

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.)

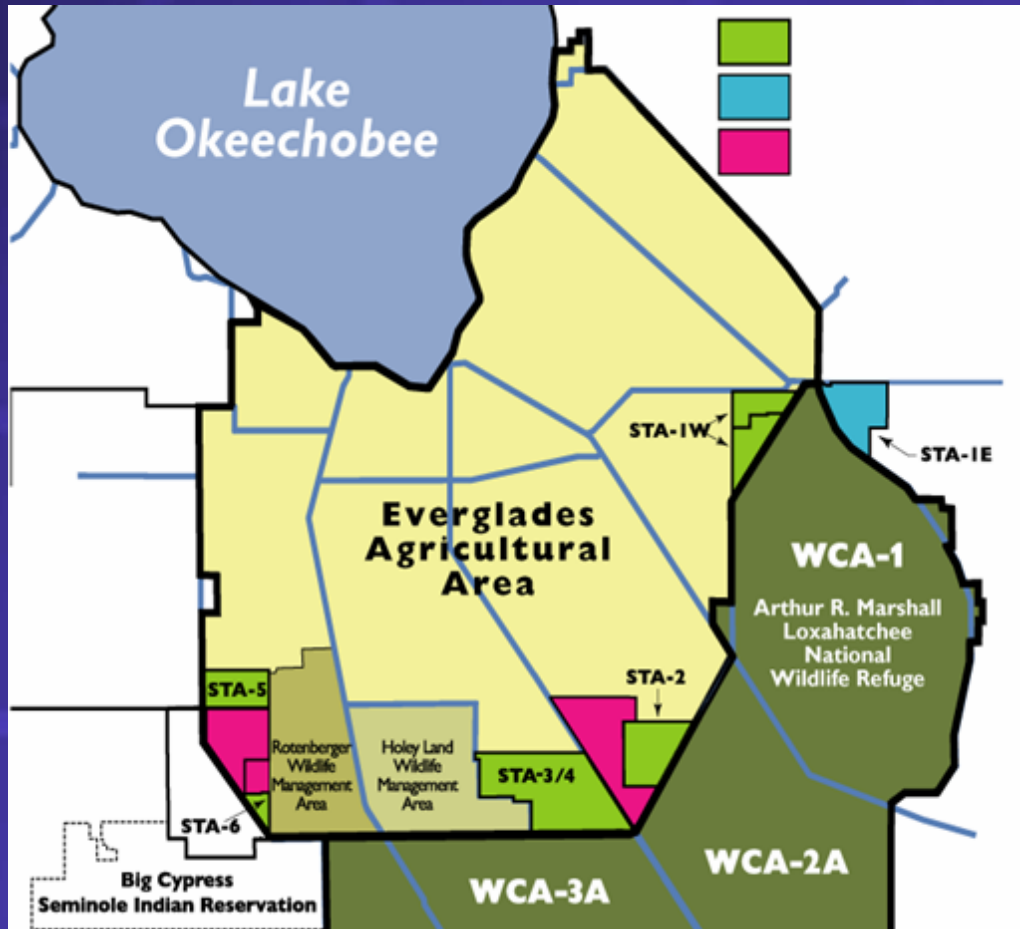
- Suit claimed violations of state water quality standards caused by runoff entering two areas of remnant Everglades: the Loxahatchee Refuge and Everglades National Park.
- Governor Chiles directed the State to settle the case and in 1992, the Court approved the Settlement Agreement among USA, FDEP,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

Settlement Agreement

Phosphorus Control Programs

- 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

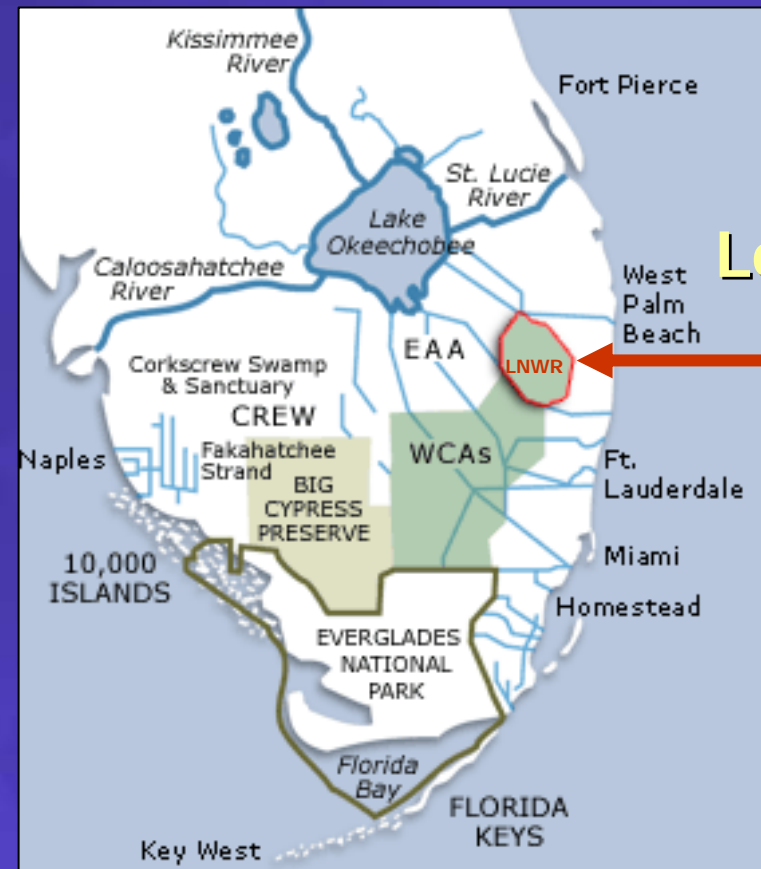
A.R.M. Loxahatchee National Wildlife Refuge in the Northern Everglades



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



Loxahatchee National Wildlife Refuge (WCA-1)



