MEMORANDUM FOR THE RECORD

SUBJECT: Lower Susquehanna River Watershed Assessment
Quarterly Team Meeting, 7 August 2012

1. On 7 August 2012, agency team members met to discuss ongoing and completed activities for the Lower Susquehanna River Watershed Assessment (LSRWA). The meeting was hosted by the Maryland Department of the Environment (MDE) in their Terra Conference Room at the Montgomery Park Building in Baltimore, Maryland. The meeting started at 10:30 am and continued through 1:00 pm. The meeting attendees are listed in the table below.

2.

Team Meeting Sign-In Sheet			
07 August 2012			
Agency	**Name**	**Email Address**	**Phone**
Exelon -- Gomez and Sullivan	Gary Lemay	glemay@gomezandsullivan.com	603-428-4960
Exelon -- URS Corp.	Marjorie Zeff	marjorie.zeff@urs.com	215-367-2549
Lower Susquehanna Riverkeeper	Michael Helfrich	LowSusRiver@hotmail.com	717-779-7915
MDE	Herb Sachs	hsachs@mde.state.md.us	410-537-4499
MDE	John Smith	jsmith@mde.state.md.us	410-537-4109
MDE	Matt Rowe	mrowe@mde.state.md.us	410-537-3578
MDE	Tim Fox	tfox@mde.state.md.us	410-537-3958
MDNR	Bruce Michael	bmichael@dnr.state.md.us	410-260-8627
MGS	Jeff Halka	jhalka@dnr.state.md.us	410-554-5503
SRBC	David Ladd	dladd@srbc.net	717-238-0425x204
SRBC	John Balay	jbalay@srbc.net	717-238-0423 x217
TNC	Kathy Boomer	kboomer@tnc.org	
TNC	Mark Bryer	mbryer@tnc.org	301-897-8570
USACE	Andrea Takash	andrea.m.takash@usace.army.mil	410-962-2626
USACE	Anna Compton	anna.m.compton@usace.army.mil	410-962-4633
USACE	Tom Lazco	thomas.d.lazco@usace.army.mil	410-962-6773
USACE	Chris Spaur	christopher.c.spaur@usace.army.mil	410-962-6134
USACE	Claire O'Neill	claire.d.o'neill@usace.army.mil	410-962-0876
USGS	Bob Hirsch	rhirsch@usgs.gov	703-648-5888
USGS	Mike Langland	langland@usgs.gov	717-730-6953
MDE	Maria Schuler	mschuler@mde.state.md.us	410-262-6160
Chesapeake Conservancy	Jeff Allenby	jallenby@chesapeakeconservancy.org	443-321-3160
USACE	Robert Pace	robert.s.pace@usace.army.mil	410-962-4900
Baltimore Sun	Tim Wheeler	tim.wheeler@baltsun.com	410-260-8002
The Conservation Fund	Bill Crouch	bcrouch@conservationfund.org	410-274-8427
DNR	Josh Davidsburg	jdavidsburg@dnr.state.md.us	410-260-8002
Exelon	Mary Helen Marsh	maryhelen.marsh@exeloncorp.com	610-765-5572
Exelon-Gomez and Sullivan	Tom Sullivan	tsullivan@gomezandsullivan.com	603-428-4960
Exelon	Kimberly Long	kimberly.long@exeloncorp.com	717-629-4198

In addition, a number of team members listened in via the conference line; those listening were:

Agency	Name	Email Address	Phone
PADEP	Patricia Buckley	pbuckley@pa.gov	717-772-1675
PADEP	Ted Tesler	thtesler@pa.gov	717-772-5621
SRBC	Andrew Gavin	agavin@srbc.net	717-238-0423x107
USACE-ERDC	Carl Cerco	carl.f.cerco@erdc.usace.army.mil	601-634-4207
USACE-ERDC	Steve Scott	steve.h.scott@usace.army.mil	601-634-2371
EPA	Lew Linker	LLinker@chesapeakebay.net	410-267-5714
NMFS	John Nichols	john.nichols@noaa.gov	410-267-5675

The meeting agenda is provided as enclosure 1 to this memorandum.

Action Items –

a. Anna will email out the draft mission statement to the team and the team will provide any further comments to the statement.
b. Anna will revise goals and objectives to state "three" vs. "four" hydroelectric dams to accurately reflect the study area of the assessment.
c. Mike will resolve issues with HEC-RAS modeling and will have a workable boundary condition file by the end of August.
d. Bruce will invite Harbor Rock to the September sediment management strategy brainstorming meeting.
e. Bob Hirsch will share draft press release on recent TS Lee study findings by USGS with selected agencies for review and input.
f. Claire will coordinate a sediment management strategy brainstorming meeting for September.
g. Claire will coordinate the next quarterly meeting for sometime in late October/early November.
h. Herb and Bruce to draft preliminary statement regarding Conowingo's time as an effective sediment trap running out to be reviewed by LSRWA team and posted to project website.

3. Welcome and Opening Remarks – After a brief introduction of the meeting attendees, Herb Sachs welcomed the LSRWA agency group. He noted that he would be retiring but would still be involved on the periphery as a volunteer, on an as-needed basis. Matt Rowe will now fill in as Herb's role on the LSRWA team. Herb discussed the recent interest in our study and a sense of urgency because of USGS findings coming out in regards to the Conowingo Dam filling sooner than expected. Herb explained that the governor of MD is up to speed on the latest findings and wants to make sure that the LSRWA moves forward.

4. Review of Action Items from April 2012 Meeting – For the first meeting discussion, the team reviewed the April 2012 action items as well as the ongoing action items.

Action Items from April Meeting:

A. Claire will discuss funding needs for FY13 with Herb.
Status-Ongoing; USACE does not know if federal funding for FY13 will be received for this study. The project is not in the President's budget that was released in February 2012. However, for this fiscal year, the study received funds from a general USACE pot of money, and it is hoped that the same action will happen in FY13. The allocation of these funds is determined by Headquarters USACE staff. These funding discussions will continue.

B. Mike will invite Bob Hirsch to attend August quarterly meeting to give presentation on his findings.-*Status-Complete; Bob attended the meeting and presented his findings.*

C. Herb and Bruce to draft preliminary statement regarding Conowingo's time as an effective sediment trap running out, with the intent that we have a consistent message to policymakers, the public, and media. *Status ongoing; Bruce and Herb needed further input from the team so this is an agenda item for today's meeting.*

Ongoing Action Items from Previous Meetings:

D. The MDE FTP website will be utilized to share internal draft documents within the team; Matt will be the point of contact for this FTP site.
Status – Ongoing; FTP is set up and any future draft documents will go through the MDE ftp website.

E. Shawn will notify team when most recent Exelon study reports are released. *Status – Recent report was sent out to team; ongoing action. Shawn was not in attendance so Tom let the group know that the Exelon application for the Conowingo dam license will be filed with FERC at the end of August and all required studies will be completed by the end of September with the exception of two fish studies.*

F. Anna will update PowerPoint slides after each quarterly meeting to be utilized by anyone on the team providing updates to other Chesapeake Bay groups. *Status – Ongoing.*

G. Anna will send out an update via the large email distribution list that started with the original Sediment Task Force (includes academia, general public, federal, non-government organization (NGO), and state and counties representatives) notifying the group of updates from the quarterly meeting. *Status – Ongoing.*

H. Mark and Anna will coordinate to conduct a literature search providing info on best management practices around the nation and world for reservoir sedimentation. *Status – Ongoing; Anna and Mark will present findings at the next LSRWA meeting.*

I. Matt will keep team informed on innovative re-use committee findings to potentially incorporate ideas/innovative techniques into LSRWA strategies. *Status – Ongoing. One company, Harbor Rock has presented ideas for beneficial re-use of dredged material. Their concepts may be technically feasible, but the financing may be difficult. This is a group that could present to the LSRWA team.*

J. The team will send Bruce documents and links that should be posted on the LSRWA website. *Status – Ongoing*

5. Communication and Coordination –Since the last quarterly meeting, there have been no official presentations of the project PowerPoint slides. Michael noted that the slides are up on the Lower Susquehanna Riverkeeper website.

Project Website Update – Bruce noted that all presentations that have been presented to this group at quarterly meetings, meeting summaries and applicable website links have been uploaded to the project website. The USGS report on Tropical Storm Lee will not be uploaded to the website until it is finalized.

Mission Statement Review – Anna noted that the group had worked up specific goals and objectives for the study; however, there was an interest in working up a mission statement as well. This would be an over-arching statement to communicate the purpose of the study to the public. This statement would go on the project website. The team commented on the draft statement and the following is what was developed at the meeting:

"To comprehensively forecast and evaluate sediment and associated nutrient loads into and from the system of hydroelectric dams located on the Lower Susquehanna River above the Chesapeake Bay and consider structural and non-structural strategies to manage these loads to protect water quality and aquatic life in the Chesapeake Bay."

Determine the effects to the Chesapeake Bay due to the loss of sediment and nutrient storage behind the hydroelectric dams on the Lower Susquehanna River

The team will provide any further comments to the draft mission statement after the meeting in order to finalize the statement.

Jeff noted that the goals and objectives contained the statement "four hydroelectric dams" when it should be "three" due to the fact that the LSRWA modeling only encompasses three hydroelectric dams on the Susquehanna. Anna will make this change to the goals and objectives.

Herb noted that we needed to be clear on the expectations of this study. This study is evaluating options and presenting them, but it will not lead directly to construction to maintain Conowingo's sediment/nutrient trapping capacity which may disappoint some people. Efforts will need to occur after this study to implement any solution developed from this study along with additional resources. Herb noted that the TMDL goal is that sediment load allocations will be met by 2025. However these loads are based on Conowingo Dam still trapping a portion of the sediments entering the Bay, but we now know the Conowingo Reservoir will most likely not continue to trap sediments through 2025. Bruce noted that there is no one single agency or group that will have the ability to address this problem.

Review Plan – Anna noted that a review plan has been prepared by USACE for LSRWA to lay out the scope and level of review for the study. The draft report will need to undergo agency technical review (ATR) before it is released to the public for review. ATR involves review by USACE senior staff that are outside of the Baltimore District. USACE will be responsible for coordinating with the ATR team and consolidating responses to ATR comments; however, the whole LSRWA team will

be responsible for working up responses to comments. ATR will occur on the draft document and public review comments. ATR will occur on the final document only if there are significant public comments. ATR is a cost-shared component of the study. The review plan is currently at USACE's division office for final approval but we do not anticipate any changes to the review plan. Anna will let everyone know when the review plan has been approved by USACE's North Atlantic Division.

6. USGS Presentation on the Susquehanna River and the Impacts of Tropical Storm Lee – Bob Hirsch from USGS presented to the group "Nitrogen, phosphorus, and suspended sediment fluxes from the Susquehanna River to the Bay in Tropical Storm (TS) Lee 2011– results and implications."

Bob Hirsch's presentation is provided as enclosure 2 to this memorandum.

Bob noted that the reservoirs initially had high trap efficiency. Eventually, steady state will occur (sediment output will equal input). What we see now is evidence that we are reaching a 100-percent full asymptote. Original prediction by Langland and Hanly in 1997 was that the reservoirs would be "full" in 17-20 years (all other things being equal). Once the reservoirs are full, it is predicted that we would see a total nitrogen (TN) flux increase of 2 percent; total phosphorus (TP) flux increase of 70 percent, and a suspended sediment (SS) flux increase of 250 percent.

Findings of this study were that TS Lee wasn't an unusual event even though it was a large rain event. Bob does not see any historical change in the frequency of high flow events but the behavior of the reservoir system has changed in response to these high flow events. There is a lower scour threshold as the reservoir fills up. Conowingo filling up is a current issue, not a future issue.

TN concentrations are continuing to decline at most discharges; however, at very high flows, they are showing some increase. Flow-normalized flux continues to fall (down about 16 percent since its high in 1987). Year to year variability in actual TN flux is increasing (standard deviation about double for 2002-2011 vs. 1978-2001). TS Lee TN flux was about 42,000 tons compared to the 2011 water year of 135,000 tons of TN, while the past decade average was 79,000 tons/year and the past 34-year average was 71,000 tons/year. TN flux change since 1996 was -3.2 percent.

Since 1996, TP increases were observed at high discharges for all seasons but particularly the tropical storm season. Small increases in TP at moderate discharges (April – July) were observed while small decreases were observed at moderate to low discharges other parts of the year. At the Marietta, PA gage, decreasing levels of TP were observed which can be correlated to management measures in the watershed. TP concentrations are relatively stable at moderate and low flows but at very high flows they have increased greatly in the past 15 years. Flux continues to rise and is becoming more and more episodic. These changes are almost certainly related to the decreasing capacity of Conowingo Reservoir. TS Lee flux for TP was about 10,600 tons. The 2011 water year flux for TP was 17,400 tons. The past decade average for TP was 4,800 tons/year. The past 34-year average was 3,300 tons/year.

For SS, little to no change in flux at most discharges and times of year. However large increases were observed for events above 100,000 cubic feet per second (cfs). SS was observed to be highest in Hurricane Ivan, TS Lee was second highest. TS Lee SS flux was estimated at about 19.0 million tons. The 2011 water year was 24.3 million tons for SS. The past decade average was 4.8 million tons.

The past 34-year average was 2.5 million tons. Flow-normalized flux is rising very steeply and variability is increasing.

Based on their findings the USGS hypothesis is that as the reservoirs fill, for any given discharge, there is less cross-sectional area, resulting in greater velocity. This leads to a decrease in the scour threshold (and thus, more frequent scouring) as well as leading to a decrease in the amount of deposition at lower discharges. The 1997 predictions (TN flux increase of 2 percent; TP flux increase of 70 percent, SS flux increase of 250 percent) in comparison to predictions with observed changes in flux since 1996 from this recent study are now, TN flux decrease of 3.2 percent, TP flux increase of 55 percent, and a SS flux increase of 97 percent.

The trapping of TP and SS by the reservoir system is decreasing. Scour is becoming more frequent and larger. There is an increasing role of high flow events for TN, TP, and SS inputs to the Bay. The "filling" of the reservoirs is asymptotic and stochastic. Findings are that the system is in transition to "full." Over the coming decades, the state of the reservoirs may be the main driver of TP and SS inputs to the Bay.

Bob noted that these findings are still considered draft. The final report will be released by USGS in the next few weeks. USGS will be putting out a news release when the report is published (the report will be posted electronically). They will decide who to include in the review process of this news release. They may want quotes from various agencies. They may also include a link to the LSRWA website and a statement about the study.

Lew mentioned that the decrease in TN could be related to the decreased amount of TN available from atmospheric deposition.

Bruce noted that SAV beds in the Bay weathered TS Lee better than TS Agnes, most likely because of the robustness of the existing bed now compared to when Agnes hit. Dissolved oxygen levels were good this year as well. DNR is evaluating the health of SAV in the Susquehanna flats to determine if there are any lingering effects from TS Lee.

Carl commented that he suspects that a lot of the nutrients going over from Conowingo aren't biologically available. We need to have more research to understand what percentage of the nutrients entering the bay from the reservoirs is biologically available.

7. Coordinated Message based on USGS Presentation-Brainstorming – There was discussion on drafting a statement regarding Conowingo's time as an effective sediment trap running out, based on USGS recent findings, with the intent that the LSRWA team has a consistent message to policymakers, the public, and media.

The following comments were offered in regards to messaging:

- The USGS study shows that the system is dynamic and complex.
- With these findings do we have a way to accelerate study? It appears we don't have the luxury of waiting?
- We need to understand the problem and should not jump to conclusions about what will happen if the Conowingo is no longer trapping sediments.

- We need to be cautious in how we communicate results as there could be impacts to the Bay TMDL.
- The USGS work shows the importance of the watershed assessment and we should not predict now what will happen to the Bay
- A lot is riding on this study efforts; we need to get it right.

Pat noted that any public message that Pennsylvania is a part of would need to go through their press office

Herb and Bruce agreed to draft a preliminary statement that would be reviewed by the LSRWA team. USGS is doing a formal news release; therefore, the LSRWA team statement would not be a news release, but instead would be posted on the LSRWA website and distributed via email to stakeholders.

Michael Helfrich asked about the trapping efficiency of the dam and if that would be determined based on new data. Mike Langland noted that we know the filling rate so we can show the remaining capacity and discuss in terms of the lack of capacity. We can assume that where trapping is going away, scouring is occurring.

8. LSRWA Technical Analyses – The various team members provided updates on their technical analyses.

MGS Data Collection – Jeff Halka noted that the crew made it out on 2 May to collect sediment samples in the Susquehanna flats. Analyses were completed and distributed to the group. Marji asked about sea-level rise evidence. Jeff noted that there is not a lot of historical grain-size and bathymetry data for the flats. Not much sand goes into the center. Water quality is good. If flats get deeper from storm scouring, we will see impacts to SAV.

HEC-RAS Modeling – USGS's Mike Langland shared the status of their HEC-RAS modeling work. The HEC-RAS model has three main components: (1) geometry, (2) hydraulics, and (3) sediment transport.

To account for geometry in the system, there were three options. The first option was to adapt the HEC-6 model constructed by USGS in the mid-1990's. This option was ruled out early because this model did not perform well. The second alternative was to convert the HEC-2 model to a HEC-RAS model. This option was ruled out because only 75 percent of the study area from Marietta to Conowingo had coverage, missing about half of Conowingo Reservoir to the dam. The third and selected option was to construct a new HEC-RAS model using LIDAR data from Maryland and Pennsylvania, as well as recent bathymetry data (1996 and 2008 datasets) and flood insurance data to fill in where bathymetry data wasn't available.

To account for hydraulics in the system, daily mean stream flows were pulled from four sites (Marietta, Conestoga, Pequea, and Conowingo) from 1996-2011. Gates were added for each of the reservoirs to help the flow simulation. Steady-state runs were made for annual mean flow, 300,000 cfs, 400,000 cfs, and 750,000 cfs. The model performed reasonably well at Safe Harbor and Conowingo, but there were problems at Holtwood. The simulations used pool elevations as

boundary conditions. Unsteady state (varying stream flow) has been less successful due to the fact that Mike does not have daily operational data for the turbine and spillway gates. This data would need to be obtained from power companies to incorporate in the model.

To account for sediment transport, Mike performed a series of tasks: (1) computed daily sediment loads for the four sites which will serve as one of the boundary files; (2) compiled estimated daily temperature data (temperature effects sediment settling); (3) built bed composition files; (4) input shear stress and erosion rates of sediments from sedflume data) for each reservoir; and (5) constructed sediment distribution with changing loads. First model runs indicate low velocities and high sheer stress resulting from an overestimation of deposition.

Mike identified two issues for resolution – unsteady state flow modeling and overestimation of deposition. He will talk with Stan Gibson about the sediment simulations using quasi-steady state and gate operations. He anticipates having a workable boundary condition file to ERDC for the 2D ADH efforts by the end of August, and will continue work on documenting the model. He will have more detailed info at the next quarterly meeting.

CBEMP Modeling Update and Data Report – Carl is in a holding pattern right now for his efforts on the study. He has been working with EPA and they have determined four modeling runs that can be done with the CBP WSM model.

Sediment Transport Modeling – Steve Scott updated the agency LSWRA team on his sediment transport modeling using the PowerPoint presentation in enclosure 3.

Steve discussed his SedFlume field activities and data analysis, and provided preliminary sediment transport results with SedFlume data.

SedFlume is a portable laboratory flume that evaluates erosion rate and critical shear of cohesive sediments. Samples (sediment cores) were collected from eight locations in Conowingo Reservoir. The entire core was analyzed; erosion rate coefficients, exponents, and critical shear stress for erosion along with bulk density and particle size distribution, were determined.

Based on the results of the SedFlume data analysis, the sediment transport model domain was divided into areas using the change in sediment properties (average sediment size fractions) as determined by the collected data.

A preliminary sediment transport simulation was run to evaluate the 2008-2011 Susquehanna River flows (run included the period-of-record TS Lee event). Sediment inflows were estimated from previous HEC-6 modeling.

Steve simulated sediment load in and out of Conowingo Reservoir from 2008-2011 using assumptions on critical shear stress and erosion from the SedFlume analysis. His findings were that total sediments into reservoir during this time period were approximately 12 million tons, and sediments out of the reservoir were 16.6 million tons. Net scour was 4.6 million tons. Steve noted that scour occurred at >350,000 cfs flows and that his results of sediment transport parallel Bob Hirsch's results. When Conowingo is at capacity the dam will fill, scour, fill, scour.

Gary asked if Steve planned to compare the 2008-2011 data results to the 2011 bathymetry data that Exelon collected; Steve explained that this data was indeed included in the his analysis.

Exelon Activities – Claire noted that she sent out the Exelon Conowingo Pond Bathymetric Survey Analysis report for review to the LSRWA team for review and will consolidate comments to provide to Exelon.

Tom let the group know that the Exelon license application for Conowingo dam will be filed with FERC at the end of August and all required studies will be completed by the end of September with the exception of two fish studies.

Literature Search Update – Anna, Mark, and Kathy are working on the literature search. Findings will be presented at the next meeting in September which will be a brainstorming session to begin developing strategies to manage sediments in the Lower Susquehanna River watershed. Anna reminded the group that a draft outline of the report was distributed via email for comment. This outline will be discussed at the next quarterly meeting. The team needs to determine what sections will go in the report and leads for each section. There is no time in the schedule for report writing, only review of the report so we need to start writing now.

9. Wrap Up – Anna will draft up notes for the group's review. Following this, the notes and presentations will be posted to the project website. The next quarterly meeting date will be coordinated by Claire for sometime in late October/early November. The next modeling conference call will be on September 6th, starting at 2:00 pm (EDT, 1:00 pm CDT). Claire will coordinate a sediment management strategy brainstorming meeting for sometime in September.

