SOUTH FLORIDA WATER MANAGEMENT DISTRICT

Regional Hydrologic Models 101 Modeling for Restoration Planning and Implementation

Use of the South Florida Water Management Model (SFWMM)

Presented by:
Walter Wilcox
Interagency Modeling Center

HYDROLOGIC & ENVIRONMENTAL SYSTEMS MODELING

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

The South Florida Water Management Model (SFWMM)

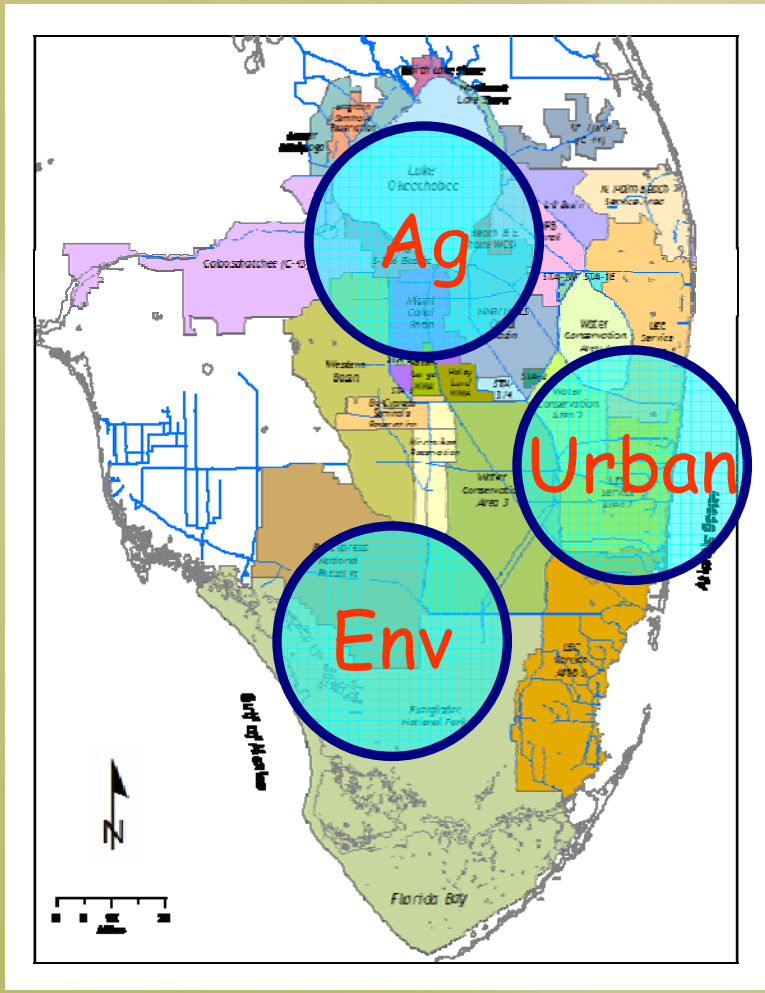
HYDROLOGIC & ENVIRONMENTAL SYSTEMS MODELING

What is the SFWMM?

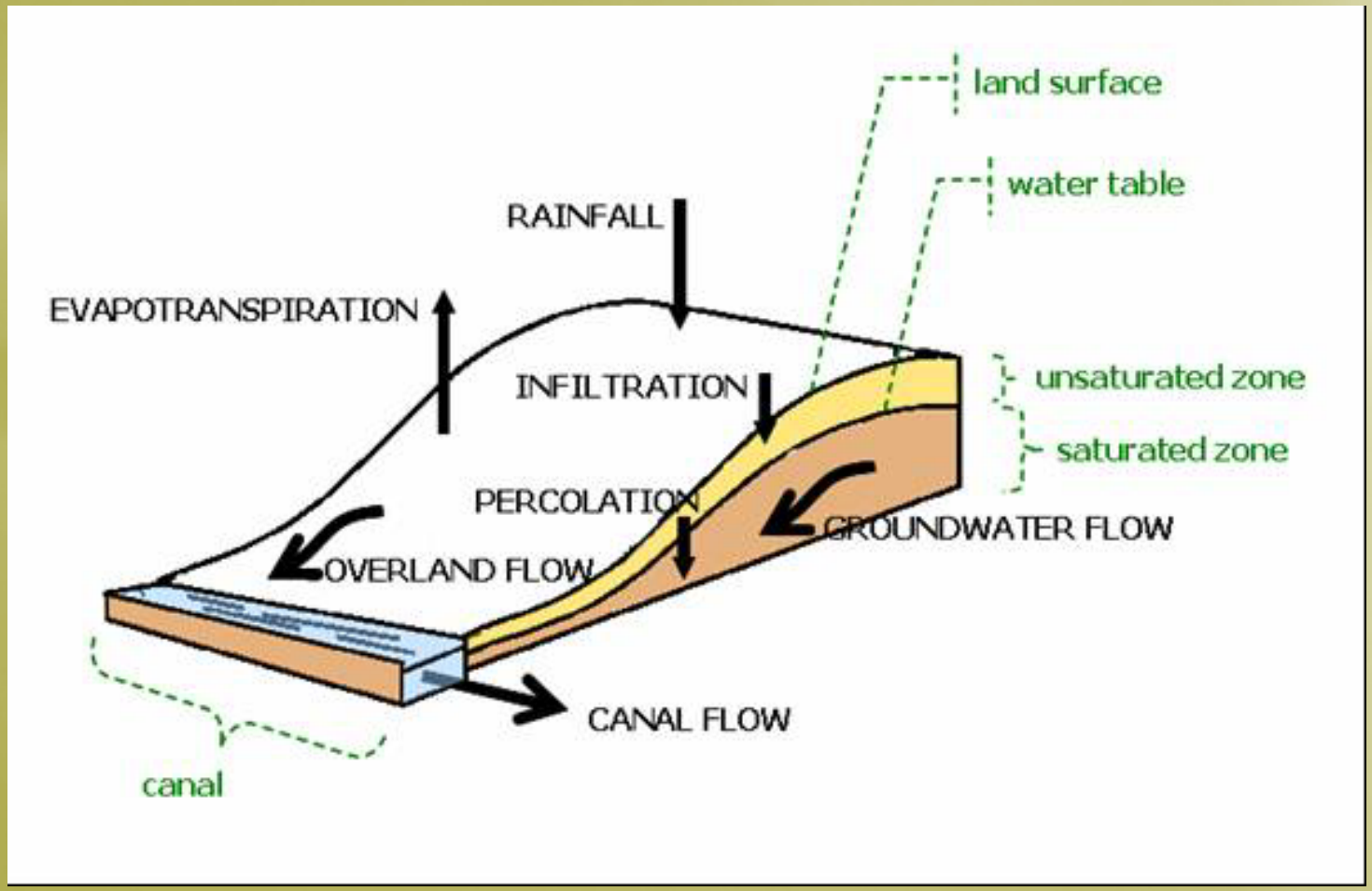
- Regional scale (2 mile x 2 mile), daily time step hydrologic simulation model
- Covers an area from north of Lake Okeechobee to Florida Bay
- Simulates key hydrologic processes (e.g. rainfall, evapotranspiration, overland flow, groundwater flow, etc…)
- Simulates water management features (e.g. regulation schedules, structure operation, well pumpage, etc…)
- Up to 41 year period of simulation (1965-2005)

The South Florida System

- Water management objectives and practices vary from area to area
- Watersheds or drainage basins are not typically delineated by natural divides, e.g. ridges, but more commonly with man-made levees
- In general, groundwater flow is not restricted by basin boundaries



General Hydrologic Processes Simulated in the SFWMM

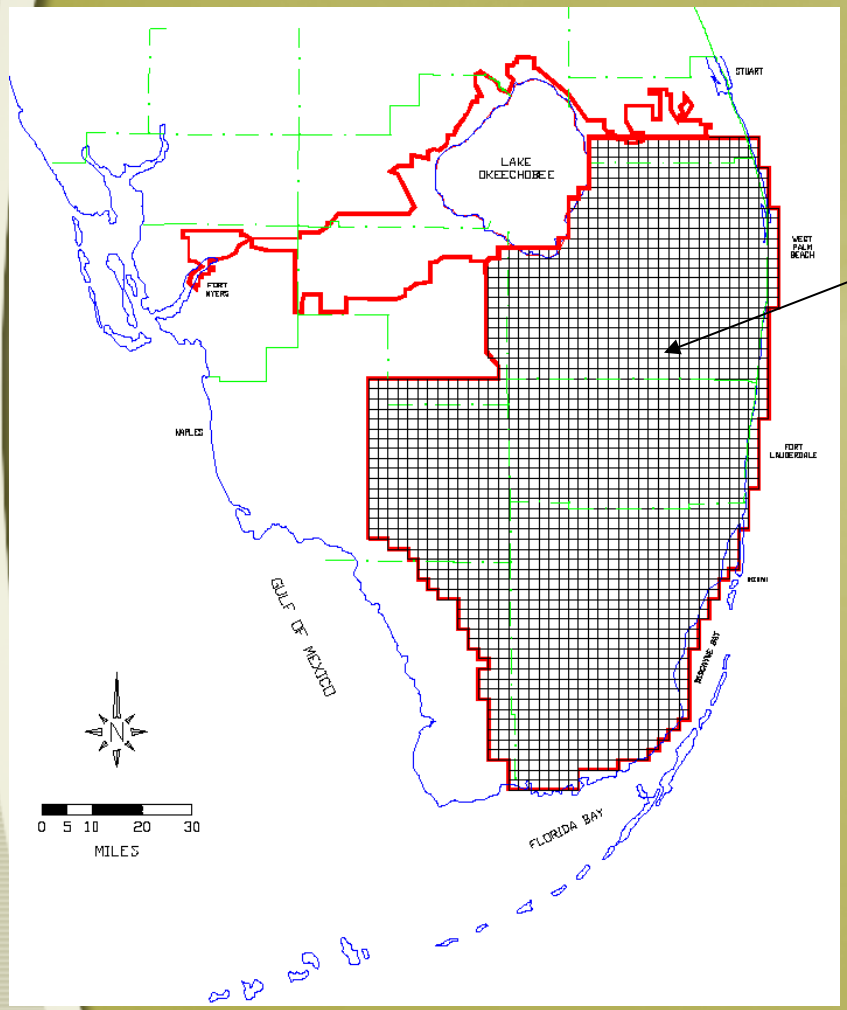


The SFWMM – 25 years in the making

The model has evolved over time:

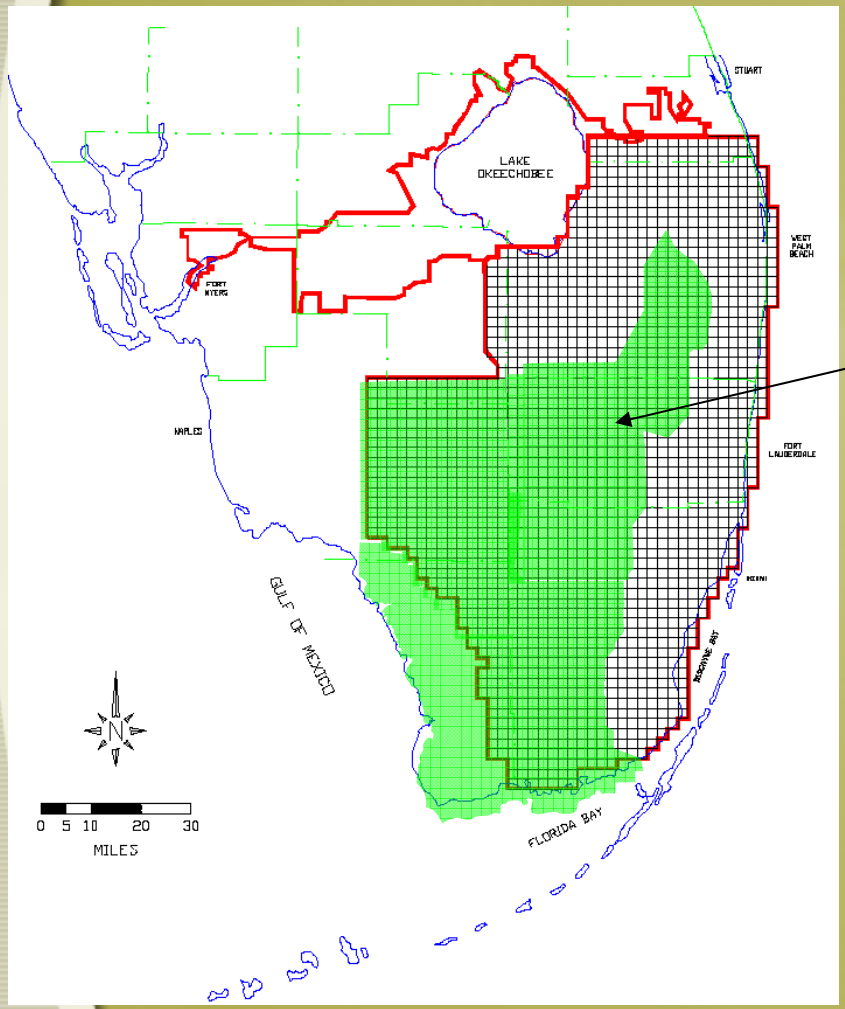
- A basic framework exists to simulate climate influences and primary hydrologic processes.
- Additional complexity has been added as needed to aid in calibration efforts or to address client needs.
- This development approach has led to some differences in the way a number of hydrologic processes are modeled in various sub-regions.

