Carolina Maran – Program Manager

SFWMD
Resilience Officer
Zoom:
• If you’re participating via Zoom – use the Raise Hand feature

Phone:
• If you’re participating via Phone –
  *6 Mutes/Unmutes
  *9 Raises Hand
WATER AND CLIMATE RESILIENCE METRICS

Public Workshop
January 22, 2021
Lemay Acosta and his daughter Layla took a boat ride through their flooded neighborhood in Plantation, Fla., on Monday. Credit...Carline Jean/South Florida Sun-Sentinel, via Associated Press

2020 shatters record for billion-dollar weather, climate disasters in US
Florida impacted by two of the events

Tropical Storm Eta Causes Flooding in South Florida

Some areas saw more than 13 inches of rainfall, and there was a storm surge along the coast.
Tropical Storm Eta

Significant rainfall occurrences in several locations

Very wet antecedent conditions
Antecedent Rainfall Conditions

Heavy rain is combining with king tides to submerge South Florida streets and contaminate beaches.

By CHRIS PERKINS and WAYNE K. ROUSTAN
SOUTH FLORIDA SUN SENTINEL
OCT 21, 2020 AT 1:54 PM

Drivers brave a flooded NW 10 Ave. in Oakland Park on Wednesday. Widespread flooding is expected as torrential rains move over the area, according to the National Weather Service. (Joe Cavaretta/South Florida Sun Sentinel)
Hourly Water Level Predictions at Virginia Key, FL for 2020
(includes contributions from the standard 37 harmonic constituents + SLR)

Presenter: Carolina Maran

New Moon Aug 19
New Moon Sep 17
Full Moon Oct 1
New Moon Oct 16
Full Moon Oct 31
New Moon Nov 15
New Moon Dec 14

Highest predicted tide: October 17, 10am
September Observed High Tides in Fort Lauderdale

Amount of time high tide remained above threshold:
9/20 pm ~ 4 hours
9/21 for ~ 5 hours

Threshold for flooding in low lying areas of City of Fort Lauderdale

If the low tides are elevated, ponded water may not discharge.

Source: Nancy Gassman, Broward TAC Presentation, October 2020

Presenter: Carolina Maran
Cyclic Analysis of Maximum Daily TW stages
(Jan 1, 1986 – Dec 31, 2019) at S-20F

2020 King Tide
(Magnified on the next slide)
Cyclic Analysis of Maximum Daily TW stages
(Jan 1,1986 – Dec 31, 2019) at S-20F

This period exceeded historical max for that period.

Date 09/22
King Tide 4.15
Average 2.13
Maximum 2.96
Minimum 1.18
P100 2.96
P99 2.95
P98 2.95
P95 2.88
P90 2.69
P75 2.43
P50 2.08
P25 1.78
P10 1.76
P05 1.73
P00 1.18

Presenter: Carolina Maran
Relative Percent Gate Closure

(Year 2020 – Avg)/Avg at S20F, when S-20F HW > 1.7 ft NVGD29

Presenter:
Carolina Maran
2020 King Tide Season

King tides bring headaches for coastal residents of South Florida

HOLLYWOOD, Fla. — The sight of a car stuck in the mud? Hollywood is evidence of the impact king tides are having on the area.

Strong onshore winds are pulling the water onto the streets.

A Hollywood resident, Morgan Lorenzo, says she's lived in the area for 25 years and has never seen the king tides flooding like this before.

"They've done some work on the road. They've raised the flood gates," she said. "But just to keep up with this, I don't think it'll probably be the worst year that it's been. It comes all the way in.

This is the end of this round of king tides, but more are expected.

King Tides leave parts of South Florida flooded

FORT LAUDERDALE, Fla. — King tides left parts of South Florida flooded Tuesday.

Local 10 News reporter Sandra Sabatino was in the area of Southwest 12th Street and Cordova Road in Fort Lauderdale Tuesday afternoon — an area known to flood.

Drivers were carefully trying to get through, although Cordova Road was blocked to traffic. City officials said Tuesday's tide is about 16 inches higher than predicted due to recent storms, and the fact that ocean levels are rising water up the coastlines.

City crews are working to build a sea wall along Cordova Road, which is about 2,500 linear feet and roughly 3 feet high.

The sea wall is expected to be finished by the end of the year.

