Monitoring Data in Support of Mid-Point Assessment

Doug Moyer Joel Blomquist, Jeni Keisman

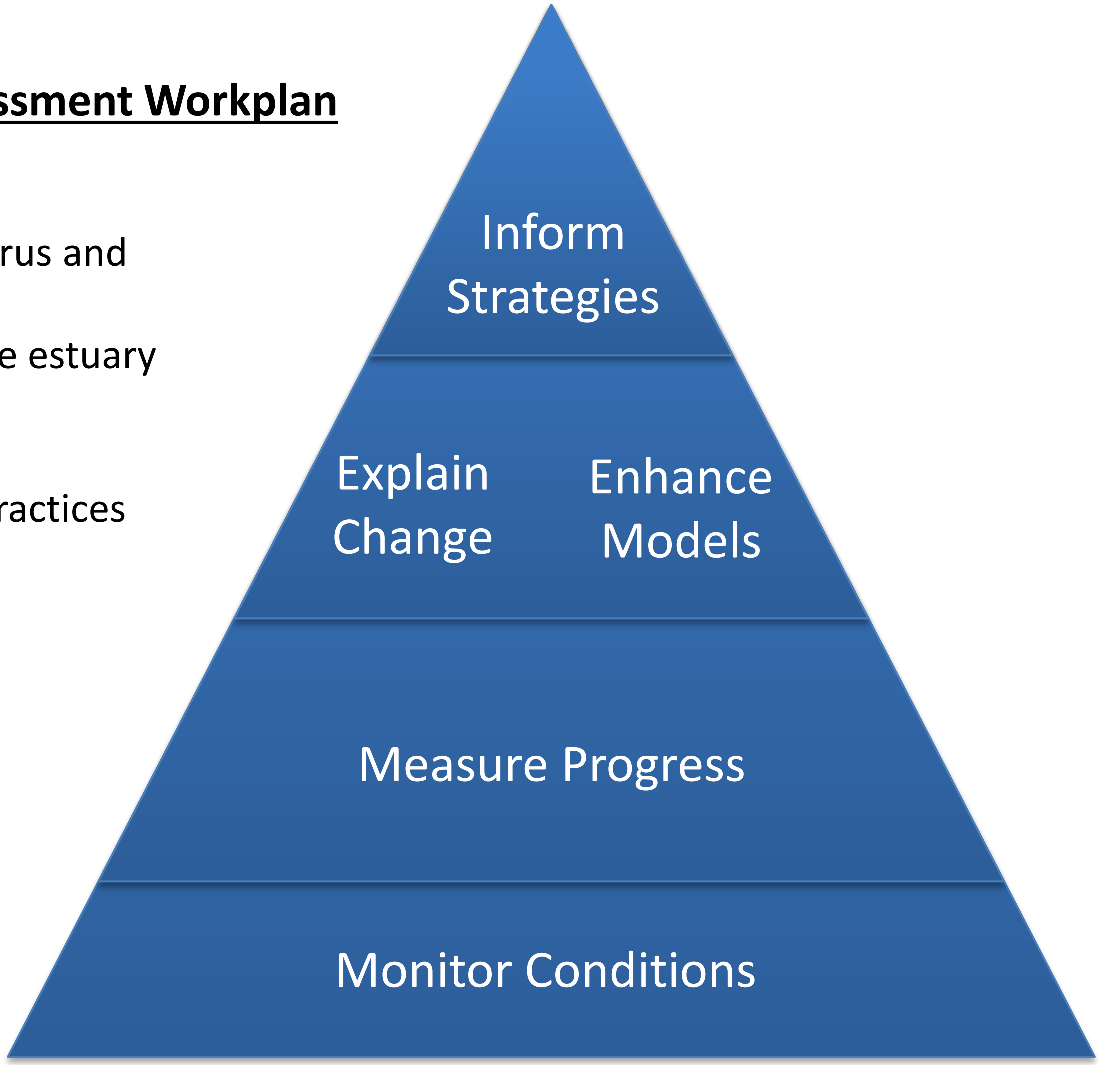
Based on contributions from dozens of incredibly smart and dedicated scientists

USGS science for a changing world

Overview: STAR Workplan Elements

Elements of STAR Mid-Point Assessment Workplan

1. Measure progress
   - Trends of nitrogen, phosphorus and sediment in the watershed.
   - Trends of water quality in the estuary
2. Explain water-quality changes
   - Response to management practices
3. Enhance CBP models
4. Inform management strategies
   - WIPs
   - Water-quality benefits



Outline

- Nontidal Trend Results
  - Discuss integration with MPA, Milestones, and WIPs.
- Explaining Changes in nontidal streams
  - Sett expectations for products that support decision making
  - Discuss mechanisms to get information into your processes
- Estuarine trends and explanation
  - Feedback on effort to demonstrate progress in tidal waters

Using Monitoring Data To Measure Progress and Explain Change

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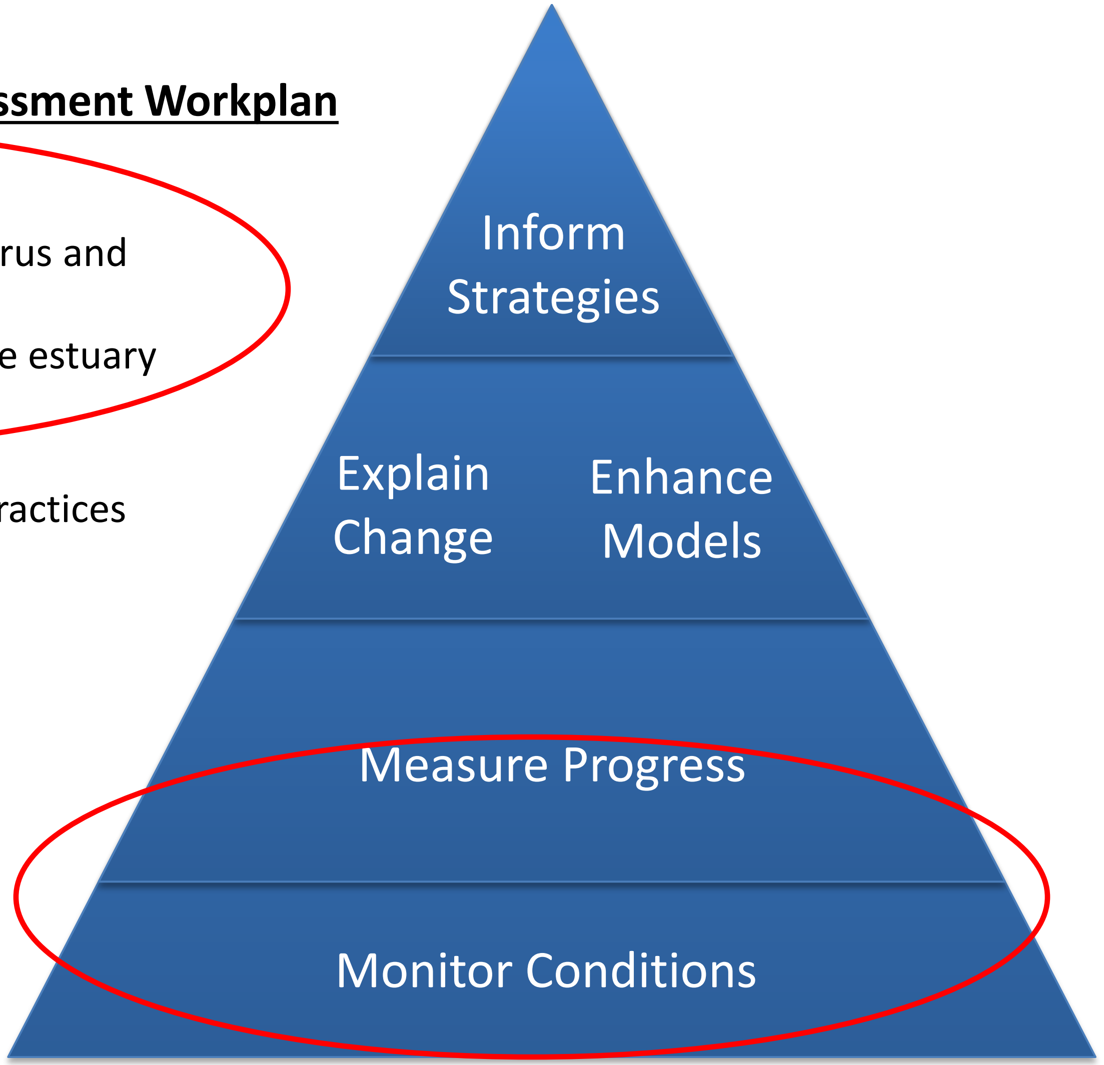
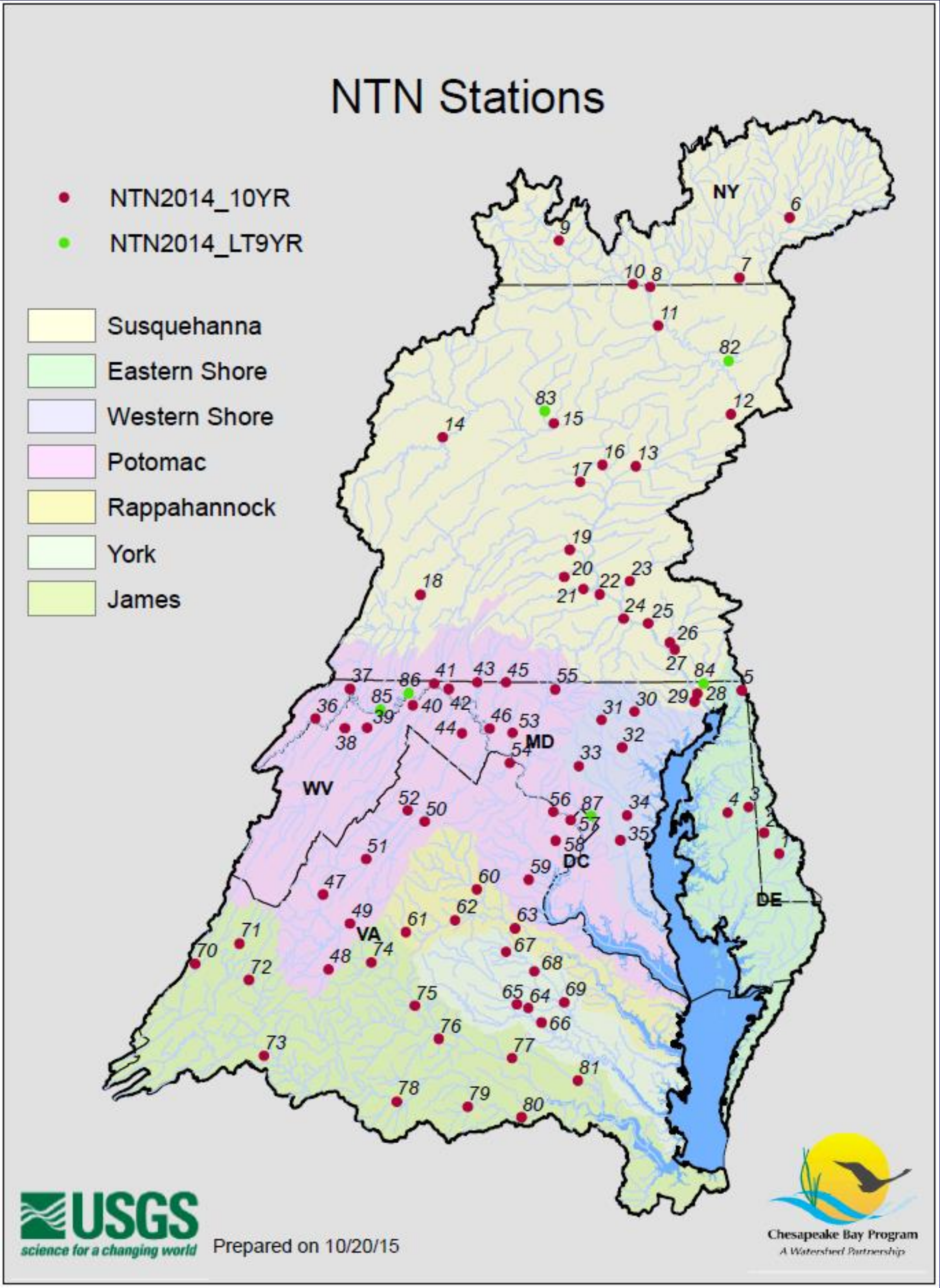


Questions Addressed

- Which NTN stations yield the greatest amount of Nitrogen, Phosphorus, and Suspended Sediment?
- How have these yield changed during the last 10 years (2005 to 2014)?

Questions for GIT

- What are the target conditions (i.e. loads) and how are they allocated (e.g. major basin, NTN station, county, …)?
- What timeperiod for trend is most beneficial for assessing progress?
- How can we best integrate our results into GIT processes?



Chesapeake Bay Nontidal Monitoring Network

How are nitrogen, phosphorus, and suspended-sediment loads responding to restoration activities and changing land use?

