Chesapeake Bay Program
Science. Restoration. Partnership.

June 4, 2026

Connecting Modeling and Monitoring at the Watershed Level: An Introduction to the METRIC* Tool

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*Monitored and Expected Total Reduction Indicator for the Chesapeake

Agenda

1. Acknowledgements
2. Motivation
3. Tool Introduction
4. Results Summary
5. Reception and Uses

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Acknowledgements

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*Zhang et al., 2025, METRIC: An interactive framework for integrated visualization and analysis of monitored and expected load reductions for nitrogen, phosphorus, and sediment in the Chesapeake Bay watershed, Environmental Modeling & Software, Volume 188

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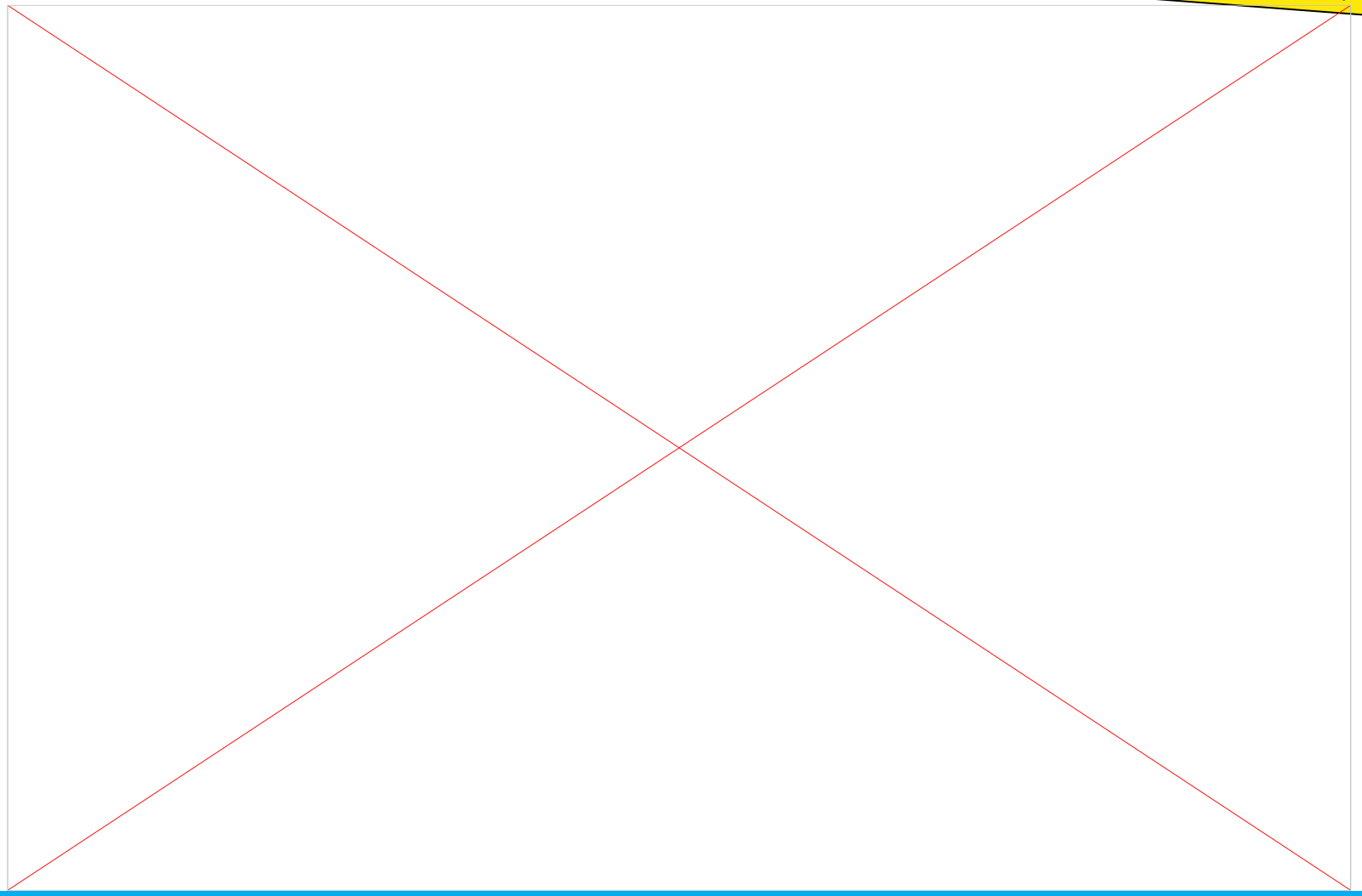
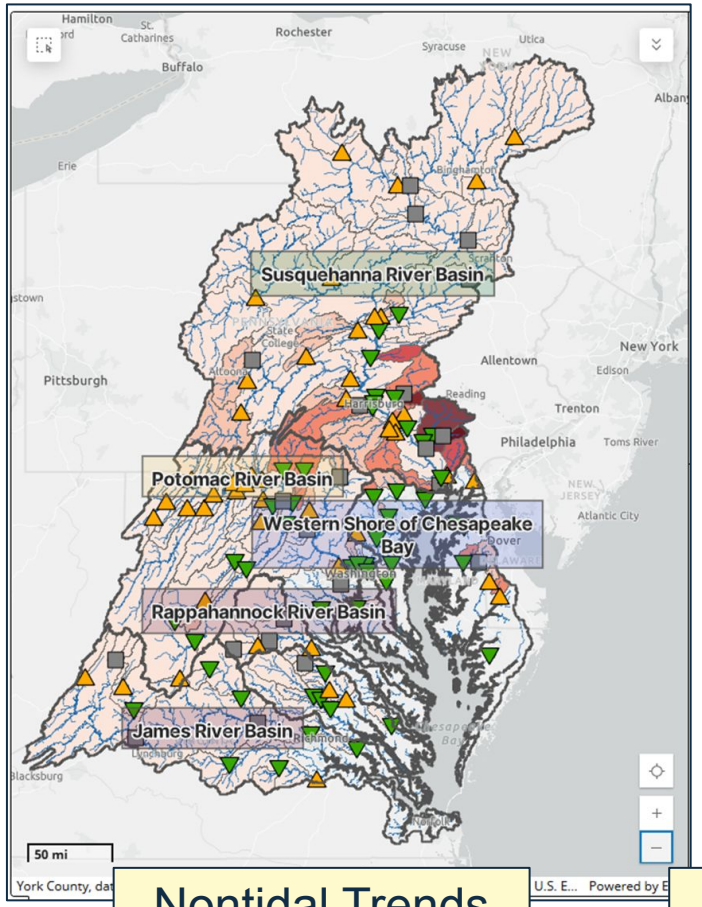
Motivation

