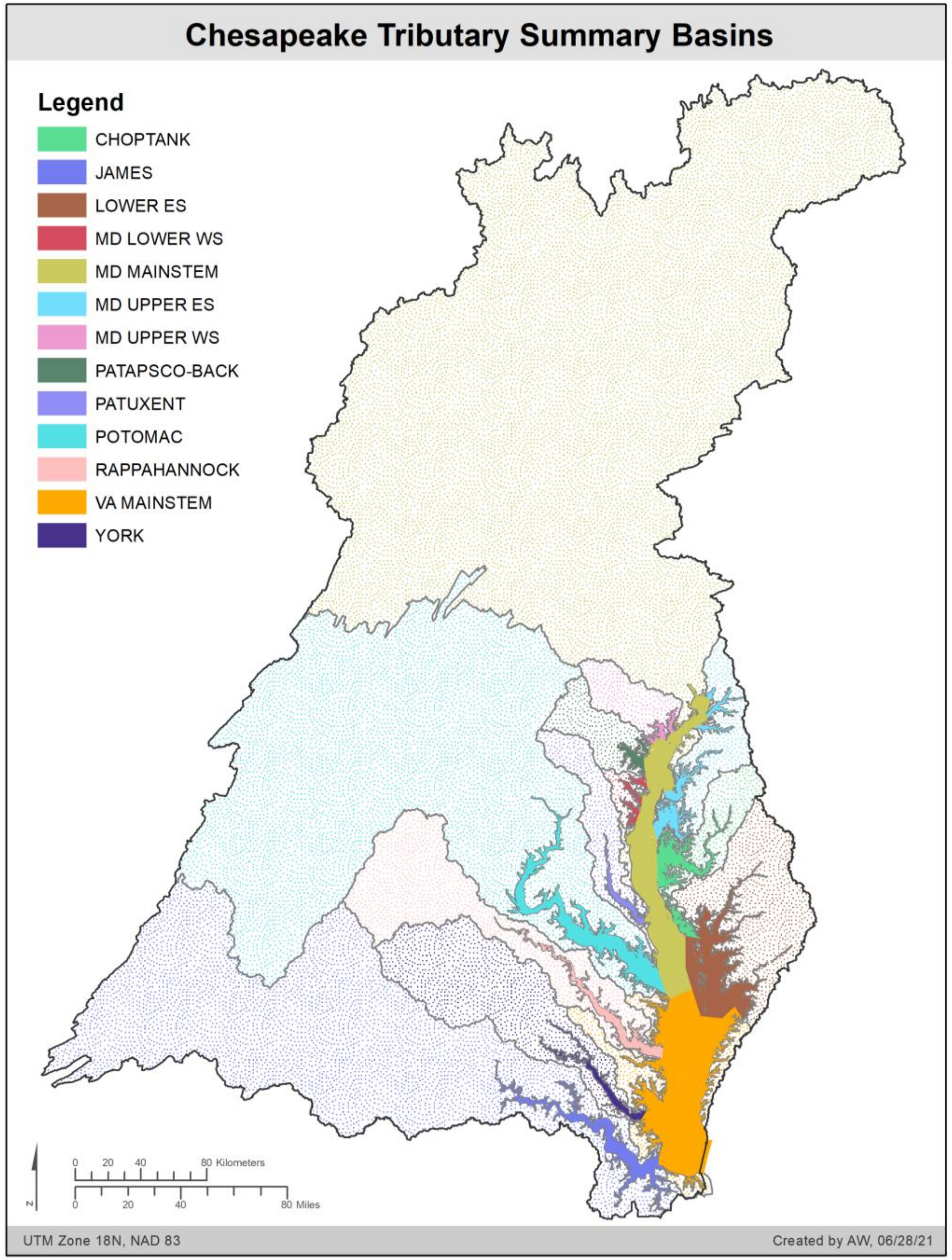
12 Tributary Trend Summaries Released!



CAST - TMDL Tracking (chesapeakebay.net)

net/Home/TMDLTracking#tributaryRptsSection

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Tributary Summaries

The Chesapeake Bay Program and its partners compiled tributary basin summaries for 12 major tributaries or tributary groups in the Chesapeake Bay Watershed. These documents summarize the following in one place: 1) How tidal water quality changes over time; 2) How factors that drive those changes change over time; and, 3) Current state of the science on connecting change in aquatic conditions to its drivers.

- Choptank (includes the Choptank, Little Choptank, and Honga) Summary, Appendix
- Potomac: Summary, Appendices, Story Map
- Maryland Mainstem (includes the five Chesapeake Bay mainstem segments within the Maryland state boundary. Drainage basins include the Susquehanna River and upper Chesapeake Bay shorelines) Summary, Appendix
- Maryland Upper Eastern Shore (includes the Northeast, Bohemia, Elk, Back Creek, Sassafras, and Chester Rivers, the Chesapeake & Delaware Canal, and Eastern Bay) Summary, Appendix
- Maryland Upper Western Shore (includes the Bush, Gunpowder, and Middle rivers) Summary, Appendix
- Maryland Lower Western Shore (includes the Magothy, Severn, South, Rhode, and West rivers) Summary, Appendix
- Patapsco and Back Summary, Appendix
- Patuxent (includes the Western Branch tributary) Summary, Appendix
- Rappahannock (includes the Corrotoman tributary) Summary, Appendices
- York (includes the Mattaponi and Pamunkey tributaries) Summary, Appendices
- James (includes the Appomattox, Chickahominy, and Elizabeth Tributaries) Summary, Appendix
- Lower E. Shore (includes the Nanticoke, Manokin, Wicomico, Big Annemessex, and Pocomoke Rivers, and Tangier Sound) Summary, Appendix
- Virginia Mainstem: Summary not available, Appendices

Special thanks to:
Olivia Devereux, Jon Harcum, Renee Karrh, Mike Lane, Rebecca Murphy, Elgin Perry, Meghan Petenbrink, Jimmy Webber, Angie Wei, and Qian Zhang

12 Tributary Trend Summaries Released!

[Chesapeake Science Partners Produce Tributary Summaries (usgs.gov)](#)

'centers/cba/science/chesapeake-science-partners-produce-tributary-summaries?qt-science_center_objects=0#qt-science_center_objects

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Chesapeake Bay Activities

Chesapeake Science Partners Produce Tributary Summaries

Overview

Issue

The Chesapeake Bay Program (CBP) partnership is striving to improve water-quality conditions in the Bay and its tidal waters. The partnership needs to understand water-quality conditions in different tributaries to help assess the influence of nutrient-reduction practices and progress toward attaining water-quality standards.

Compilation of Tributary Basin Summaries

Several Chesapeake Bay science partners collaborated to compile tributary basin summaries for 12 major tributaries or tributary groups in the Chesapeake Bay Watershed. These documents provide for each tributary:

- how tidal water quality has changed over time, and
- how factors expected to drive those patterns have changed over time.
- a vehicle to generate insights connecting changes in aquatic conditions to their drivers.

The partners who prepared the tributary summaries collaborated through the CBP Integrated Trends Assessment Team and included the Maryland Department of Natural Resources, United States Geological Survey, University of Maryland Center for Environmental Science, and Virginia Department of Environmental Quality, with additional support from Devereux Consulting.

All the materials for the tributary strategies have been posted on the Chesapeake Assessment Scenario Tool (CAST) Website https://cast.chesapeakebay.net/Home/TMDLTracking#tributaryRptsSection:

- Choptank (includes the Choptank, Little Choptank, and Honga) Summary, Appendix
- Potomac: Summary, Appendices, Story Map
- Maryland Mainstem (includes the five Chesapeake Bay mainstem segments within the Maryland state boundary. Drainage basins include the Susquehanna River and upper Chesapeake Bay shorelines) Summary, Appendix
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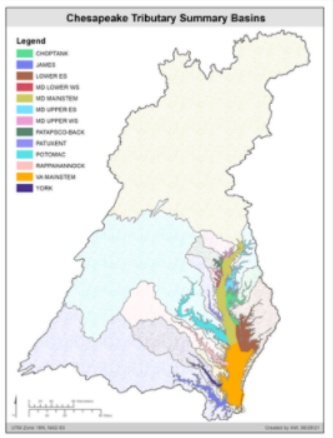

Status - Completed

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MD-DE-DC Water Science Center
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Phone: 443-498-5565

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[Potomac Tributary Report (usgs.gov)](#)

https://wim.usgs.gov/geonarrative/potomactrib/

USGS science for a changing world

Potomac Tributary Report

A summary of trends in tidal water quality and associated factors, 1985-2018.

Photo: Mattawoman Creek and the Potomac River in Charles County, MD (Courtesy of Will Parson, Chesapeake Bay Program)

Quick Links

You can scroll through the page or select one of the links below to jump to that section.

