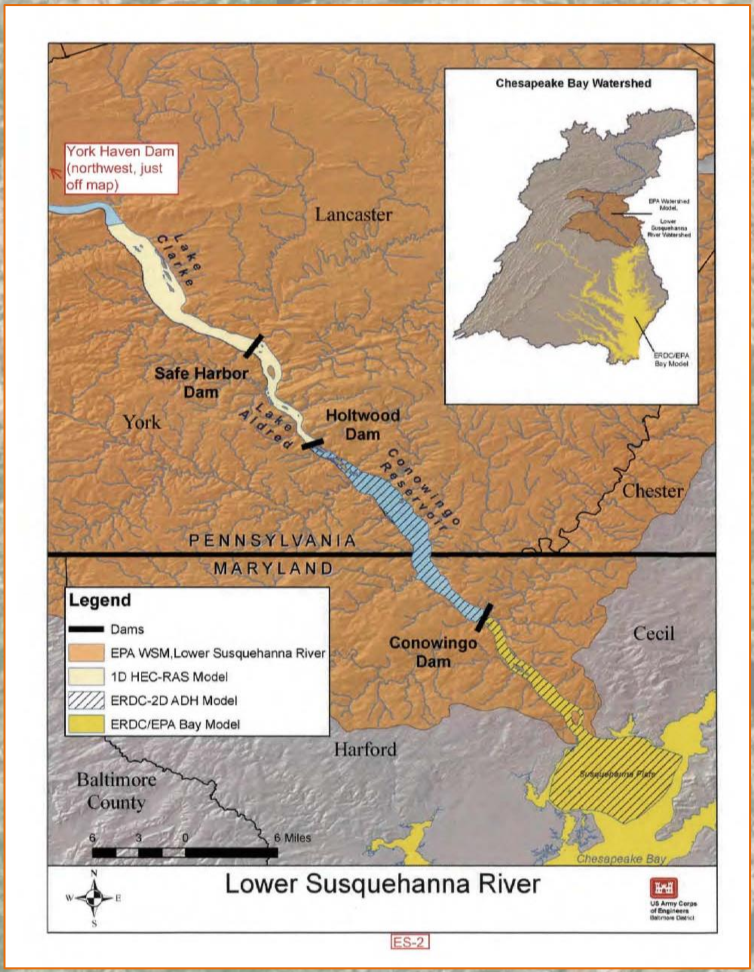
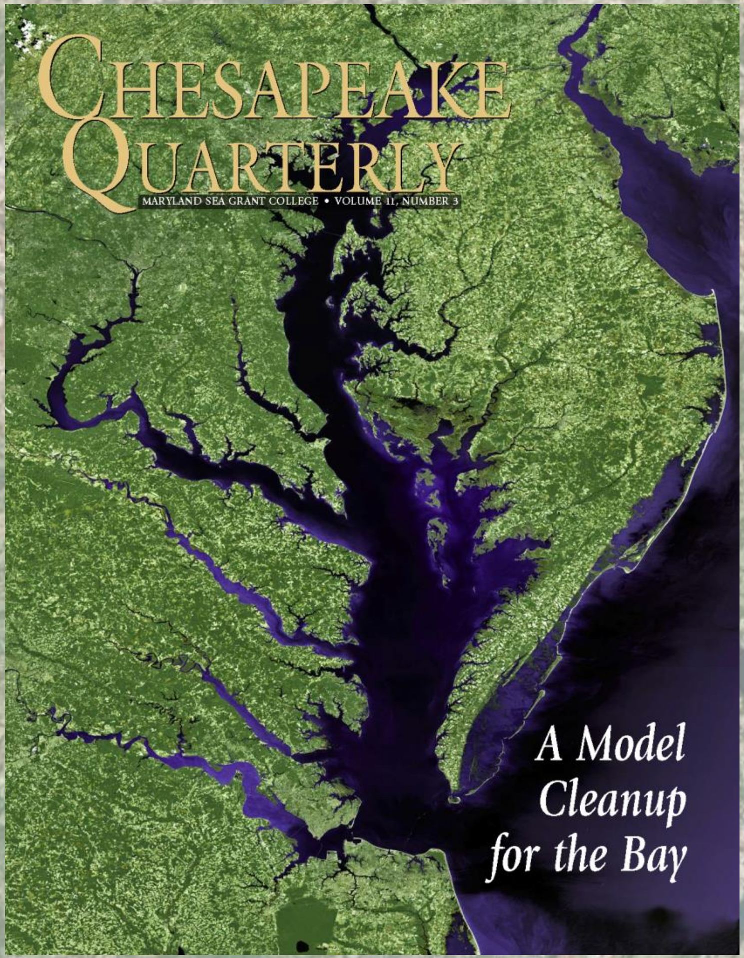
Background



- The Susquehanna River provides about half the freshwater flow to Chesapeake Bay.
- A series of three dams and reservoirs regulates flow and loads from the watershed to the bay.
- Lakes Clarke and Aldred have filled with sediment to the equilibrium level. The largest reservoir, Conowingo, is filled or nearly filled.

Problems for the TMDL?



- Reservoirs are full or nearly full to capacity with sediment.
- A major scour event transports solids and nutrients from the reservoir bottom to the bay.
- Lesser events may provide more frequent additional loading to the bay.
- Scoured solids and associated nutrients threaten the TMDL which incorporates historical deposition rates in Conowingo reservoir.

Lower Susquehanna River Watershed Assessment – A Partnership

- Baltimore District, USACE – Project management and reporting
- State of Maryland – Project sponsorship
- USEPA Chesapeake Bay Program – Assessment of impact on TMDL, watershed modeling
- US Geological Survey – Modeling of upper reservoir system
- ERDC Coastal and Hydraulic Lab – Sediment transport in Conowingo Reservoir
- ERDC Environmental Lab – Impact on Chesapeake Bay
- The Nature Conservancy – Public Relations and Advocacy

Objectives

- Forecast and evaluate sediment loads to the system of hydroelectric dams located on the Susquehanna River,
- Analyze hydrodynamic and sedimentation processes and interactions within the lower Susquehanna River watershed,
- Consider structural and non-structural strategies for sediment management, and
- Assess cumulative impacts of future conditions and sediment management strategies on Chesapeake Bay.

Critical Components

- Identification of watershed-wide sediment management strategies,
- Use of engineering models to link incoming sediment and associated nutrient projections to in-reservoir processes at the hydroelectric dams and forecast impacts to living resources in the upper Chesapeake Bay,
- Use of the Chesapeake Bay Environmental Model Package (CBEMP), a cooperative effort of the US Environmental Protection Agency Chesapeake Bay Program and the US Army Engineer Research and Development Center, to assess cumulative impacts of the various sediment management strategies to the upper Chesapeake Bay, and
- Integration of the Maryland and Pennsylvania Watershed Implementation Plans for nitrogen, phosphorus, and sediment reduction, as required to meet Chesapeake Bay TMDL’s.

