Water Management Under Severe Storm Conditions in Central and South Florida

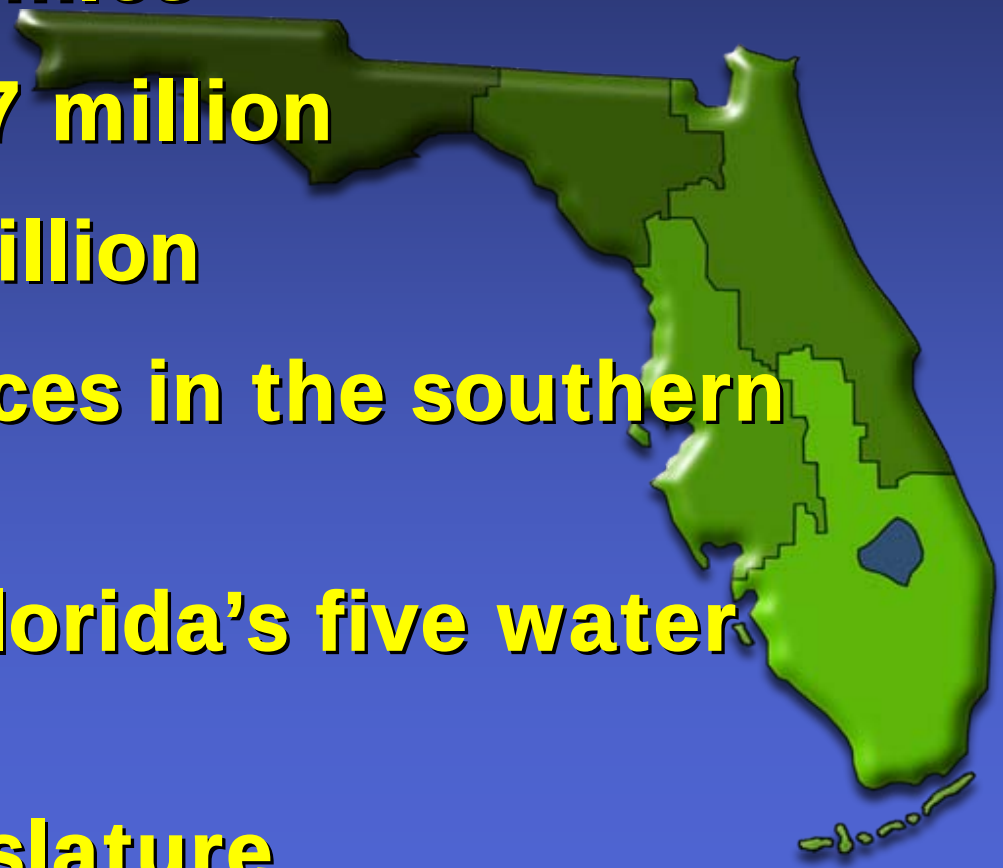
Chandra S. Pathak, Ph.D., P.E.

Severe Storm Prediction and Global Climate Impact in the Gulf Coast Conference

October 29 to 31, 2008

The South Florida Water Management District

- Covers 18,000 square miles
- Population more than 7 million
- FY 2008 Budget $1.3 Billion
- Oversees water resources in the southern half of the state
- Oldest and largest of Florida's five water management districts
- Established by the legislature

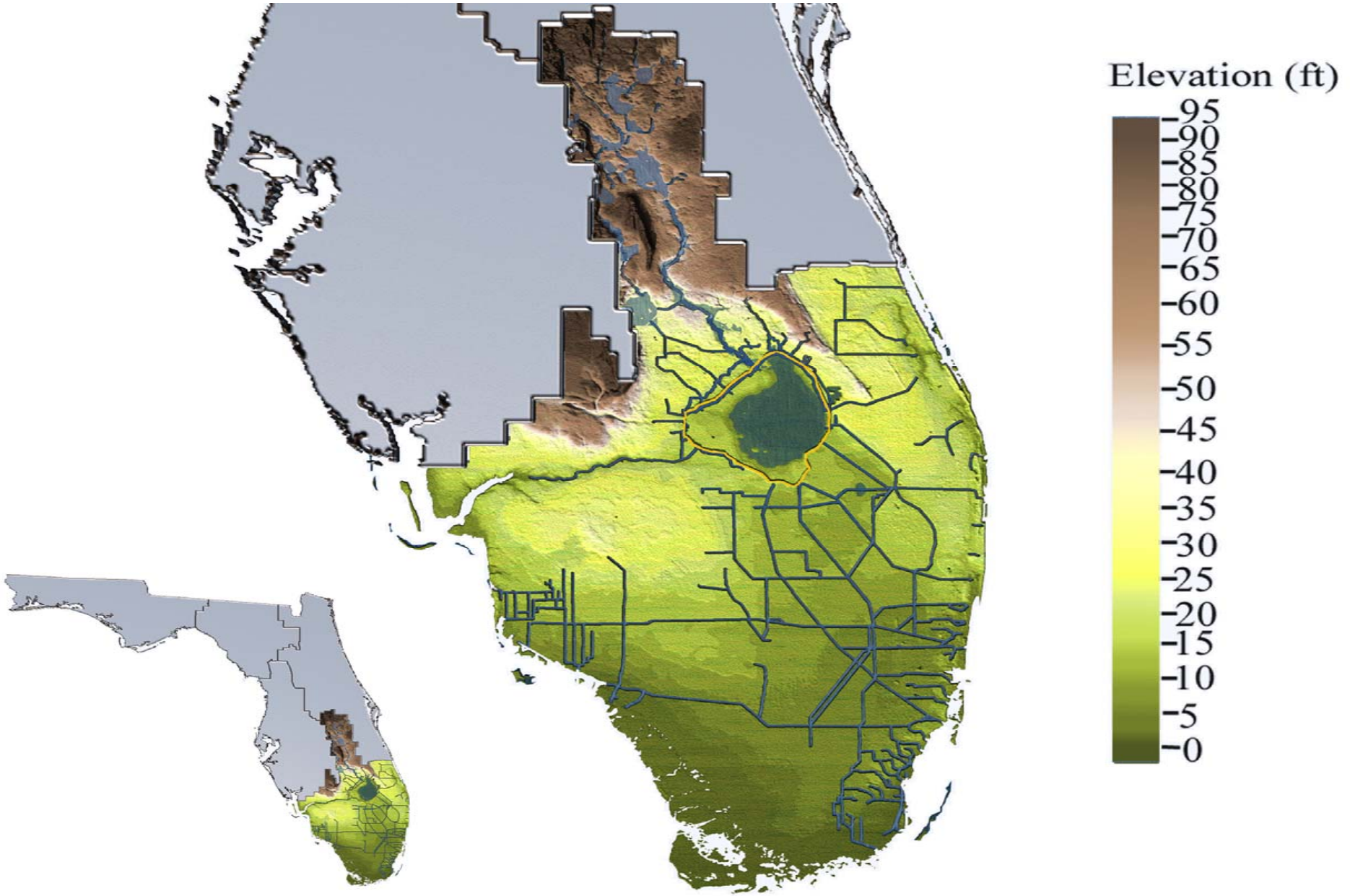


The South Florida Water Management District

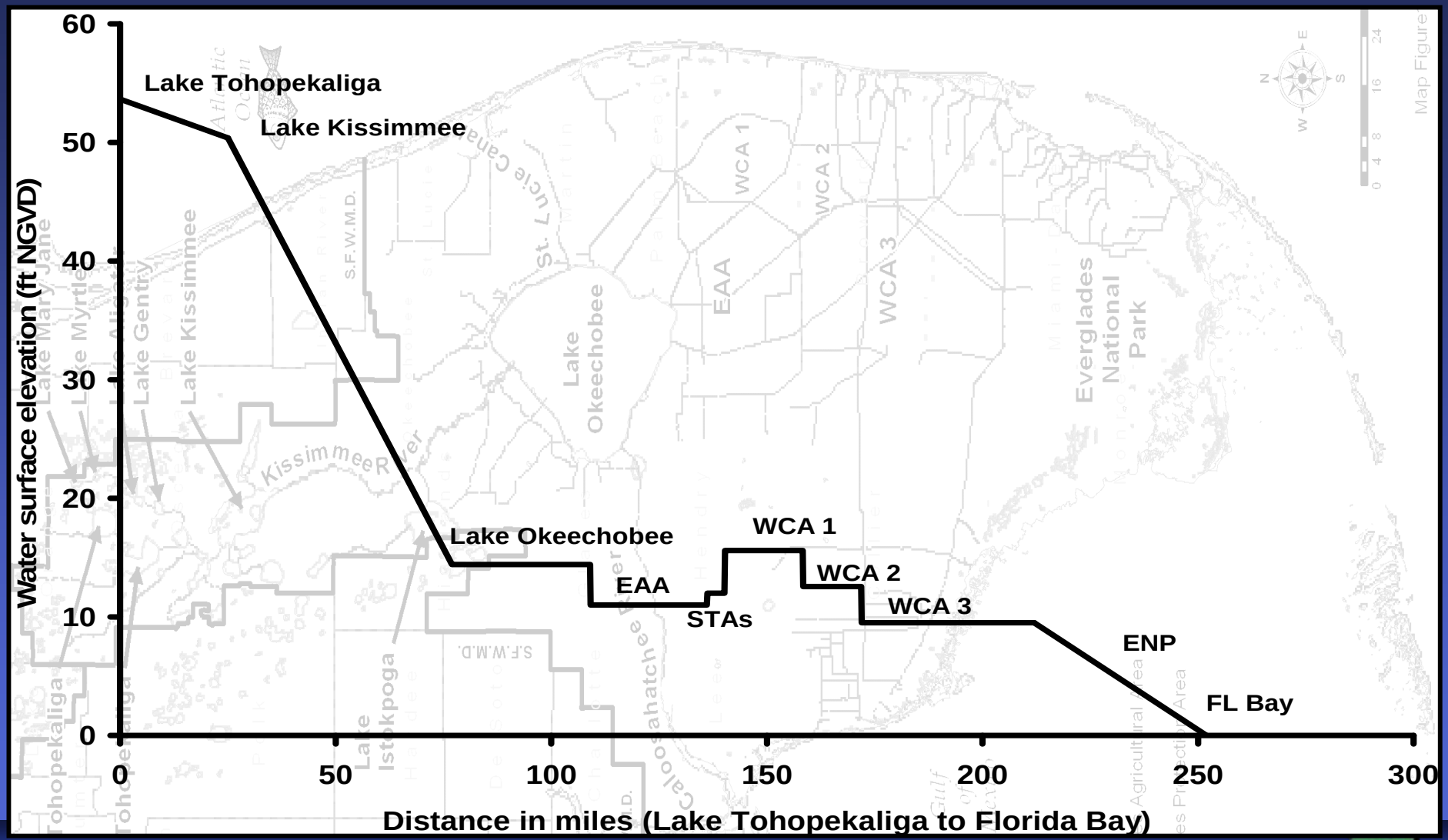
Who we are and what we do:

The SFWMD's mission is to manage and protect water resources of the region by balancing and improving water quality, flood control, natural systems and water supply. A key initiative is cleanup and restoration of the Everglades.

Topography

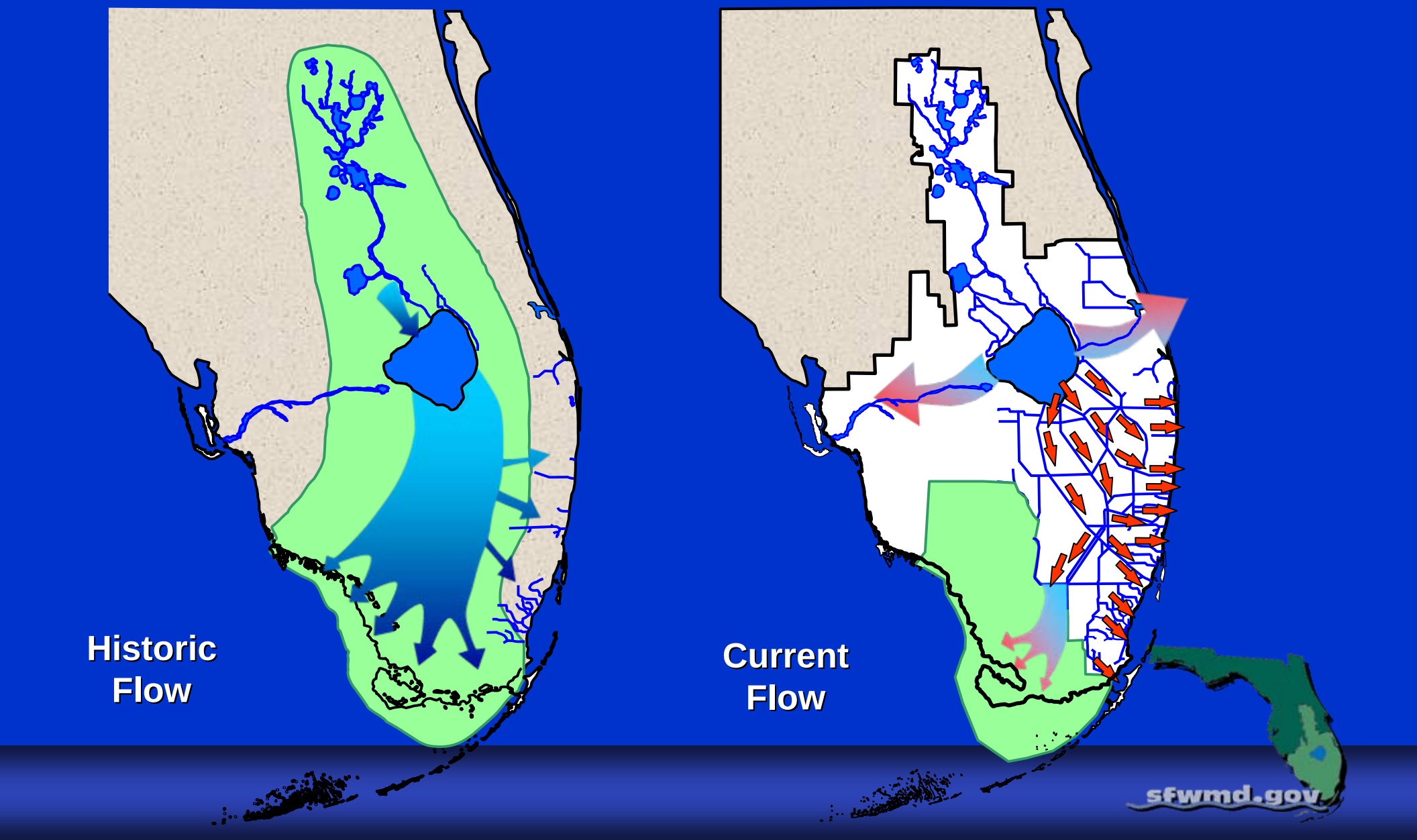


Topographic and Hydraulic Gradient



The Upper Kissimmee Chain of Lakes form the headwaters of the Kissimmee-Okeechobee-Everglades watershed

Water Resource Modifications

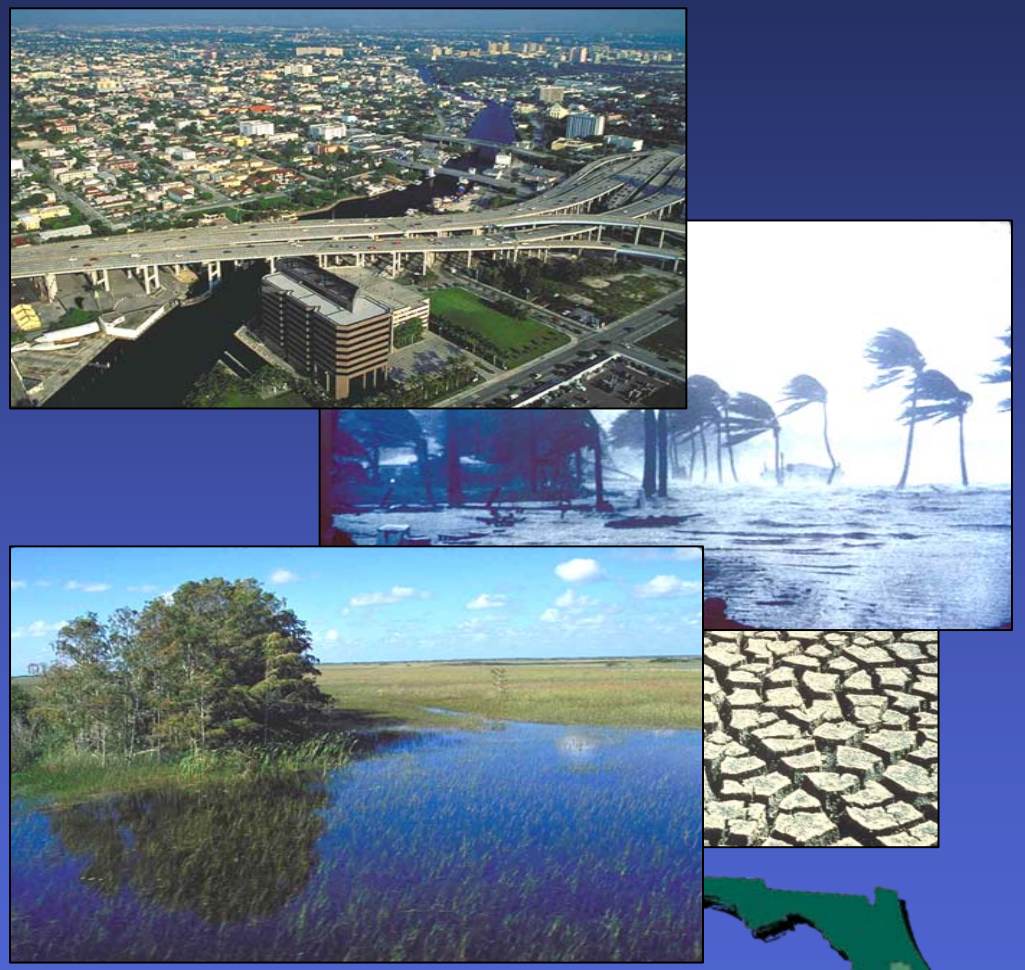


History

- Settlement in south Florida increased in the late 1800's
  - Navigation Improvements
- Everglades Drainage District
  - Initial drainage works improved development opportunities
  - Severe floods & droughts persisted

