Lower Susquehanna River Watershed Assessment

- The EPA Chesapeake Bay program and the Baltimore District USACE are working in parallel with a lot of cross-over.
- We have four categories of model runs:
  - Step 1 – Remove Conowingo Reservoir from the system. This approach assumes instantaneous equilibrium between loads entering and leaving the reservoir.

Lower Susquehanna River Watershed Assessment

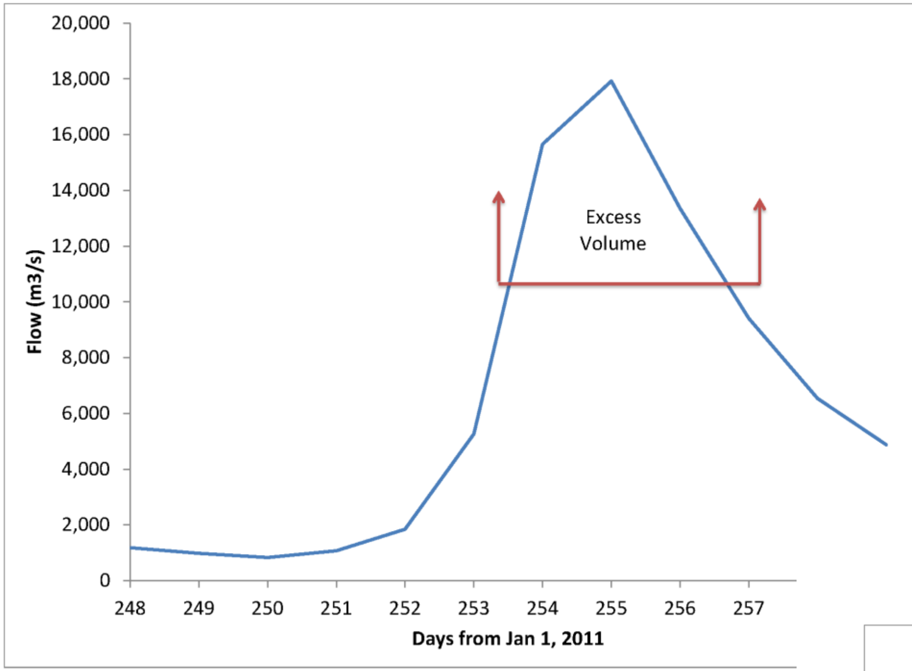
- Step 2 – Add scour to WSM representation of Conowingo Reservoir. The scour is calibrated for two cases:
  - 0% N, 50% P, 100% TSS increase in annual loads
  - 0% N, 70% P, 250% TSS increase in annual loads
- Scour for January 1996 event derived from ADH simulation of Conowingo Reservoir (CFC's favorite). Three bathymetries:
  - Current (2011) bathymetry
  - After 1996 scour event

Lower Susquehanna River Watershed Assessment

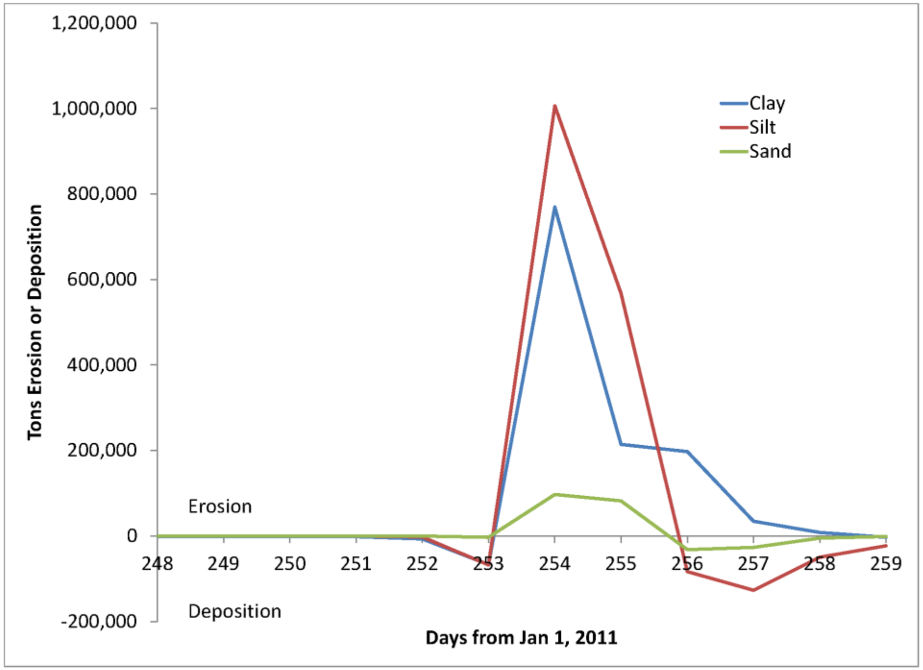
    - Reservoir-full conditions
  - Step 3 – Move the January 1996 storm event to alternate seasons of the year. Scour for one storm event from WSM with scour calibrated for 0% N, 50% P, 100% TSS increase in annual loads
- Each approach has its "pros and cons." The single event with scour based on ADH is the most realistic. Commonalities persist through all approaches. We'll have to reach a consensus on the ultimate effects.

Background

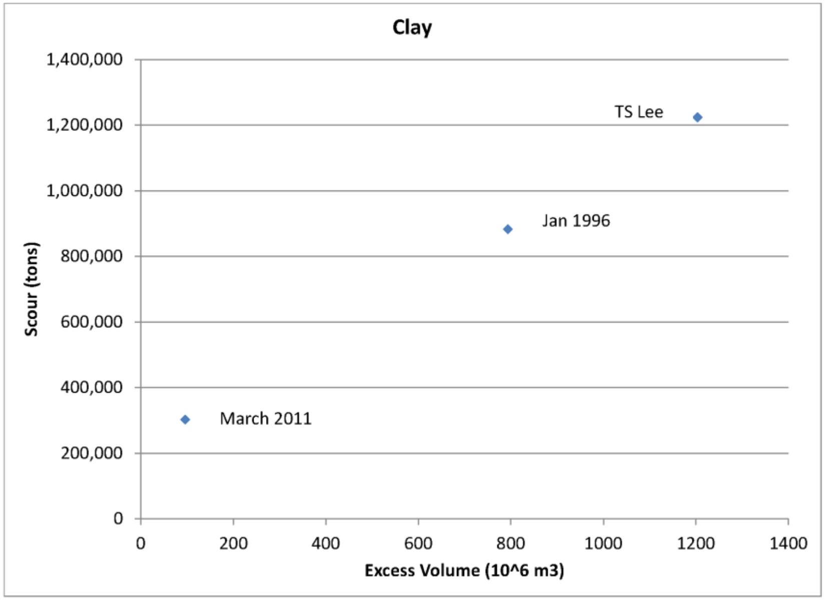
- ADH is the premier tool for computing sediment erosion, deposition, and transport in Conowingo Reservoir.
- The ADH application period, 2008 – 2011, contains two erosion events: Tropical Storm Lee and a small event in March 2011.
- We have three ADH runs based on alternate bathymetry:
  - Existing (2011) bathymetry,
  - Projected “Reservoir Full” bathymetry,
  - Bathymetry surveyed following 1996 scour event.
- ADH is not presently applied over our water quality simulation period, 1991 – 2000. We need a way to map computed erosion from 2011 to 1996.

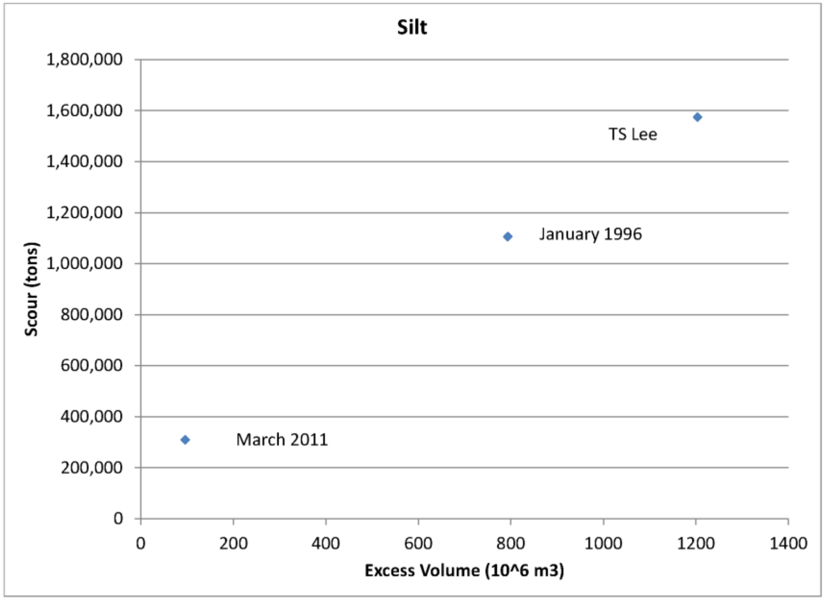


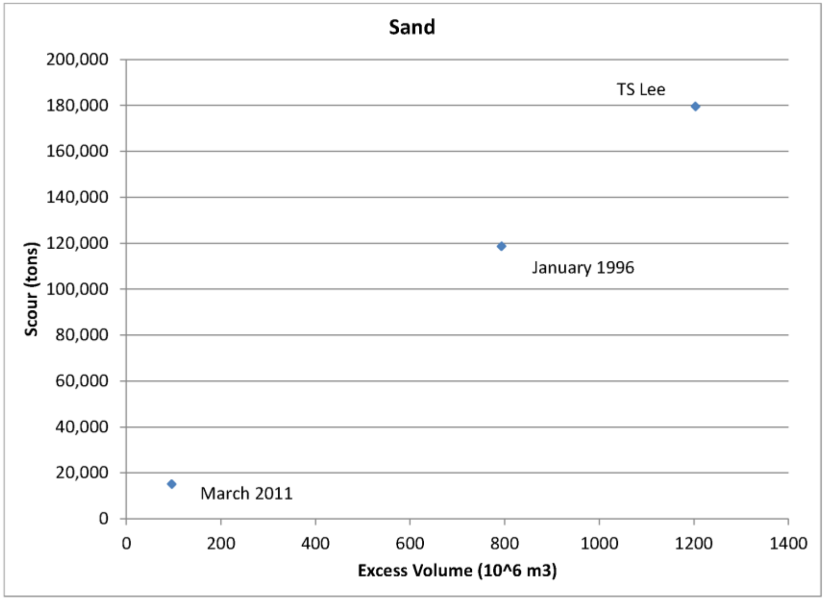
The greatest flow during TS Lee occurs on Day 255, the second day on which flow exceeds the criteria for scour: 11,000 m^3/s.



The greatest scour occurs on Day 254, the first day on which flow exceeds 11,000 m^3/s. After that, the bed armors.