Chesapeake Bay Watershed
Physiography
Land Use
Water Quality Parameters Maps:
- Annual Total Nitrogen
- Phosphorous

esri A Story Map

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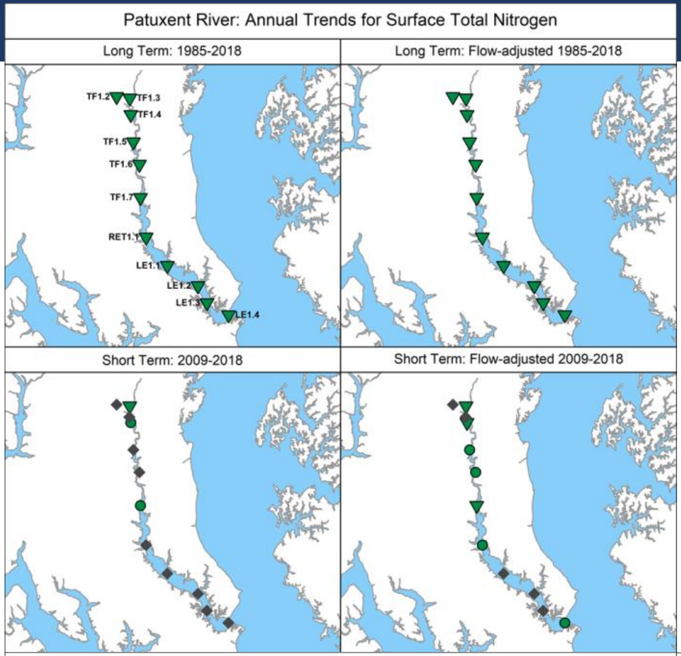
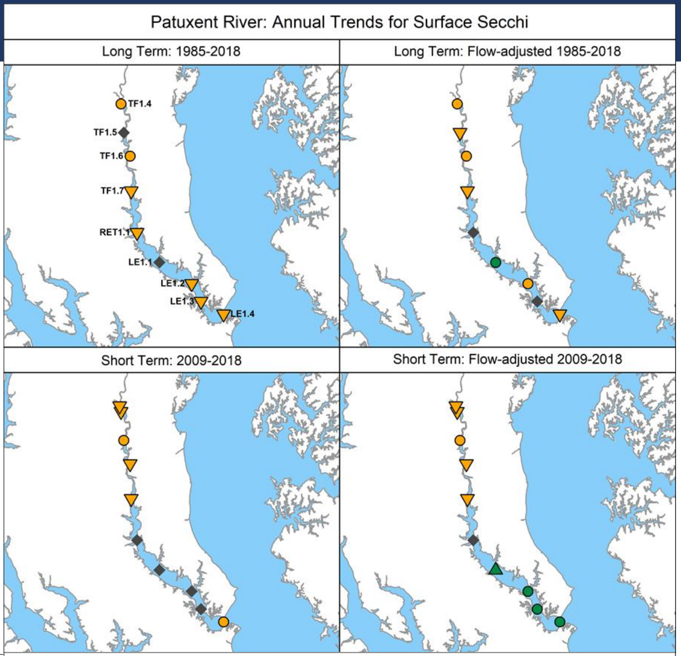
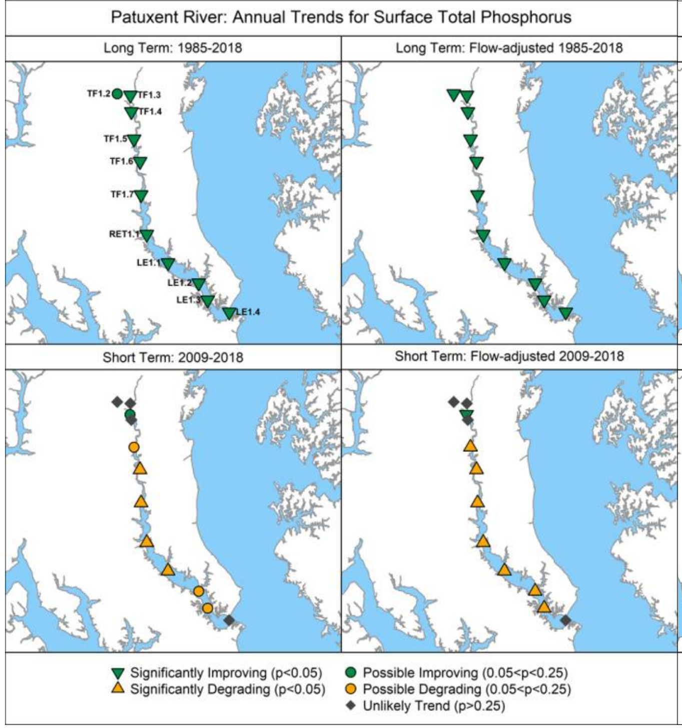
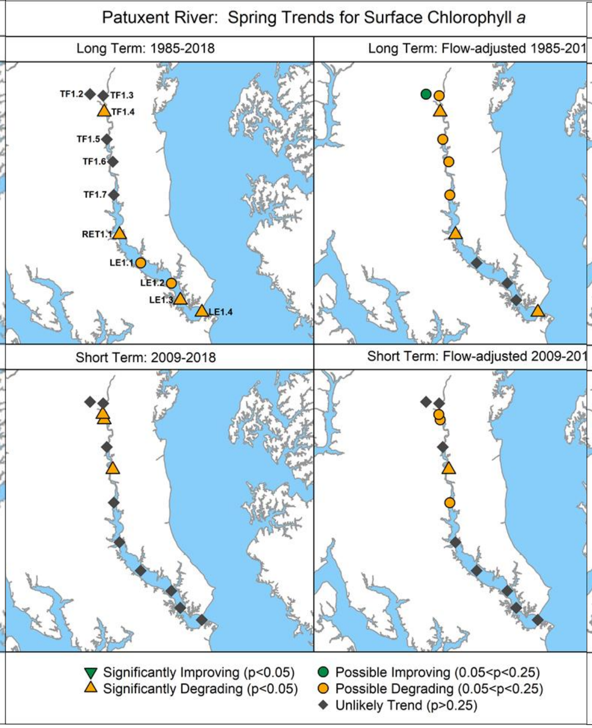
Tidal Trends Information: Trend Maps

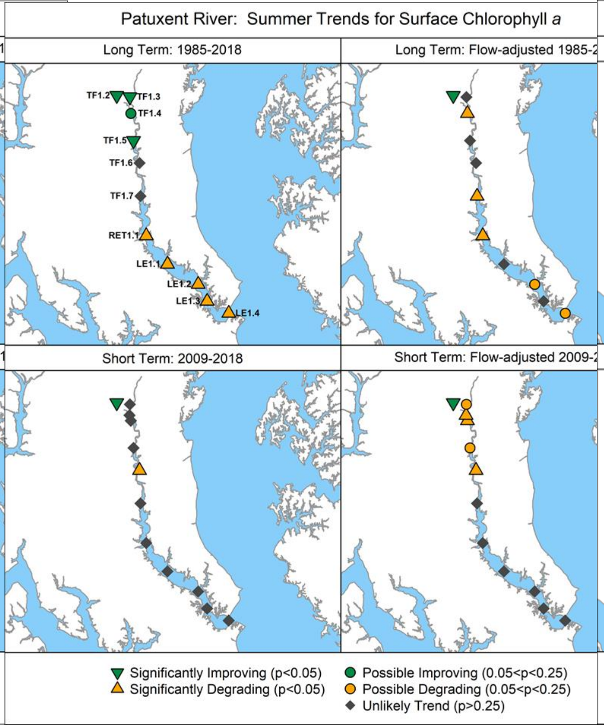


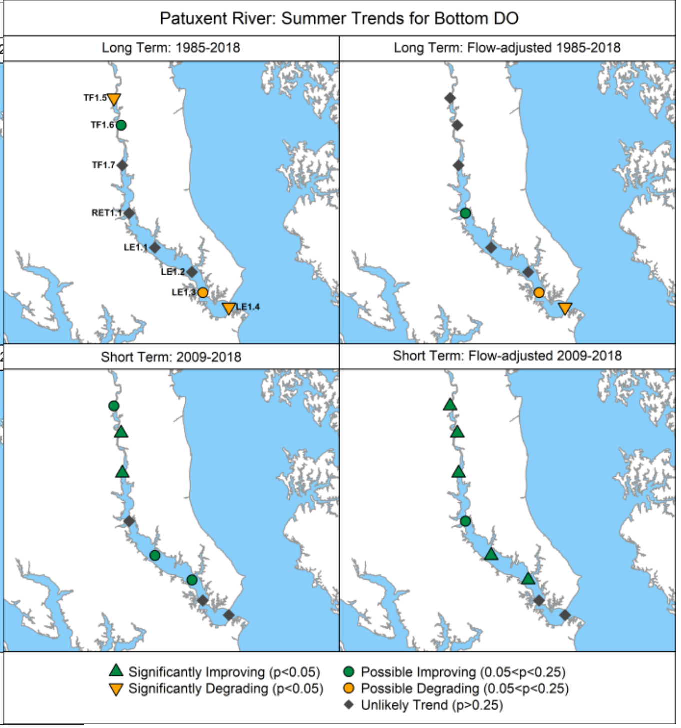
- TN, TP, Chlorophyll-a, Dissolved Oxygen, Secchi Depth
- Long- and short-term trend
- Observed condition and flow-adjusted
- More parameters in appendices







