereas a traditional canal is primarily used for water storage and conveyance.

The purpose of the proposed work is to provide increased flood protection for areas on the interior of the levee due to rising sea levels and land use changes within the basin. This project is intended to raise the current level of service (LOS) rating of the canals from 5-yr at 0 feet of sea level rise (SLR) to a 100-yr LOS rating at 3.0 feet of SLR. As a result of these changing conditions within the basin, the current levee elevations no longer adequately protect surrounding areas. By increasing the height of the levee, it is less likely there will be overtopping and flooding in adjacent areas. SFWMD is currently planning additional work on L-31E including 10 culverts and 5 pump stations along the L-31E levee. The purpose of these projects is to control water deliveries to wetlands east of the levee. The proposed culverts will be gate controlled to prevent backflow from Biscayne Bay during storm events.

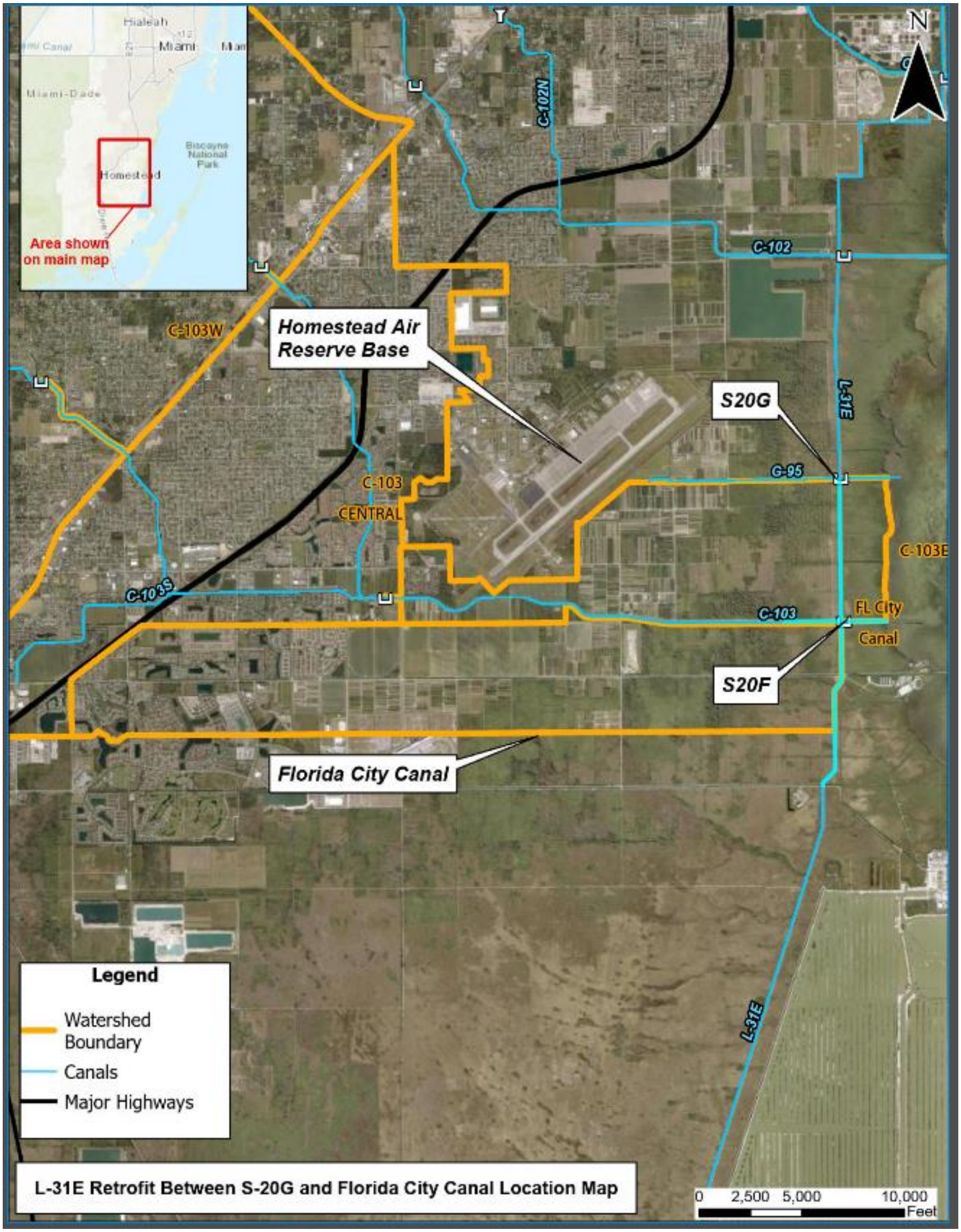


Figure 96: Project Location Map

Cost Estimate

The cost estimate for the proposed improvements is presented in the below cost summary table. The cost estimate is a high-level cost estimate based on a conceptual design and assumption listed below. The cost summary table also includes construction costs, design and construction management costs, and real estate costs. The methodology for developing the costs includes performing quantity takeoffs, and applying historical unit cost data from the District database.

Item	Cost
Raise Left Embankment	$1,840,845
Raise Right Embankment	$13,195,813
Design, Implementation & CMS at 15%	$2,255,499
Real Estate	--
Adjusted 2024 Cost Total	**$17,292,157**

Assumptions

- Left and right top of bank would be raised to three feet above the SLR 3 profile.
- Left and right banks would be a minimum of 14 feet wide at the top with 3H:1V side slopes.
- Unit cost based on interpolation of District reference costs for average embankment height of 2.3ft for the left embankment and 7ft for the right embankment. Costs were provided per linear feet of embankment in 0.5ft height increments from 0.5ft to 2.5ft.

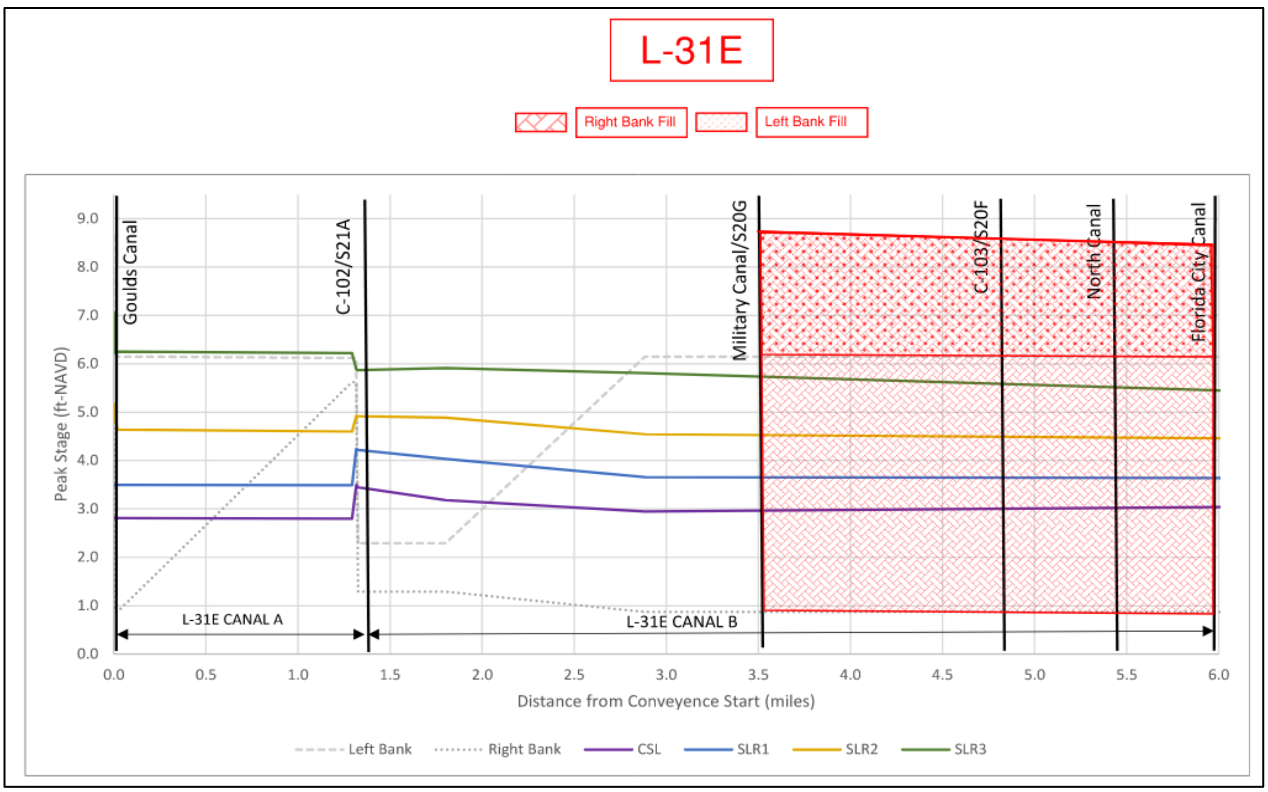


Figure 97: Recommended Fill for Canal Banks and Surface Water Profiles of Peak Stages for the 100-yr Design Storm with 3 feet SLR

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:
2. Return period, time horizon, sea level.
3. Start design considerations using the following:
4. 100-year surge elevation
5. Non-overtopping levee simulation
6. Present-day and Future sea level scenarios, starting at a 2ft increase.
7. Add freeboard according to FEMA and USACE guidance.
8. Gate opening has a negligible impact on crest elevation.
9. Edge effects need to be evaluated.
10. Take into 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 112. 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. The District proposes to raise the levee two feet from the 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.

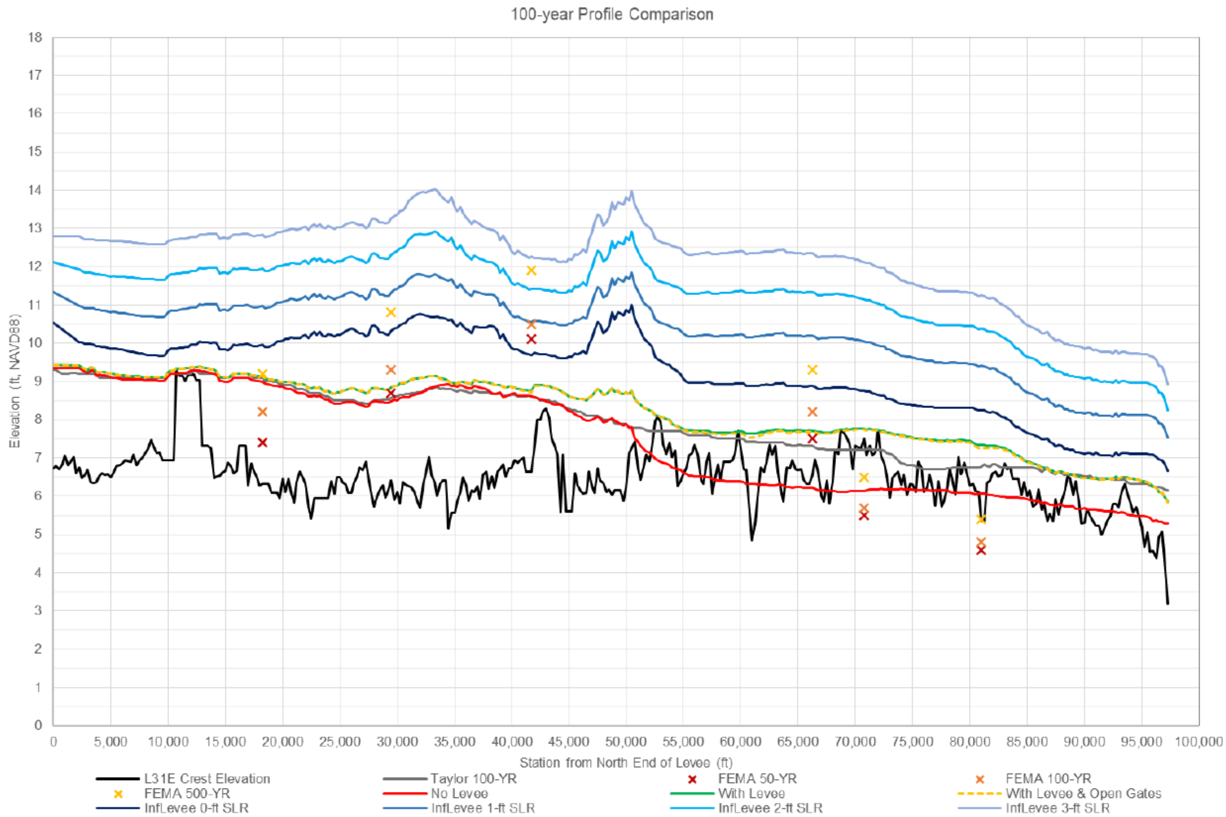


Figure 98: 100-Year Profile for Levee Crest Elevation Consideration.

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 surges 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 surges and sea level rise. Further North is a mostly residential area, 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 113 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.

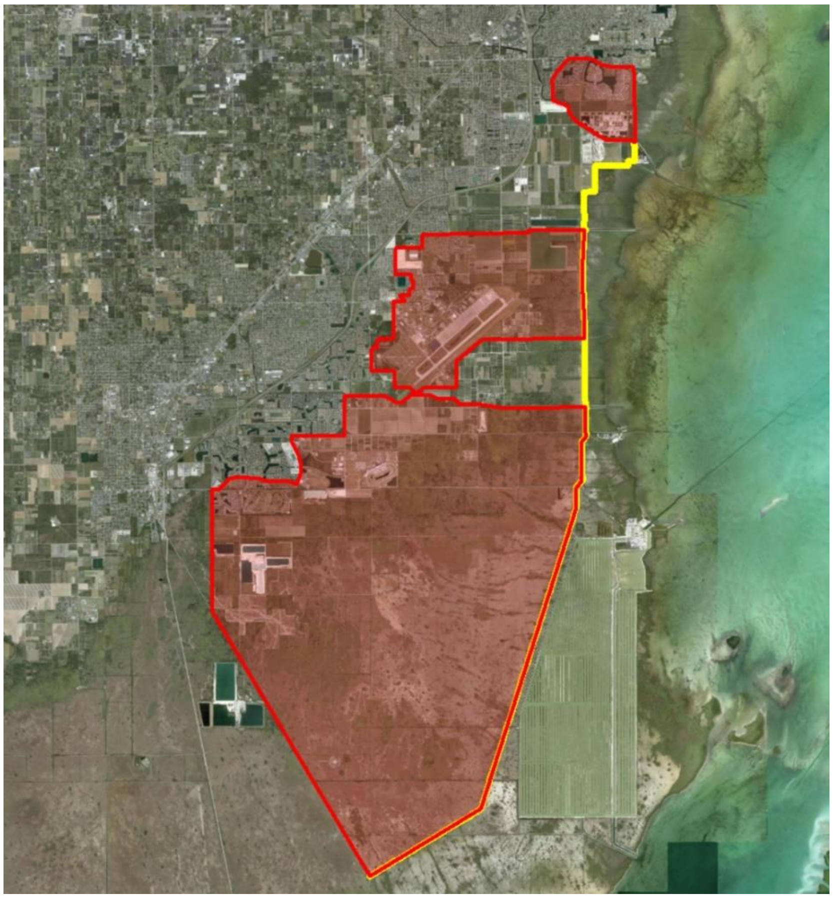


Figure 99: Location of L31E Levee (yellow) and area of influence (red).

Cost Estimate

L31E Levee Improvements	**$39M - $45M**

Henderson-Belle Meade Basin Resiliency

Henderson Creek outfall HC1, built in 1980, has limited drawdown capability with undersized manual gates proven to be susceptible to surge events & sea level rise. To provide resiliency, this structure needs to be replaced in order to improve flood control and reduce the effects of surge events which will better protect public water supply for Marco Island and reduce unwanted discharges to downstream Rookery Bay estuary. The H&H modeling should also factor in the addition of a new upstream structure, HC1A, to slow saltwater intrusion and reduce undesirable dry season discharges.

This resiliency project is mainly tied to the District's mission to provide flood control and water supply protection. HC-1 is an aging coastal structure, built in 1980, that discharges into Rookery Bay estuary, an OFW managed by FDEP, comprised of a combination of an uncontrolled fixed crest weir, two bay vertical lift sluice overflow gates, and a box culvert controlled by an upstream sluice gate and a downstream flap gate. The two sluice gates are fully automated and function as variable weirs that automatically open and close in accordance with the seasonal operational criteria. The current structure was designed to 1) prevent saltwater intrusion from downstream tidal water, 2) provide flood control and 3) prevent over drainage for the Henderson Creek basin and has a design discharge capacity of 604 cfs.

The structure, located on the north side of U.S. 41 approximately 4000 feet east of the intersection of U.S. 41 and CR 951, is maintained by the Big Cypress Basin (BCB) Field Station and managed by the BCB water managers and SFWMD Control Room.

The gates have proven to be undersized and the structure, as a whole, susceptible to surge events and limited draw-down capability. As reported in "Flood Protection Level of Service Provided by Existing District Infrastructure for Current (2015) Sea Level Conditions and Three Future (2065) Sea Level Scenarios for Golden Gate Watershed – Final Report" (October 26, 2017), due to the low topography and relatively flat-water surface profile of the Henderson Creek Canal, the HC1 structure is particularly susceptible to backwater effects associated with storm surge and sea level rise. Full build out modeling resulted in lowered level of service with reduced carrying capacity while inundating the area west of the canal by the combined effects of storm surge and high canal flows for the 5-year event and above.

Improvements are needed to harden flood performance, reduce effects of surge events and sea level rise, protect public water supply for Marco Island, and reduce unwanted wet season discharges to the downstream Rookery Bay estuary. Another area of concern noted in the FOPLOS Report is a channel restriction downstream of HC2.