Water Resources Purpose

- Flood Control
- Water Supply
  - Agriculture
  - Urban
  - Everglades National Park
  - Saltwater Intrusion
- Navigation
- Protection of “fish and wildlife”



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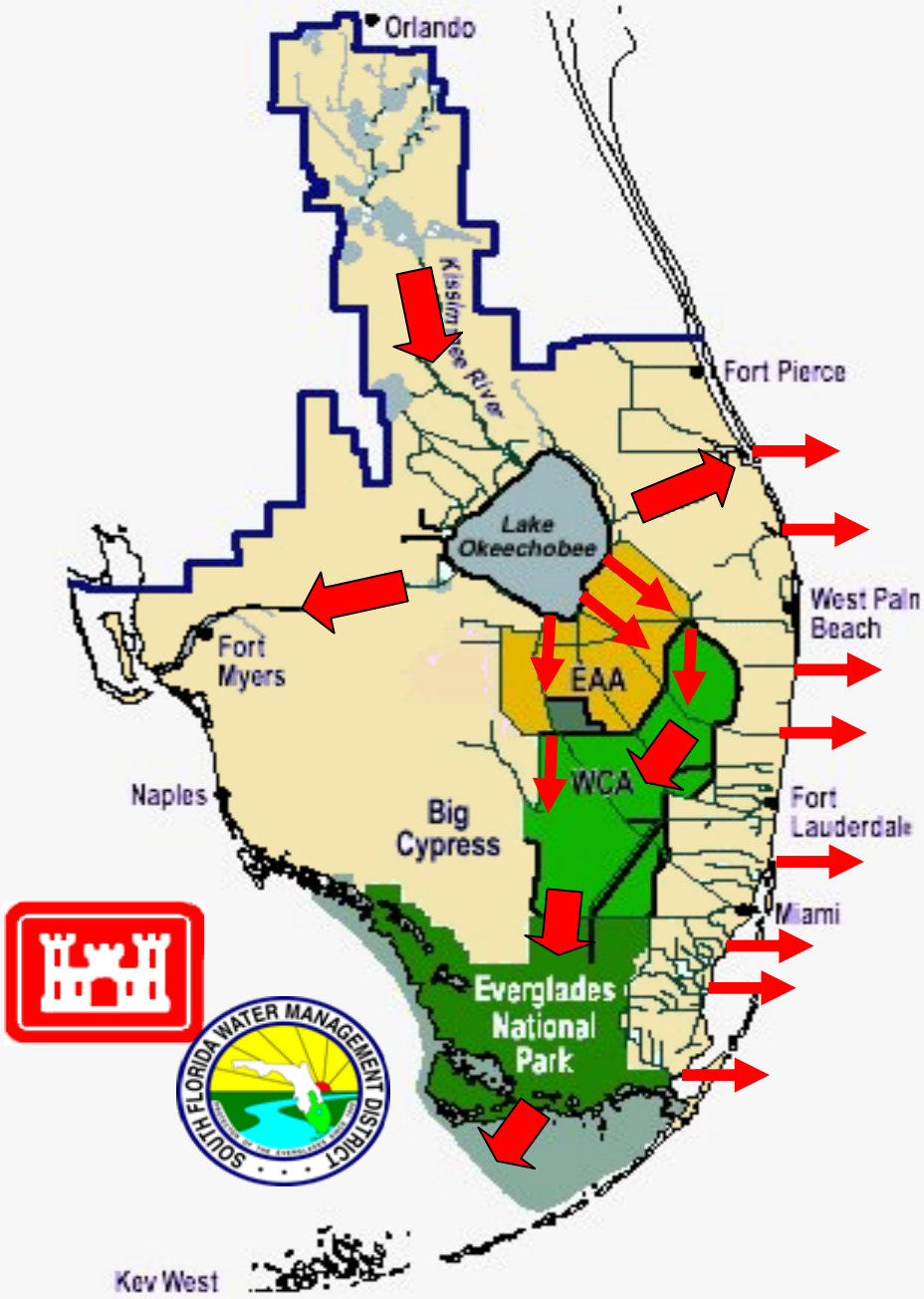
Central and South Florida Project

"Central and Southern Florida Project for Flood Control and Other Purposes"

- Initially authorized in 1948
- Constructed between 1950's and 1970's

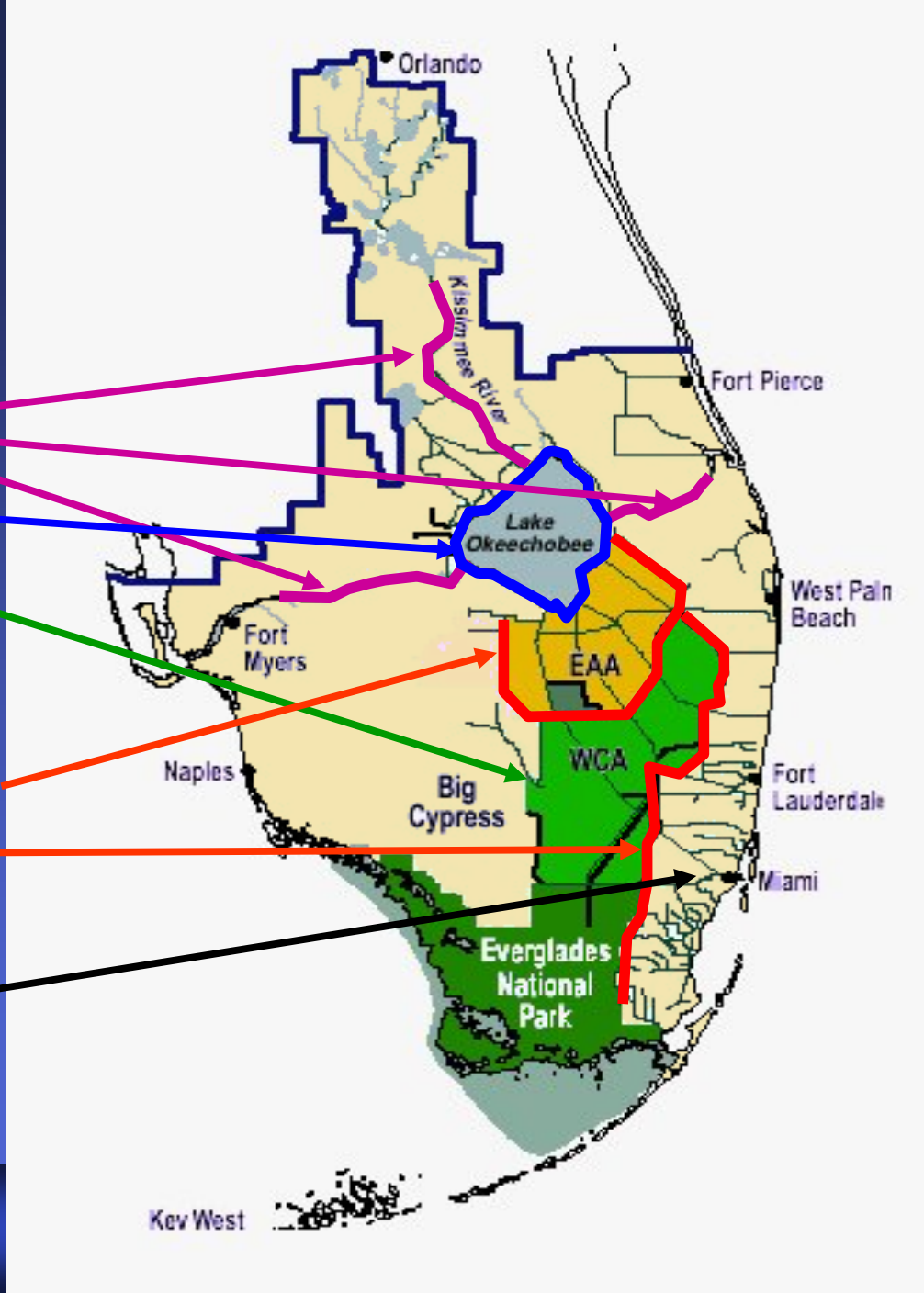
Operated in accordance with USACE criteria

- USACE
- SFWMD



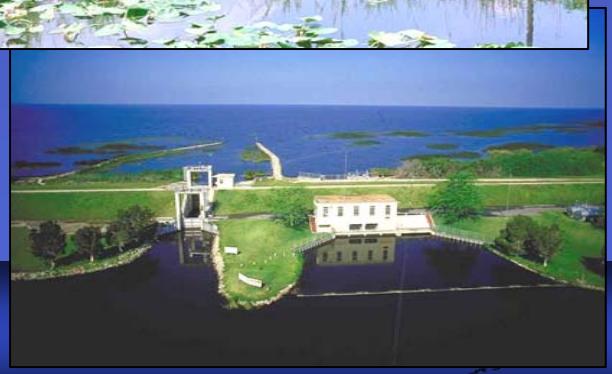
Major C&SF Project Components

- River Channelization
- Herbert Hoover Dike
- Water Conservation Areas
- Protective Levees
  - Everglades Agricultural Area
  - Lower East Coast
- Drainage Network
  - Salinity Structures



Water Management System Components

- ~1,900 miles of canals and levees
- 160 major drainage basins
- 550+ major structures
  - 200+ remotely operated
  - 300+ manually operated or fixed structures
- About 50 pump stations
  - Almost ½ with remote operation capability



Hydrologic Monitoring Network

Rainfall	279 active rain gauges NEXRAD Radar rainfall
Weather Stations	41 full and partial stations
Surface Water Level	1195 active gauges
Surface Water Flow	420 active flow sites
Groundwater	975 active wells

Water Management

- The water management system is operated by SFWMD, USACE and in cooperation between them
- USACE regulates Lake Okeechobee water level in consultation with the SFWMD
- USACE operates inflow and outflow structures on the Caloosahatchee and St. Lucie Rivers
- USACE operates outflows from WCA 1, WCA 2 and WCA 3
- SFWMD operates the rest of the system

Water Management Decision Making

- Environmental Advisory Team
  Weekly Meeting
- District Operation of Water Control Structures

  Continuous monitoring and decision making using water control manual

  - Automated and remote controlled sites
  - Automated sites
  - Manually operated sites

Drainage Responsibilities

Primary Drainage System

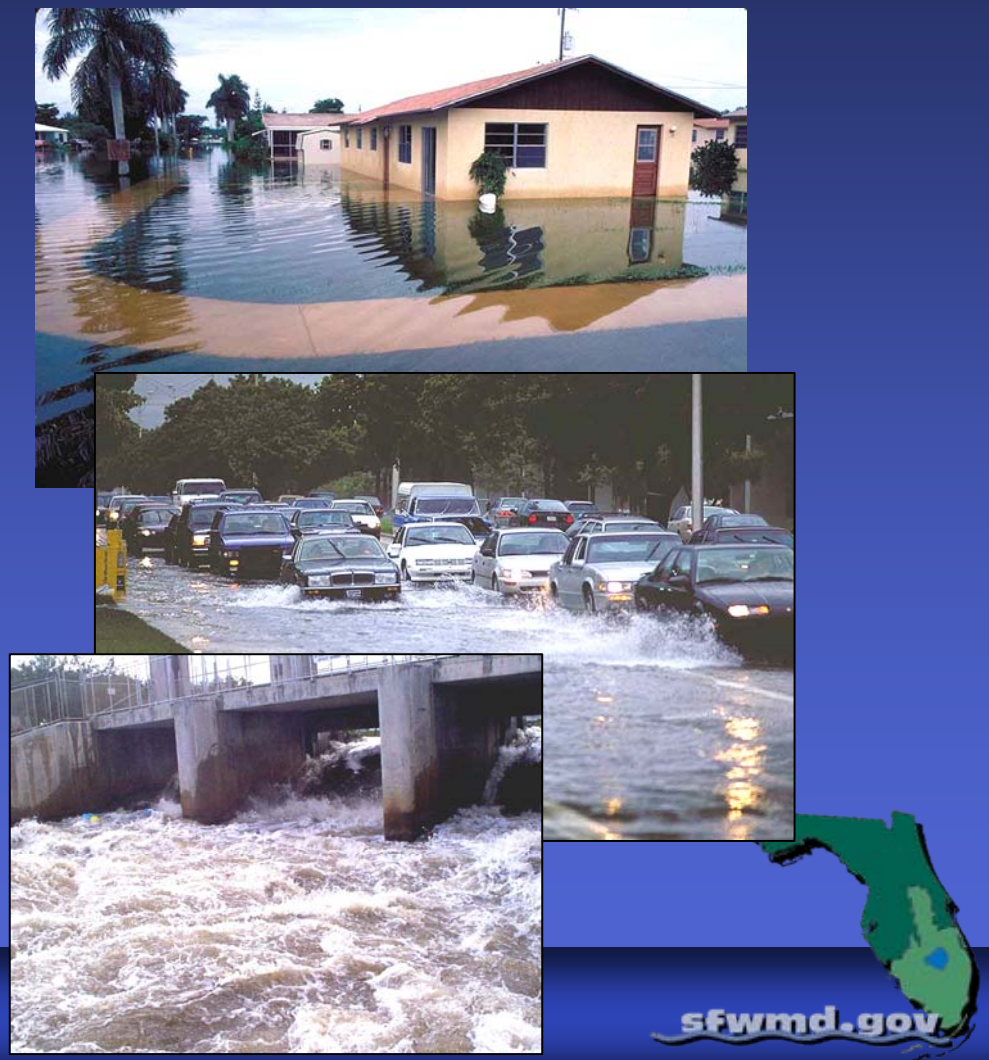
SFWMD Canals/

Primary System Operations

- *Drainage & Flood Control*
- *Water Supply*

Typical Coastal Canal Operations: *Drainage*

- Runoff conveyed away from developed areas mitigate flood impacts
- Structure operations coordinated from District headquarters
  - Most critical structures remotely automated
  - Manual operations coordinated with local field stations



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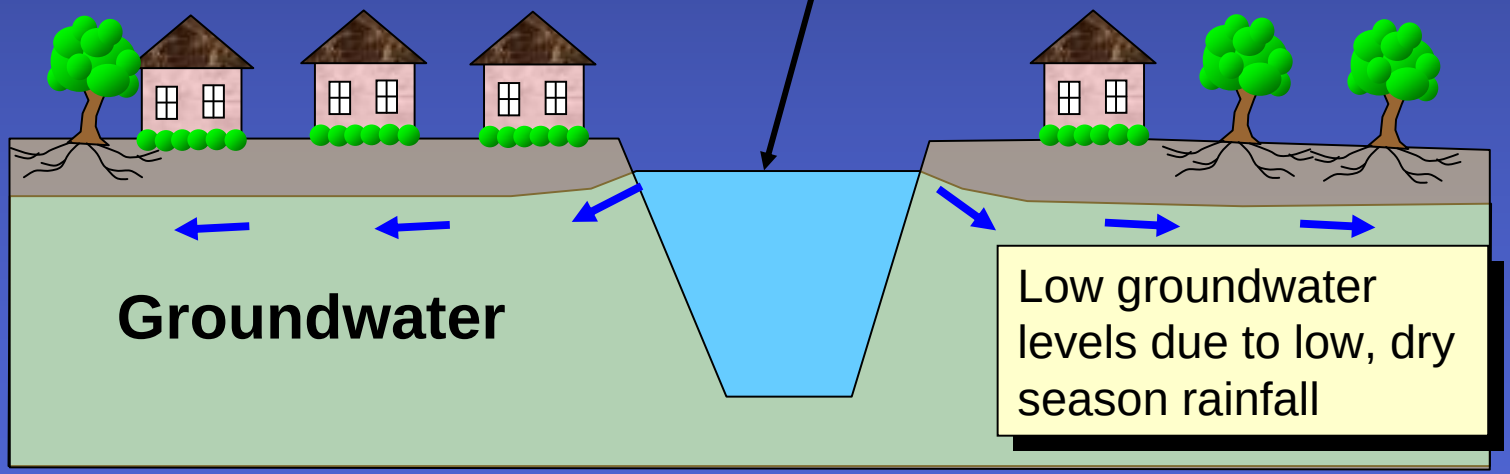
Canal / Groundwater Interaction

Normal Dry Season Operations

Canals serve two primary purposes….