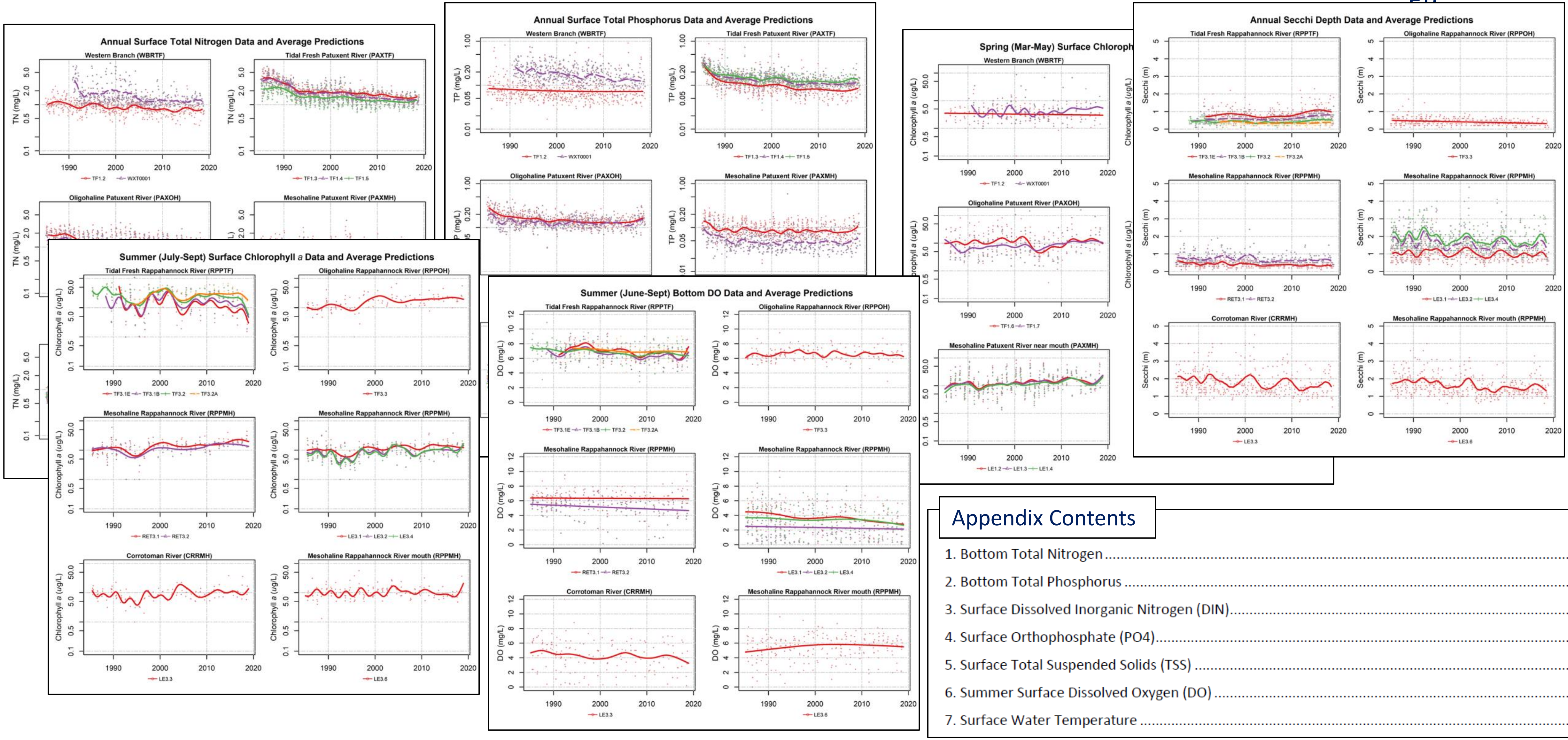




Tidal Trends Information: Station-level change over time by segment

Main report: Annual TN, Annual TP, Spring & Summer Surface Chlorophyll *a*, Annual Secchi Depth, Summer Bottom DO

Etc.



Appendix Contents

Tidal Trends Information: DO Criteria Attainment Record

Open Water Summer DO

time period	RPPTF	RPPOH	RPPMH	CRRMH
1985-1987				
1986-1988				
1987-1989				
1988-1990				
1989-1991				
1990-1992				
1991-1993				
1992-1994				
1993-1995				
1994-1996				
1995-1997				
1996-1998				
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2007-2009				
2008-2010				
2009-2011				
2010-2012				
2011-2013				
2012-2014				
2013-2015				
2014-2016				
2015-2017				
2016-2018				

DW and DC Summer DO

time period	Deep Water	Deep Channel
	RPPMH	RPPMH
1985-1987		
1986-1988		
1987-1989		
1988-1990		
1989-1991		
1990-1992		
1991-1993		
1992-1994		
1993-1995		
1994-1996		
1995-1997		
1996-1998		
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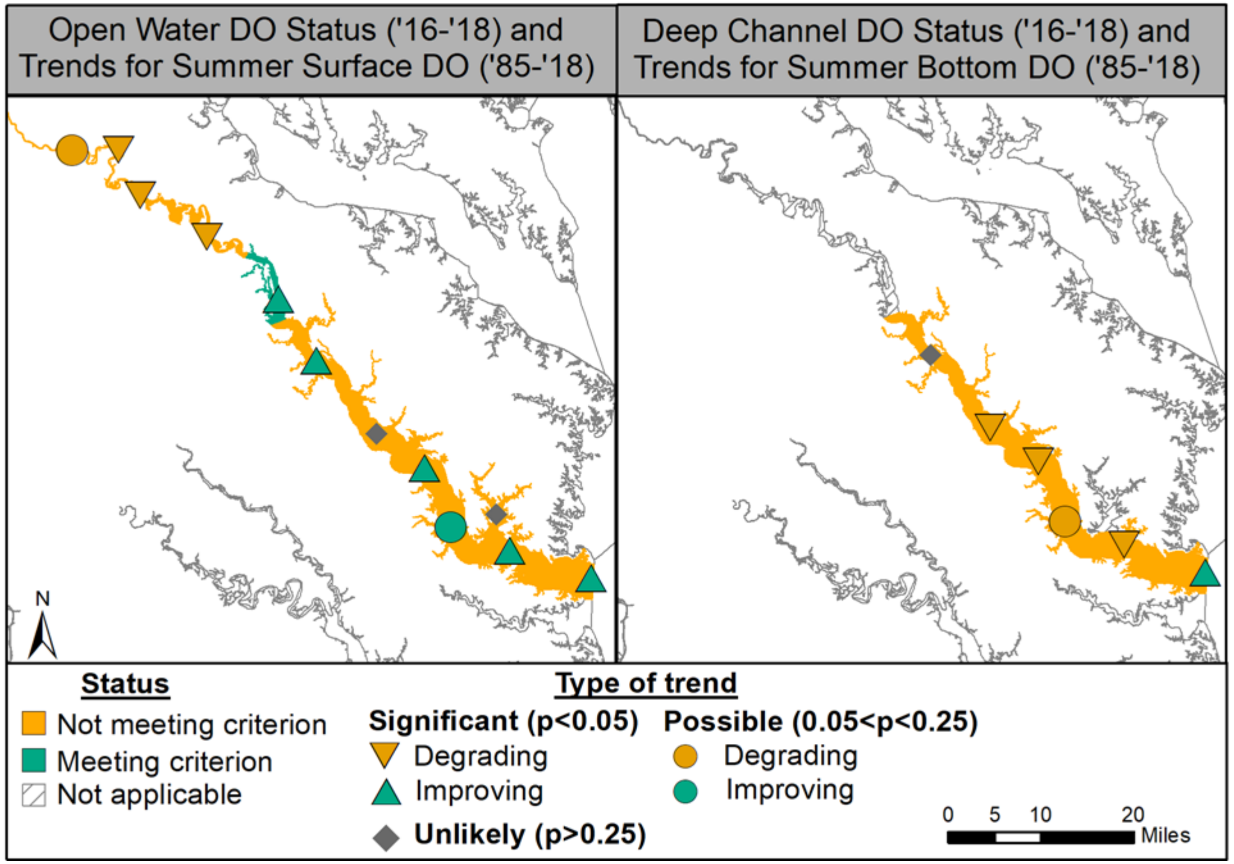
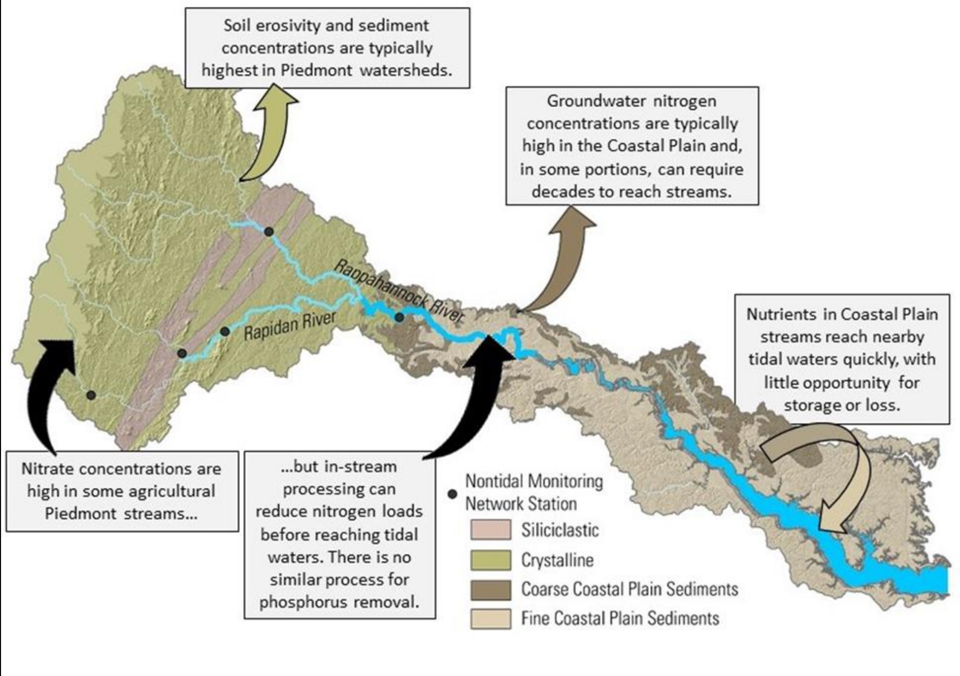
2014-2016		
2015-2017		
2016-2018		

