

**Lessons Learned  
from Monitoring Compliance  
with an Interim Phosphorus Standard  
in the Florida Everglades**

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## **United States v. South Fla. Water Management Dist. et al., Case No 88-1886-Civ-Moreno (S.D. Fla.)**

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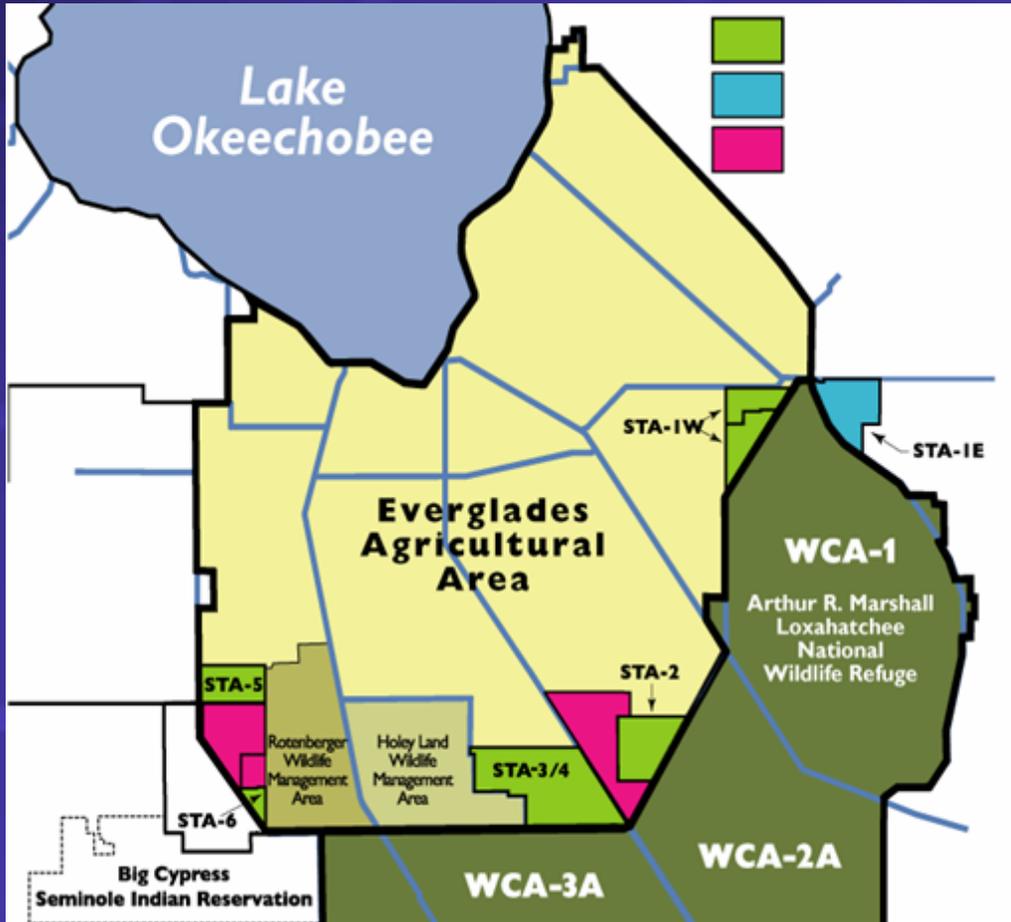
- Suit claimed violations of state water quality standards caused by runoff entering two areas of remnant Everglades: the Loxahatchee Refuge and Everglades National Park.
- Governor Chiles directed the State to settle the case and in 1992, the Court approved the Settlement Agreement among USA, FDEP, and SFWMD.

# Settlement Agreement Phosphorus Control Programs

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- Build 32,000 acres of Stormwater Treatment Areas (STA) to reduce phosphorus inflows to 50 ppb
- Implement Best Management Practices in the Everglades Agricultural Area to achieve a 25% load reduction in phosphorus discharges from the basin

# A.R.M. Loxahatchee National Wildlife Refuge in the Northern Everglades



Remnant Everglades marsh

125,000 acres

Sawgrass plains with many tree islands

Naturally low in nutrients

Peripheral areas of enrichment

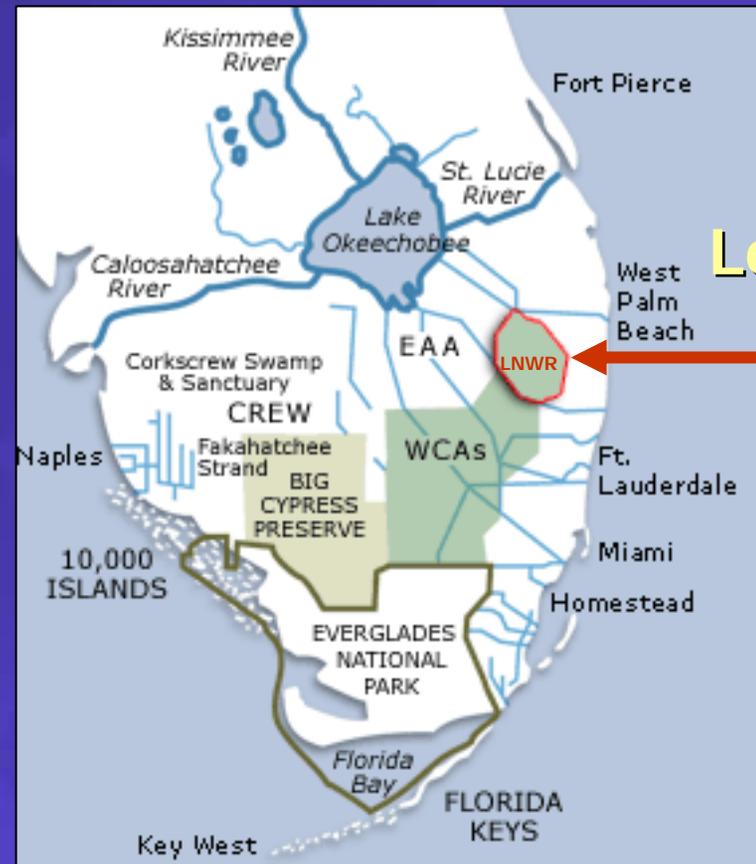
# A.R.M. Loxahatchee National Wildlife Refuge in the Northern Everglades