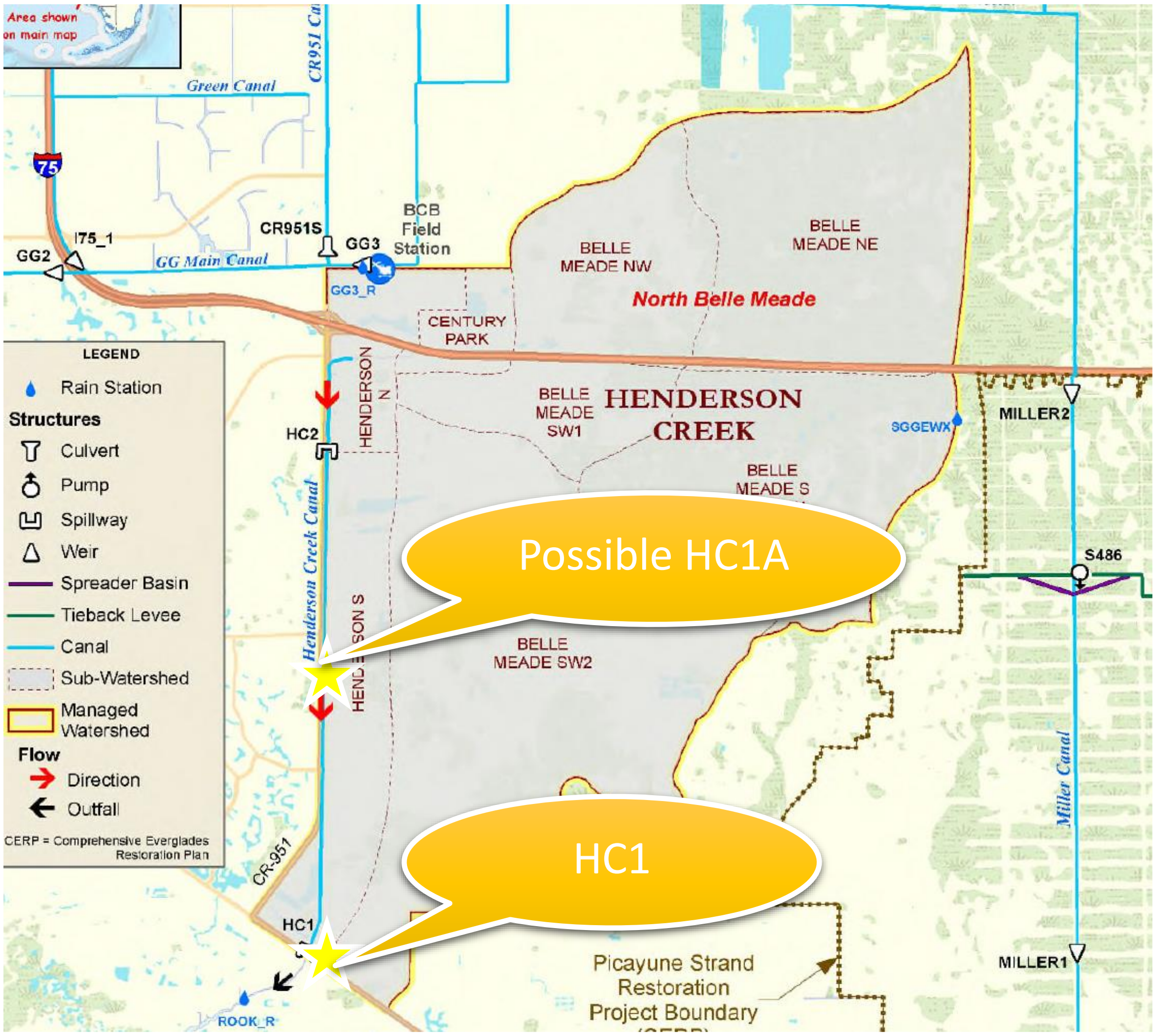
Because of the age and shortcomings of HC1, an H&H assessment must be conducted to inform its redesign improvements. It is anticipated that a new structure, HC1A, will be needed to reduce unwanted wet season flood control freshwater releases and protect both groundwater and Marco Island water supplies, without reducing the level of service. The figure illustrates such a location between the existing HC1 and HC2 structures.

The H&H study and basis of design should include the following:

- Evaluation of whether the addition of HC1A is needed and if so, where it should be located, along with conceptual (15-20% plans) with recommended operational protocols;
- Identification of ways to maintain or reduce the loss of the FPLOS of HC1 with future conditions (such as urbanization and SLR) with the replacement of the structure;
- Event and long-term H&H modeling to establish new operational criteria and rules to maximize the performance of an improved HC1 structure; and
- Conceptual level design of HC1 (10-15%) along with operational protocols/rules.

Cost Estimate

H&H Modeling	$600,000
Conceptual Design	$400,000
Total	**$1,0000**


Area shown on main map
Green Canal
CR951 Ca
75
I75_1
GG2
CR951S
GG3
BCB Field Station
GG Main Canal
GG3_R
CENTURY PARK
BELLE MEADE NW
BELLE MEADE NE
North Belle Meade
LEGEND
Rain Station
Structures
Culvert
Pump
Spillway
Weir
Spreader Basin
Tieback Levee
Canal
Sub-Watershed
Managed Watershed
Flow
Direction
Outfall
CERP = Comprehensive Everglades Restoration Plan
HENDERSON N
HC2
BELLE MEADE SW1
HENDERSON CREEK
SGGEWX
MILLER2
BELLE MEADE S
Possible HC1A
S486
Henderson Creek Canal
HENDERSON S
BELLE MEADE SW2
Miller Canal
CR-951
HC1
MILLER1
ROOK_R
Picayune Strand Restoration Project Boundary

Remaining Water Control Structures Resiliency

These resiliency projects link to the District's mission to provide flood control and water supply protection. Additional water control structures are vulnerable to SRL and other changing conditions. As estimated projections are realized in 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 95 below illustrates 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.

Initial placeholder costs are being proposed for structures identified to be within the inundation scenarios illustrated in Figure 95 above. These structures have not yet been assessed through H&H Models and will be refined during future modeling efforts and pre-design stages. The proposed costs are estimated to enhance Coastal Structures identified in Table 3, 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 structure's capacity will extend its 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 3: Remaining Coastal Structures

Basin	Coastal Structure	Area (acres)
C-100 East	S-700	8426
C-15	S-40	39423
C-16	S-41	39813
C-17	S-44	22357
C-18/Cprbett	S-46	65736
C-51 East	S-155	47012
Caloosahatchee West and Eustary	S_79; S_79 Lock	349590
Cocohatchee	COCO1	17629
Faka Union	FU-1	135740

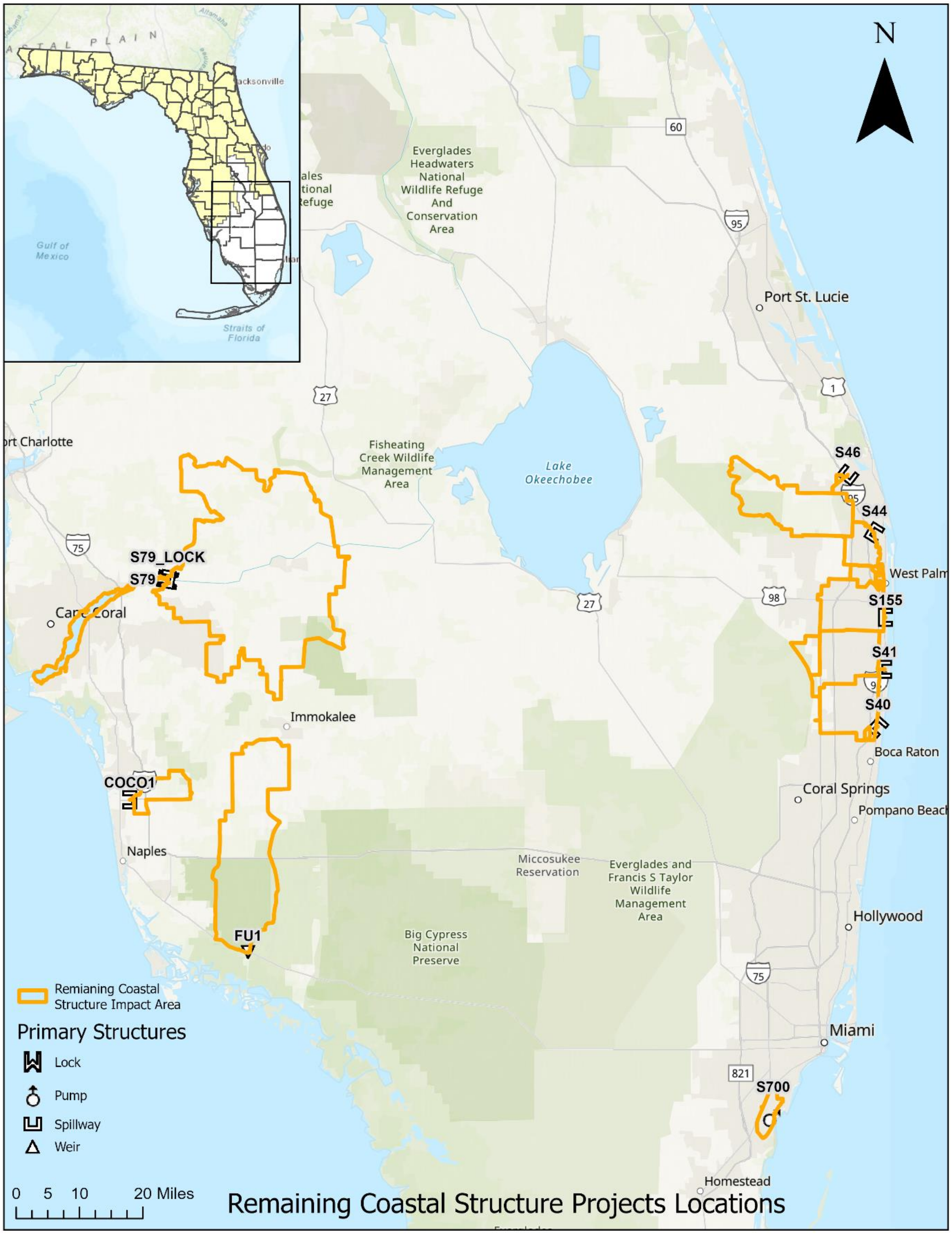


Figure 100: Remaining Coastal Structure Projects Locations

Coastal Structures Enhancement and Self-Preservation Mode

This resiliency project is mainly tied to the District's mission to provide flood control and water supply protection. Implementation of self-preservation mode at water control structures means building or retrofitting structures with systems that make the structure and its operation more resilient. A self-preservation mode system includes a backup system that can be programmed 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 backup 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 the 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 damages the structure
- 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 surges. 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 be damaged 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 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 surges/ high tailwater conditions, maximizing the 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 the 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 the 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 the 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 the tide. With increased connectivity between basins, water managers could have powerful additional tools for operating the system to optimize flood control efforts.

Table 4 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. In FY2023, this project was awarded 100% of funding needs through FDEP Resilient Florida Program, and a grant agreement has been executed. This work is being advanced in coordination with the project managers.

Self-Preservation Mode Cost Estimate

Table 4: 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)	X		X	X	
2	S-22 (2)	X		X		
3	S-27 (2)	X		*4		
4	S-28 (2)	X		*4		
5	S-21 (3)	X		X	X	
6	S-25 (1)	X		X		
7	S-20 (1)	X		X		
8	S-20F (3)	X		X		
9	S-20G (1)	X		X		
10	S-21A (2)	X		X		
11	S-25B (2)	X		X		
12	S-26 (2)	X		X		
13	S-29 (2)	X		*4		
14	S-197 (4)	X				
15	G-56 (3)	X		X		
16	COCO1		X			
17	GG-1		X			
18	HC1		X			
19	COCO2		X			
20	GG2		X			
21	COCO3		X			
22	GG3		X			
23	S487, S486, S488					X
24	G-420					X
25	G-57, S-381					X
26	Manatee Gates*2					X
27	S140, S7					X
28	S-179*3					X
	Total Cost - $12,600,000*					

* note additional funds will be needed to complete the original scope due to increased costs to meet District design standards.
*1 This option will replace the need to raise 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-
*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

This resiliency project is mainly tied to the District's mission to provide flood control, water supply protection, and ecosystem restoration. 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 strengthening and upgrading 2.6 miles of levee along the north side of ITID, starting east of the ITID Reservoir. However, the remaining eastern levee section of 3.7 miles has not been constructed due to a 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 to 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 bobcats, sandhill cranes, 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. The design shall include one telemetered surface water monitoring station for the water level within the Corbett WMA located between or adjacent to the discharge culverts.

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 the 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 N-S segment, the operational changes to Southeast JW Corbett WMA will be limited. IN FY2023, Palm Beach County was awarded 100% of funding needs through FDEP Resilient Florida Program, and the contract is currently under negotiation, including an interagency agreement with the District for the construction of the project.

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 the 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.

Cost Estimate

JW Corbett Wildlife Management Area Hydrologic Restoration and Levee Resiliency	*$11,705,000

*Total cost includes land costs of approximately $1M and the construction of the 0.6 mile north/south segment of the levee.

Hardening of S-2, S-3, S-4, S-7, S-8 Engine Control Panels – Building Resiliency in Water Management South of Lake Okeechobee

The S2, S3, S7, and S8 pump stations were built in the 1950s, and S4 was built in 1975. The purpose of the S2, S3, and S4 structures is to pump water into Lake Okeechobee via the Hillsboro and NNR Canals, the Miami Canal, and L-D1, C-20, C-21 and Industrial Canals, respectively, from the agricultural area south of the structure. The S7 and S8 provide a hydraulic gradient for discharges from STA-3/4.

The pump engine monitoring panels and equipment at these pump stations are at the end of their useful service life, limiting the capacity of the pump station operator to take critical actions necessary to prevent the failure of a pump engine. Replacement parts for the existing monitoring equipment/control panel are not available. The District routinely performs inspection reports to assess the immediate enhancement needs. This project is one of the priority needs established to increase the resiliency of water resources in this region.

Failure of S2, S3, S4, S7, and S8 structures to pump water exceedances to Lake Okeechobee will result in cascading effects downstream, such as the increase in the water levels in canals, reduction in infiltration capacity, wet antecedent conditions in watersheds and higher water tables that are likely to increase flooding conditions in urban areas in Palm Beach and Broward Counties. Floodwaters are likely to propagate across the agricultural areas towards WCA 2A or 3A, ultimately reaching the C11 and C9 urbanized areas or the Everglades National Park.

With the goal of increasing flood resiliency within its impact area, this proposed project is to replace all engine control panels in these five pump stations with modern and standardized equipment and to install equipment to implement new emergency shutdown features. These pump stations are critical features of the stormwater infrastructure and need to be upgraded. The pump engine needs enhancements to reduce flooding risks and increase water management flexibility. The engine control panel updates will improve the efficiency and reliability of these structures. Finally, this project will reduce the risk of compound flooding across Palm Beach and down South in Broward County.

In FY2023, this project was awarded 100% of funding needs through FDEP Resilient Florida Program, and construction is underway. The Notice to proceed was June 01st, 2022 with an expected completion by end of 2025.

Hardening of S-2, S-3, S-4, S-7, S-8 Engine Control Panels Cost Estimate

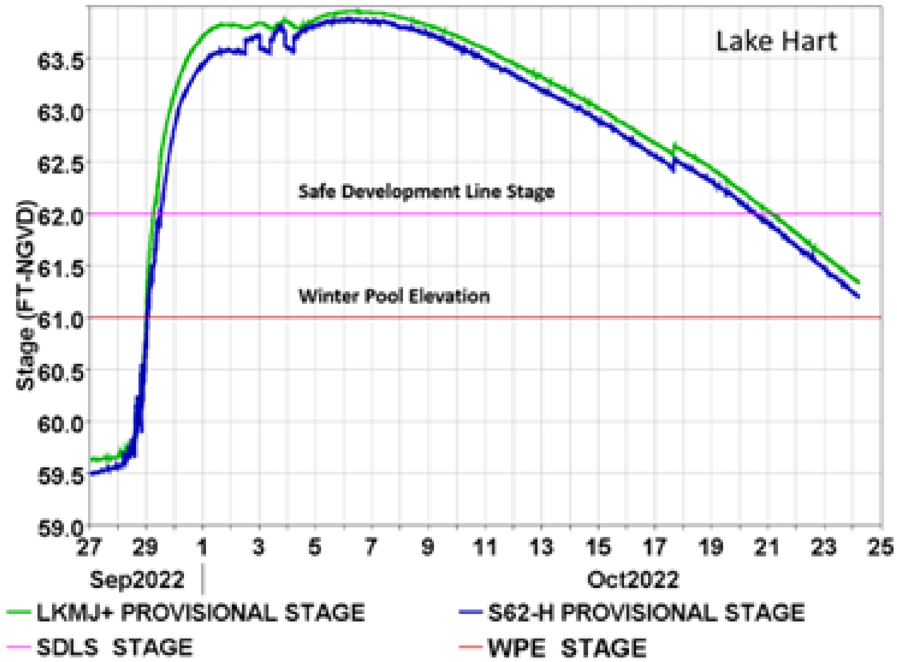
Hardening Of S-2, S-3, S-4, S-7, S-8 Engine Control Panels – Building Resiliency in Water Management South of Lake Okeechobee	$17,000,000

C-29, C-29a, C-29b and C-29c Canal Conveyance Improvement

This resiliency project is mainly linked to the District's mission to provide flood control. The C-29, C-29A, C-29B, and C-29C Canals are part of the Lake Hart basin in Orange and Osceola Counties. The C-29 canal is 1 mile long and connects Lake Hart with Lake Mary Jane. The direction of flow in the C-29 Canal is generally from Lake Mary Jane to Lake Hart. The C-29A Canal is 1.3 miles long and connects Lake Hart with Lake Ajay downstream. The C-29B canal is 1 mile long and connects Lake Ajay with Fells Cove. The C-29C Canal is 0.7 miles long and connects Fells Cove with East Lake Tohopekaliga downstream.

The S-62 Structure at the outlet of Lake Hart regulates Lake, Hart and Lake Mary Jane. The regulation schedule ranges between 59.5 feet and 61.0 feet NGVD and the design discharge of the structure is 450-640 cfs. Lake Ajay, Fells Cove, and East Lake Tohopekaliga are regulated by the S-59 Structure located in the C-31 Canal at the outlet of Lake Tohopekaliga. The lakes are maintained between 54.5 and 59.0 feet NGVD. As a result of Hurricane Ian's heavy rainfall (equivalent to a more than 200-year recurrence frequency for the region), water levels in Lake Mary Jane, Lake Hart, and Lake Ajay stayed above the safe development line for approximately 20 days, as illustrated in Figure 96. As part of the emergency response to Hurricane Ian, a mobile pump with a pumping capacity of 75 cfs of was operated at Lake Hart.

Observations made during the response to flooding from Hurricane Ian, show that canal conveyance capacity needs to be closely reassessed, and appropriate mitigation measures need to be developed. The currently proposed measures for improving conveyance at C-29, C-29-A, C-29-B, and C-29-C Canals include widening and deepening the canal, and/or elevating the canal banks and providing appropriate canal benches and berms. This work would use a 1:3 slope, up to the existing boundary of the District's right of way. Canal bank stabilization is not included in this initial project recommendation and respective cost estimates. Canal bank stabilization will be done in a future phase of this project, with an estimated cost of up to $5M per mile.



Lake Hart Water Stages resulting from Hurricane Ian's heavy rainfall event.