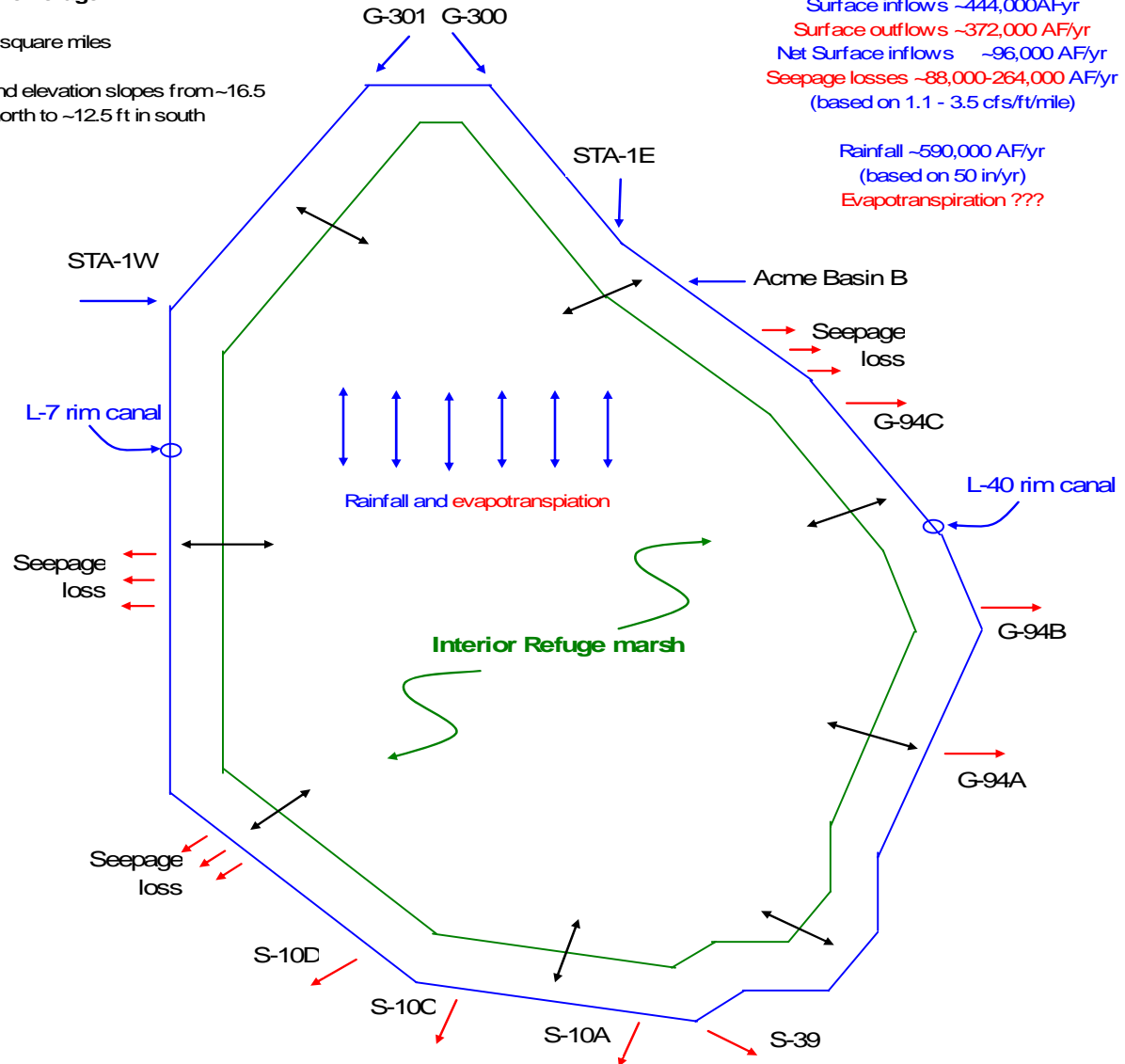
Locator Map

Schematic of Refuge Water Movement

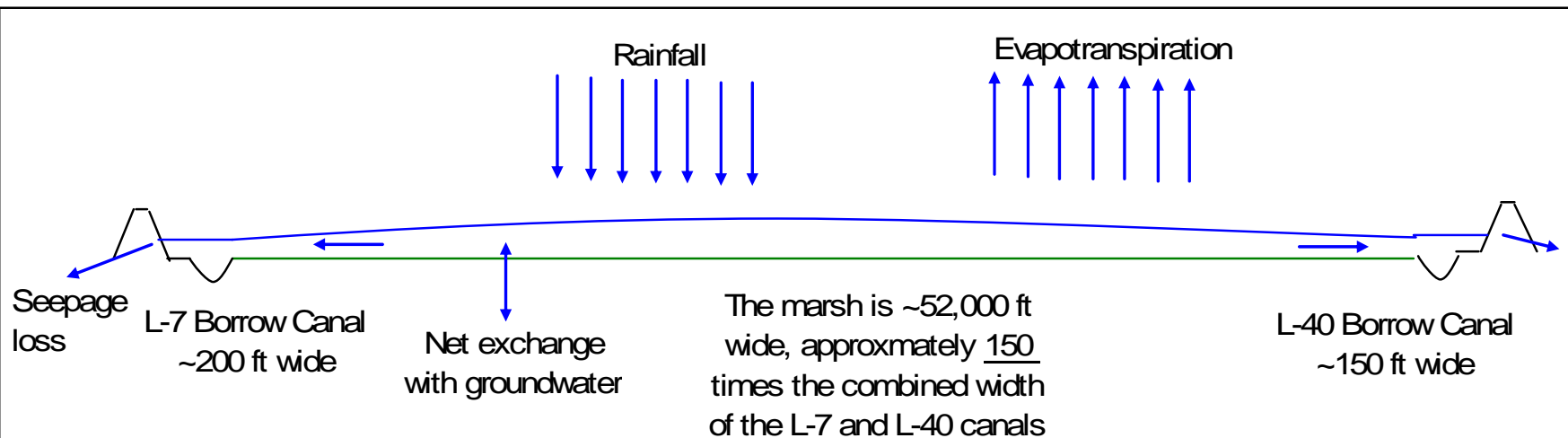
A. R. M. Loxahatchee National Wildlife Refuge

~200 square miles

Ground elevation slopes from ~16.5 ft in north to ~12.5 ft in south



Schematic of Refuge Water Movement



Generalized Cross section of Refuge (not to scale)
Flow is to rim canals when marsh stage is higher than canal stage