Plan with Models…

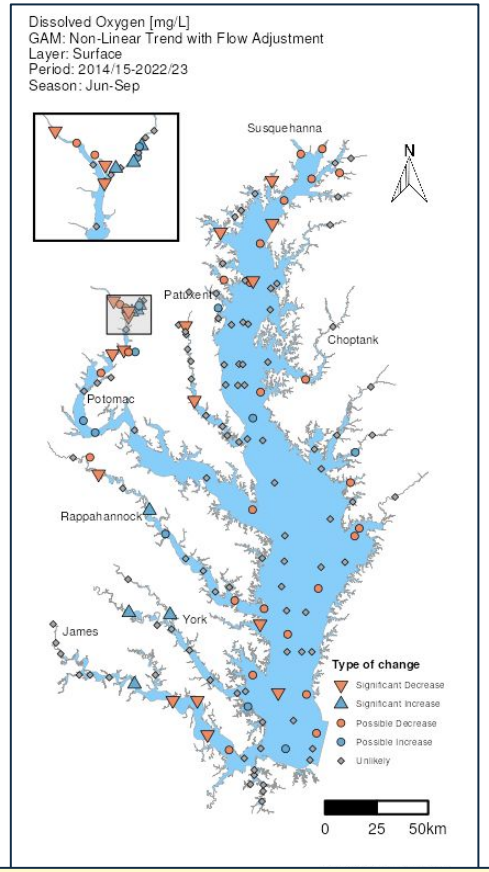
Models help us understand the "Why" of nitrogen, phosphorus, and suspended sediment loads *and* Chesapeake Bay water quality standards attainment