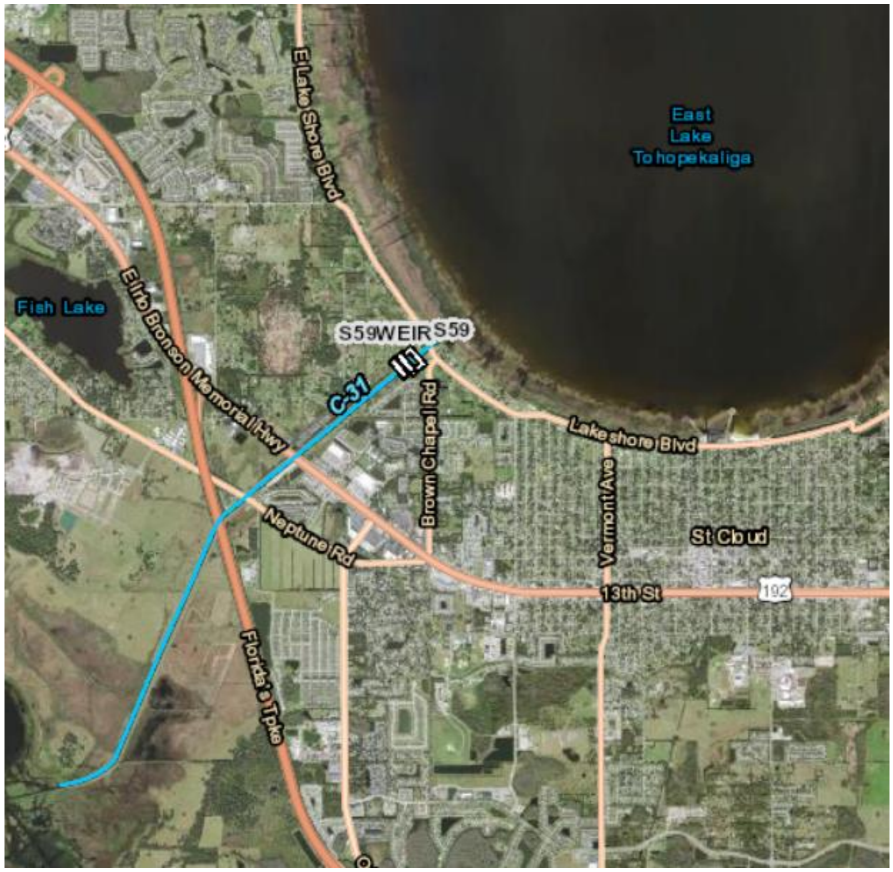
Figure 101: Lake Hart Water Stages

Cost Estimate

C-29 Dredging (0.5 miles widening and deepening)	$1,148,850
C-29A Dredging (1.41 miles widening and deepening)	$2,895,892
C-29B Dredging (1.06 miles widening and deepening)	$2,237,262
C-29C Dredging (0.77 miles widening and deepening)	$1,658,536
Total Construction Cost	**$7,940,540**

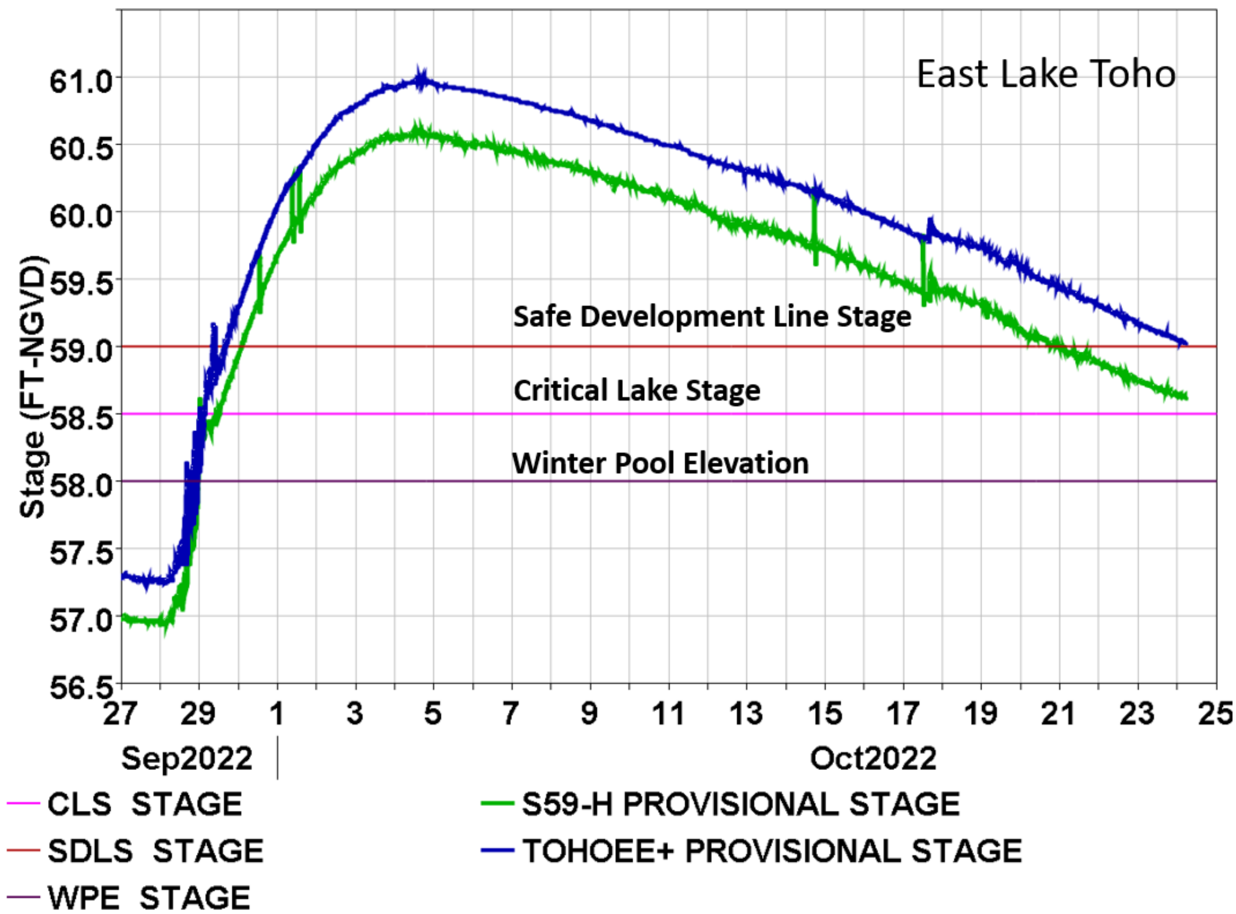
S-59 Structure Enhancement and C-31 Canal Conveyance Improvements

This resiliency project is mainly tied to the District's mission to provide flood control. The S-59 structure is a gated spillway on the C-31 Canal at the outlet of East Lake Tohopekaliga in Osceola County in the Upper Kissimmee Chain of Lakes region. The structure can be remotely operated from the SFWMD Operations Control Center. The structure has a design capacity of 590-820 cfs and is operated to maintain optimum stages in the upstream C-31 Canal and in East Lake Tohopekaliga. The structure is operated in accordance with the USACE Master Water Control Manual for Upper and lower Kissimmee basins, focusing on the East Lake Tohopekaliga Regulation Schedule, which ranges between 55.0-58.0 feet NGVD. The C-31 Canal is 3.9 miles long and connects East Lake Tohopekaliga to Lake Tohopekaliga downstream and to the south. The C-31 Canal design elevations are 52.0-55.0 feet NGVD. The two major sources of inflow to Lake Tohopekaliga are Shingle Creek and the C-31 Canal.



As a result of Hurricane 2022 Ian's heavy rainfall, (equivalent to more than 200-year recurrence frequency for the region), water levels in East Lake Toho stayed above the safe development line stage of 59 feet NGVD for approximately 25 days. During Hurricane Ian, mobile pumps were deployed to facilitate conveyance between East Lake Tohopekaliga and Lake Tohopekaliga for the period of 10/01/22 to 10/31/22, with daily flow rates as high as 290 cfs.

Observations made during the response to flooding from Hurricane Ian show that this structure needs to be upgraded to include an additional gate to address the single-gate vulnerability issue (a second gate would help to reduce this vulnerability), along with an improved erosion protective measure that would not constrain the capacity at this structure and canal conveyance improvements. The currently proposed measures include removing the existing structure and adding 2 (two) gated spillways and enhancement of the sheet pile weir with a more robust stilling basin with flow deflector and associated rip rap. Such design would remove major structure capacity limitations and potentially can result in a structure that has no Maximum Allowable Gate Openings (MAGOs) constraints. Additionally, conveyance improvement along the C-31 Canal is being proposed, especially where the C-31 Canal enters Goblet Cove in Lake Toho and includes canal dredging (deepening) and riprap augmentation. The Osceola Parkway expansion project includes widening the Partin Settlement Rd near C-31 Canal, and Coordination with FDOT is recommended.



East Lake Toho Water Stages resulting from Hurricane Ian's heavy rainfall event.

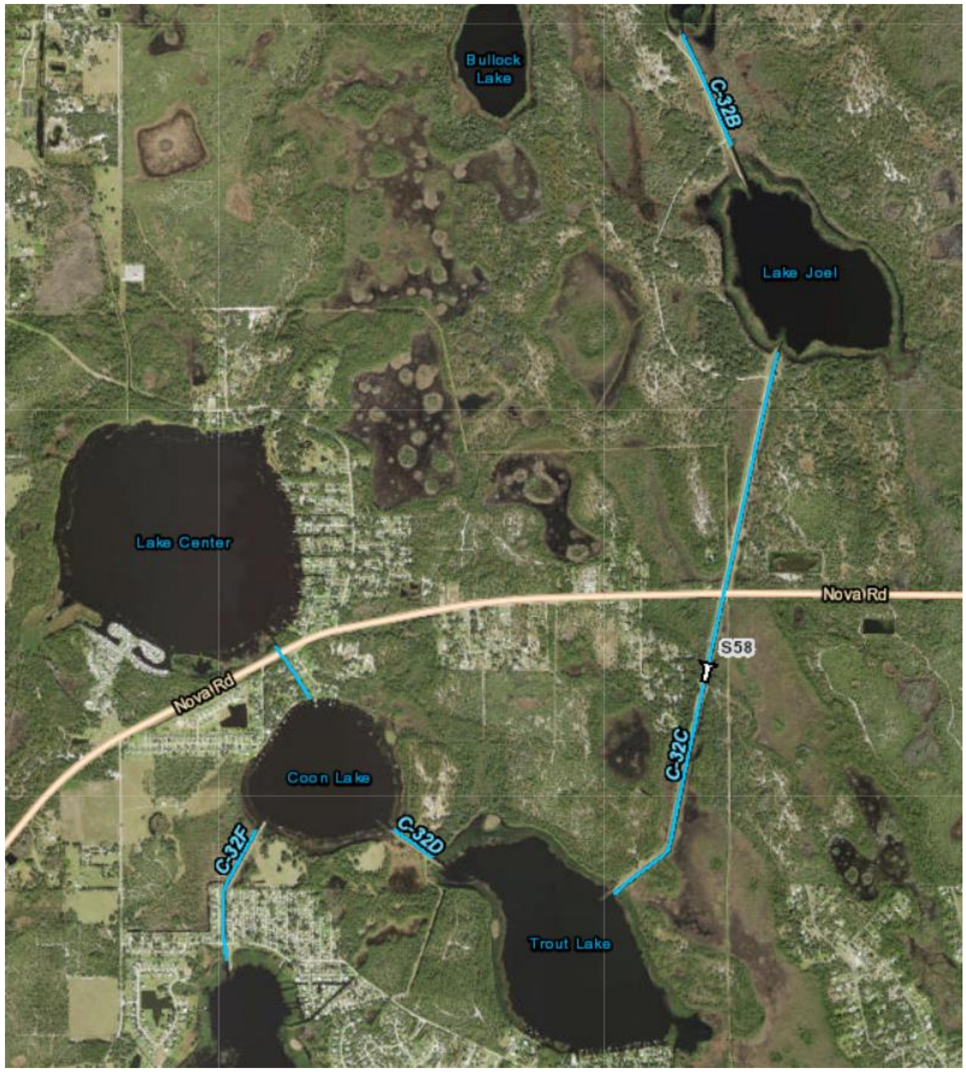
Figure 102: East Lake Toho Water Stages

Cost Estimate

Demolish Existing Structure and Replace with 2-Gated Structure	$1,929,069
C-31 Canal Widening (3 miles)	$10,646,920
Canal Armoring	$1,162,262
Mechanical and Control Building	$13,299,777
Mobilization, Overhead, Profit etc.	$10,172,669
Total Cost	**$37,210,697**

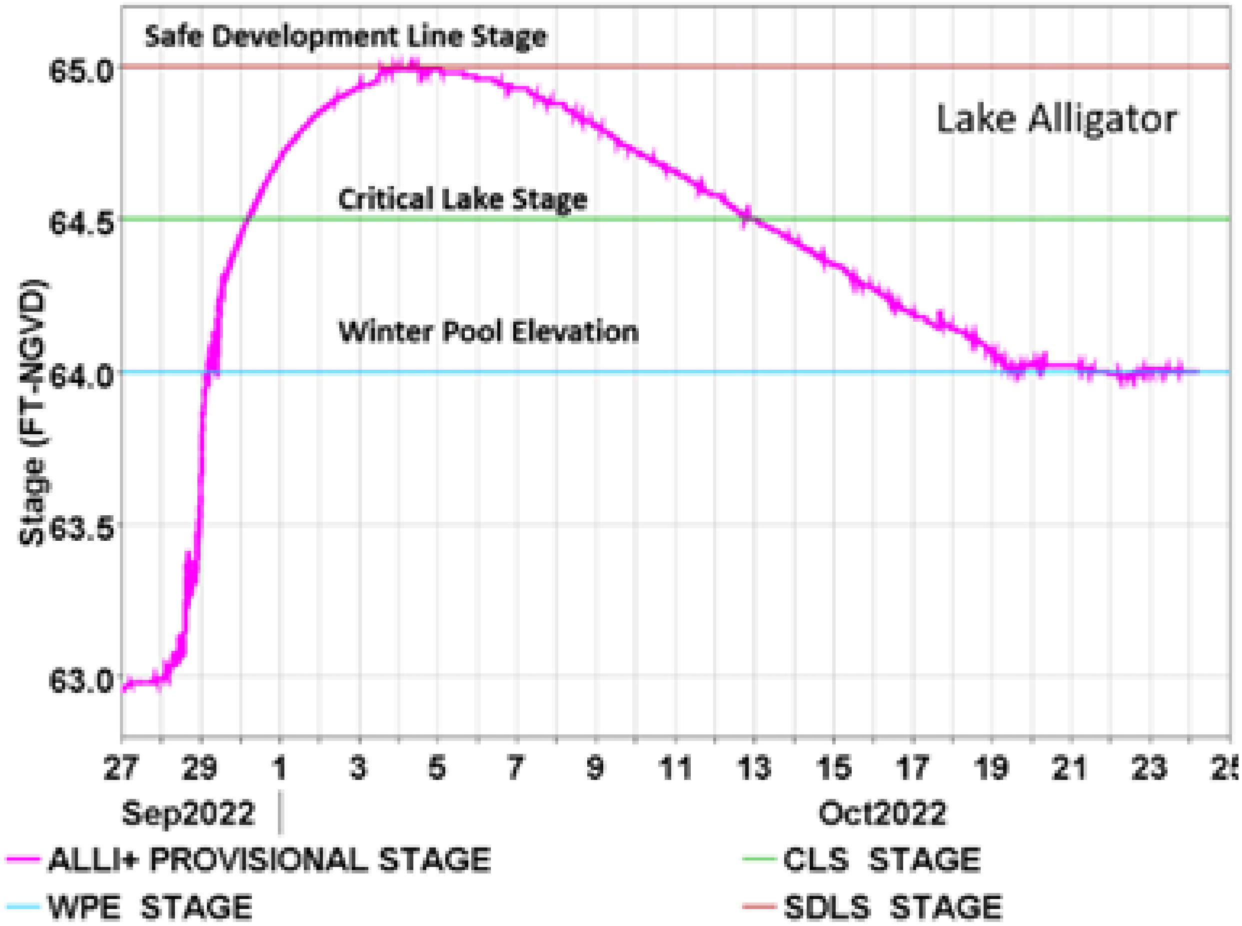
S-58 Structure Enhancement and Temporary Pump

This resiliency project is mainly tied to the District's mission to provide flood control. The S-58 Structure is a two-barrel structure located in Osceola County on the C-32C Canal, 3700 feet downstream from Lake Trout, connecting Lakes Trout and Joel. Flow is south to north in the C-32C Canal, and the structure maintains stages in the range 62.0 – 64.0 feet NGVD in accordance with the Lake Alligator Regulation schedule. The structure, which has a design discharge of 160 cfs, was originally designed to pass sufficient discharge during dry periods to maintain downstream stages and water supply demands. The S-58 Structure is currently the only structure in the primary system in this region that does not have the ability for remote operation.



As a result of Hurricane Ian's heavy rainfall (equivalent to more than 200-year recurrence frequency for the region), water levels in Alligator Lake stayed near the safe development line stage of 65 feet NGVD for approximately 3 days. During Hurricane Ian, mobile pumps were deployed to facilitate discharge to Alligator Lake for the period of 10/01/22 to 10/12/22, with daily flow rates as high as 316 cfs.

Observations made during the response to flooding from Hurricane Ian show that this structure needs to be upgraded. Additionally, there is a need to augment the S-58 Structure with platforms for a mobile pump station to alleviate flood conditions between Lakes Myrtle and Alligator. The region is under intense land development and a rapidly growing population that needs to be provided with appropriate flood control and operational capacity. The currently proposed measures include removing the existing structure and adding 2 (two) gated spillways with fully remote operation capability, along with the permanent installation of pump platforms to make mobile pump deployment quicker/easier and the purchase of two-way temporary pump(s) to have on hand for deployment. Pump capacity will take into consideration canal limitations downstream, as C-32 Canal may not be able to handle more than 250cfs. Platforms should be constructed in a way that allows pump deployment from both directions.



Lake Alligator Water Stages resulting from Hurricane Ian's heavy rainfall event.