The city has already installed a sea wall along Las Olas and the Isles of Palm Aire. There were pockets of flooding along Las Olas, but none immediately near the sea wall.

The city has also installed 177 tidal valves to reduce tidal flooding and to remove water off the roadways.

Officials are asking residents in the area by calling 850-824-4000.

NEW: Happy first day of the dry season! But not so fast, king tide flood advisory in effect, and rainy forecast

C.J. Johnson wades from his home on Marine Drive.

Experts say climate change is causing record high flooding during king tides

Sea level rise caused by climate change is causing record water highs during the seasonal king tides.

Water from the Intracoastal Waterway floods Greenwood Drive at South Flagler Drive in West Palm Beach at high tide Sunday morning, Oct. 18, 2020 after seeping up through the storm drains. The flooding is the result of the yearly King Tides, which began in September. The
How significant was 2020 compared to the record?

What impacts are we observing in South Florida?

How can we associate these impacts with Climate Change?

Are these recent events part of a long-term trend?

Presenter: Carolina Maran
WATER AND CLIMATE RESILIENCE METRICS

OBJECTIVES

1. Track and document long term trends and shifts in observed data owned/managed by SFWMD

2. Advance the understanding of the climate change impacts over the District’s mission

3. Report and Communicate the water and climate resilience aspects, and the associated science

4. Support the assessment of future conditions, and propose uniform guidelines.

Presenter: Carolina Maran
Types of Use of Climate Information

Inform
- Input data into hydrology or impact or planning model
- Inform other short-term forecast models

Communicate
- Seek funding or support for projects
- Communicate reliability in climate projections

Plan
- Undertake future planning
- Develop resource availability outlooks
- Future conditions maps or climate change reports/plans

Take Action
- Change operations & management: reservoir, storage or emergency mgmt
- Change rules, regulations, standards: permit allocations or design standards
- Infrastructure investment or retrofit: new roads or storage infra, retrofit stormwater infra
- Conservation or restoration projects

Understand
- Understand conditions that may cause management issues: Monitor relevant conditions for key events, pre-empt system risk or stress
- Understand regional atm processes or hydrology
- Understand ‘state of science’

Source: Kripa A. Jagannathan
Presenter: Carolina Maran
WATER AND CLIMATE RESILIENCE METRICS

BENEFITS

Stronger SFWMD planning capacity by documenting and publishing observed trends districtwide, based on best available data analysis and science-based approaches

Better substantiated modeling assumptions and risk informed operational decisions

Smarter infrastructure investment decisions, supported by robust assessment of current and anticipated future climate conditions

More educated and engaged stakeholders and partner agencies in water resilience aspects

Enhanced resilience of District’s projects, regarding observed or expected changes in climate

Presenter: Carolina Maran
INTERNAL WORKGROUP DRAFT REPORT

WATER AND CLIMATE RESILIENCE METRICS
Phase 1: Long-term observed trends

PROJECT TEAM

Presenter: Carolina Maran

TABLE OF CONTENTS

Introduction ................................................................................................. 1
Background ................................................................................................. 1
Nanotechnology Benefits ............................................................................ 4
Recent Water and Climate Resilience Measures ........................................... 16
Changing Climate Quantification ............................................................... 17
List of Selected Key Metrics and Associated Graphs ..................................... 29
Predictive and Stochastic Estimation of Central Structures ......................... 32
Total Stress and High Tide Elevations ......................................................... 24
Cruise Stages ........................................................................................... 36
Deltic Marine - Climate Change ............................................................... 39
Wetlands, Freshwater and Marine Water Levels - Shoreline Change ............ 44
Flood-Induced - Hurricane and Rainfall ..................................................... 46
Rainfall (Rain and Dry Extreme and Average) ............................................. 48
Discharge Patterns ................................................................................... 60
Wetland Qualification ............................................................................... 64
Environmental Indicators - Shoreline ......................................................... 72
Salinity Balance ...................................................................................... 75
Habitat and Volumes in the Estuaries ......................................................... 78
Data and Trend Analysis ............................................................................ 82
Reporting and Publications ...................................................................... 84
SIBORIO Foundation ............................................................................... 85
Communication and Data Sharing ............................................................ 86
Litterature Review .................................................................................... 87
Southeast Florida Climate Indicators

UNIFIED SEA LEVEL RISE PROJECTION

Source: Carolina Maran

Source: https://southeastfloridaclimatecompact.org/southeast-florida-climate-indicators/
Climate Change Indicators