Monitoring Stations (126 stations)

- 87 stations with ≥ 5 years
- 81 stations ≥ 10 years
- 43 stations with ≥ 30 years
- Drainage areas range from 1 to 27,100 mi^2

Monitoring:

New York, Pennsylvania, Maryland, Delaware, Virginia, West Virginia, Washington D.C., SRBC, and USGS

Online Communication Products

http://cbrim.er.usgs.gov/

- Download Results
  - Estimated Loads and Concentrations
  - Flow-Normalized Loads and Concentrations
  - Trend in Flow-Normalized Loads
- Interactive Map to display yields and trends in yields
- Load (yield) and Trend Summaries
- Static Maps
  - Trend in Yield
  - Yield
  - Combined Yield and Trend in Yield
- Available January 2016

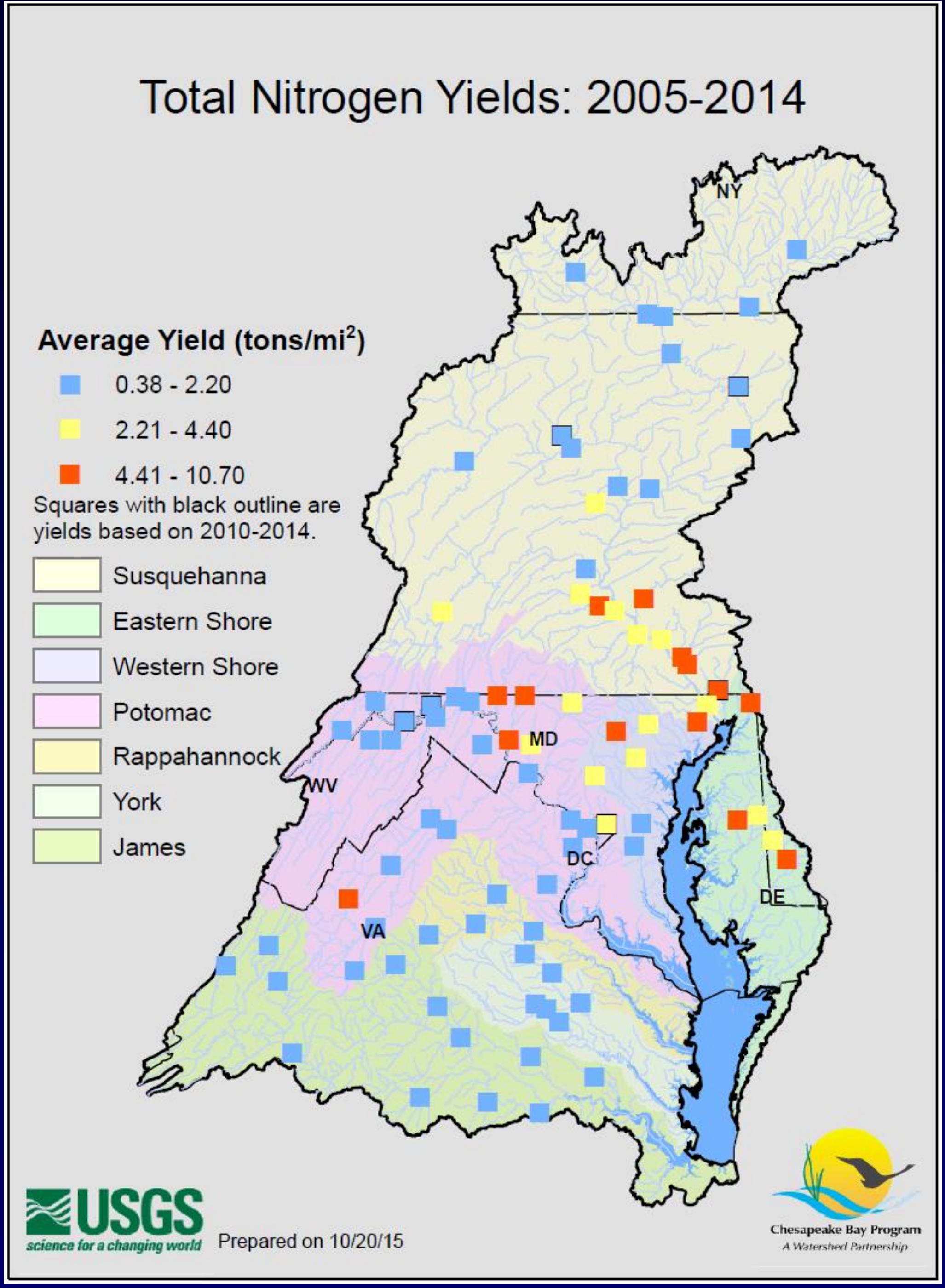
USGS

Summary of Stations with Reported Loads and Trends

Constituent	Long-Term (1980s to 2014)	Ten-Year Trends (2005 to 2014)	Short-Term Loads Only (2007 to 2014)	Newly Implemented Stations: Monitoring Only (2011 to 2014)
Total Nitrogen	43 (+13)	81 (+38)	6	39
Total Phosphorus	18 (-12)	60 (+14)	7	39
Suspended Sediment	18 (-12)	59 (+13)	7	39

USGS

Total Nitrogen Yield



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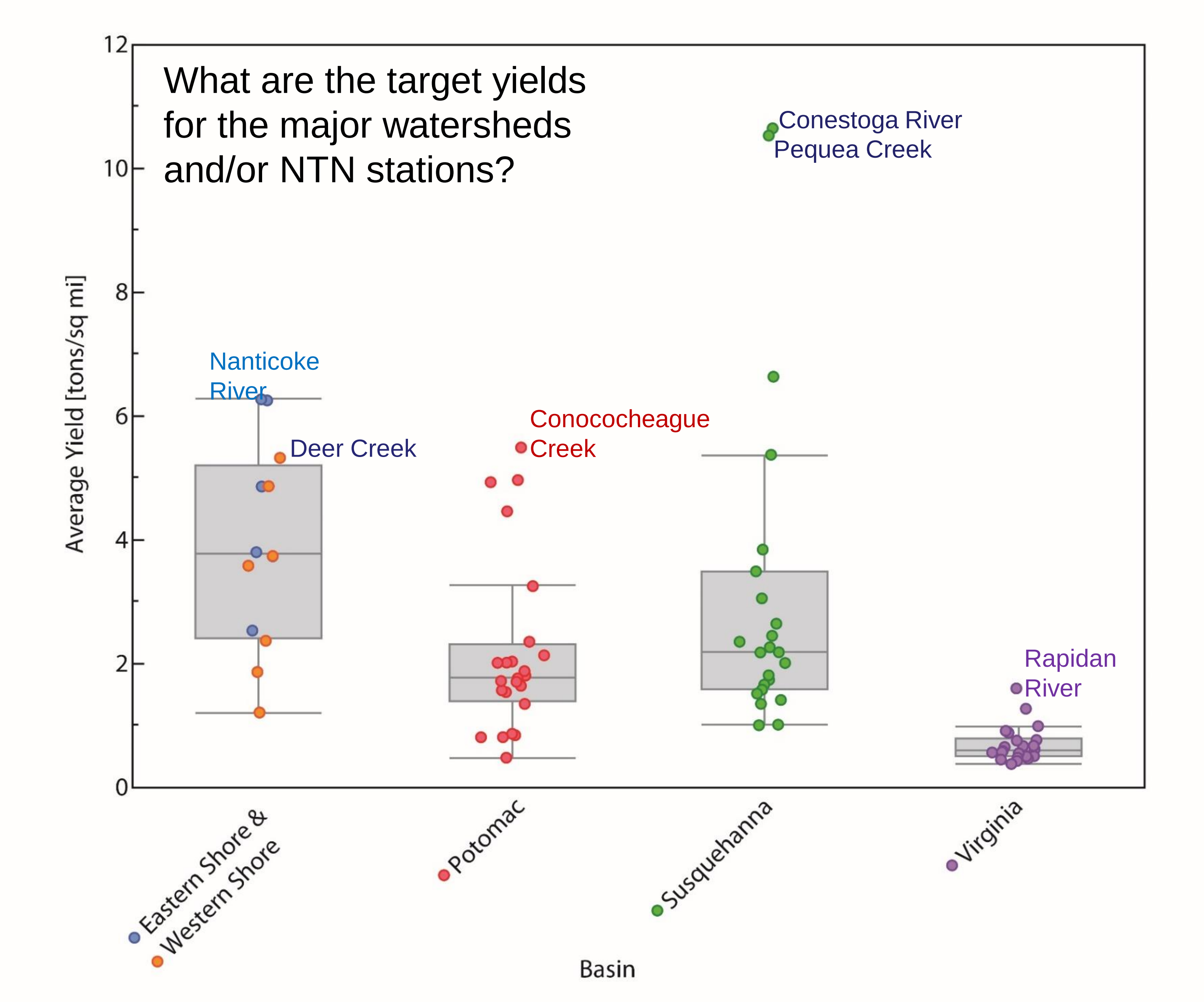
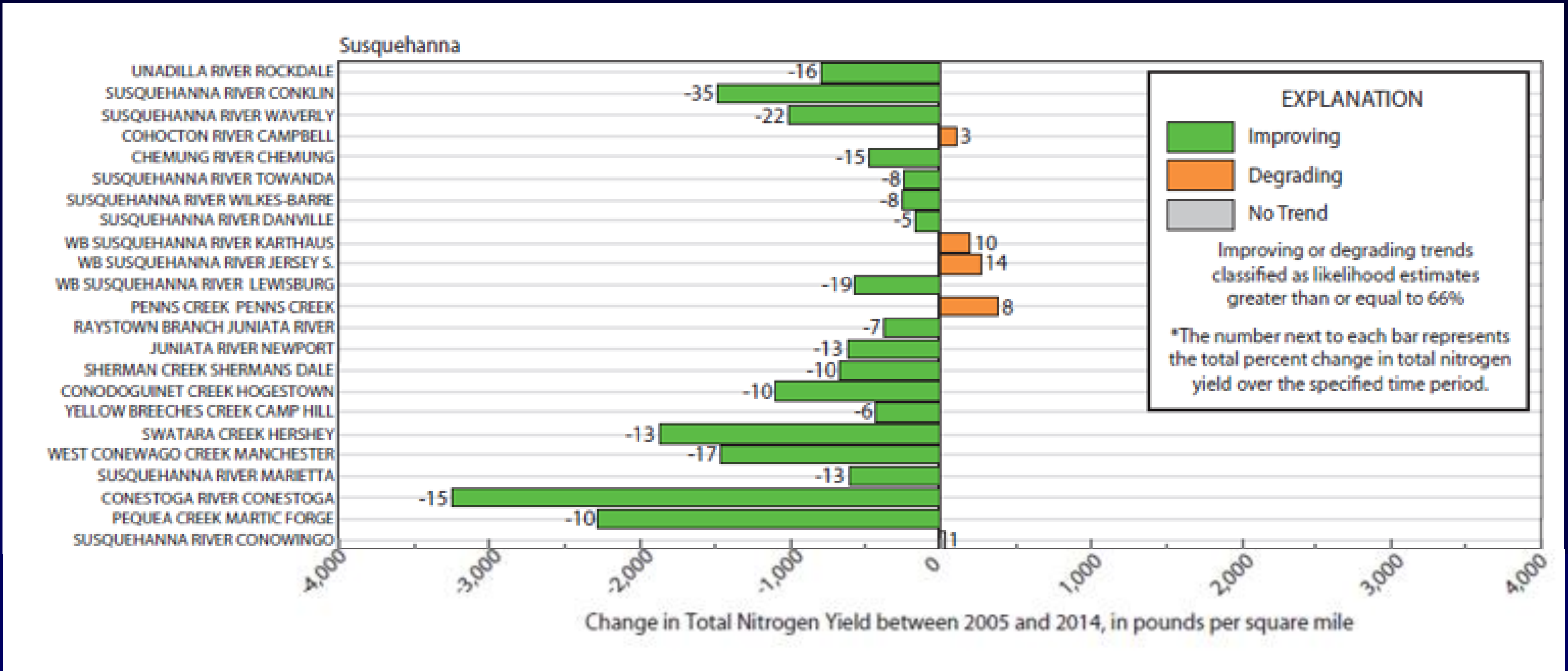
Total Nitrogen Yield: 2005-2014



USGS

Changes in Nitrogen Yields: 2005-2014

Example from the Susquehanna Watershed



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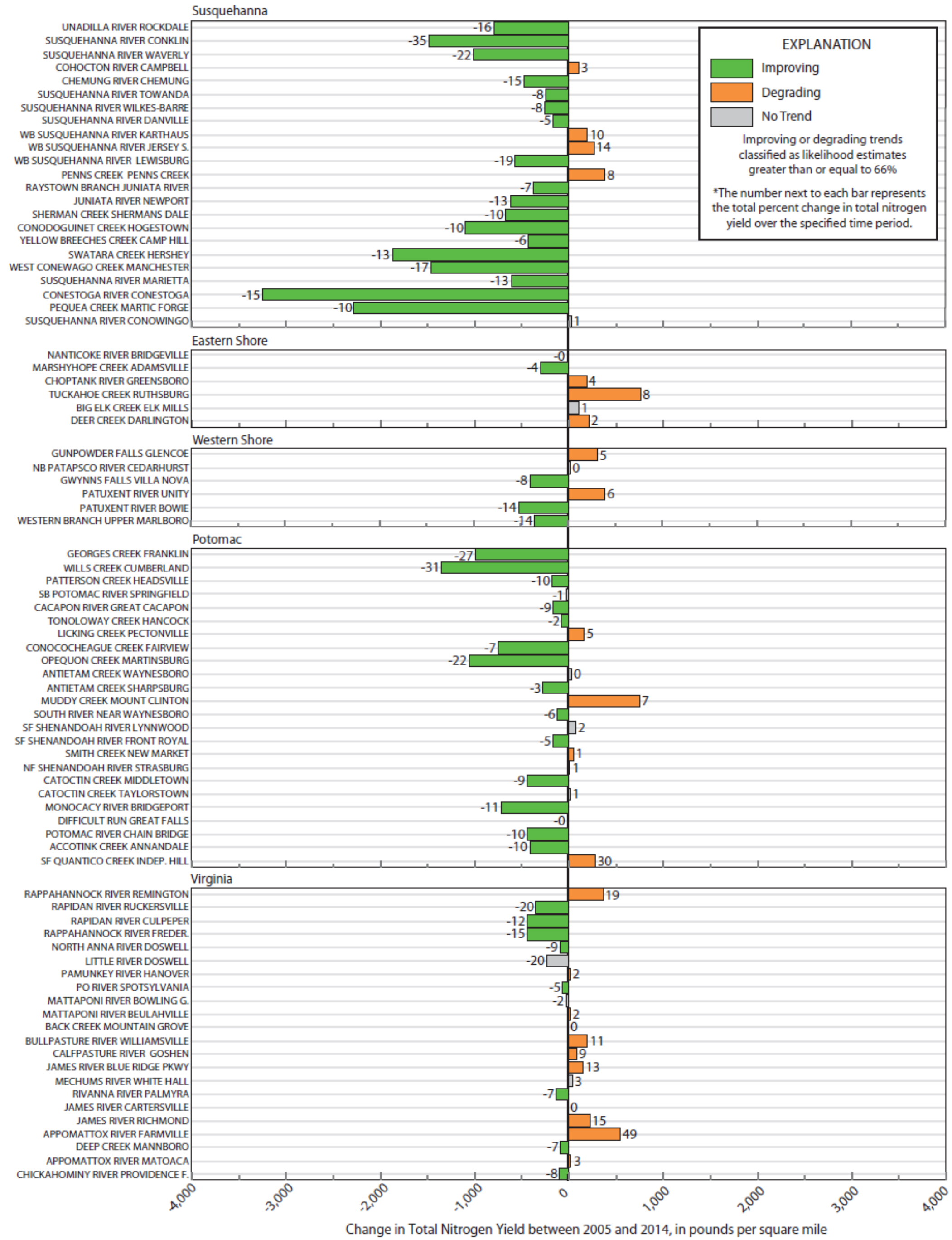
Changes in Nitrogen Yields: 2005-2014