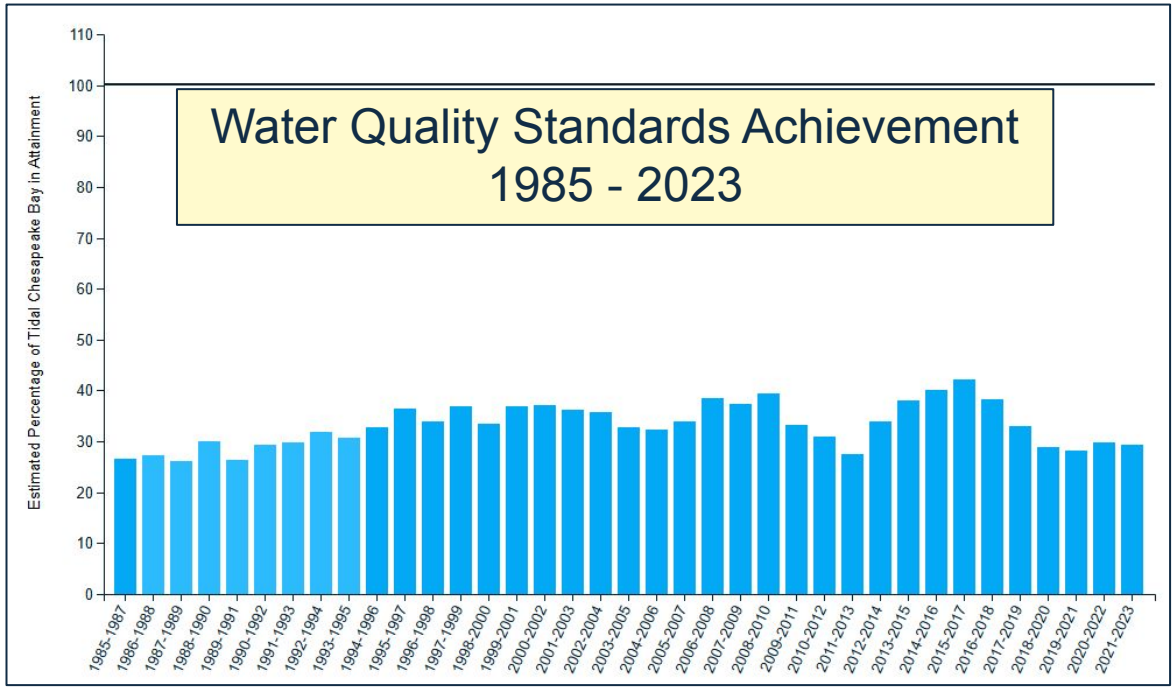
… And Assess with Data…



Nontidal Trends
2014 - 2023

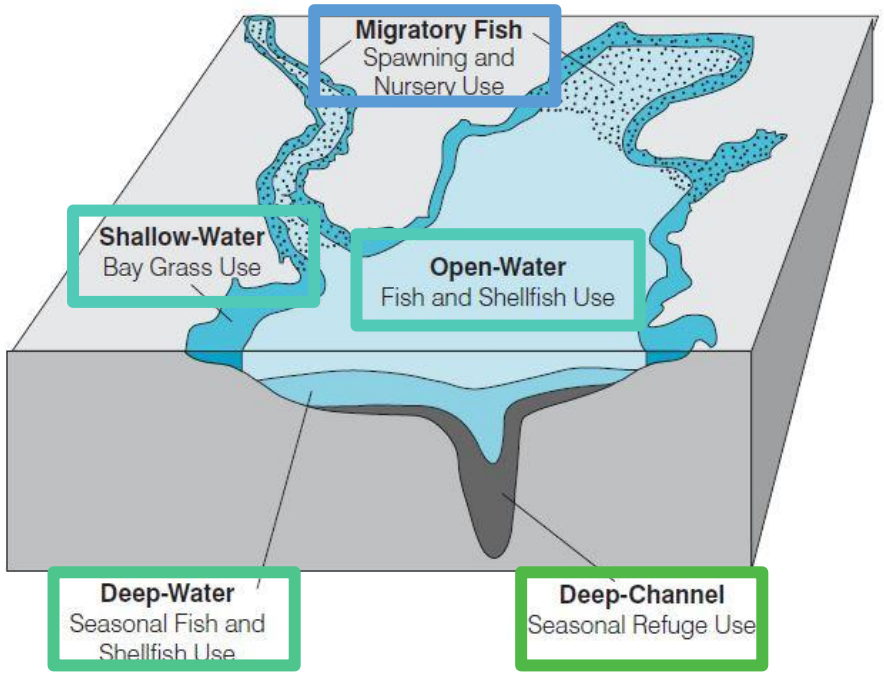


Tidal Trends
2014/2015 – 2022/2023

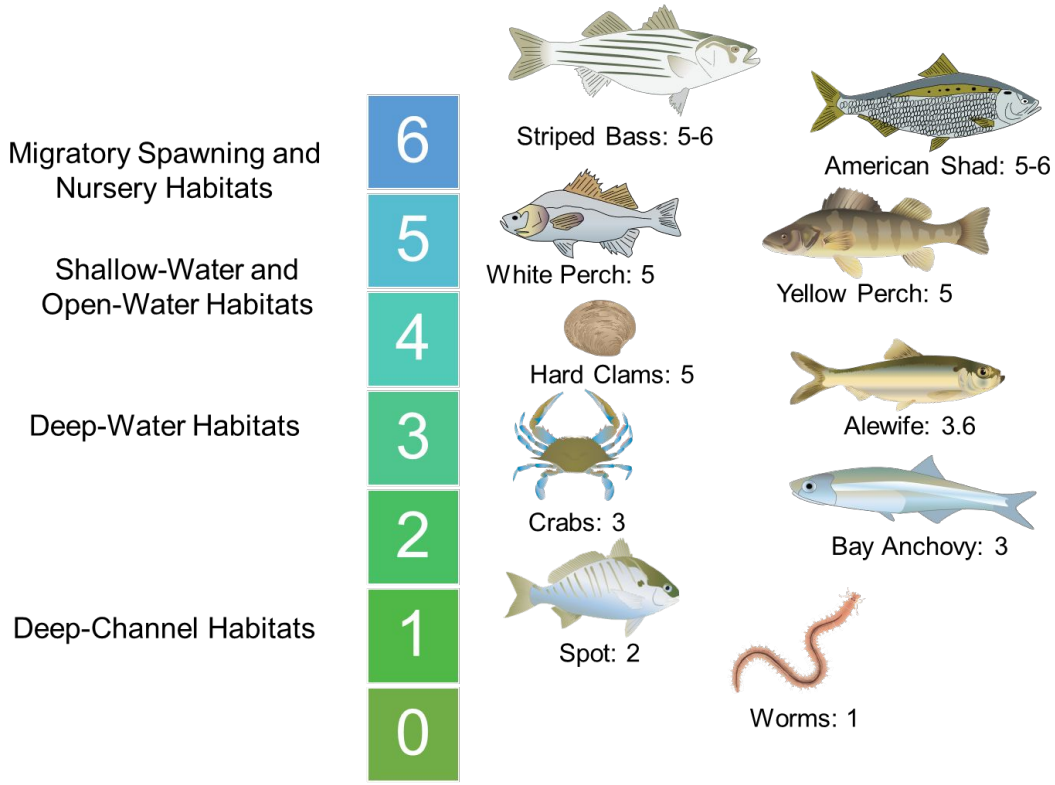


…To Achieve WQ Standards and Restore Living Resources

Five Chesapeake Bay tidal water designated use zones.