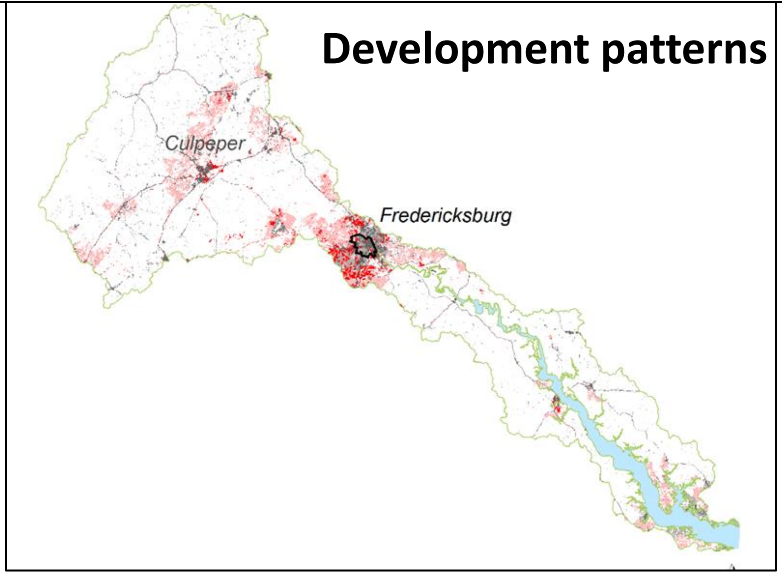


Watershed Factors Information

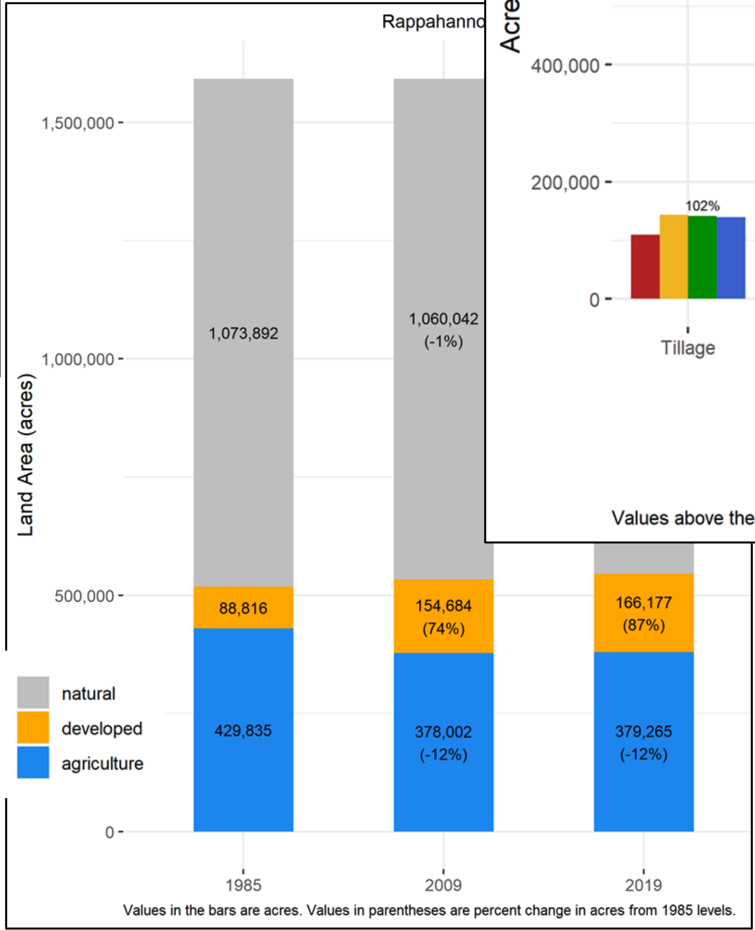
Effects of physiography on nutrient transport



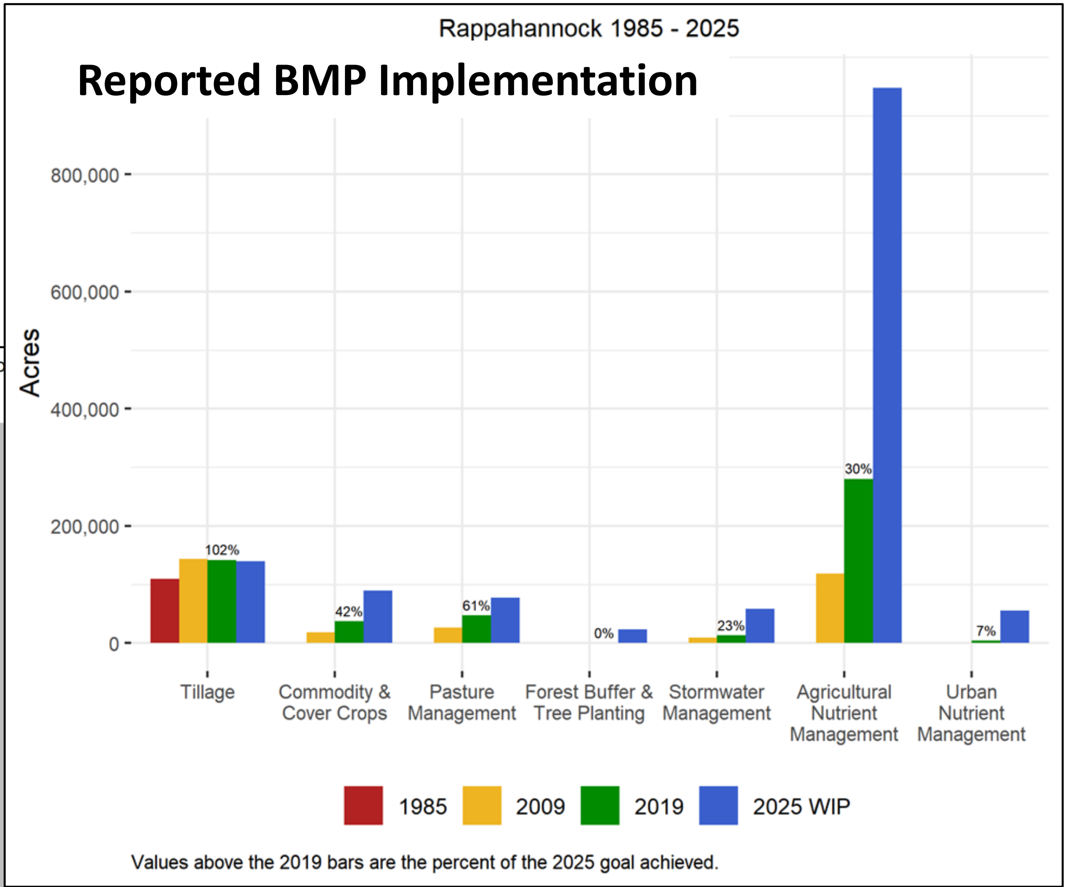
Development patterns



Land Use Change



Reported BMP Implementation

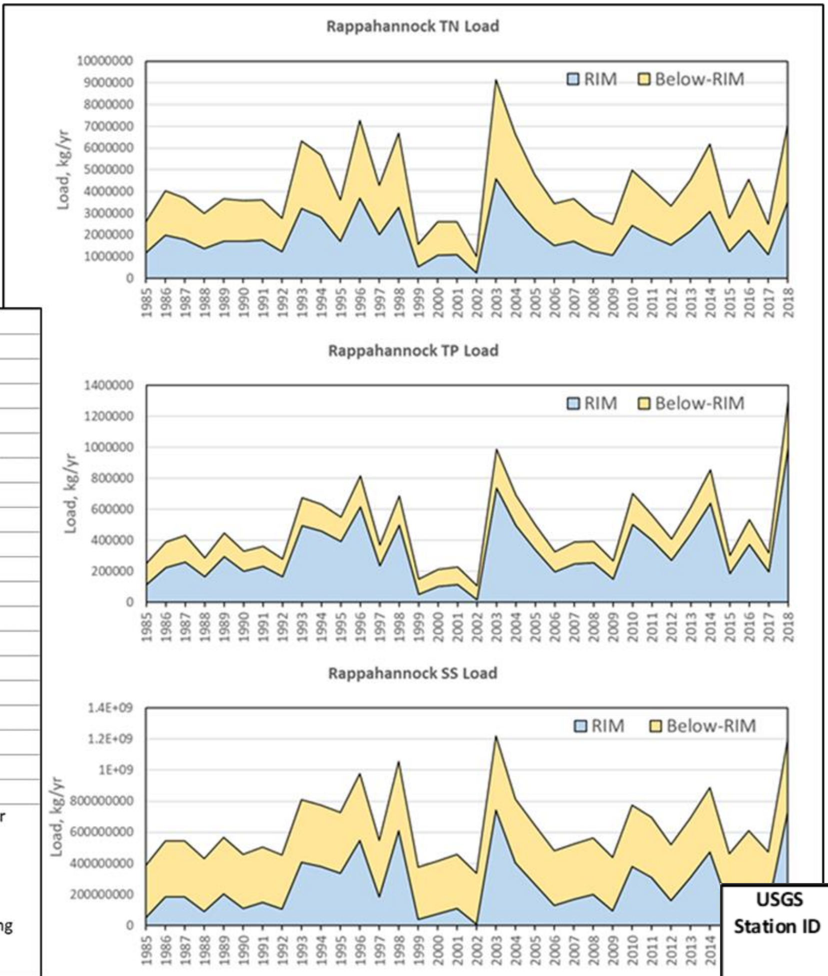


Watershed Factors Information

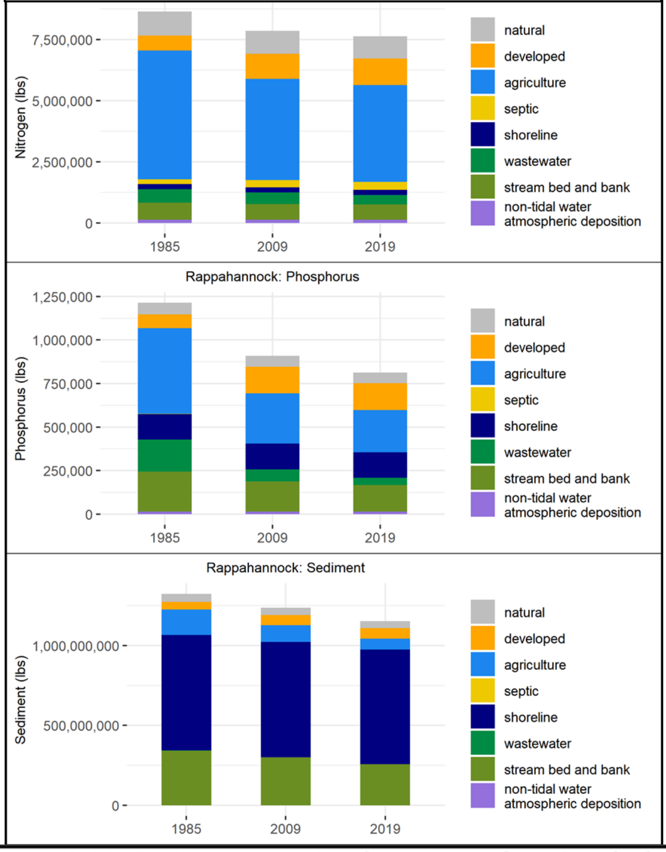
Estimated TN, TP, Sediment Loads (RIM + WSM)

Variable	Trend, metric ton/yr	Trend p-value
TN		
Total watershed	12	0.70
RIM watershed [1]	4.5	0.73
Below-RIM watershed [2]	6.7	0.55
Below-RIM point source	-2.5	< 0.01
Below-RIM nonpoint source [3]	13	0.30
Below-RIM tidal deposition	-2.0	< 0.05
TP		
Total watershed	5.4	0.15
RIM watershed	5.0	0.12
Below-RIM watershed	0.51	0.50
Below-RIM point source	-0.58	< 0.01
Below-RIM nonpoint source	1.4	< 0.05
SS		
Total watershed	4,158	0.18
RIM watershed	3,484	0.21
Below-RIM watershed	680	0.19
Below-RIM point source	-4.0	< 0.01
Below-RIM nonpoint source	678	0.19

[1] Loads for the RIM watershed were estimated loads at the USGS RIM station 01668000 (Rappahannock River near Fredericksburg, Va.; https://cbrim.er.usgs.gov/loads_query.html).
[2] Loads for the below-RIM watershed were obtained from the Chesapeake Bay Program Watershed Model (https://cast.chesapeakebay.net/).
[3] Below-RIM nonpoint source loads were obtained from the Chesapeake Bay Program Watershed Model's progress runs specific to each year from 1985 and 2018, which were adjusted to reflect actual hydrology using the method of the Chesapeake Bay Program's Loads to the Bay indicator (see https://www.chesapeakeprogress.com/clean-water/water-quality).



