Predicting the Everglades Ecosystem Response to Changes in Key Hydrologic Restoration Components

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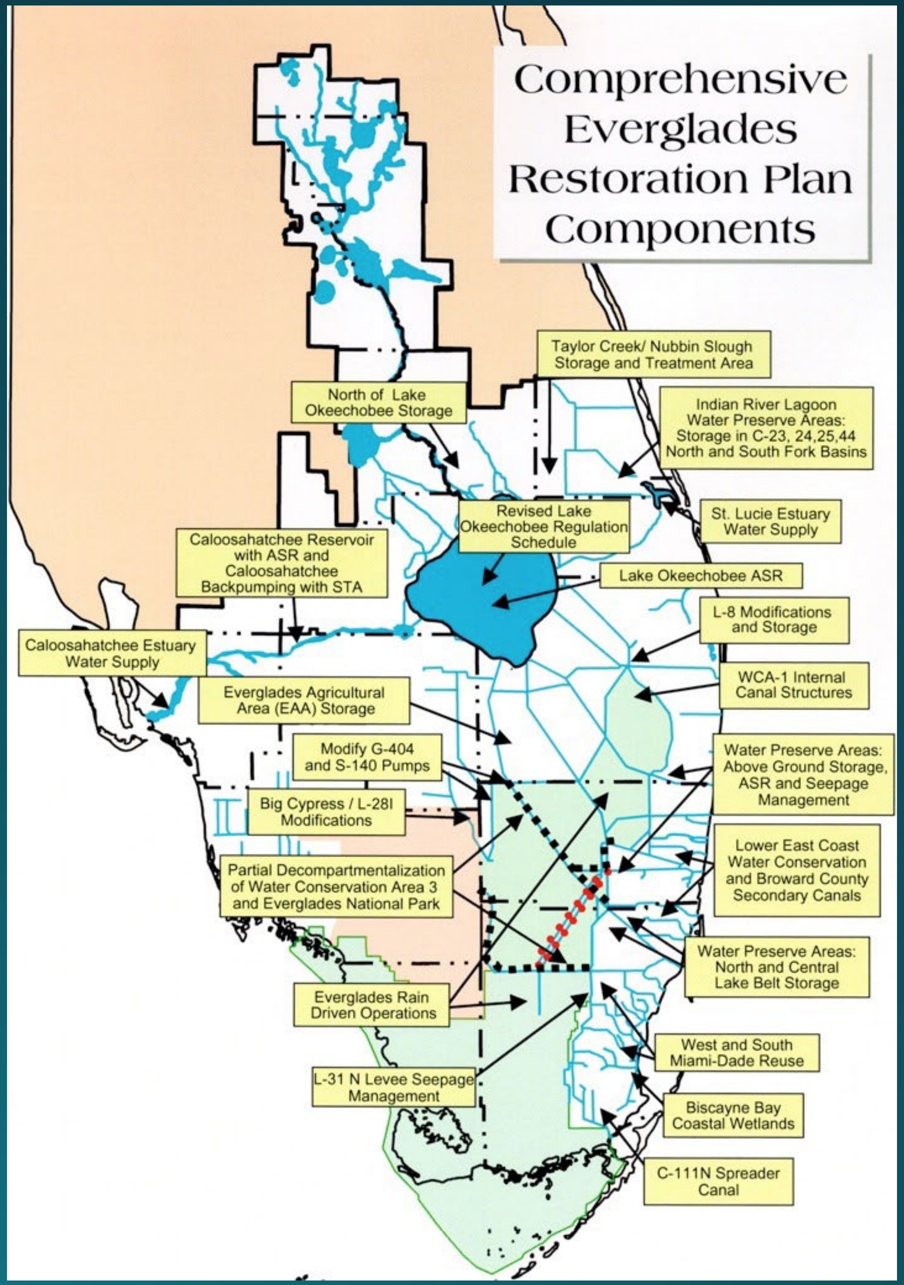
The Comprehensive Everglades Restoration Plan (CERP)

- U.S. Army Corps and South Florida Water Management District developed the CERP

- Authorized in 2000 by Florida Legislature and by Congress (WRDA 2000)

- 68 individual projects each requires authorization and appropriations

- Key components: water storage, removal of barriers to flow, seepage control, operations and demands

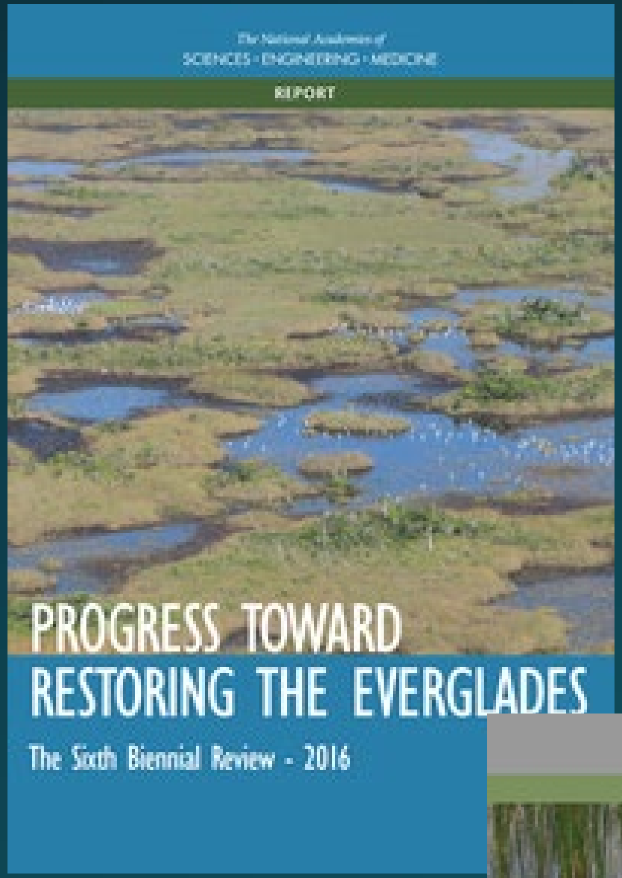


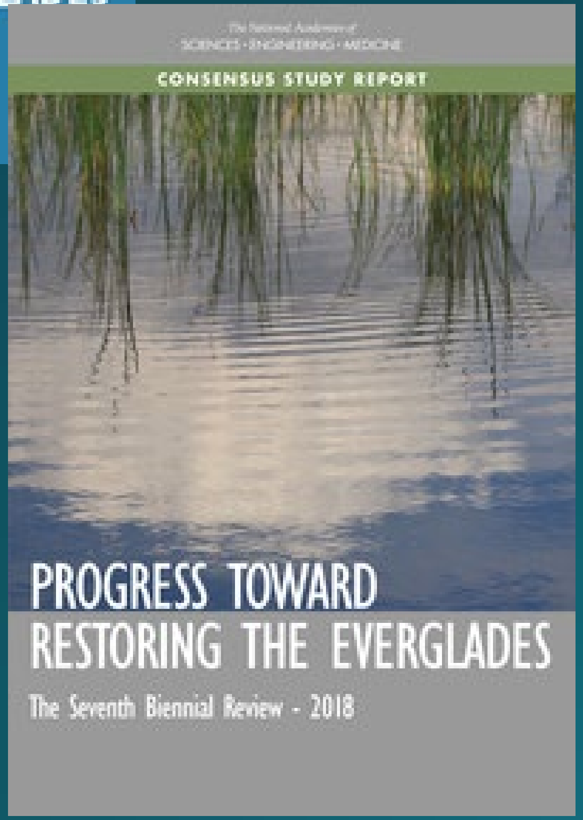
CERP Progress

- None of the major project components described in CERP has been completed
- Central Everglades Plan (CEP)
- Everglades Agricultural Area (EAA) reservoir

- Storage Issues
  - Pilot study on Aquifer Storage and Recovery (ASR) concluded that only 40% of the storage is feasible
  - Feasibility of in-ground Lake Belt Reservoir has not been done
  - In 2008, a low Lake Okeechobee Regulation Schedule (LORS 2008) was implemented that reduced significant amount of storage in the lake.

A CERP Mid-Course Assessment





In 2016 and 2018 reports, the National Academy of Sciences review of CERP recommended updating the CERP to incorporate new scientific knowledge

- 2016 Report: “Knowledge gained regarding the pre-drainage system, climate change, and sea level rise suggests that a **reexamination** of the CERP restoration goals — including both ecology and hydrology — is in order, together with a realistic assessment of what can be achieved.”

- 2018 Report: “CERP agencies should conduct **a mid-course assessment** that rigorously considers the future of the South Florida ecosystem.”

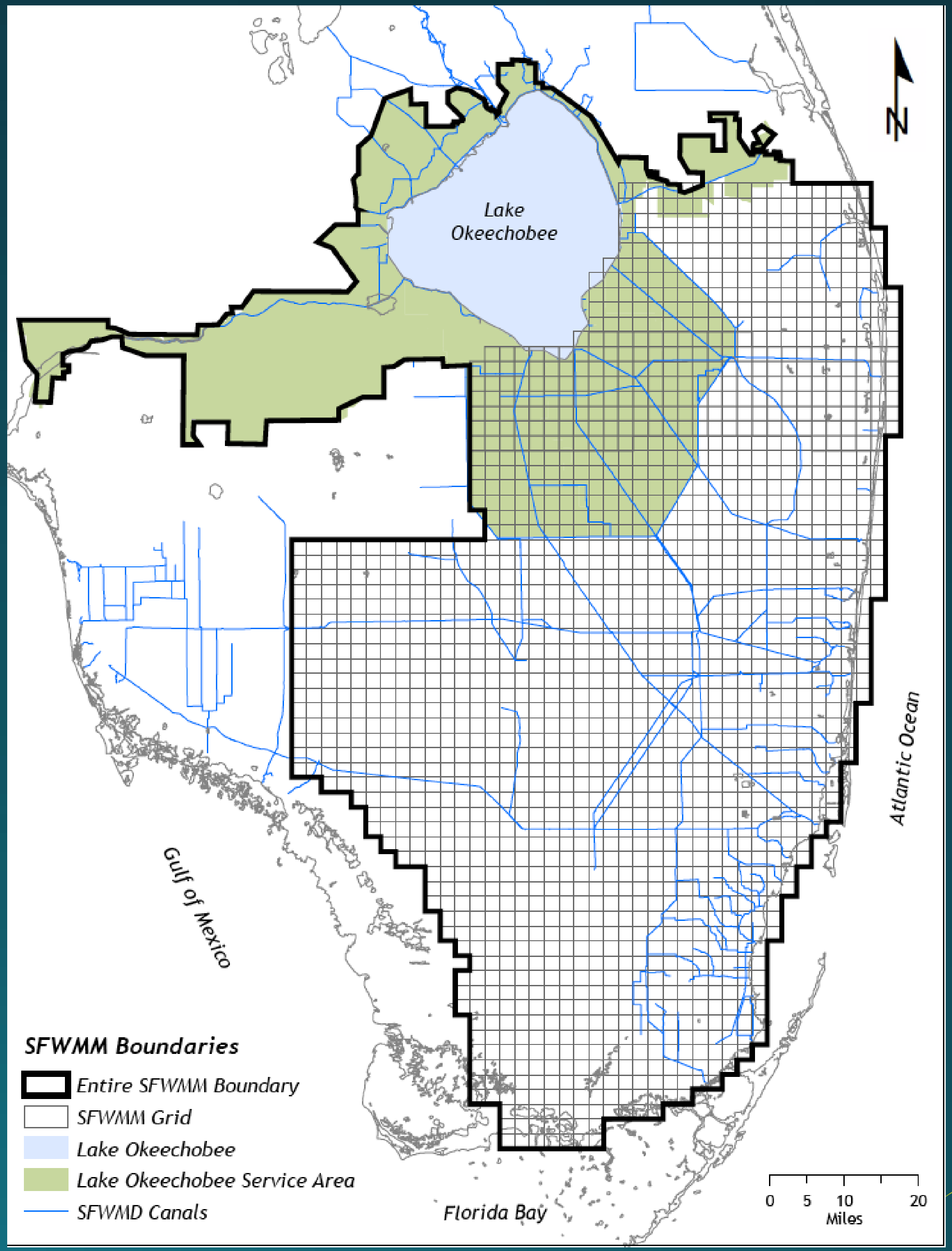
Research Motivation

- Our goal was to examine key restoration components such as storage, decompartmentalization, seepage control barrier, operational targets and demand that have the most impact on the hydrologic and ecologic responses in different regions of the Everglades.

- These components are interdependent; therefore, it is critical to have a knowledge of how these components interact and behave in the system for developing a sustainable restoration plan.