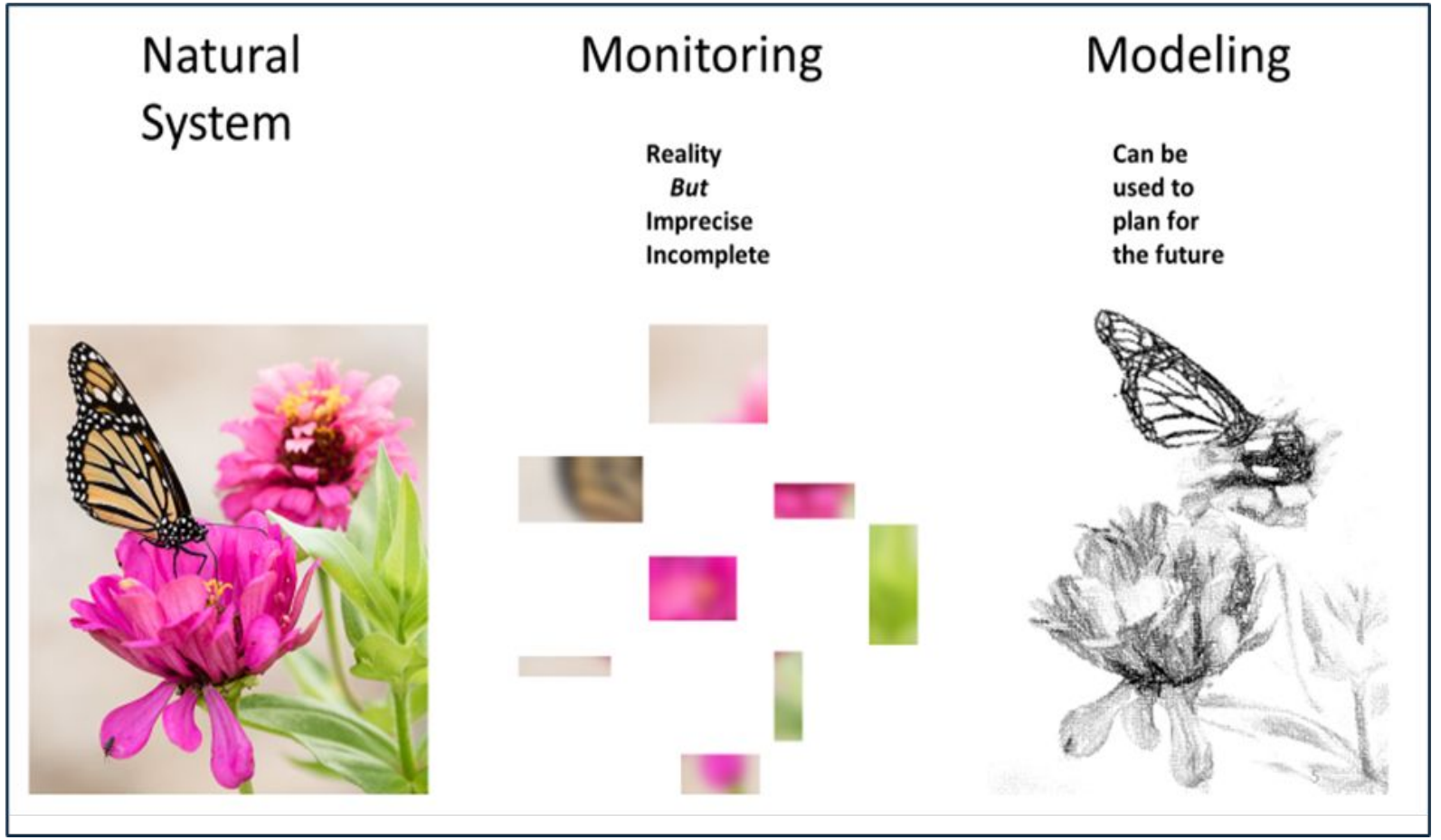


Dissolved oxygen (mg liter^{-1}) concentrations required by different species and communities.



Water quality criteria were derived to protect species *and* communities during specific time periods

Why Modeling & Monitoring?



Why Modeling & Monitoring

- **We use the best available science to understand the Bay.**
  - Advanced computer models help us see what's happening across the entire Chesapeake Bay watershed, even in places we can't measure directly.

more complete picture of the Bay's health, helping inform restoration efforts and supporting many uses beyond the

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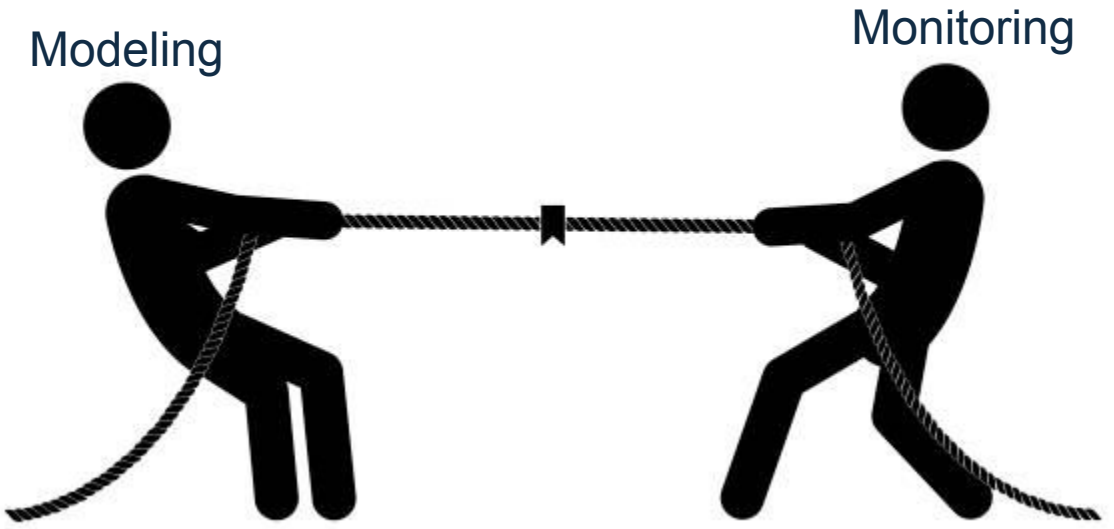
- **We check the models against real-world data.**
  - Scientists collect monitoring data from rivers, streams, and the Bay itself to make sure the models reflect actual conditions.

- **This combined information guides better decisions.**
  - Together, modeling and monitoring give leaders, and the public, a more complete picture of the Bay's health, helping inform restoration efforts and supporting many uses beyond the

Additional Context

- CBP partnership uses models to plan and monitoring to assess
- Combination of both gives us a comprehensive view of the Chesapeake ecosystem
- Both are needed to by decision-makers to determine how best to restore and protect our waters



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Modeling

Monitoring

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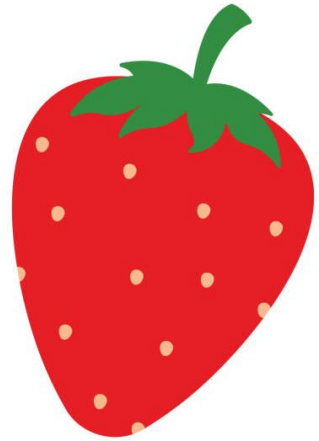
Modeling

Monitoring



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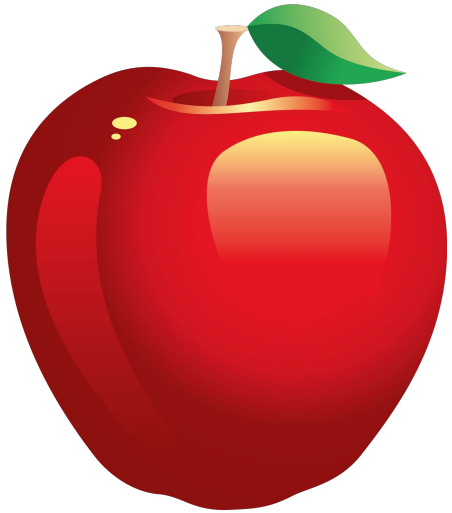
With the METRIC Tool, we can now compare them for much of the Nontidal Network!

