Simulation of Conowingo Infill in Phase 6

STAC Water Quality Sediment Transport Model Review

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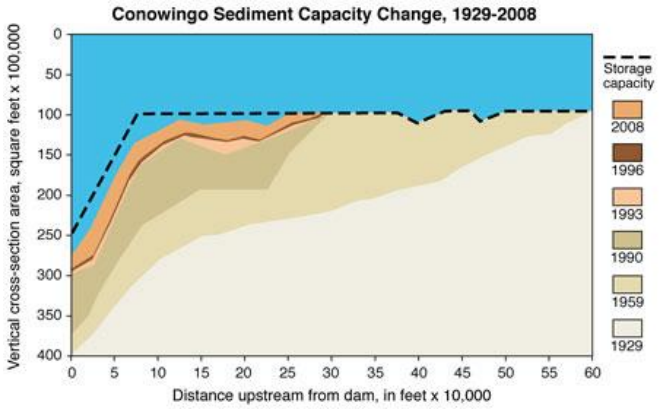
Presentation Outline

- A brief overview of the intense research, monitoring, and modeling of Lower Susquehanna Reservoirs
- Lines of evidence and approaches for the incorporation into the HSPF simulation
- A review of stationary WRTDS models
- Operational details of the simulation of Conowingo infill in the Phase 6 Model
- A scenario to illustrate the use of the calibrated model for simulating the delivery of loads under infill conditions (on/off)

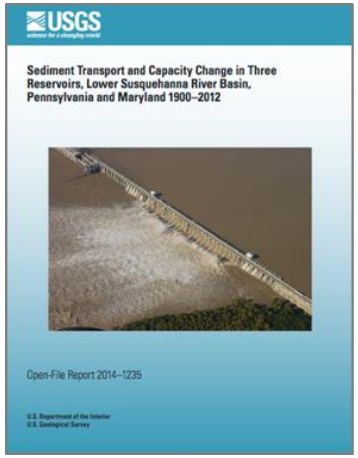
Brief Review of Conowingo Infill

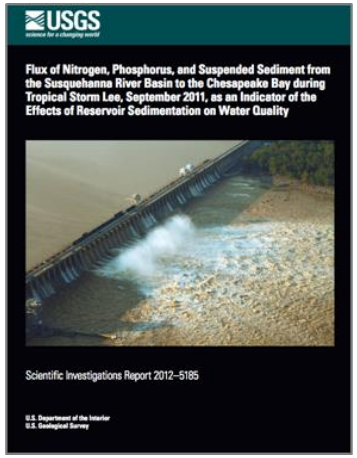
- Conowingo is nearing dynamic equilibrium, which has reduced its ability to trap sediment and nutrients.

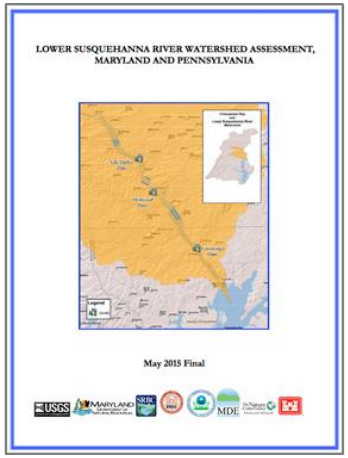


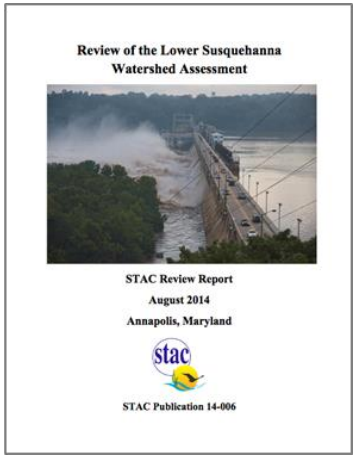
Source: Graph, Michael Langland, U.S. Geological Survey

- Several research articles have documented this and provide an analysis of changes in the transport behavior.
- They provide a strong scientific foundation, and were used as lines of evidence in the Phase 6 model development.







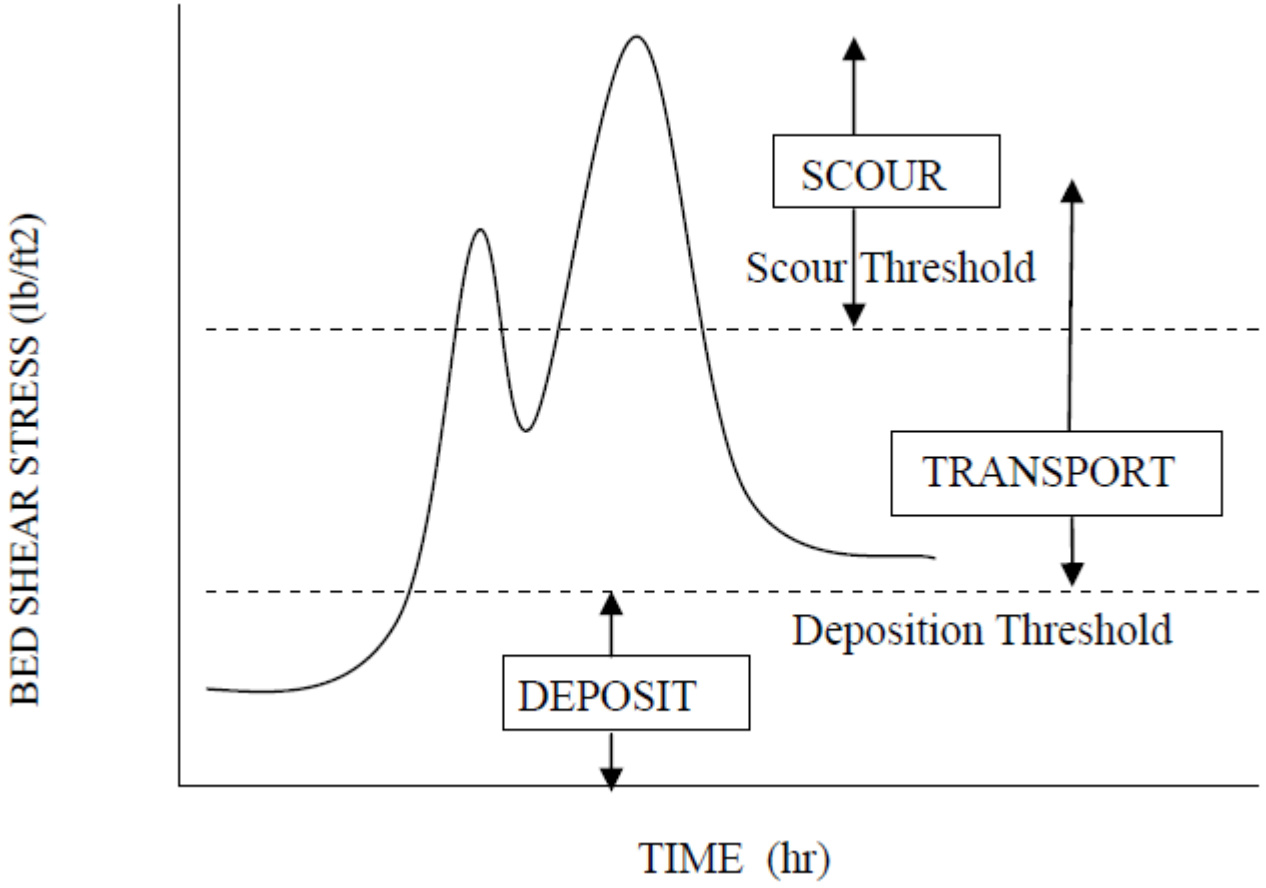


STAC Guidance on Conowingo Infill

Paraphrasing…

- Conowingo models should be evaluated based on the ability to "hindcast" data from observations and statistical analyses
- Address the full range of flows
- Address the bioavailability of sediment nutrients