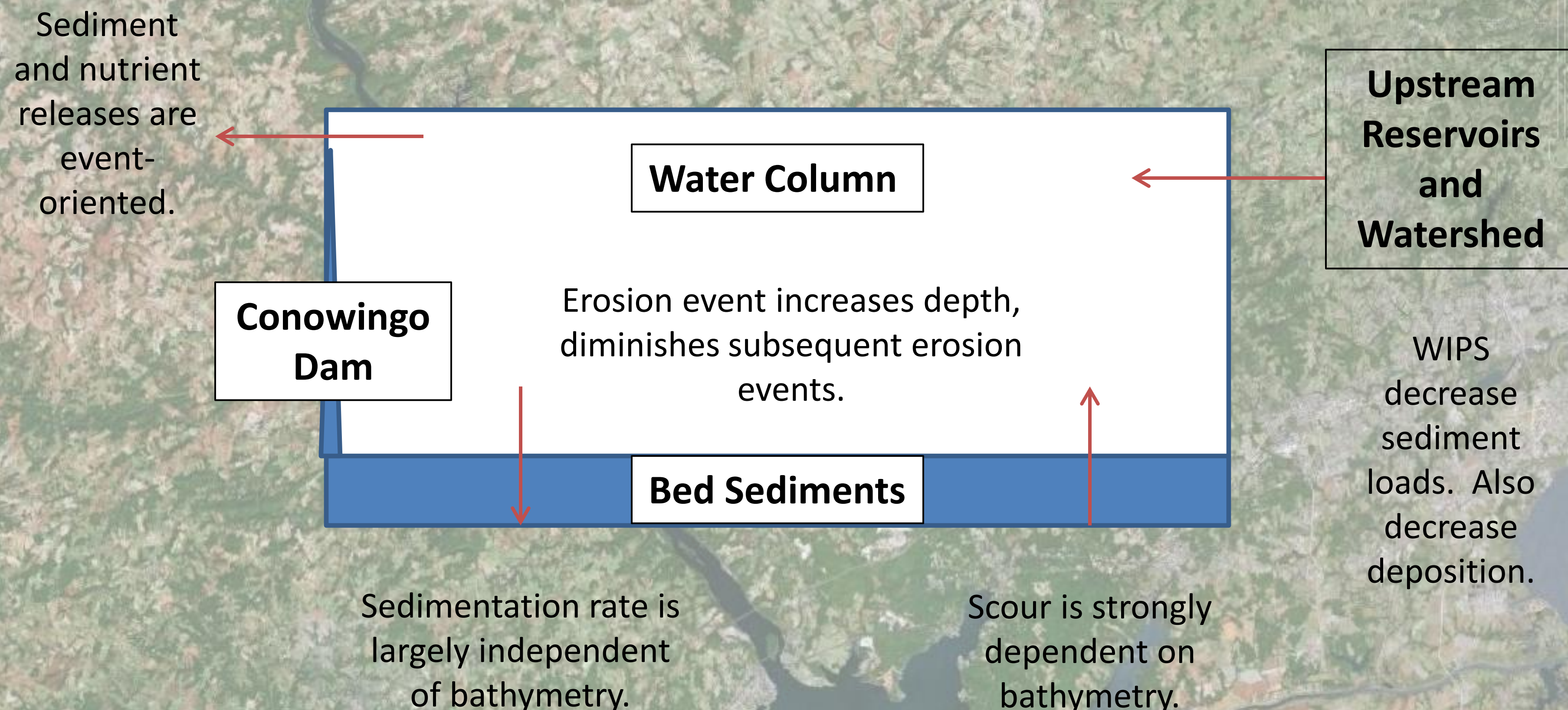
Sediment Management Alternatives

- Agitation Dredging
- Strategic Dredging
  - One-time removal of 3 mcy
  - Removal of 31 mcy over multi-year period
- Bypassing vs Off-Site Placement
- Move Sediment from Scour Areas to Depositional Areas
- Best-Management Practices in Watershed

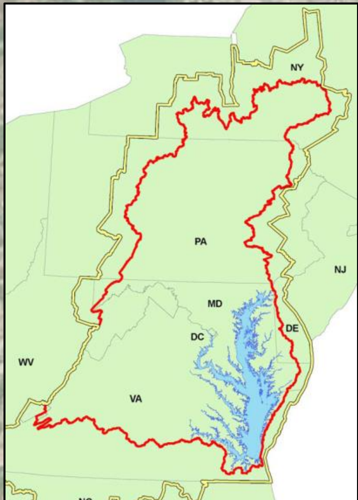
DRAFT LSRWA Reviews:

Version	Review	Target Review Timeframe	Reviewers	Type of Review	Most likely team members needed to respond	Target Timeframe to address comments
1	USACE District Quality Control Backcheck	14 Apr – 25 Apr	NAB (Angie Sowers, Andrew Roach, Chris Nolta, Bierly, Gross)	Technical, Policy and Editorial	Modelers and USACE	28 Apr – 9 May
1	(A.) USACE Agency Technical Review, (B.) USACE Office of Counsel.	14 Apr – 25 Apr	(A.) Sue Ferguson, Nashville, Plan Formulation, Kim Franklin - Nashville, Biologist, Jim Kosky – Pittsburgh, H&H, Mike Alexander – Kansas City District-H&H/Operations/Dredging (B.) Jim Bemis	Technical and Legal	Modelers and USACE	28 Apr – 23 May
(1)	Technical Edit	5 May – 23 May				
	Conowingo Senate Hearing	**5 May**				
2	LSRWA Team	26 May – 6 Jun	LSRWA Team	Technical	Modelers and USACE	9 Jun - 20 Jun
3	STAC	23 Jun – 22 Aug	STAC Selected Members	Technical	Modelers and USACE	25 Aug – 3 Oct
3	LSRWA Quarterly Workgroup	23 Jun – 18 Jul	LSRWA Quarterly Workgroup	Technical	Modelers and USACE	21 Jul – 15 Aug
4	USACE Planning Chief	18 Aug – 22 Aug	Amy Guise	Policy	USACE	25 Aug – 29 Aug
5	USACE Division	3 Sep – 2 Oct	North Atlantic Division Staff	Policy (though they often get technical)	USACE and possibly Modelers (unlikely)	10 Oct – 20 Oct
6	Public Review	23 Oct – 21 Nov	General public, agencies, widest distribution as possible (STAC comments may or may not be incorporated at prior to public review).	Public could be anything.	USACE, possibly modelers (unlikely)	24 Nov – 19 Dec
7	USACE HQ	22 Dec – 20 Jan	USACE HQ staff	Policy	USACE, possibly modelers (unlikely)	29 Jan – 5 Feb
8	Assistant Secretary of the Army office	6 Feb – 9 Mar	Assistant Secretary of the Army office staff	Policy	USACE, possibly modelers (unlikely)	10 Mar – 25 Mar

Conceptual Model of Sediment Movement through Conowingo Reservoir

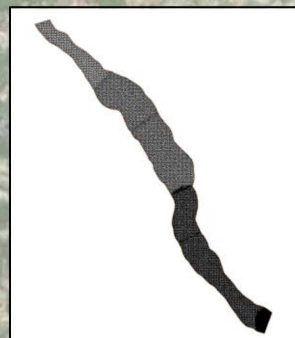


A Cascade of Models



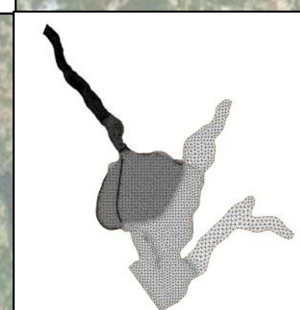
EPA Chesapeake Bay Program Watershed Model

•Simulates the 64,000 sq mile Chesapeake Bay Watershed.
•Provides daily loads of sediments and nutrients from 90 sub-basins.
•Simlulates 1985 – 2005.



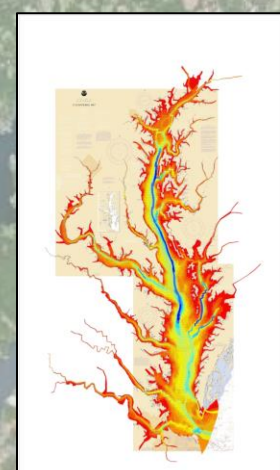
USACE ERDC Adaptive Hydraulics (ADH) Model

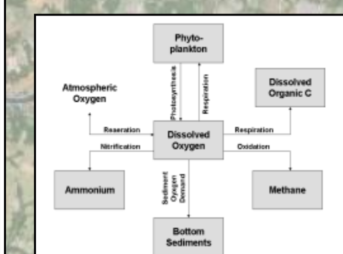
•State-of-the art for hydrodynamics and sediment transport.
•Unstructured grid for maximum resolution.
•Simulates Conowingo Reservoir and Susquehanna Flats 2008 – 2011.