Settlement Agreement

Phosphorus Monitoring and Compliance

- 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

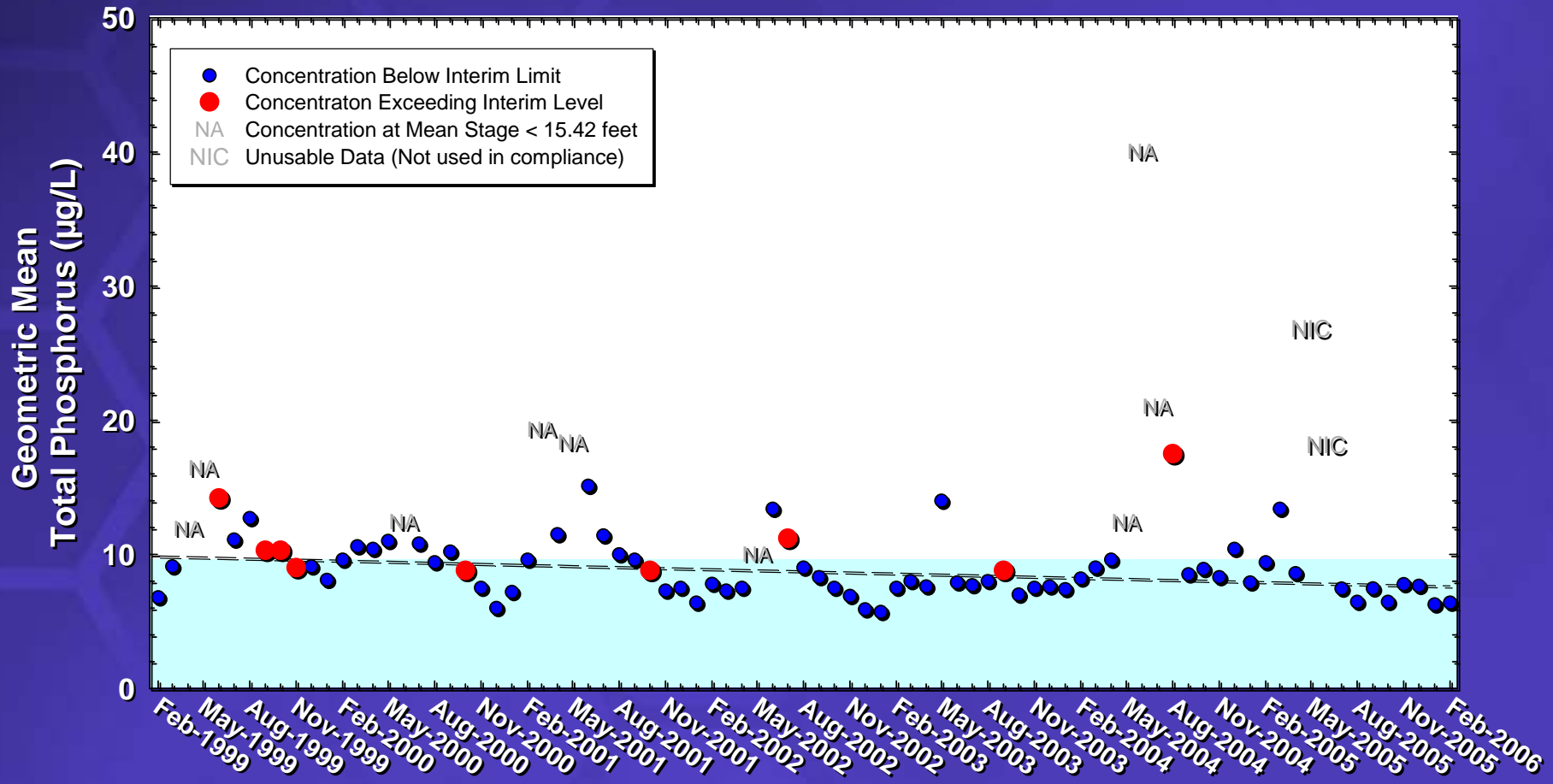
Compliance with Interim Phosphorus Levels for the Refuge

- 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

- 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

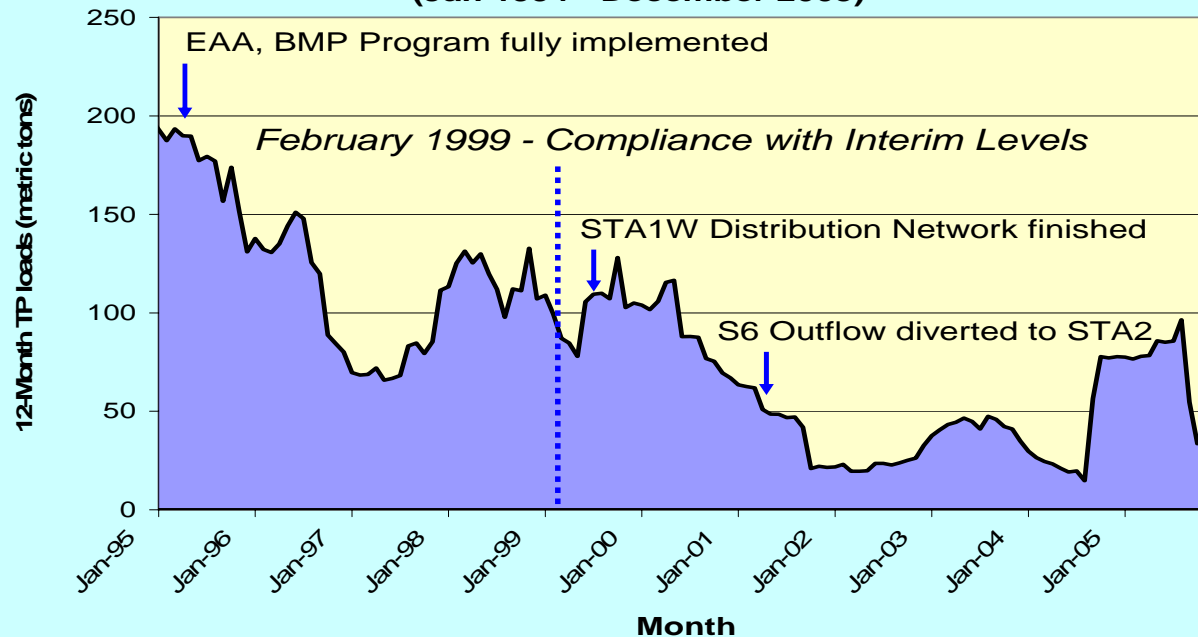
Total Phosphorus Concentrations During the Compliance Period (February 1999 to Present)