HSPF – Sediment Transport Simulation



Erodibility

Scour critical shear stress

Settling Velocity

Deposition critical Shear Stress

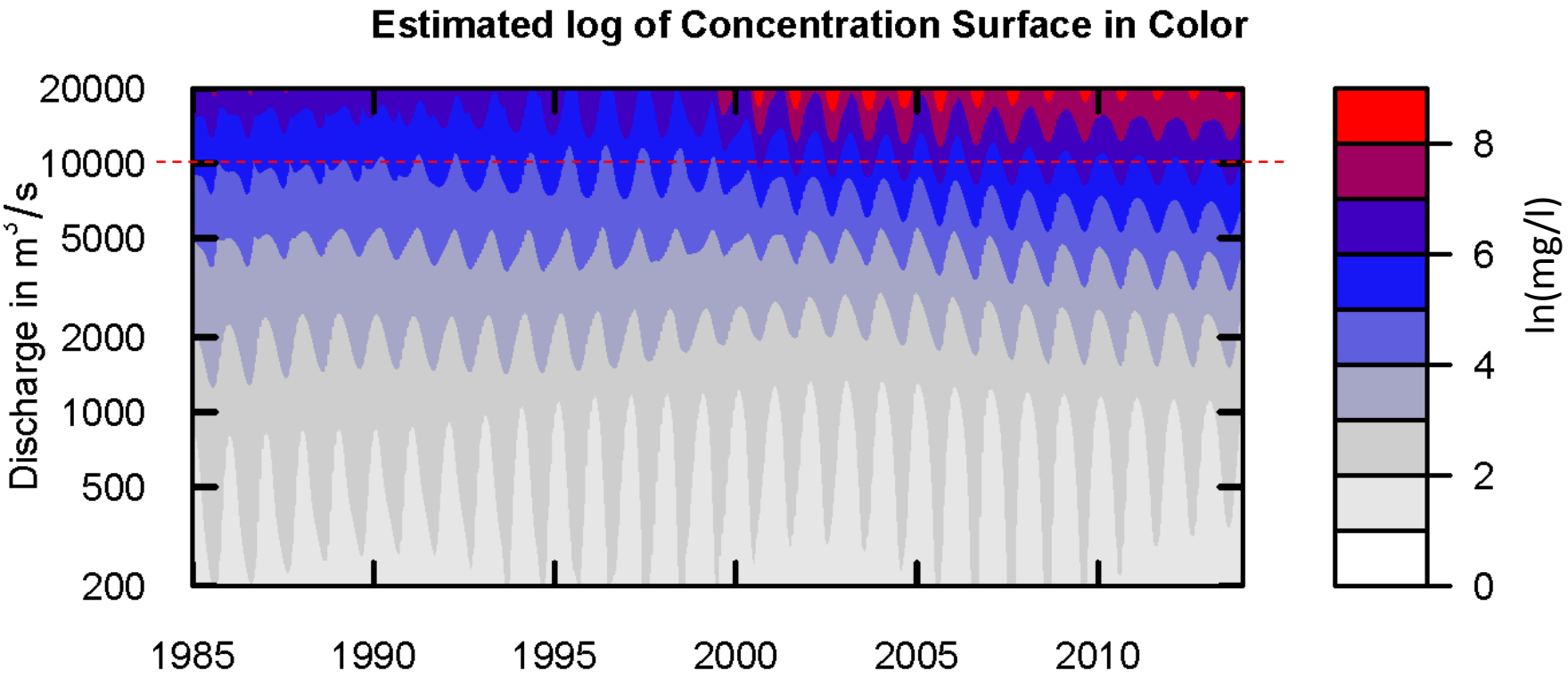
***Tau$_{CD}$, Tau$_{CS}$, Erodibility*, and *Settling Velocity* are all modifiable through time.**

The lines of evidence for incorporating Conowingo Infill

- Zhang, Hirsch, and Ball (2016), Zhang, Brady, and Ball (2013), and Hirsch (2012) provide a WRTDS based analysis of changes in sediment and nutrient transport with Conowingo infill.
- The Conowingo Pool Mass Balance Model (CPMBM) and Sediment Flux Model (SFM) also provide information on changes in transport mechanisms, particularly the variability in bioreactivity with changes in upstream loading and stormflows.
- Hirsch (2012) and Langland (2015) analyses were used for validation.

WRTDS – USGS Regression Model

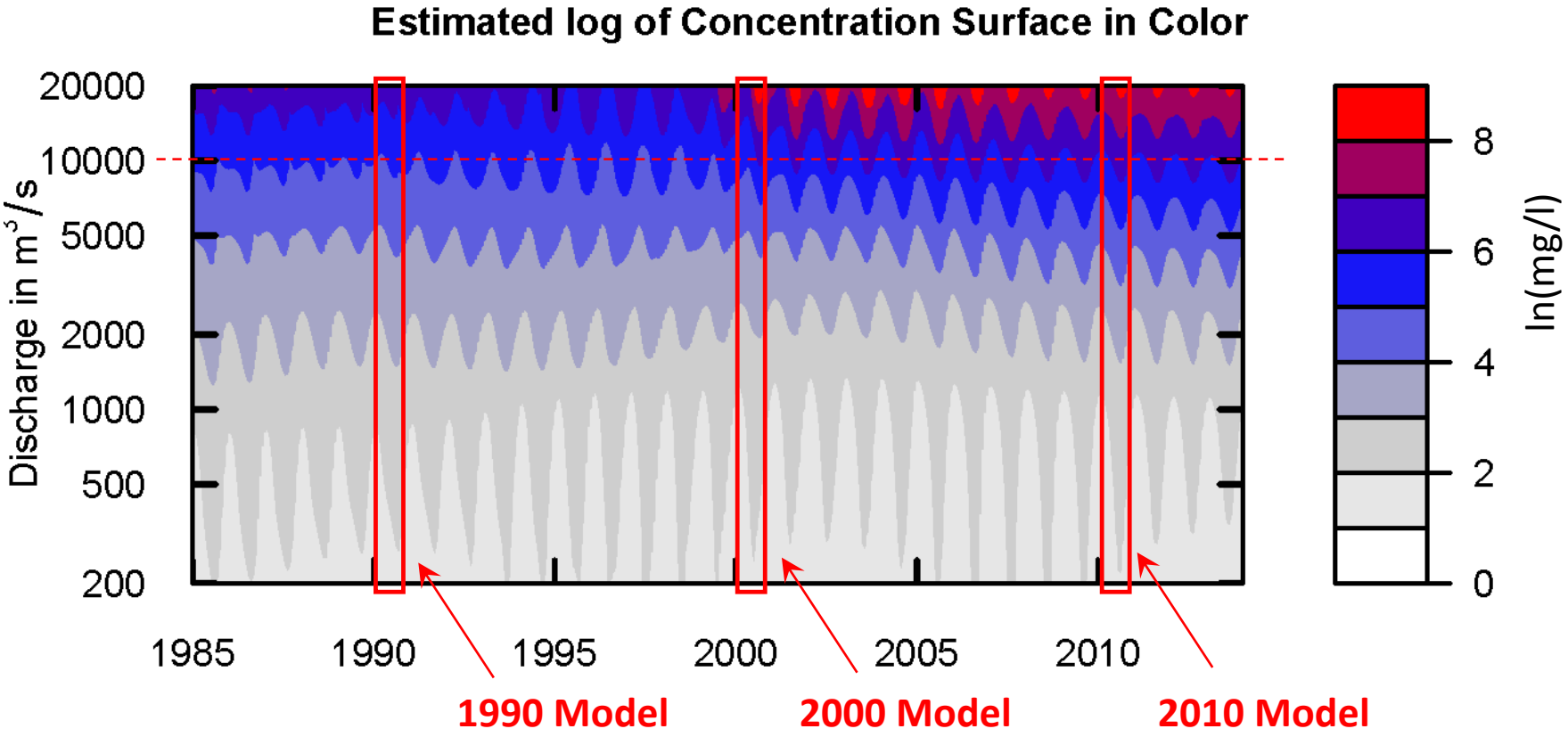
- WRTDS[1] uses time, discharge, and seasonality as regression variables for estimating concentration.



[1] Hirsch et. al 2010; Hirsch and De Cicco 2015

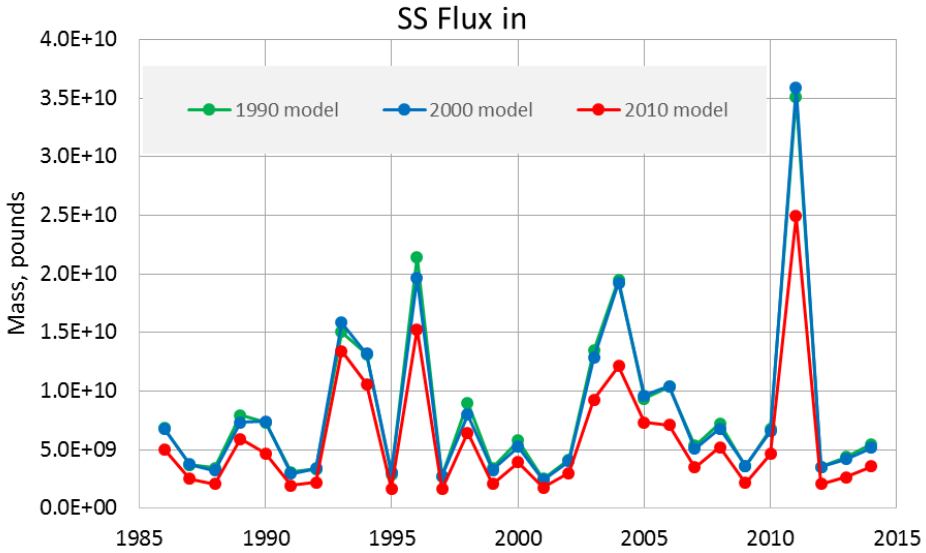
Stationary Models of Conowingo: an analysis using WRTDS