1. **Flood Control**
2. **Water Supply**

Canal stages held high to facilitate groundwater recharge and assist supplemental irrigation

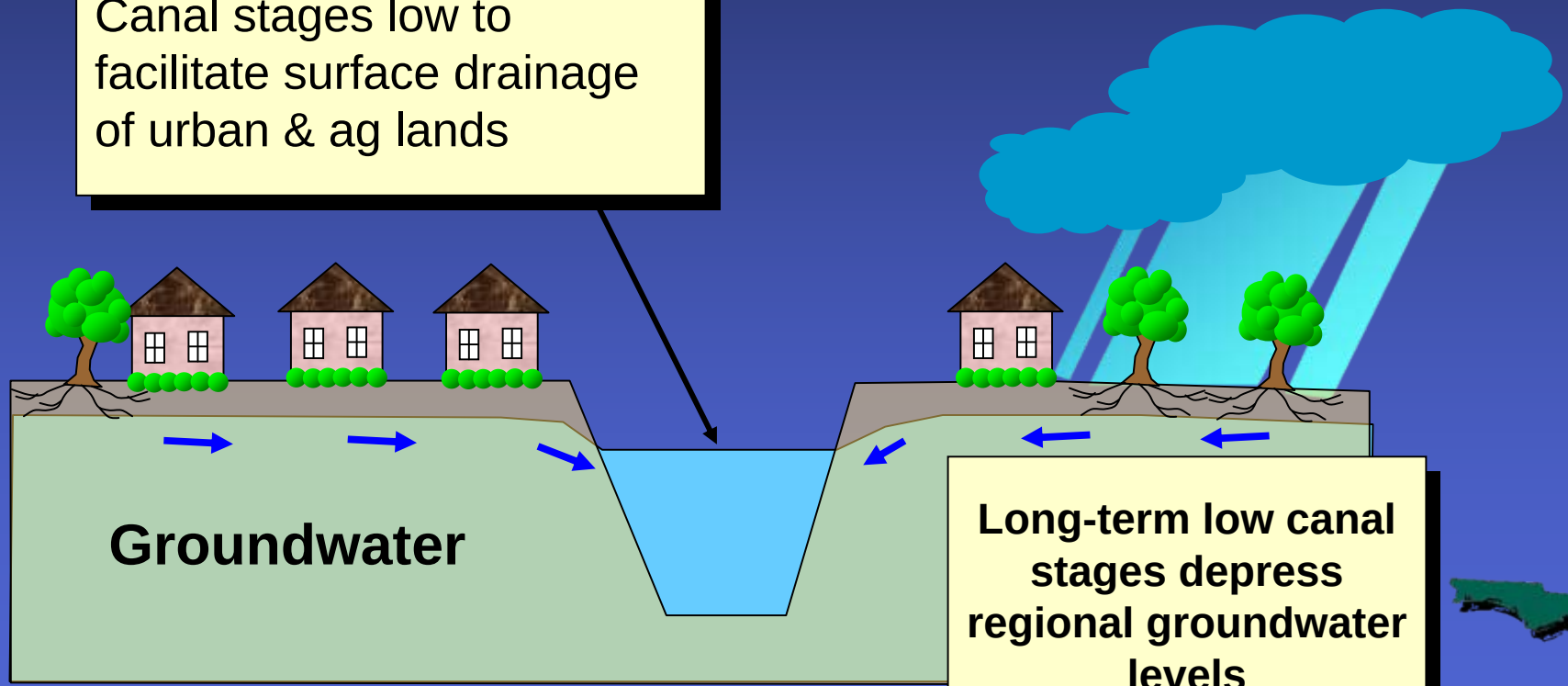


Low groundwater levels due to low, dry season rainfall

Canal / Groundwater Interaction

Normal Wet Season Operations

Canal stages low to facilitate surface drainage of urban & ag lands



Long-term low canal stages depress regional groundwater levels

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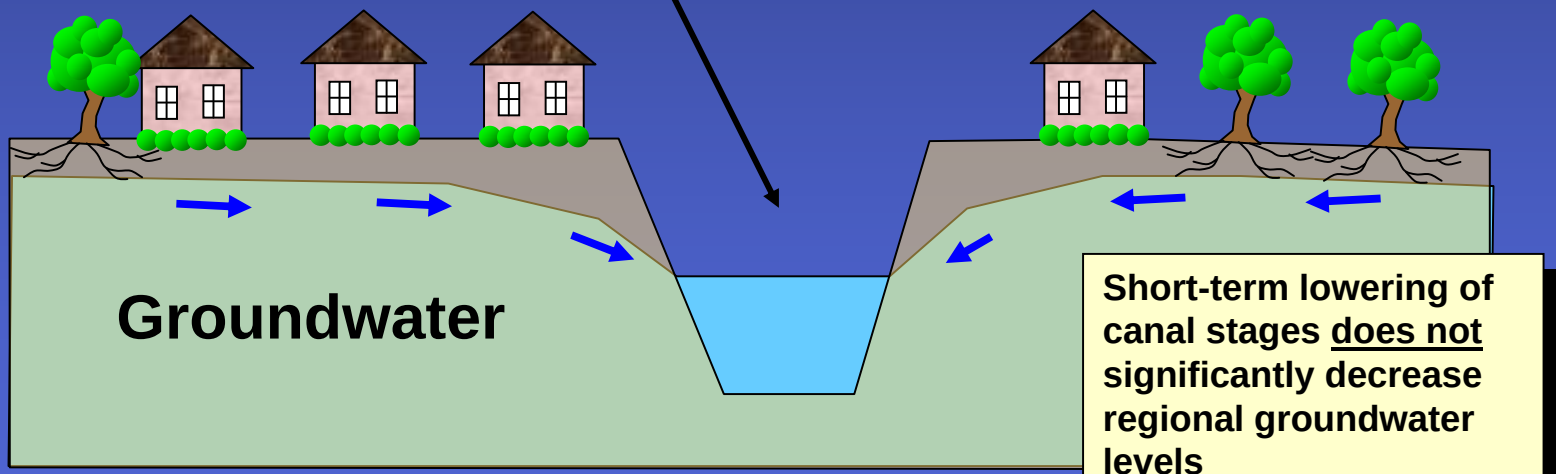
Canal / Groundwater Interaction

Pre-Storm Drawdown Operations

Canal stages lowered an additional ~1 foot to increase **surface drainage** of urban & ag lands prior forecasts storms



Short-term lowering of canal stages <u>does not</u> significantly decrease regional groundwater levels

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The 2005 Hurricane Season in South Florida

- Hurricane Dennis (July 8-10, 2005)
- Hurricane Katrina (August 24-27, 2005)
- Hurricane Rita (September 19-21, 2005)
- Hurricane Wilma (October 22-25, 2005)

Hurricane Wilma (October 22-25, 2005)

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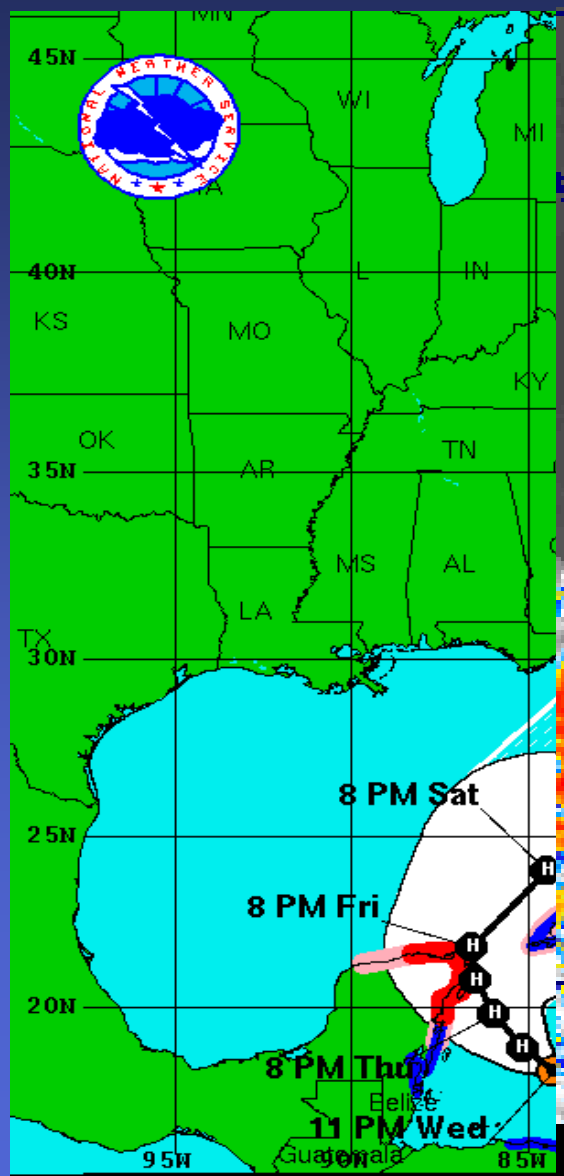
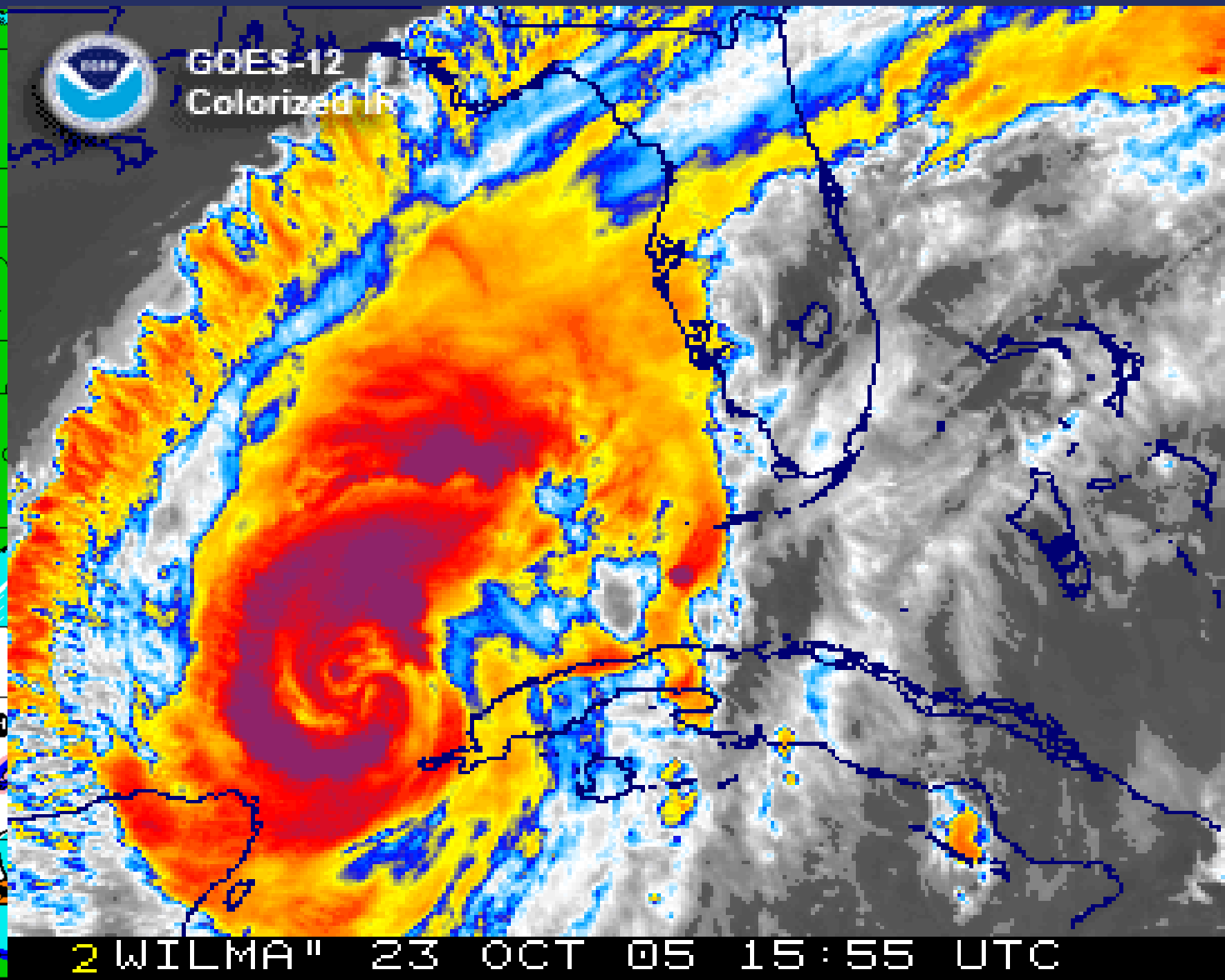
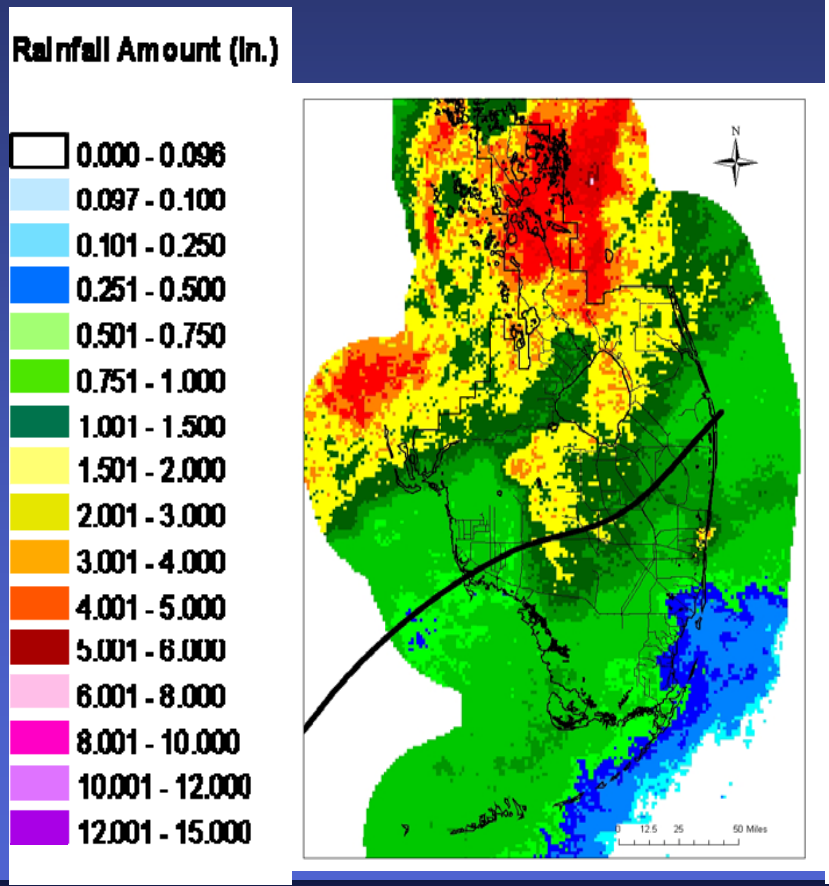
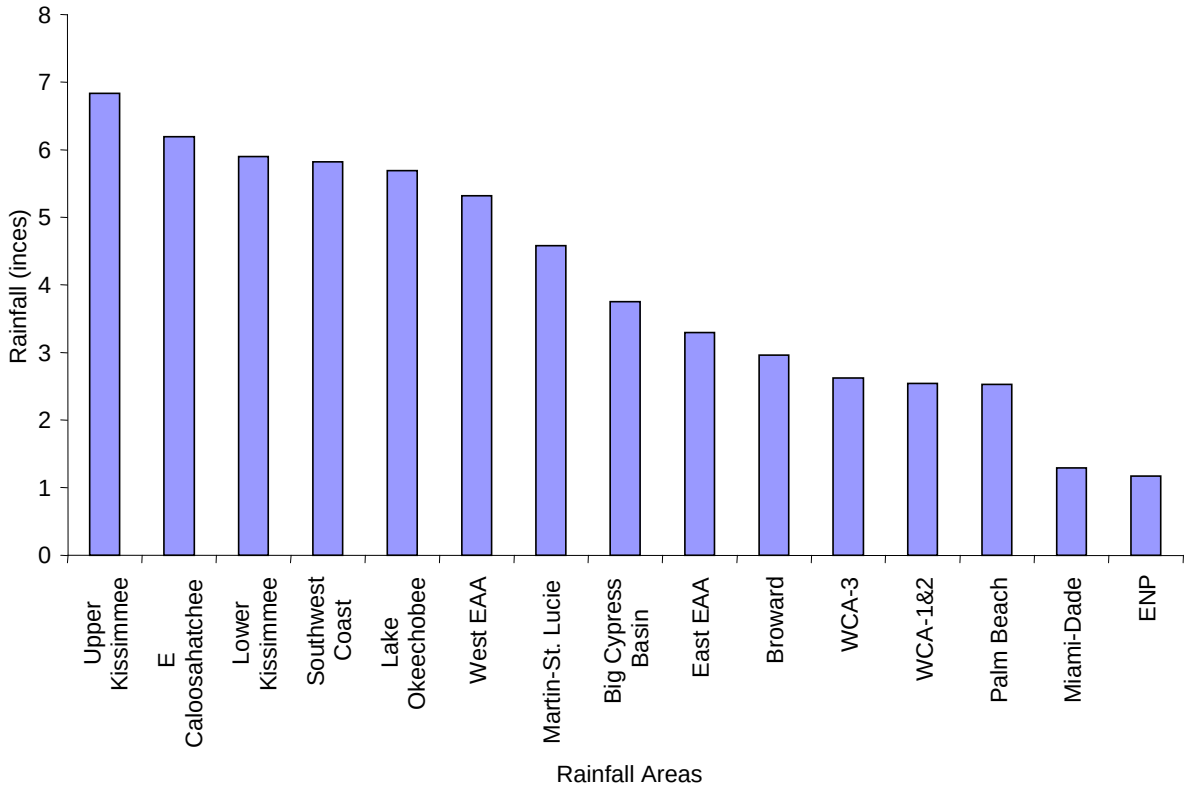
Hurricane Wilma – October 2005



