

# **Factors Contributing to 2003/4 Exceedance of Interim Phosphorus Levels in the Refuge**

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# Analysis of Compliance with Interim Levels

- Study Objective: Examine factors likely to contribute to excursions & exceedance of the Interim Phosphorus Levels in the Refuge
  - Role of external TP loading into the Refuge
  - Role of error and extraordinary natural phenomena
- Study Approach: Examine monthly trends and sources of error as contemplated by the Settlement Agreement
  - Complete data set is the centerpiece

# Topics Analyzed by the District

- Circumstances of the 2003/4 events and comparison to past excursions
- Trends in the 14-station data set and their relationship to excursions
- Correlation with external loading, periods of potential marsh penetration and rapid changes in stage

# Relevant Refuge Data

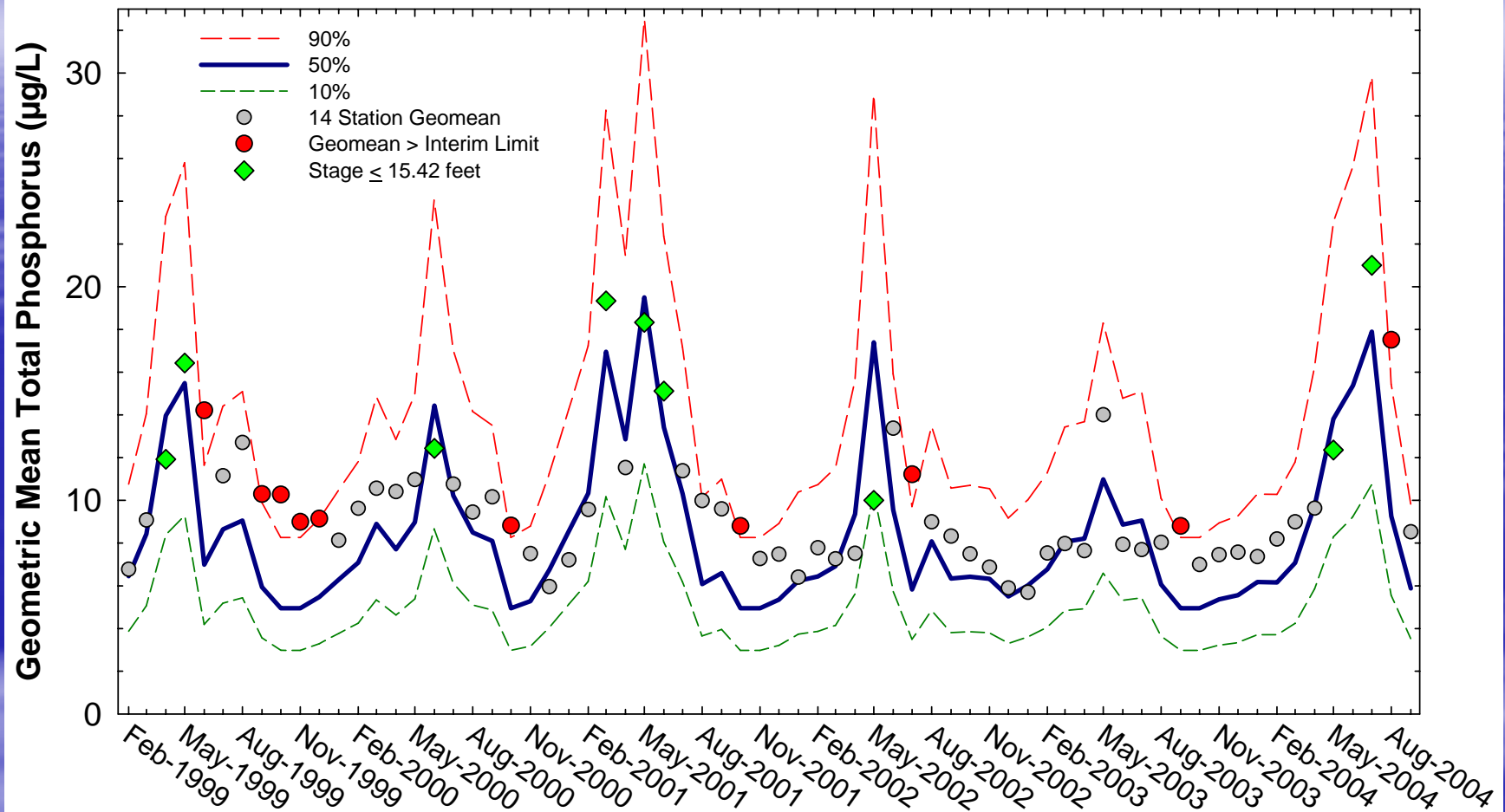
## Tables 1 and 2

- **Table 1** provides all data for the Refuge since January 1994 for individual stations
  - This table contains original data, not averages.
- **Table 2** summarizes monthly geomeans, stages, interim levels, inflows and TP loads
- Use to examine monthly trends for circumstances of the 2004 events, comparison to past excursions and patterns in the 14-station data set and their relationship to excursions

# Circumstances of the 2003/4 Events and Comparison to Past Excursions

- Since monthly sampling began in 1994, there have been 13 excursions; 9 after February 1999
- Recent Excursions (See Table 2)
  - September 2003 was 0.5 ppb and August 2004 was 2.1 ppb over the Interim Level
  - Both occurred as stage increased; a pattern often seen in past excursions (see Table 2)
  - August showed higher TP levels than seen typically; top 4 stations were 54, 33, 26 and 20 ppb (Table 1)
  - August followed 3 consecutive months of very low stage in the Refuge; an infrequent event