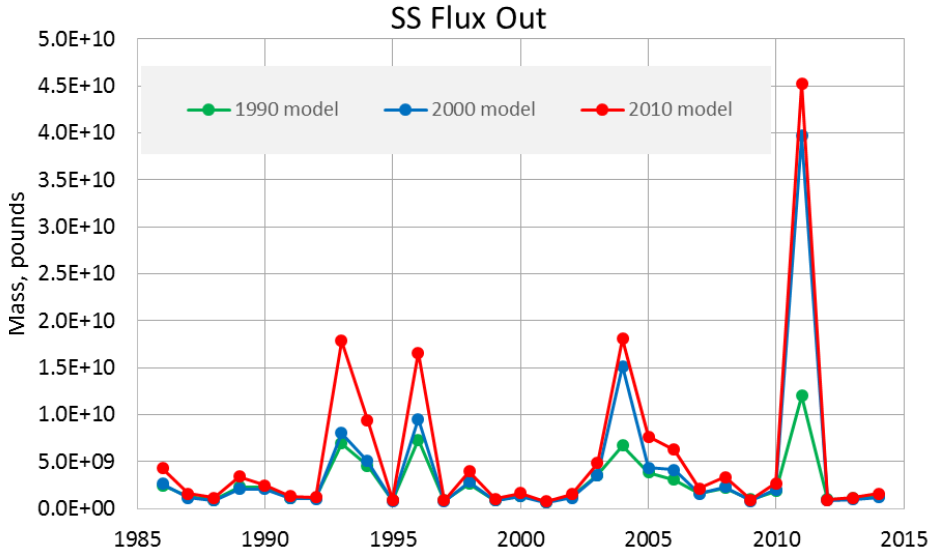
- Stationary WRTDS concentration surfaces[1] were developed:



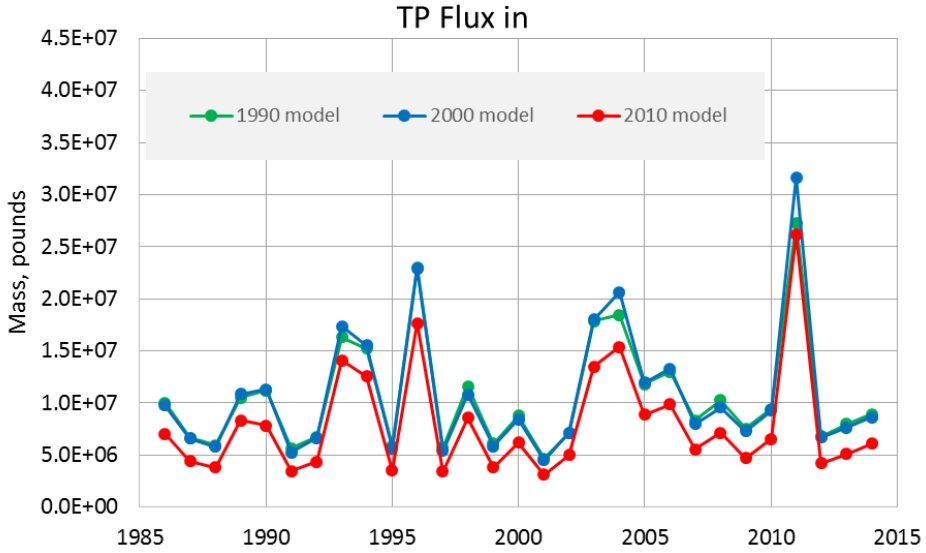
[1] Zhang, Hirsch, and Ball ES&T 2016

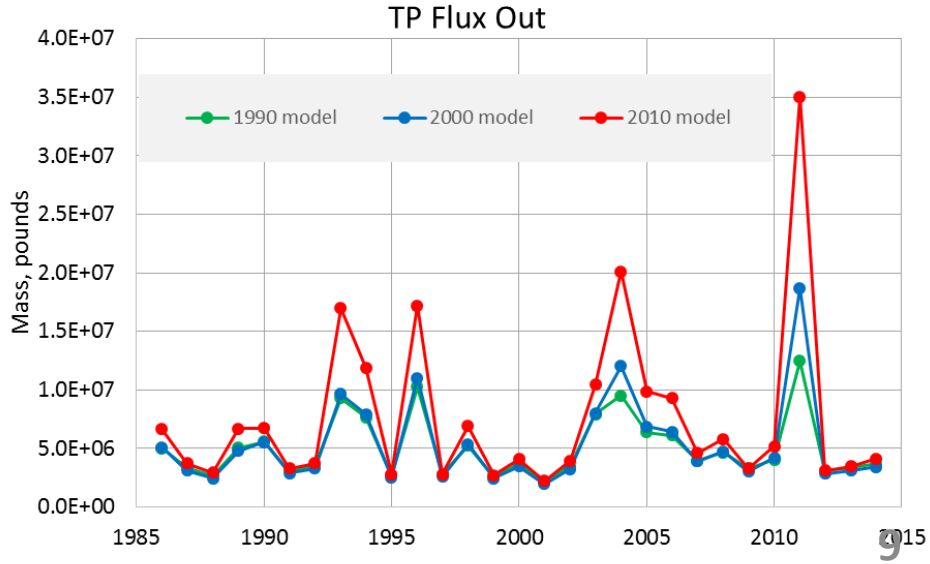
The stationary models for sediment





The stationary models for phosphorus





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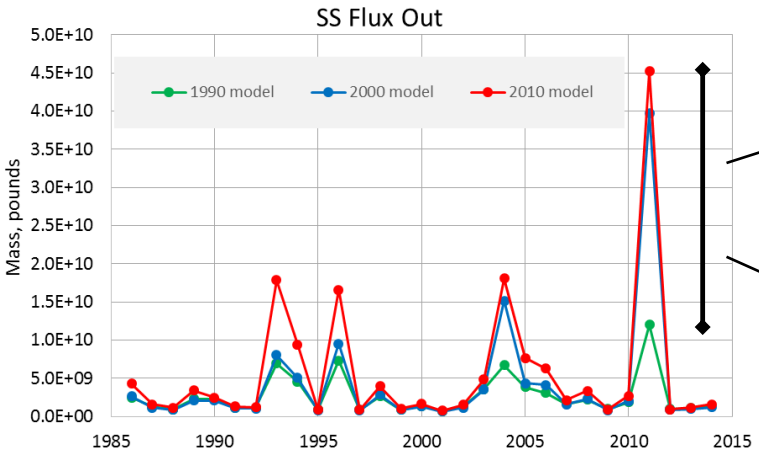
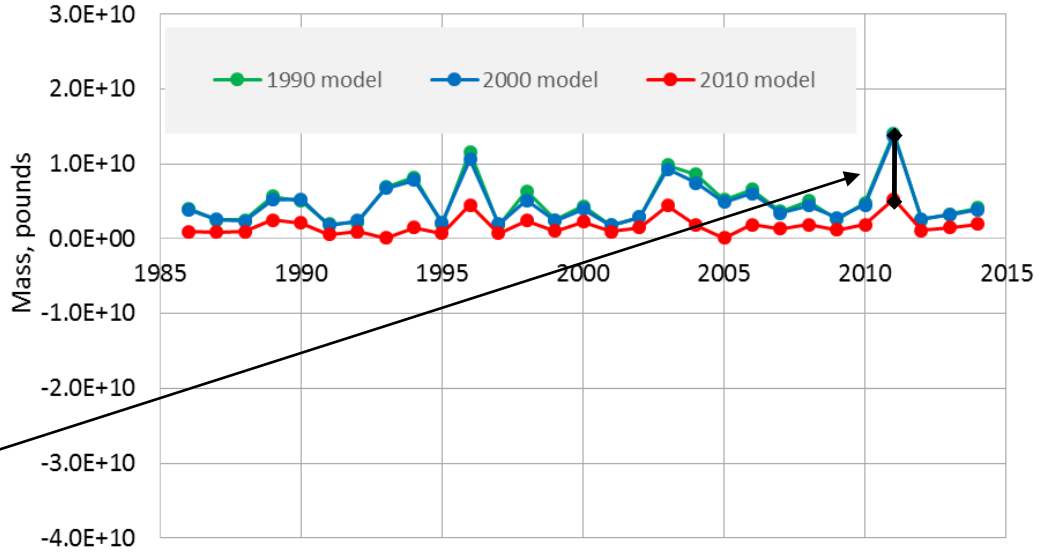


Behavior of reservoir below 10,000 cms (353k cfs)