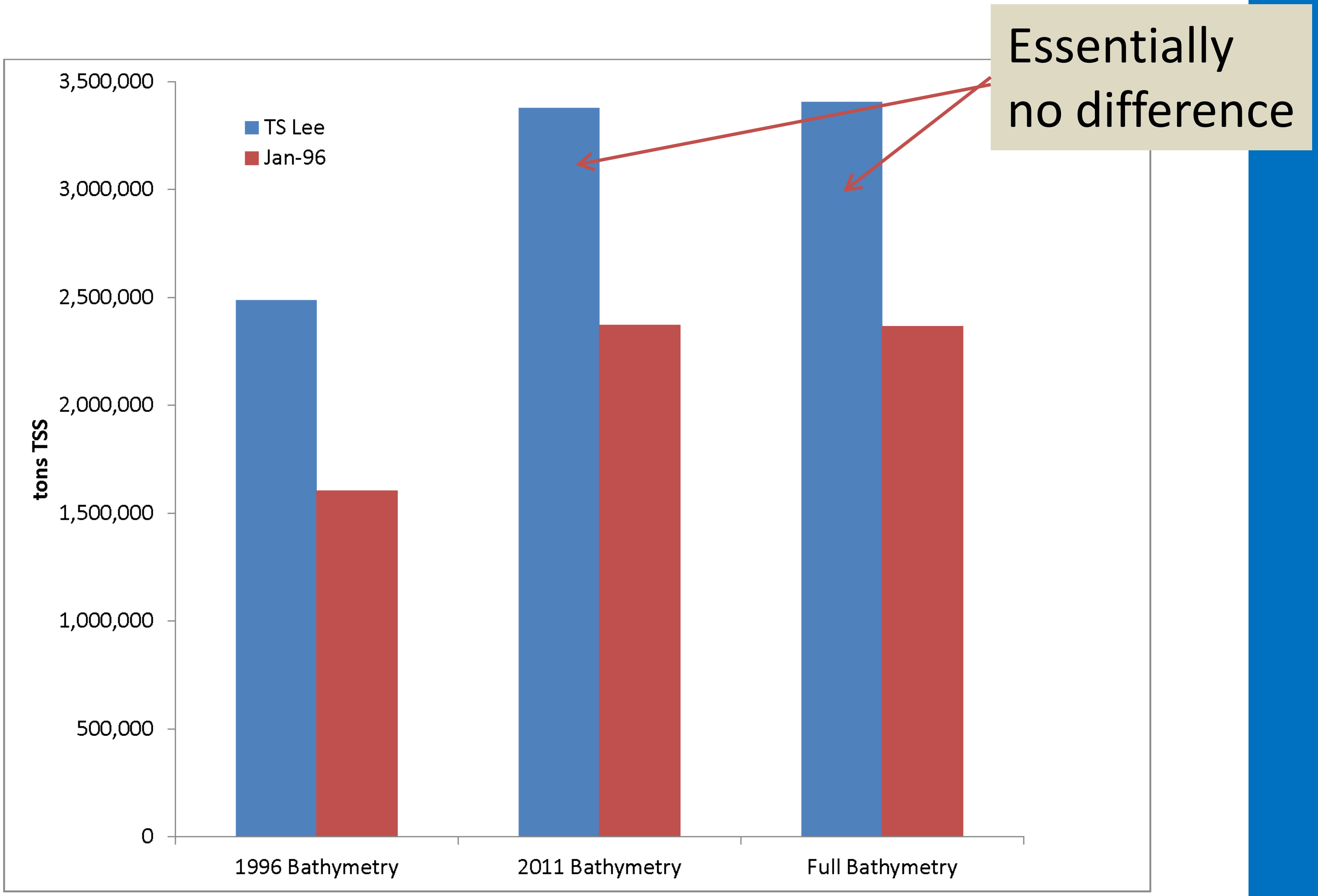




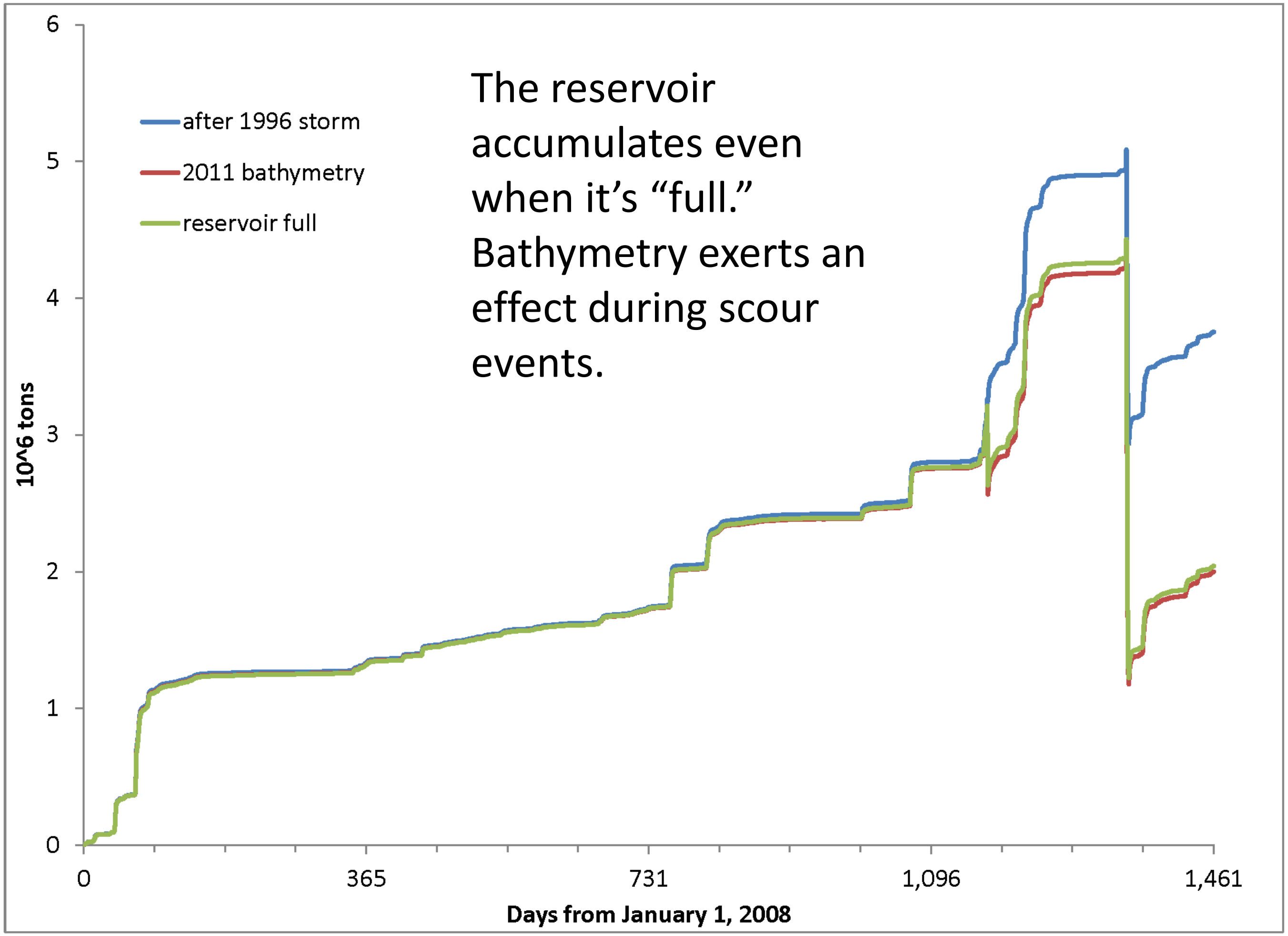


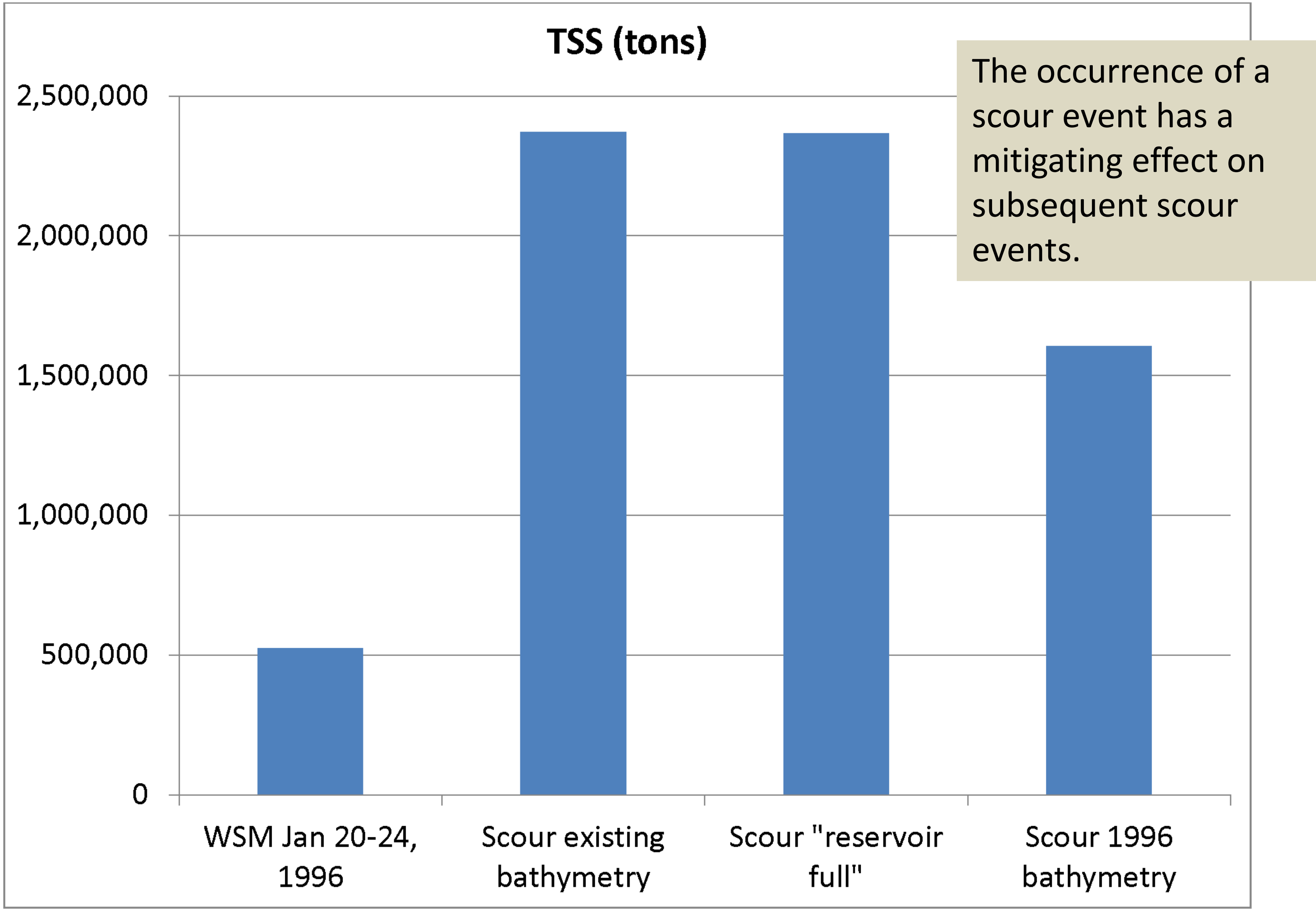
- Solids loads for January 1996 are based on excess volume. Interpolate between two events calculated for 2011.
- Nutrient and carbon loads based on bottom composition: 5% C, 0.3% N, 0.1%P.
- Add the scour loads to the WSM loads. No other adjustment to the WSM loads.

TSS Scour from ADH

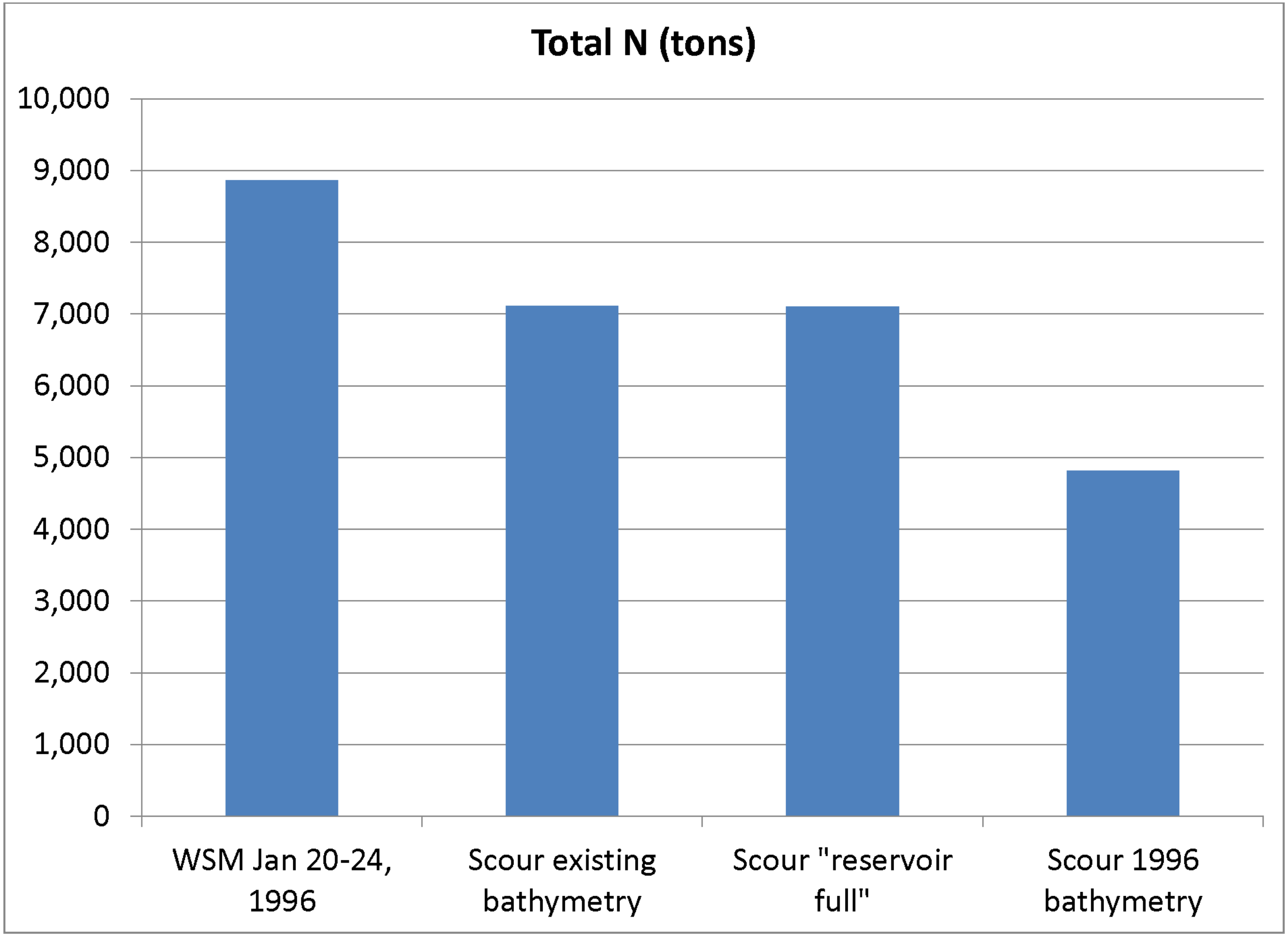


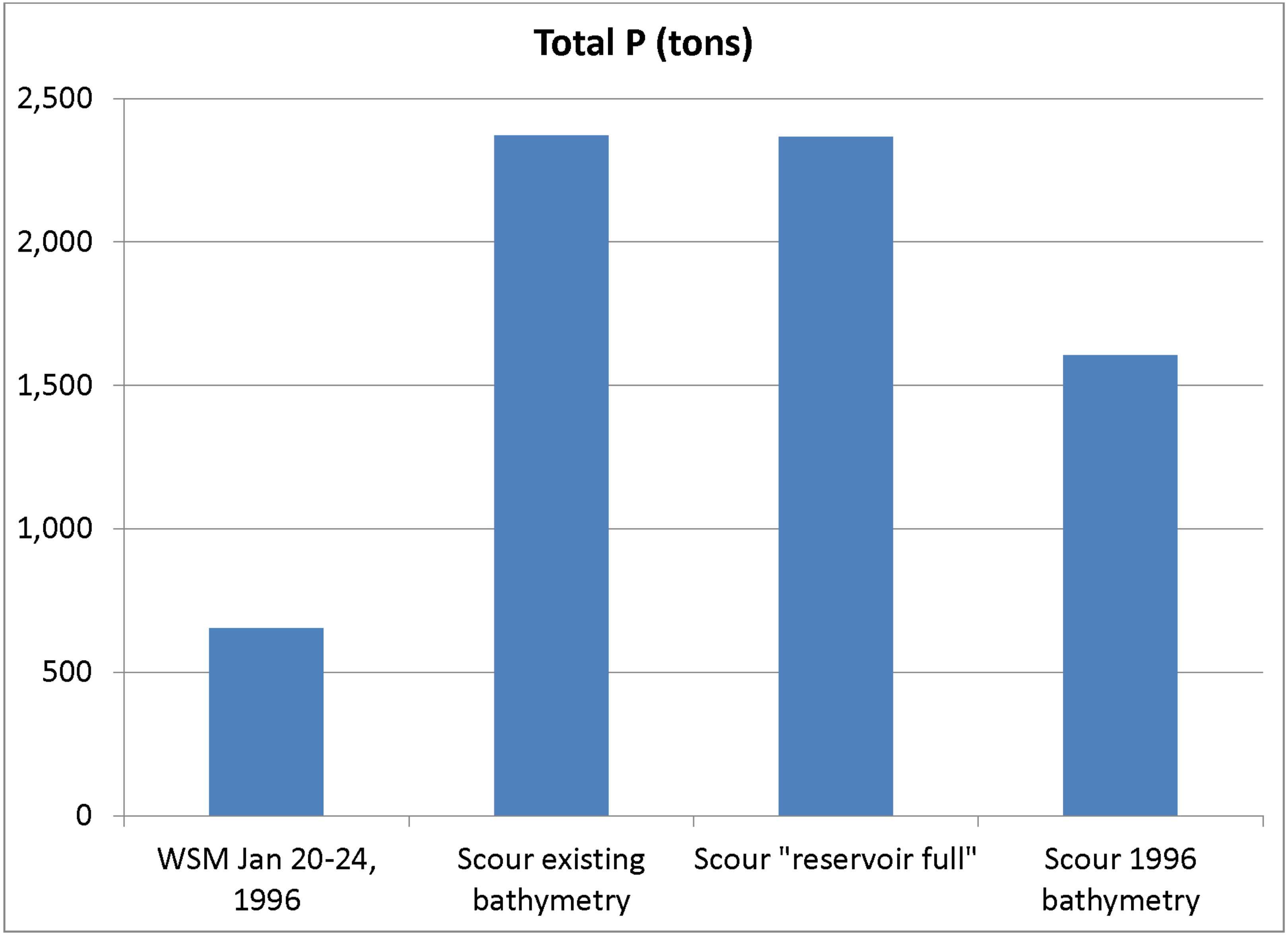
Cumulative Deposition

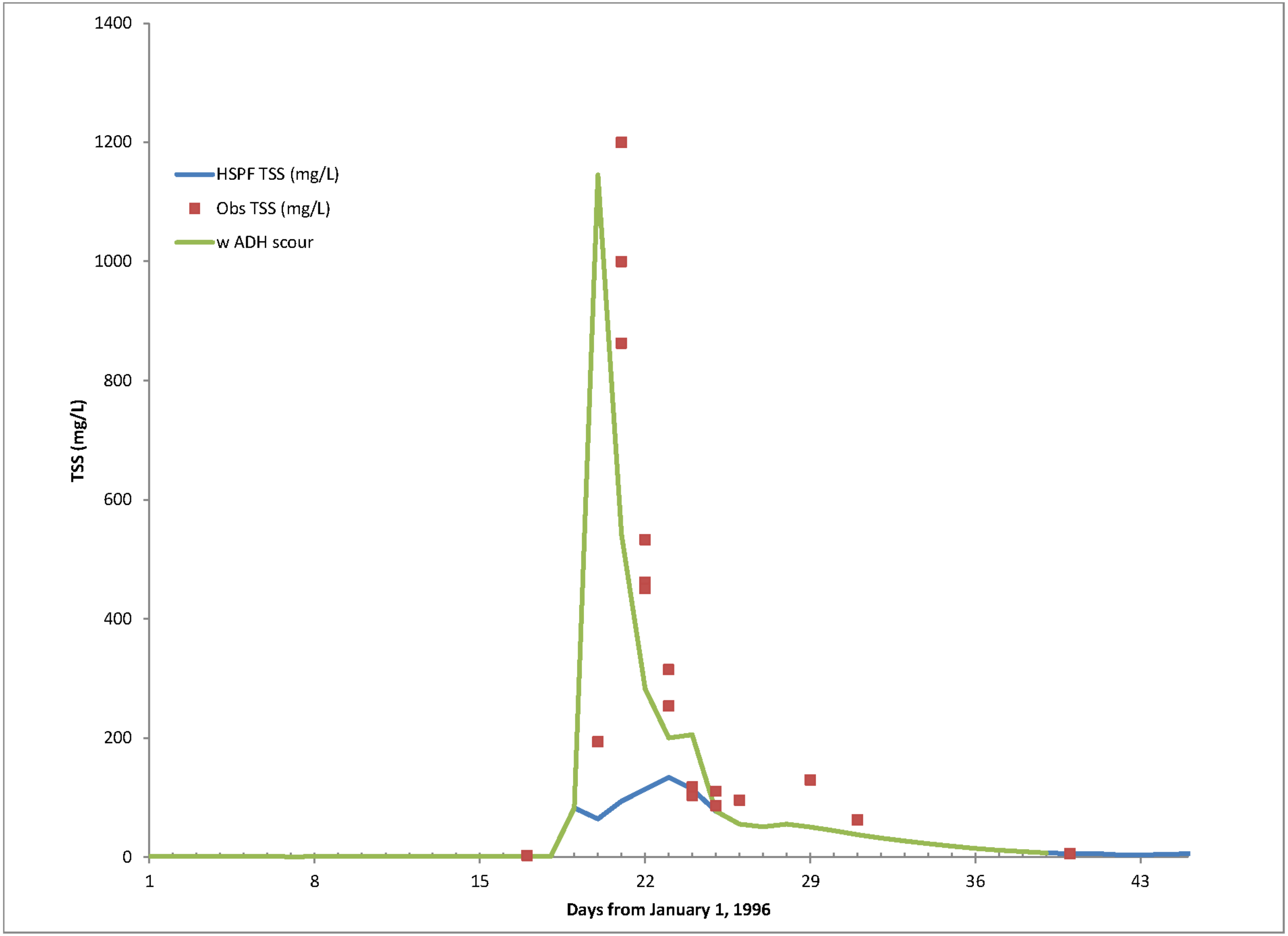




TSS (tons)
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
WSM Jan 20-24, 1996
Scour existing bathymetry
Scour "reservoir full"
Scour 1996 bathymetry
The occurrence of a scour event has a mitigating effect on subsequent scour events.

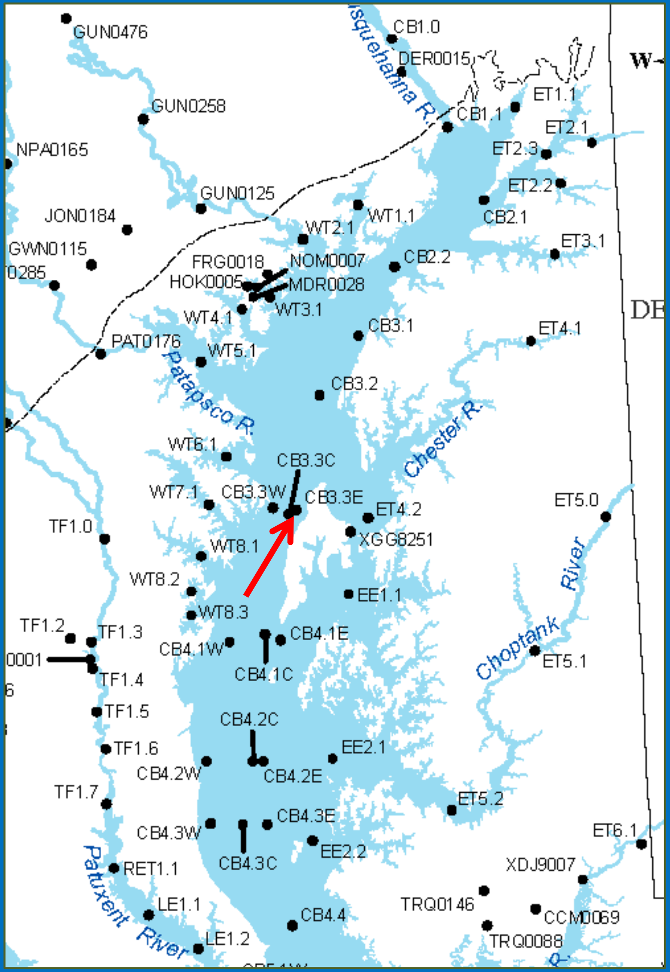

Total N (tons)
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
WSM Jan 20-24, 1996
Scour existing bathymetry
Scour "reservoir full"
Scour 1996 bathymetry


Total P (tons)
2,500
2,000
1,500
1,000
500
0
WSM Jan 20-24, 1996
Scour existing bathymetry
Scour "reservoir full"
Scour 1996 bathymetry