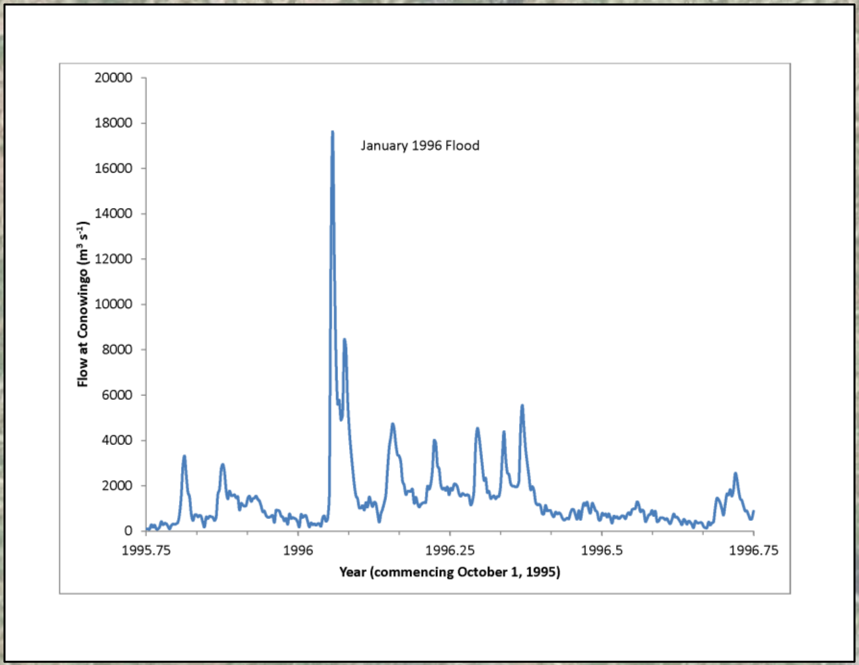
USACE ERDC CE-QUAL-ICM Model

•Simulates water quality, sediment, and living resources in three dimensions in 50,000 discrete cells.
•For this study, emphasis on chlorophyll, water clarity, and dissolved oxygen.
•Operational for 1985 – 2005.



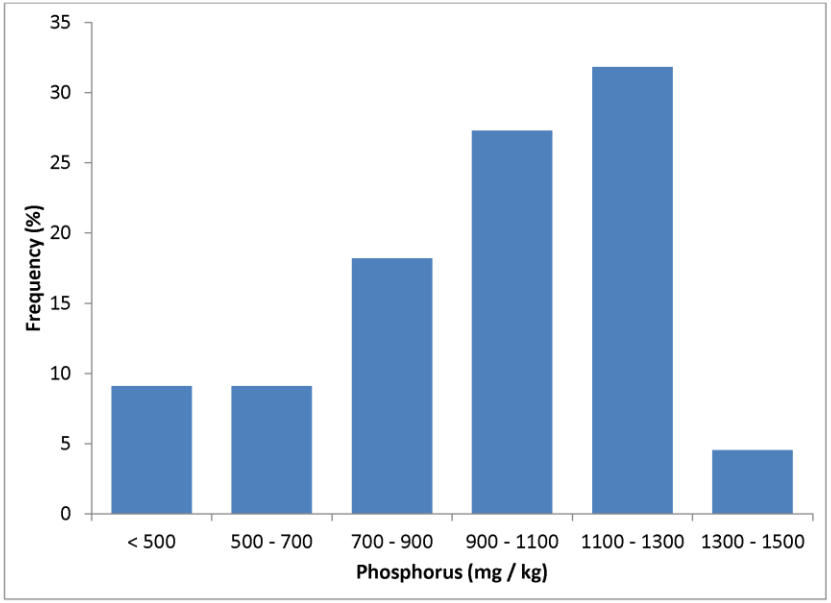


The Scenario Procedure

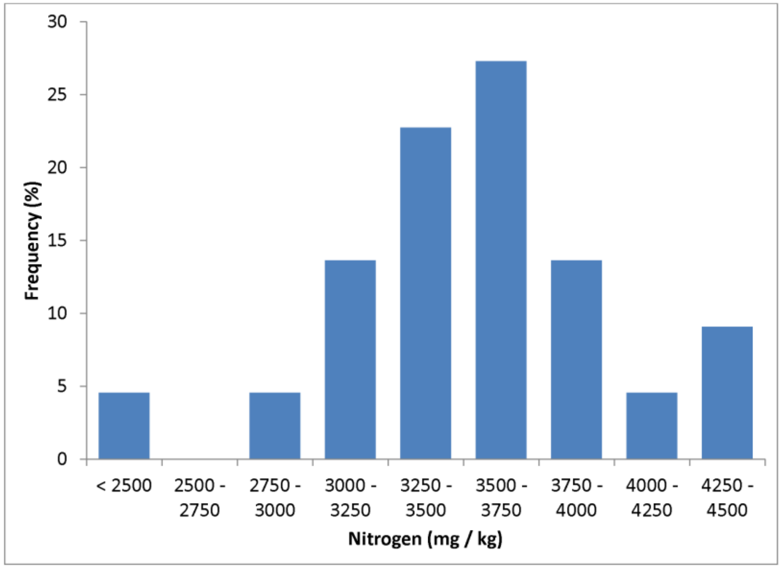


- Simulate ten years hydrology, 1991 – 2000.
- Calculate scour for the January 1996 flood event based on ADH. Add scoured nutrients and solids to watershed load.
- Watershed load from EPA CBP based on TMDL conditions.
- Focus on dissolved oxygen, chlorophyll, water clarity.

Bottom Composition

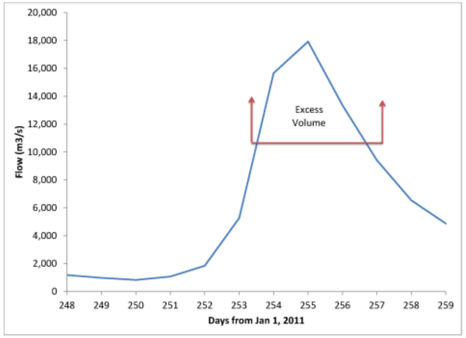


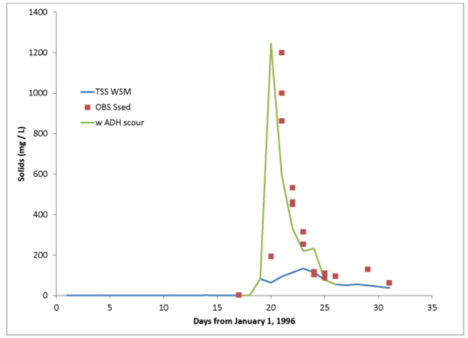
- There is three times as much nitrogen as phosphorus in bottom sediments, on a particle weight basis.
- A scour event is going to erode more nitrogen than phosphorus from the bottom.



Data courtesy Mike Langland, USGS

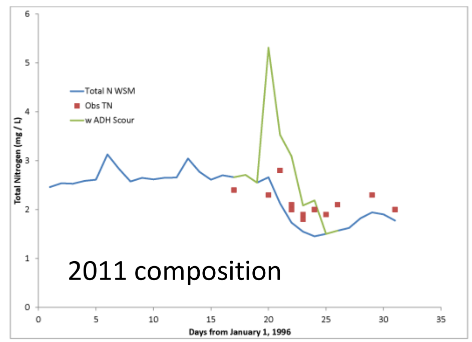
Calculate Scour Loads

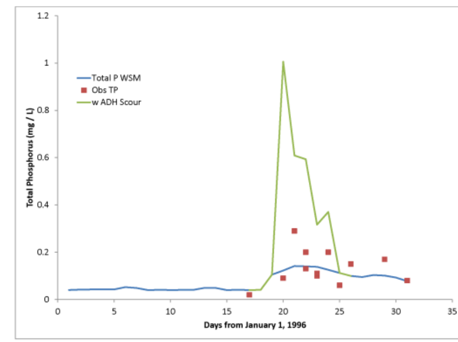


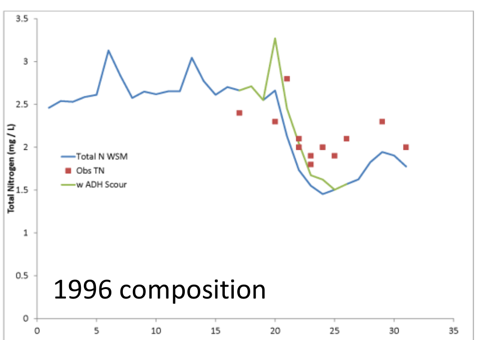


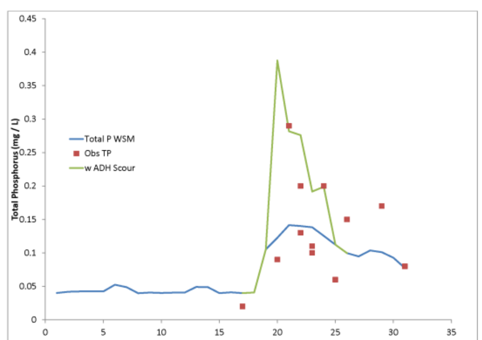
Interpolating ADH scour for Tropical Storm Lee provides good solids loads for January 1996.

