



SYMPOSIUM ON
**FLOODING
ADAPTATION**

Flooding Adaptation in South Florida: Building Community Resiliency and Reducing Flood Risks Through Structural and Nonstructural Strategies

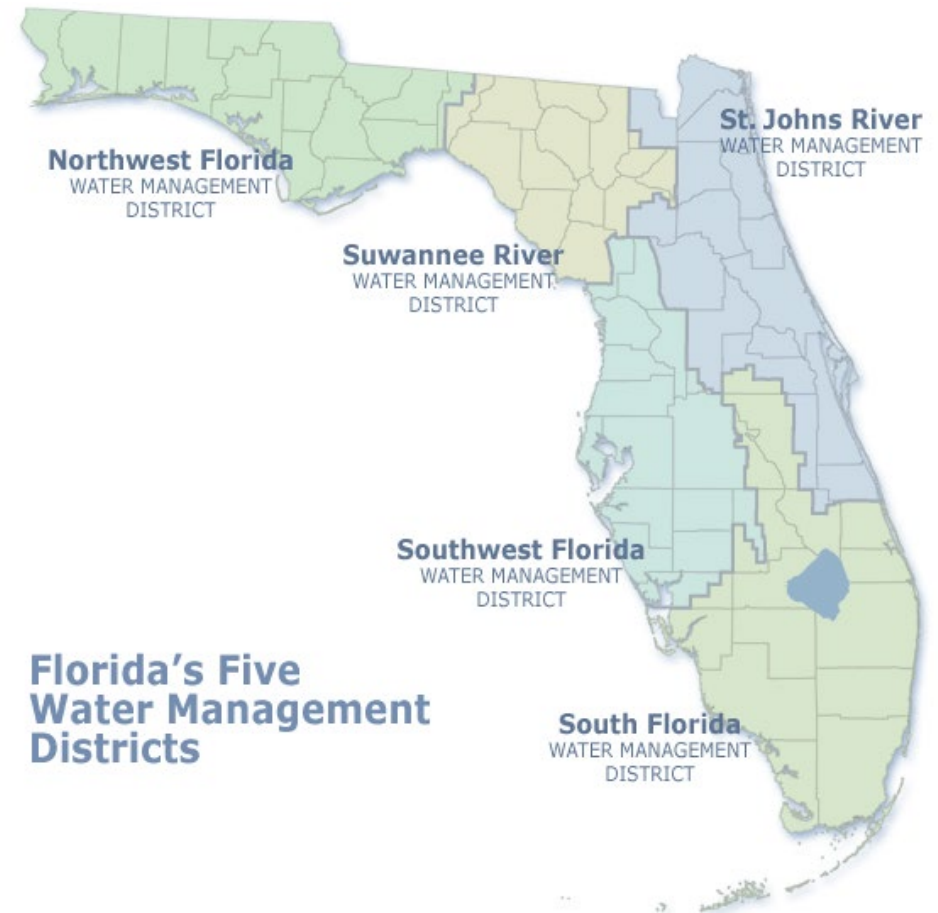
Carolina Maran, P.E. Ph.D.
Chief of District Resiliency, SFWMD



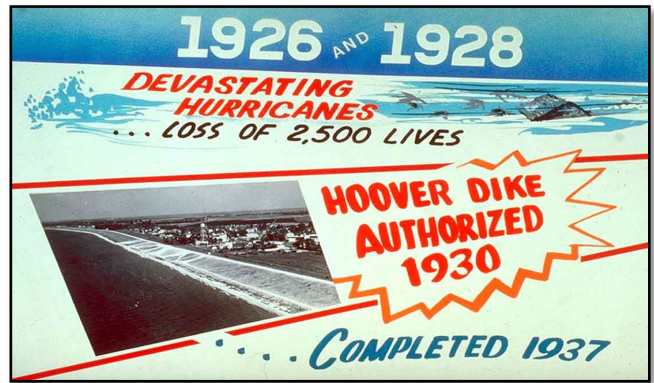
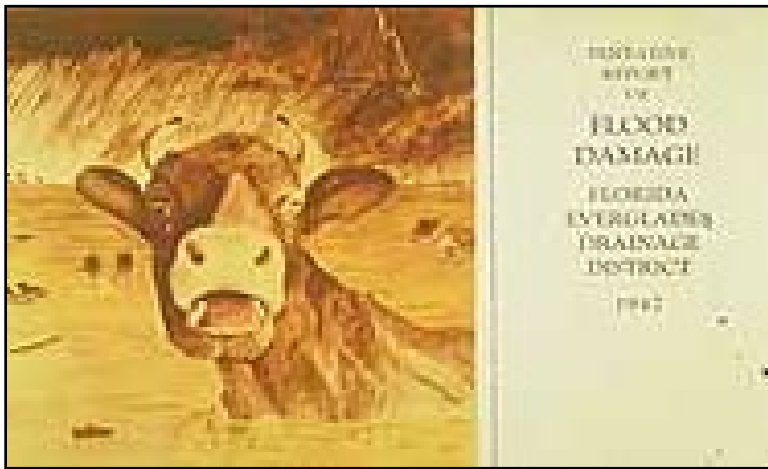
South Florida Water Management District

- Created in 1949, oldest and largest of the state's five water management districts
- Majority of structures used for flood control operations today were built in the 1950s and 1960s
- 16 counties from Orlando to the Florida Keys
- Serves a population of ~9 million residents

MISSION: To safeguard and restore South Florida's water resources and ecosystems, protect our communities from flooding, and meet the region's water needs while connecting with the public and stakeholders.



Central and Southern Florida Project



South Florida Water Management District Today

TYPES OF STRUCTURES OPERATED AND MANAGED BY THE DISTRICT

Stormwater Treatment Areas (STAs):

Large, constructed wetlands designed to remove nutrient pollution from water using natural aquatic plants.

Reservoirs and Impoundments:

Human-made water bodies used for water storage. A Flow Equalization Basin (FEB) is a type of impoundment designed to temporarily capture and hold water.

Weirs: Structures across a canal or stream that block the flow of water until the water flows over the structure.

Pumps: Mechanical control structures that force movement of water.

Spillways: Structures that allow movement of water between water bodies by use of gates.

Dikes & Levees: A barrier that diverts or restrains the flow of water. Large earthworks that surround Lake Okeechobee are generally referred to as dikes. Smaller earthworks surrounding canals and Water Conservation Areas are generally called levees.

Culverts: Structures that allow the flow of water between two areas. They are typically placed under roads or levees.

Canals: A system of human-made trenches used for the movement of water.



STA-1E



S-69 Weir



S-155A Spillway



C-18 Canal Culvert



C-44 Reservoir



Pumps Operating Post-Hurricane Ian



Herbert Hoover Dike



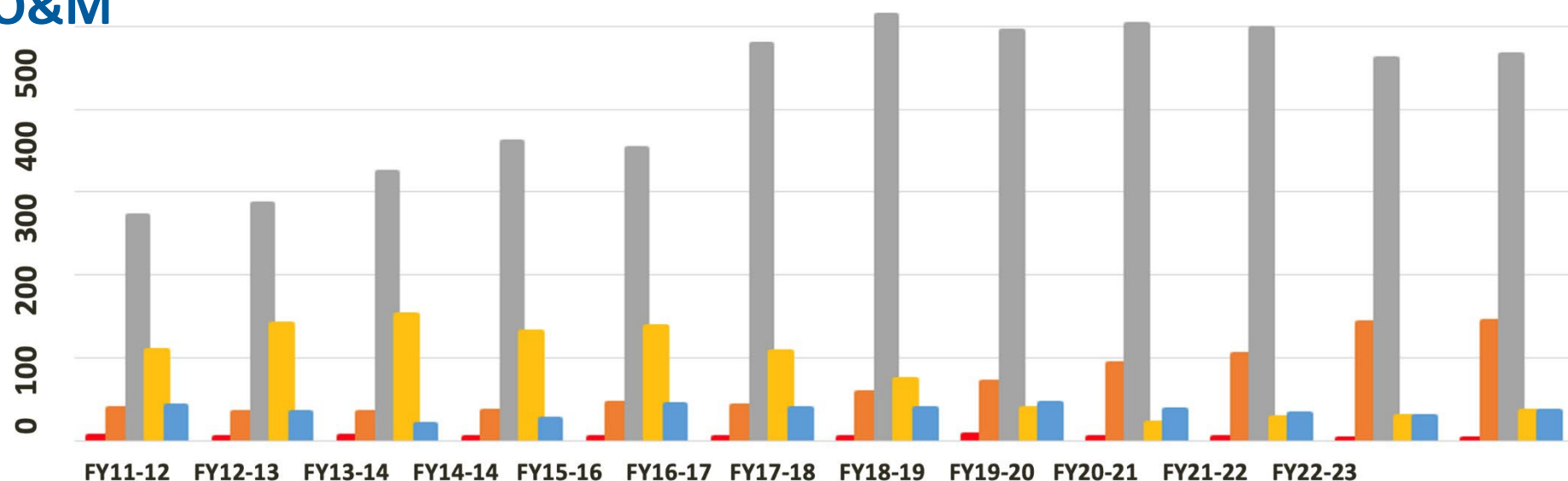
C-59 Canal

- On average the flood control system moves more than **20-million-acre feet of water each year.**
- More than **2,175 miles** of canals
- More than **2,130 miles** of levees/berms
- More than **915** water control structures
- More than **620** project culverts
- **90** pump stations
- Approx. **3,537** hydrological monitoring stations at more than **687** flow sites, including **201** rain gauges and **22** weather stations.
- Every year new capital projects add more infrastructure:
 - Comprehensive Everglades Restoration Plan
 - Northern Everglades and Estuaries Protection Plan
 - Dispersed Water Storage
 - Restoration Strategies
 - Resiliency