# Refuge Geomean TP with Interim Levels

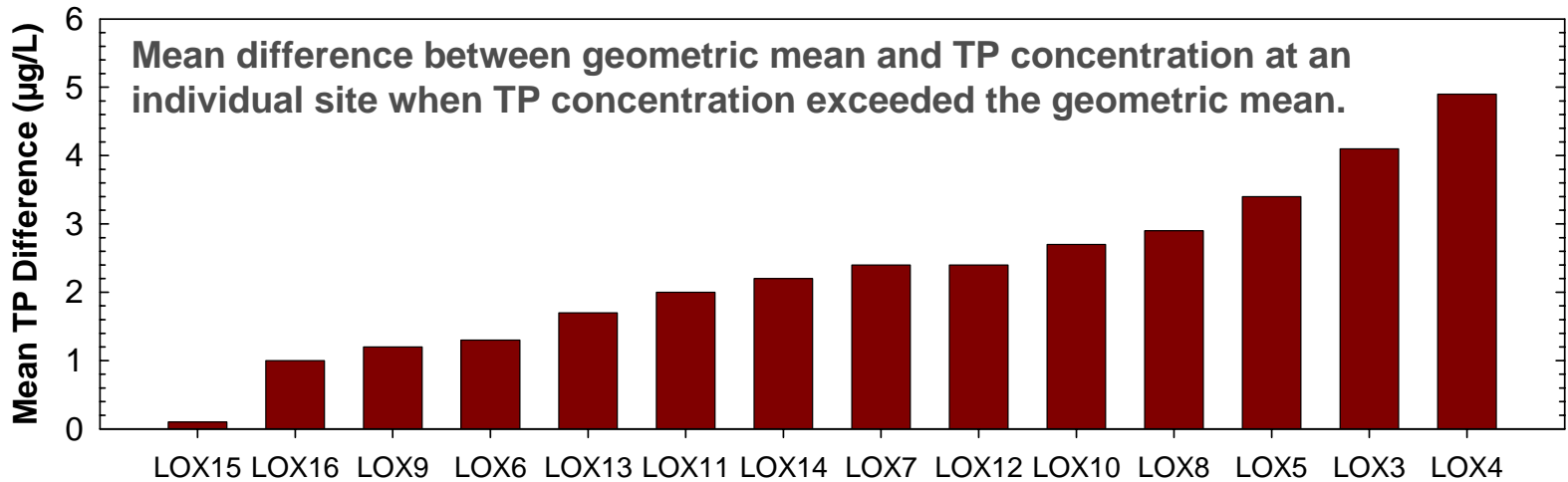
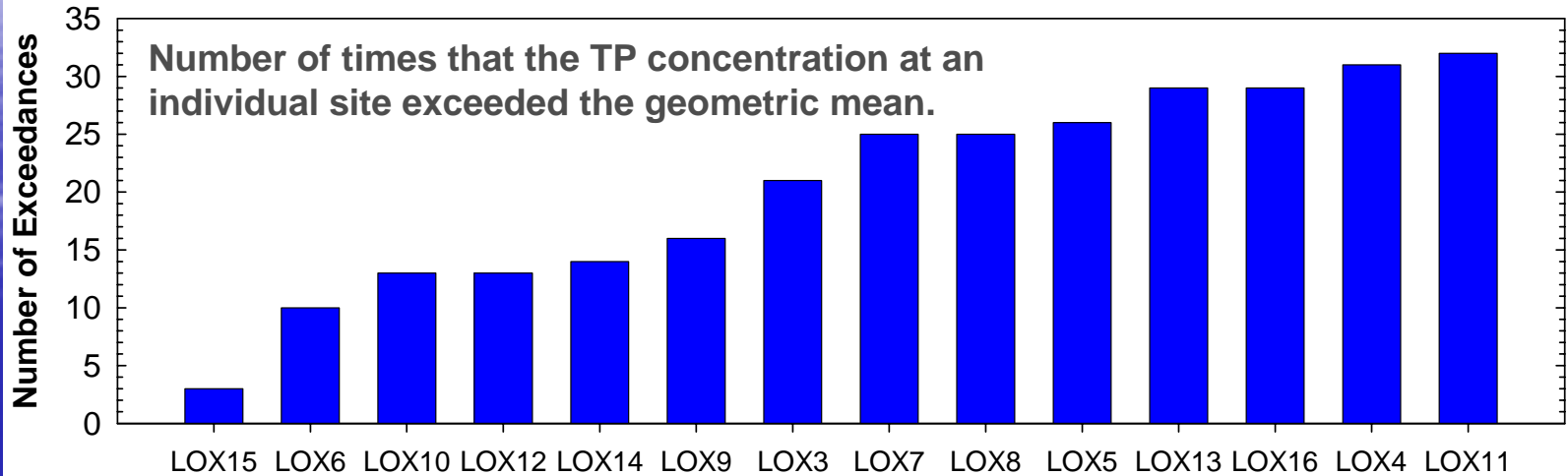


- Geomean exceeds Interim Level 9 times in 68 months
- Excursions tend to occur as stage increases.