Modeling



Monitoring

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Tool Introduction

METRIC:
Monitored and Expected Total Reduction Indicator for the Chesapeake

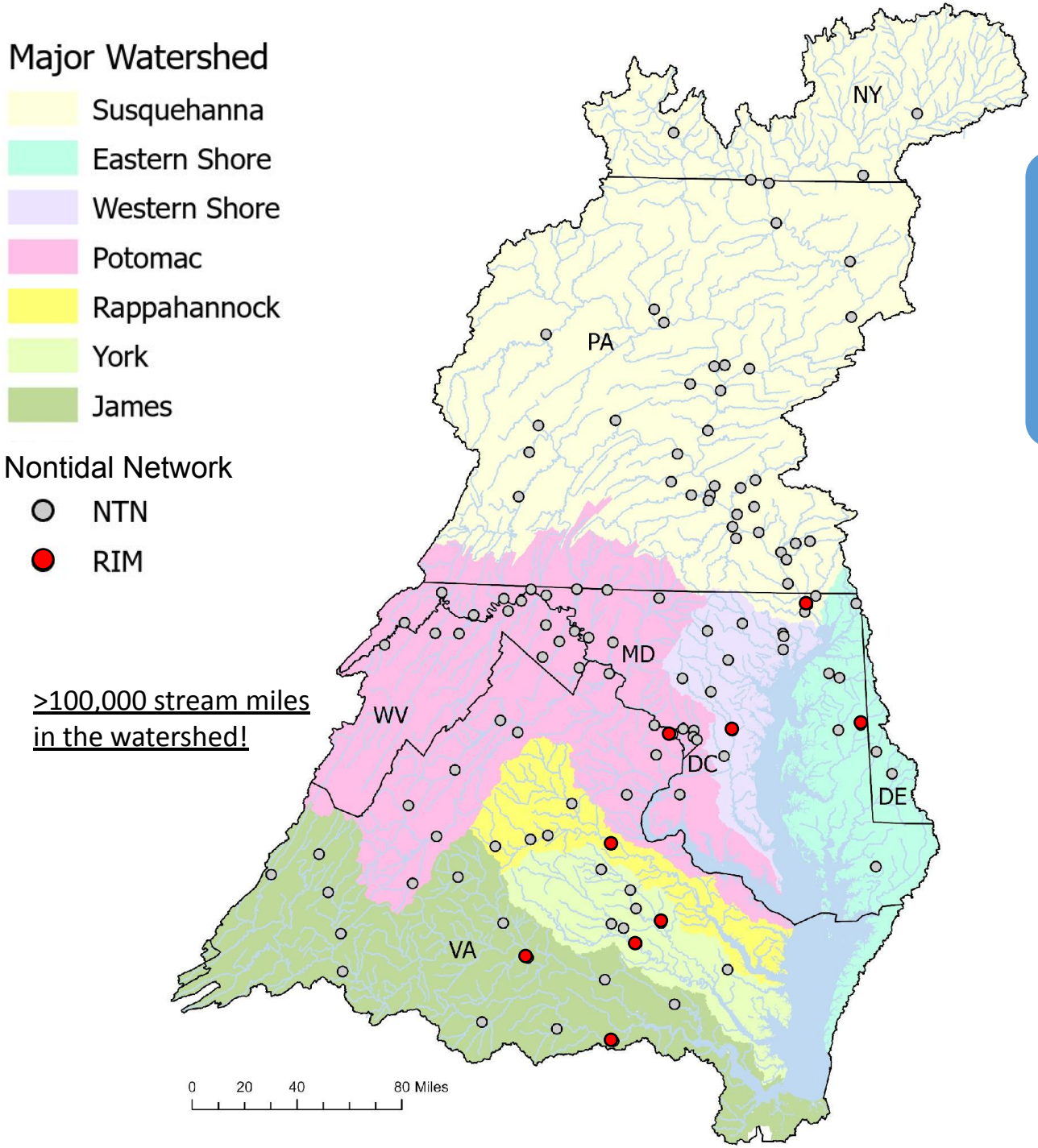
What is METRIC?

- App designed for comparing the monitored load trend and CAST-estimated load trend for the NTN catchments.

- METRIC helps us understand if the CAST model is performing the way we expect it to.

- METRIC is for comparison of modeled progress towards load reductions and observed monitored

Nontidal Network (NTN)



>100,000 stream miles in the watershed!

Established in 2004

Some datasets pre-date 1985

123 active stations sampled

9 River Input Monitoring (RIM) sites

RIM = 78% of surface water flow to the Bay

State	Surface Area in CBW (mi^2)	NTN Monitoring Stations (count)
DC	68	3
DE	713	2
MD	11,576	32
NY	6,266	4
PA	22,610	35
VA	23,925	37
WV	3,577	10
	CBW = 68,734 mi^2	

Many stations monitor catchment areas across multiple jurisdictions.

