Welcome to Water and Climate Resilience Metrics

Public Workshop

January 22, 2021

SOUTH FLORIDA WATER MANAGEMENT DISTRICT
PROTECTOR OF THE EVERGLADES SINCE 1949

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

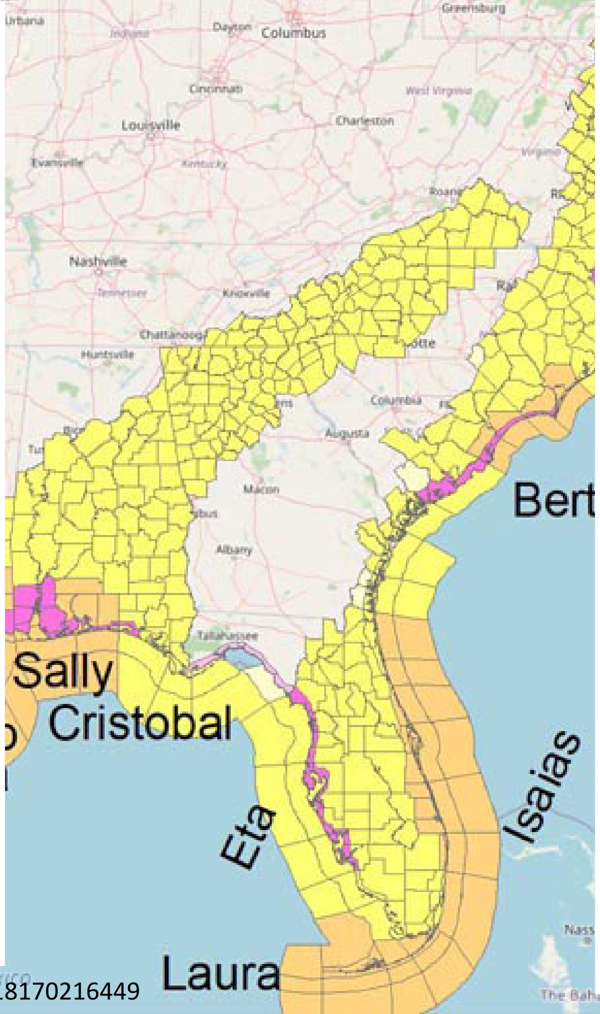
South Florida Water Management District
Protector of the Everglades since 1949

Public Workshop

January 22, 2021

Presenter:
Carolina Maran

2020 Atlantic Tropical Watches and Warnings Through November 15



LIVE TRACK: 'Huge rainmaker' Hurricane Sally threatens historic floods

Tropics stay very active

WAVELAND, Miss. – Heavy rain, pounding surf and flash floods hit parts of the Florida Panhandle and the Alabama coast on Tuesday as Hurricane Sally lumbered toward land at a painfully slow pace, threatening as much as 30 inches (76 centimeters) of rain and dangerous, historic flooding.

The storm's center churned offshore 65 miles (105 kilometers) south-southeast of Mobile, Alabama, as Sally crept north-northeast toward an expected Wednesday landfall at 2 mph (3 kph), according to the National Hurricane Center. The forecast map showed the center likely coming ashore in Alabama, near the Florida line.

Hurricane force winds extended 40 miles (65 kilometers). Rain fell sideways and began covering roads in Pensacola, Florida, and Mobile. More than 80,000 power customers were without electricity, according to **poweroutage.us** .

2020 shatters record for billion-dollar weather, climate disasters in US

Florida impacted by two of the events

...La. Laura, which ...former hurricane

...ception. The ...vents led to 22

The New York Times

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.

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

By Patricia Mazzei and Frances Robles

Published Nov. 9, 2020 Updated Nov. 12, 2020

- *Go here for the latest on Eta*

MIAMI — South Florida awoke to streets turned into shallow rivers on Monday after Tropical Storm Eta soaked the region overnight. It dumped rain inland, caused storm surge along the coast and left hundreds of thousands of people without electricity.

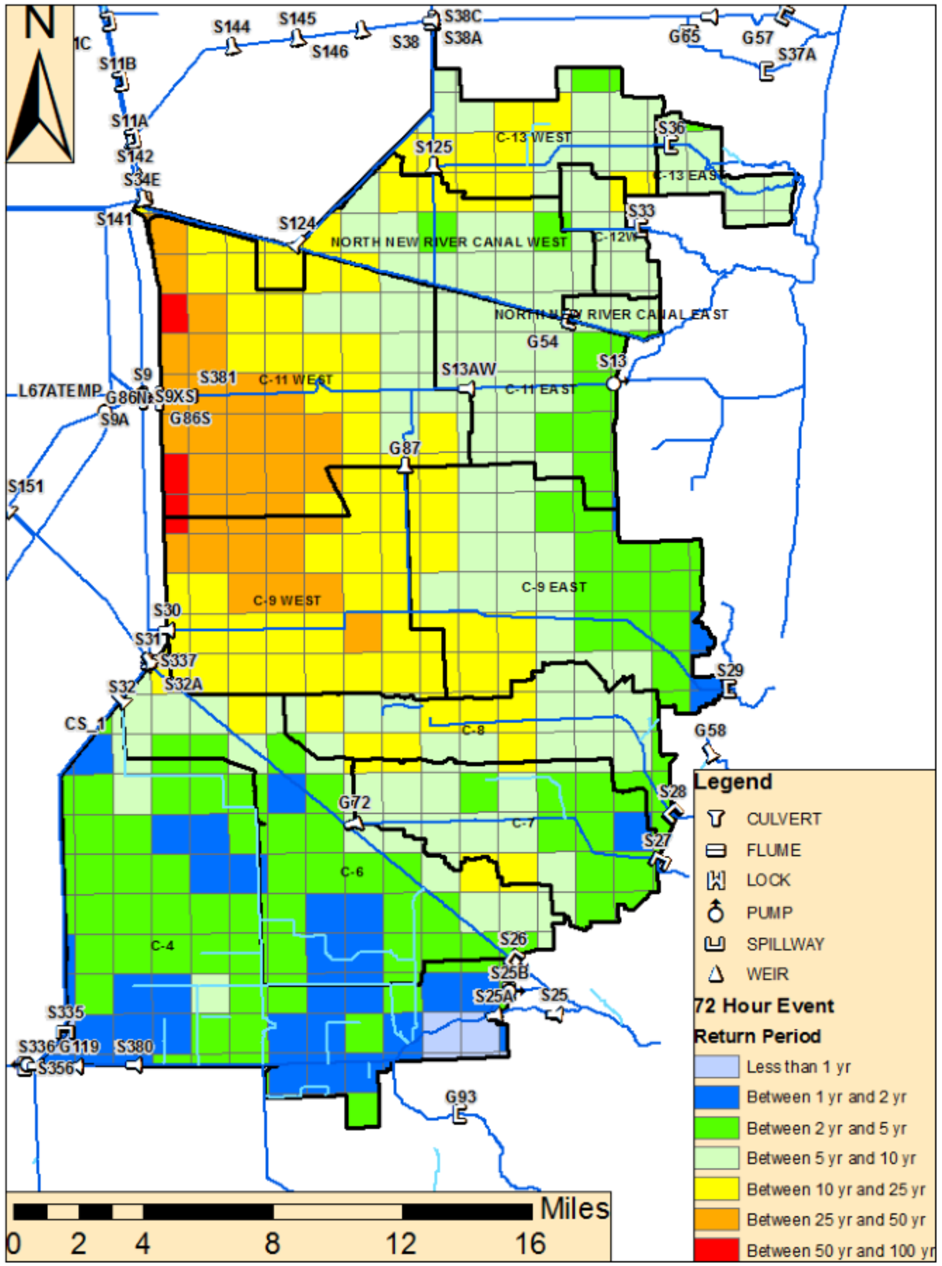
Source: https://twitter.com/NWSCorpus/status/1328398818170216449

Presenter: Carolina Maran

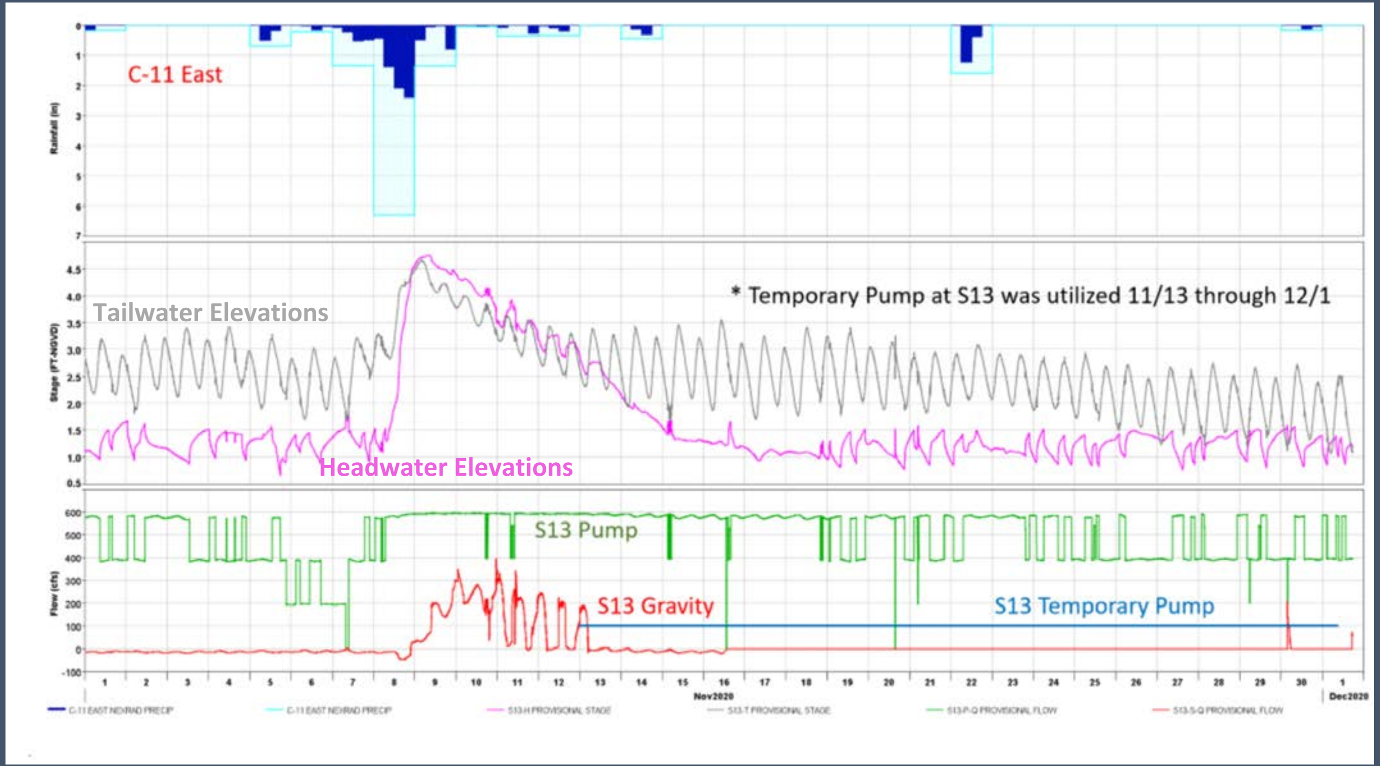
Tropical Storm Eta

Significant rainfall occurrences in several locations

Very wet antecedent conditions

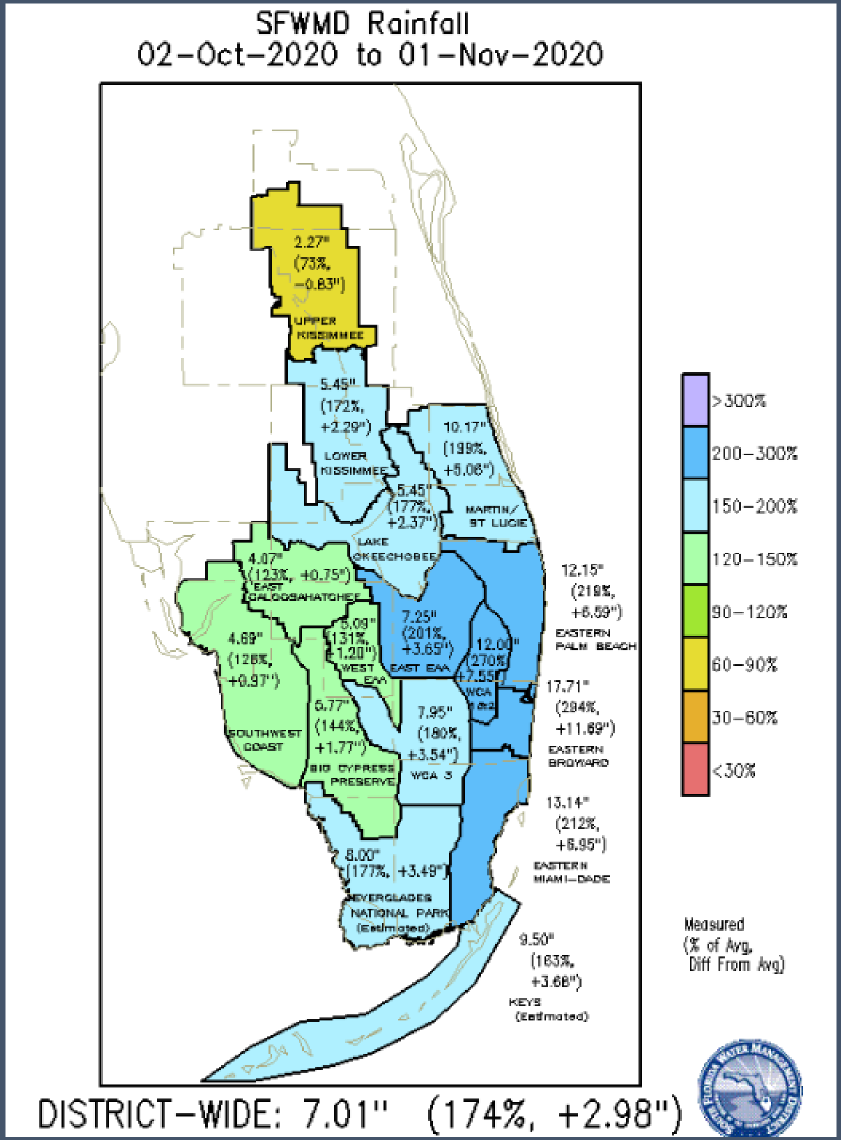


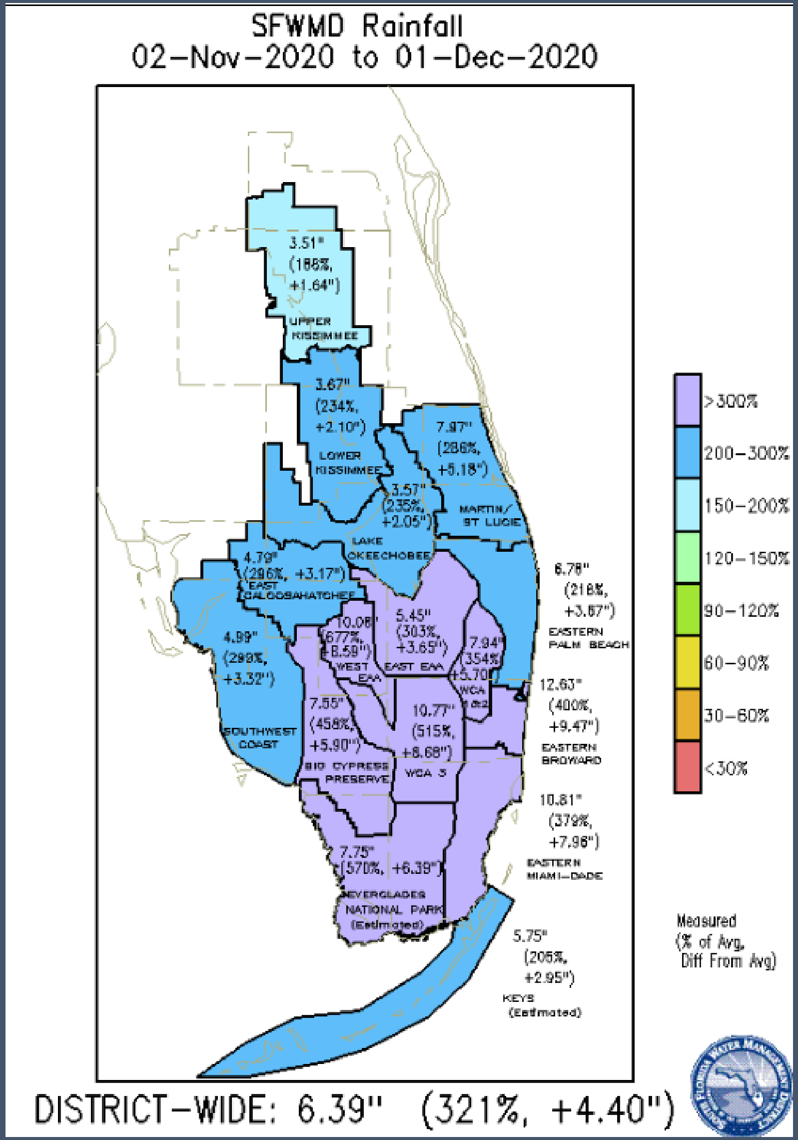
72-hour Rainfall Return Intervals over the Broward and North Miami Counties during TS Eta



Presenter: Carolina Maran

Antecedent Rainfall Conditions





SunSentinel SUBSCRIBE 8 wks/99¢ LOG IN

TRIAL OFFER | 8 weeks for 99¢

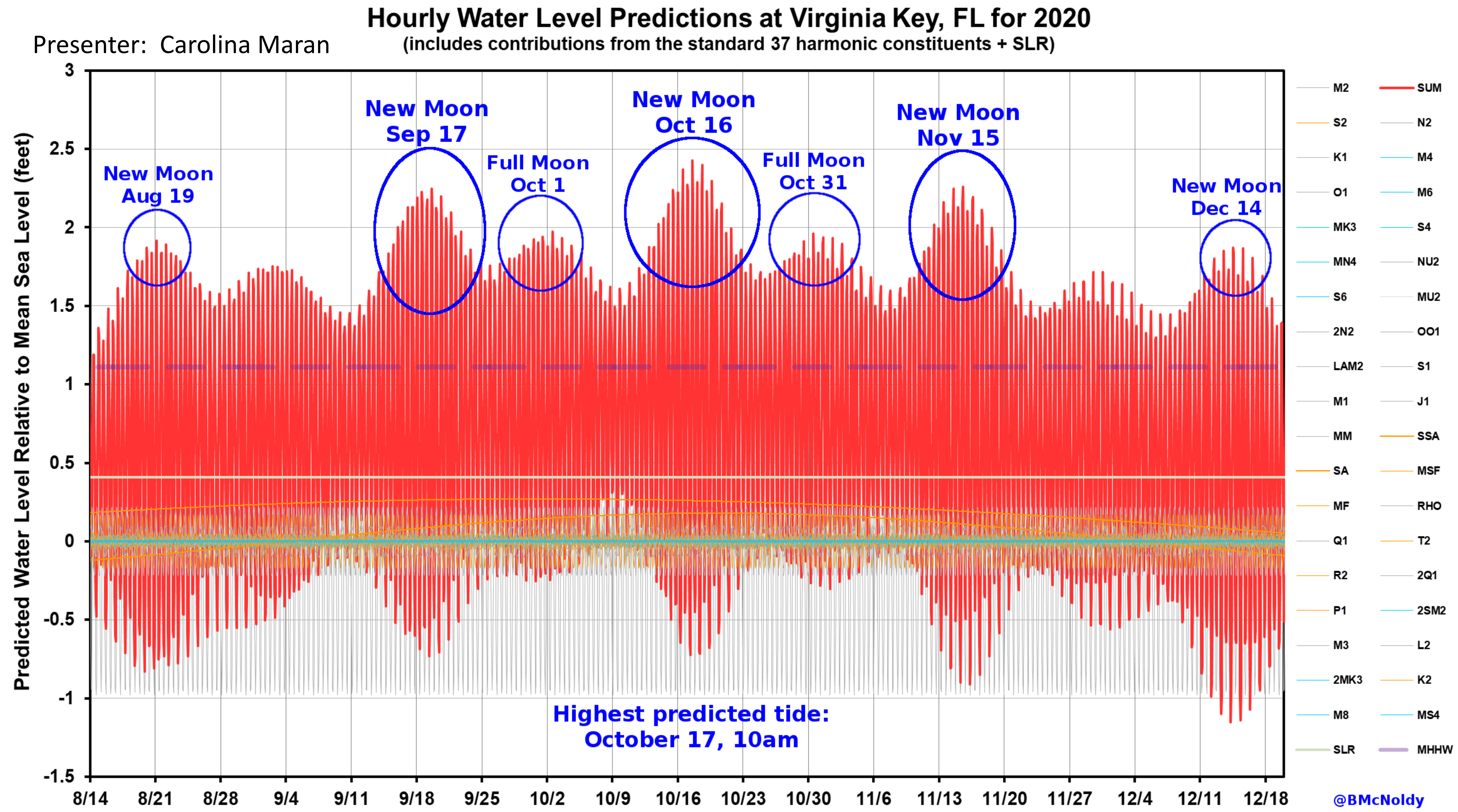
WEATHER FORECAST NEWS

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

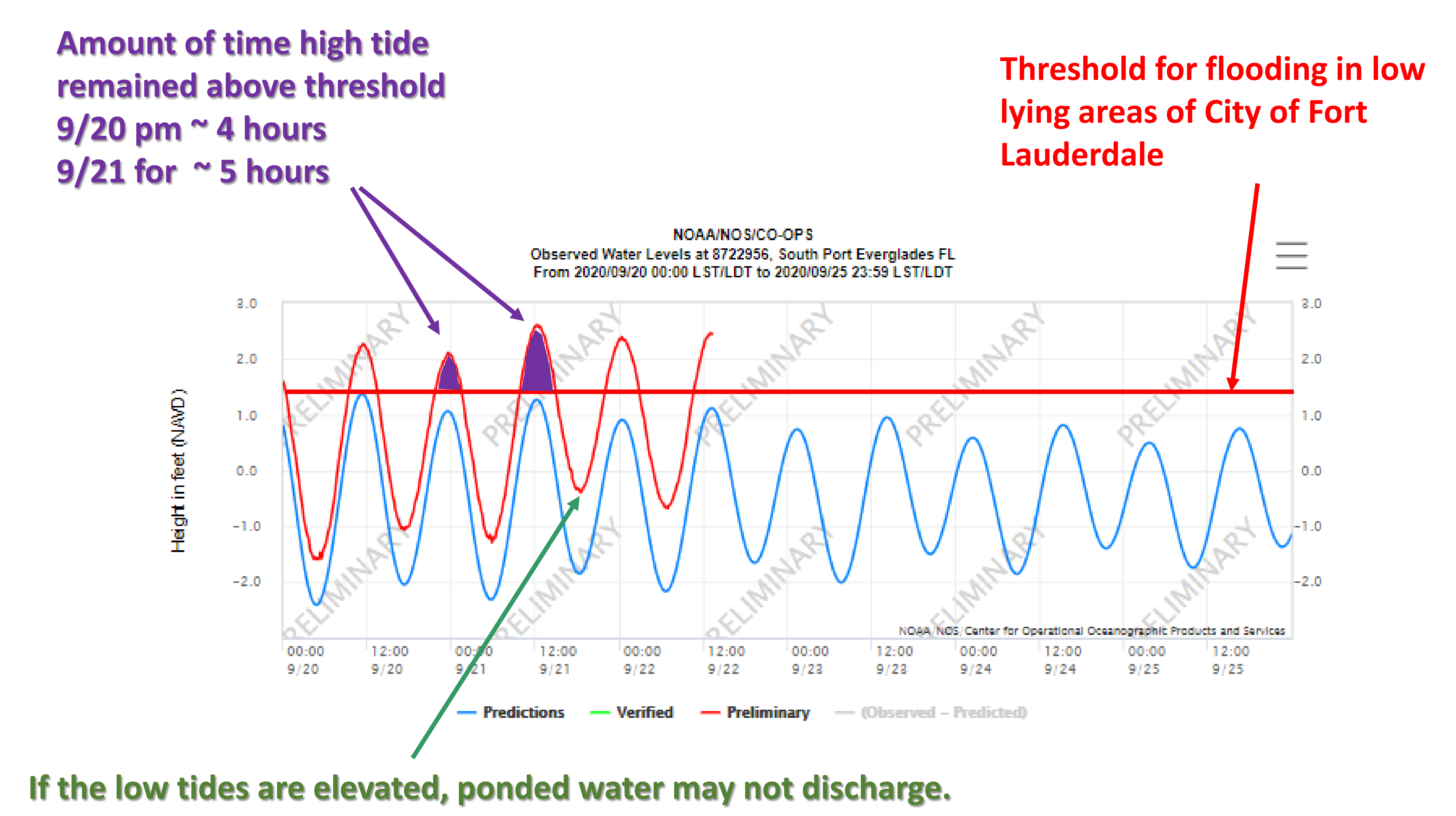
By CHRIS PERKINS and WAYNE K. ROUSTAN
SOUTH FLORIDA SUN SENTINEL
OCT 21, 2020 AT 1:54 PM

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)