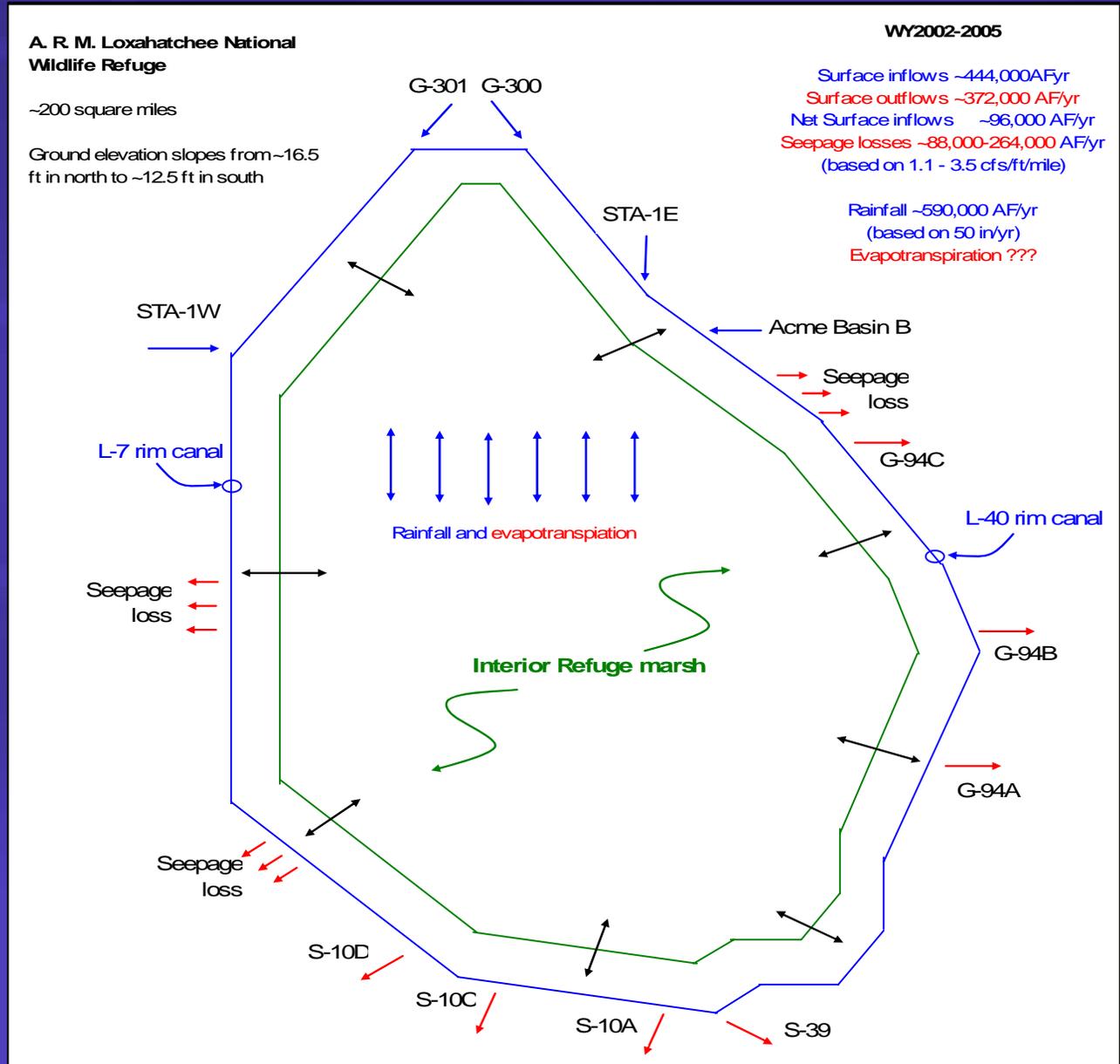
Water Quality Monitoring Stations (14) required in the Settlement Agreement



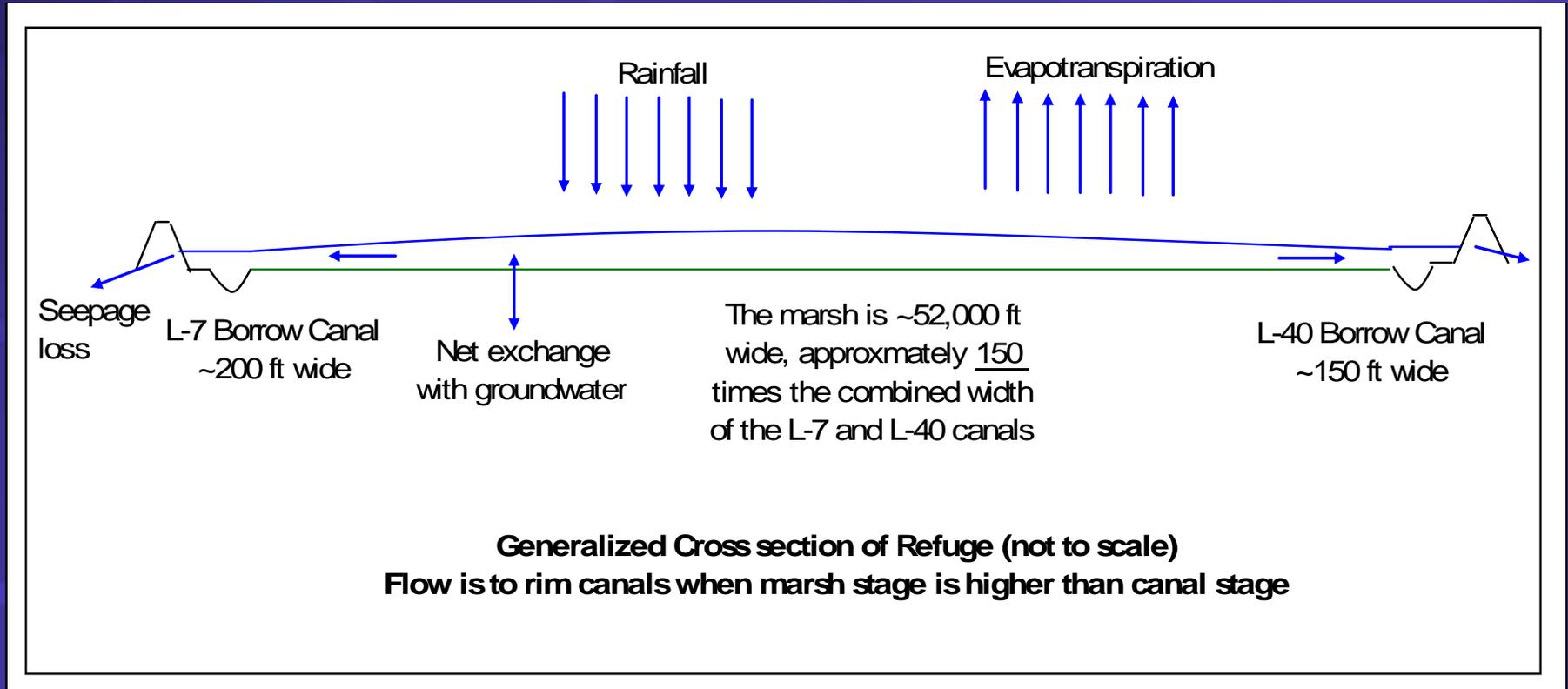
# Loxahatchee National Wildlife Refuge (WCA-1)



# Schematic of Refuge Water Movement



# Schematic of Refuge Water Movement



# Settlement Agreement

## Phosphorus Monitoring and Compliance

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- For the Loxahatchee National Wildlife Refuge, phosphorus (TP) concentrations are measured at fourteen sites and compared to predicted values from equations (based on stage) in the Settlement Agreement.
- Interim Level equation was developed from 14 monthly geometric means during a baseline period for Outstanding Florida Waters.
- Interim Levels effective since 1999, and Long-Term Levels effective 01/01/07

