Translating the Hydrologic Tower of Babel

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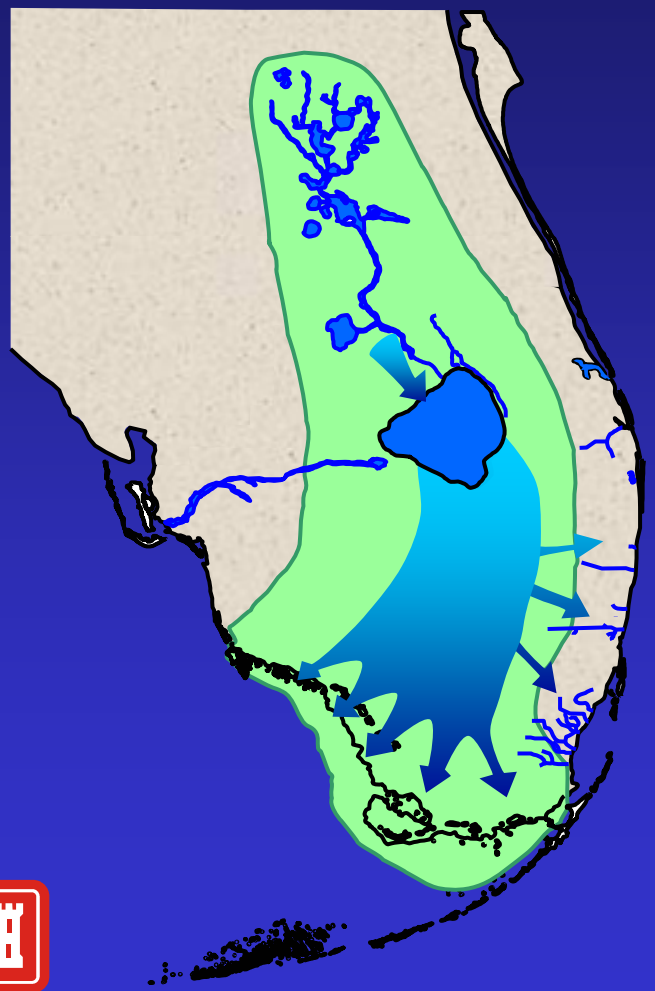
Topics to Cover

- The path to Everglades Restoration
- Regional and Sub-regional modeling tools
- Standard model outputs
- Transformation to “Performance Measures”
- Project-specific examples

The "Original" Everglades Ecosystem

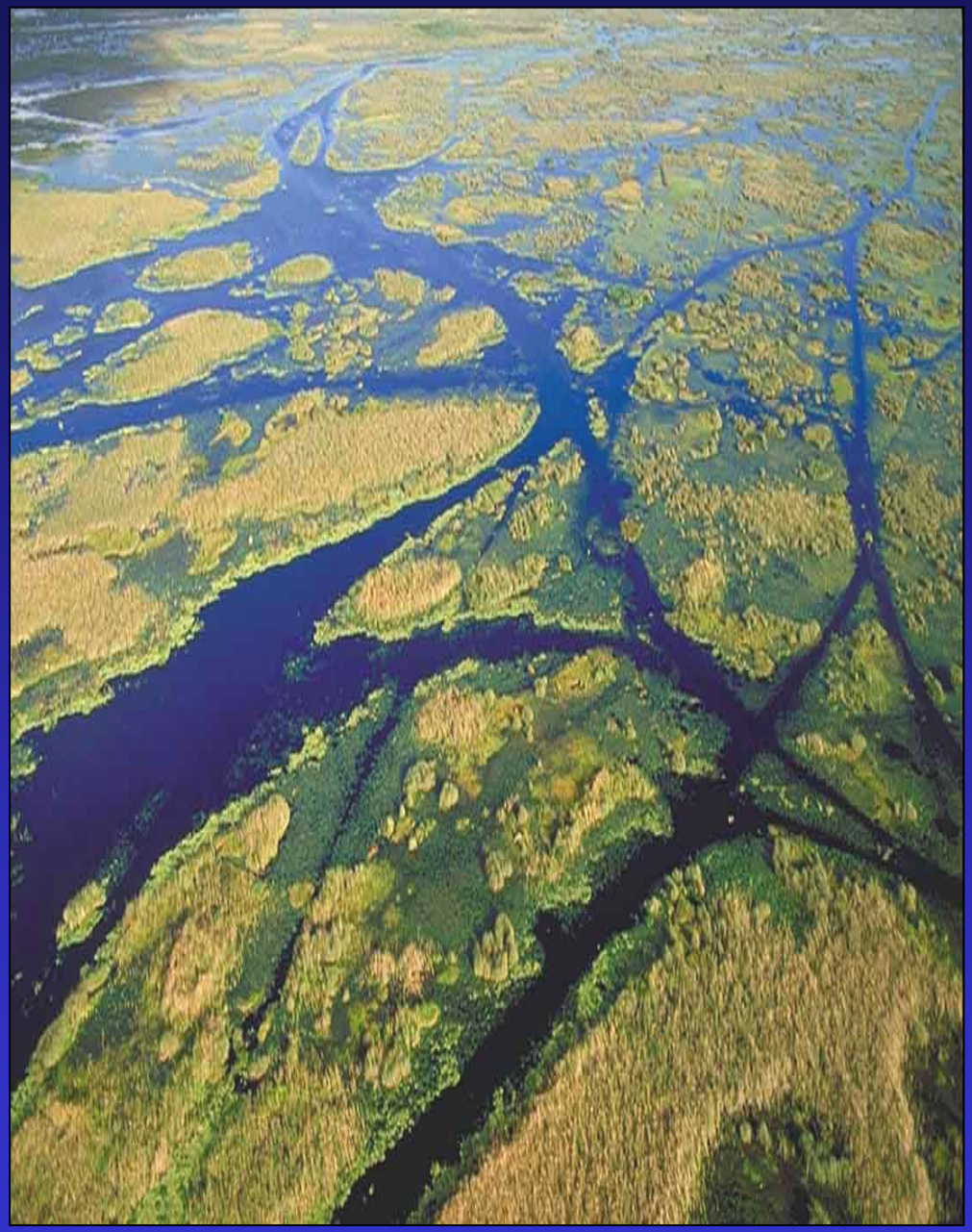
"River of Grass"

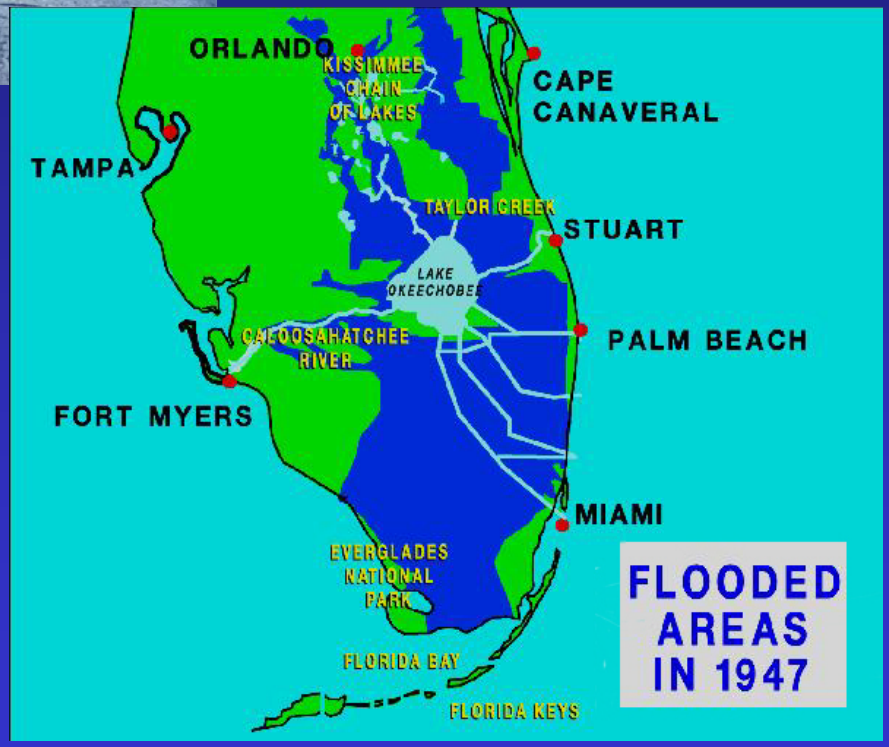


- Water connected the system, from top to bottom
- 9 million acres of wetlands providing a variety of habitat
- Diverse mosaic of landscapes and seascapes

PRE-DRAINAGE CHARACTERISTICS

- Large Spatial Extent
- Hydrologic Regime
  - Dynamic Storage
  - Sheetflow
- Diverse Habitats