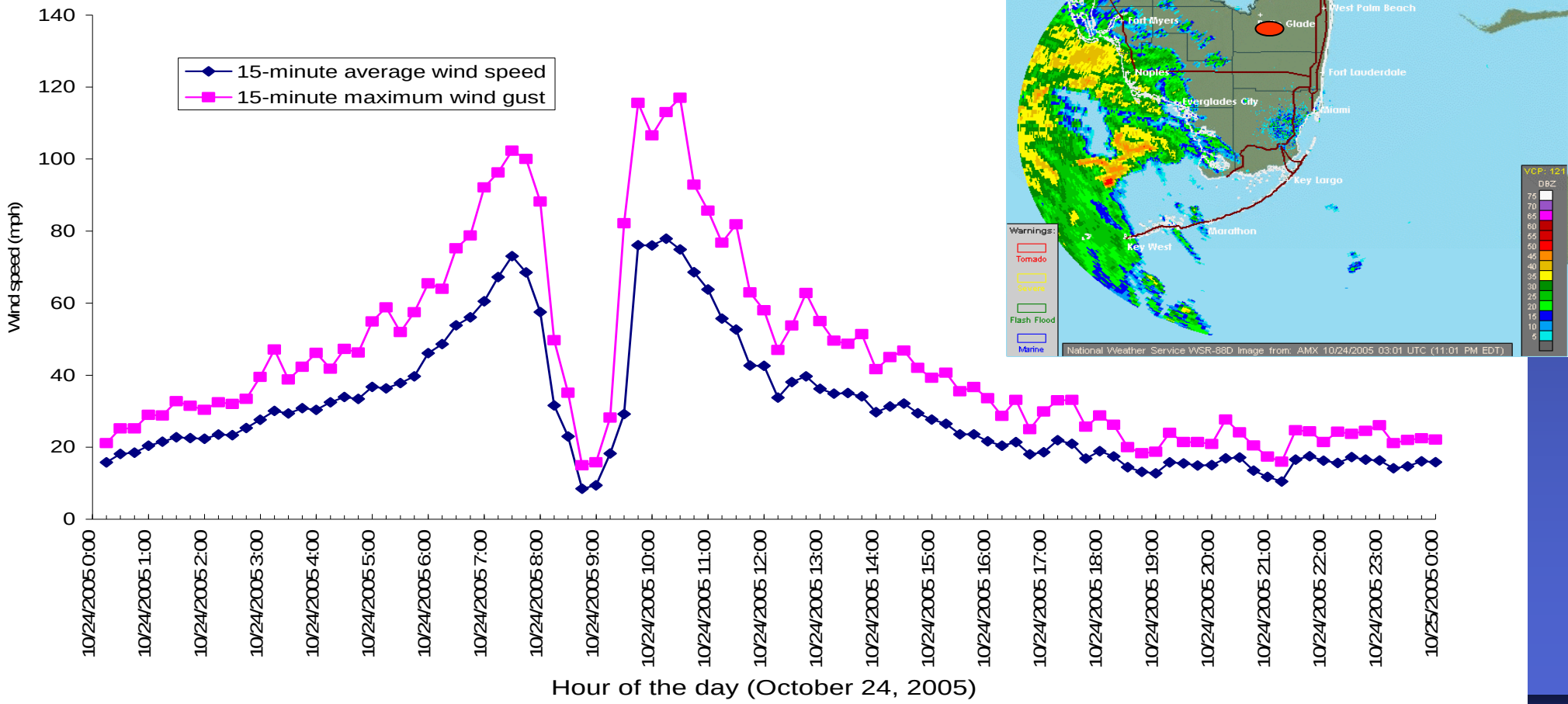


Rainfall from Hurricane Wilma

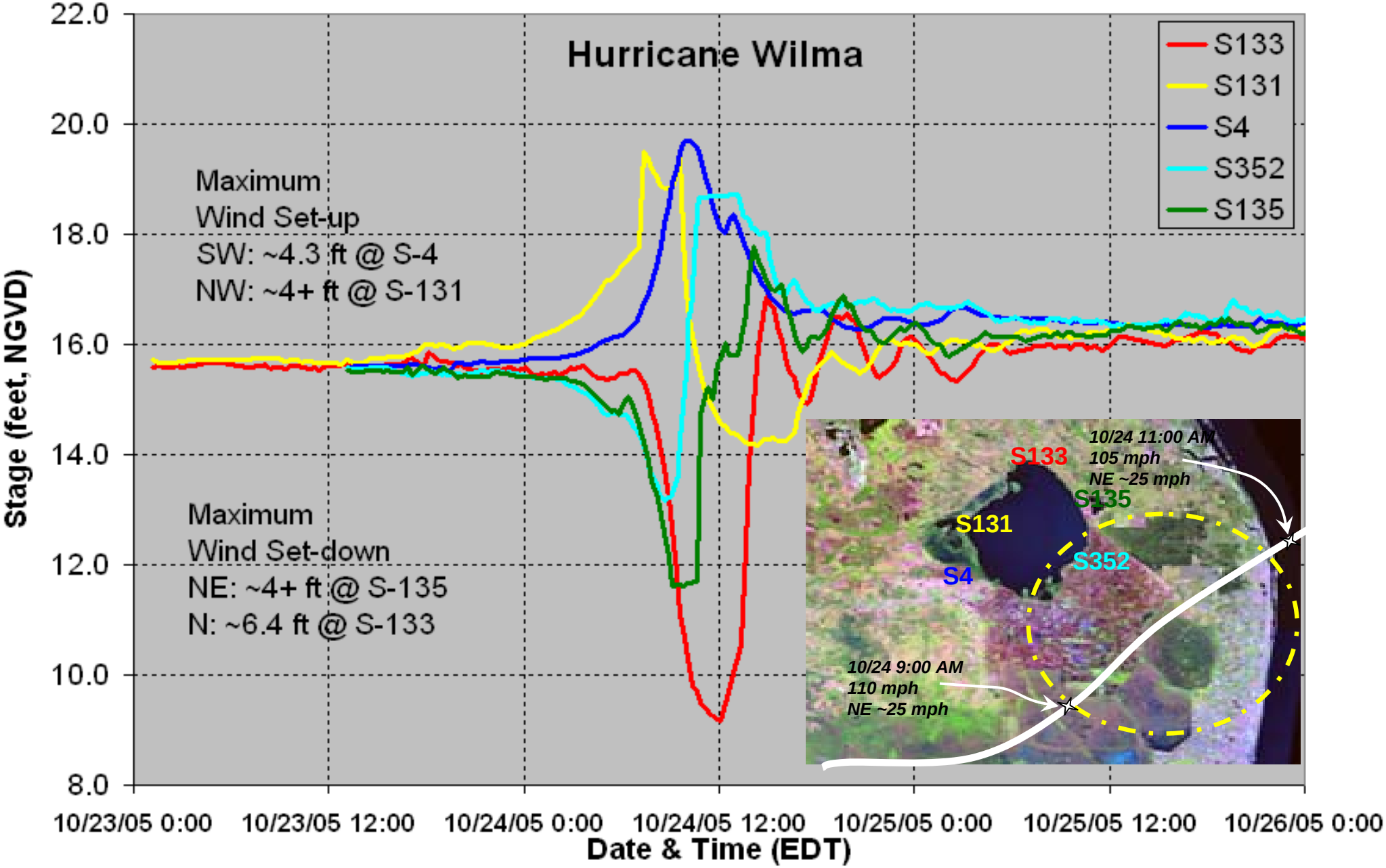




Wind Speed at Belle Glade Weather Station

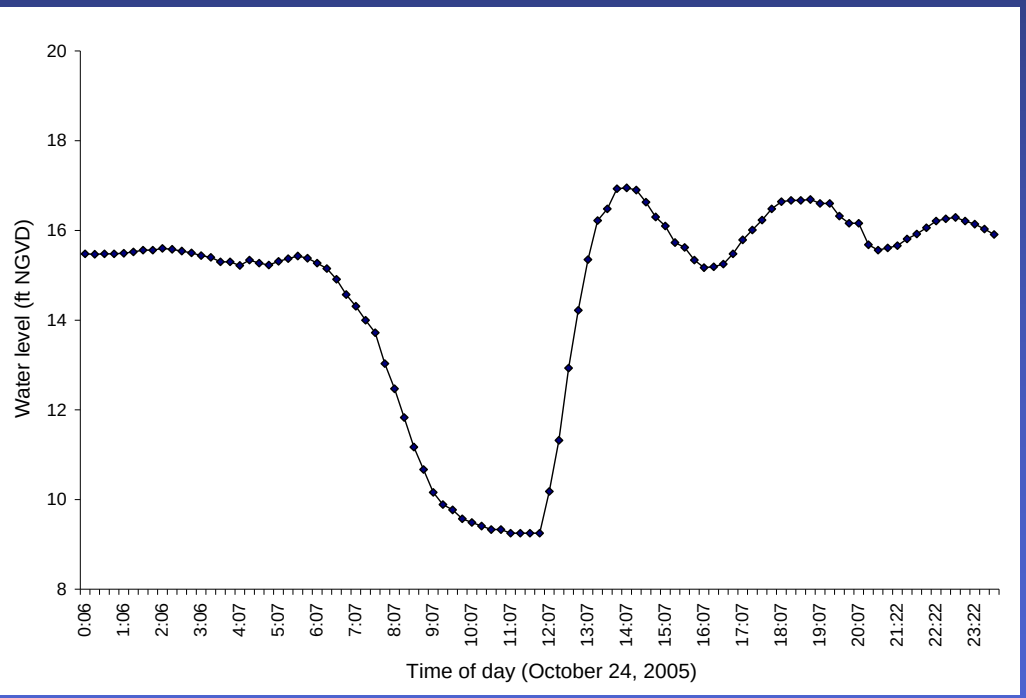


Lake Okeechobee Stages

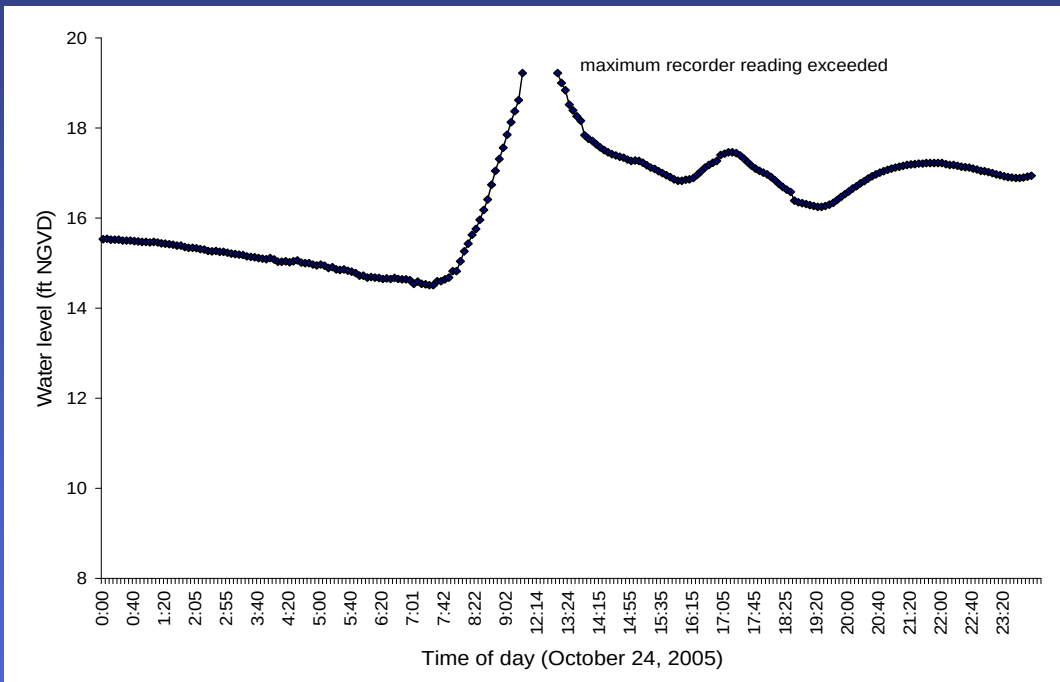


Lake Okeechobee Water Level Fluctuation during Hurricane Wilma

S-191 at the North



S2 at the South



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Damage to Herbert Hoover Levee at Lake Okeechobee

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Vegetation and Water Quality Impacts

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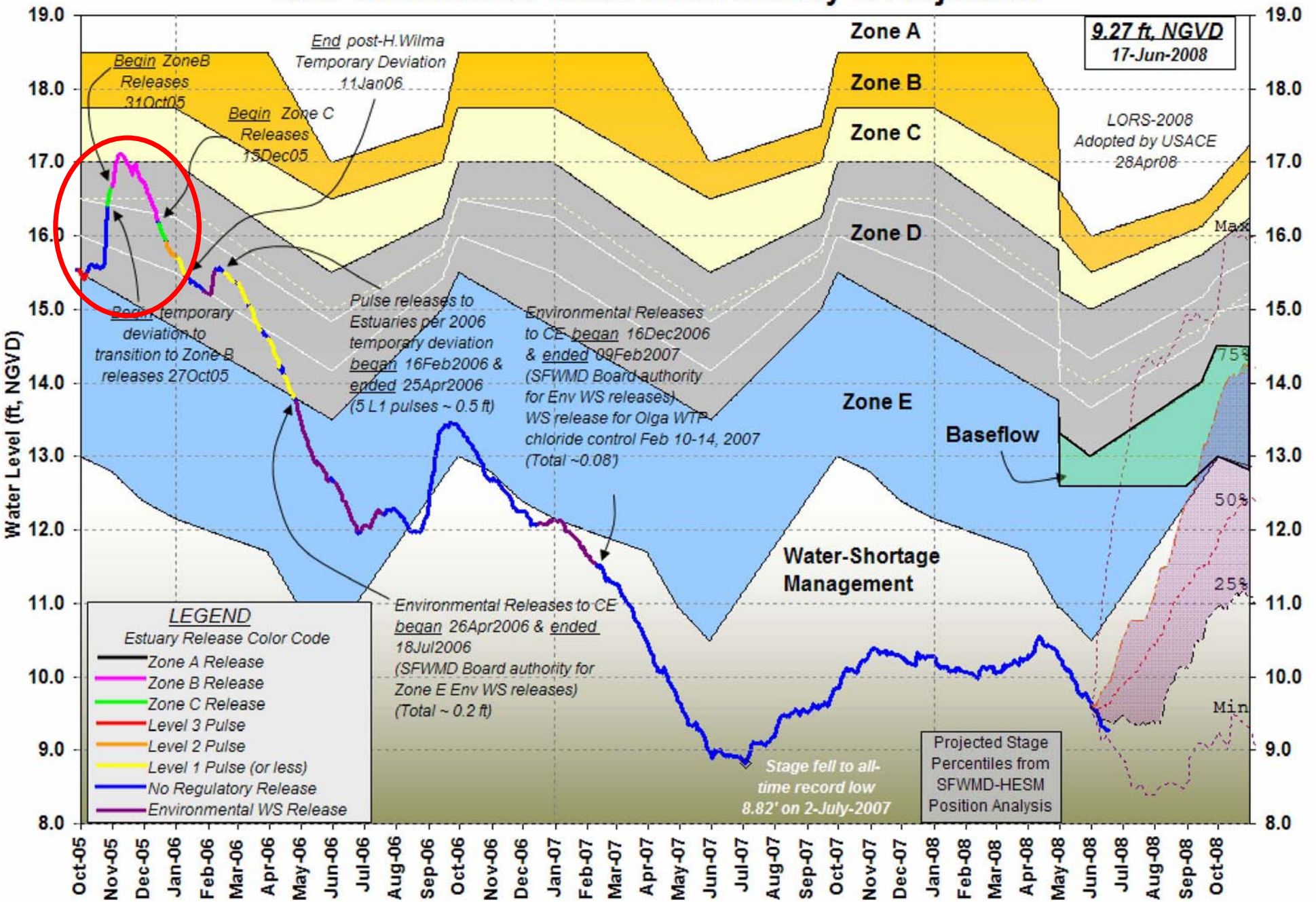
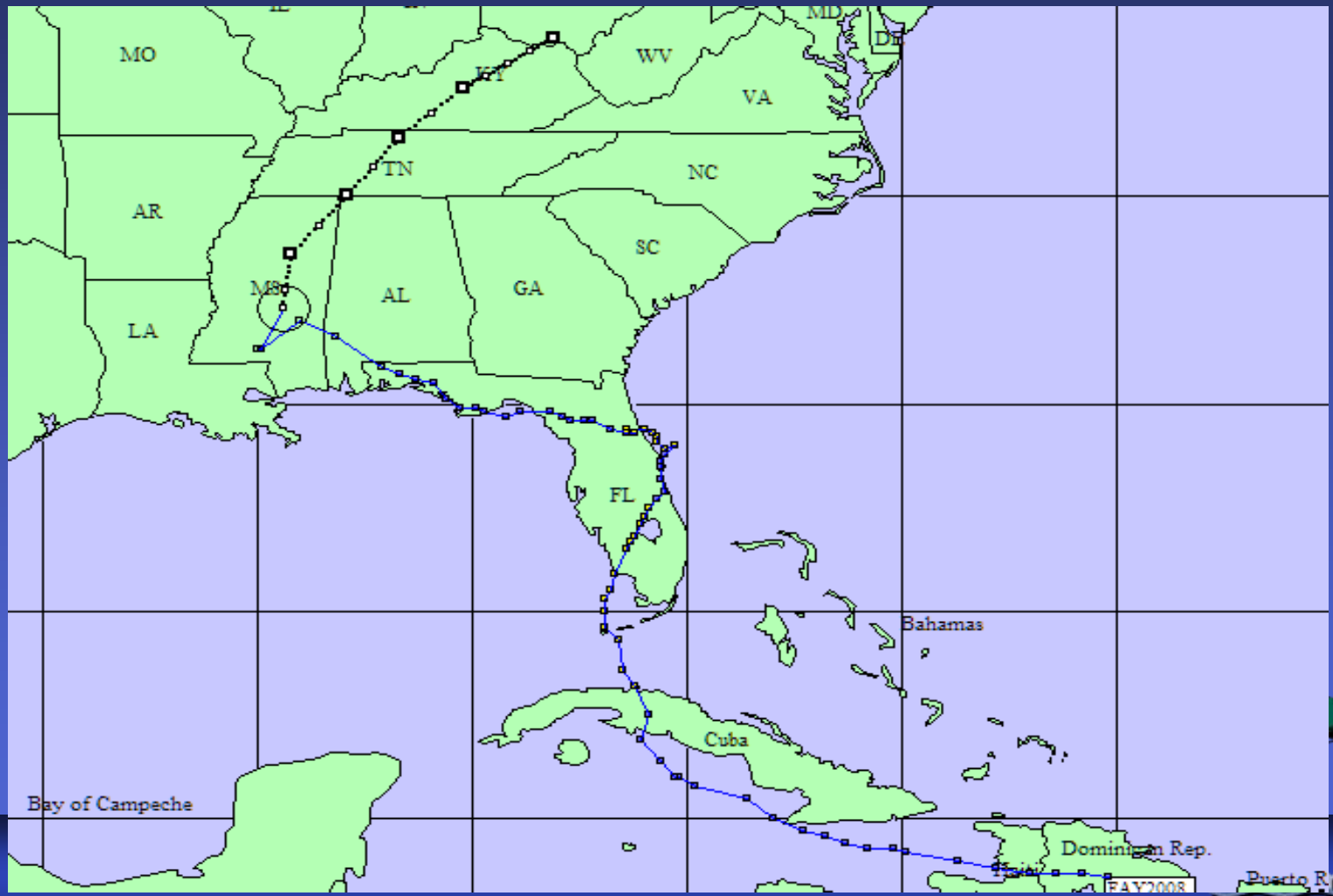
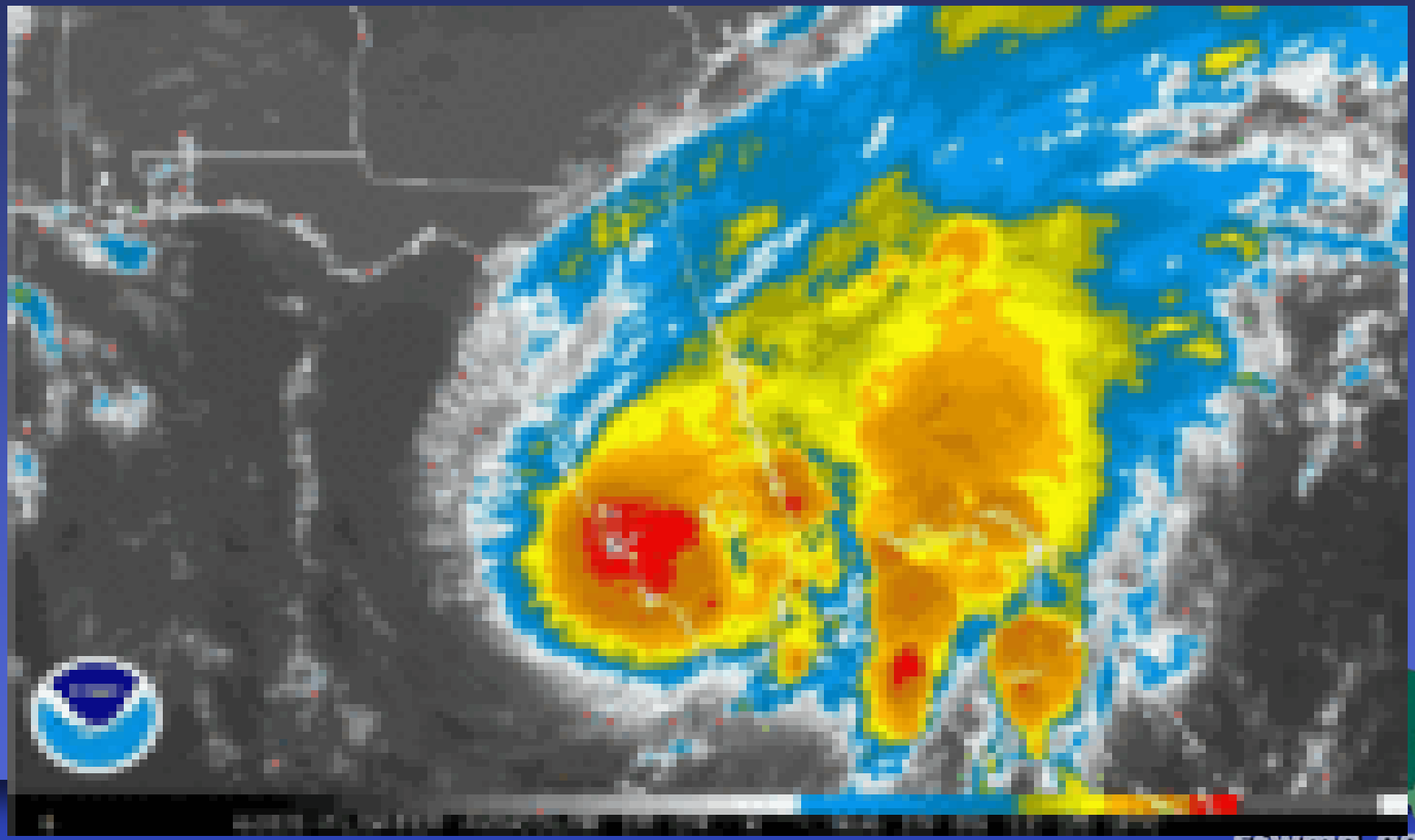
Lake Okeechobee Water Level History & Projection