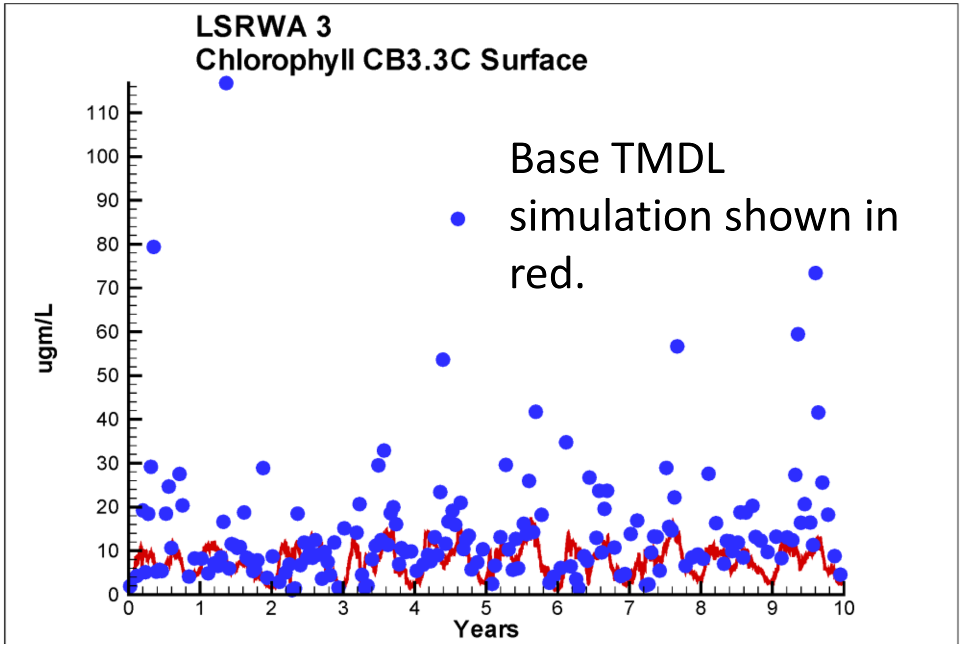


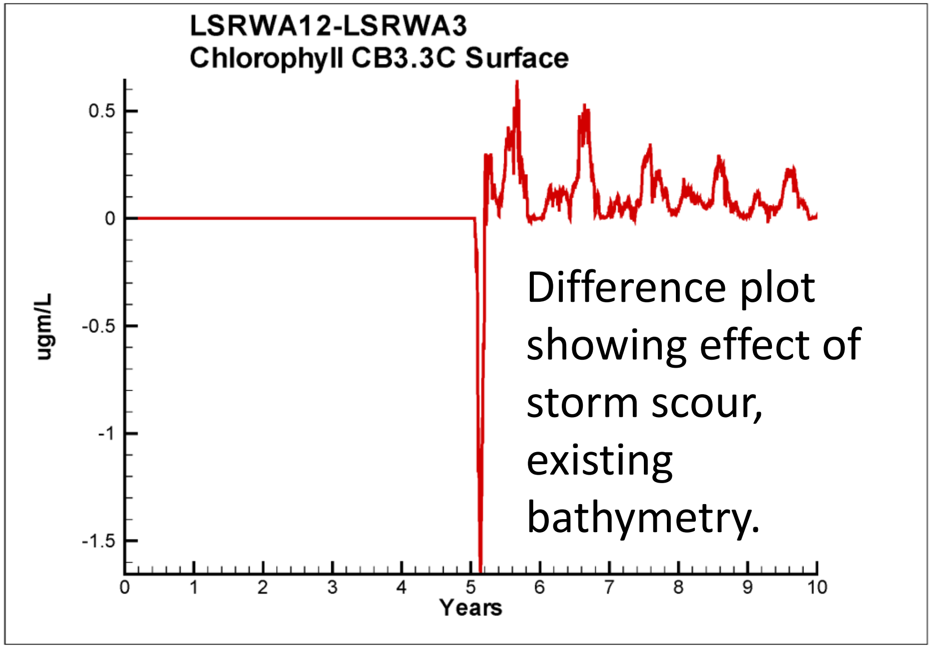
1400
1200
1000
800
600
400
200
0
TSS (mg/L)
HSPF TSS (mg/L)
Obs TSS (mg/L)
w ADH scour
1
8
15
22
29
36
43
Days from January 1, 1996

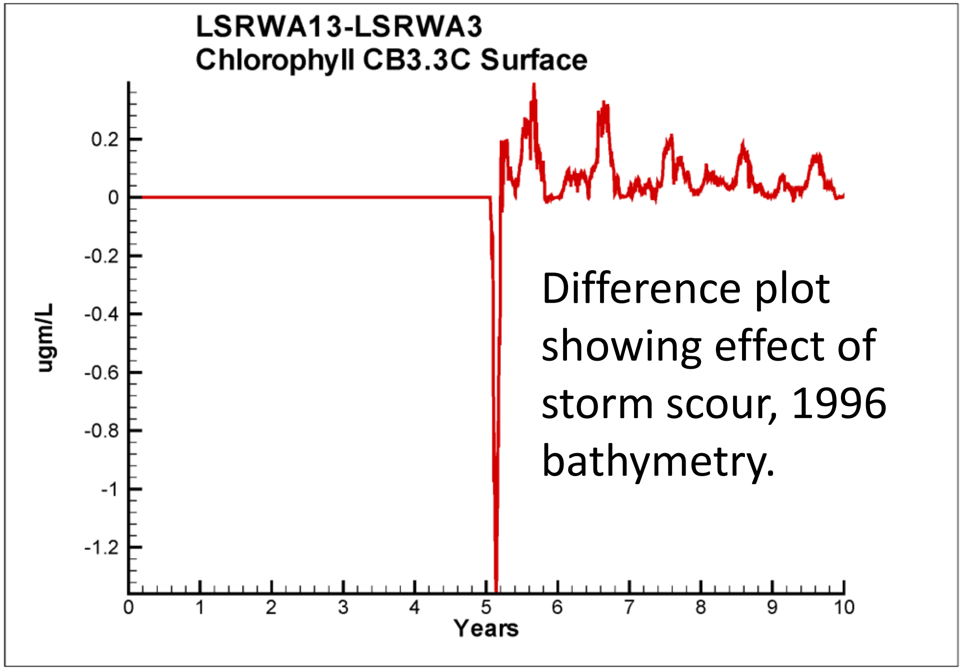
Model Results

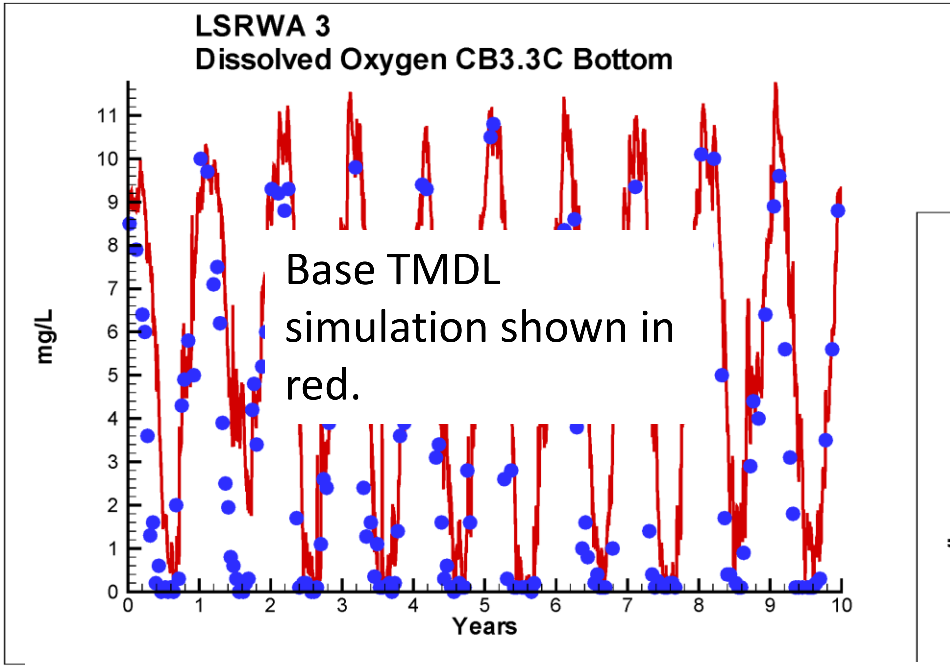


- Let’s concentrate on the TMDL (WIP) run.
- We’ll look at time series at CB3.3C and at spatial plots in summer 1996 (first summer after storm).

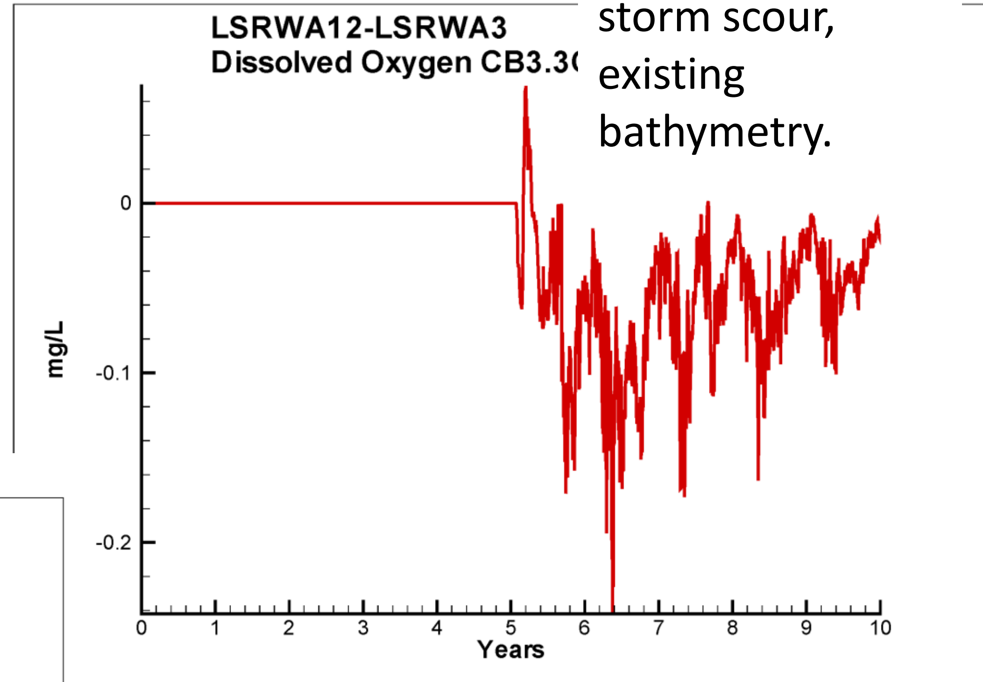

LSRWA 3
Chlorophyll CB3.3C Surface
ugm/L
Years
Base TMDL simulation shown in red.


LSRWA12-LSRWA3
Chlorophyll CB3.3C Surface
ugm/L
Years
Difference plot showing effect of storm scour, existing bathymetry.

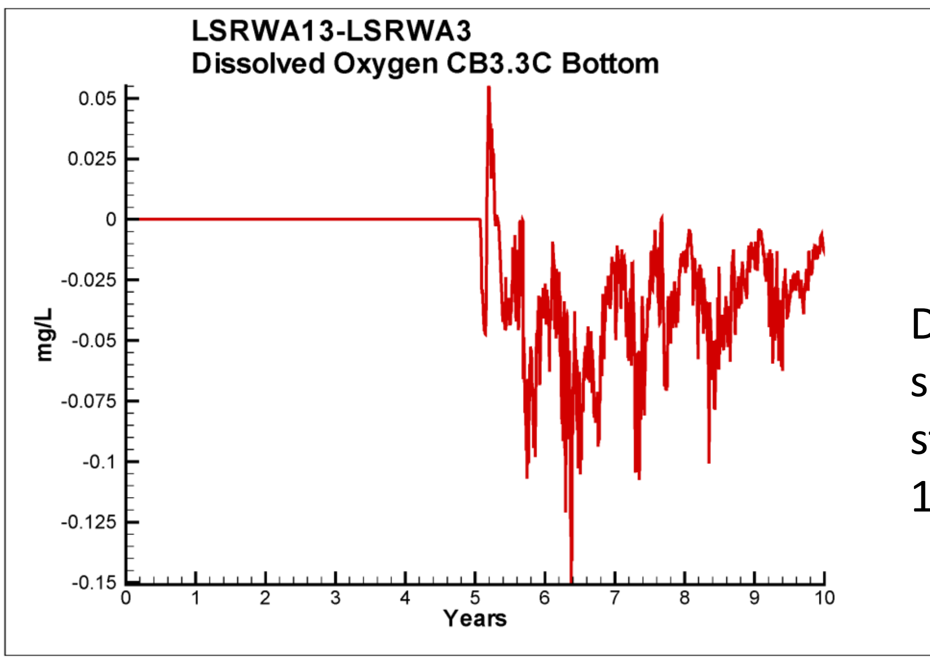

LSRWA13-LSRWA3
Chlorophyll CB3.3C Surface
ugm/L
Years
Difference plot showing effect of storm scour, 1996 bathymetry.



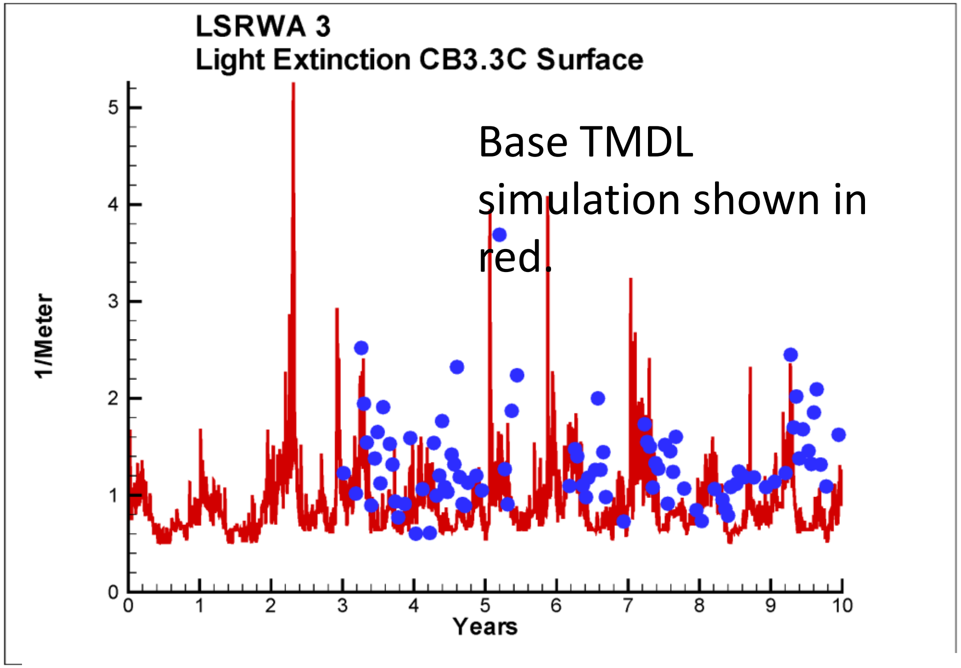
Base TMDL simulation shown in red.

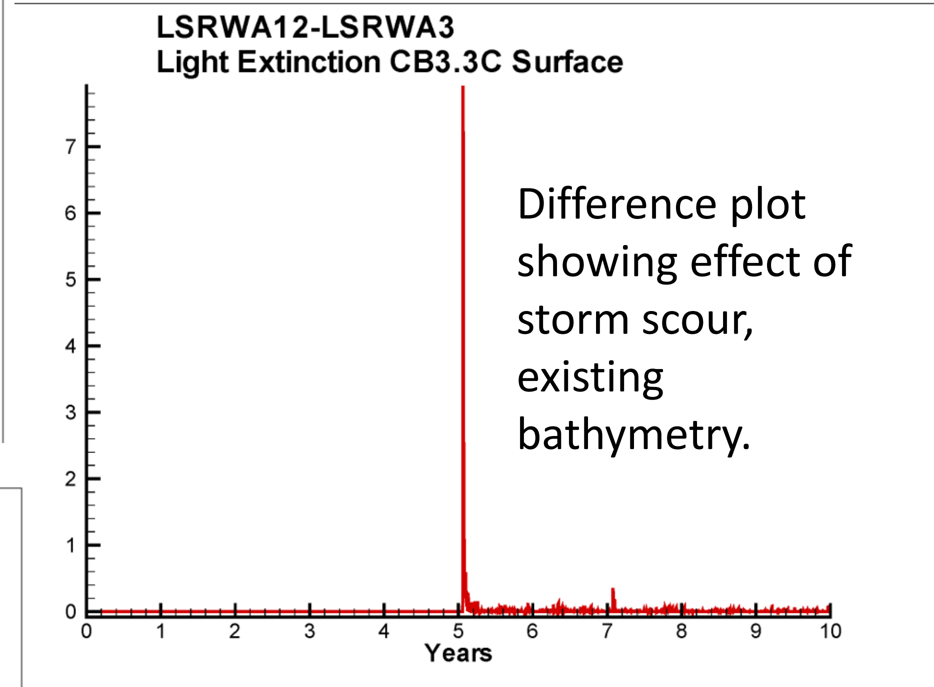


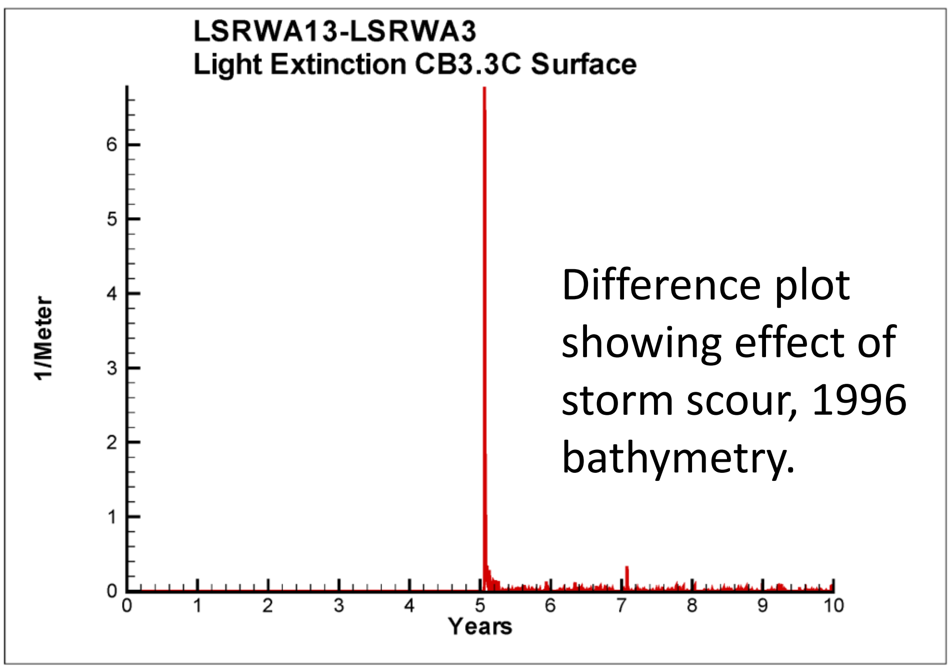
Difference plot showing effect of storm scour, existing bathymetry.