Phosphorus Loads to the Refuge

Total Phosphorus (TP) Loads to the Refuge

(Jan 1994 - December 2005)



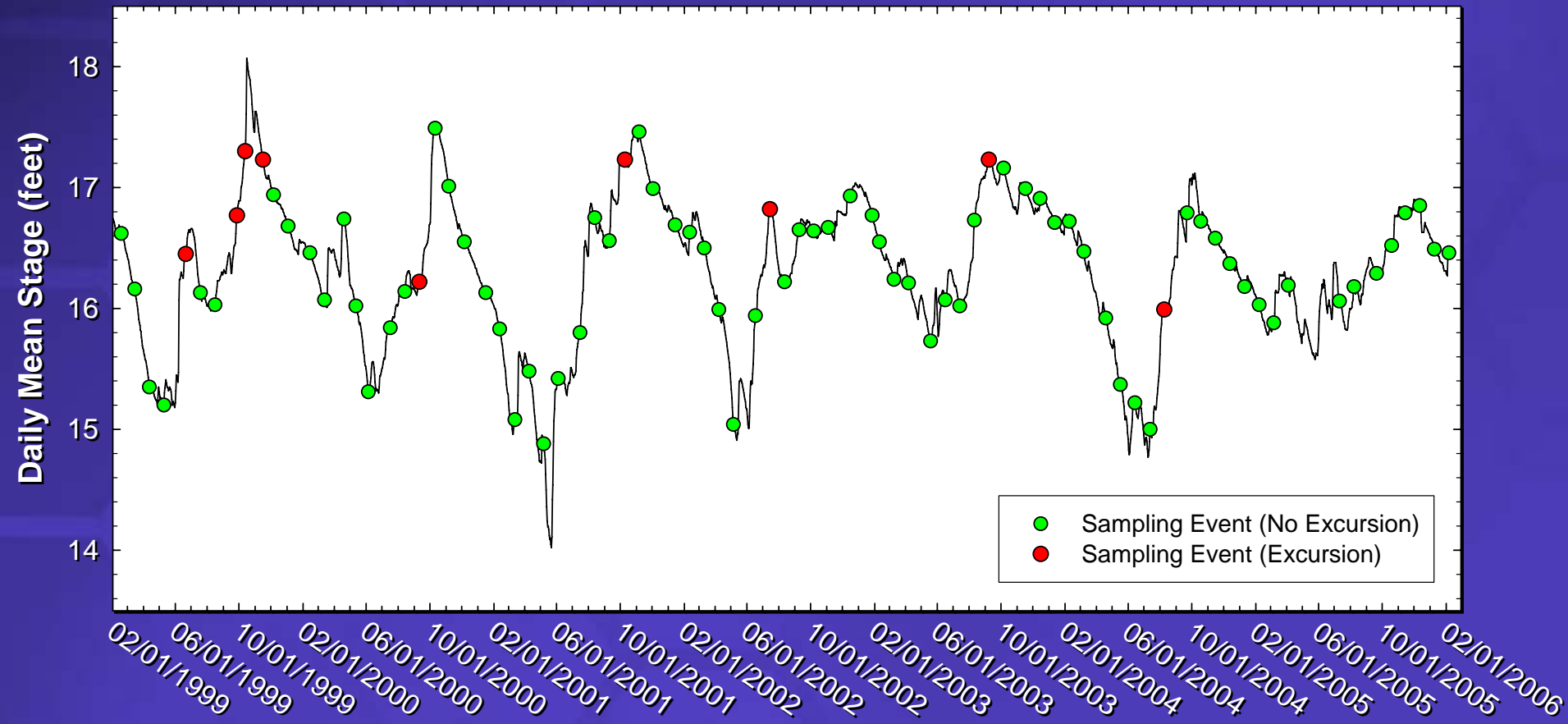
Long-Term Trends

- 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

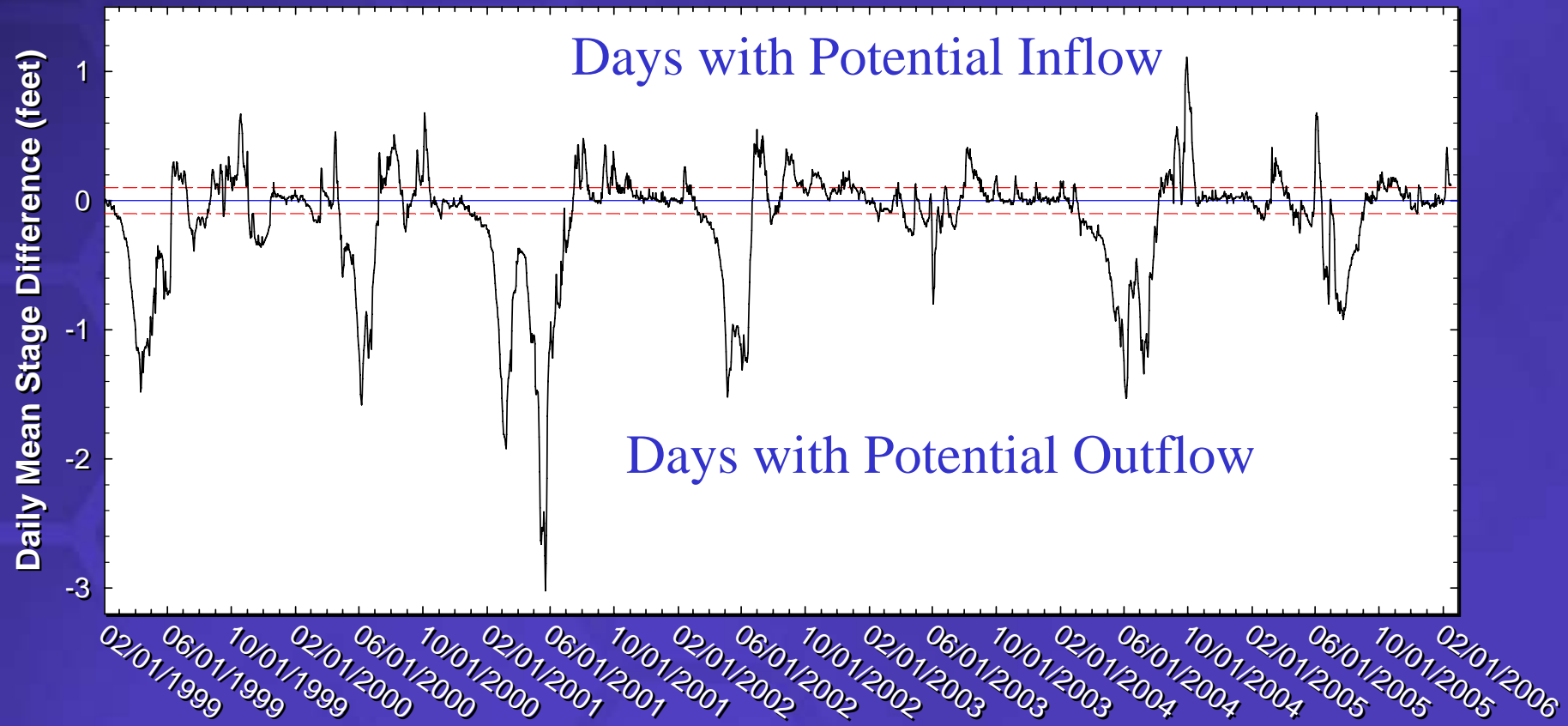
Stage, Sampling and Excursions