Source: https://www.epa.gov/climate-indicators/climate-change-indicators-heavy-precipitation

Presenter: Carolina Maran
USGCRP INDICATOR PLATFORM

Annual Global Average Surface Temperature for Land and Ocean

Source: https://www.globalchange.gov/

Presenter: Carolina Maran
NOAA NCEI CLIMATE DIVISION DATA

Presenter: Carolina Maran

Source: https://www.ncdc.noaa.gov/cag/
CLIMATE CENTRAL

Spring Warming
Average Spring Temperature

+3.4°

BIRMINGHAM AREA

More Extreme Weather
Climate Extremes Index: Temperatures, Precipitation, Tropics

Source: AGA-NAS Climate Extremes Index through August 2017

More U.S. Coastal Flooding
Cumulative Flood Days in an Average Year

Source: https://www.climatecentral.org/
<table>
<thead>
<tr>
<th>Category</th>
<th>Potential Metrics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sea Level</strong></td>
<td>Tailwater Elevations at Coastal Structures</td>
</tr>
<tr>
<td></td>
<td>Tidal Stages</td>
</tr>
<tr>
<td></td>
<td>High Tide Events (Extreme)</td>
</tr>
<tr>
<td></td>
<td>Overtop of control structures (Extreme)</td>
</tr>
<tr>
<td></td>
<td>Soil Subsidence (elevation and accretion rates)</td>
</tr>
<tr>
<td></td>
<td>Coastal subsidence</td>
</tr>
<tr>
<td></td>
<td>Storm Surge</td>
</tr>
<tr>
<td><strong>Groundwater</strong> Levels</td>
<td>Water stages</td>
</tr>
<tr>
<td></td>
<td>Soil moisture</td>
</tr>
<tr>
<td></td>
<td>Minimum Flows and Minimum Water Levels (MFLs Exceedance / Violations)</td>
</tr>
<tr>
<td><strong>Rainfall</strong></td>
<td>Wet and Dry Extreme events</td>
</tr>
<tr>
<td></td>
<td>IDF curves</td>
</tr>
<tr>
<td></td>
<td>Rainfall Average, Seasonality</td>
</tr>
<tr>
<td><strong>Flooding</strong></td>
<td>Rainfall / Nuisance Flooding Events</td>
</tr>
<tr>
<td></td>
<td>Agricultural area flooding</td>
</tr>
<tr>
<td><strong>Drought</strong></td>
<td>Water Restrictions / Shortages</td>
</tr>
<tr>
<td></td>
<td>Natural Wildfires</td>
</tr>
<tr>
<td></td>
<td>Water Budgets / Wet and Dry Seasons</td>
</tr>
<tr>
<td><strong>Saltwater Intrusion</strong></td>
<td>Chloride levels</td>
</tr>
<tr>
<td></td>
<td>Conductivity</td>
</tr>
<tr>
<td></td>
<td>Lateral saltwater intrusion into coastal public supply wellfields</td>
</tr>
<tr>
<td></td>
<td>Everglades Marshes - Salt water intrusion</td>
</tr>
<tr>
<td><strong>Temperature</strong></td>
<td>Water temperatures</td>
</tr>
<tr>
<td></td>
<td>Algae (microalgae, phytoplankton)</td>
</tr>
<tr>
<td></td>
<td>Evapotranspiration</td>
</tr>
<tr>
<td></td>
<td>Solar Radiation, Winds</td>
</tr>
<tr>
<td></td>
<td>Air temperatures</td>
</tr>
<tr>
<td><strong>Stormwater</strong></td>
<td>Canal flows</td>
</tr>
<tr>
<td></td>
<td>STA efficiency / Biological/ecological functions</td>
</tr>
<tr>
<td></td>
<td>Lake and Wetlands Stages</td>
</tr>
<tr>
<td></td>
<td>Storage capacity</td>
</tr>
<tr>
<td><strong>Water Quality</strong></td>
<td>Dissolved Oxygen</td>
</tr>
<tr>
<td></td>
<td>Algae (microalgae, phytoplankton)</td>
</tr>
<tr>
<td></td>
<td>Salinity (see above, under Saltwater Intrusion)</td>
</tr>
<tr>
<td></td>
<td>Relict seawater</td>
</tr>
<tr>
<td></td>
<td>pH</td>
</tr>
<tr>
<td></td>
<td>Specific Conductance</td>
</tr>
<tr>
<td></td>
<td>Nutrient (Total Phosphorus)</td>
</tr>
<tr>
<td></td>
<td>Regional Floridan Groundwater Monitoring Network</td>
</tr>
<tr>
<td><strong>Ecology / Habitat</strong></td>
<td>Seagrass abundance/ distribution/ species</td>
</tr>
<tr>
<td></td>
<td>Oyster distribution/ density</td>
</tr>
<tr>
<td></td>
<td>Peat Collapse</td>
</tr>
<tr>
<td></td>
<td>Nutrients and Salinity at Everglades</td>
</tr>
<tr>
<td></td>
<td>Alligator sex ratios</td>
</tr>
<tr>
<td></td>
<td>Mangrove forests inland intrusion</td>
</tr>
<tr>
<td><strong>Set of Priority Water and Climate Resiliency Metrics</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Sea Level</strong></td>
<td>Tailwater Elevations at Coastal Structures</td>
</tr>
<tr>
<td></td>
<td>High Tide Events (Extreme Tidal Stages)</td>
</tr>
<tr>
<td></td>
<td>Chloride Levels (saltwater interface)</td>
</tr>
<tr>
<td><strong>Groundwater Level</strong></td>
<td>Groundwater Stages</td>
</tr>
<tr>
<td></td>
<td>Minimum Flows and Minimum Water Levels</td>
</tr>
<tr>
<td><strong>Hydrology</strong></td>
<td>Flooding Events</td>
</tr>
<tr>
<td></td>
<td>Rainfall</td>
</tr>
<tr>
<td></td>
<td>Evapotranspiration</td>
</tr>
<tr>
<td><strong>Water Quality</strong></td>
<td>Water Temperature</td>
</tr>
<tr>
<td></td>
<td>Dissolved Oxygen</td>
</tr>
<tr>
<td></td>
<td>pH</td>
</tr>
<tr>
<td></td>
<td>Specific conductance</td>
</tr>
<tr>
<td><strong>Ecology / Habitat</strong></td>
<td>Estuarine Inland Migration - Everglades</td>
</tr>
<tr>
<td></td>
<td>Soil Subsidence</td>
</tr>
<tr>
<td></td>
<td>Salinity at Everglades</td>
</tr>
</tbody>
</table>