# Patterns in the 14-station Data Set and Their Relationship to Excursions

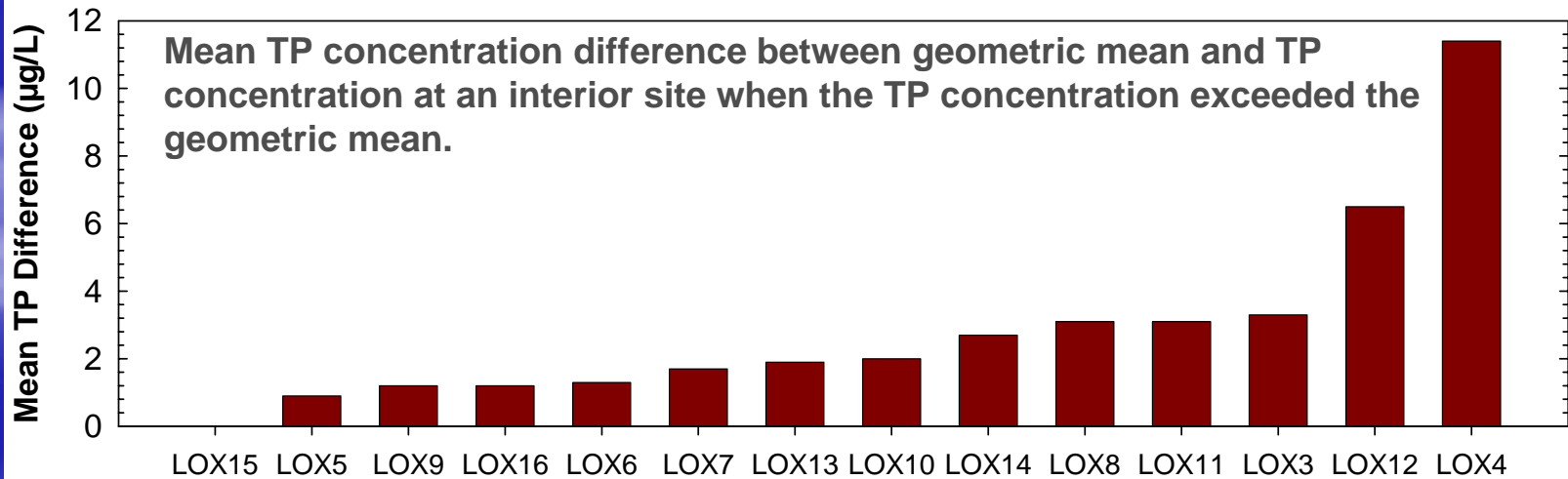
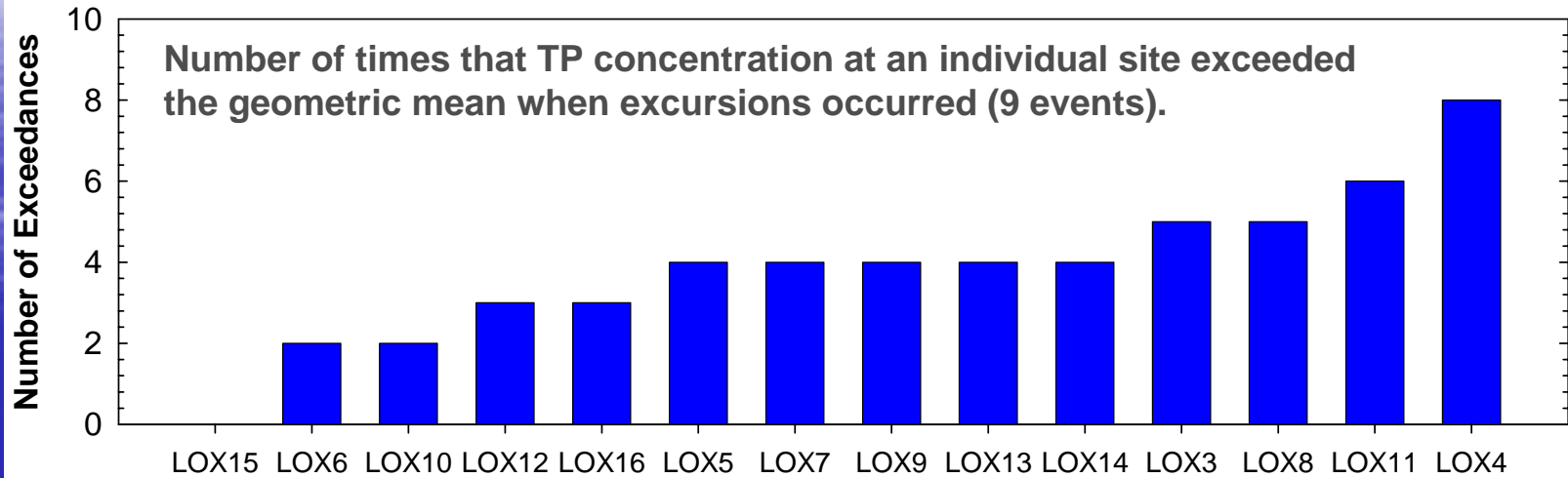
- In September 2003, stations LOX 3, 4, 7, 10 and 14 were the highest (14 – 10 ppb)
- In August 2004, stations LOX 4, 6, 12, 8 and 16 were the highest (54 – 17 ppb)
- *Were these stations high in earlier excursions and what does this tell us about possible causes?*