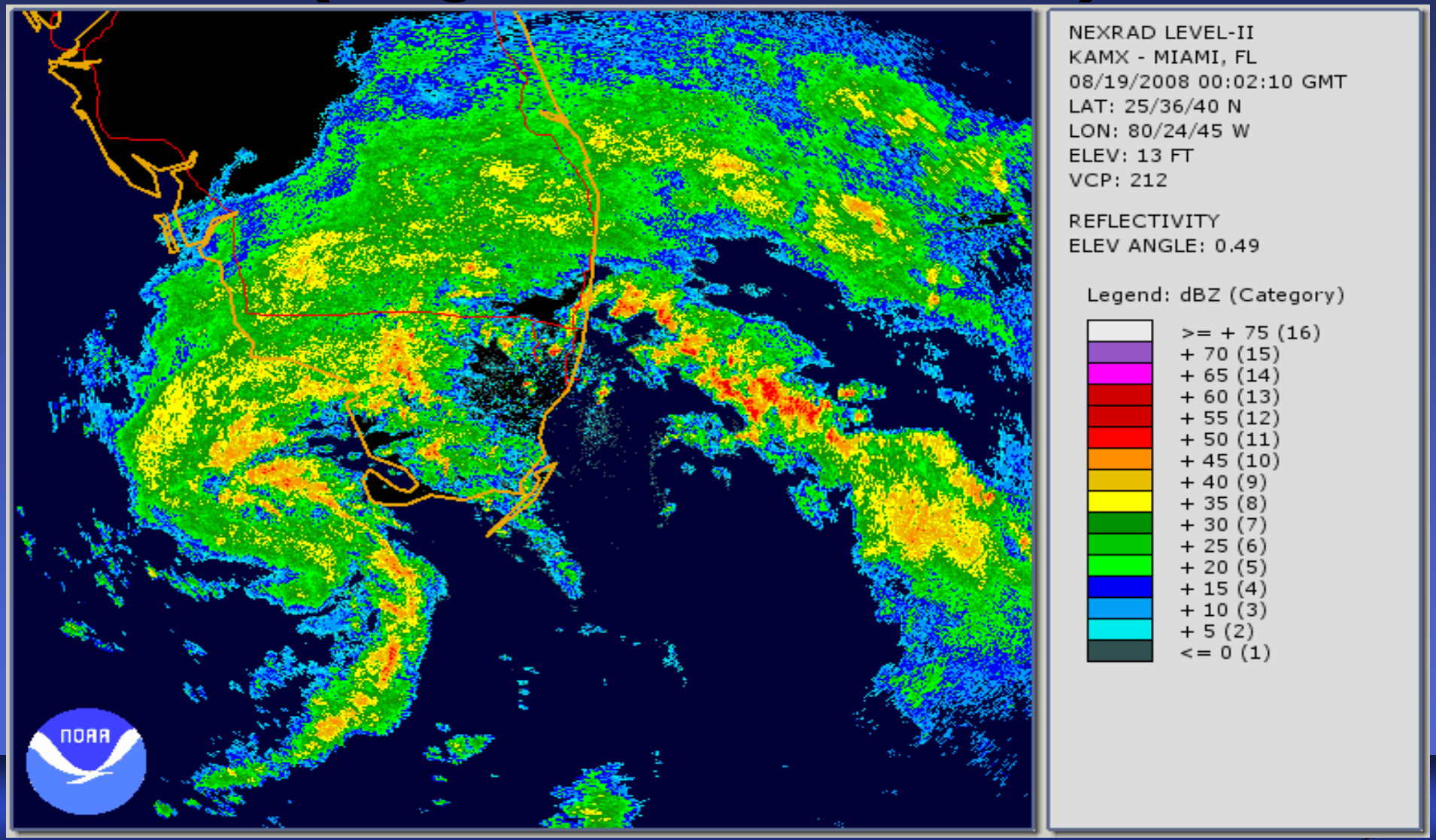
Tropical Strom Fay (August 17-20, 2008)



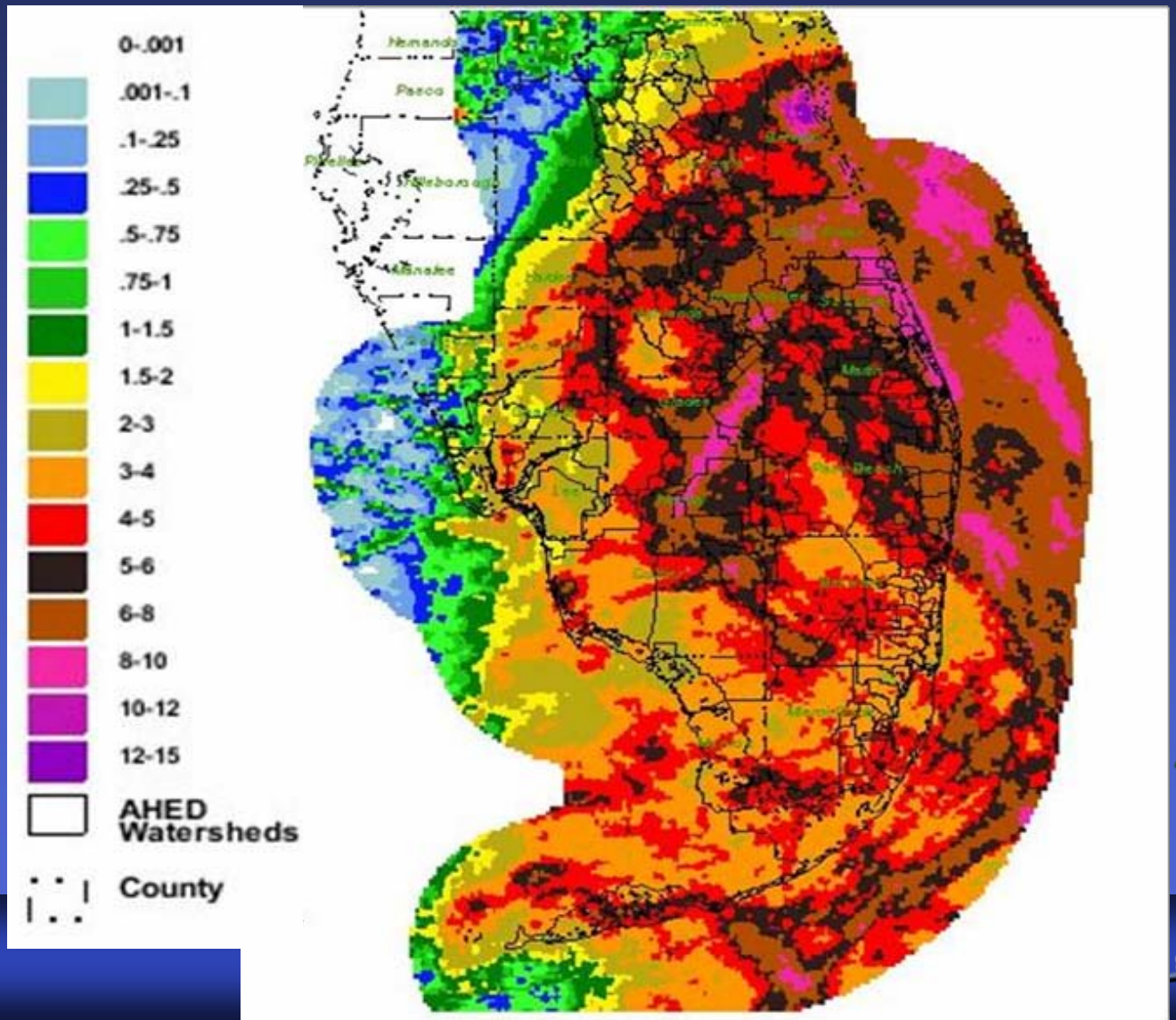
Tropical Strom Fay
(August 17-20, 2008)



Tropical Strom Fay
(August 17-20, 2008)



Tropical Strom Fay Rainfall (August 17-20, 2008)