Hydrologic Modeling Tool

- The South Florida Water Management Model (SFWMM) is a physically-based, integrated surface water-groundwater model
- 2 mile x 2 mile grid size (known as "2x2 Model")
- Climatic data from 1965 to 2000
- Simulates major components of hydrologic cycles in South Florida as well as operational criteria
- SFWMM was used to develop CERP



Restoration Scenarios and Assumptions

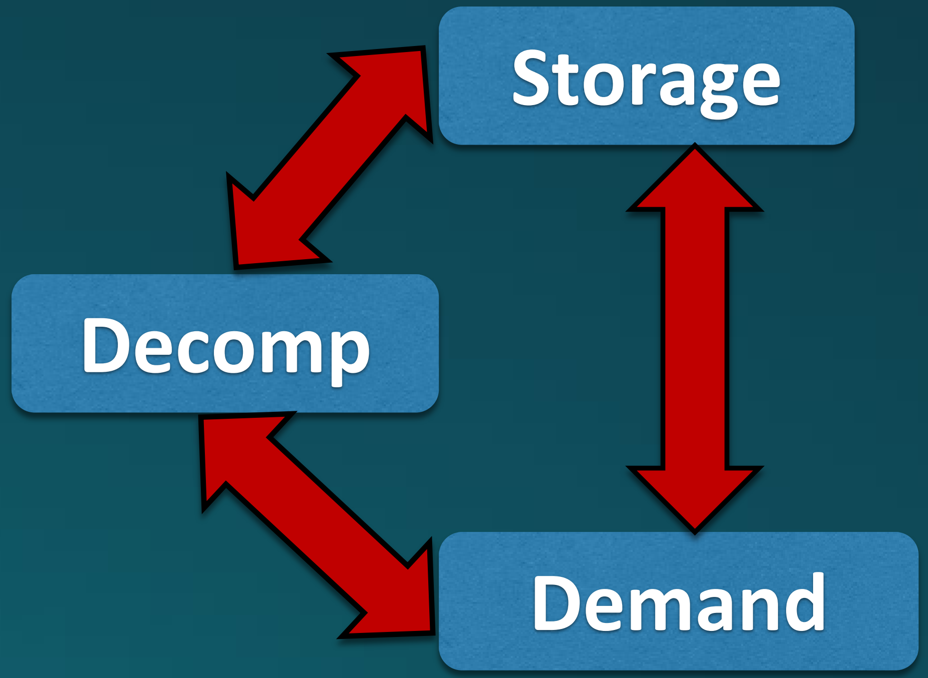
ECB = Current C&SF infrastructure and operating rules
CERP0 = Comprehensive Everglades Restoration Plan (CERP0)
CEP = Central Everglades Project including the Everglades Agricultural Area (EAA) reservoir; authorized by Congress in 2018

Following scenarios modify the CEP:

DECOMP = Decompartmentalization; removing barriers to sheetflow between Water Conservation Area 3A, 3B and Everglades National Park (ENP)
MaxS = Maximized surface water storage (~ 2 million acre feet of storage capacity)
SeepWall = Seepage control barriers along the eastern levee of WCA-3B and north-eastern part of the ENP
LakeS = Increased water storage in Lake Okeechobee
DECOMP+MaxS = Decomp with maximized surface water storage
LakeS+MaxS = Increased storage in Lake Okeechobee and maximized surface water storage

Sensitivity Analysis

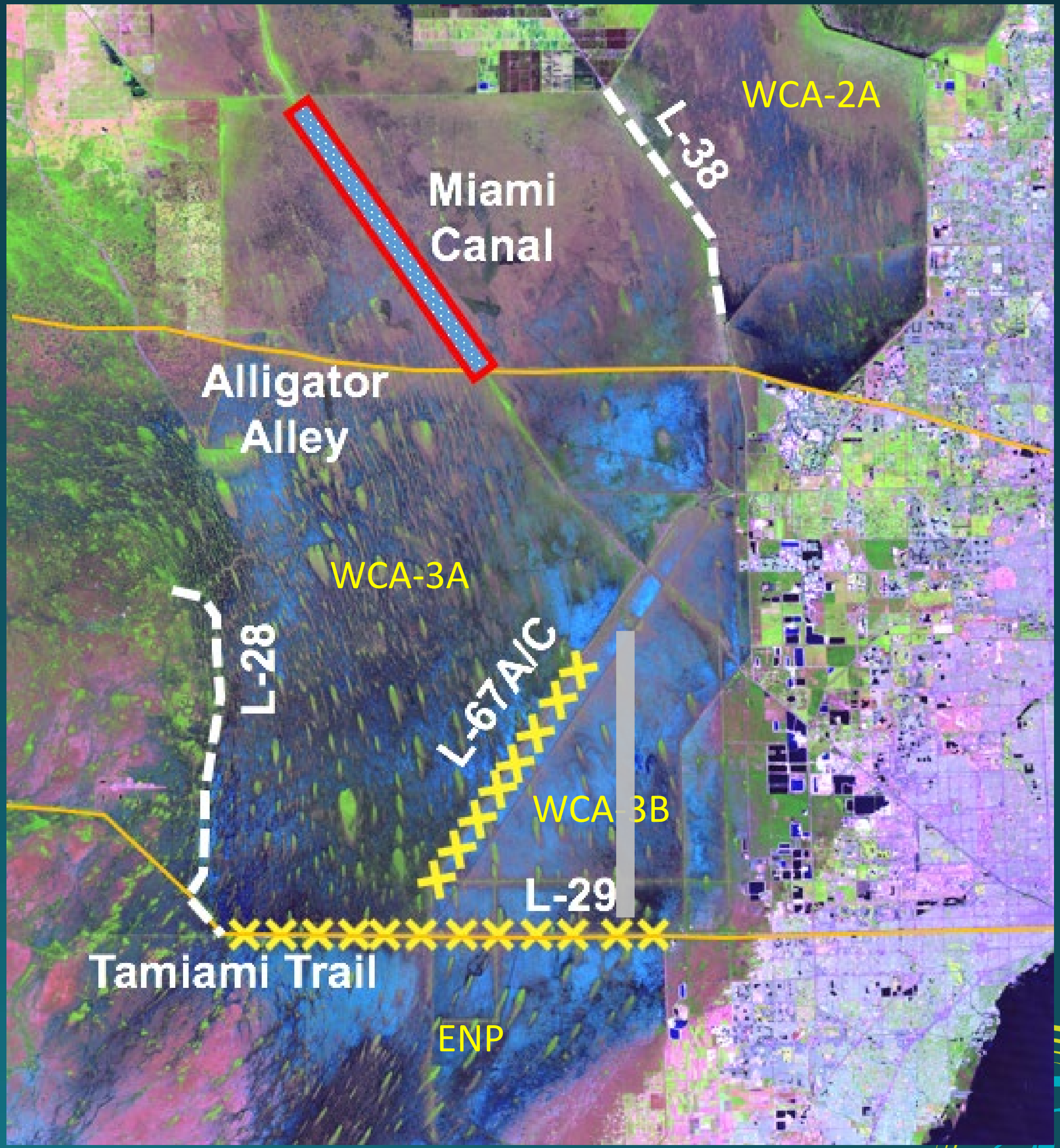
- Relationship between storage and decomp
  - Maximum storage capacity: 240,000, 500,000, 1.0 million, 1.5 million, and 2.0 million acre-feet
  - Decomp: Low-level (as used in the CEP) and high-level
- How environmental demand in Northeast Shark River Slough (NESRS) interacts with storage and decomp?



Decompartmentalization (Decomp)

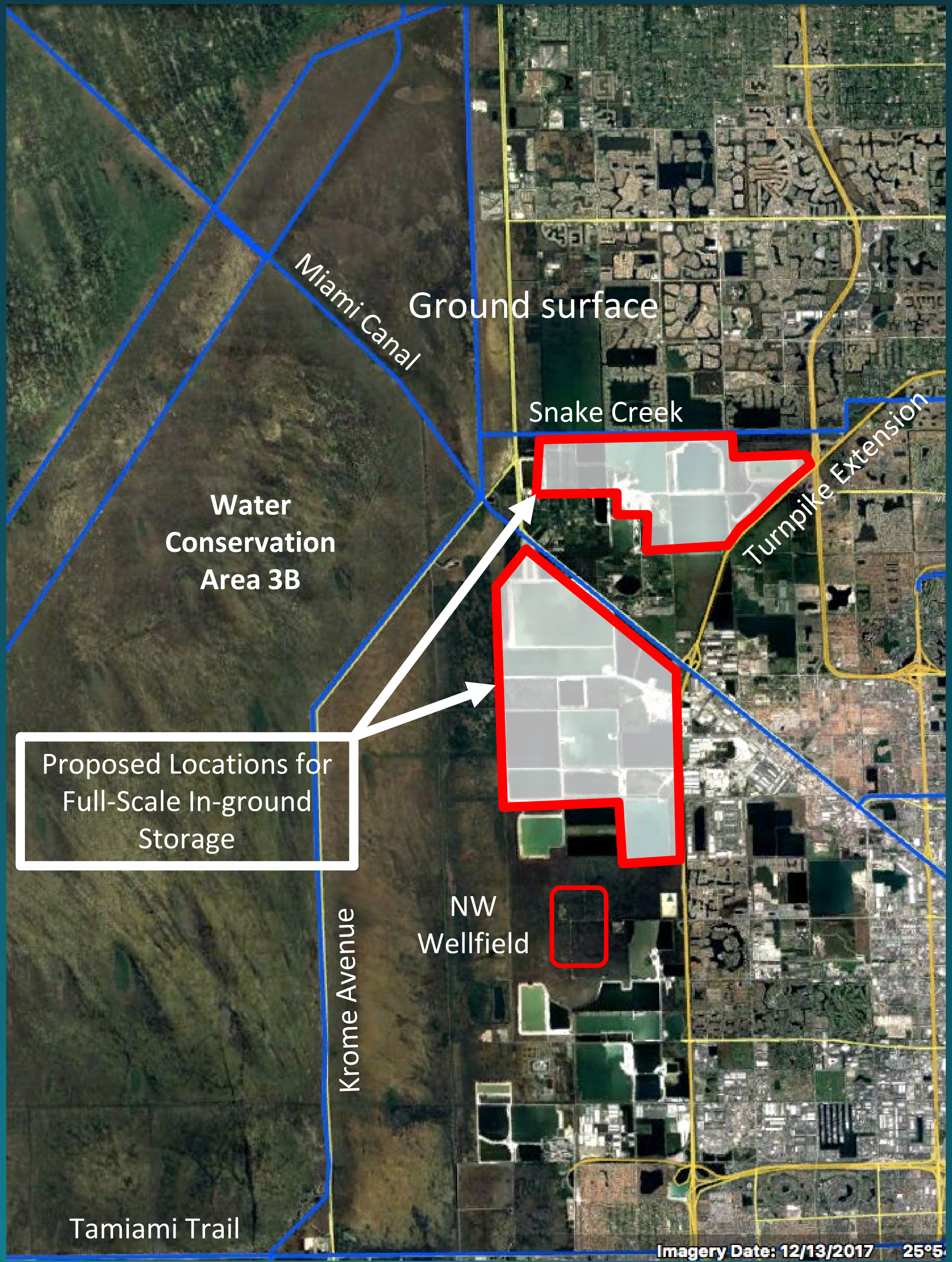
- Removed L-29 Canal and Levee
- Partially removed L-67A/C
- Expanded Blue-Shanty flow-way from CEP

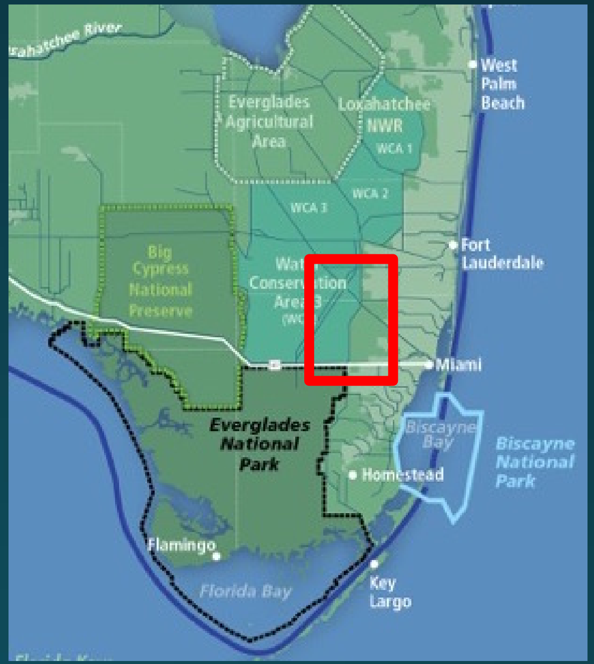
- Helps to move wet-year flows through the Everglades and reduce high-water levels in WCA-3A



Lake Belt Reservoirs

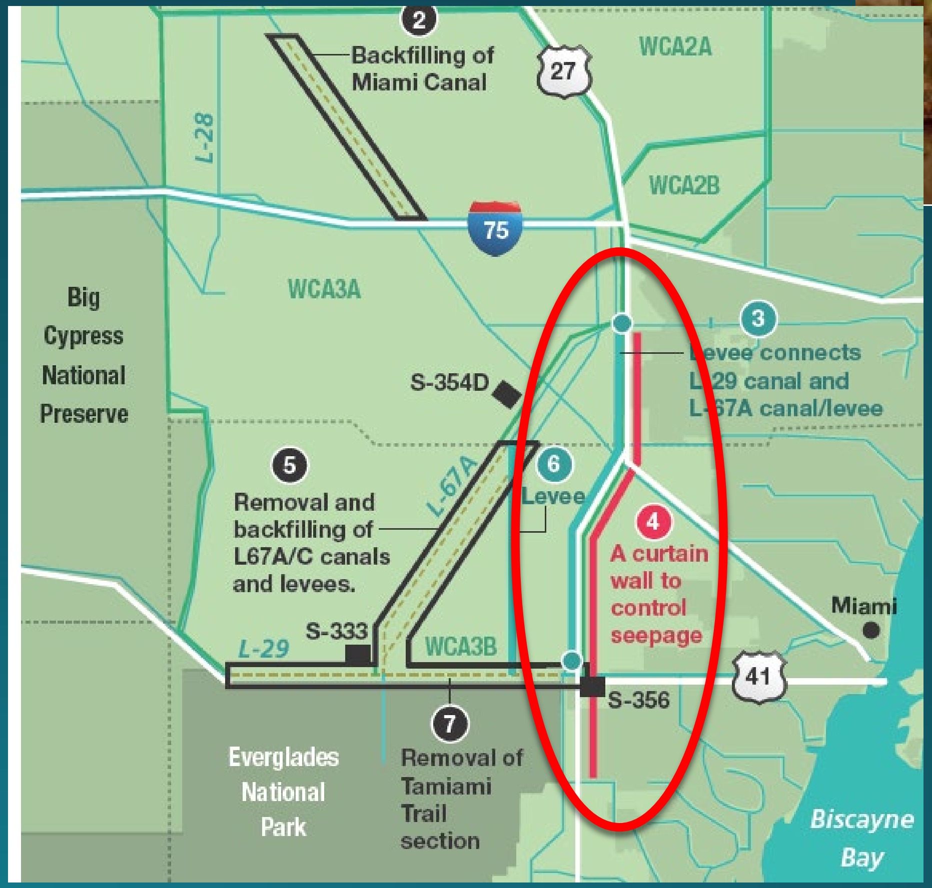
- In-ground reservoir technology
- ~ 280,000 acre-ft storage
- Located at former limestone mining sites and geology is too transmissive
- Many uncertainties
  - construction technology
  - storage efficiency
  - impacts on local hydrology
  - cost