## Compliance with Interim Phosphorus Levels for the Refuge

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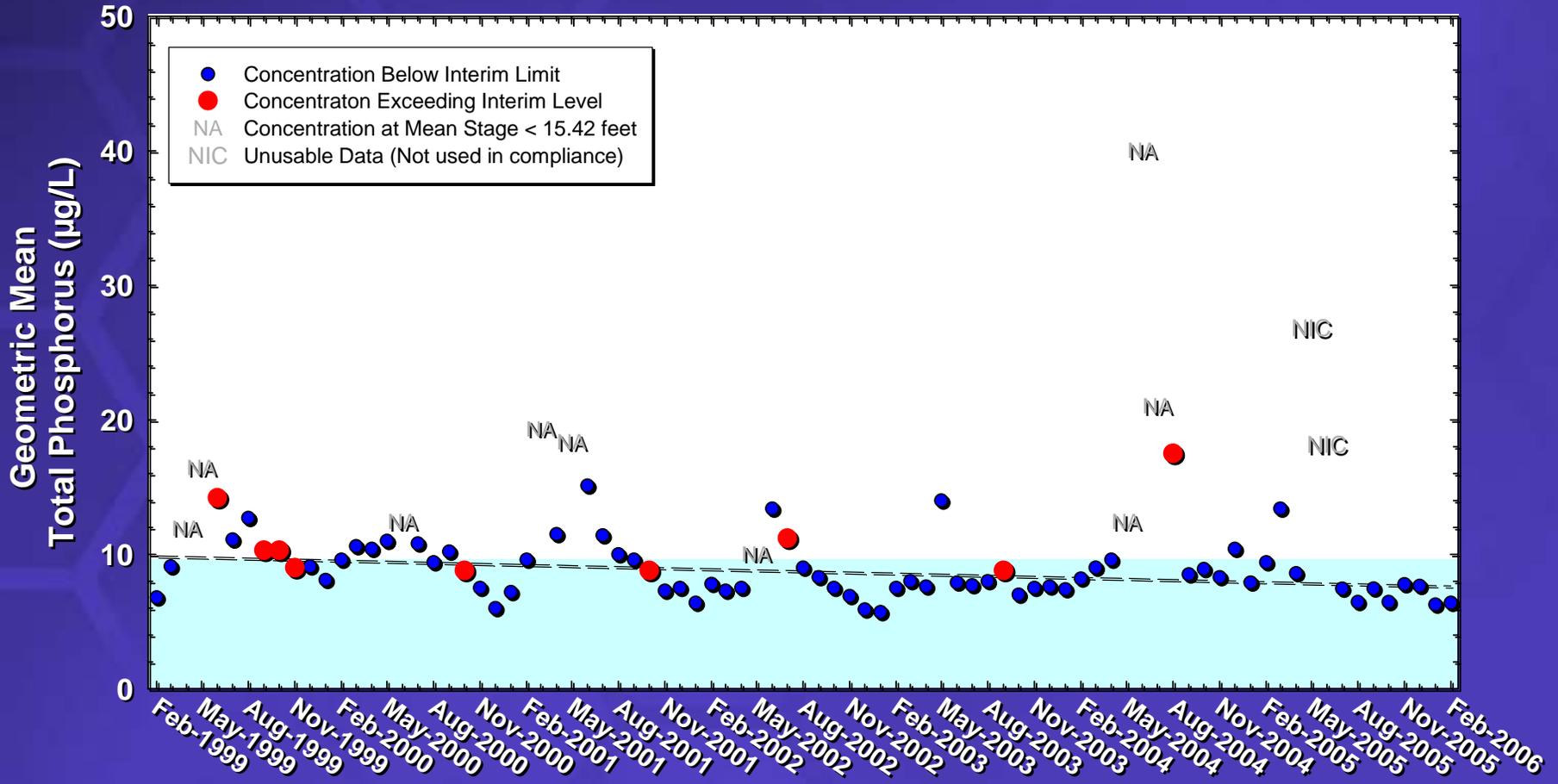
- An 'excursion' is when the marsh TP geomean is  $>$  the calculated value in one month
- An 'exceedance' or violation of the Agreement is when the TP geomean is  $>$  the calculated value two or more times in 12 months
- Premise is that external loads are linked to water quality at the 14 compliance sites
- If this assumption is not correct or the compliance system generates false positives, millions could be spent on unnecessary phosphorus control programs

## Compliance with the Interim Levels

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- Miccosukee Tribe claimed violations of Interim TP Levels in the Refuge and asked a federal Court for judicial oversight of Everglades water quality programs
- Court found that 'there is a violation of the Consent Decree due to exceedances in the Refuge' and ordered additional hearings on compliance and potential remedies
- Let's look at the evidence

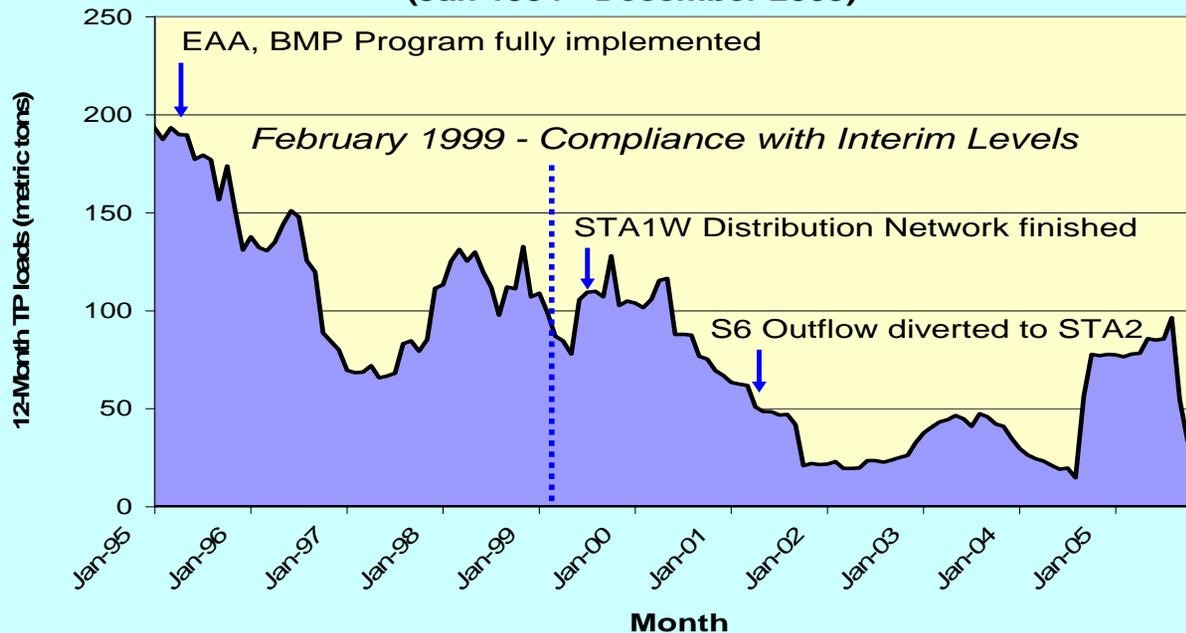
# Total Phosphorus Concentrations During the Compliance Period (February 1999 to Present)



# Phosphorus Loads to the Refuge

## Total Phosphorus (TP) Loads to the Refuge

(Jan 1994 - December 2005)