Anna Compton,
Study Manager

Enclosures:
1. Meeting Agenda
2. Bob Hirsch Presentation
3. Steve Scott Presentation

LOWER SUSQUEHANNA RIVER WATERSHED ASSESSMENT
QUARTERLY TEAM MEETING

MDE, Montgomery Park Building, Aqua Conference Room
August 7, 2012

Meeting Agenda

		Lead
10:00	Welcome and Opening Remarks	Sachs
10:05	Introductions	All
10:10	Review of Action Items from April Meeting	O'Neill
10:20	Communication and Coordination	
	PowerPoint Presentation – Feedback from Recent Meetings	All
	Project Website Update	Michael
	Mission Statement Review	Compton
	USACE Review Plan	Compton
10:30	USGS Presentation on the Susquehanna River and the Impacts of Tropical Storm Lee High Flow Events	Bob Hirsch
11:15	Coordinated Message based on USGS Presentation – Brainstorming	Michael/O'Neill
	What is Message?	
	How Should Message Be Distributed?	
11:30	LSRWA Technical Analyses	
(3-5 min)	MGS Data Collection	Halka
(3-5 min)	CBEMP Modeling Update	Cerco
(30 min)	Sediment Transport Modeling Update – SEDFlume Presentation	Scott
(3-5 min)	HEC-RAS Modeling Update	Langland
(5 min)	Exelon Activities – Conowingo Relicensing Update	LeMay/Seaman
(3-5 min)	Literature Search Update	Compton
12:20	Review of Schedule for 2012	O'Neill
	Funding Priorities for Fall-Winter 2012	O'Neill
	Report Preparation	Compton
12:40	Wrap Up	O'Neill
	Action Items/Summary	
	Next Meeting	

Call-In Information: (410) 537- 4281 (no password required)

Expected Attendees:

MDE: Herb Sachs; Tim Fox, Matt Rowe, John Smith
MDNR: Bruce Michael, Shawn Seaman
MGS: Jeff Halka
SRBC: John Balay, David Ladd, Andrew Gavin
USACE: Chris Spaur, Claire O'Neill, Andrea Takash, Robert Pace, Tom Laczo
ERDC: Carl Cerco, Steve Scott
TNC: Mark Bryer, Kathy Boomer
USEPA: Gary Shenk
USGS: Mike Langland, Bob Hirsch

Exelon: Gary LeMay, Kimberly Long, Tom Sullivan, Marjorie Zeff
Lower Susquehanna Riverkeeper: Michael Helfrich
PA Agencies: Patricia Buckley, Raymond Zomok

Action Items from April Meeting:

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B. Mike will invite Bob Hirsch to attend August quarterly meeting to give presentation on his findings.
C. Herb and Bruce to draft preliminary statement regarding Conowingo's time as an effective sediment trap running out, with the intent that we have a consistent message to policymakers, the public, and media.

Ongoing Action Items from Previous Meetings:

D. The MDE FTP website will be utilized to share internal draft documents within the team; Matt will be the point of contact for this FTP site.
   Status – Ongoing; sharing of future documents will go through the MDE ftp website.
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   Status – Recent report was sent out to team; ongoing action.
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H. Mark and Anna will coordinate to conduct a literature search providing info on best management practices around the nation and world for reservoir sedimentation.
I. Matt will keep team informed on innovative re-use committee findings to potentially incorporate ideas/innovative techniques into LSRWA strategies.

Nitrogen, Phosphorus, and Suspended Sediment fluxes from the Susquehanna River to the Bay in Tropical Storm Lee, 2011– results and implications

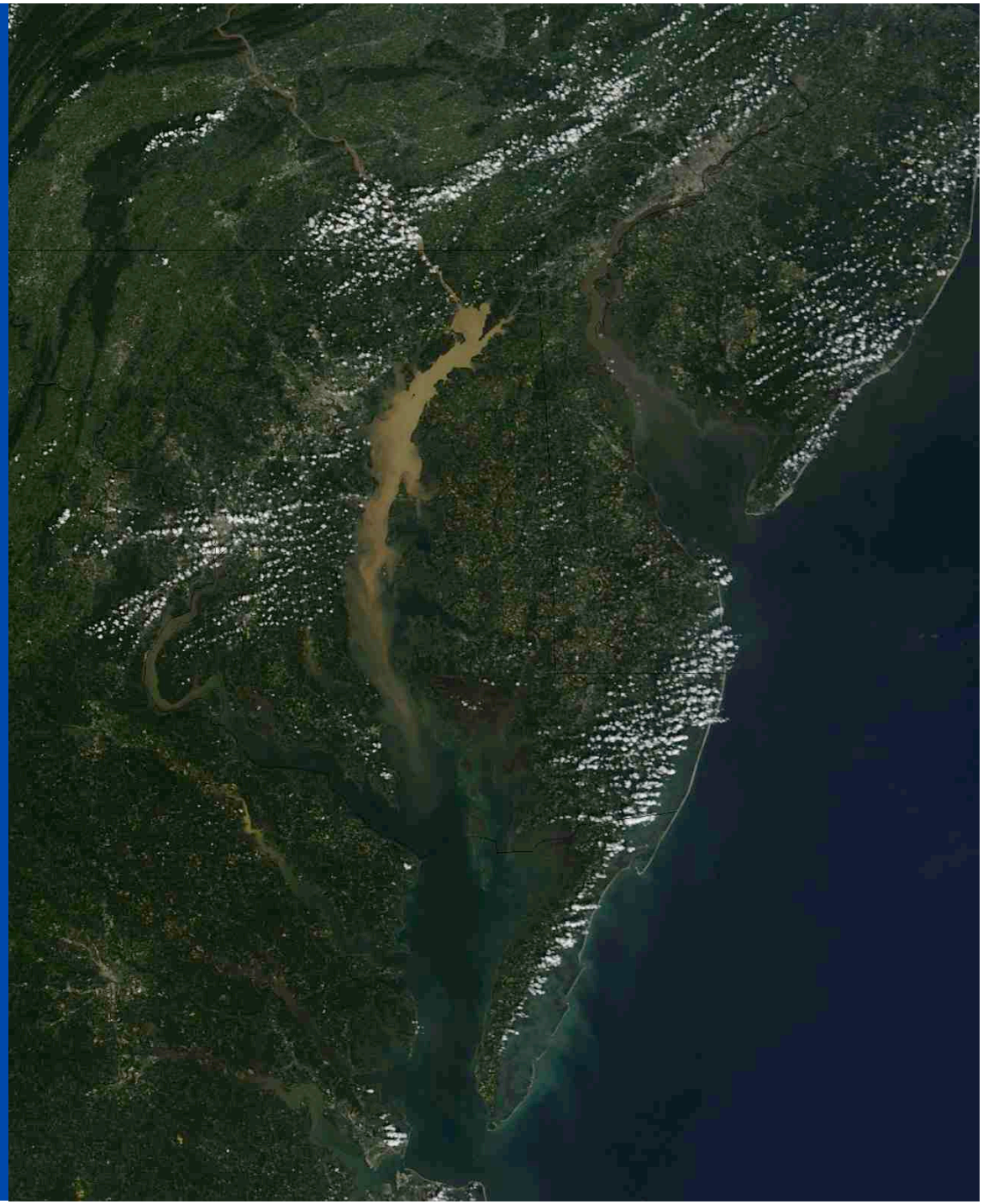
Robert M. Hirsch,
Research Hydrologist, USGS

August 7, 2012

Lower Susquehanna River Watershed Assessment

USGS Photo credit: Wendy McPherson, USGS, September 12, 2011

Photo credit: NASA MODIS, Sept. 13, 2011



USGS

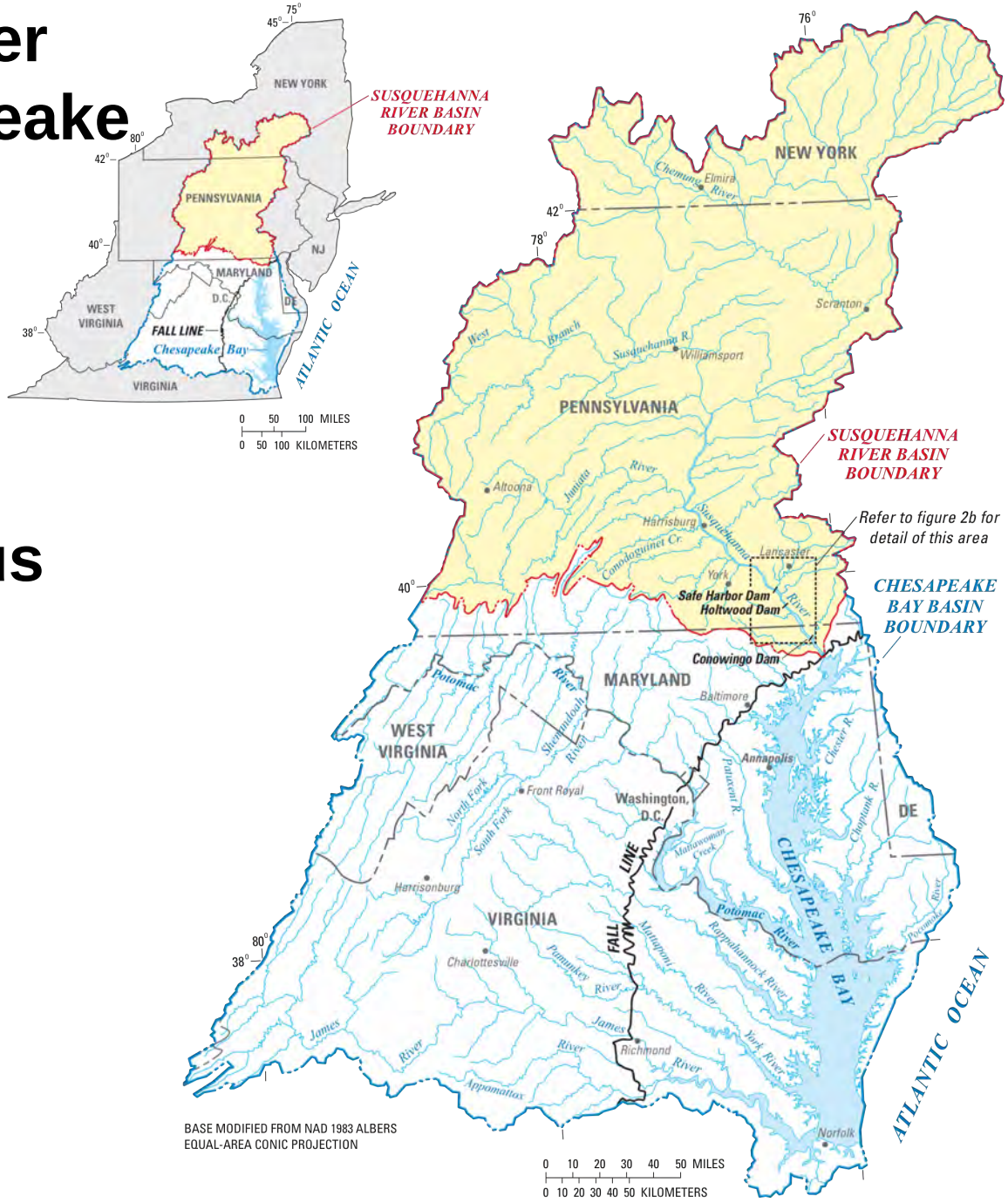
Susquehanna River As a % of Chesapeake Bay inputs

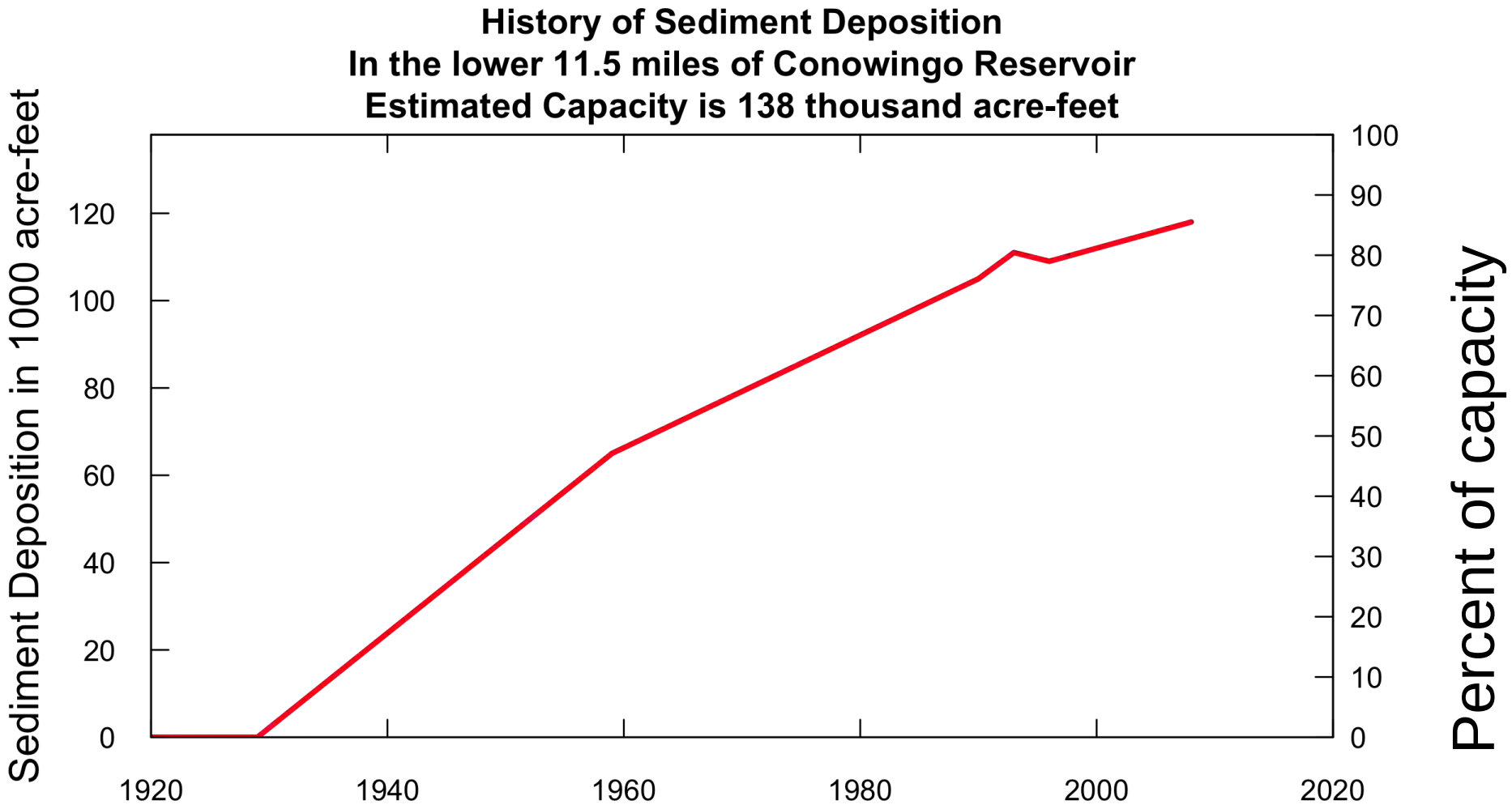
47% of freshwater

41% of nitrogen

25% of phosphorus

27% of sediment





Source: Langland, 2009
http://pubs.usgs.gov/sir/2009/5110/

Predictions by Langland and Hainly (1997)

Reservoirs would be “full” in 17 to 20 years

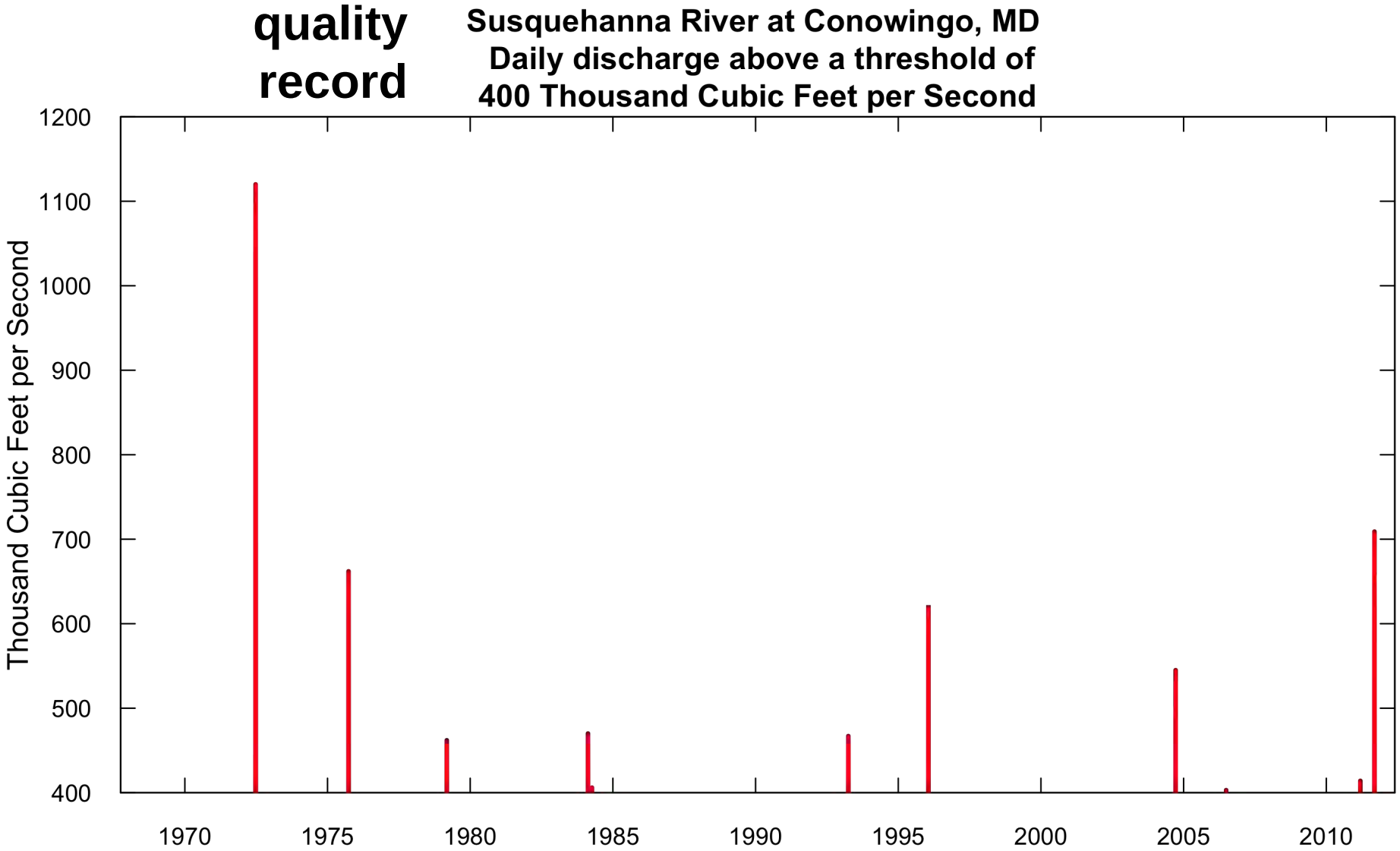
And all other things being equal

TN flux would increase 2%
TP flux would increase 70%
SS flux would increase 250%

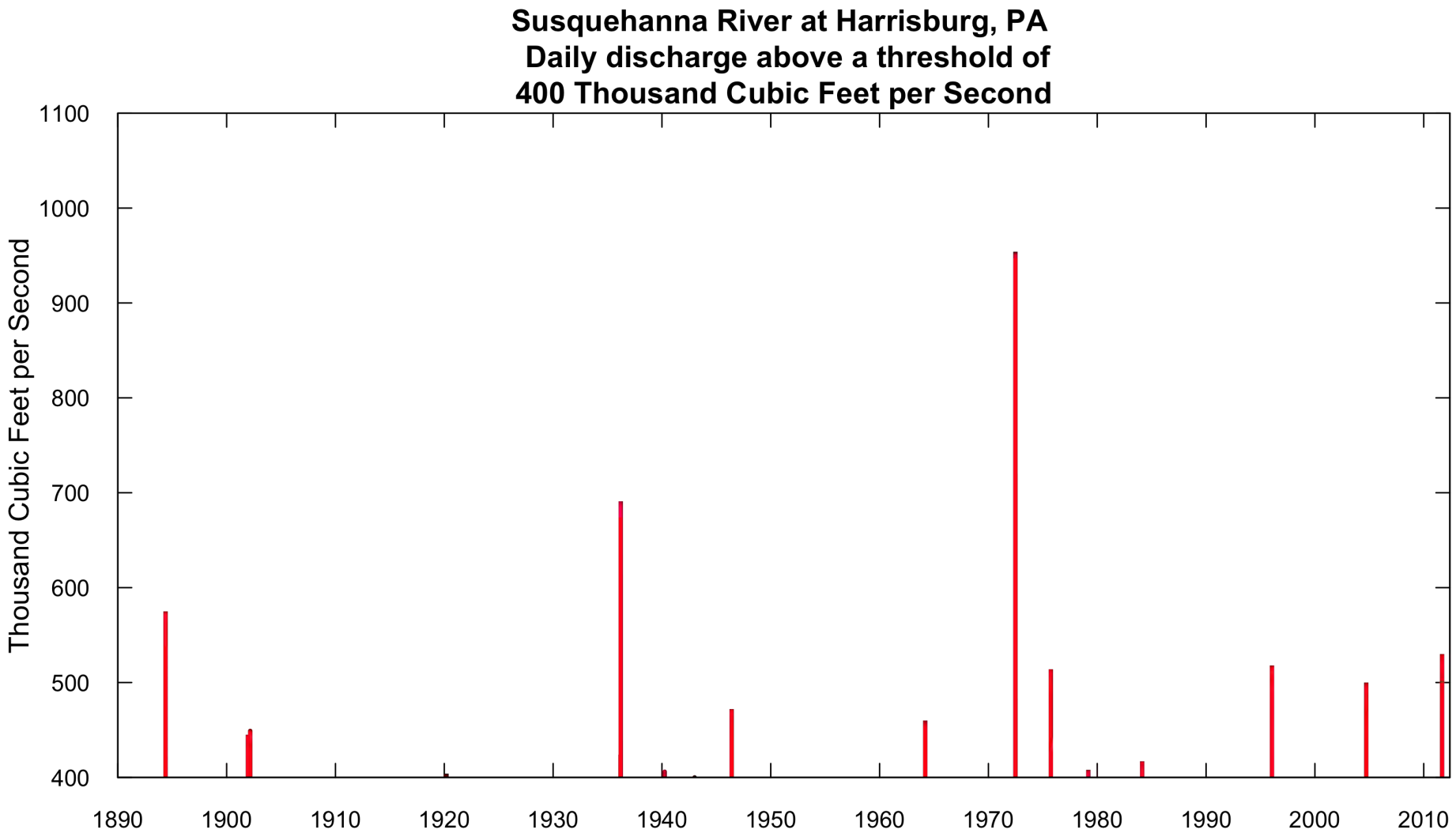
USGS

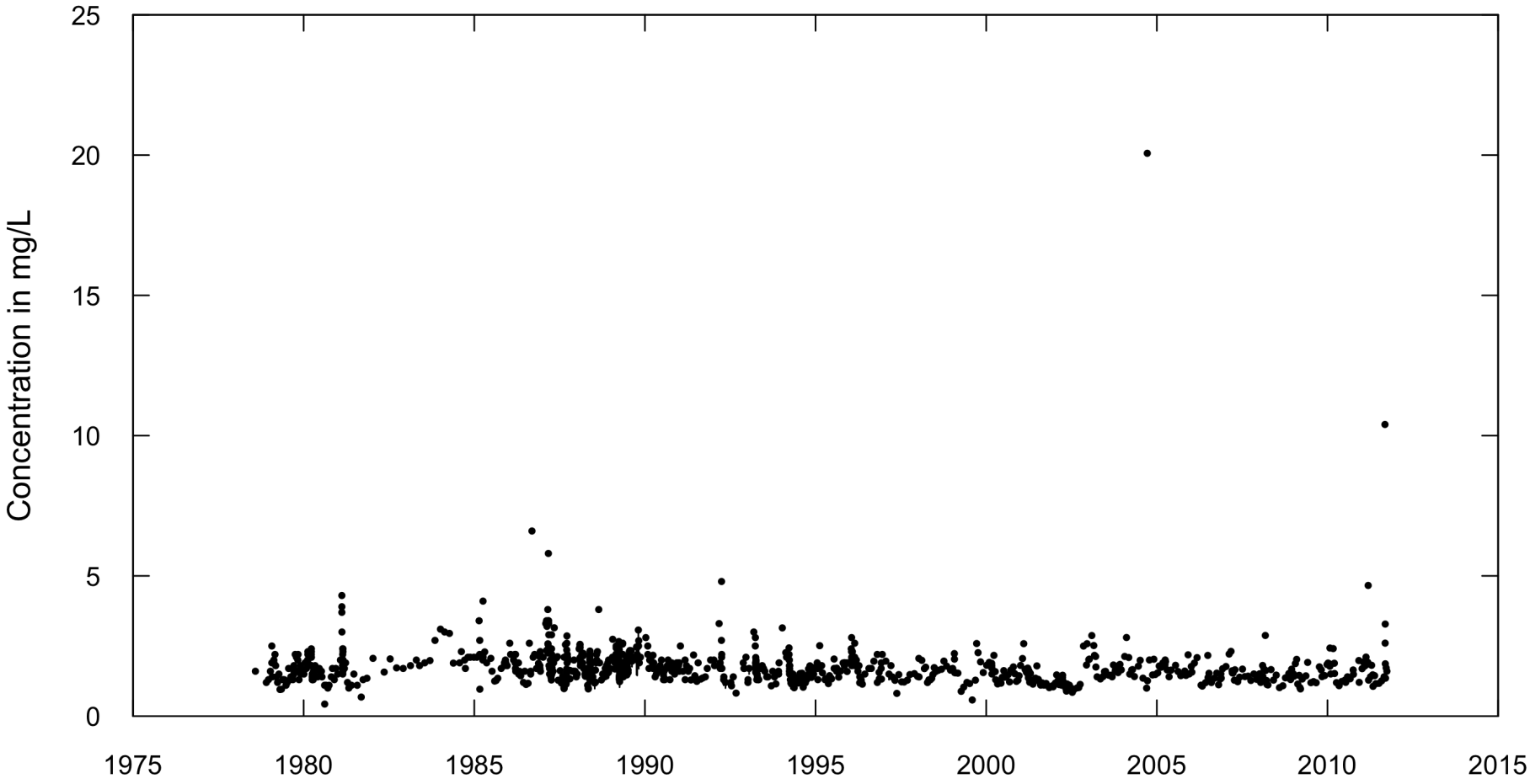
How unusual was the Tropical Storm Lee event?