# Comparison of Individual Stations to the Monthly Geomean (Feb 1999 – Sep 2004, compliance dates)





# Comparison of Individual Stations to Monthly Geomeans for Dates of Excursions (Feb 1999 – Sep 2004)

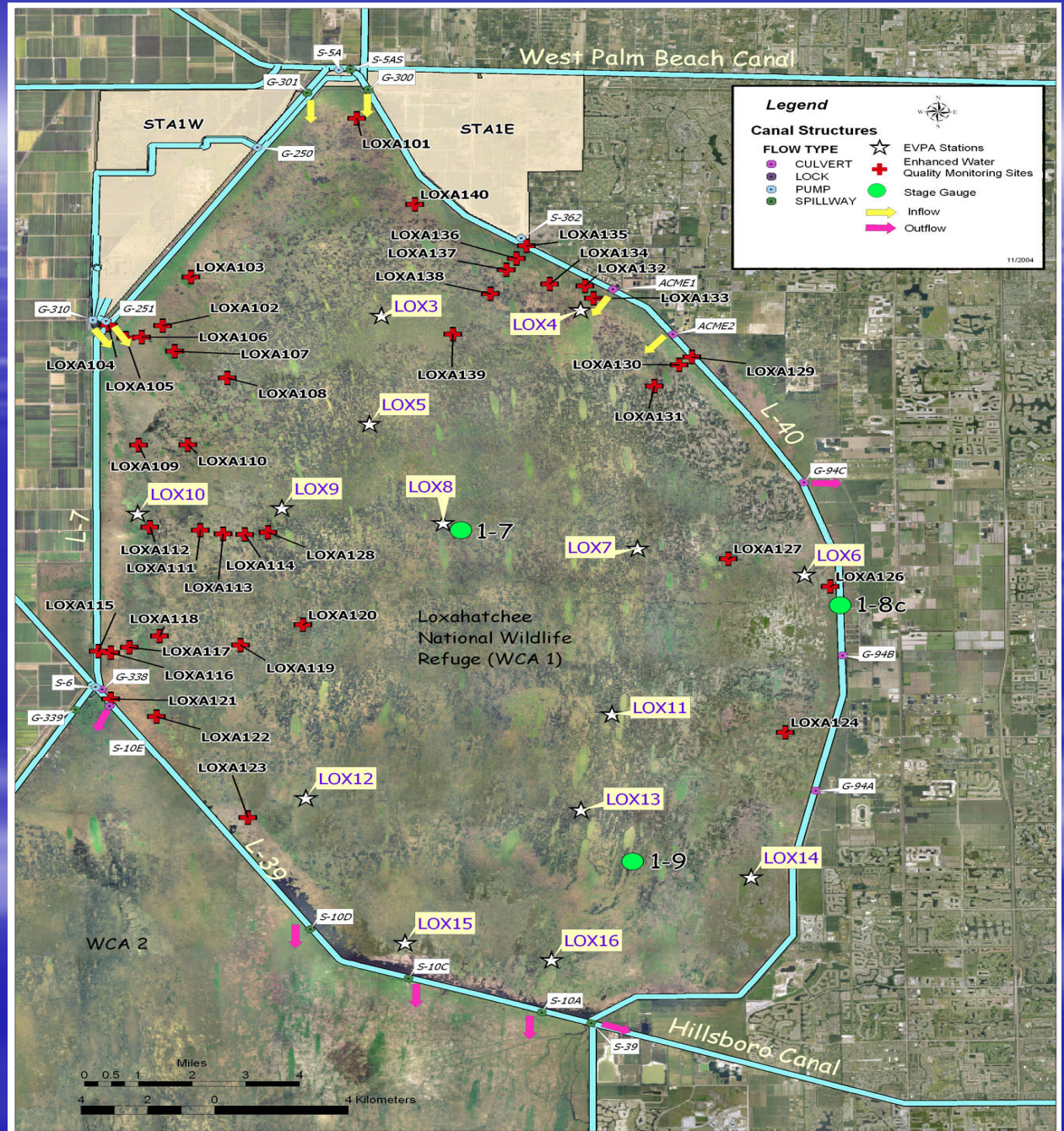


# Comparison of Individual Stations to Monthly Geomeans

(Feb 1999 – Sep 2004, Compliance dates)

- At least 8 of 14 stations are frequently above the geomean, not just a few high stations; stations 4, 5, 8 and 11 are especially influential to monthly geomeans
- Stations 3, 4, 8, 11, and 14 are most often associated with excursions; notice that 3, 8, and 11 are **centrally located in the Refuge** (see map on next slide)
  - In September 2003, stations LOX 3, 4, 7, 10 and 14 were the highest (14 – 10 ppb)
  - In August 2004, stations LOX 4, 6, 12, 8 and 16 were the highest (54 – 17 ppb)
- A mixed pattern, as seen commonly in the past