Nutrient composition observed during 2011 Tropical Storm Lee is not appropriate for 1996



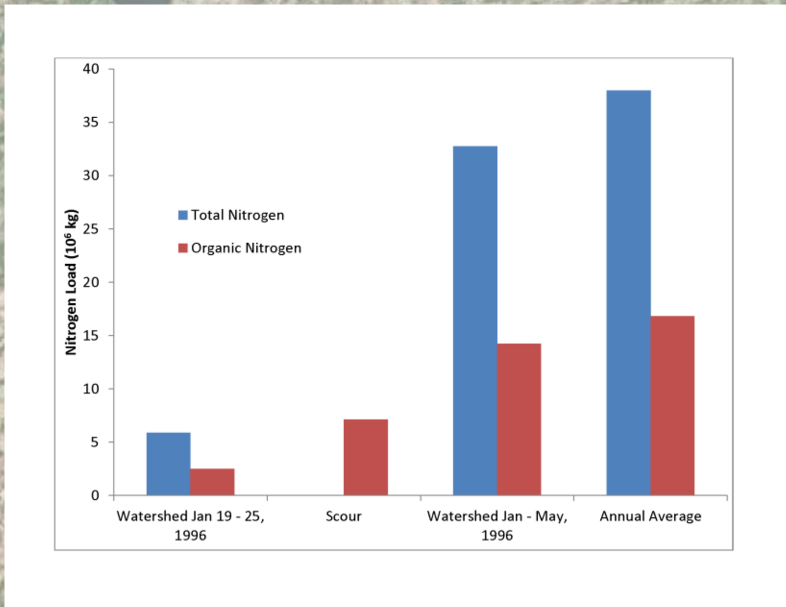


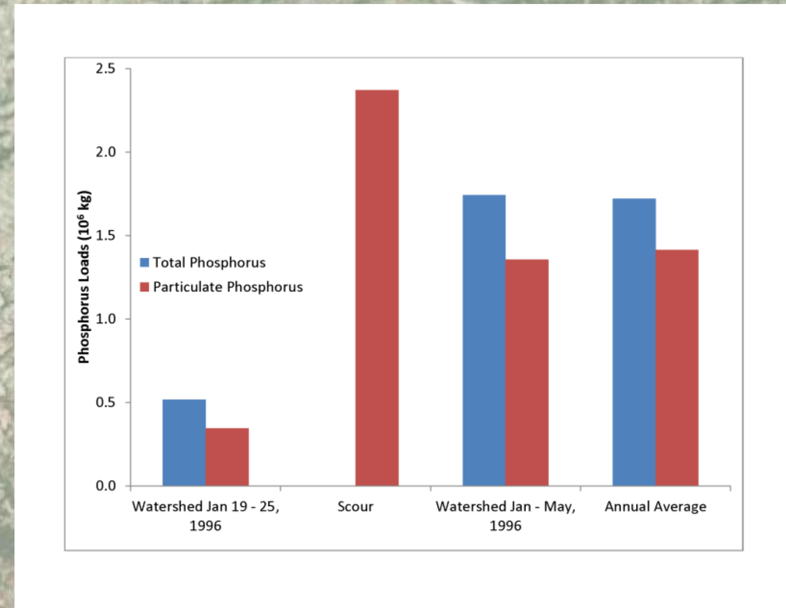




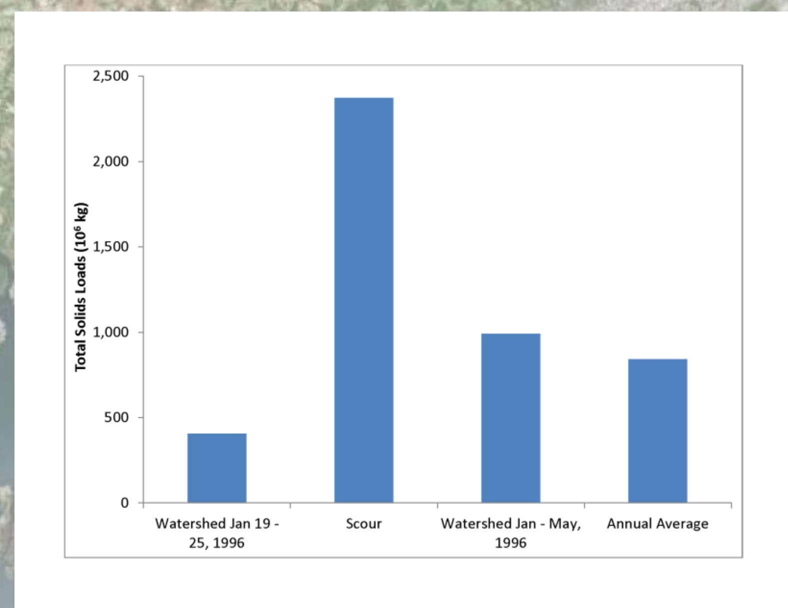
Solution: Run alternate scenarios with 1996, 2011 composition. More recent observations preferred for future projections.