Presenter: Carolina Maran



September Observed High Tides in Fort Lauderdale

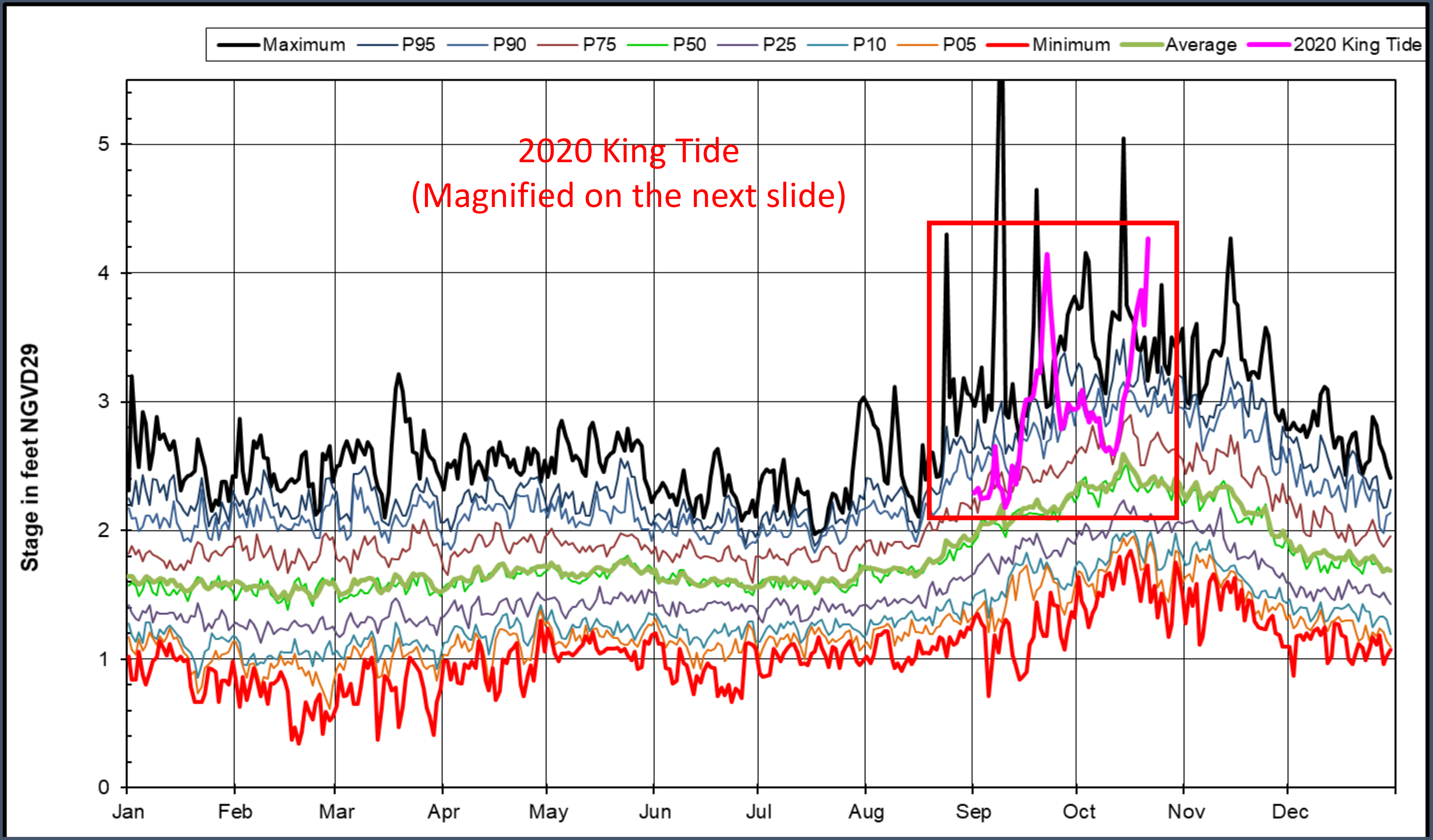


Presenter:
Carolina Maran

Source: Nancy Gassman, Broward TAC Presentation, October 2020

Cyclic Analysis of Maximum Daily TW stages

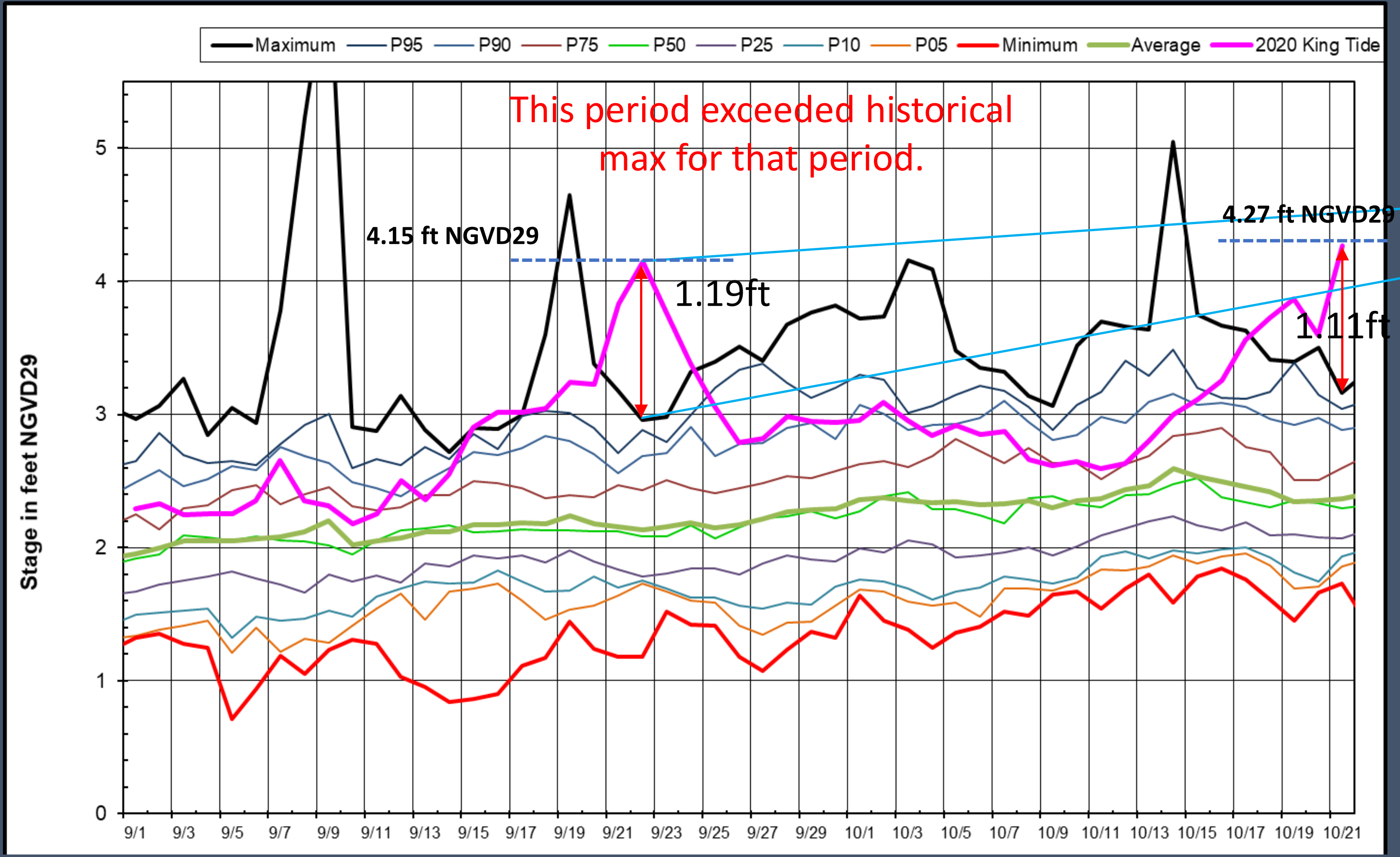
(Jan 1,1986 – Dec 31, 2019) at S-20F



Presenter:
Carolina Maran

Cyclic Analysis of Maximum Daily TW stages

(Jan 1,1986 – Dec 31, 2019) at S-20F

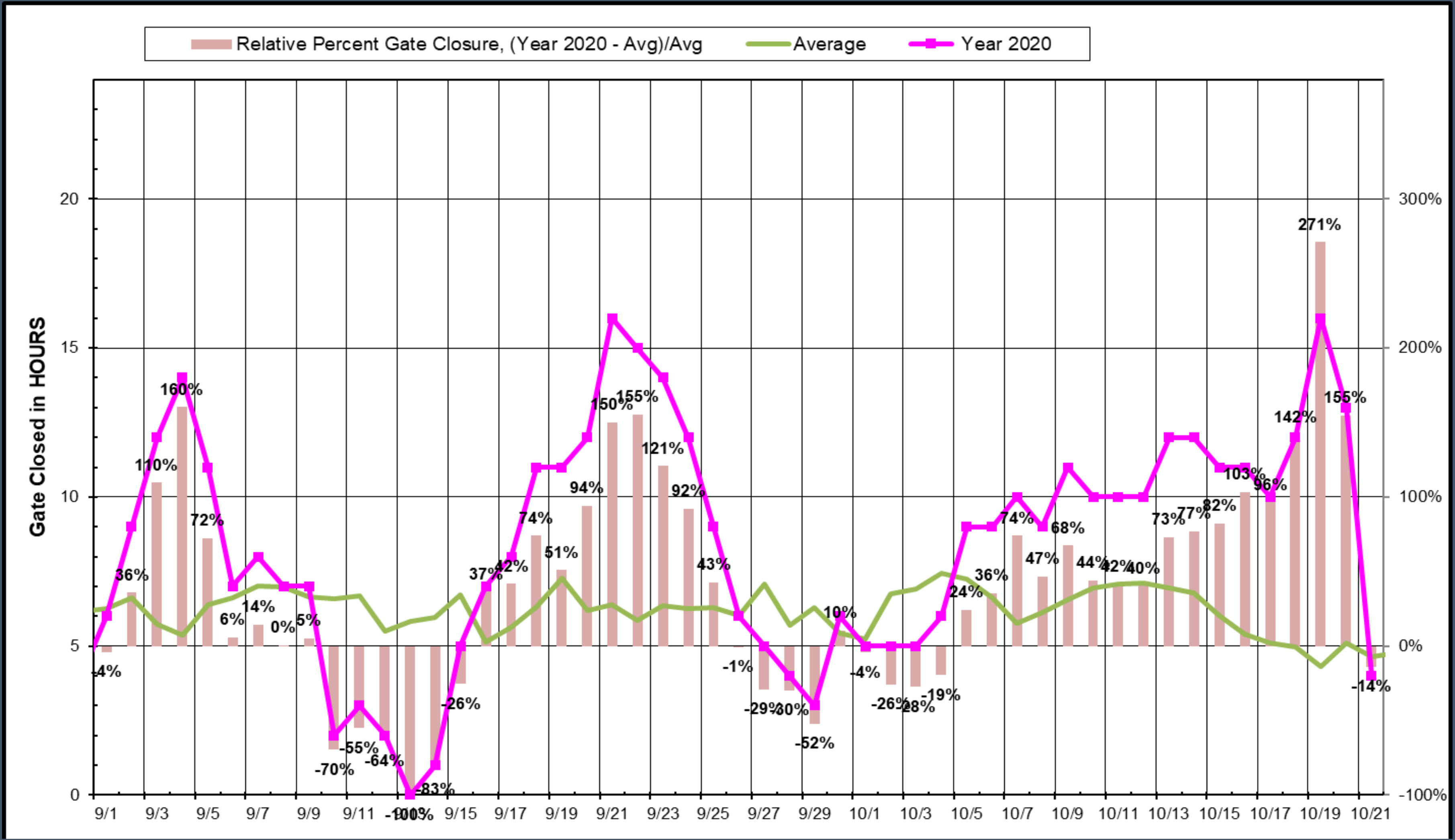


Date	09/22
2020 King Tide	**4.15**
Average	2.13
Maximum	**2.96**
Minimum	1.18
P100	2.96
P99	2.95
P98	2.95
P95	2.88
P90	2.69
P75	2.43
P50	2.08
P25	1.78
P10	1.76
P05	1.73
P00	1.18

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 midd

Hollywood is evidence of the impact king tides are havin

Strong onshore wind is piling the water onto the street i

Hollywood resident Morgan Lorenzo says she's lived in t

the past five the king tide flooding has been getting prog

"They've done some work on the road. They've raised the

she said. "But just to keep up with this, I don't think infra

probably the worst year that it's been. It comes all the wa

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

King Tides leave parts of South Florida flooded

FORT LAUDERDALE, Fla. – King Tides left parts of South Florida flooded Tuesday.

Local 10 News reporter Sanela Sabovic was in the area of Southeast 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 easterly winds are piling water up the coastline.

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 Isle of Palms Drive. 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 to report flooding in their area by calling 954-828-8000.

According to city officials, King Tides are tides expected to be within 3 inches of the threshold for

The Palm Beach Post　　Subscribe

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

The Palm Beach Post　　Subscribe

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

Presenter:
Carolina Maran

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

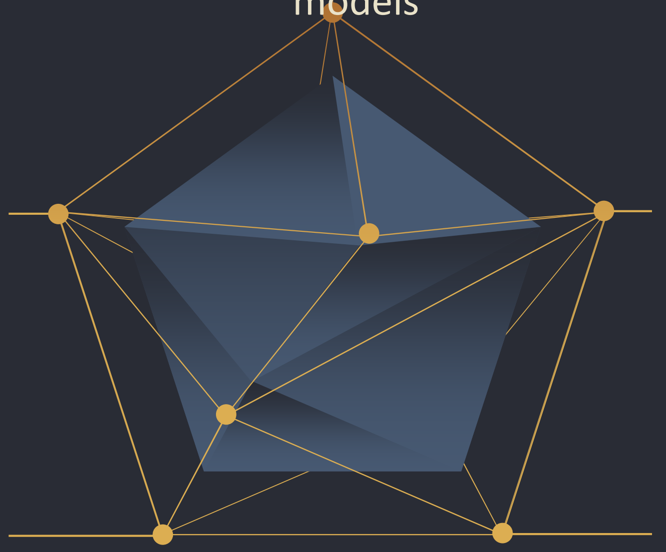
Types of Use of Climate Information

Presenter: Carolina Maran

Source: Kripa A. Jagannathan

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

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’

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

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 RESILIENCY METRICS

Phase 1: Long-term observed trends

DRAFT REPORT

Version 1.0

December 2020

Presenter: Carolina Maran

PROJECT TEAM

Akintunde Owosina	Hydrology and Hydraulics
Alan Buzard	Hydro Data Management
Amanda Kahn	Applied Science – Coastal Ecosystems
Brian Turcotte	Applied Science – Data Management
Carol Ballard	Hydrology and Hydraulics Modeling
Cassondra Armstrong	Applied Science – Water Quality Treatment
Christian Avila	Water Quality - Compliance Assessment & Reporting
Christopher Madden	Applied Science – Everglades Systems
Fred Sklar	Applied Science – Everglades Systems
Heather Kostura	Geospatial Services
Hongying Zhao	Hydrology and Hydraulics Modeling
Jeffrey Iudicello	Hydrology and Hydraulics Modeling
Jenifer Barnes	Hydrology and Hydraulics Modeling
Jenni Hiscock	District Resiliency
Jennifer Reynolds	Ecosystem Restoration and Capital Projects
Jesse Markle	Environmental Resources and Regulation Support
Jessica Frost	Applied Science – Coastal Ecosystems
Jill Margolius	Communication and Public Affairs
John Raymond	Hydro Data Management
Juli LaRock	Water Quality - Compliance Assessment & Reporting
Kris Esterson	Water Supply Planning
Lawrence Glenn	Water Resources
Mandy McDonald	Applied Science – Everglades Systems
Mark Elsner	Water Supply
Matthew Morrison	Ecosystem Restoration
Michael Brown	Hydrology and Hydraulics Modeling
Patricia Burke	Water Quality Monitoring
Ronda Albert	IT Applications
Sarah Noorjahan	Hydro Data Management
Sean Sculley	Applied Science - Lake and River Ecosystems
Sean Williams	Hydro Data Management
Seyed Hajimirzaie	Hydrology and Hydraulics Applied Hydrology
Shimelis Setegn	Applied Science – Coastal Ecosystems
Stuart Van Horn	Water Quality
Suelynn Kirkland	Operations
Toni Edwards	Applied Science – Coastal Ecosystems
Walter Wilcox	Hydrology and Hydraulics Modeling

Technical Leads

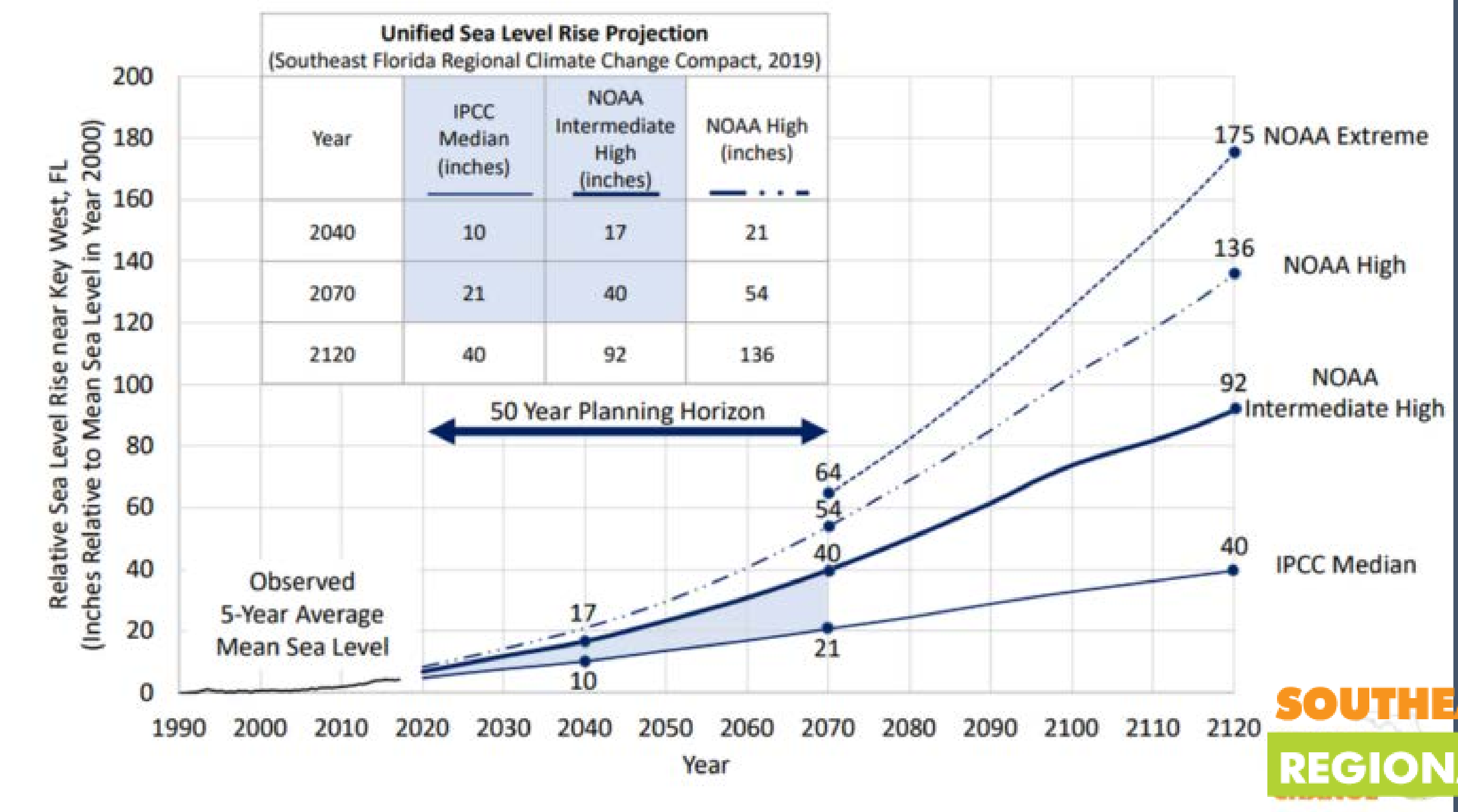
Alaa Ali	Hydrology and Hydraulics Modeling
Carlos Coronado	Applied Science – Everglades Systems
Christine Carlson	Geospatial Services
Karin Smith	Water Supply Planning
Nenad Iricanin	Water Quality - Compliance Assessment & Reporting
Tibebe Dessalegne	Hydrology and Hydraulics Applied Hydrology
Yibing Kevin Zhu	Hydro Data Management

Overall Coordination

Carolina Maran	District Resiliency

TABLE OF CONTENTS

Southeast Florida Climate Indicators



UNIFIED SEA LEVEL RISE PROJECTION

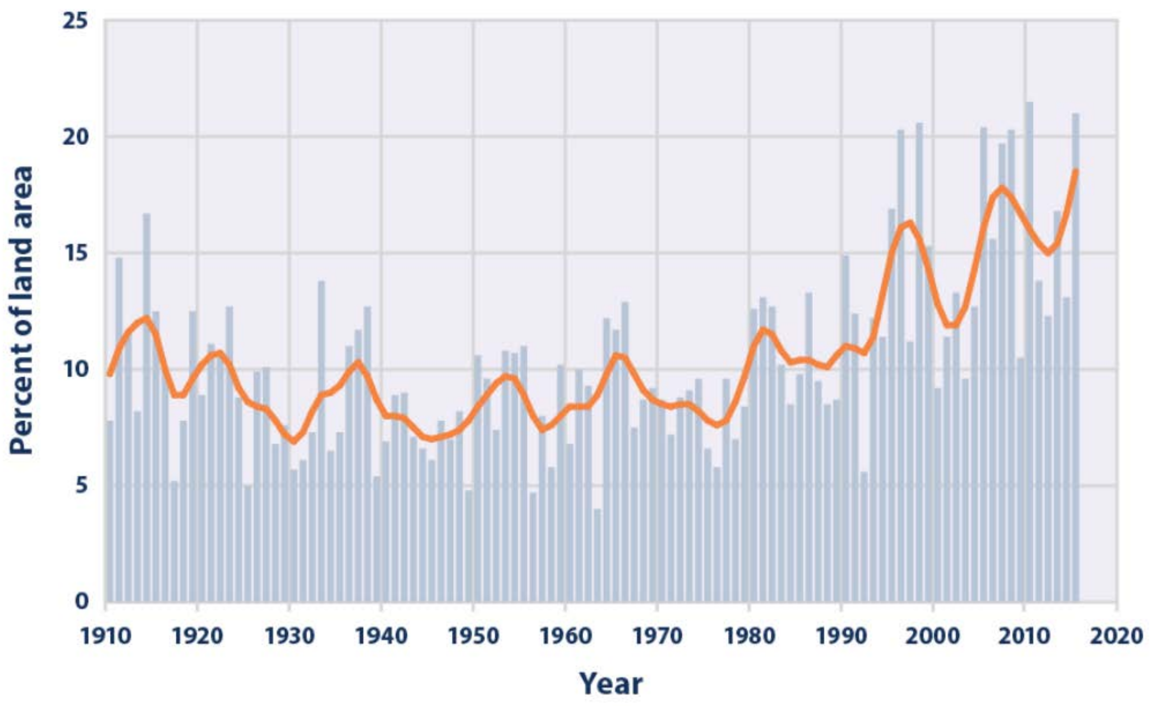
SOUTHEAST FLORIDA REGIONAL COMPACT CLIMATE CHANGE

Presenter: Carolina Maran

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

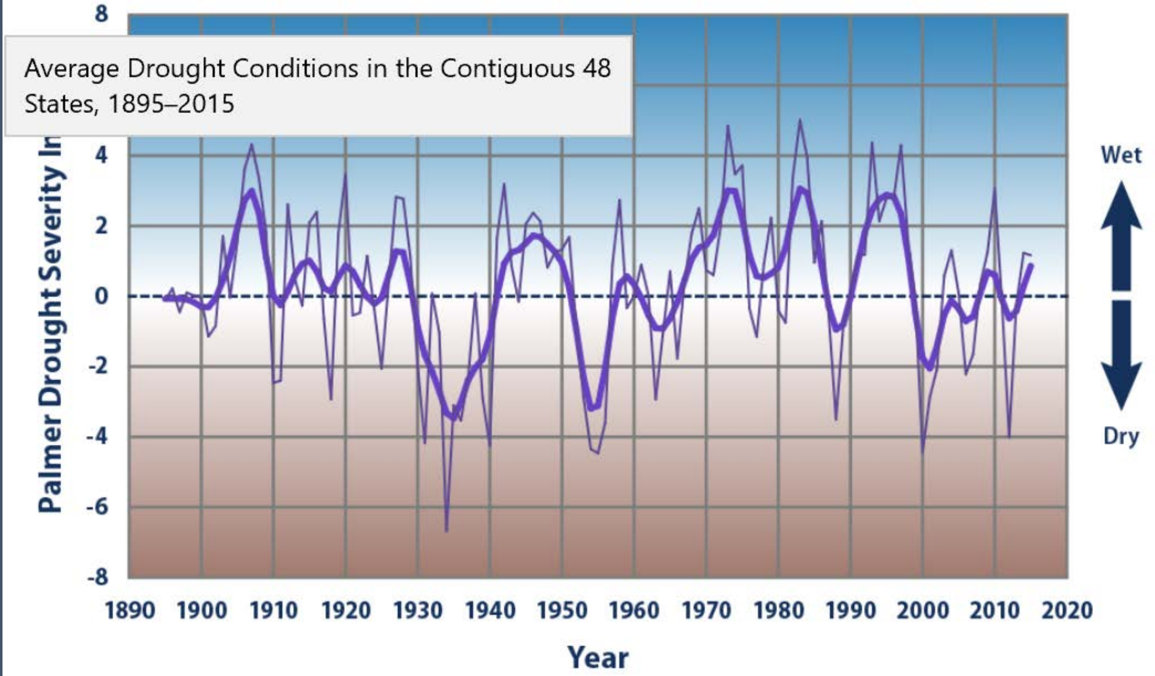
Climate Change Indicators

Figure 1. Extreme One-Day Precipitation Events in the Contiguous 48 States, 1910–2015



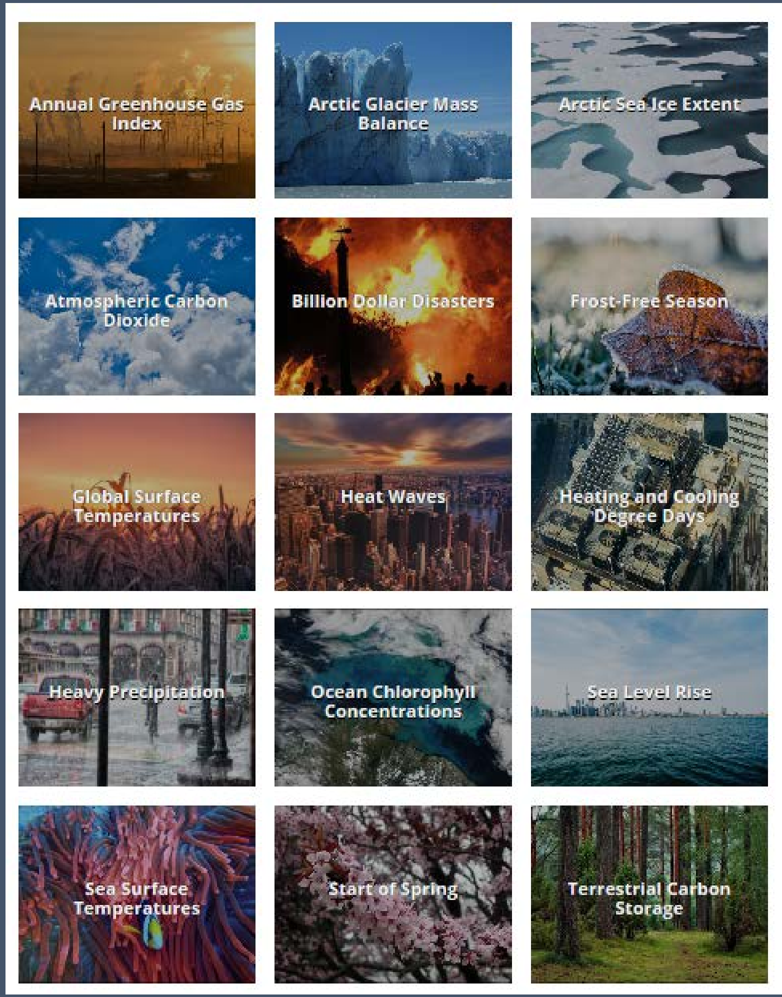
Source: https://www.epa.gov/climate-indicators/climate-change-indicators-heavy-precipitation

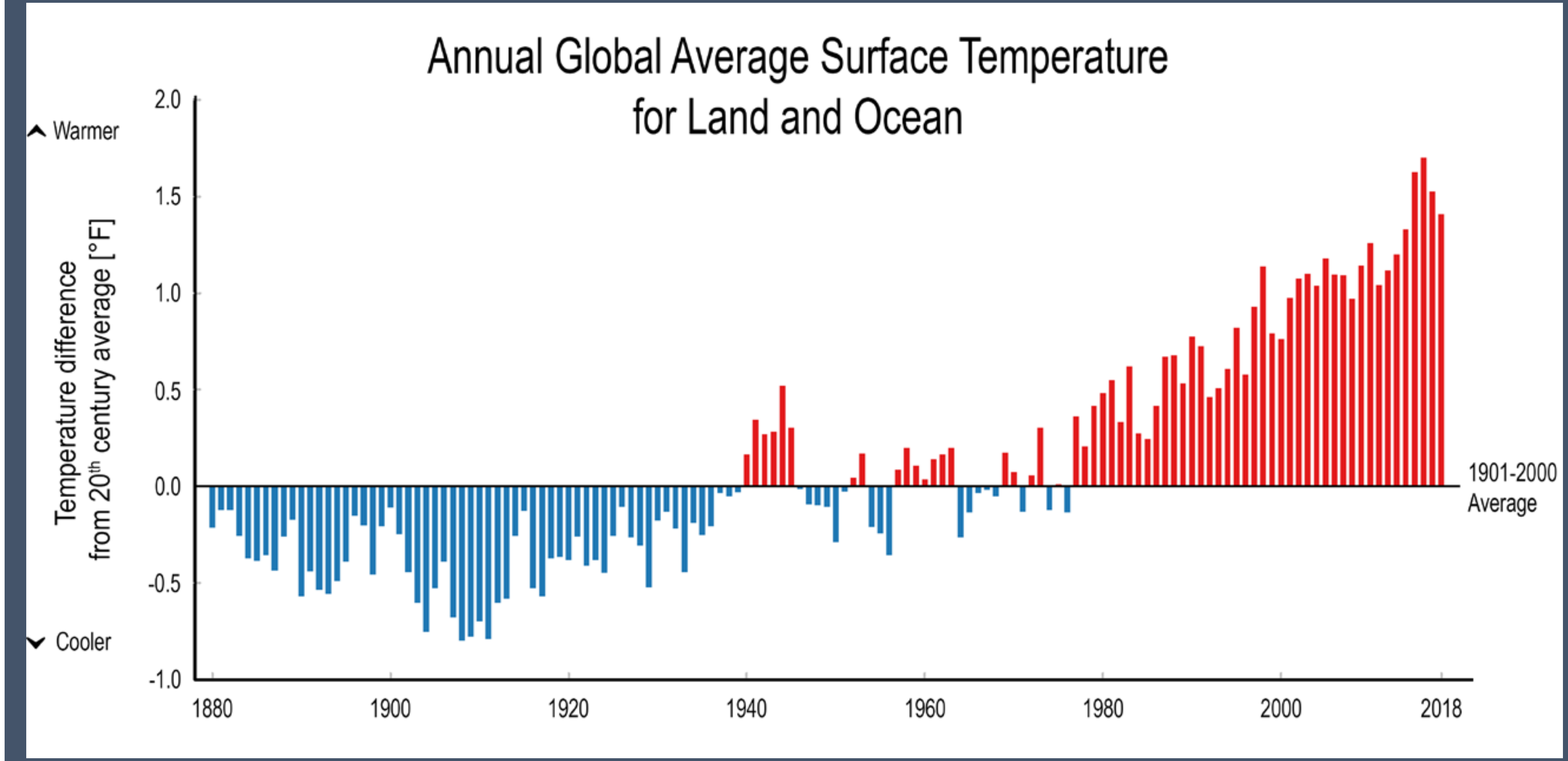
Figure 1. Average Drought Conditions in the Contiguous 48 States, 1895–2015