The Basic Framework of the SFWMM – A Distributed System (Gridded Domain)



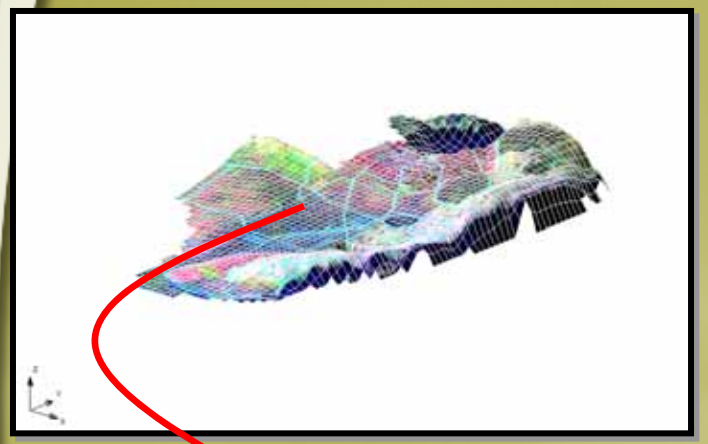
- Comprised of 2-mile by 2-mile square grid cells that cover the majority of the South Florida system south of Lake Okeechobee
- Encompasses the extent of the finite difference solution to the governing overland and groundwater flow equations.
- Model input data sets (RF, PET, Topo, etc…) are consistently derived for the entire model extent.

Relying on the Generic Framework – Natural Areas (WCAs, ENP, BCNP)



- Overland flow and groundwater flow per finite difference solution
- Canals are simulated using a mass balance approach
- Land use is assigned only one value per cell (homogenous pattern)
- The unsaturated zone is not modeled; total ET is calculated as the sum of open water evaporation and saturated zone (water table) ET.

Natural Area Cell



Rainfall

Evapotranspiration

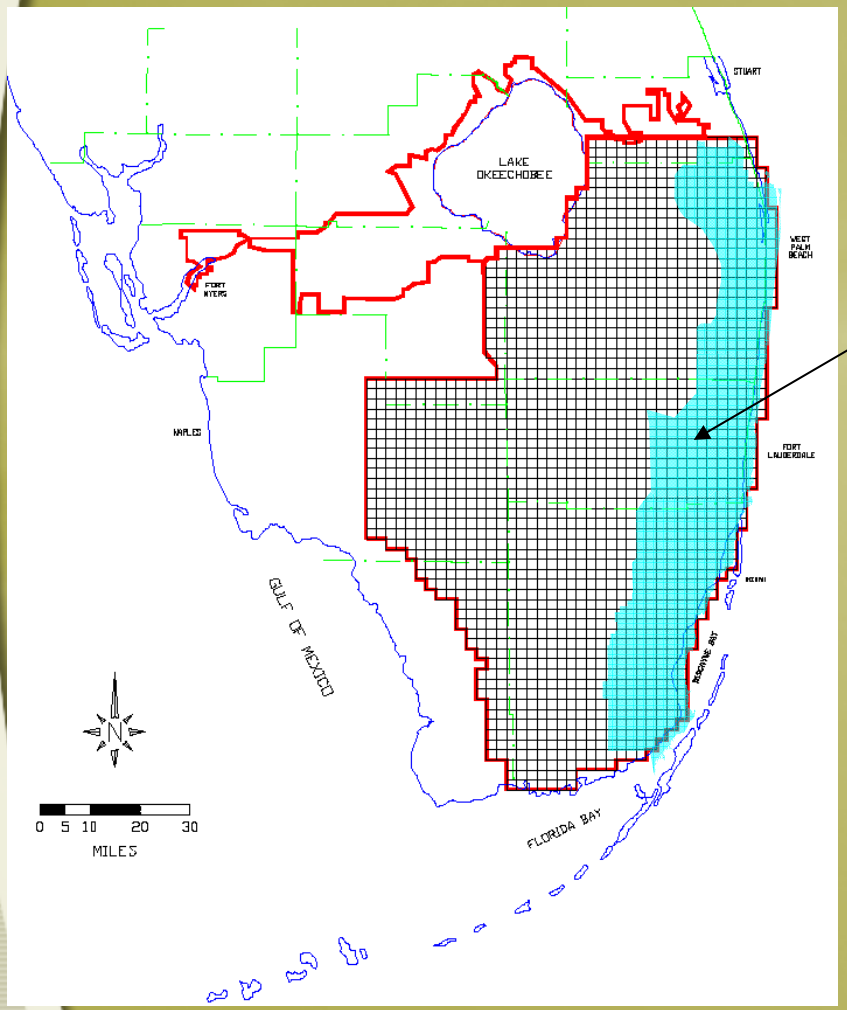
Sheetflow (in)

SF out

Groundwater flow (in)

GF out

Adding Complexity – The Lower East Coast (LEC)

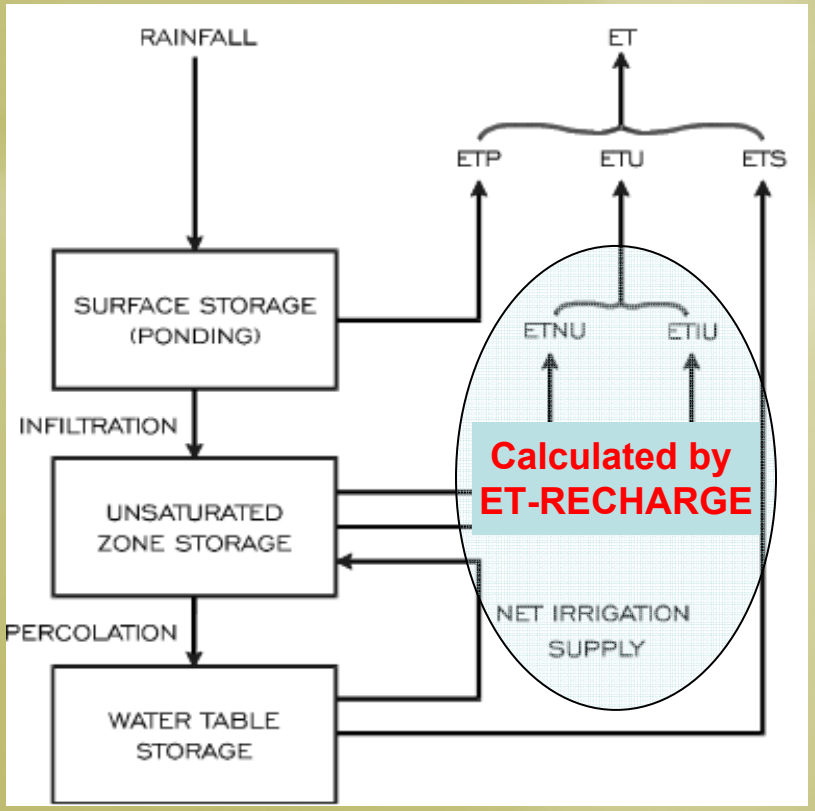


Additional considerations for LEC areas:

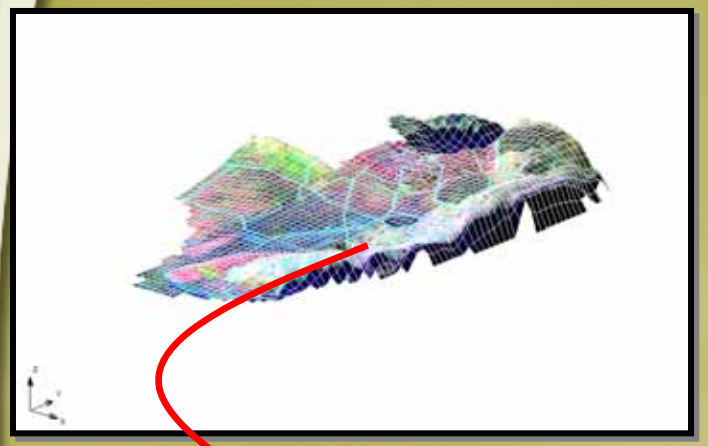
- Land use must consider a finer resolution than 2 mile x 2 mile (heterogeneous pattern); ET-Recharge
- Unsaturated zone accounting required; ET-Recharge
- Quantification of levee seepage across Everglades boundary; SEEPN

ET-Recharge Model

- Developed originally to provide a more accurate method for estimating recharge component for MODFLOW
- Computes supplemental irrigation requirements, unsaturated zone ET, recharge, … etc., on a polygon level
  - Uses AFSIRS as the primary field scale computation engine
  - Aggregates computed values to 2 mile x 2mile scale input for SFWMM
- Input requirements include land use and soil definitions, climate information, and crop coverages and parameters



Urban Area Cell



Rainfall

Evapotranspiration

Struc flow (out)

Structure Flow (in)

Groundwater flow (in)

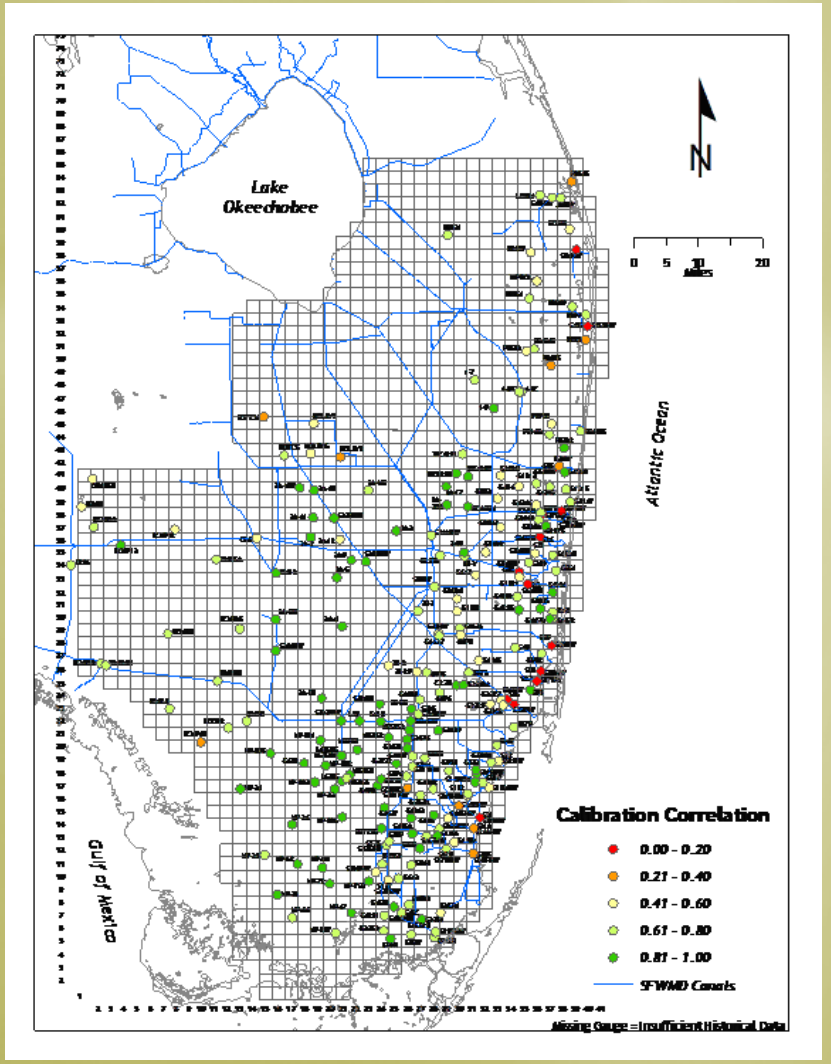
Wellfield

GF out

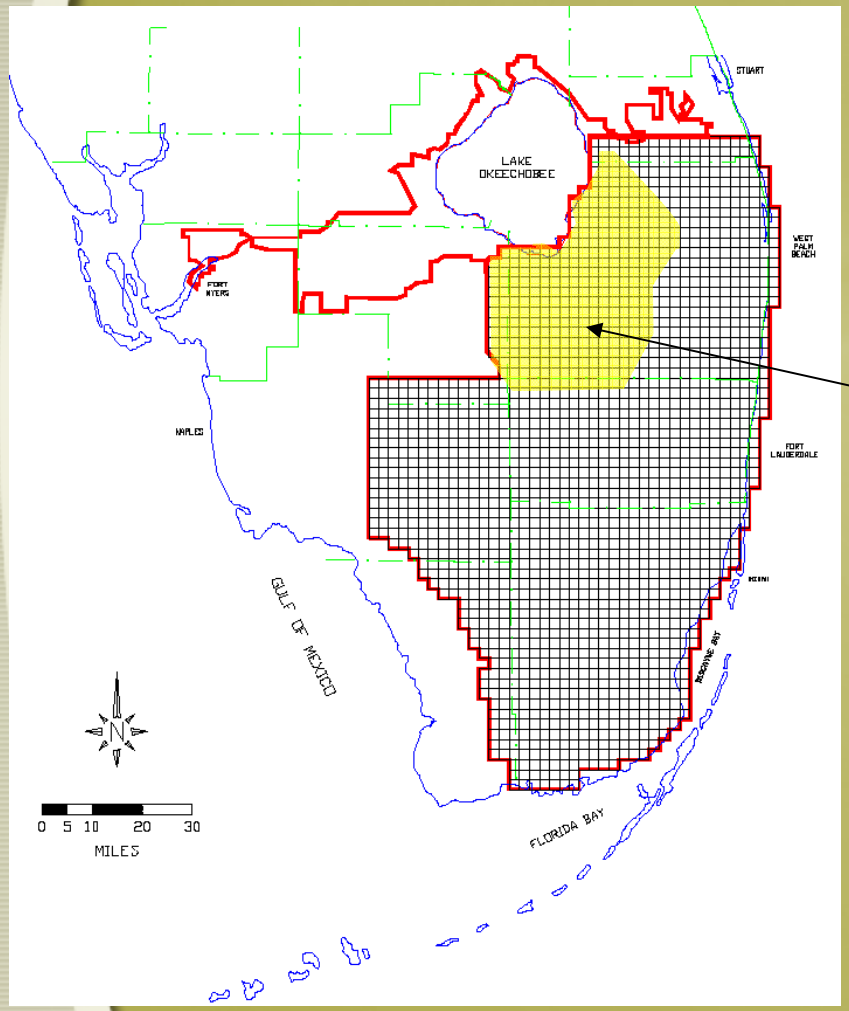
Biscayne Aquifer

LEC / Glades Calibration

- Purpose: To demonstrate the models predictive capability, historical water levels are compared against simulated values. Additionally, aggregated flow volumes as simulated are compared for reasonability against historically observed volumes.
- Long period of record: 1984-1995 for calibration and 1981-1983 & 1996-2000 for verification
- Significant data update and recalibration approximately every 4-5 years