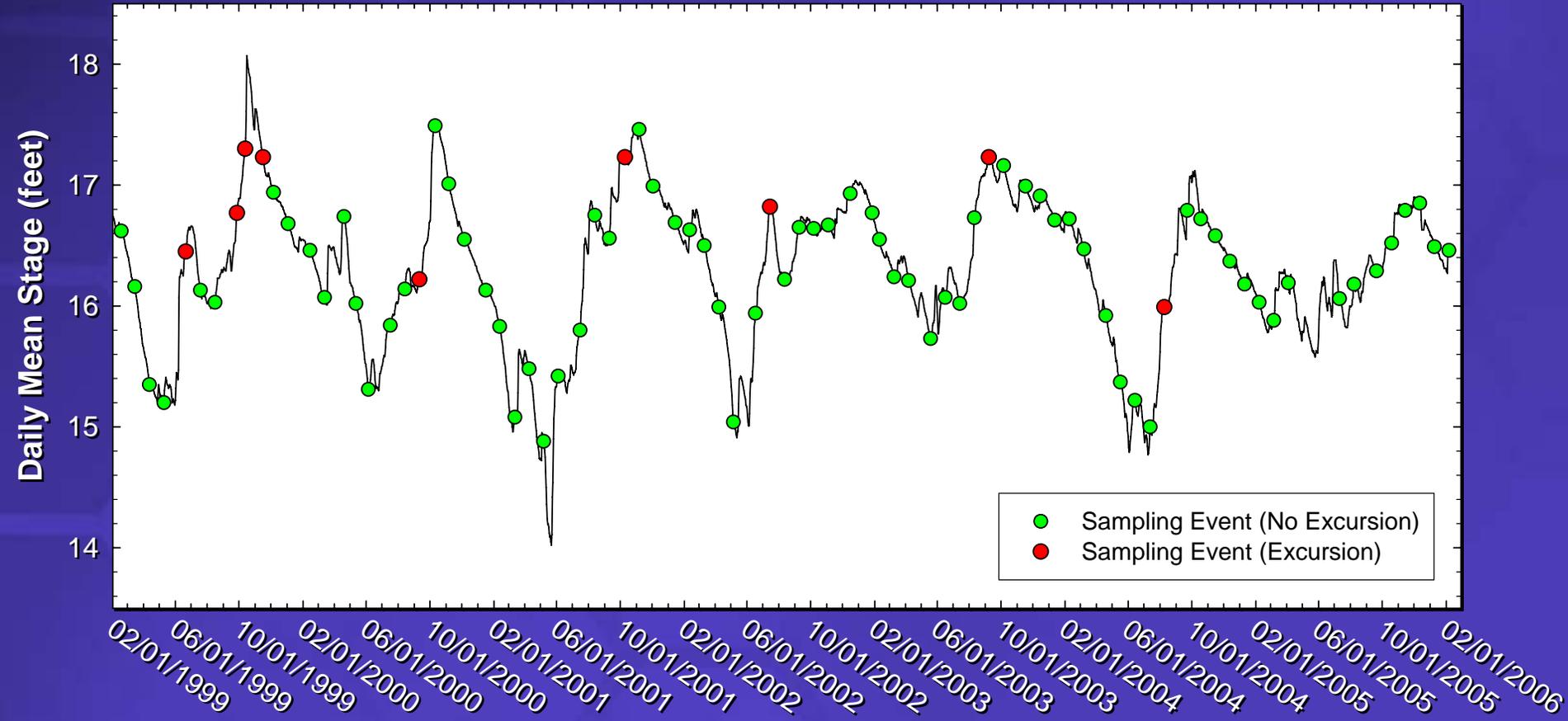
# Long-Term Trends

- External loads and concentrations have dropped
- A decade of monitoring shows no systematic trend in TP concentrations
- Annual TP values are very low at  $< 9$  ppb, at or below the baseline period
- So, why is the alarm going off?

## What is Causing Excursions Above the Interim Levels?

- Are TP inputs are causing the excursions
- Could they be caused by error in the compliance equation?
- Cause and effect chain of logic has weak links, let's look at the chain of data sets