Trend in load (yield) network is the first of it's kind

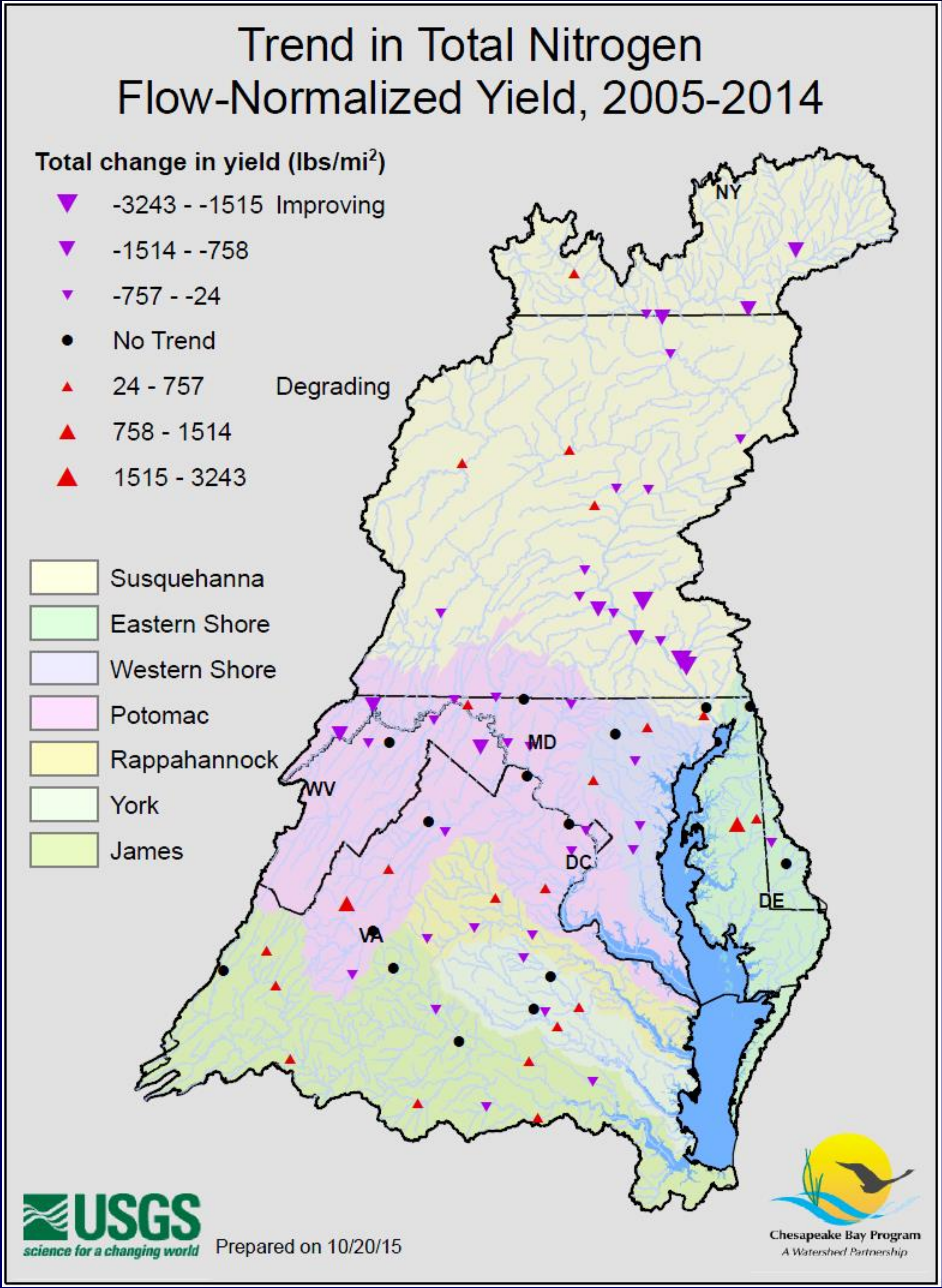
44 of 81 (54%) Stations Improving
Average Improvement = 634 lbs/mi^2
Average Percent Reduction = 12%

22 of 81 (27%) Stations Degrading
Average Degradation = 265 lbs/mi^2
Average Percent Reduction = 10%

15 of 81 (19%) Stations No Change



Changes in Nitrogen Yields: 2005-2014



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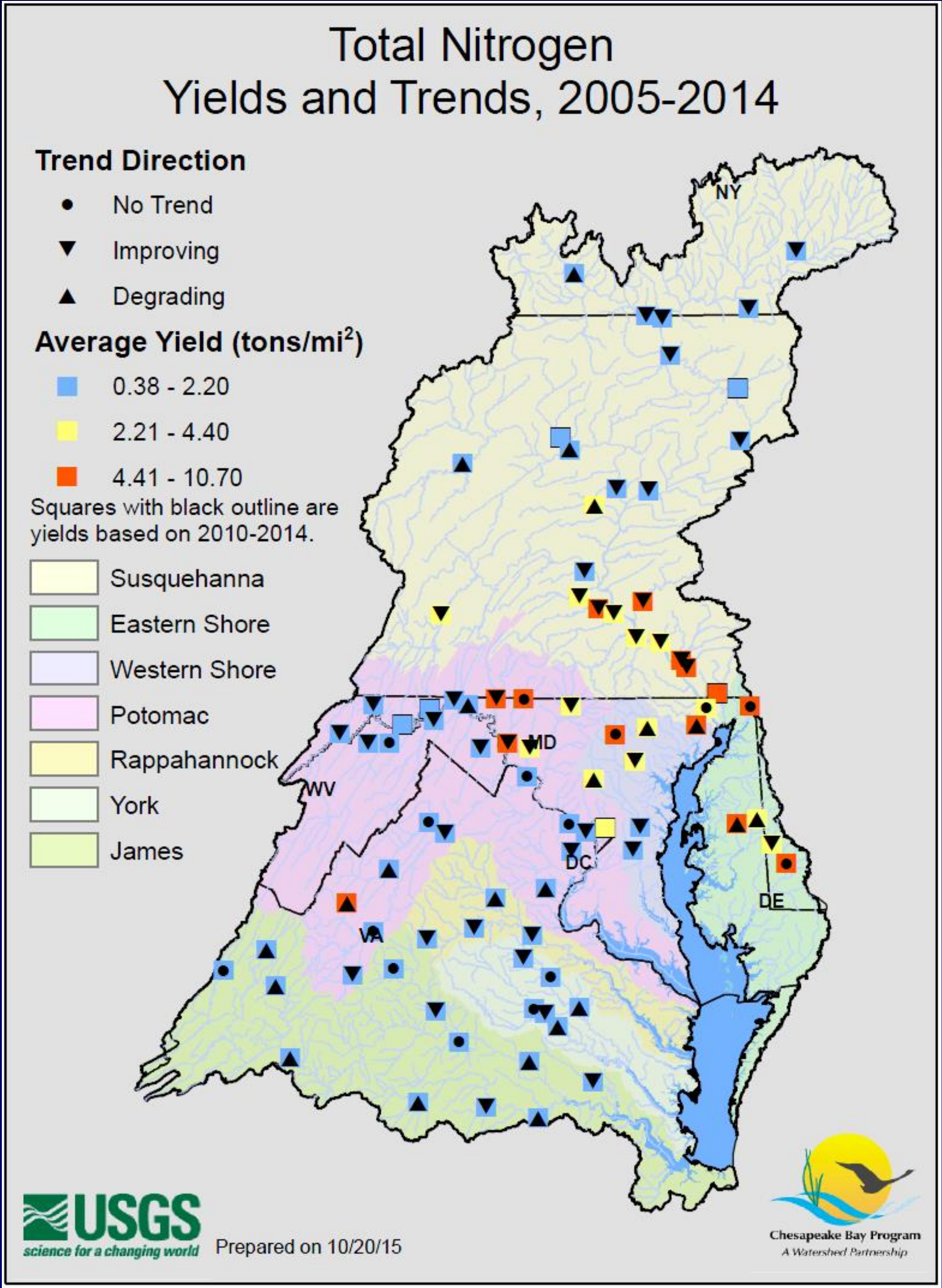
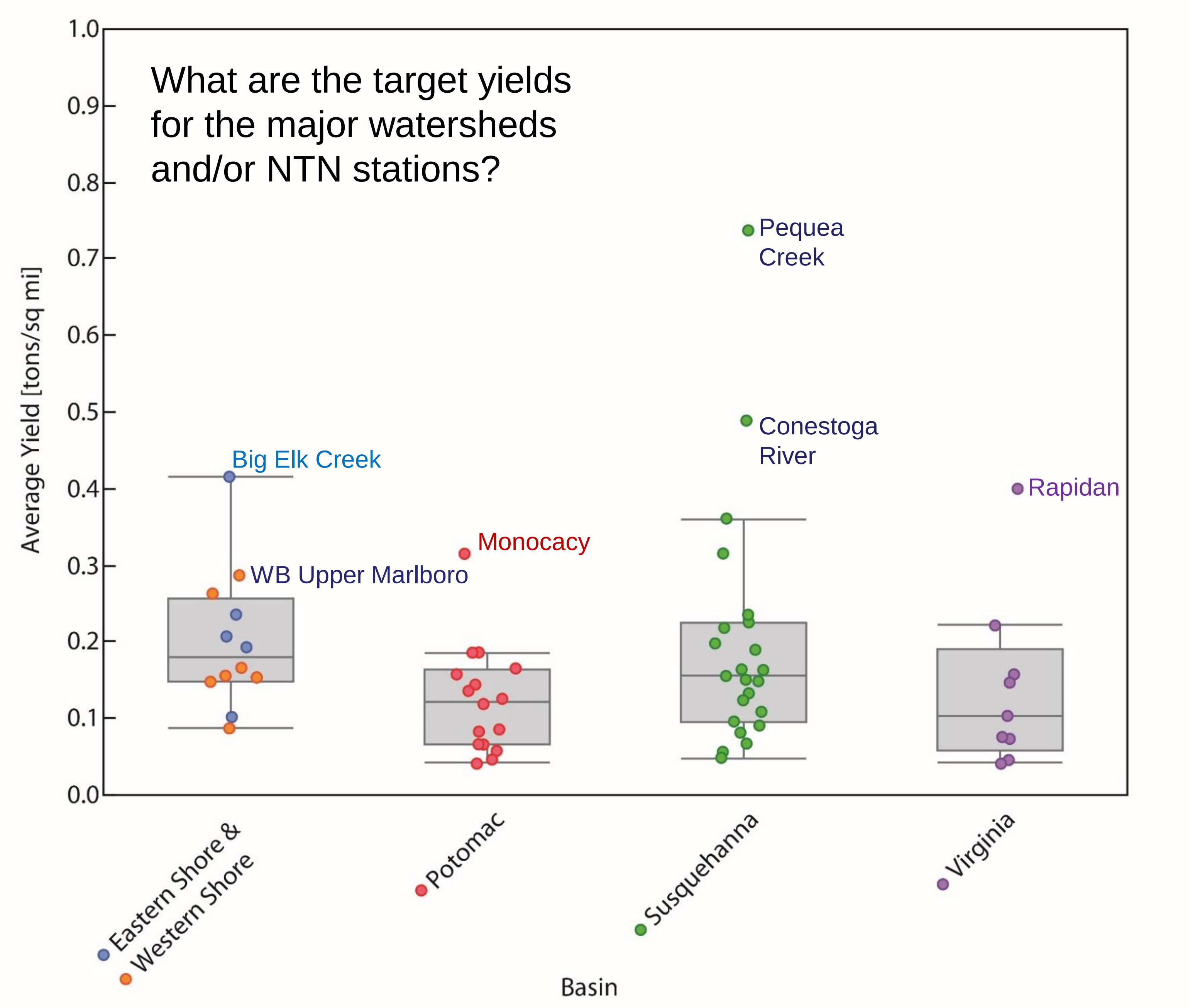
Total Nitrogen Yields and Trends: 2005-2014



USGS

Total Phosphorus Yield: 2005-2014



USGS

Changes in Phosphorus Yields: 2005-2014

Marked improvement in total phosphorus loads (yields) for the period 2005-2014 compared to 2003-2012 *(40% Improving and 48% Degrading)*.