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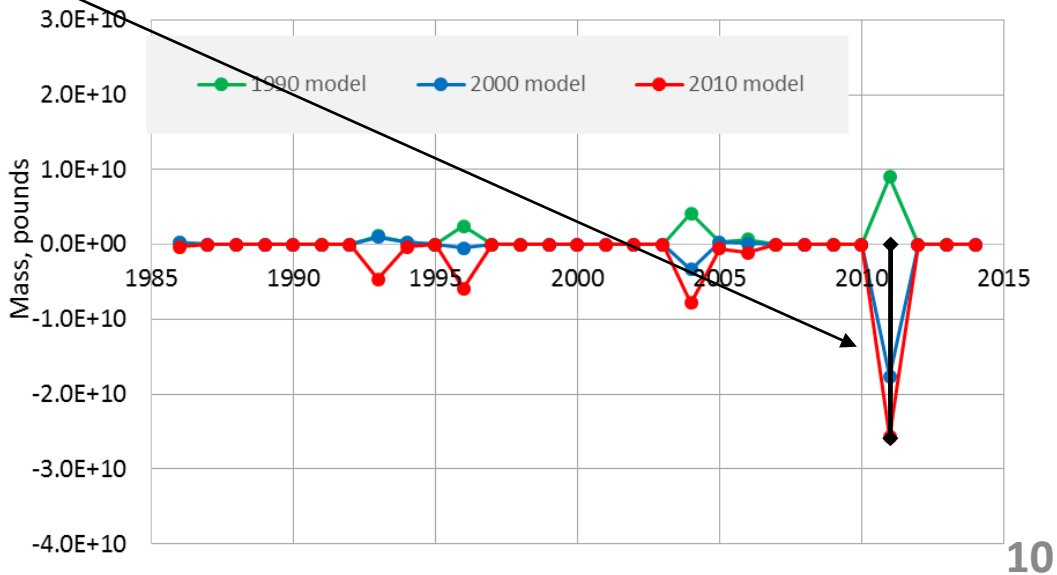
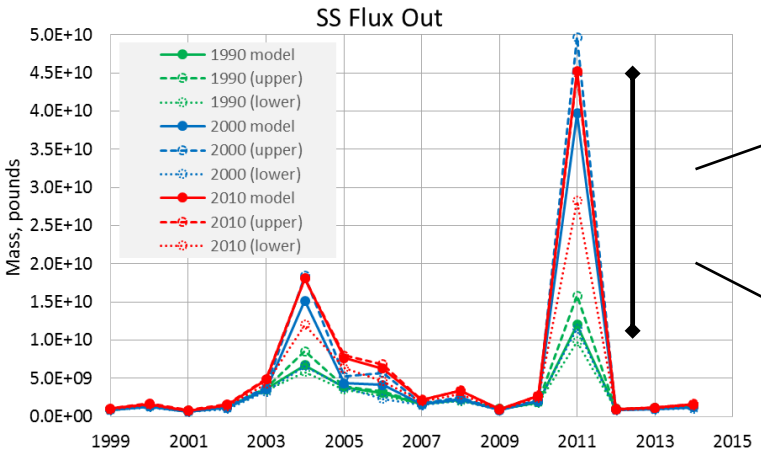


The stationary models provide quantitative estimates of changes in scour and deposition.

Uncertainty quantification



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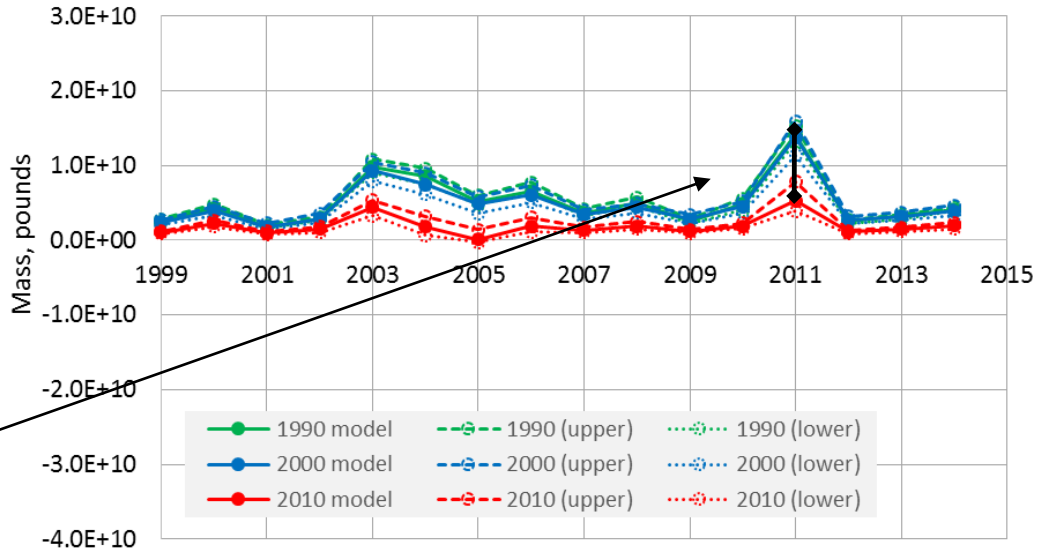

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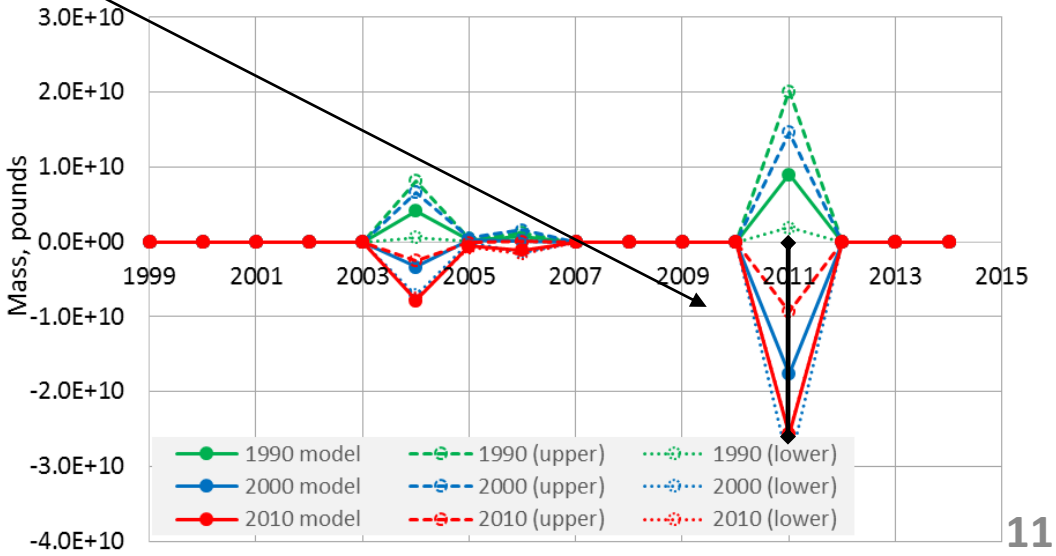
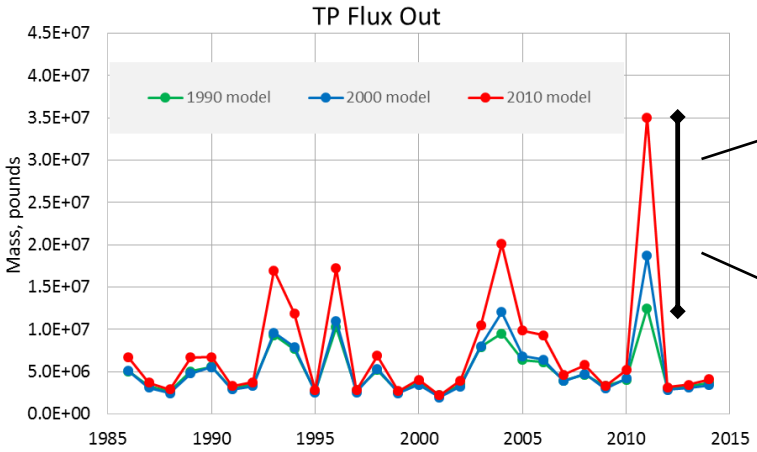


These uncertainty bounds were considered during the model calibration process.