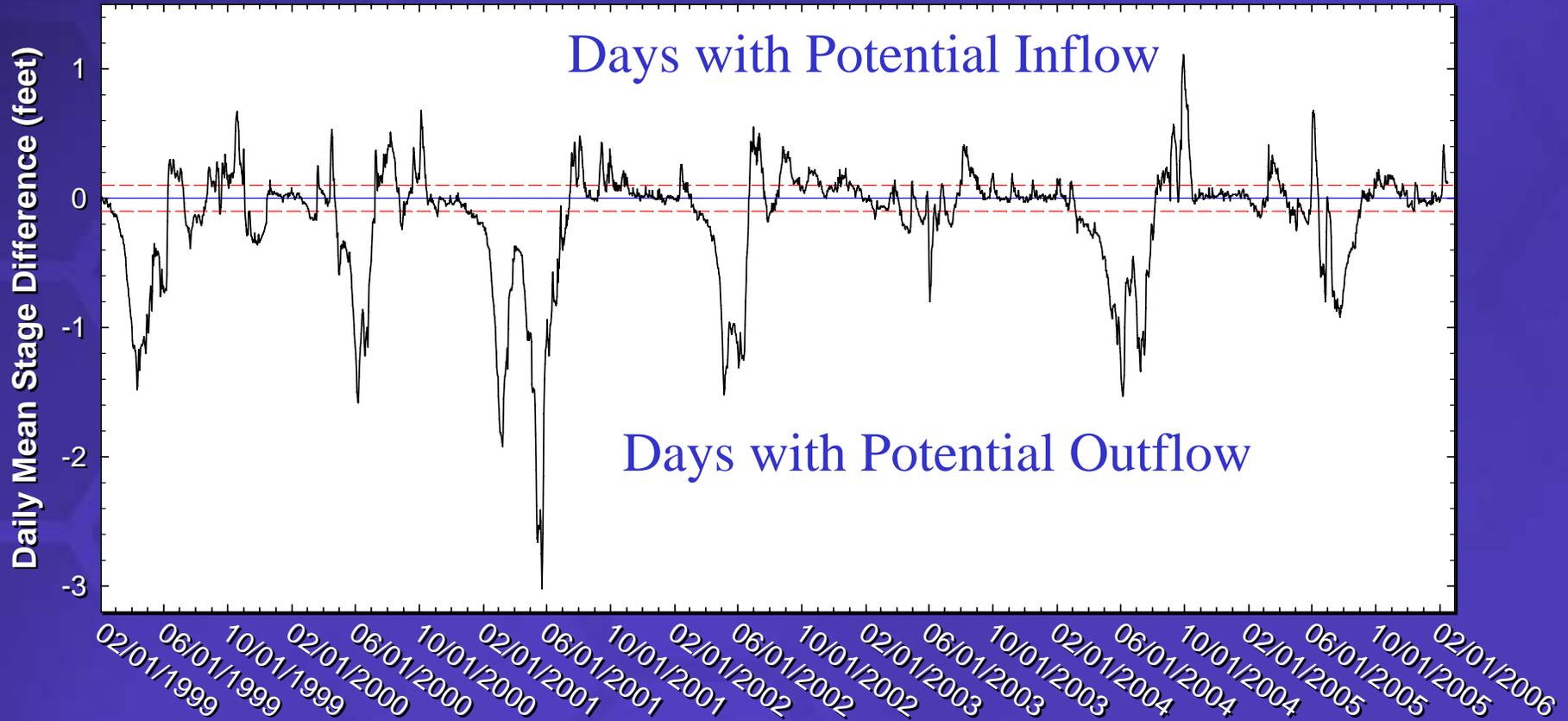
# Stage, Sampling and Excursions



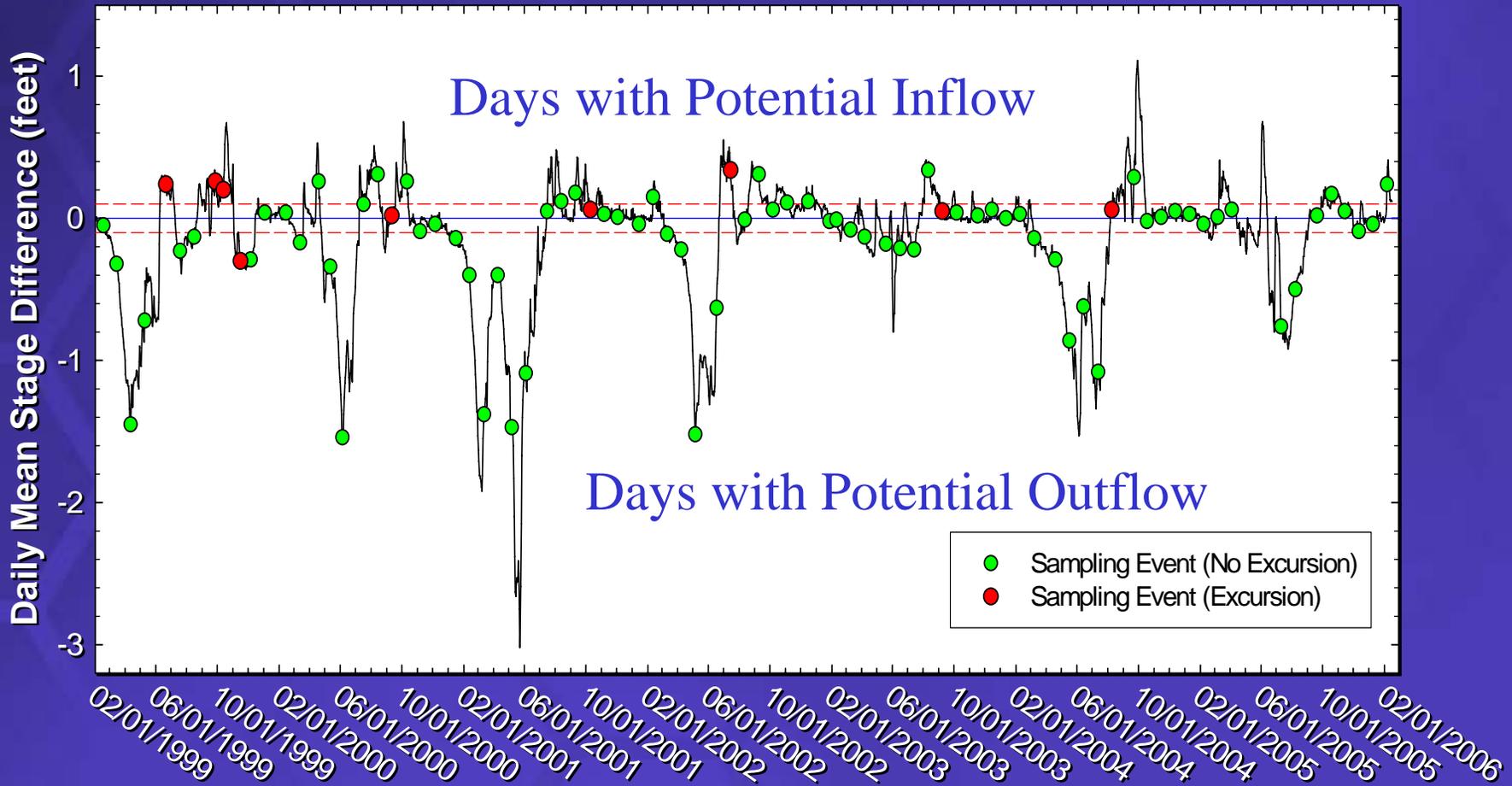
# Stage, Sampling and Excursions

- Excursions tend to occur on rising stages
- Most excursions occur at higher stages
- If rising stages are associated with water flowing into the marsh from the peripheral canal, then external causes are supported
- Let's look at potential for penetration of canal water into the marsh

# Periods of Potential Movement of Canal Water into the Marsh



# Periods of Potential Movement of Canal Water into the Marsh

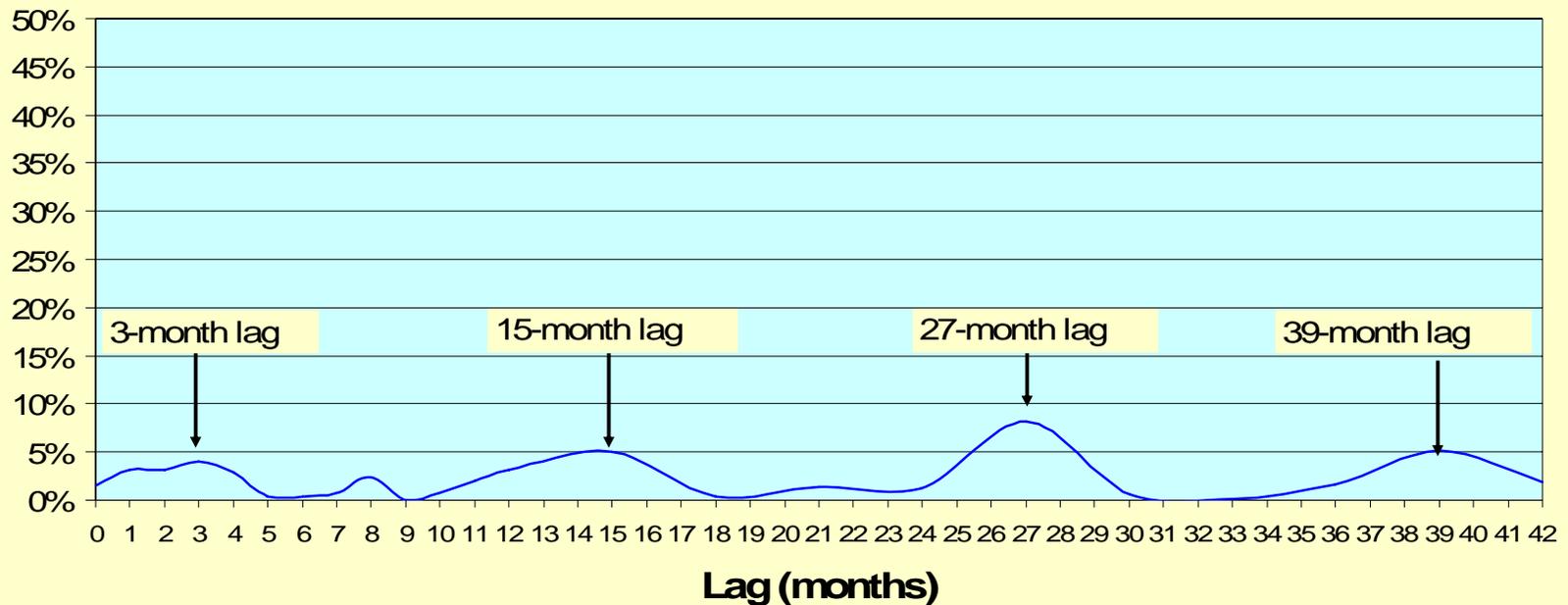


## Periods of Potential Movement of Canal Water into the Marsh and Excursions above the Interim Levels

- Pattern is inconsistent and periods of penetration can occur without excursions
- Let's look at other information that might link external inputs to marsh phosphorus concentrations
  - Is there any correlation between loads coming in and phosphorus concentrations in the marsh?