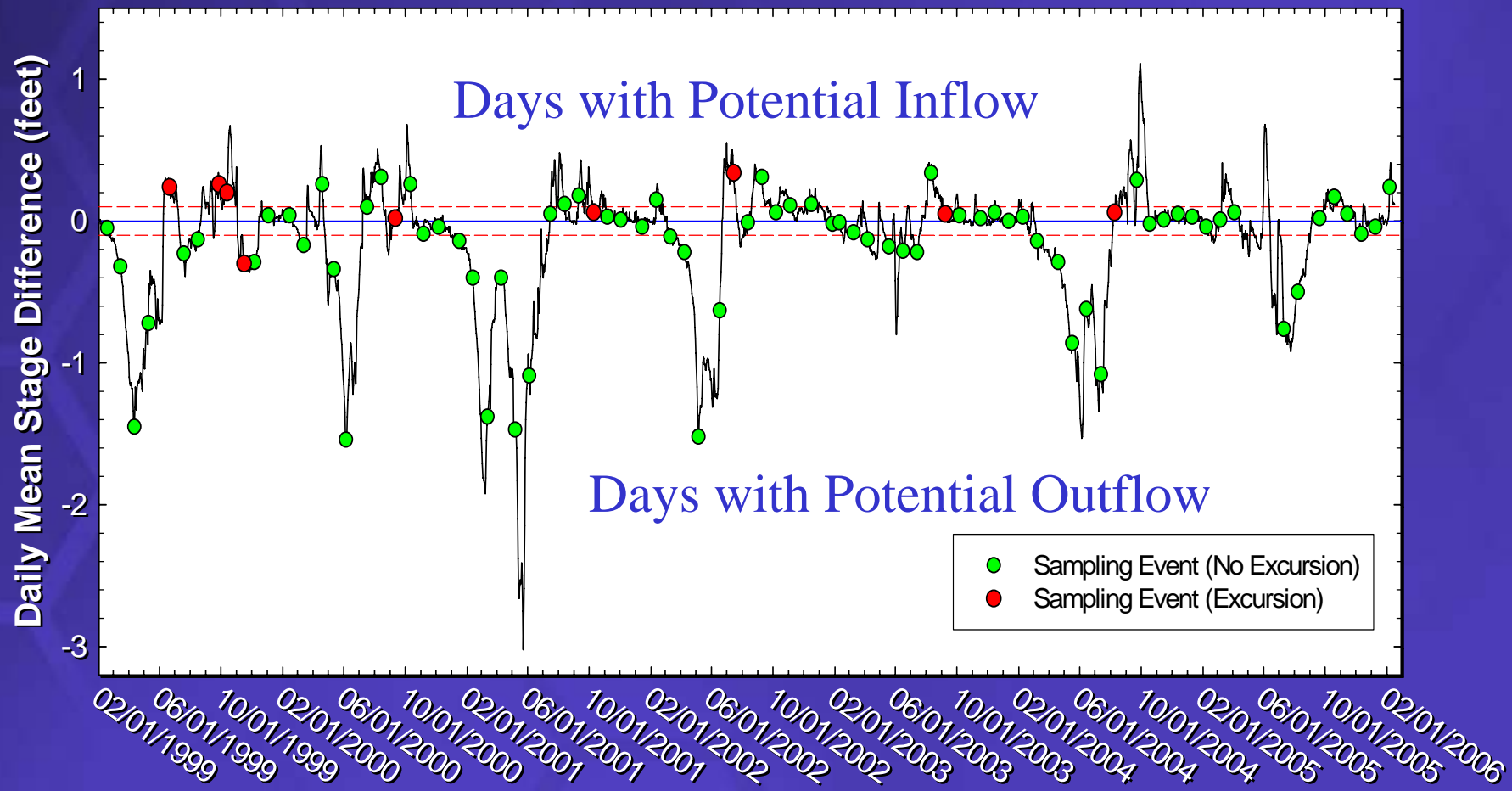
Stage, Sampling and Excursions

- 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

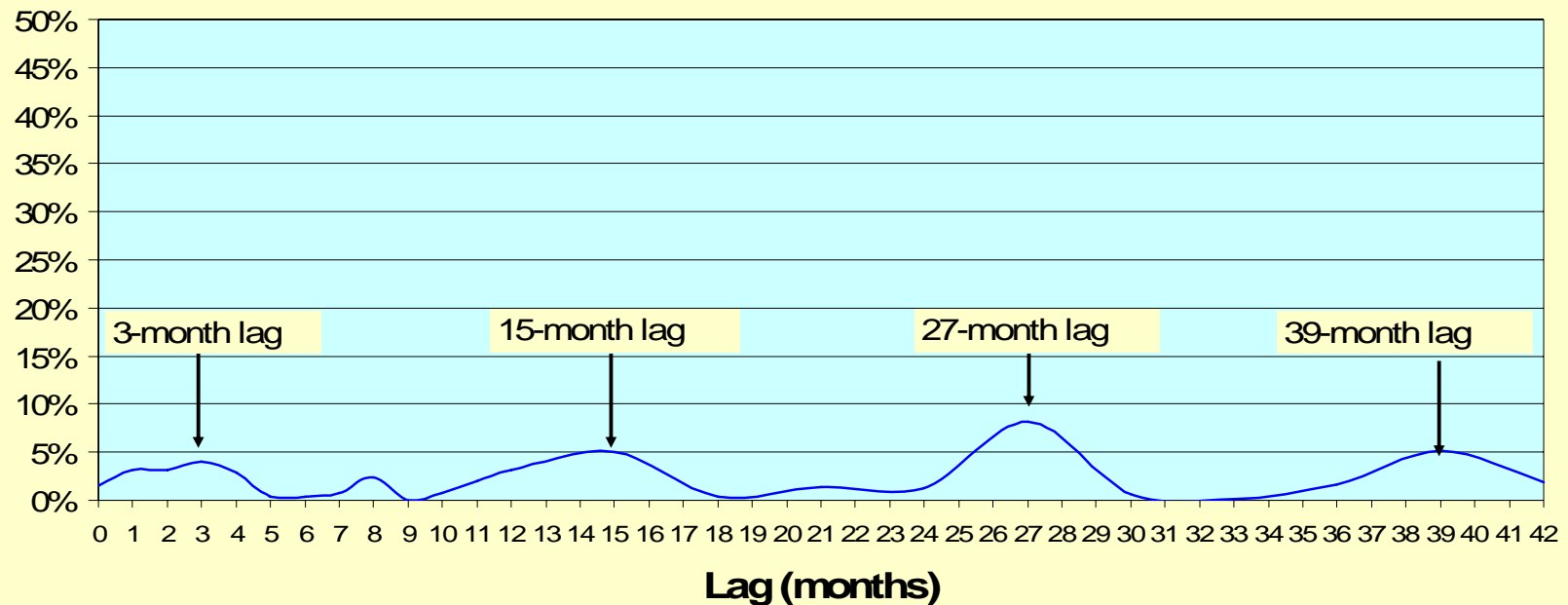


Periods of Potential Movement of Canal Water into the Marsh and Excursions above the Interim Levels