41 of 60 (68%) Stations Improving

Average Improvement = 111 lbs/mi²

Average Percent Reduction = 27%

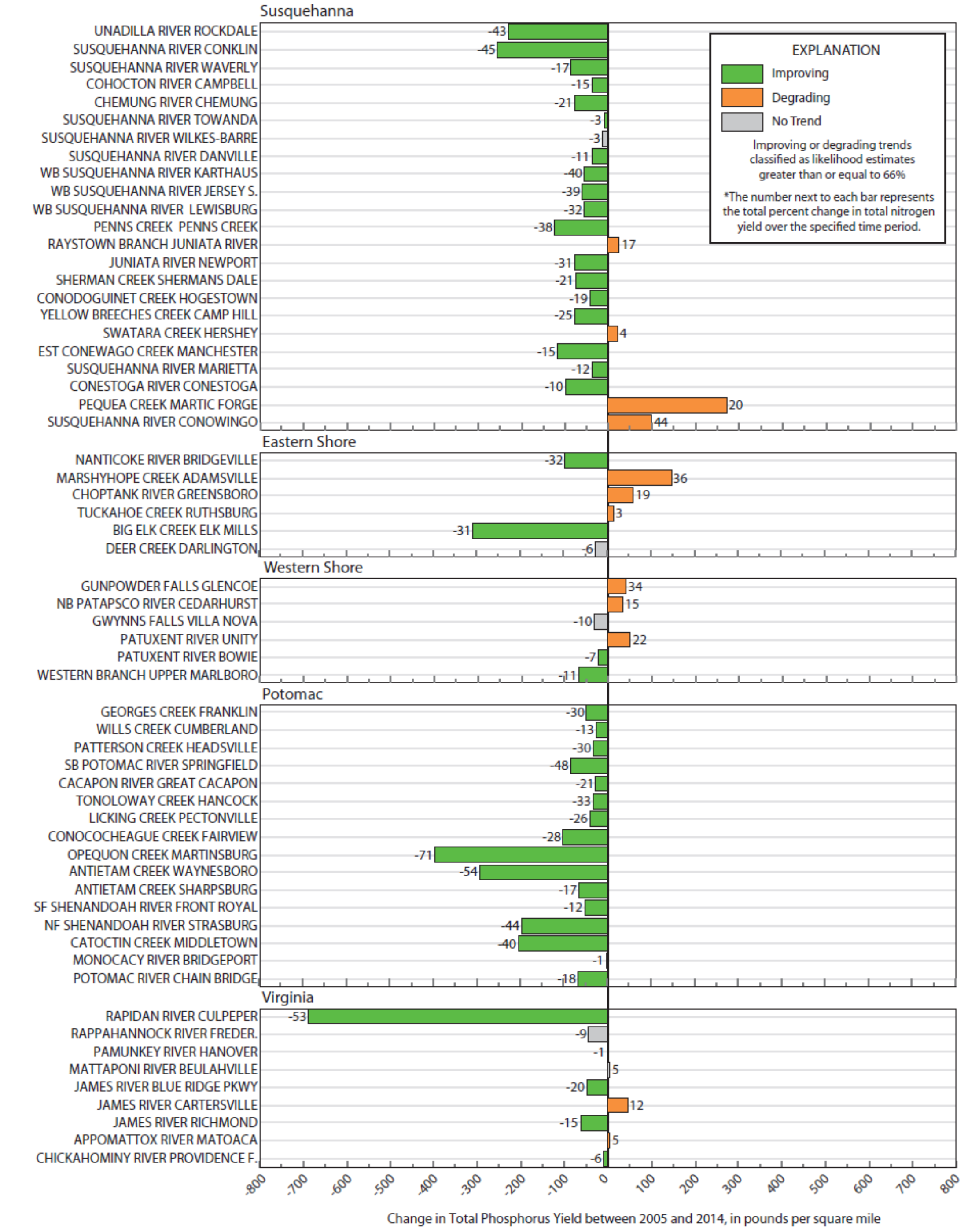
12 of 60 (20%) Stations Degrading

Average Degradation = 68 lbs/mi²

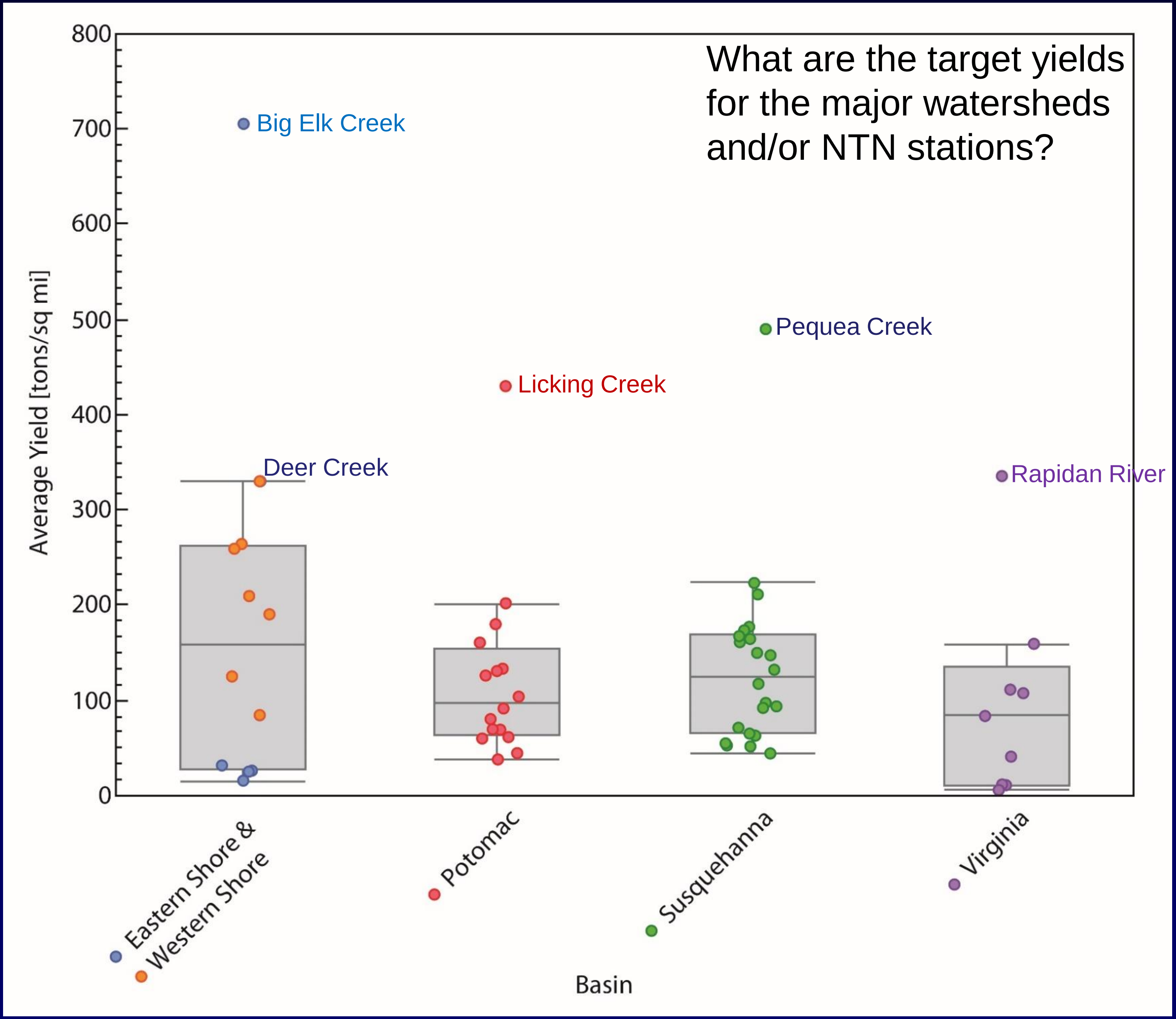
Average Percent Reduction = 19%

7 of 60 (12%) Stations No Change

USGS



Suspended Sediment Yield: 2005-2014



Changes in Suspended Sediment Yields: 2005-2014

29 of 59 (49%) Stations Improving

Average Improvement

= 144,000 lbs/mi^2

Average Percent Reduction

= 29%

19 of 59 (32%) Stations Degrading

Average Degradation

= 75,200 lbs/mi^2

Average Percent Reduction

= 43%

11 of 59 (19%) Stations No Change

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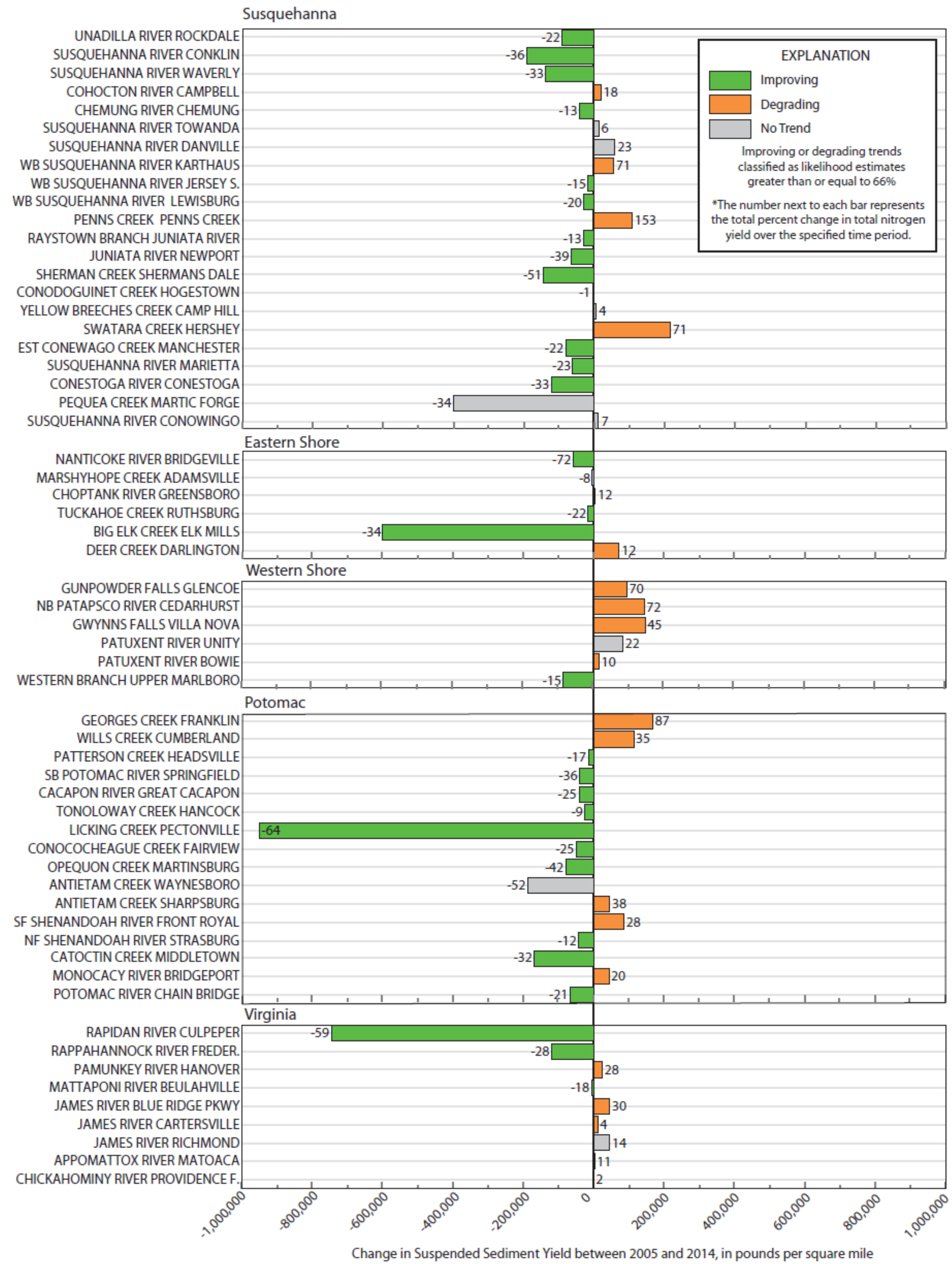
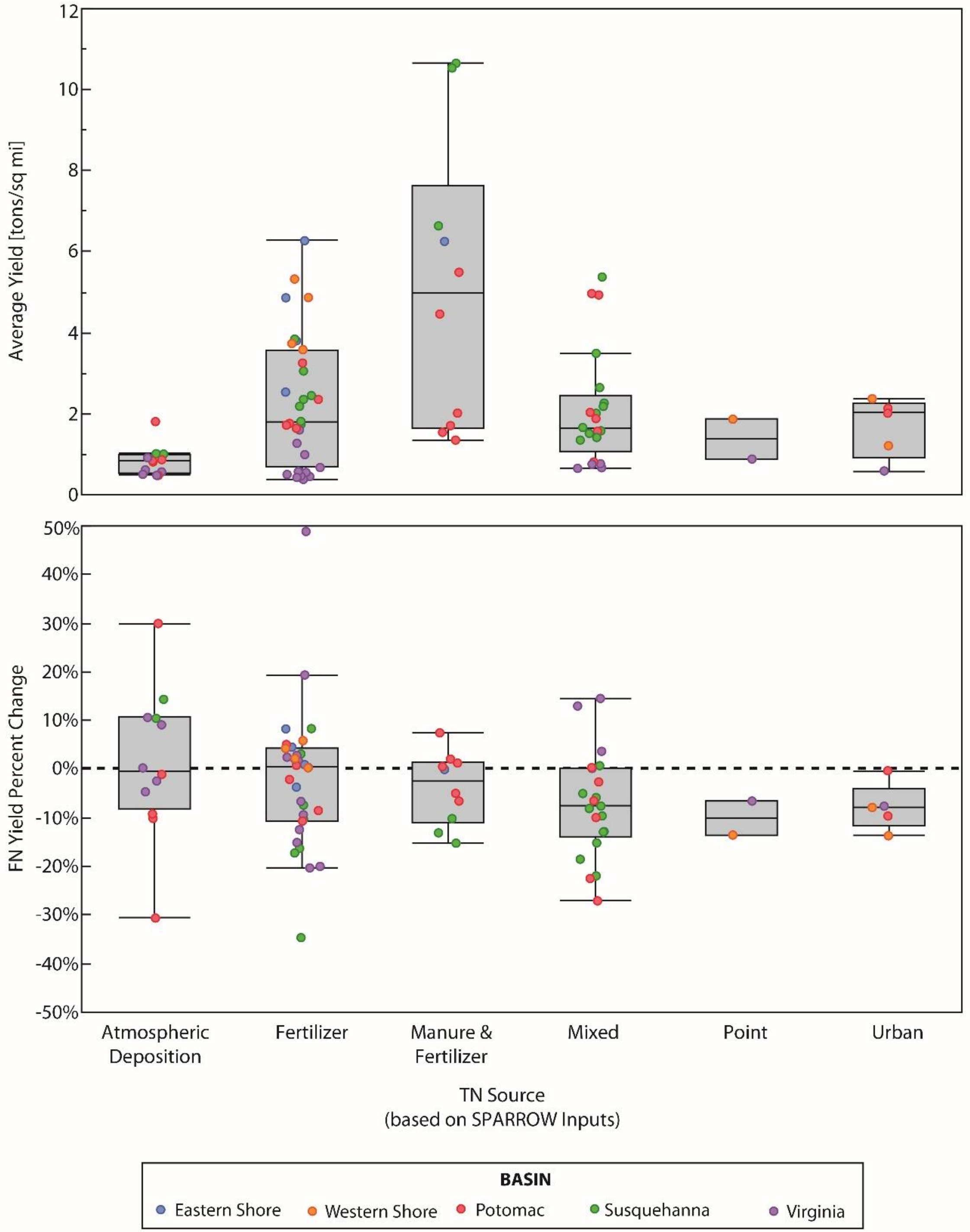


Enhanced Descriptive Analysis

Total Nitrogen Yield and Change: 2005-2014

Source categories determined using cluster analysis on the percent of each SPARROW derived nitrogen sources in each NTN watershed.



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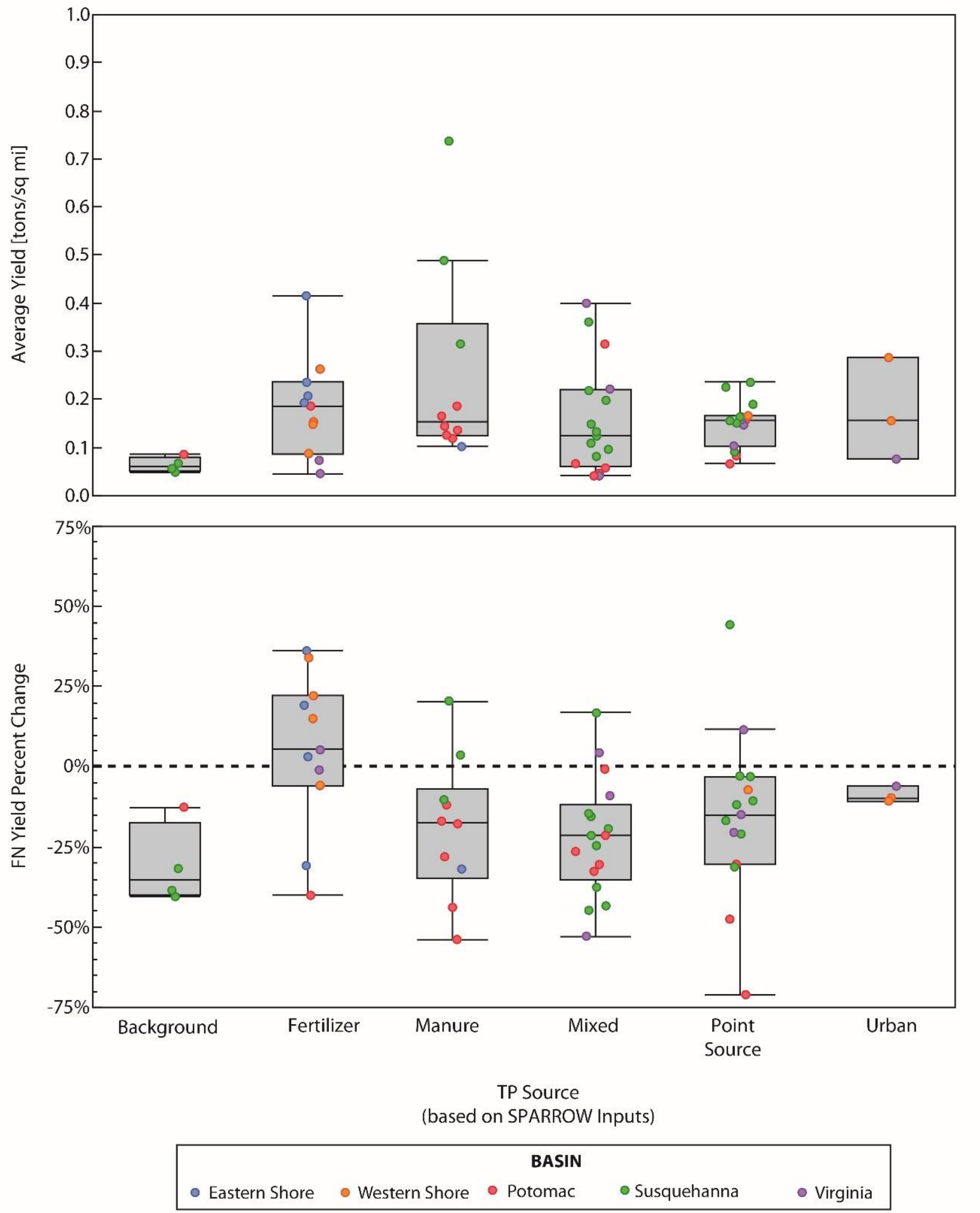