Presenter: Carolina Maran

USGCRP INDICATOR PLATFORM

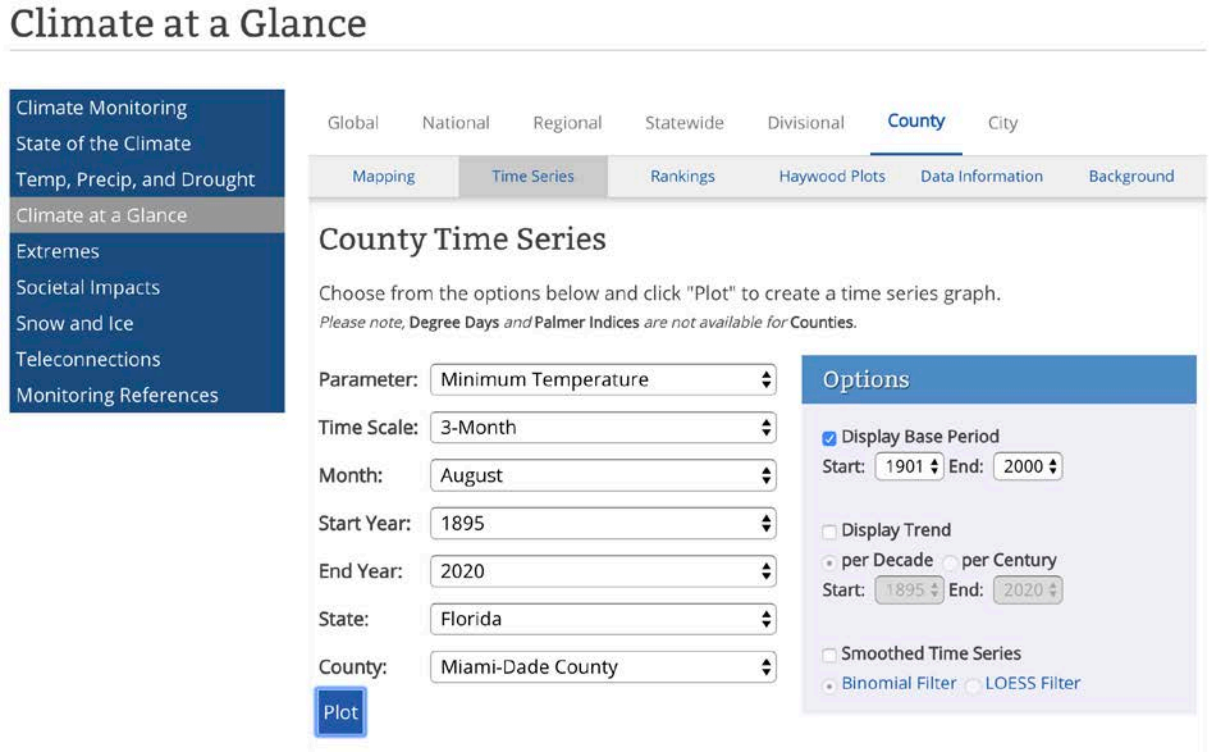


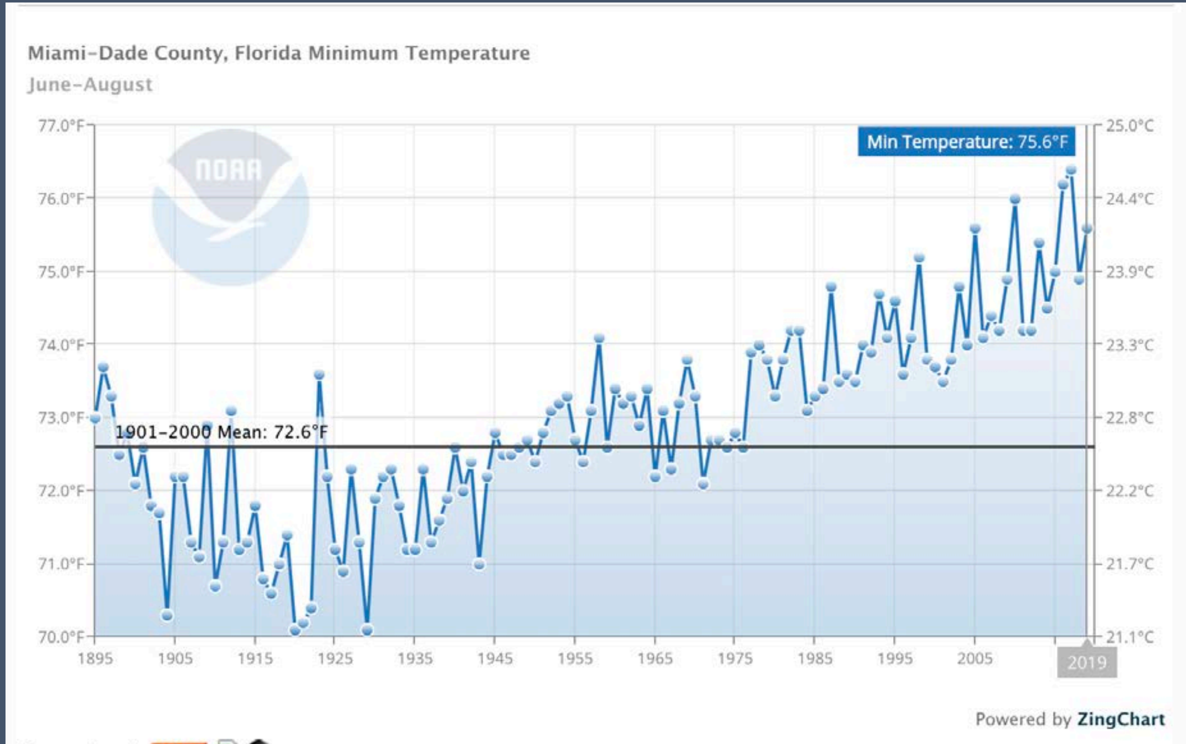


Source: https://www.globalchange.gov/

Presenter: Carolina Maran

NOAA NCEI CLIMATE DIVISION DATA





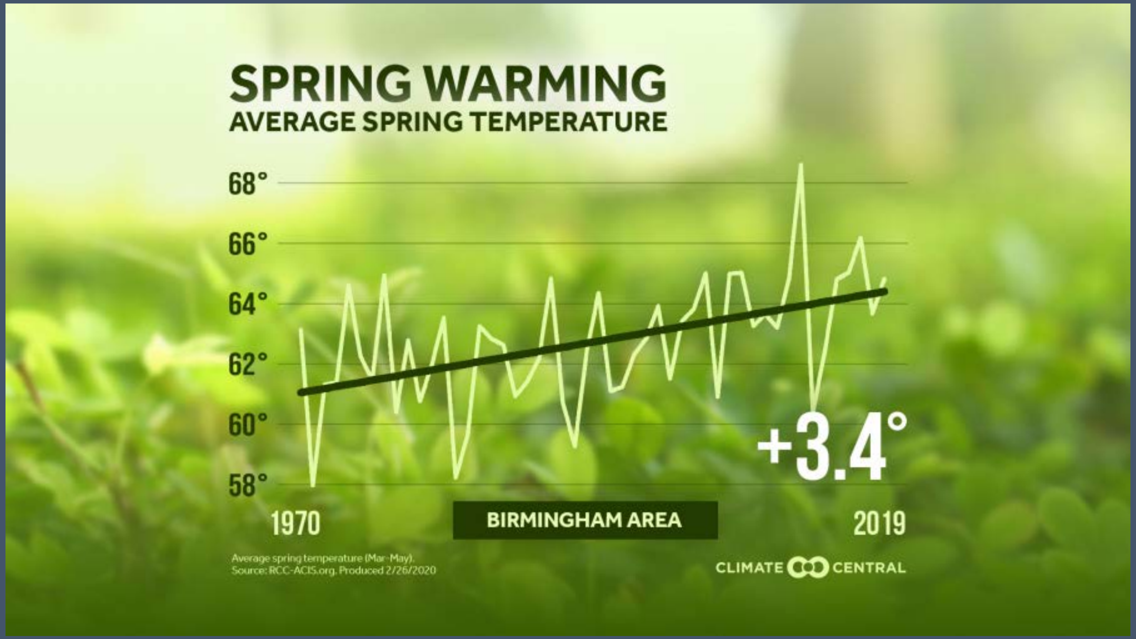
Download: XML

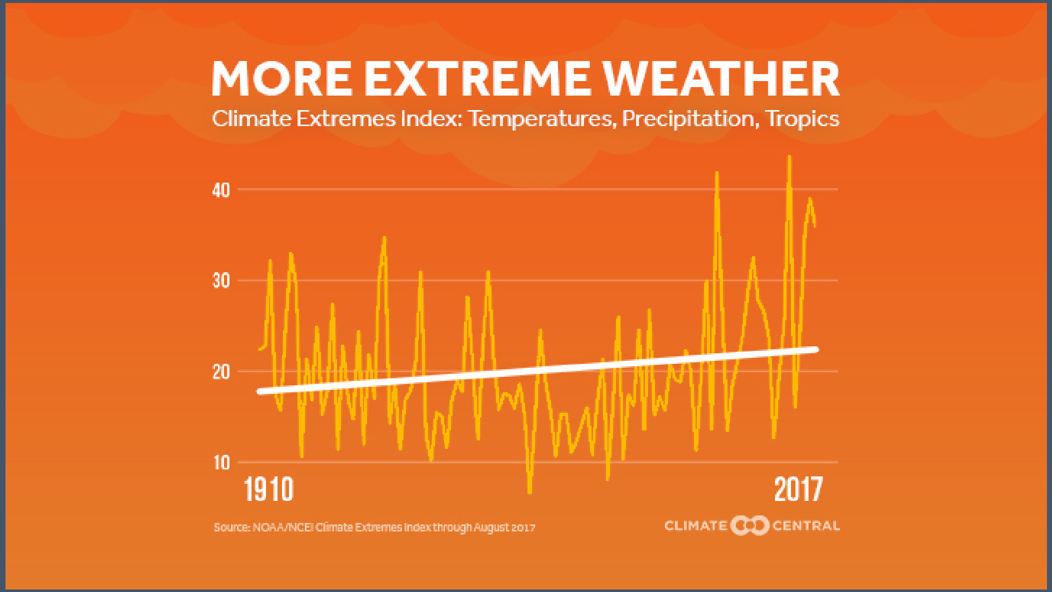
DATES	VALUE	RANK	DEPARTURE FROM MEAN (72.6°F) 1901-2000 BASE PERIOD
189506 - 189508	73.0°F	65	0.4°F
189606 - 189608	73.7°F	90	1.1°F

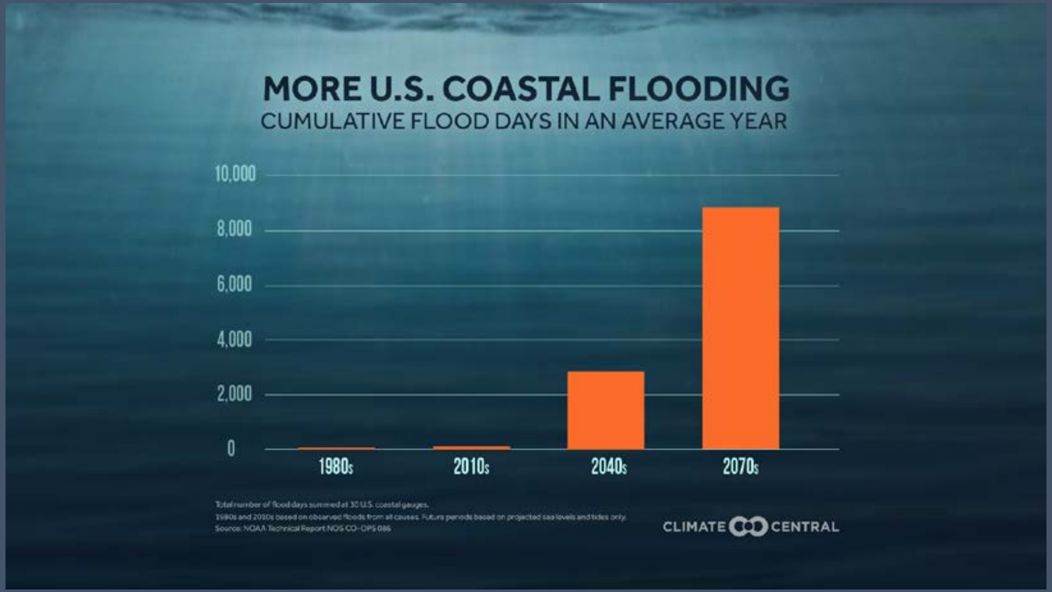
Presenter: Carolina Maran

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

CLIMATE CENTRAL







Presenter: Carolina Maran

Source: https://www.climatecentral.org/

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

Presenter: Carolina Maran

Set of Priority Water and Climate Resiliency Metrics

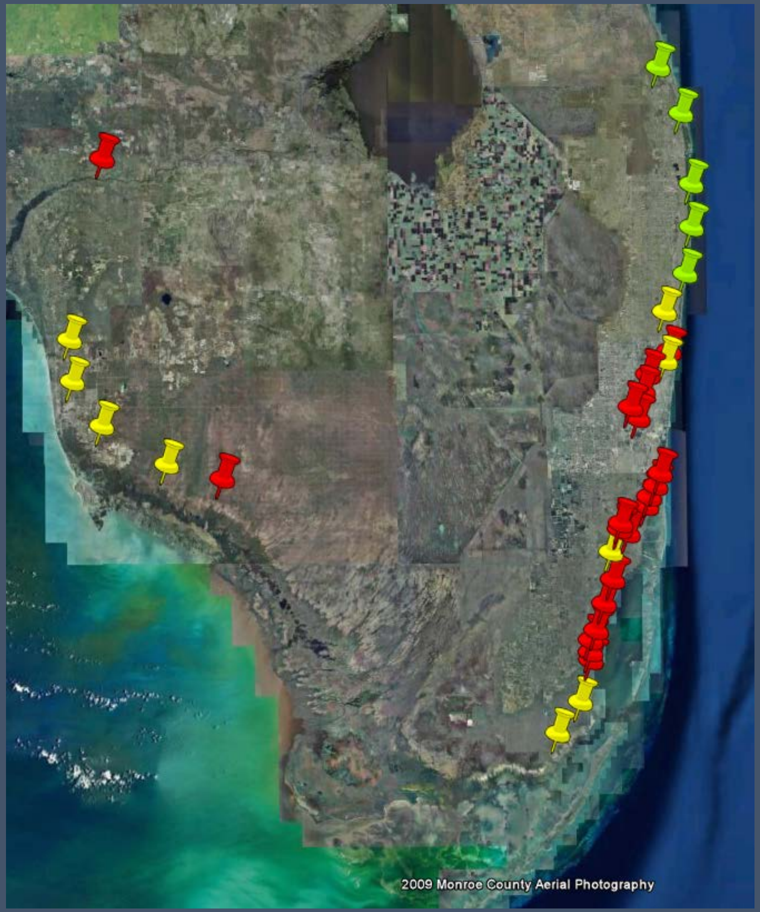
Sea Level	Tailwater Elevations at Coastal Structures
	High Tide Events (Extreme Tidal Stages)
	Chloride Levels (saltwater interface)
Groundwater Level	Groundwater Stages
	Minimum Flows and Minimum Water Levels
Hydrology	Flooding Events
	Rainfall
	Evapotranspiration
Water Quality	Water Temperature
	Dissolved Oxygen
	pH
	Specific conductance
Ecology / Habitat	Estuarine Inland Migration - Everglades
	Soil Subsidence
	Salinity at Everglades

Tibebe Dessalegne – Tidal Elevations

Section Leader
Hydrology & Hydraulics Bureau

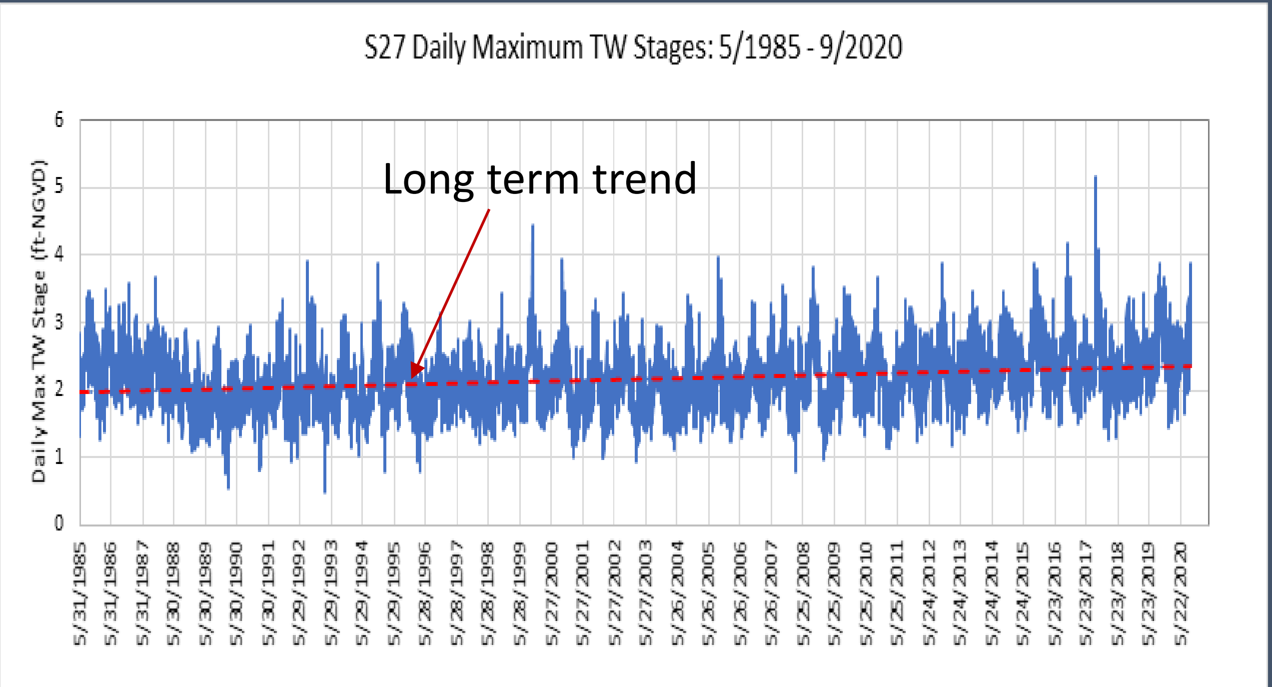
Sea Level Metric: Coastal sites and NOAA Tidal Stations

- 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

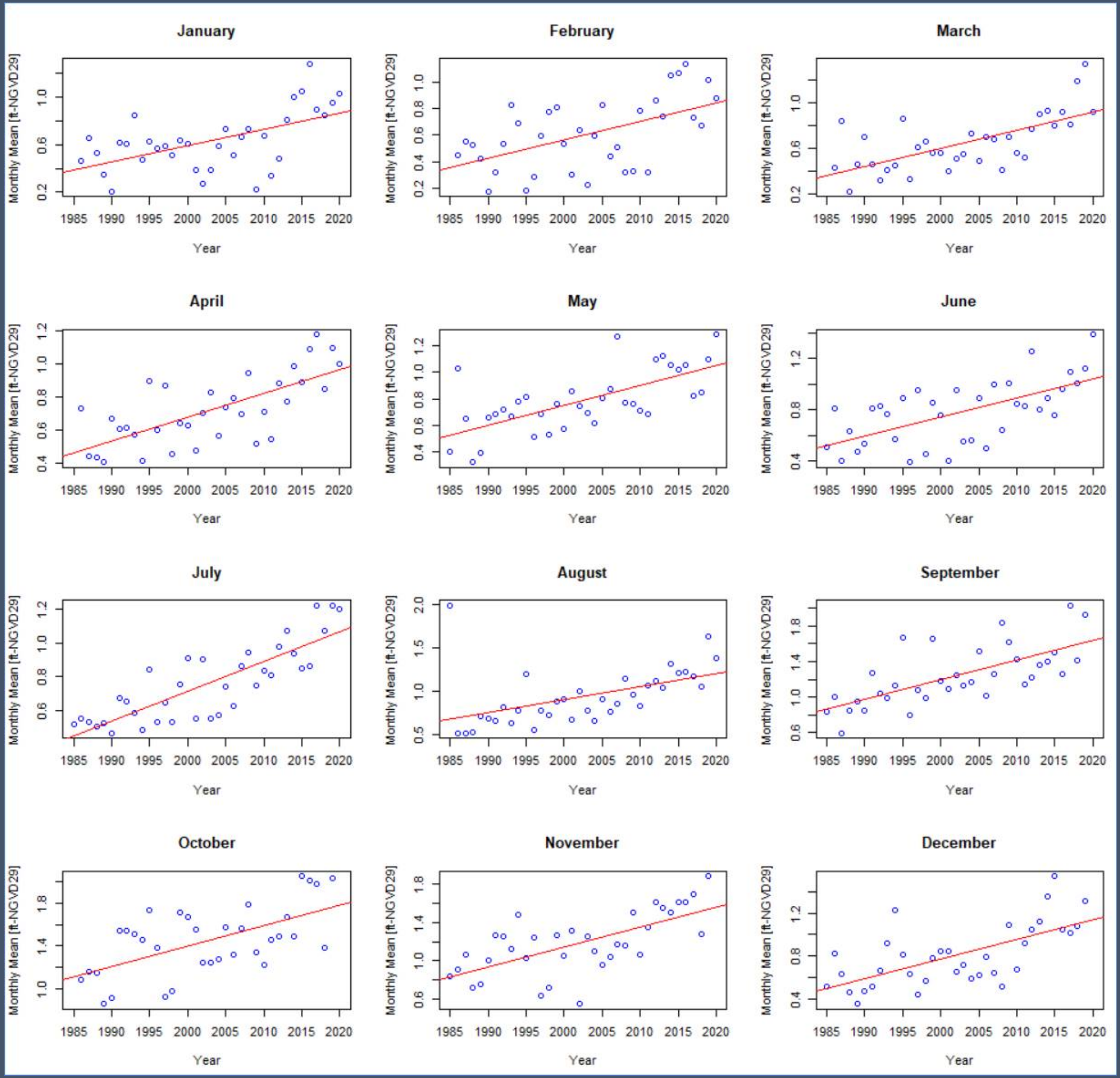


Presenter: Tibebe Dessalegne

Tailwater and Headwater Elevations at Coastal Structures



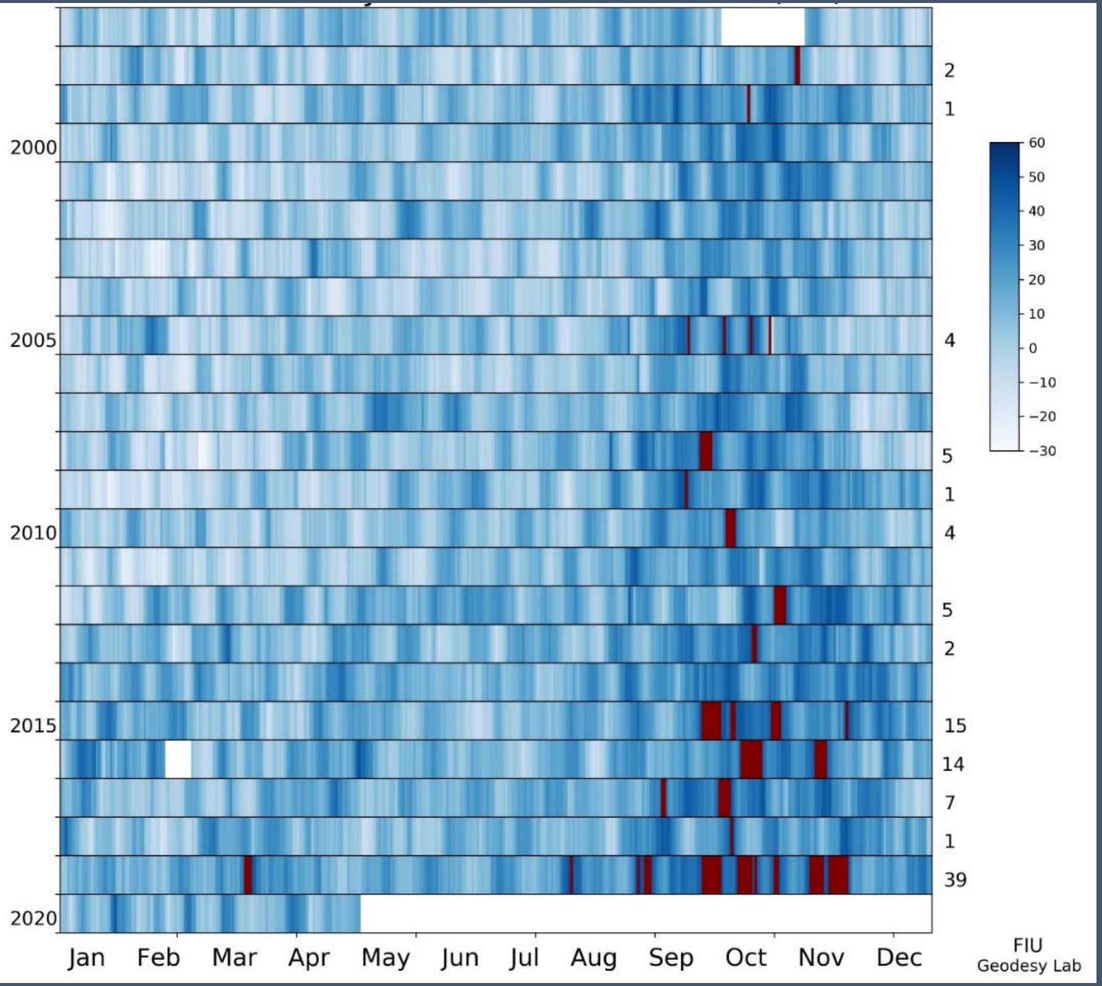
S22 – Mean Monthly TW Stages

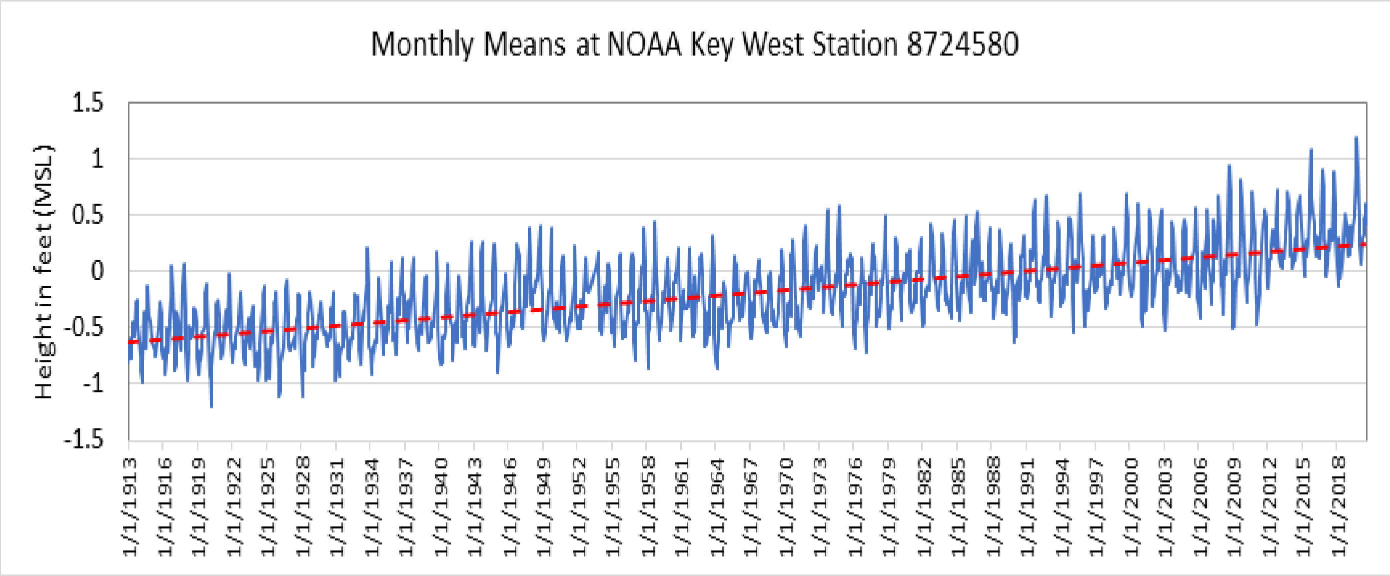


Presenter: Tibebe Dessalegne

Tidal Stages and High Tide Events (Extremes)

Virginia Key Station – Daily Maximum (cm NAVD88)



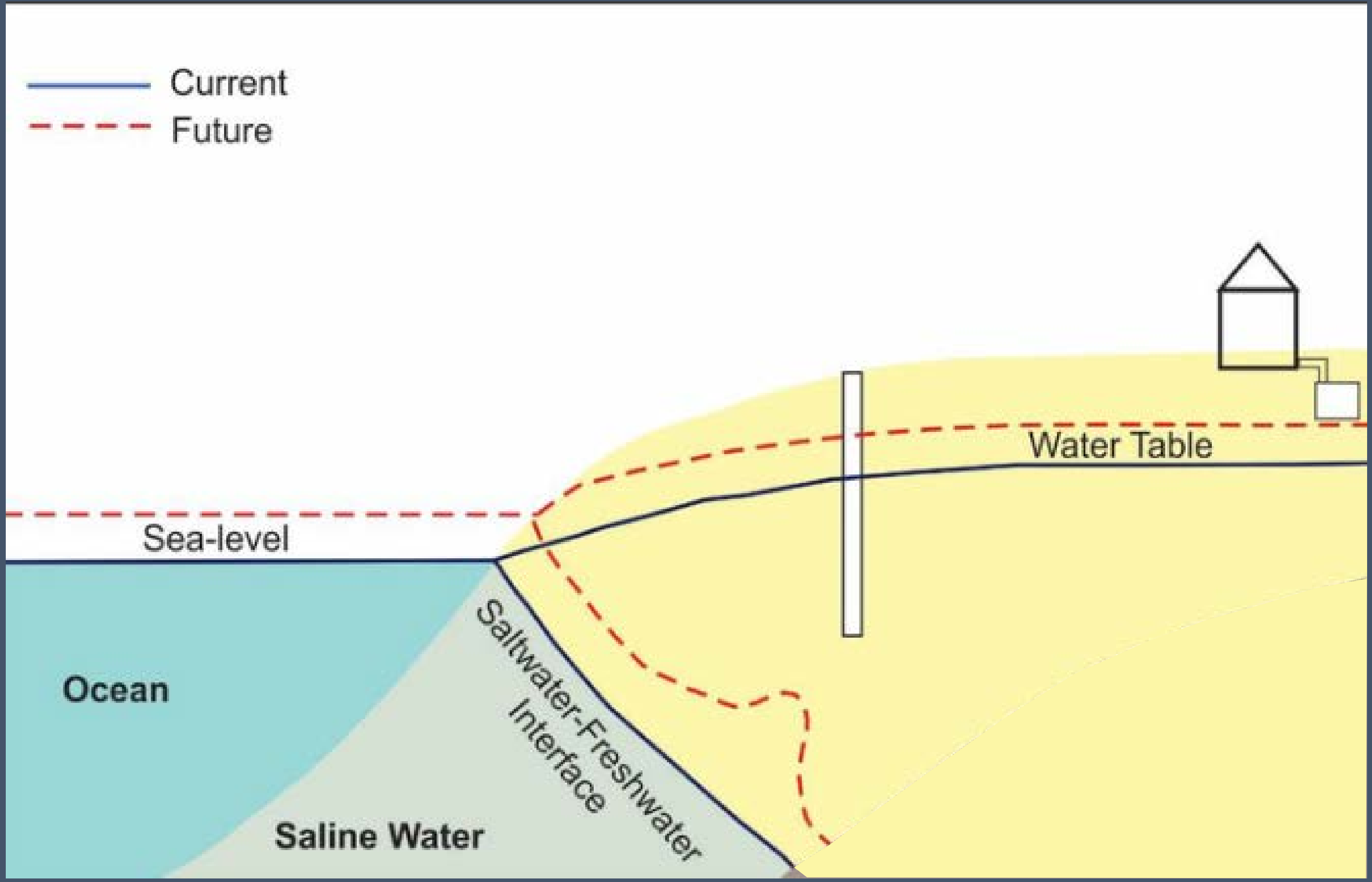


Presenter: Tibebe Dessalegne

Karin Smith – Groundwater Stages and Saltwater Intrusion

Principal Scientist
Water Supply Bureau

Groundwater Stages and Saltwater Intrusion



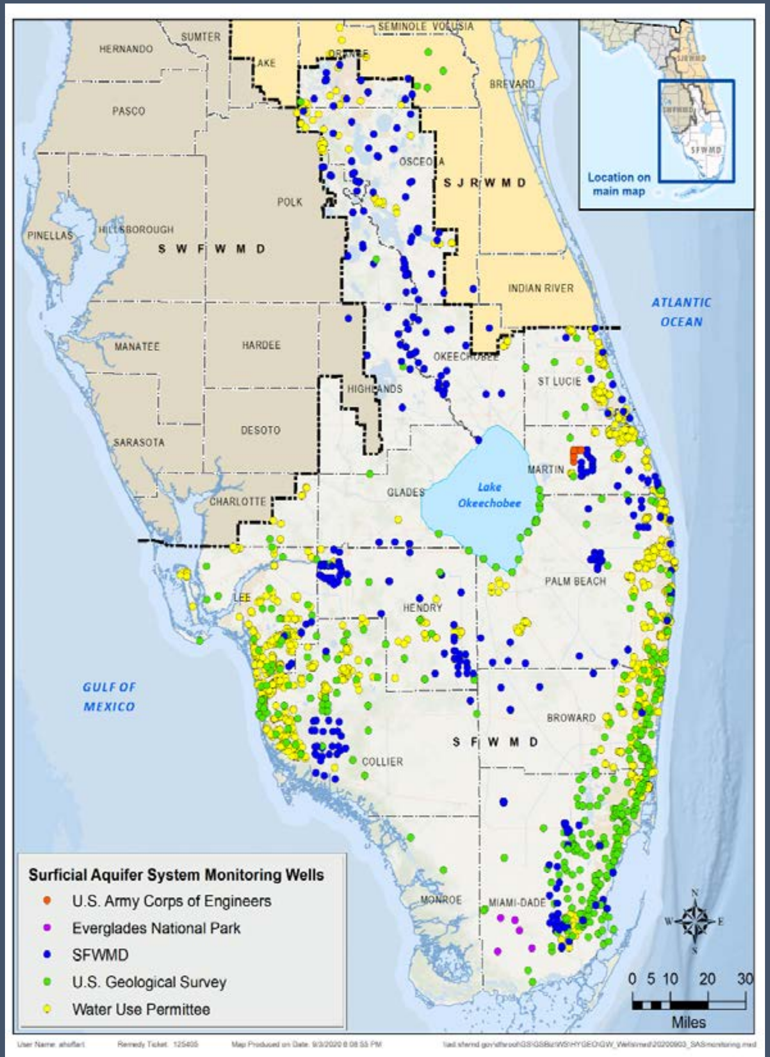
Higher sea level moves heavier saltwater further inland and pushes freshwater above it up.