- 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

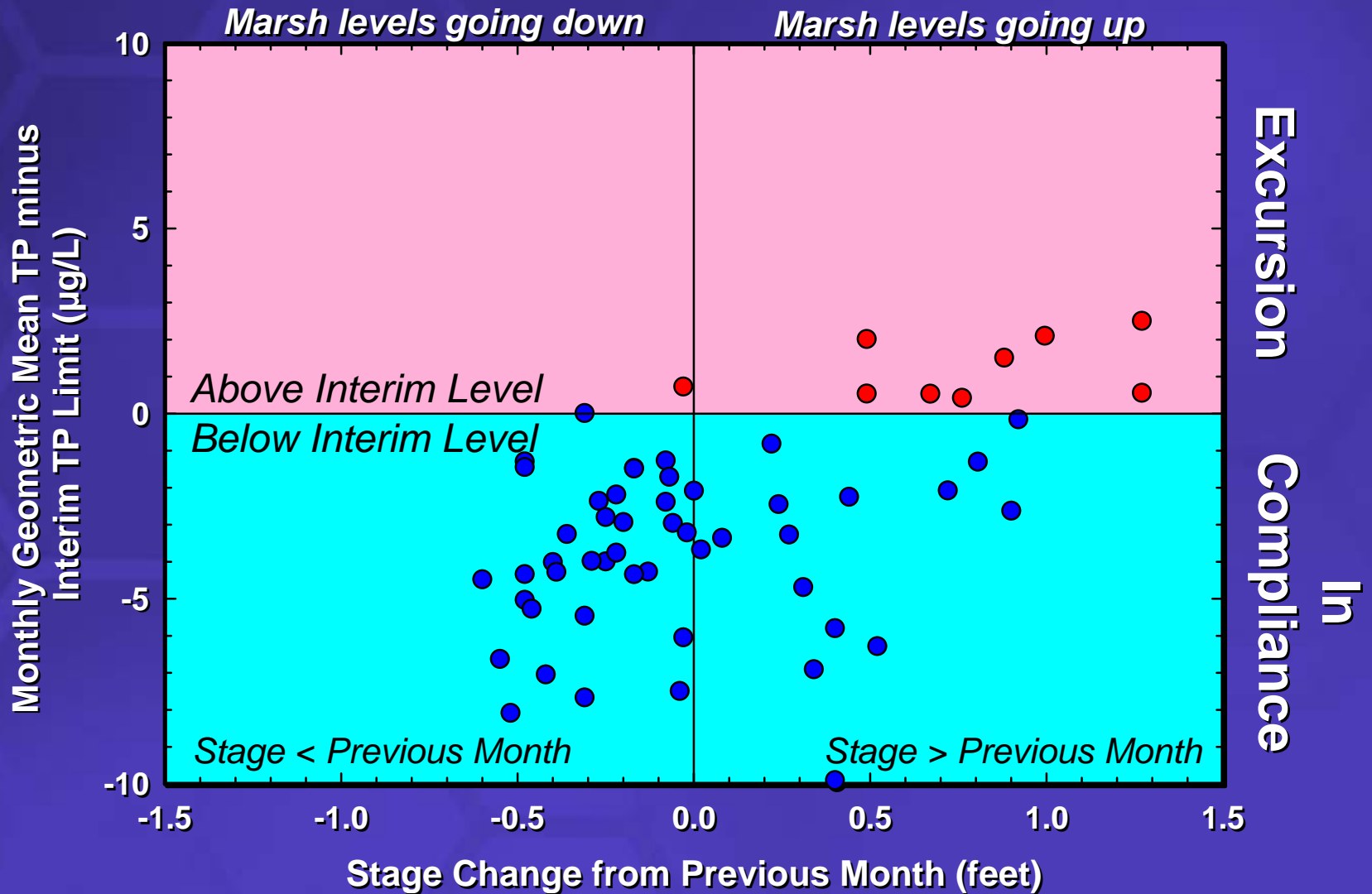
External Loading and Refuge Excursions

- 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

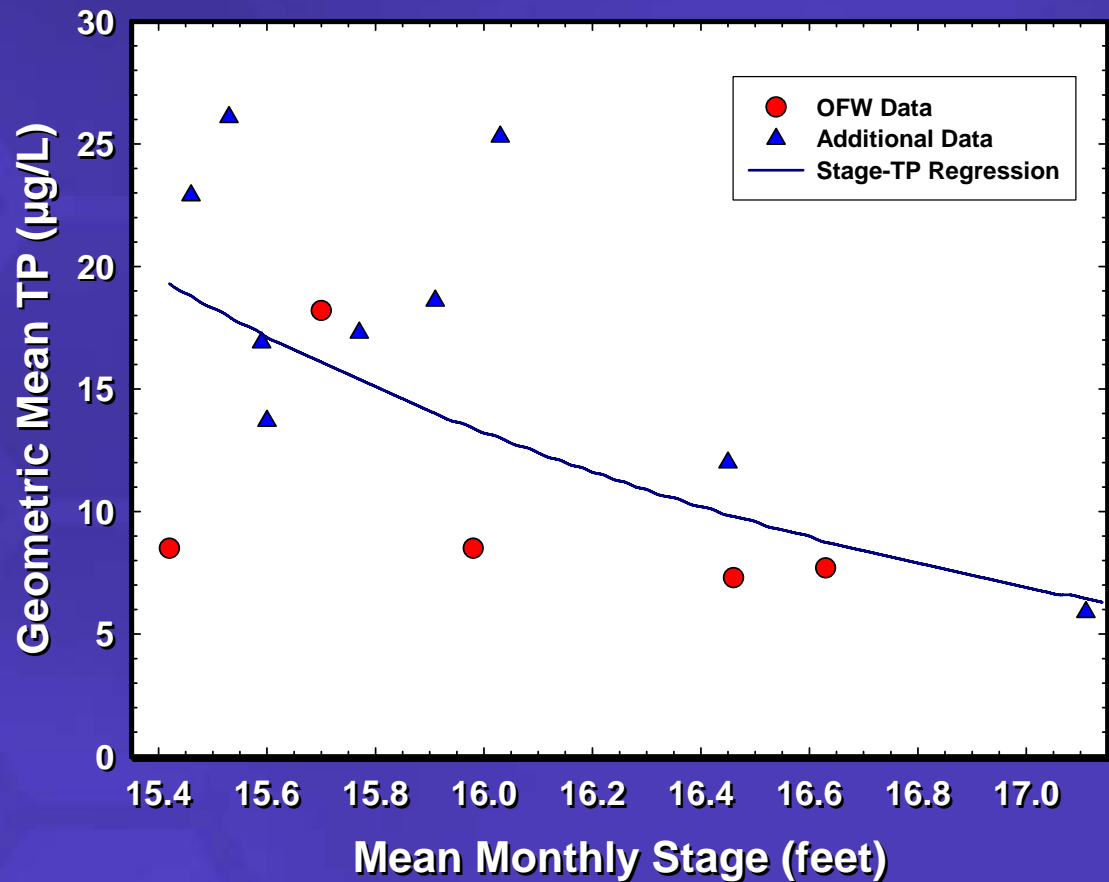


Performance of the Equation

- 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?