Adding Complexity – The Everglades Agricultural Area (EAA)

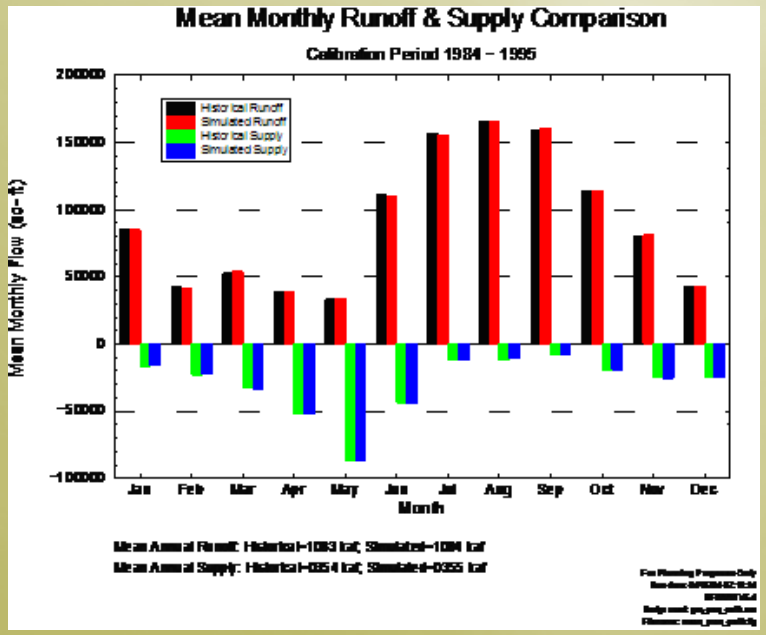


Additional considerations for EAA areas:

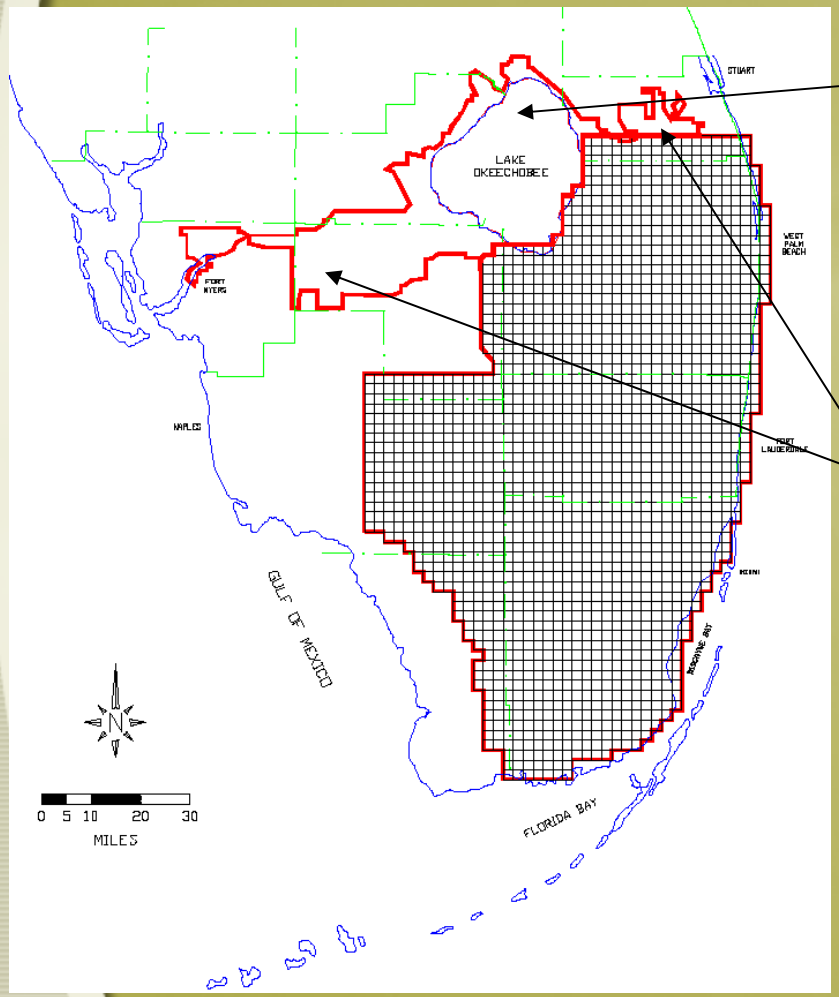
- Canal hydraulics limit ability to move water (HEC-2)
- Irrigation practices
- Volume of water that moves across regional boundaries is emphasized more than stage from a water management standpoint
- Excess water is internally routed through canal systems, rather than resulting in overland flow

EAA Calibration

- Purpose: To demonstrate the models predictive capability, historical discharges expressed in terms of net basin runoff and supplemental irrigation demand are compared against simulated values.
- Same calibration and verification periods as the LEC/Glades
- Simulated runoff and irrigation requirements and observed data were made to match as close as possible by changing the following model parameter values:
  - ET coefficients
  - local storage expressed in terms of soil moisture thresholds for triggering runoff and supplemental deliveries

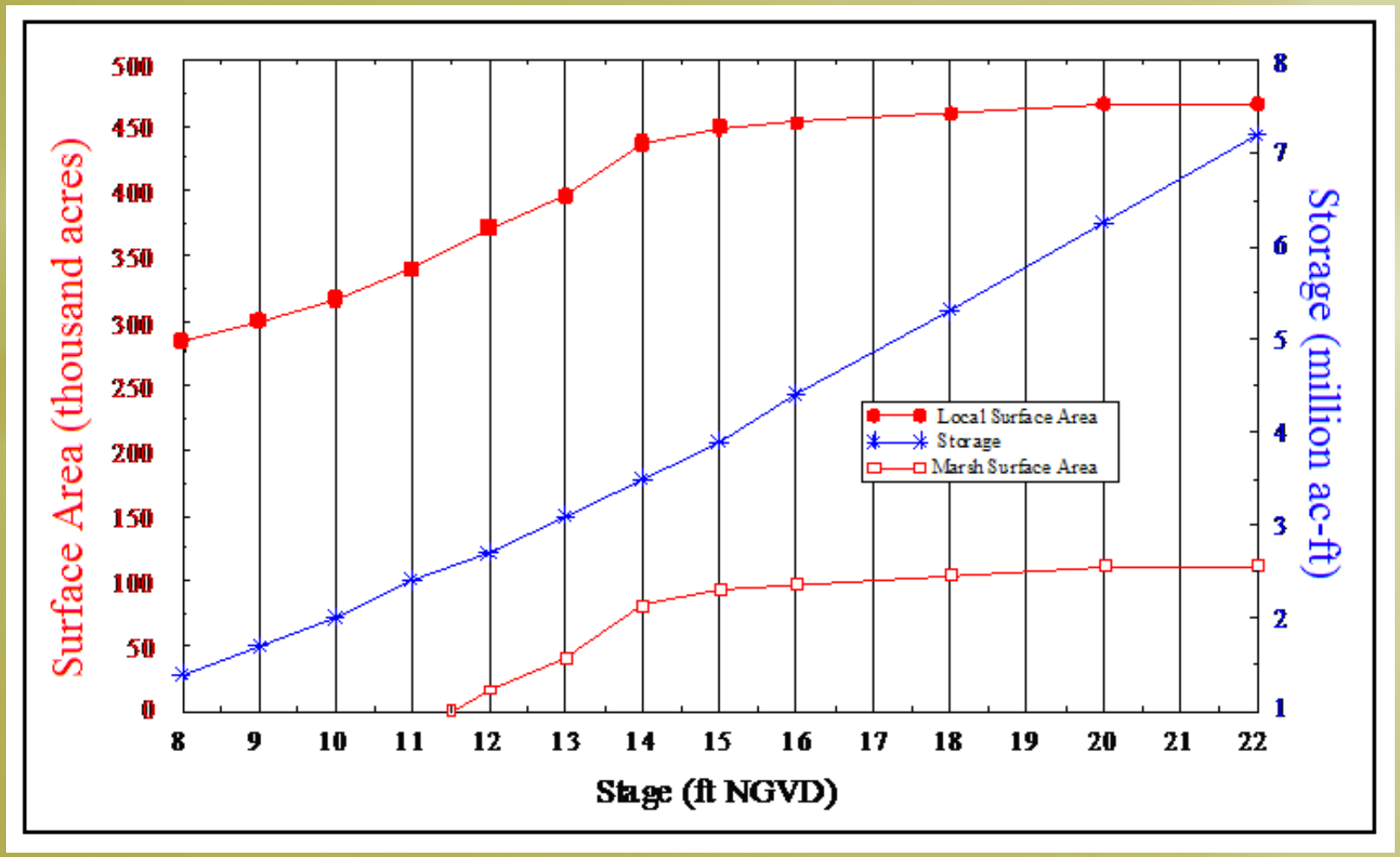


Adding Complexity - Lumped Systems

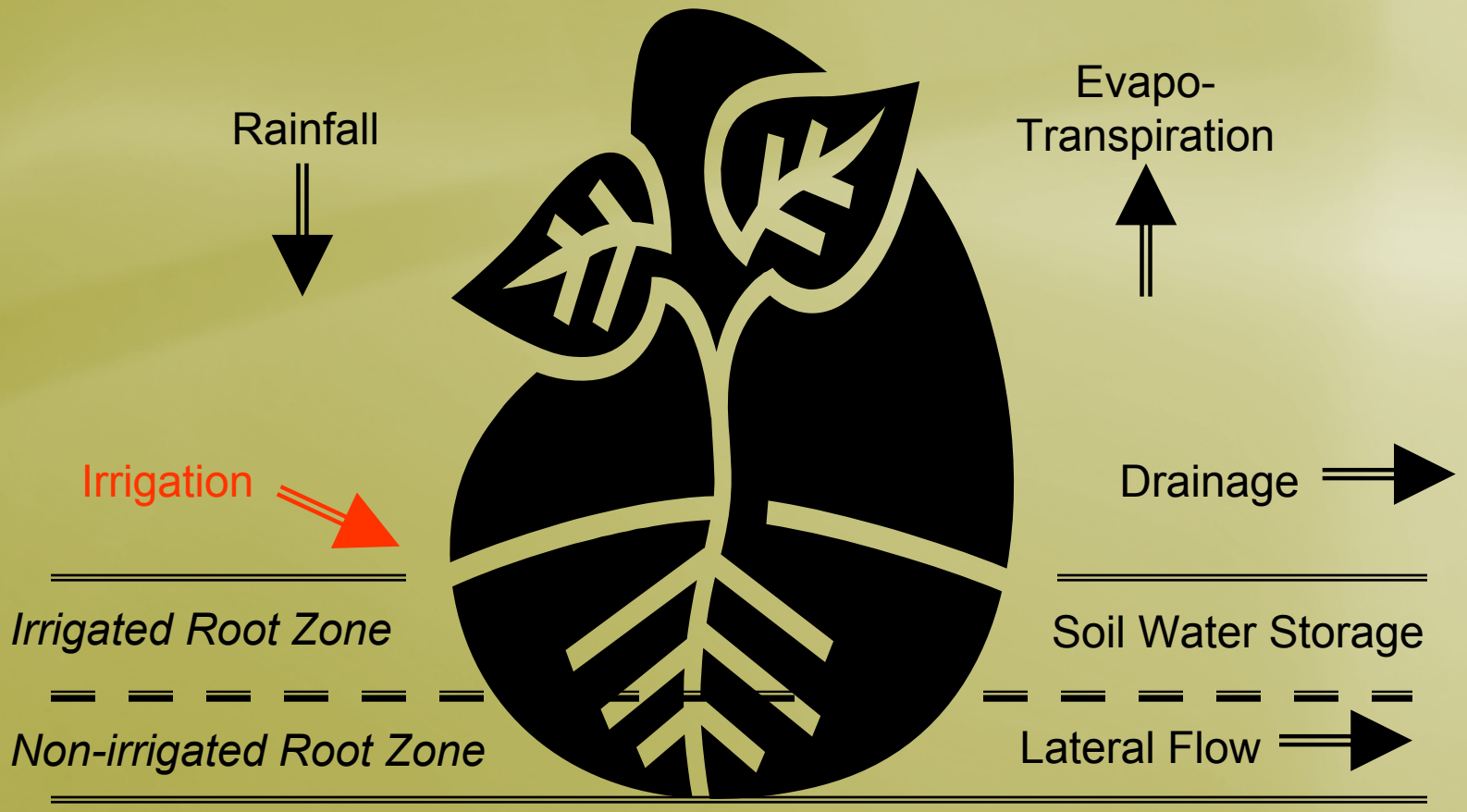


- Lake Okeechobee is modeled as a lumped system, where a single value is defined as a simulated water level. The lake interacts with the rest of the model domain through flow control structures.
- For the remainder of the Lake Okeechobee Service Areas (i.e. excluding the EAA), the AFSIRS/WATBAL water budget model is used to estimate basin scale supplemental irrigation demand and runoff