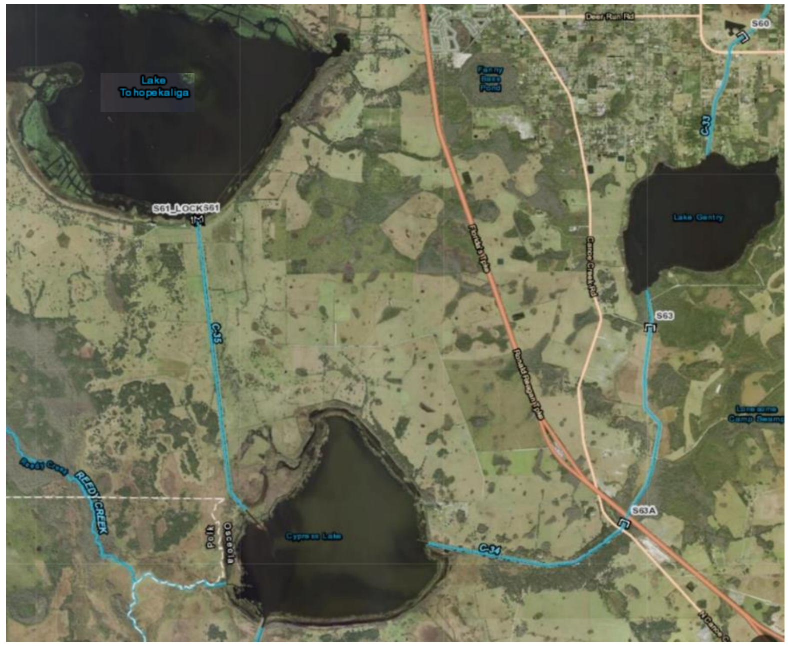
Figure 103: Lake Alligator Water Stage

Cost Estimate

Remove Existing Structure and Construct New 2-Gated Structure, Including Permanent Mobile Pump Platforms	$30,532,262
Mobilization, Overhead Profit, etc.	$9,955,315
Total Cost	**$40,487,575**

S-61 Structure Enhancement and S-61 Navigation Lock Erosion Control

This resiliency project is linked to the District's mission to provide flood control. The S-61 Structure is a reinforced concrete, gated spillway located on C-35 Canal at the outlet of Lake Tohopekaliga in Osceola County. The structure consists of one (1) 18.1 feet high by 27.8 feet wide gate with a sill elevation of 36.9 feet NGVD29. The discharge from the structure is controlled by a hydraulic driven cable drum vertical lift gate. The gate can either be remotely operated from the SFWMD Operation Control Center or controlled on-site. The structure also includes the S-61 Navigation Lock. It is 90 feet long by 30 feet wide with gates on both ends that open to permit the passage of vessels traveling through the region. The S-61 Lock is occasionally operated for flood control purposes when Lake Toho stage exceeds 48.5 feet NGVD. The S-61 Lock was not designed for flood control purposes; however, it is used to supplement the S-61 Structure conveyance capacity to pass floodwater during major storms and during emergency response. This is a delicate operation that must be closely monitored and appropriately coordinated with the U.S. Army Corps of Engineers.



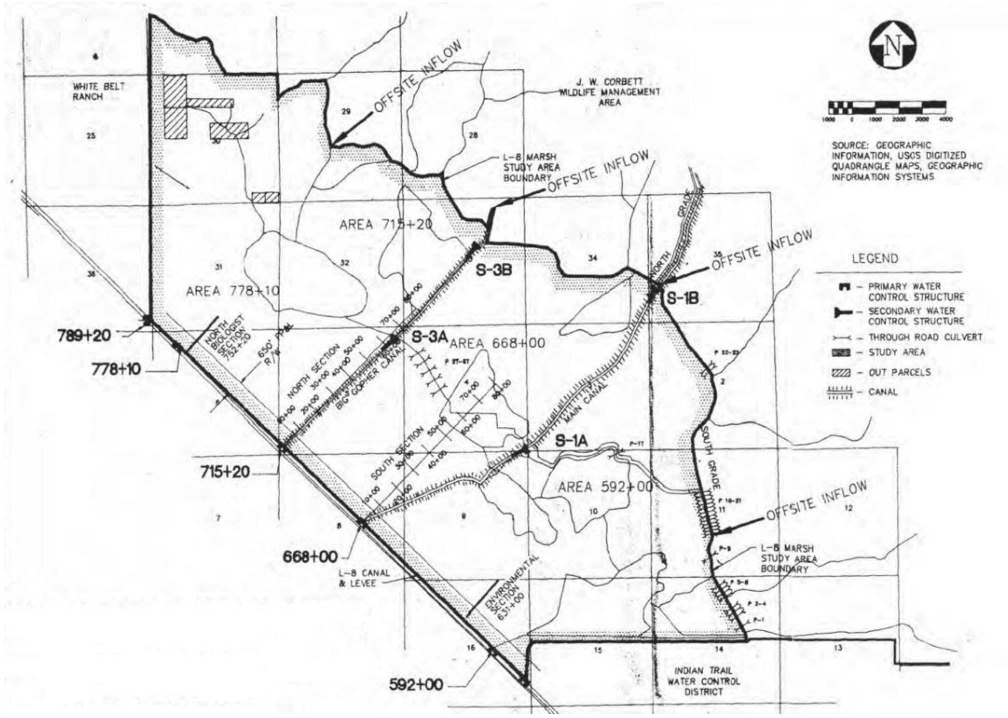
In 2017, during and after Hurricane Irma (when the S-61 Lock was used for flood control operations), the scour hole downstream of the lock increased to seven (7) feet. Further erosion damage was observed during emergency response operations from Hurricane Ian.

Observations made during the response to flooding from Hurricane Ian show that the S-61 Structure and S-61 Lock need to be augmented to handle flood control operations during emergency events, as well as to continue serving navigation purposes. The proposed measures include the construction of a new two-gated S-61 Structure, including enhancement of the C-35 around the new structure. The addition of a second gate will reduce the vulnerability of the structure and allow for improved conveyance capacity. C-35 Canal enhancement will allow for flow to be directed to the new structure, along with proper erosion control measures and sloped rip rap on the south side of the structure. Additionally, the area downstream of the S-61 Lock will be redesigned and repaired with appropriate erosion protection measures.

Cost Estimate

Existing S-61 Demolition and Removal	$3,637,693
New S-61 Two (2) Gated Spillway, including Canal Excavation	$24,961,172
Repairing The Scour Hole in S-61 Boat Locks	$3,859,551
Total Project Cost	**$32,458,416**

L-8/Corbett Levee Water Control Structures



This resiliency project is mainly tied to the District's mission to provide flood control and ecosystem restoration. Several existing culverts that pass through the L-8 Levee are currently owned, operated, and maintained by Florida Fish and Wildlife Conservation Commission (FWC). During Hurricane Ian, a partial failure of one of these culverts occurred, requiring an emergency response to block the flow of water from an adjacent property through the damaged culvert into the L-8 with an earthen berm. The remaining culverts were also exhibiting failure indications, with depressions in the levee crown adjacent to the culverts and the initiation of failure in the sandbag wing walls. This situation increases flood risk because of the potential for higher stages, creating increased pressure against the L-8 Levee, which could then lead to higher seepage and, ultimately, the potential for a breach of the Levee if backward erosion piping were to occur. The replacement of these culverts is critical to resume normal operations and reduce these flood risks. As the entity responsible for the maintenance of the L-8 Levee, it is beneficial for SFWMD to replace these structures to protect the levee and manage the appropriate stages with controlled discharges into the L-8. SFWMD is currently taking over ownership, maintenance, and operational responsibilities. This allows the replacement water control structures to be designed to the District's engineering and construction standards (minimum life expectancy of 75-100 years).

Several of these structures were originally installed as small spillways during the construction of the L-8 but were replaced by the FWC culverts when it was identified that higher upstream stages were desired to provide environmental benefits through improved hydrology in the Corbett Wildlife Management Area. The recommended project includes demolishing the existing culverts and replacing them with five new water control structures and associated riprap/erosion control. Each new structure will have a conveyance capacity of approximately 600-800 cfs. These new structures can be implemented in a phased approach.

Cost Estimate

Project Construction Cost for Box Culvert 1	$3,498,186
Project Construction Cost for Box Culvert 2	$2,318,682
Project Construction Cost for Box Culvert 3	$3,498,186
Project Construction Cost for Box Culvert 4	$3,498,186
Project Construction Cost for Box Culvert 5	$1,426,494
Construction Cost (9) Miles Road Repair at Corbett Levee	$3,489,941
Total Project Cost	**$17,729,675**

Big Cypress Basin Microwave Tower

This resiliency project is mainly tied to the District's mission to provide flood control and water supply protection. A new Microwave Tower and Electronic Equipment Shelter will be located in Immokalee, Collier County, near Lake Trafford. This new tower is required to complete communications for flood control operations for the western spur of the system and bring reliability and resiliency to the Big Cypress Basin area. This important project will help make flood control efforts in the Big Cypress Basin more resilient during storms and hurricanes. Currently, communications are through cell phone towers which can go offline during storm events. This leaves the District without communications and hinders operations.

Cost Estimate

Microwave Tower construction	**$ 6,851,027.00**

Directing Coastal Ecosystem Resilience Phase 1: the Mangrove Experimental Manipulation exercise (MEME)

In order for the coastal wetland landscape to adapt to the impacts of increasing salinity and inundation with increasing sea level rise (in the absence of restored freshwater flows), marsh species must maintain productivity levels that enable the rate of positive soil elevation change to increase at a greater rate than SL (e.g., wetland adaptive capacity). In this experiment, the overarching hypothesis that increased phosphorus availability and sediment elevation will confer the greatest adaptive capacity in a marl-forming coastal marsh (the greatest increase in annual and long-term soil elevation rate relative to the rate of sea level rise) will be tested. We further hypothesize that given the same environmental conditions (phosphorus and elevation), sawgrass species will support the same adaptive capacity as low-density red mangrove species. At a higher density of red mangroves, it is postulated that the degree of adaptive capacity will outpace that conferred by sawgrass and low-density red mangrove. To improve coastal wetland ecosystem function degraded by saltwater intrusion, this experiment will help elucidate environmental factors limiting positive wetland soil elevation change and illuminate optimum approaches for enhancing the ecological resilience of coastal Everglades sawgrass and low-productivity mangrove wetlands.

The site is located within an area of the South Florida Water Management District, at approximately 25°17’25.02” N, 80°26’51.10” W, immediately north of the C111 canal and west of US1 (Figure 117). The experimental plots support treatments of phosphorus, sediment elevation, and sawgrass with different red mangrove densities.

Study plot location in South Florida, just south of the L-31E canal, east of Card Sound Road. A. approximate plot location and B. plot location relative to US1 and Card Sound Road. The total extent of the proposed study site is 572m2 in area.

Figure 104: Study plot locations.

This pilot study uses small 1-meter test plots to assess a number of approaches that could enhance the flood protection and ecological diversity of the coastal mangroves in the face of sea level rise. The distribution of these plots within a scrub mangrove community along the C-111 canal, just west of FL Highway 1, is shown in Figure 118. MEME manipulations are replicated and include three treatments: a planting treatment, a soil addition treatment, and a phosphorus addition treatment. Due to this multi-factorial design, MEME requires some 60 plots.

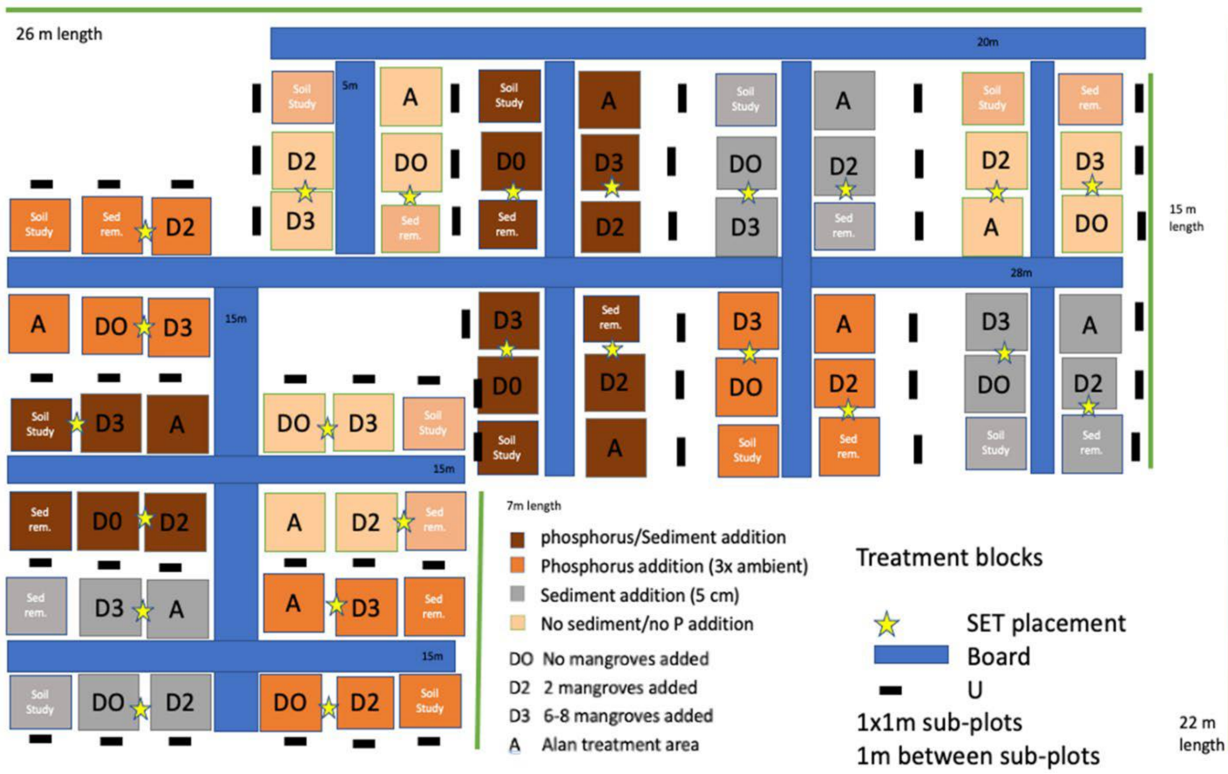


Figure 105: MEME and MEME Study Design.

MEME study design. Legend for the above MEME Study (*NA = No Amendment; S = Shallow (amendment -/+5cm); M=Moderate (+20-25cm); D = Deep (+50cm)

Many of the techniques and analyses identified as part of EMMA are also part of MEME. These include SETs, soil nutrient changes, soil elevation changes, plant growth, and plant recruitment. Primary response variables include soil elevation and surface accretion; porewater salinity, dissolved nutrients, carbon (C) and sulfide; sawgrass and red mangrove aboveground standing biomass (non-destructive technique; belowground biomass and root productivity; periphyton biomass and accumulation; water level and hydroperiod; and soil and plant tissue C, nitrogen and phosphorus. A continuous water level and salinity monitoring gauge will be deployed. Shallow 2.5cm diameter PVC samplers, installed to sample soil porewater at 15 cm below the soil surface, will be installed in each sub-plot. Secondary response variables include leaf and root decomposition rates. Red mangrove saplings will be planted at 2 saplings per meter squared and 6 per meter squared.

MEME Cost Estimate

Mangrove Experimental Manipulation Exercise	$375,000

Directing Coastal Ecosystem Resilience Phase 2: the Everglades Mangrove Migration Assessment (EMMA)

This resiliency project is mainly tied to the District's mission to provide flood control, water supply protection, and ecosystem restoration. The EMMA project is being proposed to capture the adaptive foundational resilience of coastal wetlands within the District and to demonstrate the ability of coastal wetlands to adapt to rising sea levels via enhanced soil elevation change. EMMA is designed to capture the adaptive foundational resilience of the coastal wetlands within the SFWMD, with an emphasis on nutrient-depleted mangroves. The term "adaptive" means 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 sea level rise. 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 historical 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 sea level rise, 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. The results of EMMA will have implications for and application to all coastal wetlands of Florida that are vulnerable to sea level rise.

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, and soil accretion and by supplying a medium for greater carbon sequestration, which allows coastal wetlands to keep pace with sea level rise (DeLaune et al. 1990, Baustian et al. 2015).

Goals and Objectives

Changes in water management, in concert with sea level rise, have 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 from 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 sea level rise will result in significant land loss and loss of stormwater protection. Intervention that promotes accretion rates that act to maintain or outpace sea level rise 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 project is to advance the understanding of biological versus physical controls on the capacity of coastal wetlands to persist under increased sea level rise. The 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 114) – the Charly Site located on the southeastern tip of the C-111 canal, the Pocket Site located along the C-111 Canal just west of the S-197 structure, and the Baby EMMA Site located just west of U.S. Highway 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 will divide each transect into control transects and TLP treatment transects to document the costs and benefits of TLP and help establish the protocols for the 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.

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 sea level rise. Six Class "B" (Stainless Steel rod driven to refusal) NGS stability standard monuments will be established. The work will include but is 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 would 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.

Figure 106: EMMA Assessment Locations (From left to right: Charly Site and Pocket Site)

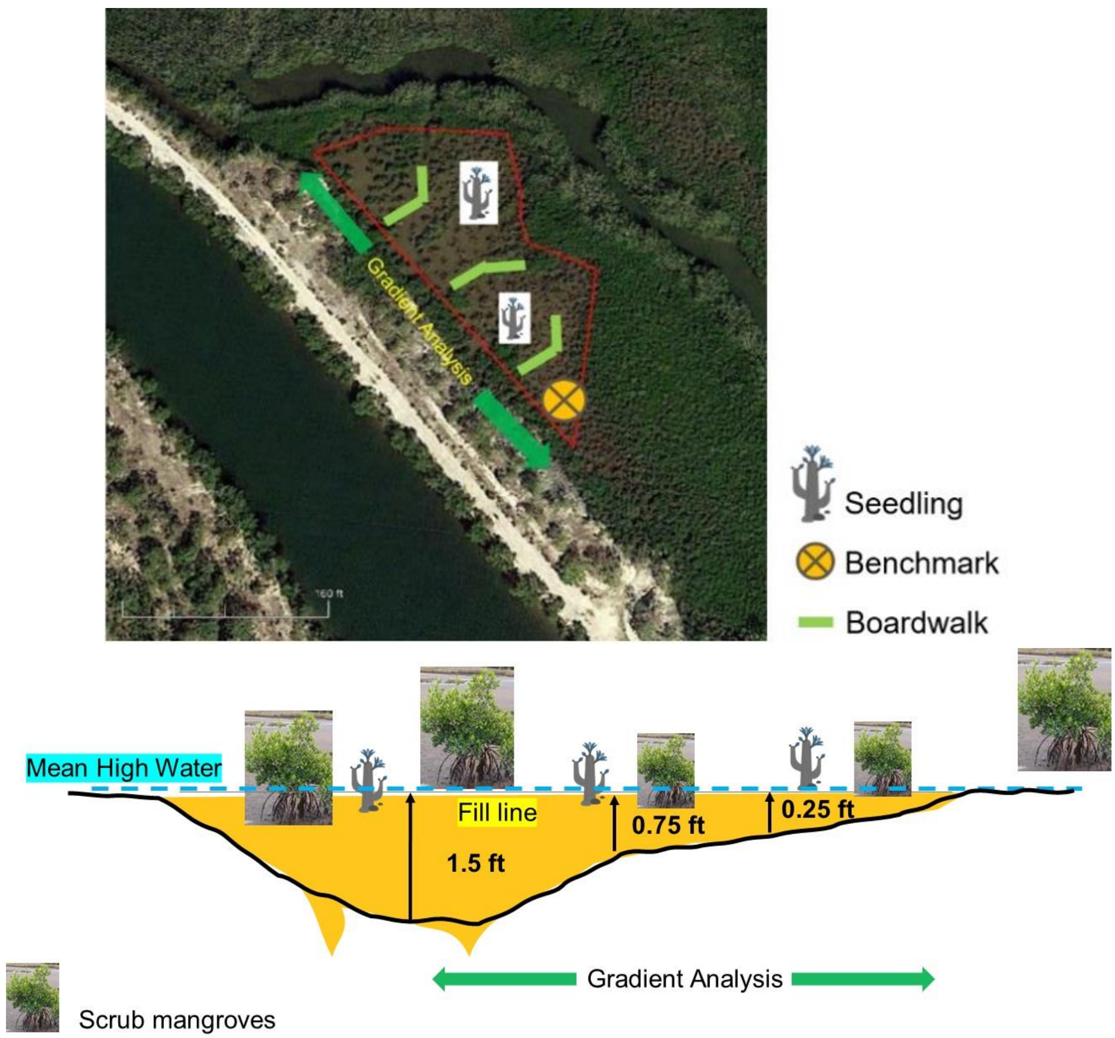


Figure 107: Pocket Site study design.