1947 Flood

US Army Corps of Engineers

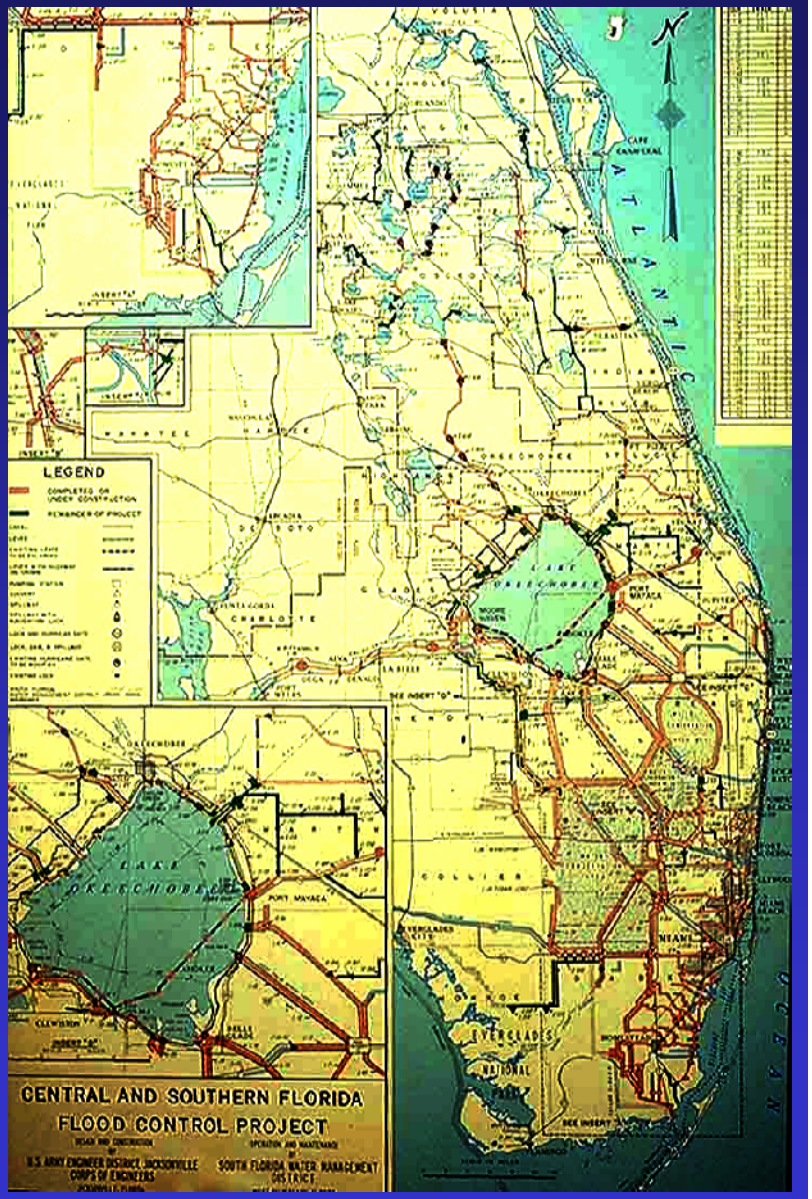
August 2005

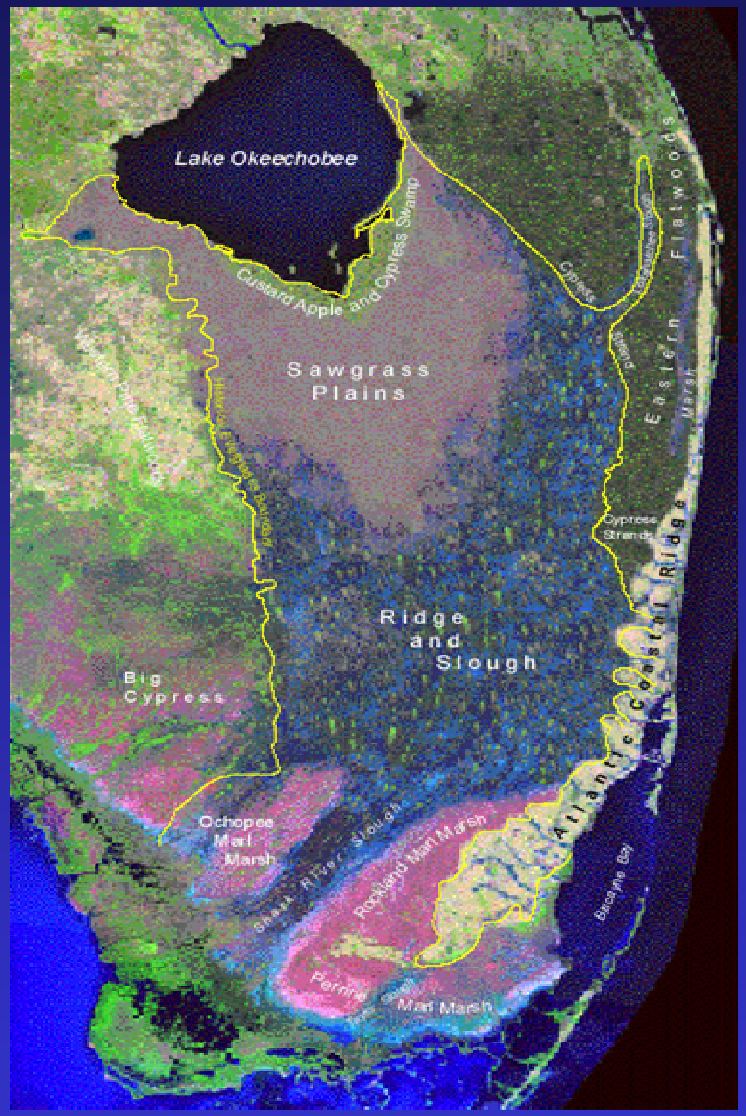
Jacksonville District

THE C&SF PROJECT

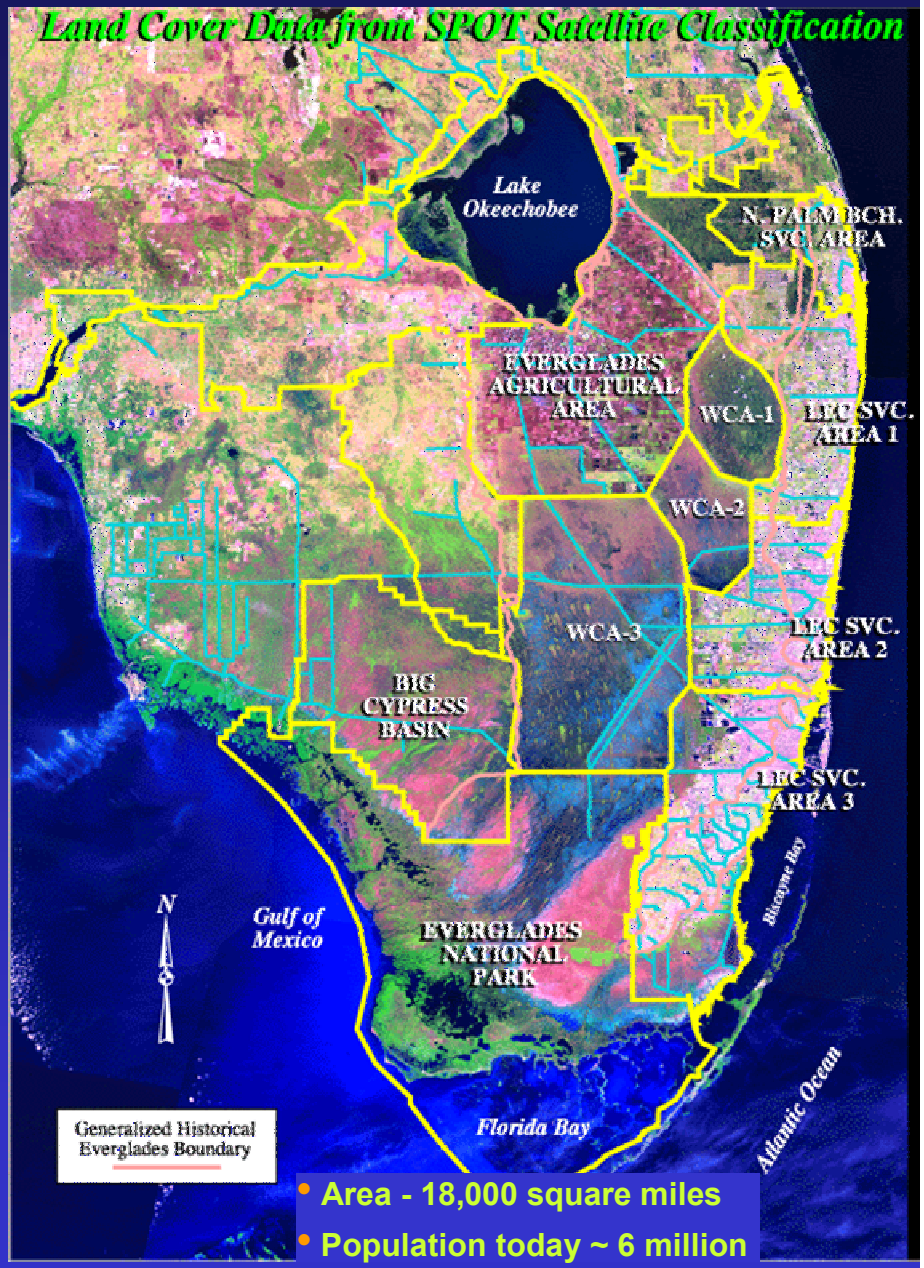
- Project Purposes: Flood control, water conservation and control, regional water supply, prevention of salt water intrusion, fish and wildlife conservation, and water supply to Everglades National Park

- Project includes: 10 locks, 1,000 miles of canals, 720 miles of levees, over 150 water control structures, and 16 pump stations





Estimated Pre-drainage System Landscape (circa 1850)



- Area - 18,000 square miles
- Population today ~ 6 million

Current System (1995) Landscape

US Army Corps of Engineers

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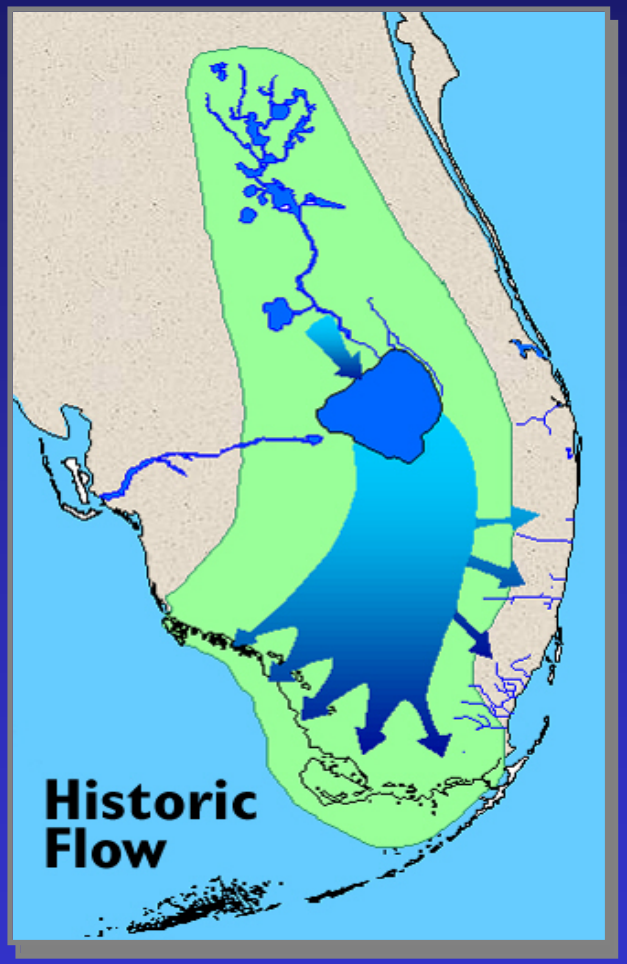
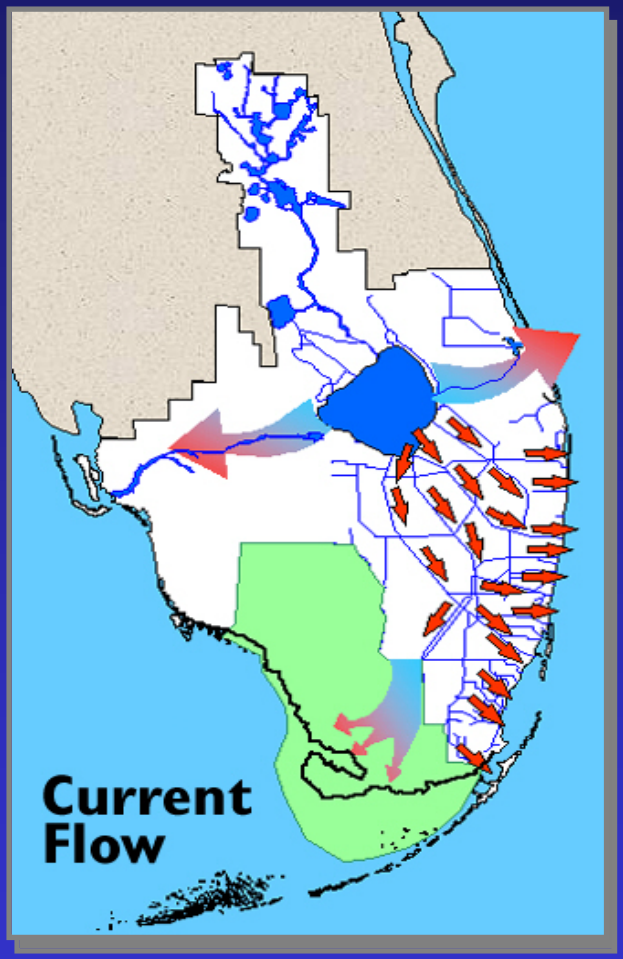
Today, water flows very differently





An Ecosystem in Trouble….

- Too much/too little water for the Everglades/south Florida ecosystem
- Massive reductions in wading bird populations
- Degradation of water quality
- Repetitive water shortages and salt water intrusion
- Declining estuary health
- 1.7 billion gallons of water a day wasted to tide

Why are the Everglades Unique and Important?

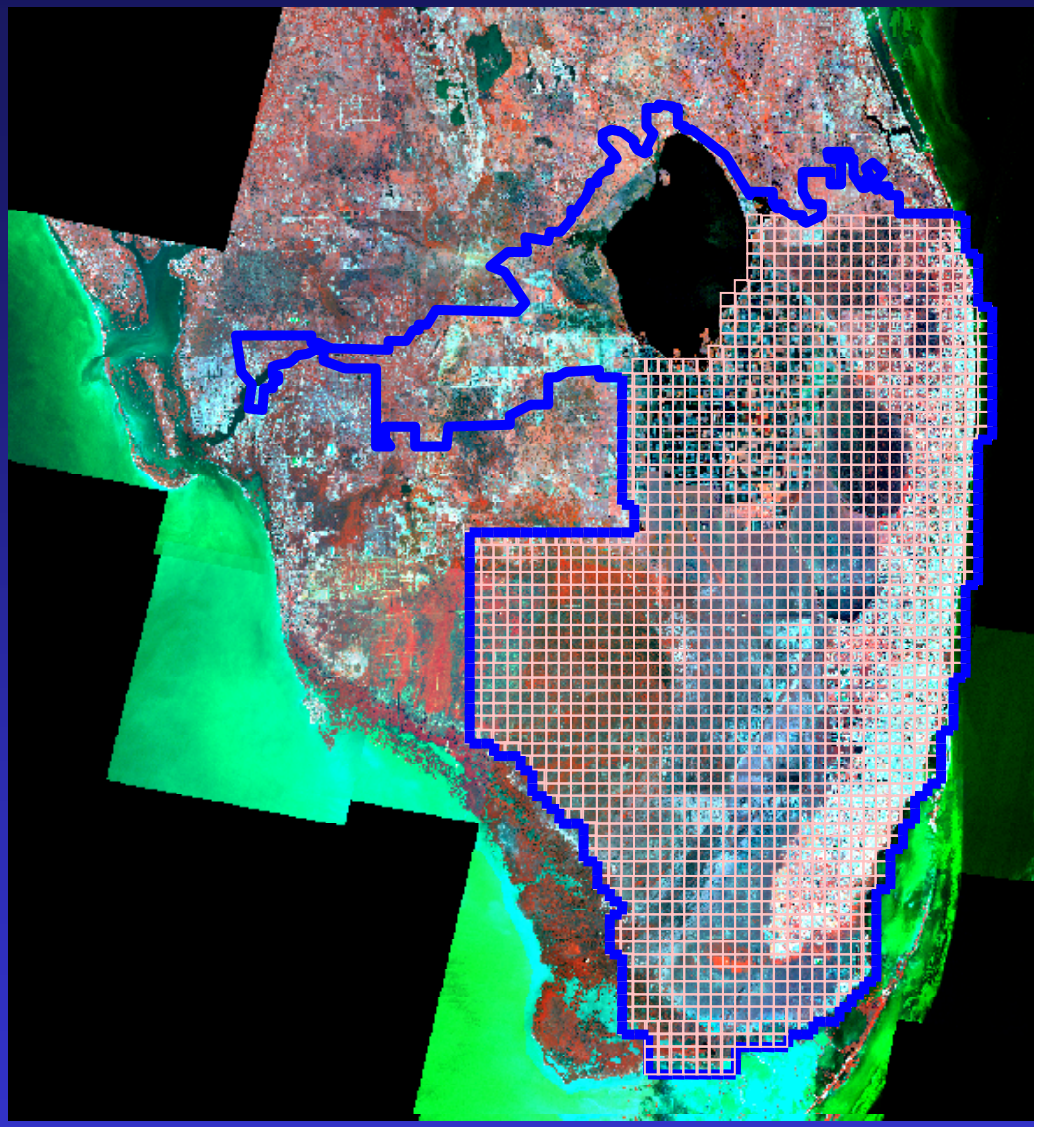
- the Everglades is a National Park
- the Everglades is an International Biosphere Reserve
- the Everglades is a World Heritage Site
- the Everglades is a Wetland of International Significance
- The Everglades function as a filter to purify water flowing into Florida Bay and the Gulf of Mexico
- The Everglades is home to 68 threatened or endangered plant and animal species
- The Everglades is home to more than 900 types of plant species
- The Everglades is home to more than 600 types of animals

Q: How do we determine the best path to Restoration?

A: Hydrologic Models

South Florida Water Management Model (the "2x2")

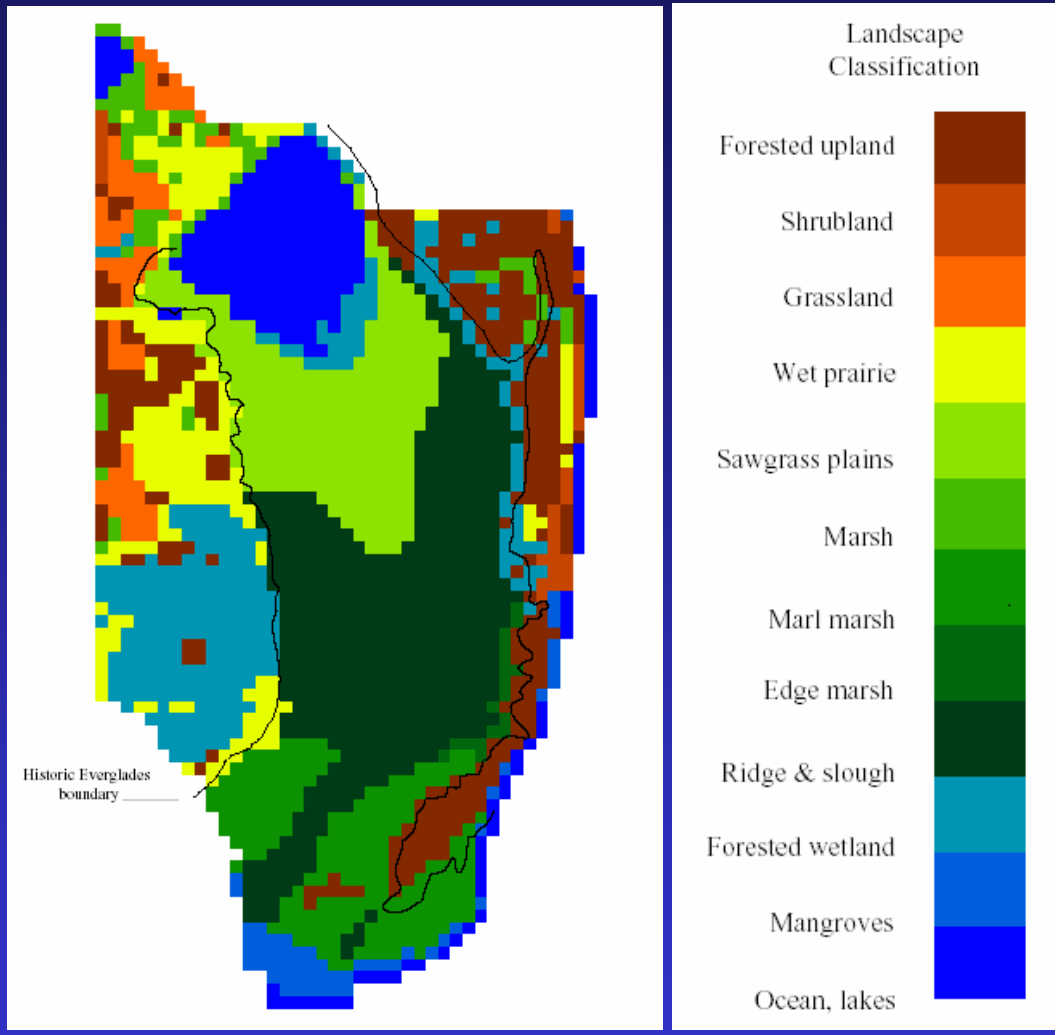
- Regional model to simulate hydrology and water management operations
- 2 mile x 2 mile grid
- Continuous daily simulation over 36 year record (1965 – 2000)
- Developed by SFWMD
- Domain from Lake Okeechobee to Florida Bay



www.sfwmd.gov/org/pld/hsm/models/sfwmm/index.html

Natural System Model (NSM)