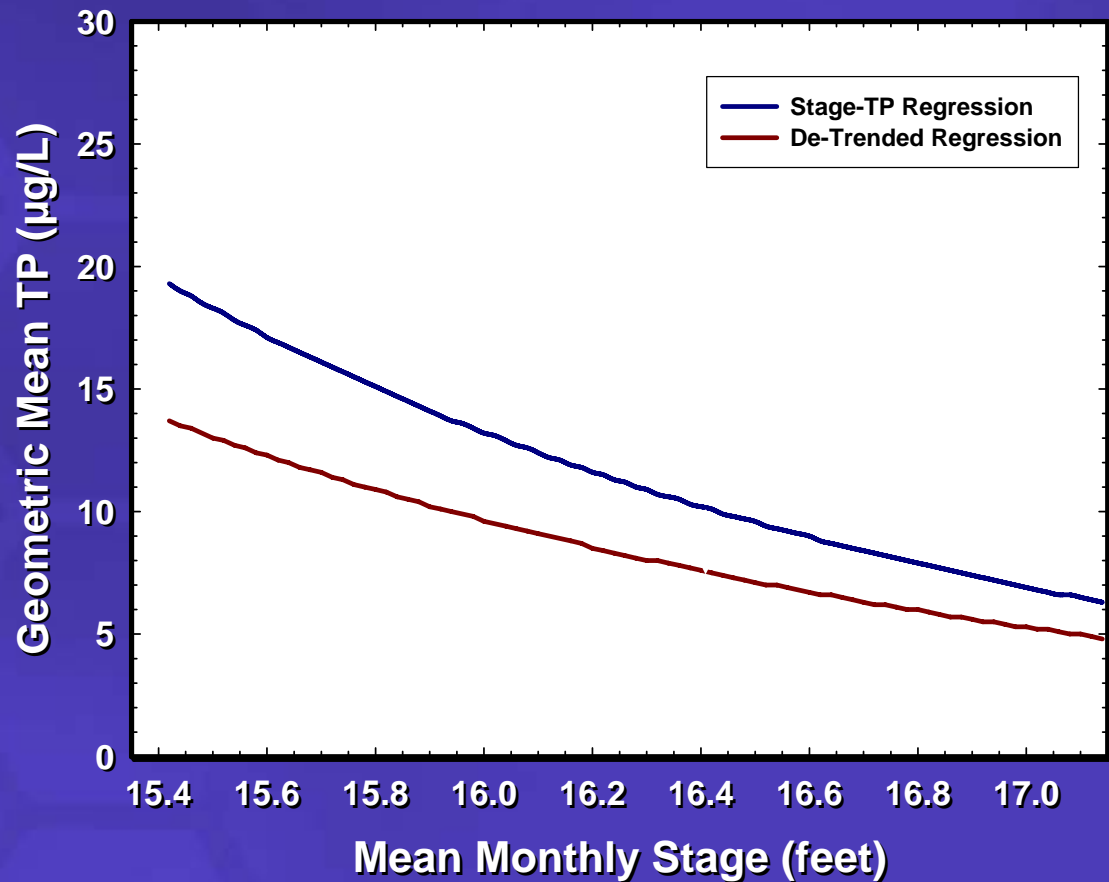
Original 14 Data Points

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



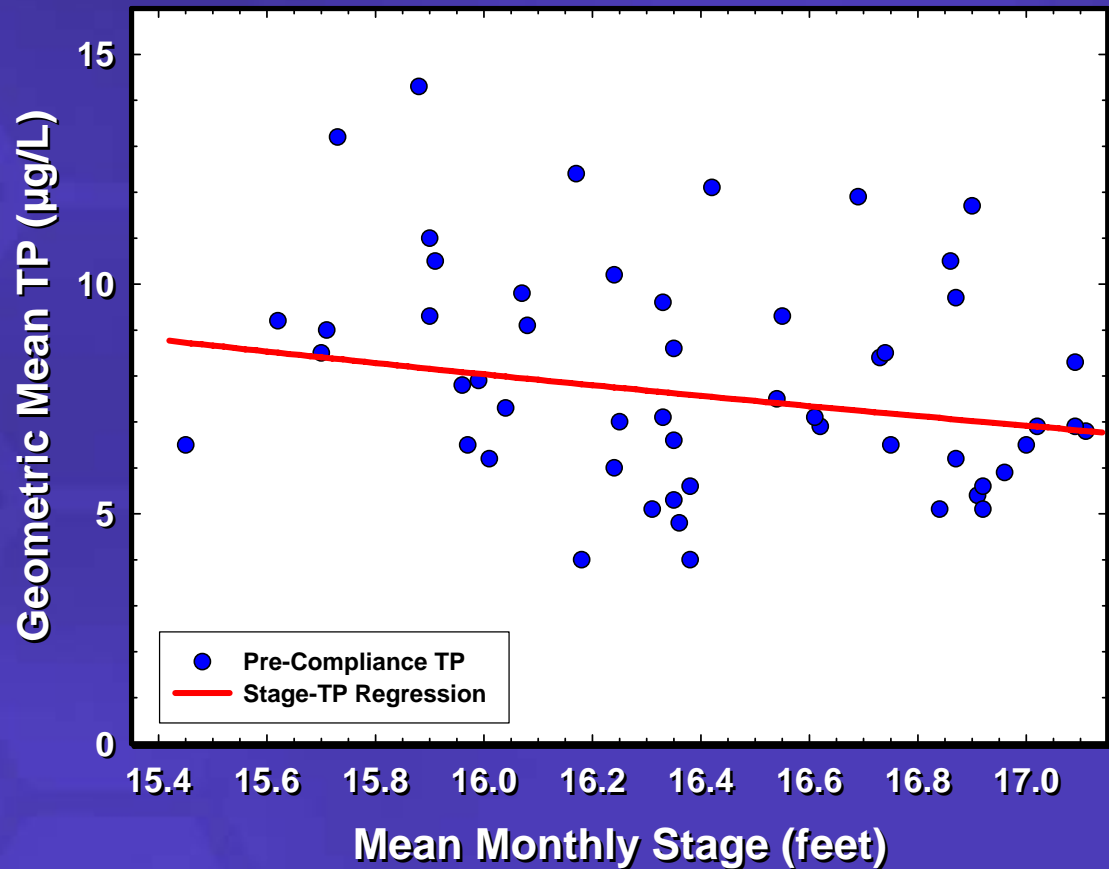
Original 14 Data Points; 9 were re-trended