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Questions Addressed

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Questions for GIT

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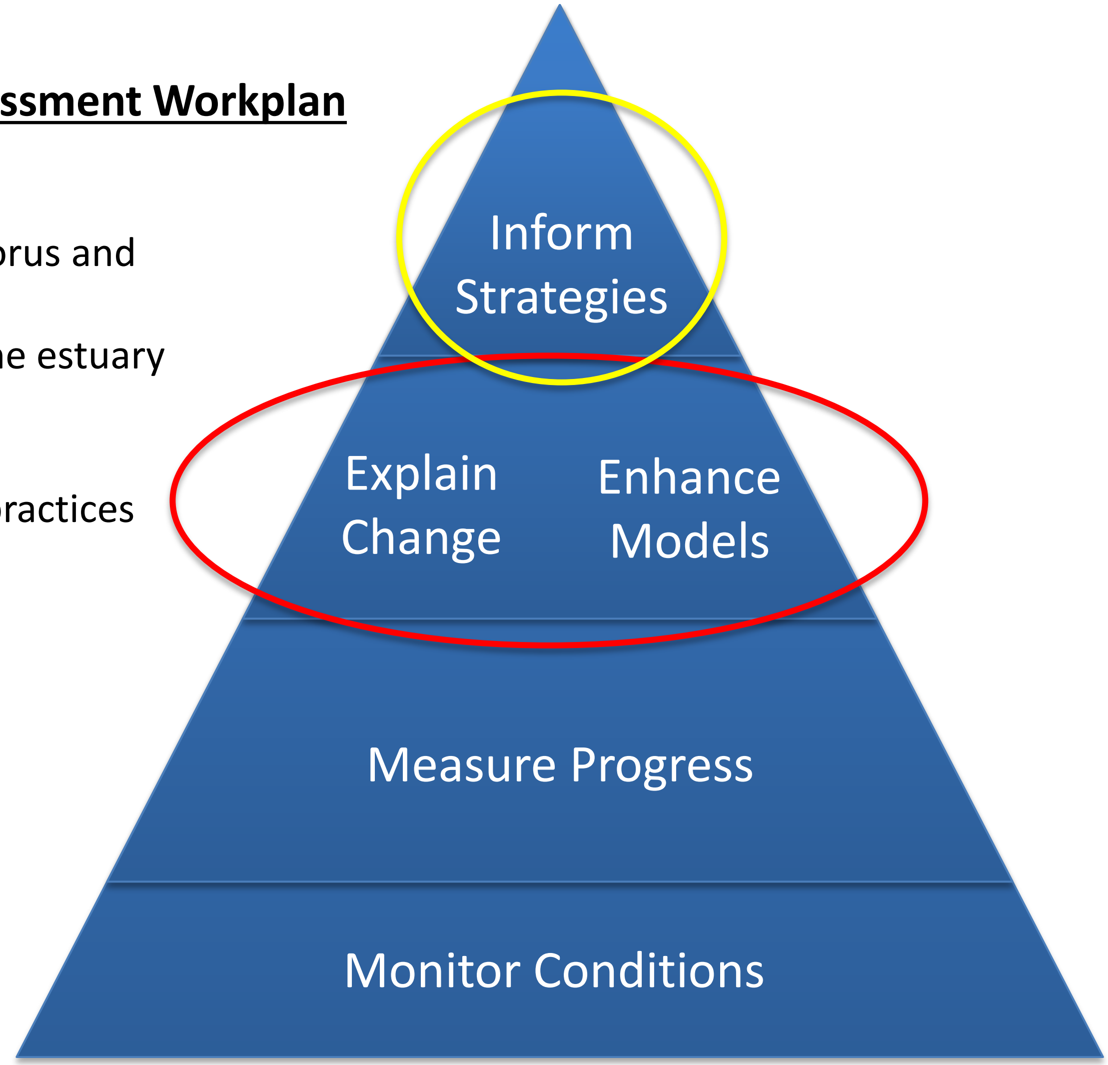

STAC Recommendations

For the 2017 Midpoint Assessment:

- GAMS estuary
- Report Uncertainty
- Use findings from current projects
- Apply selected analytical approaches In pilot watersheds
- SPARROW to inform WSM
- Make WSM data accessible

Longer-Term Enhancements for Explaining Trends by 2025:

- Improve BMP data
- Implement continuous monitoring
- additional parameters to link landscape to water quality;
- apply statistical techniques

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Explaining Change Process

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Changes in Land use, Nutrient Inputs, and BMPs

Land Use, Nutrient Inputs

- Description of spatial and temporal changes in
- Primary reference for all regional analyses

BMP implementation

- Description of spatial and temporal patterns in reported BMP across the watershed.
- Identification of expected mass reduction

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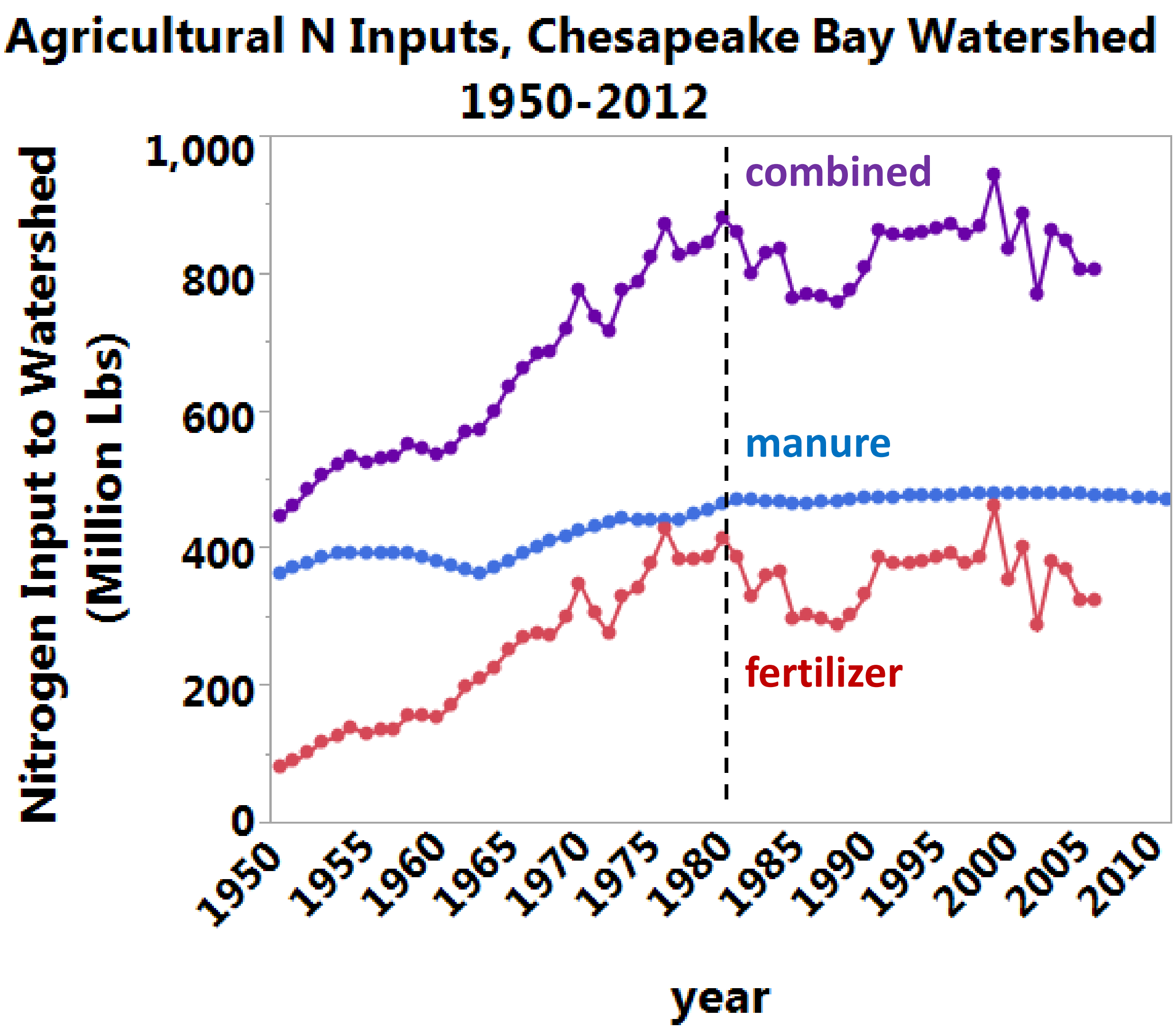
Relating N Inputs, Yields, and BMPs

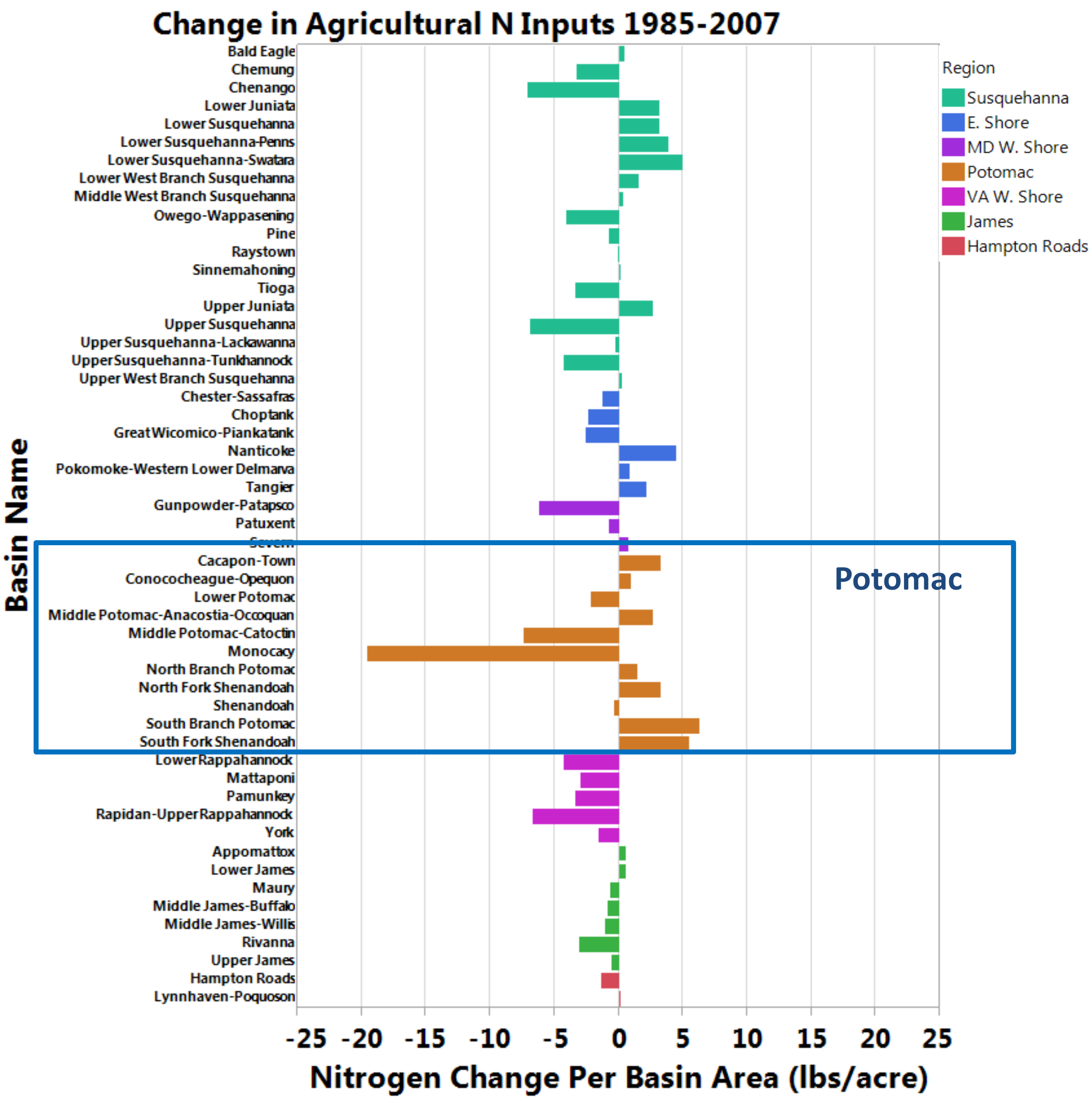
Watershed-wide Agricultural Nutrient Inputs Over Time



- Nitrogen inputs have been relatively stable since the early 1980s
- Manure-N inputs increased by about 25% from 1950-1980
- Fertilizer-N inputs increased dramatically (about 370%) over the same time period
- **If we don't see changes, then how do we explain them?**

Relating N Inputs, Yields, and BMPs

Regional Variability in Nutrient Inputs – HUC 8 scale



Comparing patterns in regional variability:

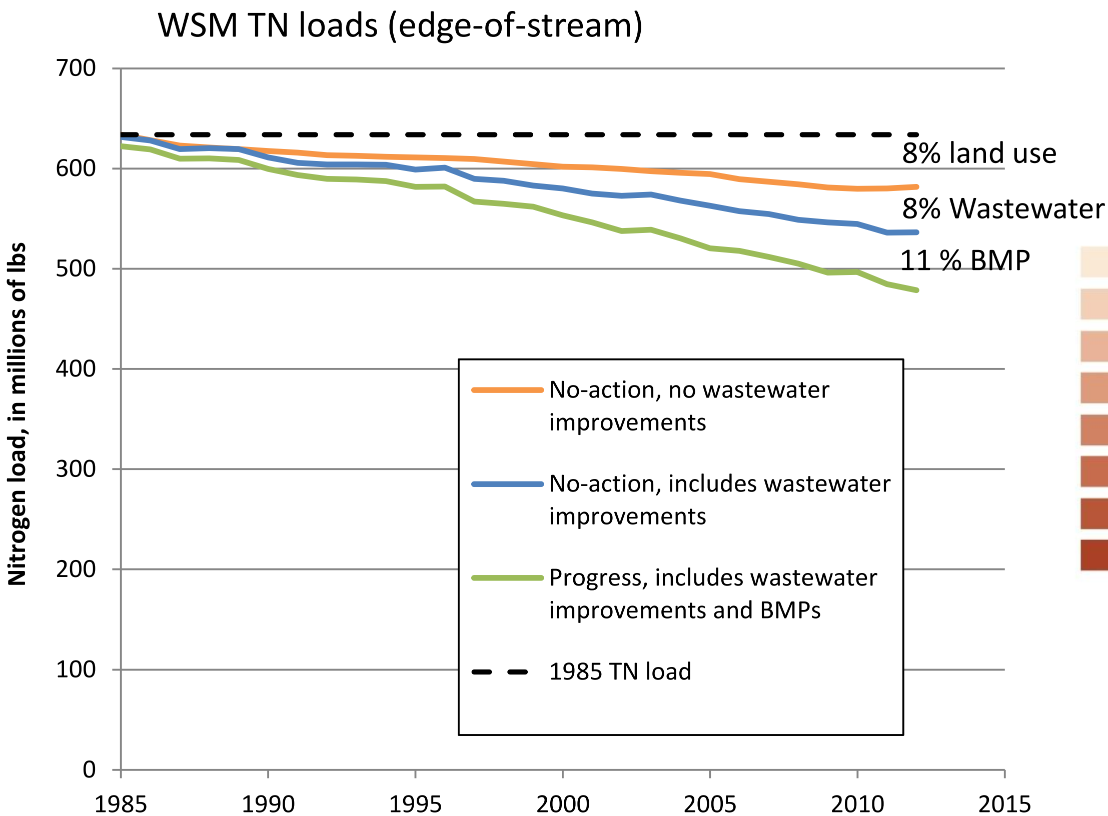
- Adds explanatory power,
- Can reveal general patterns,
- Highlights basins with unusual behavior.