Pre-water quality record

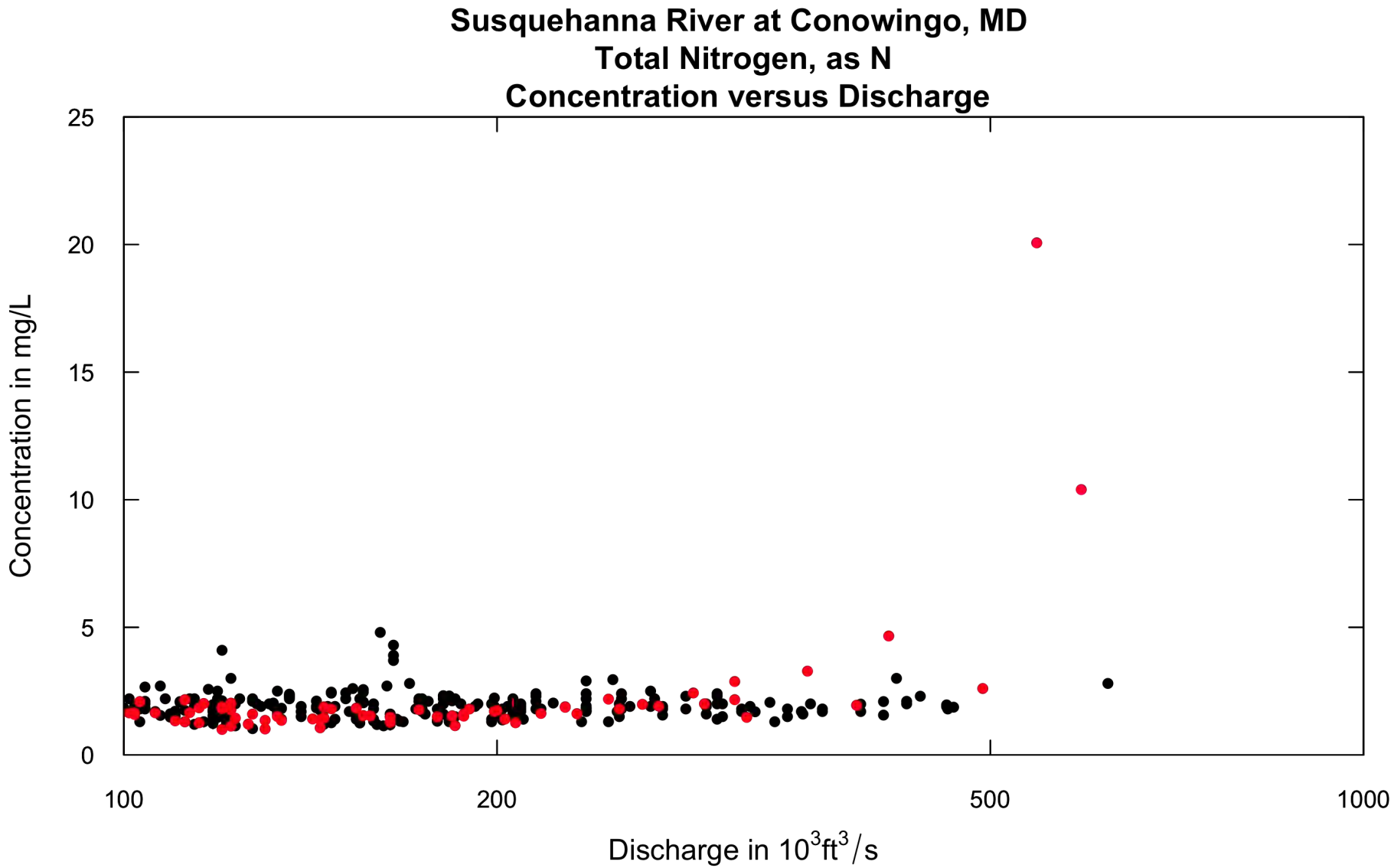


What if we look at the longer record at Harrisburg?

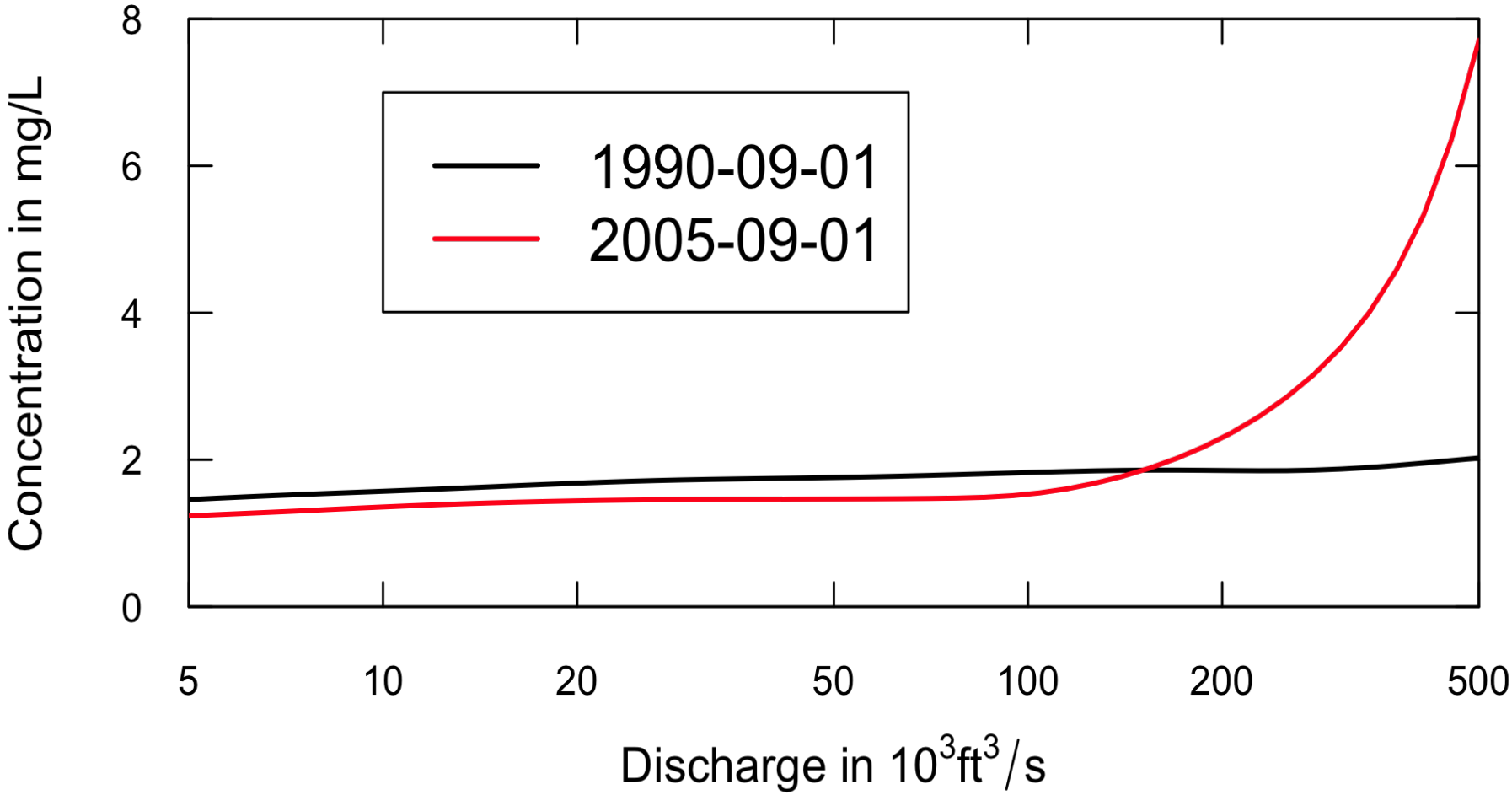



Susquehanna River at Conowingo, MD , Total Nitrogen, as N
Concentration in mg/L
25
20
15
10
5
0
1975
1980
1985
1990
1995
2000
2005
2010
2015

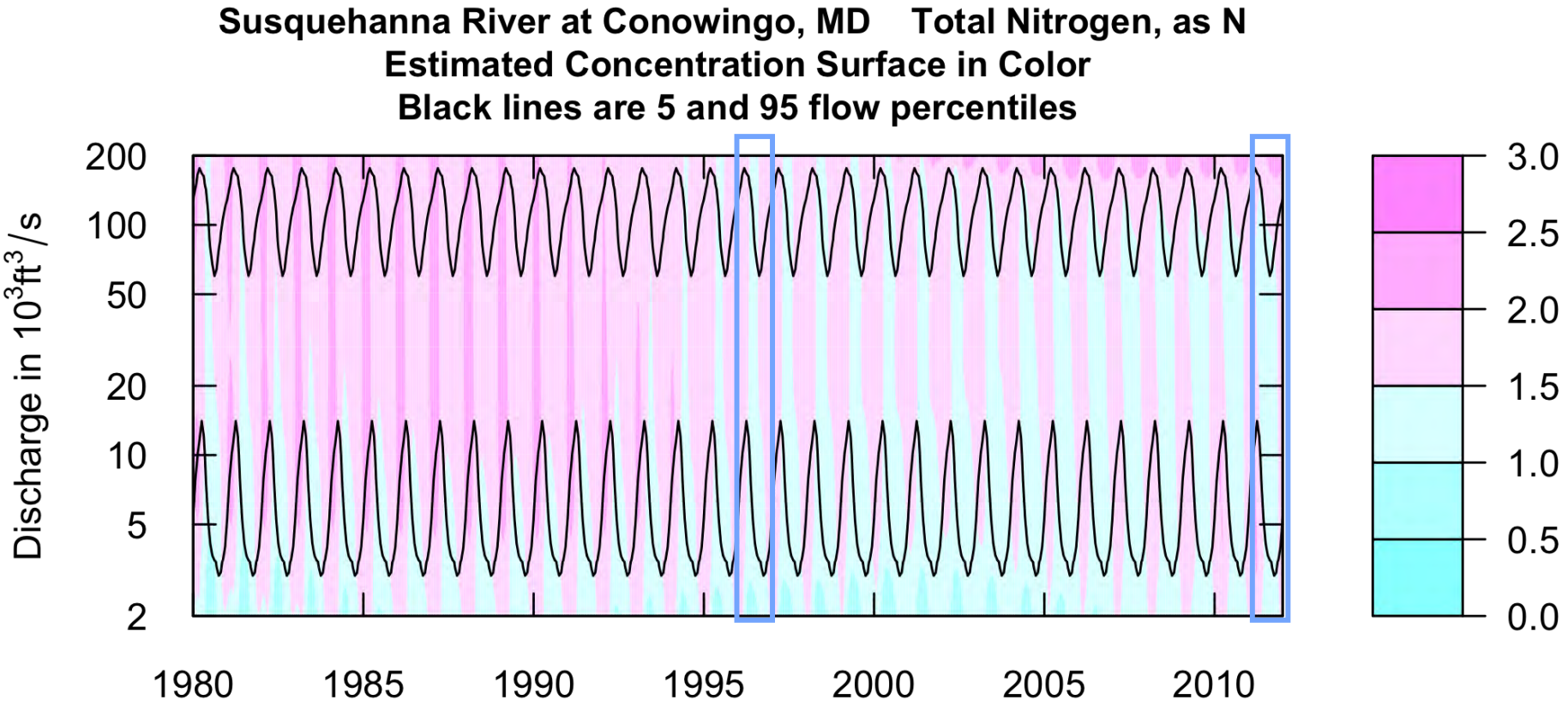
Black dots are pre-2000, Red are since 2000



Use the WRTDS (Weighted Regressions on Time, Discharge and Season) method to describe the evolving behavior of Total Nitrogen