Lake Okeechobee

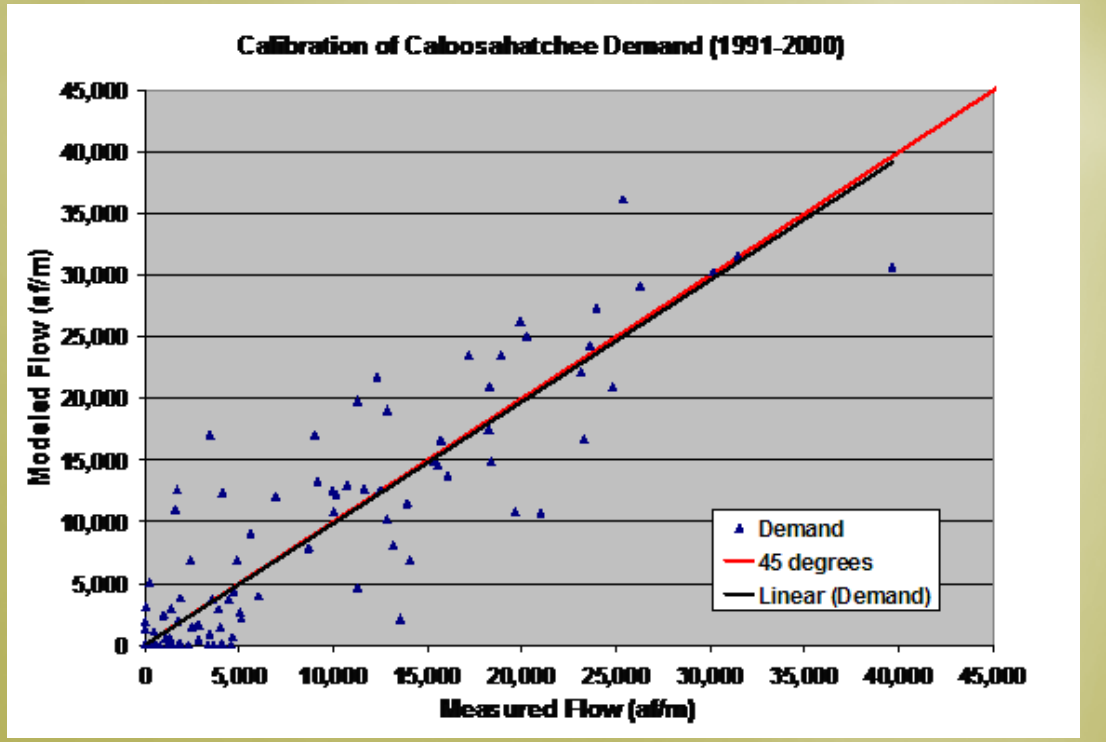


AFSIRS/WATBAL Model Overview – Conceptualization at Field Scale



AFSIRS/WATBAL Calibration

- Purpose: Similar to the EAA, historical discharges expressed in terms of net basin runoff and supplemental irrigation demand are compared against simulated values.
- Historical data availability is limited (5 to 10 years), so therefore the entire period was designated as calibration and no verification was performed.
- Limited validation performed on early periods with poorer data.



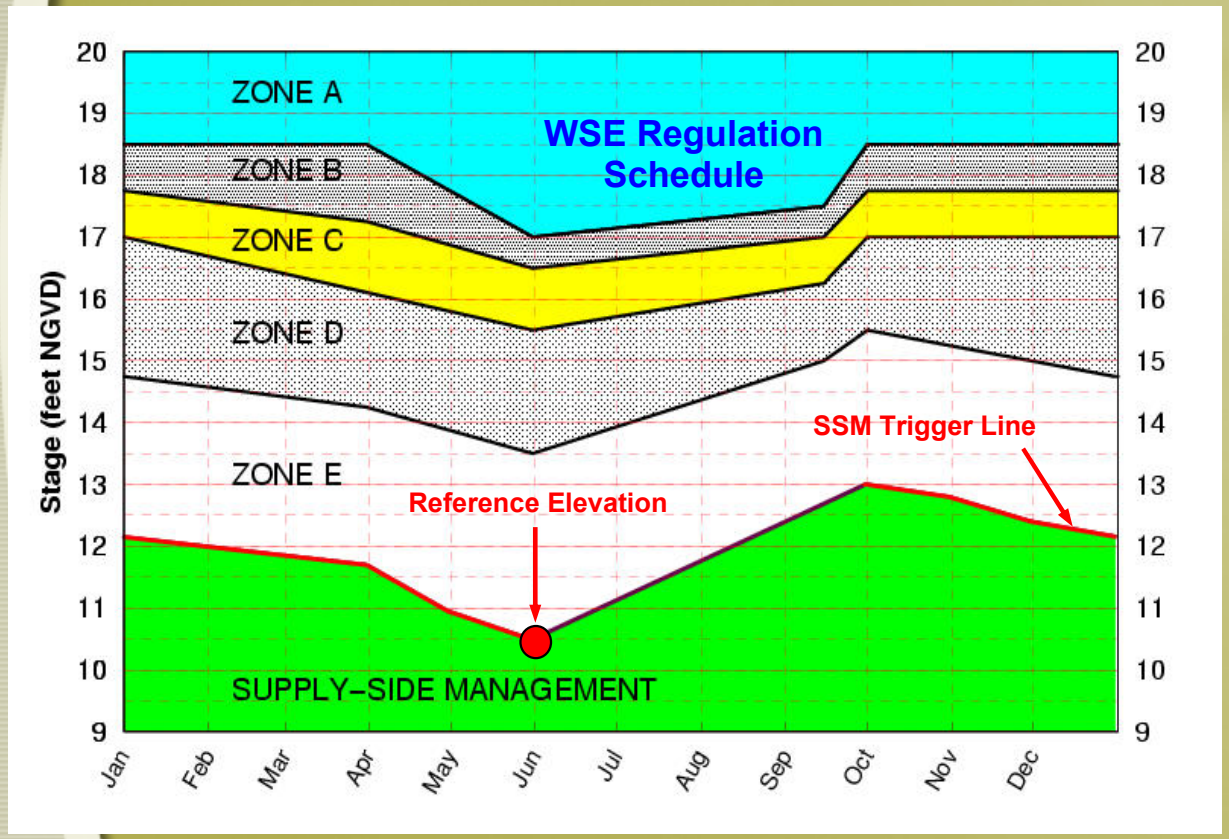
SFWMM Management & Project Features

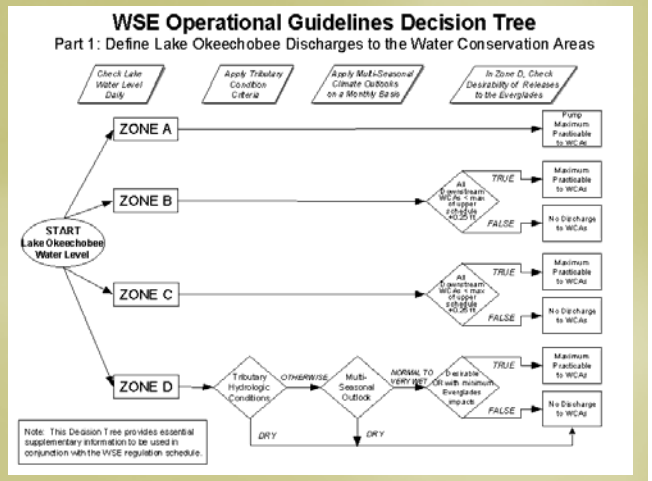
- **Simulation of Structures possibly subject to:**
  - Rising or declining headwater or tail water
  - Current water levels at remote locations (surface water or groundwater)
  - Rate of change of water levels at remote locations (surface water or groundwater)
  - Perceived downstream water supply demand (additional discussion in subsequent paragraph)
  - Drawdowns during times that major storms are anticipated or occurring (e.g. accumulation of rainfall)
  - Operational decisions at other structures (e.g. dual operations or establishing a flow-through situation)
  - Response to a pre-determined operational guideline (e.g. time-series of desired discharge)

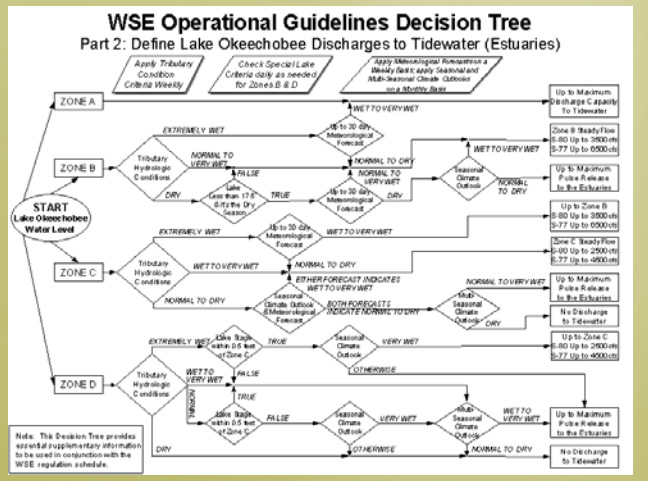
SFWMM Management & Project Features

- **Simulation of Storage Features (e.g. Reservoirs, Stormwater Treatment Areas, Aquifer Storage & Recovery, etc…) possibly subject to:**
  - Rising or declining adjacent canal stage
  - Capture of local basin runoff
  - Capture of releases from upstream storage
  - Demand in downstream basins including agricultural water supply deficit, environmental water supply, etc… (quantified in a manner similar to that described for structure operations)
  - Projected long-term or short-term climate conditions (e.g. seasonally varying operations or pre-storm discharges)
  - Mitigation of high stages in above-ground reservoir (e.g. overflow prevention)

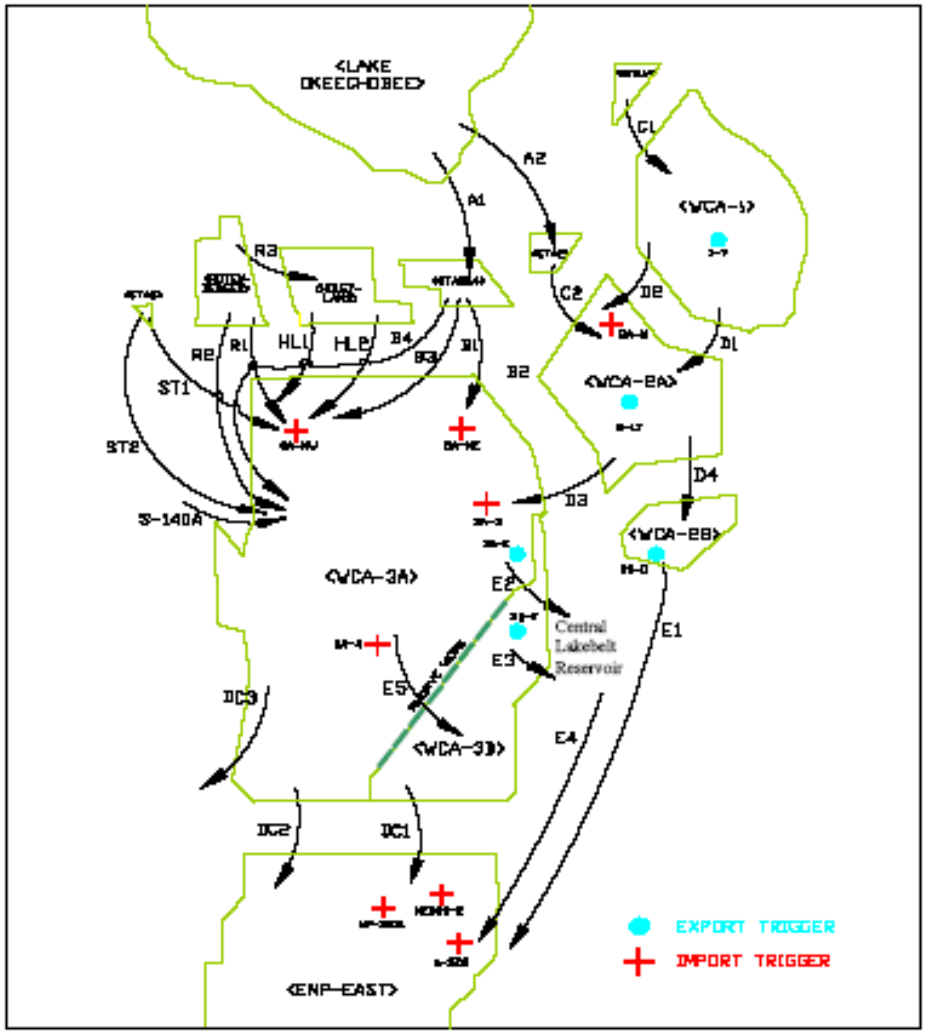
SFWMM Management Features
Lake Okeechobee Operations