# Refuge Monitoring Stations and Local Features



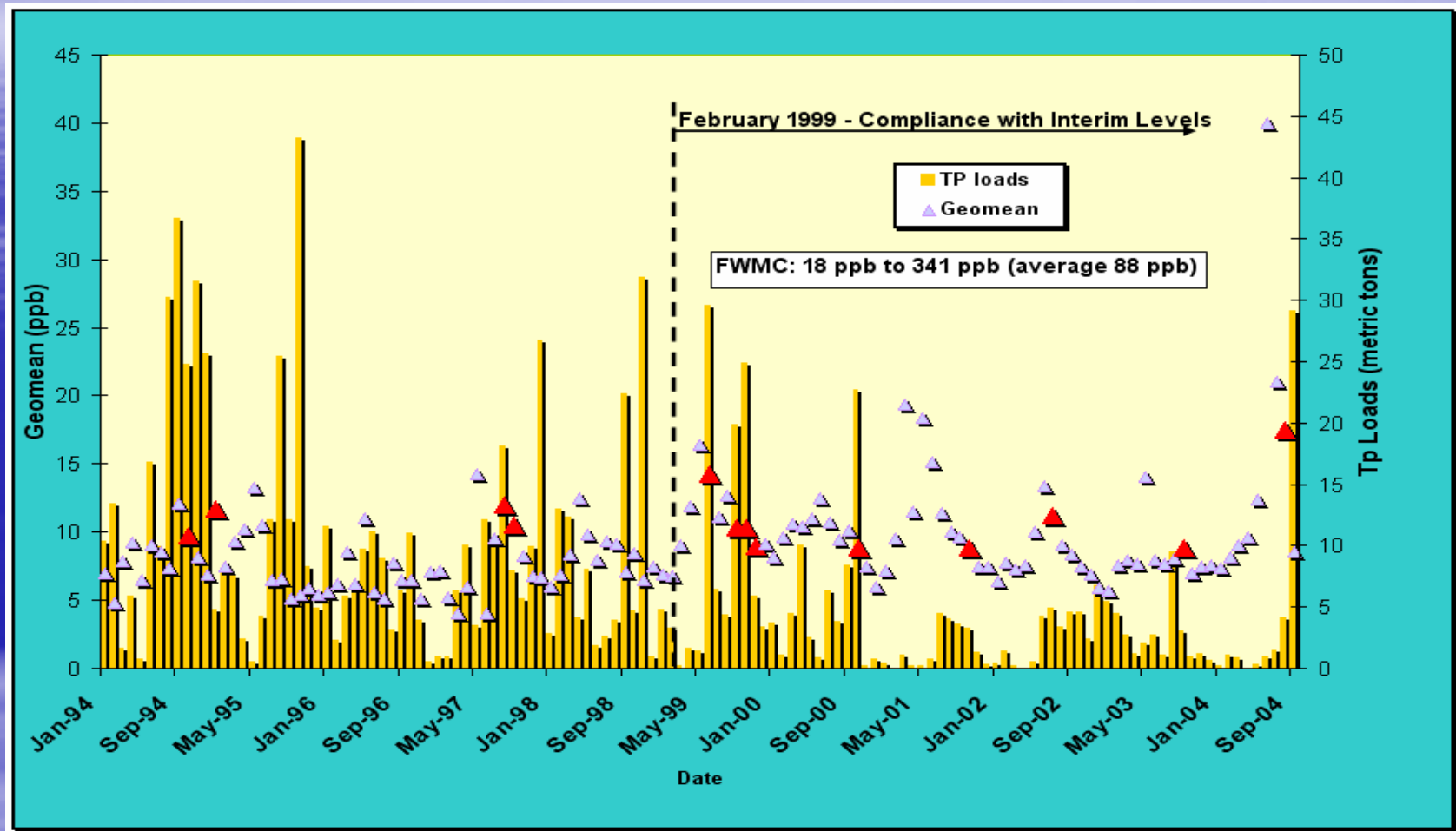
# 'Review of Monthly trends for the 14-Station Mean and Other Relevant Information'

- As noted previously, excursions tend to occur with rising stage, 11 of 13 for POR and 8 of 9 during compliance period (See Table 2).
  - Issue: Rising stage can be associated with two fundamentally different sources of phosphorus
    - External Loading from the peripheral canal
    - Internal Loading from release within the marsh particularly following low water periods
- Explore the correspondence between external loading and periods of potential marsh penetration
- Examine correspondence between rapid changes in stage and the excursions

# External Loading and Refuge Excursions

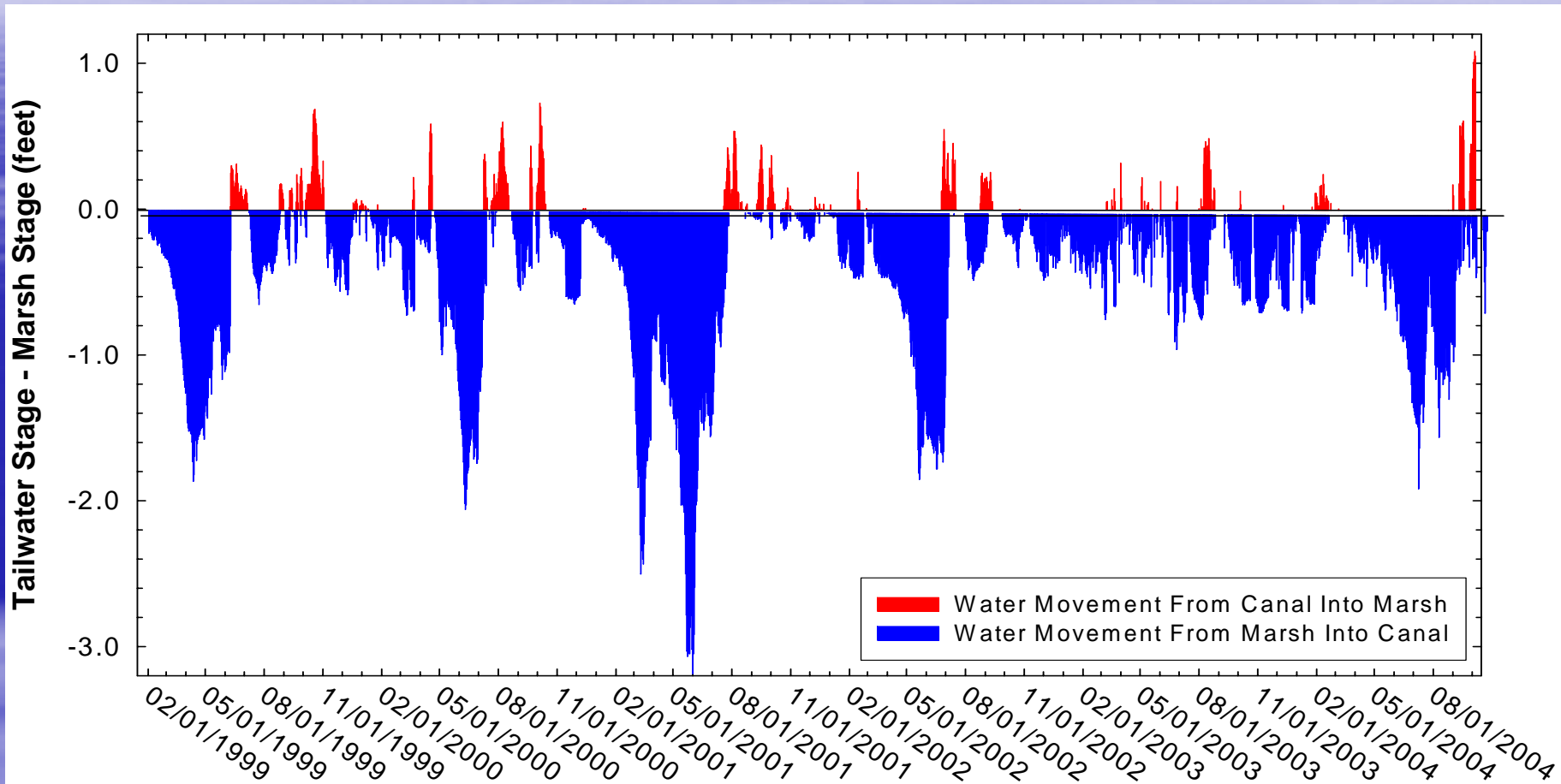
- Evaluation of earlier excursions by Walker and Kadlec (2003) suggested a correspondence between periods of potential marsh penetration and excursions above the Interim Level
  - Excursions tended to occur early in loading periods
  - Continuing loading does not tend to lead to additional excursions; 1999 is an exception
- Evaluation of existing data provides indirect evidence of relative importance external inputs, internally released P and the predictions of the Interim Level equation