Structure Inspection Program

Aging Infrastructure & O&M

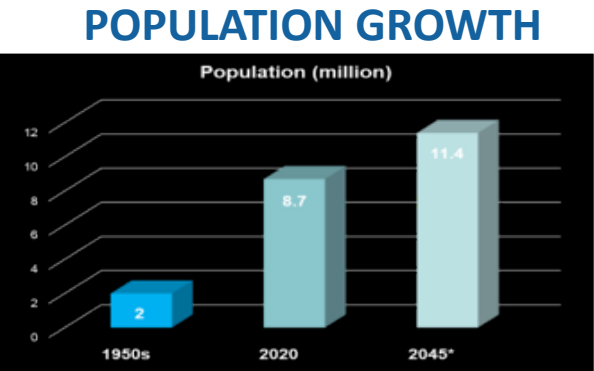
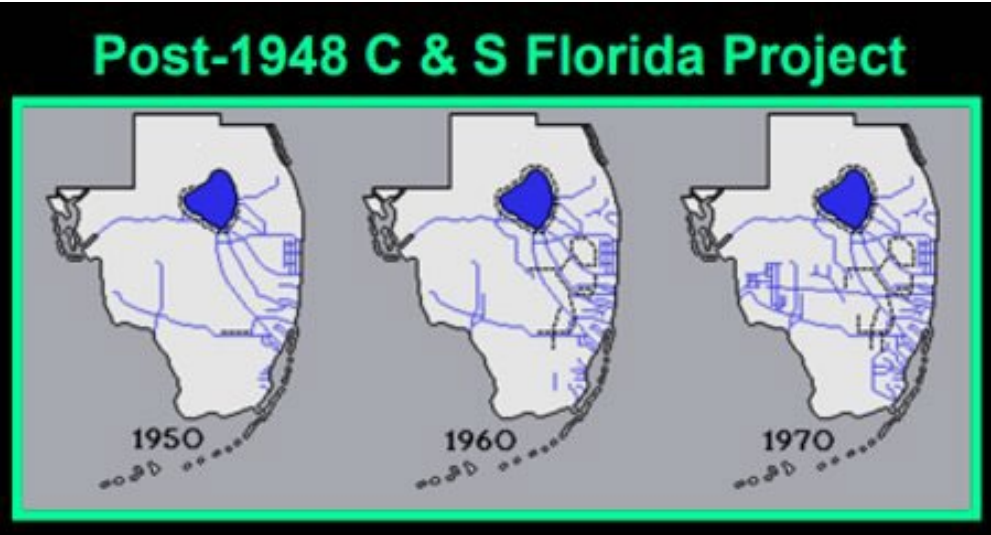
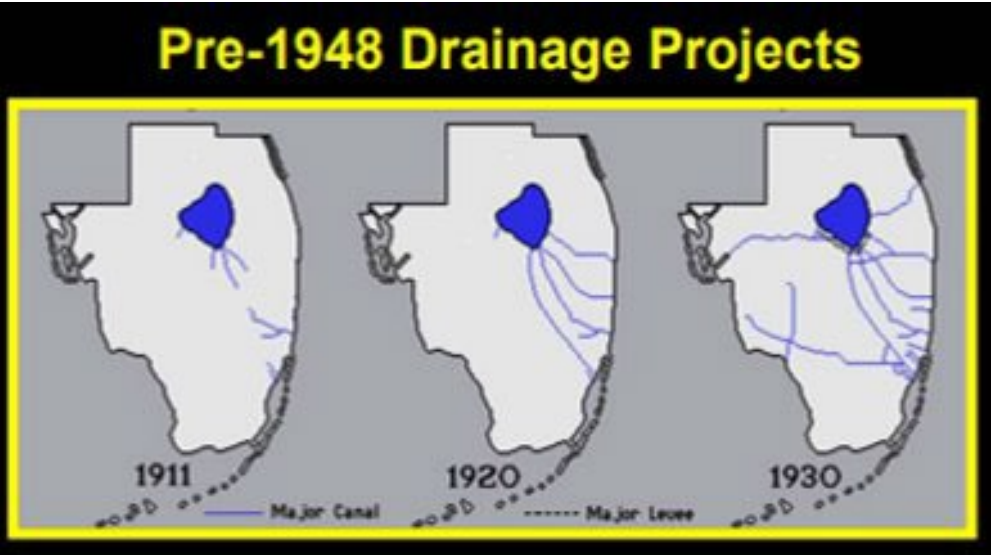
C-5	Repair within one year
C-4	Repair within 18 months
C-3	Repair within two years
C-2	Monitor
C-1	No Action



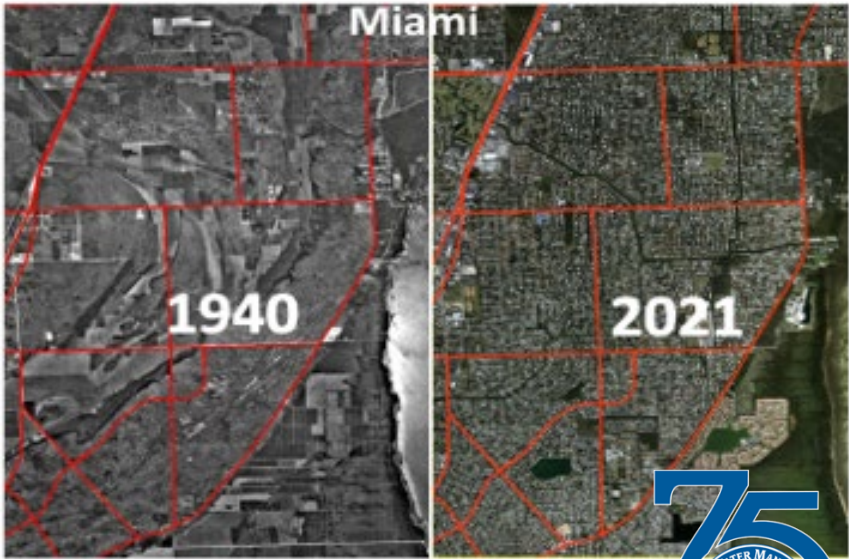
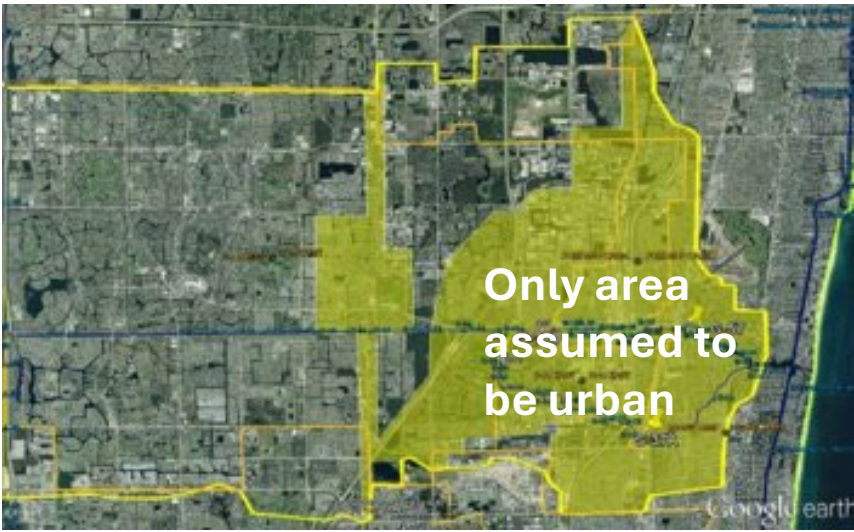
Rating	FY2011-12	FY2012-13	FY2013-14	FY2014-15	FY2015-16	FY2016-17	FY2017-18	FY2018-19	FY2019-20	FY2020-21	FY2021-22	FY2022-23	Quantity Change from FY2011-12 to FY2022-23
C-5	5	4	5	3	3	3	3	6	4	4	2	2	-3
C-4	38	34	33	35	45	41	58	70	93	103	142	143	105
C-3	271	285	324	360	353	478	514	494	503	497	461	466	195
C-2	108	140	152	131	137	107	74	39	21	28	29	36	-72
C-1	42	34	19	26	43	39	39	44	37	32	29	35	-7
Total	464	497	533	555	581	668	688	653	658	664	663	682	218

- Structures inspected every 5 to 7 year
- Overall inspection rating provides infrastructure condition