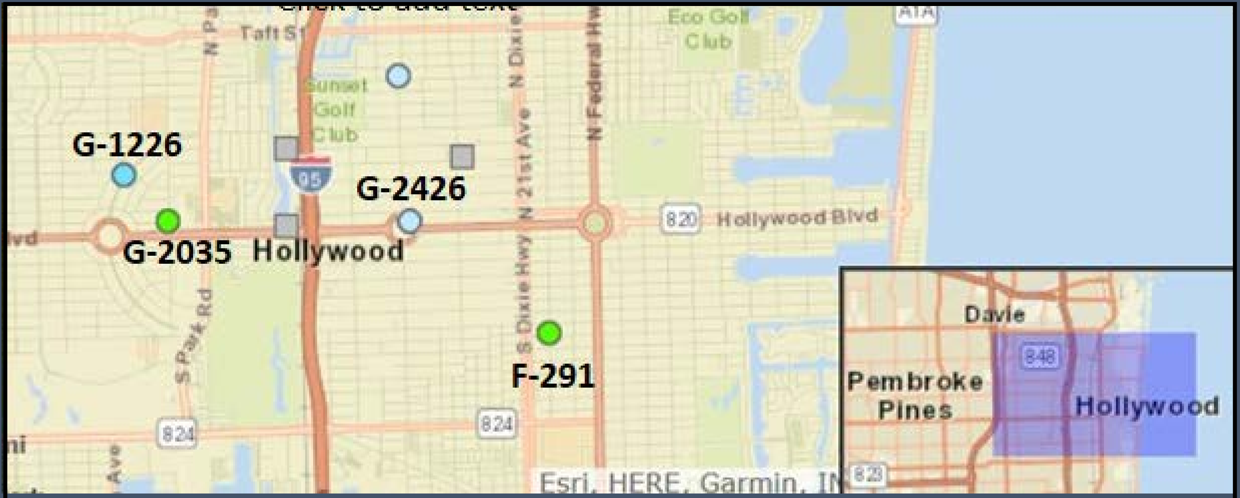
Impacts

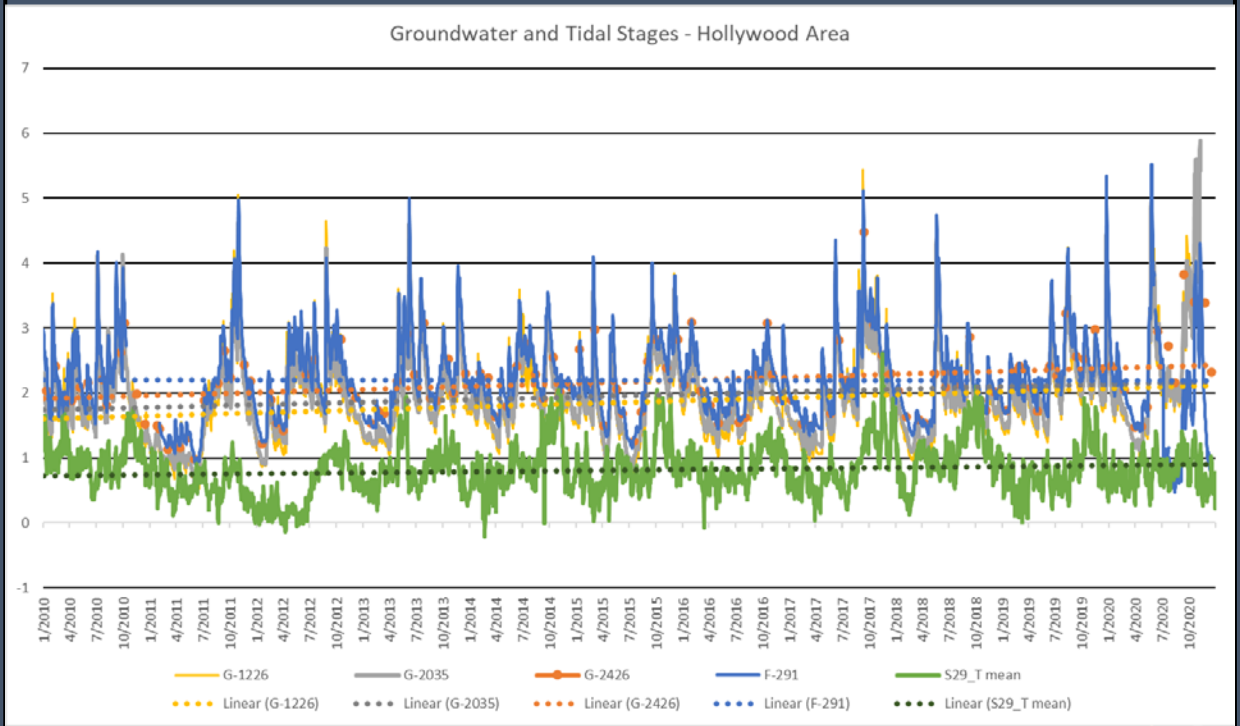
- Saline water further inland, reduced freshwater gradient
- Inland flooding from higher groundwater, reduced storm water storage capacity

Presenter: Karin Smith

Groundwater Stages

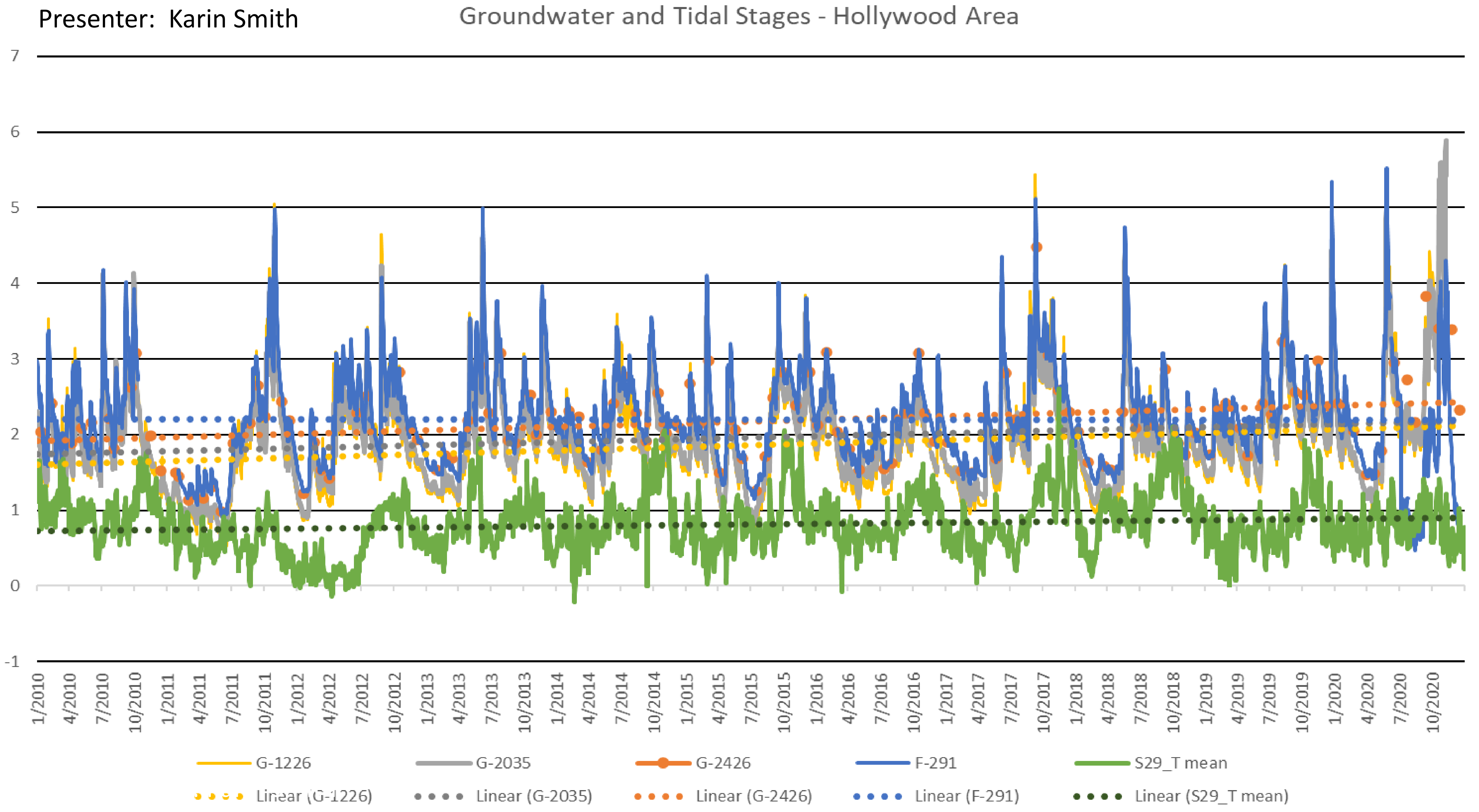






Presenter: Karin Smith

Presenter: Karin Smith



Saltwater Intrusion

BACKWARD LOOKING: Utility Wellfield	# of wells abandoned
Deerfield Beach PWS	2
Dania Beach PWS	1
Broward County 3A/3B Wellfields	9
Broward County 2a Wellfield	3
Hollywood – North & Plant wellfields	10
Lake Worth Utilities – East Wells	7
Manalapan PWS	3

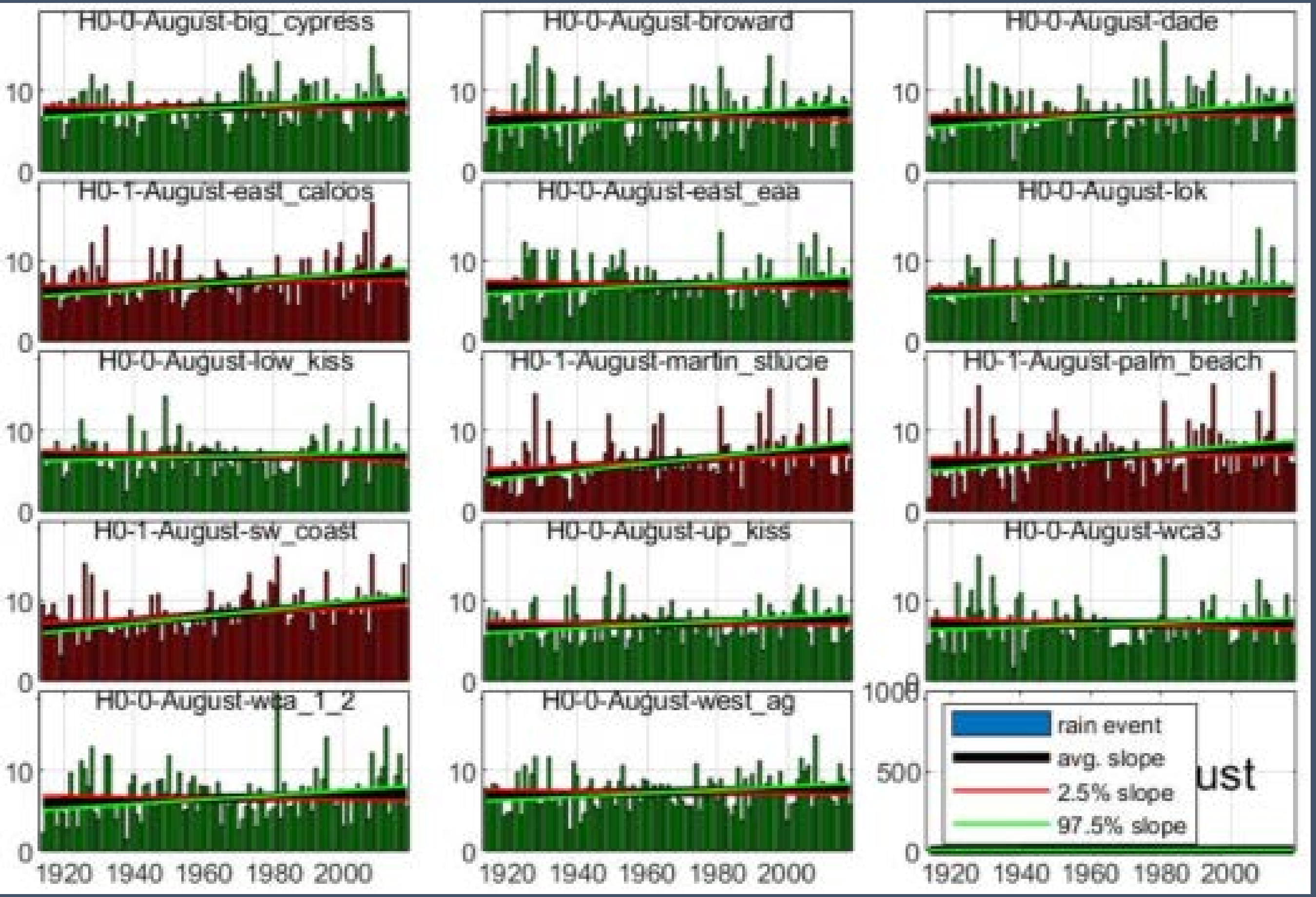
FORWARD LOOKING	Utilities Identified in Most Recent Water Supply Plan		
Water Supply Planning Region	Total Utilities	Utilities at Risk	Utilities of Concern
Lower East Coast	52	6	8
Lower West Coast	22	0	4
Upper East Coast	17	1	3