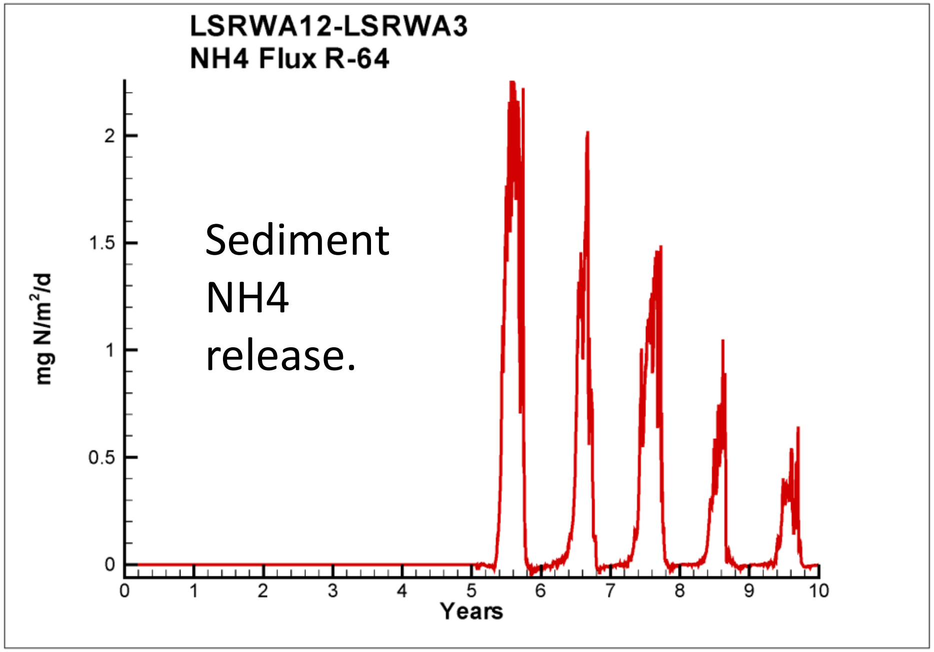


Difference plot showing effect of storm scour, 1996 bathymetry.

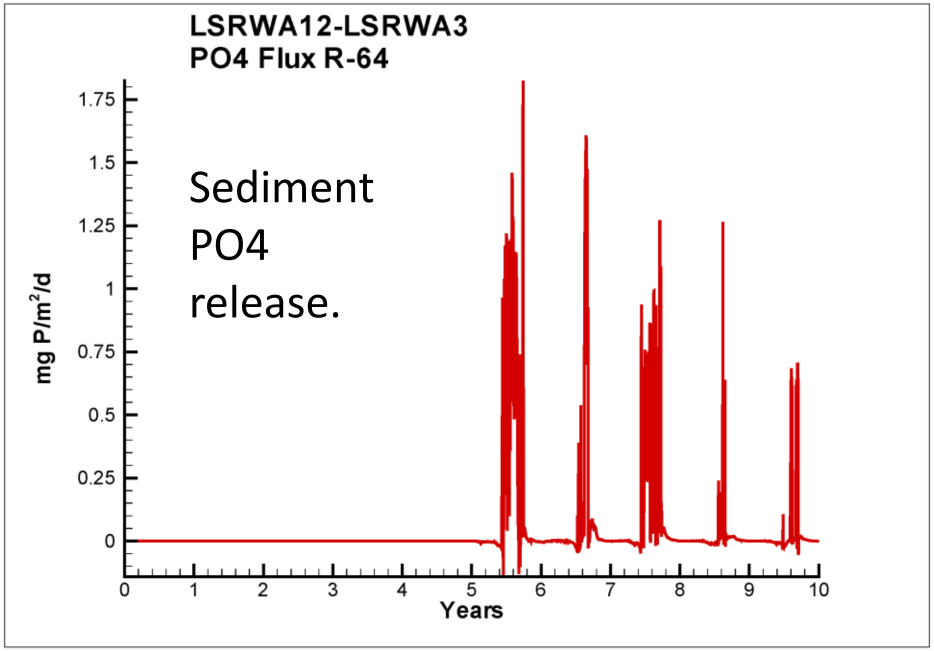

LSRWA 3
Light Extinction CB3.3C Surface
Base TMDL simulation shown in red.
1/Meter
0
1
2
3
4
5
0 1 2 3 4 5 6 7 8 9 10
Years

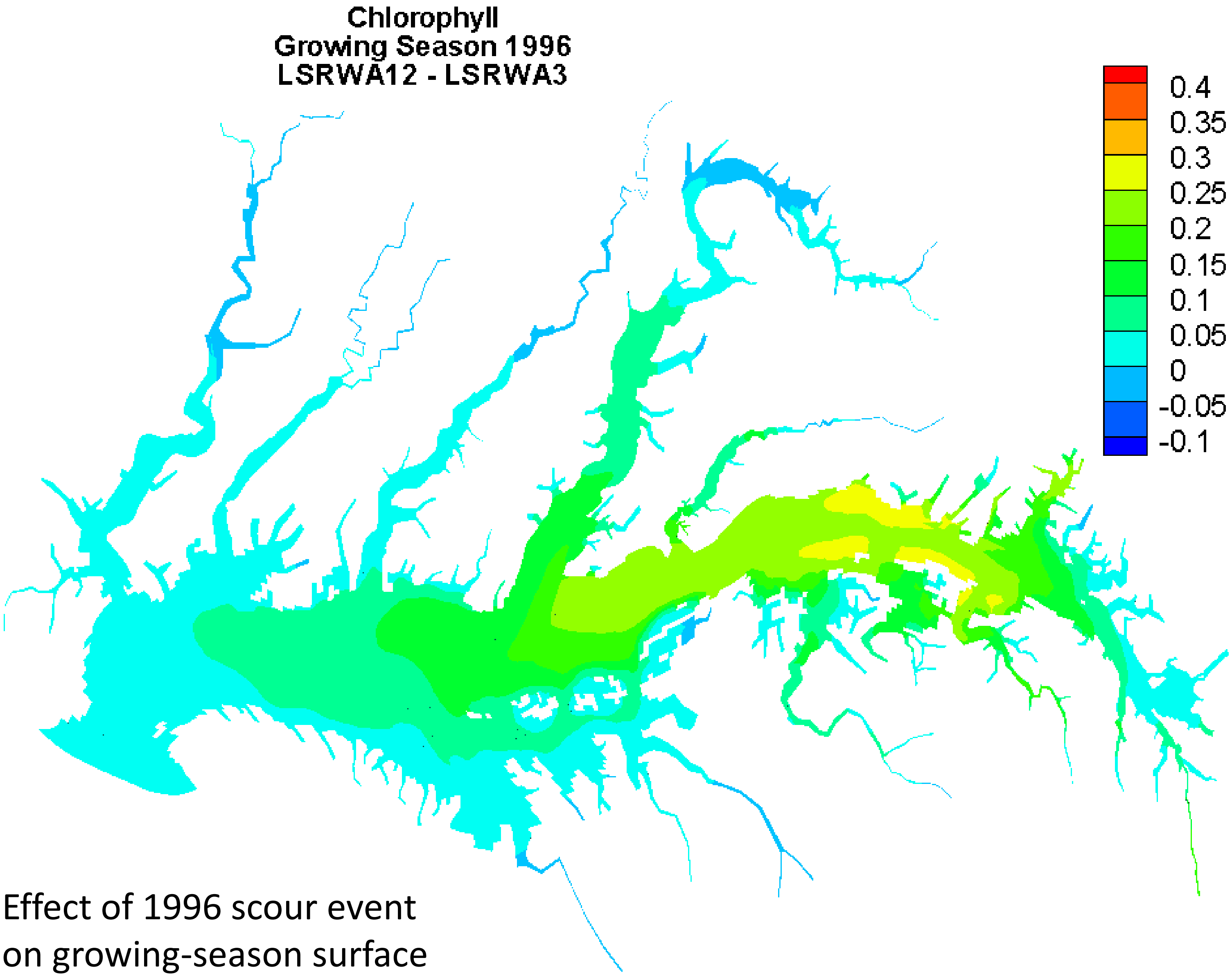

LSRWA12-LSRWA3
Light Extinction CB3.3C Surface
Difference plot showing effect of storm scour, existing bathymetry.
0
1
2
3
4
5
6
7
0 1 2 3 4 5 6 7 8 9 10
Years


LSRWA13-LSRWA3
Light Extinction CB3.3C Surface
Difference plot showing effect of storm scour, 1996 bathymetry.
1/Meter
0
1
2
3
4
5
6
0 1 2 3 4 5 6 7 8 9 10
Years

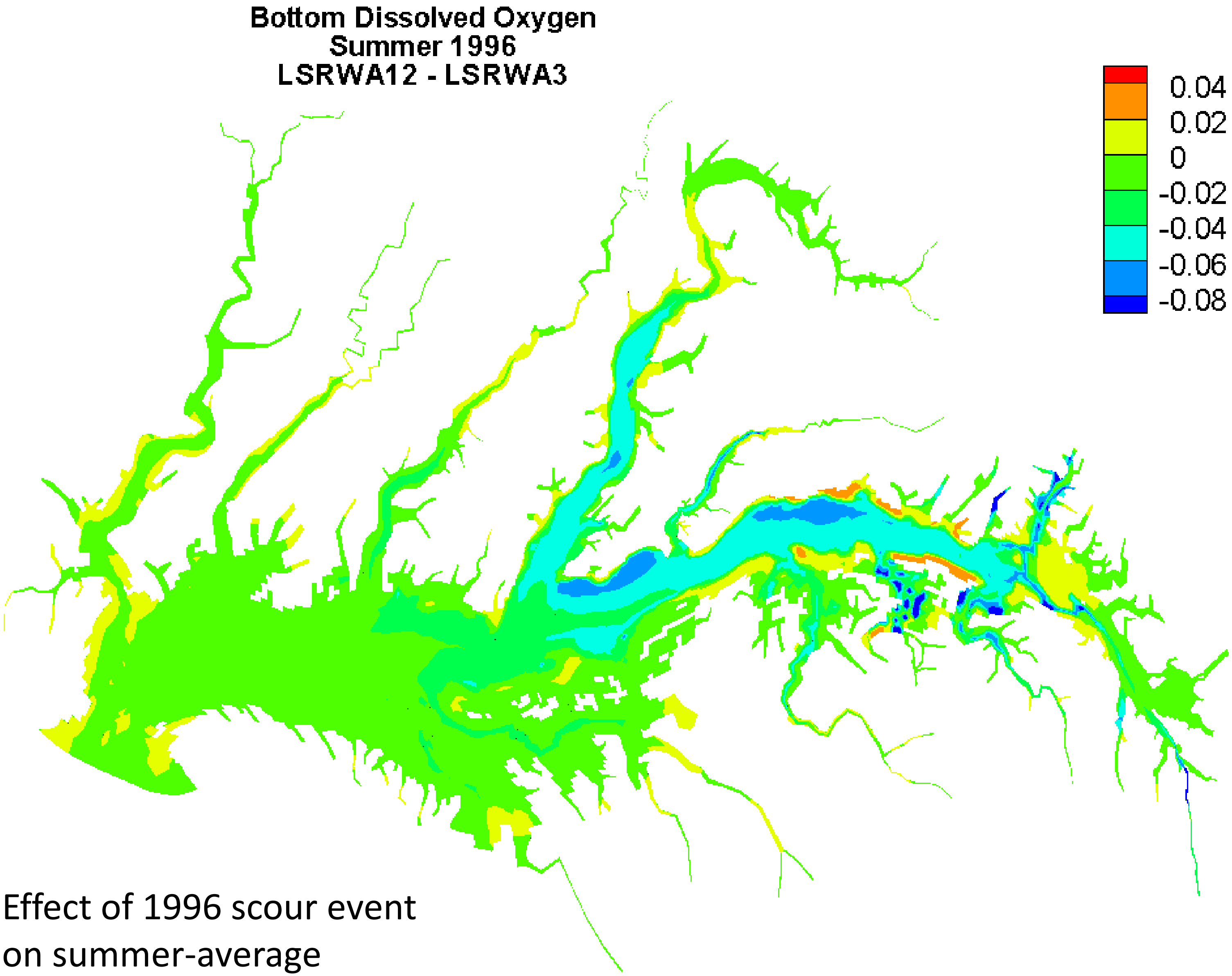


What's happening? Nutrients from the scour event deposit in bottom sediments and persist for years. Solids from scour event are inert after deposition.

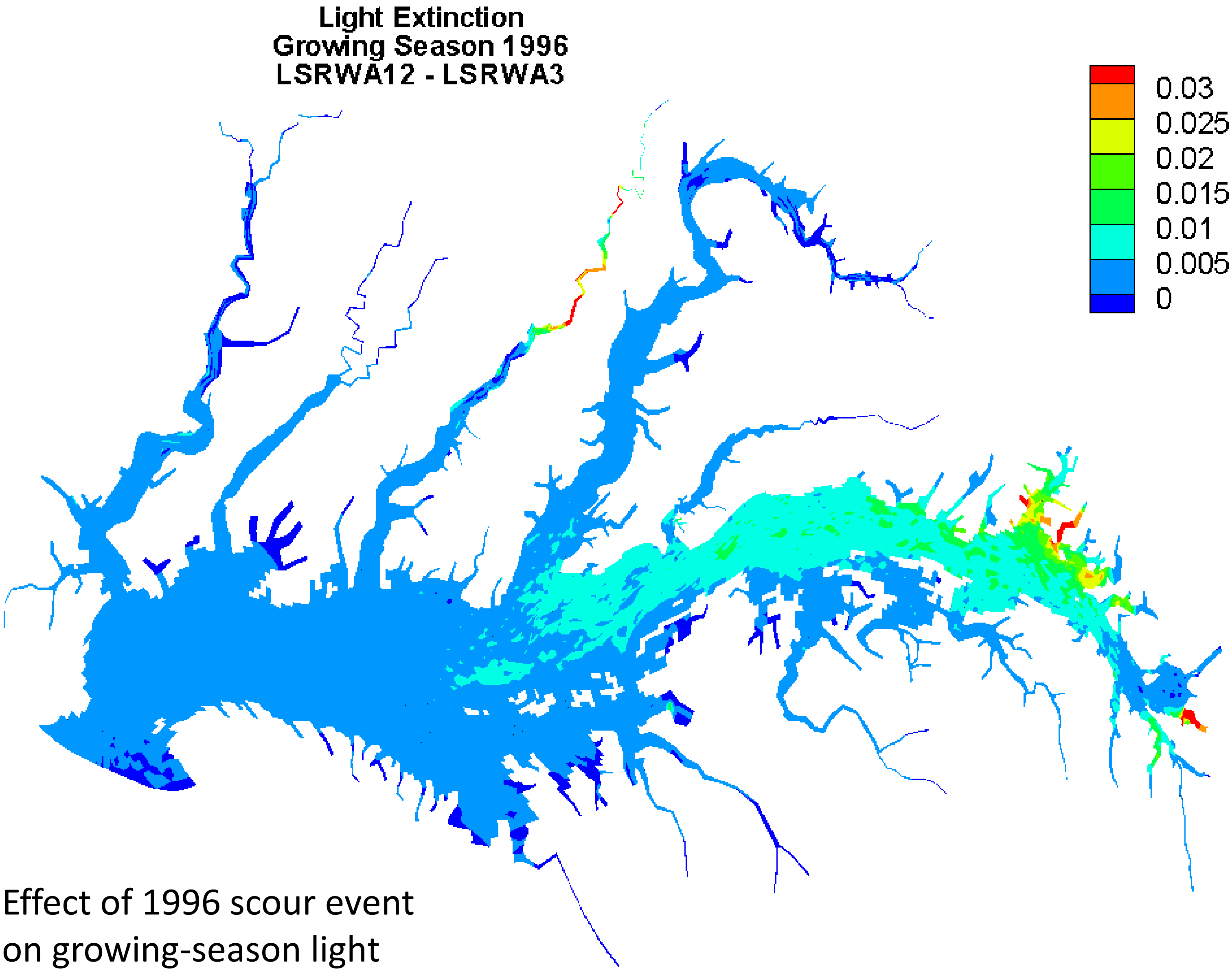




Effect of 1996 scour event on growing-season surface CHL, TMDL loads, existing bathymetry.



Effect of 1996 scour event on summer-average bottom DO, TMDL loads, existing bathymetry.



Effect of 1996 scour event on growing-season light attenuation, TMDL loads, existing bathymetry.

Let’s Switch Gears

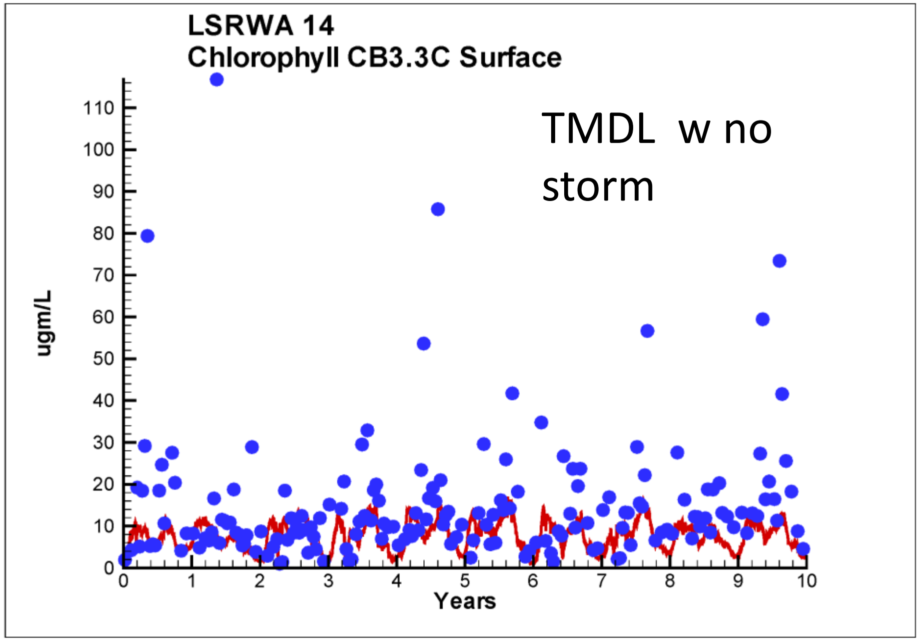
- We have been examining the effect of an erosion event. What about the timing of the event?
- CBP has produced hydrodynamics and WSM runs that move the 1996 storm to different months.