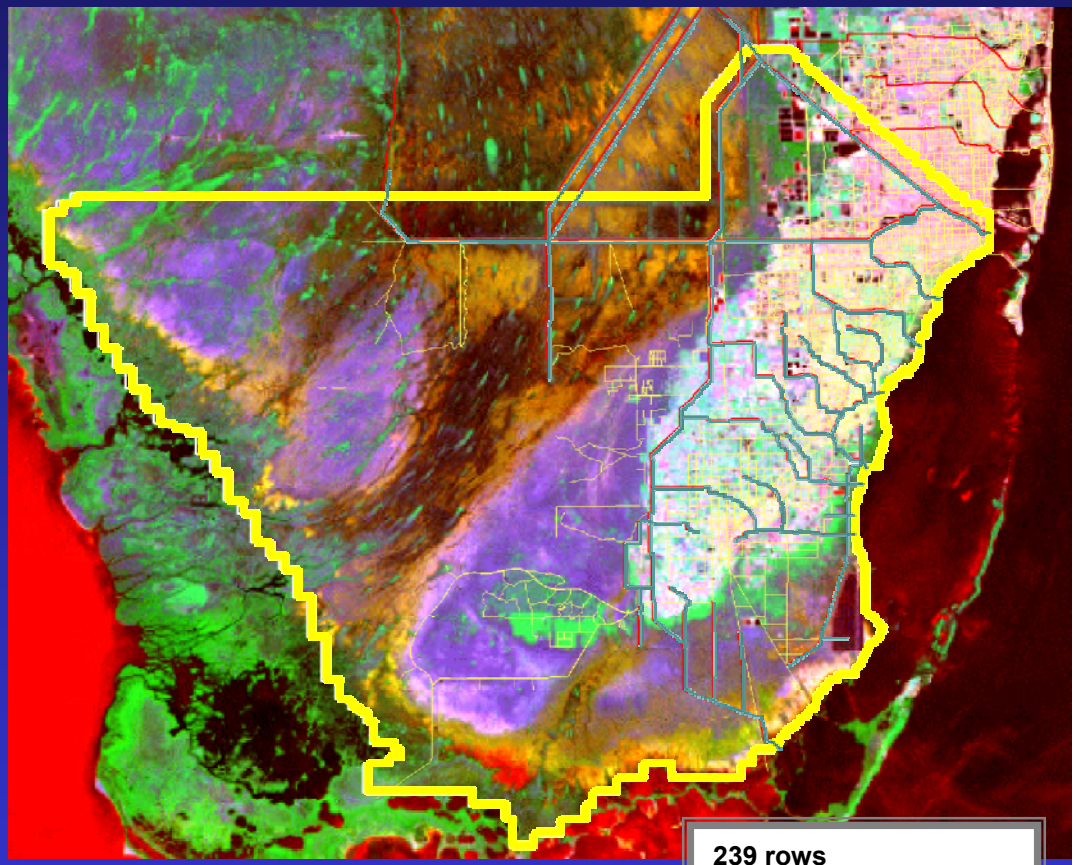
- Simulates hydrology of pre-drainage Everglades
- Based on the South Florida Water Management Model



www.sfwmd.gov/org/pld/hsm/models/nsm/nsm45doc/nsm45.htm

MODBRANCH

- Simulates hydrology and water management of sub-regions
- Highly refined and variable grid spacing
- Simulates 3D groundwater
- Used for short term simulations (~1year)
- 1-hour time steps
- Developed by USGS and USACE-Jacksonville
- Uses SFWMM2x2 results for boundary conditions
- Based on USGS MODFLOW and BRANCH models



239 rows
259 columns
5 layers
330+ miles of canals
54+ Structures

Key Tenet of South Florida Ecosystem Restoration:

Hydrologic restoration is a “must” for ecological restoration

Q: What does the term "hydrologic restoration" mean?

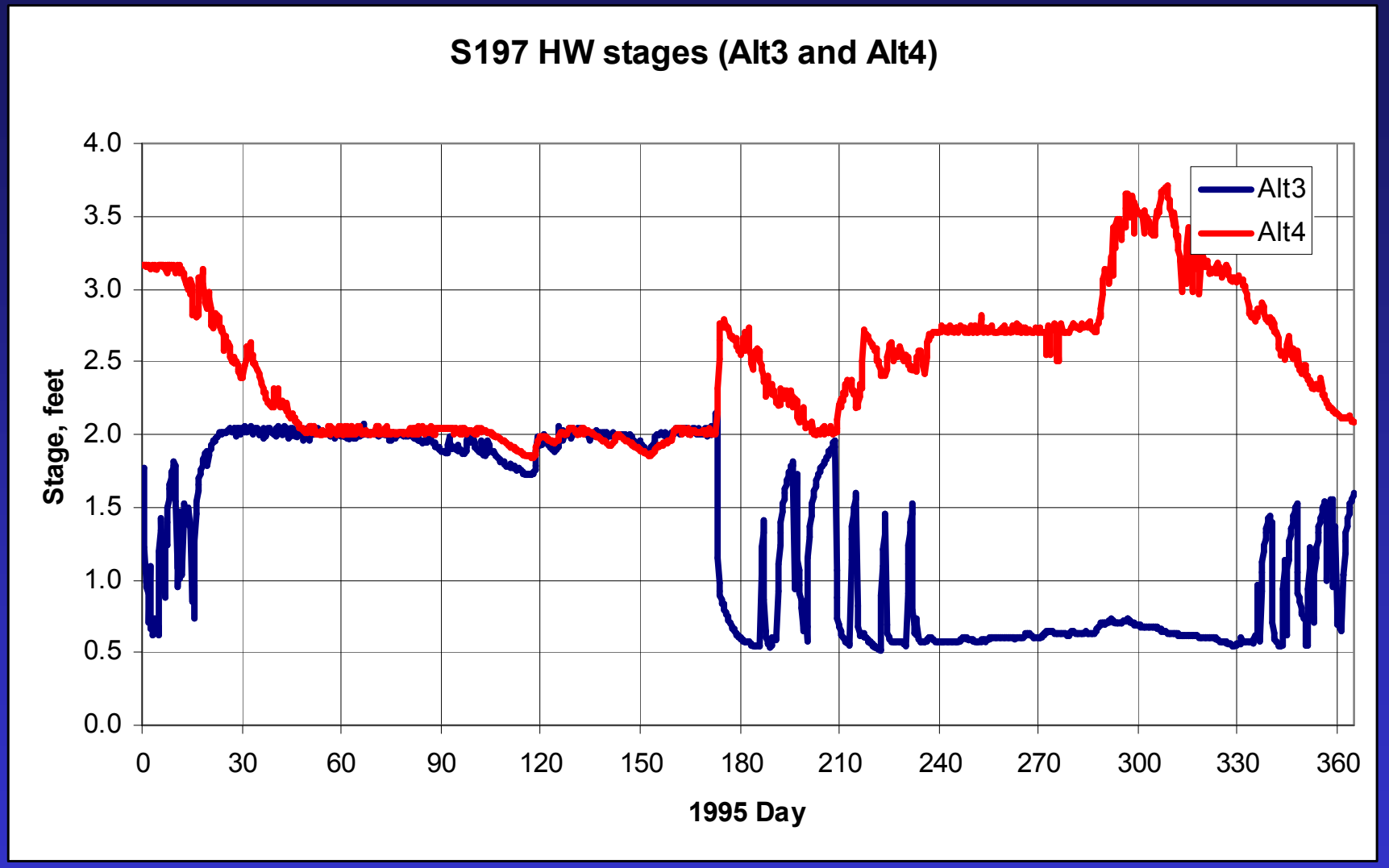
A: *It depends to whom you are talking and what are their concerns and issues!*

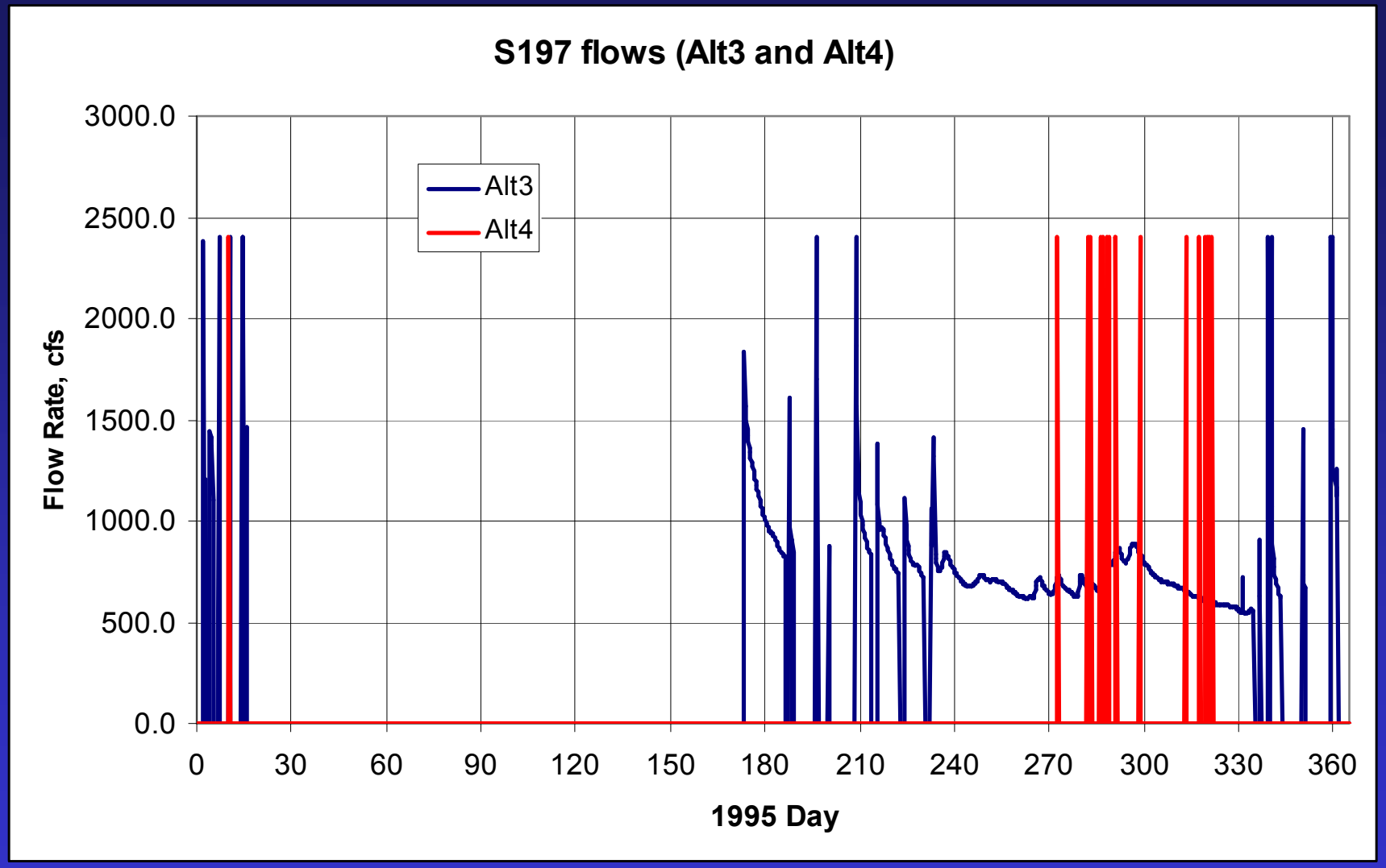
Agencies, Organizations, and other that have their own vision of restoration

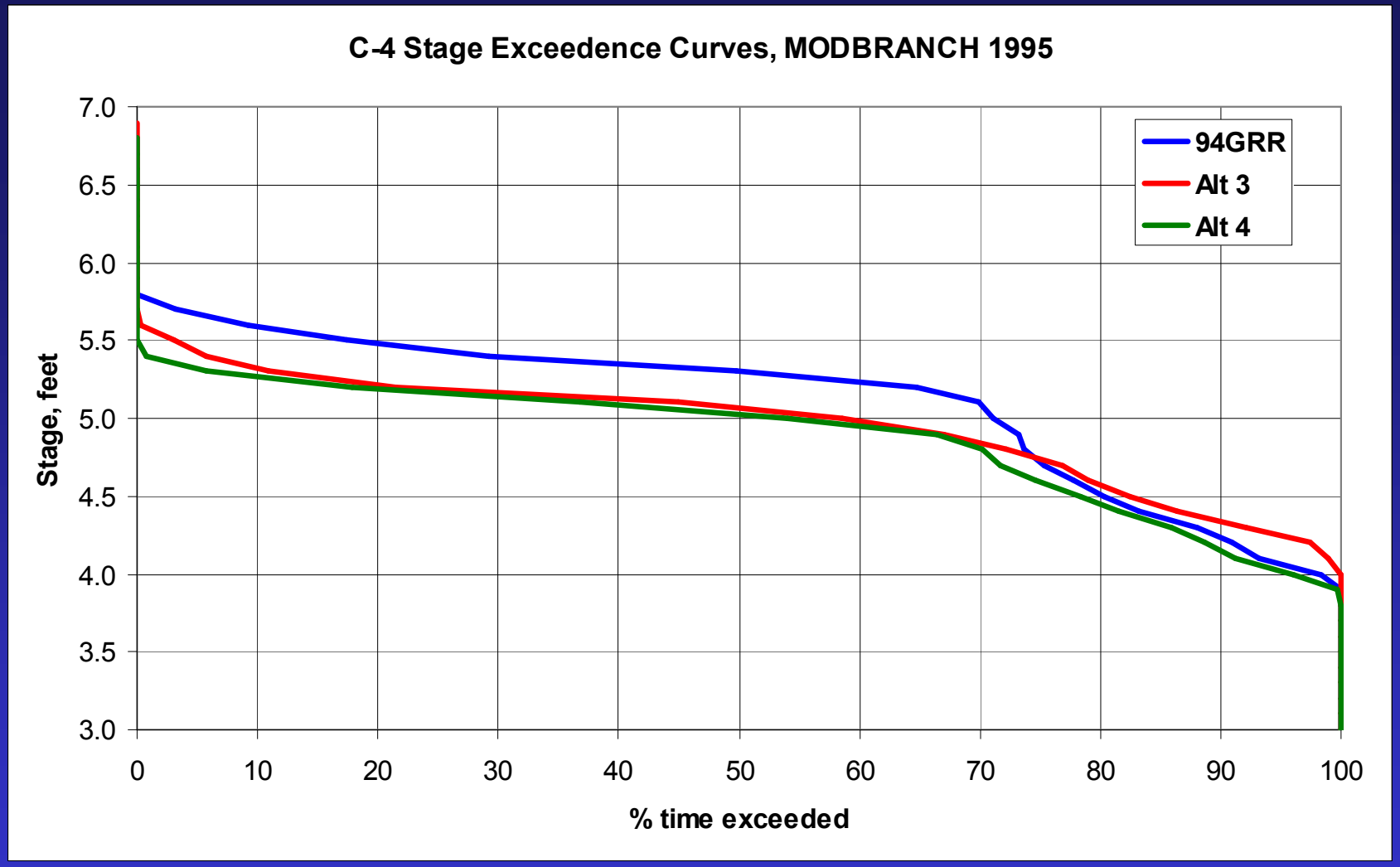
- Agricultural Interests
- Miccosukee Indians
- Department of Interior (Everglades National Park)
- Department of Interior (US Fish and Wildlife Service)
- The State of Florida
- South Florida Water Management District
- Towns and Municipalities
- County Governments
- Audubon Society
- Sierra Club
- Friends of the Everglades
- Natural Resources Defense Council, ACLU, etc.
- Homeowners
- Rock Miners
- Others…