# External Loads and Monthly Geomeans



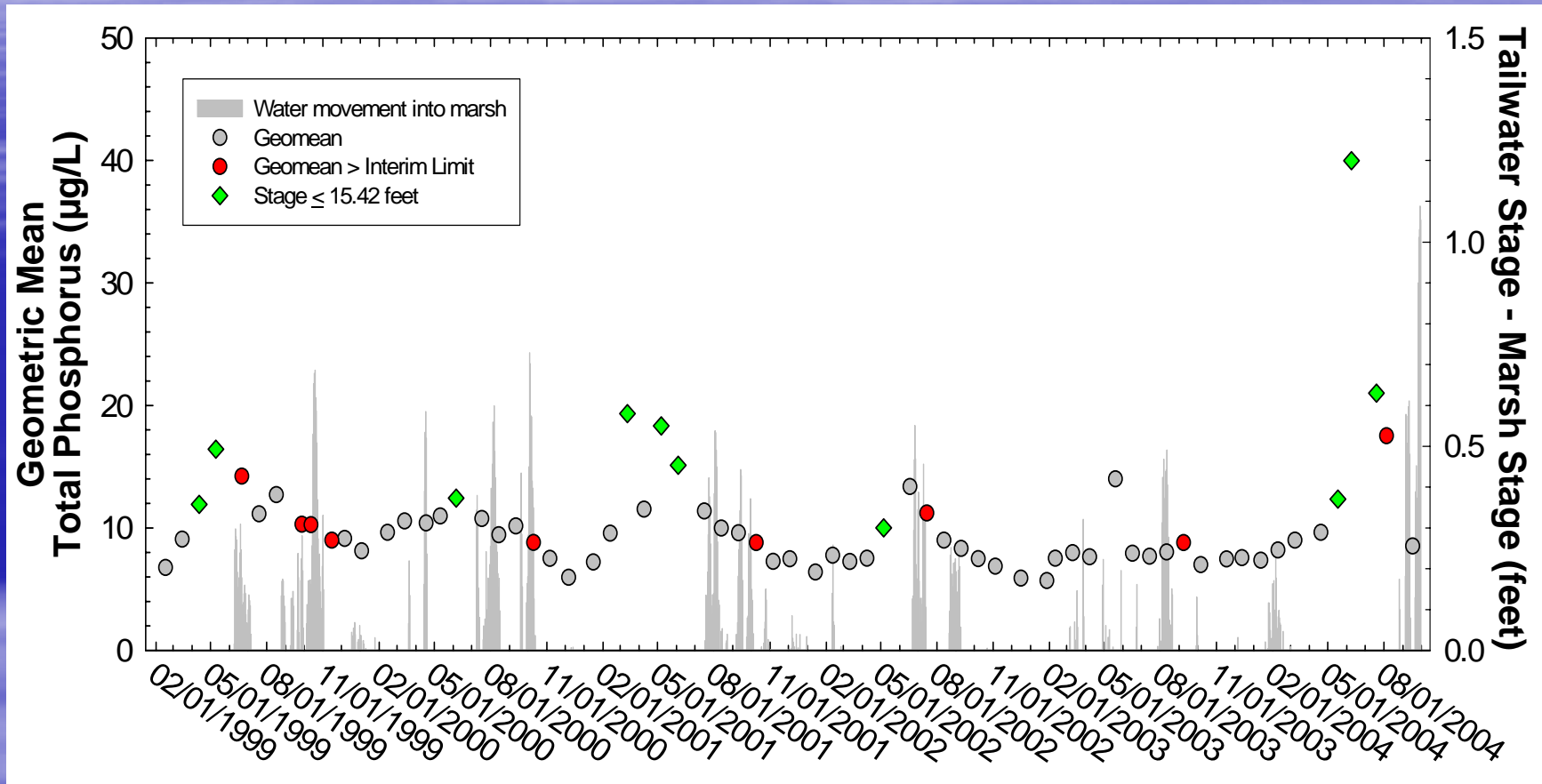
- P loads and spikes are declining
- Marsh average 8.6 ppb for recent 24 months
- Excursions often occur when loads enter the canal

# Periods of Potential Water Movement Into and Out of the Refuge Marsh



- Periods of potential water export (blue) are far more frequent than those of potential marsh penetration (red).