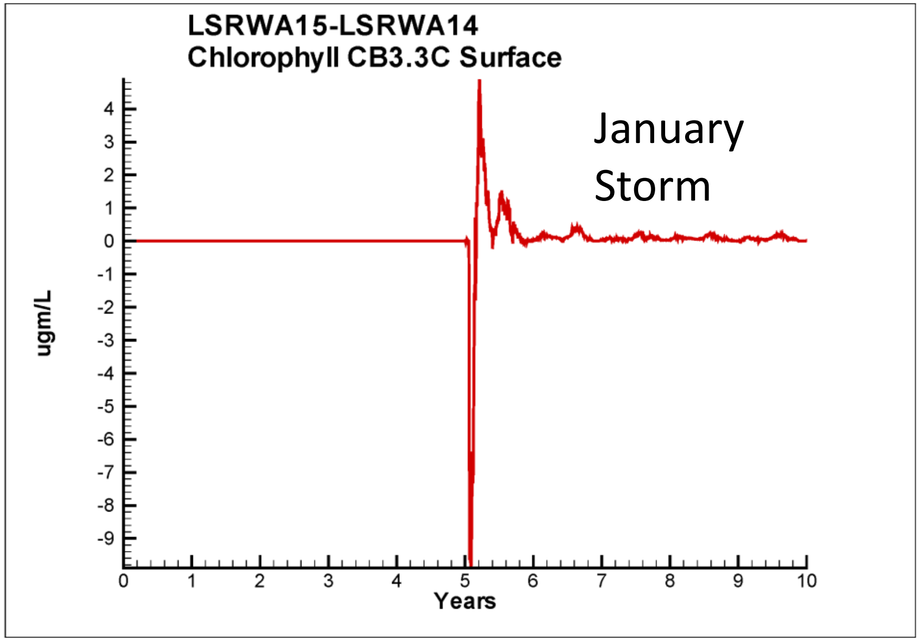
Timing of Storm Event

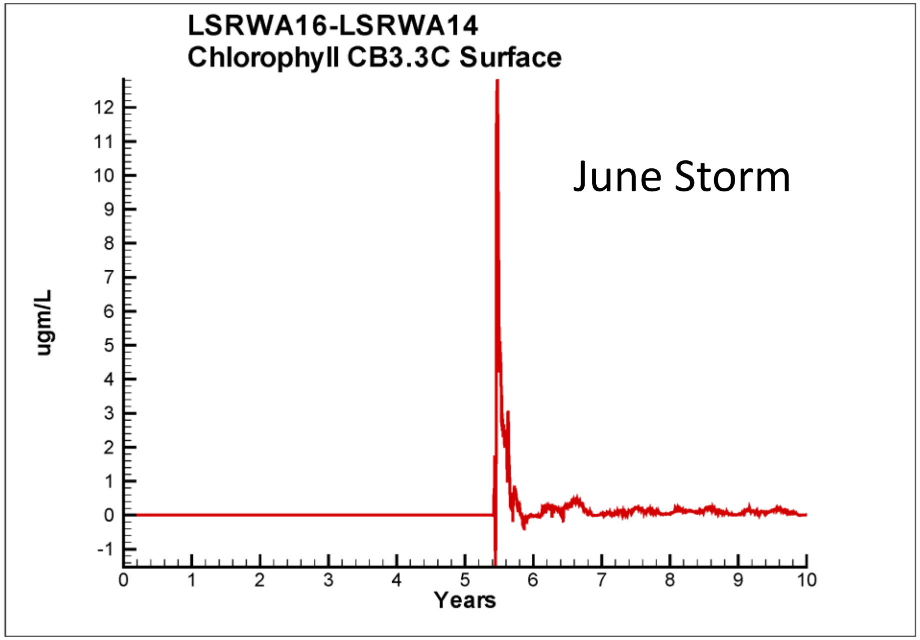
- The following runs have been completed in addition to a run with scour from the January 1996 storm:
  - No winter storm
  - Storm moved to June
  - Storm moved to October
- These runs examine the effect of the entire event including runoff and scour!

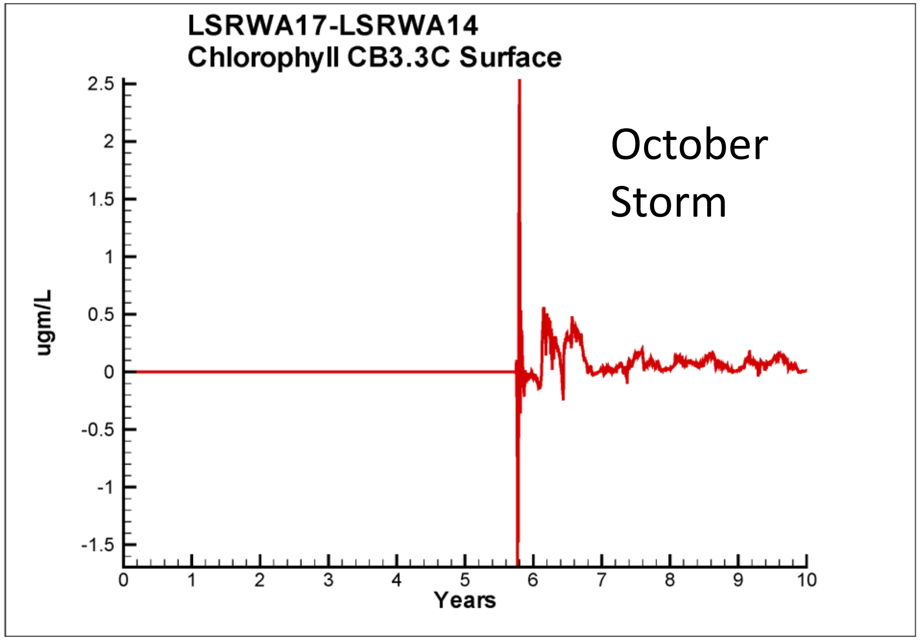
Scour Computed by Two Models

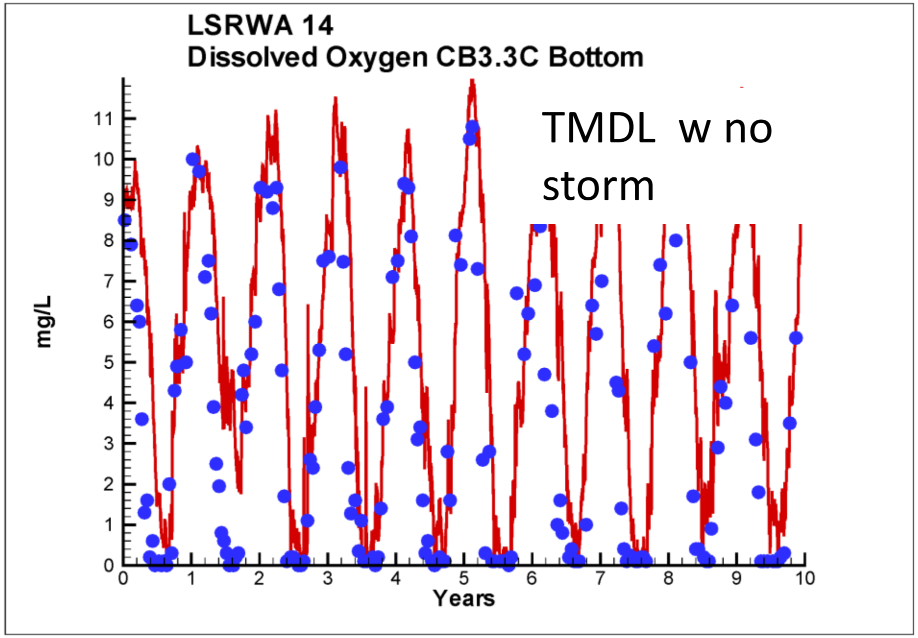
Scour	TSS (tons)	N (tons)	P (tons)
Jan 1996, ADH	2,107,311	6,322	2,107
Jan 1996, HSPF	1,837,861	588	2,141