Expected Load Change By Sector (CAST)

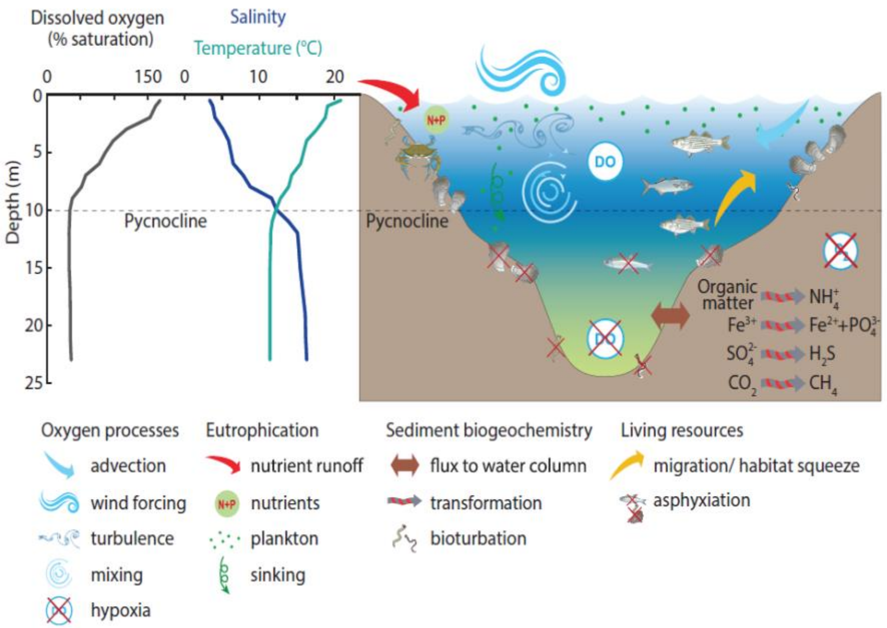


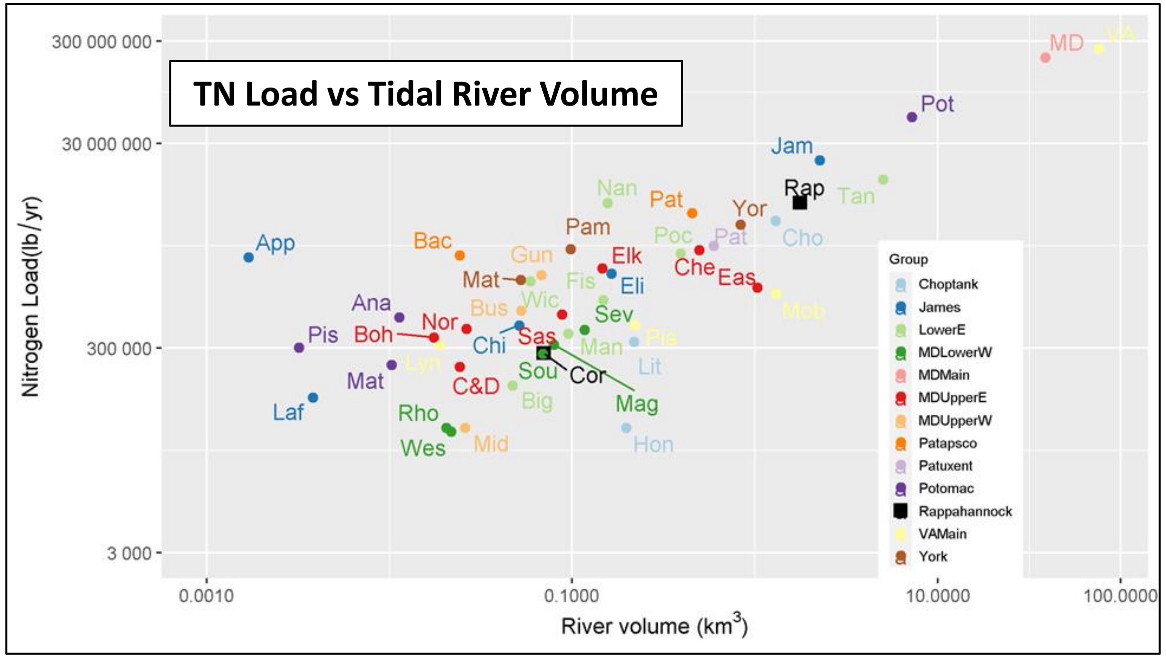
Estimated Flow-Normalized Load Change (WRTDS)

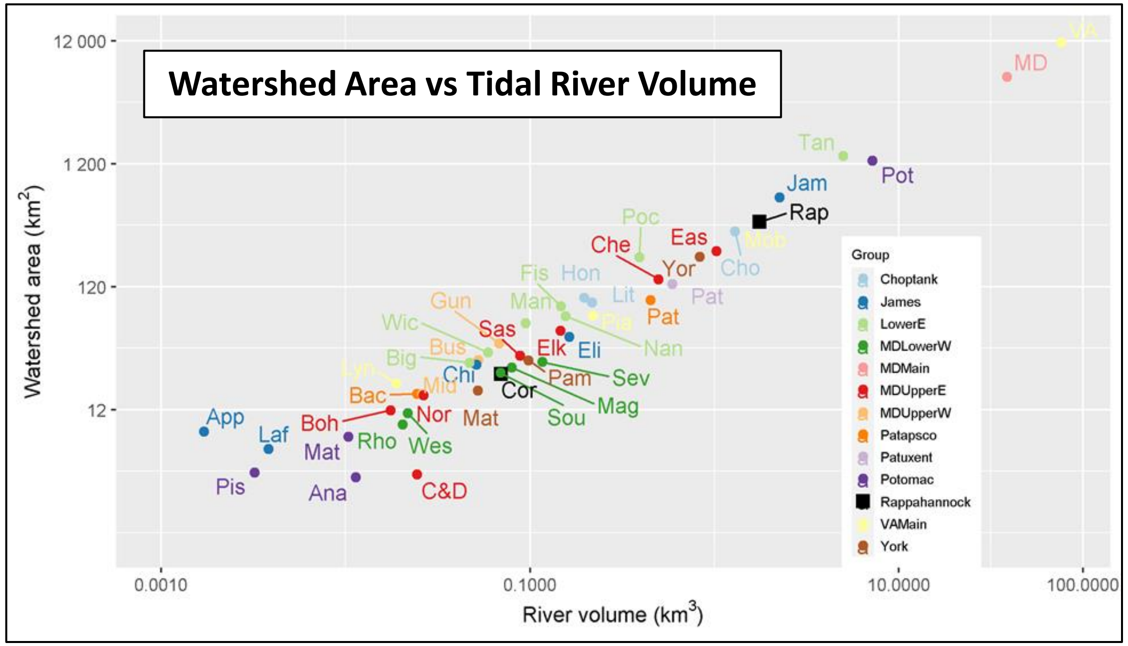
USGS Station ID	USGS Station Name	Trend start water year	Percent change in FN load, through water year 2018 TN	TP	SS
01664000	RAPPAHANNOCK RIVER AT REMINGTON, VA	1985	24.4	-	-
		2009	15.4	-	-
01665500	RAPIDAN RIVER NEAR RUCKERSVILLE, VA	2009	-5.1	-	-
01666500	ROBINSON RIVER NEAR LOCUST DALE, VA	1985	2.5	-	-
		2009	3.5	-	-
01667500	RAPIDAN RIVER NEAR CULPEPER, VA	2009	-8.9	-6.8	-7.1
01668000	RAPPAHANNOCK RIVER NEAR FREDERICKSBURG, VA	1985	-12.7	52.5	79.9
		2009	6.3	27.9	28.3

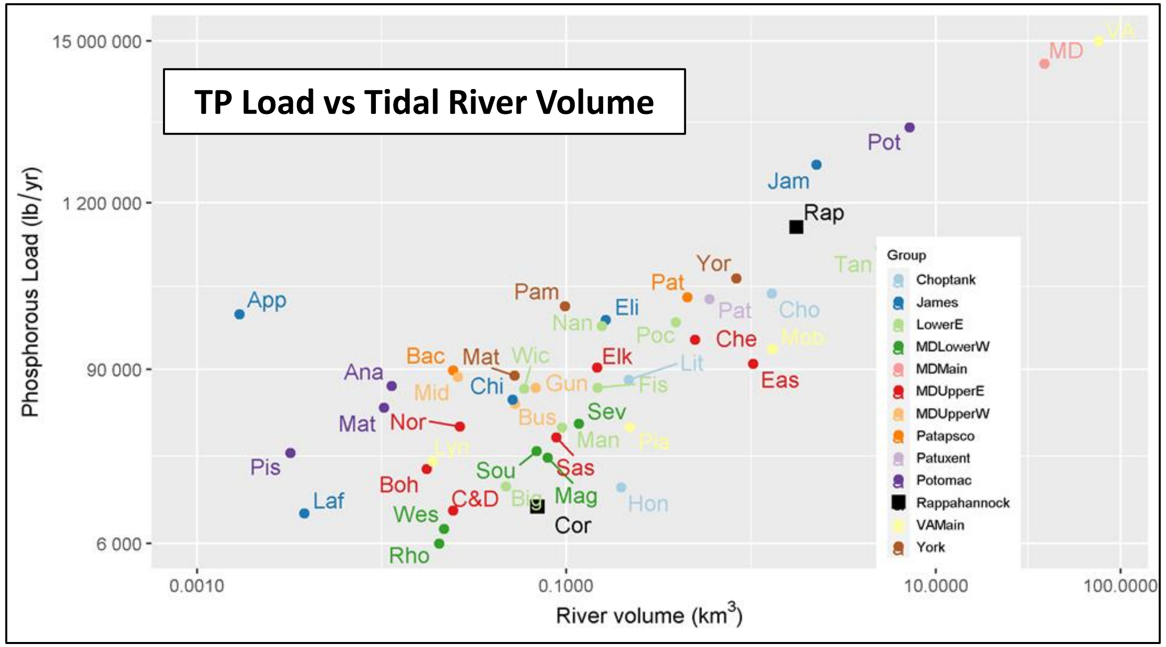
Estuarine Factors Information

Interacting Physical, Biogeochemical, Biological Factors









What Now?