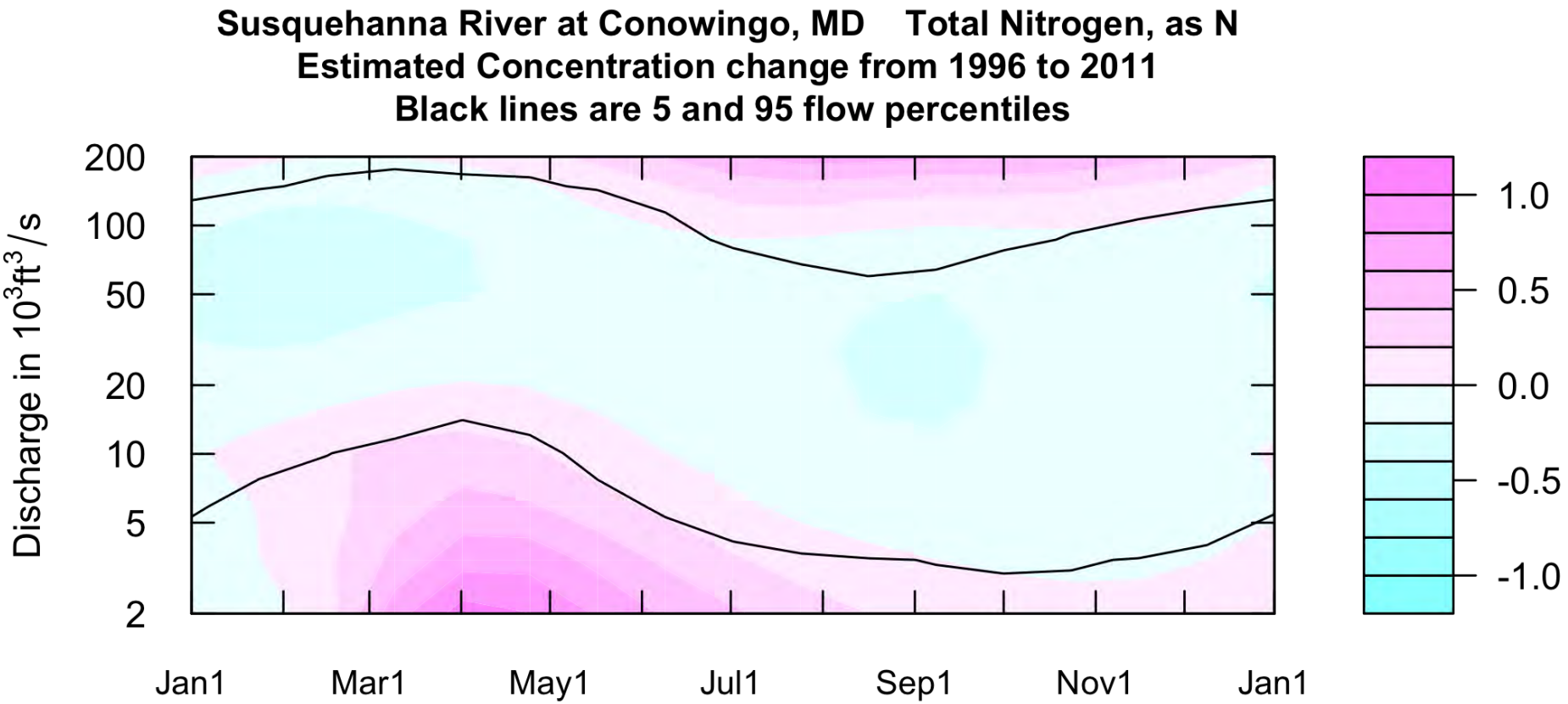


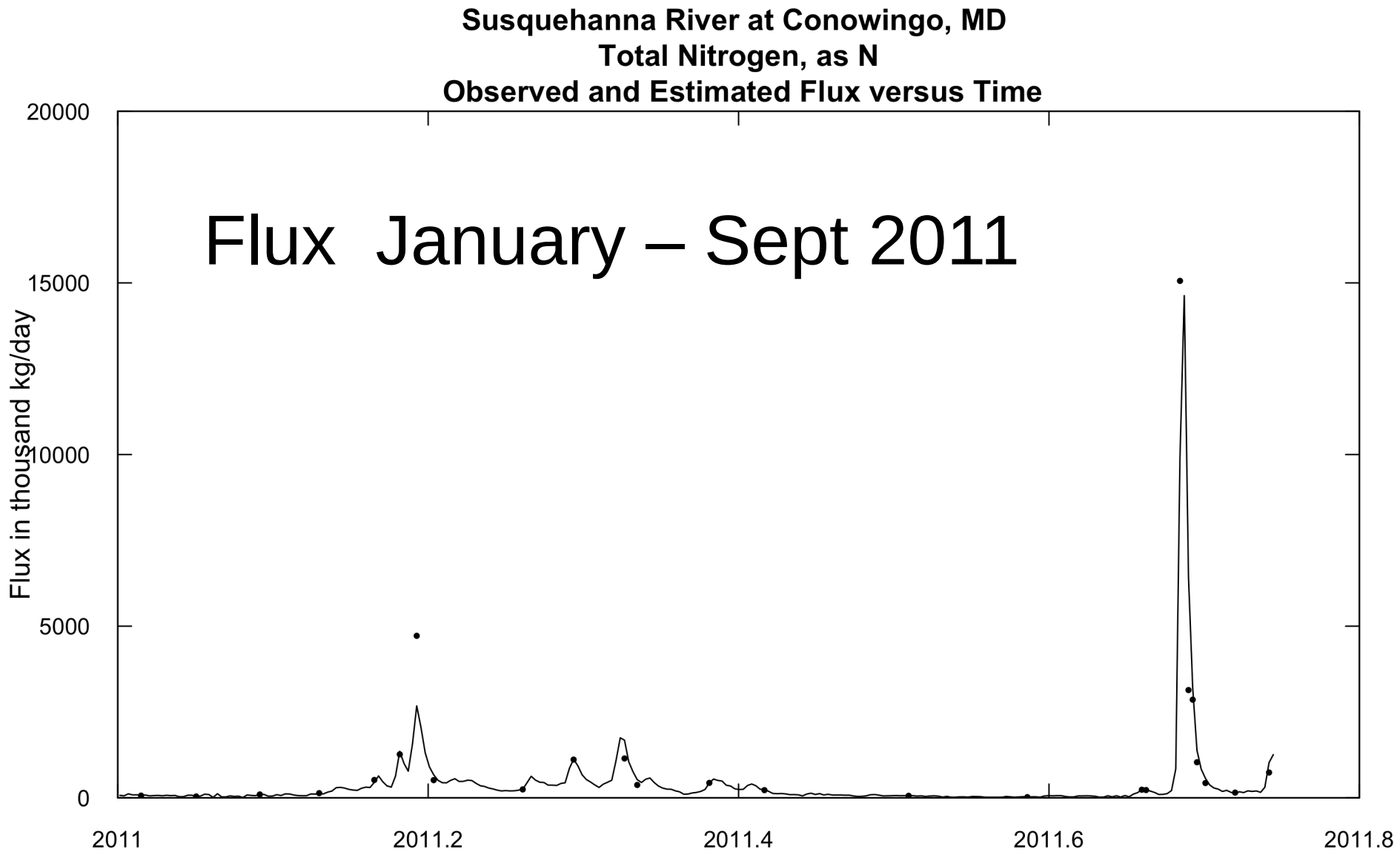
Evolving behavior of TN

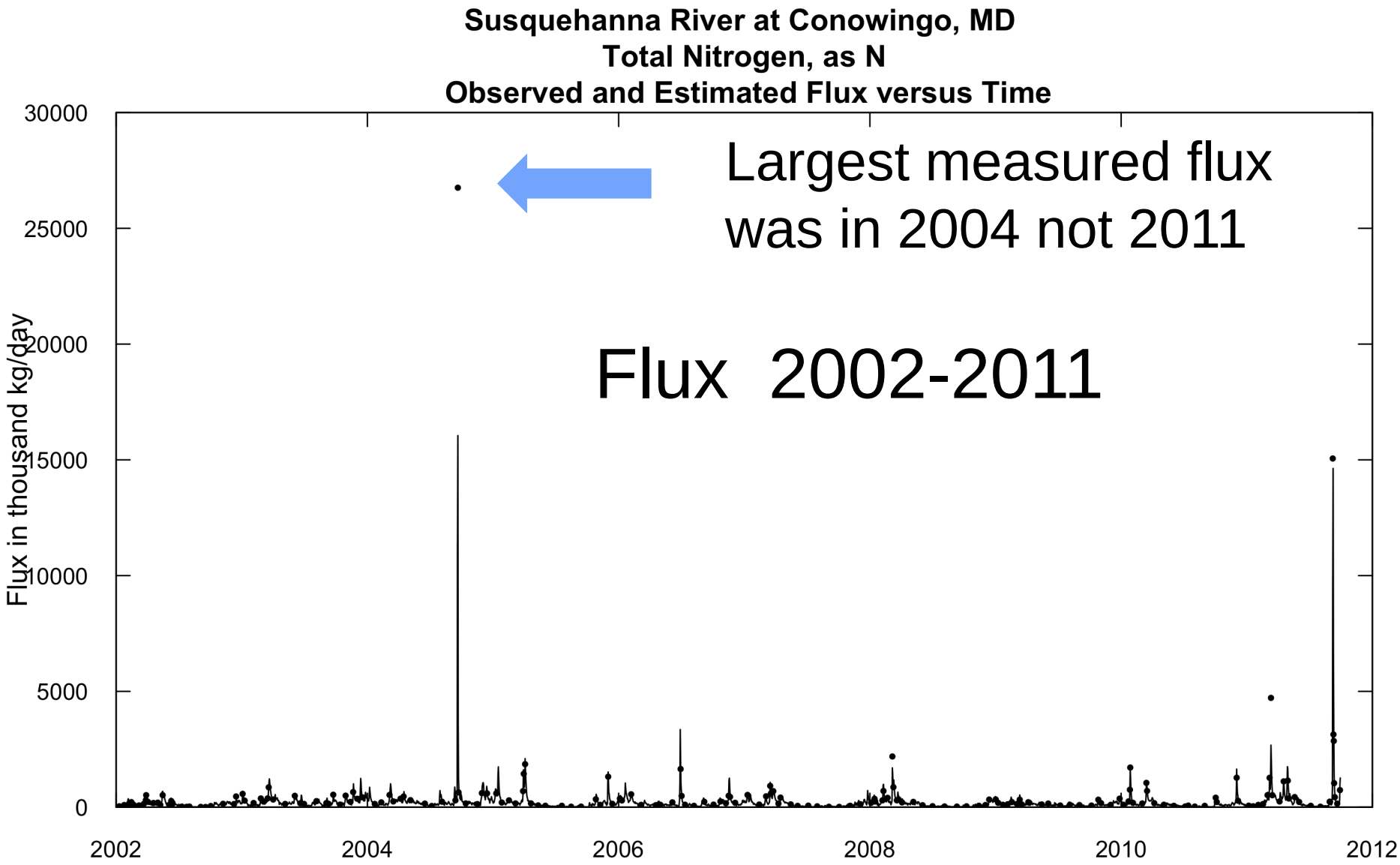


Compute the difference between two years

- **Decreased concentrations at almost all flows and seasons**
- **Biggest decrease between about 40,000 and 100,000 cfs**
- **Biggest decreases in Winter and early Summer**
- **Slight indication of increase at very low flow in Spring**
- **and at very high flow in Tropical Storm season**




Susquehanna River at Conowingo, MD
Total Nitrogen, as N
Observed and Estimated Flux versus Time
Flux January – Sept 2011
Flux in thousand kg/day
20000
15000
10000
5000
0
2011
2011.2
2011.4
2011.6
2011.8


Susquehanna River at Conowingo, MD
Total Nitrogen, as N
Observed and Estimated Flux versus Time
Largest measured flux was in 2004 not 2011
Flux 2002-2011
Flux in thousand kg/day
30000
25000
20000
15000
10000
5000
0
2002
2004
2006
2008
2010
2012

Total Nitrogen flux estimates using WRTDS

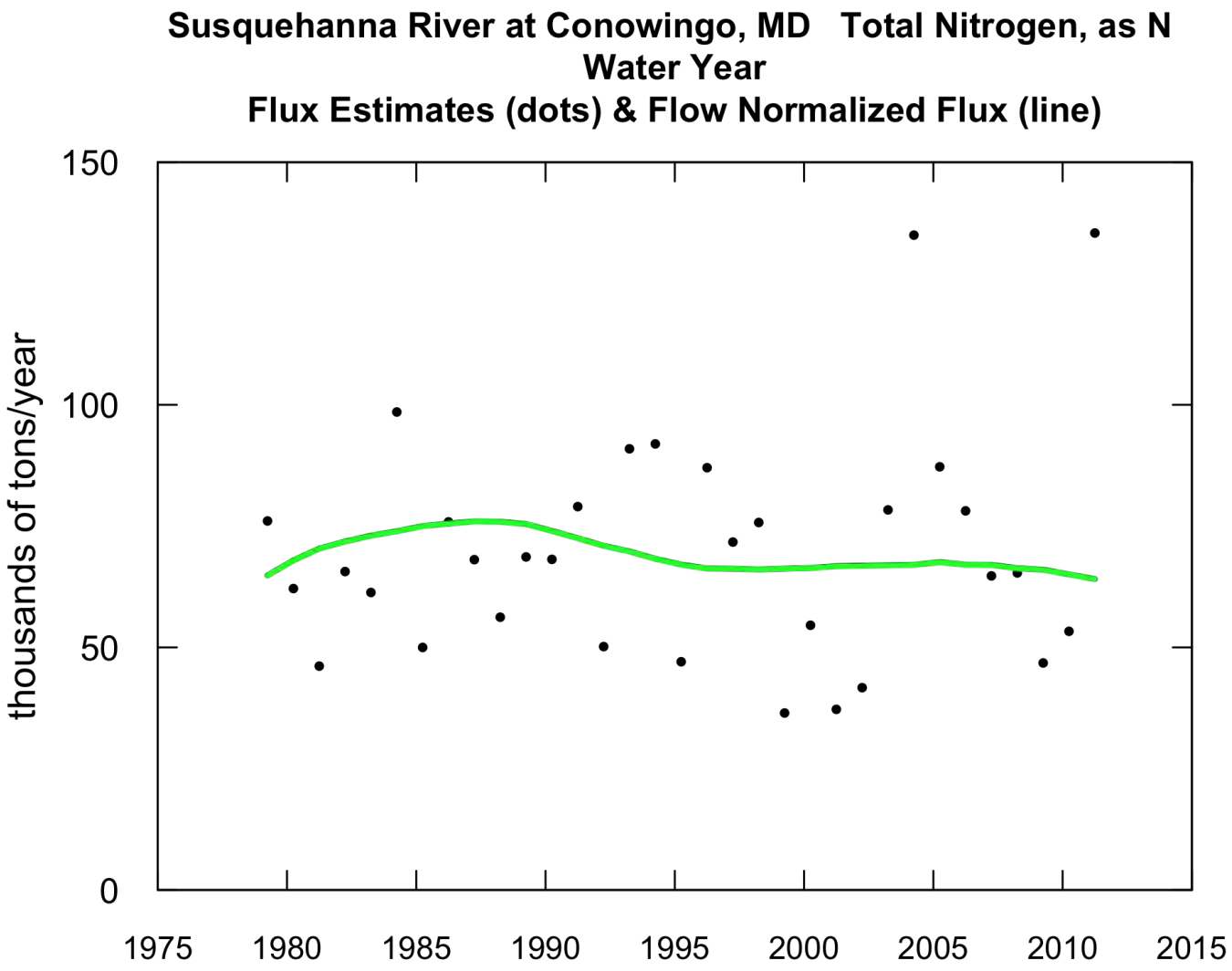
- T.S. Lee flux about 42,000 tons
- The 2011 water year 135,000 tons
- The past decade average was 79,000 tons/yr
- The past 34 year average was 71,000 tons/yr

USGS

Annual Flux
In 10^3 tons/yr

2011 = 135
2010 = 50
2004 = 135

Flow Normalized Flux Change Since 1996
-3.2%

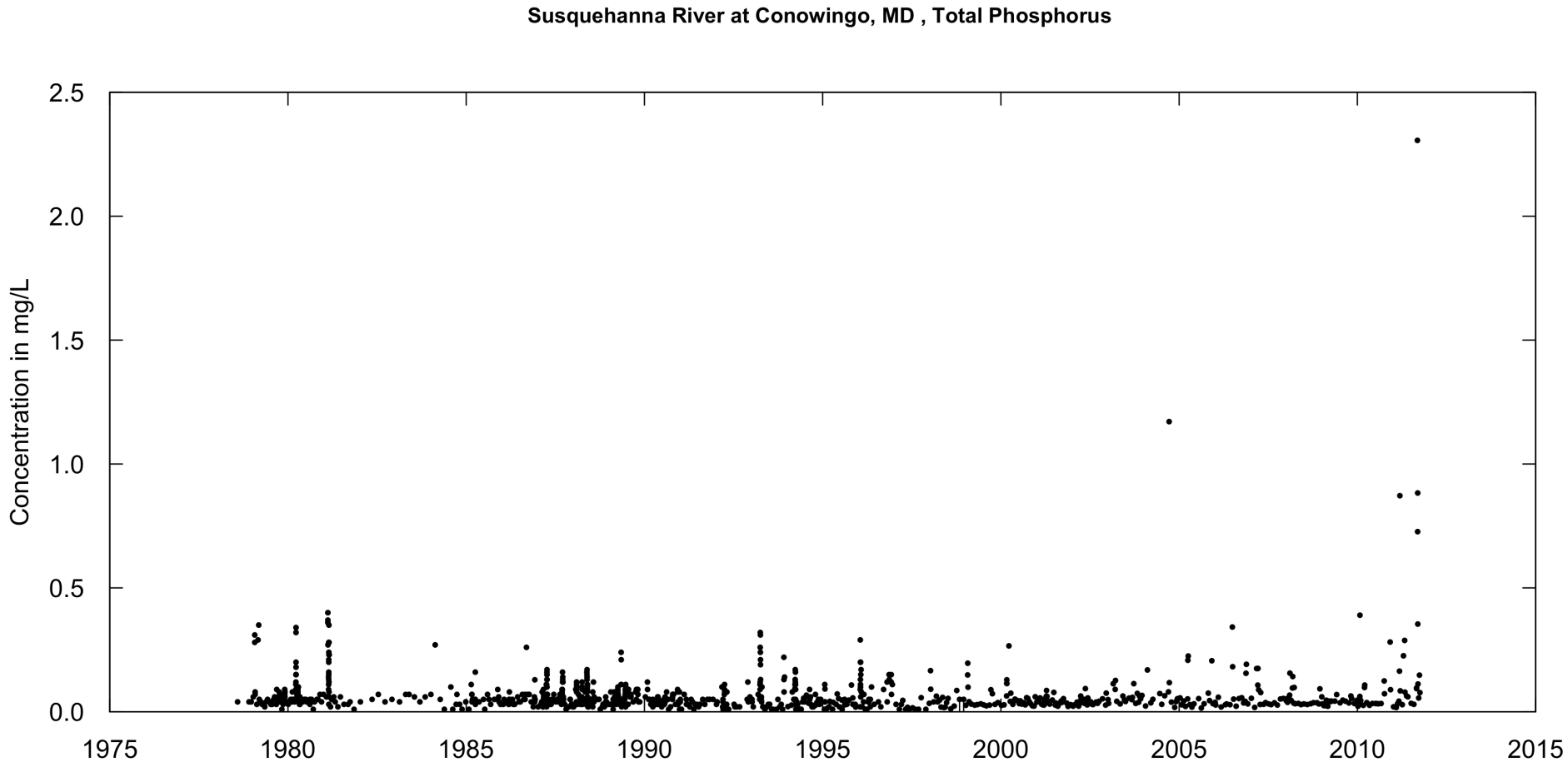


Take home messages: TN

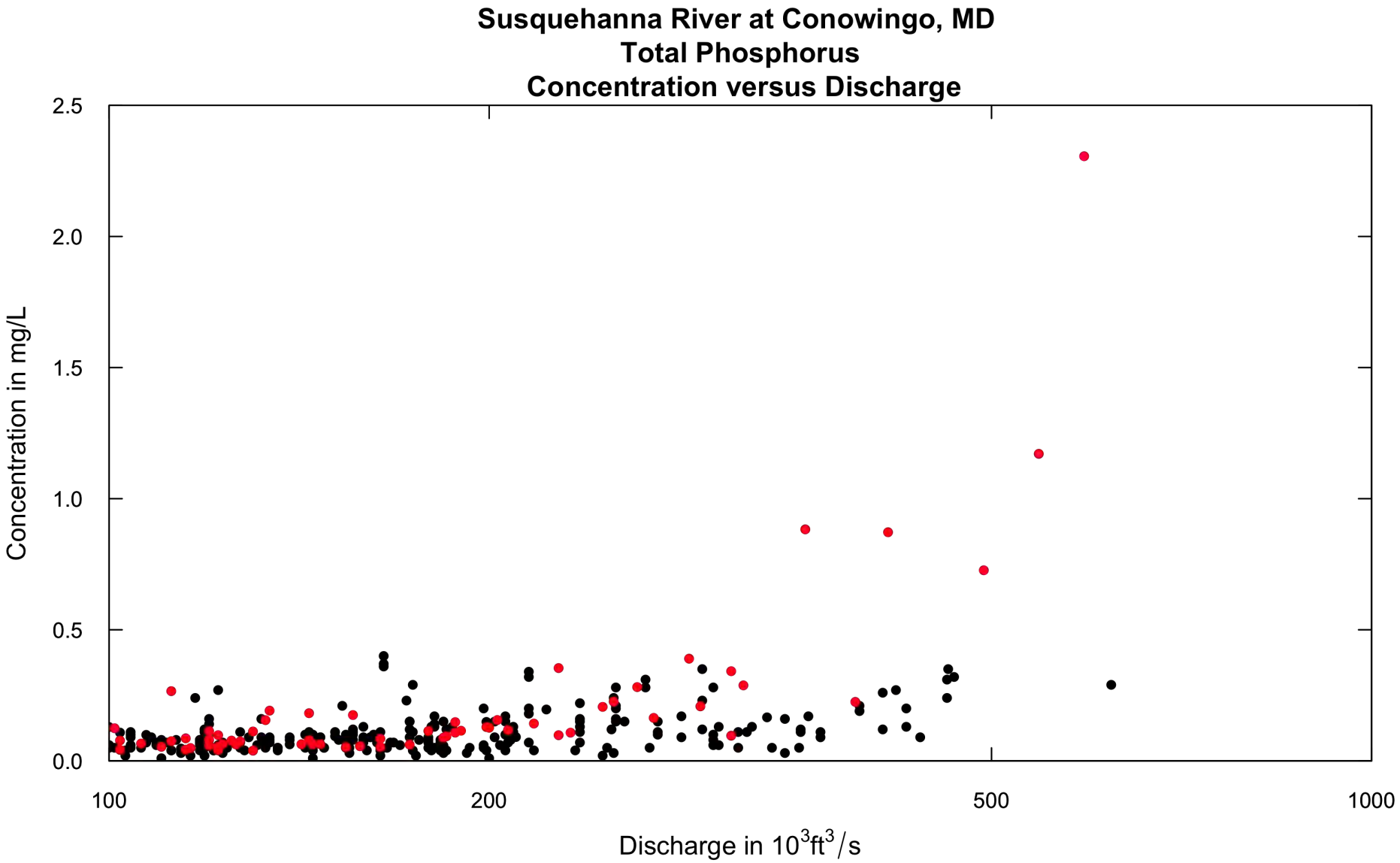
- Total Nitrogen concentrations are continuing to decline at most discharges.
- But at very high flows they are showing some increase.
- Flow-normalized flux continues to fall. Down about 16% since its high in 1987.
- Year to year variability in actual TN flux is increasing (standard deviation about double for 2002-2011 vs. 1978-2001).

USGS

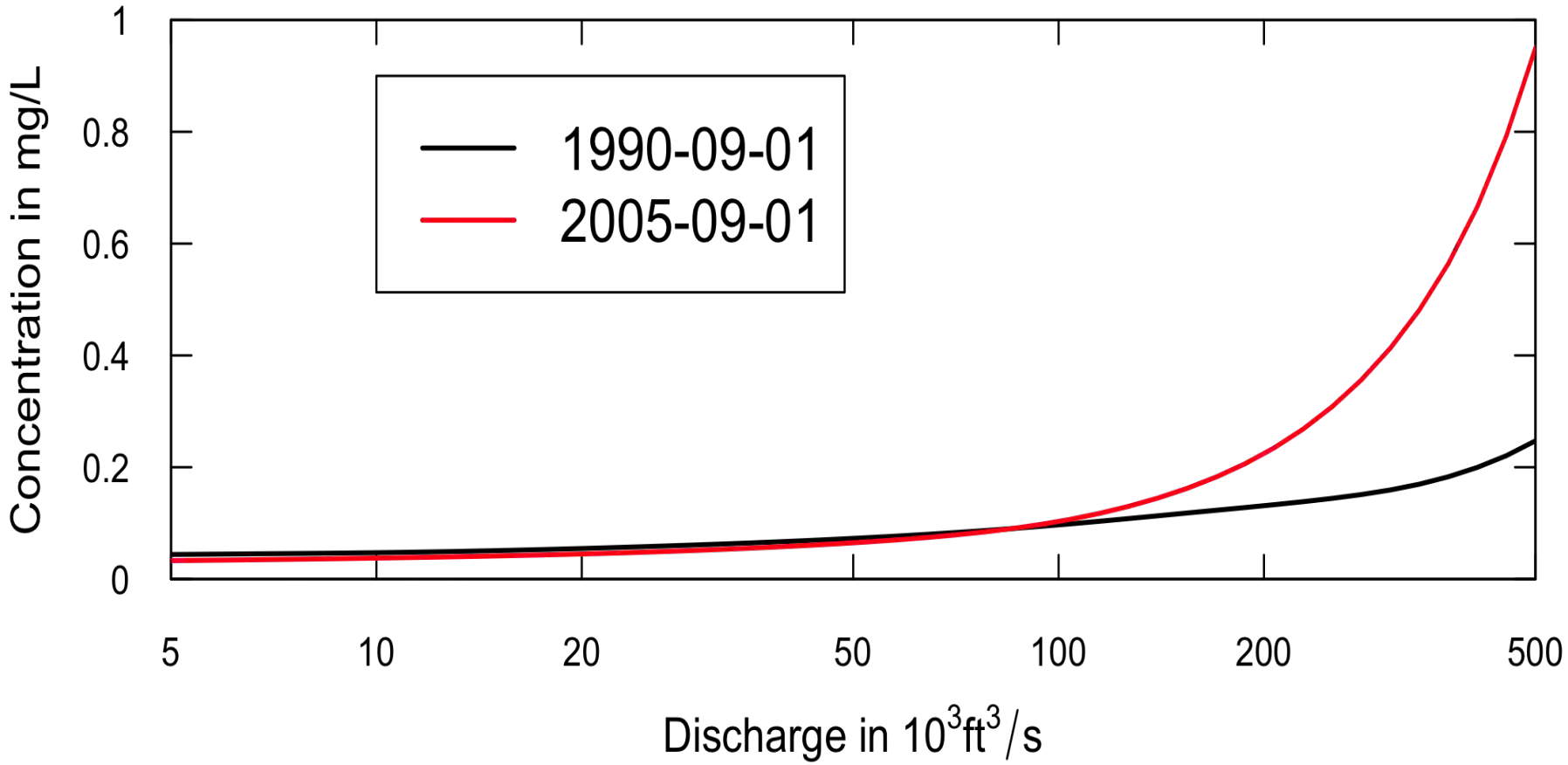
Let’s look at the full history of Total Phosphorus data collected from the USGS RIM station at Conowingo Dam



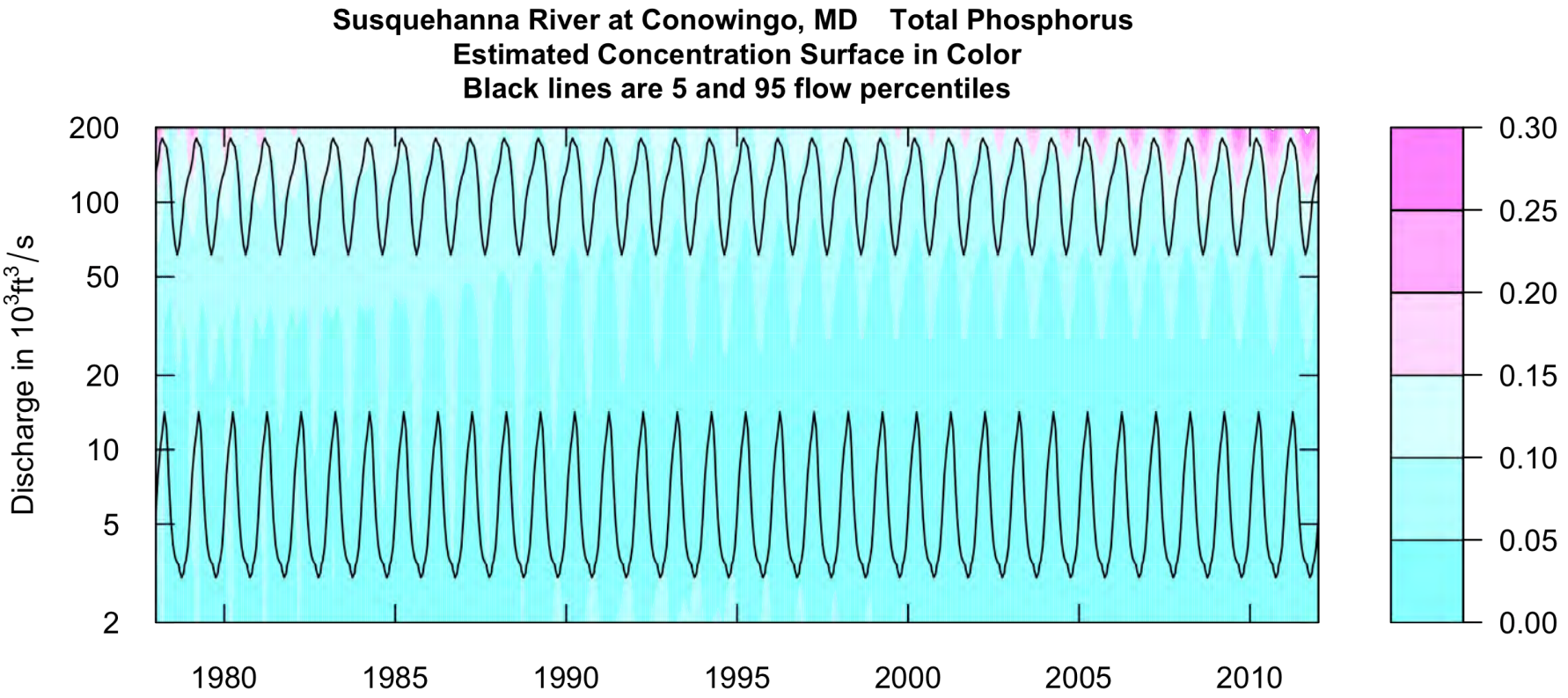
Black dots are pre-2000, Red are since 2000