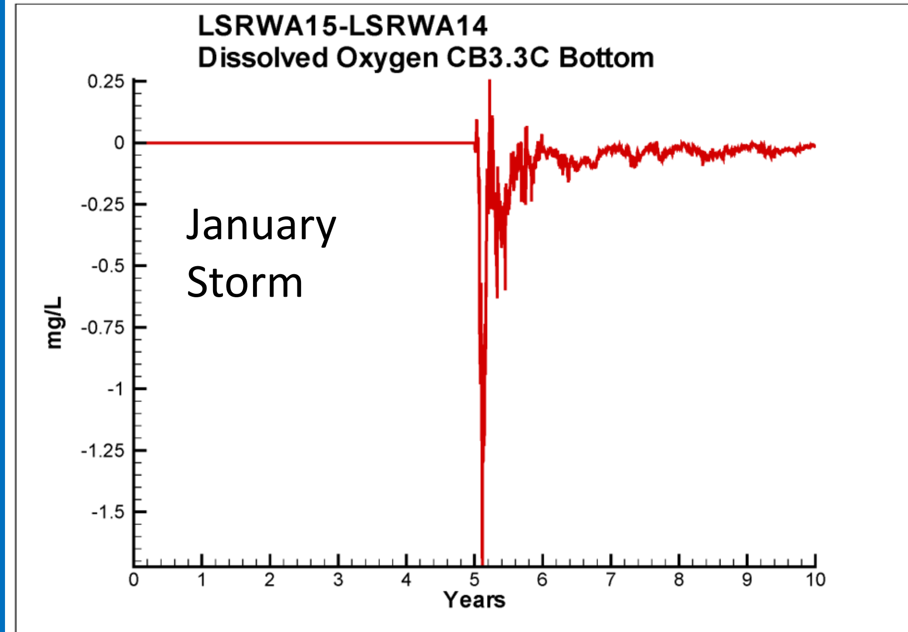

LSRWA 14
Chlorophyll CB3.3C Surface
TMDL w no storm
ugm/L
Years

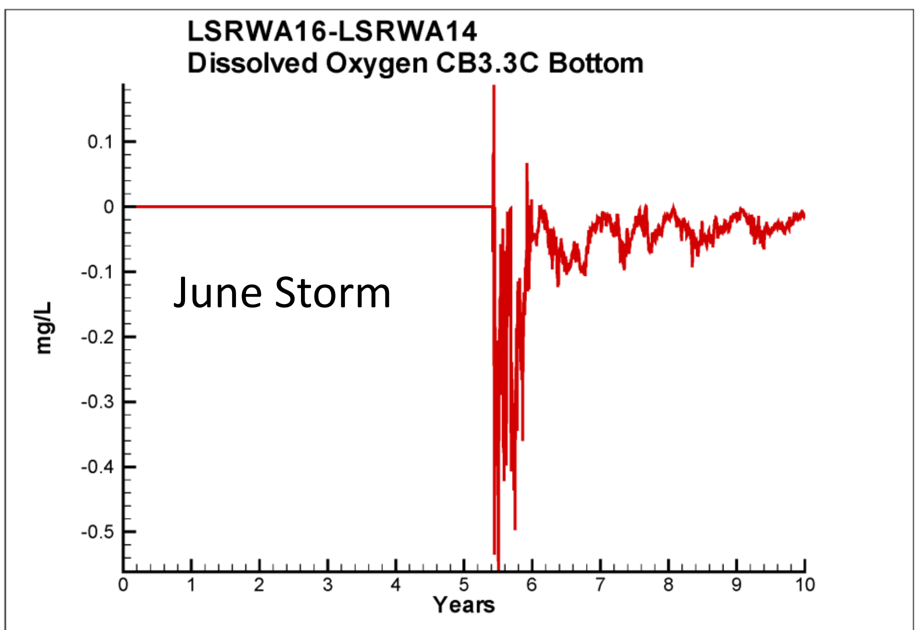

LSRWA15-LSRWA14
Chlorophyll CB3.3C Surface
January Storm
ugm/L
Years

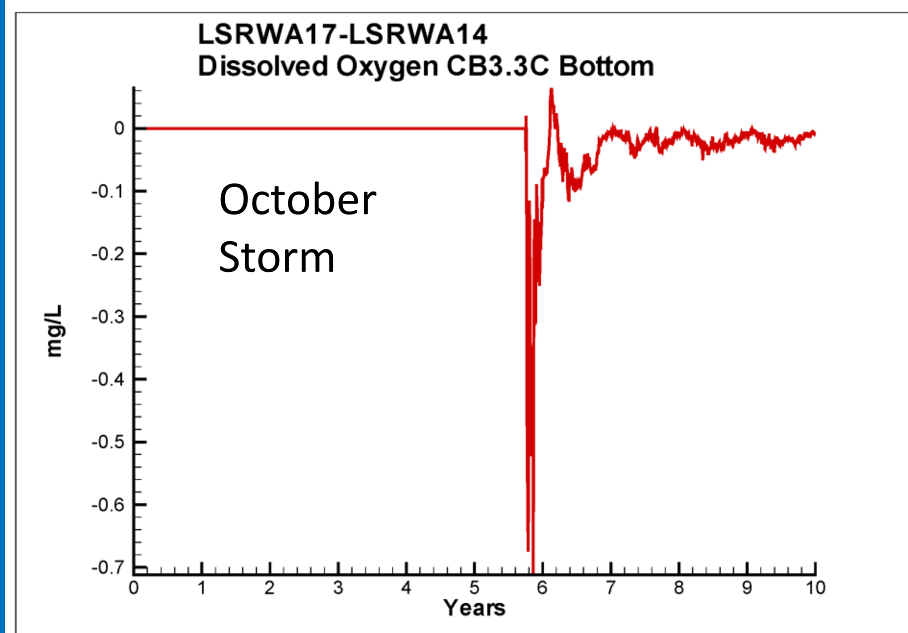

LSRWA16-LSRWA14
Chlorophyll CB3.3C Surface
June Storm
ugm/L
Years

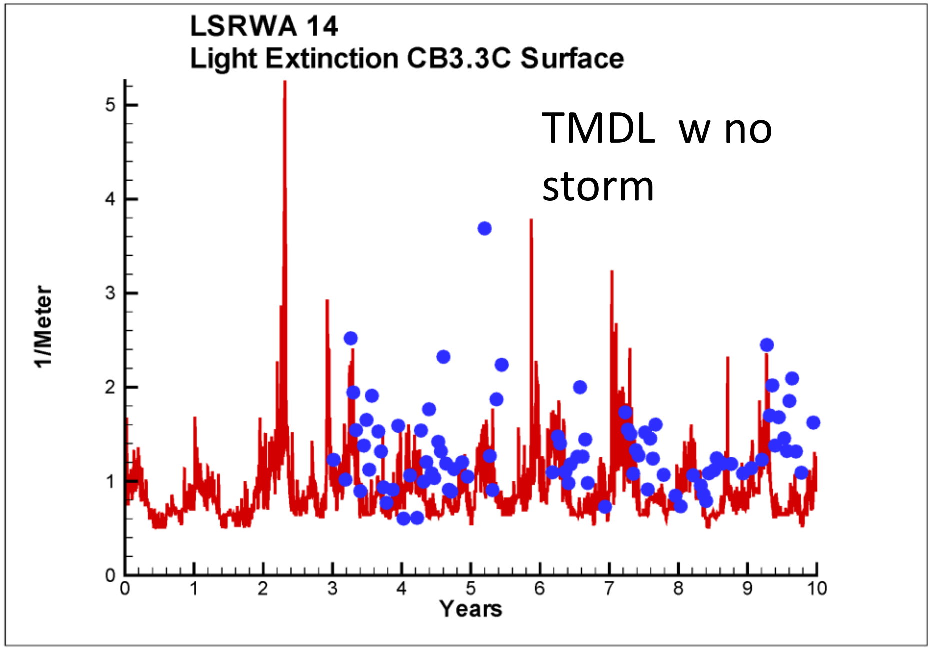

LSRWA17-LSRWA14
Chlorophyll CB3.3C Surface
October Storm
ugm/L
Years

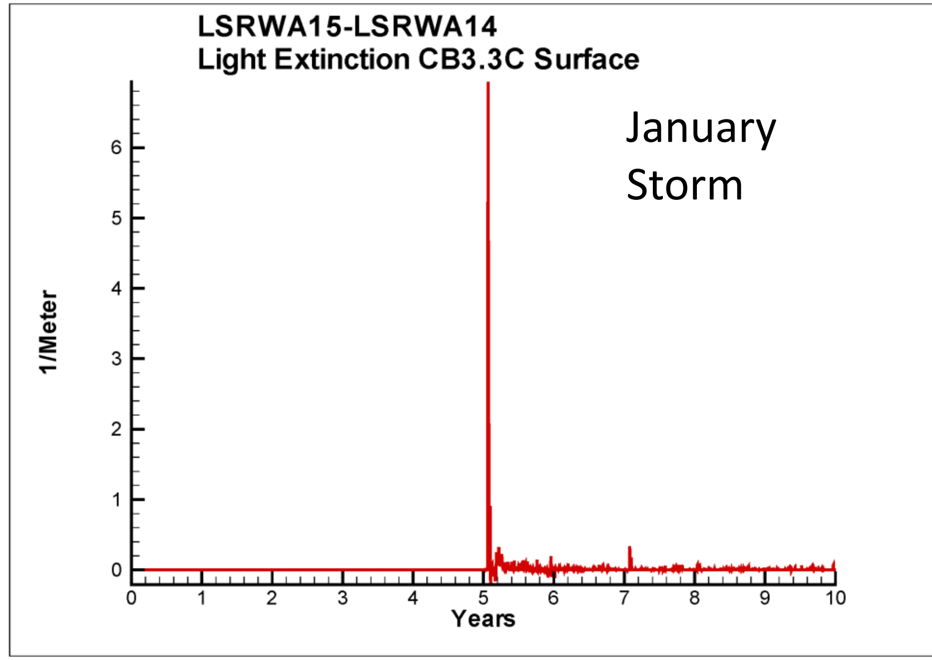

LSRWA 14
Dissolved Oxygen CB3.3C Bottom
TMDL w no storm
mg/L
Years

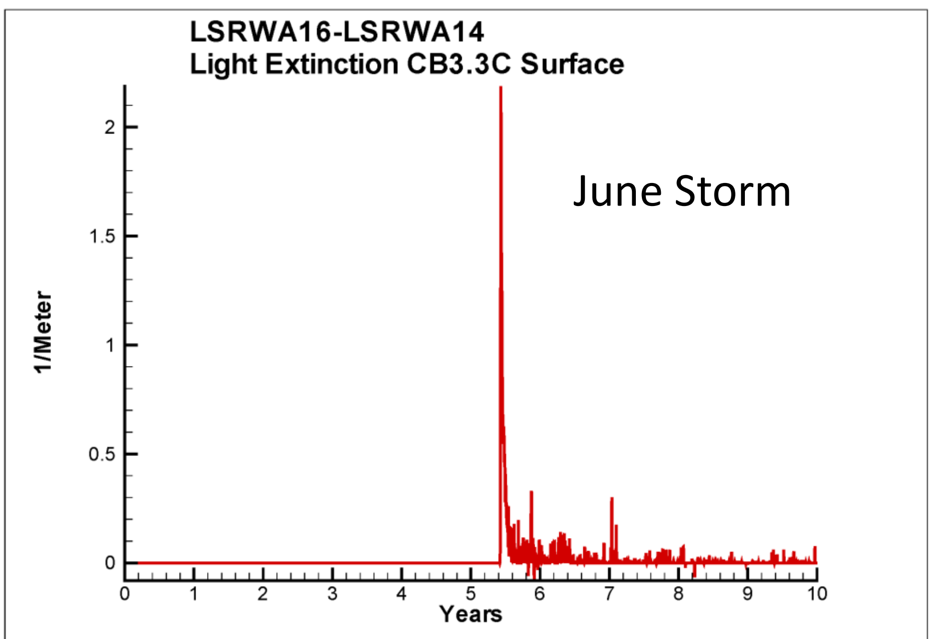

LSRWA15-LSRWA14
Dissolved Oxygen CB3.3C Bottom
January Storm
mg/L
Years

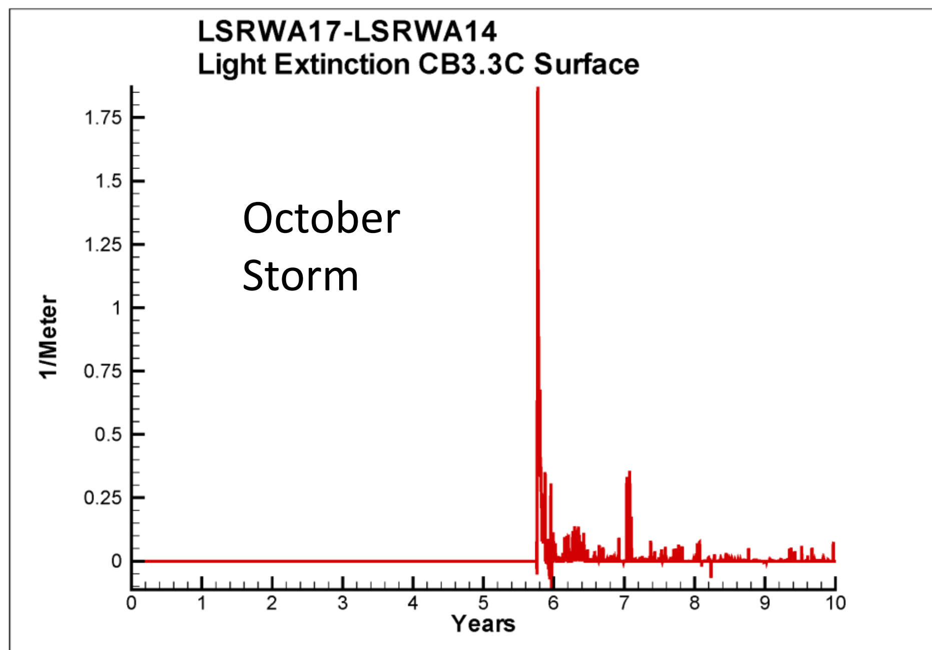

LSRWA16-LSRWA14
Dissolved Oxygen CB3.3C Bottom
June Storm
mg/L
Years

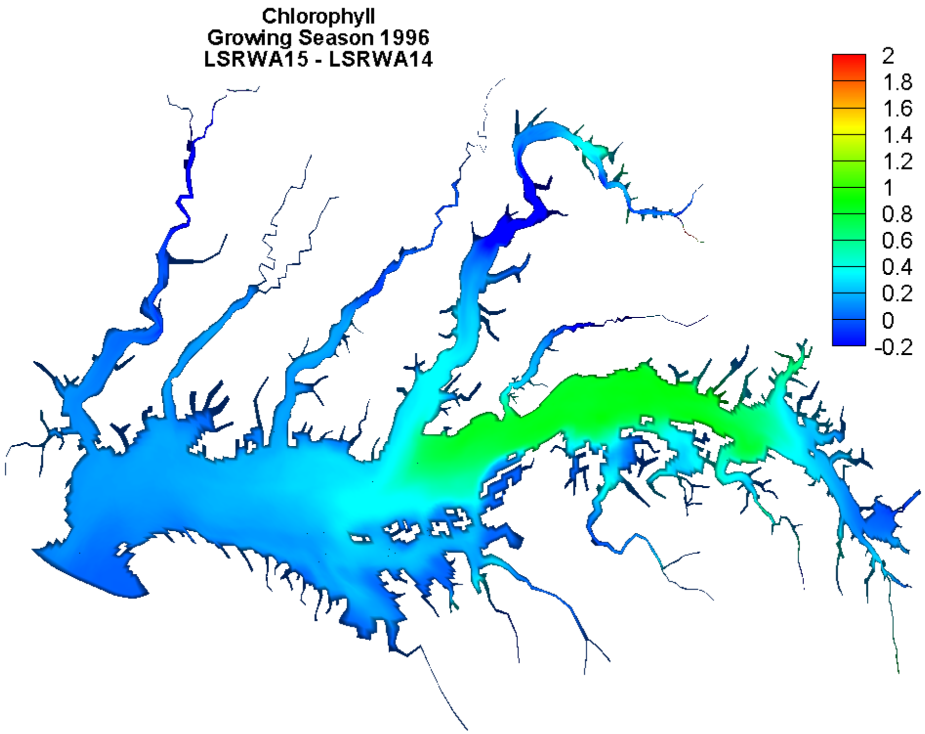

LSRWA17-LSRWA14
Dissolved Oxygen CB3.3C Bottom
October Storm
mg/L
Years


LSRWA 14
Light Extinction CB3.3C Surface
TMDL w no storm
1/Meter
Years


LSRWA15-LSRWA14
Light Extinction CB3.3C Surface
January Storm
1/Meter
Years

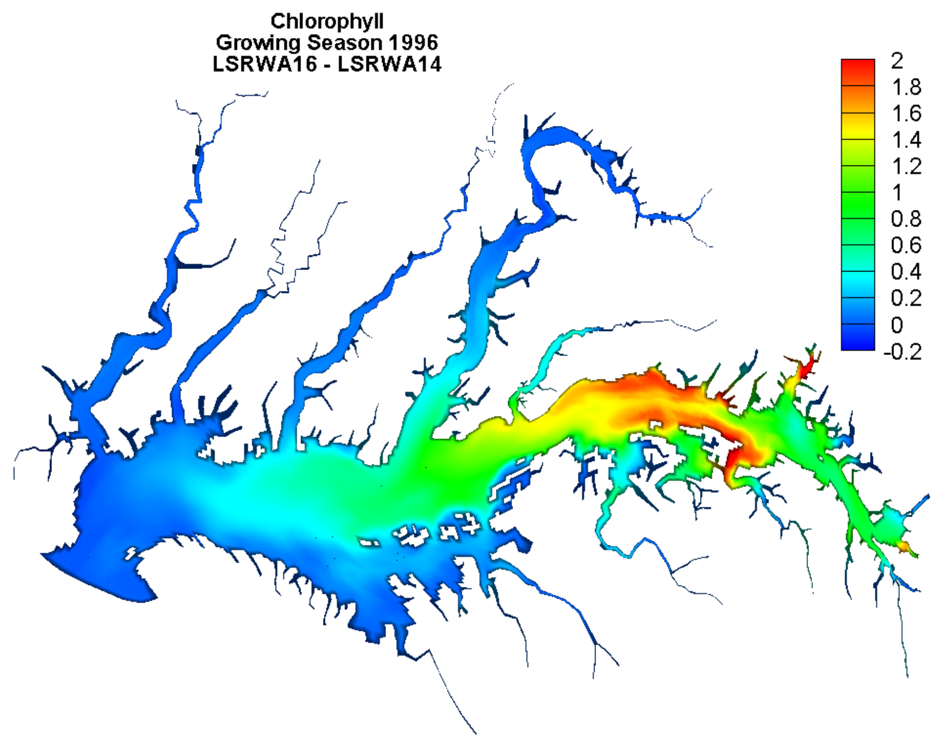

LSRWA16-LSRWA14
Light Extinction CB3.3C Surface
June Storm
1/Meter
Years

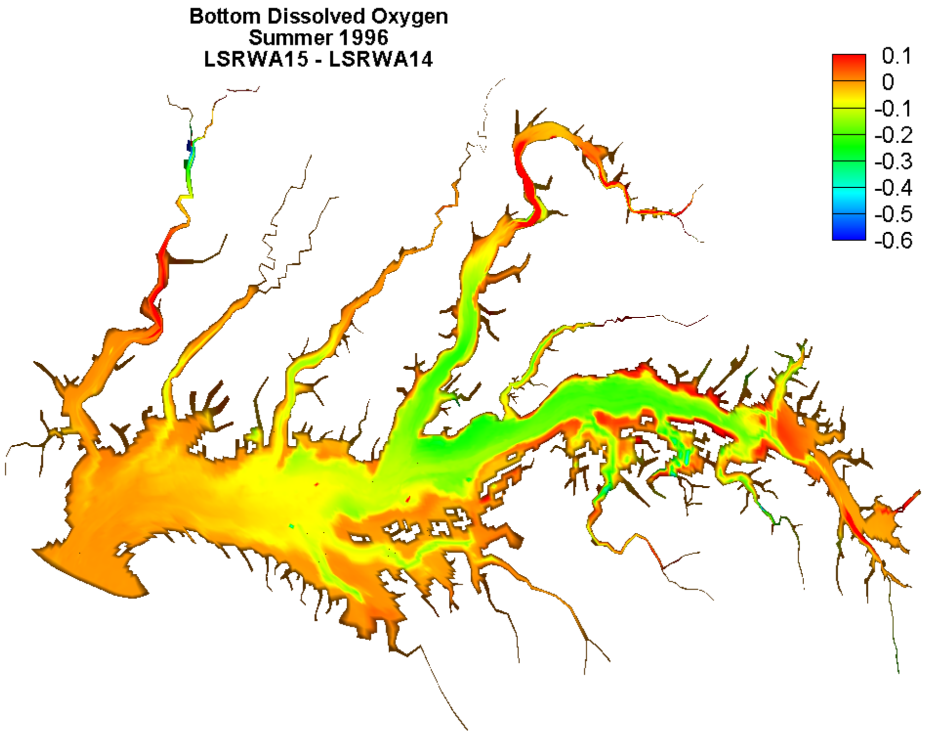

LSRWA17-LSRWA14
Light Extinction CB3.3C Surface
October Storm
1/Meter
Years



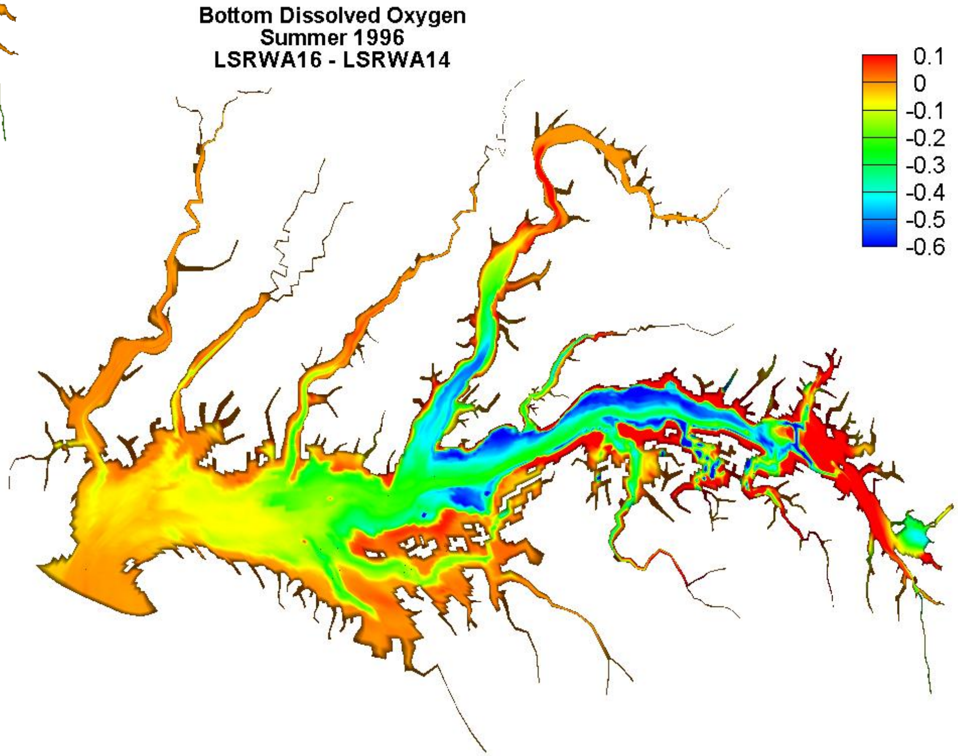
Marginal Effect of
January Storm

Marginal Effect of
June Storm

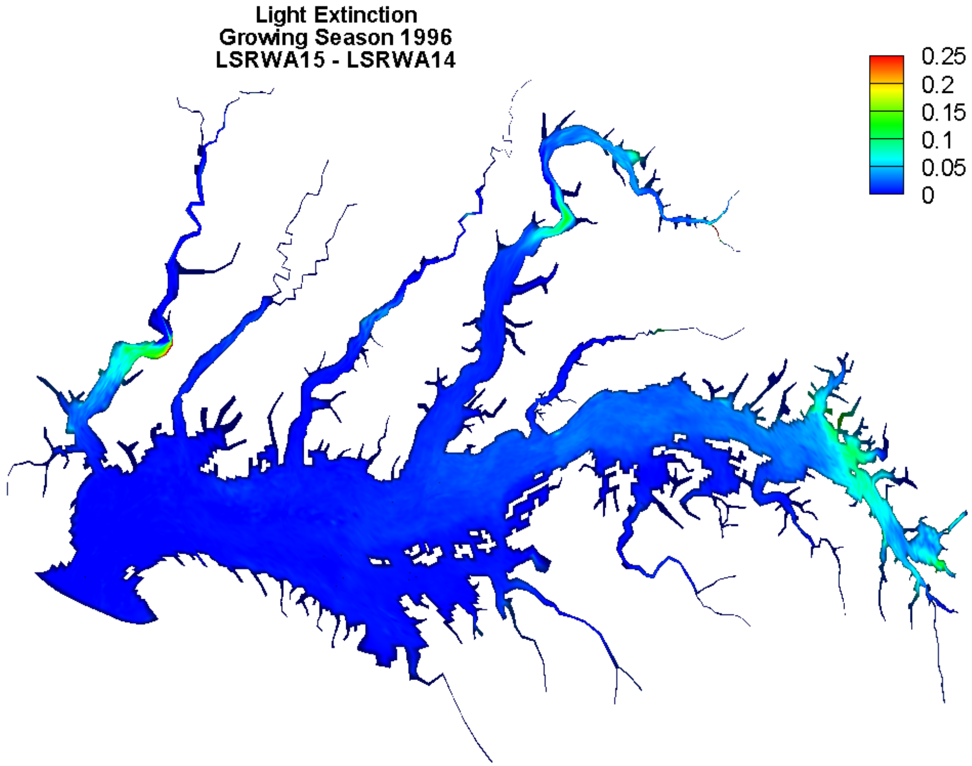




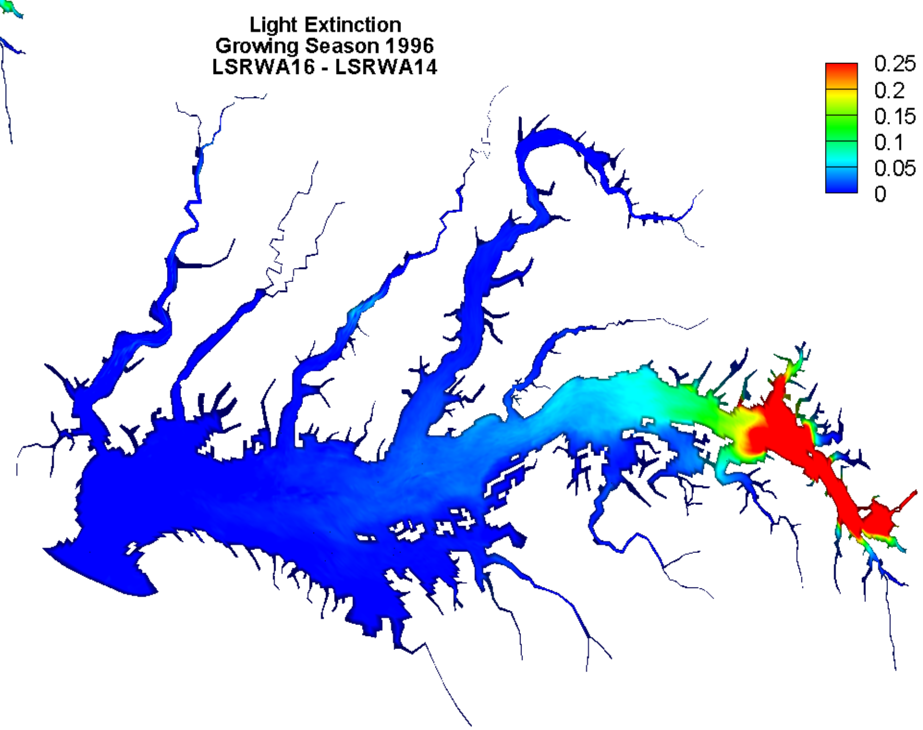
Marginal Effect of
January Storm



Marginal Effect of