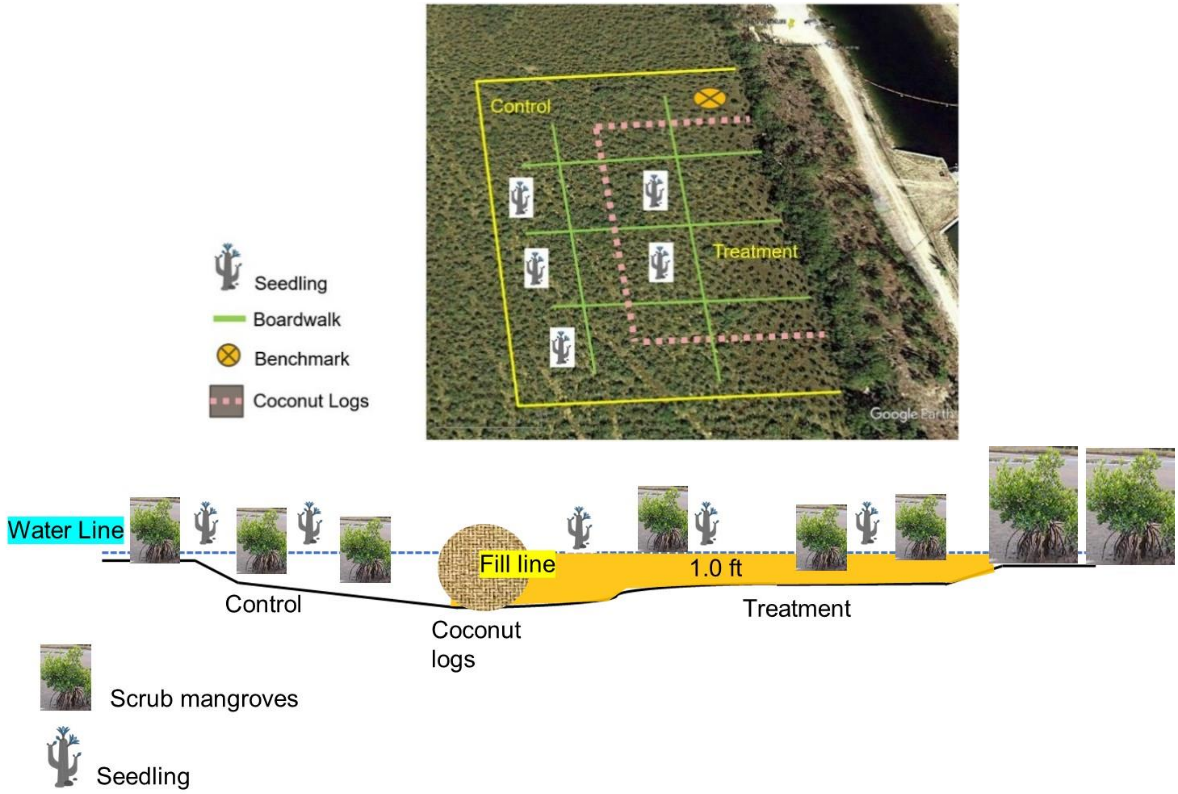


Figure 108: Pocket Site study design.

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 the below ground processes in this pilot study is understood. 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).

Water and Soil Analysis

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 a 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, and 50–100 cm. Root and soil samples will be analyzed for Total Carbon, Total Nitrogen, and Total Phosphorus.

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 was rinsed twice before obtaining a clear water sample, from which salinity was measured using a YSI-30 multiprobe sensor.

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

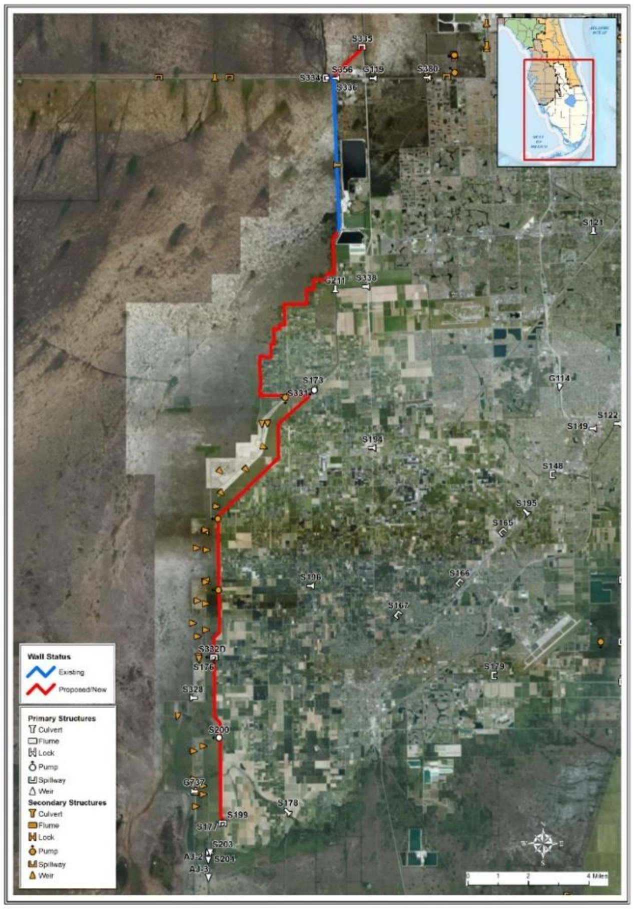
Schedule and Costs:

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 are not yet known and will need to be negotiated.

EMMA Cost Estimate

Everglades Mangrove Migration Assessment	$2,760,000

South Miami-Dade Curtain Wall



This resiliency project is mainly tied to the District's mission to provide flood control, water supply protection, and ecosystem restoration. 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 are of interest to private, public, local, state, and federal stakeholders in the region.

The Curtain wall project has been advanced in waves starting from planning studies in 2015 and 2018 to demonstrate the effectiveness of the feature as a solution that reduces flood risk while simultaneously enhancing restoration benefits. The recent modeling 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 119 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.

More detailed work to support the design of the regional curtain wall was initiated in 2020 as part of a detailed public planning process, which was later suspended to allow for the expedited, detailed look for the limited curtain wall adjacent to the 8.5 SMA, and then the continuation of that wall as part of CEPP to connect to the L31N levee. Both these initial reaches are either completed or nearing completion Figure 119 illustrates the alignment options along which geotechnical exploration was undertaken as part of the public planning process. The hydrogeologic information gathered from geotechnical borings and geophysical logs was necessary to improve the model representation of the underlying geology of the possible wall alignment and provide important design information. The actual alignment and depth of the wall, as well as the designed gaps to avoid adverse impacts on Taylor Slough, will be determined when the public planning process is re-engaged. The information garnered from the currently implemented sections of the wall and from the additional hydrogeologic data acquisitions will ensure the layout of the remainder of the curtain wall sections addresses stakeholder concerns (including water supply, saltwater intrusion, flows to Biscayne Bay, etc.) and is cognizant of future conditions, including planned projects in the region. The modeling and tools developed for this study will be made available through the Statewide Model Management System for interested parties.

The results of the H&H modeling, illustrated in Figure 120, 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.

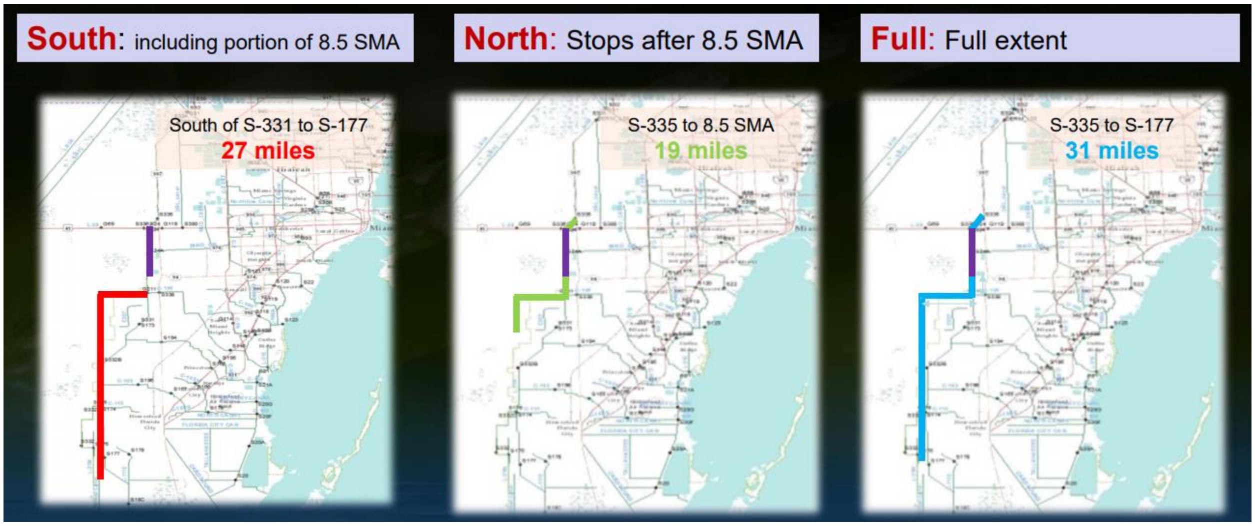


Figure 109: Location and extension of three curtain wall configuration scenarios (2018).

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 120 and Table 5 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 flow 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.

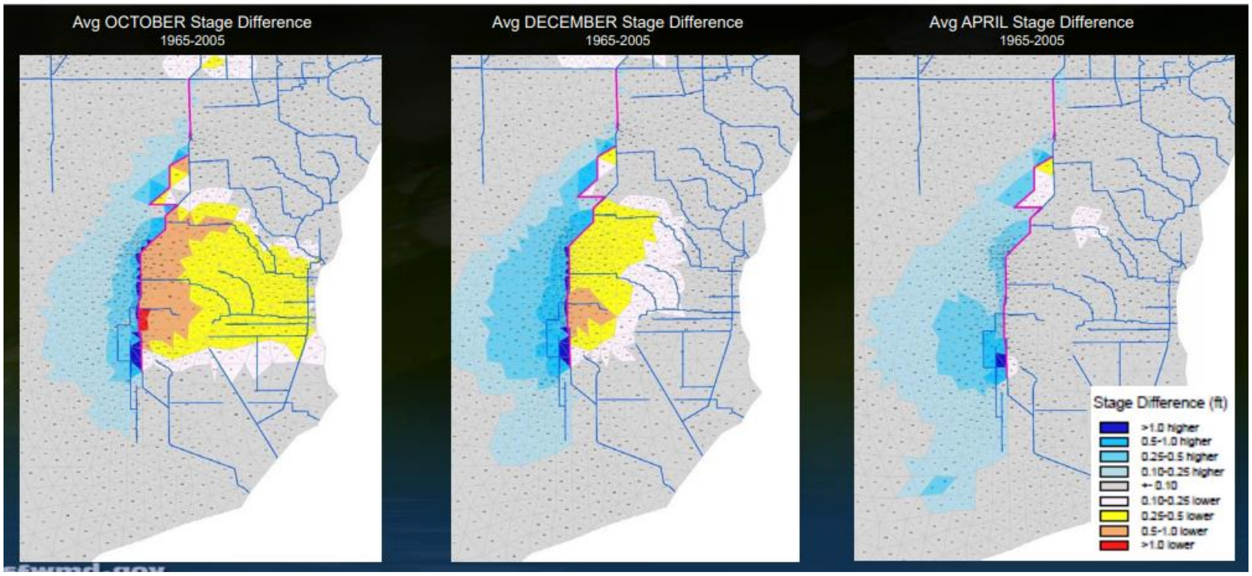


Figure 110: H&H modeling results illustrating the average water stage difference with and without the full extent curtain wall scenario.

Table 5: 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 the 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.

The additional new funding will facilitate the 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.

Cost Estimate

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

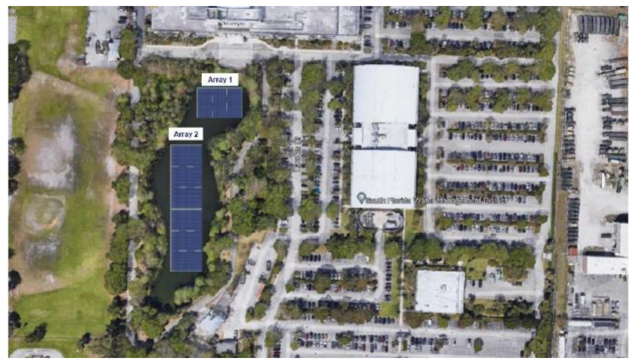
Renewable Energy Projects

Solar Canopy at District Headquarters

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 the cooling effect of water (in some cases 10+%), neutral or positive environmental impact, improved water quality, and reduced algal blooms due to the shading of the water column.



Solar Panel Installations at C-43 and C-44

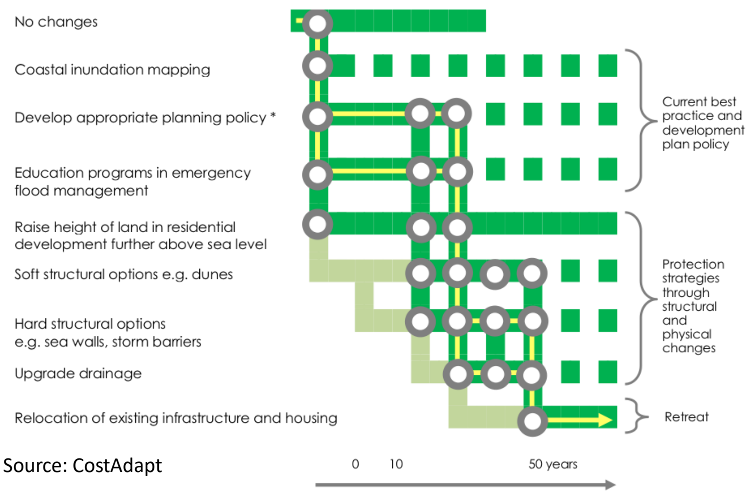
In addition, the District is initiating coordination with Florida Power and Light to potentially install solar panel facilities at the C-43 and C-44 Reservoir adjacent lands with the goals of reducing energy costs at these facilities as well as offsetting carbon emissions from existing and new proposed pump stations that rely on non-renewable sources. Different options are under consideration, including both smaller 2–5-megawatt projects to power local energy needs and solar farms up to 75 megawatts to generate power to the grid, using District lands.

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

Total Amount of Funding Request	Duration
C-43 Solar Panel Installation Costs (2-5MW: $8,000,000 – 10,000,000)	1 year
C-44 Solar Panel Installation Costs (2-5MW: $8,000,000 – 10,000,000)	1 year

PRIORITY PLANNING PROJECTS DESCRIPTIONS AND COST ESTIMATES

FPLOS Adaptation and Mitigation Planning (Phase II Studies)



Source: CostAdapt

FPLOS Phase II studies will build upon previously developed FPLOS Phase I water management (H&H) models to identify feasible flood adaptation and mitigation solutions in critical basins. The 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.

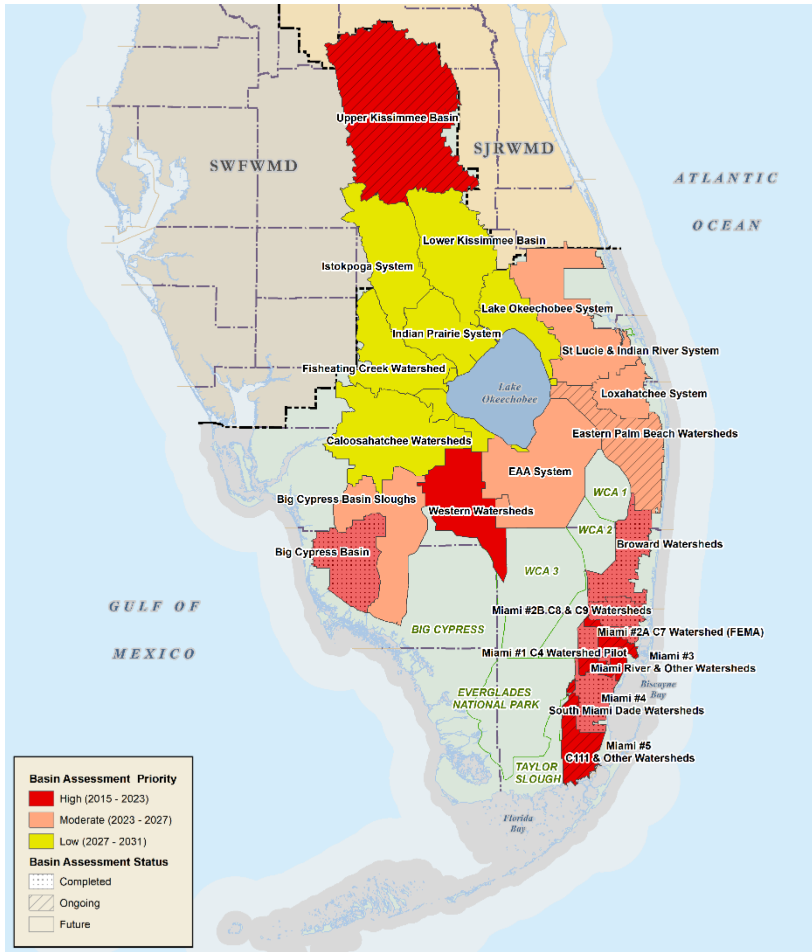
It is crucial that this phase of the FPLOS program be properly funded, preferably with recurring funds, because it identifies projects that are ready to design and build, both for the District and for local stakeholders that are responsible for secondary and tertiary flood control assets. Results from 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 predetermined performance criterion, additional mitigation strategies are triggered, setting up a plan on how multiple strategies can be implemented over time.