# External Loads and Internal Concentrations

Correlation Between Inflow Loads and Interior Concentrations  
January 1994 - August 2004



# Frail Logic Links Loads and Excursions

- Statistical correlation between monthly loads and TP geomeans is almost non-existent
- Data on loads, stage & marsh penetration help explain why:
  - Loads are not correlated with stage due to water management of canals and marsh (open system)
  - High stage is not consistently related to potential movement of canal water into the marsh; inflow can occur at any stage above 15.8 feet
  - No sign that stations nearer canal drive excursions, in fact they show lower TP concentrations than those more interior

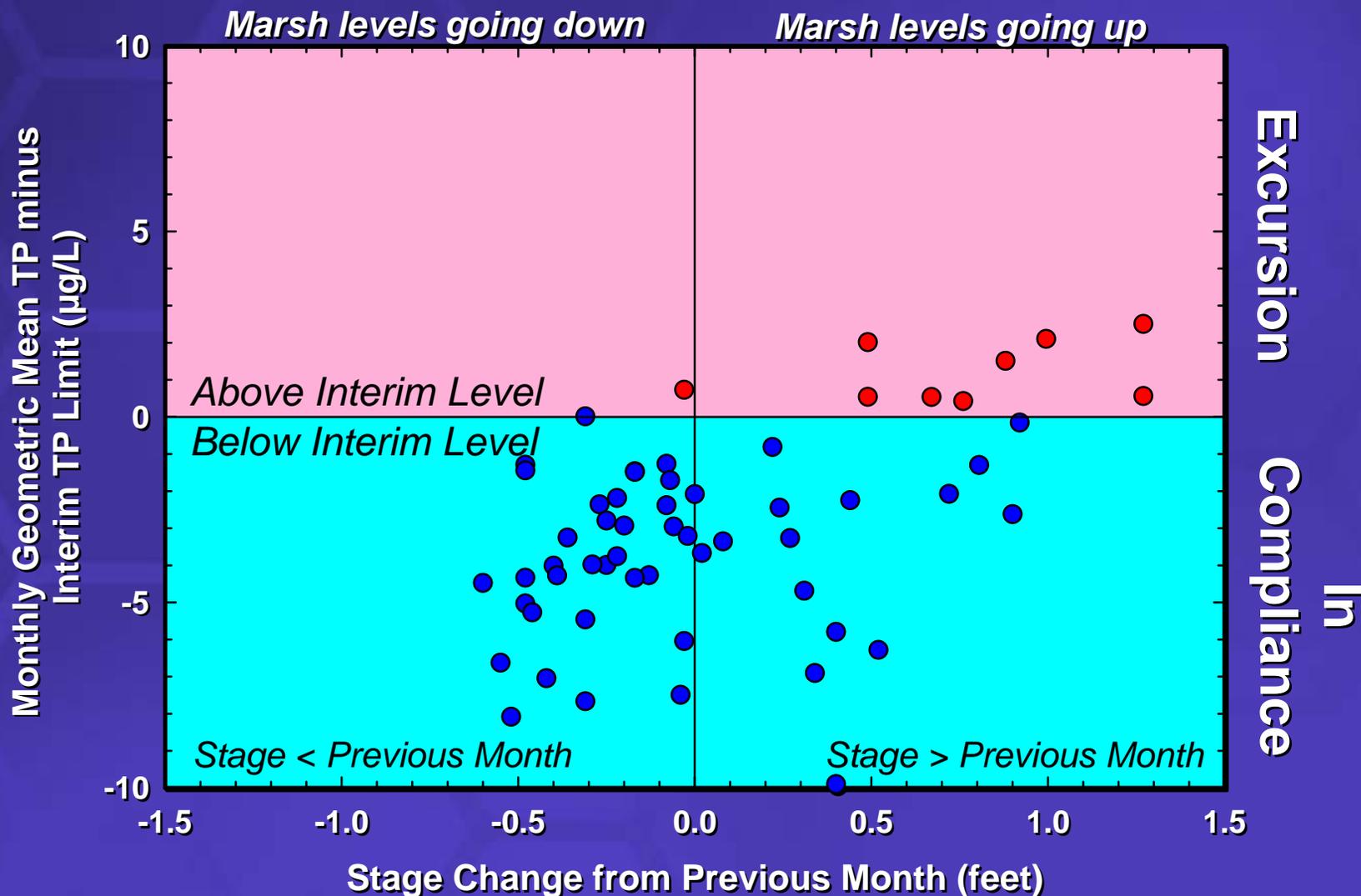
# External Loading and Refuge Excursions

- The longer-term temporal correspondence between loads and excursions is very weak.
  - e.g., Huge hurricane loads in the September 2004 did not produce an excursion
  - There has been no change in the frequency of excursions with years of loading reductions
- If not external loads, then could the equation be producing false positives?

# Excursion Pattern

- As mentioned earlier, excursions tend to occur at high and rising stages
- Pattern of excursions appears uneven
  - 8 of 9 excursions occur at high and rising stages
    - Counterintuitive: TP levels tend to be higher at lower stage and there is a greater chance of sampling problems