Seepage Management

- Cut-off wall
- Captures seepage to the Lower East Coast, and re-routes to the eastern side of the ENP
- 26-mile long

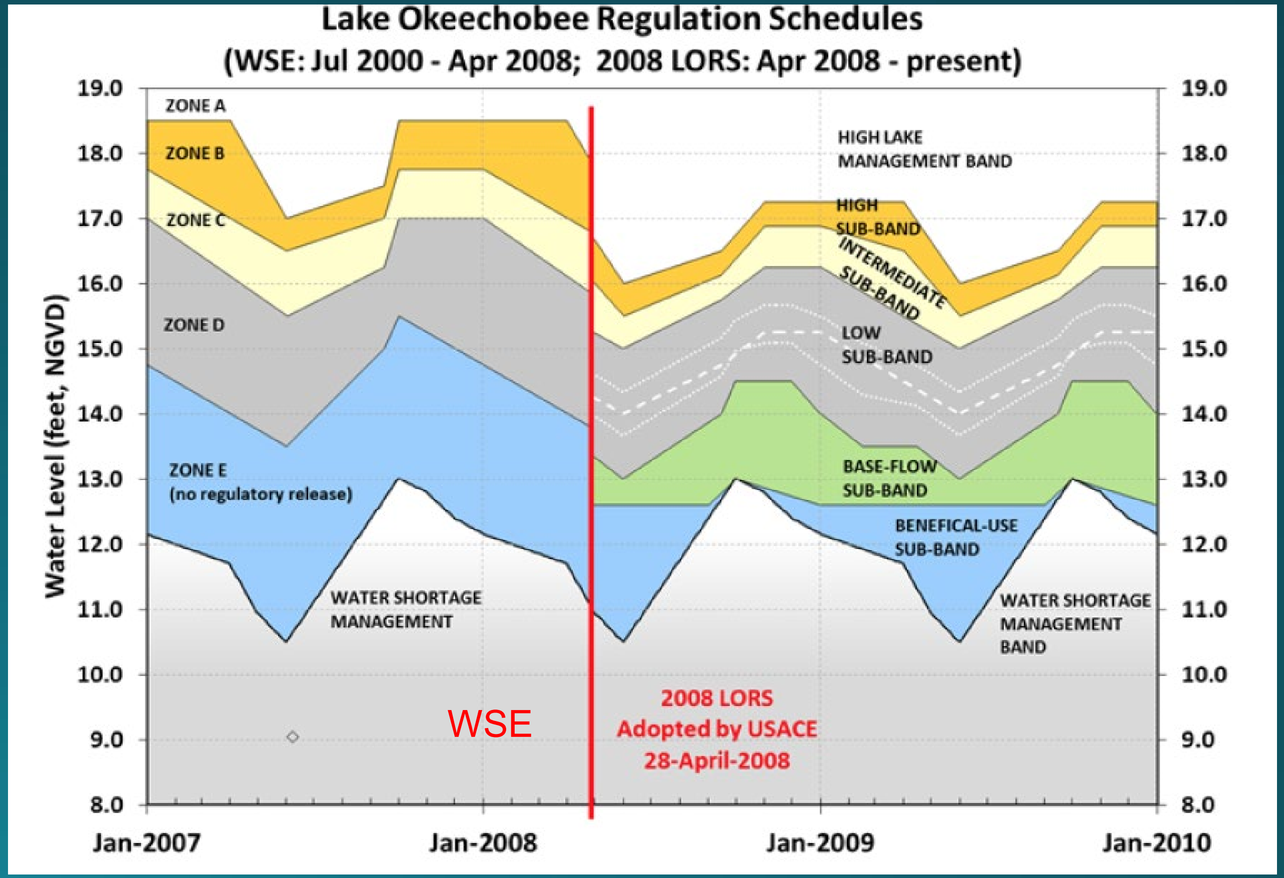


- To test whether seepage control barrier can be a replacement of Lake Belt reservoirs used in the CERP0 to provide dry season/drought flows to the ENP.

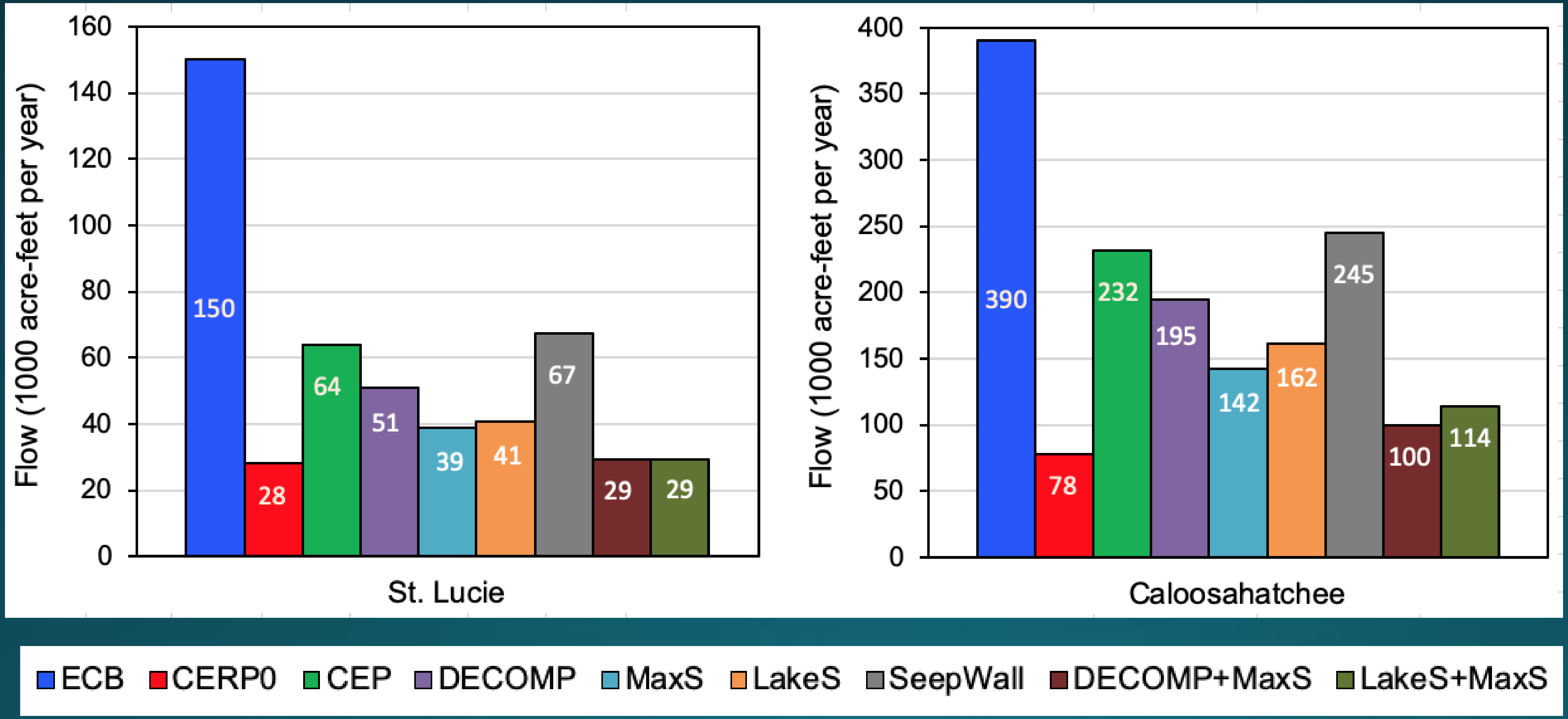
Lake Okeechobee Operations

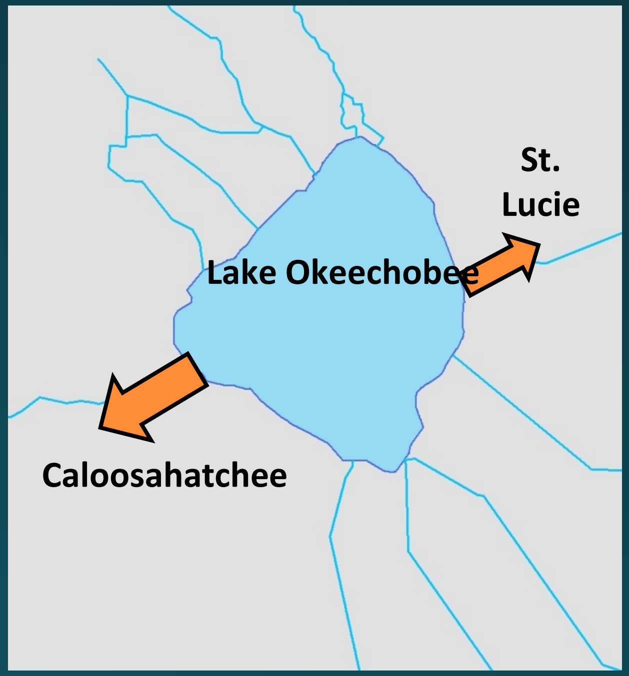
- In 2008, USACE implemented an interim Lake Okeechobee Regulation Schedule 2008 (LORS 2008)
    - ➢ Operates the lake in a lower level than WSE schedule
- To evaluate the response of the lake with higher lake stages under the assumption that the lake would be able to hold more water after the dike repair completes.