Recognizing Changed Conditions



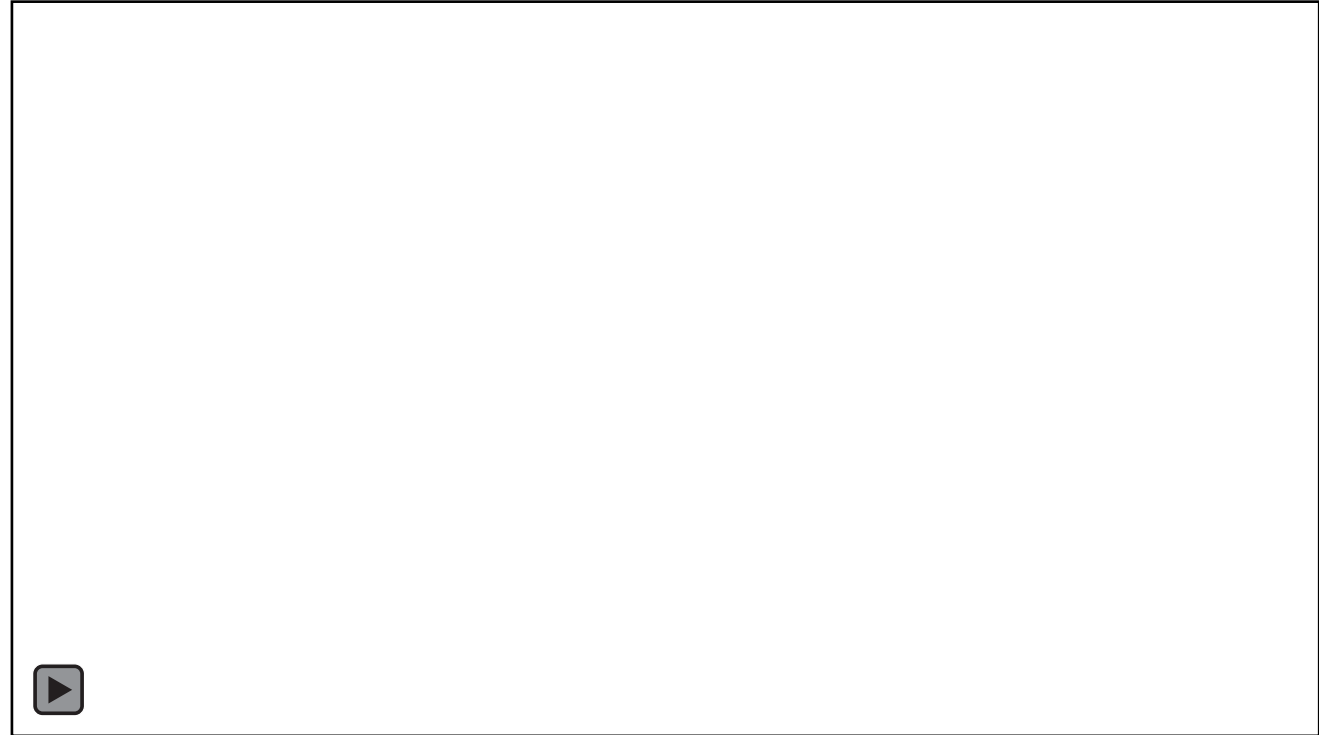
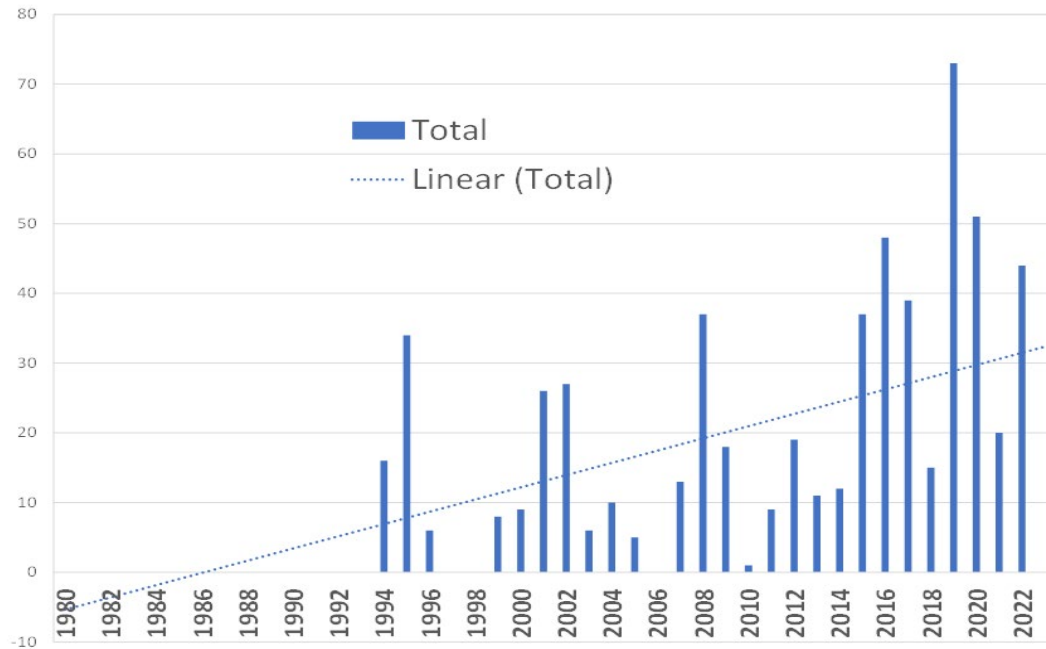
*Estimate taken from BEBER 2017 publication (Median SFWMD boundaries)



Changed Conditions: Sea Level Rise


Coastal Structure Gate Overtop

S28 - Number of Days in a Year where TW > HW




Saltwater moving inland, bypassing the top of the gate of the salinity coastal structure during a High Tide event in 2019.

Monitoring Changing Conditions – Water and Climate Resilience Metrics




Resilience Metrics Hub




Regional Rainfall

Changes in rainfall patterns will impact people and ecosystems by altering the amount of water in our region throughout the year.




Evapotranspiration Trends in South Florida

Evapotranspiration (ET) determines water exchanges between the land, plant communities, and the atmosphere.




Tidal Elevations at Coastal Structures and Sea Level

Flood control and the prevention of saltwater intrusion in South Florida relies heavily on the operation of coastal gravity structures.



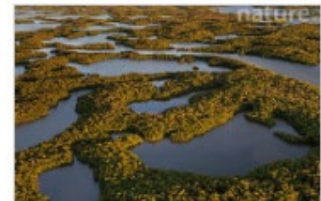
Saltwater Intrusion in Coastal Aquifers

The inland migration of saltwater poses a threat to water supply and critical freshwater habitats.




Salinity in the Everglades

The salinization of previously freshwater systems poses threats to several factors.



Estuarine and Mangrove Inland Migration

Trends in Estuarine Inland Migration provide insights to the impacts of sea level rise in...



Soil Subsidence in South Florida

Maintaining soil elevations within coastal and intertidal habitats, as sea level changes, is a...

Early Insights in Regional Resiliency

Efforts for data collection and preliminary data analysis.

South Florida Flood Information Resource

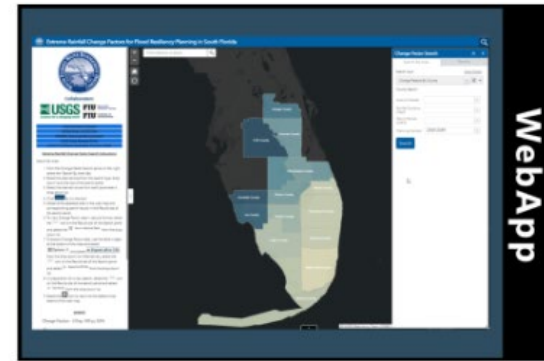
Search, Visualize, Download, Create, Communicate, Collaborate




A resource for collecting and consolidating flood observations to help us better understand evolving flood patterns associated with King Tides, Rarafall, Tropical Storms, Hurricanes and Storm Surge.

Future Outlook in Regional Resiliency

Projections based on current data and models to inform long-term planning and decision-making.



WebApp



Future Extreme Rainfall Change Factors for Flood Resiliency Planning in South Florida Web Application

This tool provides access to future extreme rainfall change factors for resiliency planning for the 16 counties and 14 rainfall areas within...

Enhanced Tide Predictions

Locally Relevant Tide Forecasts to Support Effective Planning and Response

2024 Wet Season Tools & Innovations

Engagement with Local Partners for
Data Crowdsourcing, Flood Sensors
Installation and Radar Data Collection