# Compliance and Change in WCA-1 Marsh Levels

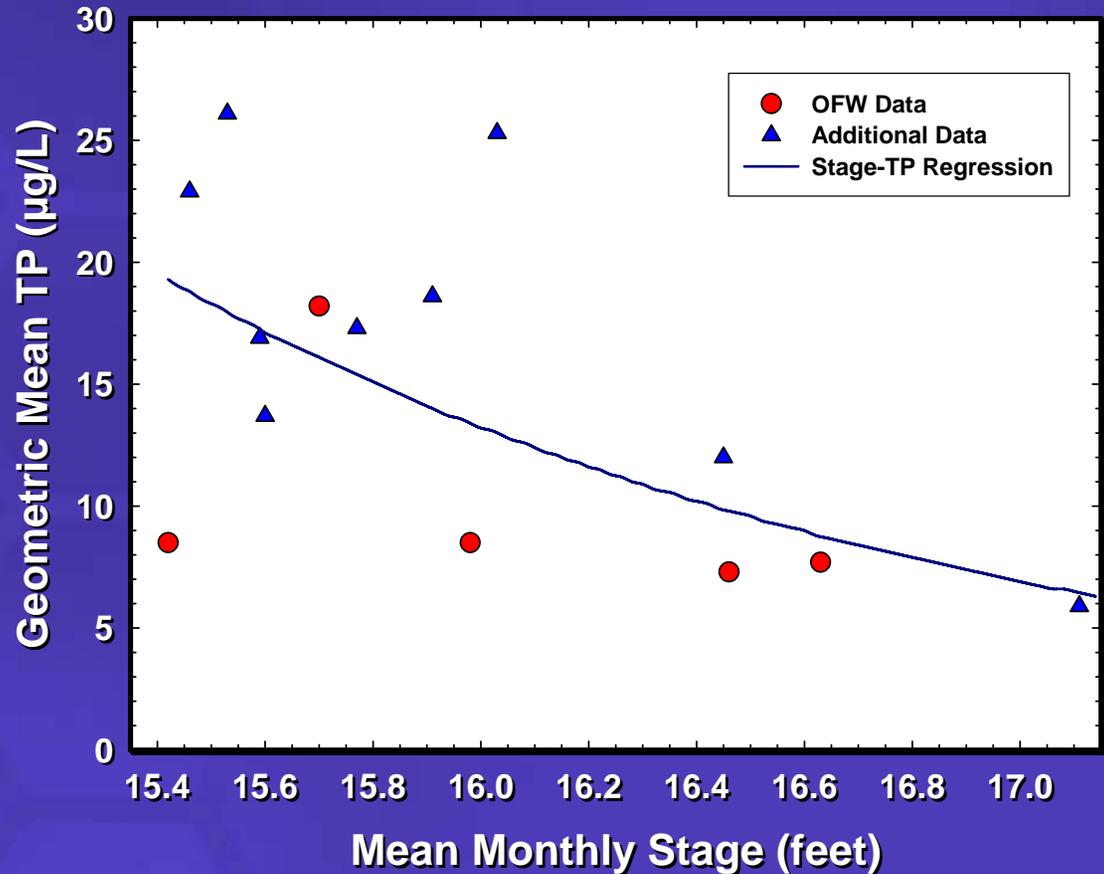


# Performance of the Equation

- Potential for bias in the equation
  - Based on limited data, 14 dates in five year period
  - Sampling was never done in consecutive months
  - Stage levels were lower than today
  - Many changes have occurred in Refuge since 1978-79
- Why don't we see hits at low or falling stages?

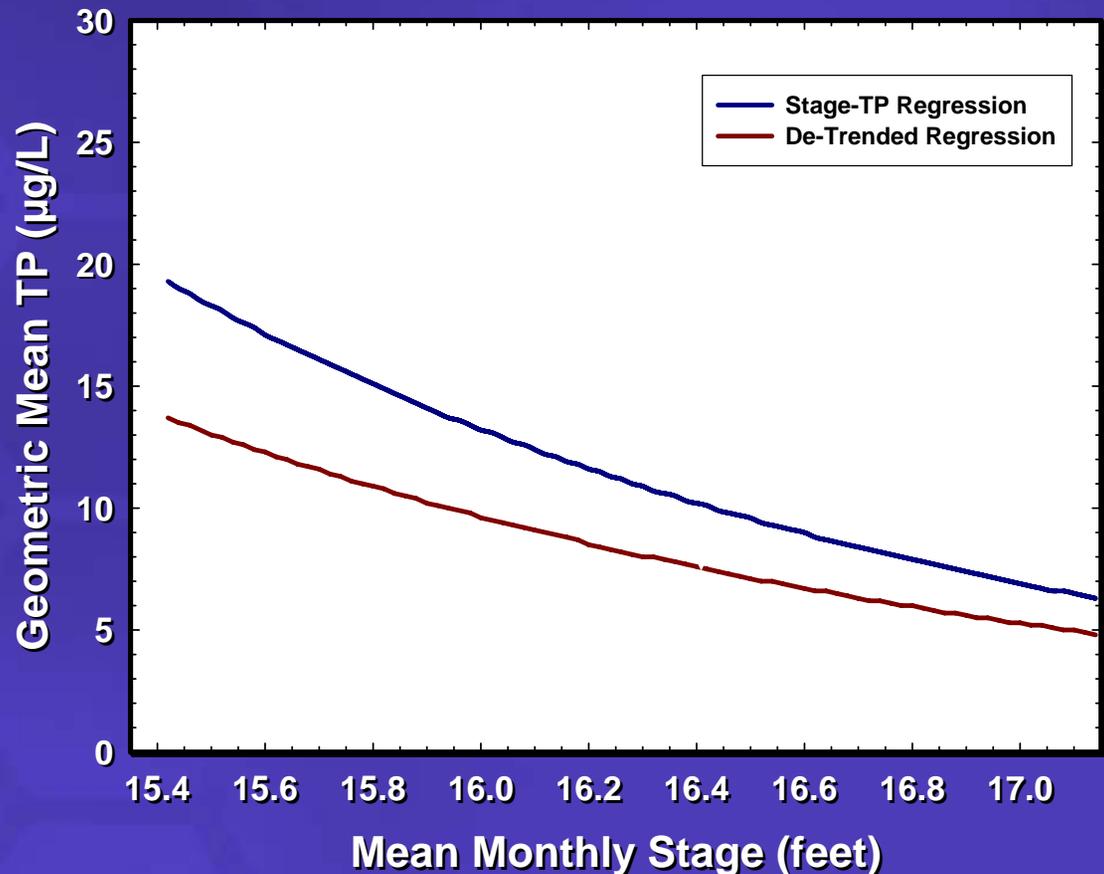
# Original 14 Data Points

- Many high values at lower stages
- Produces a strong TP stage relationship



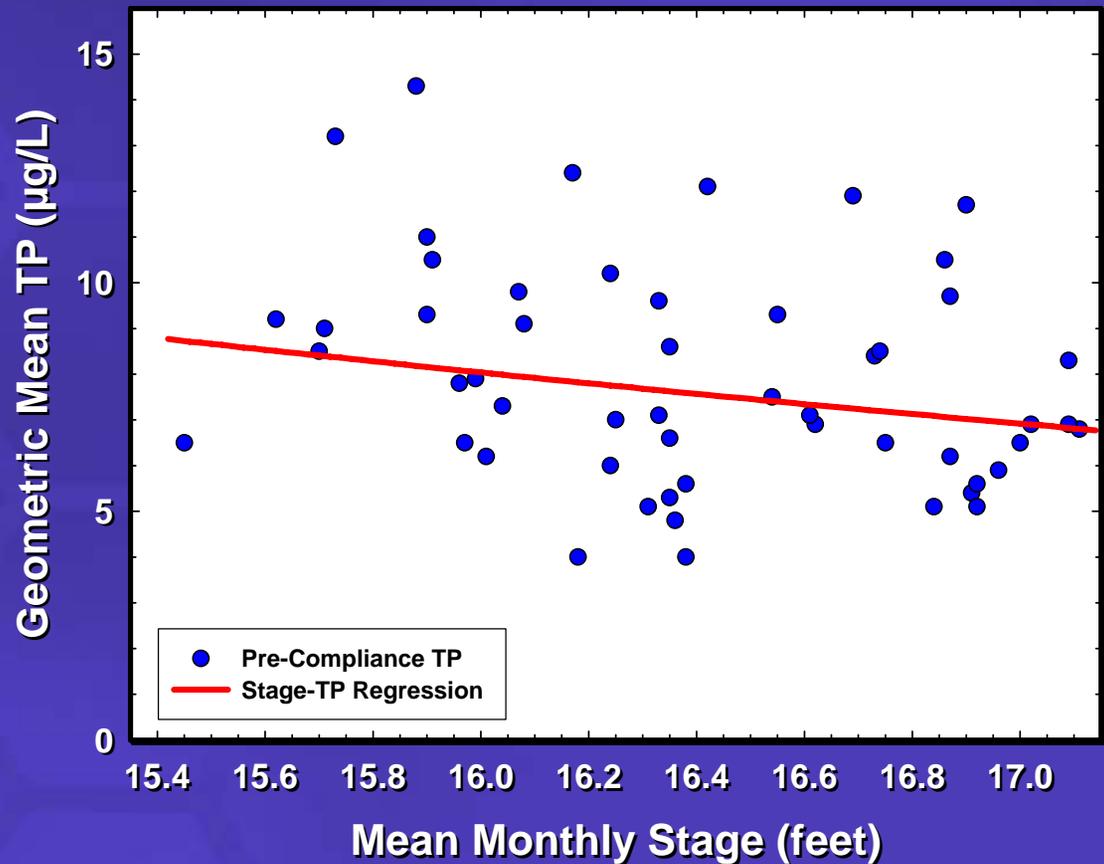
# Original 14 Data Points; 9 were re-trended