In FY23, Phase II Studies were completed for the C-9 and C-8 Basins in Broward and Miami-Dade counties. The C-7 Pilot Phase II Study is under initiation. The Program's 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
$3,000,000	Yearly - recurring

FPLOS Assessment (Phase I Studies)



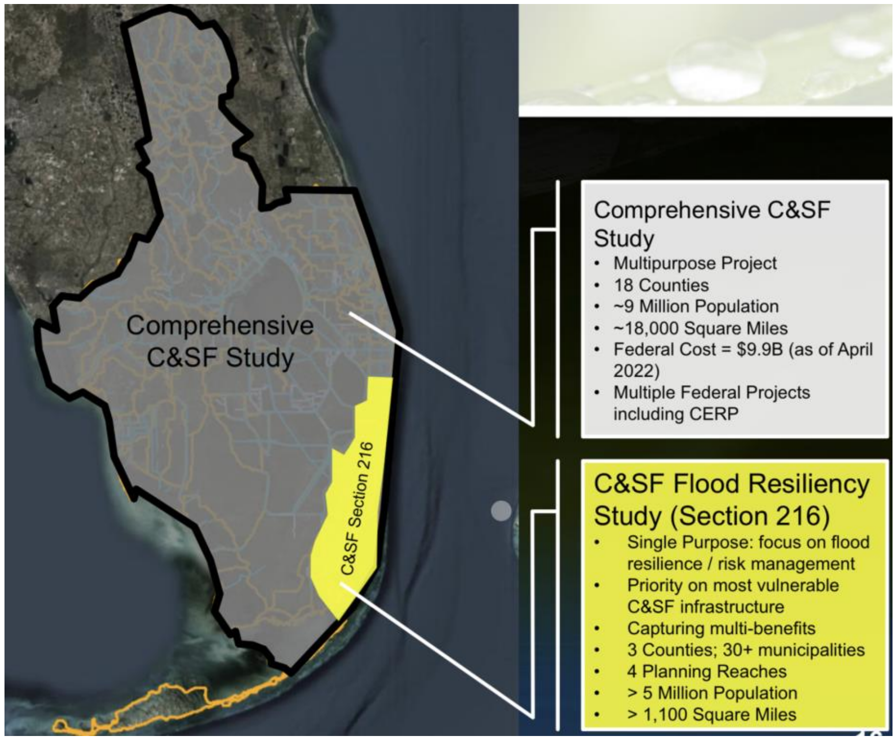
FPLOS Phase I Studies have been ongoing for the past eight years. These studies identify and prioritize long-term infrastructure improvement needs in response to population growth, land development, SLR, and climate change. The requested funding will be used to advance the development of water management (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 SLR. 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 cost estimate detailed below 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.

Total Amount of Funding Request	Duration
$2,000,000	Yearly - recurring

Comprehensive Central & Southern Florida Study

A Comprehensive Central and Southern Florida (C&SF) Study has been authorized under Water Resources Development Act of 2022 (WRDA 2022) as a multipurpose feasibility study for resiliency and comprehensive improvements or modifications to existing water resources development projects in the central and southern Florida area expanding from the ongoing single-purpose flood risk management (FRM) C&SF Flood Resiliency Study, authorized by Section 216 of the Flood Control Act of 1970.



The Comprehensive C&SF Study will cover approximately 18,000 square miles, which includes all or portions of the 18 counties in central and southern Florida. The District will partner with the United States Army Corps of Engineers (USACE) – Jacksonville District (SAJ), and St. Johns River Water Management District (SJRWMD) to complete the planning level study.

This study will be completed under the authority of Section 8214 of the WRDA 2022, which authorizes the Secretary of the Army to carry out the study, review the report of the Chief Engineers on central and southern Florida, and other related reports of the Secretary; and report to Congress with recommendations on cost-effective structural and nonstructural projects for implementation that provide a systemwide approach without interfering with the efforts undertaken to carry out the Comprehensive Everglades Restoration Plan (CERP). SFWMD and USACE SAJ initiated discussions for the execution of a Feasibity Study Cost-Share Agreement.

Goals and Objectives

The Comprehensive C&SF Study will identify technically feasible, environmentally acceptable, and cost-effective project recommendations justifying federal participation, in collaboration with the project local sponsors – SFWMD and SJRWMD, for the purposes of flood risk management, water supply, ecosystem restoration (including preventing saltwater intrusion), recreation and related purposes. The project components and alternatives will provide an integrated regional assessment for the evaluation of the larger stormwater management system, as well as propose the best adaptation strategies to prevent flood risks from storm surge, extreme rainfall, high tides and groundwater levels, along with saltwater intrusion. Project components and alternatives not advanced as part of other ongoing or recently completed regional studies, e.g. C&SF Flood Resiliency Study, or Miami-Dade Back Bay Study within the proposed project area might be incorporated as part of project study components of the upcoming Comprehensive C&SF Study. Study costs will be determined in collaboration with USACE, upon study initiation.

Water Supply Vulnerability Assessment

The SFWMD is conducting a Water Supply Vulnerability Assessment aimed at understanding how future development and climate conditions impact the regional water supply. 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 diagram summarizes a subset of initial recommendations and assumptions that are integrated into the proposed approach. More detailed information on the approach and next steps are described in the Appendix C report: Water Supply Vulnerability Assessment .

As an initial effort, SFWMD is developing the East Coast Surficial Groundwater Model (ECSM) to be density-dependent, allowing for SLR scenarios to be incorporated into the model simulations. To begin with, the ECSM will be run for the 5-year update to the Lower East Coast Water Supply Plan, anticipated to be completed in 2024, and later for other upcoming water supply plan (WSP) efforts.

Using the ECSM, the vulnerability assessment will be based on WSP methodologies for growth rates, withdrawal rates, and available water supply sources while independently analyzing climate effects. Public water supply and domestic self-supply's 20-year growth rates have been extrapolated to 50 years through a contract with the University of Florida's Bureau of Economics and Business Research. Respective withdrawal rates will be calculated using the 20-year (2045) per capita use rate. Agriculture, landscape, and recreational withdrawal rates will include projected temperature, rainfall, and ET rates at 50 years (2075). 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.

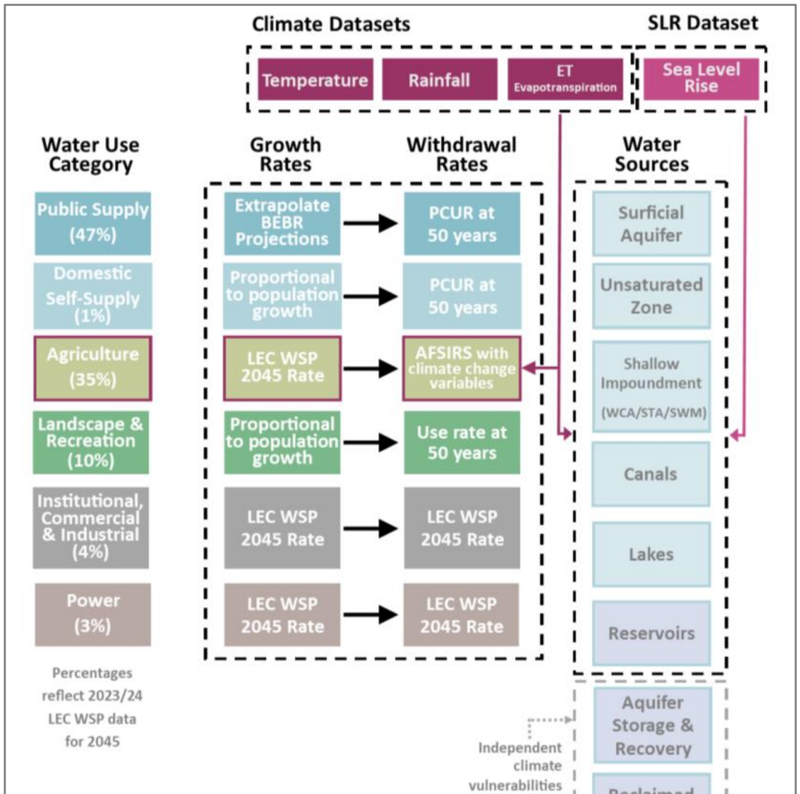


Diagram summarizing workgroup recommendations

SFWMD has contracted Florida International University (FIU) and the US Geological Survey (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 is currently working with USGS and FIU to evaluate projected changes in drought characteristics (duration, magnitude, frequency, extent) for the state based on downscaled climate datasets for future 50-year moving periods compared to the historical period from downscaled models (1950-2005) and observations. The outcome from this work will be a selected set of future climate datasets that will provide a reasonable range of future changes in drought conditions. This task is currently ongoing and is expected to be completed by April 2025.

To properly analyze the effects of climate change, including SLR, 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 proposes 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 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 Water Supply Vulnerability Analysis will be conducted in an open public process with periodic updates and public meetings throughout the process. Notifications will be sent at the appropriate time. The funding request is to support modeling scenarios formulation and development, followed by the analysis and reporting of results.

Total Amount of Funding Request	Duration
$300,000	Yearly - recurring

Water and Climate Resiliency Metrics

As part of the District's ongoing resiliency initiatives, SFWMD has established an initial set of water and climate resilience metrics across the region. These science-based metrics track and document long-term trends and shifts in observed water and climate data. They support the assessment of current and future climate condition scenarios and related operational decisions, informing vulnerability assessments, adaptation planning, and decision-making to determine District resiliency investment priorities. Additionally, this effort informs stakeholders, the public, and partner agencies about the District's resiliency efforts while supporting local resiliency strategies.

The Water and Climate Resiliency Metrics represent an important step towards planning for the future by considering long-term observed trends and their impacts on the District's mission. As part of phase I of metrics implementation, analyses for the initial set of selected water and climate resilience metrics are being automated for publication through an interactive web portal. This portal provides navigation to different locations District-wide and access to real-time data, generating alternative mapping, chart, and graph options to display and communicate trend results, supported by a story map. In phase II, the District seeks to partner with local, regional, and national agencies, as well as academic research institutions, to build upon the existing water and climate data analysis efforts in support of further advancing water resources resilience planning.

Phase I: Web Tool Implementation

The ArcGIS-based Resilience Metrics Hub provides real-time updates of observed data and automated trend analyses for eight of the fifteen prioritized Water and Climate Resiliency Metrics. Real-time automation minimizes the need to rework and reprocessing of data and trend analyses for the selected metrics based on the latesst available data and is integrated into the District's existing database tools, through DBHydro Insights. Currently automation is completed for tidal elevations at SFWMD's costal structures, groundwater levels and chlorides concentrations at groundwater monitoring wells, and evapotranspiration for the region. Automation of the water quality metrics is projected to be completed in FY2024. Each automated trend analysis web tool is accompanied by a story map for the metric that provides context for the processes behind the observed data, including how, where, and why the data is typically collected, and its relevance to resiliency planning. These story maps offer an interactive experience for public end users, informing and engaging with valuable content. Additional, story maps will be finalized for metrics that are not yet automated, including regional rainfall, salinity in the Everglades, soil accretion/subsidence, and estuarine and mangrove inland migration.

This funding request will be used to continue automation activities, finalize additional story maps, and incorporate new metrics and analyses. Overall, funding will support continued integration between DBHydro and the 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.

Phase II: Enhanced Analyses

Phase II aims to enhance and build upon the existing water and climate data analysis efforts to continue advancing water resources resilience planning and well-informed infrastructure investment decisions. The primary goals include:

- Enhancing existing metrics' analyses by identifying relevant datasets that support further analysis of identified trends and determining influencing factors that describe observed trends.
- Incorporating of new and novel resilience metrics, such as droughts, stormwater flows, ecological coastal indicators (seagrass, oysters, algae, carbon storage potential).
- Enhancing data collection by incorporating of real-time flood sensors and weather stations.
- Continuously assessing existing climate model datasets and regional climate model runs.
- Strengthening scientific understanding of evolving conditions by linking present-day observations to historical trends and future projections.
- Evaluating existing trends in the context of underserved communities, continuing to prioritize outreach, education, and communication to enhance regional awareness and engagement.
- Contributing to expanded results, approaches, and lessons learned, statewide.

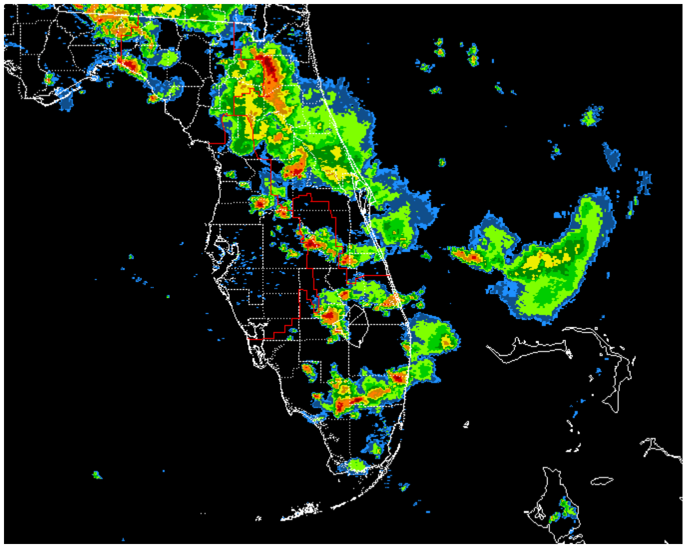
Example recommended/proposed activities:

- **Flood Observations Analysis**: Comprehensive examination of flood extent, frequency, and compound flood characteristics in coastal areas, utilizing historical observations of rainfall, storm surge, and high tide data.
- **Enhanced Flood Monitoring and Radar/Satellite Data Integration**: Integrating new flood data from enhanced monitoring systems, including rapid deployment gauges in partnership with USGS. Incorporating, novel radar and satellite datasets, such as ICEYE products, to enhance flood assessment capabilities.
- **Enhanced Analysis of Tidal Elevations:** Conducting additional analyses to consider nonlinear trends in rising sea/tailwater levels, exploring rapid rises in the last decade, and assessing the changing frequency of threshold exceedances using nonstationary modeling.

- **Advanced Tidal Forecasting**: Developing a sophisticated tidal forecasting approach, in collaboration with University of Miami, that factors more recent sea level rise, global and local variables such as wind strength, direction, and persistence and ocean currents to provide more accurate tidal predictions.
- **Gulf Stream Current Study**: Examining the influence of the Gulf stream current and coastal dynamics on rainfall patterns and sea level rise.
- **Evapotranspiration Trends**: Analyzing regional evapotranspiration rates using new datasets, such as NOAA data, to support droughts scenario formulation in collaboration with USGS and FIU.
- **Saltwater Intrusion Assessment**: Assessing saltwater intrusion rates and freshwater withdrawal, alongside enhanced monitoring, to understand and mitigate the effects potential impacts on water resources, particularly coastally located water supply wellfields due to of sea level rise and saltwater intrusion.
- **Weather Station Deployment and Integration**: Deploying additional weather stations and integrating them with the District/NWS's AWIPS II system, ensuring enhanced weather monitoring capability.
- **Water Temperature Study**: Analyzing new water temperature data to provide insights into temperature trends affecting coastal ecosystems and the impacts of shrink and swell dynamics on local tidal levels.
- **Sub-daily Rainfall and Drought Characterization**: Develop comprehensive analysis of sub-daily rainfall data and better characterizing drought events to enhance trend analysis and projections, based on historical data and downscaled global climate model datasets in collaboration with FIU and USGS.
- **Stormwater Volume and Flow Analysis**: Evaluating the reliability of historic stormwater volume and flow datasets and determining the best approach for assessing trends in stormwater dynamics.
- **Enhanced Mangrove Monitoring:** Developing an imagery classification workflow in Google Eath Engine to discern tree species, informative to coastal managers, through the pilot project 'Loxahatchee River Coastal Salinity Intrusion (LOX-CSI): A Remote Sensing-Based Approach to Understanding Coastal Ecotone Shifts Under Evolving Conditions.' This involves comprehensive biological field data collection and imagery processing for in-depth historical trend analysis. In addition to detailing mangrove extent, this study will lay the foundation for enhanced monitoring strategies and future research endeavors, including expanding mangrove monitoring to other District areas and conducting carbon uptake studies.
- **Assessment of Coastal Carbon Storage Potential**: Evaluating the carbon storage potential of coastal ecosystems using existing and new data, considering indicators such as sawgrass mass, oyster population, and algae occurrence are considered.
- **Regional Climate Model Data Efforts**: Developing a regional climate model led by the Florida Flood for Applied Research and Innovation to understand regional climate dynamics and trends that influence coastal processes that affect flood risks.

Total Amount of Funding Request	Duration
$400,000	Yearly - recurring

Hydrometeorological Data Monitoring



This 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 continue to 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 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 the 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 more frequent intervals, including sub-daily analyses. 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 hydrometeorological 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. As of May 2024, A total of 272 gauges have been installed throughout the project impact area and are actively collecting data.

Total Amount of Funding Request	Duration
$300,000	Yearly - recurring

Statewide Regional Climate Projections

Statewide Regional Climate Projections are being developed by the Florida Flood Hub and in coordination with the Florida Department of Environmental Protection (FDEP), USGS, academia, Water Management Districts, Regional Planning Councils, Florida Department of Transportation, 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 the operation of District infrastructure and mission implementation. The District has a specific interest in the determination of future rainfall scenarios as part of FPLOS Phase I Assessments and the Water Supply Vulnerability Assessment.

The District, the U.S. Geological Survey, Florida International University (FIU), and local governments have been working over the past six-plus years to evaluate 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, in partnership with USGS and FIU, assessed the best available downscaled climate datasets and published the “Extreme Rainfall Change Factors for Flood Resiliency Planning in South Florida” in the Resilience Metrics Hub. The Florida Flood Hub has partnered with the same team to extend these projections statewide, which was recently initiated in FY2023 under the technical supervision of an established working group with representatives from all the partner agencies listed above. A parallel long-term effort is being conducted, as recommended in the 2019 Workshop because the use of available climate datasets for estimating future rainfall in Florida shows biases in extreme rainfall, which are relatively large when comparing past observations with the climate model’s historical data. The Statewide Regional Climate Projections modeling effort will be better suited to capture conditions/mechanisms of rainfall occurrences in South Florida, including contributions from tropical storms and sea breeze, as well as Florida shelf and ocean dynamics and other important climatic processes. It will reduce future rainfall uncertainty estimates and provide data on climate change the state of Florida and the extent of all hydrologic process including major Florida aquifers and would provide information on rainfall-depth duration frequency at resolution needed in Florida for resiliency planning including flood and water supply vulnerability assessments. In addition, the fact that the proposed model will capture the details of Florida neighboring seas and how they affect in-land rainfall and coastal flooding, the results are expected to provide a more comprehensive assessment of changes in extreme than that are extracted from the currently available global and regional climate models. The District is currently working with the University of Miami (UM) to enter into an agreement to proceed with the development of a state-of the art high resolution regional climate model simulations that can stand alone as a critical source for understanding climate projections of extreme rainfall and flood risk throughout the state of Florida for a range of future scenarios and can be used to drive very high resolution climate projections with coupled land-ocean-atmosphere regional climate model. The financial contribution from SFWMD to this project, in support of the Florida Flood Hub, is summarized below.