South Florida Flood Information Resource

www.sfwmd.gov/FloodResource

Document the Flood Survey

sfwmd.gov/FloodingApp

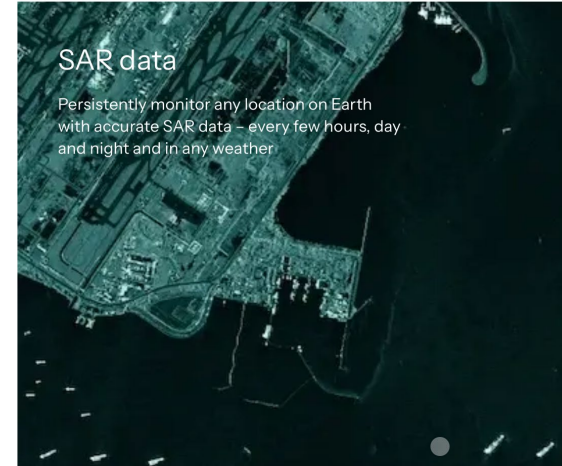
Who to Contact

<https://apps.sfwmd.gov/WAB/LocalContactViewer/index.html>

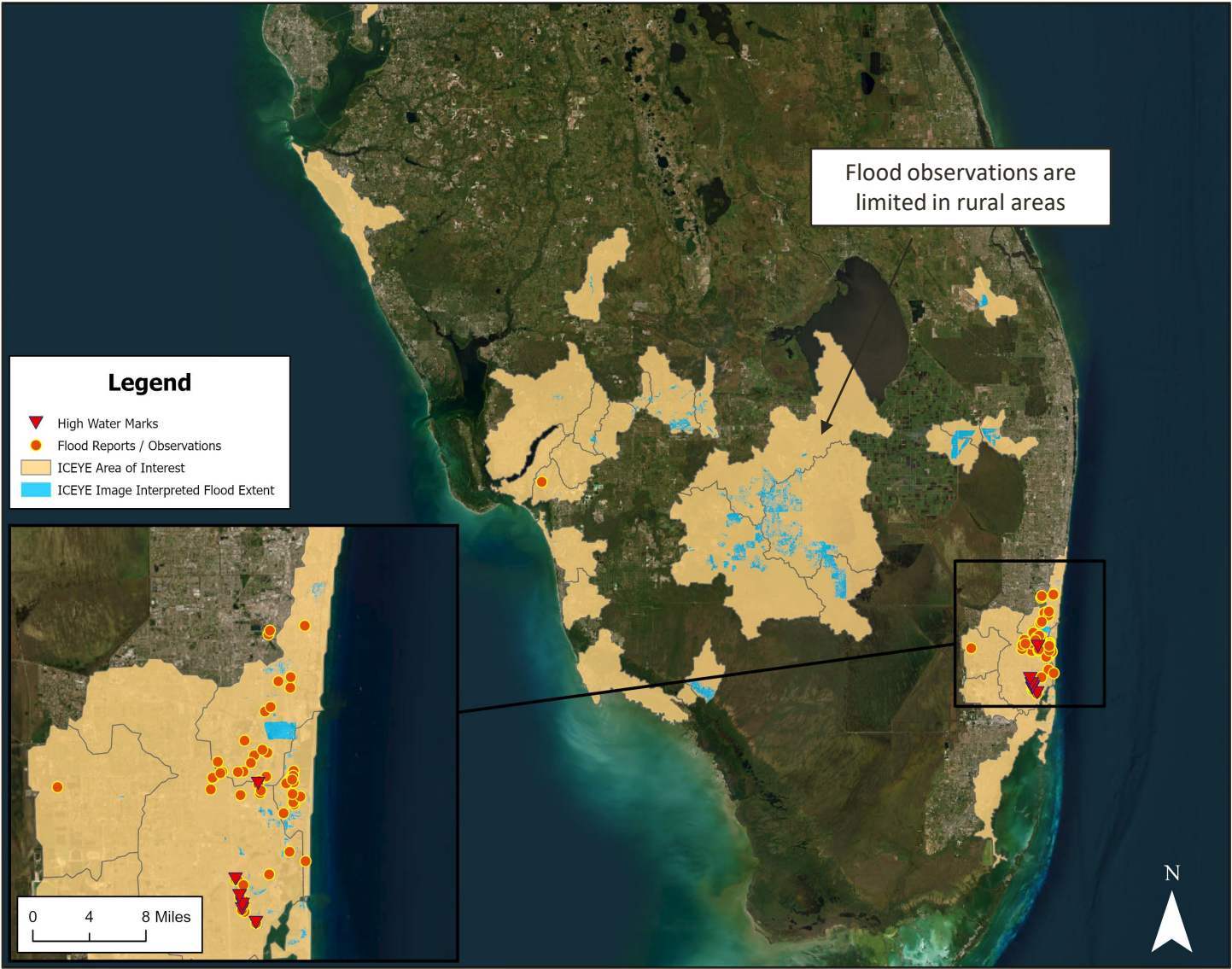
ICEYE

SAR data

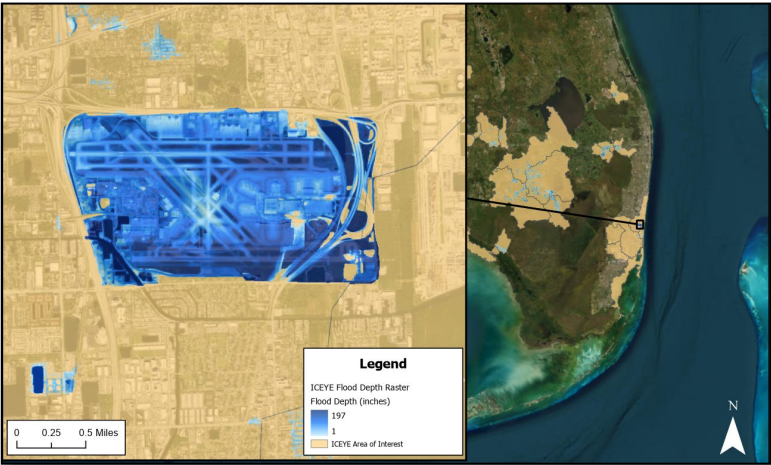
Persistently monitor any location on Earth
with accurate SAR data – every few hours, day
and night and in any weather



South Florida June Heavy Rainfall

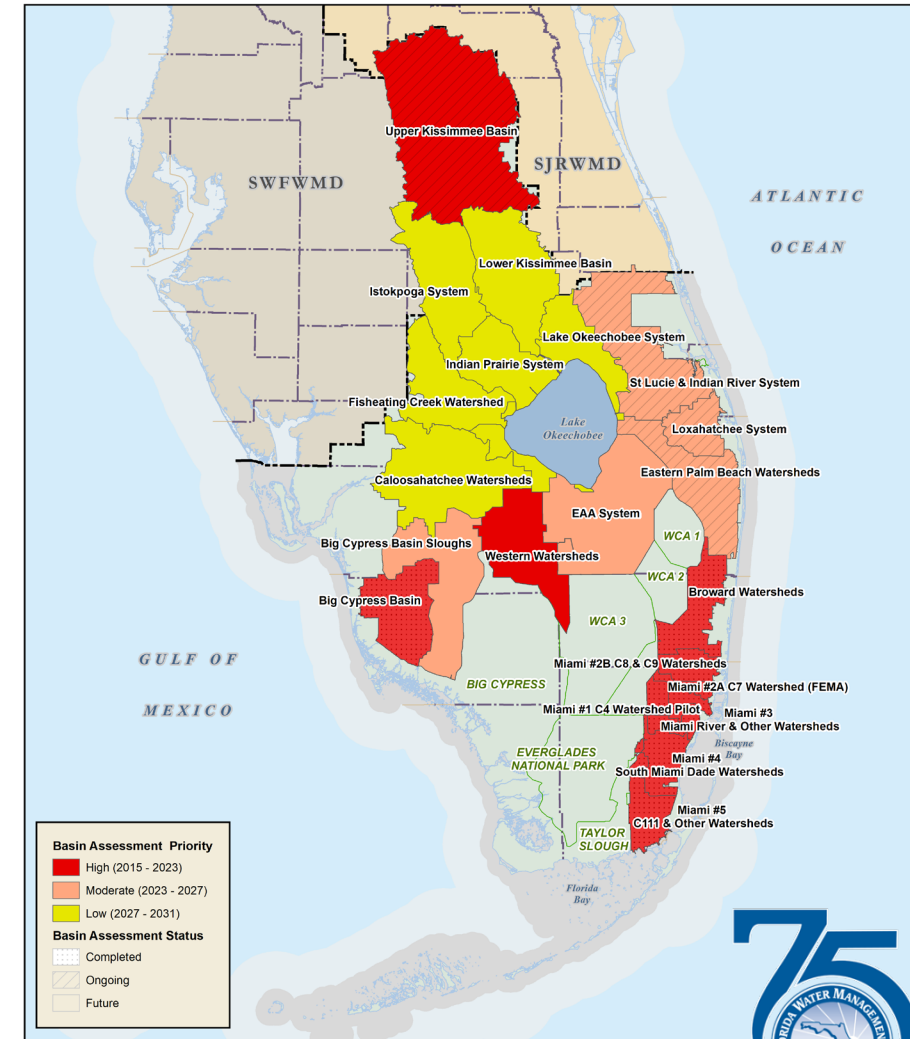


Location	Flood Reports	Observation Type
Hollywood	29	Flood Report & ICEYE
Ft. Lauderdale	5	Flood Report & ICEYE
Dania Beach	3	Flood Report & ICEYE
Oakland Park	3	Flood Report & ICEYE