Individual Station Interface

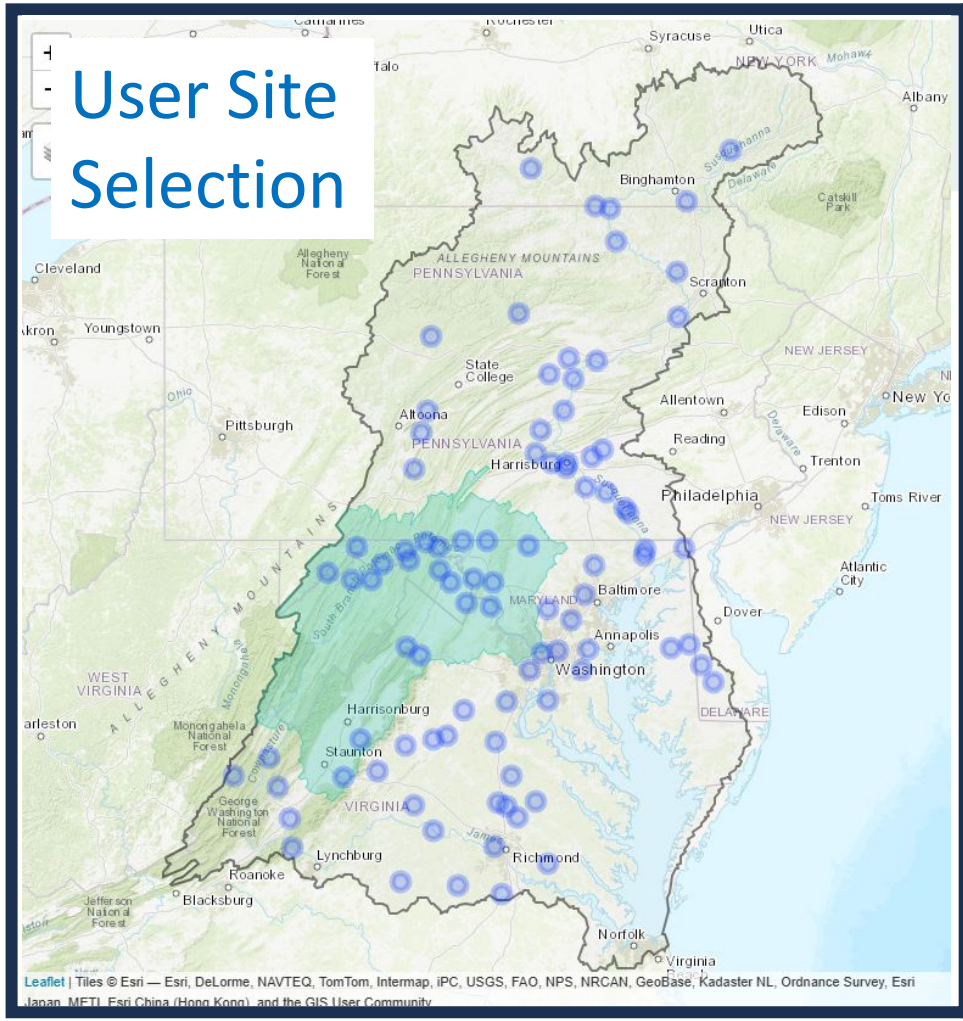
As of May 14, 2026 METRIC has load and trend data for 92, 80, and 78 NTN stations for Total Nitrogen (TN), Total Phosphorus (TP), and Suspended Sediment (SS), respectively.

Monitored and Expected Total Reduction Indicator for the Chesapeake (METRIC)

* This app is designed for comparing the monitored load trend and CAST-estimated load trend for the Chesapeake Bay Non-Tidal Network (NTN) stations.
* This app contains load and trend data for 92, 80, and 78 NTN stations for Total Nitrogen (TN), Total Phosphorus (TP), and Suspended Sediment (SS), respectively.
* This app is an extension to the Chesapeake Bay Total Maximum Daily Load (TMDL) Indicator, which has been approved and published on Chesapeake Progress.

Purpose

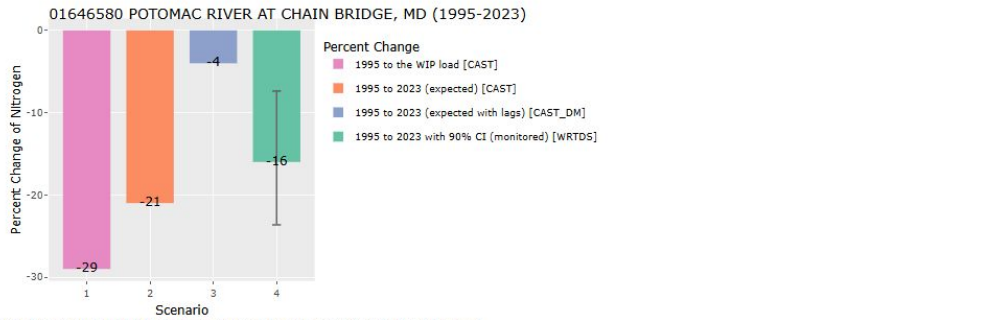
User Site Selection



Results

About | Timeseries | WIP Load | Progress | Download

Interactive Plot



(Note 1: Negative values indicate load reductions; positive values indicate load increases.)

(Note 2: To obtain values in million pounds (Mlbs), multiply the percent change shown in this plot by the CAST load in the first year of the assessment period, which is available in the Data Table under the Timeseries tab.)

Data Type

WRTDS: Monitored load - computed using the USGS WRTDS flow-normalization method (source).

CAST: Expected load in the long term - computed using the Chesapeake Bay Program Watershed Model (source).

CAST_DM: Expected load with lags - computed using the Chesapeake Bay Program Watershed Model (source).

Interpretive Text

For Nitrogen at 01646580 POTOMAC RIVER AT CHAIN BRIDGE, MD, the period of analysis is 1995-2023.