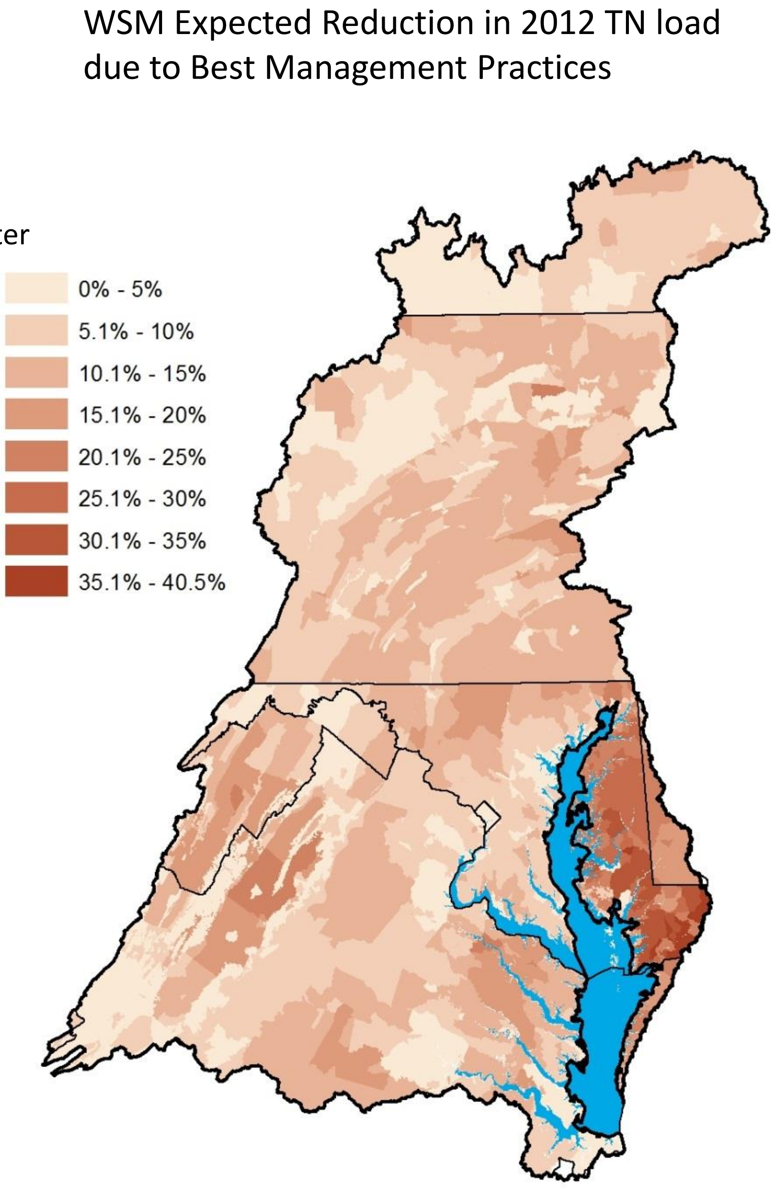
Direction and magnitude of change varied across and within regions

N inputs from agriculture increased in 7 out of 11 basins in spite of decreases in agricultural land

- In 6 of the 7 basins where N inputs increased, the increase was driven by manure *(not shown)*

SPATIAL AND TEMPORAL PATTERNS IN BMP IMPLEMENTATION: Changes in Delivered Nutrient Loads due to Best Management Practices Using the CBP Watershed Model





Model-Monitoring Comparison

- Analysis of observed (WRTDS) and Expected (WSM 5.3) changes in load for 9 major tributaries.
- Revealed varying levels of agreement between the expected changes in WSM loads over time relative to changes observed using WRTDS.
- Should apply a similar approach for WSM 6.0

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SPARROW TO EXPLAIN CHANGE

Decadal Land Use SPARROW model

SPARROW with BMP effects

Dynamic nitrogen model including groundwater lags

Dynamic phosphorus model including storage.

Delta SPARROW

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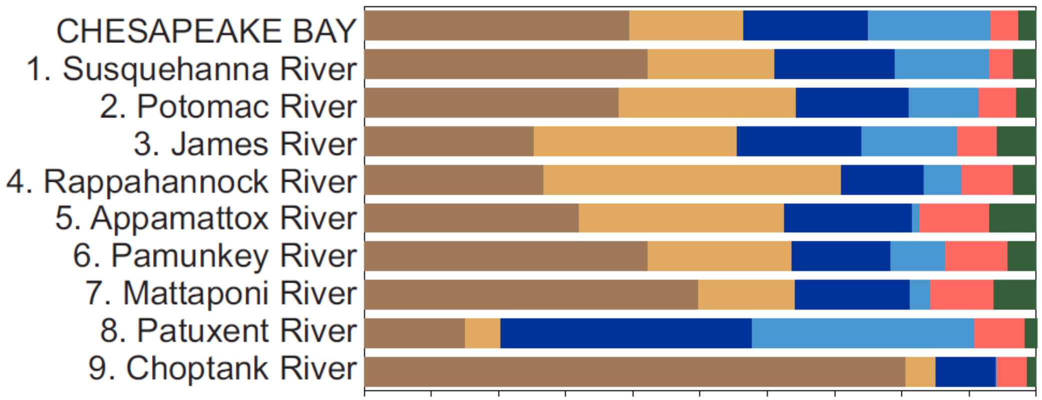
Land Use Modeling: Nitrogen (TN) Yields

- Mean yield of TN from selected land-use settings, in kilograms per hectare per year, as estimated by the *CBTN_v4LU* model:

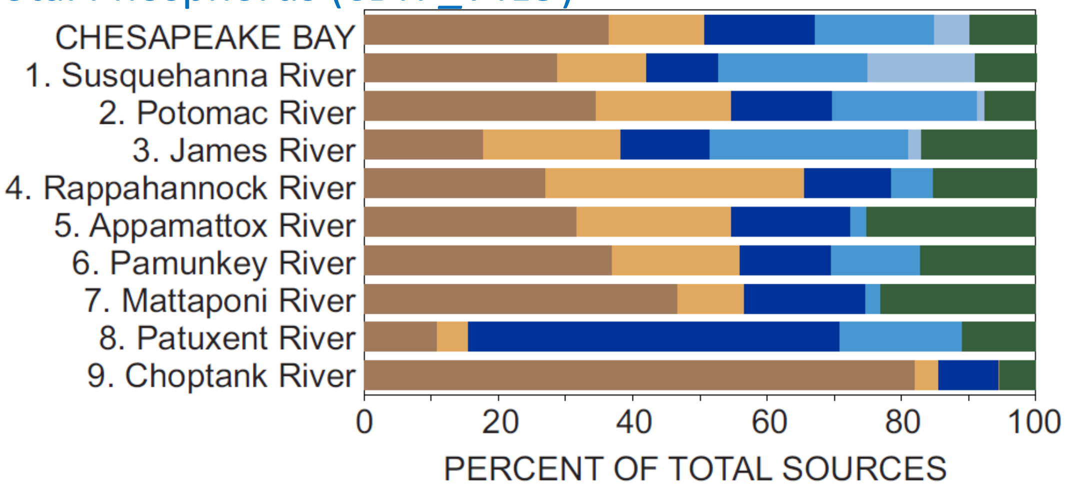
Land Use	Mean Yield (kg/ha/yr)	Std Error (% of Yield)	1 sided P-value
Cropland	25.5	14%	<0.0001
Pasture	10.7	22%	<0.0001
Developed	8.7	18%	<0.0001
Natural	0.5	68%	0.0700

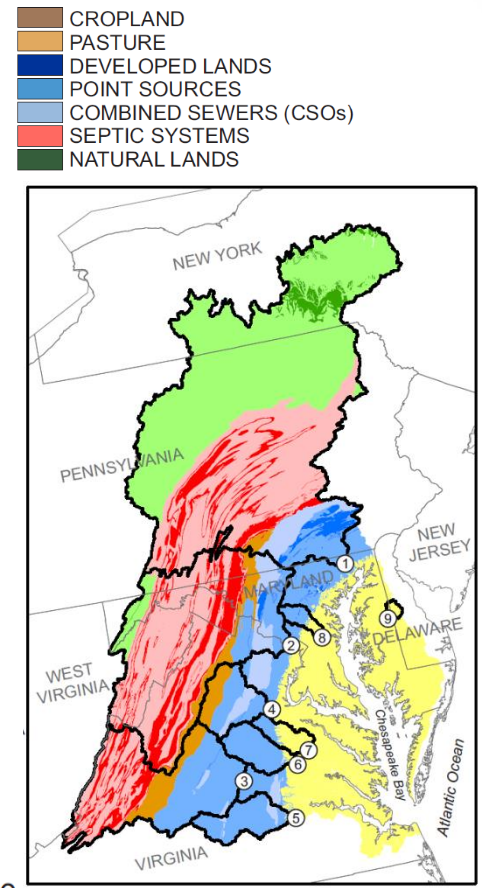
Land Use Modeling: Sources of TN and TP

Total Nitrogen (*CBTN_v4LU*)



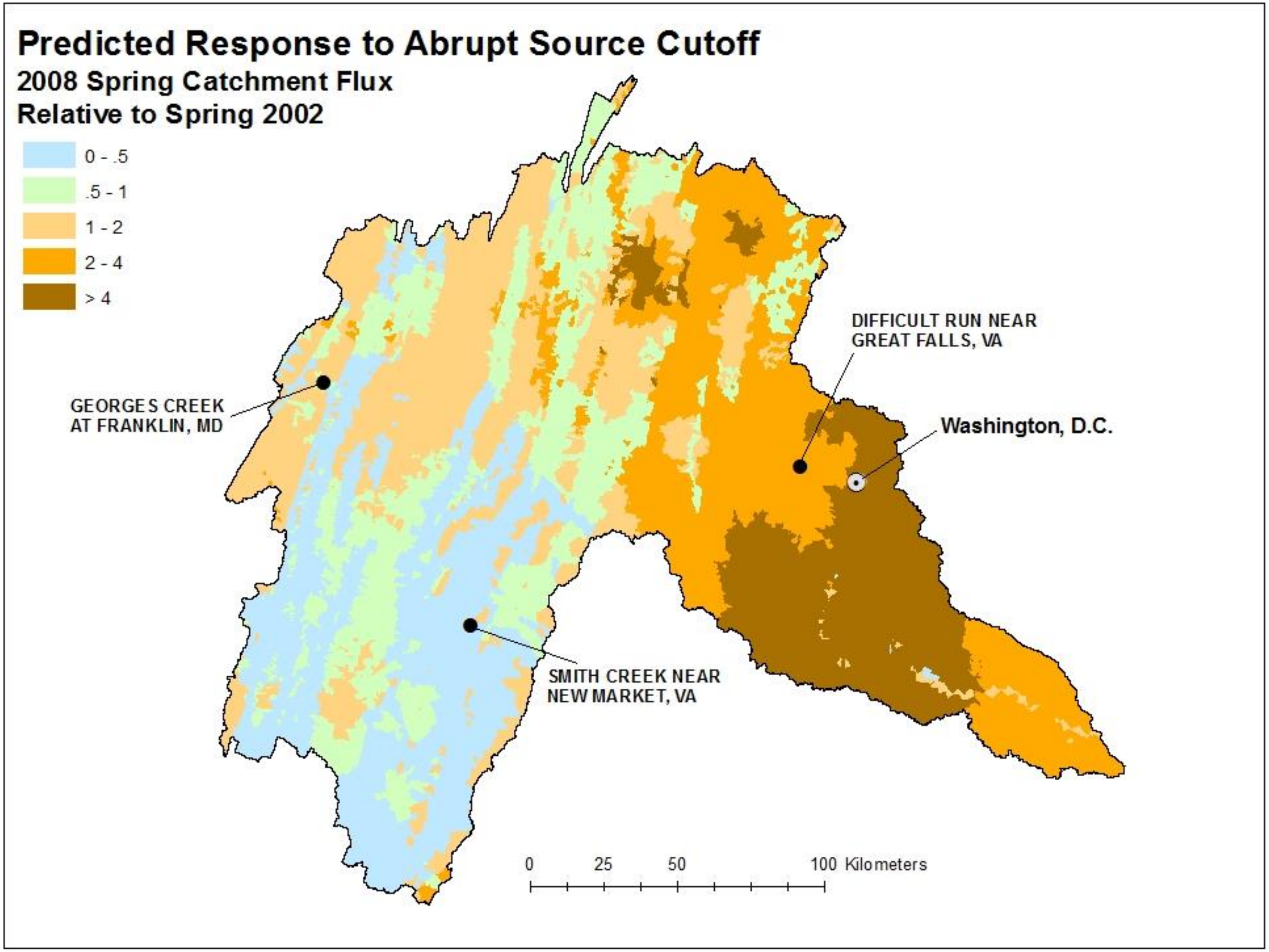
Total Phosphorus (*CBTP_v4LU*)





- Contributions of TN and TP to Chesapeake Bay and major tributaries.
- Note that CSOs in the *CBTP_v4LU* model are not significantly indistinguishable from zero (see Appendix, and point #5 under “Model Specification,” above).