Presenter: Karin Smith

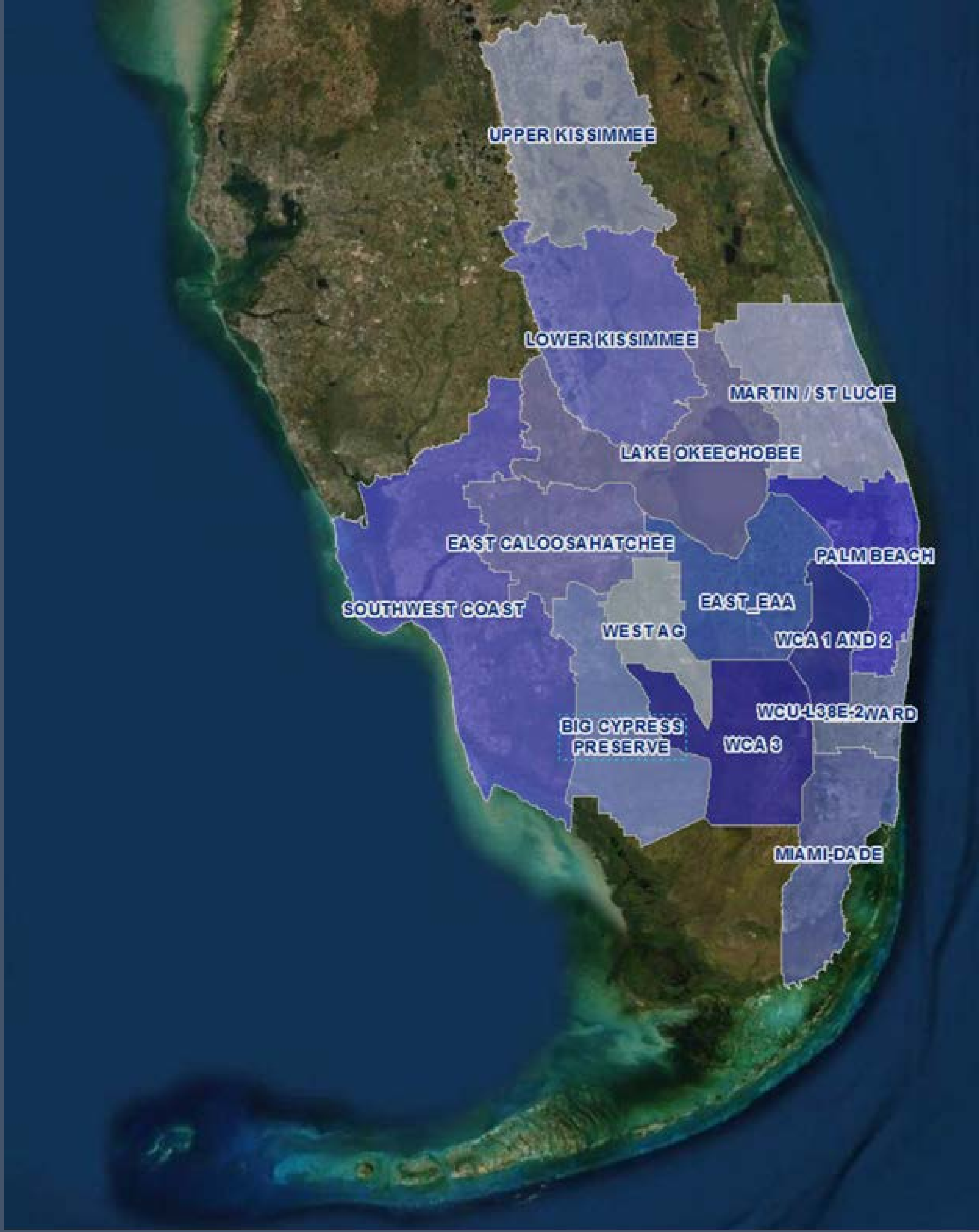
Alaa Ali - Rainfall

Chief Engineer
Hydrology & Hydraulics Bureau

Rainfall

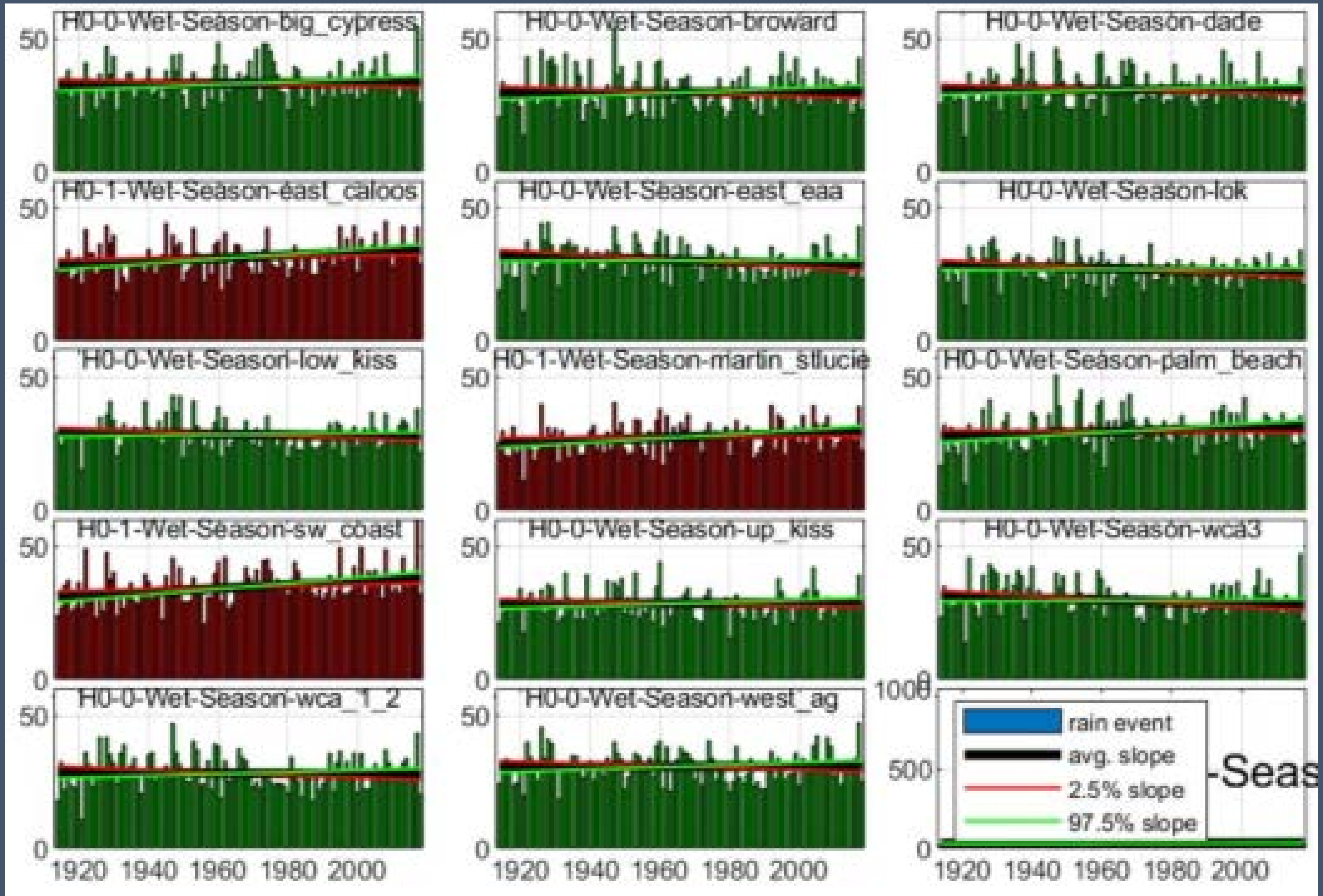


Monthly Rainfall Trend Analysis Results, illustrated by the month of August



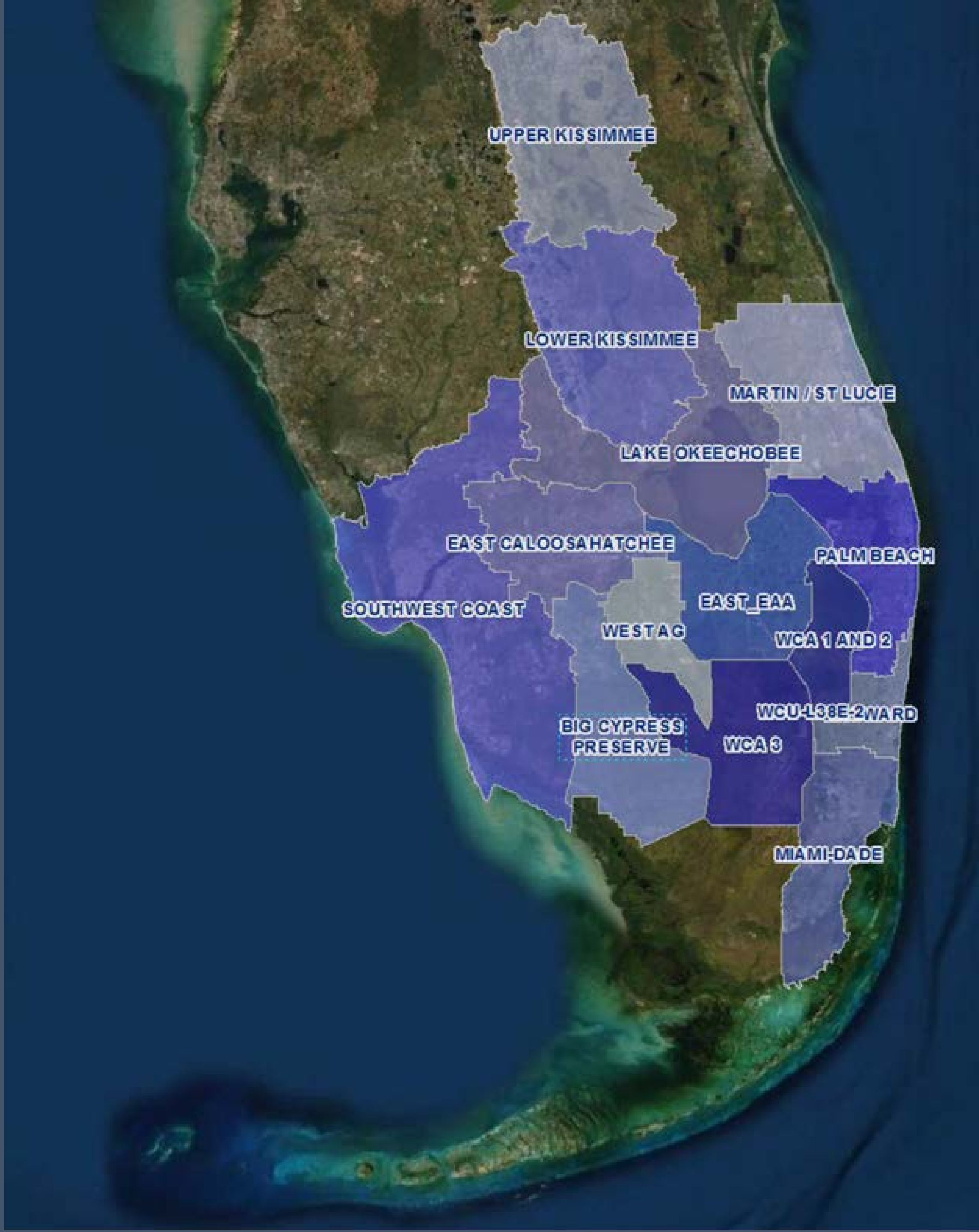
Presenter: Alaa Ali

Rainfall

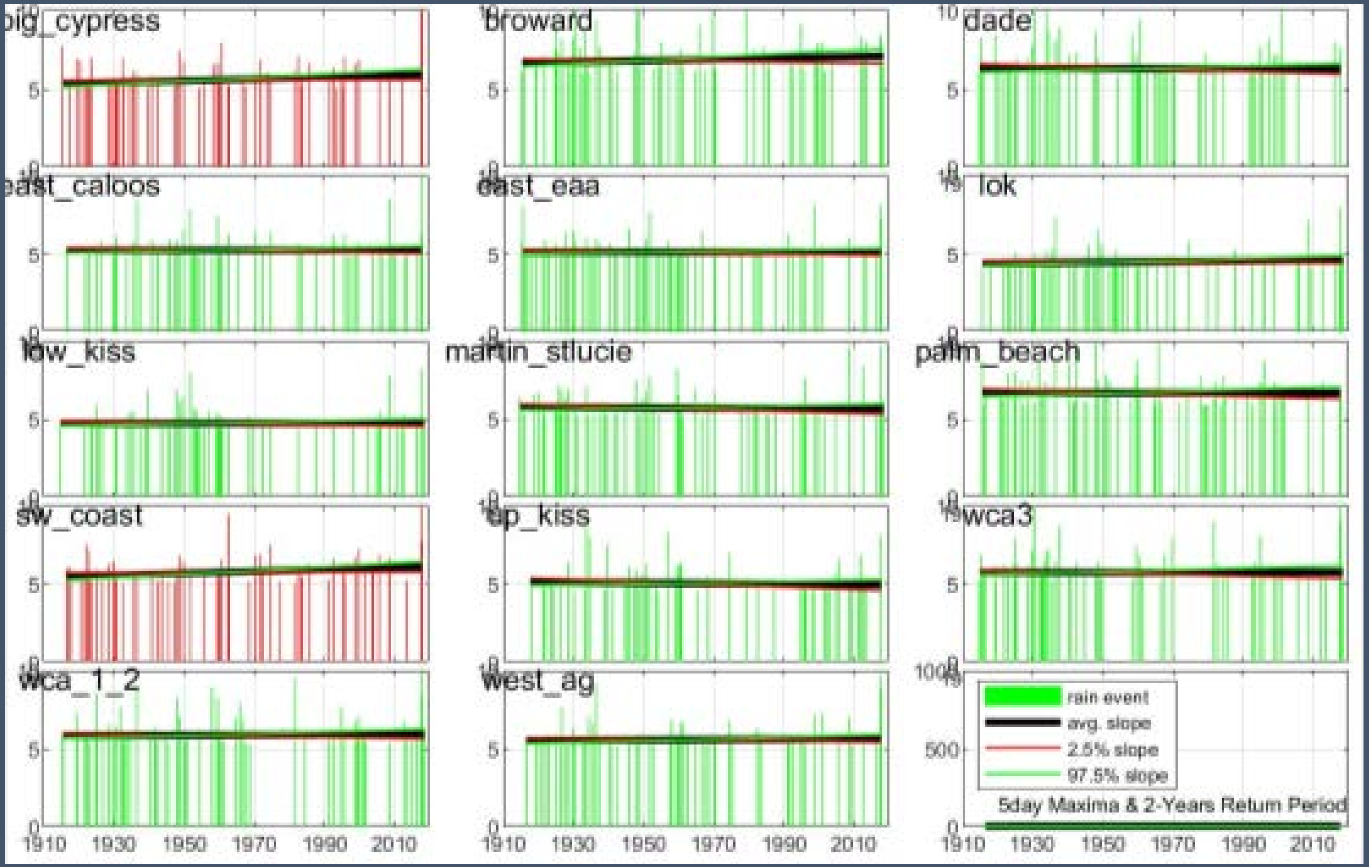


Wet Season Rainfall Trend Analysis Results

Presenter: Alaa Ali

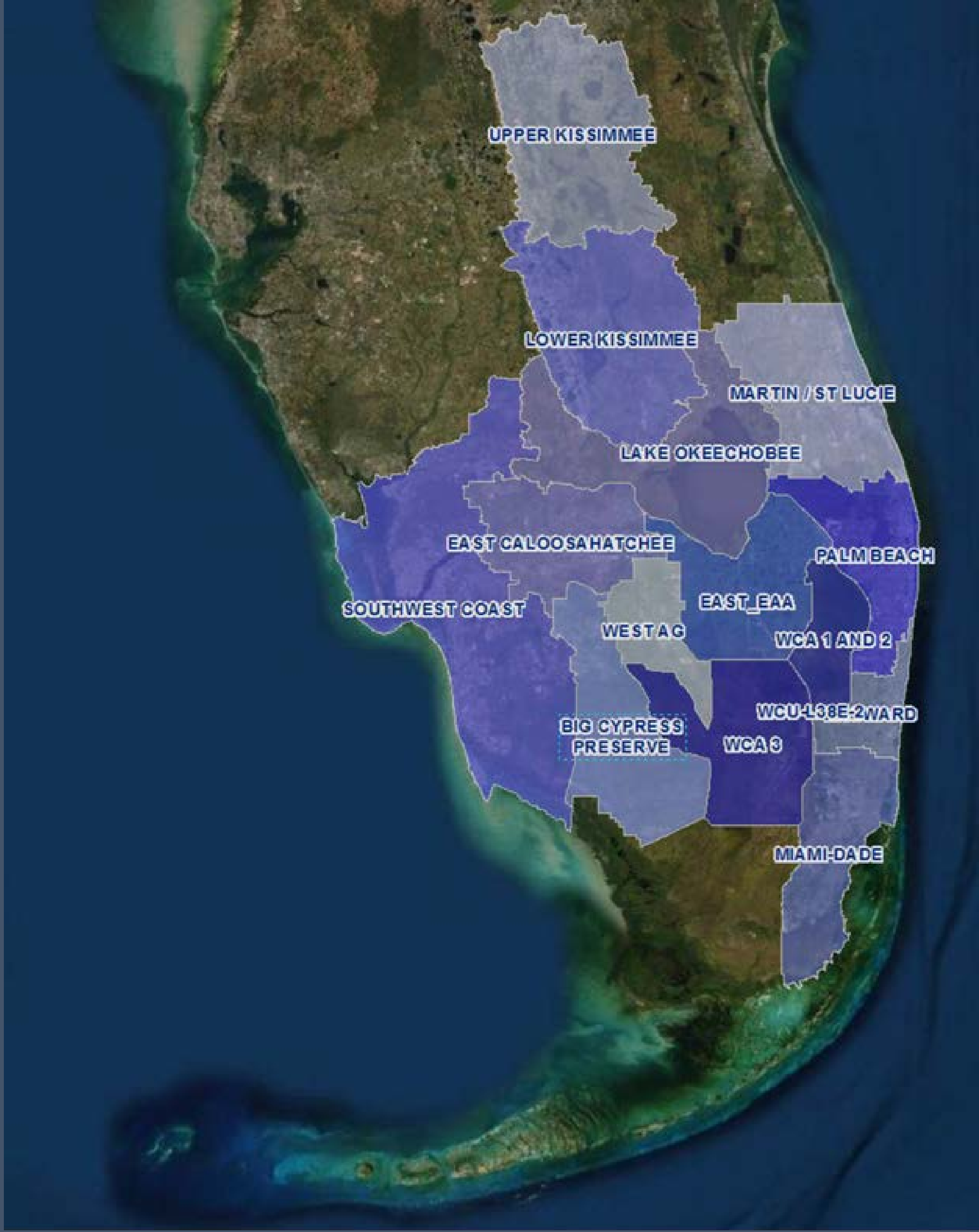


Rainfall



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

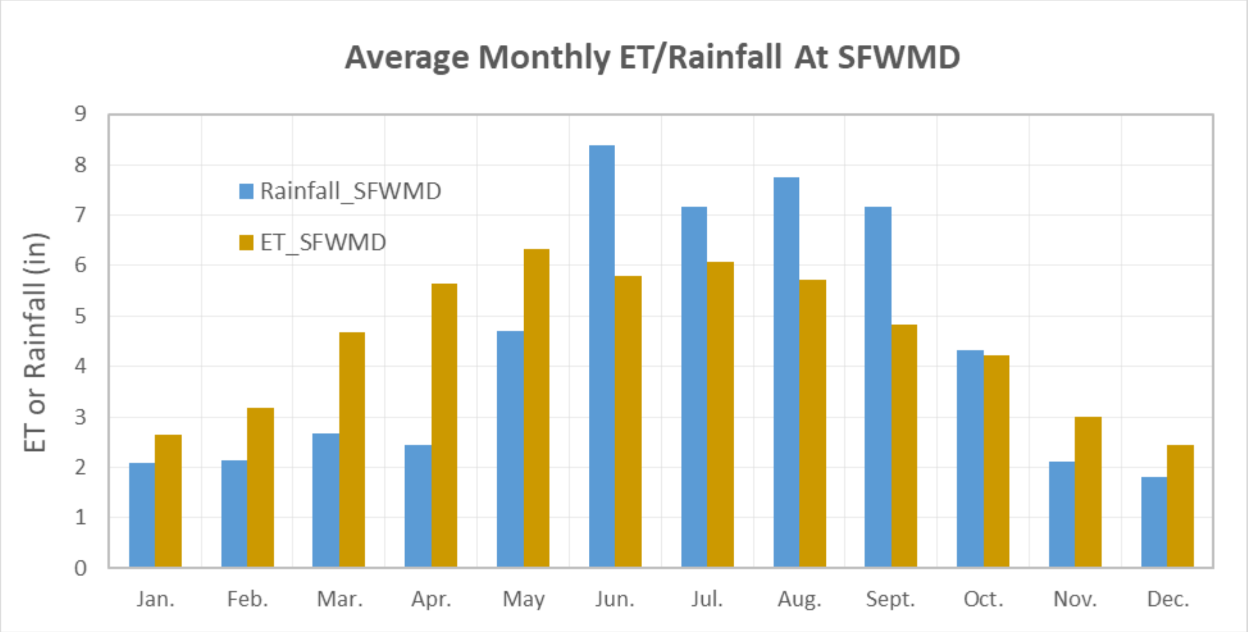
Presenter: Alaa Ali

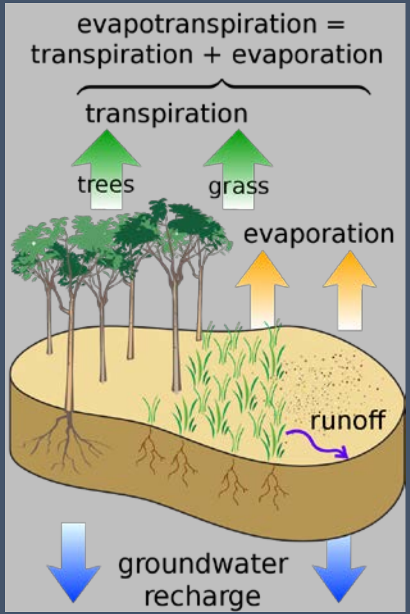


Kevin Zhu - Evapotranspiration

Staff Engineer
Hydrology & Hydraulics Bureau

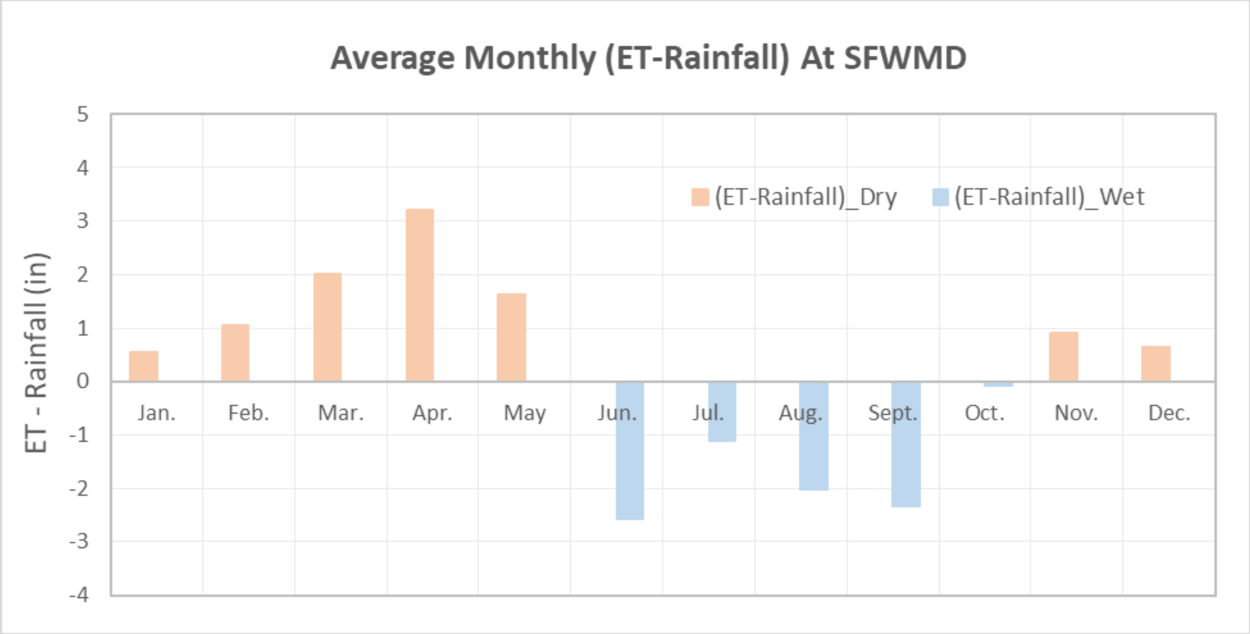
Evapotranspiration (ET)





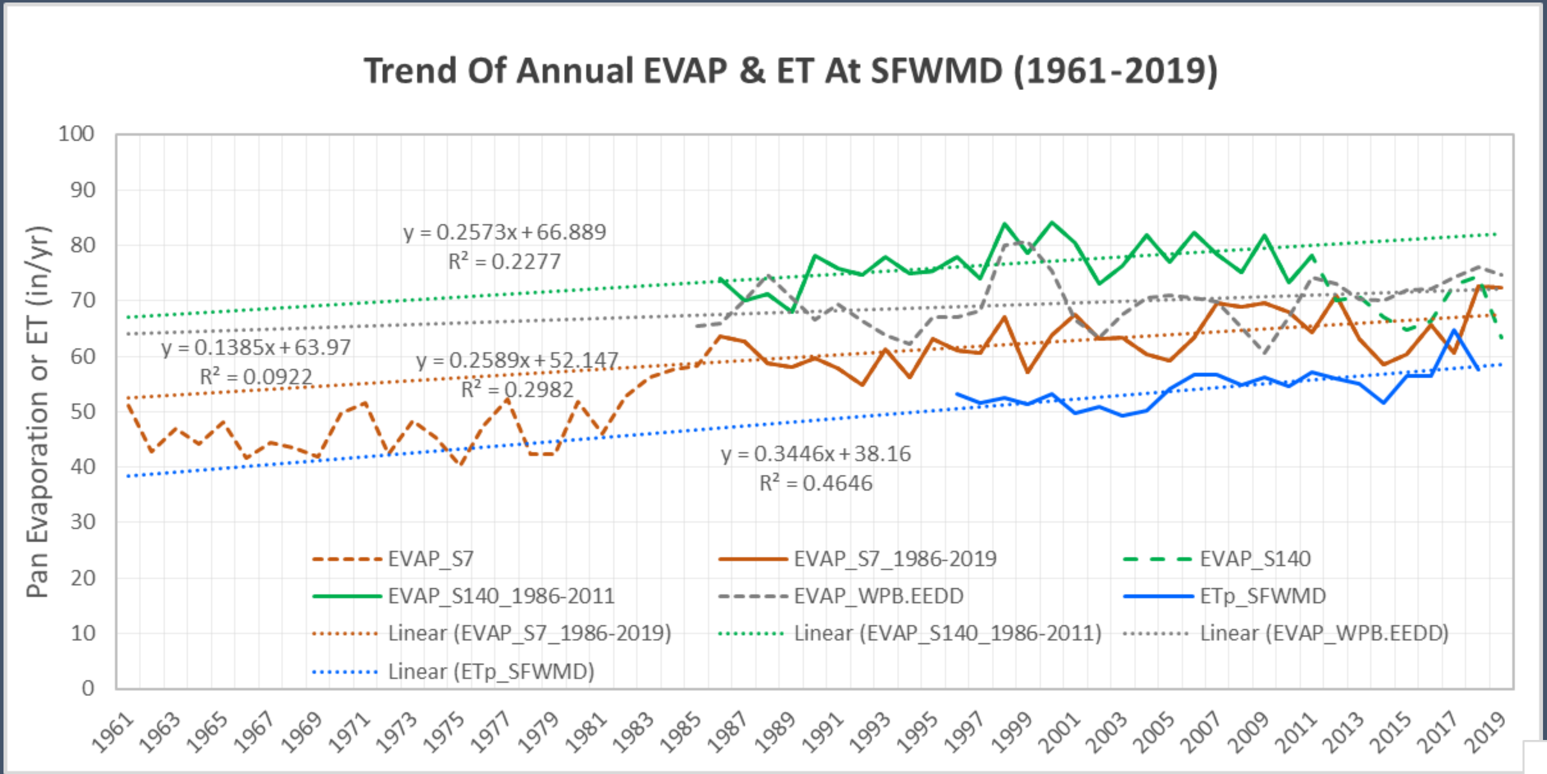
By M. W. Toews - Own work, CC BY 4.0, https://commons.wikimedia.org/w/index.php?curid=2843655

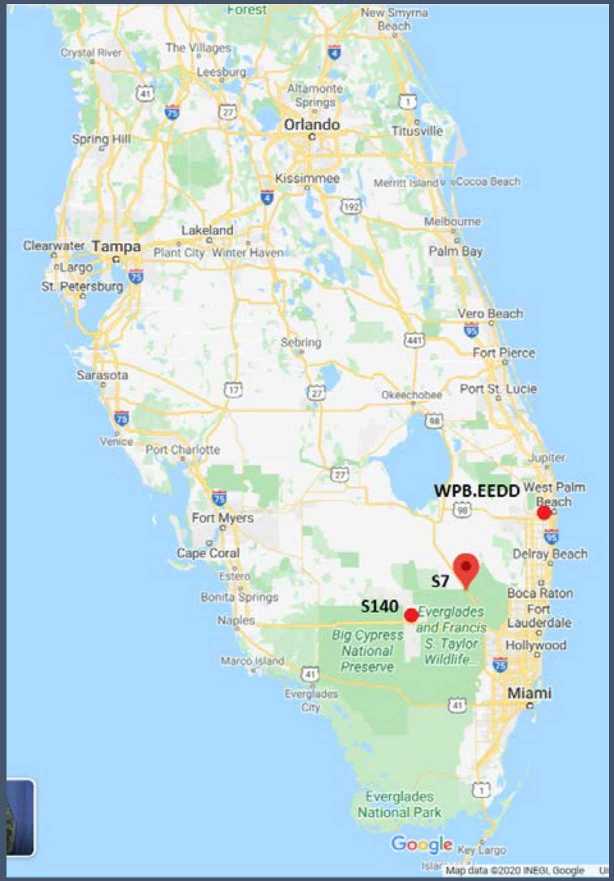
1. Solar Radiation
2. Air Temperature
3. Wind Speed
4. Relative Humidity



Presenter: Kevin Zhu

Evapotranspiration (ET)





EVAP_S7_1986-2019 Mann-Kendall Test	
alpha	0.05
MK-stat	**197**
s.e.	67.4562
z-stat	2.9056
p-value	**0.0037**
trend	yes

EVAP_S140_1986-2011 Mann-Kendall Test	
alpha	0.05
MK-stat	**101**
s.e.	45.3689
z-stat	2.2042
p-value	**0.0275**
trend	yes

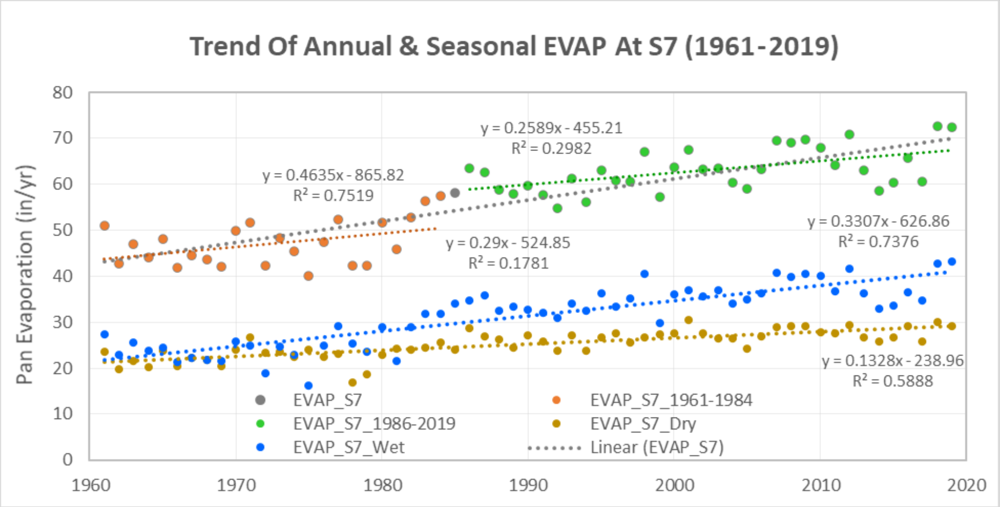
EVAP_WPB.EEDD Mann-Kendall Test	
alpha	0.05
MK-stat	**168**
s.e.	70.4083
z-stat	2.3719
p-value	**0.0177**
trend	yes

ETp_EntireDistrict Mann-Kendall Test	
alpha	0.05
MK-stat	**121**
s.e.	37.8638
z-stat	3.1693
p-value	**0.0015**
trend	yes

S7_1961-2019 Kendall Test	
	0.05
MK-stat	**1129**
s.e.	152.9172
z-stat	7.3765
p-value	**0.0000**
trend	yes

EVAP_S7_Dry-SZN Mann-Kendall Test	
alpha	0.05
MK-stat	**1035**
s.e.	152.9172
z-stat	6.7618
p-value	**0.0000**
trend	yes

EVAP_S7_Wet-SZN Mann-Kendall Test	
alpha	0.05
MK-stat	**1125**
s.e.	152.9172
z-stat	7.3504
p-value	**0.0000**
trend	yes



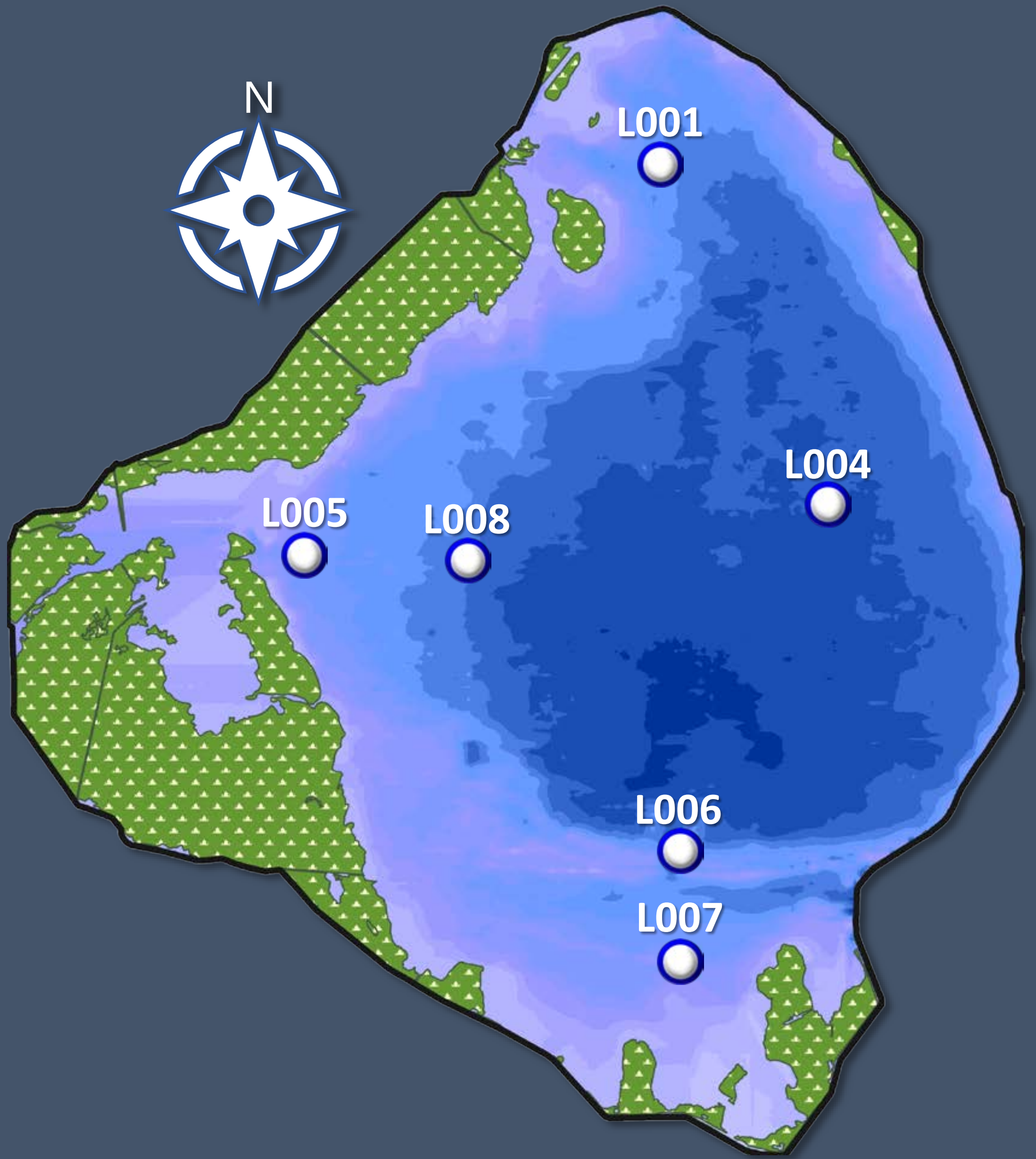
Presenter: Kevin Zhu

Nenad Iricanin – Water Quality

Principal Scientist
Water Quality Bureau

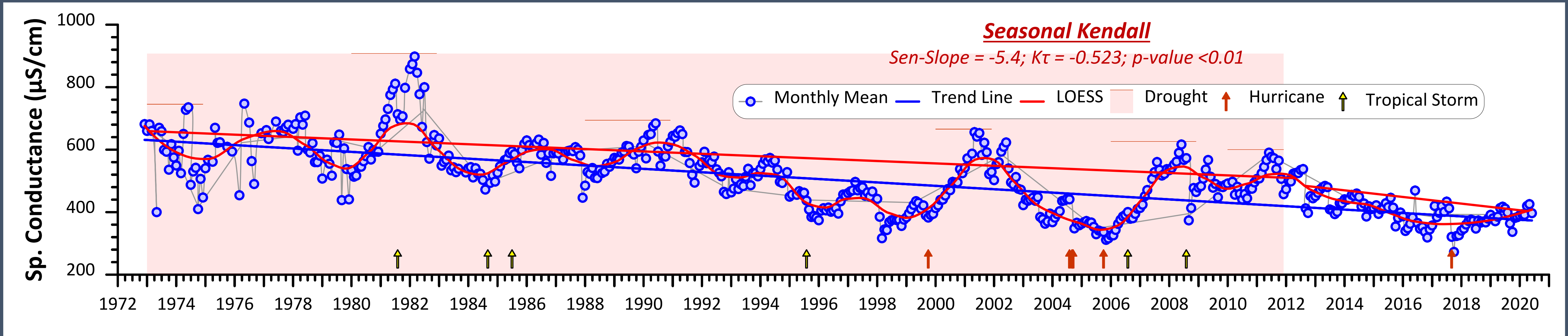
Water Quality

- **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)

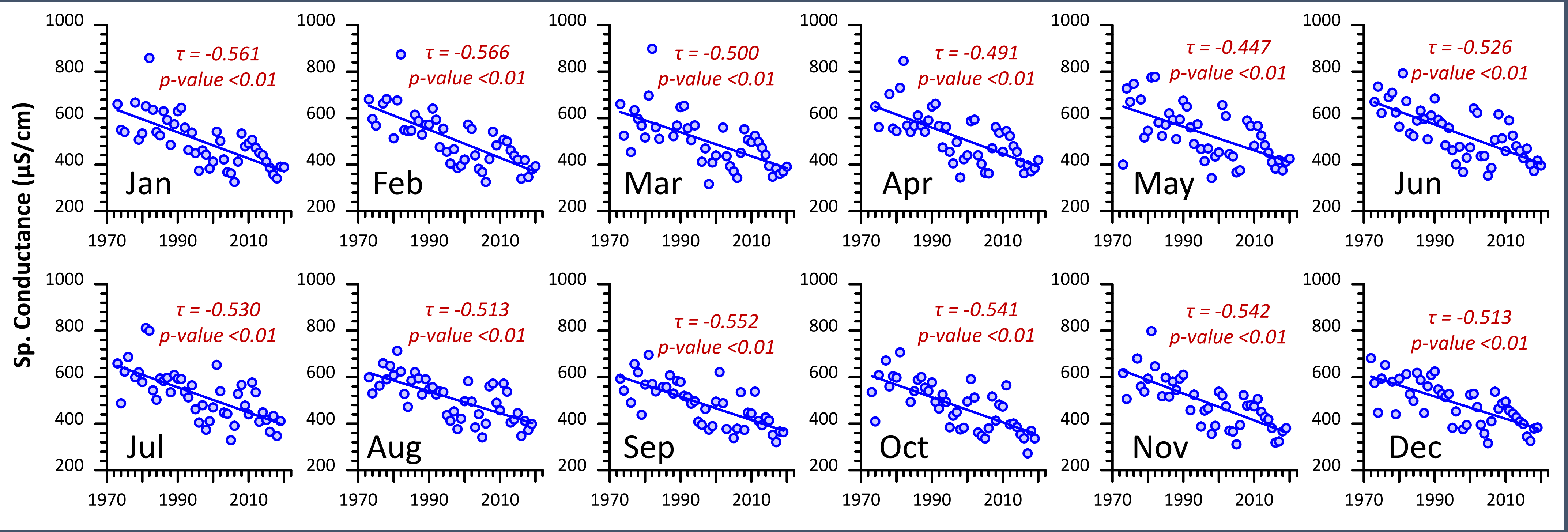
Hand, J (2004). Typical Water Quality Values for Florida's Lakes, Streams, and Estuaries. Watershed Assessment Section, Florida Department of Environmental Protection. Tallahassee, Florida.

Presenter: Nenad Iricanin

Statistical Significance at p-value <0.05

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

Statistical Significance at p-value <0.05

Specific Conductance – Major Ions

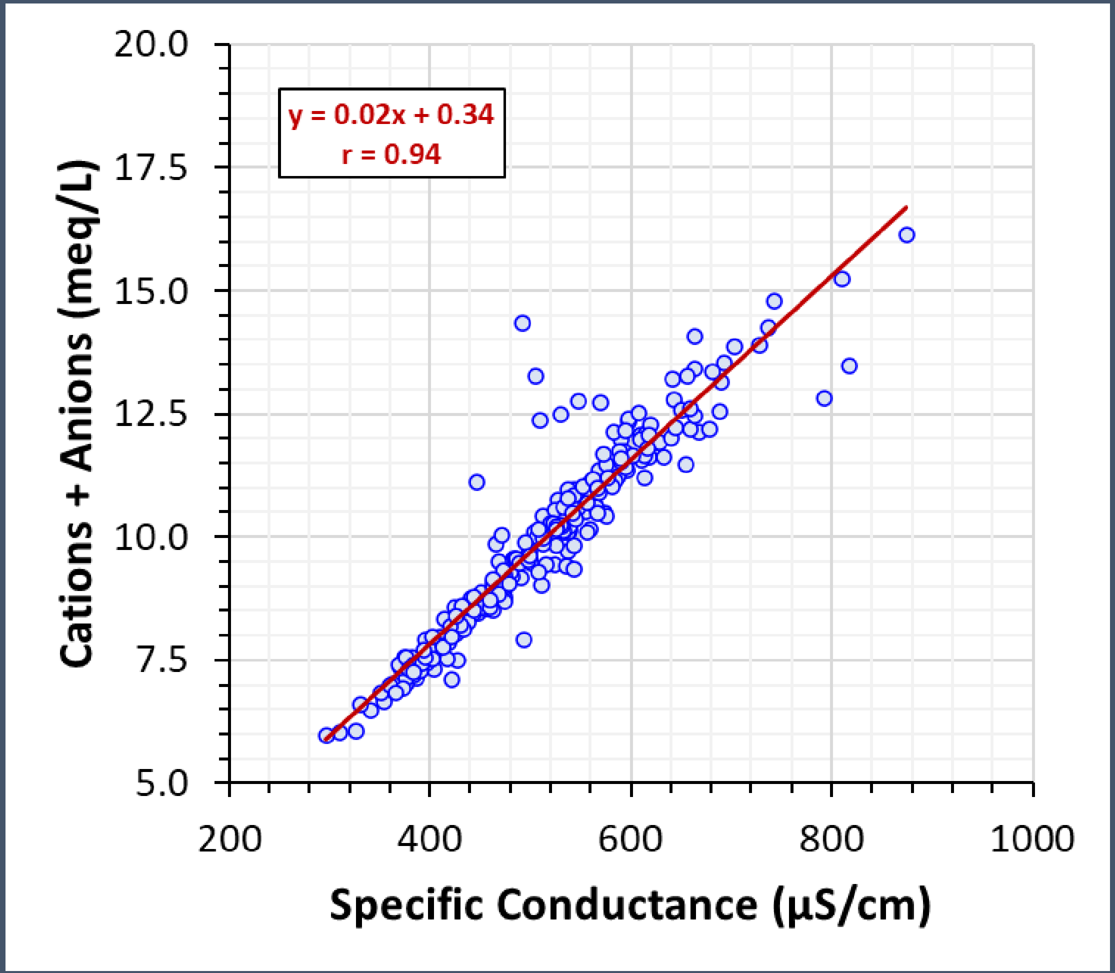
Specific conductance measures the ability of water to carry an electrical current, varying by types and amounts of ions present in solution. Therefore, it is highly correlated with the ionic content of the solution being measured.