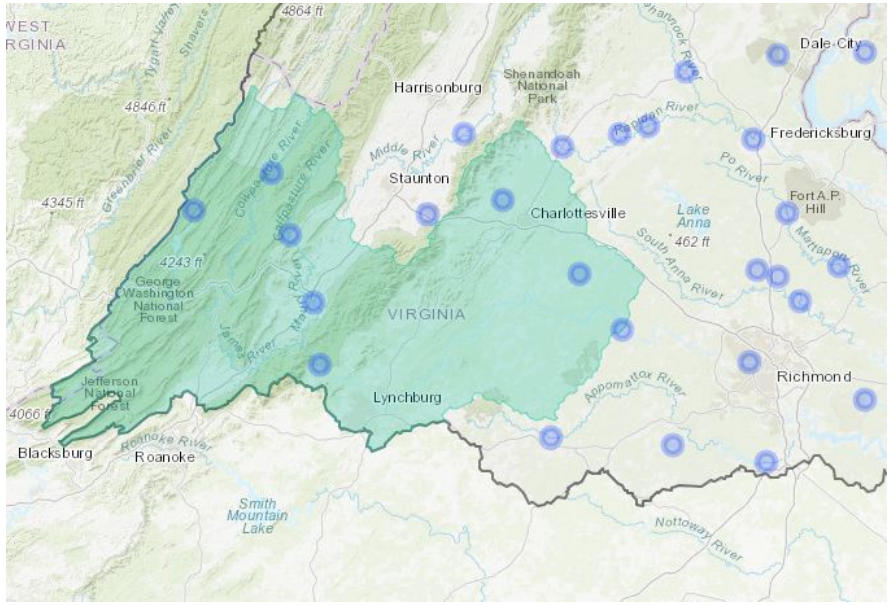
1. Overall reduction - comparing the baseline year of 1995 with the WIP load:
[Bar 1] CAST estimates a reduction of 29 percent in the long term from implementation of the WIP using 2025 land use and inputs.

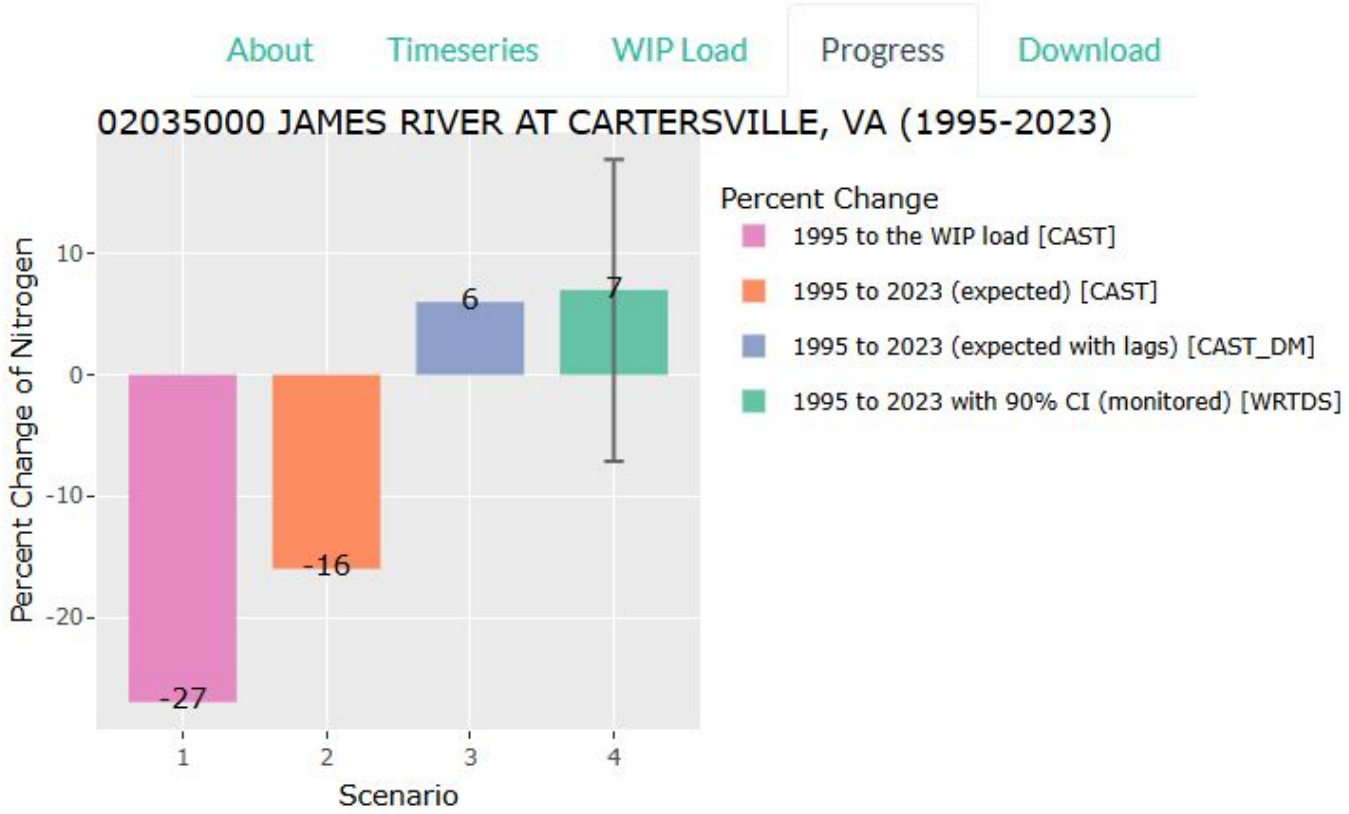
2. Current progress - comparing the baseline year of 1995 with the current year of 2023:
[Bar 2] CAST estimates a reduction of 21 percent in the long term from 2023 land use, inputs, and management practices.
[Bar 3] The Dynamic Watershed Model (i.e., CAST_DM) estimates that a reduction of 4 percent would have been seen by 2023, accounting for lags, sampling frequency, and other factors.
[Bar 4] The river monitoring data (i.e., WRTDS) show a reduction of 16 percent with a 90% uncertainty range of (-24%, -7%).