Generalized Hydrologic Numerical Models produce the following basic data:

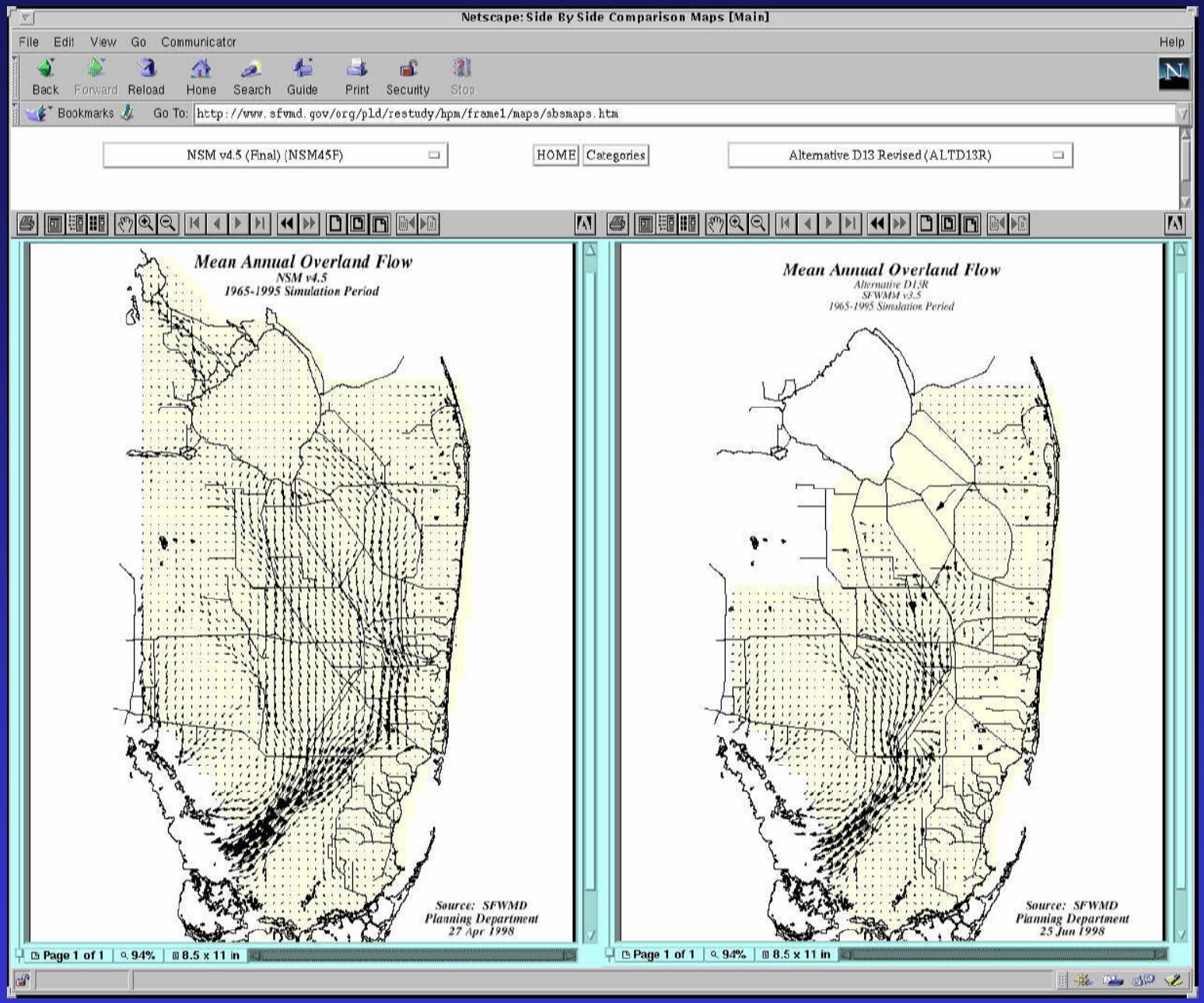
- **Stage for each time step**
- **Flow rates for each time step**

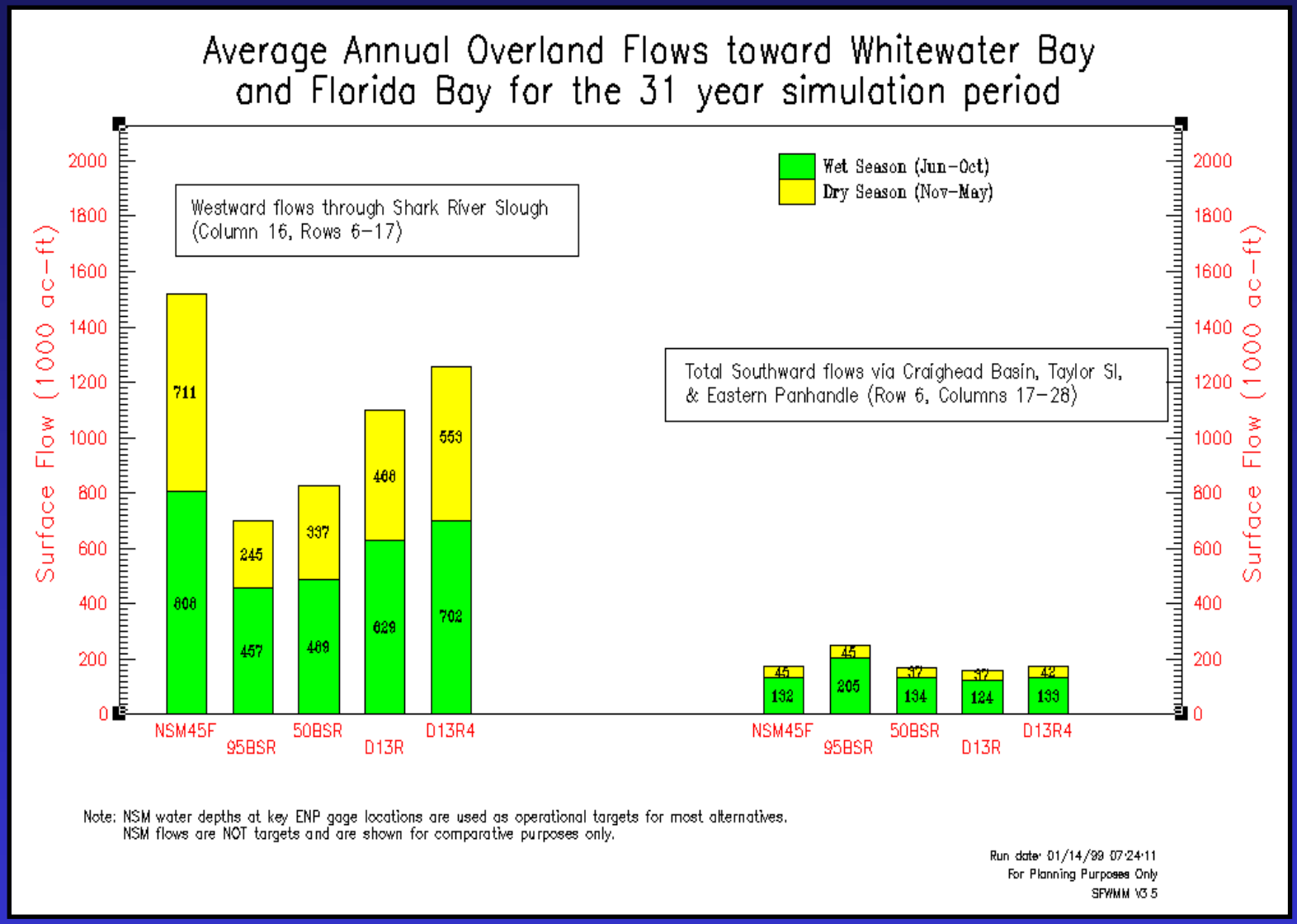

S197 HW stages (Alt3 and Alt4)
Stage, feet
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
30
60
90
120
150
180
210
240
270
300
330
360
1995 Day
Alt3
Alt4

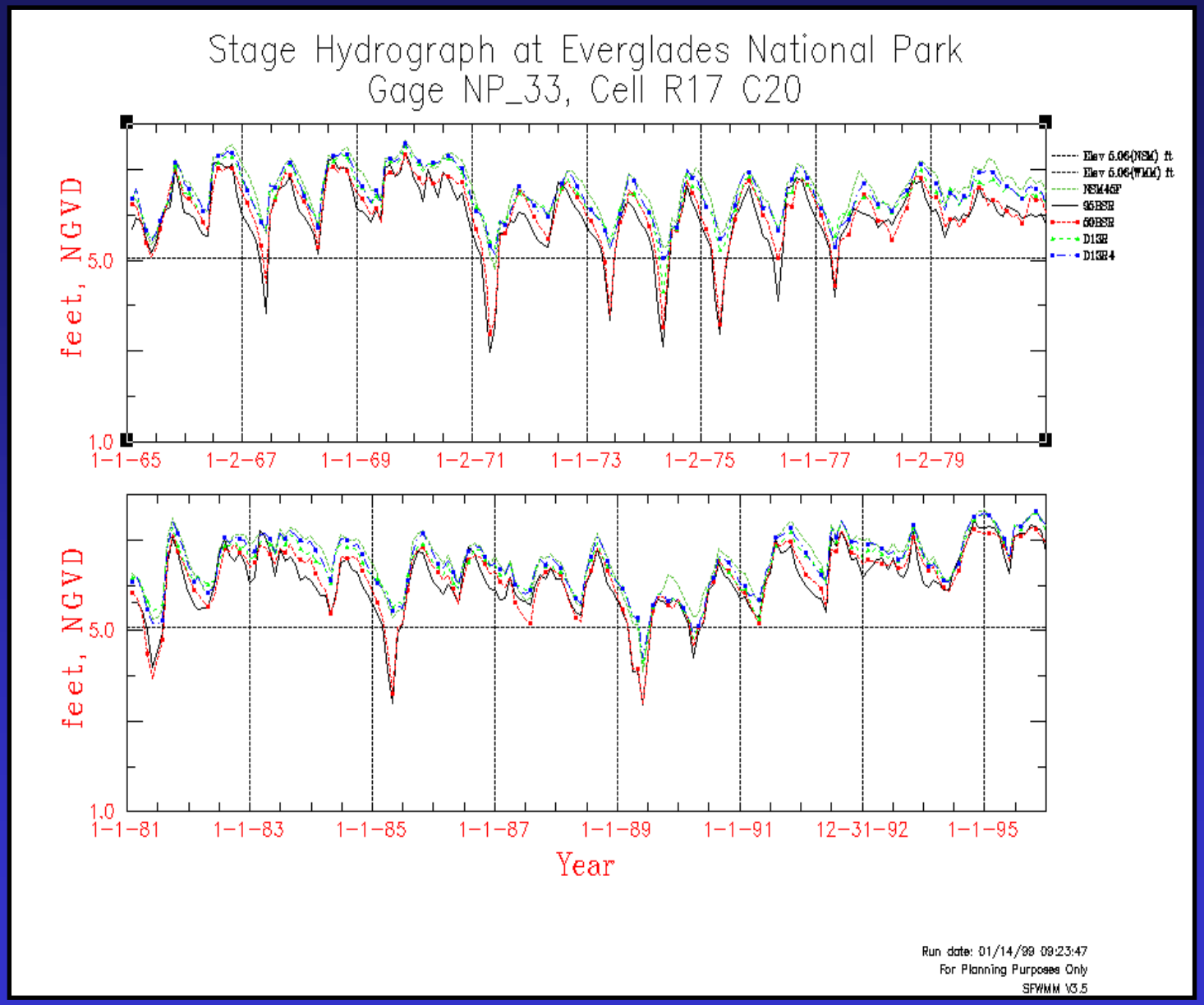

S197 flows (Alt3 and Alt4)
Flow Rate, cfs
3000.0
2500.0
2000.0
1500.0
1000.0
500.0
0.0
Alt3
Alt4
0
30
60
90
120
150
180
210
240
270
300
330
360
1995 Day



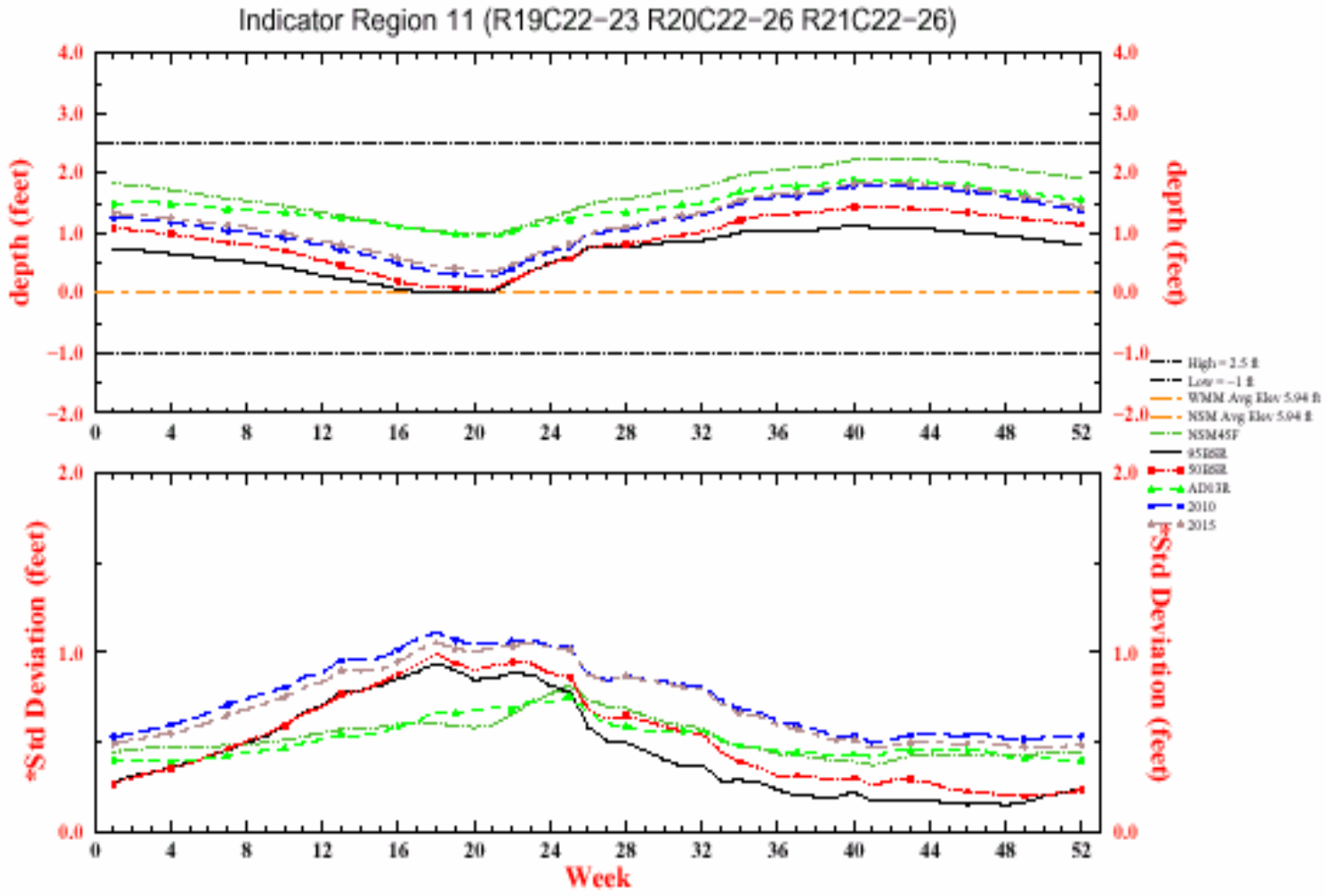
Stage-duration curves are derived directly from stage and time.