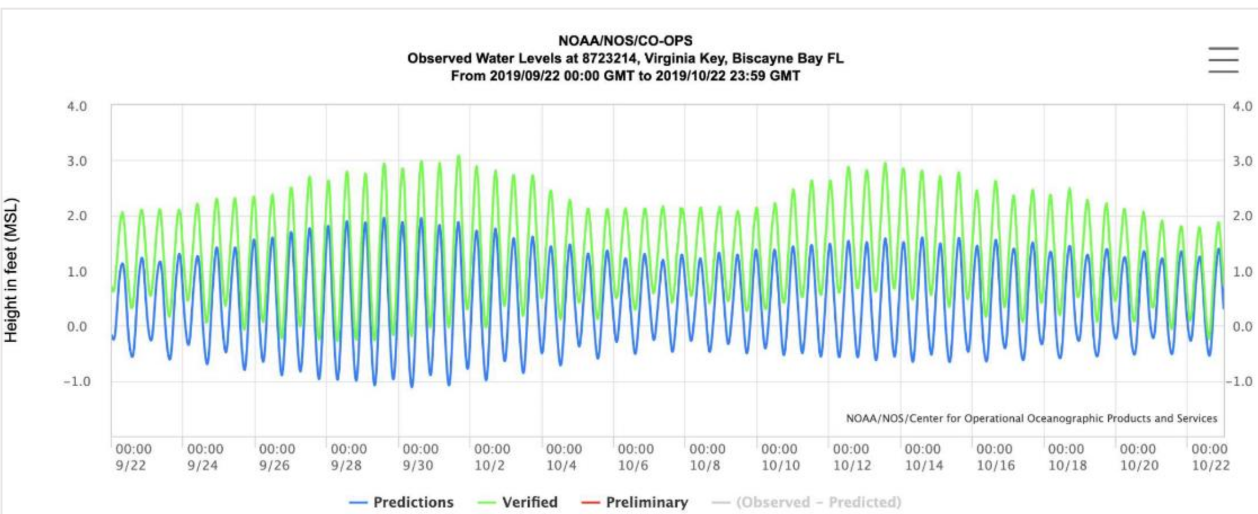
Total Amount of Funding Request	Duration
$150,000 (SFWMD contribution only)	Three Years – One Time

Enhancing Tidal Predictions

Local near-future tidal predictions are being 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 SLR on the 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 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 2022, UM RSMAS completed improvements to 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 has been run and validated 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.



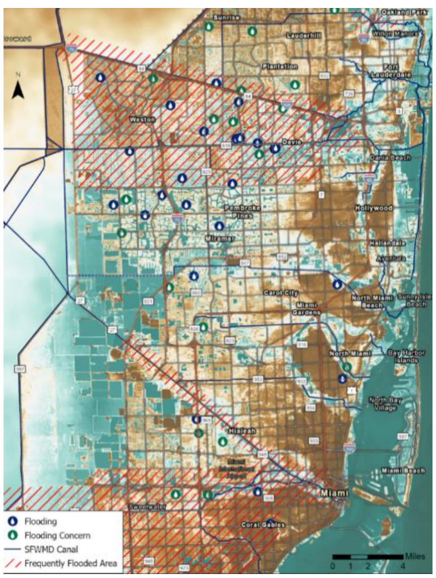
The District is partnering with UM RSMAS to build on current efforts and refine the model for use at additional tide stations along South Florida's east coast: Port Everglades, Lake Worth, Key West, Vaca Key, and Naples. Near-future tidal predictions based on the latest available data and best available science would provide water managers at the SFWMD and local agencies with more accurate and necessary information to respond to variable weather conditions now and in the future. Deployment of predictions to the Resilience Metrics Hub is projected to be completed from late summer to early fall of FY2024.

Total Amount of Funding Request	Duration
$ 65,000	2 Years – One time

Flooding Observation Survey and Notification System

Identification and documentation of high-water marks and other flood observations are critical to understanding flood depth and extent and provide observations necessary to validate simulation models attempting to replicate flood occurrence. Identifying where to record and measure high-water marks is a challenge. Flood observations during events can be used to inform high-water 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 the 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 regional system of collection and notification would provide local tools to assist local agencies in responding to and documenting flood occurrences 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.



The development of a regional flood observation and reporting system is proposed to standardize and centralize flood observation information. Once established, this repository can serve as the basis for the 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 is needed to understand how these trends impact the effectiveness of local and regional stormwater management systems and how mitigation measures are improving those conditions. This proposal is to establish cloud-based regional flood data collection tools and a repository for the standardization of flood observation and high-water mark data to evaluate flood occurrence over time and mitigation measure effectiveness.

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

Evaluating the Performance of the SFINCS Hazard Model to Support and Accelerate the FPLOS and SEFL Regional Adaptation Planning Efforts

Following the recently finalized collaborative development of the South Florida Water Management District Flood Impact Assessment Tool (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: First, integration of coastal and inland flood modeling is currently lacking. As a result, the studies do not consider compound flooding. Second, 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 southeast 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 hydrometeorological 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, for example, 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 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 models and readily available field observations used to calibrate and verify the MIKE models. The costs for this in-depth performance evaluation are approximately $75,000 and include 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. In FY2023, a workgroup was established with representatives from SFWMD, Deltares, USGS, FIU, the University of Miami, and the University of California Irvine to support the development of this project and additional parallel efforts currently in development for the support of flood adaptation planning.

Total Amount of Funding Request	Duration
$100,000	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 the 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.

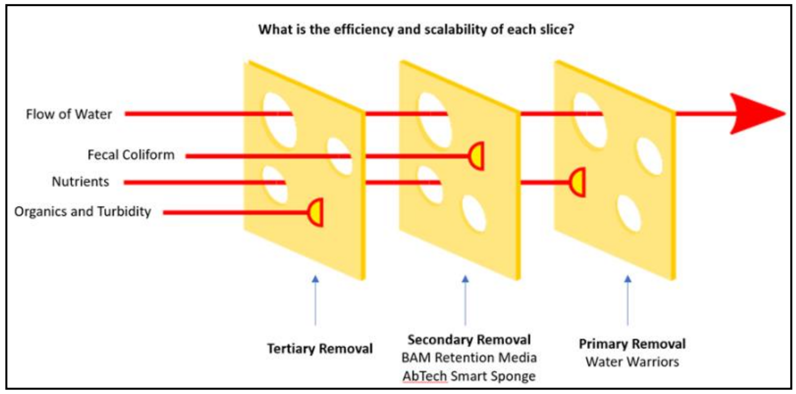
To enhance regional adaptive capacity for addressing the increasing challenges of flood and water quality protection, a more comprehensive approach to watershed management is needed. This project proposes to address the overarching question: What are the flood mitigation and water quality benefits of 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 the expertise of local academic and NGO collaborators, it facilitates enhancing 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 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 the 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. This project is funded with NFWF funding to FIU. The District will collaborate with FIU to complete the project.

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, waterways and canals act as a channel that collects and moves contamination that flows in from basins. This contamination ranges from dissolved nutrients to large debris and eventually makes its way into water bodies, such as Biscayne Bay and the ocean and their natural inhabitants. These water bodies are an essential part of South Florida and the 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 advances 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 preventing 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.

SFWMD and Miami-Dade County received funding for this project in FY23 through FDEP Innovative Tech Grant. The WIPE-Out Project will identify a selection of promising technologies with scaling potential to pilot in The Snake Creek Canal (C-9 Basin). The Project WIPE-Out is a pilot initiative to demonstrate the effectiveness and benefits of capturing stormwater run-off pollutants at or near the source before they reach the bay using three different technological approaches. The jointly SFWMD/ Miami Dade County is initiating an evaluation of innovative approaches to filter out fine and dissolved contaminants that contribute to the propagation of harmful algal blooms and eutrophication. The intent is to integrate proven filtration media in the convenance network (in canals or on their shoreline) at key source or discharge locations to assess performance for treatment efficiency, impact on maintenance and operation, flood resiliency, and social economic metrics. This project is a critical step in validating targeted treatment technologies before integration into them into the redesign and upgrading of the area stormwater convenance systems to quantify the environmental and operational effectiveness of a given treatment solution.

Total Amount of Funding Request	Duration
$3M	1.5 – 3 years

Future Conditions District Internal resources for Regulation

The District's Regulation Division is proposing the development of an internal tool that will give staff quick access to critical information and resources relevant to both Environmental Resource Permitting analyses and Water Use Permitting analyses as a first step in the District's initiatives for enhancing regulation standards to account for future climate conditions and for building resiliency into projects. Criteria currently used by the Regulation Division for evaluating permits, such as rainfall and groundwater levels, are subject to change because of non-stationary future climate projections and trends that have already been observed. This information is being incorporated into the Water and Climate Resilience Metrics Hub (Resiliency Metrics Hub (arcgis.com)) to group key parameters that will serve this purpose.

Total Amount of Funding Request	Duration
$ 150,000 (in kind)	3 Years – One time

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

This resiliency planning project links to the District's mission to provide flood control and ecological restoration. 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 this 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 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.
Decreased nutrient runoff pulses to estuary, reduce harmful algal blooms and protect fisheries.

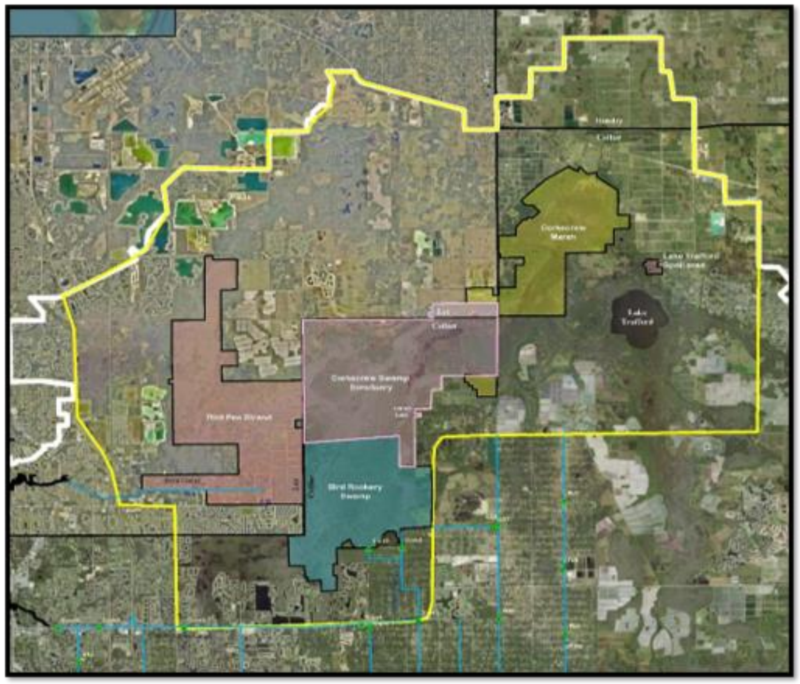
The project area includes Yucca Pens Wildlife Management Area (WMA), part of the largest remaining hydric pine flatwoods in southwest Florida, and its tidal creeks that flow into Charlotte Harbor. The WMA's coastal wetlands are within northern Lee and southern Charlotte Counties. The proposed project 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 SLR, as well as confirmed and potential future land acquisition and restoration projects, was finalized in Sep. 2022.

Specifically, ditch blocks in smaller ditches would increase storage and surface water hydrology. The re-establishment 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 a 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 SLR.

The total project costs are around $650,000, and a full proposal ~~has~~ was ~~been~~ submitted to the Coastal & Heartland National Estuary Partnership (CHNEP) in December 2022 and ~~may~~ includes matching funds from FDEP and FWC. The project duration is 3 years. The project has subsequently been awarded a grant from the EPA, with disbursement to CHNEP expected in summer 2024. As the result of this project is final design and permitting, additional funding will be needed for construction. Other components of the CHFI that contribute to the resiliency of the region will also require funding in the future. This includes projects to store and convey water from the Cecil M./Babcock Webb WMA east of I-75, to the Yucca Pens WMA west of U.S. 41. These projects include a southwest discharge feature from the Bond Farm Hydrologic Enhancement Impoundment (HEI), conveyance and storage of these flows to the west of I-75, and a potential flow-way to direct these flows west of U.S. 41 into the Yucca Pens WMA. These conveyance and storage projects are in various stages of property negotiation, planning and design.

Total Amount of Funding Request	Duration
$650,000	3 Year – one time

Corkscrew Watershed Initiative



The objective of the Corkscrew Watershed Initiative Project, a 3-year public planning process, is to achieve ecological restoration of the Corkscrew System, by improving wetland hydroperiods and natural flows, while reducing flood risk in flood-prone areas, without adversely impacting water supply. The Corkscrew Swamp Sanctuary (CSS) ecology is affected by shortened hydroperiods and increased water level recession rates throughout the dry season. The project area includes Norther Collier County and Southern Lee County.

The Big Cypress Basin Watershed Model will be utilized at the main modeling tool for the study. The modeling approach can be summarized in the following steps:

Refine BCB Watershed Model to ensure accurate representation of the CWI project area. Need to ensure that the model accurately reflects hydrologic conditions within the project area, to be able to identify specific hydrologic and hydraulic issues. This will NOT be a cut-out of the BCB model and does NOT involve re-calibration.

Existing Condition Model Simulation. After the refined model is approved, an existing conditions model will be developed using rule-based structure operations. This will identify areas of flooding, water supply and ecologic concern. This model will be compared with the future baseline condition model. Includes both a long-term simulation and various design storm simulations.

Future Baseline Condition Model Development/Evaluation. Once the TWG has defined what the future condition will be, the future baseline condition model serves as the baseline “without project” condition for evaluation of the proposed project alternatives. Uses the same rule-base operations so can compare to existing condition model. Includes both a long-term simulation and various design storm simulations.

Future Alternative Model Development/Evaluation. Simulates the proposed alternatives defined by the TWG. This model is needed to compare and contrast between proposed alternatives, and to demonstrate whether the proposed alternatives meet the intended restoration goals. The results of this evaluation will also be compared to the baseline models to ensure that the alternatives improve upon the existing and future baseline conditions. A Long-term simulation and one design storm are run for intermediate alternatives. Final recommended alternative(s) will run a long-term simulation and all required storm event simulations.

Total Amount of Funding Request	Duration
$2.7M	one time

Carbon Storage Monitoring and Reporting

To establish routine reporting on carbon uptake and storage totals associated with ecosystem restoration efforts, it is necessary to collect appropriate data for individual restoration projects. This will enable a better representation of their associated mitigation benefits and estimation of resilience benefits. The following data are needed:

- **Soil carbon characteristics:** To capture short-term and long-term carbon storage, soil bulk density and soil organic carbon content shall be measured at multiple depth increments to capture short-term and long-term carbon storage.
- **Soil accretion:** To capture soil surface changes and vertical accretion, surface elevation tables and feldspar marker horizons should be used to monitor soil building and erosion.
- **CO_2 and CH_4 gas dynamics:** To capture the direction (into the ecosystem or out to the atmosphere) of gas movement and determine the net uptake of carbon at the landscape scale, eddy flux towers shall be used to measure the uptake and release of carbon gasses (carbon dioxide and methane).
- **High-resolution multispectral imagery:** To differentiate tree species in coastal ecotones and determine biomass, high-resolution multispectral imagery shall be processed using cloud-based data processing and machine learning frameworks, along with archival true-color (RGB) and color-infrared (CIR) imagery, field vegetation assessment ground-truthing campaigns and long-term ecological data.

The District is actively investigating the potential for using satellite, radar, and lidar imagery to capture changes in plant biomass and land cover, as well as to detect changes in land subsidence and topography at the regional scale. Satellite and radar imagery can help the District to effectively track changes in vegetation over time, differentiate between various land cover types, estimate the amount of green biomass present in an area, and determine the potential for carbon uptake. These technologies would also support the detection of changes in land elevation over time and aid in the mapping of topography in both urban and managed natural areas across the region.

In the context of carbon monitoring, exploring the latest scientific publications on the use of satellite and radar imagery can provide a complementary approach to enhance the District's current planning projects for carbon monitoring. Bringing these additional data and analyses would further improve the accuracy and efficiency of carbon monitoring. SFWMD is currently analyzing several relevant scientific publications listed below to explore the full potential of these technologies.

NASA Satellites Help Quantify Forests' Impacts on Global Carbon Budget – Climate Change: Vital Signs of the Planet: Developing an approach that integrates satellite, laser, and field data can enhance the accuracy of global forest vegetation and carbon stock estimates, thereby facilitating a better understanding of carbon removal rates in forest landscapes moving forward.

The Vegetation of Everglades National Park: Final Report (Spatial Data) - data.doi.gov: An accurate and comprehensive vegetation map of Everglades National Park created using color-infrared aerial imagery from 2009, providing a valuable baseline to measure the effectiveness of restoration efforts associated with the Comprehensive Everglades Restoration Plan (CERP). The geospatial dataset generated from this imagery will enable the monitoring of changes in vegetation and help gauge the response to hydrologic modifications resulting from the implementation of the CERP.

A Remote Sensing Technique to Upscale Methane Emission Flux in a Subtropical Peatland - Zhang - 2020 - Journal of Geophysical Research: Biogeosciences - Wiley Online Library: Developed a remote sensing approach to model CH4 emission flux in the subtropical Everglades wetland by upscaling using Landsat data and in situ model inputs to account for hydrological seasonality.

Quantifying net loss of global mangrove carbon stocks from 20 years of land cover change | Nature Communications: Used Synthetic Aperture Radar (SAR) global mosaic datasets to estimate the net changes in the global mangrove carbon stock resulting from land cover change between 1996 and 2016 to quantify proportional changes in carbon stock during processes of mangrove loss and gain due to deforestation and forestation.

Global hotspots of salt marsh change and carbon emissions | Nature: Conducted a global analysis using Landsat imagery from 2000 to 2019 to quantify salt marsh ecosystem loss, gain, and recovery due to landward migration and extreme weather disturbances and estimated the impact of those changes on blue carbon stocks.

By employing these measurements across District restoration projects, accurate assessments of carbon capture and storage associated with different SFWMD and partner agencies' ecosystem restoration efforts can be made. These efforts can be leveraged to demonstrate carbon uptake potential and provide better estimates of their contribution to climate resiliency.

The objective of this proposed project is to establish ongoing monitoring and reporting mechanism for highlighting the benefits of the District's restoration efforts associated with carbon uptake potential. The project costs listed below do not account for expenses related to acquiring satellite, radar, or lidar data, as well as the necessary ground data monitoring required to verify the accuracy of remotely sensed data. The expenses associated with these supplementary efforts will be included in the budget at a later stage after an approach for expanding the project to include the additional work is selected.