Dynamic nitrogen model including groundwater lags



Additional Approaches to Explain Change

- Time Series Analysis
- Time series analysis of constituent ratios
- Multivariate Analysis
- Structured Equation modeling (SEM)

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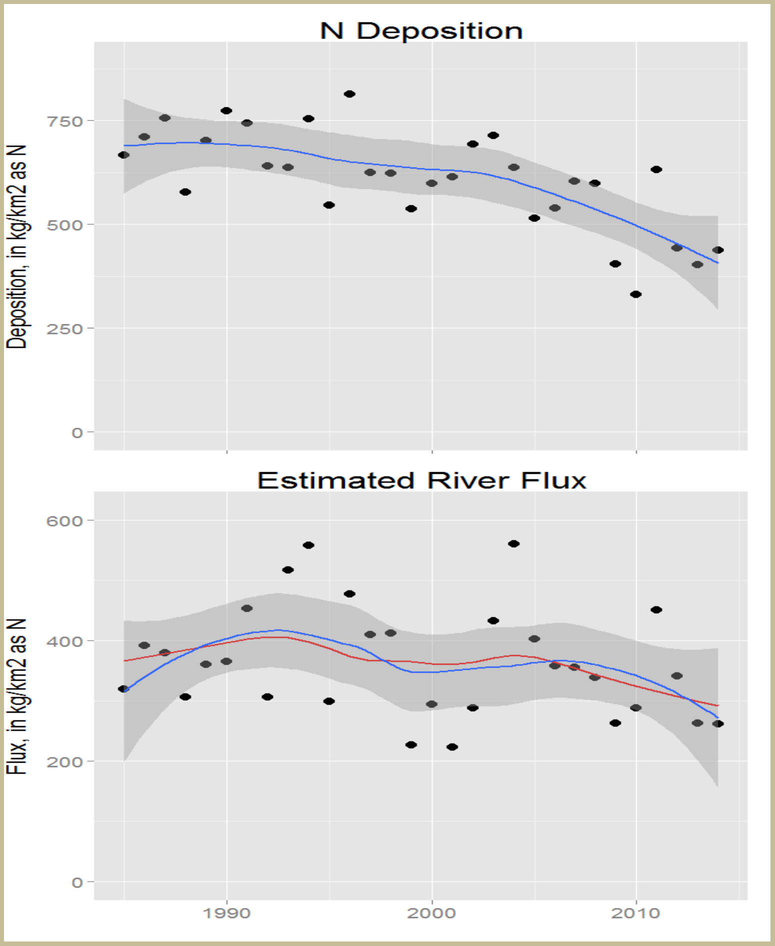
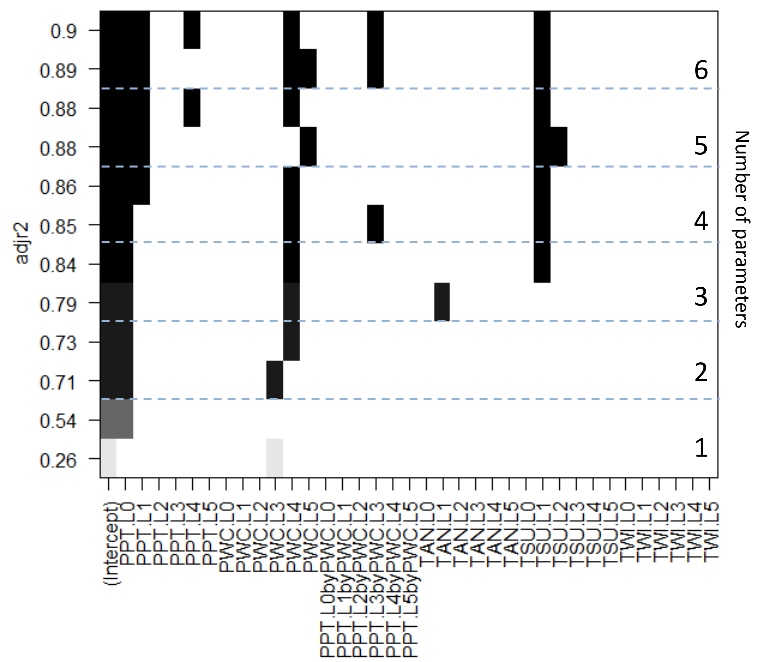
Time-series / regression analysis of input-output relations

Question: "What can analysis of highly-resolved input-output time series tell us about the dynamics of watershed-scale impairment / recovery?"



Strongest atmospheric predictors of river DIN flux
West Br. Susquehanna River near Lewisburg, PA



Approach: Regression and time-series analysis of relations between atmospheric N deposition and stream N flux, focusing on stations where atmospheric deposition is a dominant source.

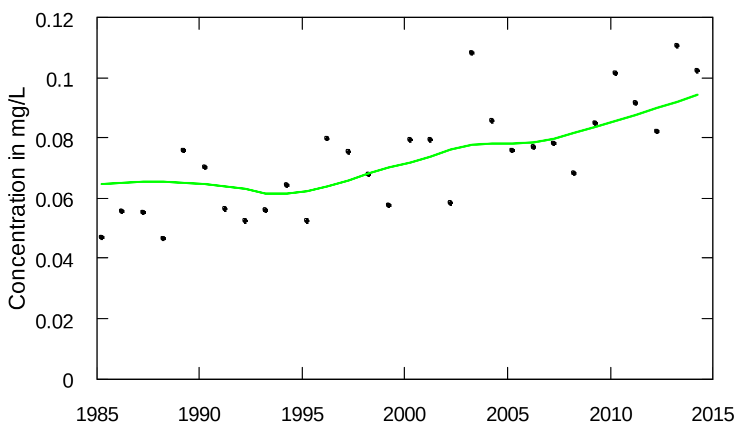
Interpreting trends in nutrient speciation

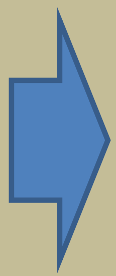
Question: "Can patterns in relations between constituents over time hint at land-use/BMP effects that might not be evident from examining individual time series?"

Approach: Graphical analysis, coupled with weight-of-evidence association with documented changes in land use / BMP implementation.

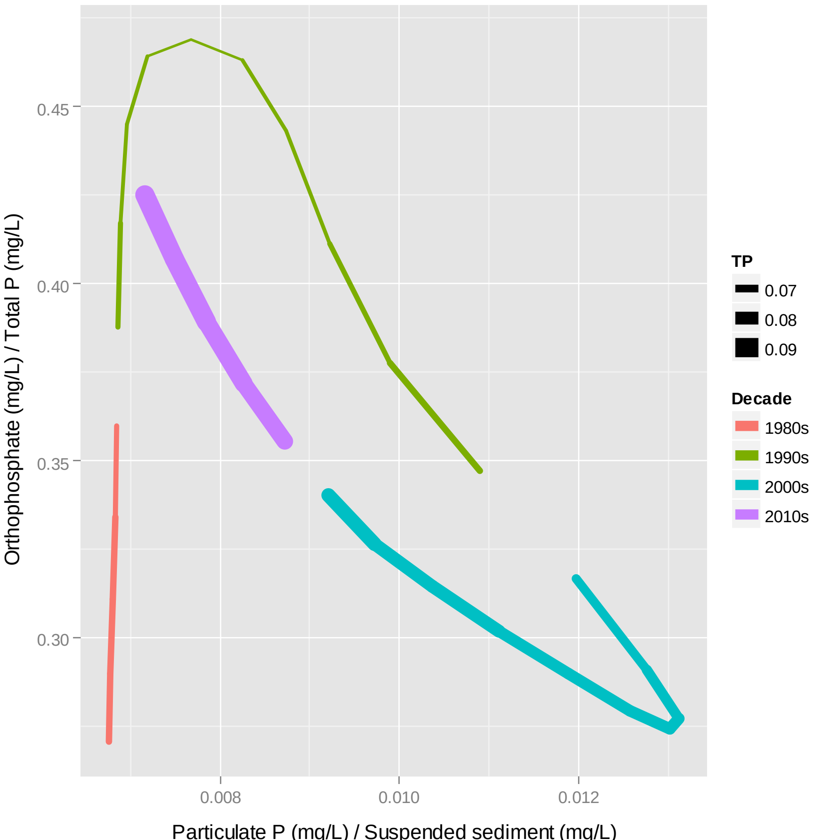
Pilot constituent: Total phosphorus

Time series of concentration of total phosphorus, Choptank River, 1985-2012





Evolution of phosphorus speciation, Choptank River, 1985-2012



Partner Contributions

- JHU
- UM-AEL
- ITAT
- Jurisdictions

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Small Watershed Studies

- Initial field studies of 3 NRCS targeted watersheds and 1 urban watershed completed.
- Long-term monitoring ongoing
- Review process nearly completed
- Report available 2016
- Need to prioritize topical presentations for partners in 2016 and 2017

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Water-Quality Monitoring in the Chesapeake Bay Showcase Watersheds

Report in editorial review

Primary Collaborators

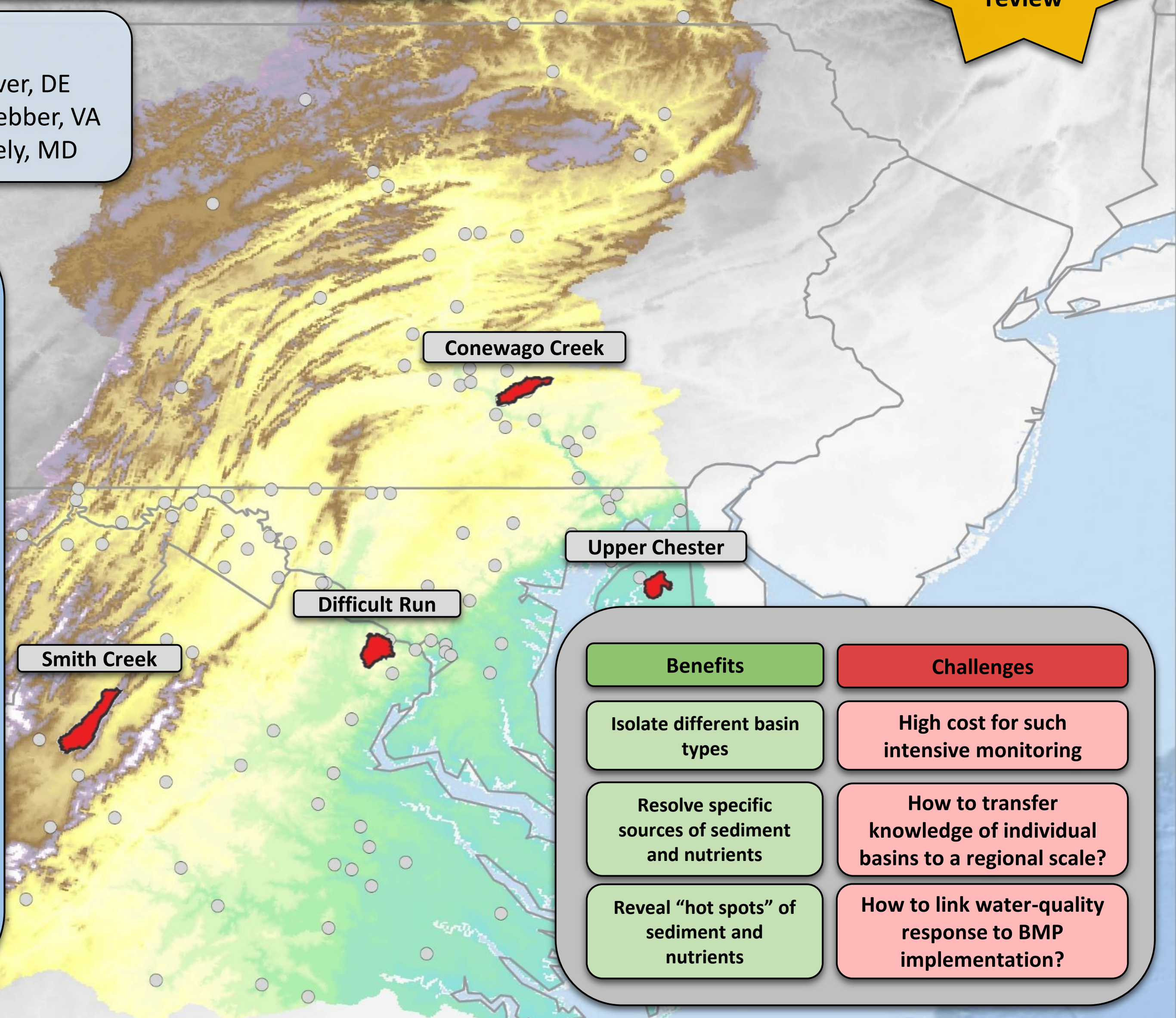
Ken Hyer, VA
Mike Langland, PA
JK Böhlke, Reston, VA
Judy Denver, DE
Jimmy Webber, VA
Dean Hively, MD

~120 sites in the NTN

How is the water quality of rivers and estuaries responding to restoration actions and changing land use?

USGS & USDA partnership in 4 Showcase Watersheds (2009 Executive Order)

USDA	USGS
Implement conservation practices	Document current water-quality conditions
	Identify nutrient and sediment sources, sinks, and transport processes
	Document changes in water quality



Benefits	Challenges
Isolate different basin types	High cost for such intensive monitoring
Resolve specific sources of sediment and nutrients	How to transfer knowledge of individual basins to a regional scale?
Reveal "hot spots" of sediment and nutrients	How to link water-quality response to BMP implementation?

Questions and Discussion topics

- As results are coming forward, how can we best disseminate new findings?
- How can we get feedback on the approaches that are being implemented?
- How can we engage jurisdictions into the process of explaining patterns at individual sites?