June Storm



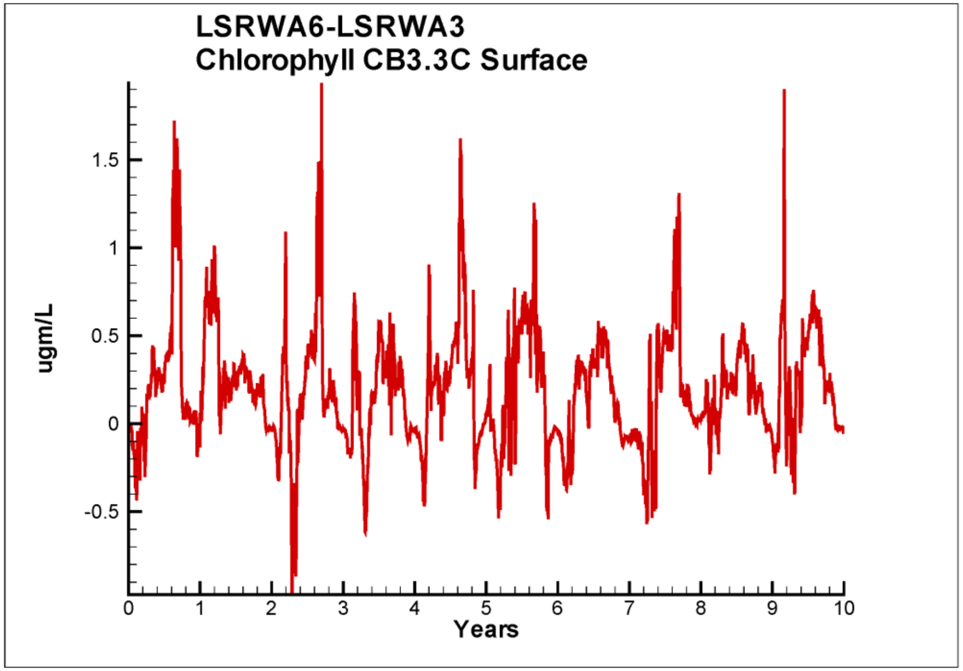
Marginal Effect of January Storm



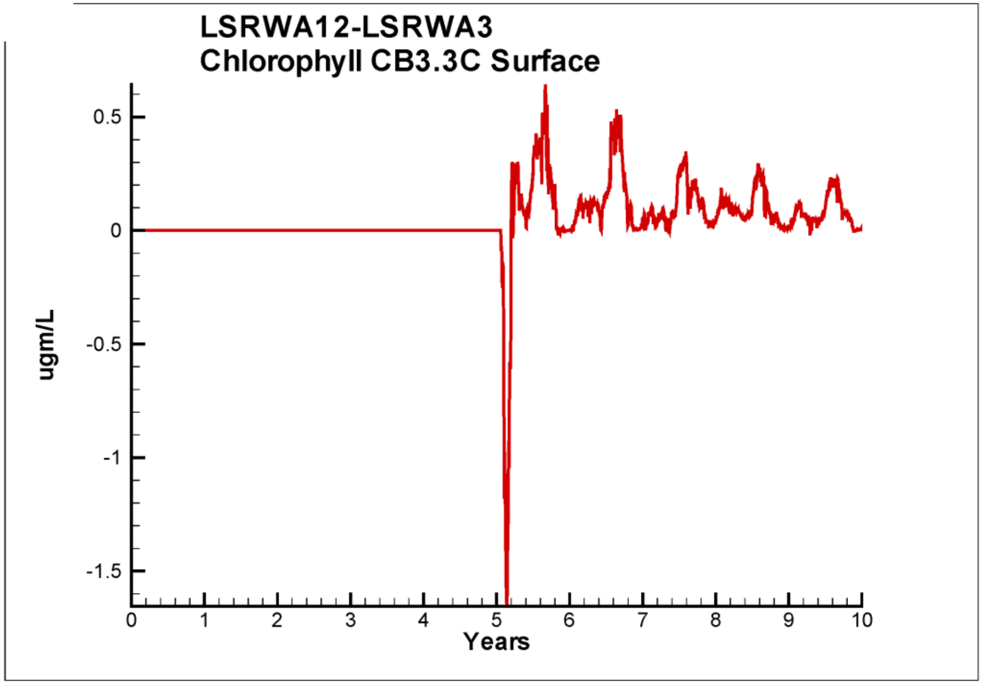
Marginal Effect of June Storm

Step 1 - Basis for Scenarios

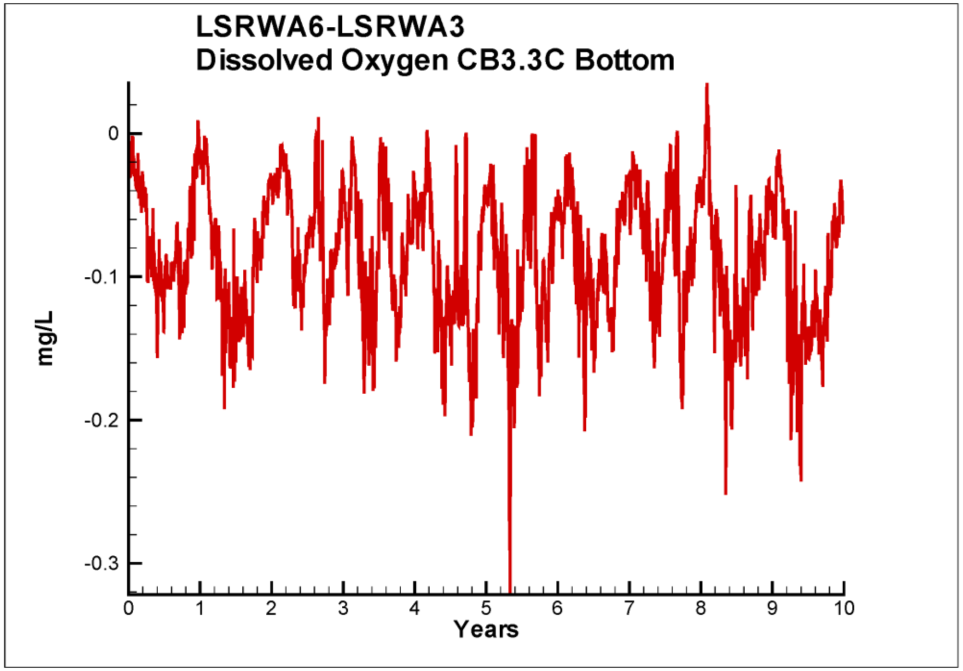
- Our first approach to examining the effect of Conowingo infill is to eliminate it from the WSM system.
- The system is full. No more settling.
- The WQM receives loads directly from the Susquehanna River plus local loads to the Conowingo Reservoir.



Difference plot showing effect of eliminating Conowingo.

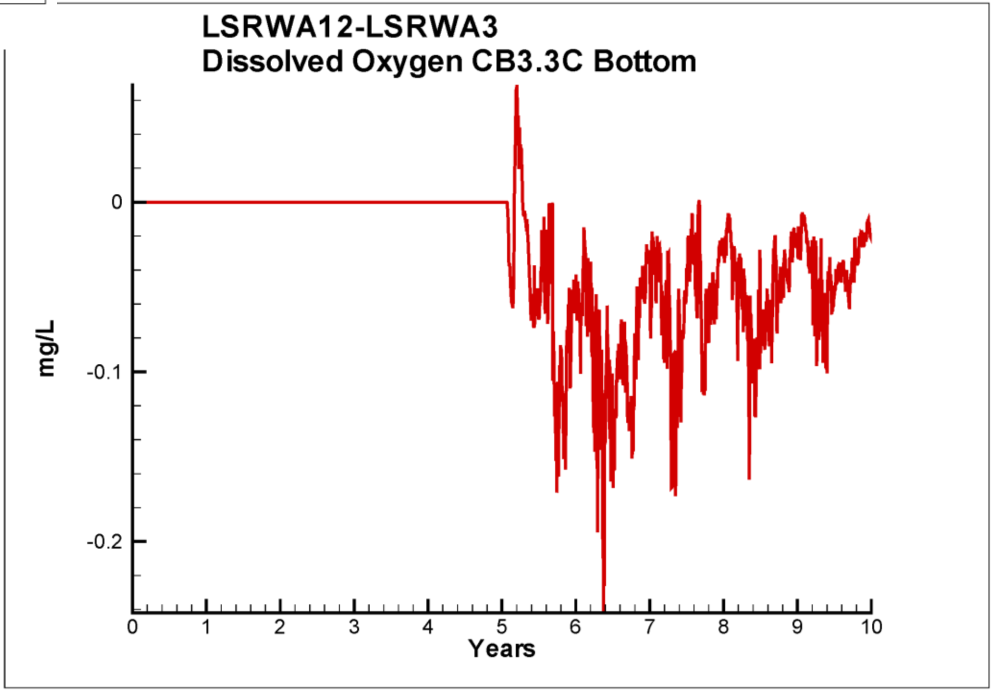


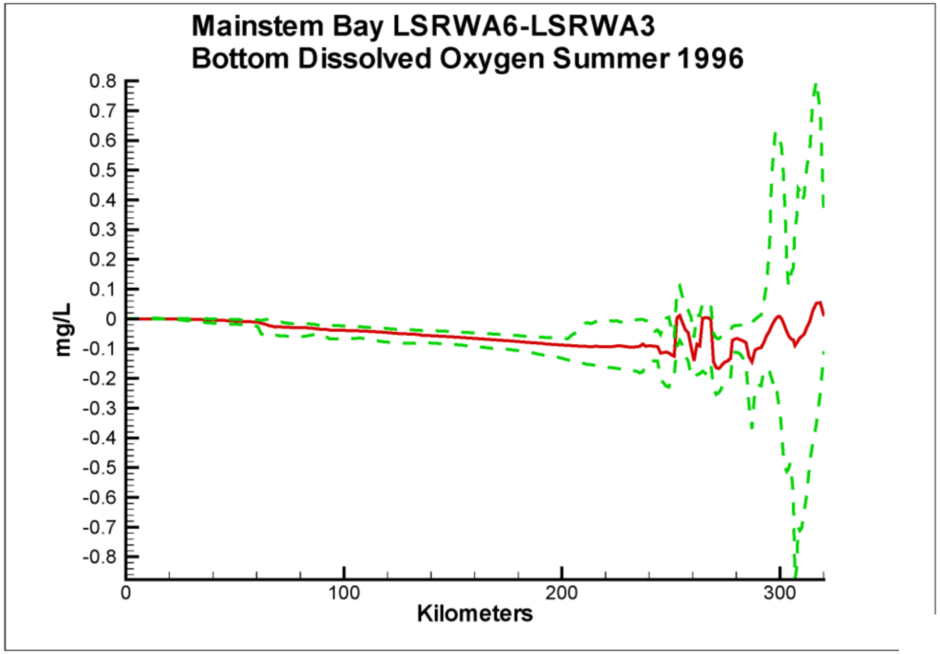
Difference plot showing effect of storm scour.



Difference plot showing effect of eliminating Conowingo.

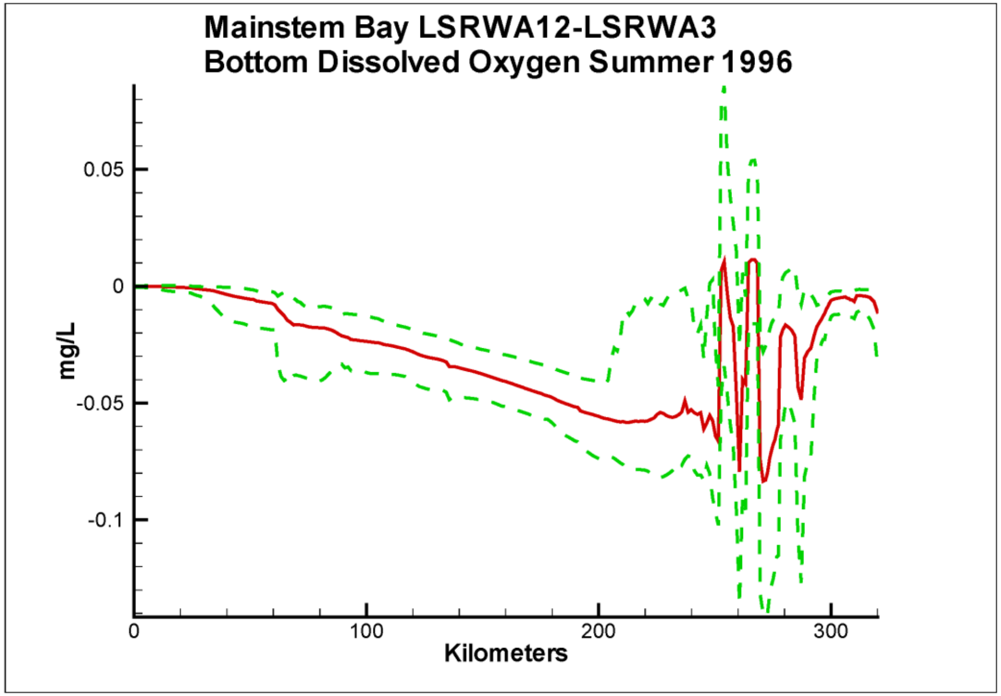
Difference plot showing effect of storm scour.

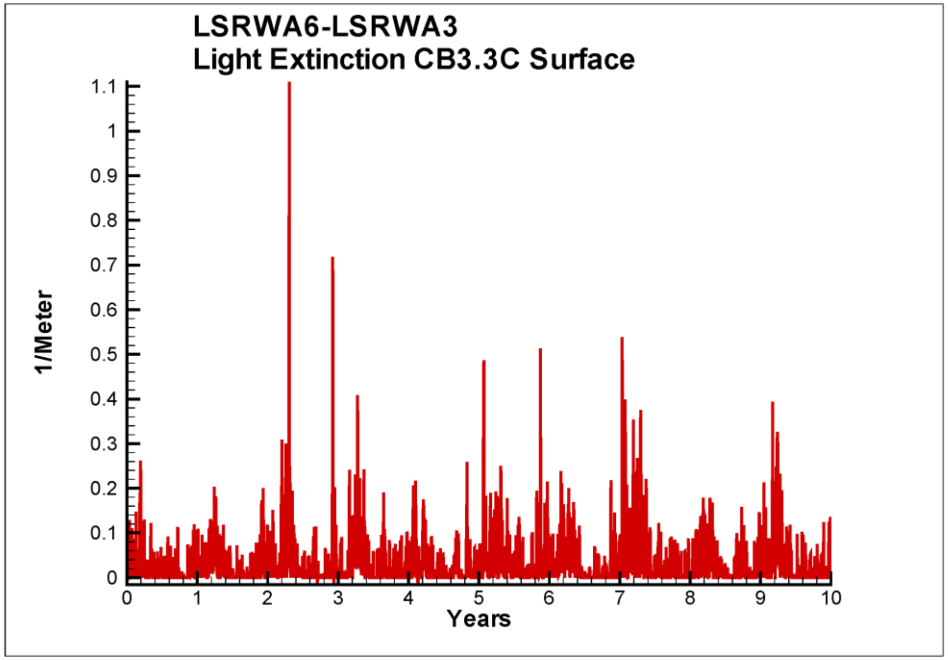




Difference plot showing effect of eliminating Conowingo.

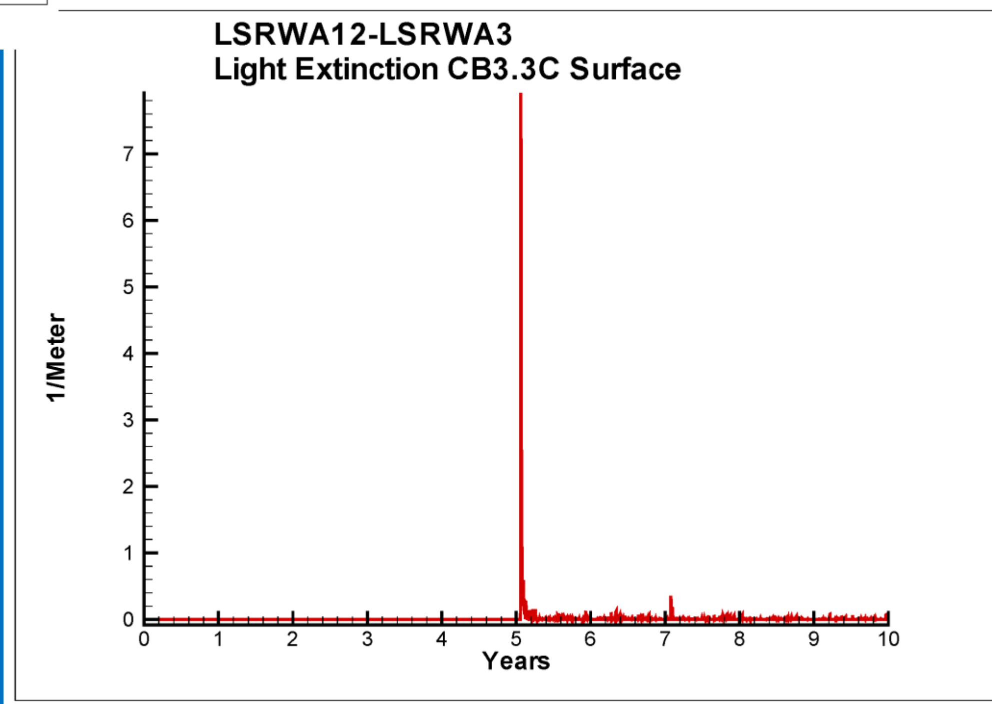
Difference plot showing effect of storm scour.





Base TMDL simulation shown in red.

Difference plot showing effect of storm scour.

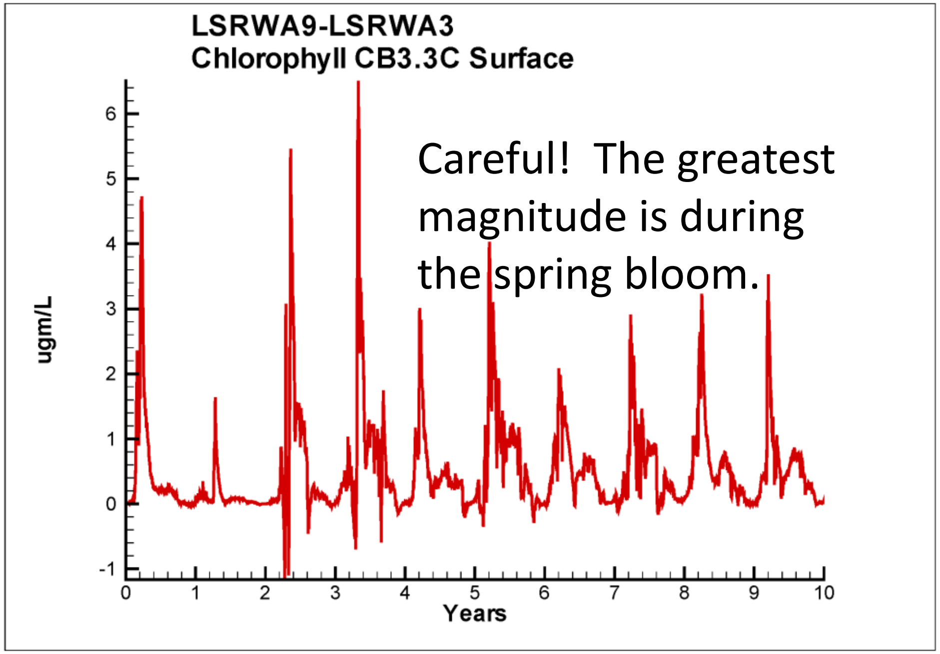


Step 1 Runs – Current Thoughts

- The continuous spillage is more harmful to water quality than a scour event. Excess loading occurs continuously, including the periods of critical water quality.
- The ADH runs suggest continuous spillage is not a good picture. ADH suggests deposition occurs even when the reservoir is "full."
- I can't completely dismiss these runs.