Herbert Hoover Dike

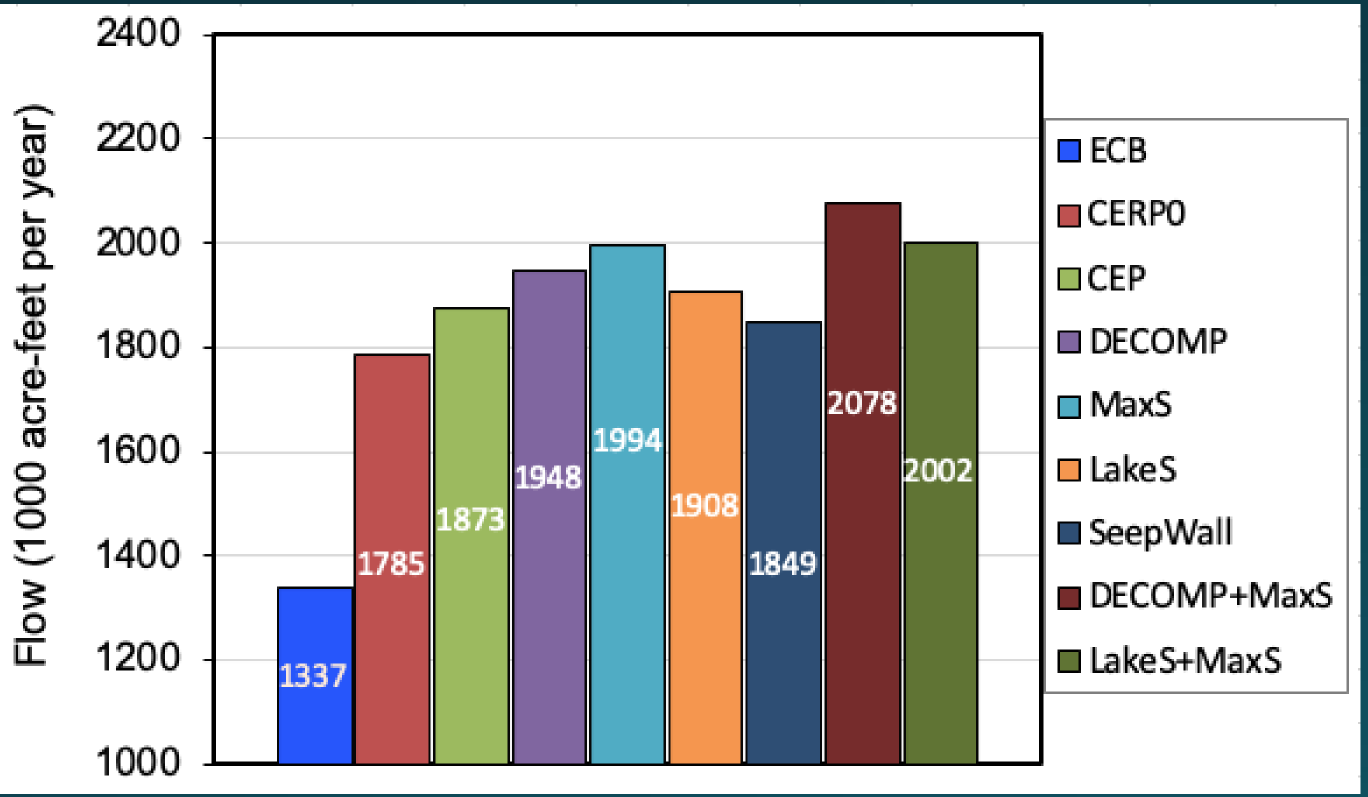


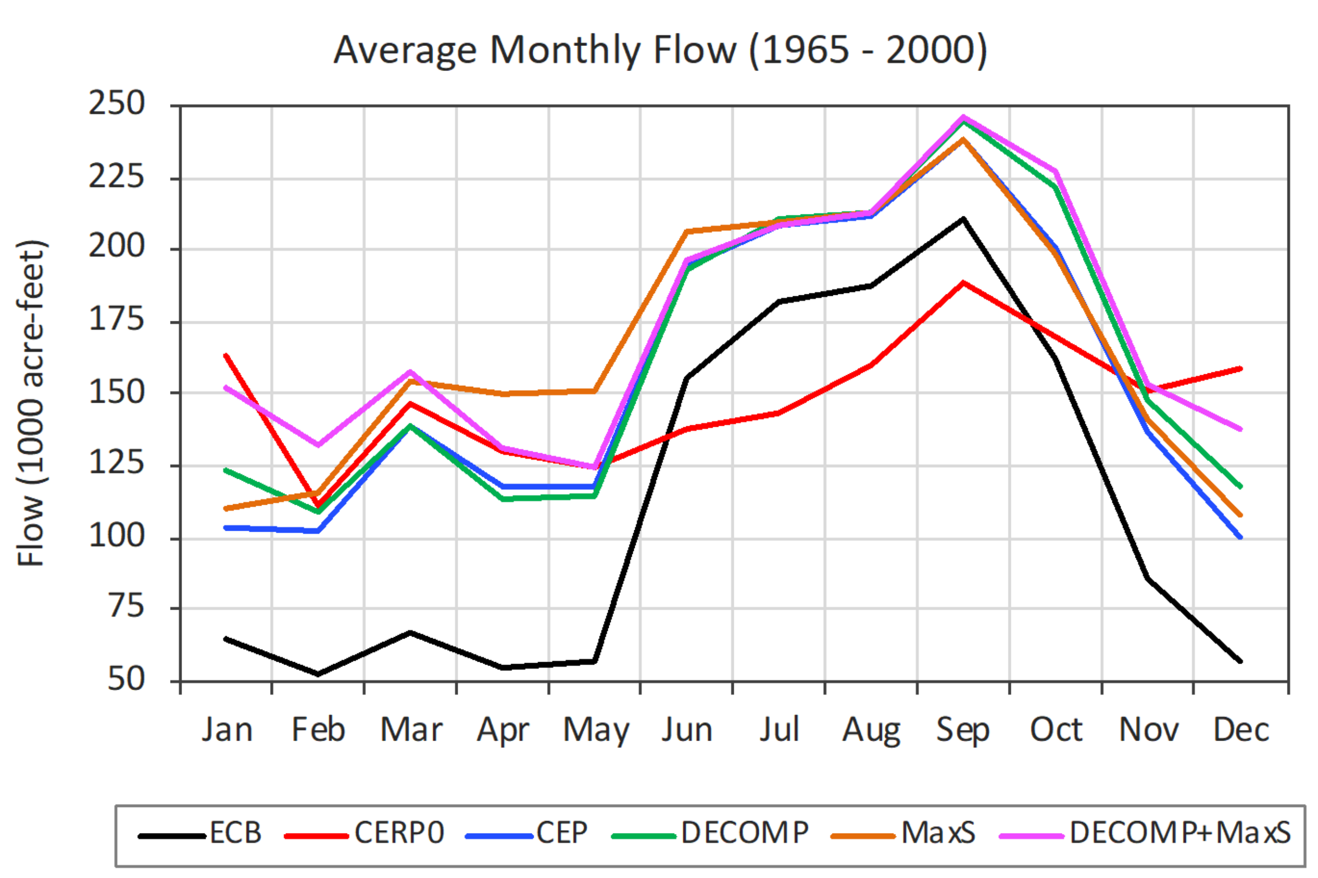
Regulatory Discharges to Northern Estuaries