Presenter: Carolina Maran
Tibebe Dessalegne – Tidal Elevations

Section Leader
Hydrology & Hydraulics Bureau
Sea Level Metric: Coastal sites and NOAA Tidal Stations

- Coastal structures
  - Outer boundary of the Water Management system
  - Critical for flood control and prevention of saltwater intrusion
  - Gravity driven
  - Require positive hydraulic gradient
  - Reduced discharging capacity at high tide level

- Sea level metric
  - Statistical analysis on water level timeseries data
    - Trend analysis on instantaneous water level data at different time scales (daily, monthly, annual)
  - Assists in identifying the most vulnerable structures and planning mitigation measures such as forward pumps

Presenter: Tibebe Dessalegne
Tailwater and Headwater Elevations at Coastal Structures

S22 – Mean Monthly TW Stages

Long term trend


Presenter: Tibebe Dessalegne
Karin Smith – Groundwater Stages and Saltwater Intrusion

Principal Scientist
Water Supply Bureau
Higher sea level moves heavier saltwater further inland and pushes freshwater above it up.

Impacts
- Saline water further inland, reduced freshwater gradient
- Inland flooding from higher groundwater, reduced storm water storage capacity

Presenter: Karin Smith
Groundwater Stages

Presenter: Karin Smith
## Saltwater Intrusion

### BACKWARD LOOKING: Utility Wellfield

<table>
<thead>
<tr>
<th>Utility Wellfield</th>
<th># of wells abandoned</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deerfield Beach PWS</td>
<td>2</td>
</tr>
<tr>
<td>Dania Beach PWS</td>
<td>1</td>
</tr>
<tr>
<td>Broward County 3A/3B Wellfields</td>
<td>9</td>
</tr>
<tr>
<td>Broward County 2a Wellfield</td>
<td>3</td>
</tr>
<tr>
<td>Hollywood – North &amp; Plant wellfields</td>
<td>10</td>
</tr>
<tr>
<td>Lake Worth Utilities – East Wells</td>
<td>7</td>
</tr>
<tr>
<td>Manalapan PWS</td>
<td>3</td>
</tr>
</tbody>
</table>