- Many high values at lower stages
- Produces a strong TP stage relationship
- De-trending lowered line but left a strong downward trend in TP-stage relationship



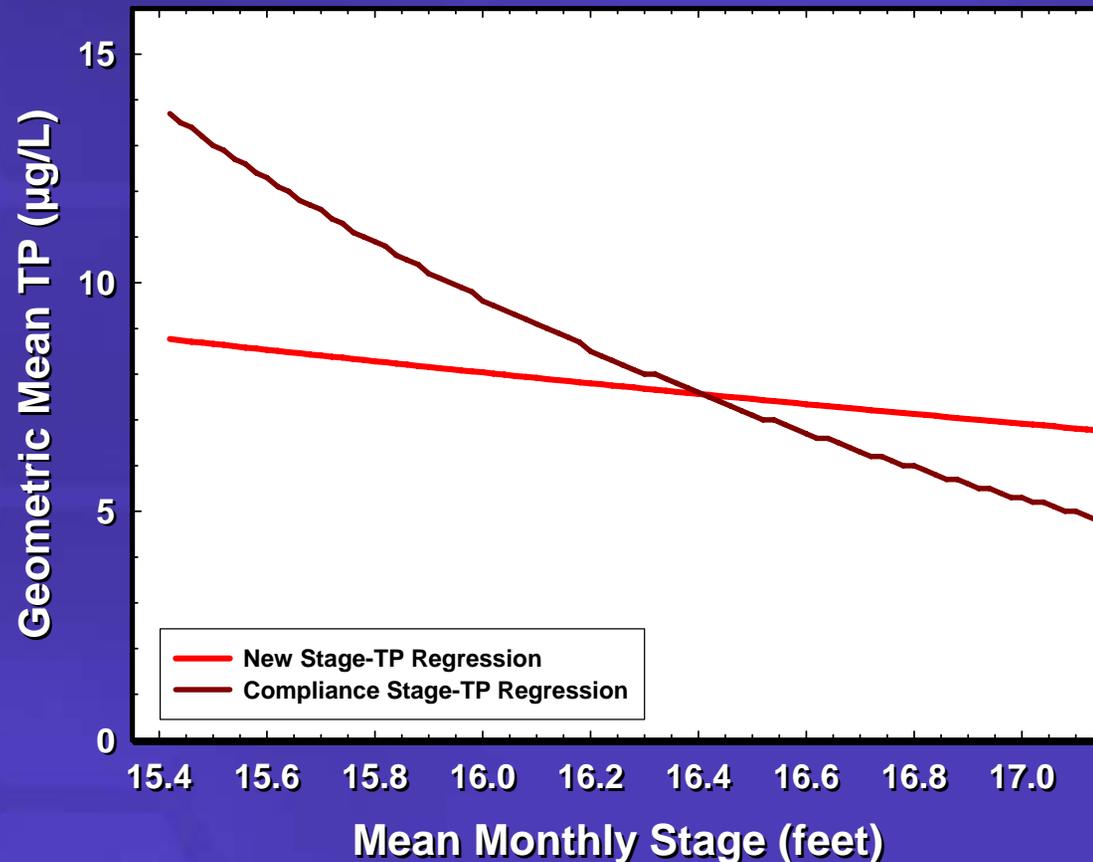
# Data from 1994-1999 Tells Another Story

- Monthly geometric means from pre-compliance period
- 60 values taken sequentially
- TP-Stage Relationship much weaker with a slight downward trend



# Data from 1994-1999 Tells Another Story

- Differences in the TP-stage relationship has implications for excursions
- Most excursions at higher stages
- Most excursions are <math>< 1.5\text{ ppb}</math>
- Divergence of the curves at higher stages could lead to false positives: calculated levels are unrealistically low



# Data from 2000 to 2006 Tells the Rest of the Story

- Rising stage is a surrogate for changing conditions
- When excursions occur, marsh almost always meets the Interim Level the next month
- Instantaneous response is unrealistic
- Equation had no sequential data

Month-Year	TP Geomean (ppb)	Interim Level (ppb)	Average Stage (feet)
Jun-99	14.2	11.7	16.47
Jul-99	11.1	14.4	16.11
Sep-99	10.3	9.9	16.79
Oct-99	10.3	8.3	17.28
Nov-99	9	8.3	17.25
Dec-99	9.1	9.1	16.94
Oct-00	8.8	8.3	17.49
Nov-00	7.5	8.8	17.01
Oct-01	8.8	8.3	17.24
Nov-01	7.4	8.3	17.46
Jul-02	11.2	9.7	16.82
Aug-02	9	13.5	16.22
Sep-03	8.8	8.3	17.23
Oct-03	7	8.3	17.15
Aug-04	17.5	15.4	16
Sep-04	8.5	9.9	16.79

# The Story in Brief

- The implication of external loading is not supported by the facts:
  - Loads uncorrelated with marsh levels
  - High and rising stages are associated with excursions through the equation's performance, not external loading
  - Marsh TP levels are low and meet the Interim Levels within a month of changed conditions
- Weight of evidence says that excursions are false positives, not reflecting a water quality concern at the 14 compliance sites.

# Lessons from this TP Compliance System

- *Prima facie* evidence isn't always right
  - Case of the fallacy: *Post hoc ergo propter hoc*
- Should have built-in a validation and updating process in the Agreement
  - Five years of pre-compliance data would have shown that the original premise was not valid – TP at the 14 sites is not linked meaningfully to external loads
  - Pre-compliance data are more representative and would have provided a more robust compliance system

# Lessons from this TP Compliance System

- Assessing compliance monthly is unrealistic in a large wetland
  - FL Phosphorus standard will correct with testing based on data from a network sampled over 1 to 5 years
- Long-term data sets are highly valuable
  - Patterns in loads, concentrations, stages and marsh concentrations told the story

# Lessons Learned from Monitoring Compliance with an Interim Phosphorus Standard in the Florida Everglades

- Hearings on compliance have been held and the Court's Special Master is writing an analysis as this presentation is given.
- Judge Moreno is a tough judge, so now is your last chance for questions!