The stationary models for phosphorus



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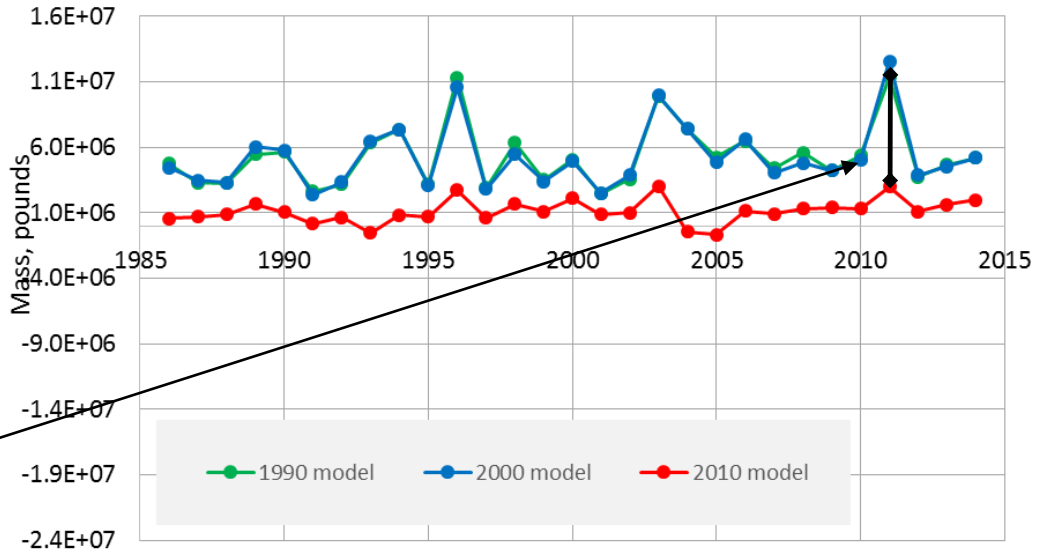

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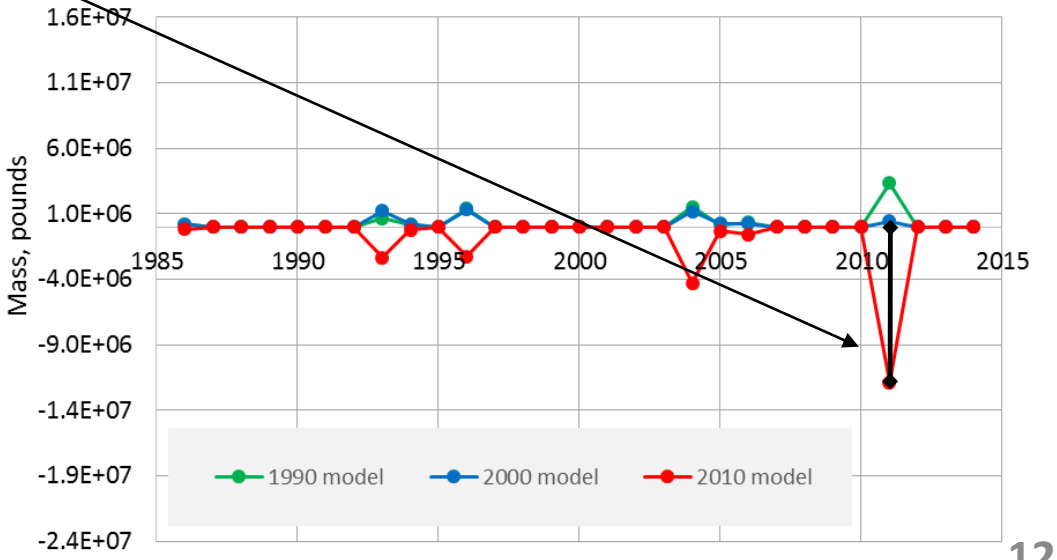
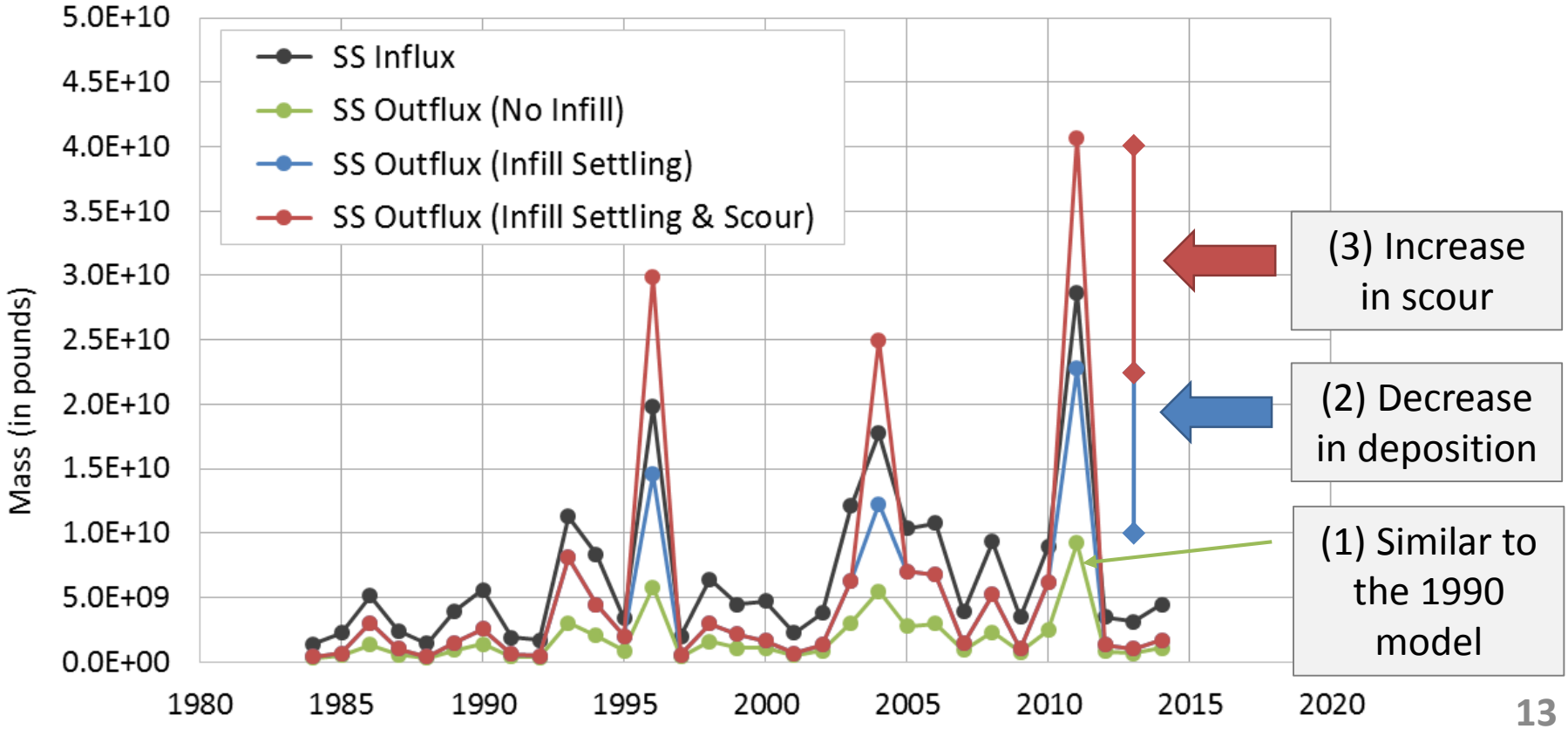


The stationary models provide quantitative estimates of changes in phosphorus transport with scour and deposition.

The Phase 6 WSM Application

A four step calibration strategy was developed:

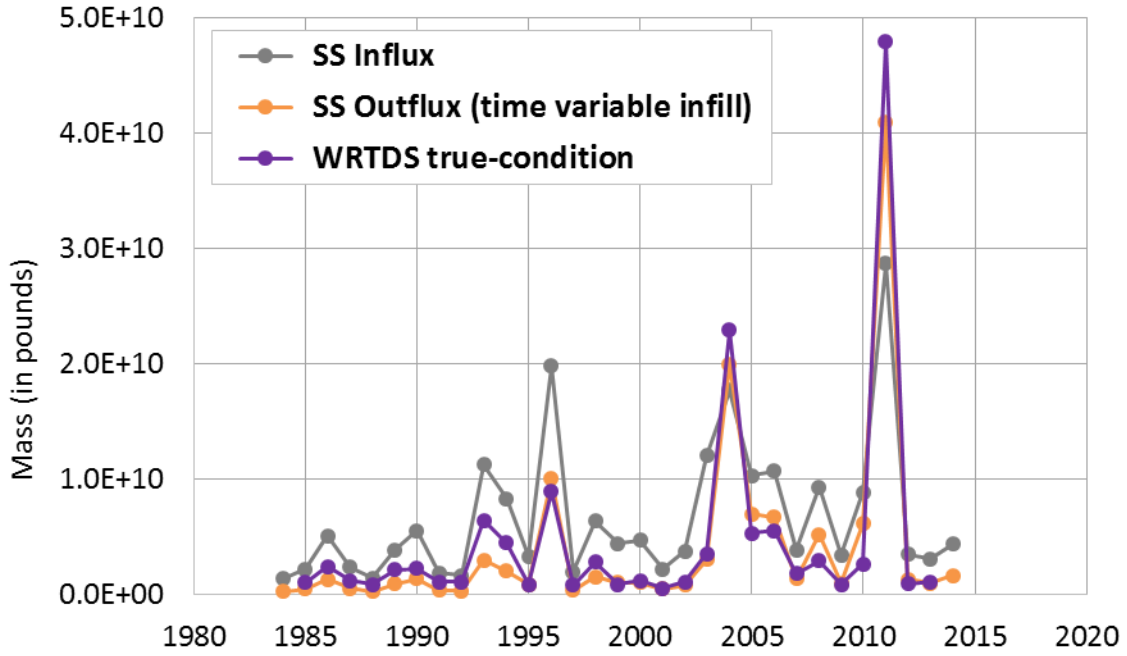
1. Estimate no-infill model parameters
2. Estimate changes in deposition parameters
3. Estimate changes in scour parameters
4. Estimate temporal variability in deposition/scour parameters