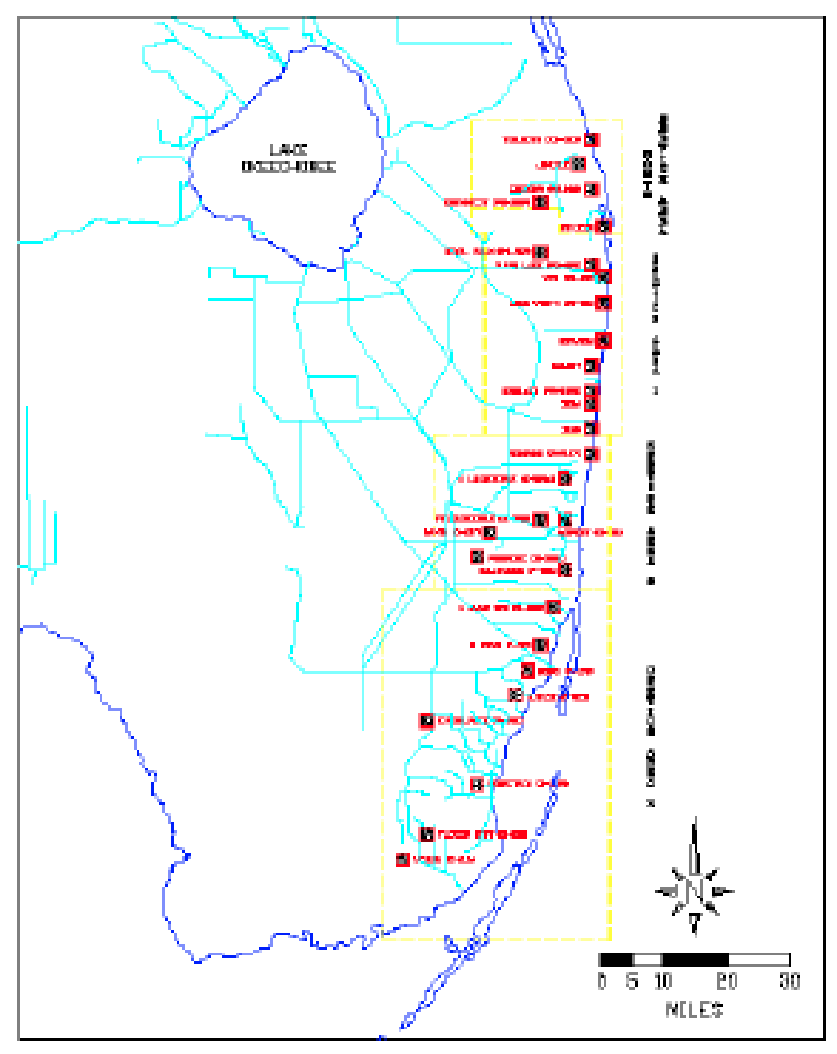


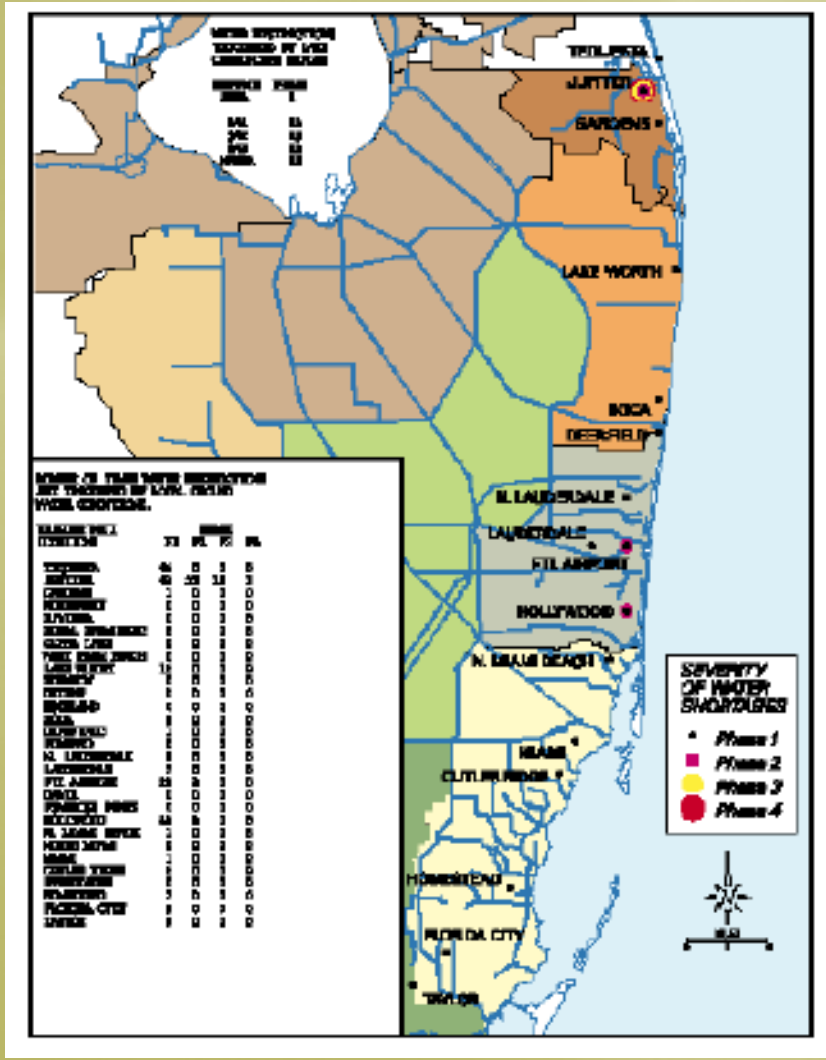


SFWMM Management Features
Rainfall Driven Operations



SFWMM Management Features
Lower East Coast Water Supply





SFWMM Strengths

- Regional-scale planning tool useful for comparison of alternatives
- Specifically designed for South Florida conditions
- Evaluation of long-term effects of water management actions
- Provides input for more detailed modeling

SFWMM Limitations

- Not appropriate for detailed flood impact analysis or drawdowns of small or isolated wetlands
- Averages results over a 4 mi^2
- Powerful tool, but requires experience
- Usual modeling limitations-models are as good as input data

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

Post Processing and Performance Measure Evaluation of the SFWMM

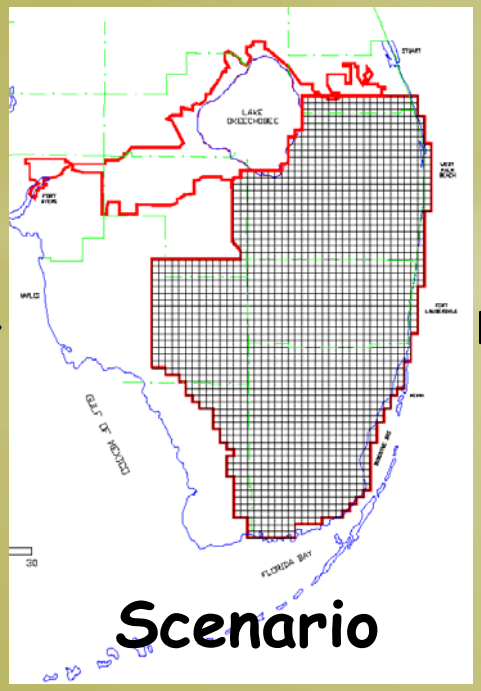
HYDROLOGIC & ENVIRONMENTAL SYSTEMS MODELING

CERP Regional Modeling Approach

SFWMM Model

- Climatic Input
  - Rainfall
  - ET
- Boundary Conditions

Period of simulation: 1965-2000 (typically)



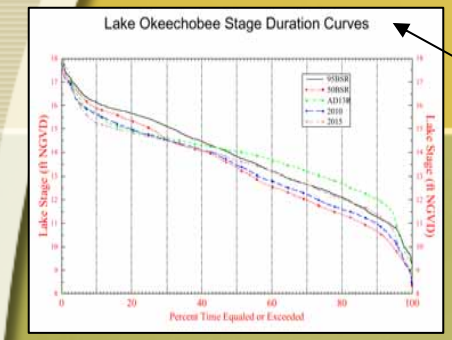
- Land Use/Land Cover
- Water Demands
- Operating Criteria

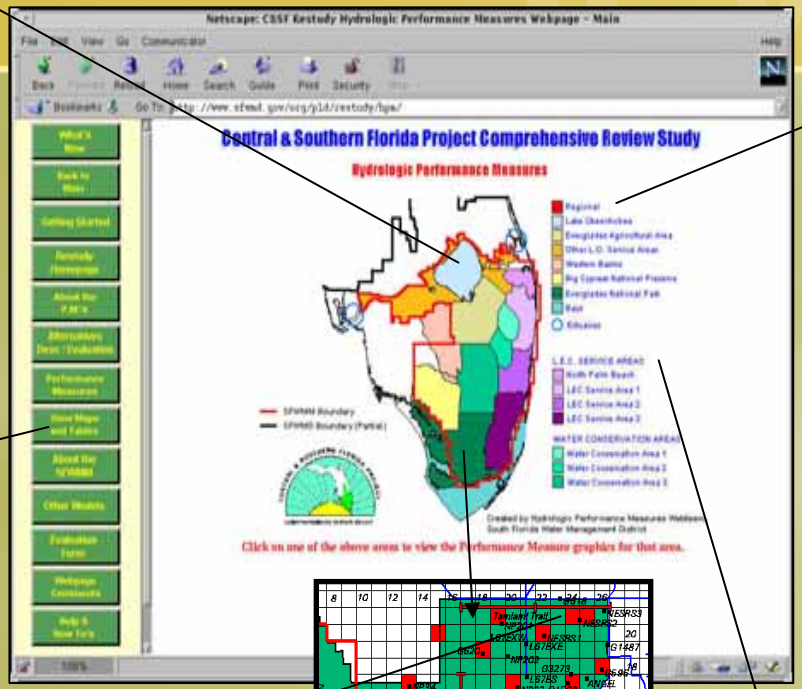
Model Output

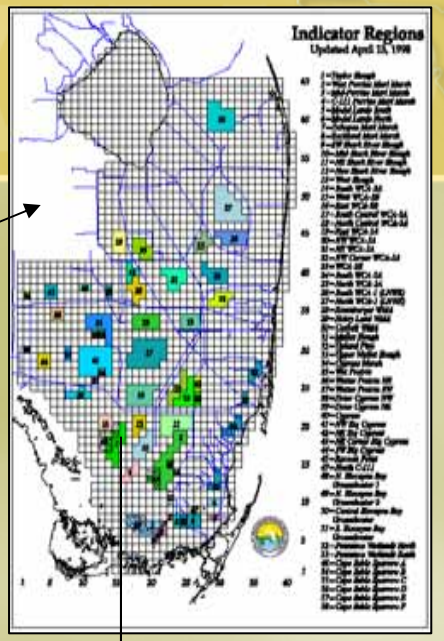
- Daily time series of water levels, flows
- Demands not met

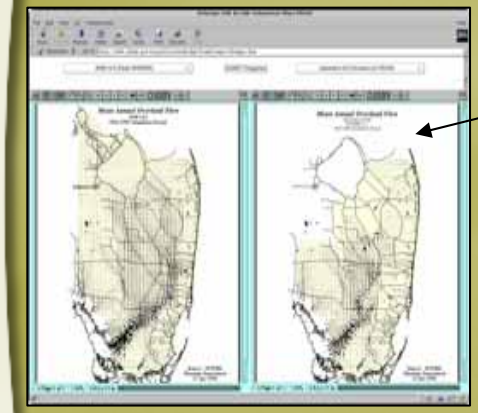
Performance Measures (Ag, Env, Urban)