Use the WRTDS model to describe the evolving behavior of Total Phosphorus

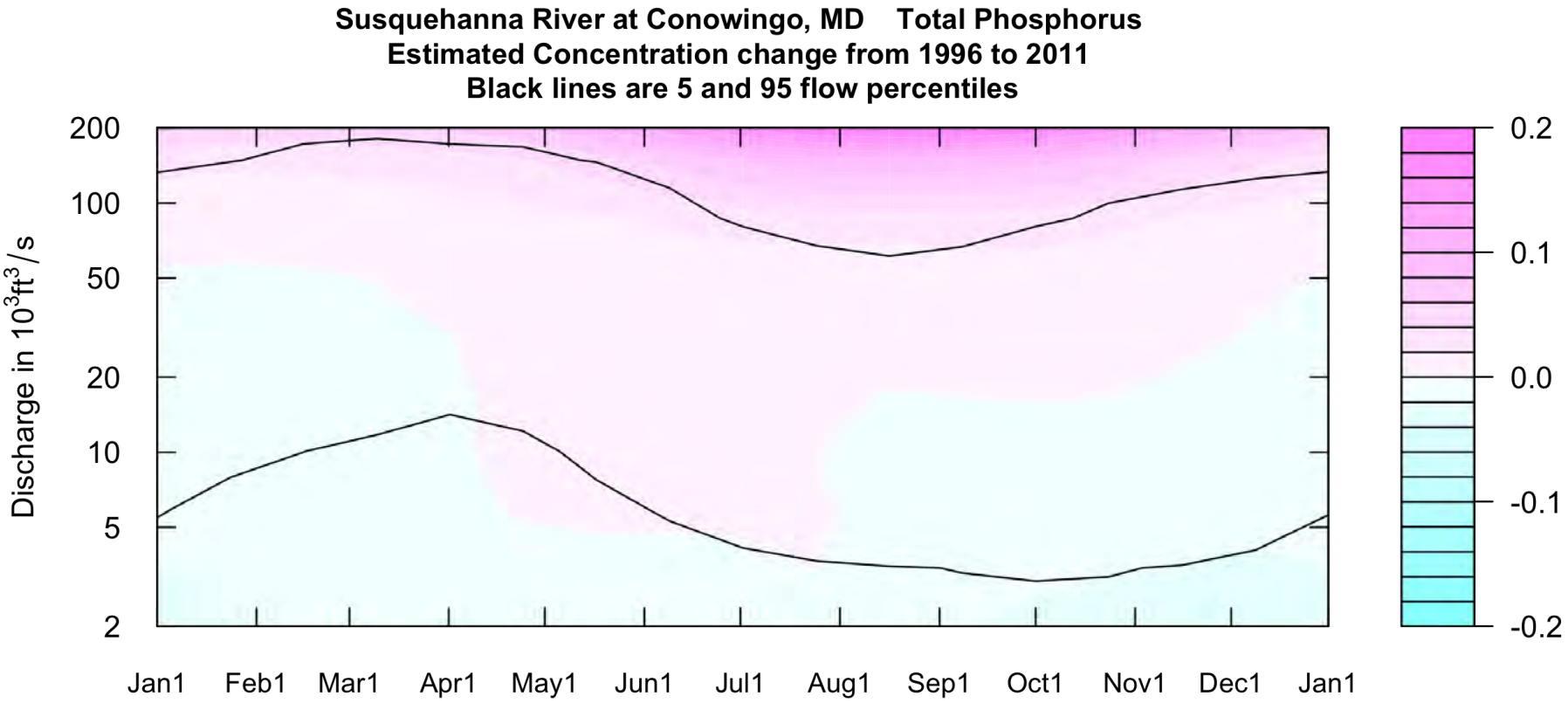


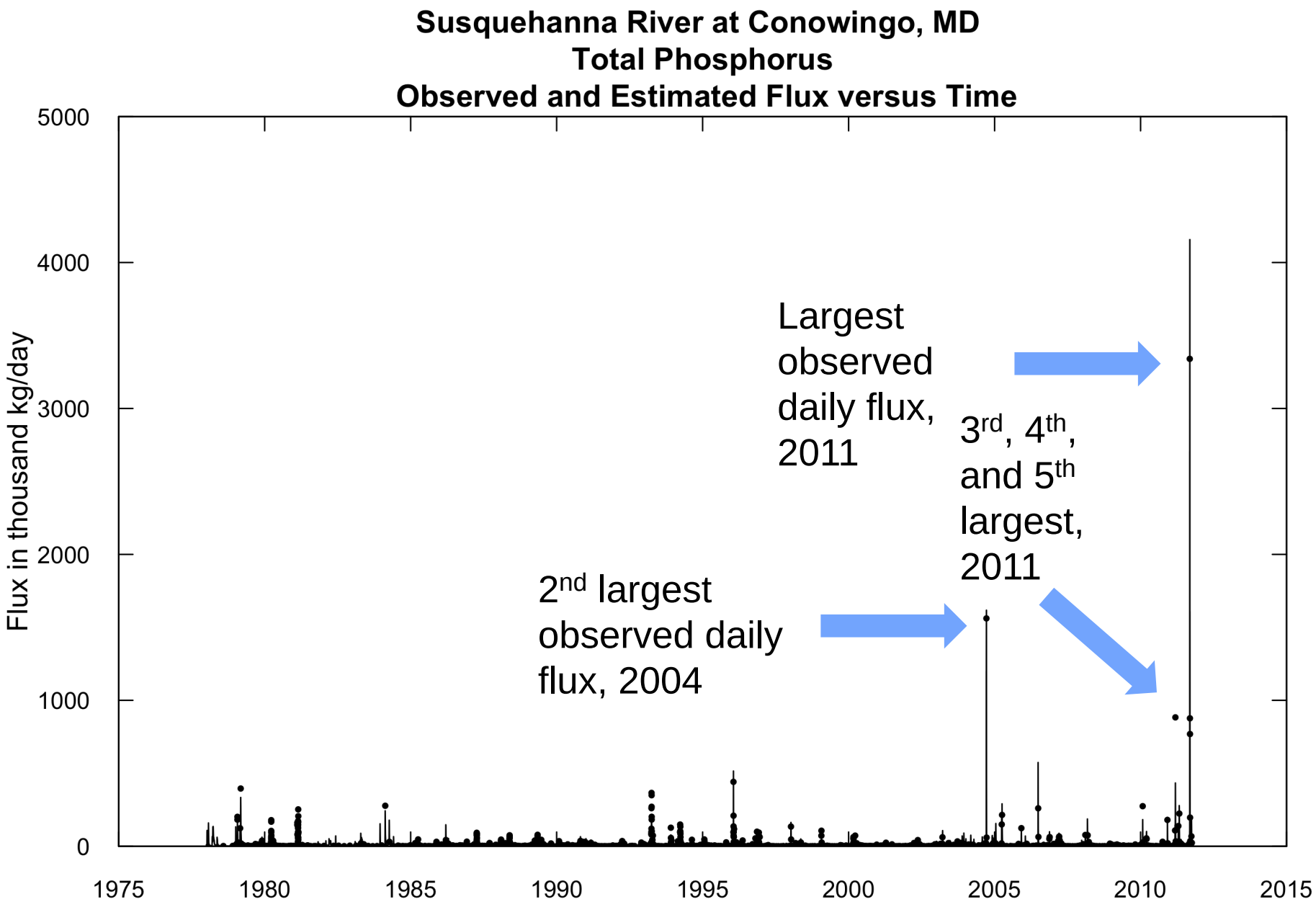
The changing behavior of Total Phosphorus concentrations at Conowingo over the 34-year monitoring period

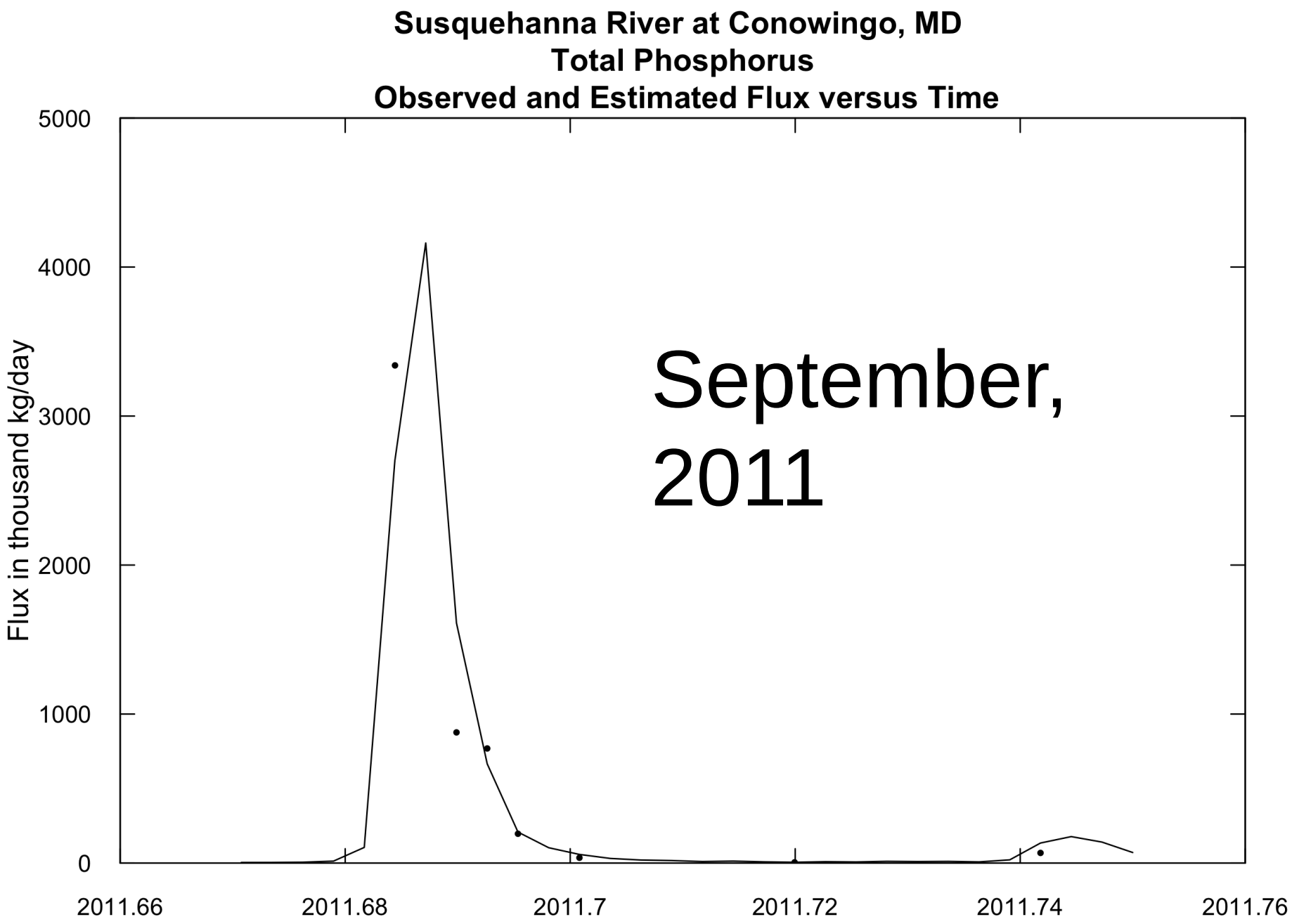


Let's compare 1996 and 2011

- **Increases at high discharge, all seasons but particularly the tropical storm season**
- **Small increases at moderate discharges April – July**
- **Small decreases at moderate to low discharges other parts of the year**




Susquehanna River at Conowingo, MD
Total Phosphorus
Observed and Estimated Flux versus Time
Flux in thousand kg/day
5000
4000
3000
2000
1000
0
1975
1980
1985
1990
1995
2000
2005
2010
2015
Largest observed daily flux, 2011
3rd, 4th, and 5th largest, 2011
2nd largest observed daily flux, 2004


Susquehanna River at Conowingo, MD
Total Phosphorus
Observed and Estimated Flux versus Time
Flux in thousand kg/day
5000
4000
3000
2000
1000
0
2011.66
2011.68
2011.7
2011.72
2011.74
2011.76
September,
2011

Total Phoshporus flux estimates using WRTDS

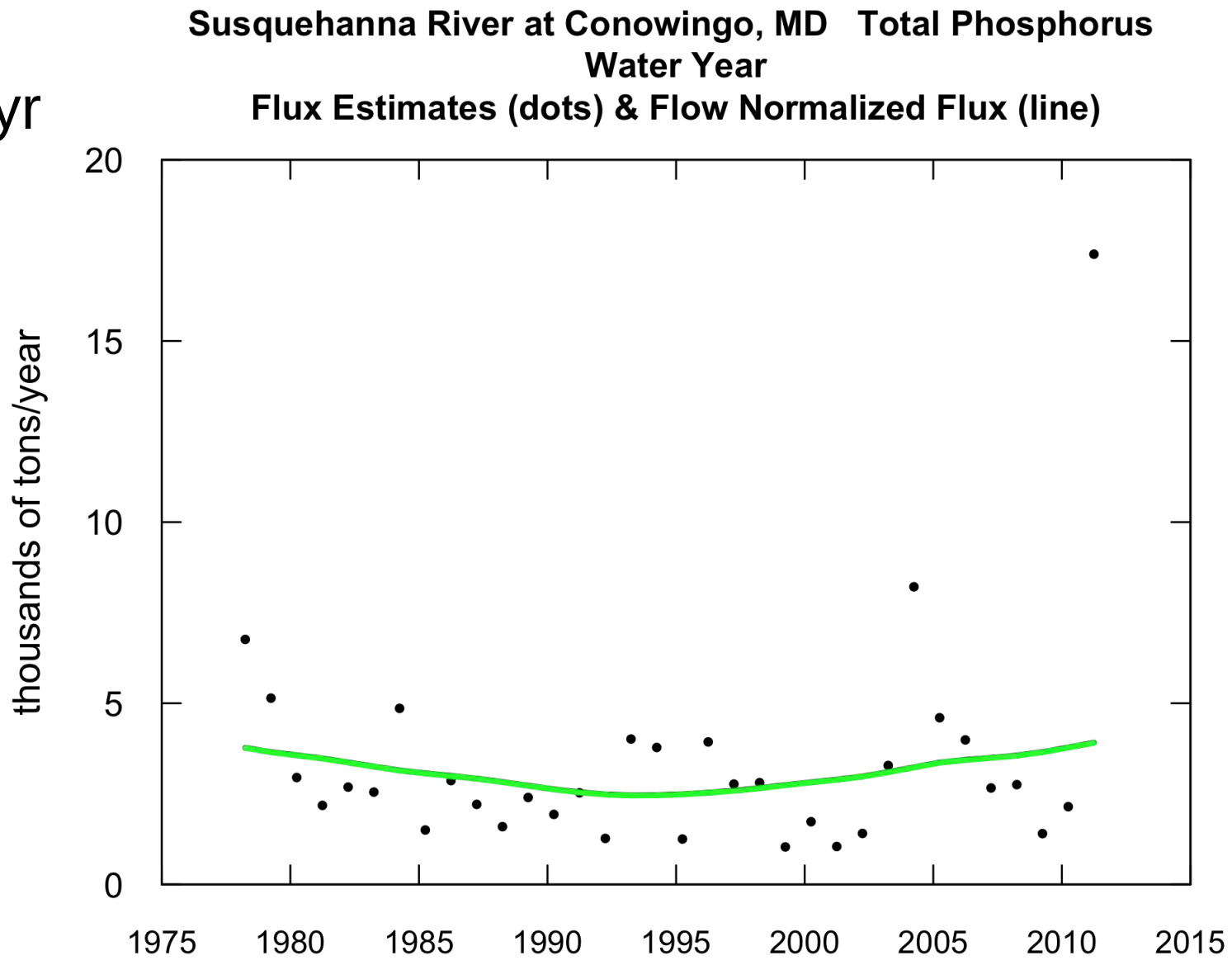
- T.S. Lee flux about 10,600 tons
- The 2011 water year 17,400 tons
- The past decade average was 4,800 tons/yr
- The past 34 year average was 3,300 tons/yr

USGS

Annual
Flux
In 10^3 tons/yr

2011=17
2010= 2
2004= 8

Flow
Normalized
Flux
Up 55%
Since 1996

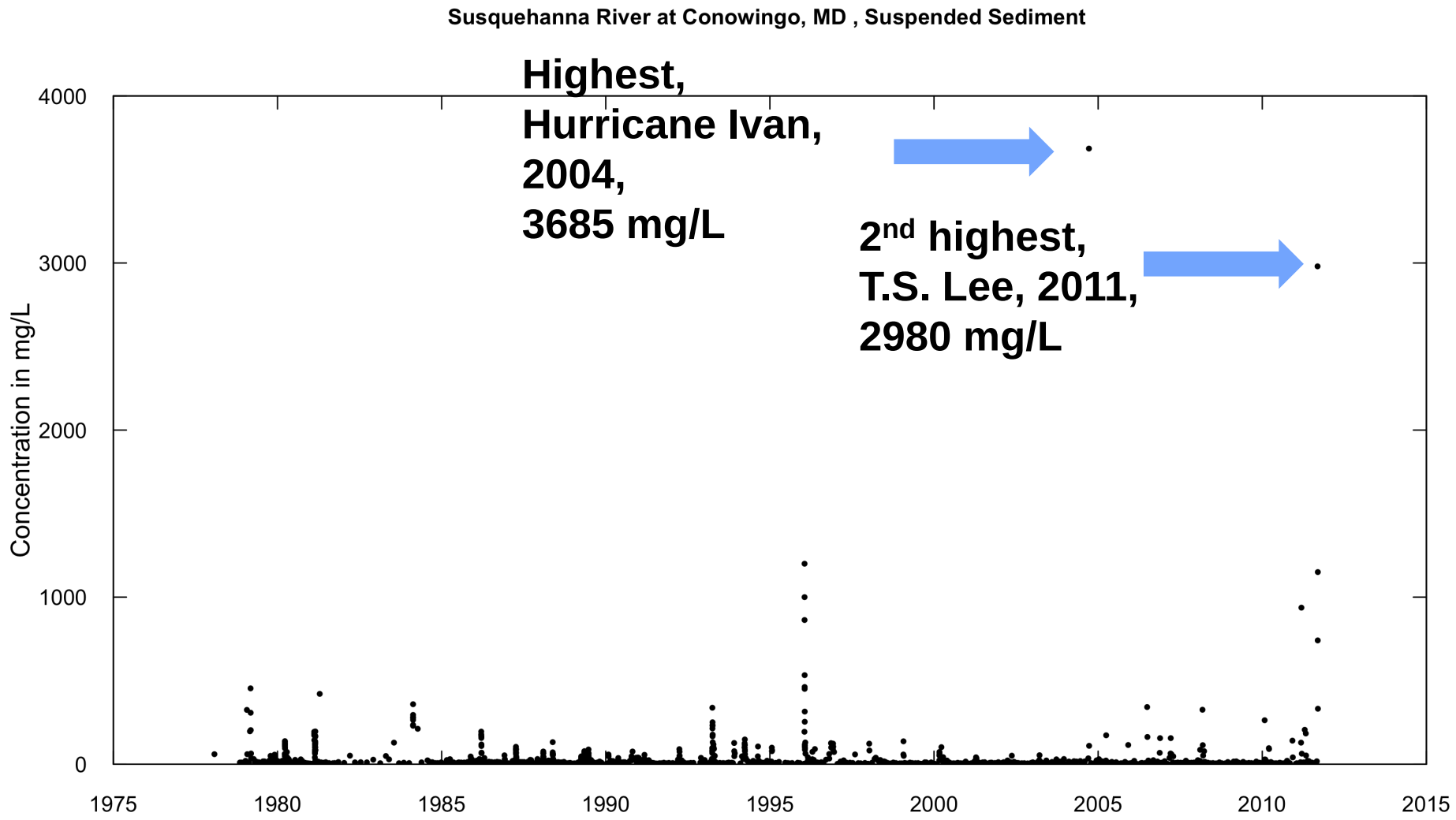


Take home messages about TP

- Concentrations are relatively stable at moderate and low flows
- But at very high flows they have increased greatly in the past 15 years
- Flux continues to rise – and is becoming more and more episodic
- These changes almost certainly are related to the decreasing capacity of Conowingo Reservior