Netscape: Side By Side Comparison Maps [Main]
File Edit View Go Communicator Help
Back Forward Reload Home Search Guide Print Security Stop
Bookmarks Go To: http://www.sfwmd.gov/org/pld/restudy/hpm/frame1/maps/sbsmaps.htm
NSM v4.5 (Final) (NSM45F)
HOME Categories
Alternative D13 Revised (ALTD13R)
Mean Annual Overland Flow
NSM v4.5
1965-1995 Simulation Period
Source: SFWMD
Planning Department
27 Apr 1998
Page 1 of 1 94% 8.5 x 11 in
Mean Annual Overland Flow
Alternative D13R
SFWMM v3.5
1965-1995 Simulation Period
Source: SFWMD
Planning Department
25 Jun 1998
Page 1 of 1 94% 8.5 x 11 in


Average Annual Overland Flows toward Whitewater Bay and Florida Bay for the 31 year simulation period
Wet Season (Jun-Oct)
Dry Season (Nov-May)
Westward flows through Shark River Slough (Column 16, Rows 6-17)
Total Southward flows via Craighead Basin, Taylor Sl, & Eastern Panhandle (Row 6, Columns 17-28)
Surface Flow (1000 ac-ft)
0
200
400
600
800
1000
1200
1400
1600
1800
2000
711
808
245
457
337
489
466
629
553
702
45
132
45
205
37
134
37
124
43
133
NSM45F
95BSR
50BSR
D13R
D13R4
Note: NSM water depths at key ENP gage locations are used as operational targets for most alternatives.
NSM flows are NOT targets and are shown for comparative purposes only.
Run date: 01/14/99 07:24:11
For Planning Purposes Only
SFWMM V3.5


Stage Hydrograph at Everglades National Park
Gage NP_33, Cell R17 C20
feet, NGVD
5.0
1.0
1-1-65
1-2-67
1-1-69
1-2-71
1-1-73
1-2-75
1-1-77
1-2-79
Elev 5.06(NSM) ft
Elev 5.06(WMM) ft
NSM45F
95BSH
60BSH
D13H
D13H4
feet, NGVD
5.0
1.0
1-1-81
1-1-83
1-1-85
1-1-87
1-1-89
1-1-91
12-31-92
1-1-95
Year
Run date: 01/14/99 09:23:47
For Planning Purposes Only
SFWMM V3.5

Temporal Variation in Mean Weekly Stage for NE Shark River Slough



WEEK 1 STARTS JAN 1

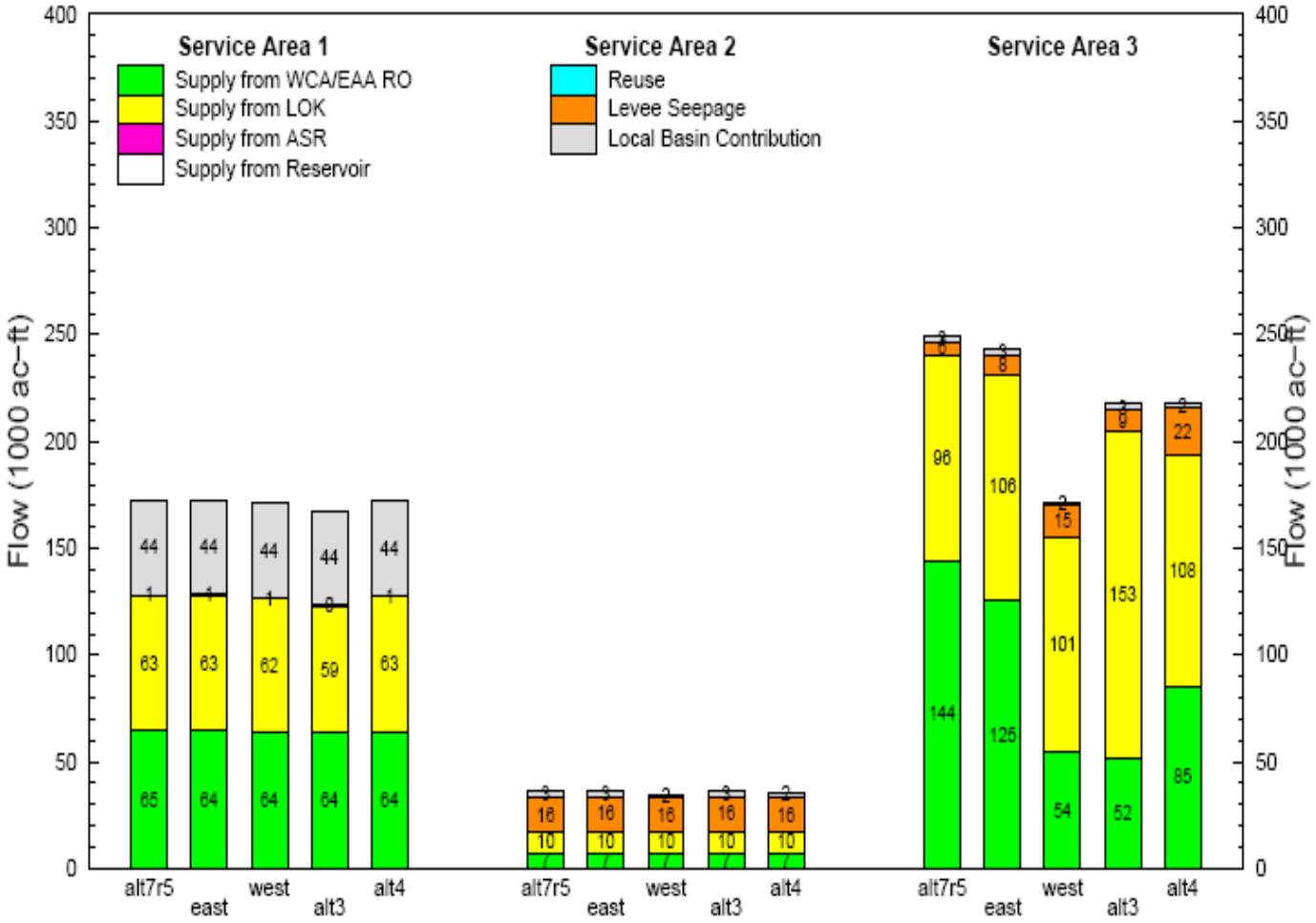
Depth and elev are weekly means for the indicator region for a 31 year simulation

High/Low = 0 indicates criteria undefined for region

* Standard Deviations are calculated among-year values;
* they illustrate interannual variation in mean weekly depth over the 31 year simulation period.

Run date: Wed May 26 12:23:37 EDT 1999
For Planning Purposes Only
SFWMM V3.4

Average Annual Regional System Water Supply Deliveries to LEC Service Areas for selected drought years (71,75,81,85,89)



So, what's the big deal?

- Engineers speak in terms of stage, flow, and Reynold's numbers.

- Biologists and Environmental Scientists speak in terms of breeding success and species diversity.

- Municipal and county governments talk about economic damages in dollars.

- Native Americans need to know how the plan will affect their way of life.

- Agricultural interests need to know if crops are likely to be damaged of if new crops need to be planted.

Biologist, farmers, and others need more than the hydrological output of the models.

They need to have information that is important to them!

Q: How do we translate the hydrologic "babble" of stage and flow into information that is useful to people who speak and think in different ways?

A: Performance Measures!

Whether or not a plan is “good” for a specific purpose is determined by the use of “performance measures.”

Performance Measures are functions of stage, flow, and other variables.

$$PM = f(\text{stage, flow, ground elevation, season, etc.})$$

A Performance Measure’s functional definition is determined by the biologist, ecologist, economist, or other specialist.

The definition is provided to the hydrologist/engineer. The hydrologist/engineer and programmers use it to produce the performance measure from the standard numerical model outputs of stage and flow.

Performance Measures

A “performance measure” is a data value or a data set that will give an indication of how close an alternative will come to attaining a specific goal.

There can be as many different Performance Measures as there are interested parties!

Examples of Select CSOP Performance Measures

Peat Forming Wetlands
Marl Forming Wetlands
Cape Sable Seaside Sparrow (CSSS) habitat
Average Hydroperiod
Jurisdictional Wetlands
Recession Rates in Marl Wetlands
Stage-Duration Curves
Slough “wet days” for selected periods
Slough Tabular data

Example: Spatial Distribution of Marl Prairie Habitat

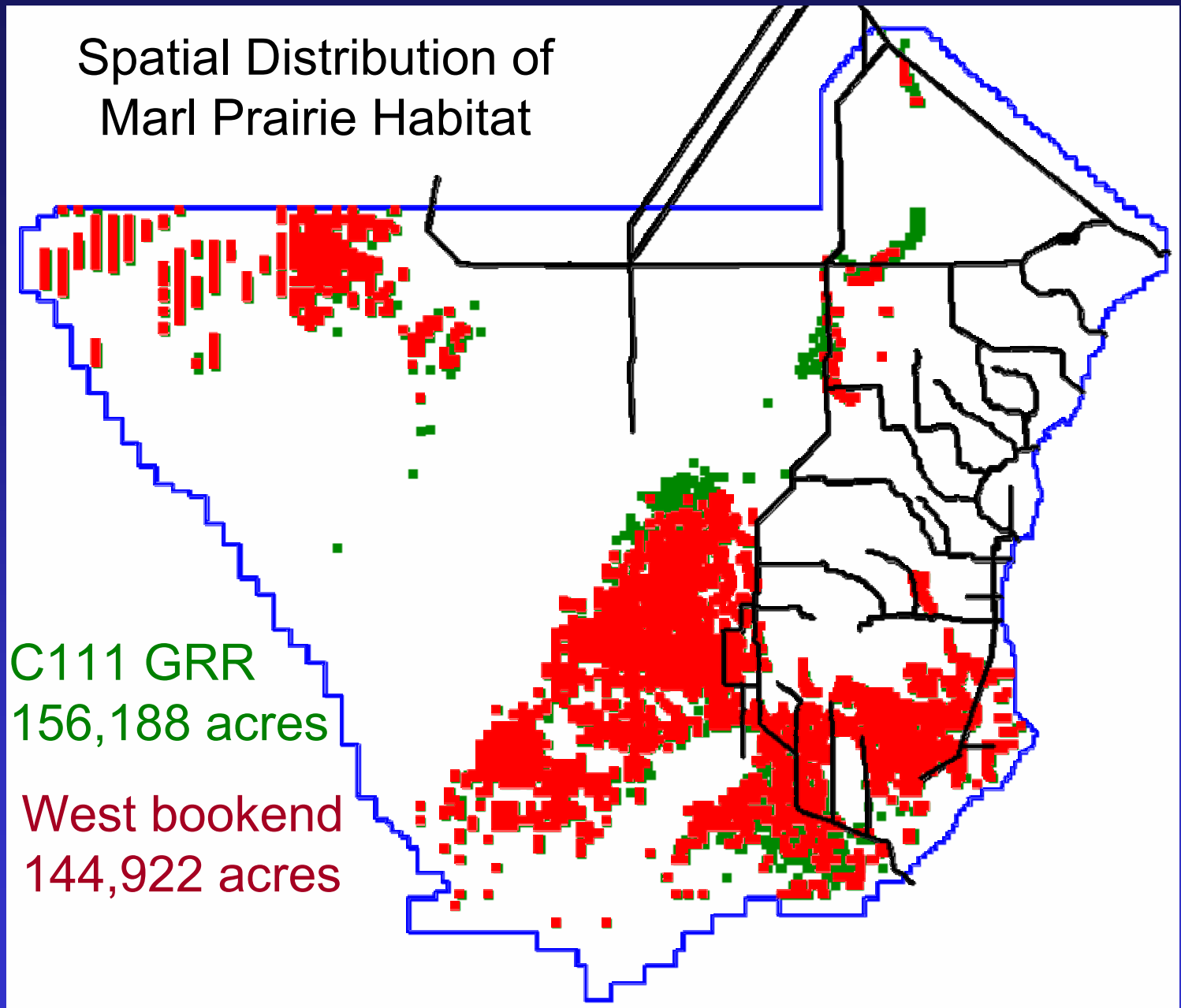
Delineation of habitat according to hydroperiod:

Required:

Wet year:	120 – 364 days
Average Year:	60 – 364 days
Dry Year:	0 – 270 days

60 days minimum during an average year to discourage woody plant incursion in the dry end of marl prairie.
The maximum of 270 days during the dry year reflects conditions observed during the dry year.

Spatial Distribution of Marl Prairie Habitat

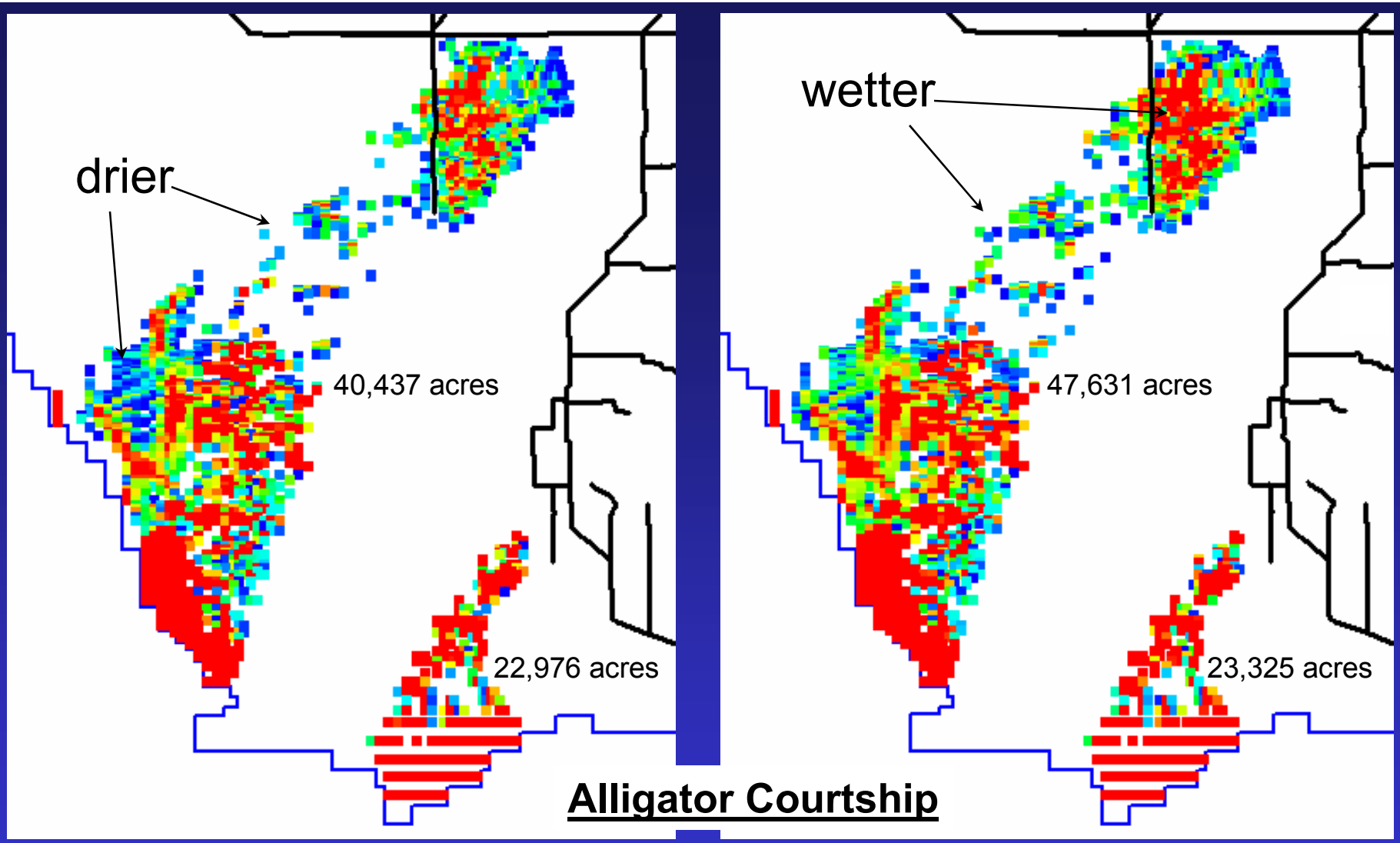


Example: Alligator Courtship

The number of adult female alligators that initiate nesting during June each year is proportional to the area of surface flooding in the sloughs during the courtship period in April and May.