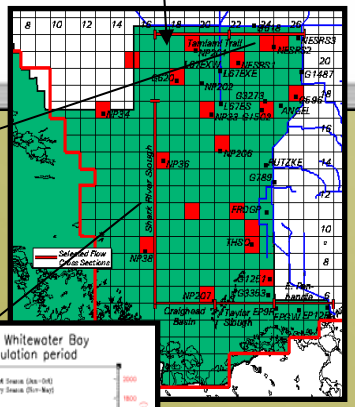
Performance Measures

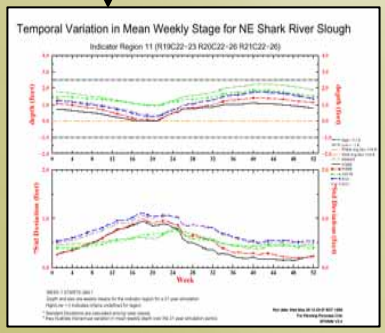


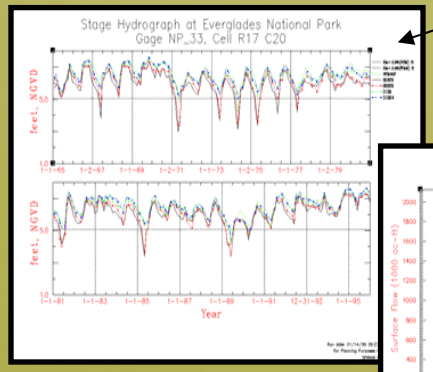


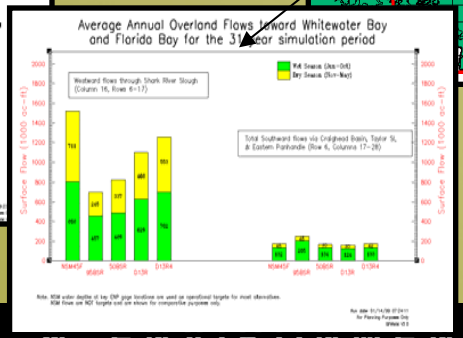


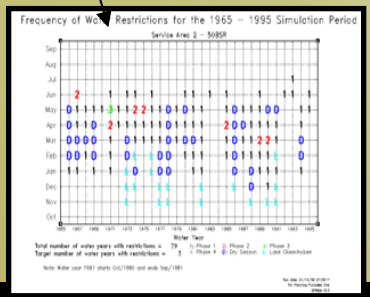




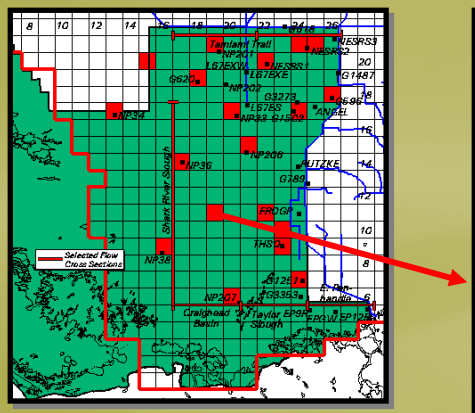


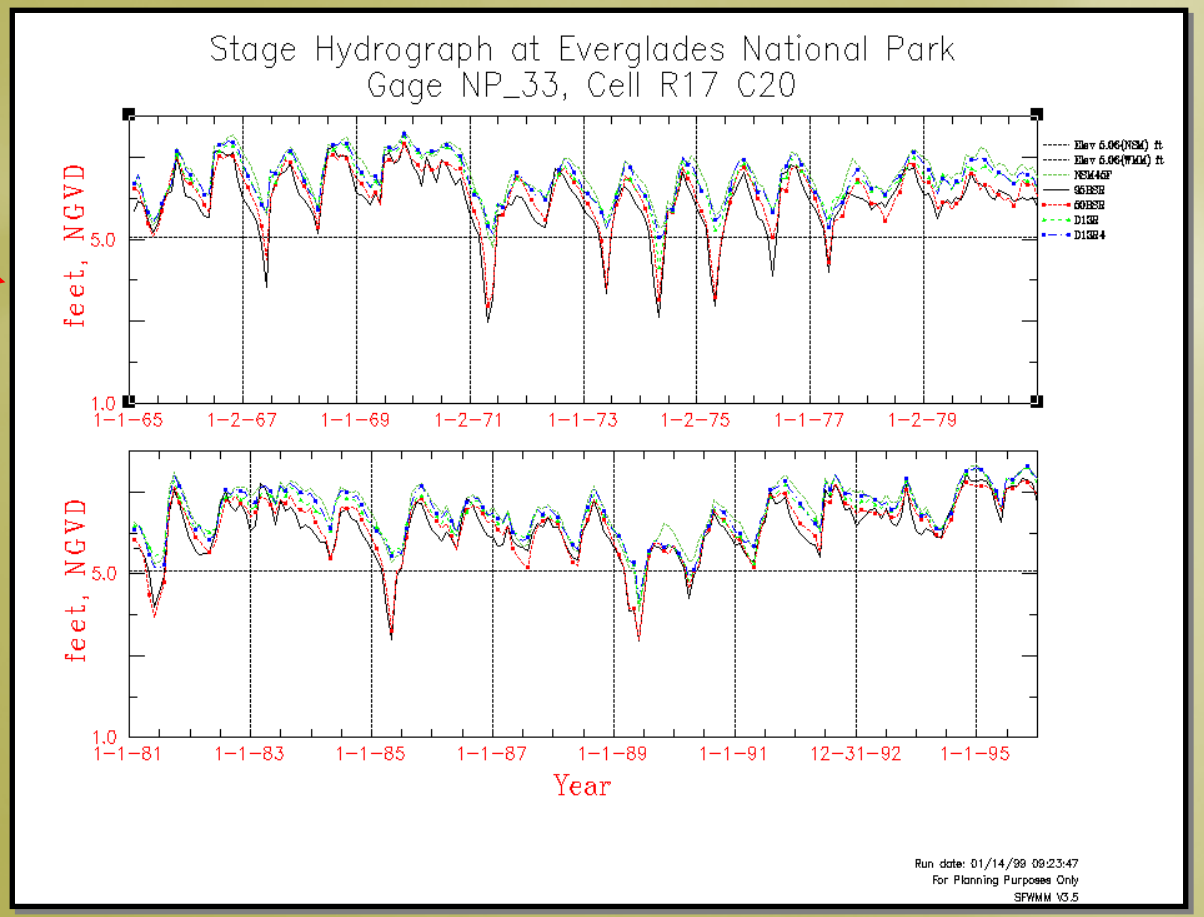




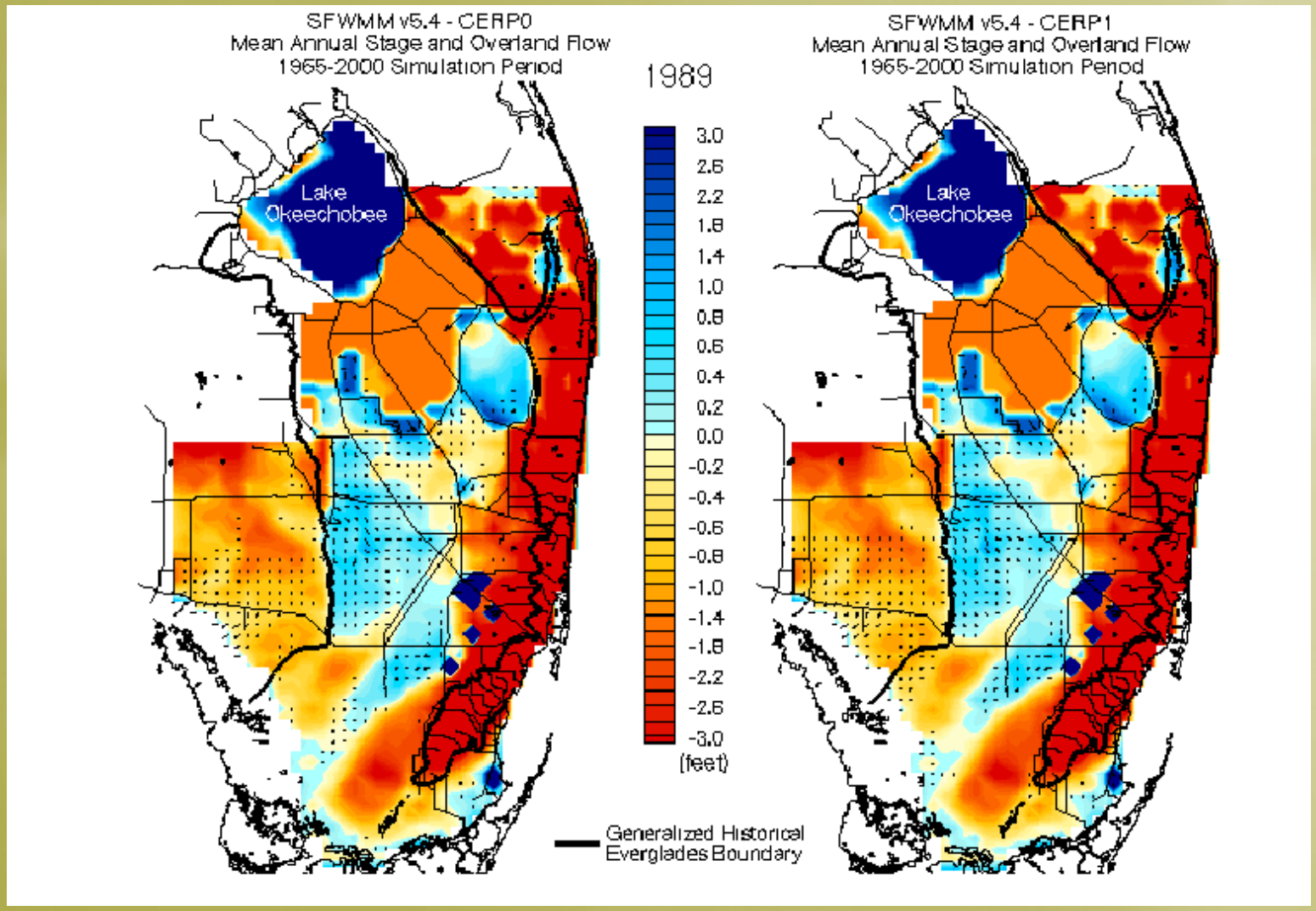


Sample SFWMM Output - Stage Hydrographs

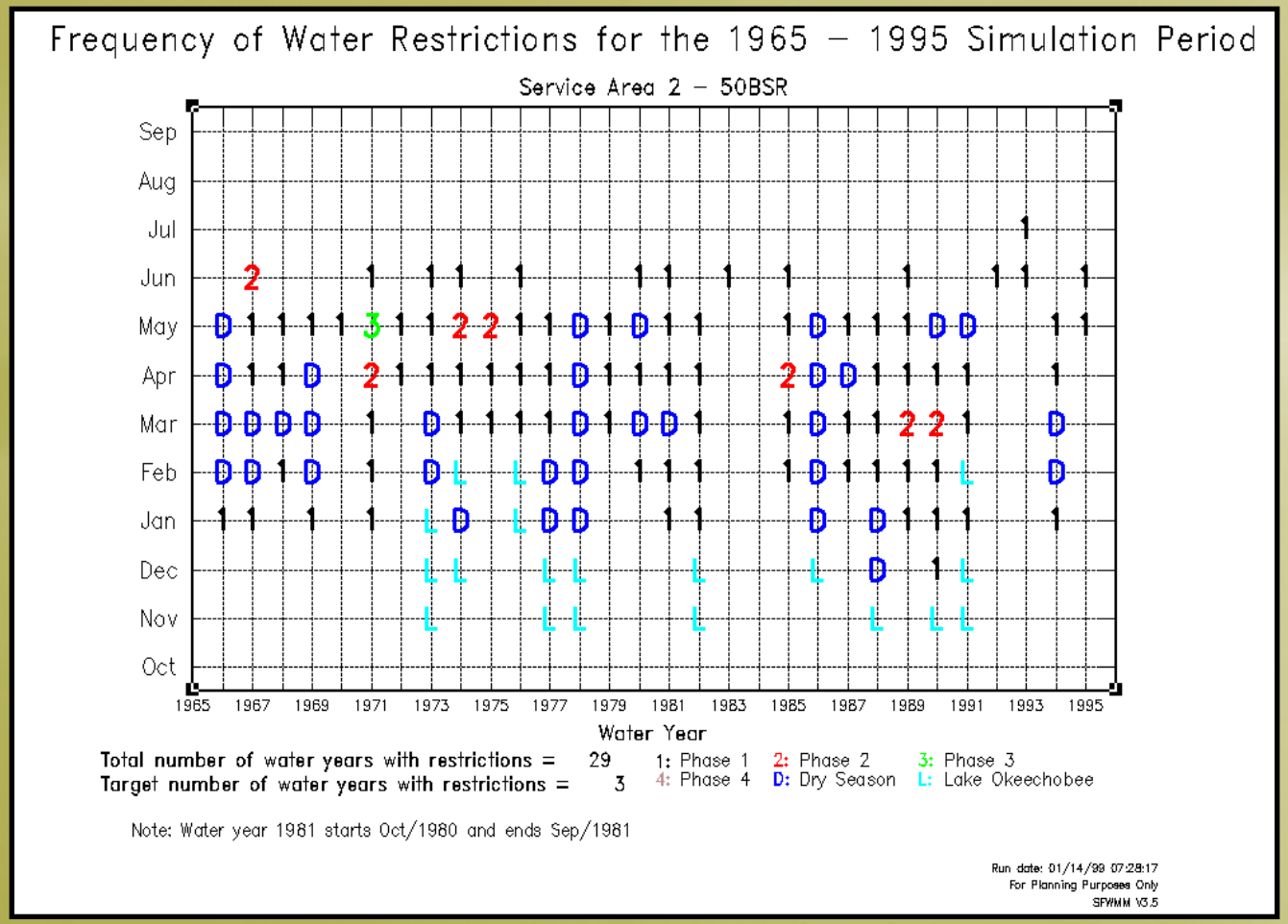




Sample SFWMM Output -
Maps (Ponding, Flow Vectors, etc..) & Animations

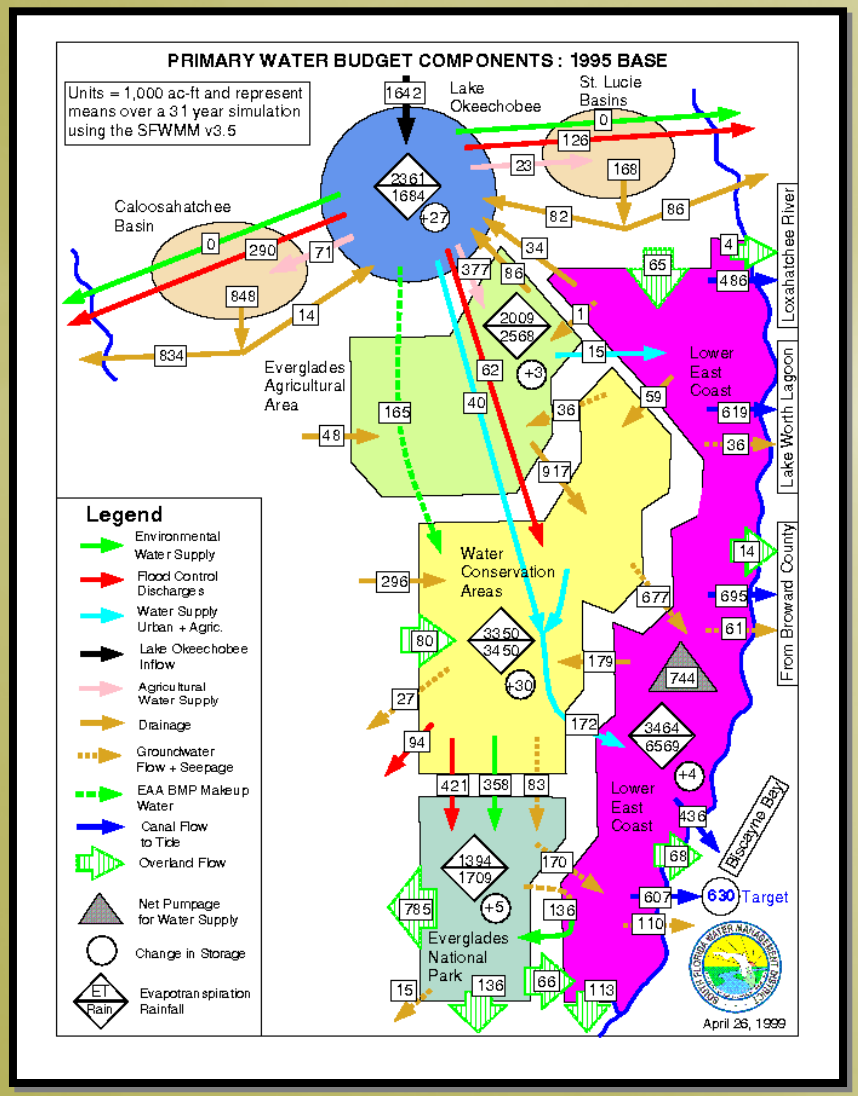


Sample SFWMM Output - Frequency of Water Restrictions

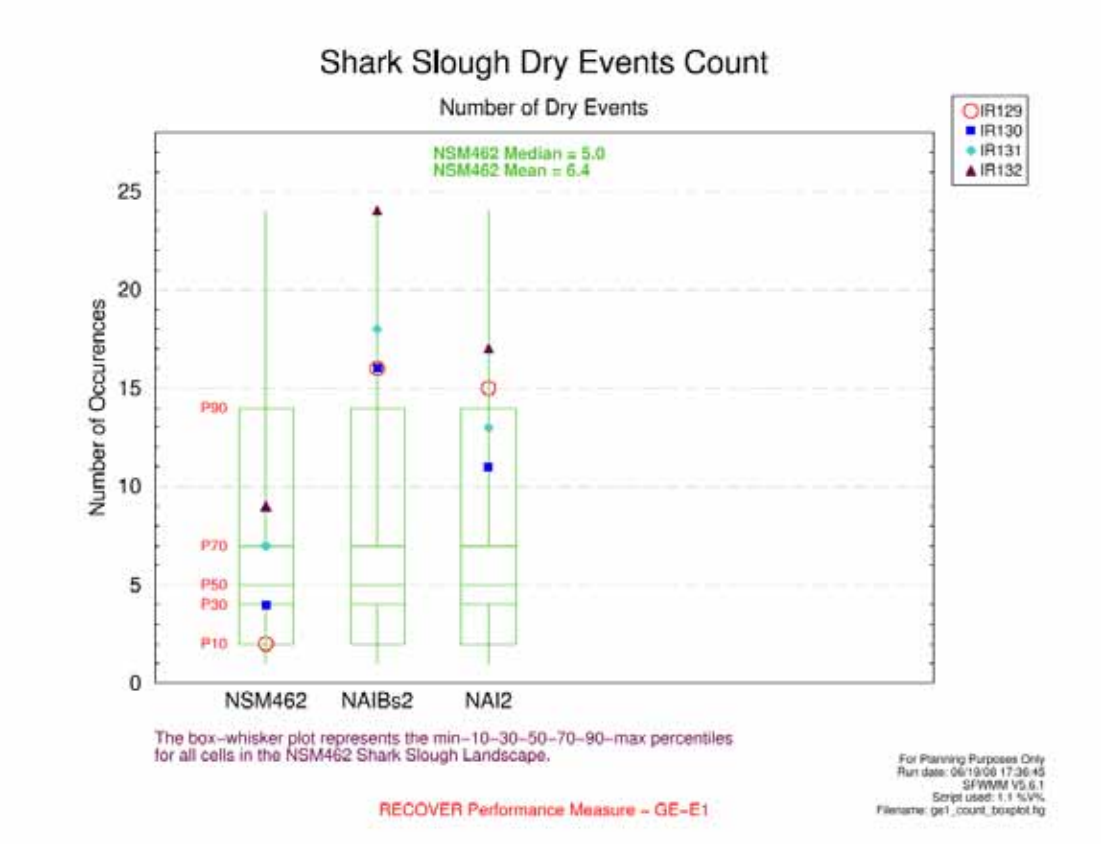


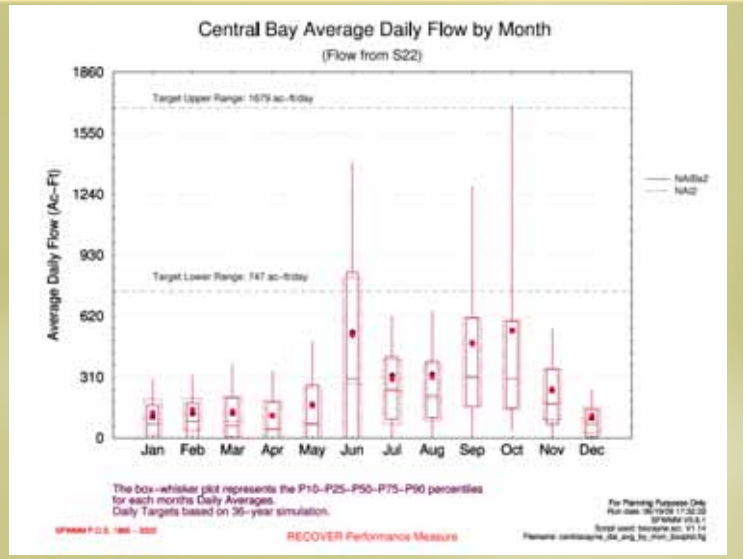
Sample SFWMM Output

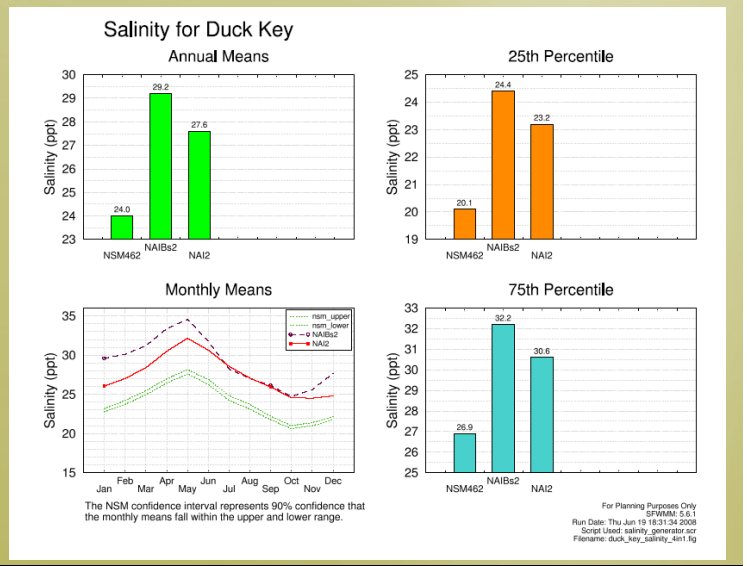