Contents

Insights On Change (Potomac)

- Summarize insights from research, monitoring, modeling studies.
- What can we explain?
- What new work could advance our understanding?

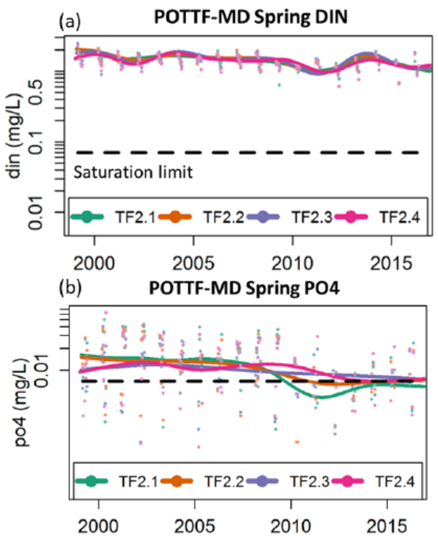


Figure 26. Spring dissolved inorganic nitrogen (a) and spring phosphate (b) at monitoring stations in the tidal Potomac River from 1999 to 2018. Black dotted lines represent nutrient saturation thresholds. Courtesy Rebecca Murphy.

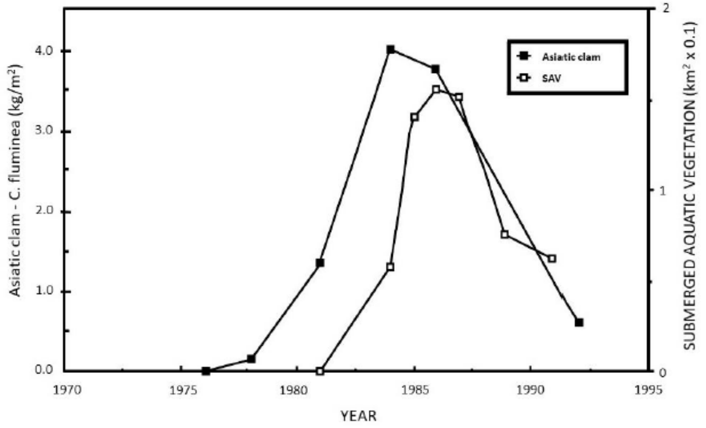


Figure 27. *Corbicula fluminea* abundance and submerged aquatic vegetation acreage in the Potomac River estuary near Washington, D.C., 1970-1992. Adapted from Phelps (1994).

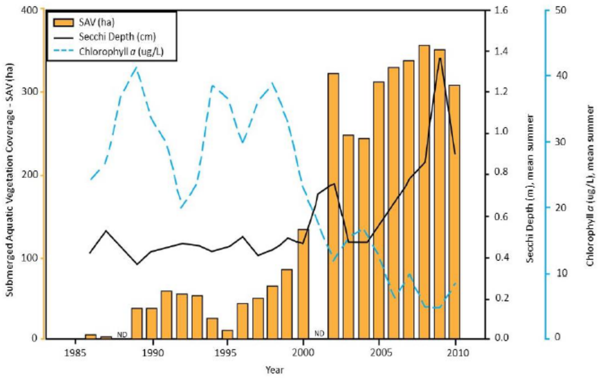


Figure 24. Annual summary of SAV coverage (ha), water clarity (Secchi disk depth), and algal biomass (chlorophyll *a* concentration) for the period 1986-2010 in Mattawoman Creek. Note the large change in SAV coverage and water clarity associated with the large decline in algal biomass. From Boynton *et al.* (2014).

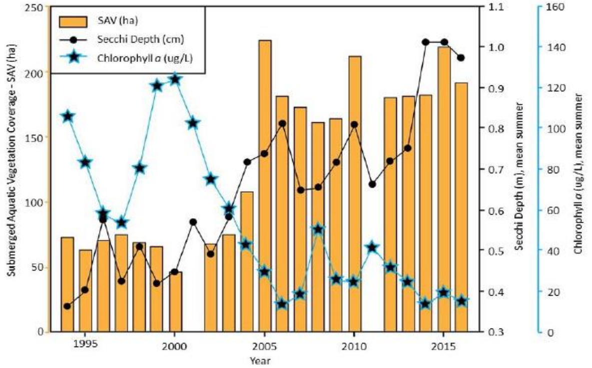


Figure 25. Algal biomass (as chlorophyll *a*), Secchi depth, and SAV acreage for the period 1994 – 2016 in Gunston Cove. From Jones *et al.* (2017).

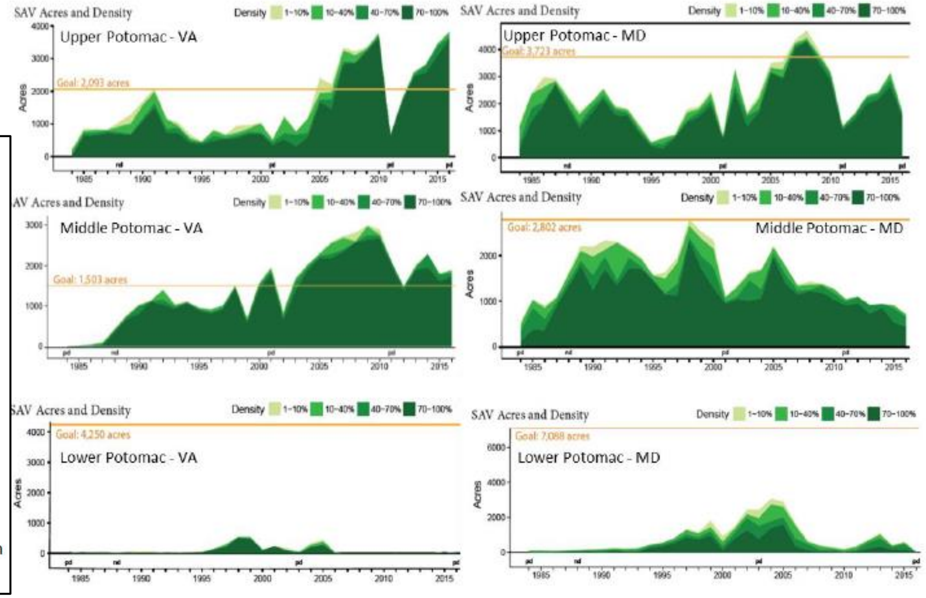


Figure 28. Changes in SAV acreage and density over time across salinity zones of the tidal Potomac River. Graphs and interpretation presented here are excerpted from the SAV Synthesis Effort and the Chesapeake Bay Program's SAV Fact Sheets, available through the Chesapeake Bay Watershed Data Dashboard, Tidal Waters section (https://gis.chesapeakebay.net/wip/dashboard/).