### FORWARD LOOKING: Utilities Identified in Most Recent Water Supply Plan

<table>
<thead>
<tr>
<th>Water Supply Planning Region</th>
<th>Total Utilities</th>
<th>Utilities at Risk</th>
<th>Utilities of Concern</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower East Coast</td>
<td>52</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Lower West Coast</td>
<td>22</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Upper East Coast</td>
<td>17</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>
Alaa Ali - Rainfall

Chief Engineer
Hydrology & Hydraulics Bureau
Rainfall

Monthly Rainfall Trend Analysis Results, illustrated by the month of August

Presenter: Alaa Ali
Rainfall

Wet Season Rainfall Trend Analysis Results

Presenter: Alaa Ali
Rainfall

5-day Annual Maxima Rainfall Trend Analysis Results, illustrated by the 2-year return

Presenter: Alaa Ali
**Evapotranspiration (ET)**

1. Solar Radiation
2. Air Temperature
3. Wind Speed
4. Relative Humidity

**Presenters:**
- Kevin Zhu

**Graphs:**
- Average Monthly ET/Rainfall At SFWMD
- Average Monthly (ET-Rainfall) At SFWMD

**Image:**
- Evapotranspiration = transpiration + evaporation
  - trees
  - grass
  - evaporation
  - runoff
  - groundwater recharge

---

By M. W. Toews - Own work, CC BY 4.0,
https://commons.wikimedia.org/w/index.php?curid=2843655
Evapotranspiration (ET)

Trend Of Annual EVAP & ET At SFWMD (1961-2019)

\[ y = 0.2573x + 66.889 \quad R^2 = 0.2277 \]
\[ y = 0.1385x + 63.97 \quad R^2 = 0.0922 \]
\[ y = 0.2589x + 52.147 \quad R^2 = 0.2982 \]
\[ y = 0.3446x + 38.16 \quad R^2 = 0.4646 \]

Pan Evaporation or ET (In/yr)

EVAP_S7
EVAP_S140_1986-2011
Linear (EVAP_S7_1986-2019)
Linear (EVAP_S140_1986-2011)
Linear (EVAP_WP.B.EEDD)
Linear (ETp_SFWMD)

Trend Of Annual & Seasonal EVAP At S7 (1961-2019)

Presenter: Kevin Zhu
Water Quality

• Initial analysis of water quality
  • Focus on specific conductance

• Water quality data retrieved from DBHYDRO for six in-lake stations
  • L001, L004, L005, L006, L007, and L008 - longest data records

• Period of record retrieved:
  • November 1972 – June 2020

• Analyses performed for specific conductance
  • Seasonal Kendall trend analysis
  • Identifying climatic events (Droughts, Tropical Storms)
  • Interpretation of observed trend

Presenter: Nenad Iricanin
Specific Conductance – Trend Analysis

- Seasonal variations in specific conductance are caused by evaporation (increase in specific conductance during droughts and dry season months) and precipitation (decrease in specific conductance during tropical events and wet season months)
- Over 48-year period, specific conductance decreased significantly by 40% (~660 µS/cm in 1973 to ~400 µS/cm in 2020)
- Typical specific conductance for Florida lakes is 385 µS/cm (Hand 2004)

Specific Conductance – Trend Analysis

Significant decreases in specific conductance were observed for all months over the period of record (1972 – 2020)

What are the causes for the observed decreasing trend in specific conductance?

Presenter: Nenad Iricanin
Specific conductance measures the ability of water to carry an electrical current, varying by types and amounts of ions present in solution. Therefore, it is highly correlated with the ionic content of the solution being measured.

**Major Ions Affecting Specific Conductance**
- Cations (positive charge): Na⁺, K⁺, Ca²⁺, Mg²⁺
- Anions (negative charge): Cl⁻, SO₄²⁻, HCO₃⁻

A fundamental law of nature is that all aqueous solutions must be electrically neutral (or balanced):

\[
\sum \text{Cations} = \sum \text{Anions}
\]

Plot shows the strong correlations of specific conductance and cations and anions in Lake Okeechobee during the period of record.

Ion concentrations converted to meq/L to account for ionic charge.