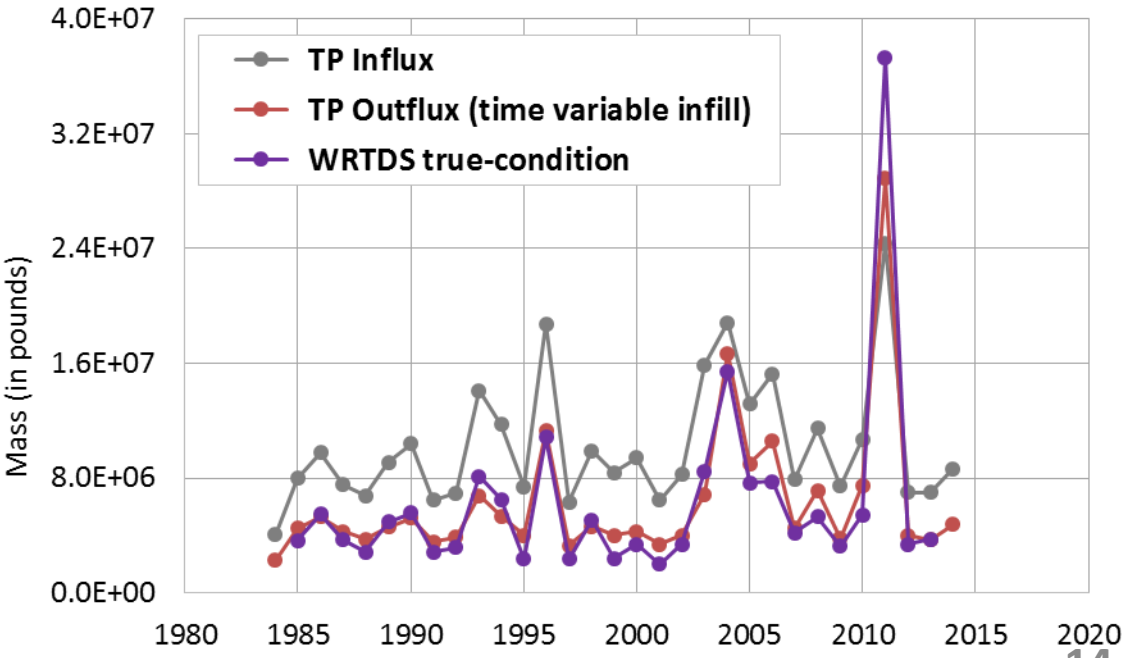


The Calibrated WSM

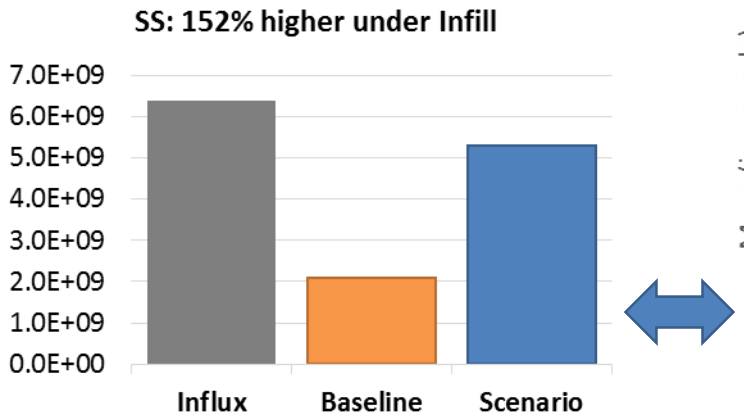
- The calibrated sediment and phosphorus loads are shown.
- Both scour and deposition parameters varied with time in the simulation.

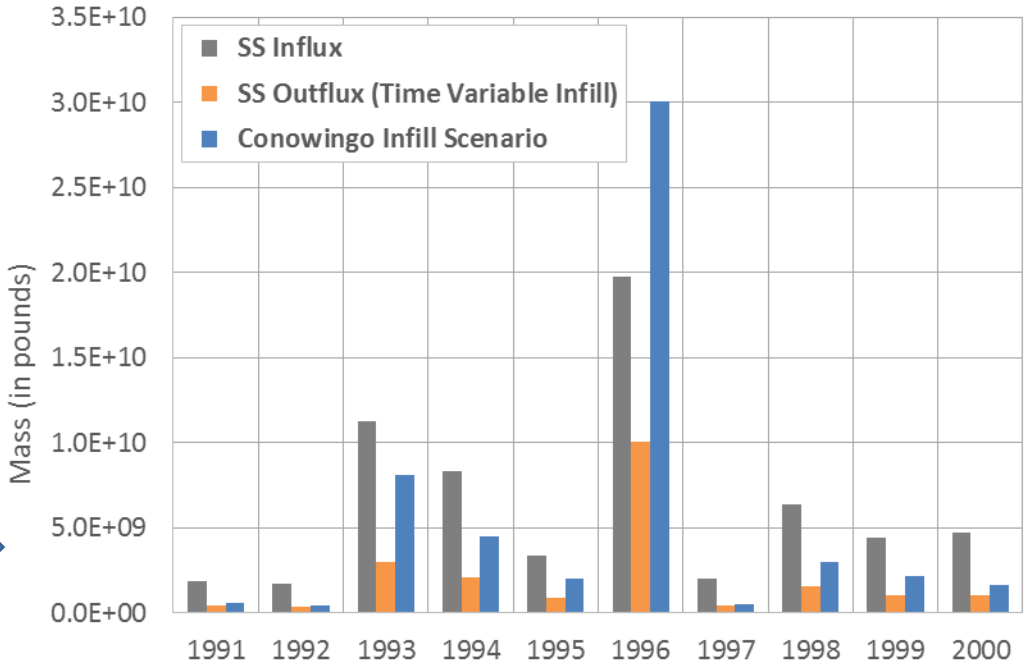
Model Performance (NSE)		
	SS	TP
Annual	0.957	0.912
Monthly	0.944	0.905