New Insights: TN & TP Changes explained by RIM & BFL Point Source Loads

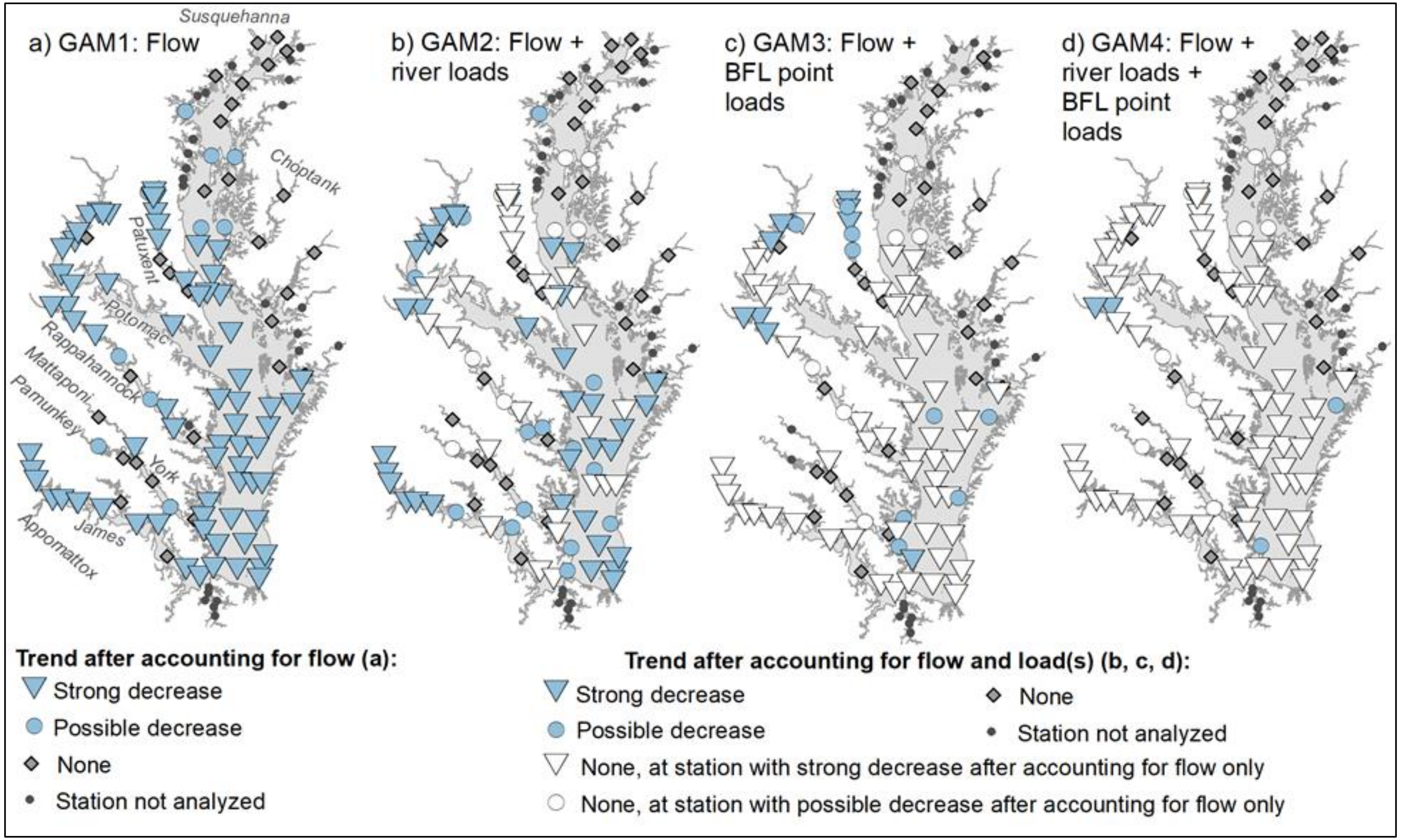
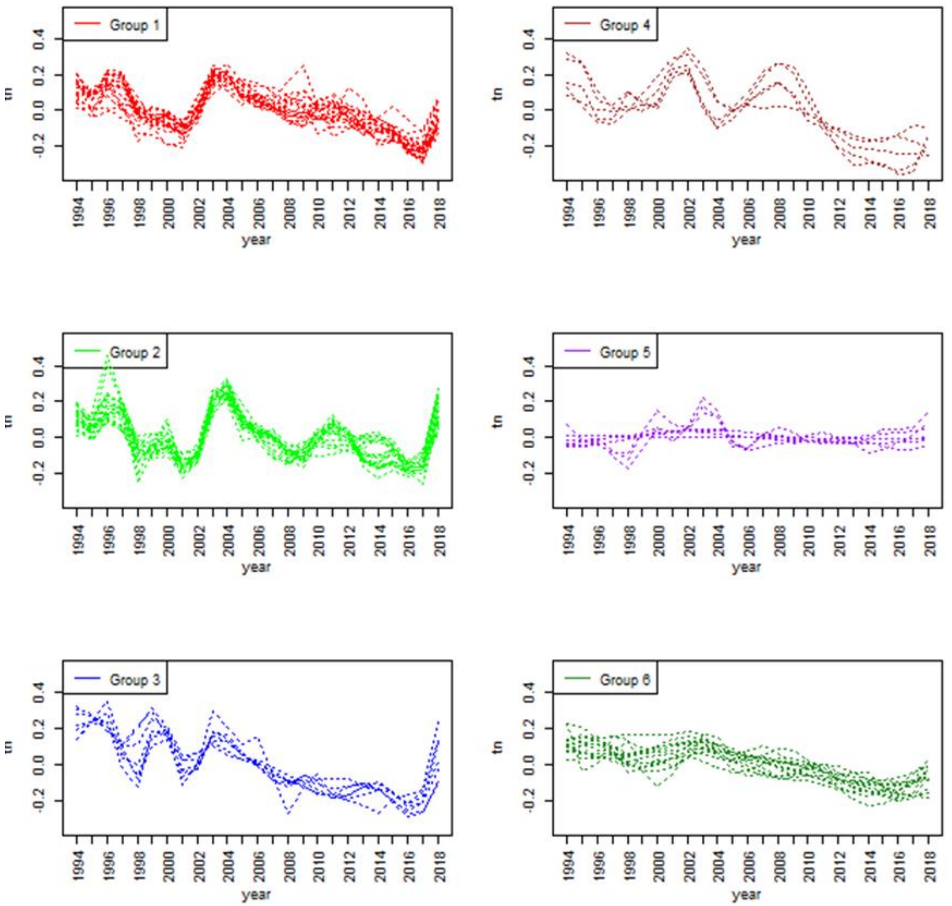


Figure 5. Surface total nitrogen (TN) 1999-2018 analysis summarizing remaining trend after accounting for freshwater flow (a), river load (b), BFL point load (c) and both loads (d). Filled symbols indicate trend was not explained by the variable(s), open symbols indicate trend was explained by the variable(s) added in that equation.

Rebecca Murphy and colleagues, in preparation

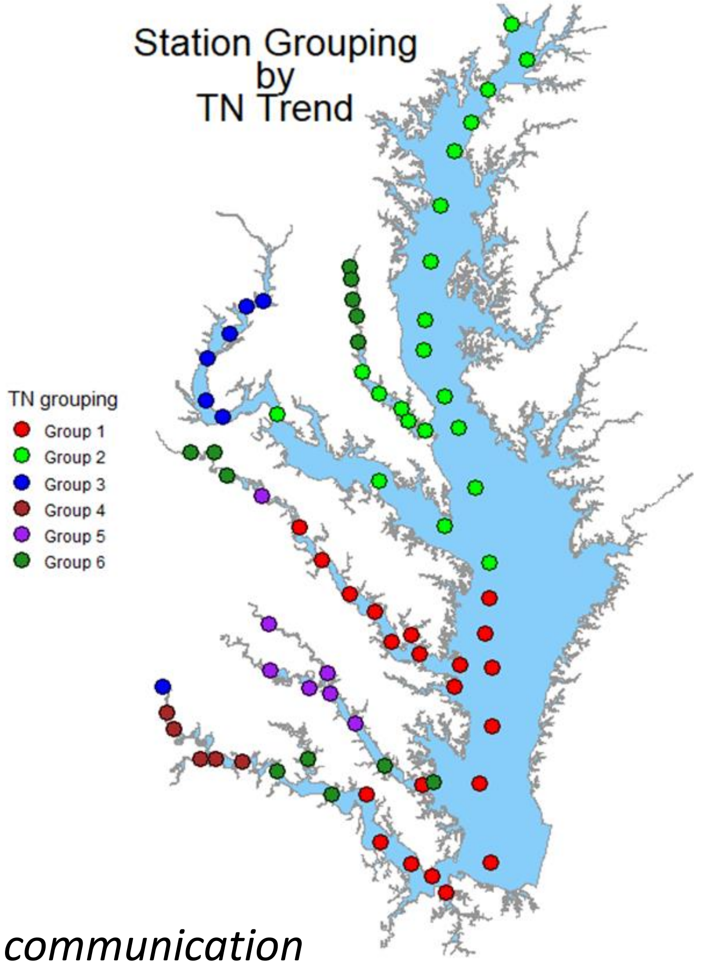
Ongoing Analysis: Spatial patterns may help explain change over time

Light green & Red:
- Similar responses to flow.
- Green in the upper bay and the mesohaline of upper bay tributaries
- Red in the lower bay and mesohaline of lower bay tributaries.
- The response to flow tends to attenuate moving seaward.



Brown:
- Confined to the TF James.
- A pattern we associate with dilution in that high flow years tend to have lower TN.
- Suggests that TN in the James is primarily controlled by point sources and ground water which are diluted in high flow events.

Purple:
- No improvement.
- Confined to the upper York and one Rappahannock station.



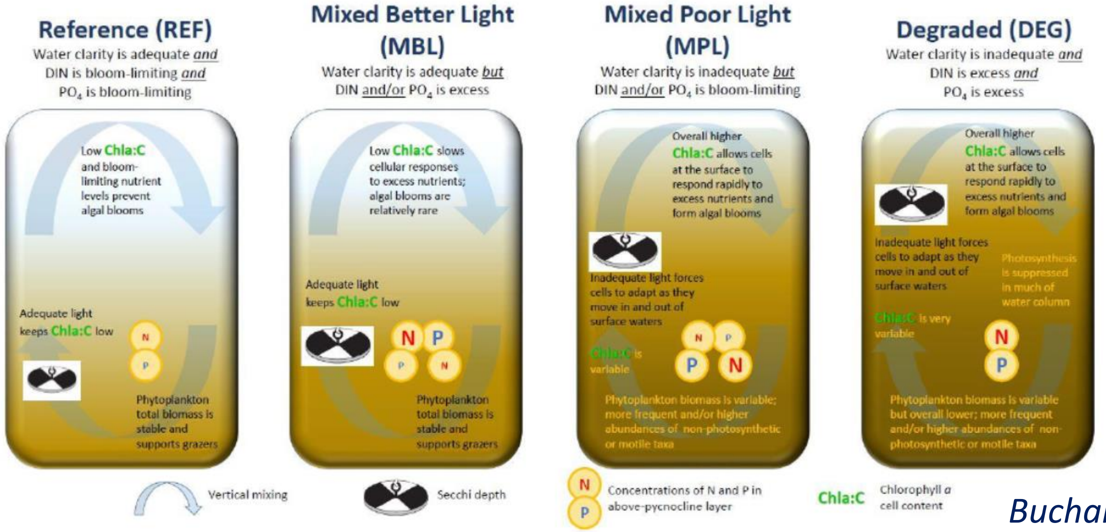
Blue:
- Mostly the tidal fresh Potomac and the uppermost tidal fresh James.
- Shows high TN around 1999 that does not occur for red and green.
- Did the western Bay watershed experience a precipitation event in 1999 that missed the more eastern rivers and the Susquehanna?

Dark green:
- Improvement; little response to flow.
- Occurs in the tidal fresh of the Rappahannock and Patuxent.