Flood Protection Level of Service Program

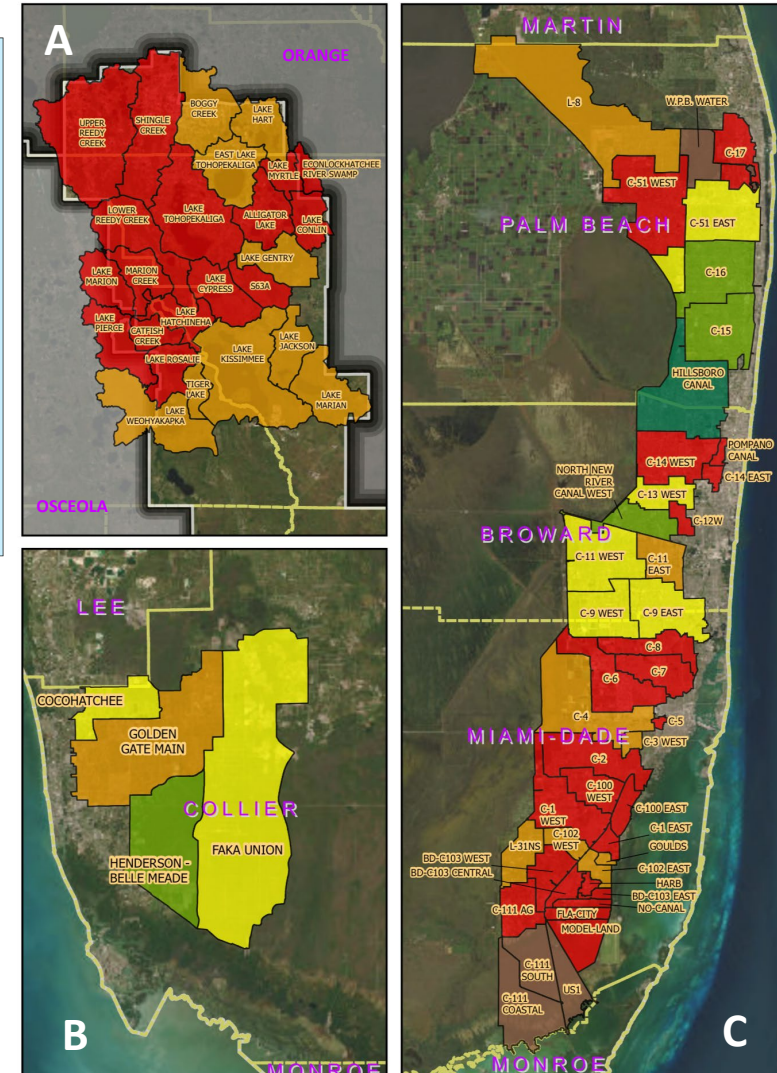
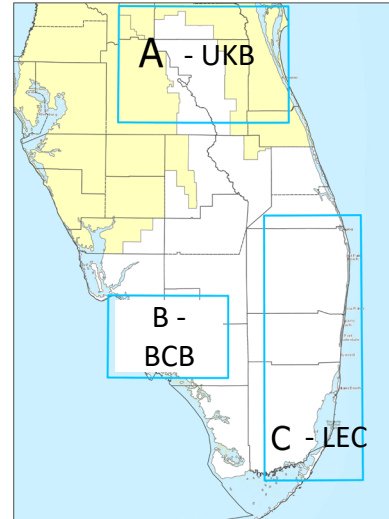
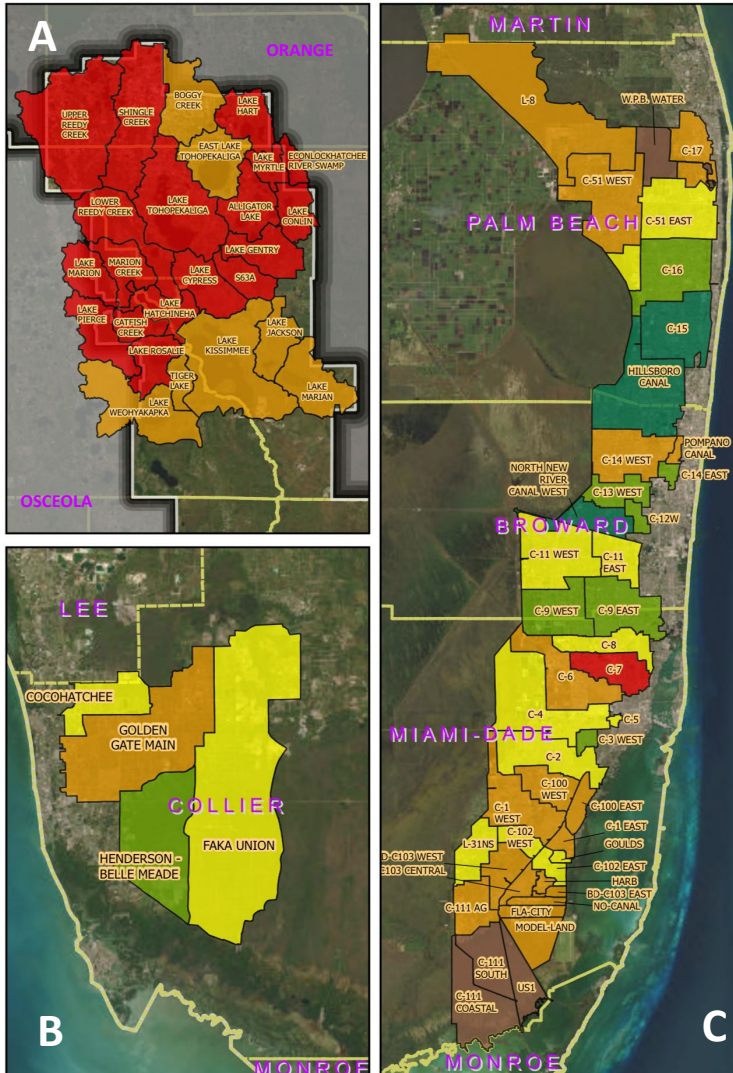
- SFWMD's strategy for assessing the impacts of land development and changing climate on flood control infrastructure
- Evaluate current and future flood risks to communities in South Florida
 - Performance metrics: canal stages, discharge capacity, overland flood inundation and duration
 - Considers rainfall, groundwater levels, tides, storm surge and sea level: compound flooding analysis
 - Regional Basin-wide integrated H&H modeling
- Support decision making on prioritizing infrastructure investments



Flood Protection Level of Service

Current and Future Conditions

Current
Conditions
Level of
Service



Future
Conditions
Level of
Service

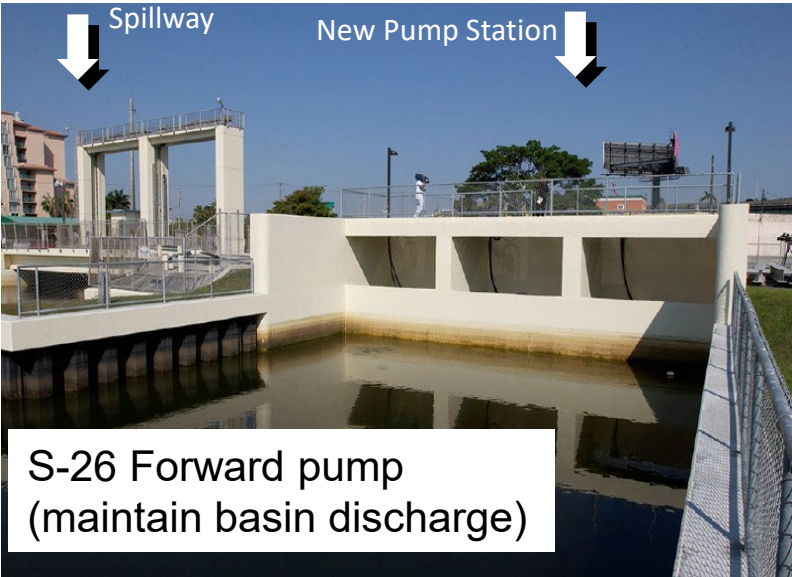
2ft SLR for LEC
& BCB Basins

Extreme
Rainfall
Increase for
UKB Basins

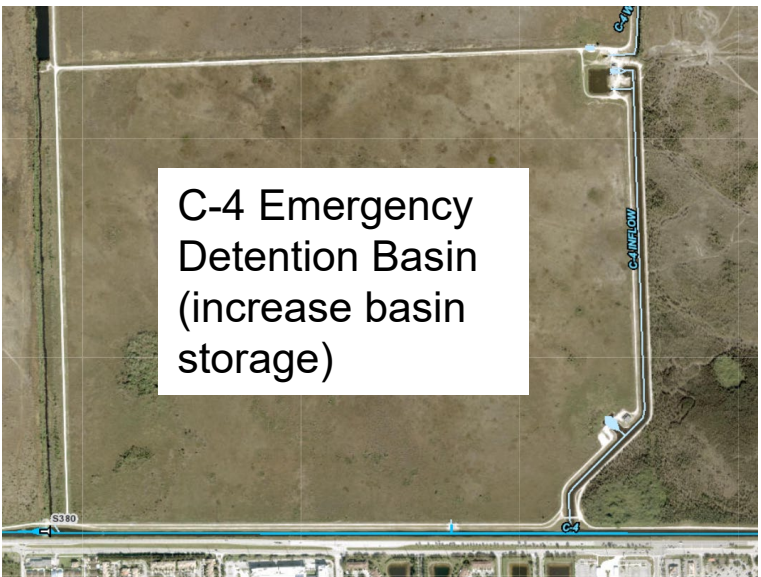
Examples of Flood Mitigation Solutions



Seawall (protect against surge)



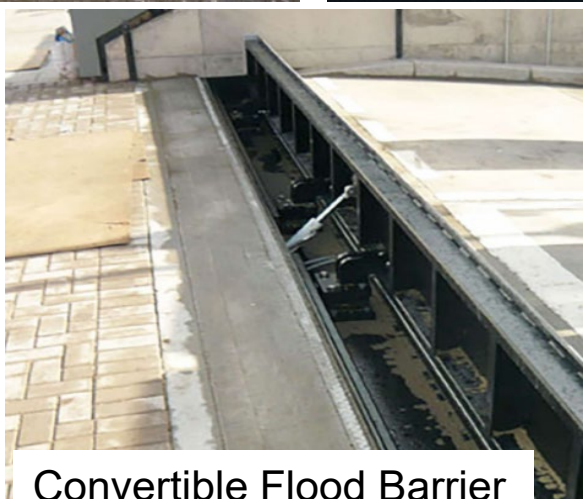
S-26 Forward pump (maintain basin discharge)



C-4 Emergency Detention Basin (increase basin storage)



Raised Canal Banks C-4 Floodwall (conveyance)



Convertible Flood Barrier (harden infrastructure)