Presenter: Nenad Iricanin
Stiff Diagrams

- Resulting polygon shape extends from either side of the zero axis with cations represented on the left side and anions represented on the right side. All ions are plotted in units of meq/L.
- Stiff patterns are a useful method for making rapid visual comparisons between waters from different sources.

Schoeller Plots

- Semi-logarithmic plots to represent major ion concentrations and demonstrate different hydro-chemical water types
- Plot also shows the changes in ionic composition by identifying dominant ion pairs

Presenter: Nenad Iricanin
Changes in Lake Okeechobee Ionic Composition

Schoeller Plot

Specific Conductance Ranges (µS/cm)
- 642 - 874 µS/cm
- 591 - 642 µS/cm
- 558 - 591 µS/cm
- 534 - 558 µS/cm
- 508 - 534 µS/cm
- 476 - 508 µS/cm
- 450 - 476 µS/cm
- 422 - 450 µS/cm
- 384 - 422 µS/cm
- 297 - 384 µS/cm

Mean Concentration (meq/L)
- Cations: K, Mg, Na, Ca
- Anions: Cl, HCO₃⁻, SO₄²⁻

Na-Cl and Ca-HCO₃⁻ Co-dominated

Stiff Diagrams

Apparent shift in ionic composition with Na-Cl more dominant at higher specific conductance and Ca-HCO₃⁻ more dominant at lower specific conductance

Shift in Composition

Concentrations for Schoeller plots and Stiff diagrams in meq/L

Presenter: Nenad Iricanin
Changes in Lake Okeechobee Ionic Composition

- Ionic composition and specific conductance have changed over time
- 1973 – 1992 period, higher ion concentrations (higher specific conductance), Na-Cl dominant
- 1973 – 1982 period Na:K ratios potentially influenced by a more marine-like source (e.g., connate seawater)
- 2003 – 2020 period concentrations decreased with composition shifting to more Ca-HCO₃ dominate source
- Overall lower ionic concentrations in 2013-2020 resulted in lower specific conductance levels more typical for Florida lakes

Presenter: Nenad Iricanin

Ratios based on ion concentrations in meq/L
Specific Conductance Trend Analysis Summary

• A significant decreasing trend was observed for specific conductance in Lake Okeechobee over a 48-year period (1972 – 2020)
• Further evaluation of the additional data identified that the lake’s ionic composition appears to have changed from Na-Cl dominated in 1970s to a more Ca-HCO₃ dominated composition in more recent periods
• This change in composition coincides with observed decrease in specific conductance
• Additionally, ion ratios (Na:K) suggest that the elevated specific conductance observed in 1970s may have been affected by a more marine-like source, possibly upwelling of connate groundwater
• While air and water temperatures, as well as precipitation, have predictable effects on water quality, attributing changes in water quality to climate change is more complicated due to multiple cascading factors, such as changes in land use, hydro-management, and other anthropogenic activities, that exert great influence on water quality

Presenter: Nenad Iricanin
Carlos Coronado – Soil Subsidence

Lead Scientist
Applied Sciences Bureau
Conceptual framework detailing the potential pathways that a healthy wetland (panel a) that is exposed to various acute or chronic environmental stressors (panel b) can result in vegetation death (panel c), leading to four potential (non-exclusive) mechanisms of soil surface elevation loss (panel d) and ultimately conversion to an open water pond or mudflat (panel e). Figure by Chambers et al. 2019
Soil subsidence is a process in which there is a loss of soil strength and structural integrity that contributes to a decline in vertical elevation below the lower limit for plant growth and natural recovery.

Presenter: Carlos Coronado
Frequently Flooded n=5

- Elevation Change: 3.9 mm yr\(^{-1}\)
- Vertical Accretion: 2.1 mm yr\(^{-1}\)
- Soil Expansion: 1.8 mm yr\(^{-1}\)

Permanent Flooded n=7

- Elevation Change: 1.7 mm yr\(^{-1}\)
- Vertical Accretion: 1.9 mm yr\(^{-1}\)
- Soil Subsidence: -0.2 mm yr\(^{-1}\)

Presenter: Carlos Coronado
• Despite the lack of inorganic sediment input, there is a consistent elevation gain observed on mangrove forests with the "right hydrology (i.e., frequent inundation regimes) underscoring the importance of belowground processes, such as root production and decomposition, on soil elevation trajectories.