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2004-05 SFWMD Aerial Photography
2007 Palm Beach County Aerial Photography
2005 Miami-Dade County Aerial Photography
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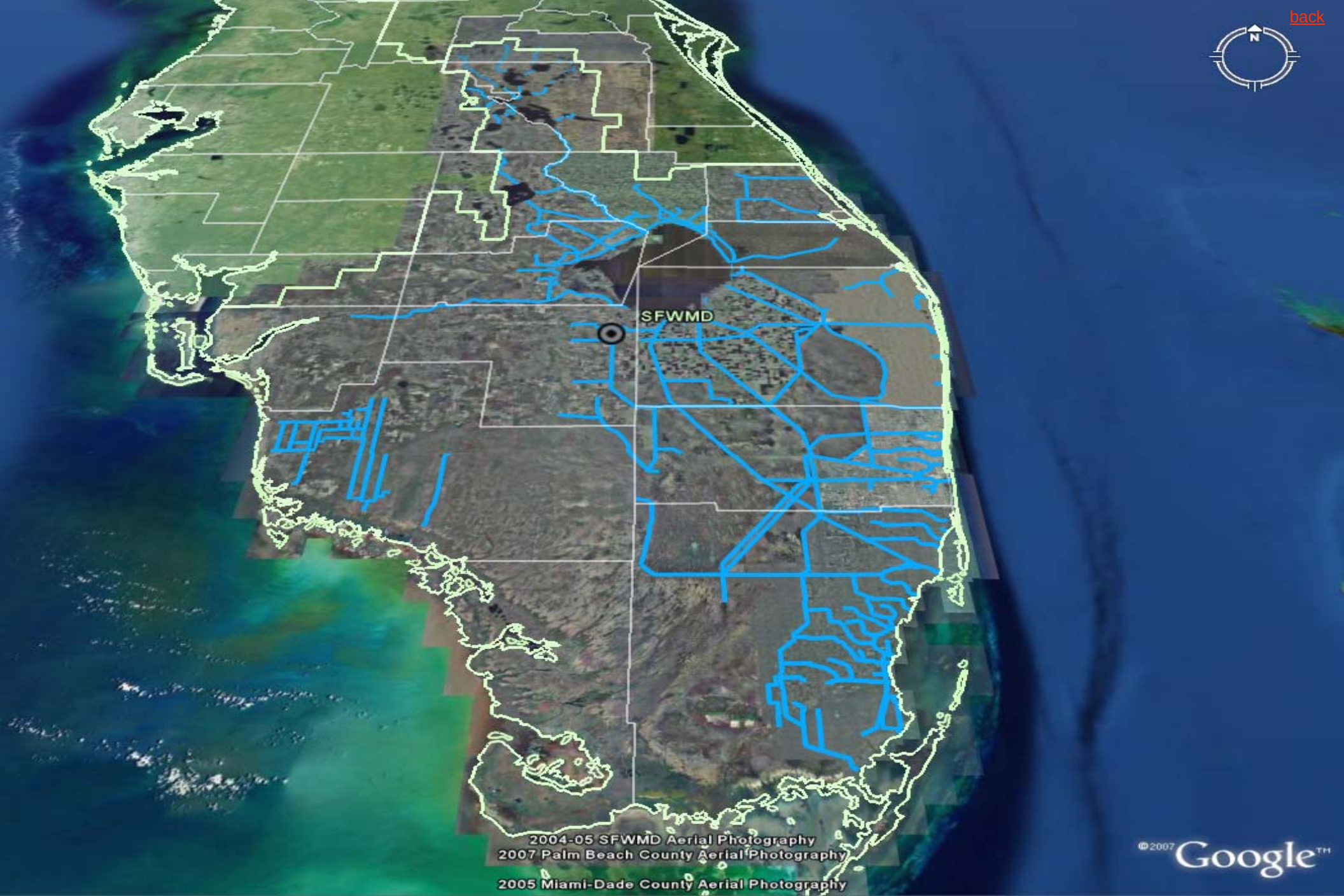
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2007 Palm Beach County Aerial Photography
2005 Miami-Dade County Aerial Photography
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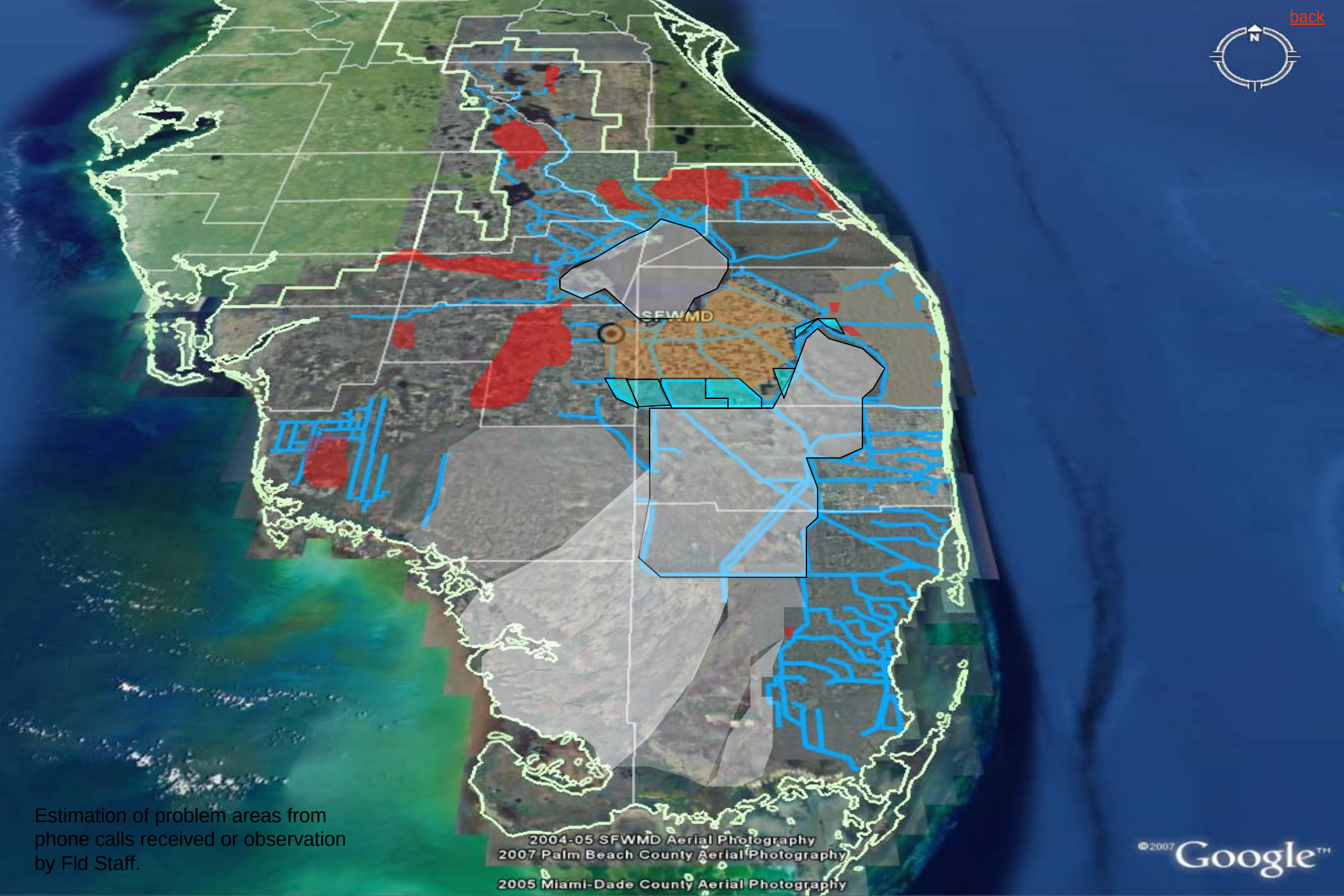
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SFWMD
Estimation of problem areas from phone calls received or observation by Fld Staff.
2004-05 SFWMD Aerial Photography
2007 Palm Beach County Aerial Photography
2005 Miami-Dade County Aerial Photography
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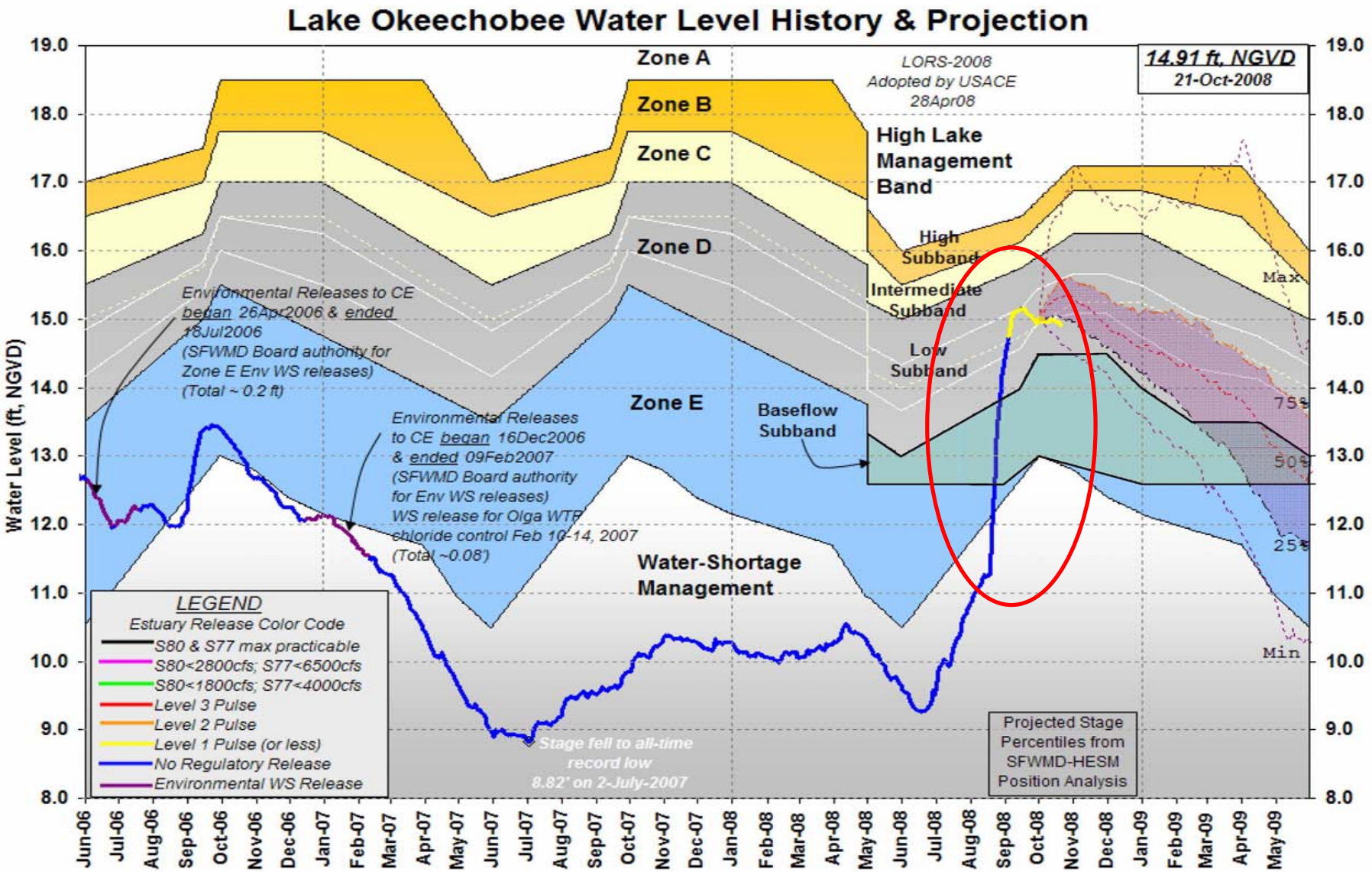
Lake Okeechobee Water Level History & Projection
Water Level (ft, NGVD)
Zone A
Zone B
Zone C
Zone D
Zone E
LORS-2008
Adopted by USACE
28Apr08
14.91 ft, NGVD
21-Oct-2008
High Lake Management Band
High Subband
Intermediate Subband
Low Subband
Baseflow Subband
Water-Shortage Management
Max
75%
50%
25%
Min
Environmental Releases to CE began 26Apr2006 & ended 18Jul2006
(SFWMD Board authority for Zone E Env WS releases)
(Total ~ 0.2 ft)
Environmental Releases to CE began 16Dec2006 & ended 09Feb2007
(SFWMD Board authority for Env WS releases)
WS release for Olga WTP chloride control Feb 10-14, 2007
(Total ~0.08')
Stage fell to all-time record low
8.82' on 2-July-2007
LEGEND
Estuary Release Color Code
S80 & S77 max practicable
S80<2800cfs; S77<6500cfs
S80<1800cfs; S77<4000cfs
Level 3 Pulse
Level 2 Pulse
Level 1 Pulse (or less)
No Regulatory Release
Environmental WS Release
Projected Stage Percentiles from SFWMD-HESM Position Analysis
19.0
18.0
17.0
16.0
15.0
14.0
13.0
12.0
11.0
10.0
9.0
8.0
Jun-06
Jul-06
Aug-06
Sep-06
Oct-06
Nov-06
Dec-06
Jan-07
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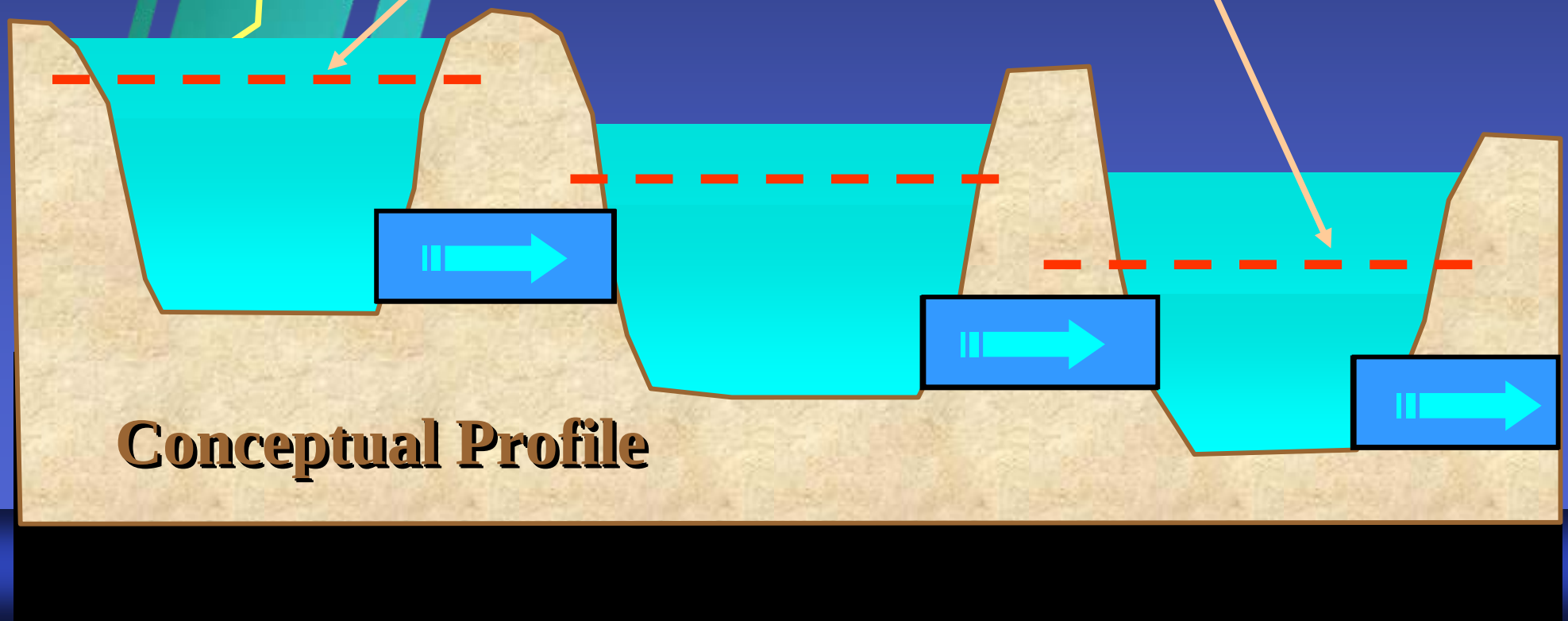
Jan-09
Feb-09
Mar-09
Apr-09
May-09

Questions?


SOUTH FLORIDA WATER MANAGEMENT DISTRICT
PROTECTOR OF THE EVERGLADES SINCE 1949

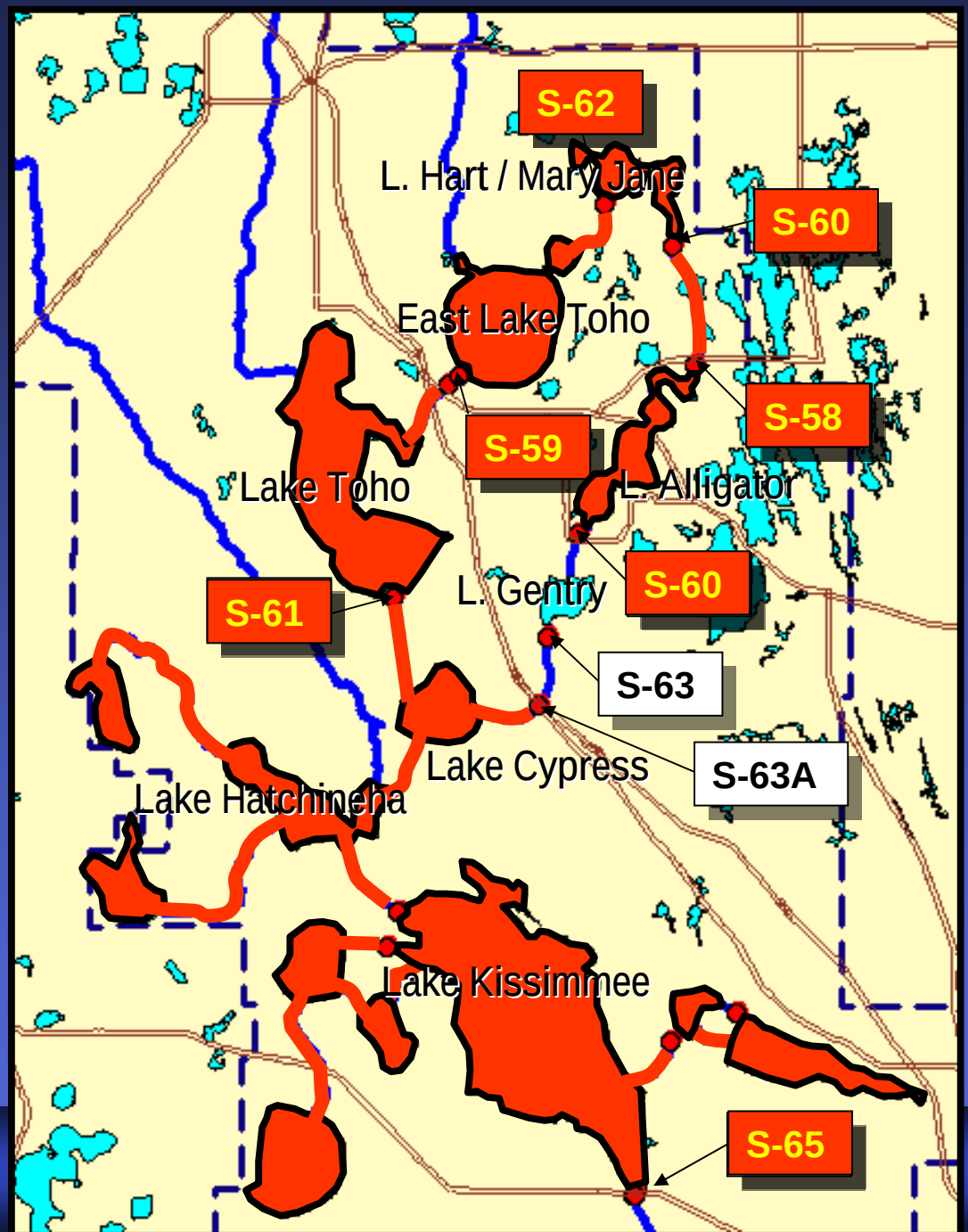
Basic Lake Operations.....

Regulation Schedules



Upper Kissimmee Chain of Lakes Operations

- 6 major lake pools
  - Kissimmee, Hatchineha & Cypress
  - Toho
  - East Toho
  - Hart & Mary Jane
  - Myrtle, etc.
  - Alligator, etc.
- 7 major water control structures