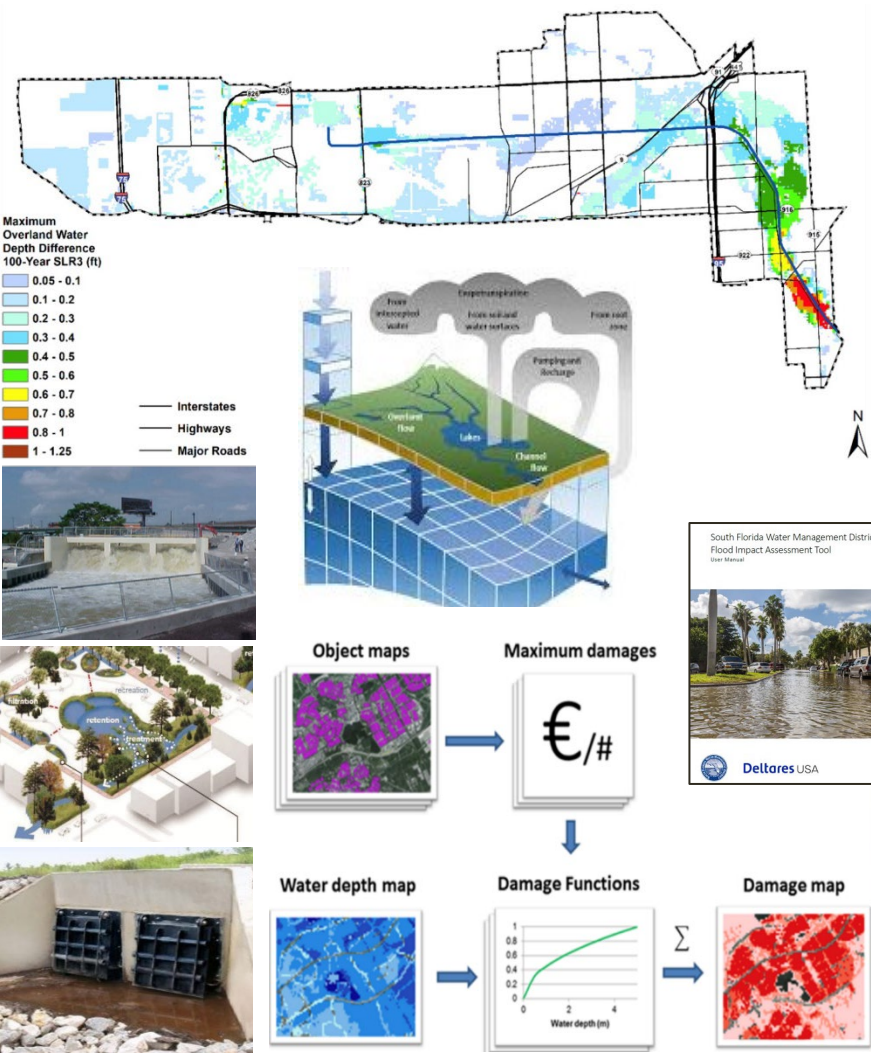


Flap Gate (enhance basin connectivity & backflow prevention)







Green Infrastructure / Nature Base Features

District Resiliency Planning



Reducing the risks of flooding, sea level rise and other climate impacts on water resources and increasing community and ecosystem resiliency in South Florida

2024 SEA LEVEL RISE
AND FLOOD RESILIENCY PLAN

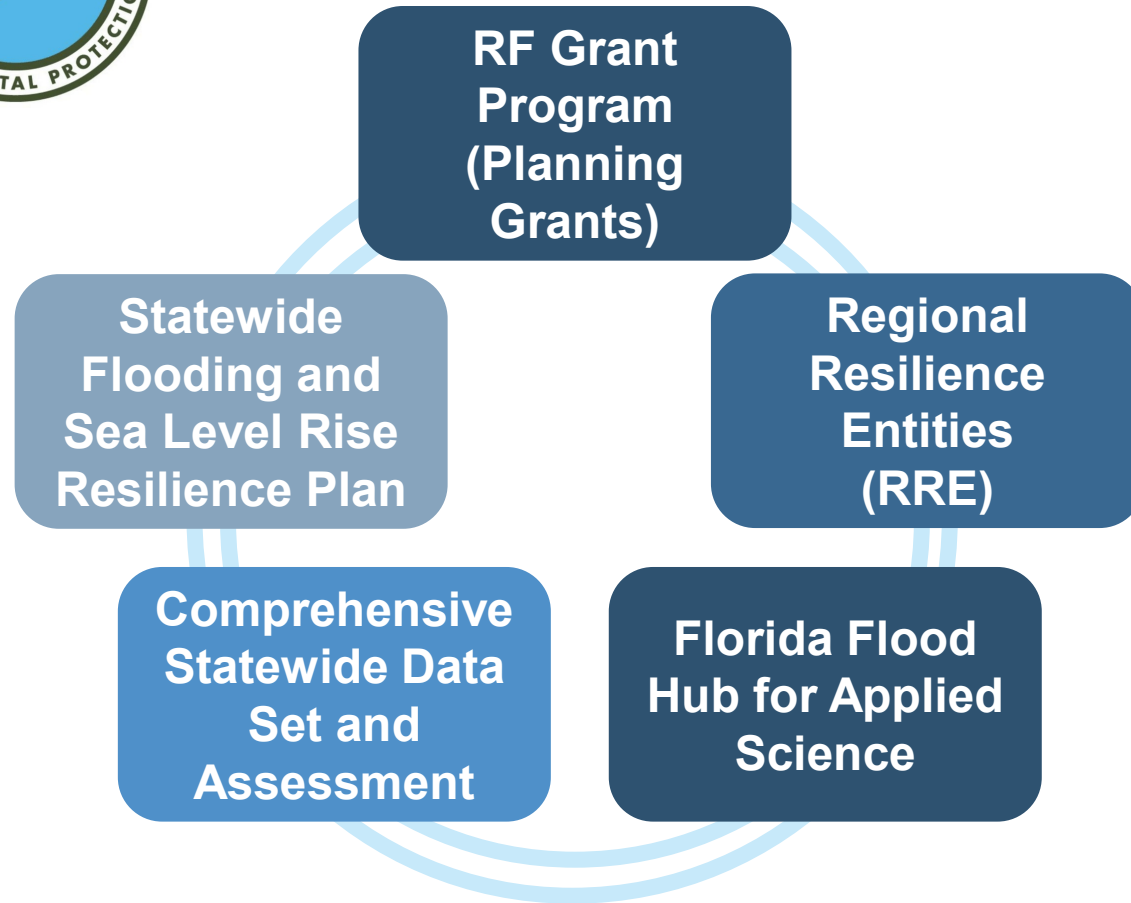


Building Resilience and Mitigating Risks
to South Florida's Water Resources

FINAL SEPTEMBER 1, 2024



FDEP Resilient Florida



“Always Ready Bill” Establishing the Program and 380.093, F.S.

Senate Bill 1954/2021 & House Bill 7019/2021

Unanimously passed in both chambers.

New in 2023: WMDs support to local government adaptation planning and the Florida Flood Hub for Applied Research and Innovation and FDEP in data creation and collection, modeling, and the implementation of statewide standards.

FEMA/FDEM BRIC, HMA, HMGP Programs

- Incentivize public infrastructure projects (flood risk reduction)
- Incentivize projects that mitigate risk to one or more lifelines (critical infrastructure)
- Innovative Solutions & Future Conditions
- Incentivize projects that incorporate nature-based solutions
- Shared responsibilities, community capability and partnership



Hazard Mitigation Assistance Program and Policy Guide

Hazard Mitigation Grant Program, Hazard Mitigation Grant Program Post Flood, Building Resilient Infrastructure and Communities, and Flood Mitigation Assistance

Effective March 23, 2023

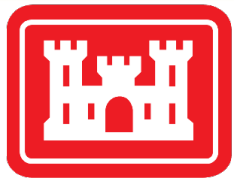
Version 1.0 - Updated September 13, 2023

Federal Emergency Management Agency (FEMA) (FEMA-000-000)



FEMA

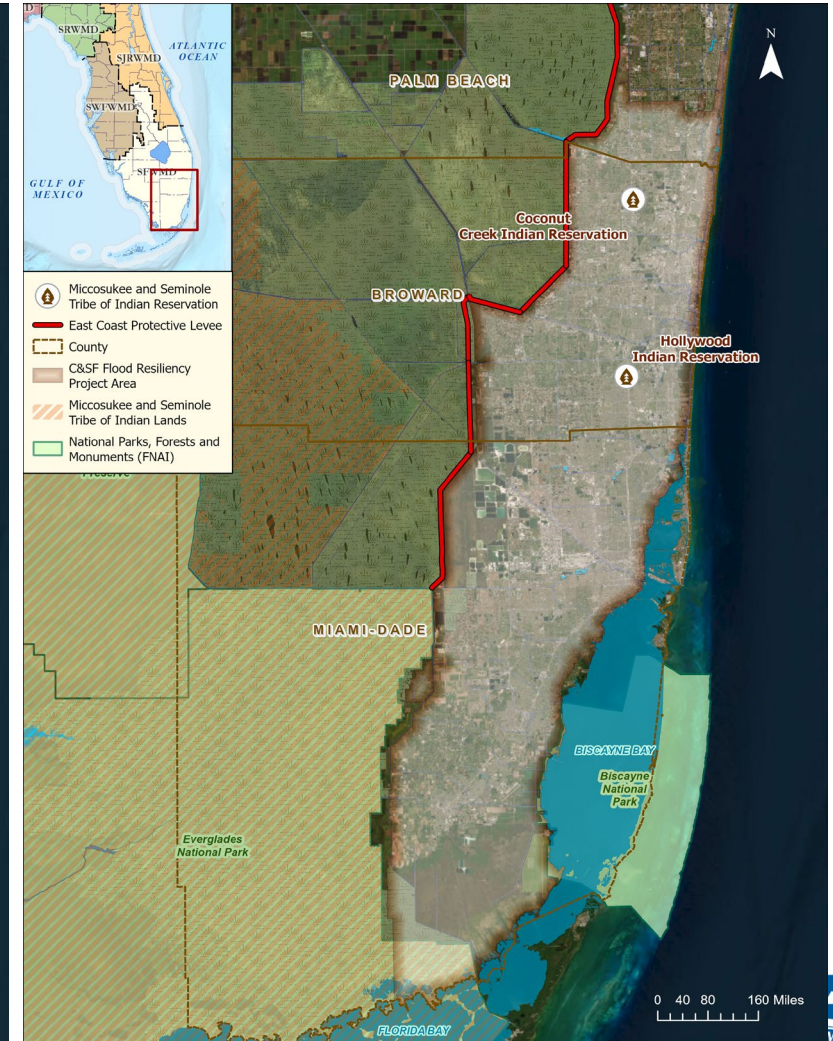
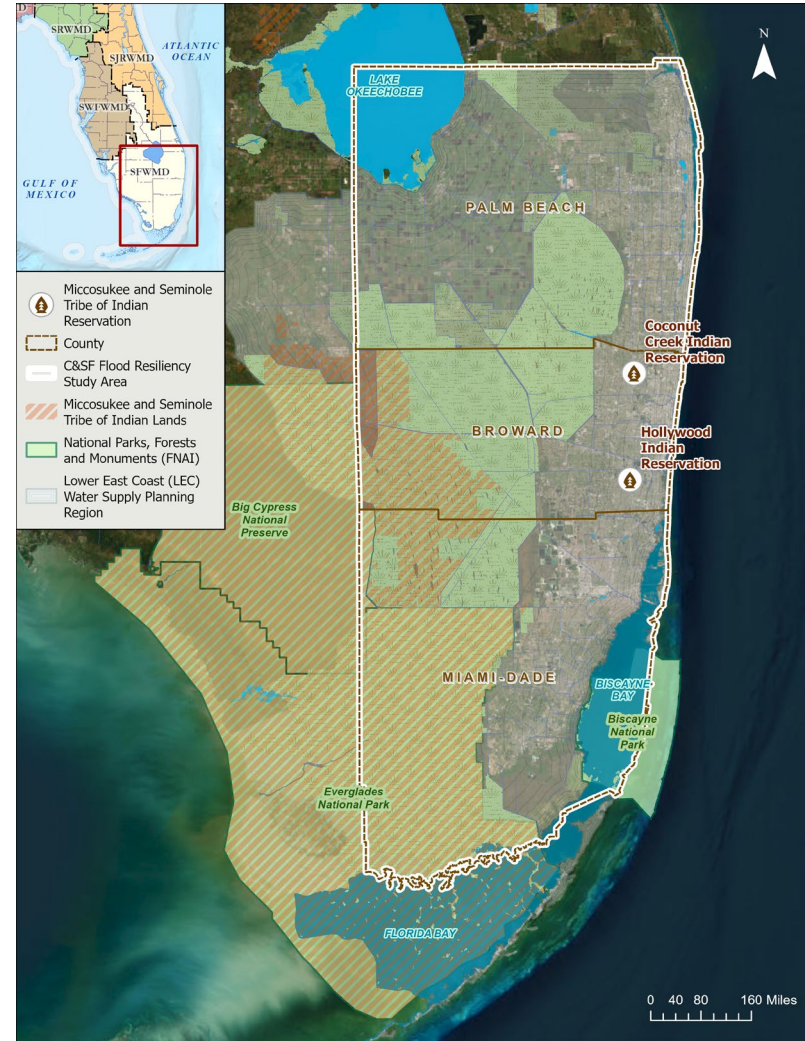