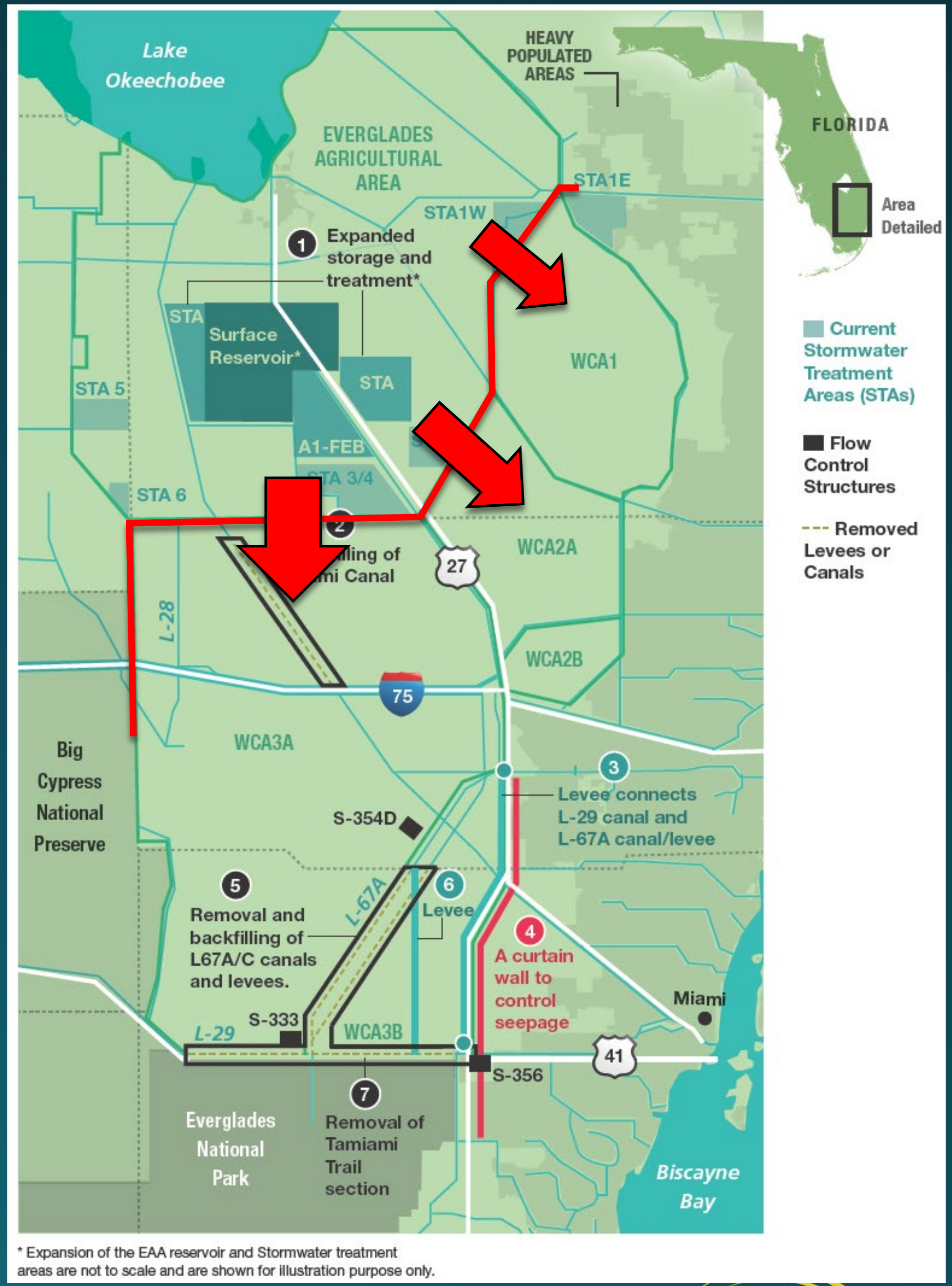




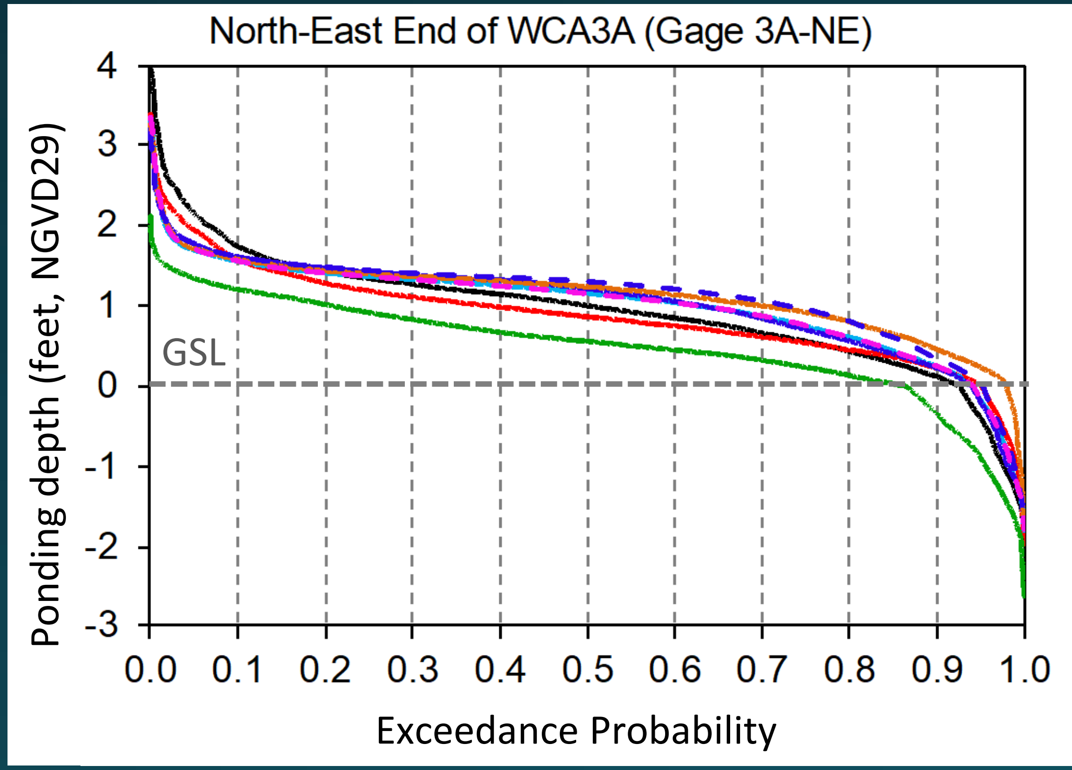
Flow into the Everglades

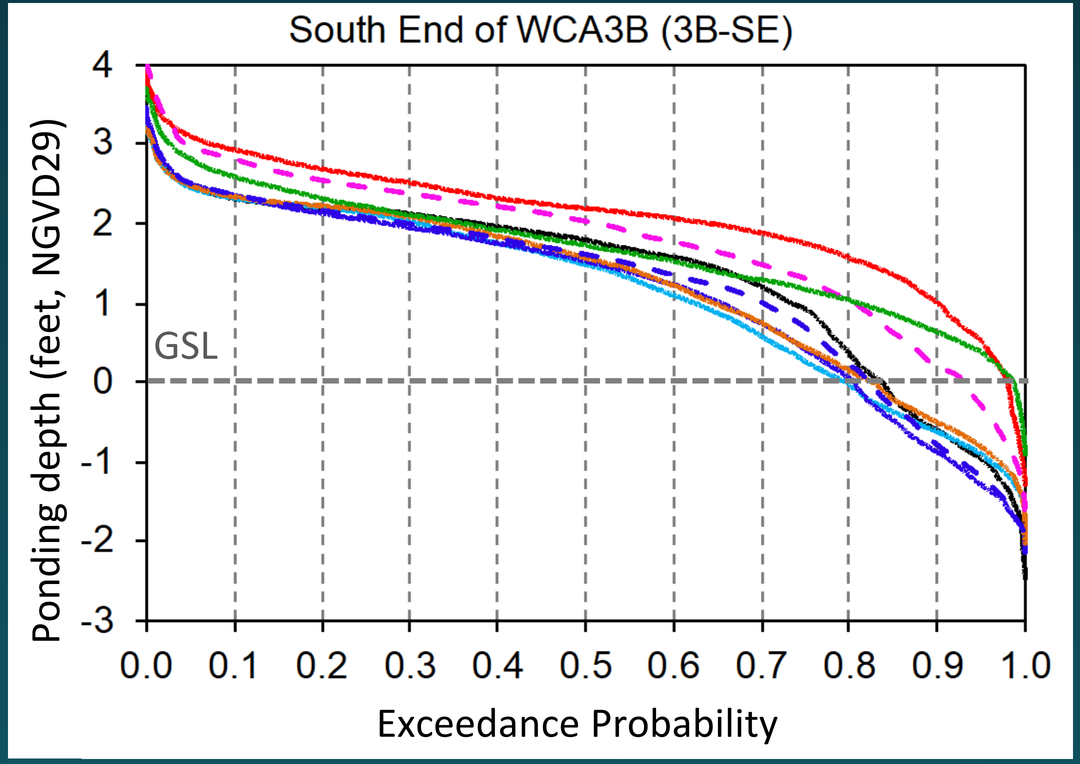


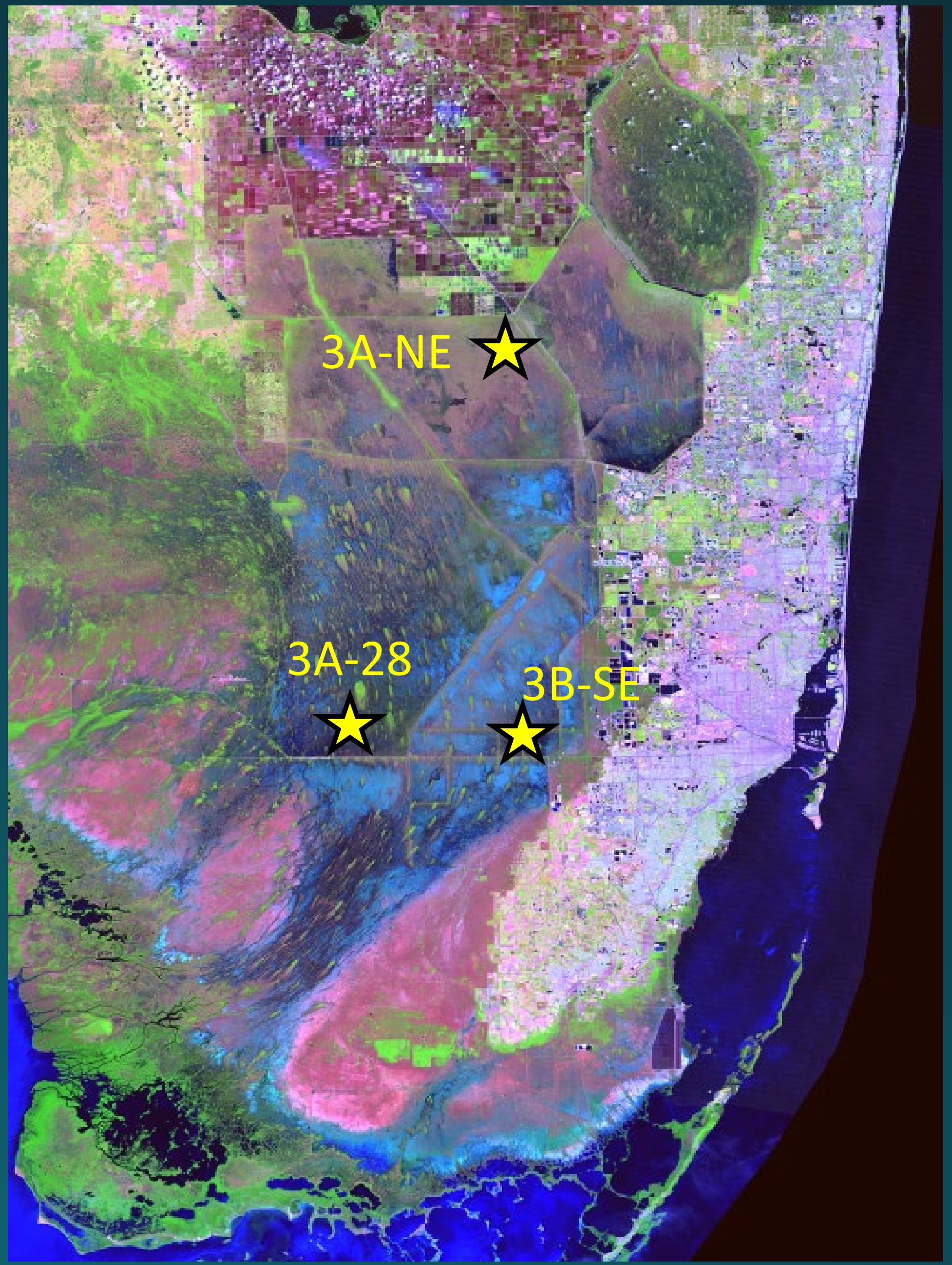


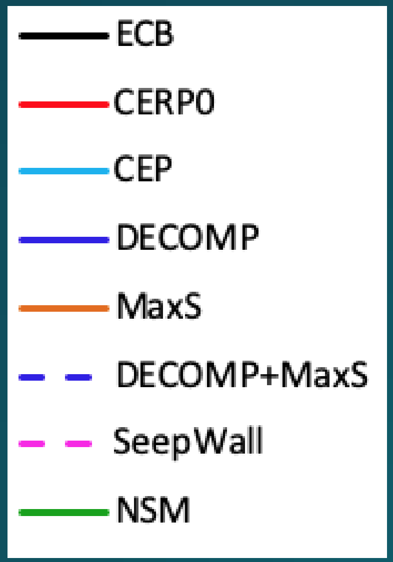


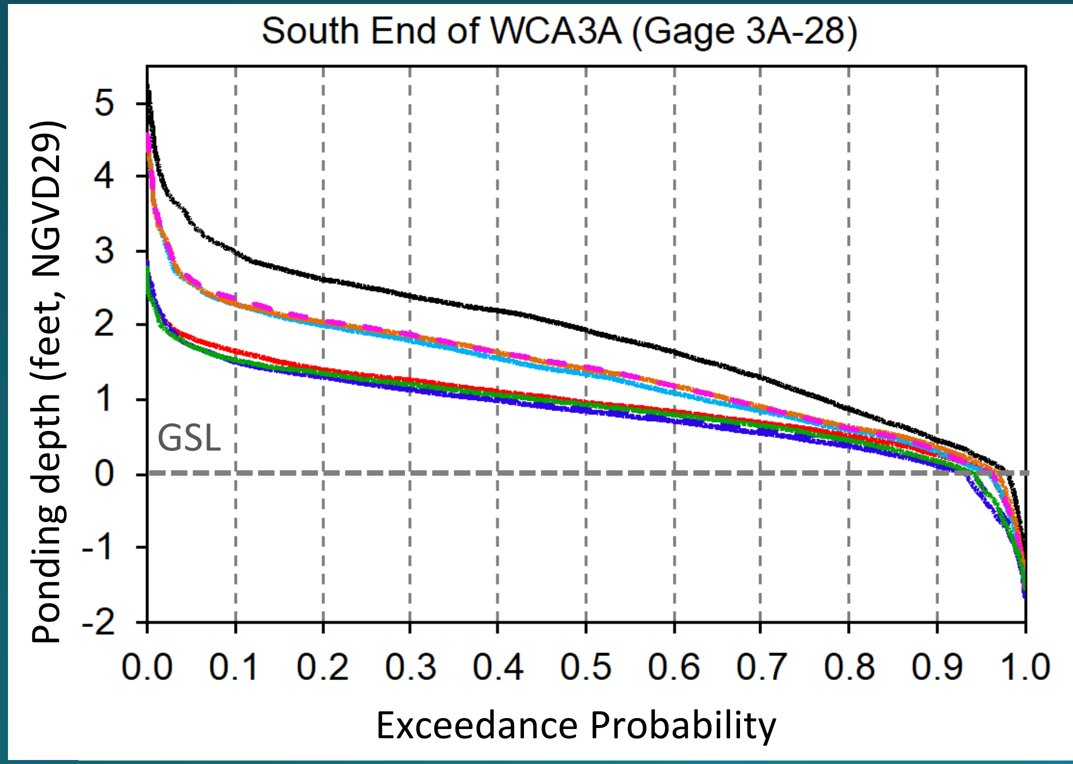