Total Amount of Funding Request	Duration
$1,250,000 - $2,330,000	3 Years – One time

A Surface Elevation Table Network To Monitor Accretion and Address Impacts from Climate Change

Introduction

Between the 1780s and 1980s, Florida lost 9.3 million acres of wetlands (Caffey and Schenayder 2003). Wetlands are critical components of Florida's landscape due to the many ecological services they provide. For instance, mangrove and marsh systems sequester nutrients and sediment in water runoff, produce and store carbon in above-and below-ground biomass, fuel various food webs, serve as nurseries for many fishery species, and constitute habitat for migratory birds, diamondback terrapins, bald eagles, dolphins, manatees, and many other species (Mitch and Gosselink 2000). Current models suggest that another 20% of coastal wetlands may be lost due to climate change (Webb et al. 2013) through the direct effects of rising sea levels and increases in flooding depths, hydroperiods, and storm intensity. Over the long term, rising seas threaten to erode or sink large parts of Florida's coastal zone (Church et al. 2001, Sklar et al. 2021). However, the many projects associated with Everglades restoration (i.e., CERP) have the ability to increase freshwater, brackish, and saline wetland resilience by enhancing wetland accretion and carbon capture.

In the Everglades, mangroves and marshes have the capacity to maintain elevation via vertical accretion primarily driven by belowground biogenic processes such as root production and decomposition. In some other areas, elevation change may be dependent on inputs of sediment from rivers and storms (Cahoon 2006). However, in Florida, there is insufficient data to indicate where wetlands have the capacity to maintain elevation and how much mangroves and marshes have the capacity to store carbon. Therefore, to better understand the hydrological drivers of carbon capture and to better predict the effects of SLR as part of a general resiliency program, long-term soil elevation change, and accretion rates are needed.

This accretion monitoring program, like the one built into MEME, will study the processes that affect wetland accretion, determine, and compare the rates at which they accrete, compare rates of accretion in differing habitat types and geographical locations, and increase the knowledge of such functions to a level needed to formulate an accurate representation, via multivariant statistical or deterministic models, of the physical and biotic processes involved in elevation change. This, in turn, will permit the District to identify the drivers (i.e., salinity, flow, structure operations, storms, nutrients, etc.) that dominate elevation change, carbon capture, and resilience.

Formulation

This monitoring program constitutes a critical piece of a broader, long-term effort by various state and federal agencies and universities to enhance wetland resilience, sequester carbon, address the potential effect of climate change, and restore the Everglades. The strategy is to integrate the District, USGS, and FIU surface elevation tables (SETs) into this larger effort and insert new SET sites where most appropriate. To accomplish this objective, the four-phased approach described below is recommended.

1. First phase is to identify and map all known SET locations in the Greater Everglades, including Big Cypress and the Stormwater Treatment Areas and identify geographical gaps in monitoring coverage.
2. The second phase is to install SETs where coverage is poor or absent. These sites will include regions that appear to maintain high accretion rates and sites that can be used as general indicators of large landscapes.
3. The third phase is to monitor the SETs and measure changes in elevation, vegetation structure, and soil composition in relation to changes in sea level, hydroperiods, nutrient inputs, and water management.

4. The fourth phase is to analyze cause-and-effect interactions via multivariate and/or mechanistic models to determine where physical processes dominate elevation change and where biotic processes predominate,

Goal and Objectives

The goal of this monitoring is to determine how water management, restoration, climate change, and SLR will impact accretion, carbon sequestration, and wetland resilience.

Objectives:

1. Compare rates of elevation change and accretion between inland marsh, STA's, coastal marsh, and mangrove habitats
2. Compare rates of elevation change and accretion with local rates of SLR, salinity, hydroperiods, depths, flow, and landscape characteristics.
3. Determine primary drivers of the biotic and physical processes that are linked to accretion and elevation change.

Project Design and Methodologies

An array of SETs and marker horizons (MH) will be installed and monitored in wetland habitats across the Greater Everglades. The network of SET-MH will allow researchers the opportunity to study the impacts of water management, restoration, climate change, and SLR on a large regional scale. This program will integrate into one database that is already funded and installed by the District, the FCE-LTER program at FIU, Everglades National Park, USGS, and NOAA. Data for the entire network, District, and Federally funded sites will be combined and analyzed by structural, multivariant, or mechanistic equation modeling.

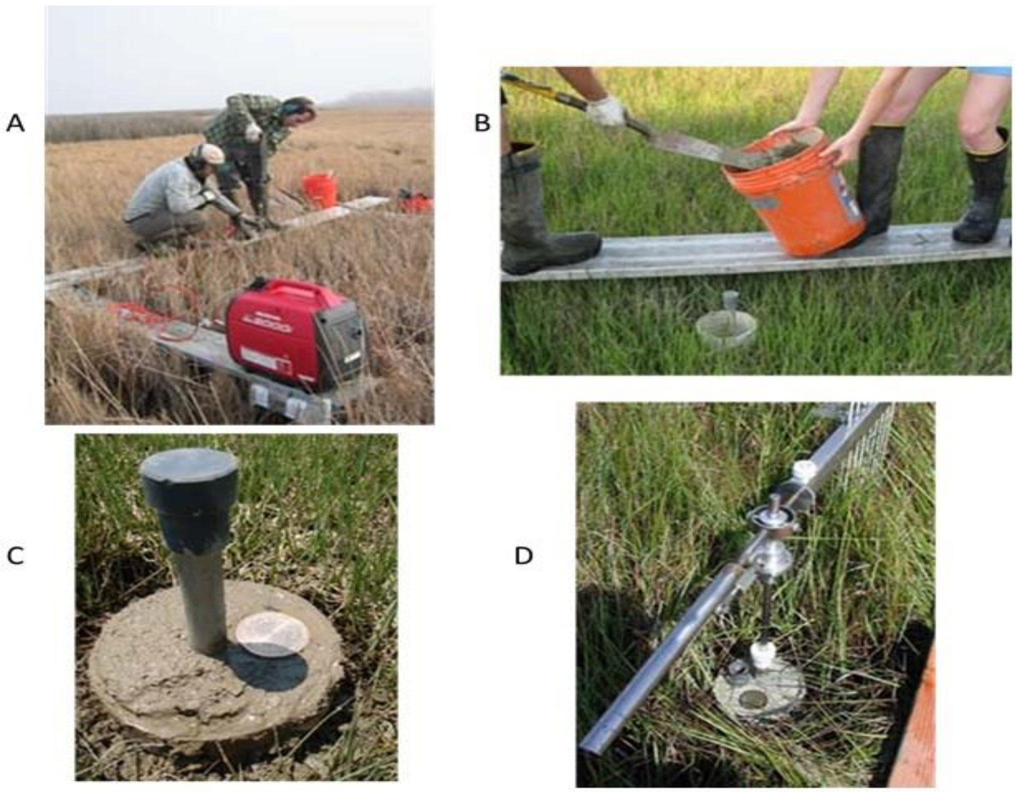
Hypotheses:

1. Rates of elevation change will differ between marsh and mangrove habitats; and with differing soil types (for example, mainly organic vs primarily sand/silt, etc.).
2. The biotic and physical processes of elevation change will produce differing rates of accretion and will differ with anthropogenic inputs such as water management and nutrients.
3. Rates of elevation change and accretion can be enhanced to improve carbon storage, accretion, and climate change resilience.

Surface Elevation Table technology, coupled with marker horizons of inert material such as feldspar, has been used effectively in numerous wetlands to measure the rates of elevation gain and loss over a fine scale (Cahoon et al. 2002 a,b). In Rookery Bay, southwestern Florida, SLR is approximately 2-4 mm/yr (Cahoon and Lynch 1997). Elevations there, measured by SET, have largely kept pace with SLR, although the mangrove fringe forest dominated by Rhizophora mangle has lagged behind the Avicennia germinans dominated basin forest (Boumans et al. 2002). One study at Shark River, Everglades National Park, found that despite Hurricane Wilma depositing 3.7 cm of new sediment, 10 mm of elevation was lost a year after the storm (Whelan et al. 2009). Over longer periods of time, the increasing CO2 concentrations associated with climate change may stimulate plant growth and partially offset losses caused by changes in hydroperiod (Cherry et al. 2009).

Due to Florida's variable soil types, tidal ranges, and dominant vegetation, understanding long-term changes in wetland soil elevation change requires study over many sites and years. Further, the ability of wetlands to keep pace with SLR that are currently transitioning from marsh to mangrove at the temperate/subtropical boundary is entirely unknown. To address these data gaps, a more regional scale approach is needed.

The Rod-SET is now the preferred deep SET and will be used here. SET installation and construction details are given by (Cahoon et al. 2002a,b, http://www.pwrc.usgs.gov/set/). Both deep (>2 m) and shallow RSETs (collectively termed SET hereafter) will be installed at each site to allow investigation of physical as well as biological (root zone) processes. SET installation and use are illustrated in Fig. 1 from D. Cahoon's USGS website listed above.



A. Driving rods after constructing the platform. B. Cementing collar and receiver. C. View of a completed receiver with a brass marker. D. SET arm attached to receiver for first readings. Pictures from: http://www.pwrc.usgs.gov/set/

Figure 111: SET Installation.

Expected Results, Applications, and Benefits

The sites proposed for SET installation in this program will improve the understanding of wetland soil accretion and erosion throughout the greater Everglades. These new SETs will be designed and installed in a way that will tie into the already existing, but currently not centrally coordinated, SET sites in the state. Ultimately, this system will tie into a large national network such as the NOAA Sentinel Site program. Currently, there is a coordinated effort establishing a SET monitoring network in the Gulf of Mexico, Texas through the Panhandle of Florida, and Mid-Atlantic states, Virginia to Georgia. The establishment of the Florida monitoring network could then be added to the existing Gulf Coast and Mid-Atlantic networks to provide a standardized monitoring network from Virginia to Texas.

Flux Towers

The Flux tower monitoring plan described below was developed in partnership with the Everglades Foundation and Florida International University. Flux towers are micrometeorological towers that use eddy covariance methods to determine the exchange rates of carbon dioxide, methane, water vapor, and energy between the biosphere and the atmosphere. Sensors are placed on the tower above the surrounding vegetation in the mixing zone for wind current eddies between the vegetation and atmosphere. The sensors allow the tower to capture the full profile of atmospheric conditions from the top of the vegetation canopy to the ground. Data collected by these sensors can be used to measure carbon storage (or emission) rates of a particular ecosystem.

Although wetland ecosystems are important globally for their capacity to sequester and store carbon (C) (Aselmann and Crutzen, 1989; Whiting and Chanton, 1993), many wetlands are at risk due to anthropogenic pressure, shifts in climate, and SLR (Spencer et al., 2016). In one of the most dynamic wetland complexes in the world, the Florida Everglades, changes in freshwater supply and accelerated rates of SLR are stressing ecosystems. Particularly striking shifts in ecosystem structure and function occurring on the Everglades landscape include peat collapse (Chambers et al., 2014), the establishment of non-native species (Doren et al., 2009), inland encroachment of coastal woody species (Davis and Ogden, 1994), and the expansion of a low productivity zone along the coast called the “white zone” (Ross et al., 2000). The severity of these changes is further exacerbated by anthropogenic impacts on the quantity, quality, and timing of freshwater discharge and shifts in disturbance regimes.

The subtropical Everglades landscape was created by strong spatial and temporal gradients of water flow that formed a unique network of upland freshwater and coastal wetland ecosystems. The hydrology and disturbance regime in the Everglades region developed a rich diversity of communities that have variable capacities to capture and sequester carbon. Like other coastal wetland ecosystems, primary productivity, respiration, and other processes in the carbon cycle change in response to climate, inundation regime, and salinity.

In the greater Everglades region, the use of the eddy covariance method to measure fluxes of CO2, CH4, H2O, and energy is recommended. Long-term eddy covariance studies by scientists at FIU include 15 years of CO2 and 8 years of CH4 data in a marl prairie (TS/Ph-1) and freshwater marsh (SRS-2), 6 years of data from a mangrove scrub (TS/Ph-7), and 18 years of CO2 and 5 years of CH4 from the tall riverine mangrove forests (SRS-6). The network includes two recently established research sites in the estuary (Bob Allen; 2 years of CO2) and at the ecotone between freshwater marl prairies and the mangrove scrub (SE-1; 3 years of CO2 and CH4). Towers operated by the USGS were recently incorporated into the greater Everglades micronet and include a pine upland (PU), cypress swamp (CS), and dwarf cypress (DC) to create a transect that extends from upland ecosystems to coastal wetlands and the ocean.

Everglades flux towers are currently managed by independent groups of investigators that contribute data to the FCE-LTER and Ameriflux. While funding streams are currently independent, investigators collaborate to coordinate equipment assistance and data processing assistance. Scientists at FIU and at the District are currently looking for funds to organize support efforts to ensure long-term maintenance of towers, equipment updating, and data processing for towers in coastal mangroves and in Shark River Slough, as well as identifying locations for new towers (e.g., an STA).

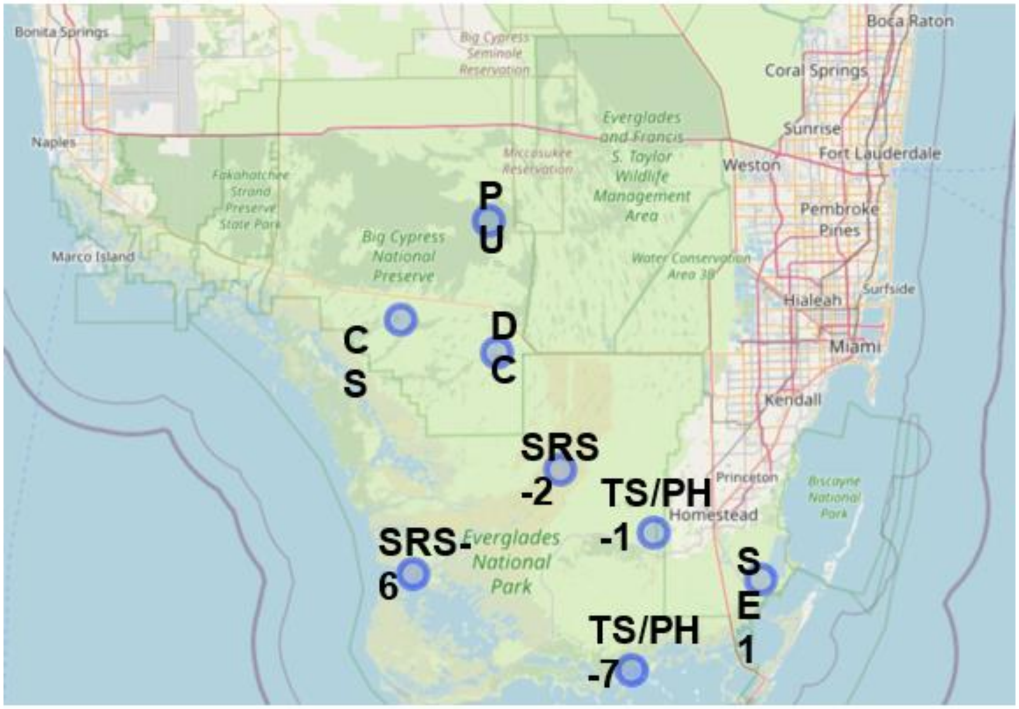


Figure 112: Everglades eddy covariance tower sites.

Table 6: Covariance Towers, principle investigators, permit and network association.

Tower	Investigators	ENP Permit	Network Association
SRS6	Tiffany Troxler Edward Castenada Sparkle L. Malone	EVER-2019-SCI-005	FCE-LTER
TS/Ph-7		EVER-2019-SCI-0055	FCE-LTER
TS/Ph-1	Steven F. Oberbauer Gregory Starr Christina Staudhammer	EVER-2019-SCI-0055	FCE-LTER/Ameriflux
SRS-2		EVER-2021-SCI-0035	FCE-LTER/Ameriflux
SE-1		NA	FCE-LTER/Ameriflux
DC	Barclay Shoemaker Andrea Daniels Sparkle Malone	NA	FCE-LTER/Ameriflux
PU			
CS			
The existing towers are managed by various groups of investigators, though they have similar setups and are all associated with the Florida Coastal Everglades Long-term Ecological Research (FCE-LTER).			

Cost estimates

Flux Towers - Instrumentation

Tower instrumentation requires upgrades and replacement every 5-10 years (Table 7). The current priority for instrumentation is to add methane analyzers to TS-PH-7, PU, and CS. In addition to the $90K needed to add methane to towers, an annual instrumentation budget of $30K is necessary to replace equipment.

Table 7: Major instrumentation for the eddy covariance method.

Description	Instrument Used	Estimate
Shortwave/Longwave (*pyranometer*) solar radiation/terrestrial	CNR4-L net radiometer	$28,000
Wind speed /direction	05103-L Wind Monitor	
Air temp and RH	RAD10E	
Sonic anemometer- 3D wind speed and direction		
Incoming PAR density- LI-250Q	Quantum sensor	$1,200
LI-7500		$78,527
LI-7700		
CR1000		$5,000
CR3000		
	Total per tower	$112,727
Major instrumentation for the eddy covariance method include radiation, gas analyzers, and sonic anemometers. These costs represent the cost of deploying one flux tower. Scientists at the District and FIU are in the process of determining how many towers are needed and where they should be deployed.		

Personnel Support

To support fieldwork for the maintenance of all tower sites, a full-time technician ($65K/ per year) will be available to assist all investigators in data collection and uploading to a general server. Data processing will be done by the Malone Disturbance Ecology Lab through the partial support of a postdoctoral scholar who will assist with data processing and research ($50K/ year).

Table 8: Total annual budget for the Greater Everglades Carbon Project

Description	Category	Estimate
LI-7700; CH4 analyzer	Equipment	90K * onetime
Repairs and replacements	Equipment	30K
Personnel	Field Technician	65K
Personnel	Data Processing	50K
Total		145,000 /Year + 90K

*Overhead is not included in current estimates.

Soil Accretion Monitoring

It is difficult to define a total, comprehensive cost for monitoring accretion because the total number of new SET-MH sites is not yet known. However, personal experience indicates that an additional 16 sites are likely the maximum needed to capture the full suite of habitats, hydrological conditions, and water management options. This would include 2 sites in the ENP, 6 sites in WCA-3, 2 sites in WCA-2A, 3 sites in an STA, and 3 sites in Big Cypress. It may be possible to acquire significant data with only 10 additional SET-MH sites. These costs below assume that the District FTE contribution is limited to 0.4 FTE per year.

Phase 1: $75,000

Phase 2 and Phase 3:

Average Installation Labor and Equipment Cost per station: $30,000.

Average Annual Labor, Lab and Field Monitoring Cost per station: $20,000

Year 1 Total Cost for 16 sites: $480,000

Year 1 Total Cost for 10 sites: $300,000

Year 2 Annual Monitoring Cost for 16 sites: $320,000

Year 2 Annual Monitoring Cost for 10 sites: $200,000

The Total for 5 years of monitoring is between $1.0 and $2.0 million.

Total Cost for 6 years (5-yrs of monitoring) for 16 sites: $2,080,000

Total Cost for 6 years (5-yrs of monitoring) for 10 sites: $1,000,000

Phase 4: $175,000

Total Cost Range: $1,250,000 -- $2,330,00

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