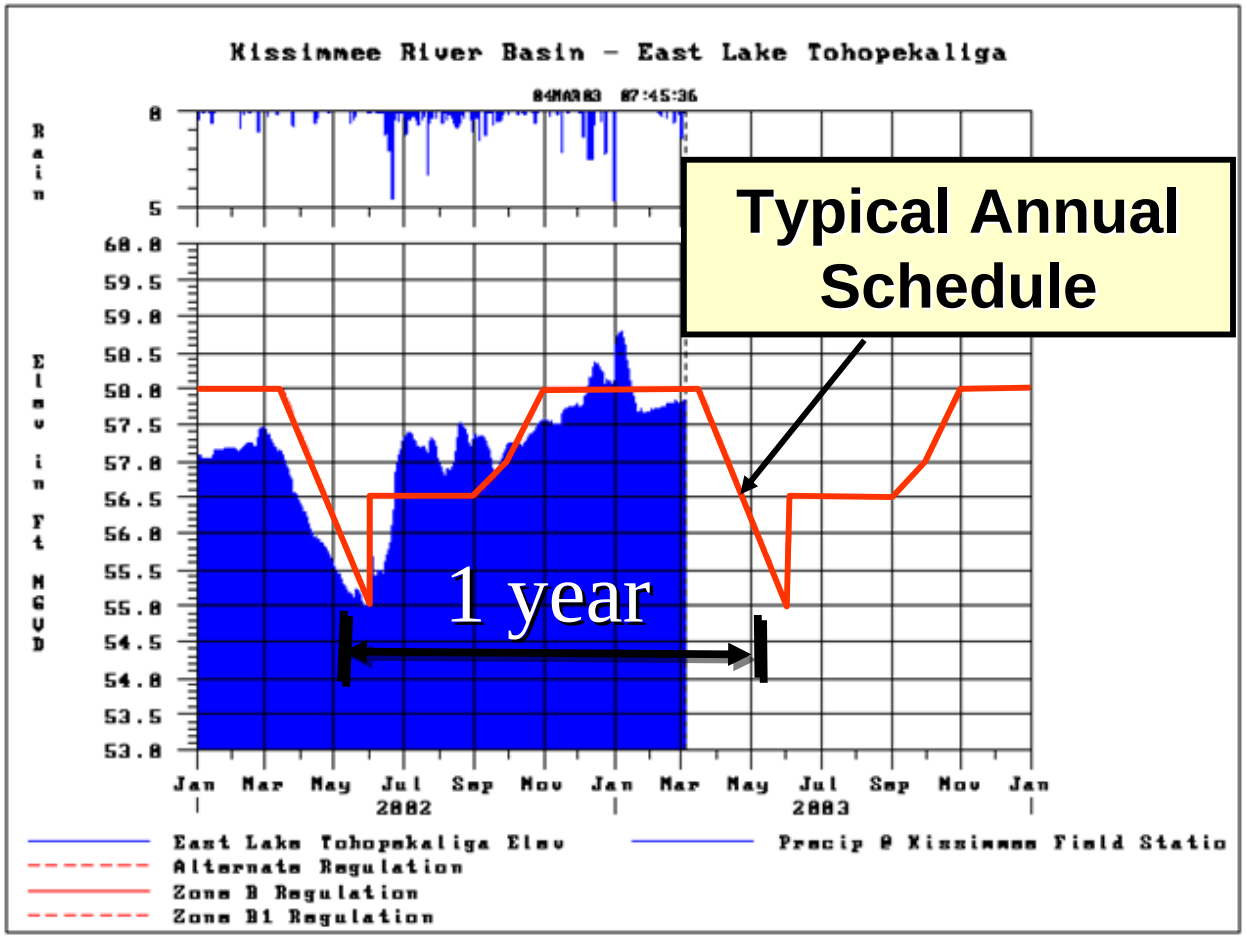


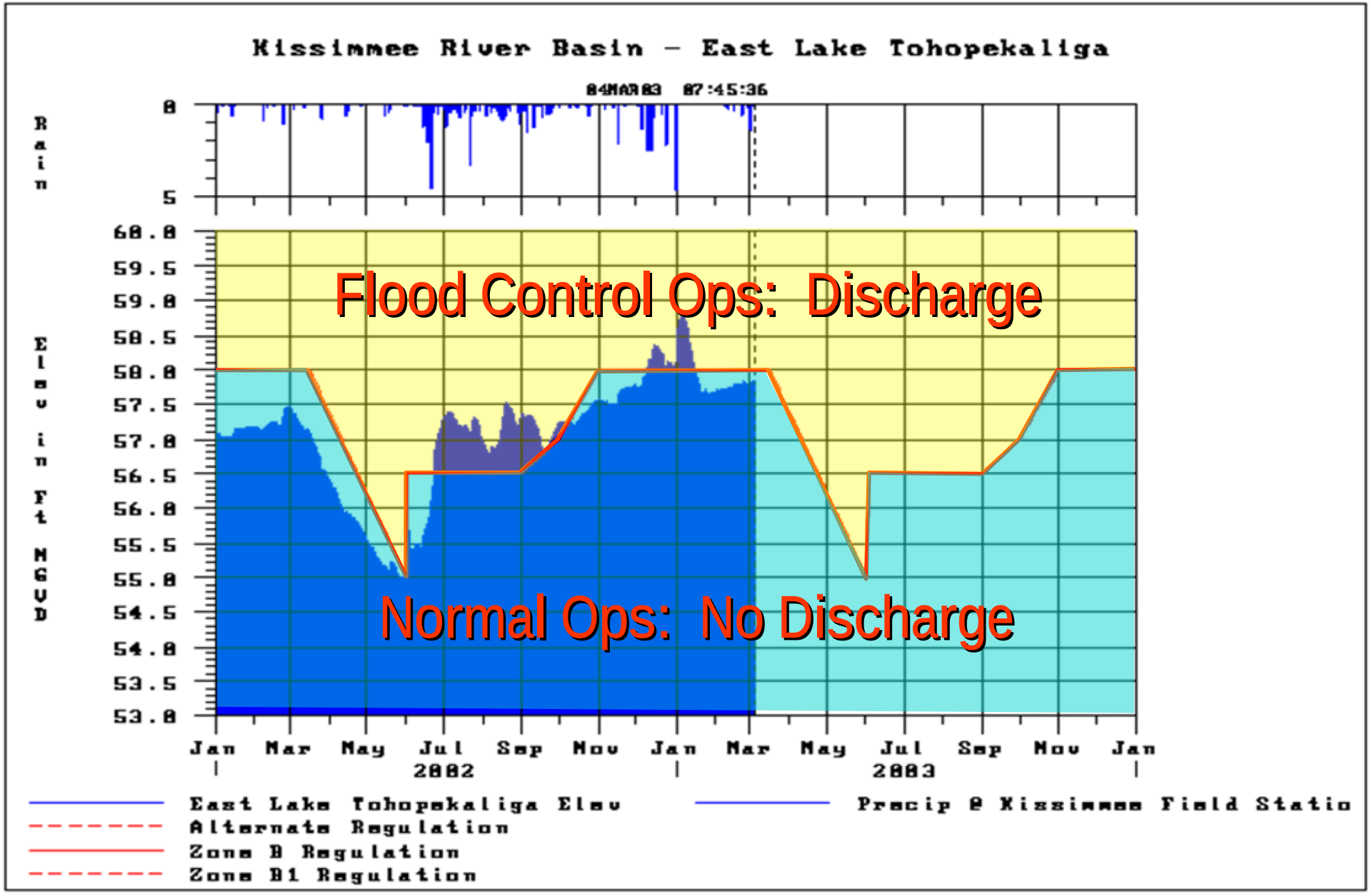
What is a Regulation Schedule?

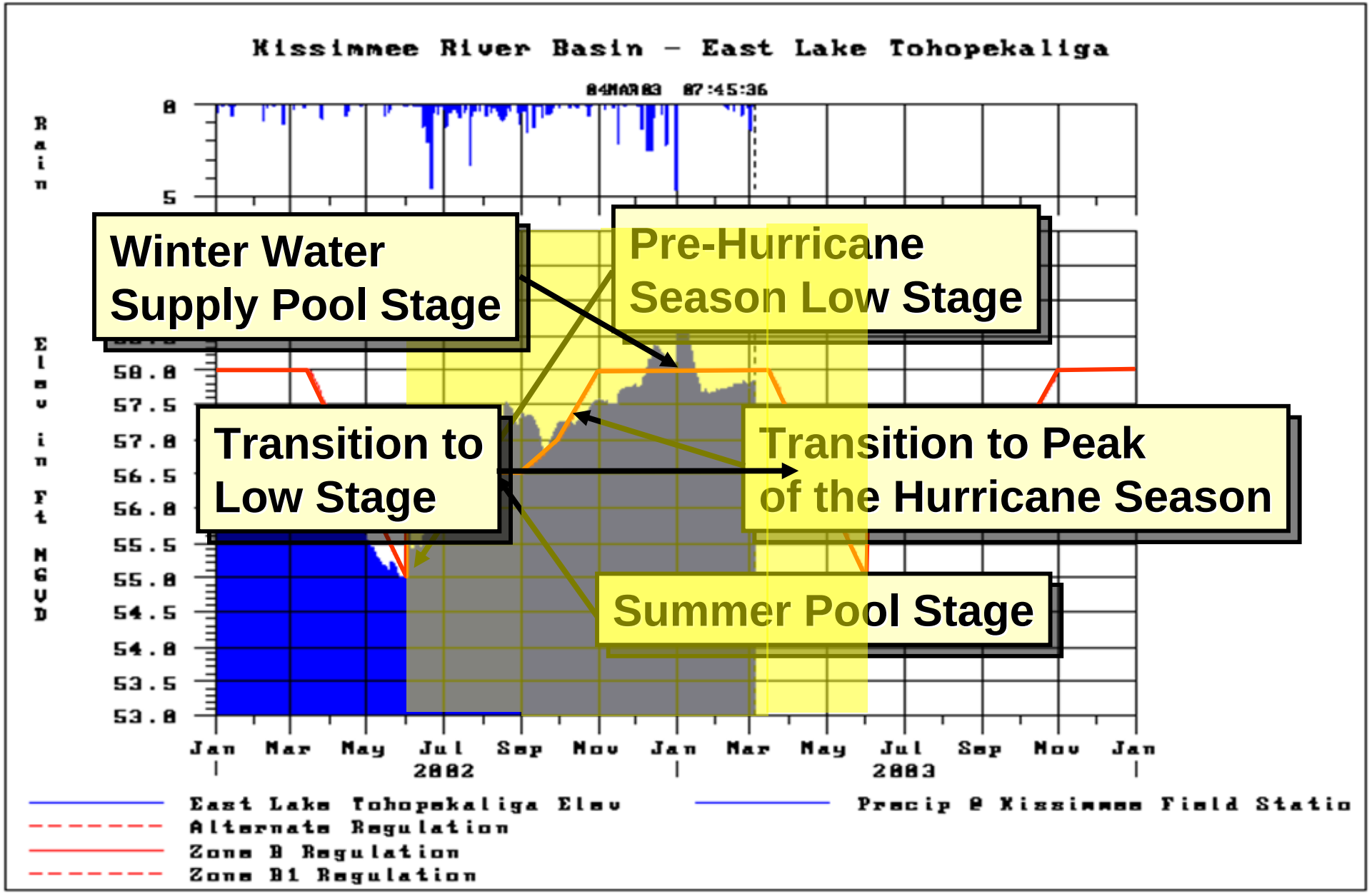
- Tool for managing/regulating water levels in a reservoir/lake
- Triggers regulatory discharges (aka flood control discharges)
- Does not trigger water supply deliveries
- Designed to balance multiple & competing objectives

Regulation Schedules

- Represents seasonal & monthly storage limits
- Considers varying & often conflicting purposes
  - Flood Control: Designed for no damages up to 30% SPF (~1 in 10 yr.)
  - Water Supply: Runoff in wet season is stored for use in dry season

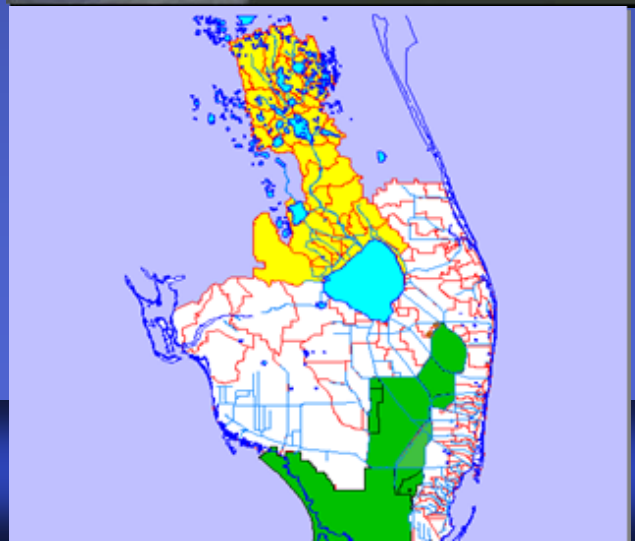



Kissimmee River Basin – East Lake Tohopekaliga
04MAR03 07:45:36
Rain
0
5
Elev in Ft NGVD
60.0
59.5
59.0
58.5
58.0
57.5
57.0
56.5
56.0
55.5
55.0
54.5
54.0
53.5
53.0
Flood Control Ops: Discharge
Normal Ops: No Discharge
Jan Mar May Jul Sep Nov Jan Mar May Jul Sep Nov Jan
2002
2003
East Lake Tohopekaliga Elev
Precip @ Kissimmee Field Statio
Alternate Regulation
Zone B Regulation
Zone B1 Regulation


Kissimmee River Basin – East Lake Tohopekaliga
04MAR03 07:45:36
Rain
Elev in Ft NGVD
8
5
58.8
57.5
57.8
56.5
56.8
55.5
55.8
54.5
54.8
53.5
53.8
Jan Mar May Jul Sep Nov Jan Mar May Jul Sep Nov Jan
2002
2003
Winter Water Supply Pool Stage
Pre-Hurricane Season Low Stage
Transition to Low Stage
Transition to Peak of the Hurricane Season
Summer Pool Stage
East Lake Tohopekaliga Elev
Precip @ Kissimmee Field Statio
Alternate Regulation
Zone B Regulation
Zone B1 Regulation

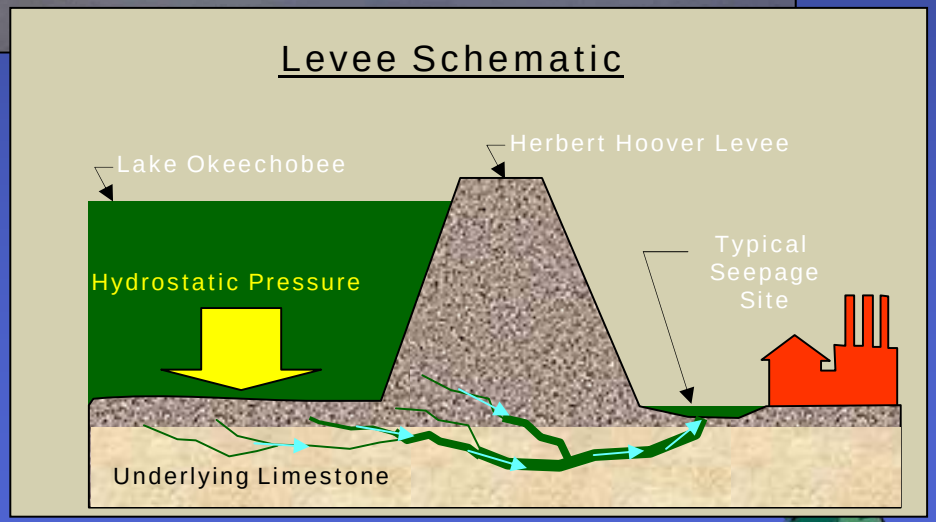
Lake Okeechobee

- Lake Okeechobee covers over 730 square miles, with a contributing basin of over 5,000 square miles
- Water levels driven largely by climatic conditions



Herbert Hoover Levee Issues

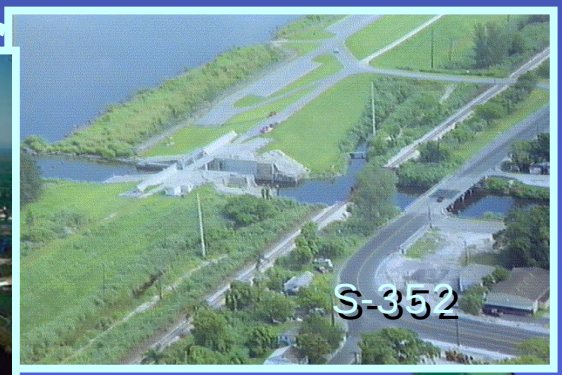
- The levee protects communities surrounding the lake from storm surge flooding
- High stages place tremendous pressure on the levee which could effect stability



Herbert Hoover Dike

(U.S. Army Corps of Engineers)

Lake Okeechobee
Major Water Control Structures



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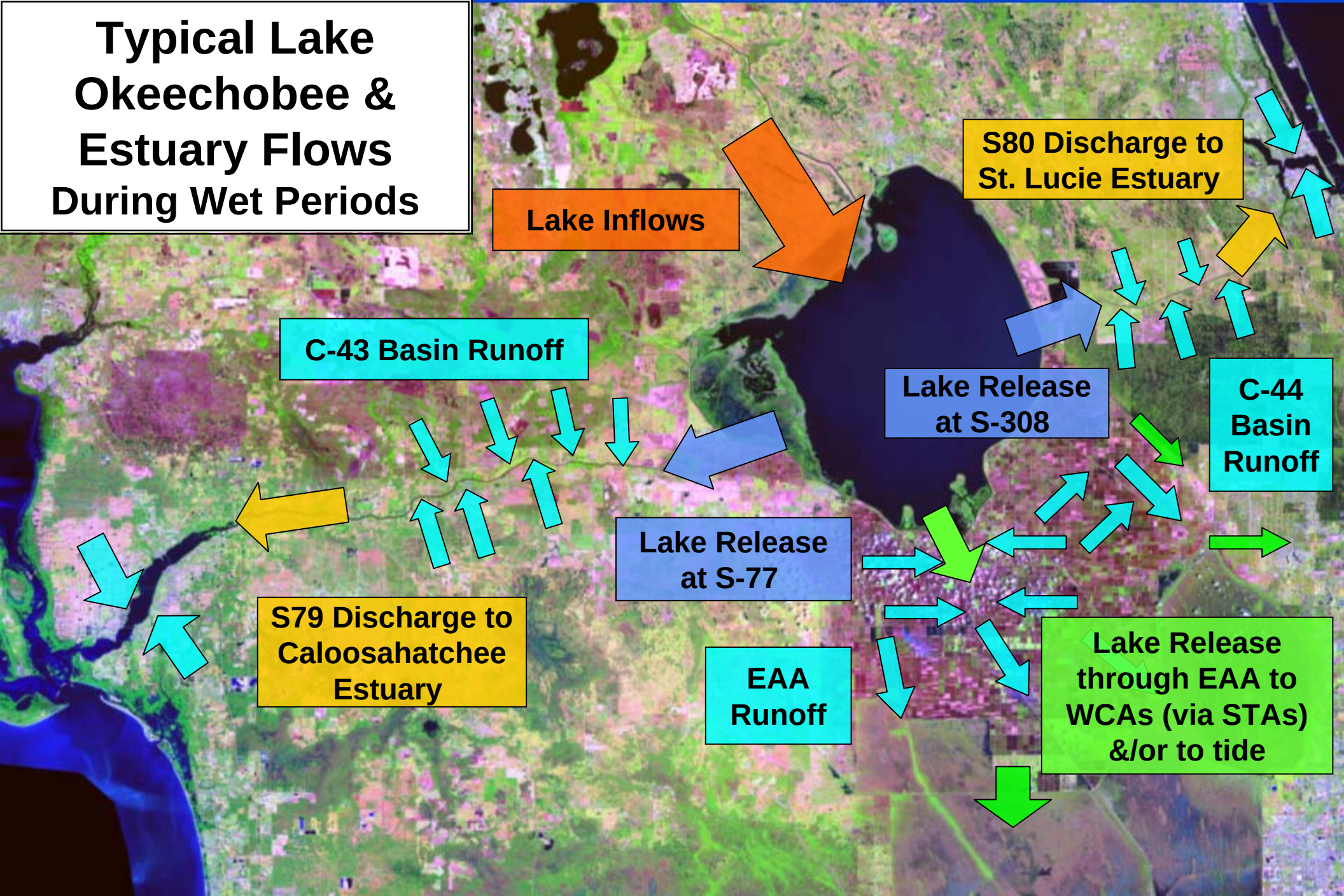
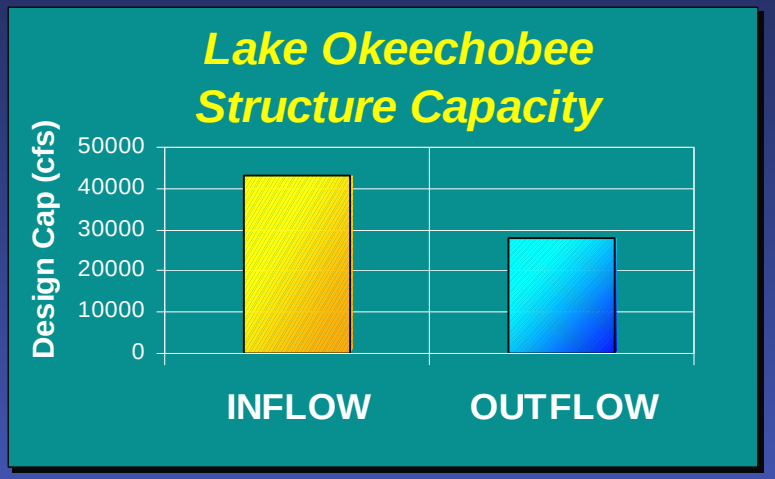
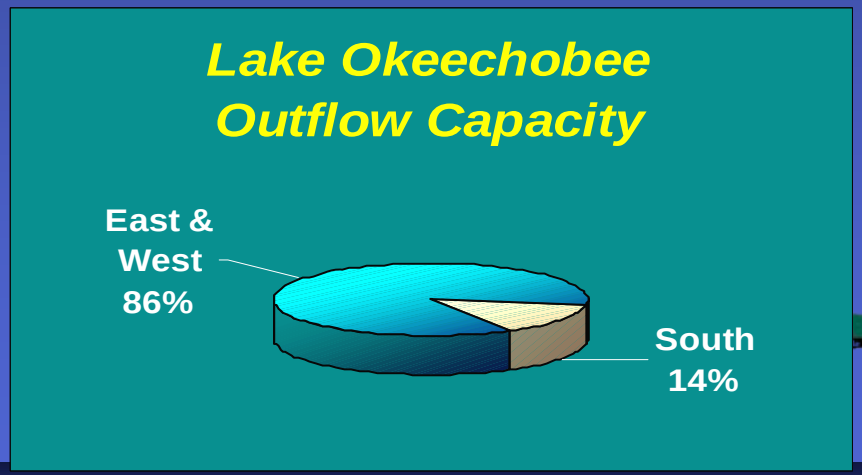