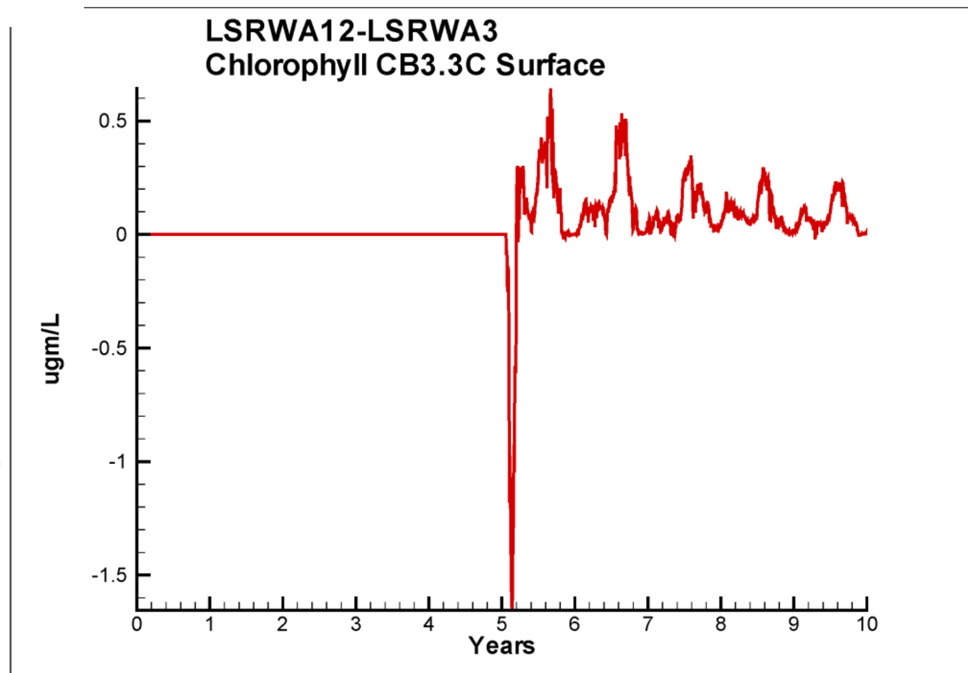
CBP Three-Step Program

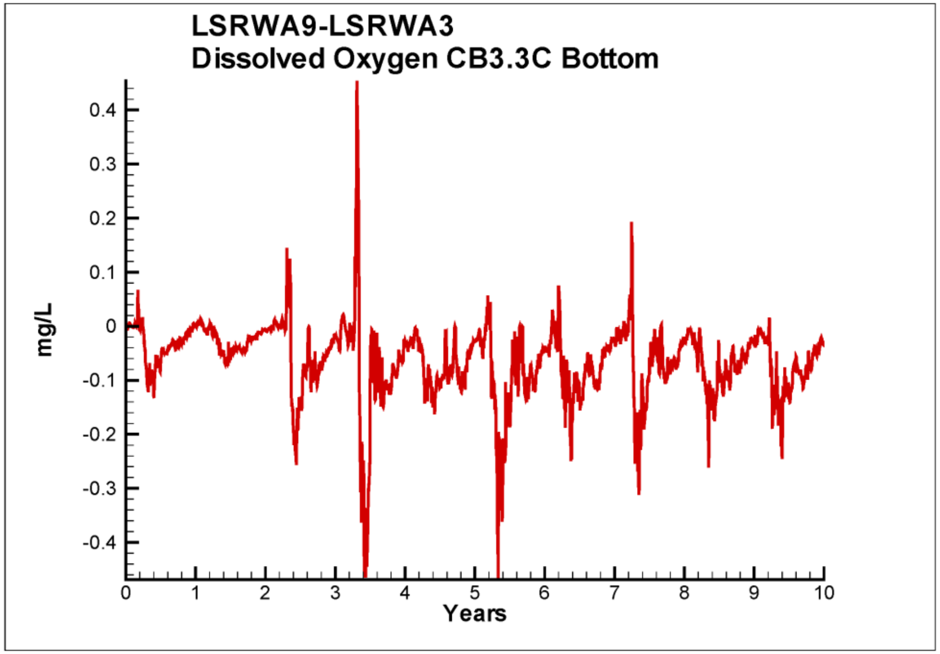
- Step 2 – Scour in Conowingo Reservoir
  - Try to match two reported outcomes.
    - 0% N, 50% P, 100% TSS increase in annual loads (Hirsch estimate of change from 1996 – 2001).
    - 0% N, 70% P, 250% TSS increase in annual loads (Hirsch citation of Langland and Hainly 1997 report).
  - Erosion implemented in Conowingo section of CBP Watershed Model.
  - Settling remains implemented between scour events.
  - Simulations for 2010 Progress Run (existing conditions) and TMDL (future conditions).



Difference plot showing effect of Step 2 scour events.

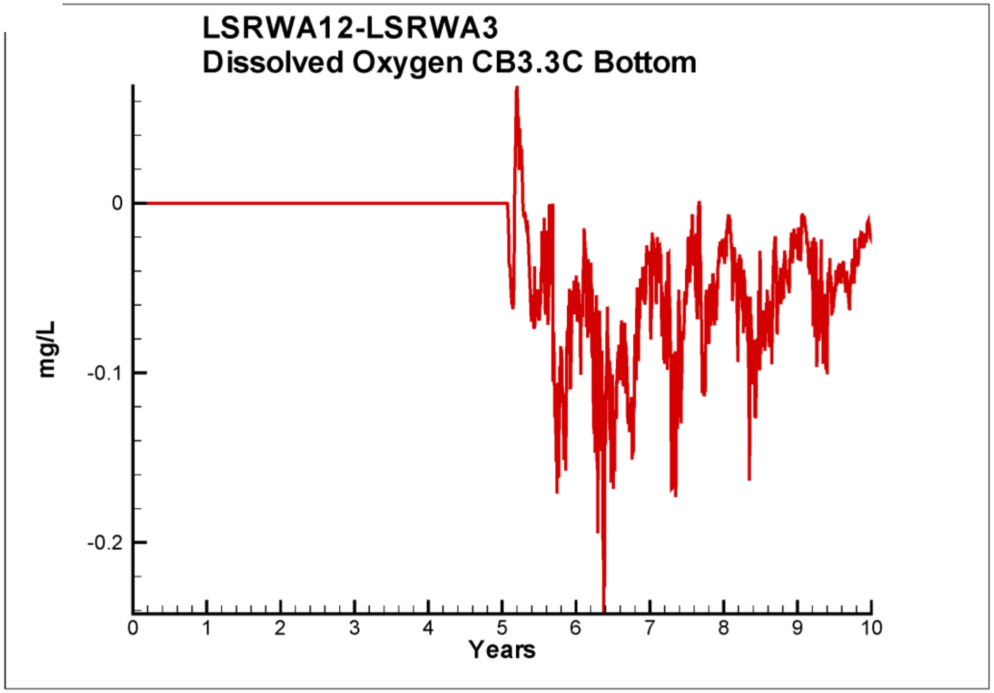
Difference plot showing effect of scour from a single storm.

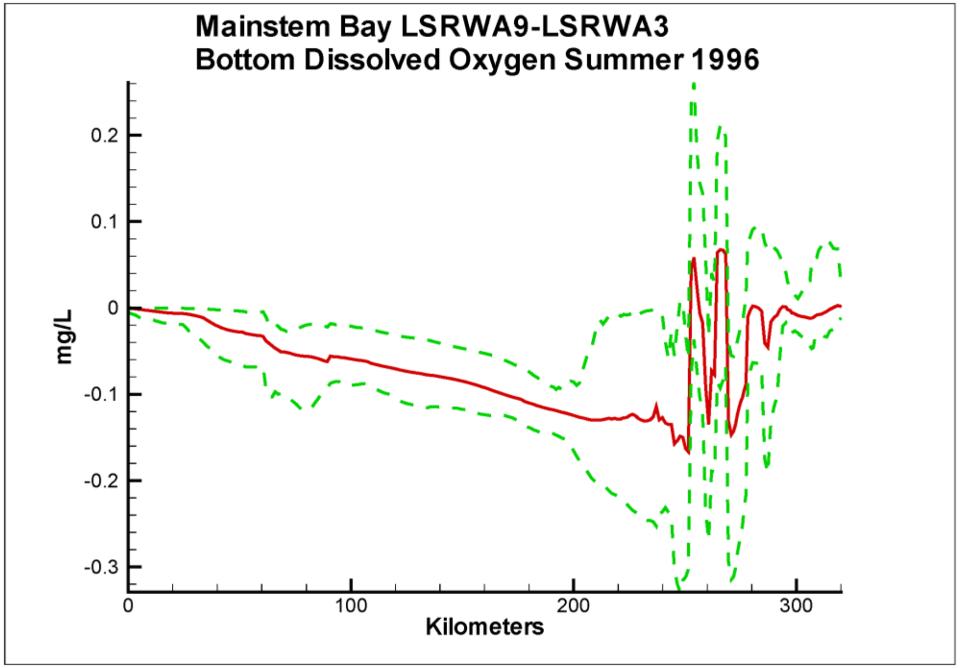




Difference plot showing effect Step 2 scour events.

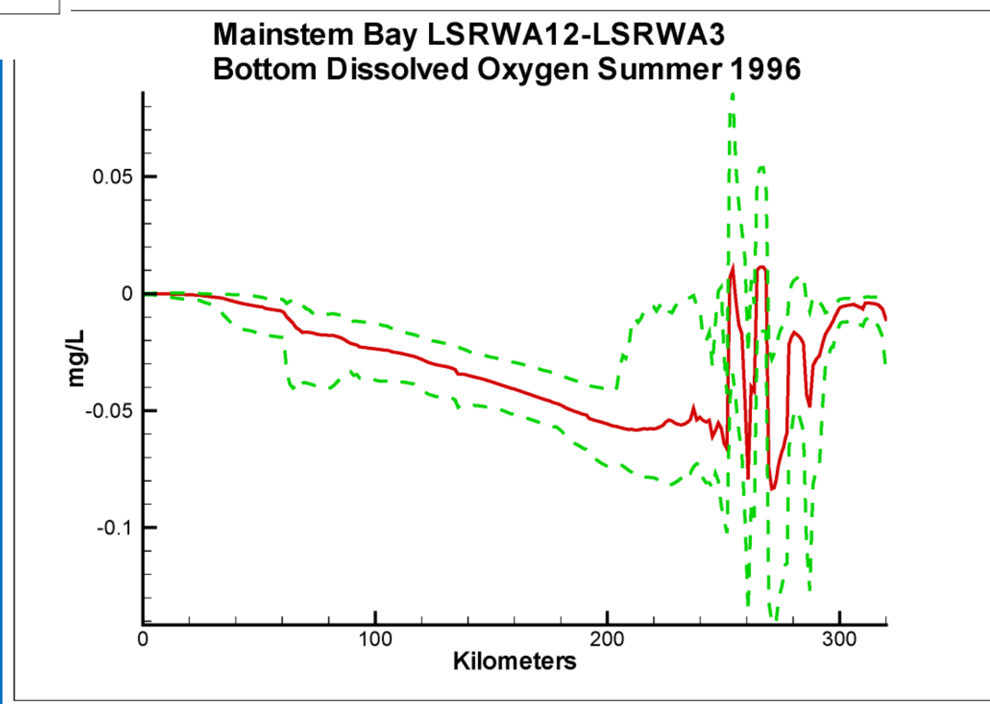
Difference plot showing effect of scour from a single storm.

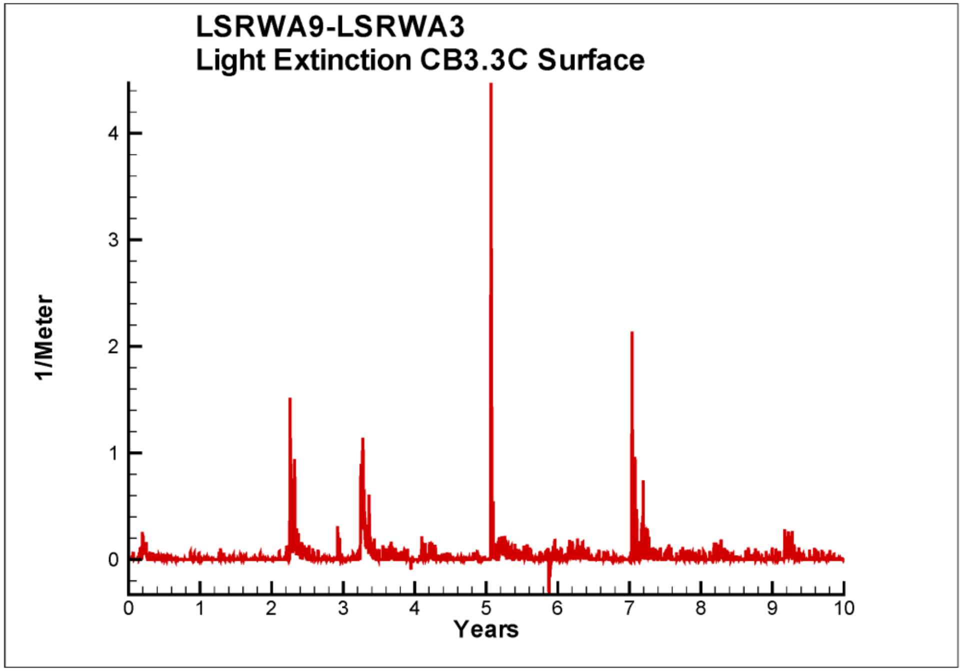




Difference plot showing effect Step 2 scour events.

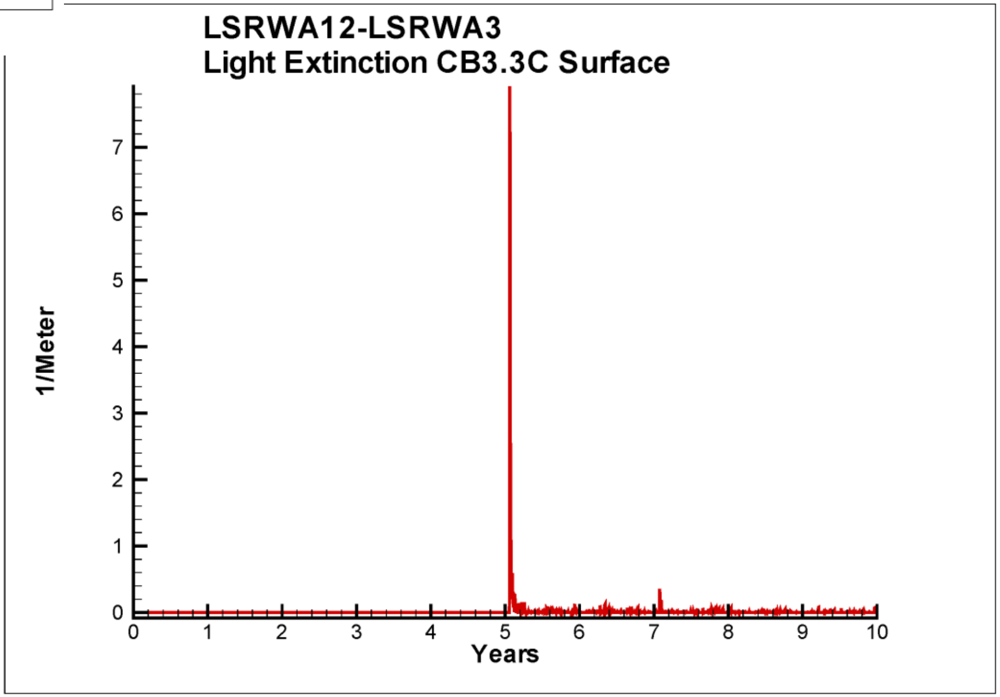
Difference plot showing effect of scour from a single storm.



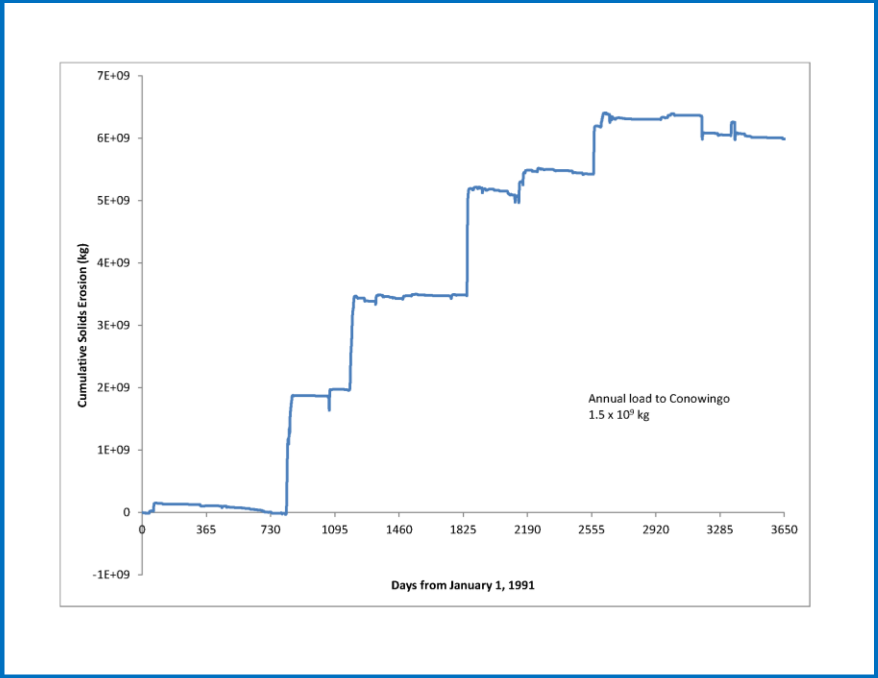


Base TMDL simulation shown in red.

Difference plot showing effect of storm scour.

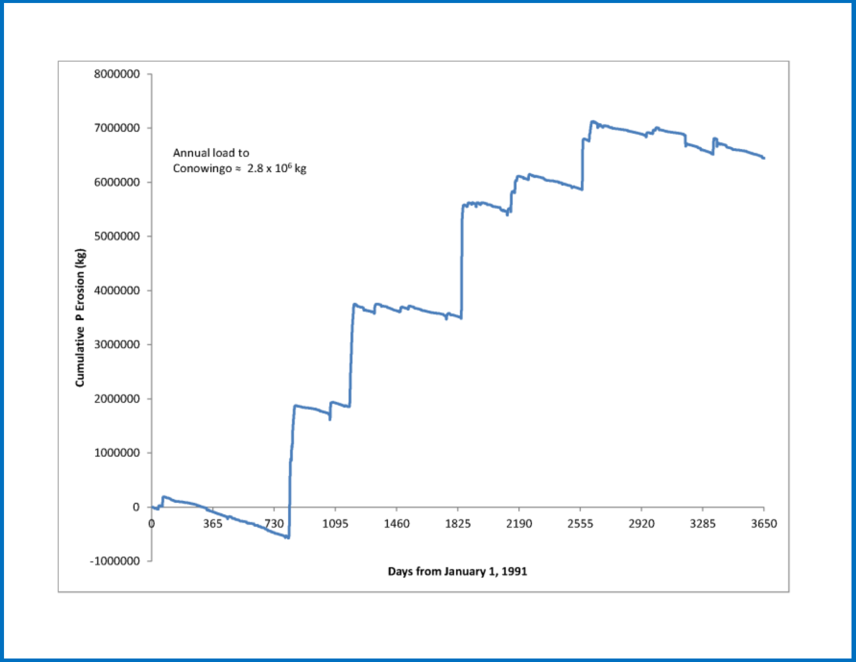


Step 2 Runs – Current Thoughts



- As expected, the effect of multiple scour events is worse than the effect of a single event.
- These are the least realistic of the runs we have conducted. The frequency and magnitude of scour events is unreasonable.

Step 2 Runs – Current Thoughts



- The HSPF model does not consider bed armoring or feedback between bathymetry changes and scour.
- We need to carefully examine and interpret forecasts that call for annual load increases of 50% P, 100% TSS or more.