• Permanent flooded sites, located in the white zone, are not keeping pace with current sea level rise trend. It is hypothesized that poor forest structure, low production and salt intrusion are among the factors controlling this trend.

• Although subsidence rates are low, soil elevation at Northeastern Florida Bay locations is not increasing high enough to keeping pace with current sea level rise. Subsidence rates suggest that most of the mangrove forests in South Florida are highly vulnerable to sea level rise.

Presenter: Carlos Coronado
WATER AND CLIMATER RESILIENCE METRICS

Current Main Outcomes

- An initial set of prioritized metrics
- Recommended approaches to statistical and data analyses
- Alternative mapping, chart and graph options to display and communicate results

Presenter: Carolina Maran
Overview of the USGS Water Level and Salinity Analysis Mapper

Tara Root
Hydrologist
USGS Caribbean-Florida Water Science Center
Water resources in low lying coastal areas are facing a variety of risks driven by climate change and sea level rise.

How do we make the data we collect useful for water resources management?

Presenter: Tara Root
Science-based decision making to prepare for and respond to these risks requires…

1. Data

Presenter: Tara Root
Science-based decision making to prepare for and respond to these risks requires...

1. Data
2. Analyses

Presenter: Tara Root
Science-based decision making to prepare for and respond to these risks requires...

1. Data
2. Analyses
3. Visuals

USGS Water Level and Salinity Analysis Mapper (WLSAM)

Source for images: https://fl.water.usgs.gov/mapper/

Presenter: Tara Root
Overview of WSLAM

Online search tool and map interface

Source for images: https://fl.water.usgs.gov/mapper/
Overview of WSLAM

Data analysis & visuals

• Temporal trends in water level or salinity
• Symbol indicates direction of change
• User can select weekly, monthly, or long-term

Select water level analysis
- Change in the last week
- Change in the last month
- Five-year trends
- Twenty-year trends
- Composite trends

Map explanation

Explanation: Water levels

Water level change
- Upward change in water levels
- Downward change in water levels
- No change
- Insufficient data

Source for images: https://fl.water.usgs.gov/mapper/

Presenter: Tara Root
Overview of WSLAM

Data analysis & visuals

- How do current conditions compare to historical data?

Higher than historical norm
Similar to historical norm
Lower than historical norm

Source for images: https://fl.water.usgs.gov/mapper/

Presenter: Tara Root
Overview of WSLAM

Data analysis & visuals

- Extent of saltwater intrusion
- Color indicates chloride concentration
- Can view saltwater intrusion line over time

Source for images: https://fl.water.usgs.gov/mapper/

Presenter: Tara Root
Overview of WSLAM

Data analysis & visuals

Pop-up when user selects site
- Most recent value
- Magnitude of recent change
- Long-term trend directions

Image source: https://fl.water.usgs.gov/mapper/

Presenter: Tara Root
Maximum daily water level above NGVD29, in feet.
The most recent daily water level, measured on 2020-11-16, is 7.29 feet. This is the highest water level at this site on the day of the year was 7.29 feet, and the lowest was 5.21 feet.

<table>
<thead>
<tr>
<th>Day of the year</th>
<th>Maximum</th>
<th>Mean</th>
<th>Minimum</th>
<th>Available data points for this day</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
<td>6.22</td>
<td>5.45</td>
<td>4.42</td>
<td>26</td>
</tr>
<tr>
<td>2.00</td>
<td>6.17</td>
<td>5.44</td>
<td>4.36</td>
<td>26</td>
</tr>
<tr>
<td>3.00</td>
<td>6.30</td>
<td>5.45</td>
<td>4.36</td>
<td>26</td>
</tr>
<tr>
<td>4.00</td>
<td>6.34</td>
<td>5.43</td>
<td>4.36</td>
<td>26</td>
</tr>
<tr>
<td>5.00</td>
<td>6.38</td>
<td>5.43</td>
<td>4.34</td>
<td>26</td>
</tr>
<tr>
<td>6.00</td>
<td>6.30</td>
<td>5.41</td>
<td>4.34</td>
<td>26</td>
</tr>
<tr>
<td>7.00</td>
<td>6.27</td>
<td>5.40</td>
<td>4.34</td>
<td>26</td>
</tr>
<tr>
<td>8.00</td>
<td>6.27</td>
<td>5.38</td>
<td>4.33</td>
<td>25</td>
</tr>
<tr>
<td>9.00</td>
<td>6.27</td>
<td>5.35</td>
<td>4.33</td>
<td>25</td>
</tr>
<tr>
<td>10.00</td>
<td>6.27</td>
<td>5.34</td>
<td>4.27</td>
<td>25</td>
</tr>
<tr>
<td>11.00</td>
<td>6.21</td>
<td>5.33</td>
<td>4.26</td>
<td>25</td>
</tr>
<tr>
<td>12.00</td>
<td>6.12</td>
<td>5.30</td>
<td>4.21</td>
<td>26</td>
</tr>
<tr>
<td>13.00</td>
<td>6.08</td>
<td>5.27</td>
<td>4.21</td>
<td>25</td>
</tr>
<tr>
<td>14.00</td>
<td>6.05</td>
<td>5.27</td>
<td>4.17</td>
<td>25</td>
</tr>
</tbody>
</table>