1996 Scour Loads vs Watershed Loads

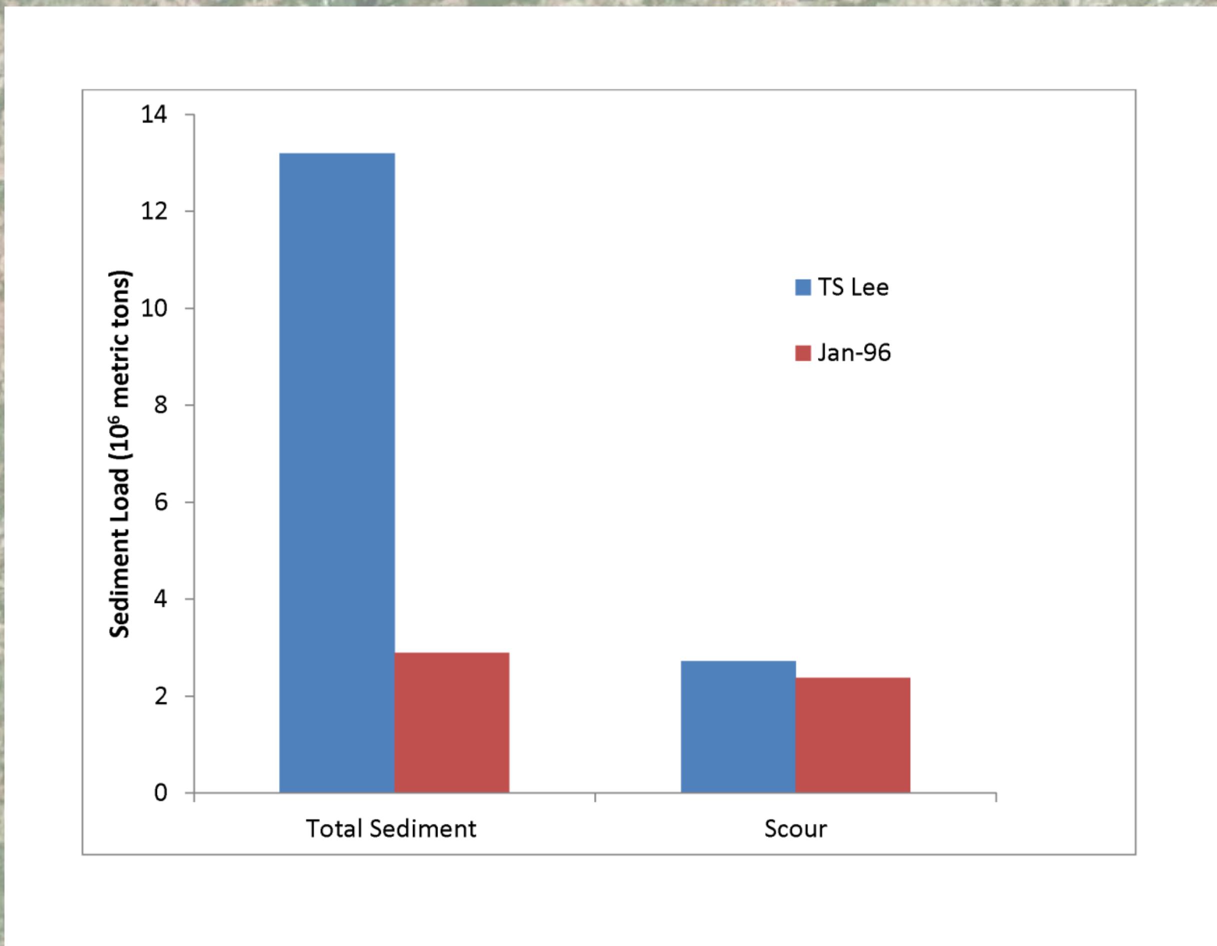




- The nitrogen scour load is greater than the TMDL watershed storm load but a small fraction of the annual average load.
- The phosphorus scour load is immense compared to the TMDL watershed storm load or the annual average load.
- The solids scour load is immense compared to the TMDL watershed storm load or the annual average load.
- ***The nitrogen scour load is three times the phosphorus scour load.***

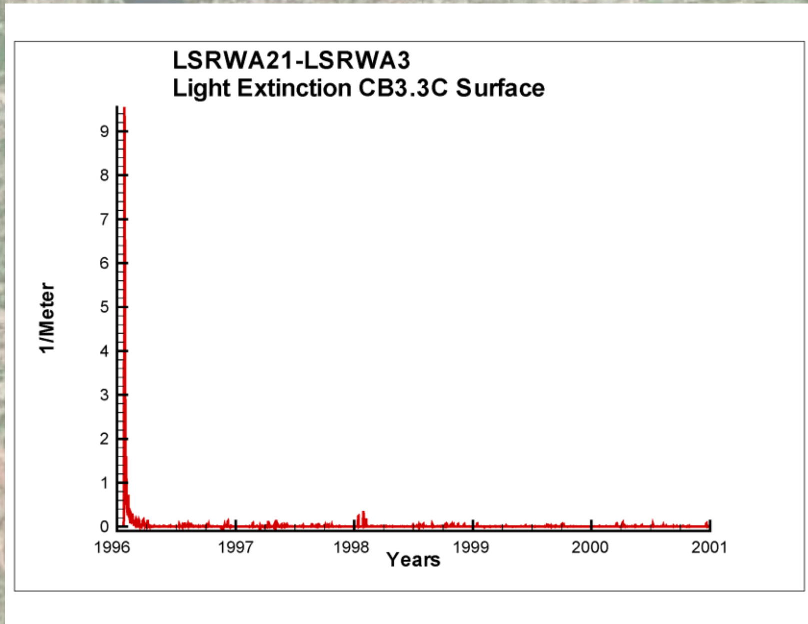


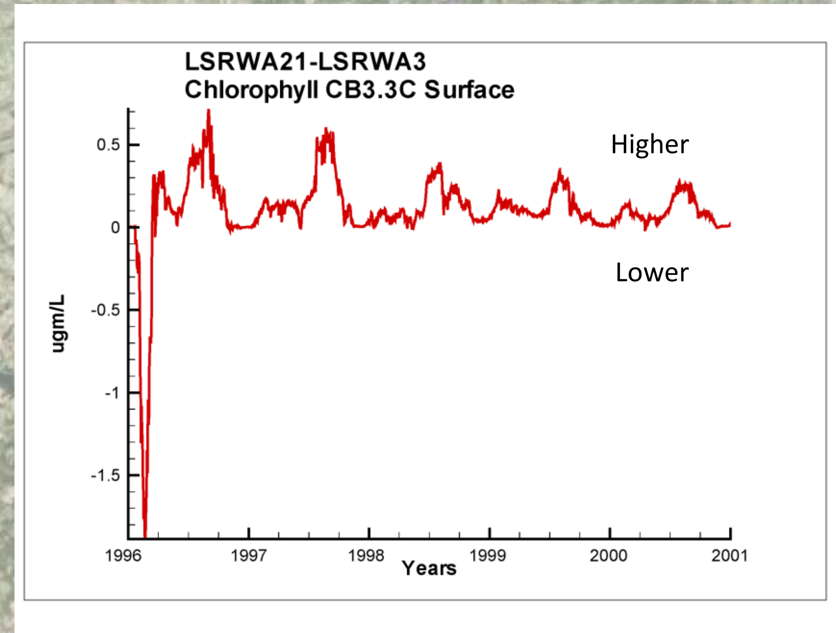
January 1996 vs. Tropical Storm Lee

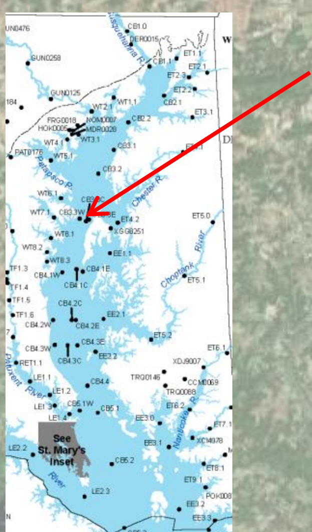


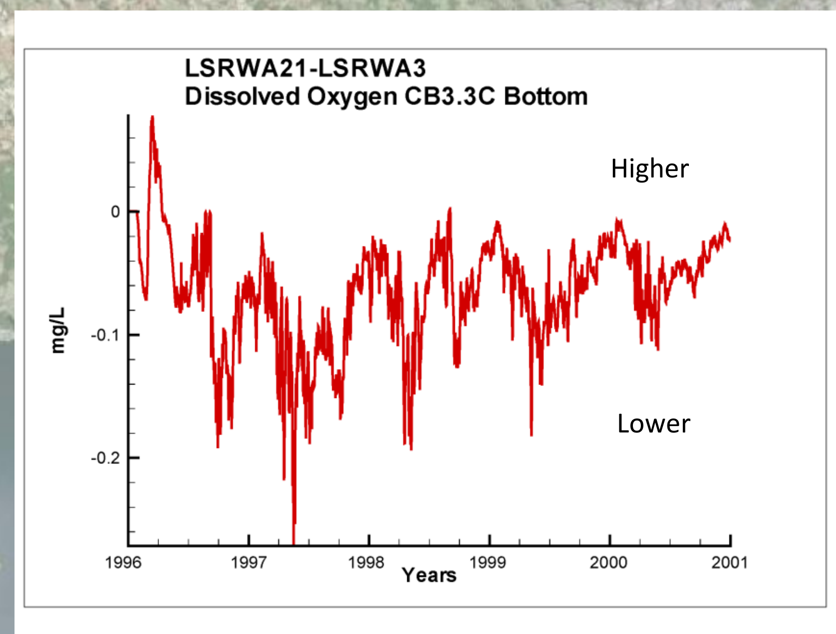
- The scour loads from the two events are similar. However, the watershed load from TS Lee vastly exceeded the watershed load in January 1996.
- Scour comprised 82% of the total sediment load during the January 1996 event but only21% of the total sediment load during TS Lee.
- It's hard to generalize about a "typical" "extreme" event.