Elgin Perry, personal communication

Ongoing Analysis: Synthesis effort insights can be incorporated

May see transient increase in mean chlorophyll a along a restoration trajectory, but fewer extremes



Buchanan 2020

Drivers have different relative importance depending on habitat characteristics

Contemporary riverine sediment sometimes plays a role

Sediment inputs have transient role, but internal resuspension and productivity of ETM dominate long-term trends

Shoreline sediment inputs interact with internally produced particulate and dissolved compounds.

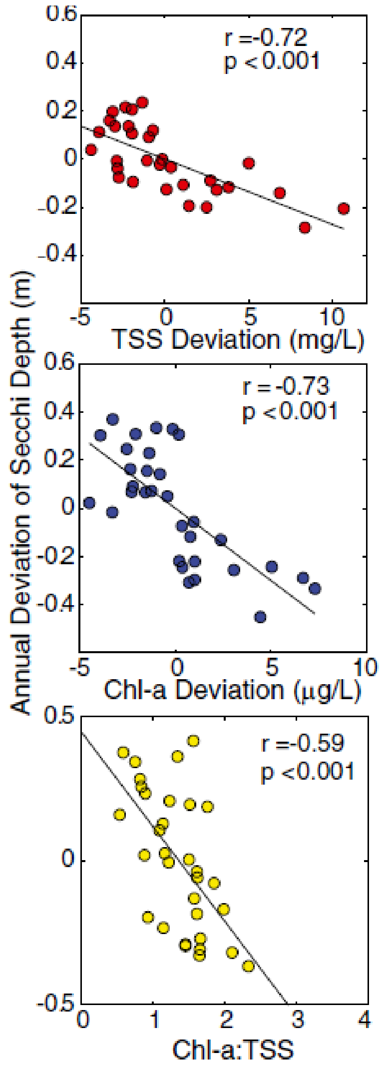
Salinity Zone	Depth	coastal morphology
Tidal Fresh (< 0.5 ppt)	< 2 meters	open
		semi-enclosed
	>= 2 meters	open
		semi-enclosed
Oligohaline (0.5 - 5 ppt)	< 2 meters	open
		semi-enclosed
	>= 2 meters	open
		semi-enclosed
Mesohaline (5 - 18 ppt)	< 2 meters	open
		semi-enclosed
	>= 2 meters	open
		semi-enclosed
Polyhaline (>= 18 ppt)	< 2 meters	open
		semi-enclosed
	>= 2 meters	open
		semi-enclosed

In embayments with longer residence times in all salinity zones, shoreline sediment inputs interact with biological factors

Figure 1: Proposed "water clarity habitats" framework for exploring drivers of water clarity across environmental settings in Chesapeake Bay and its tidal tributaries

Keisman and colleagues 2019

- *TSS is most closely associated with secchi depth in the upper bay*
- *Material associated with phytoplankton is most closely related to secchi depth in the mid-bay.*
- *In the lower bay, Secchi is lower when phytoplankton-derived material is a larger contributor to TSS pools.*



Testa and colleagues 2019

Ongoing analysis to generate insights

Your work here?

Exploring “Why” Questions

time period	WBRTF	PAXTF
1985-1987	ND	
1986-1988	ND	
1987-1989	ND	
1988-1990	ND	
1989-1991		
1990-1992		
1991-1993		
1992-1994		
1993-1995		
1994-1996		
1995-1997		
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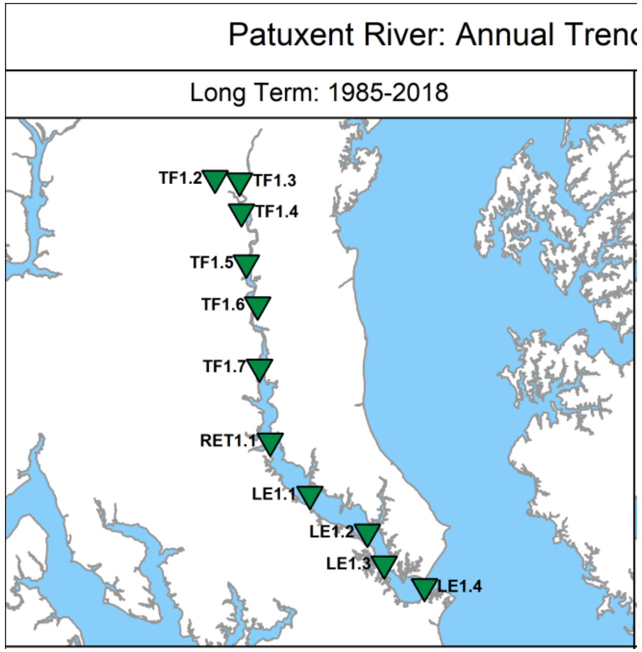
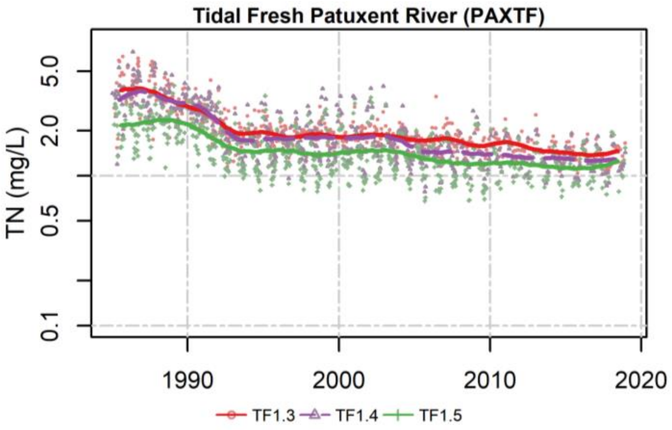
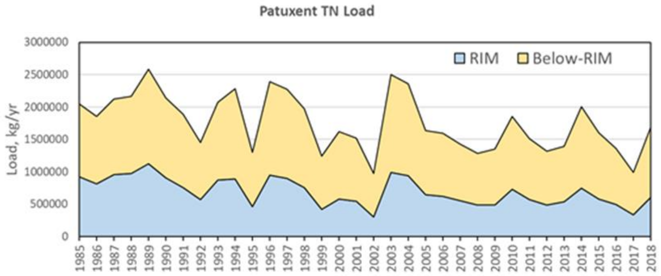
2016-2018		

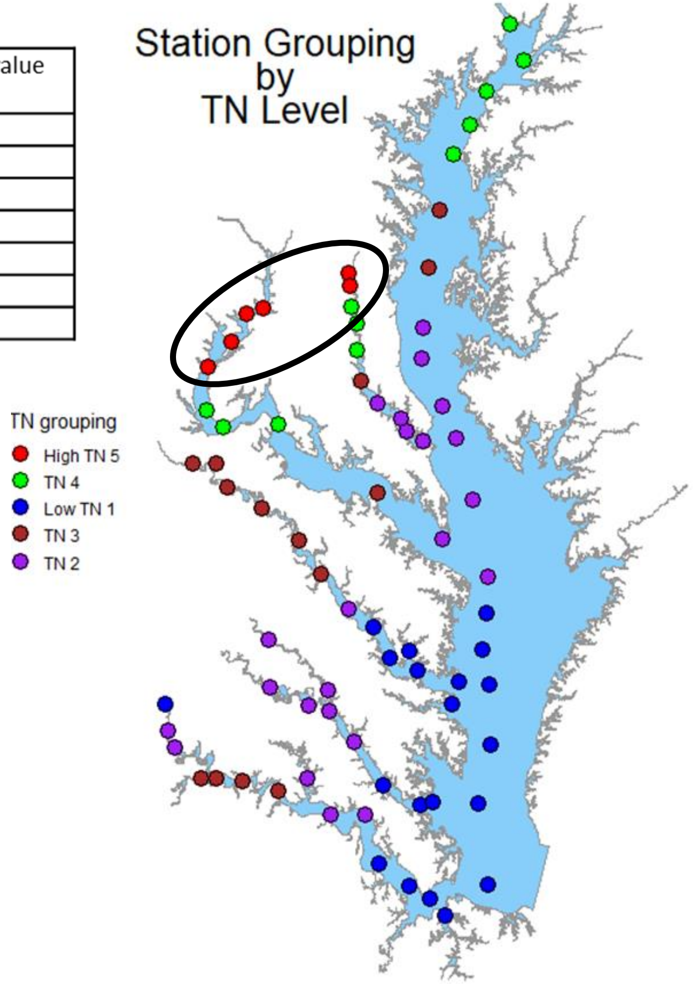




USGS Station ID	USGS Station Name	Trend start water year	Percent change in FN load, through water year 2018		
			TN	TP	SS
01591000	PATUXENT RIVER NEAR UNITY, MD	1985	2.7	-58.6	-1.3
		2009	7.5	18.5	19.4
01594440	PATUXEN RIVER AT BOWIE, MD	1985	-65.4	-64.2	-39.8
		2009	-20.7	-6.4	1.2
01594526	WESTERN BRANCH AT UPPER MARLBORO, MD	2009	-6.3	-10.4	-9.9

Variable	Trend, metric ton/yr	Trend p-value
TN		
Total watershed	-22	< 0.01
RIM watershed [1]	-14	< 0.01
Below-RIM watershed [2]	-9.8	< 0.05
Below-RIM point source	-6.5	< 0.01
Below-RIM nonpoint source [3]	-2.0	0.68
Below-RIM tidal deposition	-0.90	< 0.01





Discussion

Reference for tributary modeling efforts:

- "Get to know your trib"
- Are these patterns consistent with theory?
- Are these patterns consistent with process model predictions?
- Identify priorities for new analysis and modeling studies

Inform management:

- "Why?" discussions

Stakeholder engagement

- Gives local watershed groups valuable technical information that they can't produce themselves
  - MWCOG used content in their 2019 Potomac Water Quality report
    Potomac_River_Water_Quality_Report_-_Final.pdf
  - Friends of the Rappahannock report card?
- Discussions are vehicle for new citizen science connections
  - Rappahannock meeting SAV discussion

Updating:

- Almost all "dynamic" figures are produced using automated scripts. Minimal descriptive text is standard across all summaries for easier updating
- Watershed load information that was added/modified during review process is documented. Produce cheat sheet for updating? Consider potential automation with scripts?

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