Metric: Surface flooding in sloughs in April and May

Target: Maximize the area of surface flooding in the sloughs during the alligator courtship period in April and May



Alligator Courtship

C111 GRR West Bookend

Number of Days Flooded April – May, 1989

20 25 30 35 40 45 50 55 60

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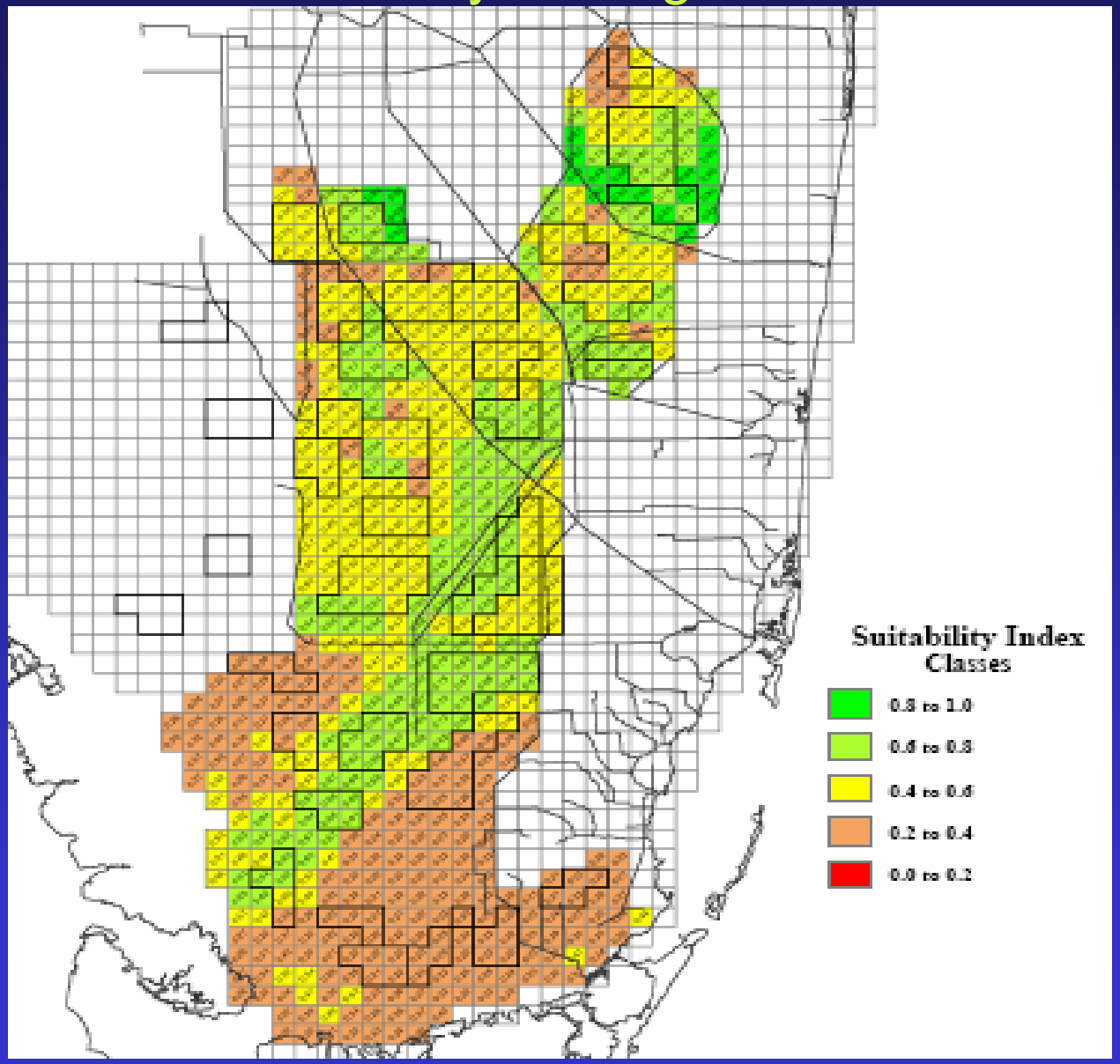
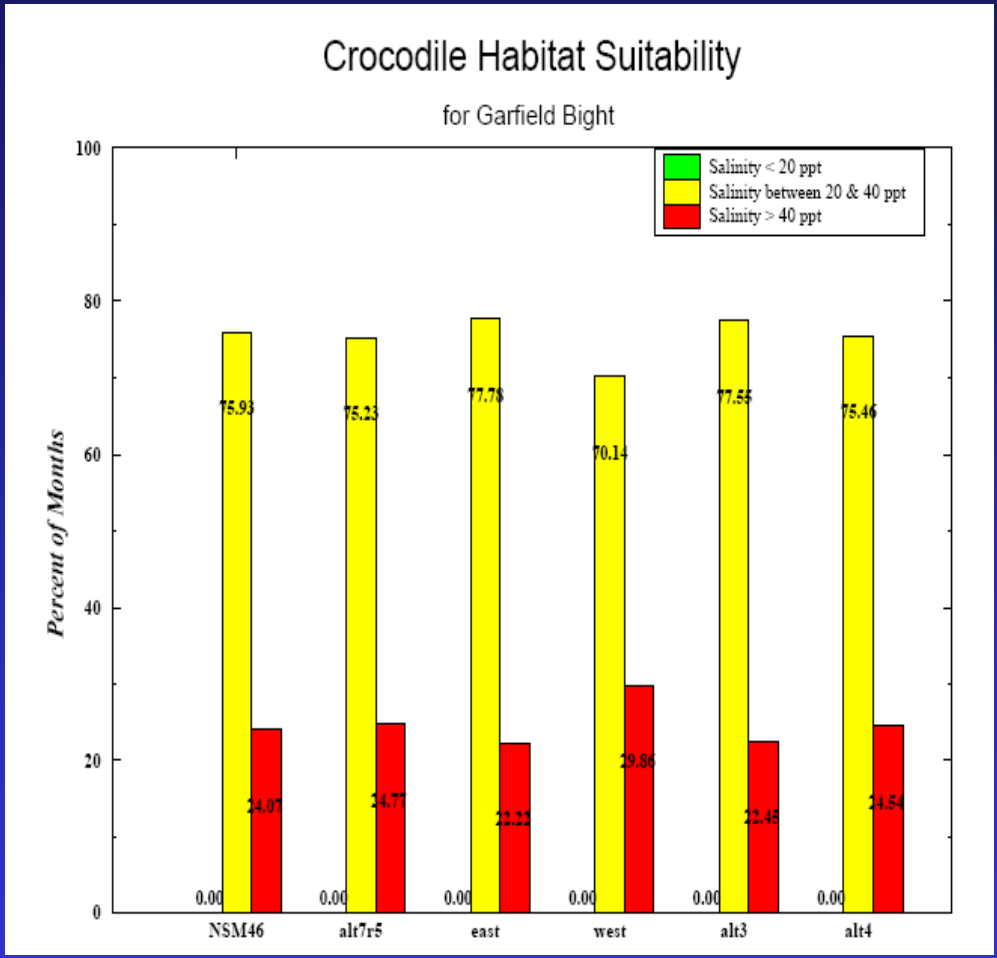
Example: Habitat suitability for alligators

What happens if we lump several performance measures together?



Example: crocodile habitat suitability

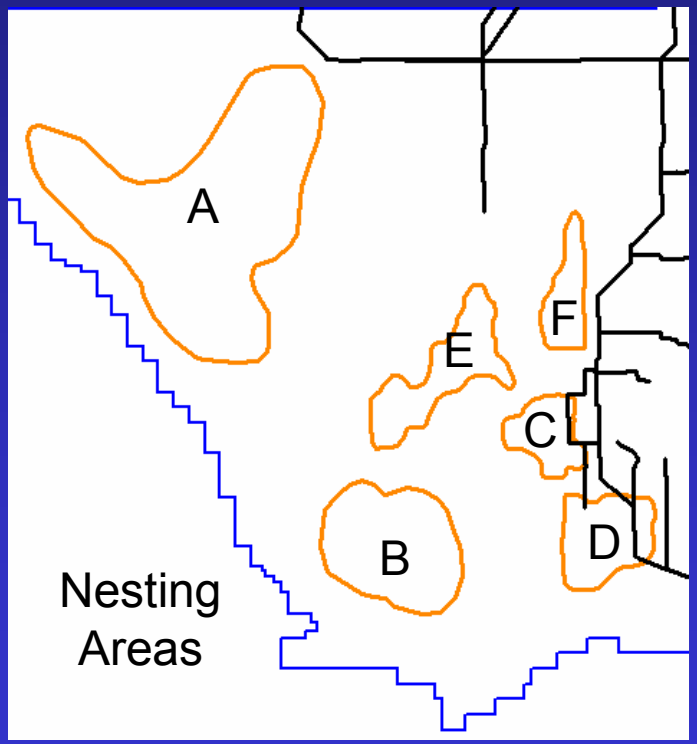


Salinity conditions in Florida Bay (a function of flows received from the Everglades system) directly impact species habitat range.

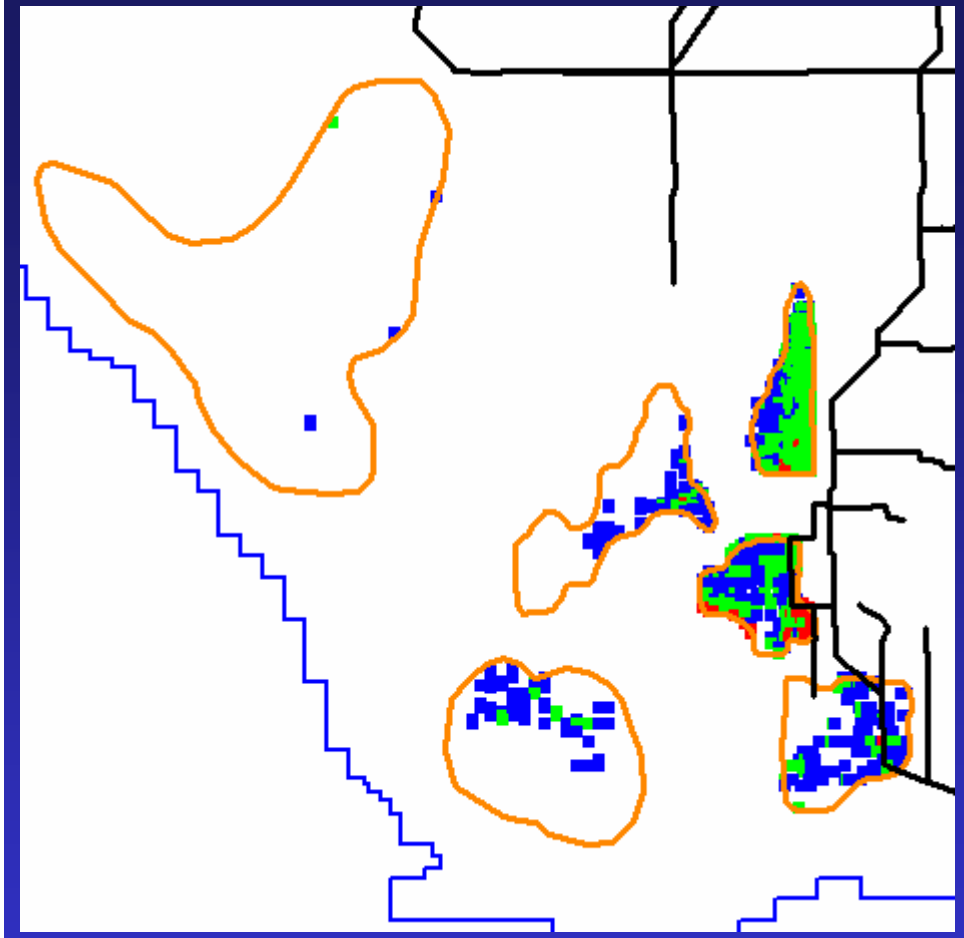
Example: Cape Sable Seaside Sparrow Breeding Success

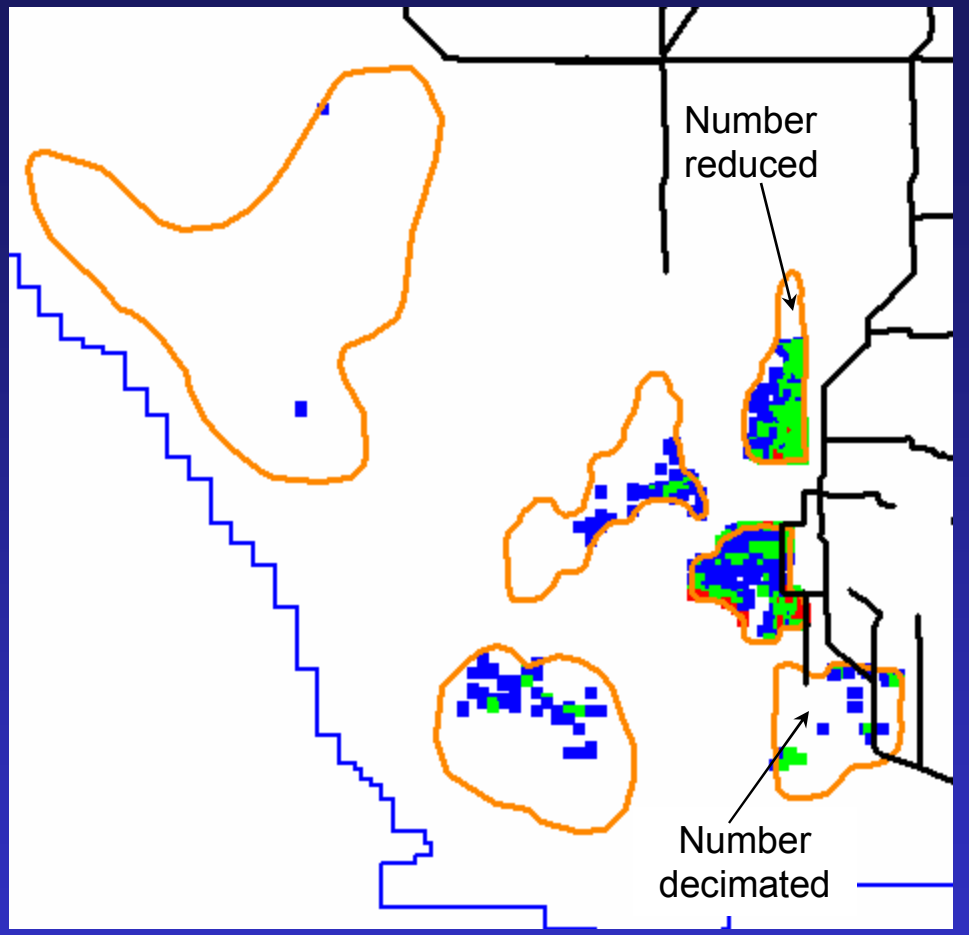
The Cape Sable Seaside Sparrow nests between March 1 to July 15.