Marginal Effect of a Scour Event on TMDL Conditions

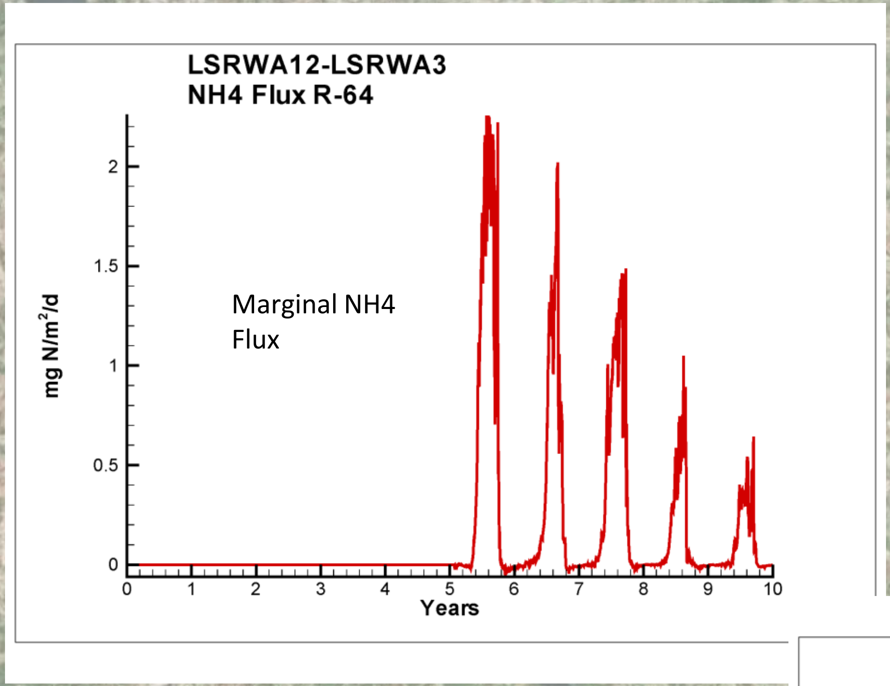


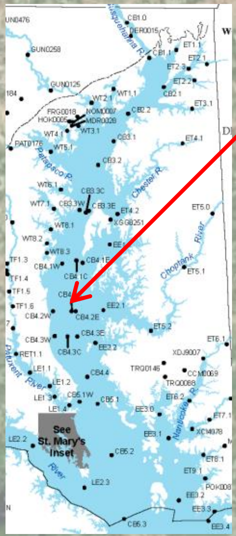


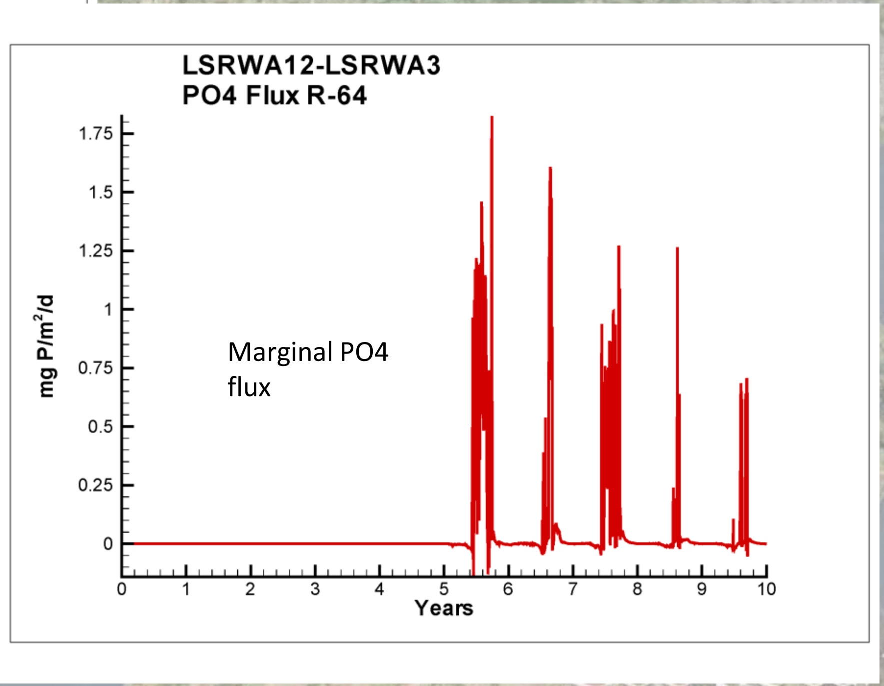




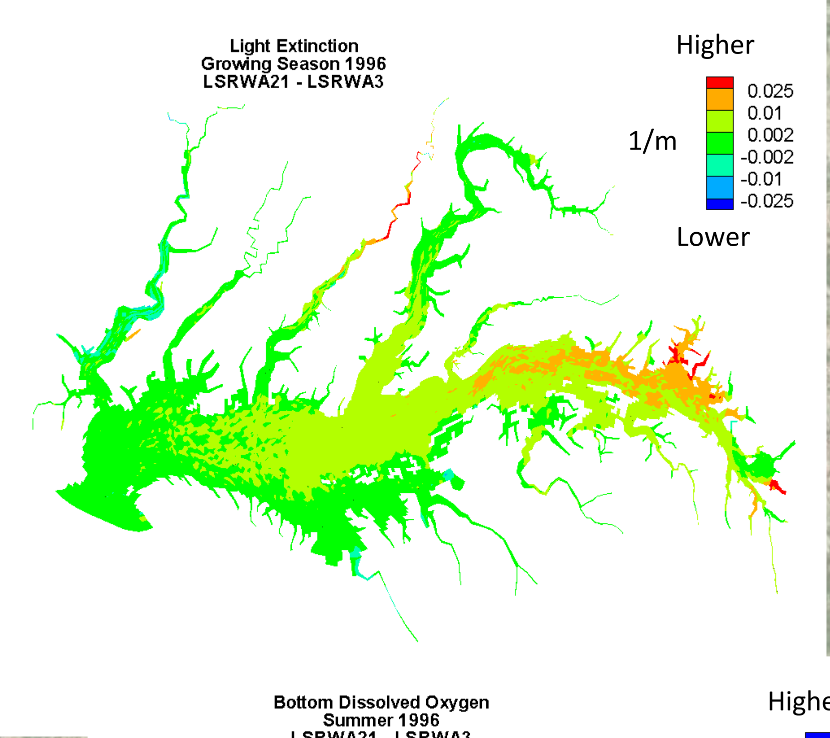
Enhanced Sediment Diagenesis due to Scoured Nutrients