Major Ions Affecting Specific Conductance

- Cations (positive charge): Na^+, K^+, Ca^{2+}, Mg^{2+}
- Anions (negative charge): Cl^-, SO_4^{2-}, HCO_3^-

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.

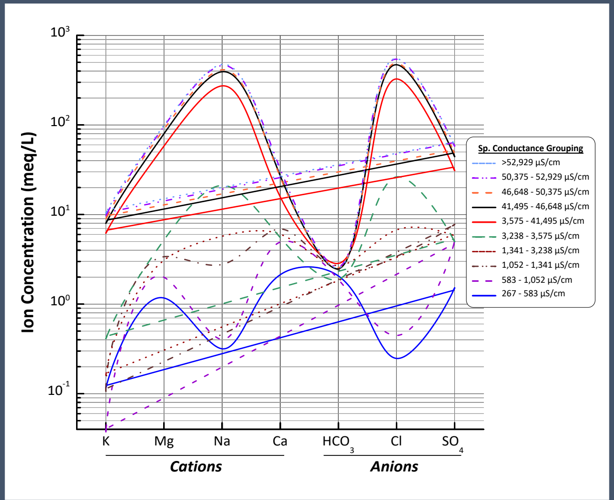
Ion concentrations converted to meq/L to account for ionic charge

Presenter: Nenad Iricanin

Specific Conductance – Major Ions

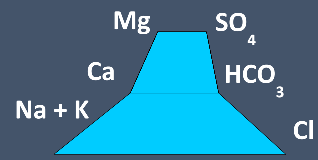
Schoeller Plots

- 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

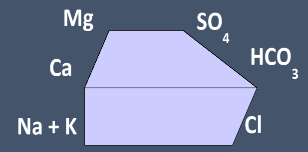


Stiff Diagrams

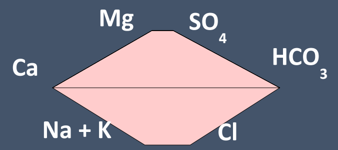
- Resulting polygon shape extends from either side of the zero axis with cations represented on the left side and anions represented on the right side. All ions are plotted in units of meq/L.
- Stiff patterns are a useful method for making rapid visual comparisons between waters from different sources.



Na-Cl dominated source water



Ca-HCO_3 and Na-Cl co-dominated source water

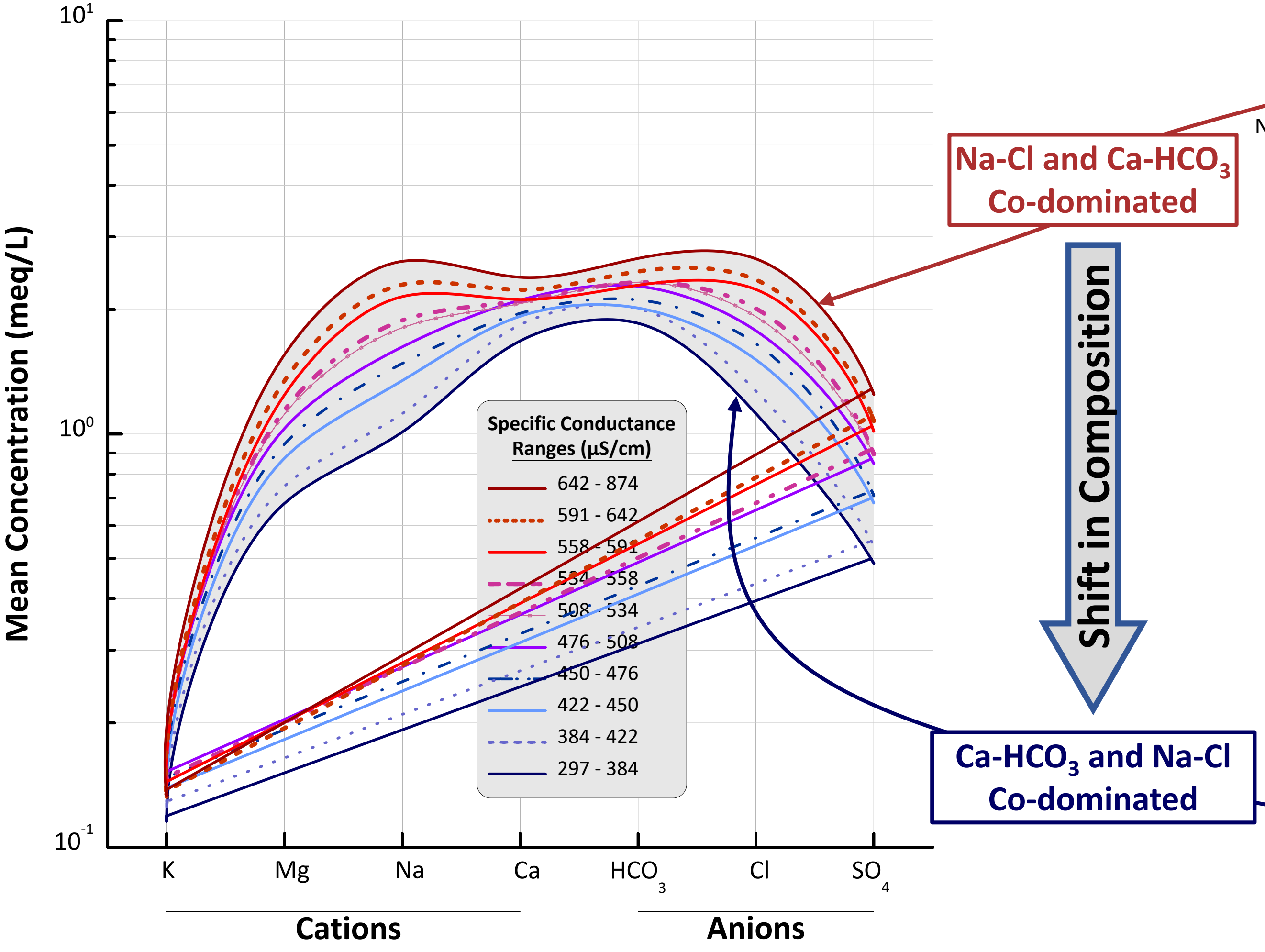


Ca-HCO_3 dominated source water

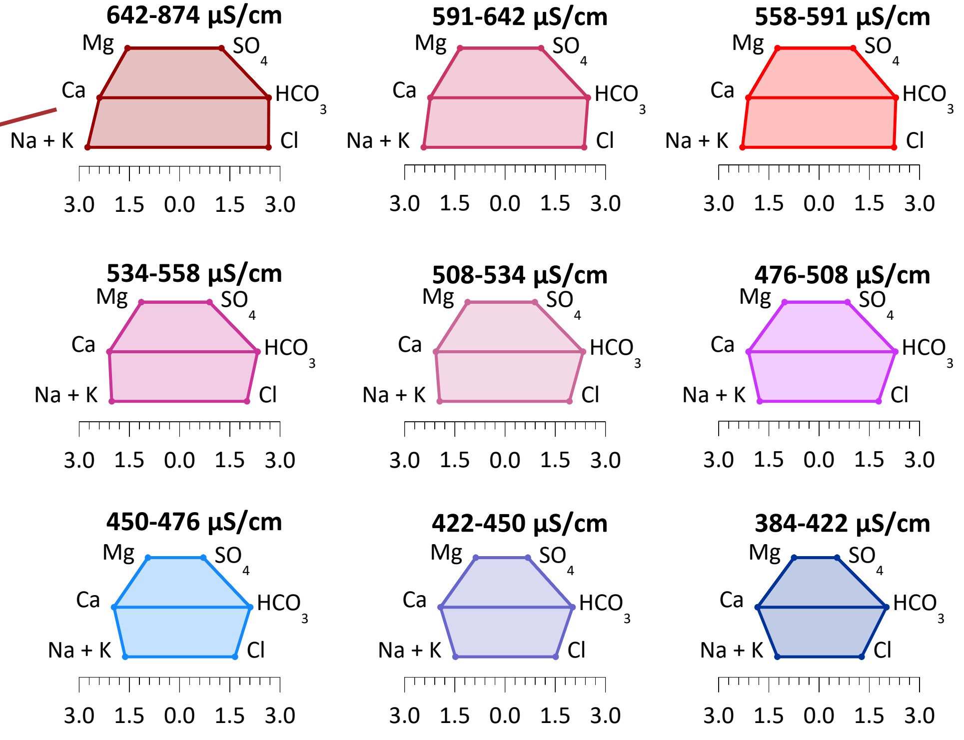
Presenter: Nenad Iricanin

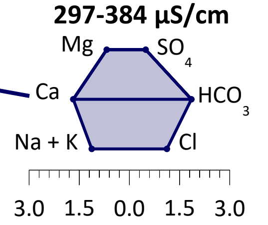
Changes in Lake Okeechobee Ionic Composition

Schoeller Plot



Stiff Diagrams



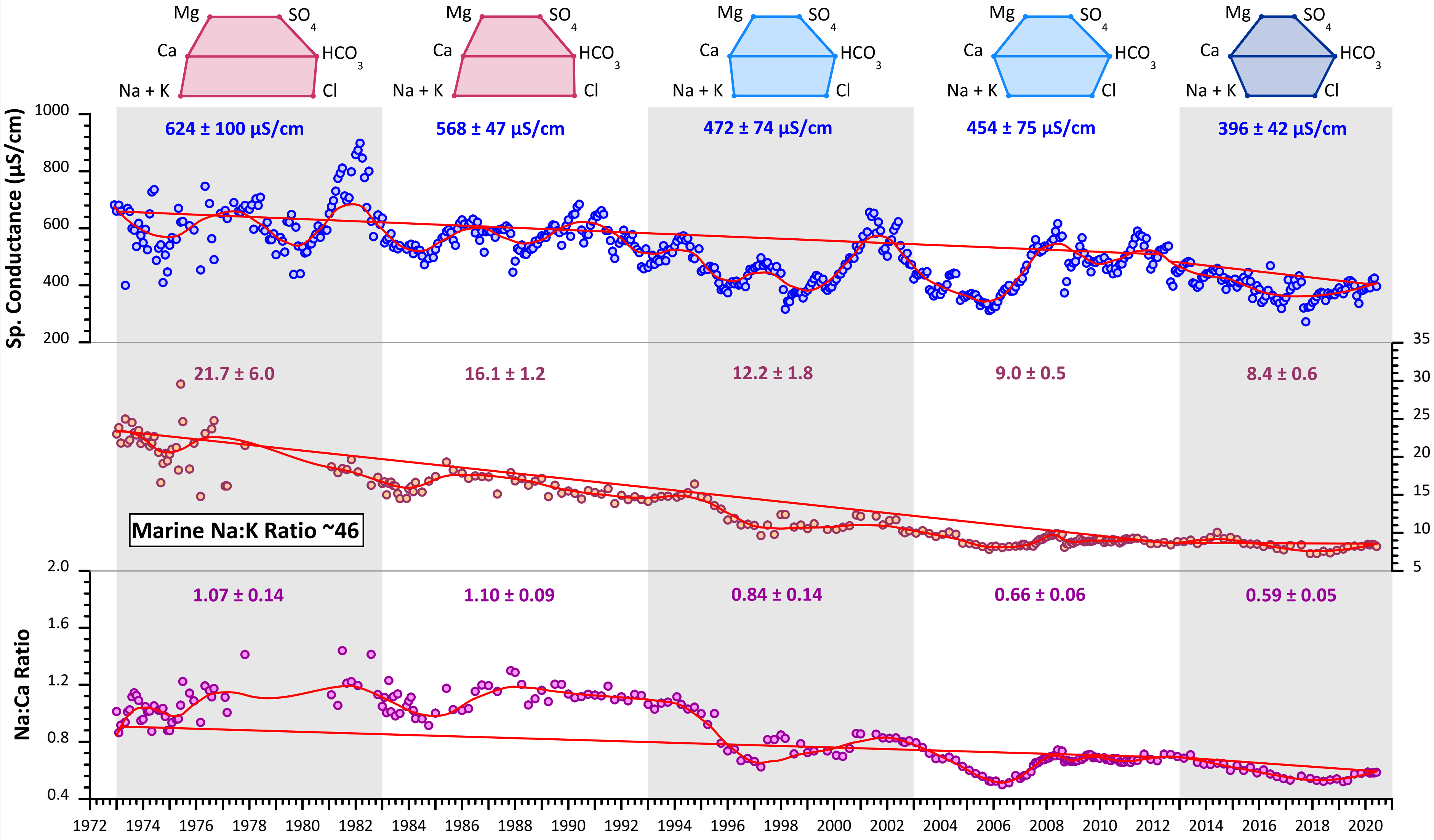


Apparent shift in ionic composition with Na-Cl more dominant at higher specific conductance and Ca-HCO_3 more dominant at lower specific conductance

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-HCO_3 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

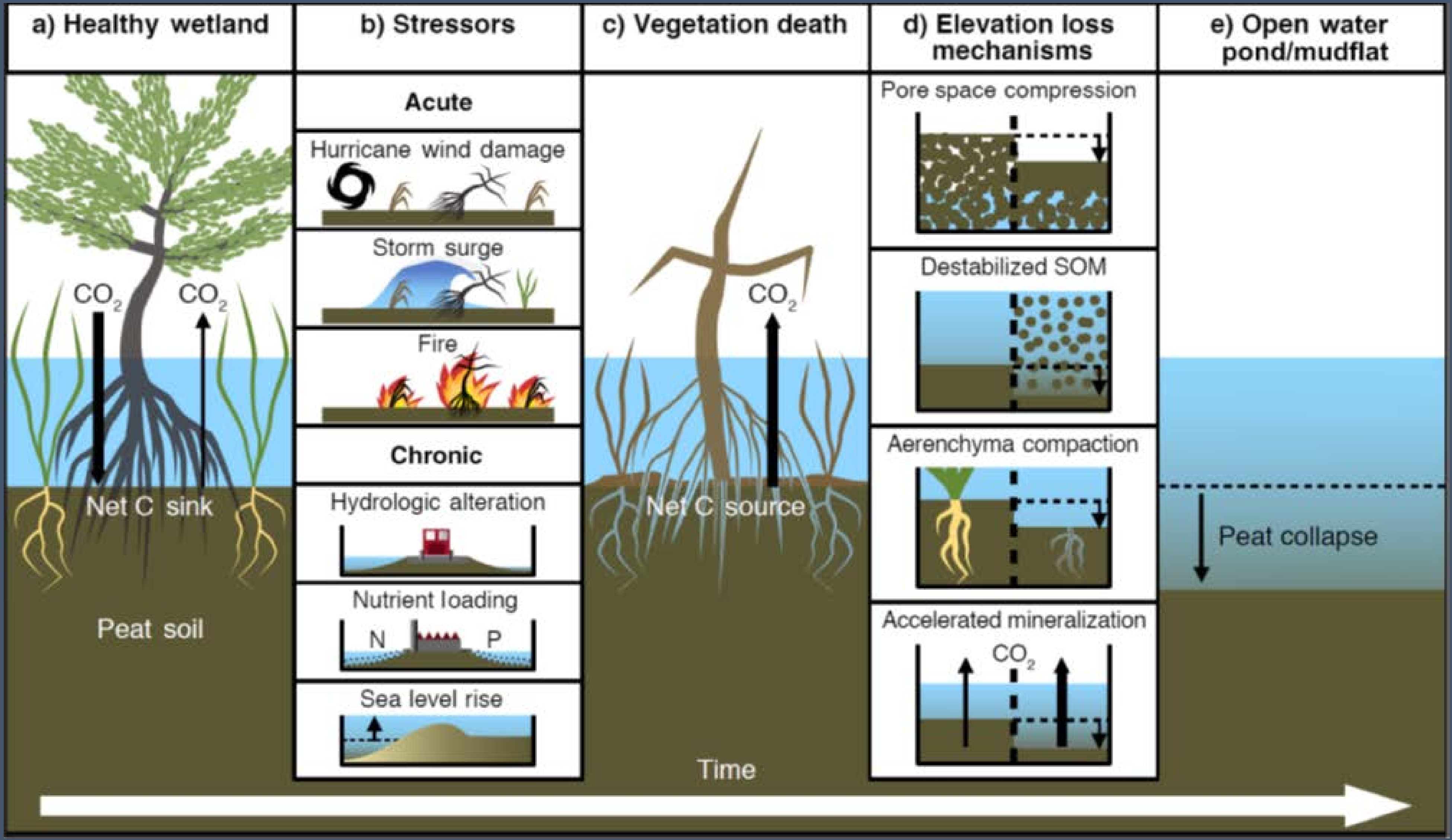
- A significant decreasing trend was observed for specific conductance in Lake Okeechobee over a 48-year period (1972 – 2020)
- Further evaluation of the additional data identified that the lake's ionic composition appears to have changed from Na-Cl dominated in 1970s to a more Ca-HCO_3 dominated composition 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

Soil elevation and Soil Subsidence: Metrics to Assess Sea Level Rise

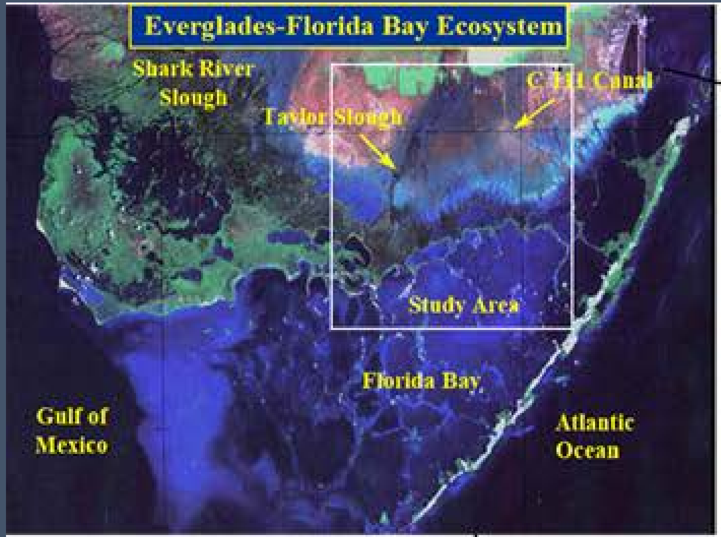


Conceptual framework detailing the potential pathways that a healthy wetland (panel a) that is exposed to various acute or chronic environmental stressors (panel b) can result in vegetation death (panel c), leading to four potential (non-exclusive) mechanisms of soil surface elevation loss (panel d) and ultimately conversion to an open water pond or mudflat (panel e). Figure by Chambers et al. 2019

Presenter: Carlos Coronado

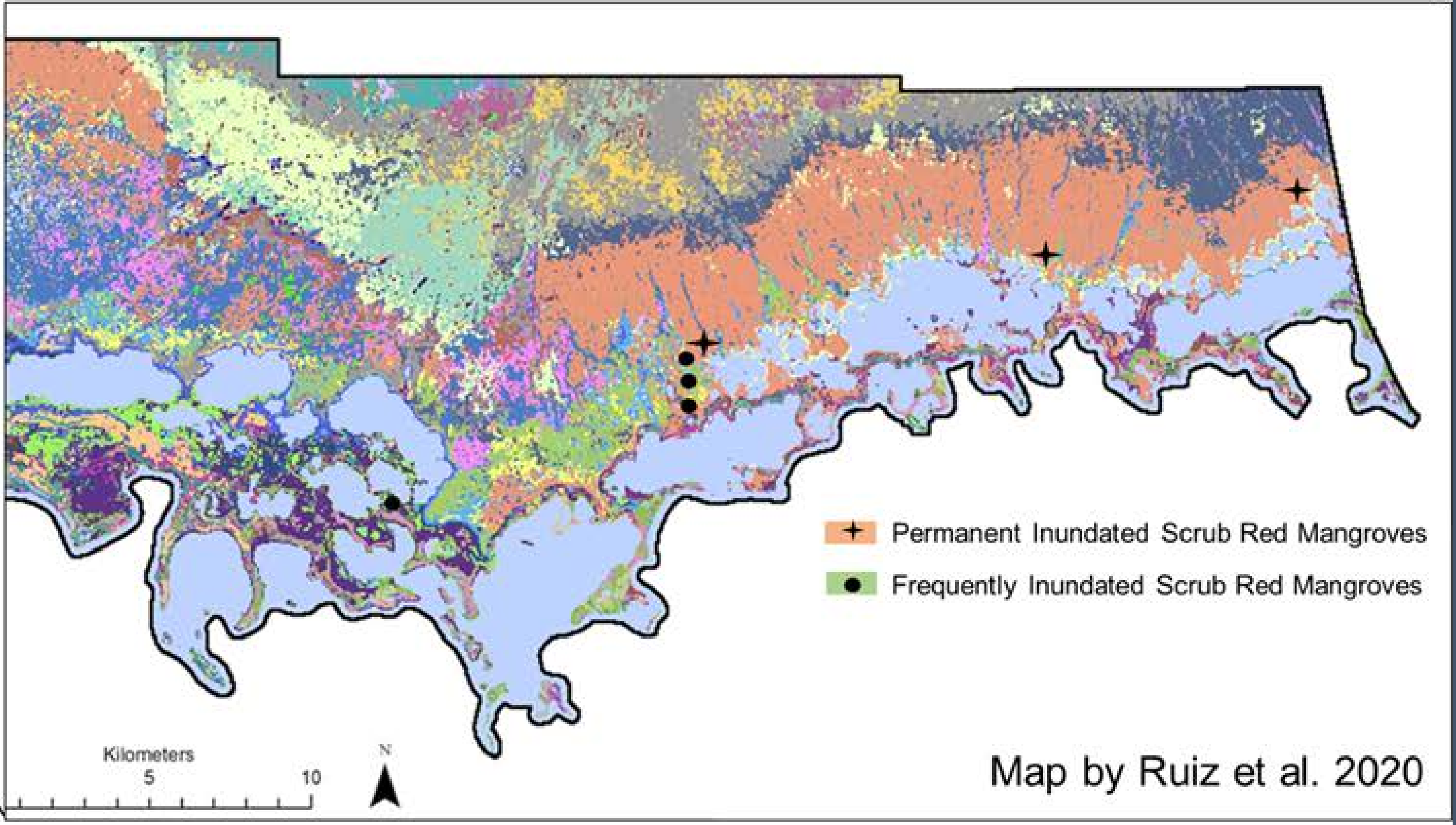
Monitoring Sites Northeastern Florida Bay

Presenter: Carlos Coronado

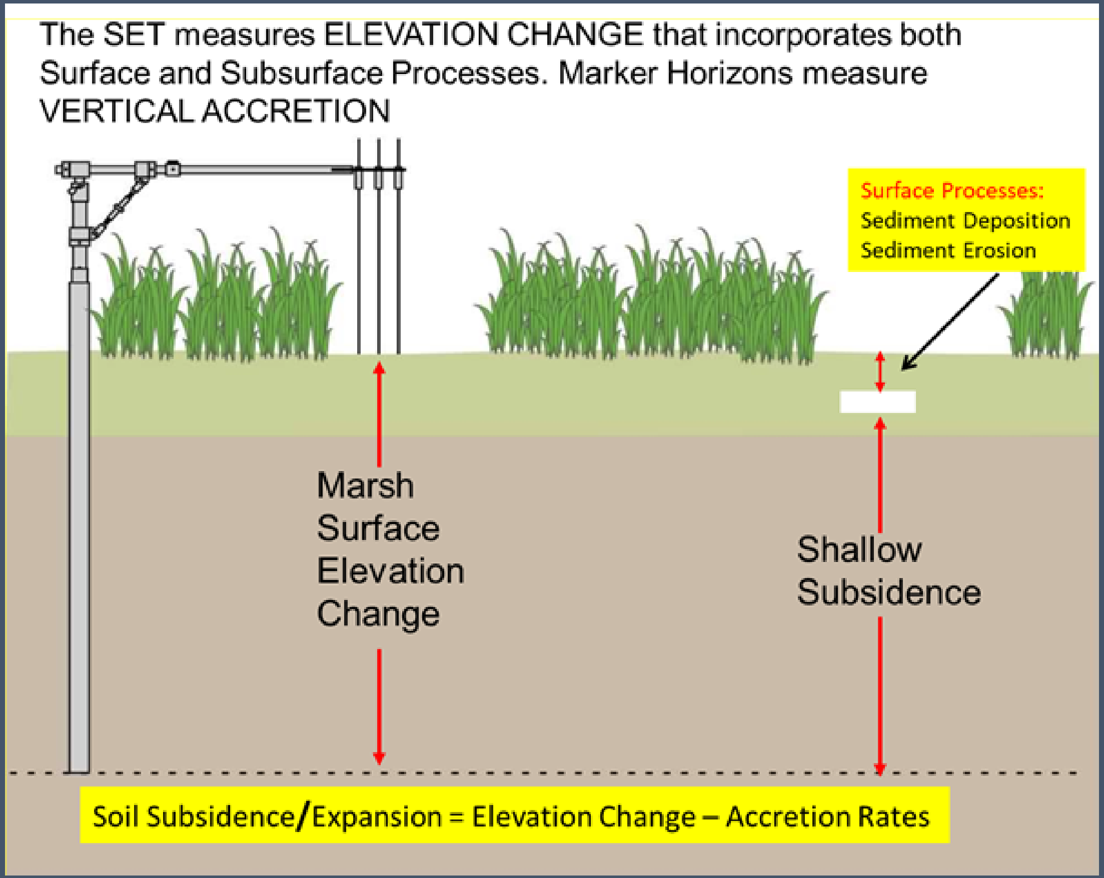


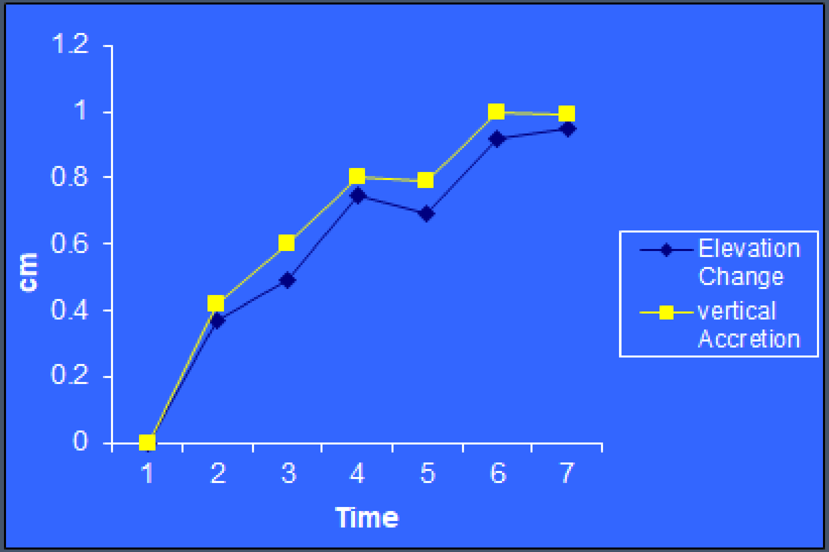
Permanent Inundated Scrub Red Mangrove

Frequently Inundated Scrub Red Mangrove

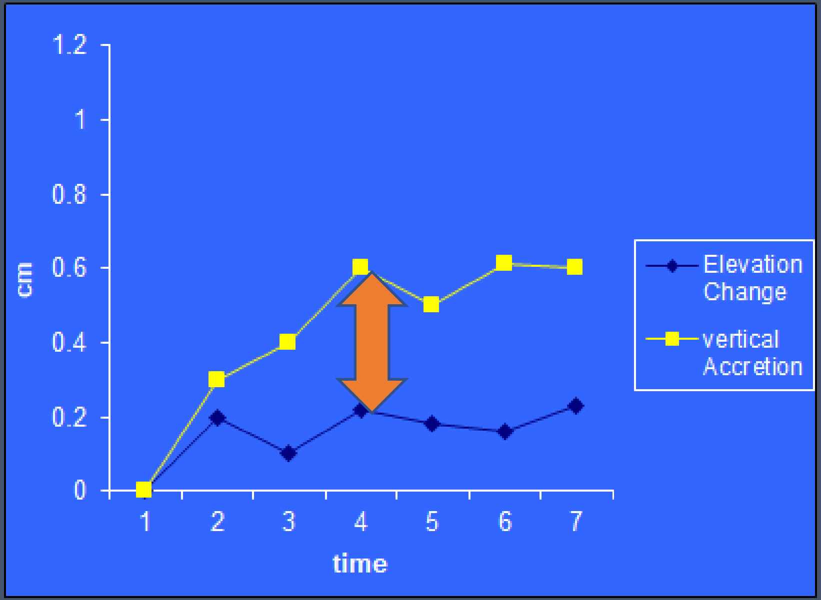


Field Method: Sediment Elevation Table (SET) and Marker Horizon (MH)