Download daily statistics of maximum daily water level data in table format

Analyses for 5- and 20-year trends in chloride concentration

<table>
<thead>
<tr>
<th>Trend test</th>
<th>Test result</th>
<th>P-value</th>
<th>Kendall’s tau</th>
<th>Slope</th>
<th>Intercept</th>
</tr>
</thead>
<tbody>
<tr>
<td>Five Year</td>
<td>Up</td>
<td>0.00</td>
<td>0.79</td>
<td>1.16</td>
<td>-14,223</td>
</tr>
<tr>
<td>Twenty Year</td>
<td>Up</td>
<td>0.00</td>
<td>0.92</td>
<td>1.30</td>
<td>-17,121</td>
</tr>
</tbody>
</table>

Analysis

<table>
<thead>
<tr>
<th>Date of first sample</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1959-03-06</td>
<td>24</td>
</tr>
<tr>
<td>First sample result (mg/L)</td>
<td>2020-12-03</td>
</tr>
<tr>
<td>Date of last sample</td>
<td>7,400</td>
</tr>
<tr>
<td>Last sample result (mg/L)</td>
<td>1991-02-21</td>
</tr>
<tr>
<td>Date of first sample within 250 to 999 mg/L</td>
<td>4,850</td>
</tr>
<tr>
<td>Date of first sample with 1,000 mg/L or greater</td>
<td>233</td>
</tr>
<tr>
<td>Minimum (mg/L)</td>
<td>17</td>
</tr>
<tr>
<td>Maximum (mg/L)</td>
<td>7,410</td>
</tr>
<tr>
<td>Mean (mg/L)</td>
<td>2,721.136</td>
</tr>
<tr>
<td>First quartile (mg/L)</td>
<td>233</td>
</tr>
<tr>
<td>Median (mg/L)</td>
<td>2,350</td>
</tr>
<tr>
<td>Third quartile (mg/L)</td>
<td>4,850</td>
</tr>
<tr>
<td>Number of samples</td>
<td>257</td>
</tr>
</tbody>
</table>

Download chloride concentration summary statistics data in table format
Overview of WSLAM

• Online search tools and map interfaces
• Access to data tables
• Data analysis and visuals
  • Temporal trends
  • Current data compared to historical norms
  • Graphical and tabular displays of temporal trends and statistical analysis

Presenter: Tara Root

Water Level and Salinity Analysis Mapper

https://fl.water.usgs.gov/mapper/
Next Steps: Implementation

Coastal Structures Tidal/Tailwater Elevation Trends

High Tide Elevations / Extreme Tidal Stage Trends

Saltwater Intrusion/Chloride Level Trends

Learn more
(Data Analysis Approach & Trends Significance)
SFER Annual Reporting

- Home for the scientific discussions
- Chapter / Section to be determined
- Rotating Metrics: major highlights and shifts occurred each year

Presenter: Carolina Maran
Next Steps

• Incorporate comments and advance districtwide implementation

• Continuous scientific analysis and correlation with additional data, to tease out Climate Change Impacts, as appropriate and possible

• Estimate Future Projections

Presenter: Carolina Maran
Thanks

Questions?

Carolina Maran, Ph.D., P.E.
District Resiliency Officer
cmaran@sfwmd.gov
3. Public Comment

Want to comment?

**Zoom:**
- If you’re participating via Zoom – use the Raise Hand feature

**Phone:**
- If you’re participating via Phone –
  *6 Mutes/Unmutes
  *9 Raises Hand
4. Adjourn

THANK YOU