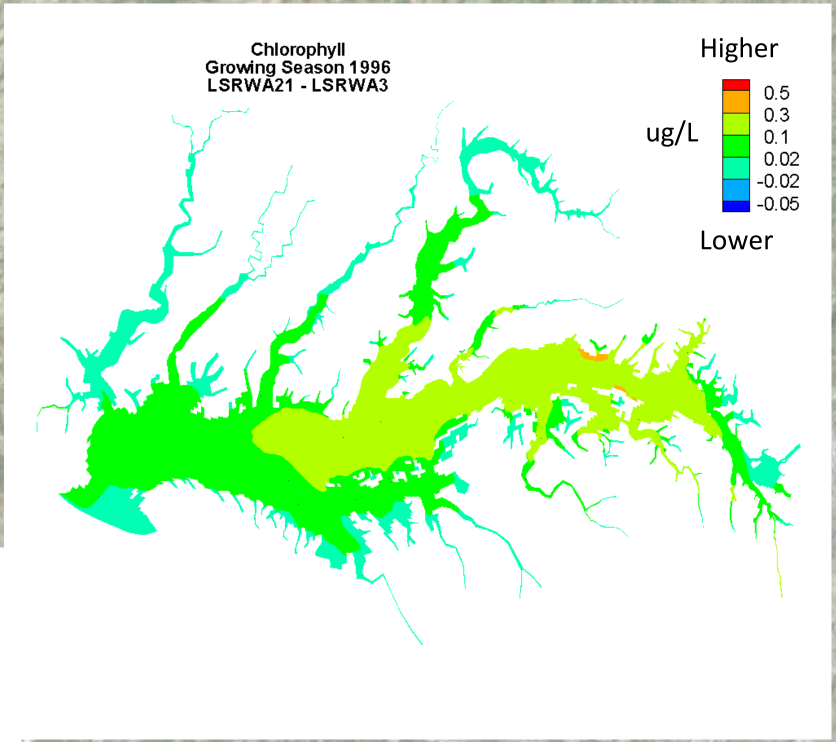


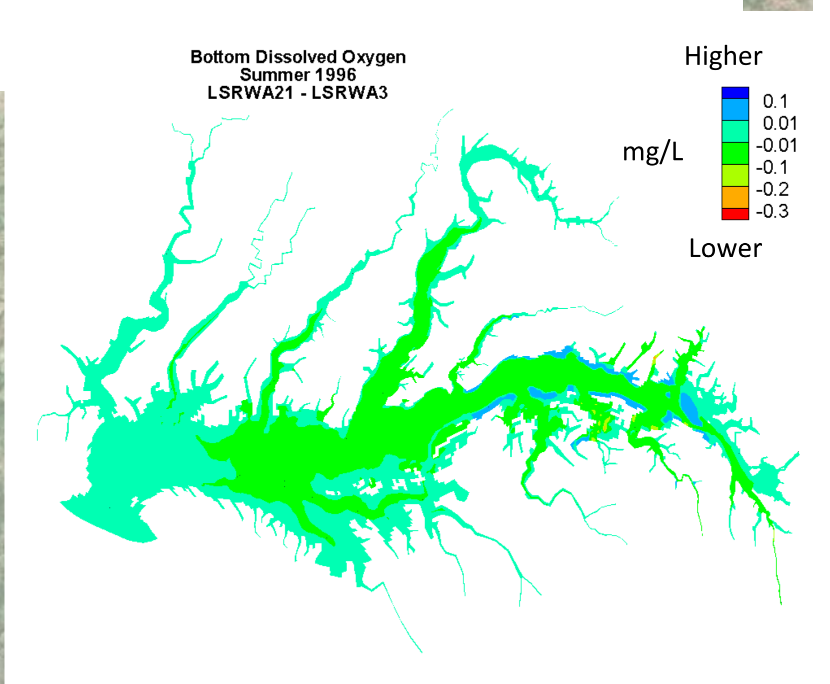




Marginal Effect of a Scour Event on TMDL Conditions





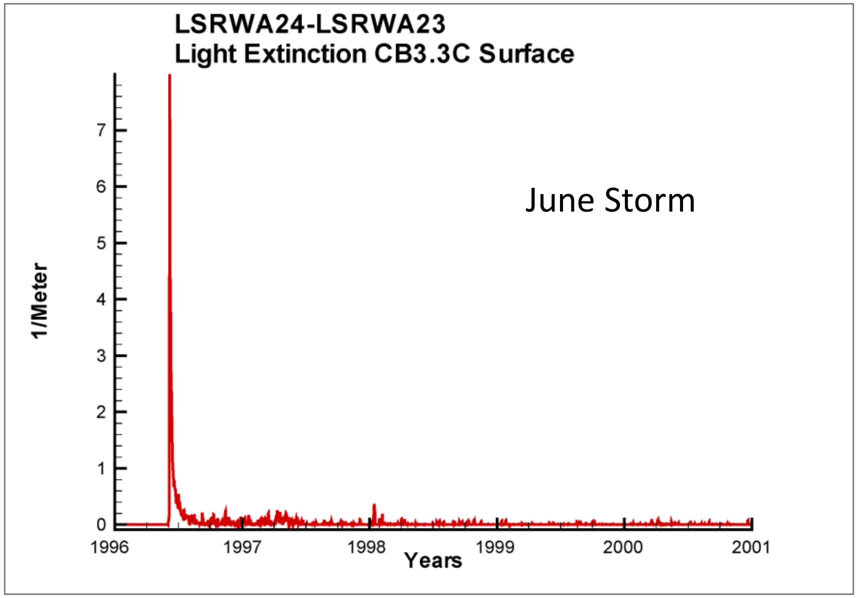


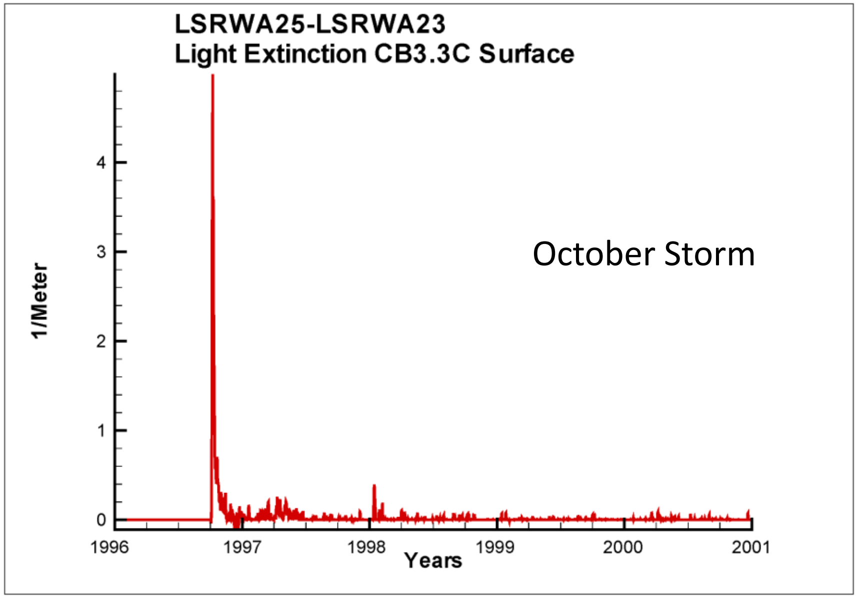
Google earth

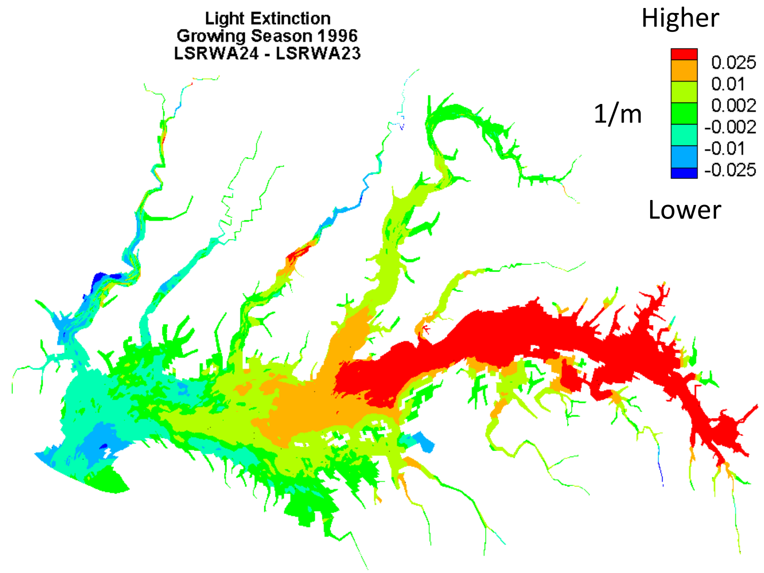
Sensitivity to Seasonality of Storm Events

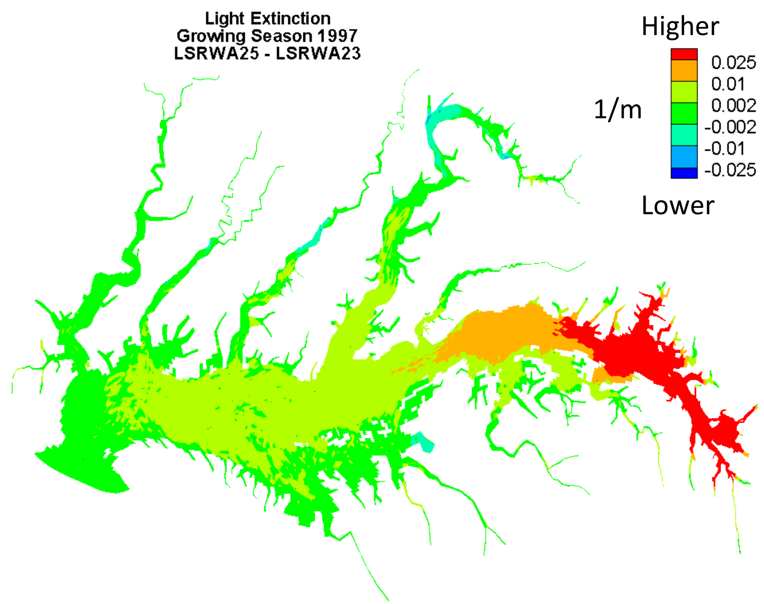
- Runoff events with flows sufficient to scour reservoir sediments occur at various times of the year.
- Floods occur in the Susquehanna in late winter and early spring due to precipitation and snowmelt.
- Tropical storm events are most common during late summer and early fall.
- The notorious Tropical Storm Agnes occurred in June 1972.
- To investigate the effect of storm season, scenarios were completed with the January 1996 Susquehanna storm flows and loads moved to June and October 1996. These were compared to a base scenario with the storm removed.