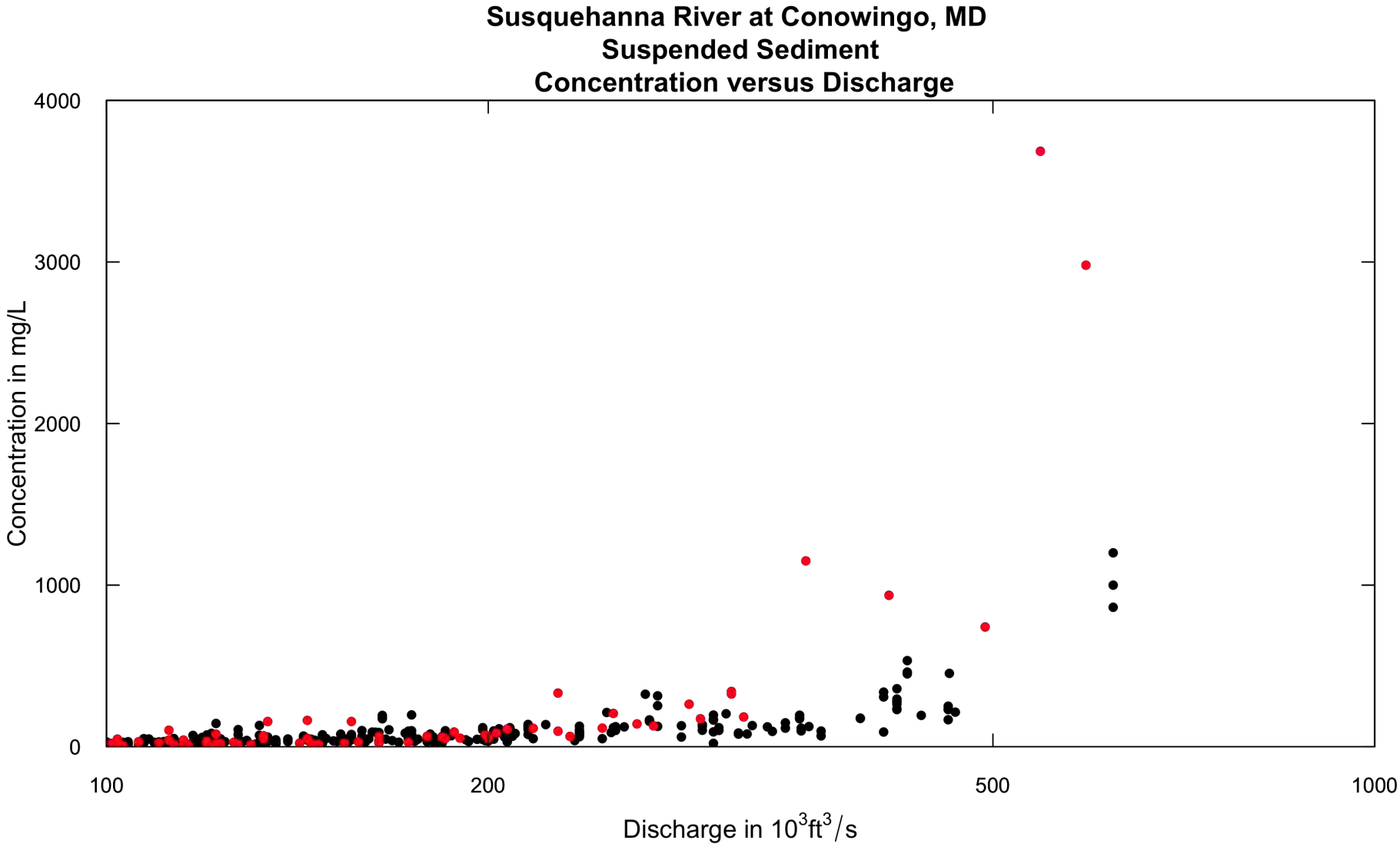
USGS

Suspended Sediment

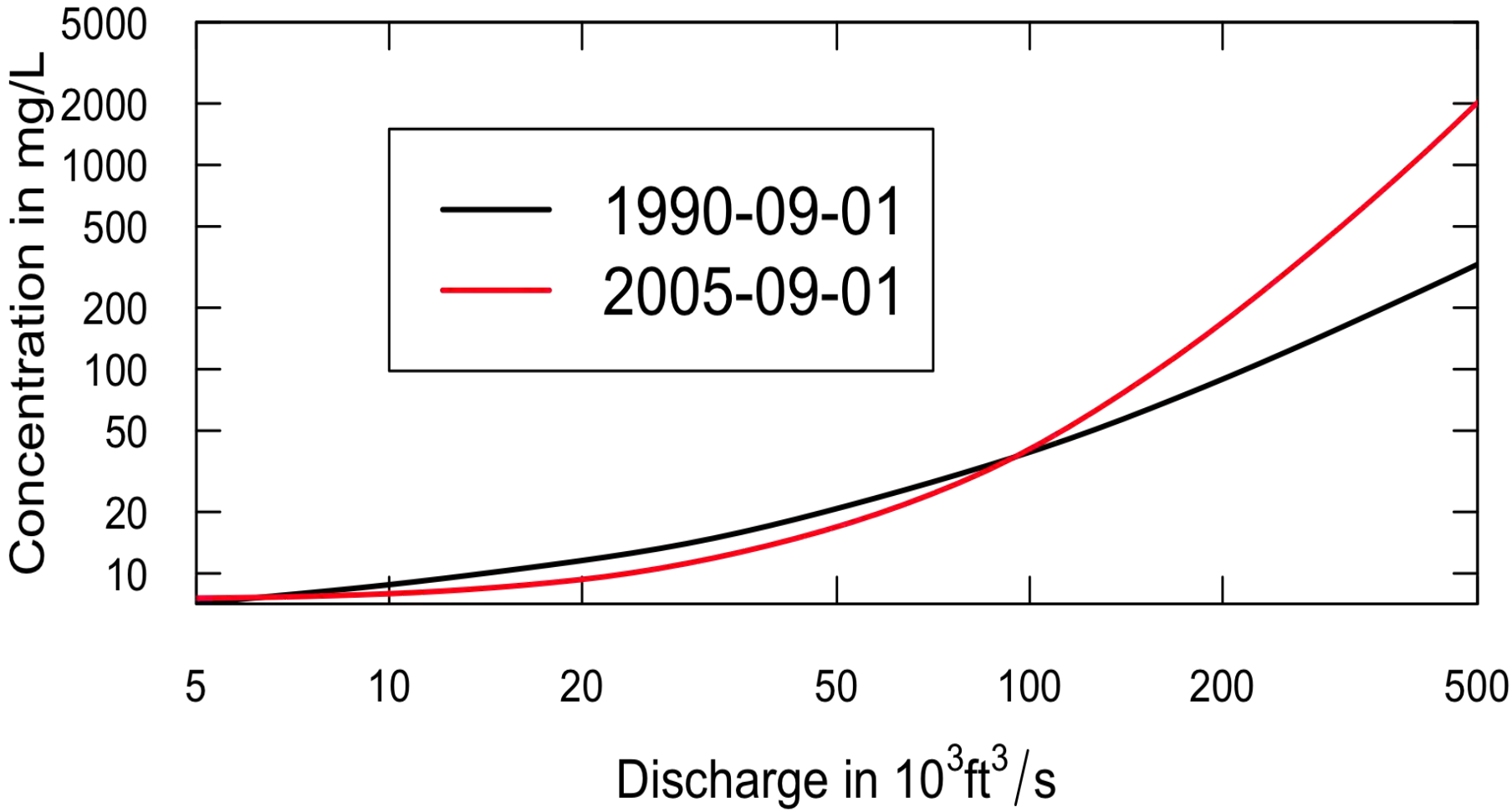


USGS

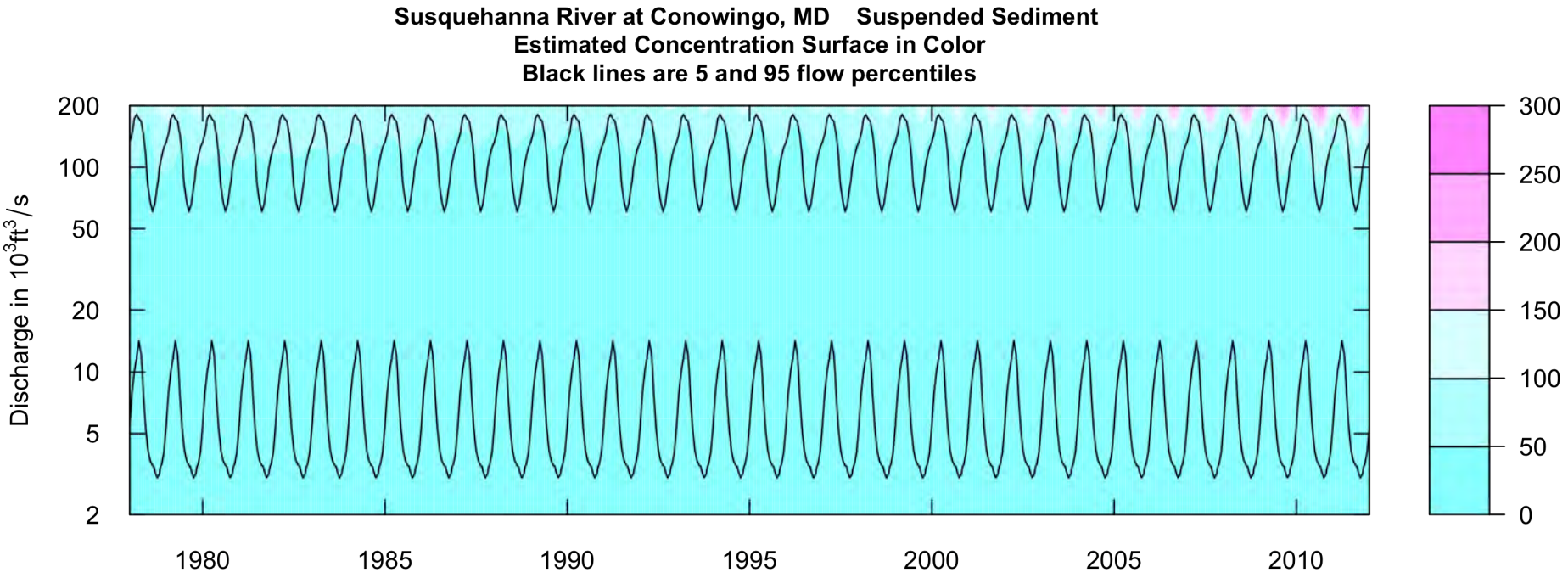
Black dots are pre-2000, Red are since 2000



Use the WRTDS model to describe the evolving behavior of suspended sediment (note log scale on vertical axis)



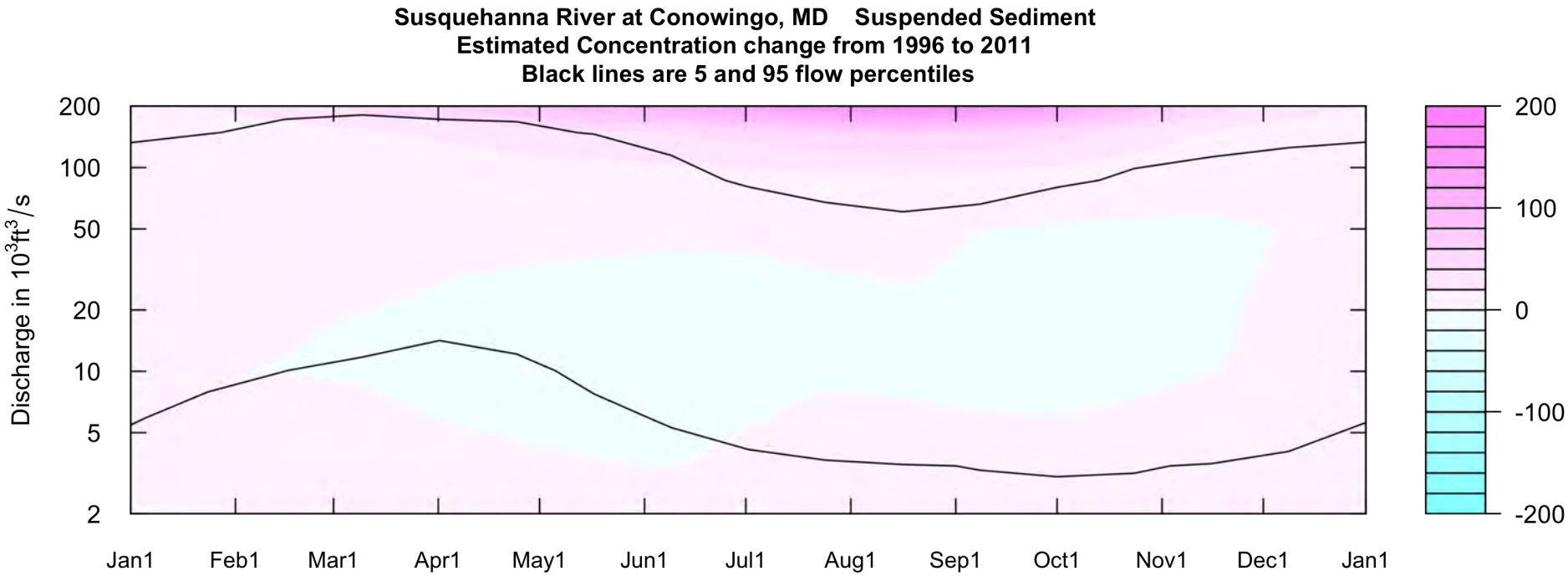
Evolving behavior of Suspended Sediment

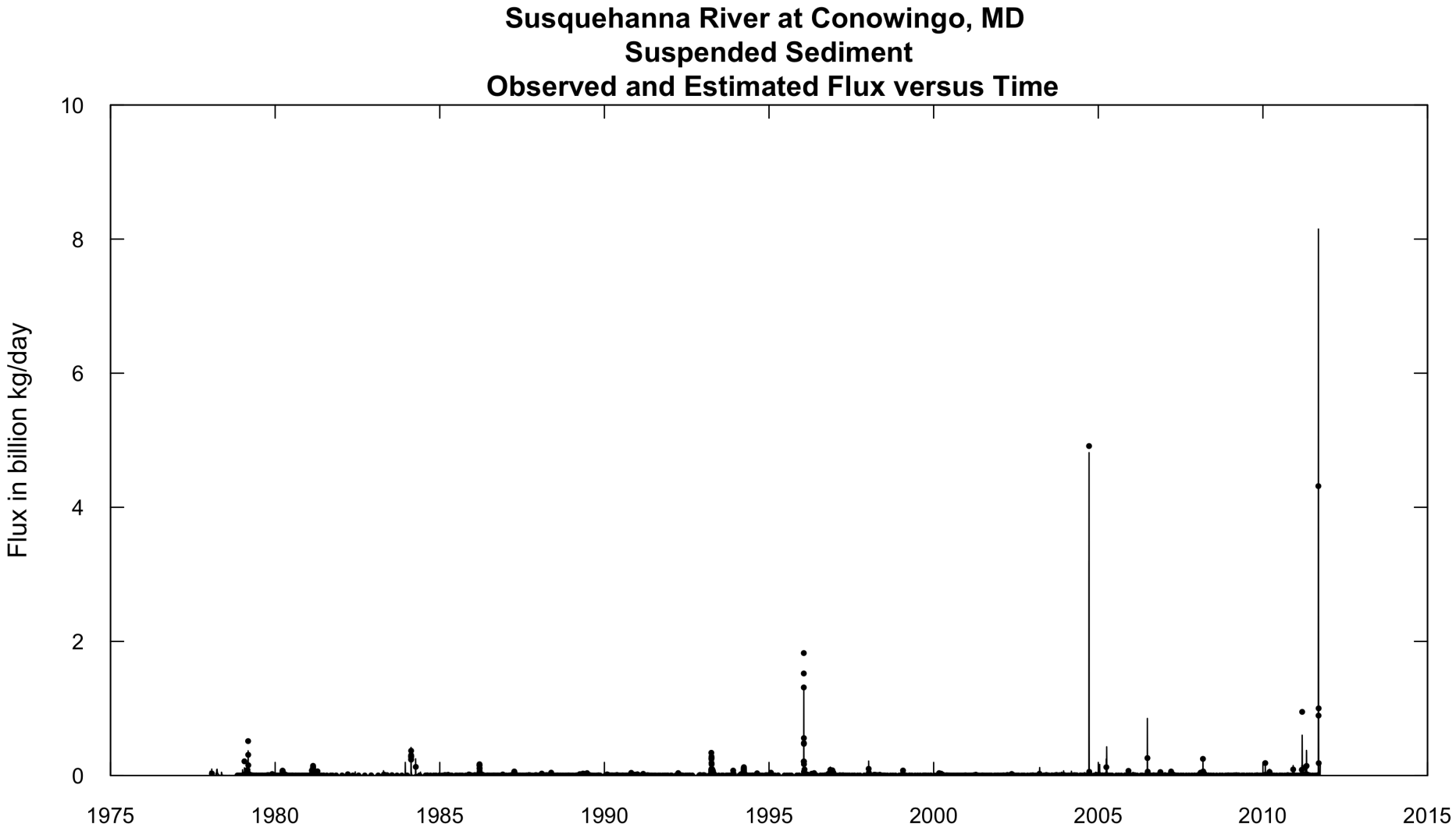


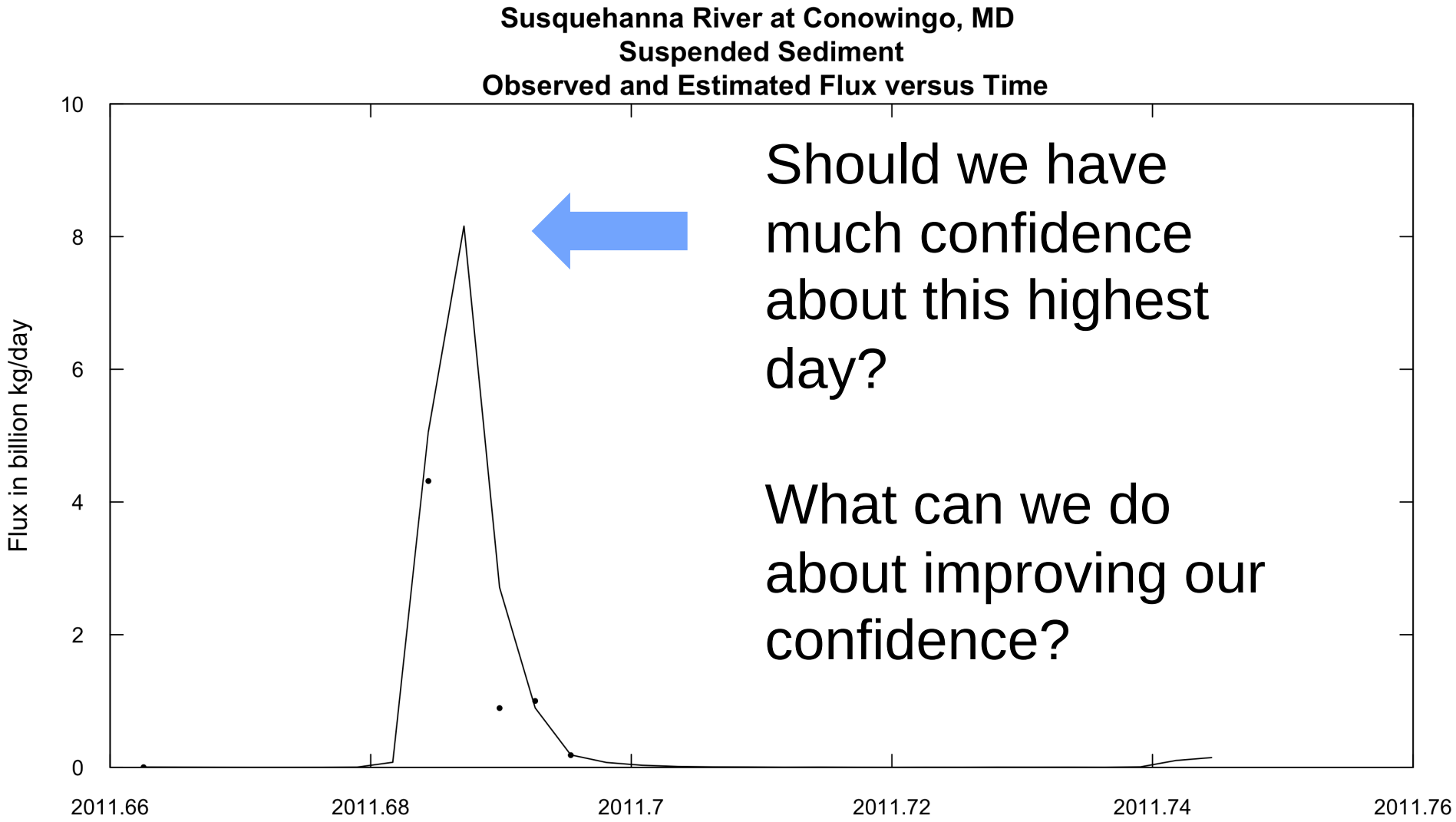
Very difficult to define:
So much depends on a few rare events

Little to no change at most discharges and times of year

Except, large increases above 100,000 cfs




Susquehanna River at Conowingo, MD
Suspended Sediment
Observed and Estimated Flux versus Time
Flux in billion kg/day
0
2
4
6
8
10
1975
1980
1985
1990
1995
2000
2005
2010
2015



Should we have much confidence about this highest day?

What can we do about improving our confidence?