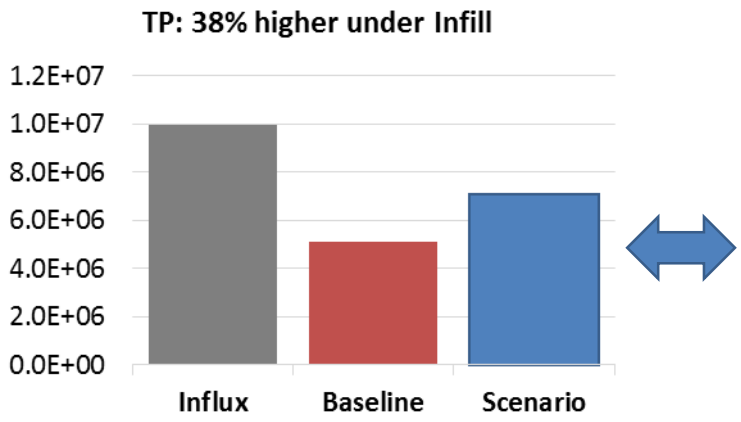


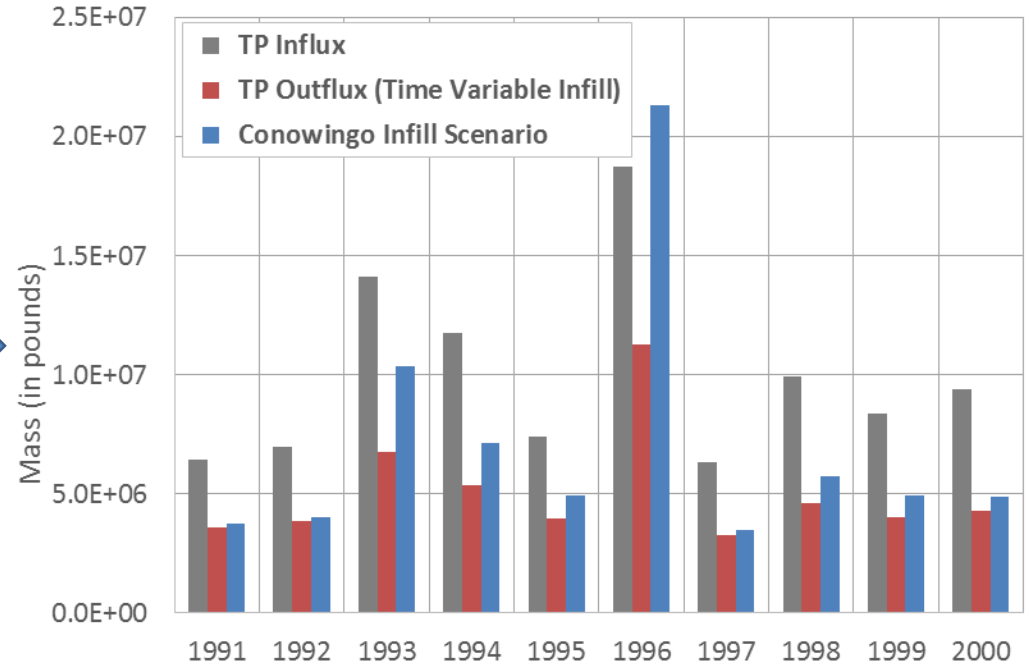


Conowingo Infill Scenario







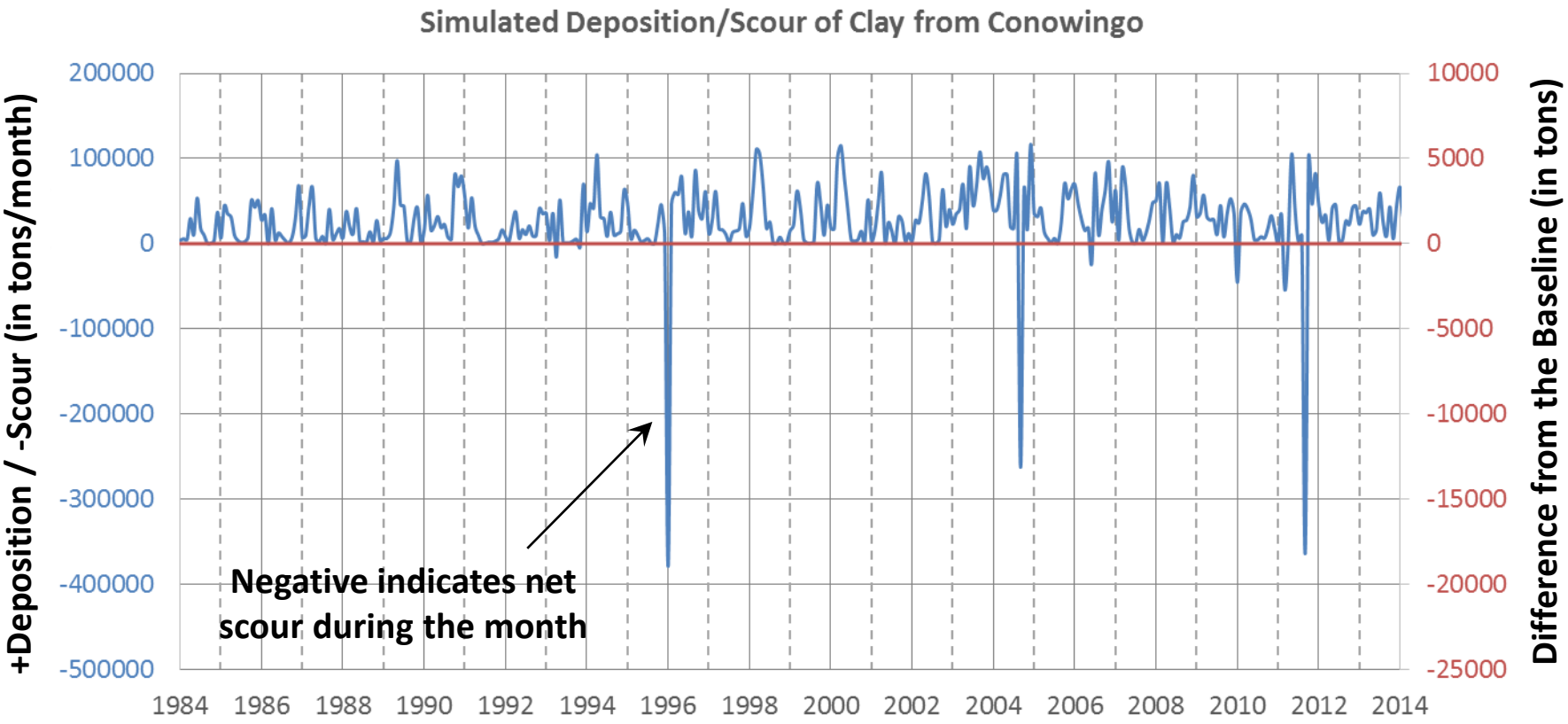


reduced trapping over the 10 year period as compared to the baseline

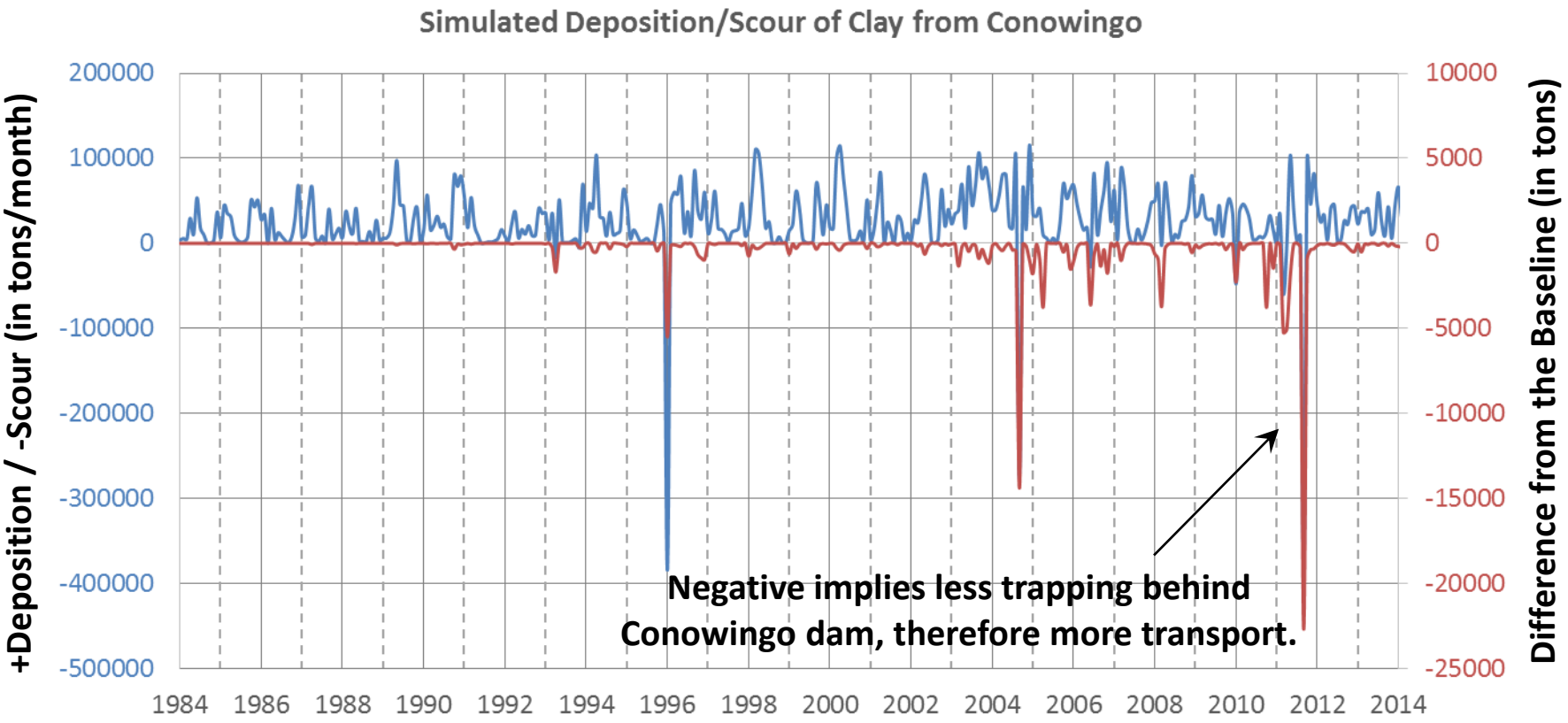
Summary and Conclusions

- New science based on intensive research, monitoring, and modeling of Lower Susquehanna Reservoirs were used in the development of the Phase 6 Model.
- The changes in the behavior of the Conowingo (i.e., the reduced trapping capacity) were calibrated using multiple lines of evidence including Stationary WRTDS models, mass-balance analyses, monitoring data, bathymetric surveys, and WRTDS (true-condition).
- The calibrated model performed quite well in matching monitoring data as well as monthly and annual loads estimated by WRTDS.