Depth Duration Curves











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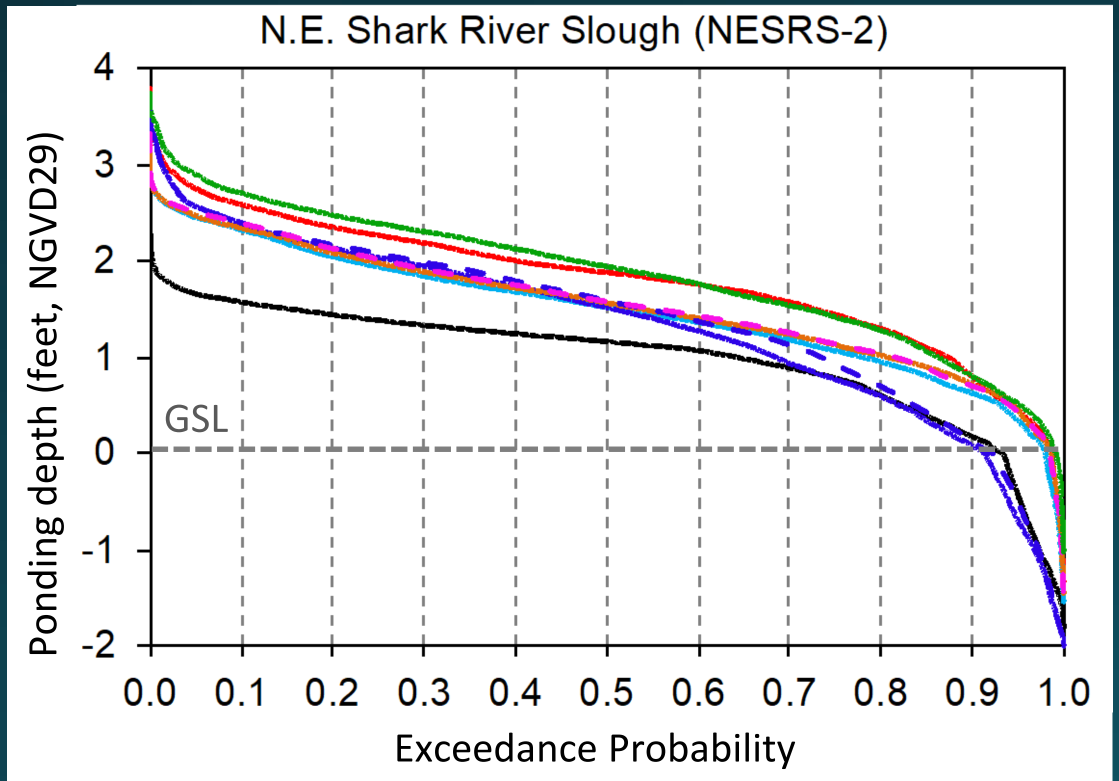
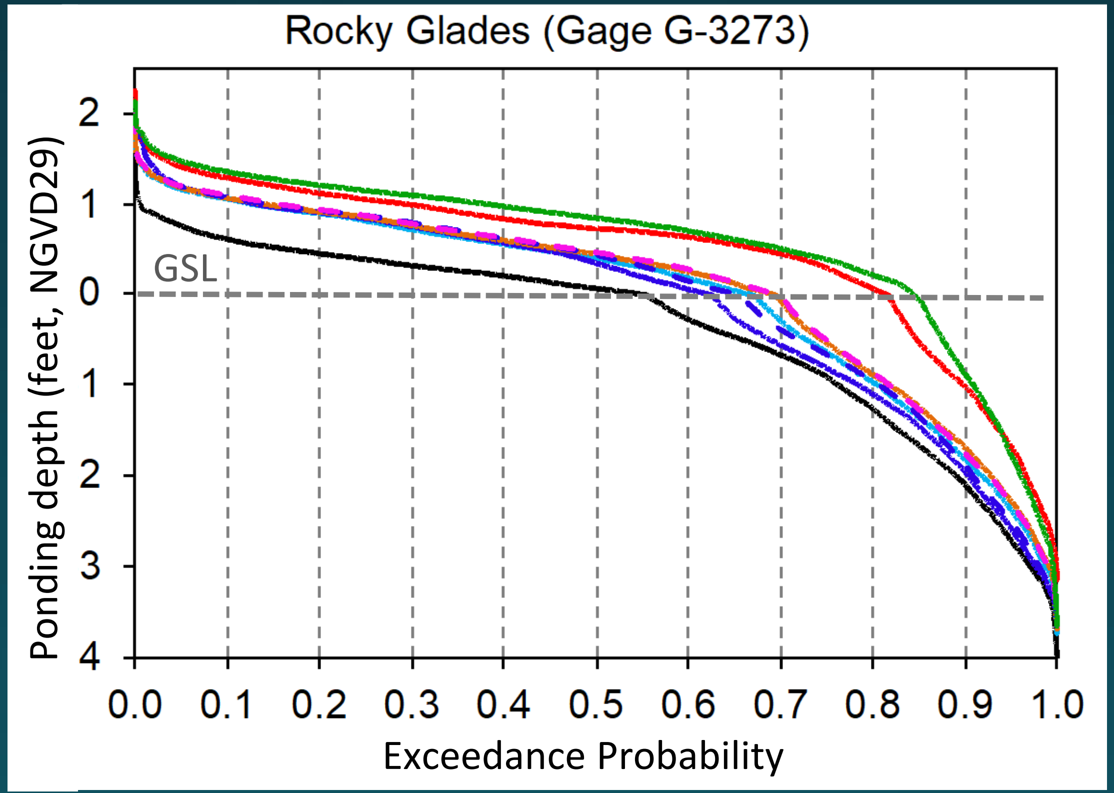
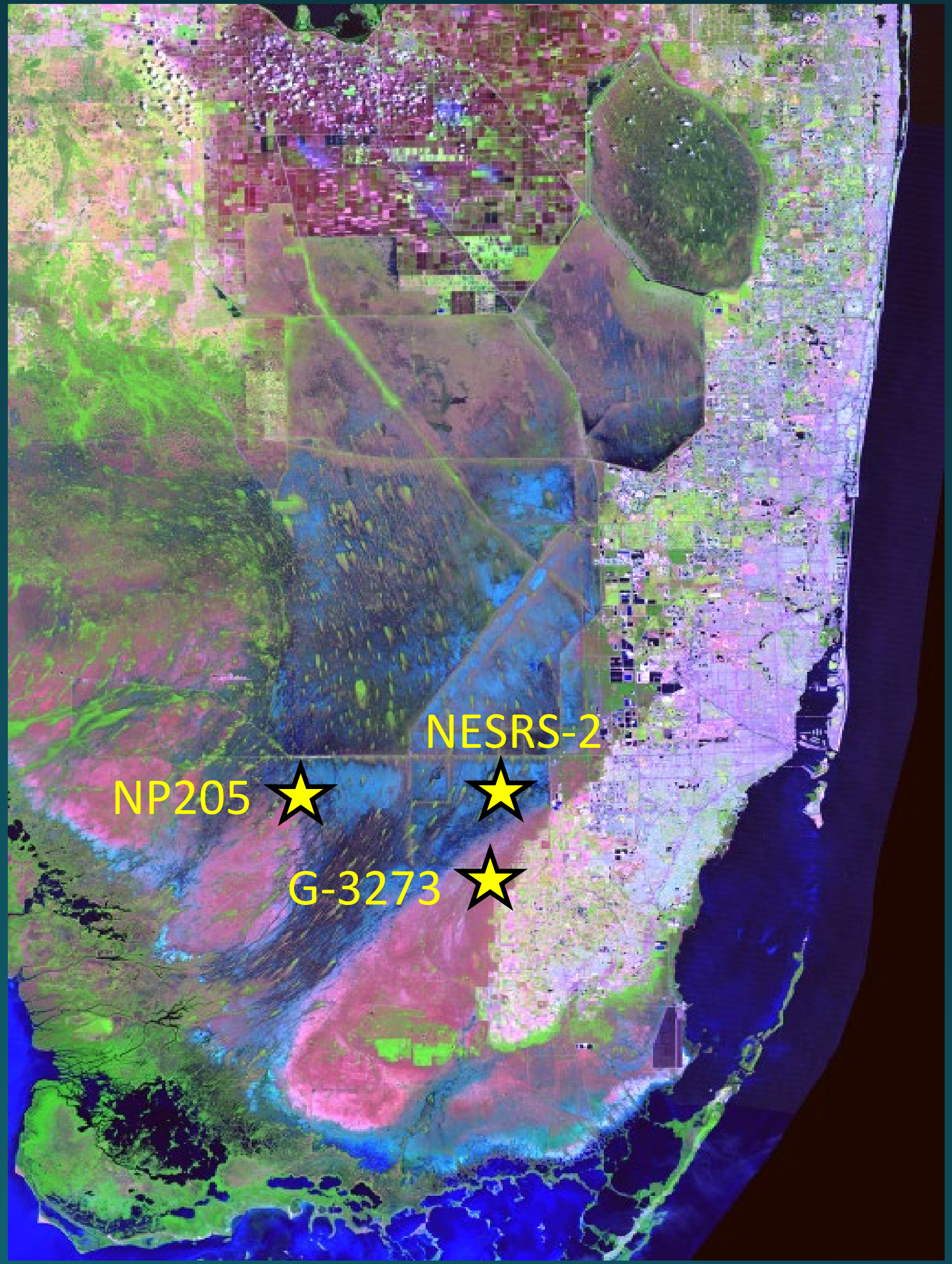
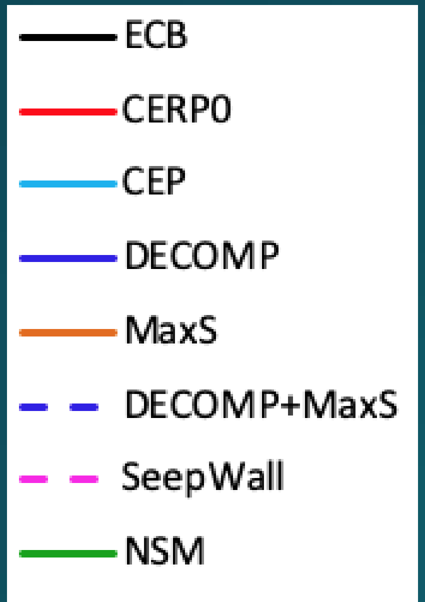
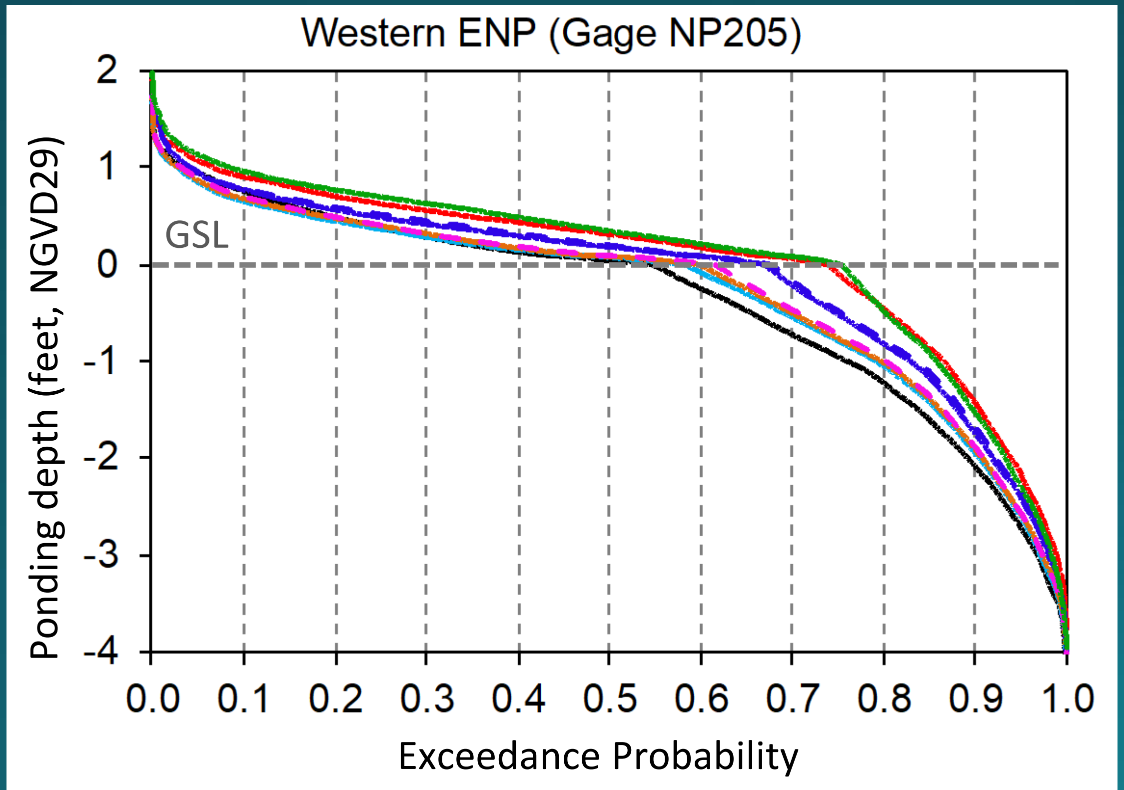