USGS

Suspended sediment flux estimates using WRTDS

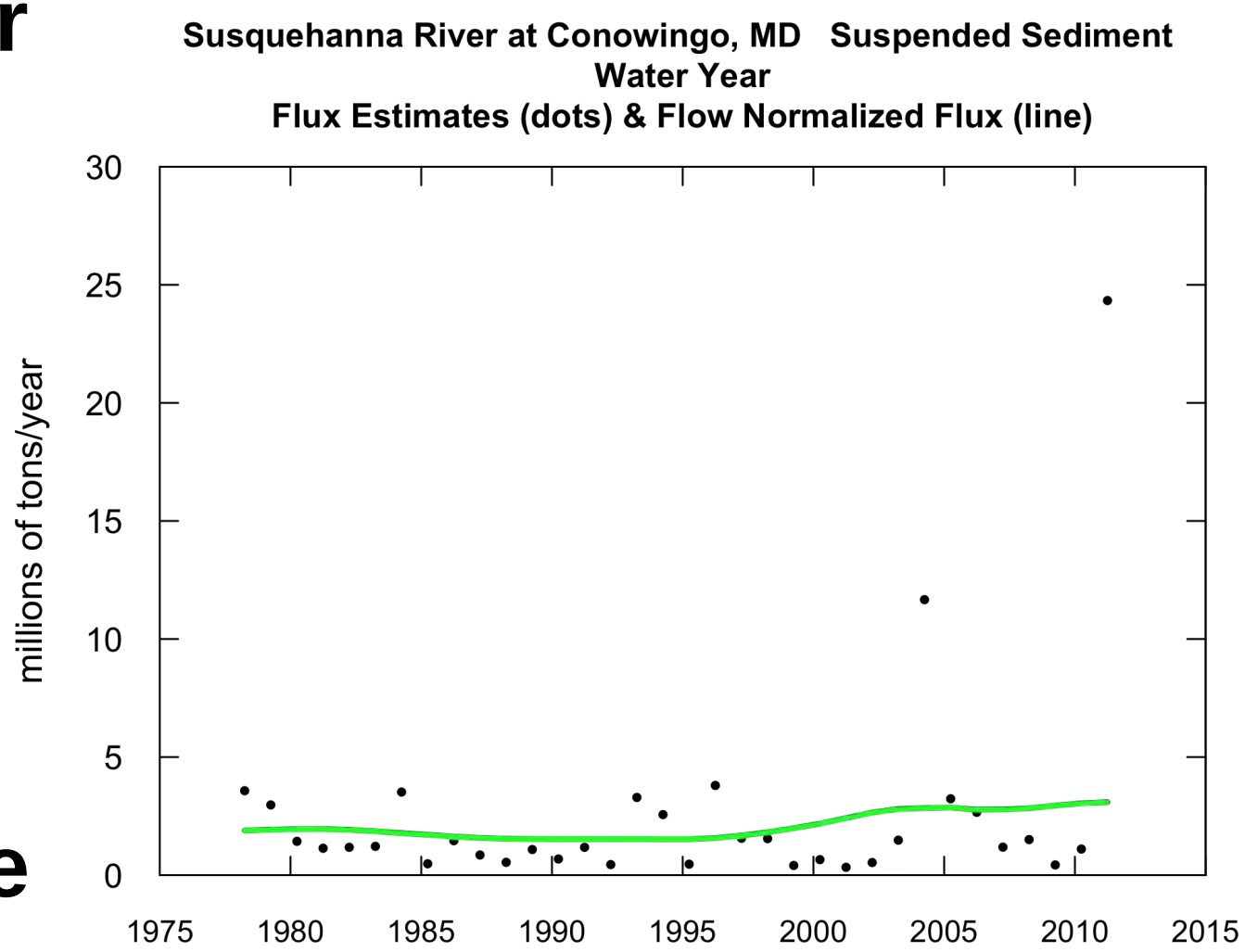
- T.S. Lee flux about 19.0 million tons
- The 2011 water year 24.3 million tons
- The past decade average was 4.8 million tons
- The past 34 year average was 2.5 million tons

USGS

Annual Flux in10^6 tons/yr

2011 = 24
2010 = 1
2004 = 12

Flow Normalized Flux Change Up 97% Since 1996



Take away message for Suspended Sediment

- Flow-normalized flux is rising very steeply
- Variability increasing

USGS

	T.S. Lee as a % of 2011	T.S. Lee as a % of last decade	T.S. Lee as a % of full record
Time	2%	0.2%	0.06%
Flow	12%	1.8%	0.6%
Nitrate	11%	1.5%	0.5%
Total Nitrogen	31%	5%	1.8%
Ortho Phosphate	20%	3%	1.1%
Total Phosphorus	61%	22%	9%
Suspended Sediment	78%	39%	22%

	T.S. Lee as a % of 2011	T.S. Lee as a % of last decade	T.S. Lee as a % of full record
Time	2%	0.2%	0.06%
Flow	12%	1.8%	0.6%
Total Nitrogen			
Total Phosphorus			
Suspended Sediment			

	T.S. Lee as a % of 2011	T.S. Lee as a % of last decade	T.S. Lee as a % of full record
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Total Phosphorus			
Suspended Sediment			

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Suspended Sediment			

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Flow	12%	1.8%	0.6%
Total Nitrogen	31%	5%	1.8%
Total Phosphorus	61%	22%	9%
Suspended Sediment	78%	39%	22%

Hypothesis:

- As the reservoirs fill, for any given discharge, there is less cross-sectional area, resulting in greater velocity
- This leads to a decrease in the scour threshold (more frequent scour)
- This also leads to a decrease in the amount of deposition at lower discharges

USGS

Prediction: Without dredging, reservoir output must equal input

	Langland and Hainley's 1997 prediction of change in flux	Observed change in flux since 1996
TN	+2%	-3.2%
TP	+70%	+55%
SS	+250%	+97%

What does this all mean for the Bay?

- **Trapping of TP and SS is decreasing. Scour is becoming more frequent and larger**
- **Increasing role of high flow events for TN, TP, and SS inputs to the Bay.**
- **“Filling” is asymptotic and stochastic. We are well into the transition to “full.”**
- **Over the coming decades, the state of the reservoirs may be the main driver of TP and SS inputs to the Bay.**

USGS

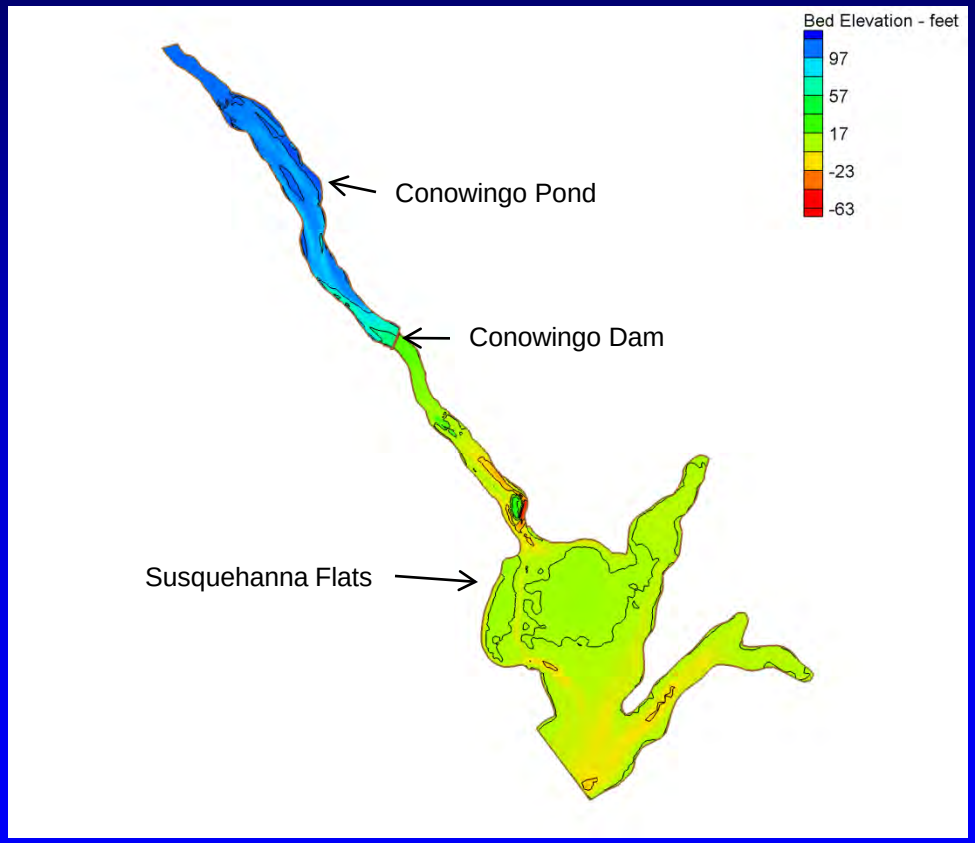
Science needs

- Continued data collection upstream and downstream of reservoirs
- Improved temporal resolution of monitoring during high flow events
- Temporal analysis of inputs and outputs leading to improved estimates of deposition and scour
- Measurements and simulation models of scour and deposition processes

USGS

Lower Susquehanna River Watershed Assessment

SedFlume Findings and Initial 2D Sediment Model Results



Lower Susquehanna River Watershed Assessment

Topics:

- SedFlume Field Activities and Data Analysis
- Preliminary Sediment Transport Results with SedFlume Data

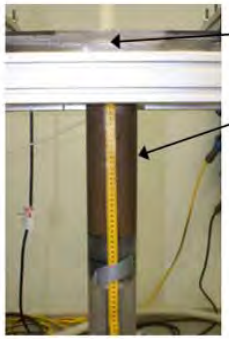
Lower Susquehanna River Watershed Assessment

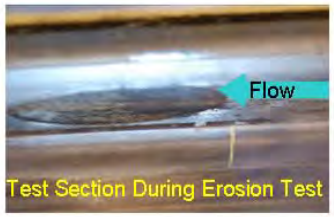
SedFlume Description

- **Field – Portable Laboratory Flume**
- **Used to Evaluate Erosion Rate and Critical Shear of Cohesive Sediments**

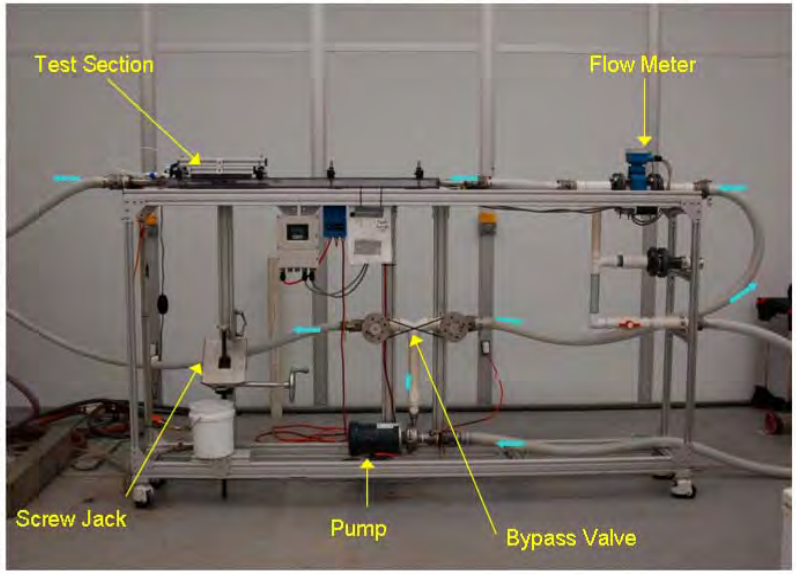
Lower Susquehanna River Watershed Assessment

SedFlume Operations





Shear stress t (Pa)	Flow Rate (GPM)
0.1	6.1
0.2	9.1
0.4	13.5
0.6	17.0
0.8	20.1
1.2	25.3
1.6	29.8
2.4	37.4
3.2	44.0
4	49.9
5	56.6
6.4	65.0
8	73.7
10	83.5
12	92.5
13	96.7
14	100.8



Lower Susquehanna River Watershed Assessment

Description of Sediment Coring Process

A) Gravity Corer

B) Plungers with Bentonite paste

C) Core with plunger inserted.

Figure 3. Sampling devices.

Lower Susquehanna River Watershed Assessment

Sampling Locations in Conowingo Reservoir

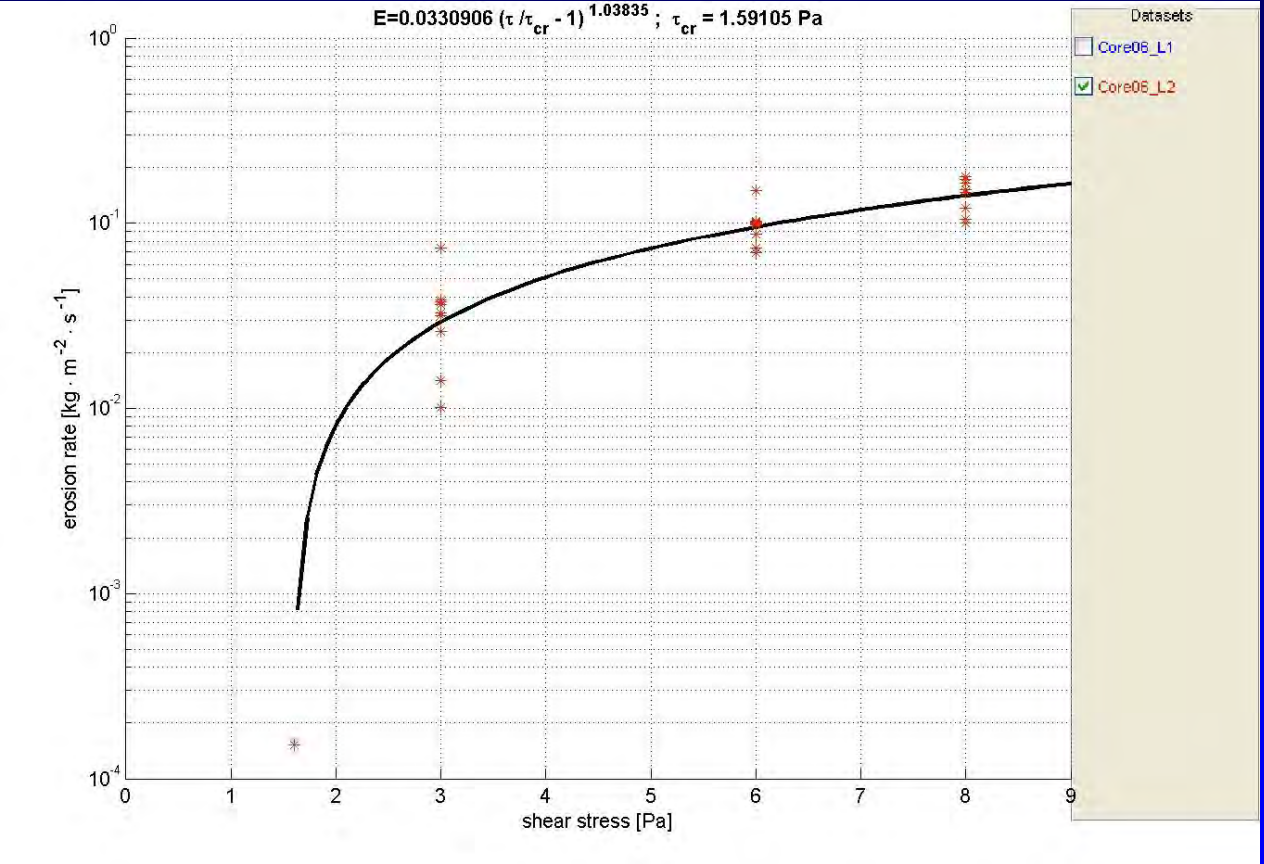
Lower Susquehanna River Watershed Assessment

SedFlume Analysis

- Core Lengths Varied From Approximately 6 – 12 inches
- The Entire Core was Analyzed
- Erosion Rate Coefficients and Exponents Evaluated by Layer Along with Critical Shear Stress for Erosion
- Core Bulk Density and Particle Size Distribution Evaluated

Lower Susquehanna River Watershed Assessment

SedFlume Analysis Results



Lower Susquehanna River Watershed Assessment

Example of SedFlume Results

Analyst: Jarrell Smith

Parteniades (full) $E=M*(\tau / \tau_{cr} -1)^{n}$, E(kg/m2/s)

Core 1

- 5.5-9% clay, 6-14% sand.
- Bed density fairly constant at 4.25 cm and deeper (1.32-1.33 g/cm^3)
- Erosion Rates are consistent between 0-5 cm.
- Layers
  - L1(0-4 cm) M=2.02 e-2, n=1.14, τ_{cr} = 0.20 Pa;
  - L2(5-14 cm) M=2.89 e-2, n=1.10, τ_{cr} = 0.40 Pa;
  - L3(10-14cm) M=3.52 e-2, n=0.96, τ_{cr} = 0.80 Pa;

Core 2

- Core is sandy (>50% sand) between 0-10 cm.
- 10-33 cm has ~5% clay, 15-25% sand
- Erosion data suggest the following layers:
  - L1(0-10 cm) M=1.01 e-1, n=1.05, τ_{cr} = 0.20 Pa;
  - L2(10-17 cm) M=5.98 e-2, n=1.52, τ_{cr} = 0.40 Pa;
  - L3(17-24 cm) M=3.73e-2, n=1.36, τ_{cr} = 0.80 Pa;
  - L4(24-32 cm) M=9.18e-2, n=0.92, τ_{cr} = 1.6 Pa;
  - L34(17-32 cm) M=3.86e-2, n=0.92, τ_{cr} = 0.80 Pa;

Lower Susquehanna River Watershed Assessment

Core Physical Properties

- Bulk Density Range – 1320 kg / m^3 to 1500 kg / m^3
- Sediment Fractions

  Sand: 10% - 45%
  Silt: 50% - 82%
  Clay: 5% - 9%

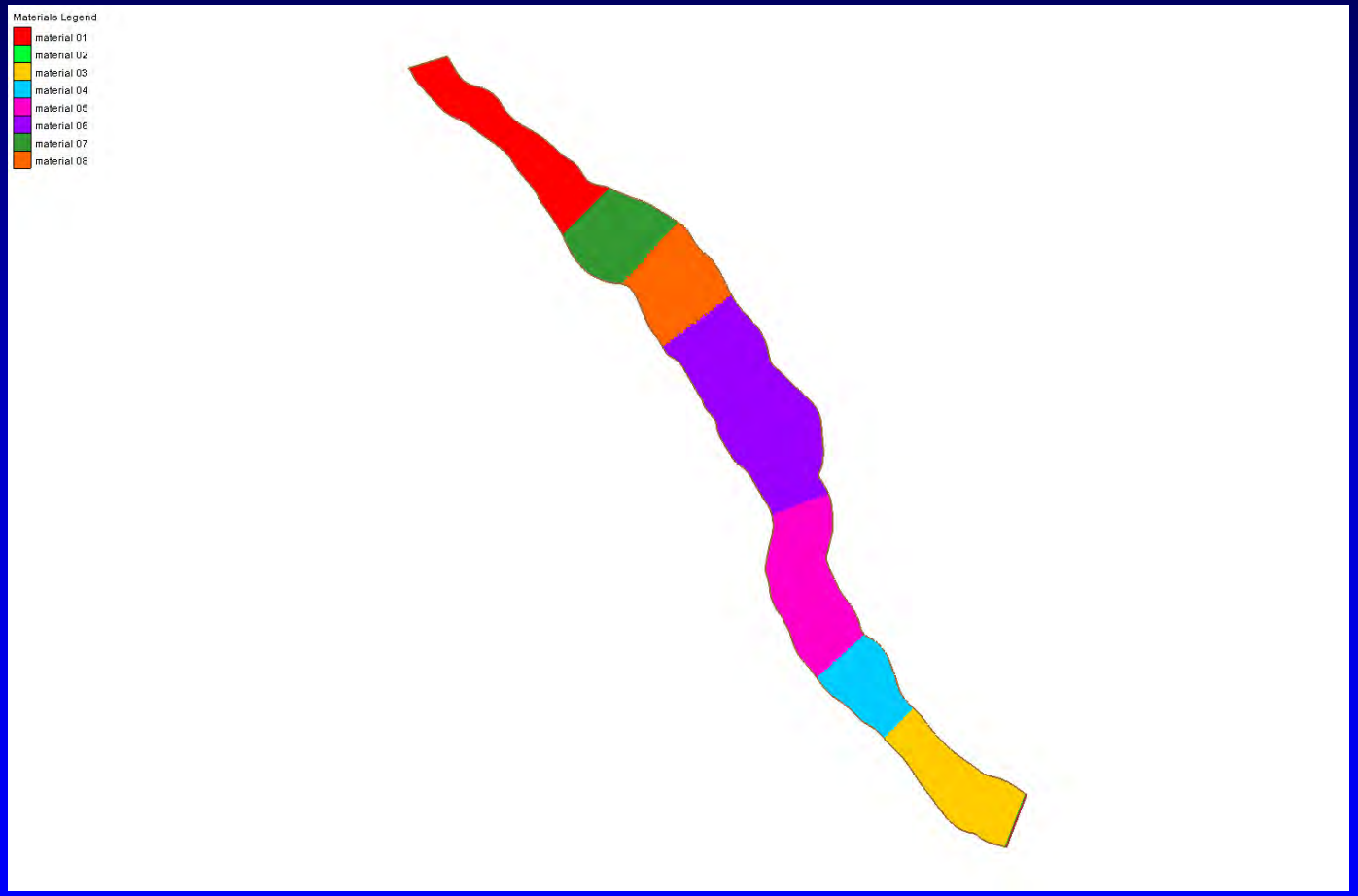
Lower Susquehanna River Watershed Assessment

SedFlume Data Assigned by Material Type in Model

- Model Domain Divided into Areas Based on Change in Properties
- Three Layers Assigned in Model Using Average SedFlume Data
- Average Sediment Size Fractions Assigned to Layers

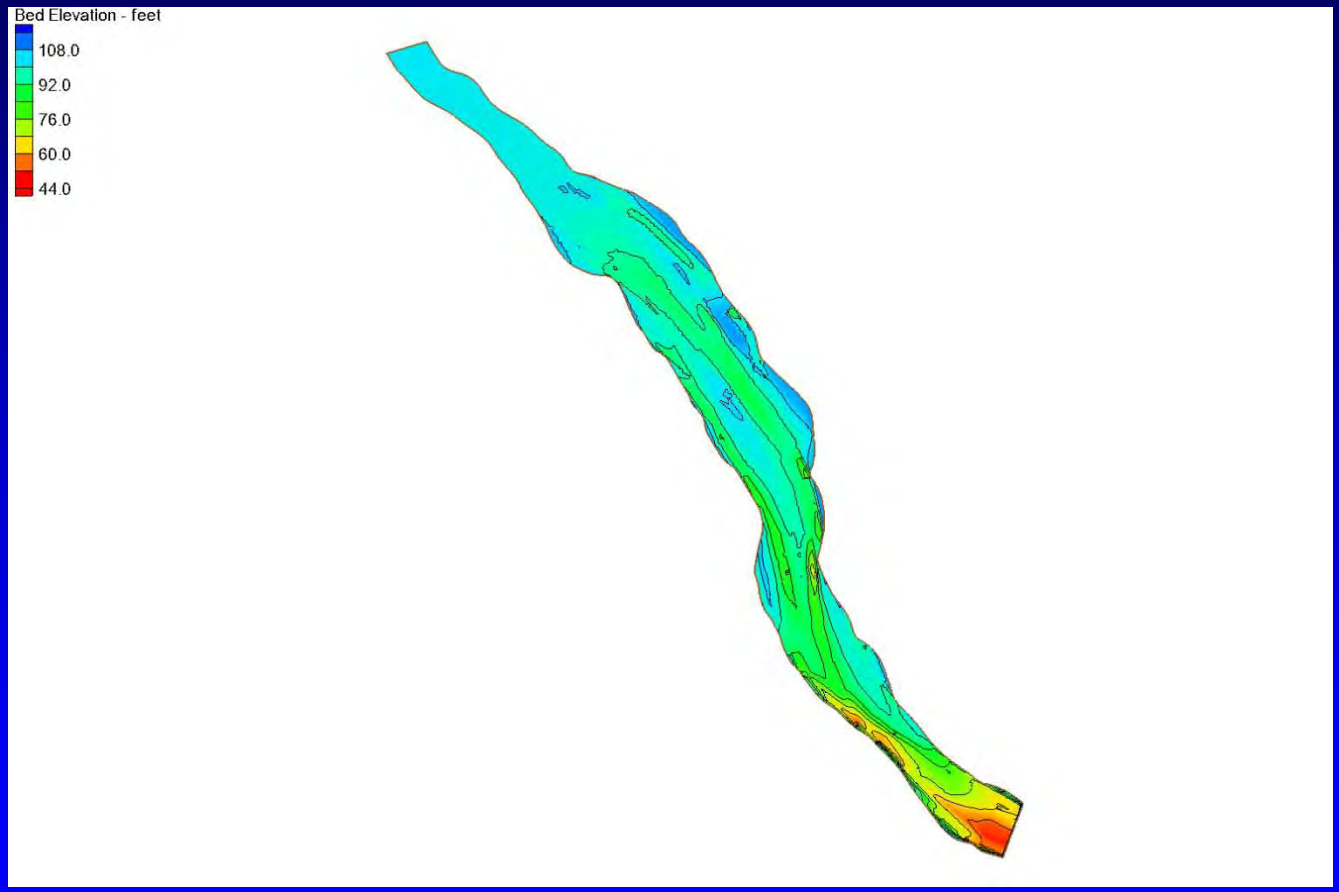
Lower Susquehanna River Watershed Assessment