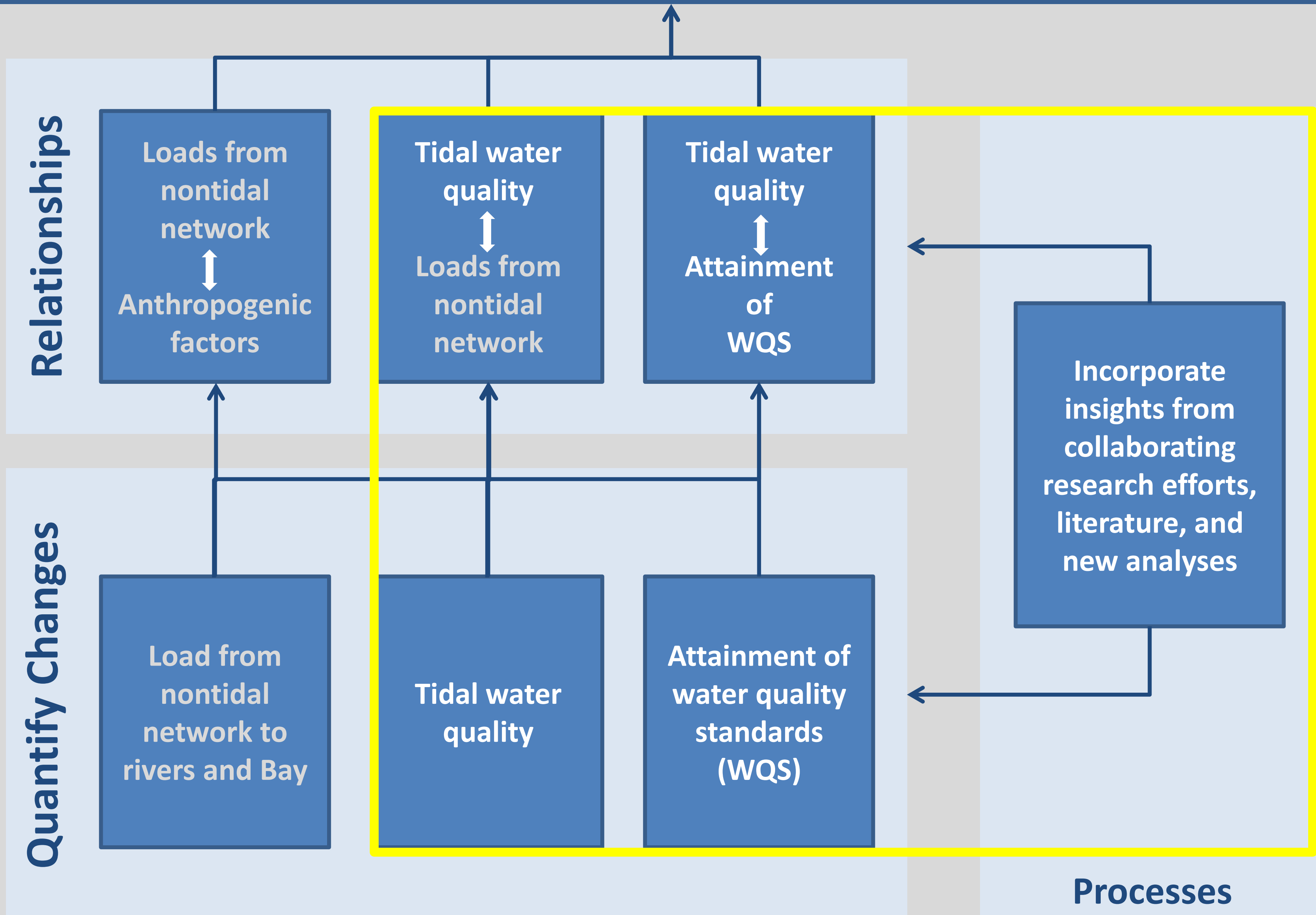
Measuring and Explaining Trends in Estuarine Water Quality

Jeni Keisman (USGS)**, Rebecca Murphy** (UMCES-CBPO)**, Melinda Ehrich** (UMCES-CBPO)**, Richard Tian** (UMCES-CBPO)**, Kyle Hinson** (CRC-CBPO)

Water Quality Goal Implementation Meeting

December 15, 2015

Using Monitoring Data To Measure Progress and Explain Change



Using Monitoring Data To Measure Progress and Explain Change

Changes in Water Quality Standards Attainment

Quantify Changes

Attainment of water quality standards (WQS)

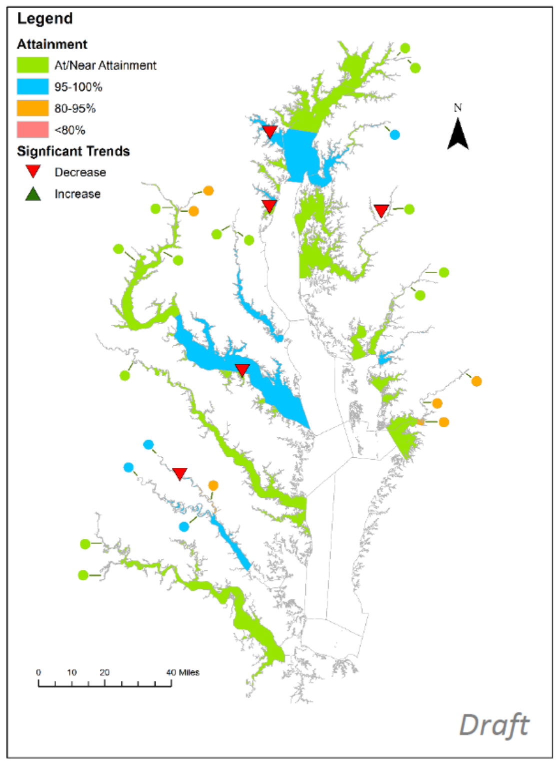
January – June 2016

- Summary report of trends in estuarine WQS attainment, 1985-2014
- Interactive visualization tools of WQS attainment trends on chesapeakebay.net

Segment Level Analysis

Percent to attainment:

Migratory Fish, Spawning, and Nursery Use DO 1985-2013



Category	Count	Category	Count
At/Near Attainment	54	80-95%	6
95-100%	13	<80%	0

Trends	
Significant ↑	0
Significant ↓	5

"Open Water" Percent to Attainment

PAXOH (Patuxent River)

July - December 2016

- Presentation that communicates linkages and reasons for differences between attainment patterns and water quality variable patterns

Using Monitoring Data To Measure Progress and Explain Change

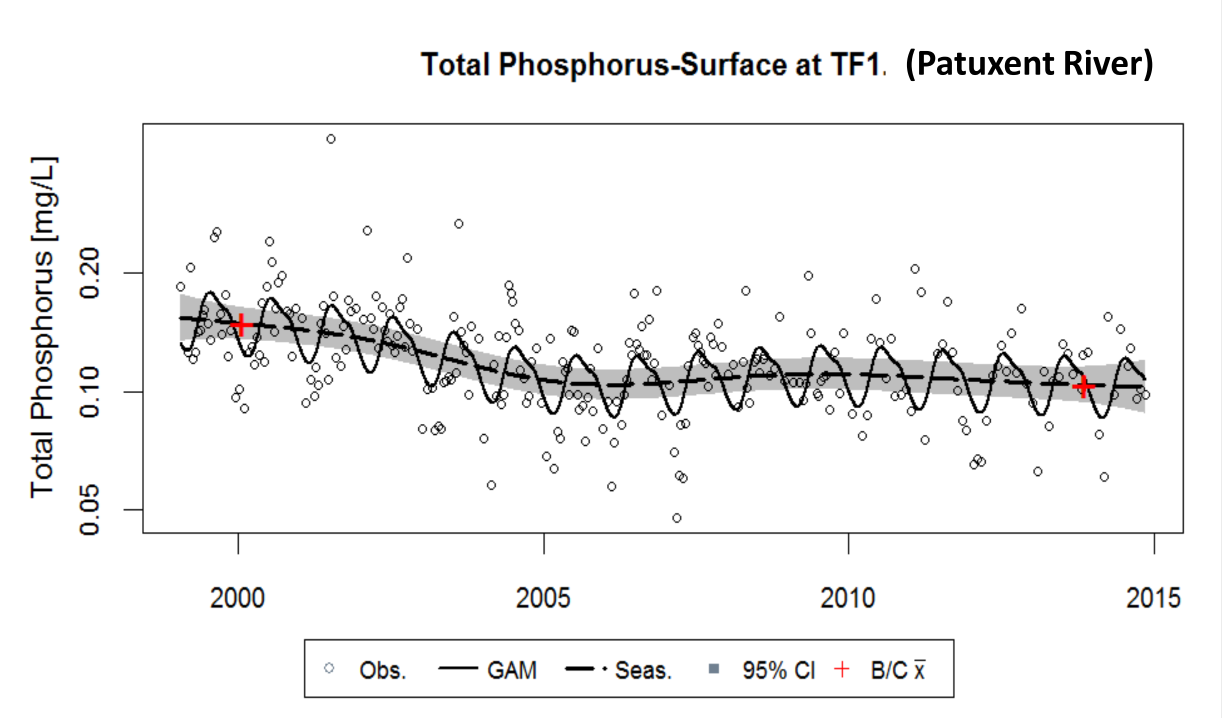
Changes in nutrients and water quality parameters in tidal waters

Quantify Changes

Tidal water quality

January – June 2016

- Summary report of GAM-computed trends, 1999-2015 (secchi disk depth, chlorophyll-*a*, dissolved oxygen, total phosphorus, total nitrogen)



July - December 2016

- Flow-adjusted 1999-2015 GAM-based trends at tidal stations
- STAC GAMs Review report
- Preliminary results on long-term trends and flow-adjusted trends in tidal WQ (1985-2015)

Using Monitoring Data To Measure Progress and Explain Change

Relate changes in tidal water quality to trends in N/P/S loads

Relate Changes

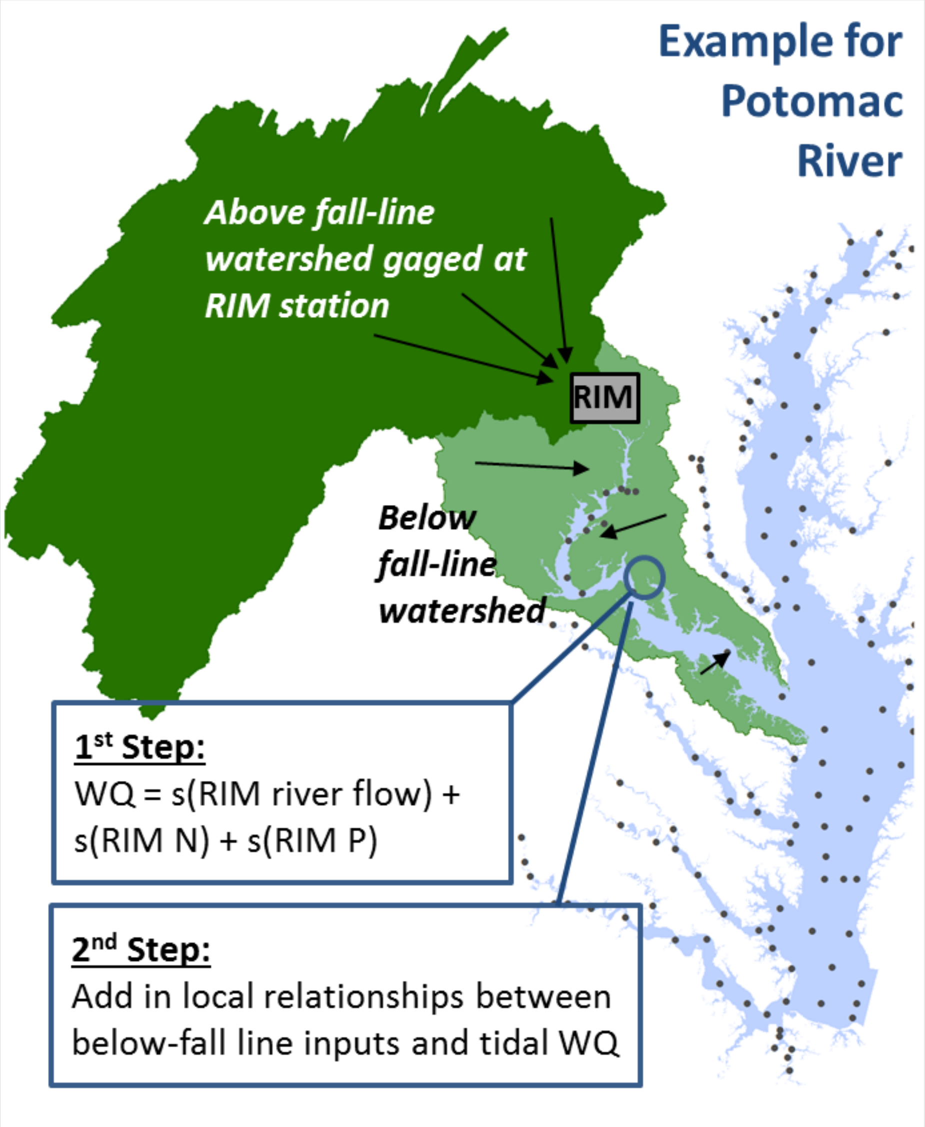
Tidal water quality
↕
Loads from nontidal network

January – June 2016

- Design methodology and initial case study results for using GAMs to link estuary trends to fall-line nutrient loads

July - December 2016

- Draft results from using GAMs to link all tidal stations to fall-line loads (and next steps)
- Draft results/methodology for linking below fall-line volumetric inputs to tidal water quality data



Using Monitoring Data To Measure Progress and Explain Change

Insights from collaborative research efforts

Explain Changes

Incorporate insights from collaborating research efforts, literature, and new analyses

Timing/Purpose	Product	Team
Jan – June 2016		
Translate existing research into knowledge useful to management	Presentation	CBP team
Build support for GAM method by applying it in a comparative case study to WRTDS in tidal Patuxent	Journal article	Research partners and CBP team
July – Dec 2016		
Evaluate climate-caused seasonal shifts that may complicate responses	Submitted journal article	Research partners and CBP team
Evaluate relative impact of non-tidal loads, point sources, and climatic factors on Potomac tidal water quality	Submitted journal article/ presentation	ITAT Potomac collaborate synthesis group
Review/link multiple Bay-wide efforts (including GAMs) to reveal large-scale patterns, factors, and responses	Presentation (article later)	ITAT synthesis team and partners
Translate this new research into knowledge useful to management	Presentation	CBP team

Using Monitoring Data To Measure Progress and Explain Change

Summary of 2016 Products

Quantify changes in WQS attainment

January – June 2016:

- Summary report of trends in estuarine WQS attainment, 1985-2014
- Interactive visualization tools of WQS attainment trends on chesapeakebay.net

July – December 2016:

- Presentation that communicates linkages and reasons for differences between attainment patterns and water quality variable patterns

Quantify changes over time in tidal water quality parameters

January – June 2016

- Summary report of 1999-2015 GAM-computed trends for secchi depth, chlorophyll-*a*, dissolved oxygen, total phosphorus, total nitrogen

July – December 2016

- Flow-adjusted 1999-2015 GAM-based trends at tidal stations
- Preliminary results on 1985-2015 trends and flow-adjusted trends in tidal WQ
- STAC GAMs Review report

Relate tidal water quality to fall-line nutrient loads from the watershed

January – June 2016

- Initial case study results for using GAMs to link estuary trends to fall-line nutrient loads

July – December 2016

- Draft results from using GAMs to link all tidal stations to fall-line loads
- Methodology and draft results for linking below fall-line volumetric inputs to tidal water quality data

Using Monitoring Data To Measure Progress and Explain Change

Topics Addressed

1. We showed you the latest results on trends in yields from the watershed

2. We explained how we are digging into the data to explain observed patterns

3. We described some of our plans for work in 2016.

Alignment with Managers' Needs

1. What time period is most useful for reporting trends in water quality?
2. Are there questions that you have about trends in water quality that are not represented in our plans?
3. Within your organization, who are the key people with whom we should work directly to align your questions with our work?

We will use your feedback to target content for future presentations