# Periods of Potential Water Movement Into the Refuge Marsh and the Monthly Geomean



- Marsh penetration is only associated with excursions in roughly one-half of input episodes.



# External Loading and Refuge Excursions

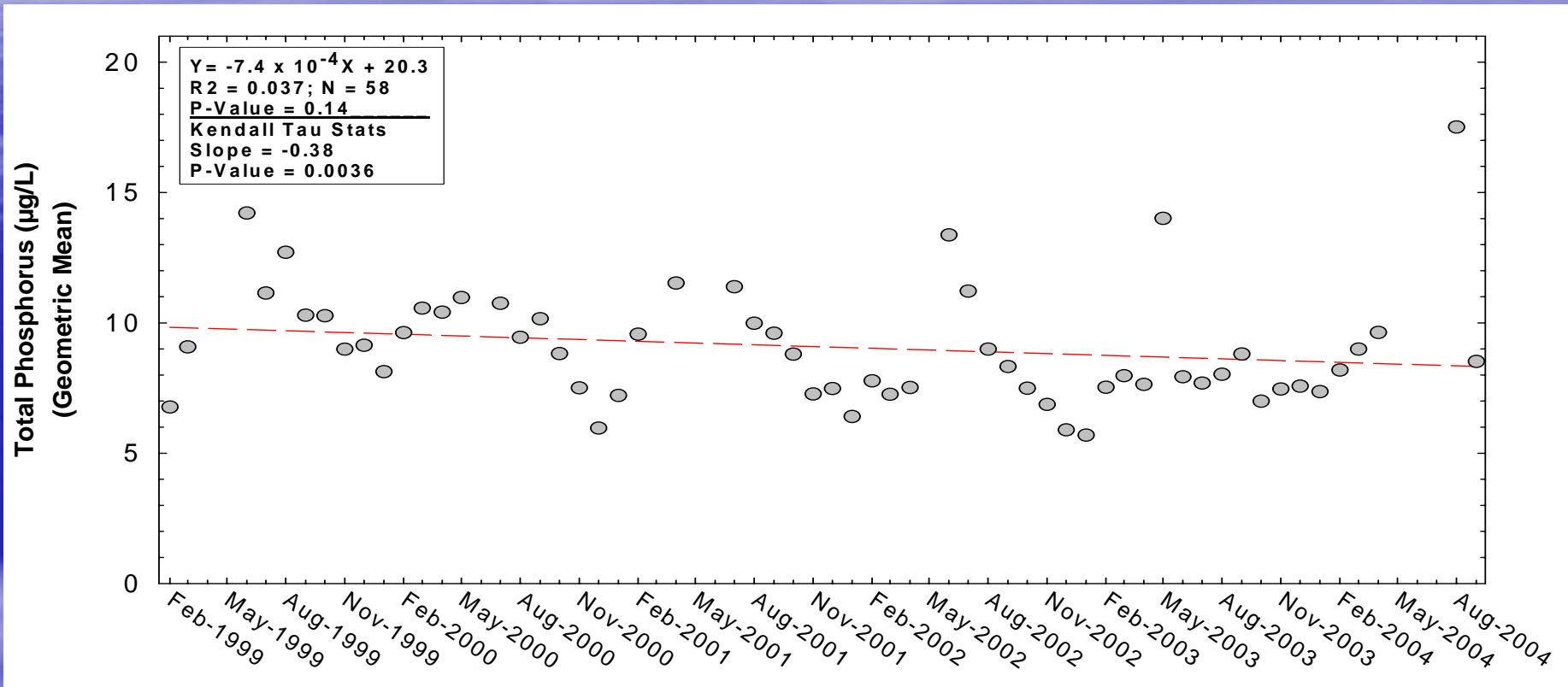
- Statistical correlation between monthly loads and geomeans explains only 0 to 4% of the variation in the geomean using lags of 0 to 4 months (3 month lag was highest)
- The direct, short-term correspondence of canal imports on the marsh is inconsistent.
- Huge loads in the September 2004 did not produce an excursion (see Table 2).
- Conclusion: Loading influences are complex and occur over periods longer than monthly.

# External Loading and Refuge Excursions

- External inputs might lead to gradual, long-term TP increases in marsh and increase the likelihood of excursions.
- *Is there evidence that the P climate getting worse in the Refuge?*
- Examine -
  - long-term trends in monthly geomeans
  - trends in individual stations
  - changes in the frequency or magnitude of excursions

# Geomean TP Concentration in the Refuge

(Feb. 1999 – Sep. 2004, Compliance Dates)



- Although more time is needed to confirm a trend, TP in the water column of the marsh has decreased over the compliance period.
- Long-term average remains less than 10 ppb; 8.6 for the last 24 months

# External Loading and Refuge Excursions

- *Is there evidence that the P climate getting worse in the Refuge?*
  - No upward trend is evident in geomeans over last six years
  - No upward trend is evident in data from individual stations
    - Six stations show a significant declining trend
  - No upward trend is evident in magnitude or frequency of excursions
    - Excursions average 1.2 ppb for the POR and 1.2 ppb for the compliance period
    - No evident change in the frequency of excursions
- For Settlement Agreement compliance stations, there is no evidence that marsh P climate is getting worse.

# Loading and 2003/4 Excursions

- For September 2003, role of external loading is uncertain
- For the August excursion, external loading could not have entered the marsh.
  - P levels were very high for two months preceding excursion when external inputs could not have entered the marsh due to stage differential.
  - Ability of the Interim Level equation to accurately predict P levels during rapid changes in stage could also have been a contributing factor.
- Sources for the internally-generated P increases for August are not known.