Material Designation in AdH Model



Lower Susquehanna River Watershed Assessment

2D Model Development – 2008 Bathymetry



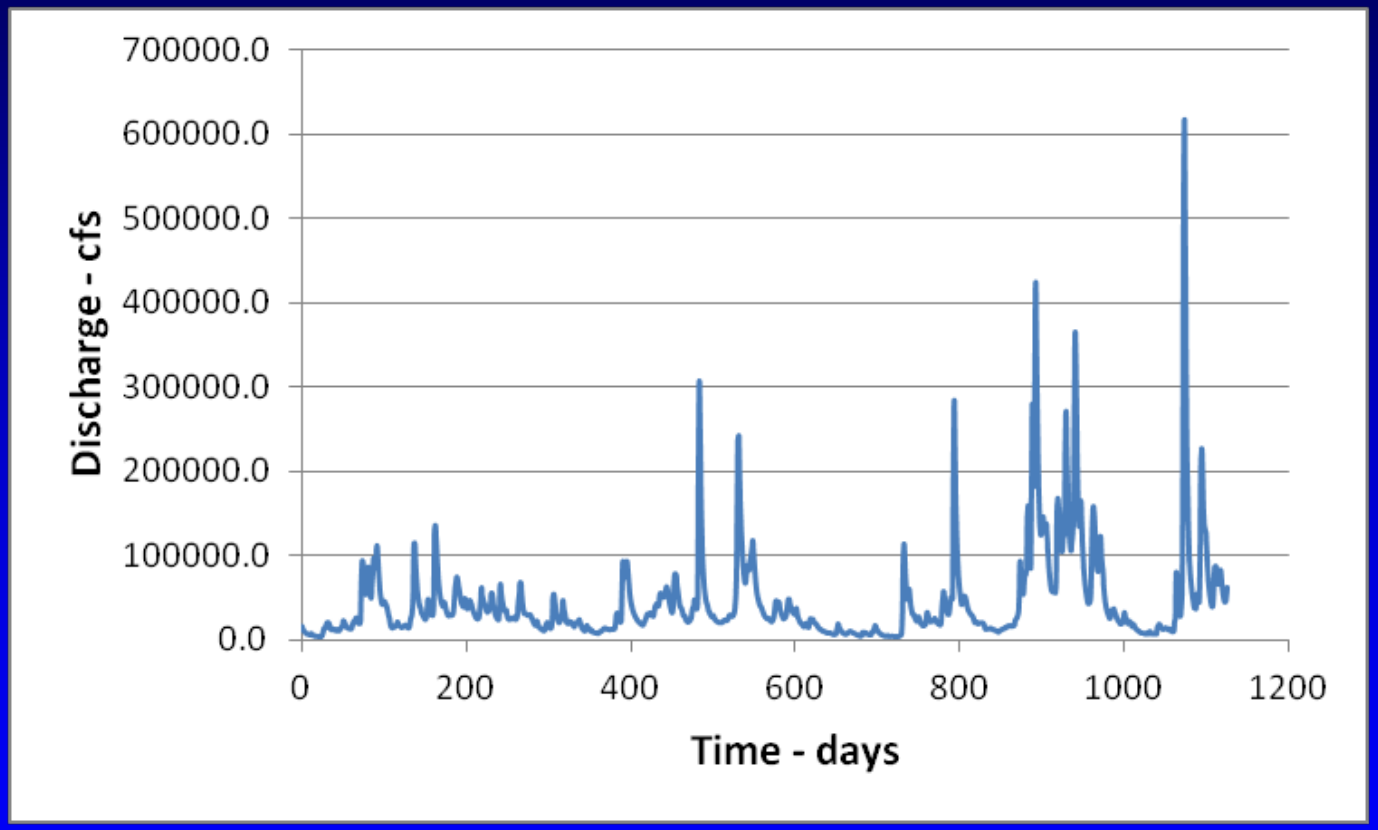
Lower Susquehanna River Watershed Assessment

Preliminary Sediment Transport Simulation

- Evaluate the 2008 – 2011 Susquehanna River Flows
- Period of Record Includes the September 2001 Tropical Storm Lee Event
- Sediment Inflows Estimated From Previous HEC-6 Modeling

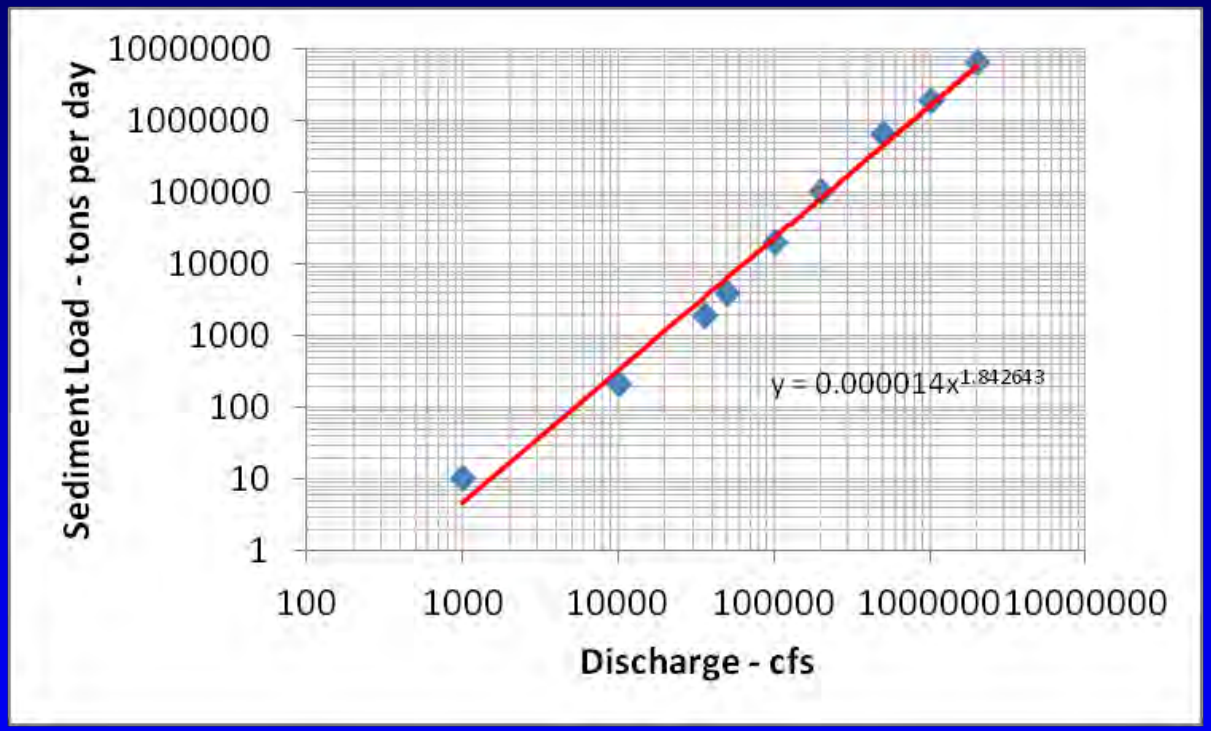
Lower Susquehanna River Watershed Assessment

2008 – 2011 Susquehanna Flow Record



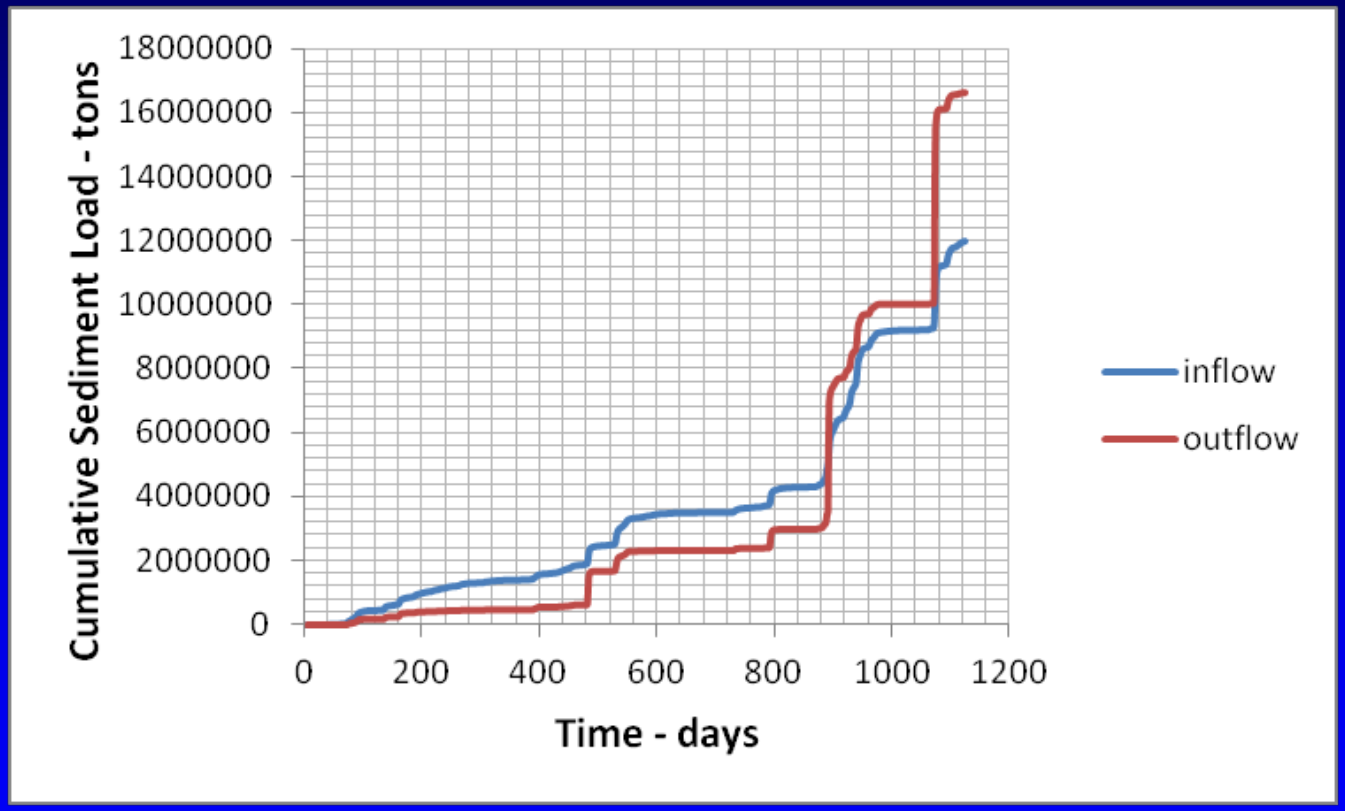
Lower Susquehanna River Watershed Assessment

Sediment Rating Curve for 2008 – 2011 Simulation



Lower Susquehanna River Watershed Assessment

Simulated Sediment Load in and out of Conowingo Reservoir: 2008 – 2011



Assumptions:

Top 1 ft layer critical Shear = 2 Pa

Below 1 ft layer critical shear = 4 Pa

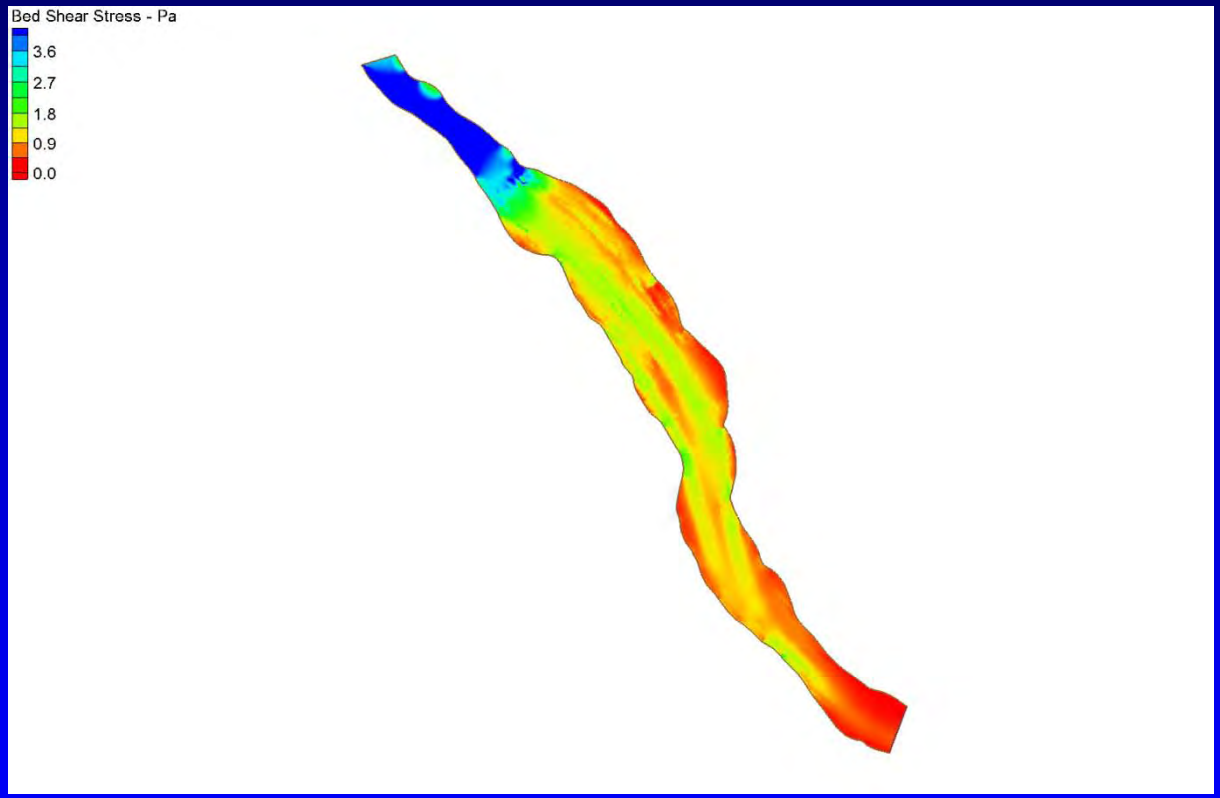
Total In: 12 million tons

Total Out: 16.6 million tons

Net Scour: 4.6 million tons

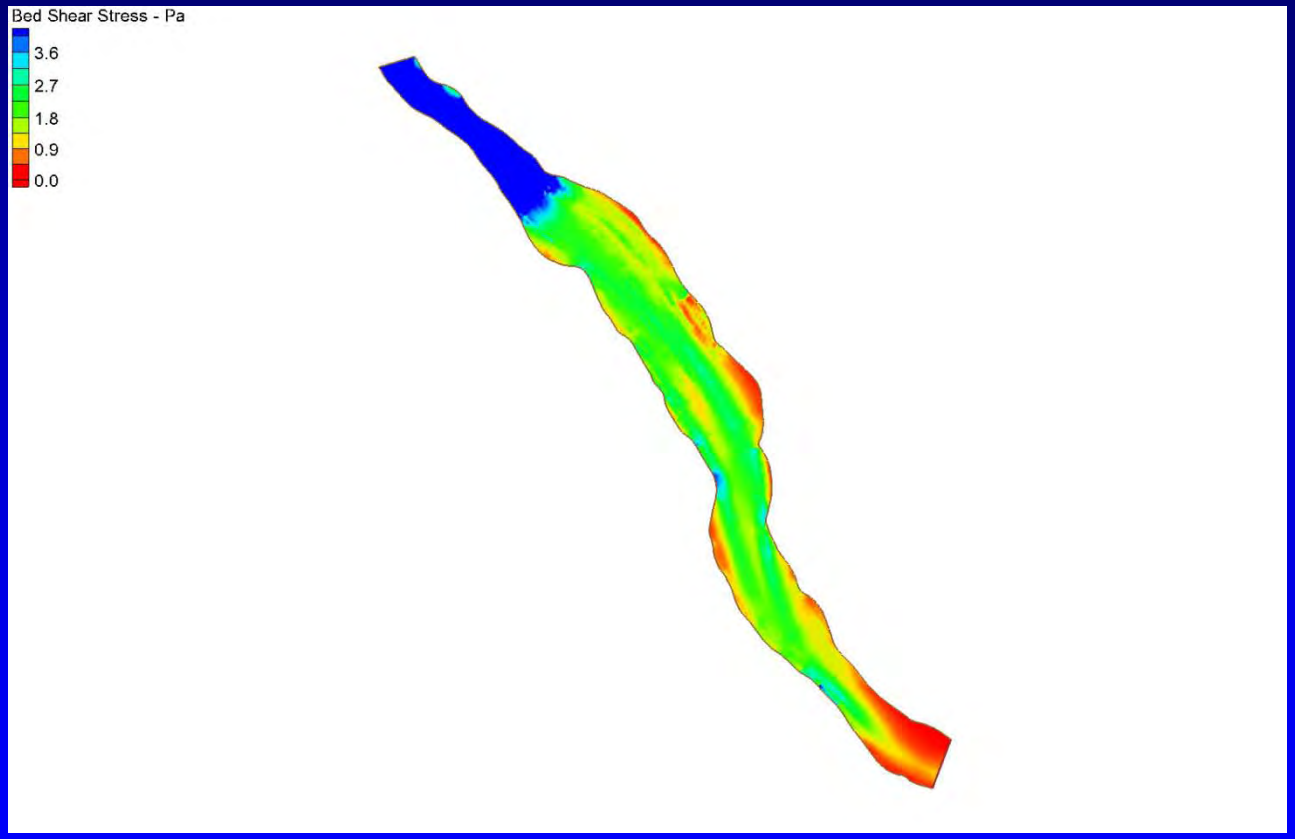
Lower Susquehanna River Watershed Assessment

Computed Bed Shear Stress for 300,000 cfs



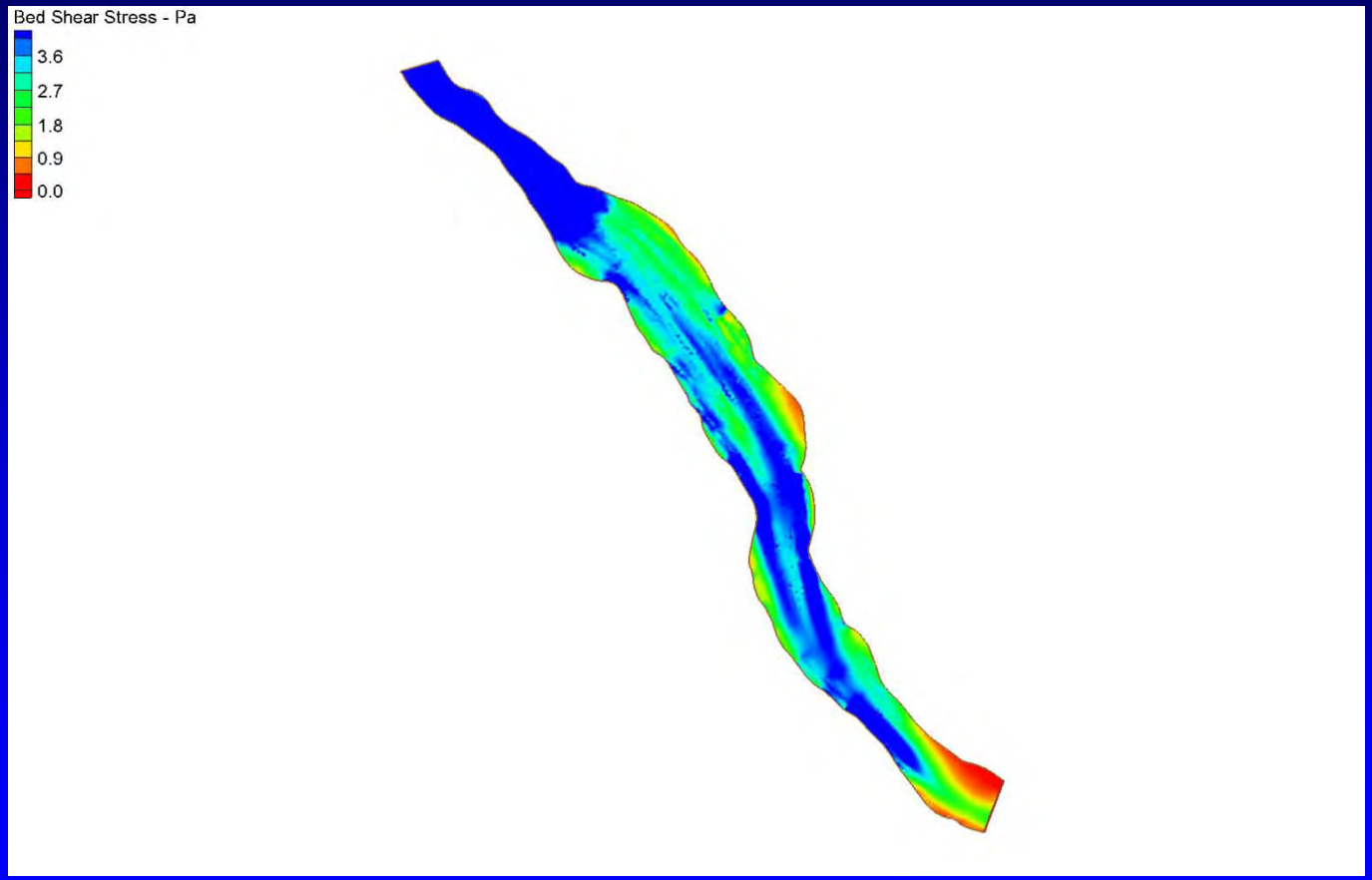
Lower Susquehanna River Watershed Assessment

Computed Bed Shear Stress for 400,000 cfs



Lower Susquehanna River Watershed Assessment

Computed Bed Shear Stress for 600,000 cfs



Lower Susquehanna River Watershed Assessment

Bed Change After the 2008 – 2011 Simulation