Detailed Water Budgets



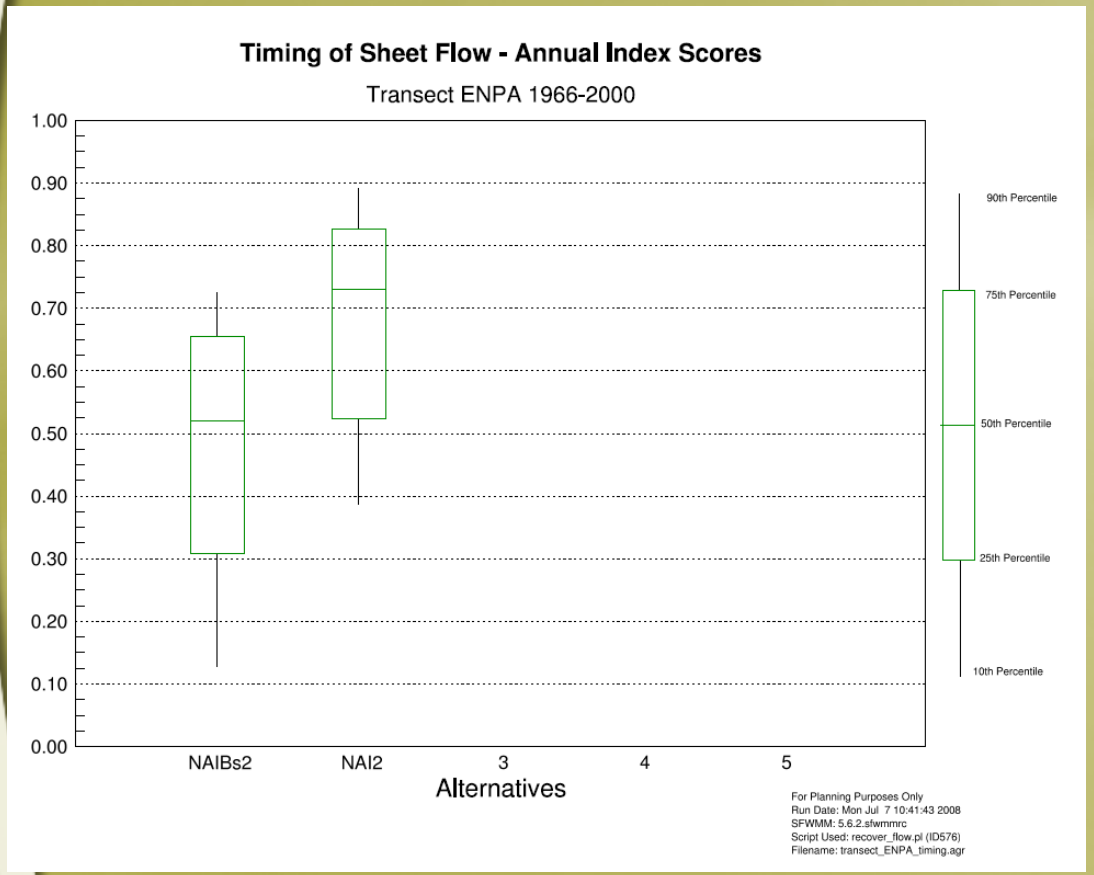
Sample SFWMM Output - TREND Comparing to Distributions or Percentiles

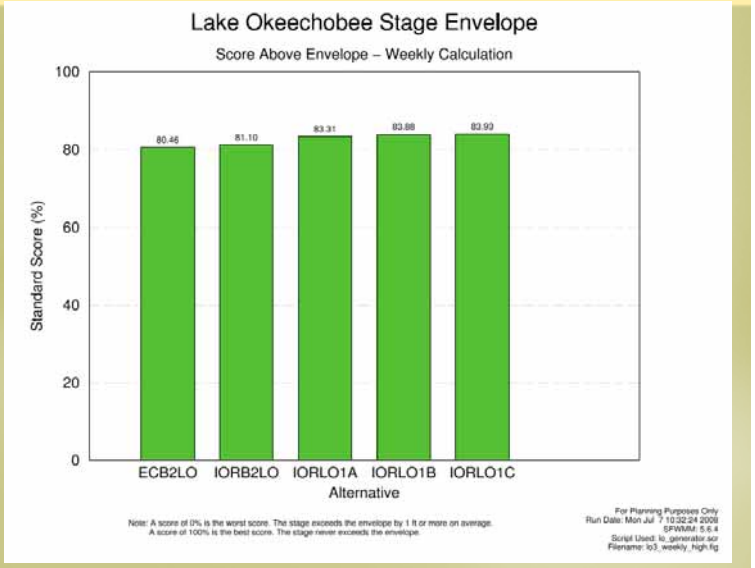


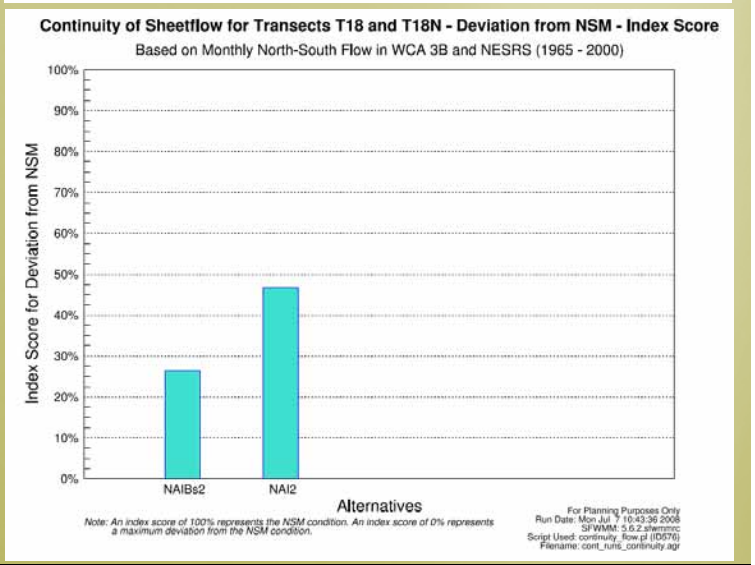




Sample SFWMM Output - TREND Standard Scoring







SOUTH FLORIDA WATER MANAGEMENT DISTRICT

Use of the SFWMM in the CERP Planning Process

HYDROLOGIC & ENVIRONMENTAL SYSTEMS MODELING

Programmatic Regulations

- Description of Analyses for PIRs identify several required comparisons - regional models can help illustrate effects of projects.
- Work involves both project (e.g. EAA reservoir) and program (e.g. future with CERP) level scenarios.
- Additional post-processing (beyond performance measures) is usually required.