Typical Lake Okeechobee & Estuary Flows
During Wet Periods
Lake Inflows
S80 Discharge to St. Lucie Estuary
C-43 Basin Runoff
Lake Release at S-308
C-44 Basin Runoff
Lake Release at S-77
S79 Discharge to Caloosahatchee Estuary
EAA Runoff
Lake Release through EAA to WCAs (via STAs) &/or to tide

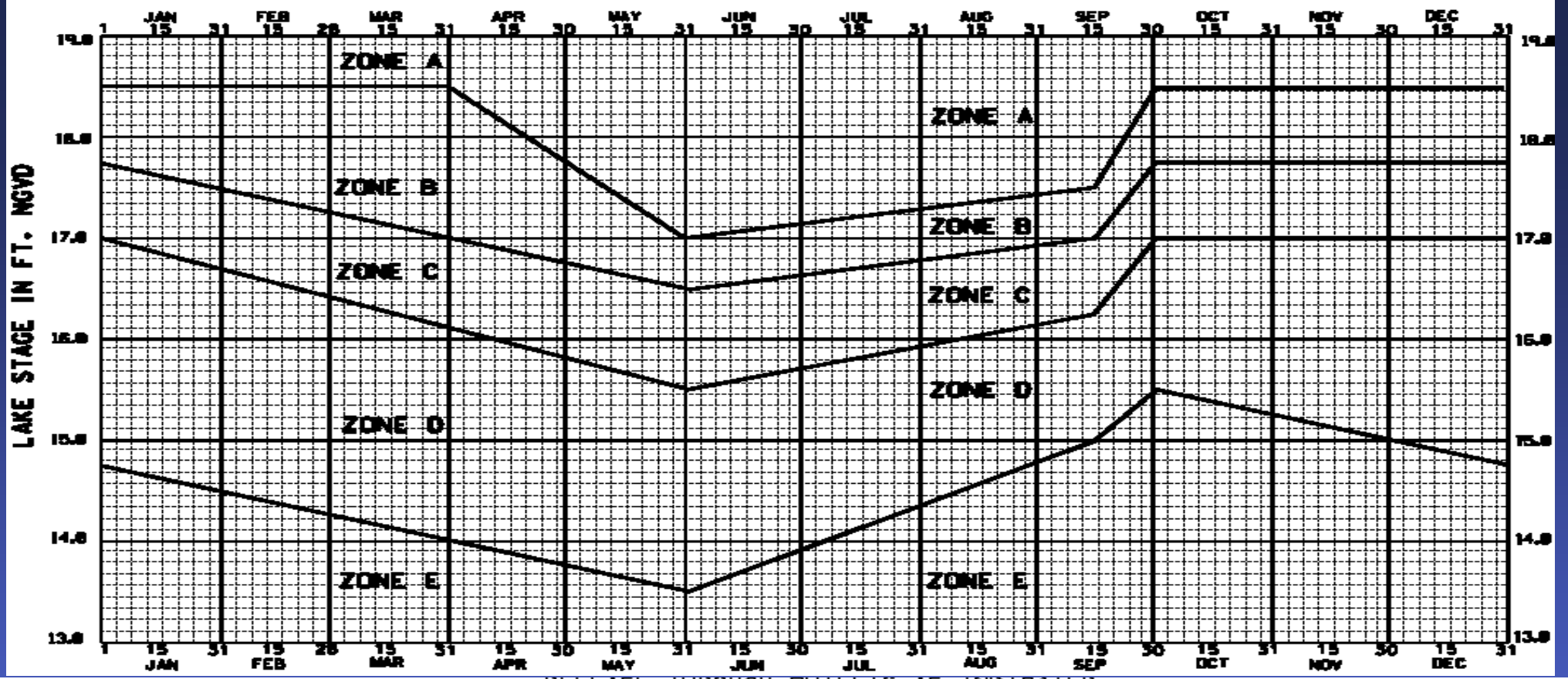
Lake Okeechobee
Design Discharge Capacities

- Inflows to the lake frequently exceed total outflow capacity

- Outflow capacity to the St. Lucie & Caloosahatchee far exceeds outflow capacity to the Water Conservation Areas







RELEASE THROUGH OUTLETS AS INDICATED

ZONE	AGRICULTURAL CANALS To WCAs (1,2)	CALOOSAHATCHEE RIVER AT S-77 (1,2,4)	ST. LUCIE CANAL AT S-80 (1,2,4)
A	PUMP MAXIMUM PRACTICABLE	UP TO MAXIMUM CAPACITY	UP TO MAXIMUM CAPACITY
B (3)	MAXIMUM PRACTICABLE RELEASES	RELEASES PER DECISION TREE (THESE CAN RANGE FROM MAXIMUM PULSE RELEASE UP TO MAXIMUM CAPACITY)	RELEASES PER DECISION TREE (THESE CAN RANGE FROM MAXIMUM PULSE RELEASE UP TO MAXIMUM CAPACITY)
C (3)	MAXIMUM PRACTICABLE RELEASES	RELEASES PER DECISION TREE (THESE CAN RANGE FROM NO DISCHARGE UP TO 6500 CFS)	RELEASES PER DECISION TREE (THESE CAN RANGE FROM NO DISCHARGE UP TO 3500 CFS)
D (3,5)	AS NEEDED TO MINIMIZE ADVERSE IMPACTS TO THE LITTORAL ZONE WHILE NOT ADVERSELY IMPACTING THE EVERGLADES. (SEE NOTE 5.)	RELEASES PER DECISION TREE (THESE CAN RANGE FROM NO DISCHARGE UP TO 4500 CFS)	RELEASES PER DECISION TREE (THESE CAN RANGE FROM NO DISCHARGE UP TO 2500 CFS)
E	NO REGULATORY DISCHARGE	NO REGULATORY DISCHARGE	NO REGULATORY DISCHARGE

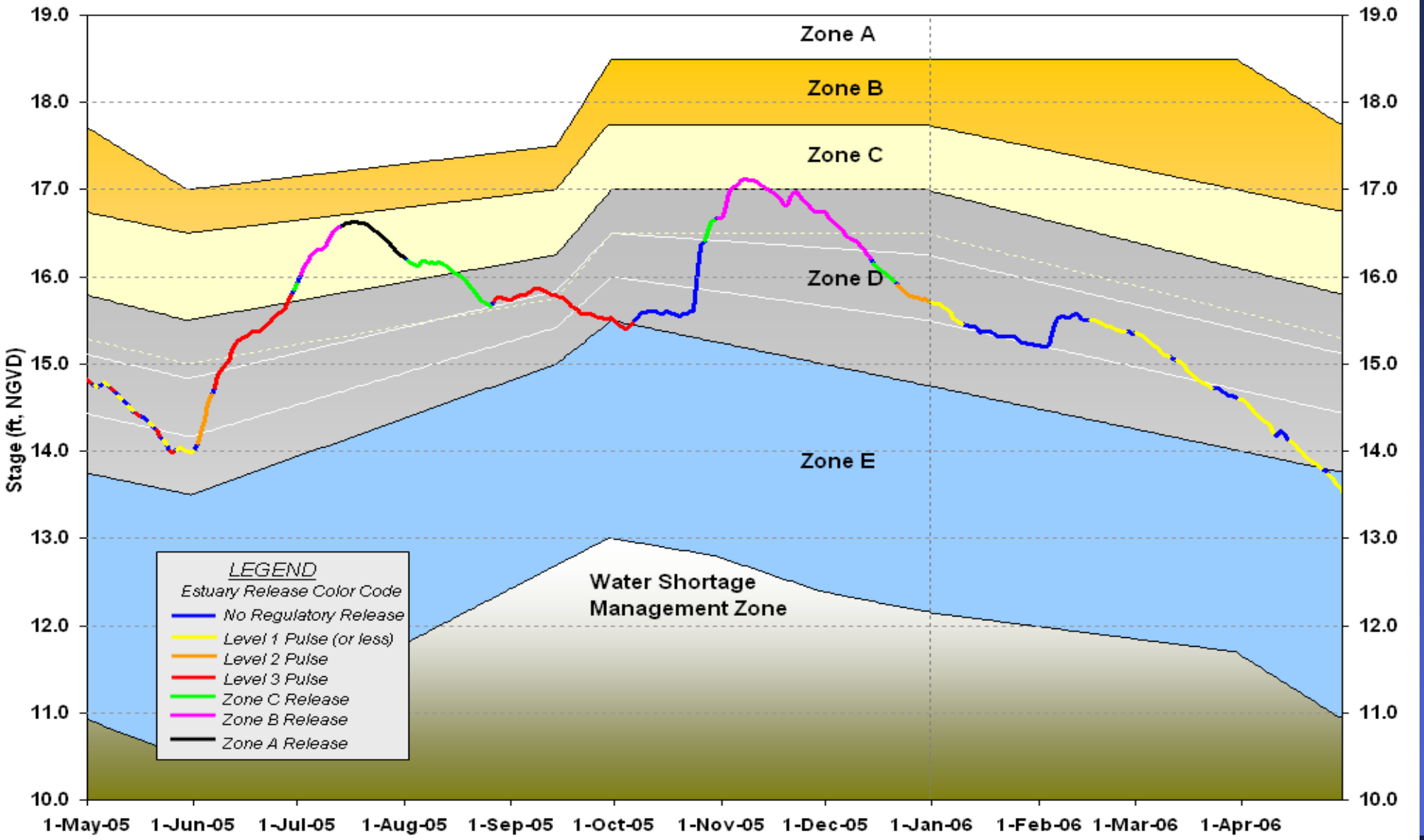
NOTES: (1) SUBJECT TO FIRST REMOVAL OF RUNOFF FROM DOWNSTREAM BASINS
(2) GUIDELINES FOR WET, DRY AND NORMAL CONDITIONS ARE BASED ON: 1) SELECTED CLIMATIC INDICES AND TROPICAL FORECASTS AND 2) PROJECTED INFLOW CONDITIONS. RELEASES ARE SUBJECT TO THE GUIDELINES IN THE WSE OPERATIONAL DECISION TREE, PARTS 1 AND 2.
(3) RELEASES THROUGH VARIOUS OUTLETS MAY BE MODIFIED TO MINIMIZE DAMAGES OR OBTAIN ADDITIONAL BENEFITS. CONSULTATION WITH EVERGLADES AND ESTUARINE BIOLOGISTS IS ENCOURAGED TO MINIMIZE ADVERSE EFFECTS TO DOWNSTREAM ECOSYSTEMS.
(4) PULSE RELEASES ARE MADE TO MINIMIZE ADVERSE IMPACTS TO THE ESTUARIES
(5) ONLY WHEN THE WCAs ARE BELOW THEIR RESPECTIVE SCHEDULES

CENTRAL AND SOUTHERN FLORIDA
INTERIM REGULATION SCHEDULE
LAKE OKEECHOBEE

DEPARTMENT OF THE ARMY, JACKSONVILLE DISTRICT
CORPS OF ENGINEERS, JACKSONVILLE, FLORIDA
DATED: 5 NOVEMBER 1999

WSE (WITH CLIMATE OUTLOOK)

Lake Okeechobee Stage & Regulatory Discharge History

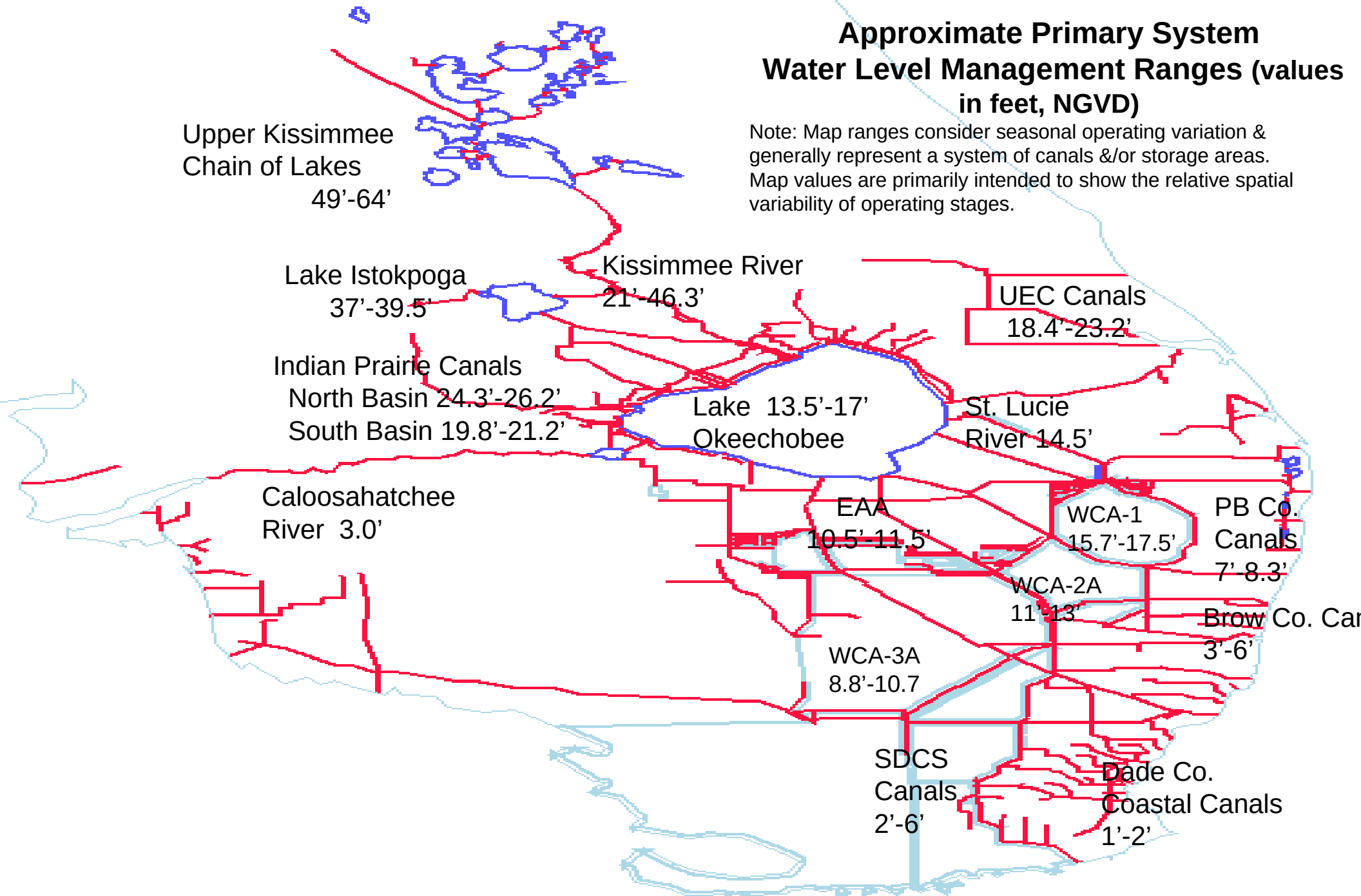


C&SF Project Strengths & Weaknesses

- Provides significant benefits to developed areas
  - Flood control
  - Water supply
- Unintended ecological impacts associated with C&SF construction and operation

South Florida Water Resource Management Challenges

- Florida's climate is one of "extremes"
- System stressed by population & land use
- <u>BALANCE</u>
  - Multiple water resource objectives
  - Objectives often conflict


Approximate Primary System
Water Level Management Ranges (values in feet, NGVD)
Note: Map ranges consider seasonal operating variation & generally represent a system of canals &/or storage areas. Map values are primarily intended to show the relative spatial variability of operating stages.
Upper Kissimmee Chain of Lakes 49'-64'
Lake Istokpoga 37'-39.5'
Kissimmee River 21'-46.3'
UEC Canals 18.4'-23.2'
Indian Prairie Canals North Basin 24.3'-26.2' South Basin 19.8'-21.2'
Lake Okeechobee 13.5'-17'
St. Lucie River 14.5'
Caloosahatchee River 3.0'
EAA 10.5'-11.5'
WCA-1 15.7'-17.5'
PB Co. Canals 7'-8.3'
WCA-2A 11'-13'
Brow Co. Can 3'-6'
WCA-3A 8.8'-10.7
SDCS Canals 2'-6'
Dade Co. Coastal Canals 1'-2'