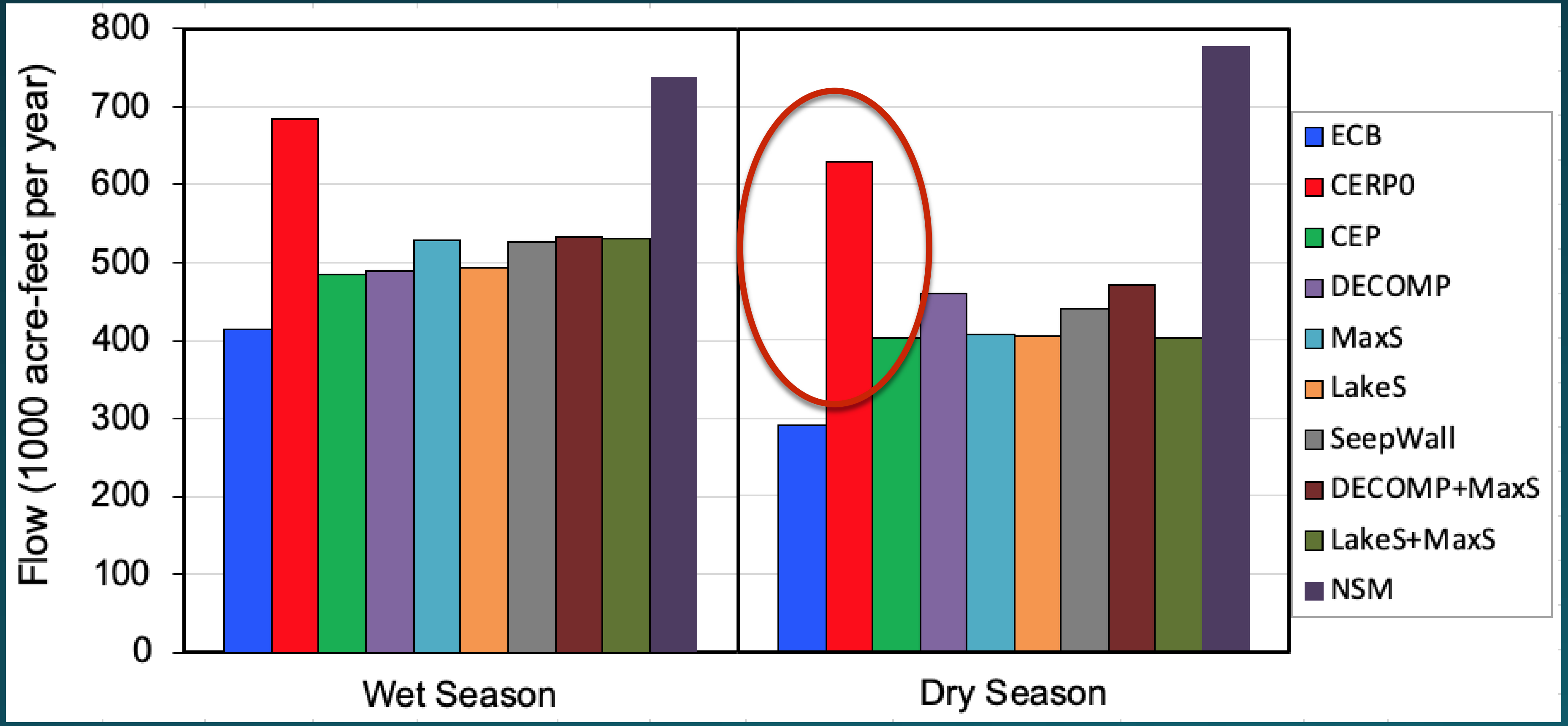


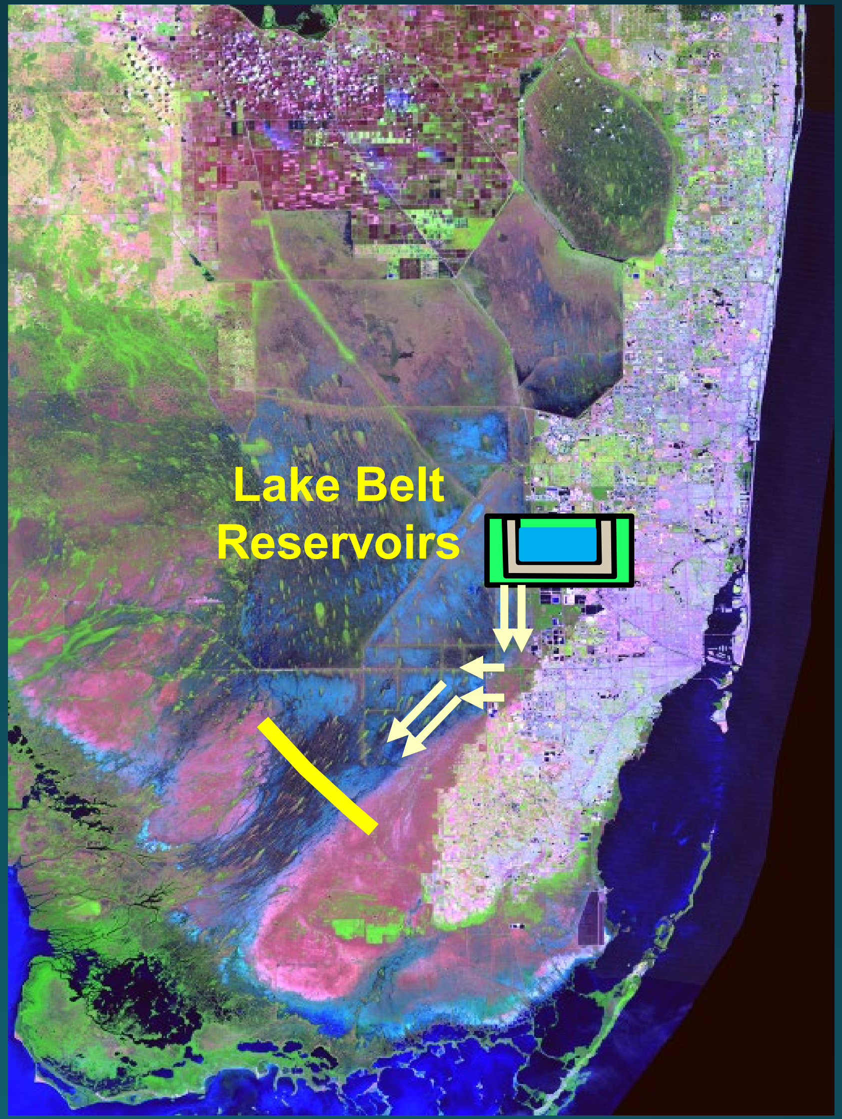






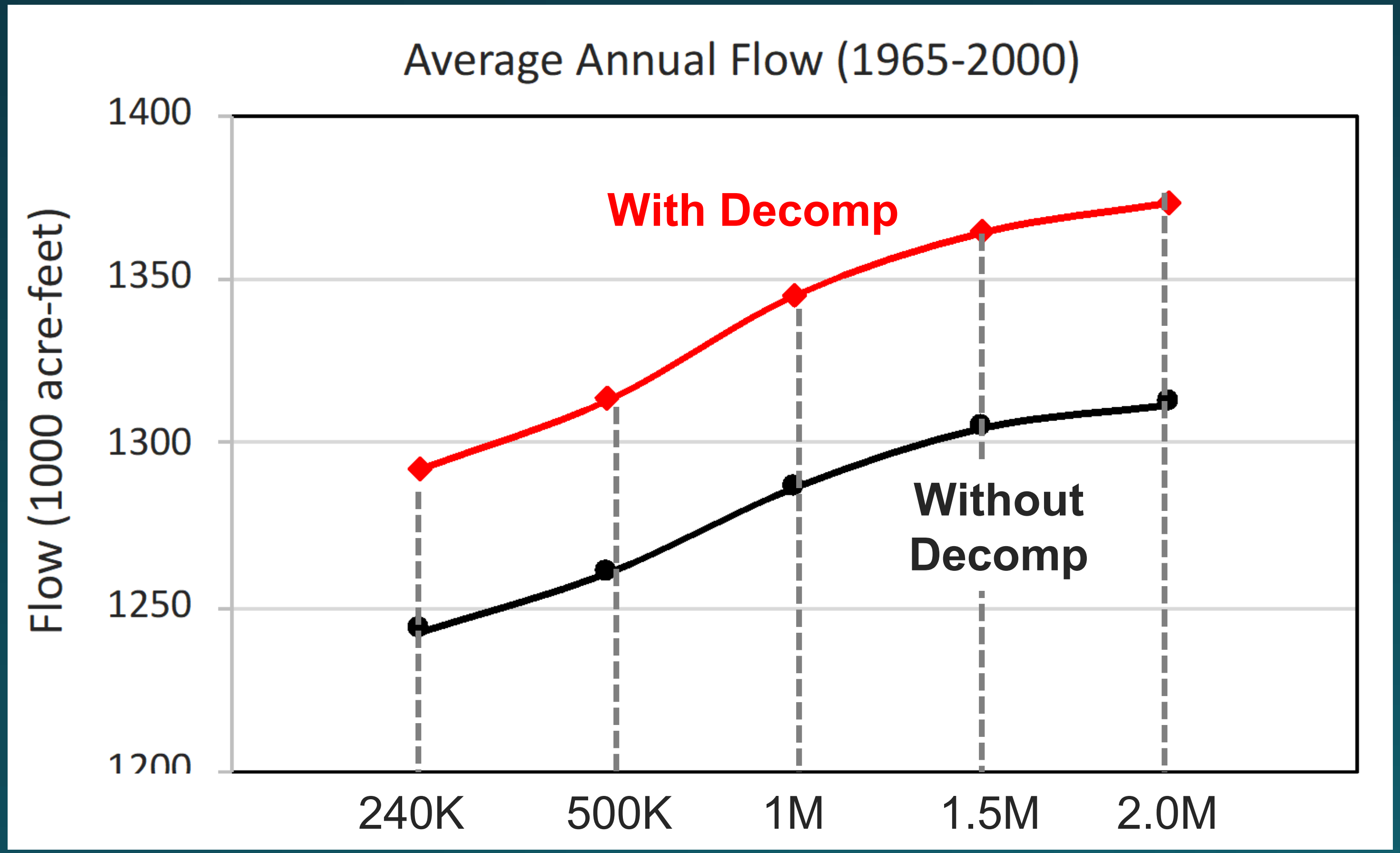
Flow through Shark River Slough

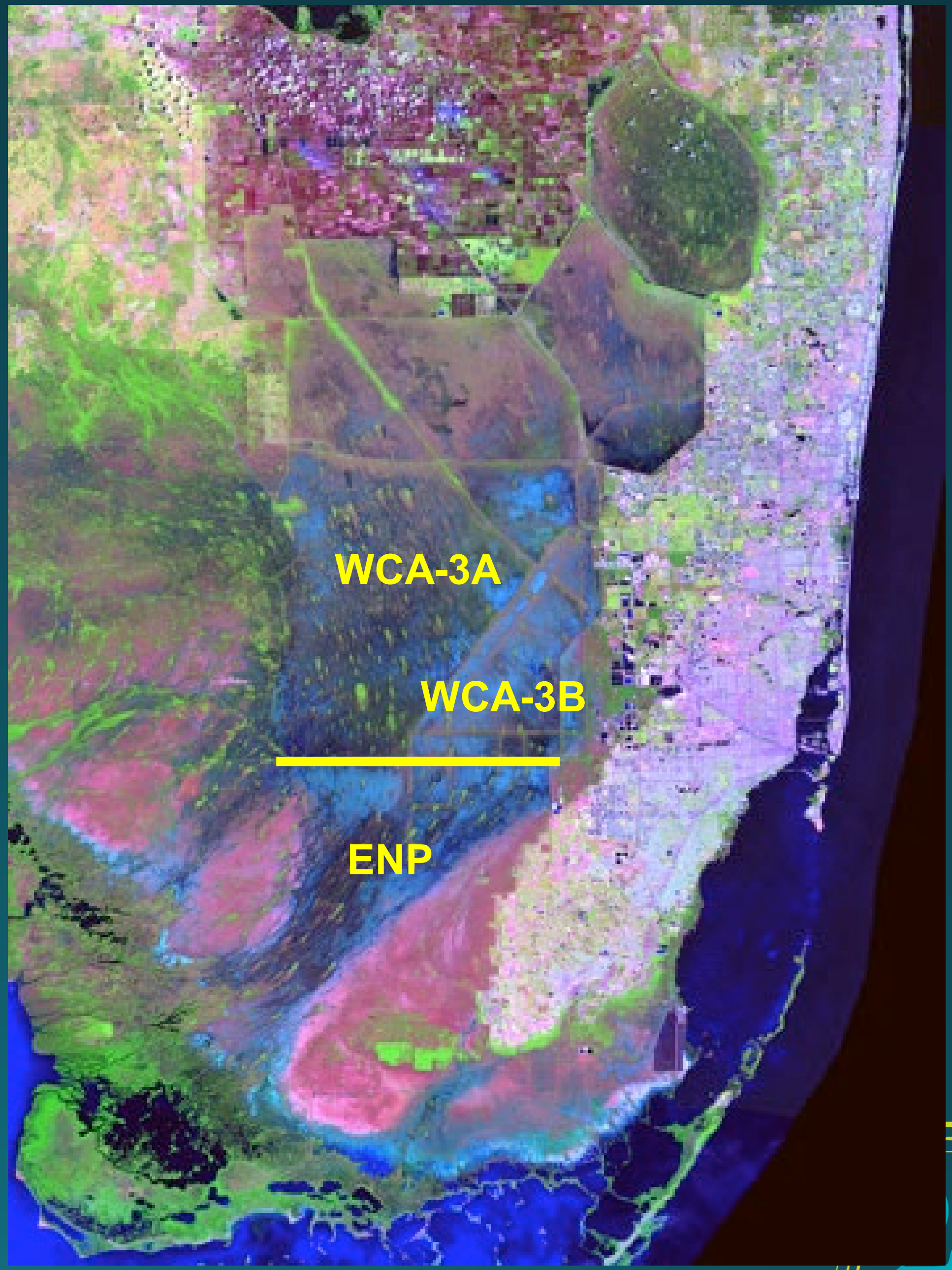




- Benefits to the Everglades National Park are highly dependent on Lake Belt reservoirs.
- By replacing Lake Belt reservoirs with seepage control barriers (curtain walls), we didn't get the same benefits to ENP and Biscayne Bay.

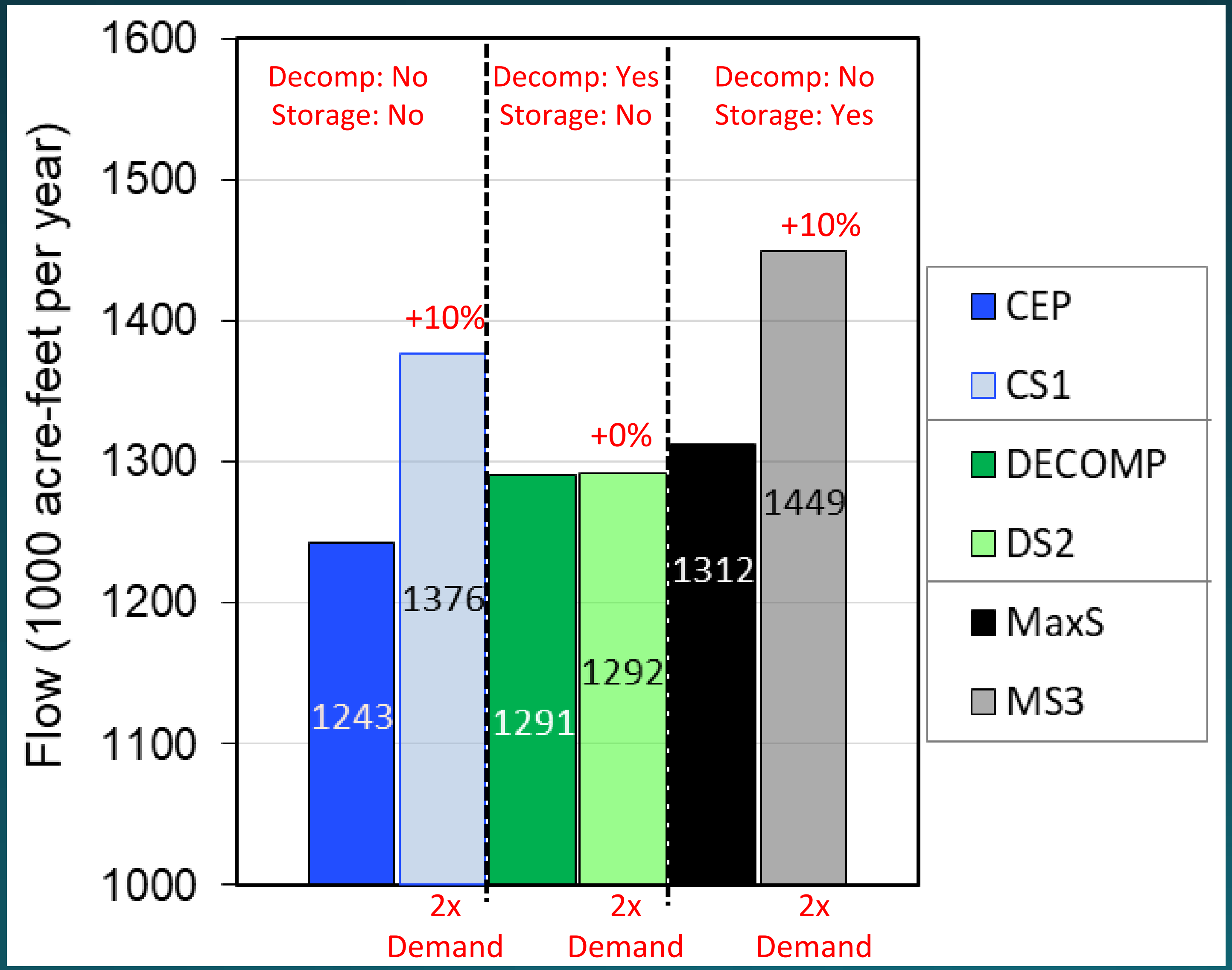
Storage vs Decomp

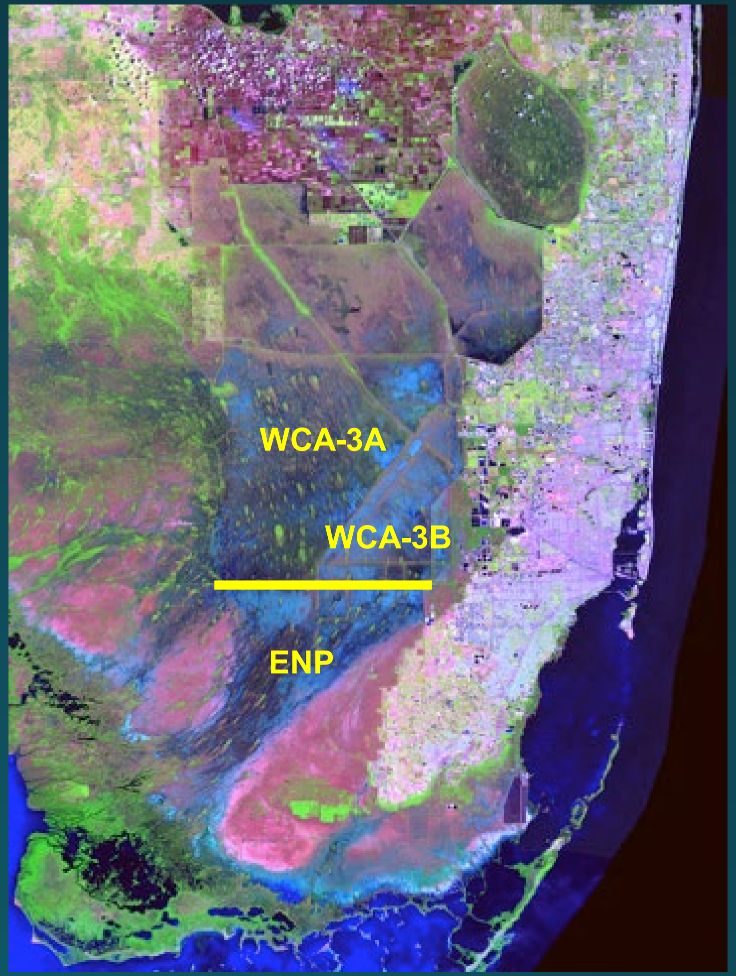




- The increase in the amount of flow through the Everglades is not substantial relative to the size of the storage
- High water levels in northeastern region of WCA-3A is constraining the delivery of water from the reservoir

SRS Demand vs Storage/Decomp



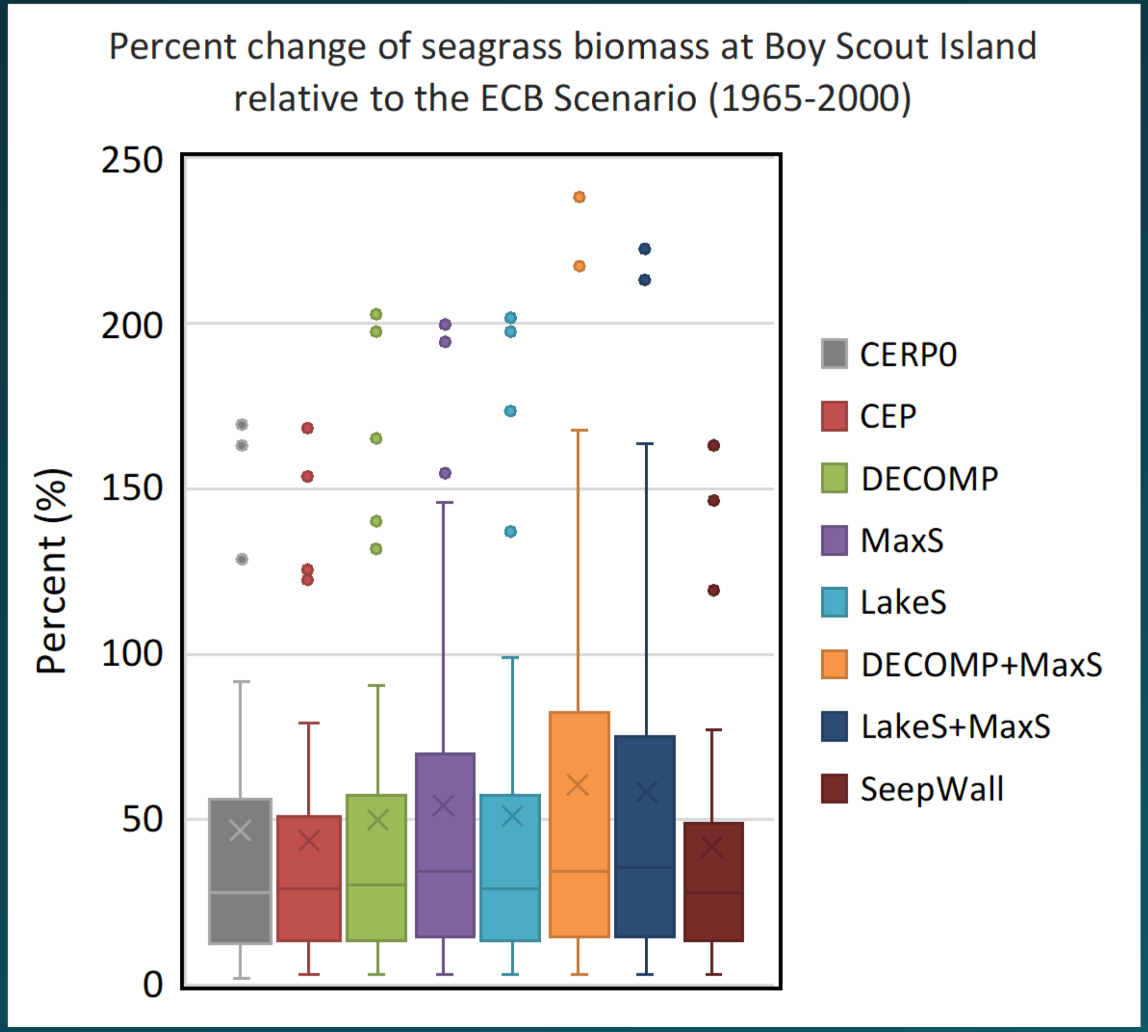


- The environmental demand in ENP had impacts on the delivery of water from WCA3 to ENP.
- The SRS demand was influenced by the storage size but insensitive to flow under the decomp conditions.