Low subsidence

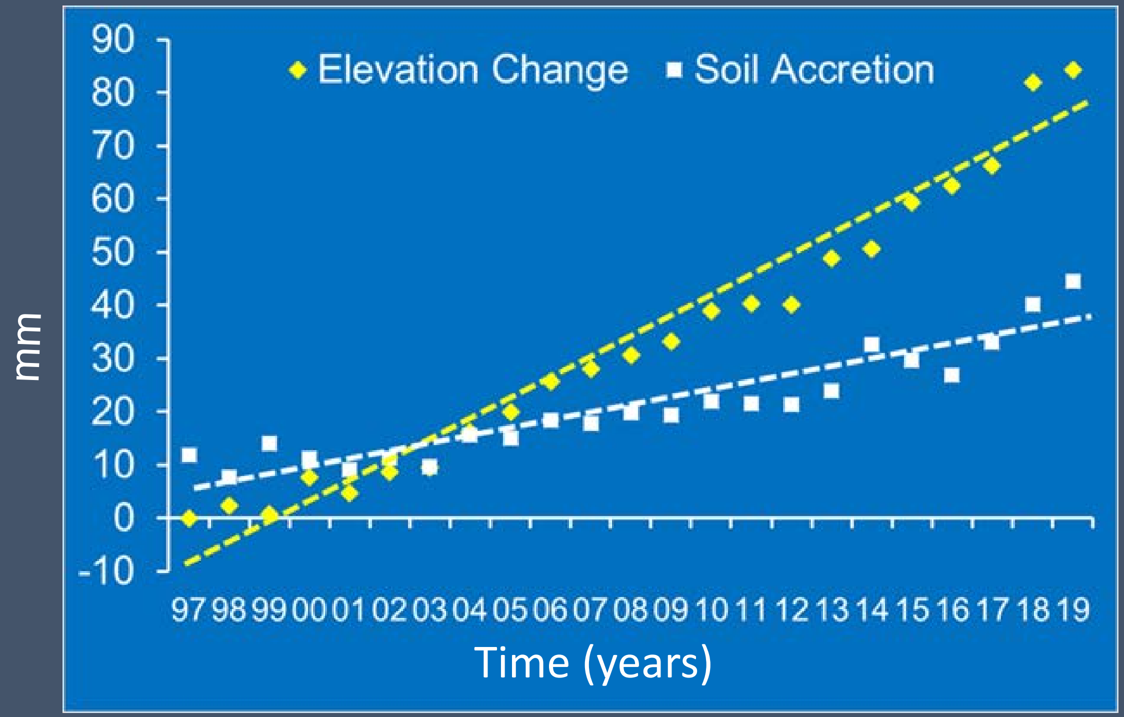


High Subsidence

Soil subsidence is 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

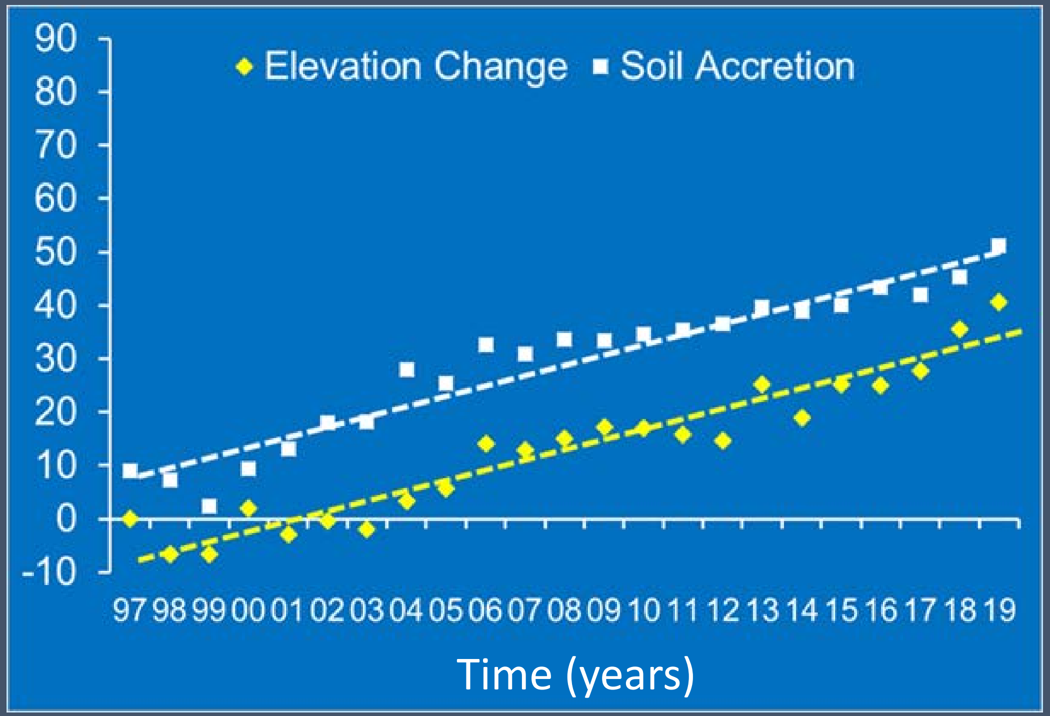
Presenter: Carlos Coronado

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

Summary

- 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

USGS
science for a changing world

Overview of the USGS Water Level and Salinity Analysis Mapper

Tara Root

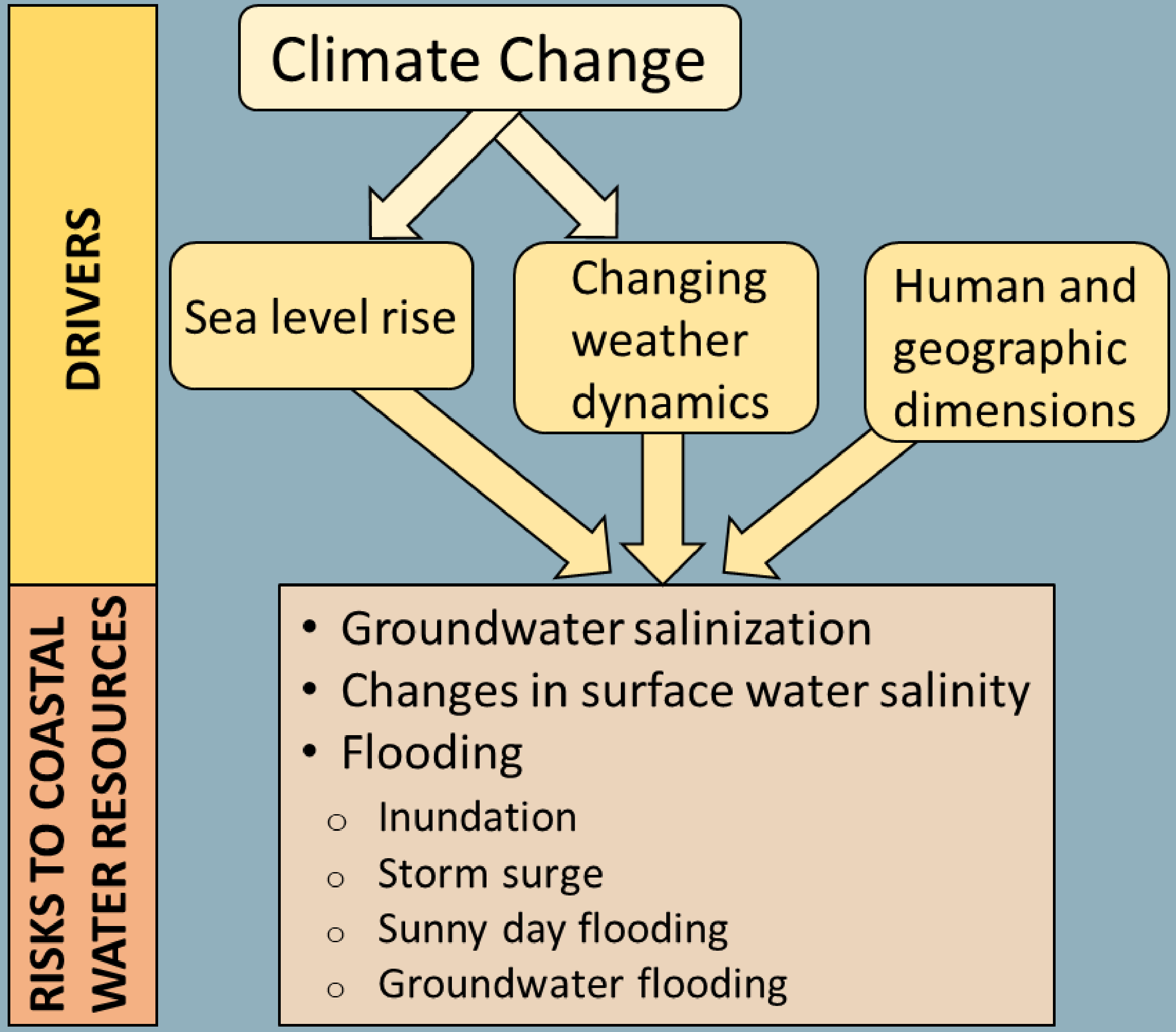
Hydrologist

USGS Caribbean-Florida Water Science Center

U.S. Department of the Interior
U.S. Geological Survey

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?



USGS

Presenter: Tara Root

Science-based decision making to prepare for and respond to these risks requires…

1. Data

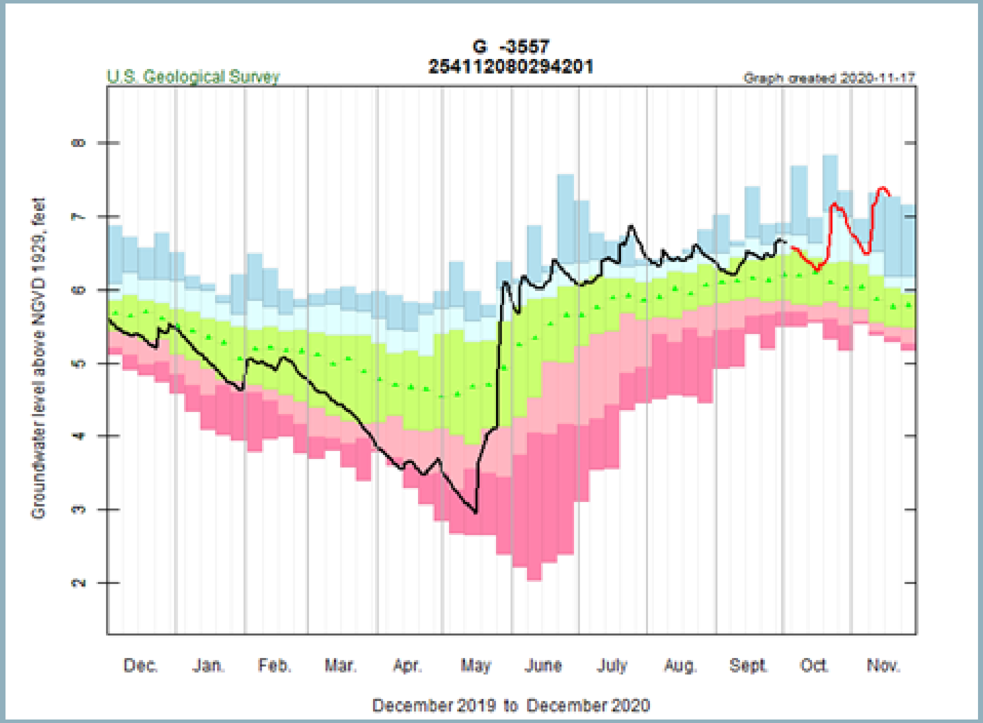
```
agency_cd        site_no site_tp_cd      lev_dt   lev_tm   lev_tz_cd        lev_va   sl_lev_va
lev_age_cd
5s       15s      6s       10d      5d       5s       12s      12s      10s      1s       5s       1s
USGS     254107080165201 GW      1975-10-06                                     2.67     NGVD29
USGS     254107080165201 GW      1976-03-12         11:00    EST                2.65     NGVD29
USGS     254107080165201 GW      1976-03-26         13:30    EST                2.03     NGVD29
USGS     254107080165201 GW      1976-04-16         11:20    EST                2.03     NGVD29
USGS     254107080165201 GW      1976-04-23         13:05    EST                1.77     NGVD29
USGS     254107080165201 GW      1976-05-03                                     1.97     NGVD29
USGS     254107080165201 GW      1976-05-17         11:20    EDT                2.24     NGVD29
USGS     254107080165201 GW      1976-06-01         11:55    EDT                3.27     NGVD29
USGS     254107080165201 GW      1976-10-04         15:20    EDT                2.56     NGVD29
USGS     254107080165201 GW      1977-05-02         14:40    EDT                1.68     NGVD29
USGS     254107080165201 GW      1977-10-03         10:15    EDT                2.48     NGVD29
USGS     254107080165201 GW      1978-05-02         10:05    EDT                2.37     NGVD29
USGS     254107080165201 GW      1978-10-12                                     2.87     NGVD29
USGS     254107080165201 GW      1979-10-15         08:31    EDT                3.05     NGVD29
USGS     254107080165201 GW      1980-05-08                                     2.39     NGVD29
USGS     254107080165201 GW      1980-10-06         13:50    EDT                2.15     NGVD29
USGS     254107080165201 GW      1981-03-17         12:45    EST                2.25     NGVD29
USGS     254107080165201 GW      1981-05-11         10:45    EDT                2.47     NGVD29
USGS     254107080165201 GW      1981-10-05                                     1.89     NGVD29
USGS     254107080165201 GW      1982-02-23         12:10    EST      8.98
USGS     254107080165201 GW      1982-06-09         14:25    EDT                2.87     NGVD29
USGS     254107080165201 GW      1982-10-18         09:40    EDT                2.62     NGVD29
USGS     254107080165201 GW      1983-05-16         12:36    EDT                2.28     NGVD29
USGS     254107080165201 GW      1983-10-19         15:21    EDT                2.53     NGVD29
USGS     254107080165201 GW      1983-10-26         09:25    EDT                2.71     NGVD29
USGS     254107080165201 GW      1984-05-23         15:30    EDT                1.85     NGVD29
USGS     254107080165201 GW      1984-05-24         09:40    EDT                1.84     NGVD29
USGS     254107080165201 GW      1984-10-17         09:40    EDT                2.81     NGVD29
USGS     254107080165201 GW      1984-10-17         12:35    EDT                2.79     NGVD29
USGS     254107080165201 GW      1985-02-21         10:15    EST                2.14     NGVD29
USGS     254107080165201 GW      1985-03-15         10:40    EST                2.03     NGVD29
USGS     254107080165201 GW      1985-03-26         13:15    EST                2.24     NGVD29
USGS     254107080165201 GW      1985-04-09         12:55    EST                2.01     NGVD29
USGS     254107080165201 GW      1985-04-15         11:15    EST                2.00     NGVD29
USGS     254107080165201 GW      1985-04-23         12:30    EST                2.05     NGVD29
USGS     254107080165201 GW      1985-10-21         11:45    EDT                2.91     NGVD29
```

USGS

Presenter: Tara Root

Science-based decision making to prepare for and respond to these risks requires…

1. Data
2. Analyses



Maximum daily water level above NGVD29, in feet.
The most recent daily water level, measured on 2020-11-16, is 7.29 feet. This value is above the 90th percentile for week 46 of the year.

Weekly frequency analysis of daily maximum water level record

Week of the year	Lowest median	10th percentile	25th percentile	50th percentile	75 percentile	90th percentile	Highest median	Number of years
1.00	4.34	4.71	5.05	5.44	5.72	6.02	6.21	26.00
2.00	4.11	4.58	4.93	5.35	5.62	6.00	6.09	26.00
3.00	4.02	4.71	4.78	5.27	5.59	5.83	5.94	26.00
4.00	3.95	4.62	4.77	5.06	5.50	5.67	6.23	26.00
5.00	3.80	4.61	4.71	5.19	5.46	5.86	6.52	26.00
6.00	3.97	4.51	4.64	5.21	5.50	5.77	6.30	26.00
7.00	4.00	4.31	4.57	5.17	5.45	5.68	6.02	26.00
8.00	3.78	4.17	4.47	5.16	5.46	5.77	5.88	26.00
9.00	3.70	4.00	4.40	5.11	5.43	5.79	5.97	26.00
10.00	3.81	4.00	4.30	4.99	5.39	5.80	6.01	26.00
11.00	3.60	3.91	4.21	5.06	5.40	5.74	6.05	26.00
12.00	3.40	3.99	4.17	4.89	5.40	5.71	5.96	26.00

Note: An analysis of water level frequencies is conducted, and data for the last year are plotted on the resulting graph.

USGS

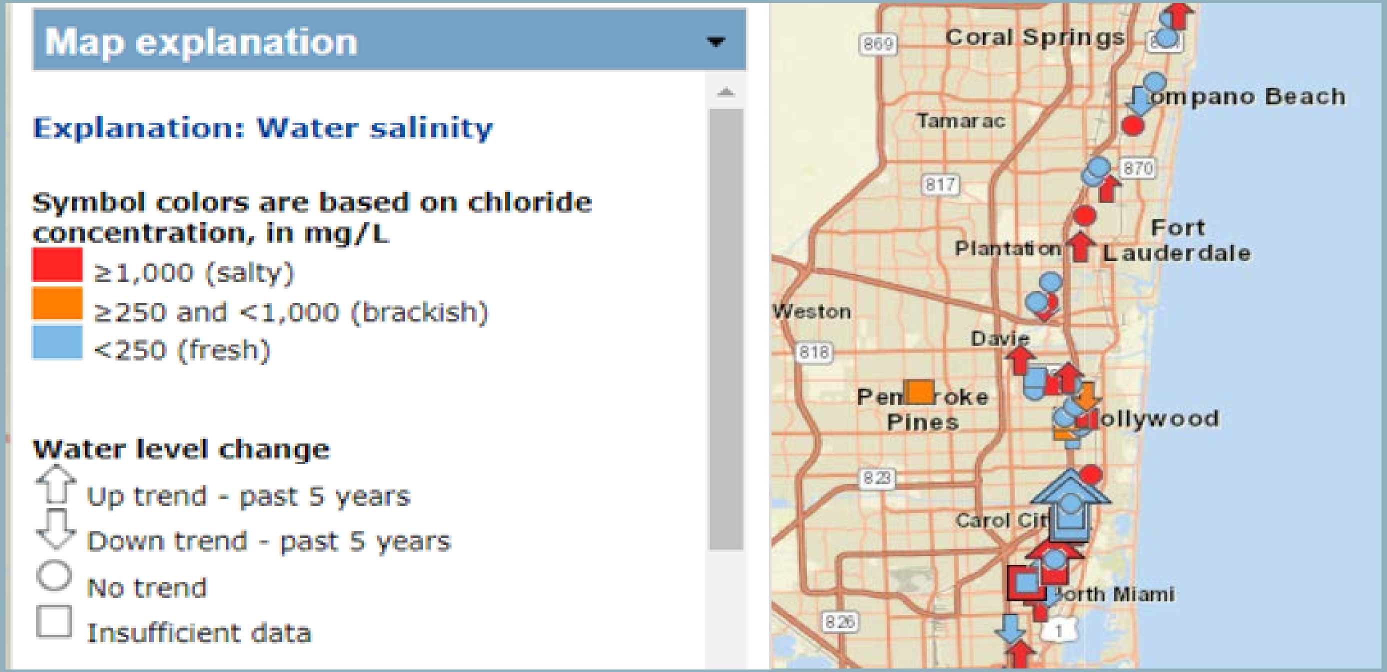
Presenter: Tara Root

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)

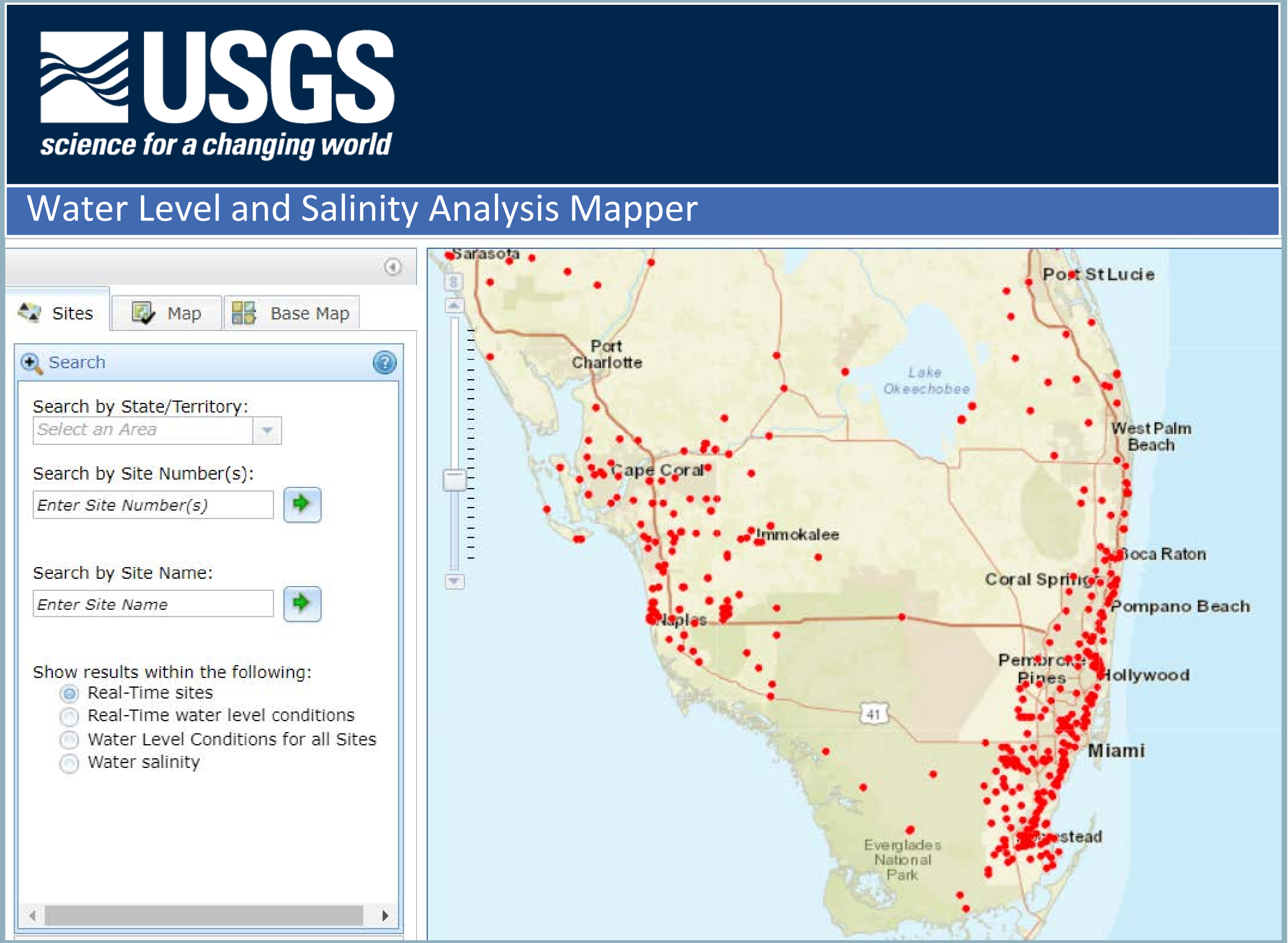
USGS Presenter: Tara Root



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

Overview of WSLAM

Online search tool and map interface



USGS

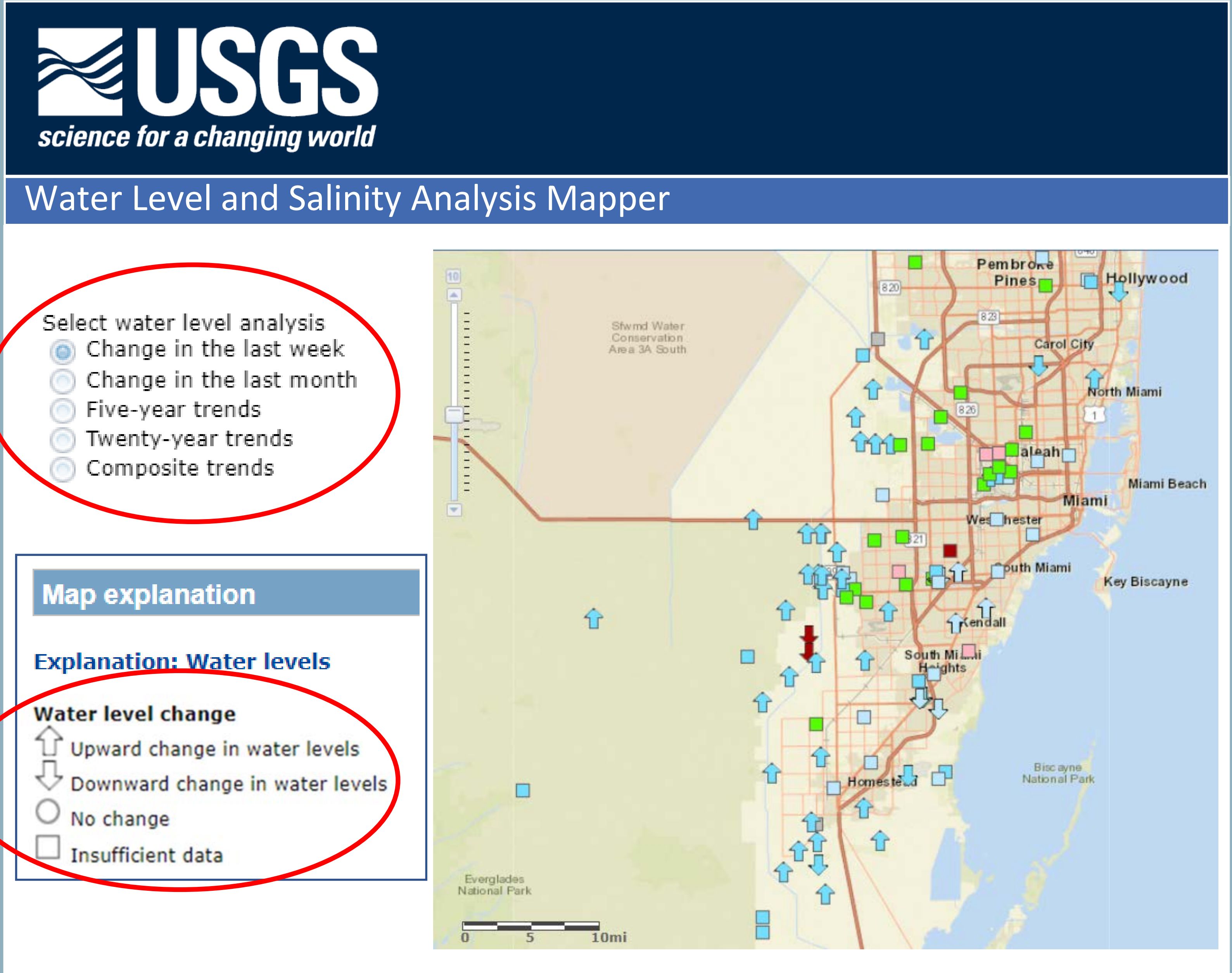
Presenter: Tara Root

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



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

USGS 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

USGS

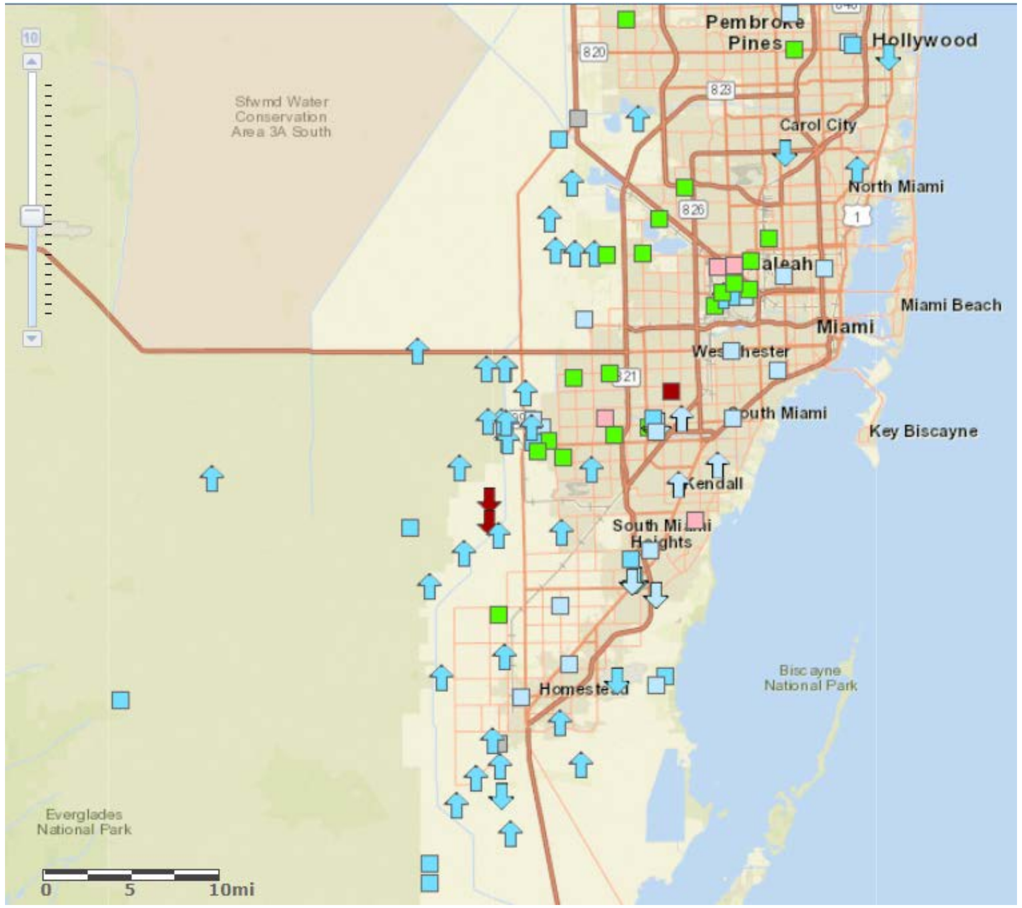
science for a changing world

Water Level and Salinity Analysis Mapper

Map explanation

Explanation: Water levels

- > 90th percentile
- 76th to 90th percentile
- 25th to 75th percentile
- ≥ 10th to < 24th percentile
- < 10th percentile
- Insufficient data for analysis