- 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



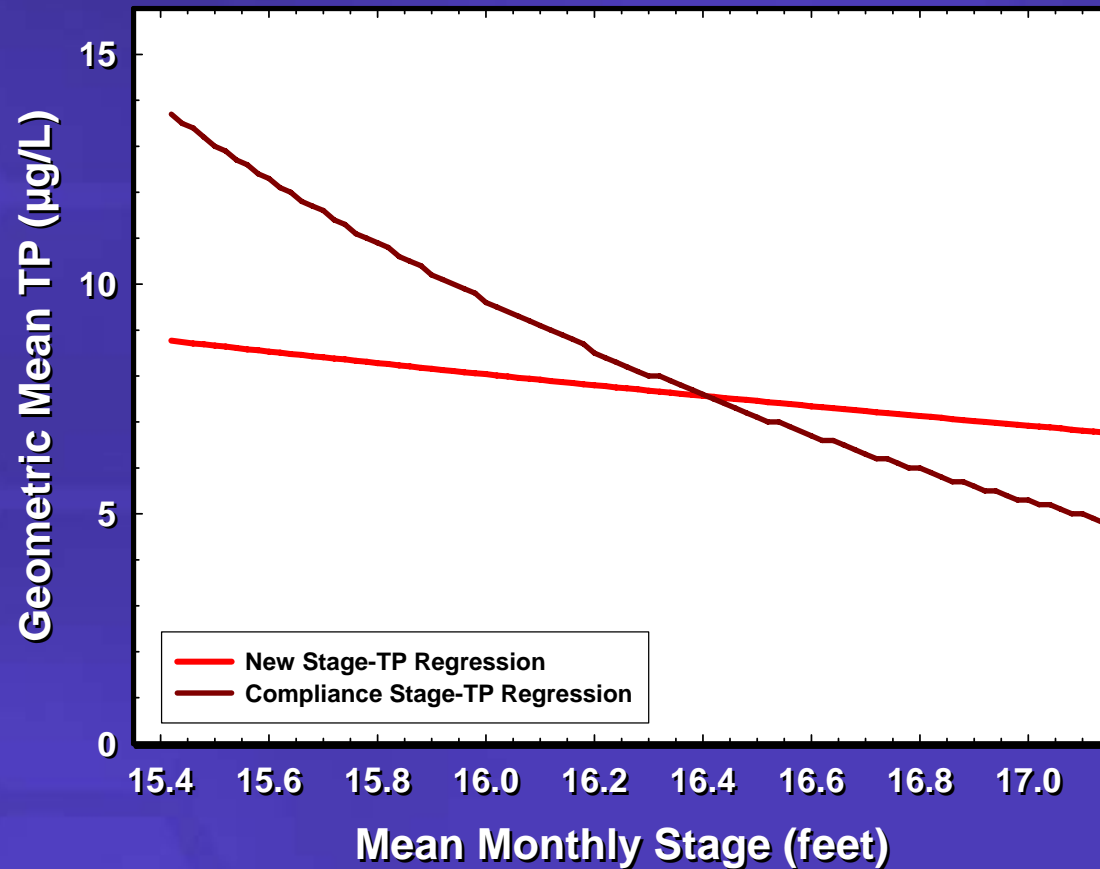
Data from 1994-1999 Tells Another Story

- 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 <1.5 ppb
- 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!