C&SF Flood Resiliency Studies



- Reduce flood risk and increase flood resiliency in high-risk urban watersheds in southeast Florida, while looking to enhance the overall benefits of the multipurpose C&SF Project
- Enhance SEFL Communities'
- Ongoing study phase: Future Without Scenarios – Flood Vulnerabilities & Total Benefits
- Upcoming C&SF Comprehensive Study





C&SF Studies: Integrated Path Forward



Planning Reach A - Broward County Basins

- Section 203 Feasibility Study – Target WRDA 26
- Funding support from FDEP and Broward County

Planning Reach B - C-7, C-8, C-9 Basins

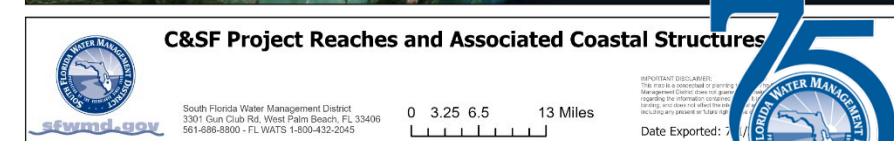
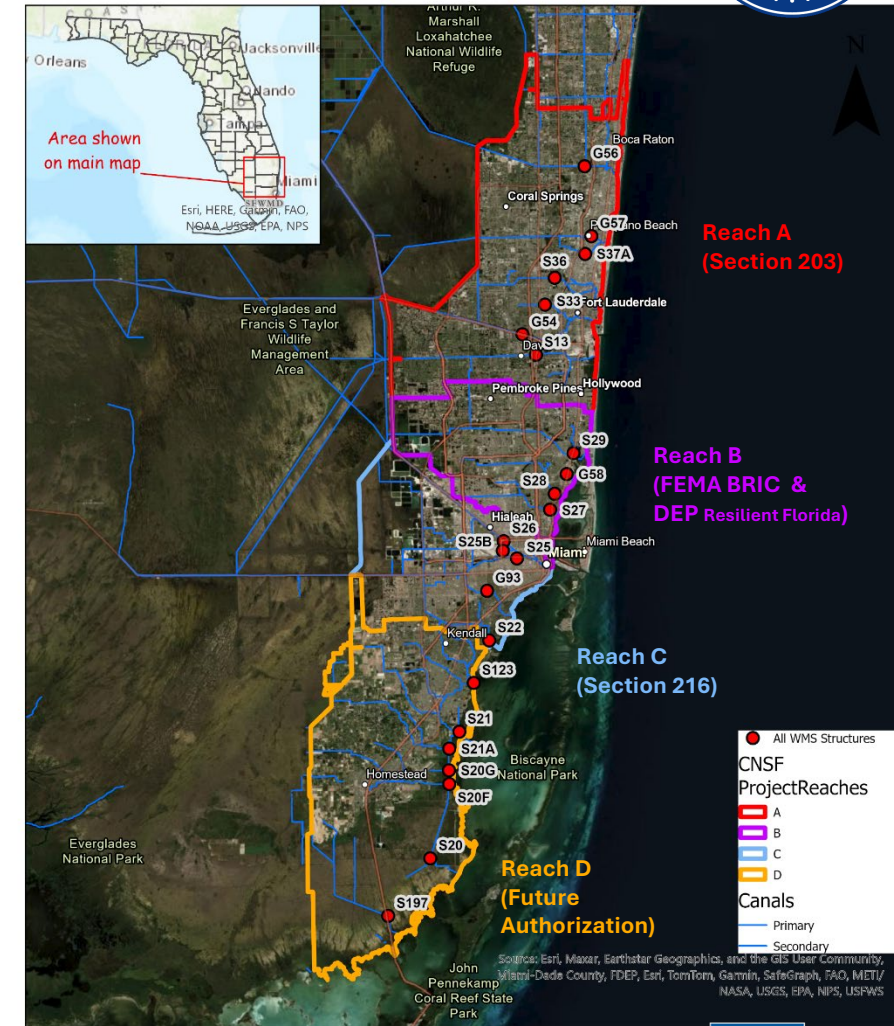
- FEMA Building Resilient Infrastructure and Communities (BRIC)
- Resilient Florida Grant Funding Available
- Funding support from Miami Dade County

Planning Reach C – Miami River Basins

- C&SF Flood Resiliency Study – Section 216 Authorization – Seeking Budget
- Feasibility Study - Target WRDA 28

Planning Reach D - South Dade Basins

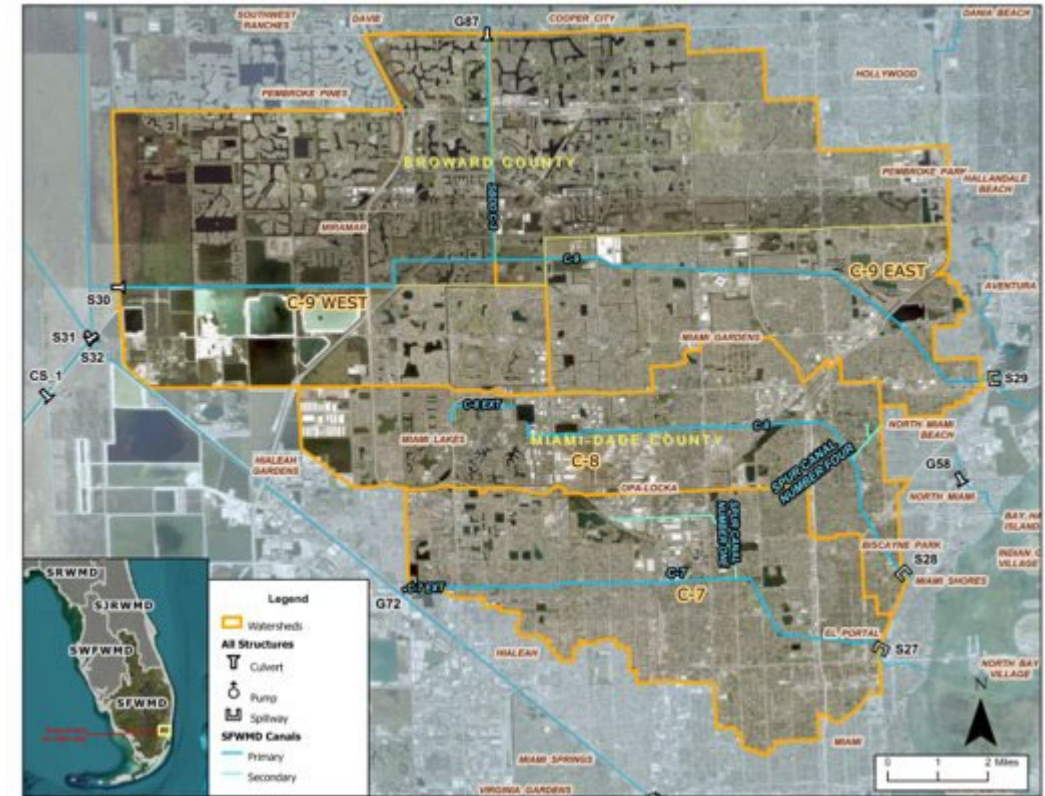
- CS&F Comprehensive Study or future planning studies



Reach B: C-7 C-8 C-9 Basins Resiliency

Basin-wide strategy to reduce flood risks due to sea-level rise and extreme rainfall; protect water resources