It requires a minimum of 45 days of dry conditions to successfully rear one clutch.



Example: Cape Sable Seaside Sparrow Breeding Success





C111 GRR

West Bookend

Possible Number of Successful CSSS clutches, 1995

1 2 3

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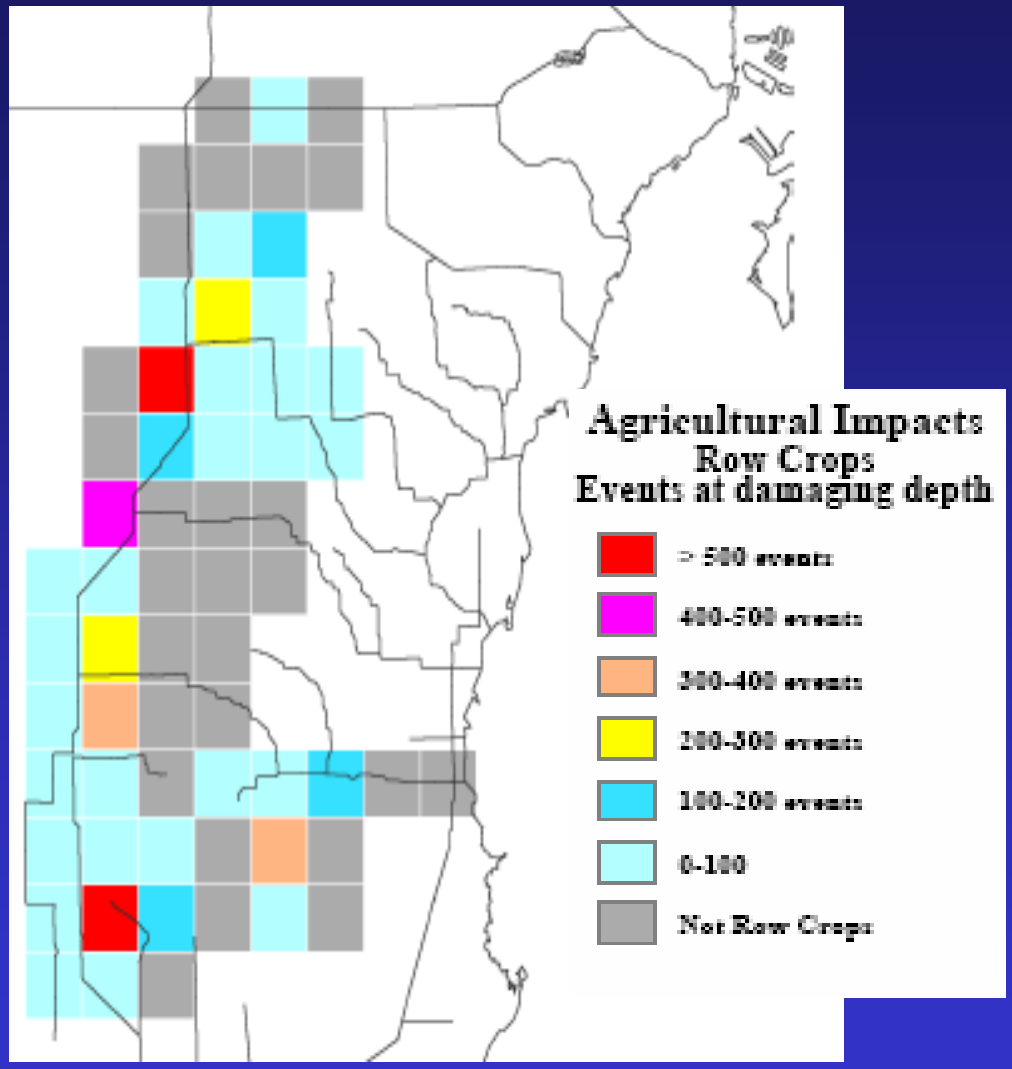
Example: regional agricultural impacts to fruit crops



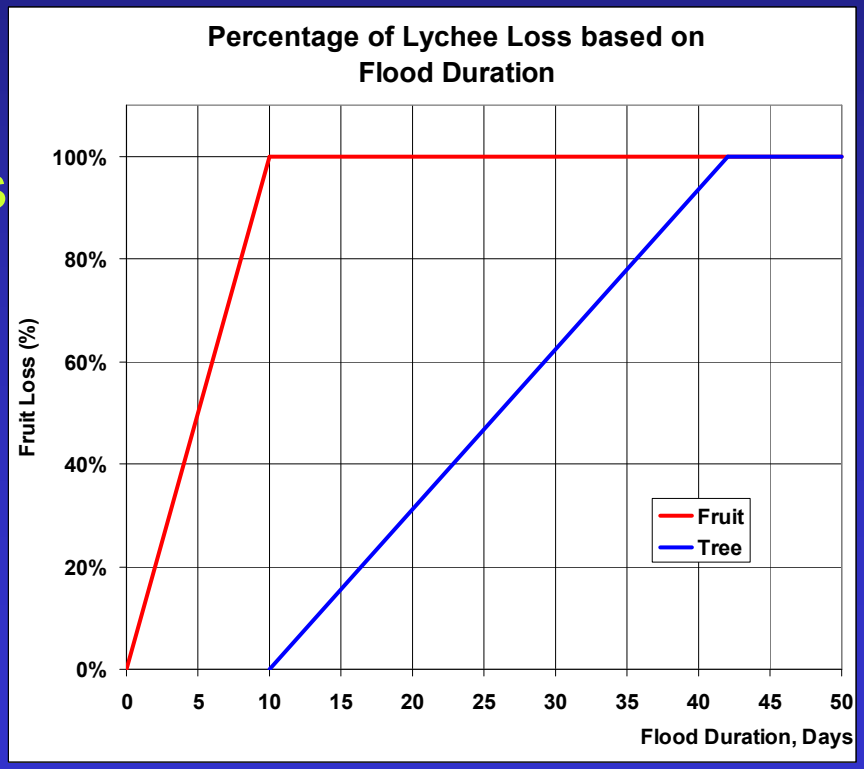
Damage to tree crops occurs whenever water is within 1.5 feet of the ground surface for a specified amount of time.

Example: Potential % Lychee Fruit Lost

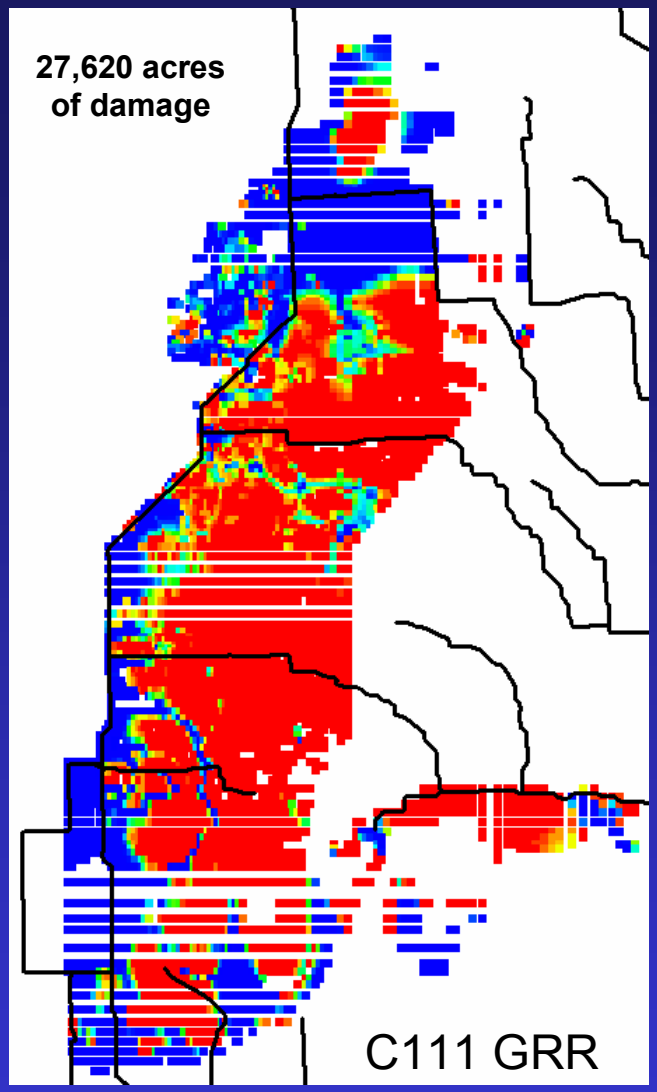
Potential damage to tree crops occurs whenever water is within 1.5 feet of the ground surface for a specified amount of time.

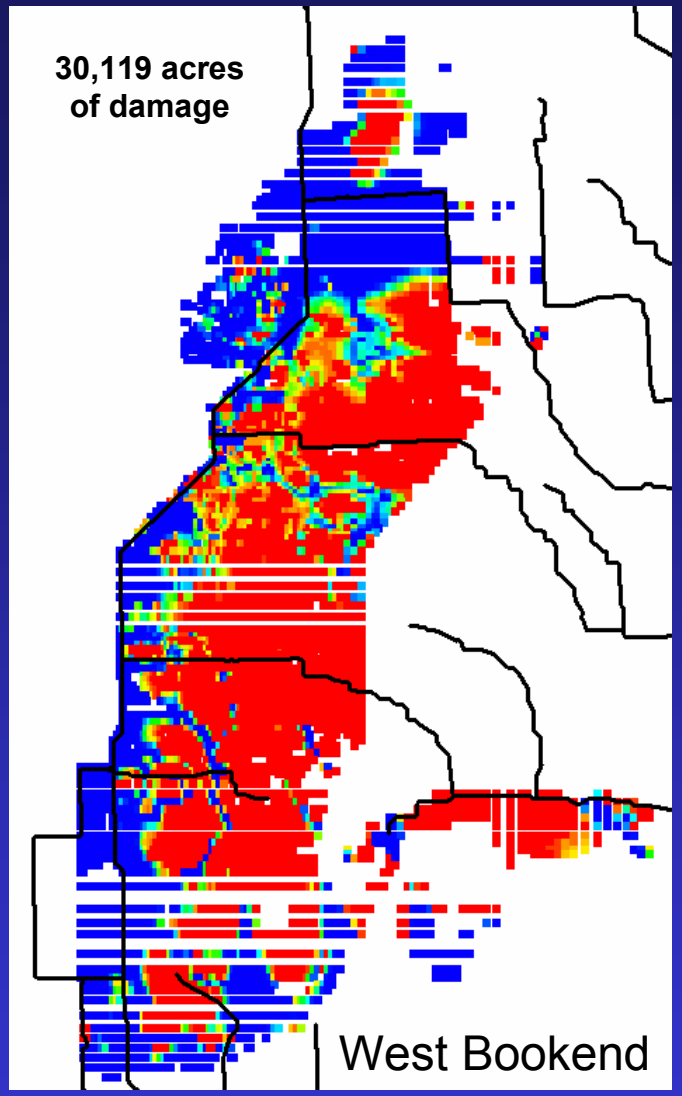
For Lychee trees the damage begins at 10 days with 100% loss at 42 days (reality vs. model)

For Lychee fruit the damage begins at 0 days an 100% crop loss at 10 days.