The Baseline Calibration

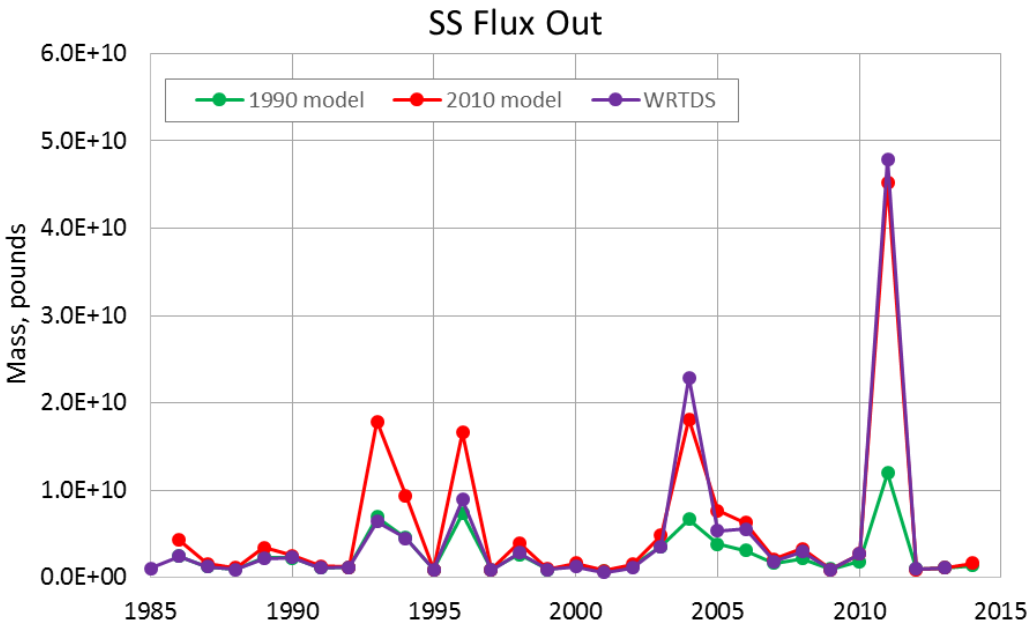


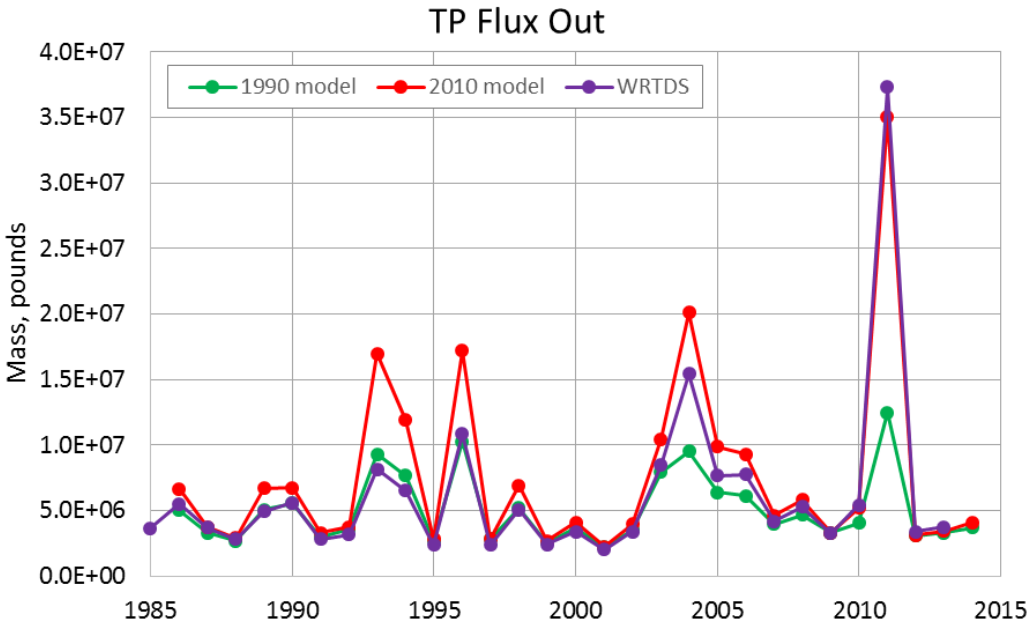
Variable Critical Shear Stress for Clay Deposition Prototype



The Phase 6 WSM Application

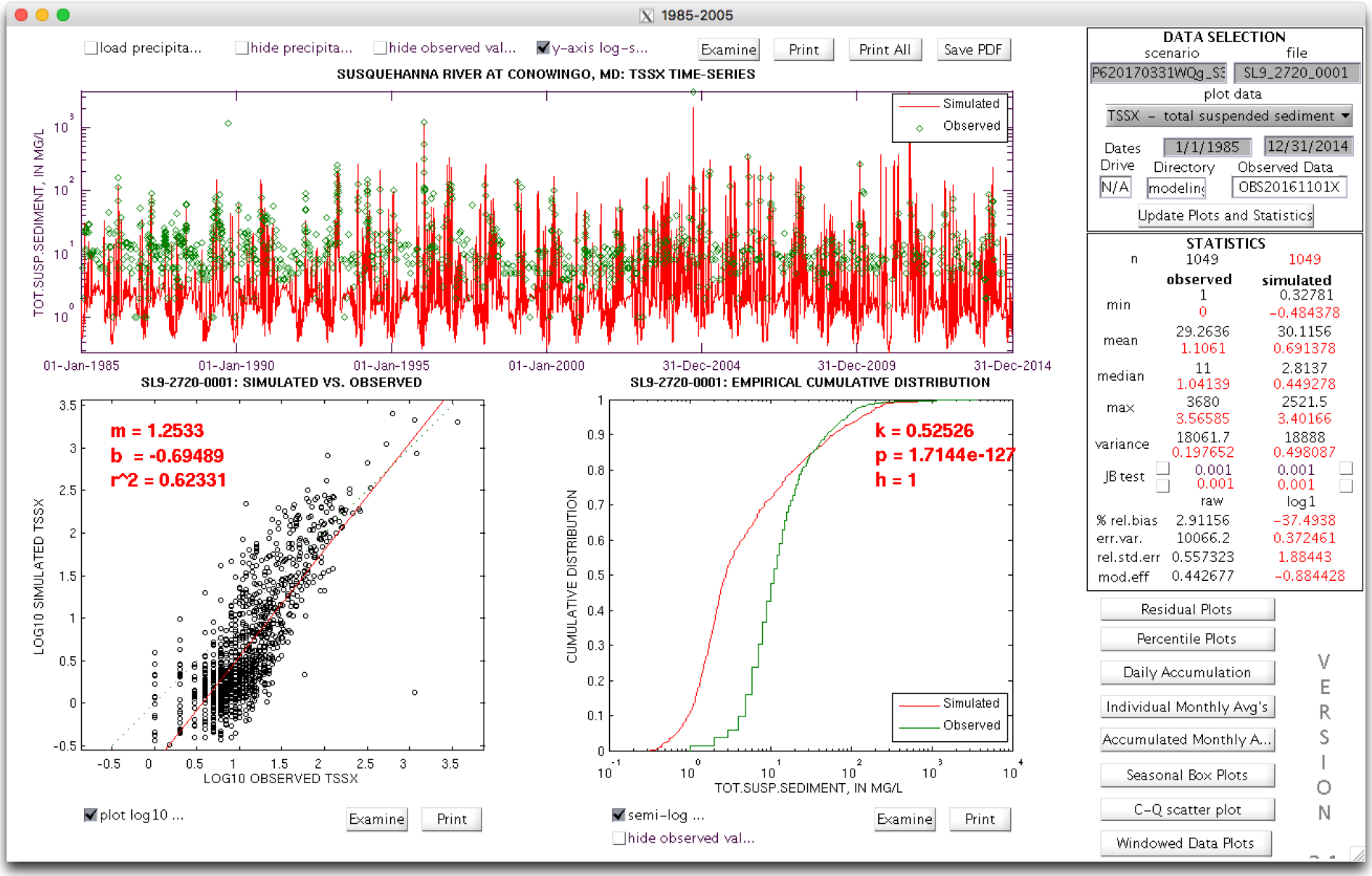
- The goal is to estimate how model parameters should change with infill.
  - Specifically a transition from 1990 to 2010 model.
- The calibrated parameters are then changed with time.
- Once parameters are known, scenarios are run using fixed parameters that represent different infill conditions (i.e. infill on/off).





Susquehanna at Conowingo

SEDIMENT



Susquehanna at Conowingo

PHOSPHORUS