- Integration of green and gray infrastructure
 - Existing coastal structure enhancements/replacements
 - Restore original discharge capacity of the coastal structures by adding forward pump stations
 - Increase the basin's flood protection level of service in collaboration with project partners
 - Nature based solutions including living shorelines and temporary stormwater retention areas for extreme events
- **FDEP Resilient Florida & FDEM/FEMA BRIC: \$178M in Grant Awards (Pending Final Agreements Execution)**



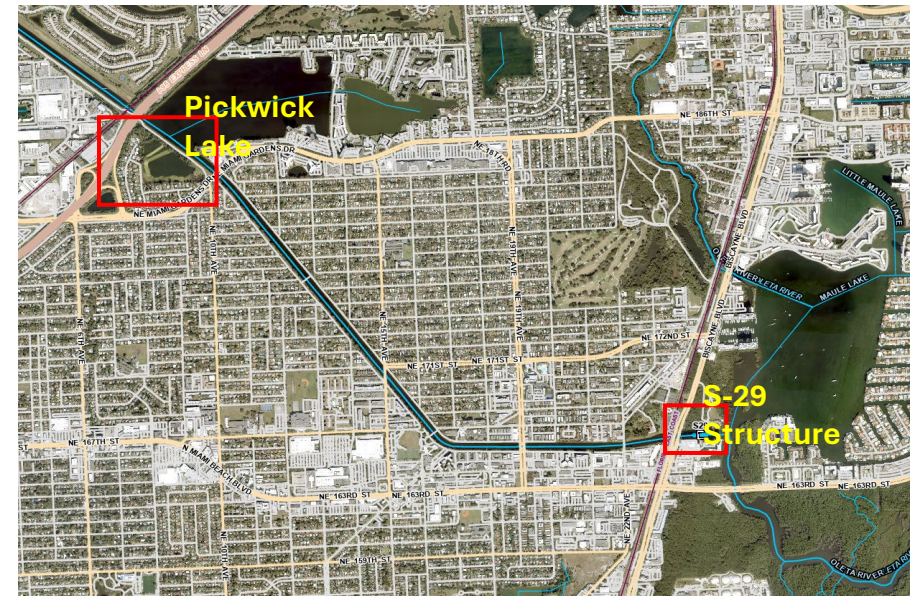
C-9 Basin Resiliency

- **FDEM/FEMA BRIC Award:** \$50M (25%/75% cost share agreement under Phase I final negotiation)
- S-29 Gated Structure enhancements
 - Raising elevations of the control structure, gate enhancements, corrosion resistance, a new hardened and elevated control building
- S-29 Forward Pump Station
- Green Infrastructure/NBS
 - Enhancement of Pickwick Lake stormwater detention
 - Living Shoreline
 - Enhanced Storage with absorption media
 - Connecting the lake with C-9 Canal via inflow/outflow water control (culvert) structures
- Secondary Canal Enhancements and Elevation to Six Canal Banks – Miami Dade County
- Sluice Gates with Green Walls – South Broward Drainage District



Photo: S-29 Structure (Looking Downstream)

Source: 9/20/2023 SIP Report

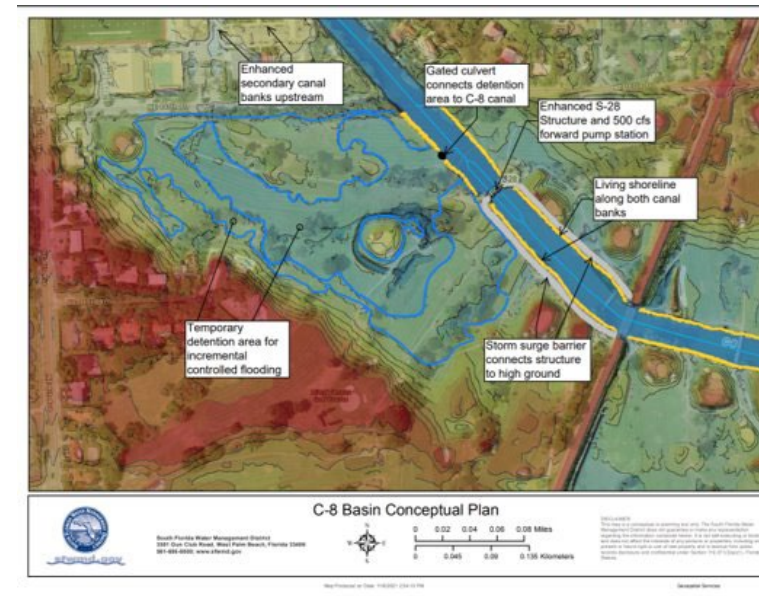


C-8 Basin Resiliency

- **FDEM/FEMA BRIC Award:** \$50M (25%/75% cost share agreement under Phase I final negotiation)
- **FDEP Resilient Florida Grant Award:** \$28.1M (50%/50% cost share agreement under final negotiation)
- **Project Components**
 - S-28 structure replacement, forward pump station, tie back levee/ salinity barrier
 - Green infrastructure - living shoreline, temporary stormwater detention area at Miami Shores Country Club
 - Secondary Canal Enhancements and Elevation to Six Canal Banks



Photo: Upstream of S-28 Structure



C-7 Basin Resiliency

- **FDEM/FEMA BRIC Award:** \$50M (25%/75% cost share agreement under Phase I final negotiation)
- **Project Components**
 - S-27 Gated Structure enhancements
 - Raising elevations of the control structure, gate enhancements, corrosion resistance, a new hardened and elevated control building
 - S-27 Forward Pump Station
 - Green Infrastructure/NBS
 - Enhancement of stormwater detention area at W.H. Turner School Property
 - Living Shoreline
 - Connecting the stormwater detention area with C-7 Canal via inflow/outflow structures

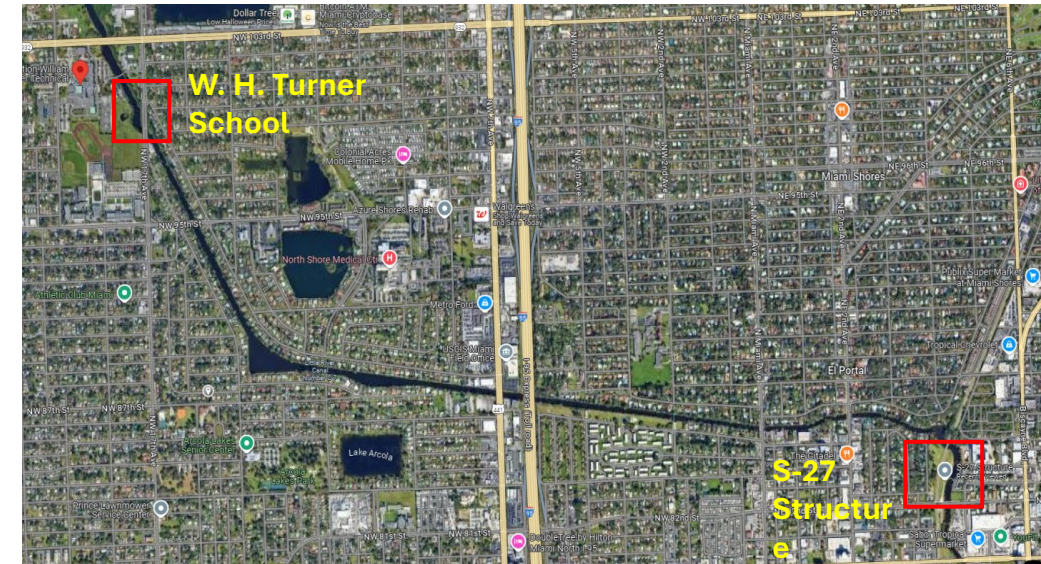


Photo: Aerial View of S-27 Structure
(Looking Upstream)

Resiliency Initiatives Coordination

Integrating Inland and Coastal Flood Mitigation Strategies

Counties Studies/
Projects

Water Control
Districts and
Municipalities
Projects

USACE Studies/
Projects

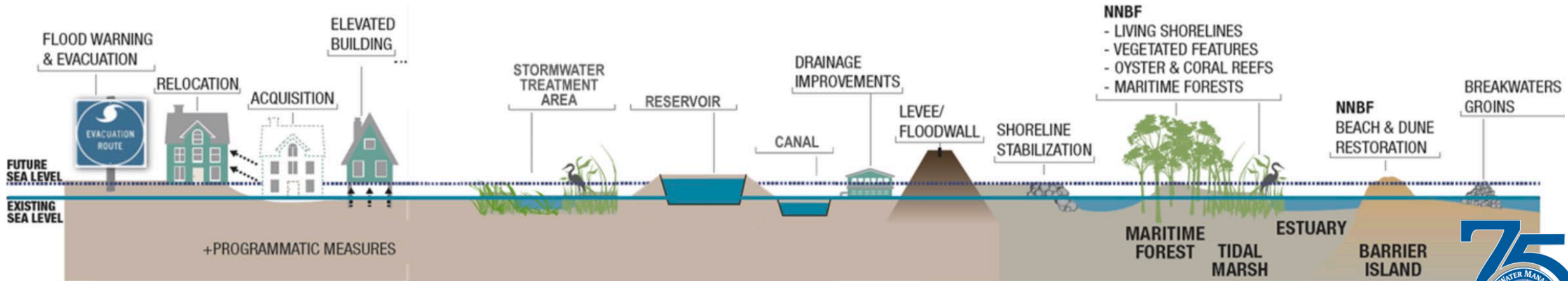
Regional Climate
Compacts

Other Partners

POTENTIAL MEASURES TO IMPROVE RESILIENCE AND SUSTAINABILITY

Graphic modified from https://ewn.el.erdc.dren.mil/nmbf/other/5_ERDC-NNBF_Brochure.pdf

Structural – Non-Structural – Nature-Base Solutions





THANKS FOR YOUR ATTENTION

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South Florida Water Management District

www.sfwmd.gov/resiliency