Example: Potential % Lychee Fruit Lost





% of Lychee Crop Loss, 1995

0 20 40 60 80 100

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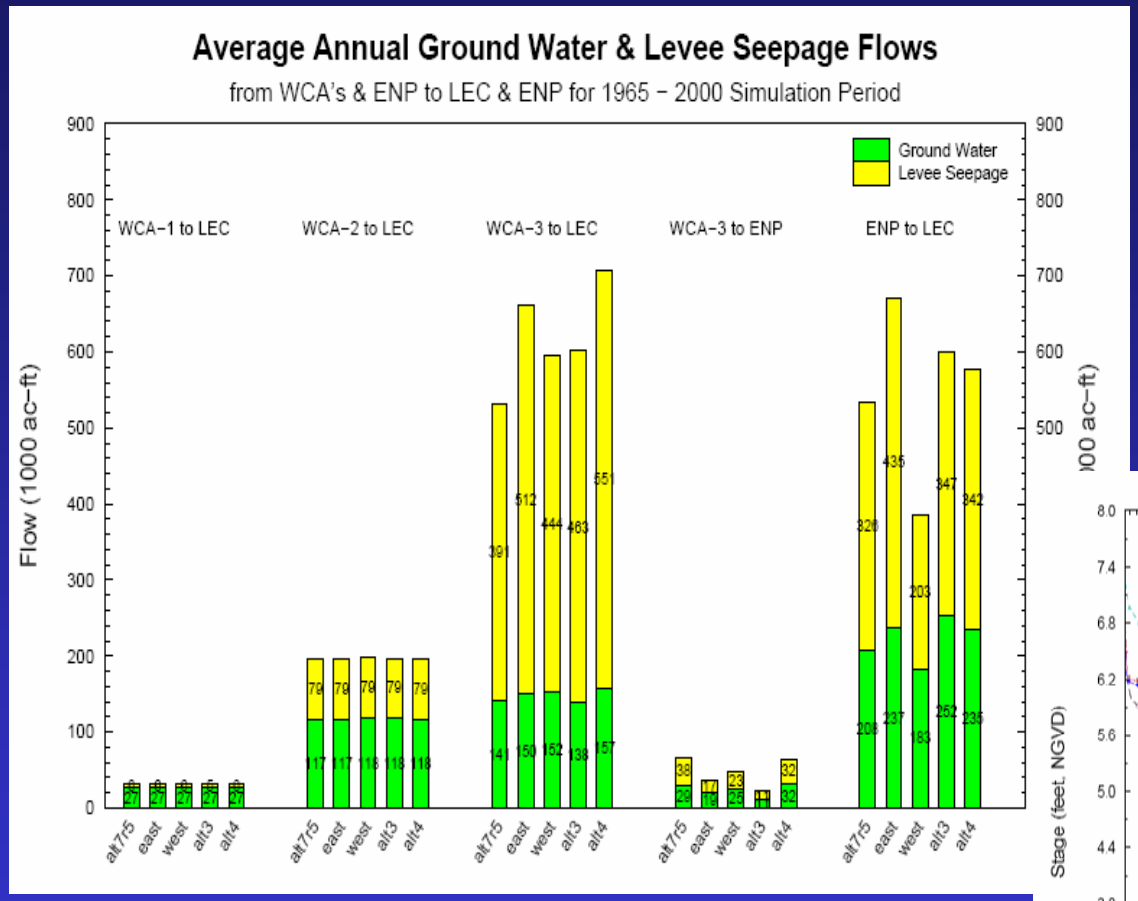
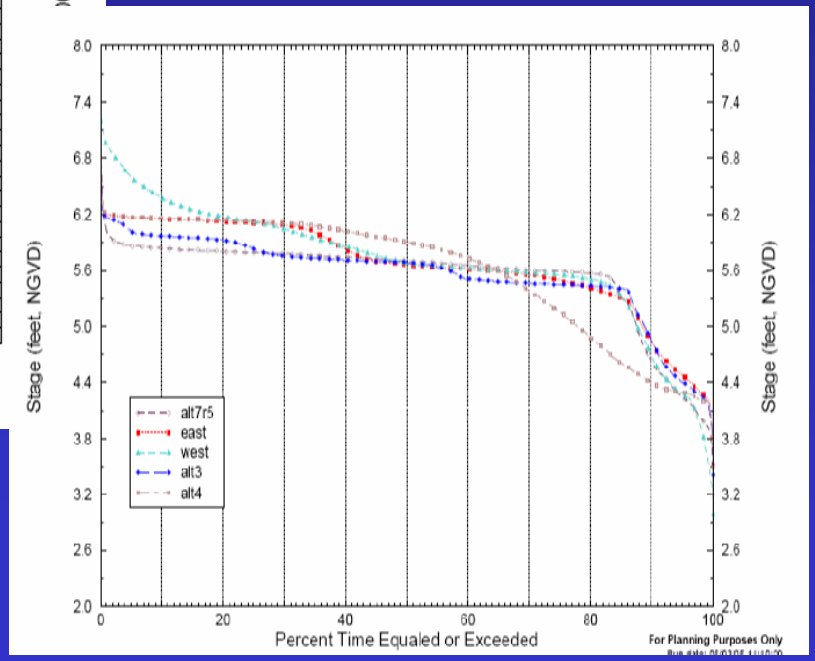
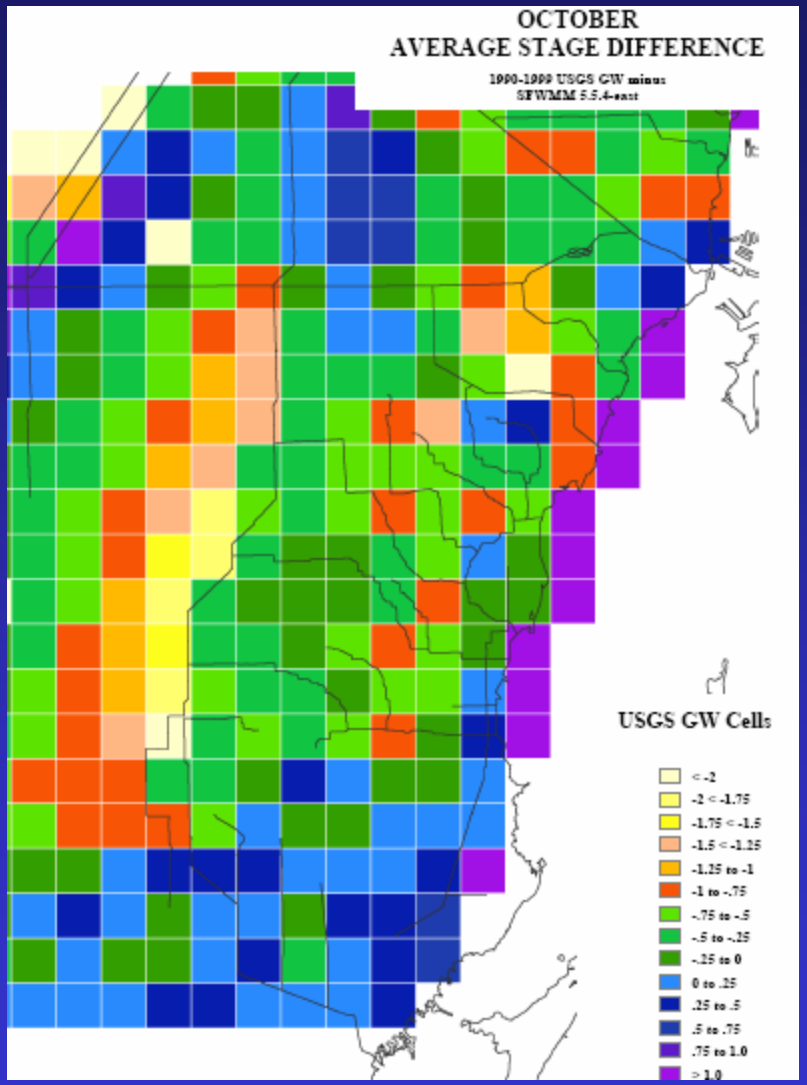
Generalized performance measures for flooding potential





Example: average stage difference at the end of the wet season

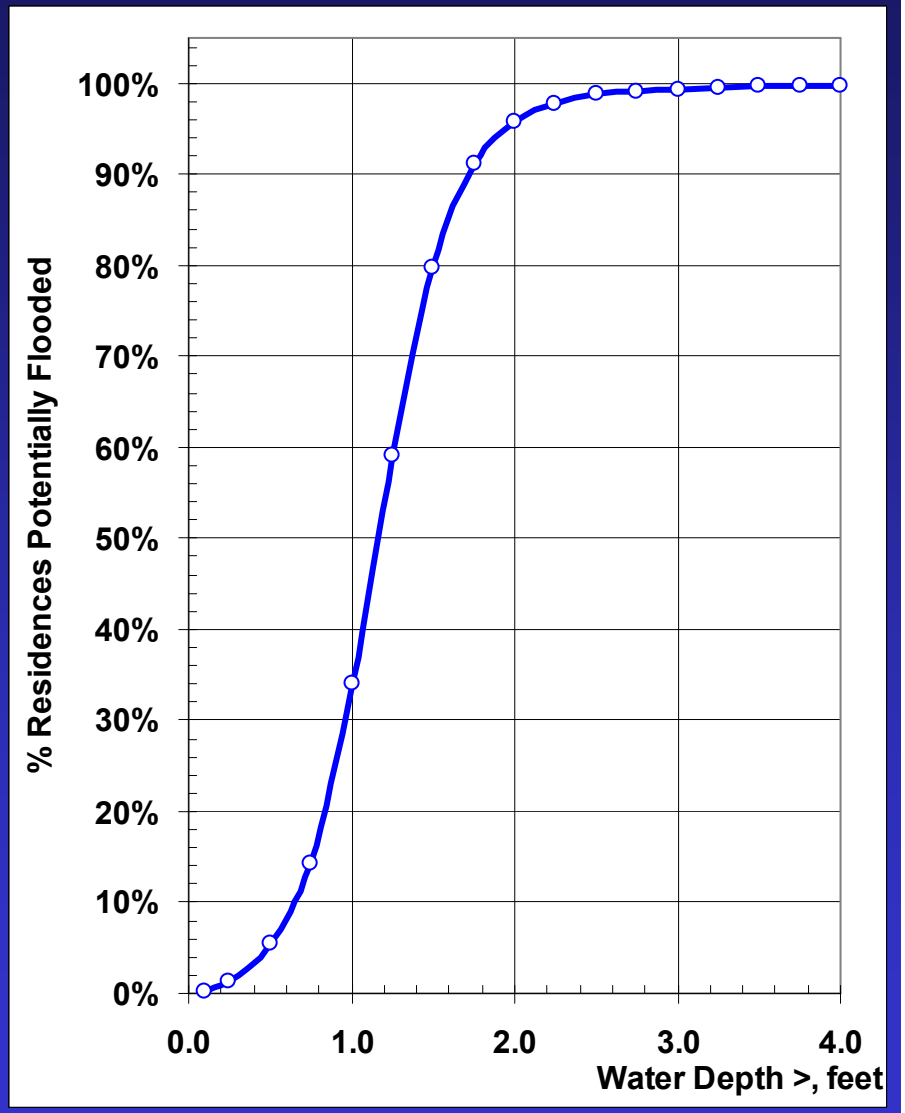
Direct comparison of model output stages to an observed "target" period of record



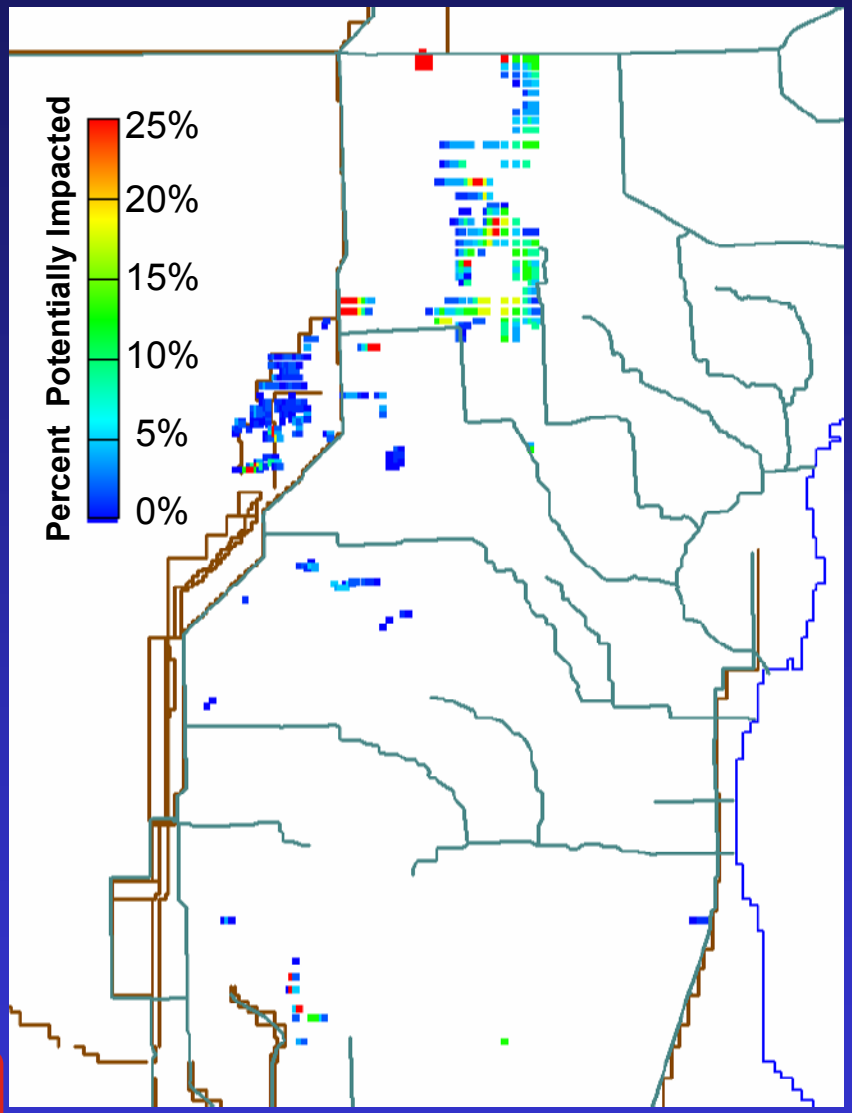
Example: Estimating the potential number of homes flooded

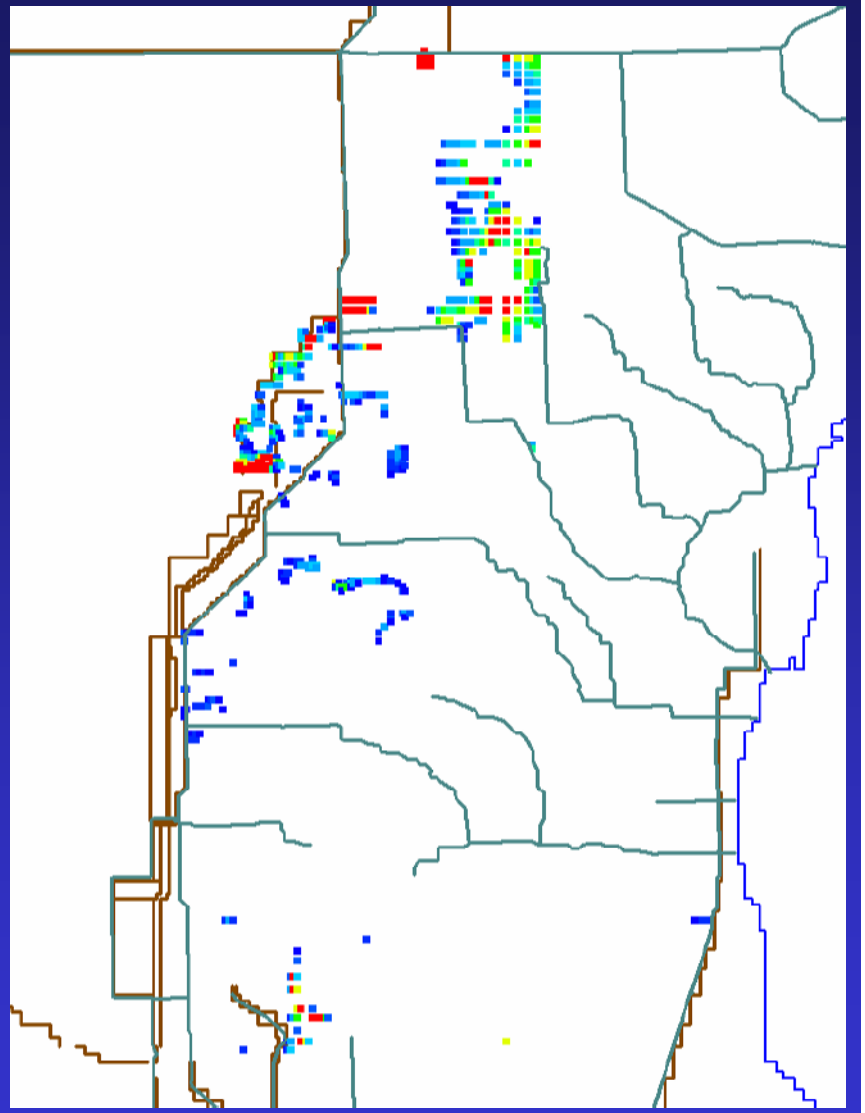
The potential number of homes that could be flooded under specified conditions is estimated based on peak stage, computational cell elevation, and a % Residence Flooded curve.

The probability curve is derived from 3,567 points consisting of surveyed 1st floor elevations and corresponding ground elevation.



Example: Estimating the potential number of homes flooded





What happens next?

- The suite of performance measures (several sessions would be needed to cover them all) are reviewed by interagency “experts”
- The results are tabulated, weighted, and compared to arrive at a recommended plan by the Project Delivery Team
  - Additional constraints are considered
- “Experts” can agree to disagree

- Special thanks to……..
  - Robert Evans
  - Richard Punnett
  - Dan Vogler
  - Schuyler Bishop

Questions?

Solutions?

- Contact Information

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