# Aspects of Error

- *Context of variability.*
  - For a given month, the Interim Level has a 10 % probability of being exceeded based on the derivation statistics of the Settlement Agreement.
  - For a given 12-month period, this probability produces a 23 % chance that an exceedance will occur based solely the variability of measurement, assuming the equation works well over the range of variation in Refuge ecology.
- *Does the Interim Level equation predict P levels accurately when Refuge stage increases rapidly?*
  - A data summary follows looking at this aspect.
  - Internal loading might sometimes interfere.

# Compliance and Marsh Levels

**Geomean >  
Interim Level**

Excursions Above Interim Levels

Marsh levels going down

Marsh levels going up

**Geomean <  
Interim Level**

In Compliance with Interim Levels

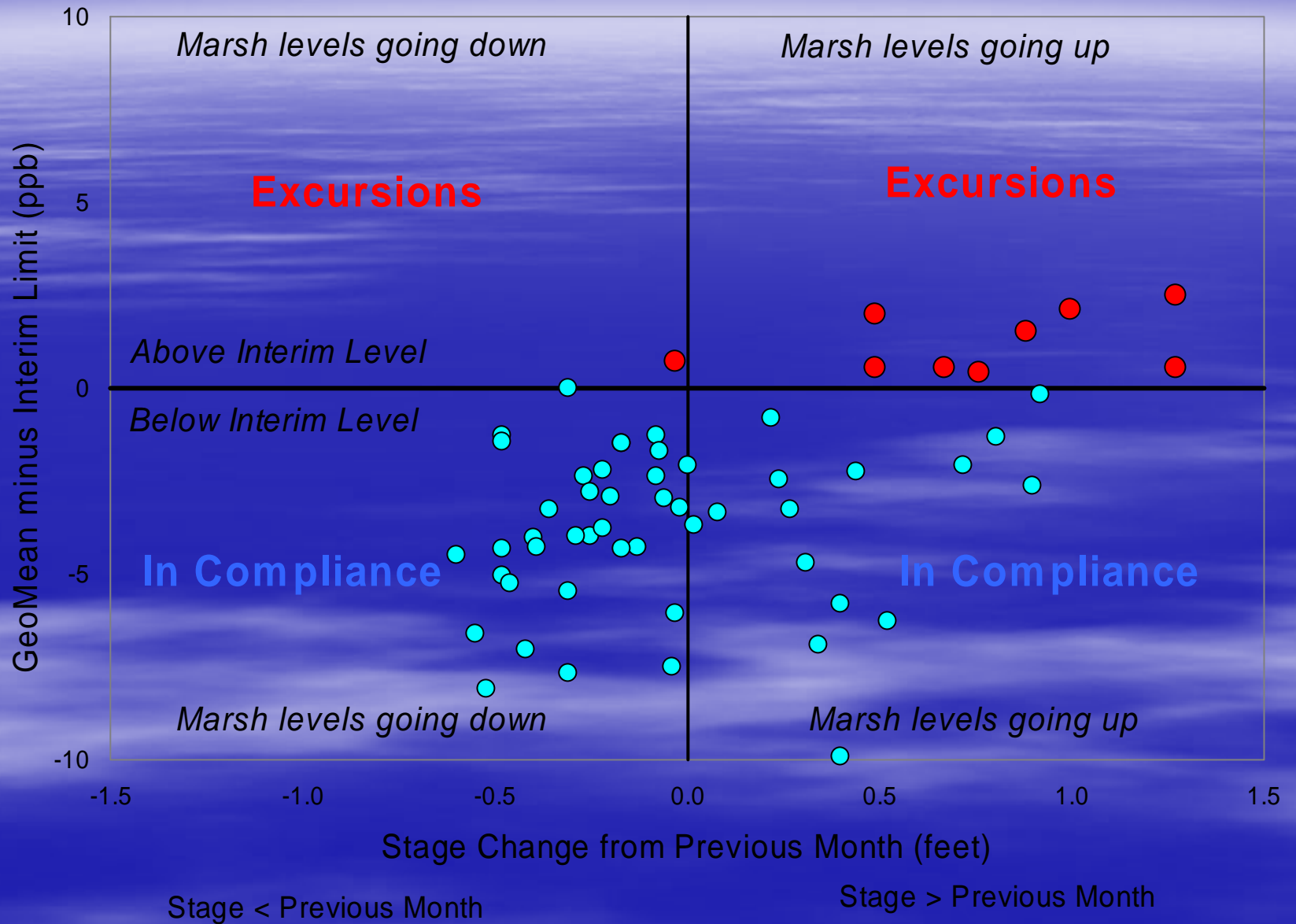
Marsh levels going down

Marsh levels going up

Stage < Previous Month

Stage > Previous Month

# Compliance and Change in WCA-1 Marsh Levels





# Preliminary Conclusions from the District

- Analysis of data from across Refuge stations suggests many simultaneous factors, such as external P loading and uncertainty in the compliance equation, may contribute to Refuge excursions.
- The combination of factors underlying the 0.5 ppb excursion of September 2003 is not certain.
- The ability of the Interim Level equation to predict P accurately during a period of rapidly rising stage with high P concentrations from an antecedent dry period is likely to have been a primary factor in the 2.1 ppb excursion of August 2004.
- Influences of external loading are complex and long-term.

# Preliminary Conclusions from the District

(Continued)

- A decreasing trend in phosphorus levels was found for the Refuge compliance station geomeans and there are no P data demonstrating marsh enrichment at any of the individual compliance stations.
- The ability of the compliance equation to predict P concentrations accurately during rapid increases in stage was a contributing factor in 2003/4 exceedance.
- Little additional information is available for TOC to attempt to establish causation over that evaluated in 2003.
- A better use of time and resources is to implement recommendations agreed to in 2003.