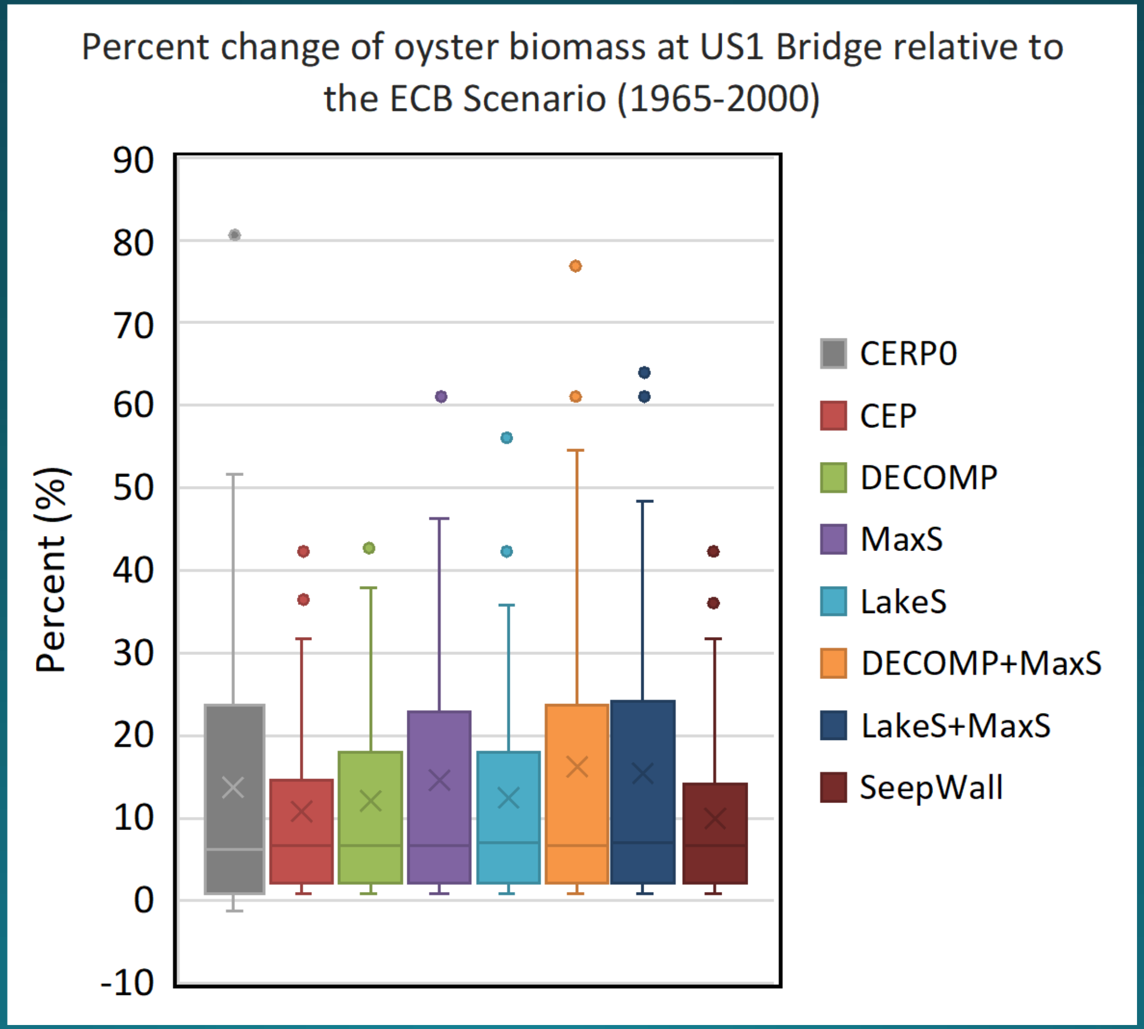
Ecological Tools used in this Study

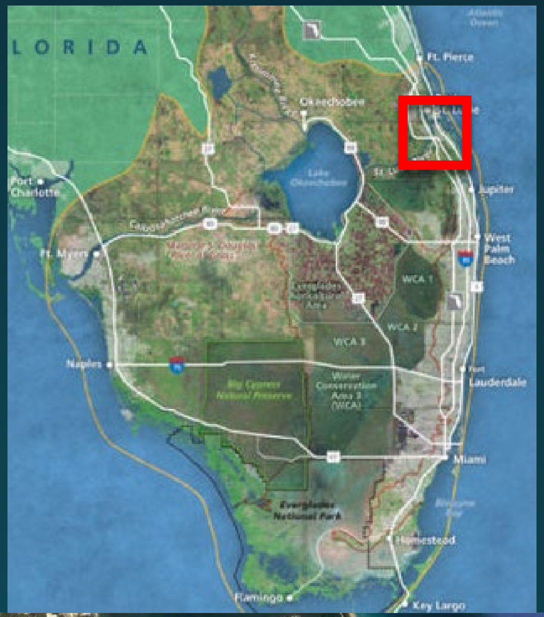
- Oyster and seagrass density for Caloosahatchee and St. Lucie River Estuaries
- Wading birds (Occurrence, foraging probability)
- Prey-based freshwater fish density
- Alligator habitat suitability index
- Everglades Landscape Vegetation Succession Model (ELVeS)
- Slough vegetation index
- Apple snail population
- Marl Prairie/Cape Sable Seaside Sparrow habitat suitability
- Tree islands
- Crocodiles (population size, growth rate, nest numbers and survival rates)
- Pink shrimp growth and harvest

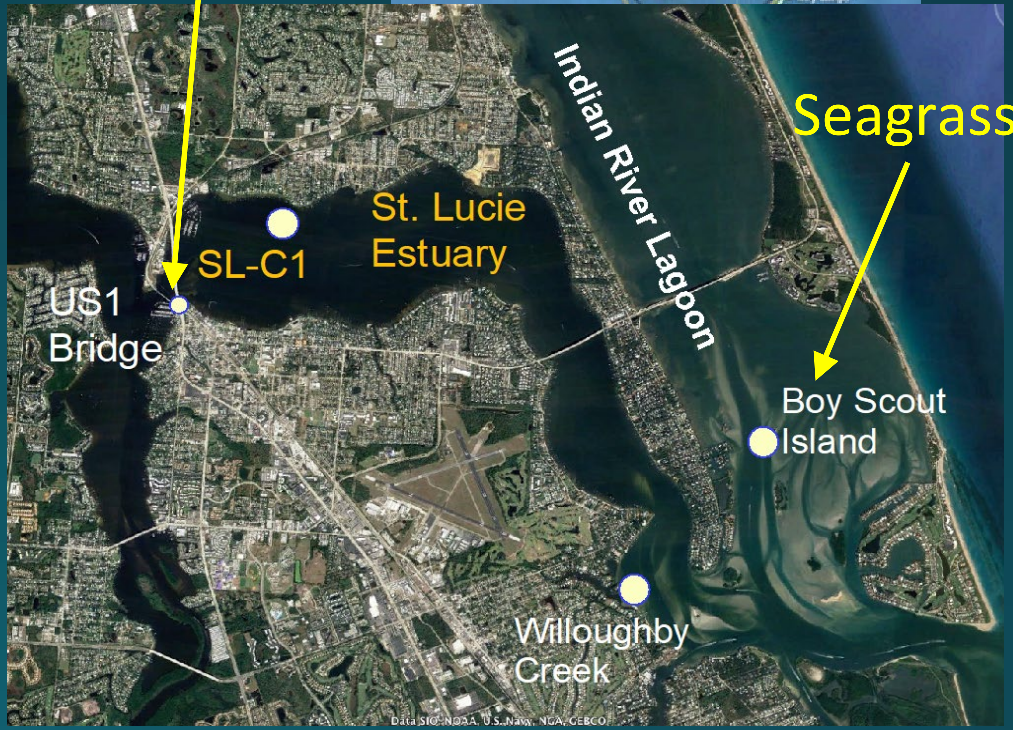
St. Lucie River Estuary



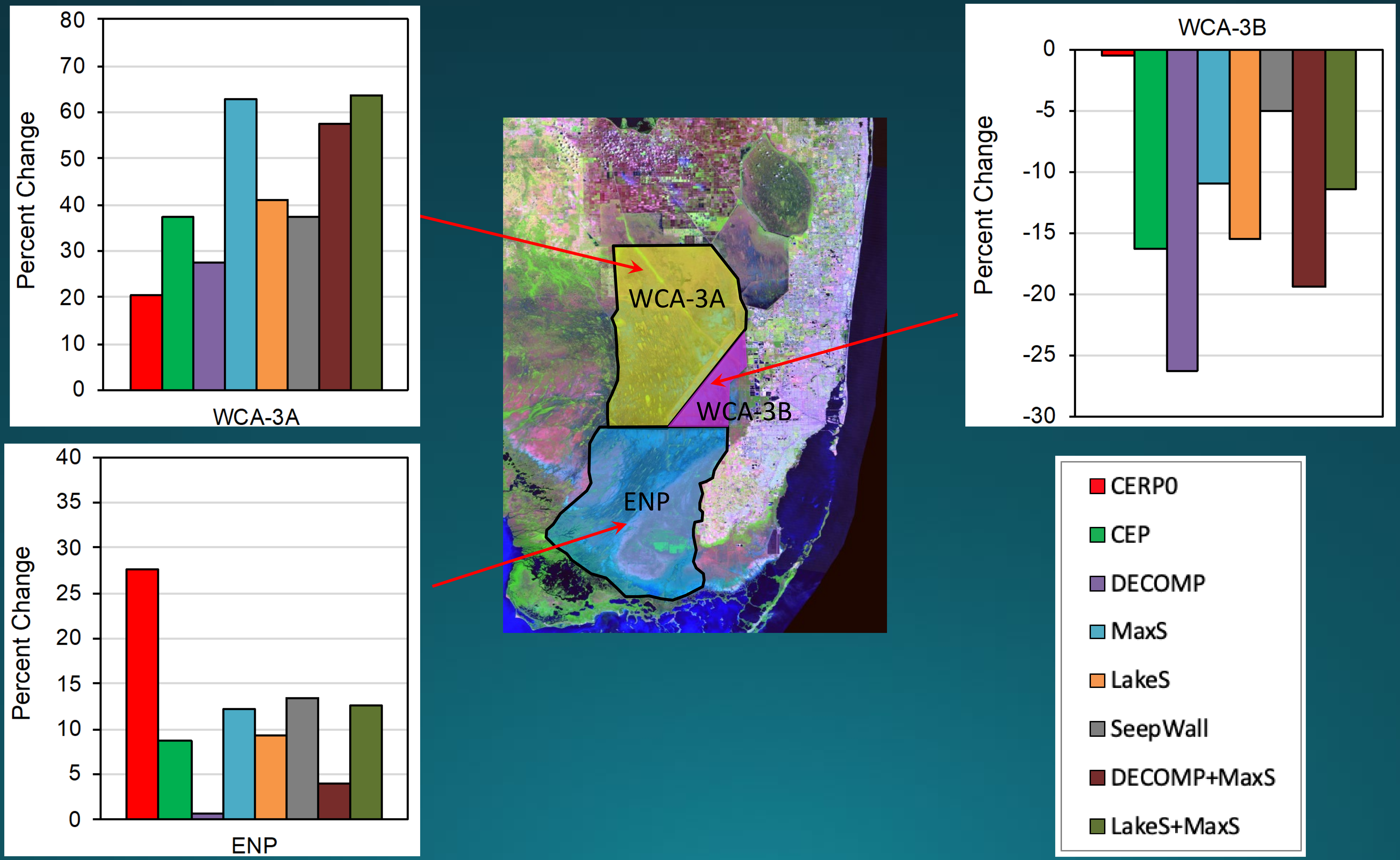
Mean annual % change relative to the ECB	
CERP0	47.0
CEP	43.4
DECOMP	49.4
MaxS	54.3
LakeS	50.8
DECOMP+MaxS	60.4
LakeS+MaxS	57.9
SeepWall	41.8







Alligator



Percent Change
80
70
60
50
40
30
20
10
0
WCA-3A
WCA-3B
0
-5
-10
-15
-20
-25
-30
Percent Change
40
35
30
25
20
15
10
5
0
ENP
ENP
CERP0
CEP
DECOMP
MaxS
LakeS
SeepWall
DECOMP+MaxS
LakeS+MaxS

Conclusions

- Decomp is essential to reduce excessively high-water conditions in central and southern WCA-3A.
  - Decomp alone drains WCA-3A during both wet and dry periods; therefore, it should be done with conjunction of storage to provide dry season flow to ENP.
  - Decomp raises water levels in WCA-3B.
- The increased size of the storage increases benefits in reducing the regulatory discharges; however, the rate of increased flow through the Everglades decreases relative to the size of the storage – a diminishing return.
- Location of storage features and environmental demand are important components.
- The ENP demand is strongly influenced with the amount of storage.
- Storing water in the Lake Okeechobee provides benefits to the northern estuaries as well as water supply benefits but only marginally increases flow to the south.
- There are trade-offs in ecological benefits between different basins and regions.

Sailing the River of Grass back when the Everglades was still untouched. Source: American Museum of Natural History

Caloosahatchee River Estuary