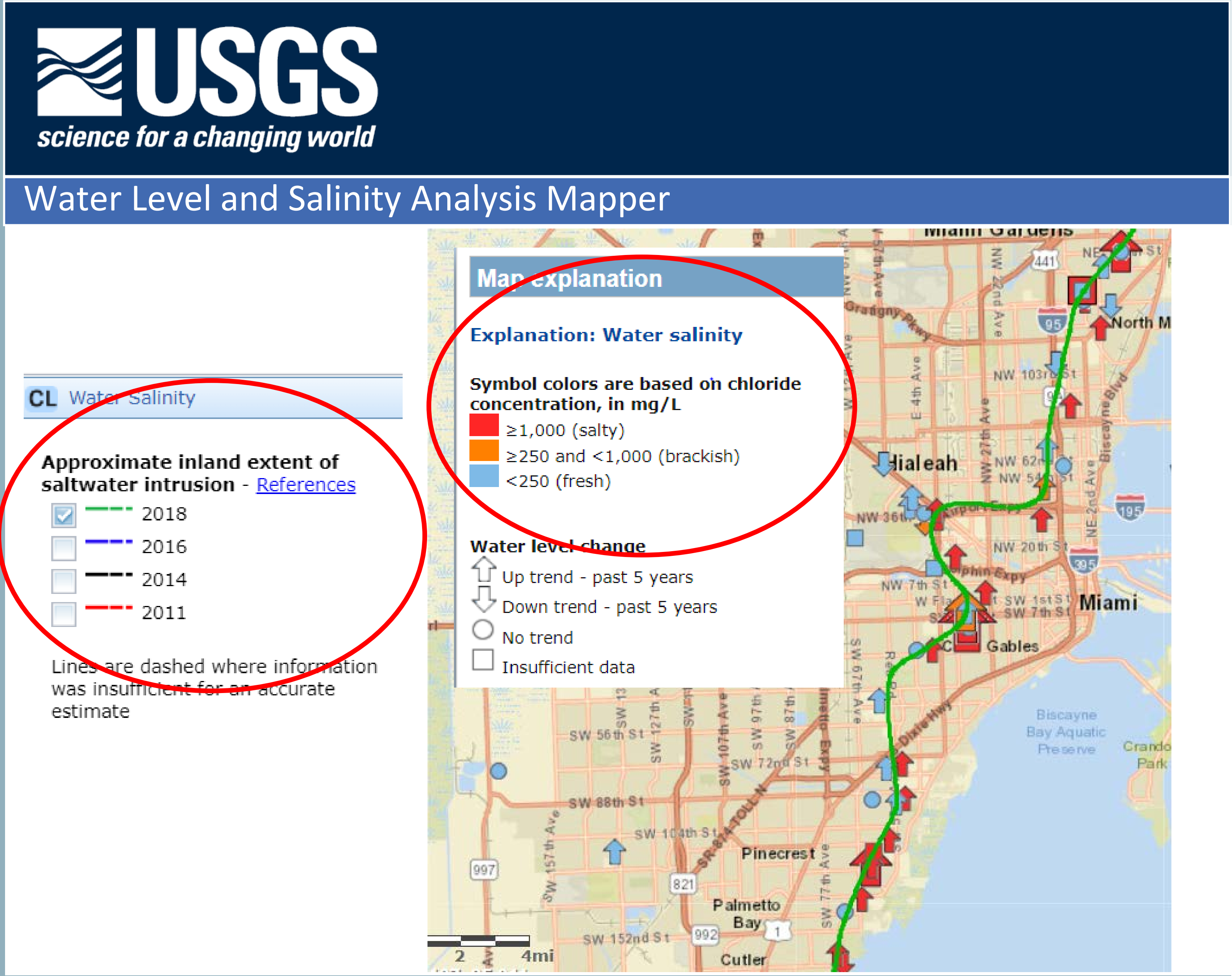
Source for images: https://fl.water.usgs.gov/mapper/

USGS 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/

Overview of WSLAM

Data analysis & visuals

Pop-up when user selects site

- Most recent value
- Magnitude of recent change
- Long-term trend directions

USGS Presenter: Tara Root

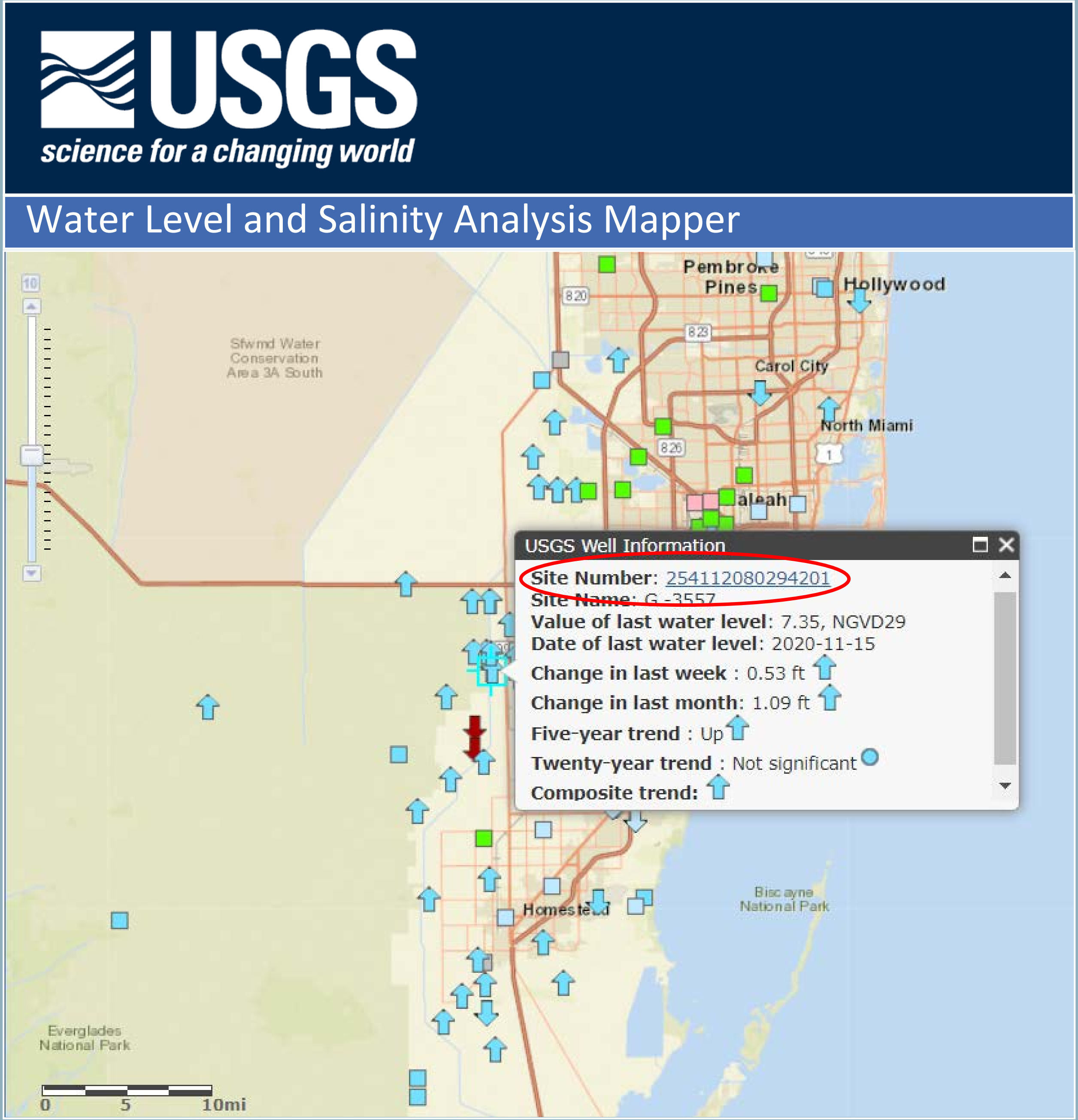
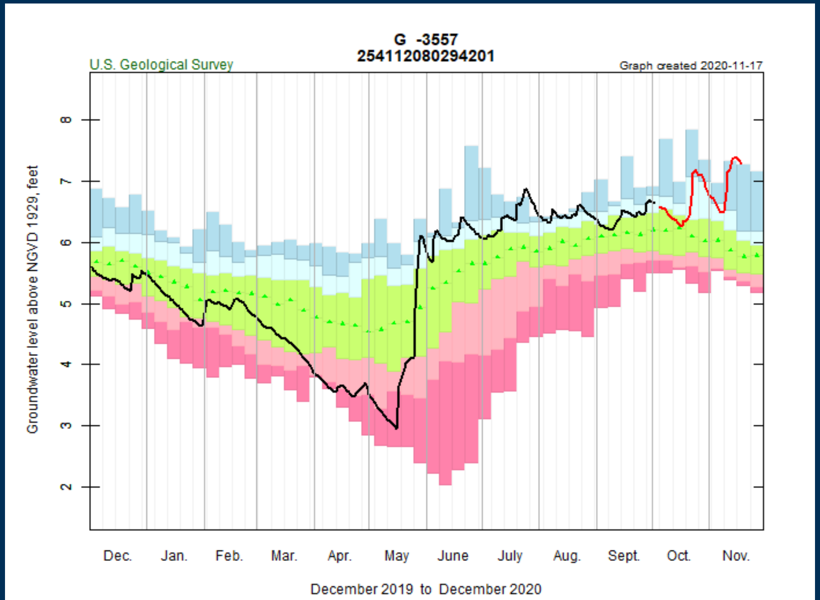
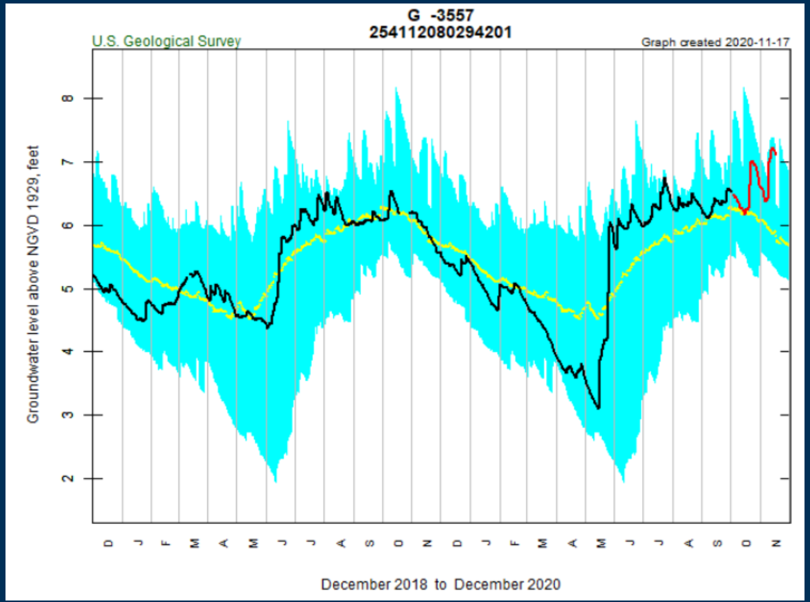
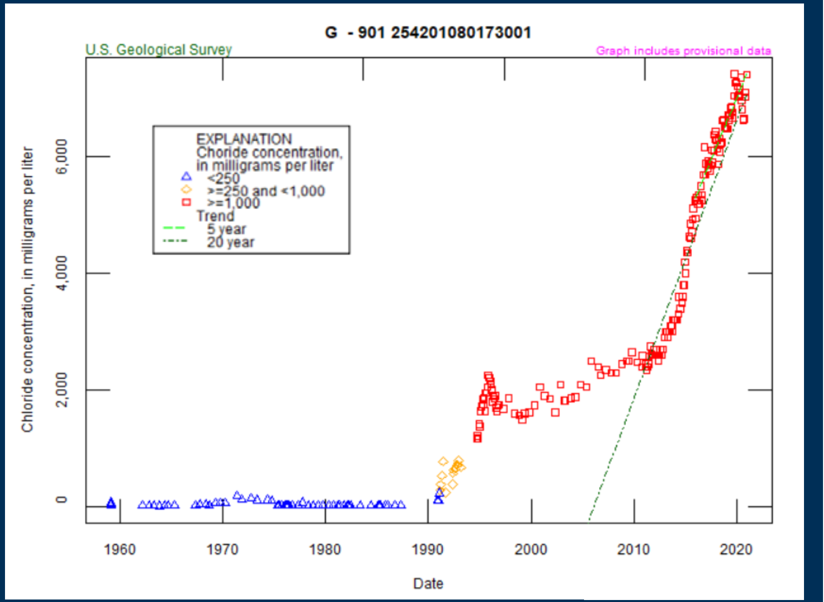


Image source: https://fl.water.usgs.gov/mapper/







Maximum daily water level above NGVD29, in feet.
The most recent daily water level, measured on 2020-11-16, is 7.29 feet. This value is above the 90th percentile for week 46 of the year.

Weekly frequency analysis of daily maximum water level record

Week of the year	Lowest median	10th percentile	25th percentile	50th percentile	75 percentile	90th percentile	Highest median	Number of years
1.00	4.34	4.71	5.05	5.44	5.72	6.02	6.21	26.00
2.00	4.11	4.58	4.93	5.35	5.62	6.00	6.09	26.00
3.00	4.02	4.71	4.78	5.27	5.59	5.83	5.94	26.00
4.00	3.95	4.62	4.77	5.06	5.50	5.67	6.23	26.00
5.00	3.80	4.61	4.71	5.19	5.46	5.86	6.52	26.00
6.00	3.97	4.51	4.64	5.21	5.50	5.77	6.30	26.00
7.00	4.00	4.31	4.57	5.17	5.45	5.68	6.02	26.00
8.00	3.78	4.17	4.47	5.16	5.46	5.77	5.88	26.00
9.00	3.70	4.00	4.40	5.11	5.43	5.79	5.97	26.00
10.00	3.81	4.00	4.30	4.99	5.39	5.80	6.01	26.00
11.00	3.60	3.91	4.21	5.06	5.40	5.74	6.05	26.00
12.00	3.40	3.99	4.17	4.89	5.40	5.71	5.96	26.00

Note: An analysis of water level frequencies is conducted, and data for the last year are plotted on the resulting graph.

Maximum daily water level above NGVD29, in feet.
The most recent daily water level, measured on 2020-11-16, is 7.29 feet. The highest water at this site on this day of the year was 7.29 feet, and the lowest was 5.31 feet.

Statistics of maximum daily water level record

Day of year	Maximum	Mean	Minimum	Available data points for this day
1.00	6.22	5.45	4.42	26
2.00	6.17	5.44	4.36	26
3.00	6.30	5.45	4.36	26
4.00	6.36	5.43	4.36	26
5.00	6.36	5.43	4.34	25
6.00	6.30	5.41	4.34	25
7.00	6.27	5.40	4.34	25
8.00	6.27	5.38	4.33	25
9.00	6.27	5.35	4.33	26
10.00	6.27	5.34	4.27	26
11.00	6.21	5.32	4.26	26
12.00	6.12	5.30	4.21	26
13.00	6.08	5.27	4.21	25
14.00	6.05	5.27	4.17	25
15.00	6.02	5.27	4.13	26

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

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

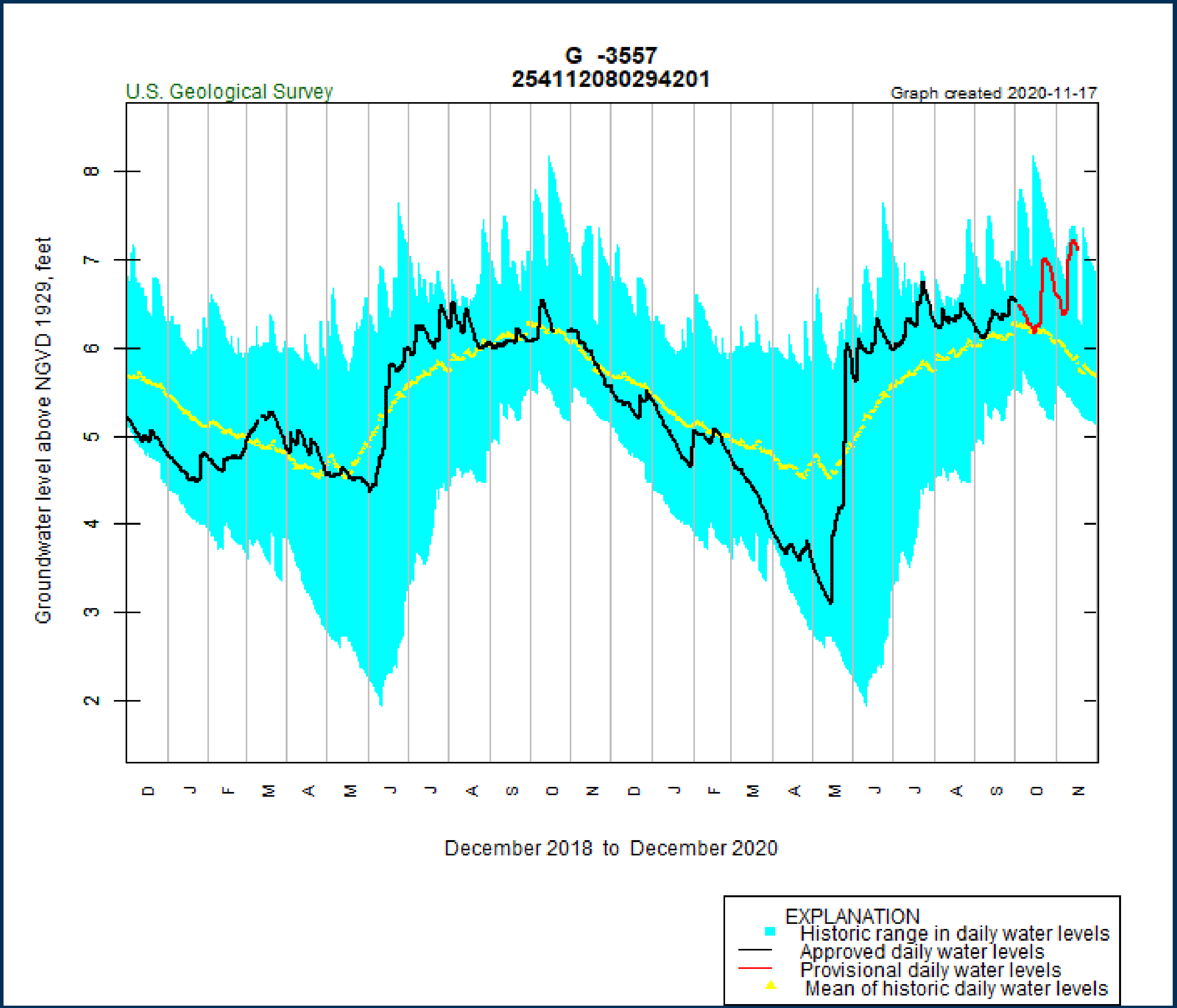
Trend test	Test result	P-value	Kendall's tau	Slope	Intercept
Five Year	Up	0.00	0.79	1.16	-14,223
Twenty Year	Up	0.00	0.92	1.30	-17,121

Analysis	Result
Date of first sample	1959-03-06
First sample result (mg/L)	24
Date of last sample	2020-12-03
Last sample result (mg/L)	7,400
Date of first sample within 250 to 999 mg/L	1991-02-21
Date of first sample with 1,000 mg/L or greater	1994-09-08
Minimum (mg/L)	17
Maximum (mg/L)	7,410
Mean (mg/L)	2,721.136
First quartile (mg/L)	235
Median (mg/L)	2,350
Third quartile (mg/L)	4,850
Number of samples	257

Download chloride concentration summary statistics data in table format

USGS

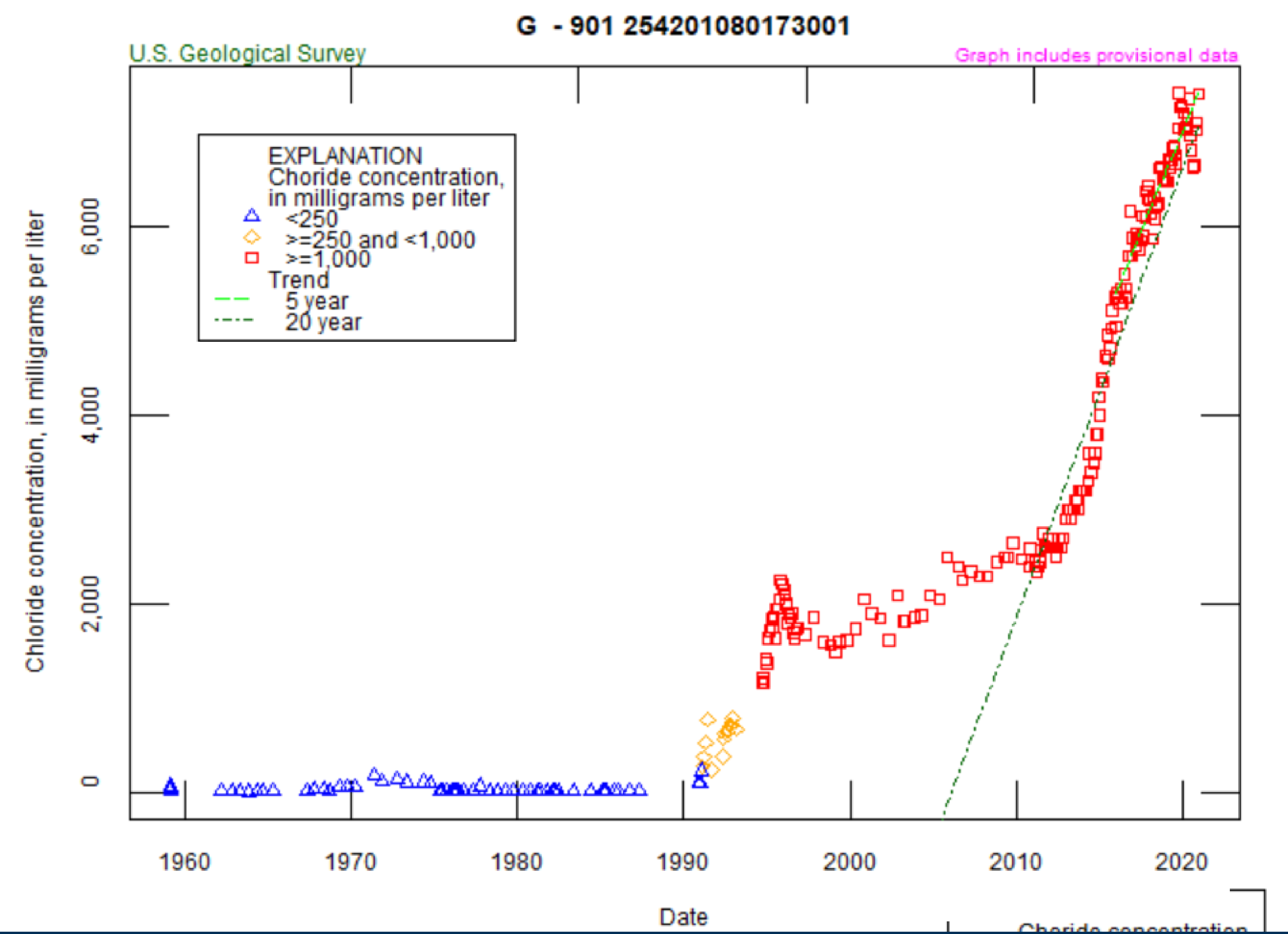
Presenter: Tara Root



Presenter: Tara Root

USGS

Source for image https://fl.water.usgs.gov/mapper/waterlevel_site_info.php?site=254112080294201



Presenter: Tara Root

USGS

Source for image: https://fl.water.usgs.gov/mapper/site_info.php?site=254201080173001&stationType=gw

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

USGS science for a changing world

Water Level and Salinity Analysis Mapper

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

USGS Presenter: Tara Root

Next Steps: Implementation

Presenter: Carolina Maran

South Florida Water Management District

SFWMD Water and Climate Resilience Metrics

This interactive map contains information about South Florida Water Management District Water and Climate Resilience Metrics

Contact Info / number of metrics / link to the main report.

Read more about **Our Work**. For general information **Contact Us**.

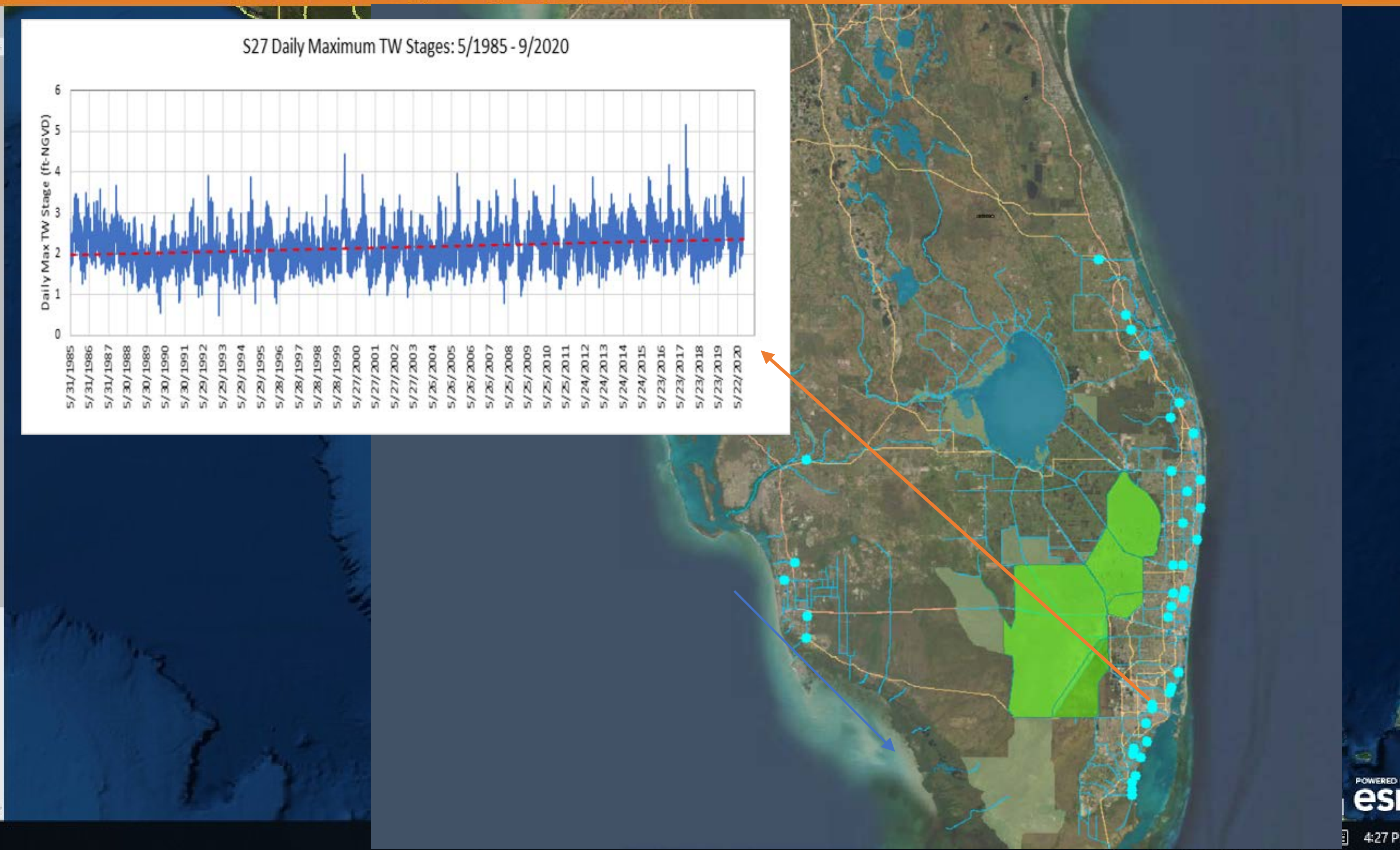
SEA LEVEL | HYDROLOGY | WATER QUALITY | ECOLOGY

Coastal Structures Tidal/ Tailwater Elevation Trends

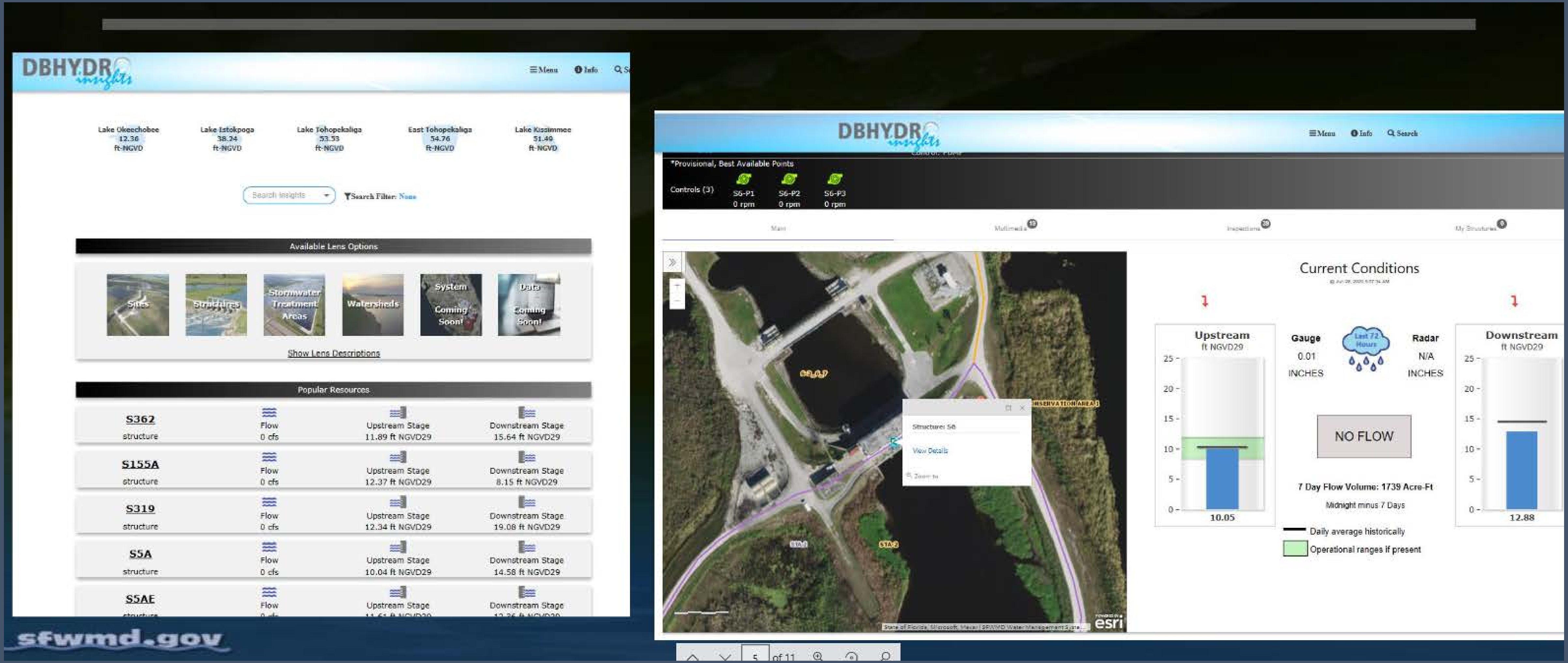
High Tide Elevations / Extreme Tidal Stage Treds

Saltwater Intrusion/ Chloride Level Trends

Learn more
(Data Analysis Approach & Trends Significance)



DBHydro Insights



Presenter: Carolina Maran

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

Time's up!

<u>Want to comment?</u>

<u>Zoom:</u>

- If you're participating via Zoom – use the Raise Hand feature

<u>Phone:</u>

- If you're participating via Phone –

  *6 Mutes/Unmutes

  *9 Raises Hand

4. Adjourn

THANK YOU