Table1-3: Summary of Analyses for PIRs

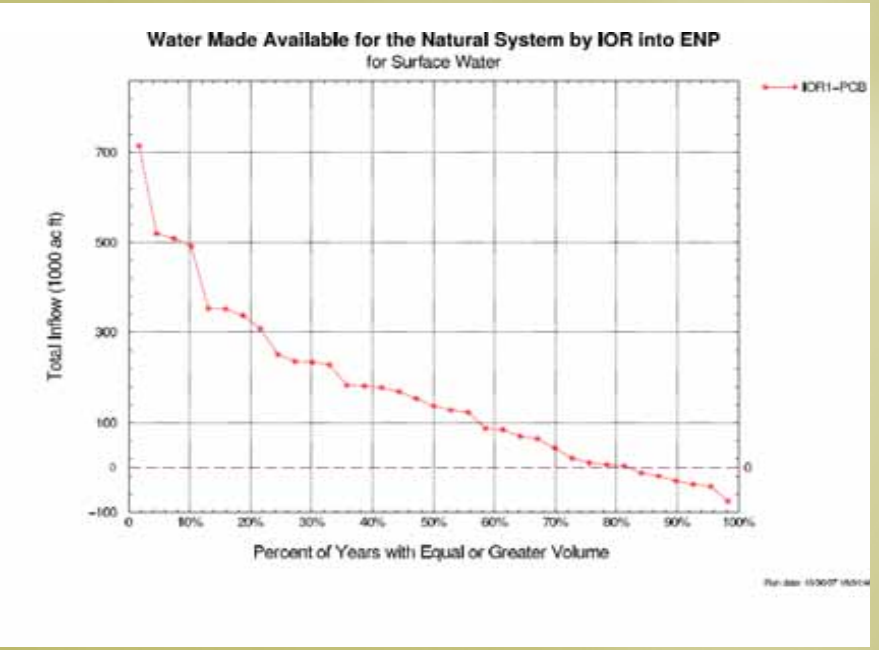
Analysis	*"Without Condition"*	*"With Condition"*
	Screening Analyses	
Determining if Pre-CERP Baseline Water is Still Available	Pre-CERP Baseline	Existing Conditions Baseline
Savings Clause Screening of Alternative Plans	Existing Conditions Baseline	Existing Conditions Baseline + alternative plan
	Formulation and Evaluation	
Formulation and Evaluation of Alternative Plans	Future Without CERP Baseline	Future Without CERP Baseline + alternative plan + rest of the Plan
Next-Added Increment Analysis	NAI Baseline	NAI Baseline + tentatively selected plan (i.e. NAI Condition)
	Savings Clause Analyses	
Intervening Non-CERP Activities	Existing Conditions Baseline	Initial Operating Regime
No Intervening Non-CERP Activities	Pre-CERP Baseline	Initial Operating Regime
	Project Operating Manual	
Project Operating Manual	N/A	Initial Operating Regime
	Identification of Water Made Available	
Identification of Water Made Available	1. Existing Conditions Baseline 2. NAI Baseline	1. Initial Operating Regime 2. NAI Baseline + tentatively selected plan (i.e. NAI Condition)
	Identification of Water to be Reserved or Allocated	
Identification of Water to be Reserved or Allocated	Existing Conditions Baseline	Initial Operating Regime

Project Benefits, Water Made Available and Savings Clause Analysis Metrics

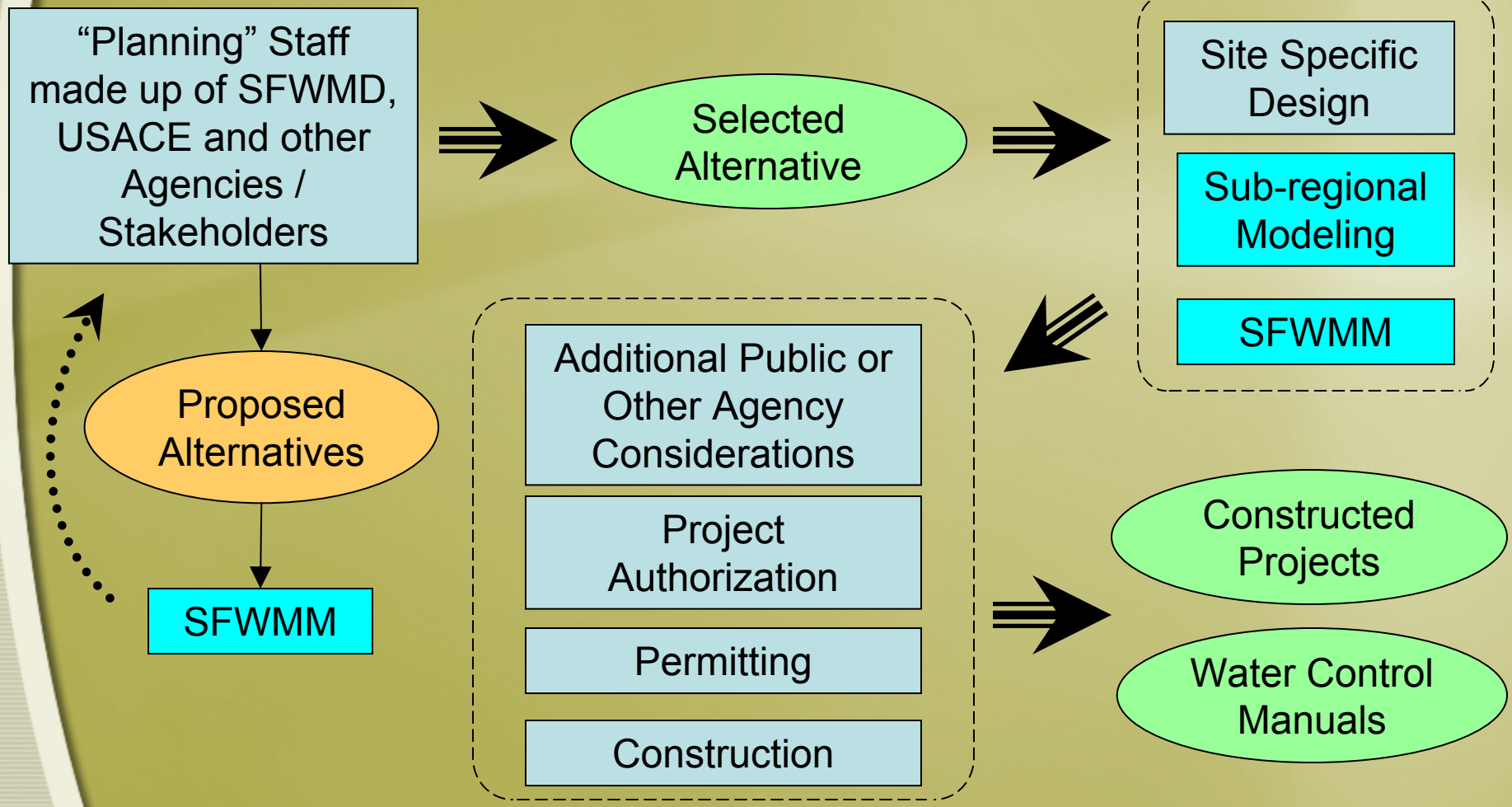
Example Benefits Analysis Table

Greater Everglades & Lake Okeechobee & Estuaries	
Performance Measure	HUs
GE-2 and GE-3 averaged	21,596
Lake O. & Estuaries	5,431
Total	27,027

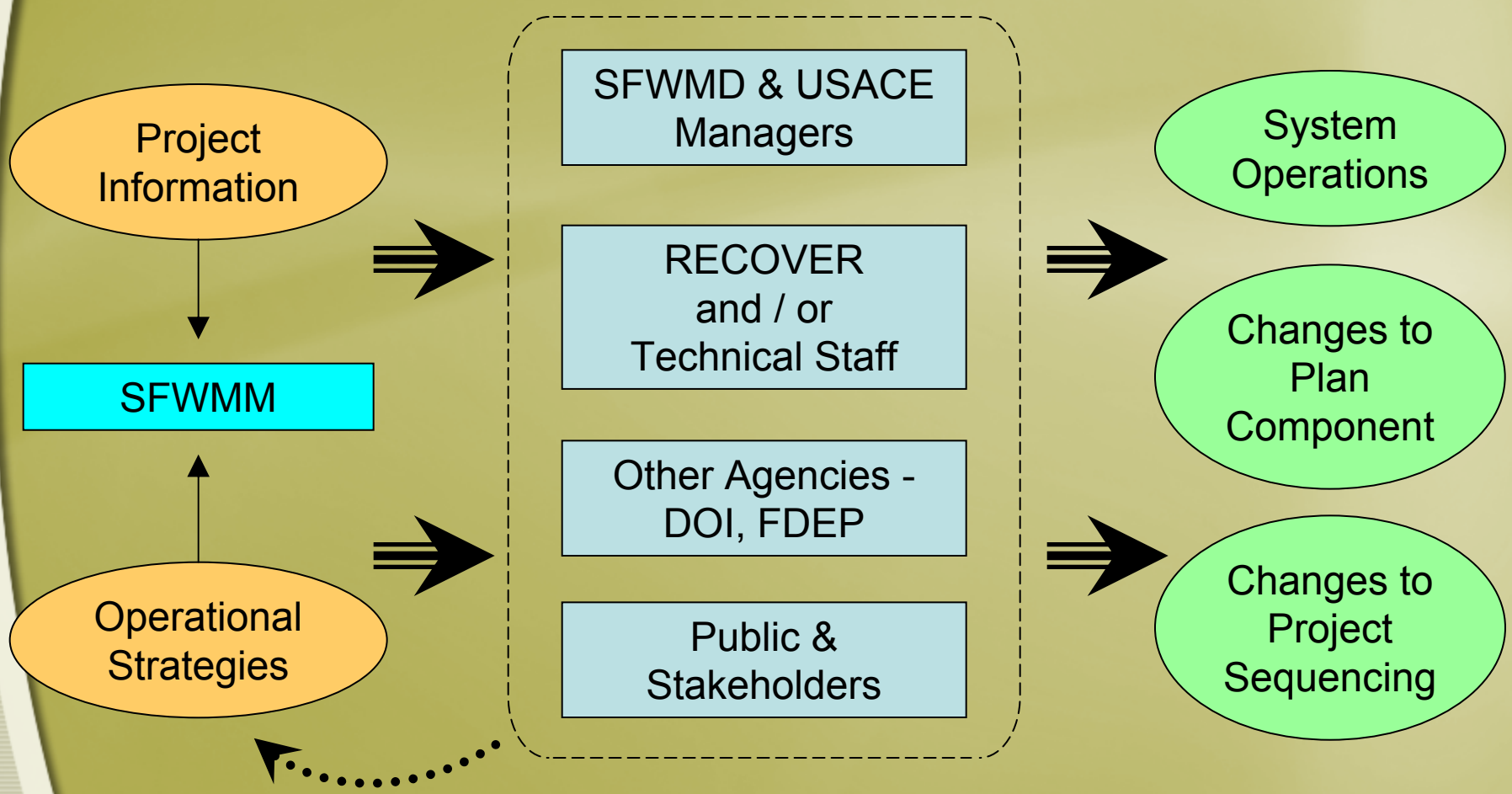
Example Water Made Available Graphic



CERP Project Planning – Modeling Process



CERP Project / Program Updates – Adaptive Management



Questions?