June vs October Storm

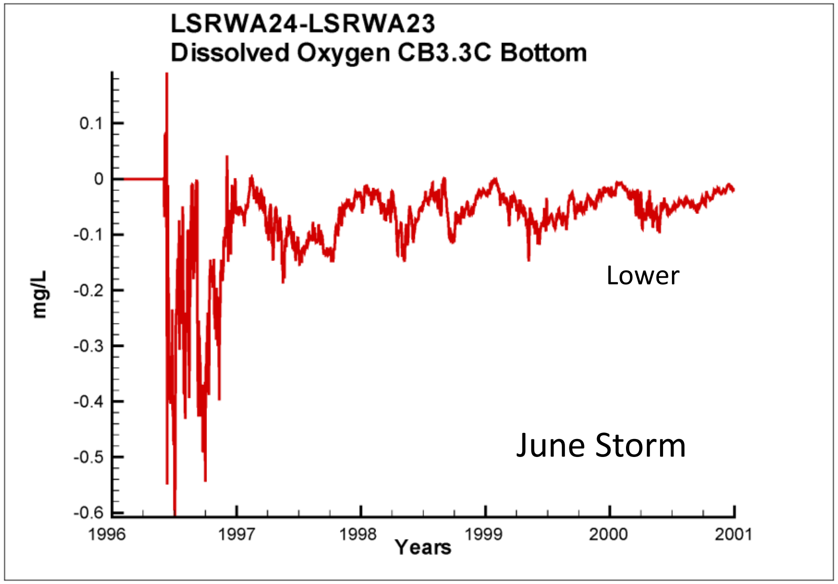


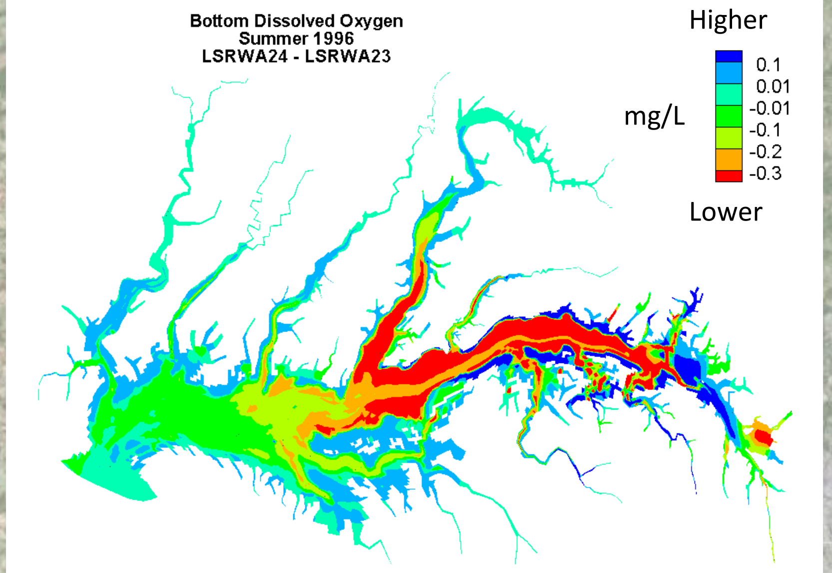


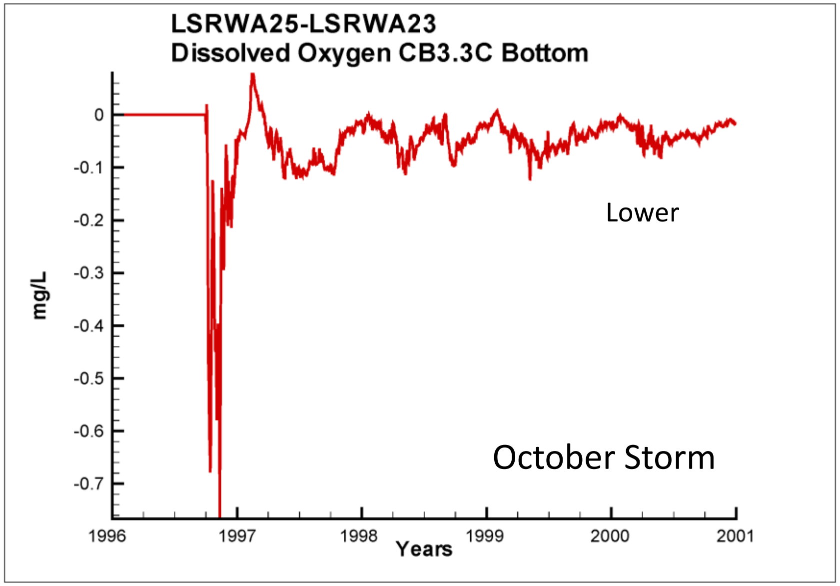


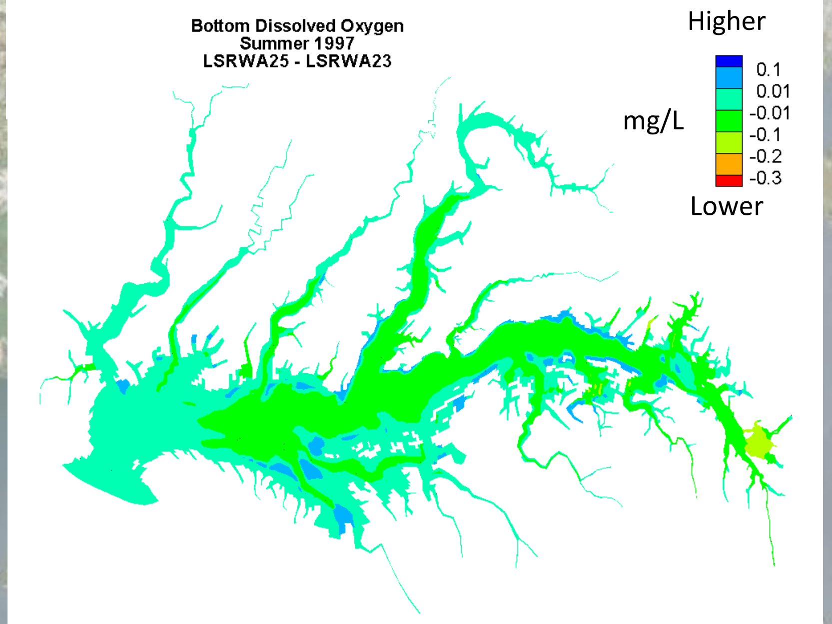


June vs October Storm









Conclusions

- A single scour event is not a cataclysm.
- The longer the interval between a storm event and the SAV growing season, the better (October > January > June).
- Solids scour loads are less of a menace than the accompanying nutrient loads.
- Nitrogen scour loads exceed phosphorus scour loads (N ≈ 3 x P)
- The major quantifiable threat of scour loads to the TMDL is to dissolved oxygen.
- By definition, an extreme event is unusual. It's difficult to generalize their characteristics or effects.