Data Sources

- Watershed Implementation Plans (WIPs)
  - Expected long-term load reductions once the Phase III WIPs are fully implemented
- Monitoring
  - Weighted Regressions on Time, Discharge, and Season (WRTDS): Monitored load - computed using the USGS WRTDS flow-normalization method
- Modeling
  - Chesapeake Assessment Scenario Tool (CAST): Expected load in the long term - computed using the time-averaged version of the Chesapeake Bay Program Phase 6 Watershed Model.
  - CAST Dynamic Model (CAST-DM): Expected load with lags - computed using

Example 1: 02035000 James River at Cartersville, VA Total Nitrogen



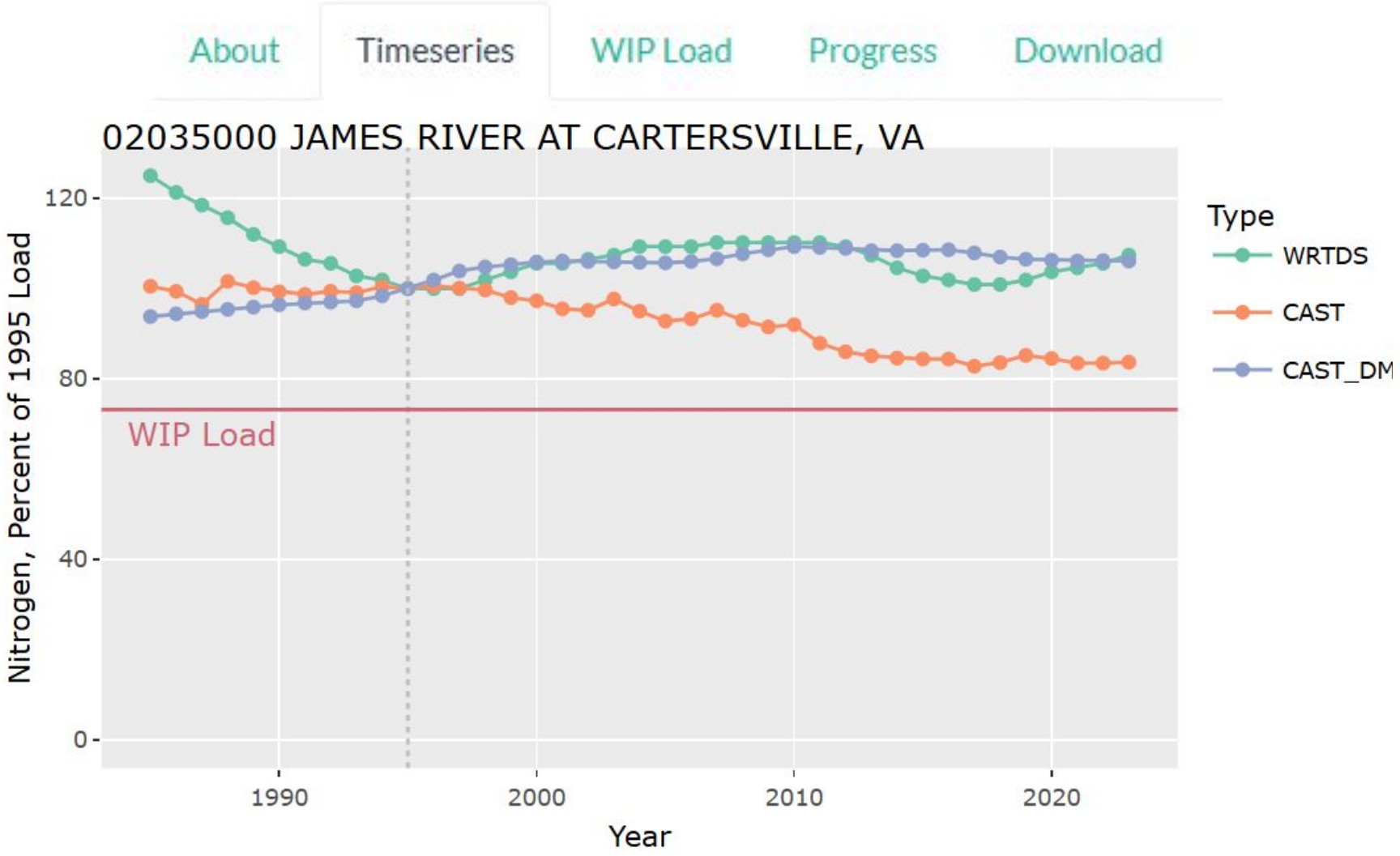


Interpretive Text

1. CAST estimates a 27 percent reduction in the long term from **implementation of the WIP** using 2025 land use and inputs.
2. CAST estimates a 16 percent reduction in the long term from **2023** land use, inputs, and management practices.
3. The Dynamic Watershed Model estimates that only a 6 percent increase would have been seen by 2023, accounting for lags, sampling frequency, and other factors.
4. The river monitoring data show a 7 percent increase with a 90% uncertainty range between 7 and 18 percent reduction.

Implication: The observed response is as expected over the period of 1995-2020.

Results: Timeseries



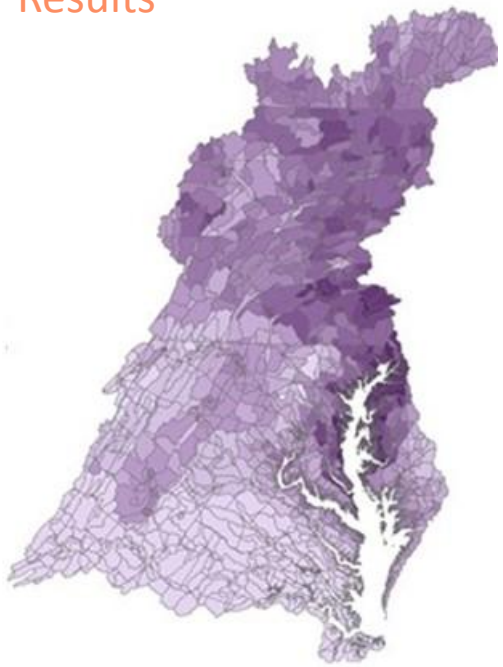
Interpretive Text

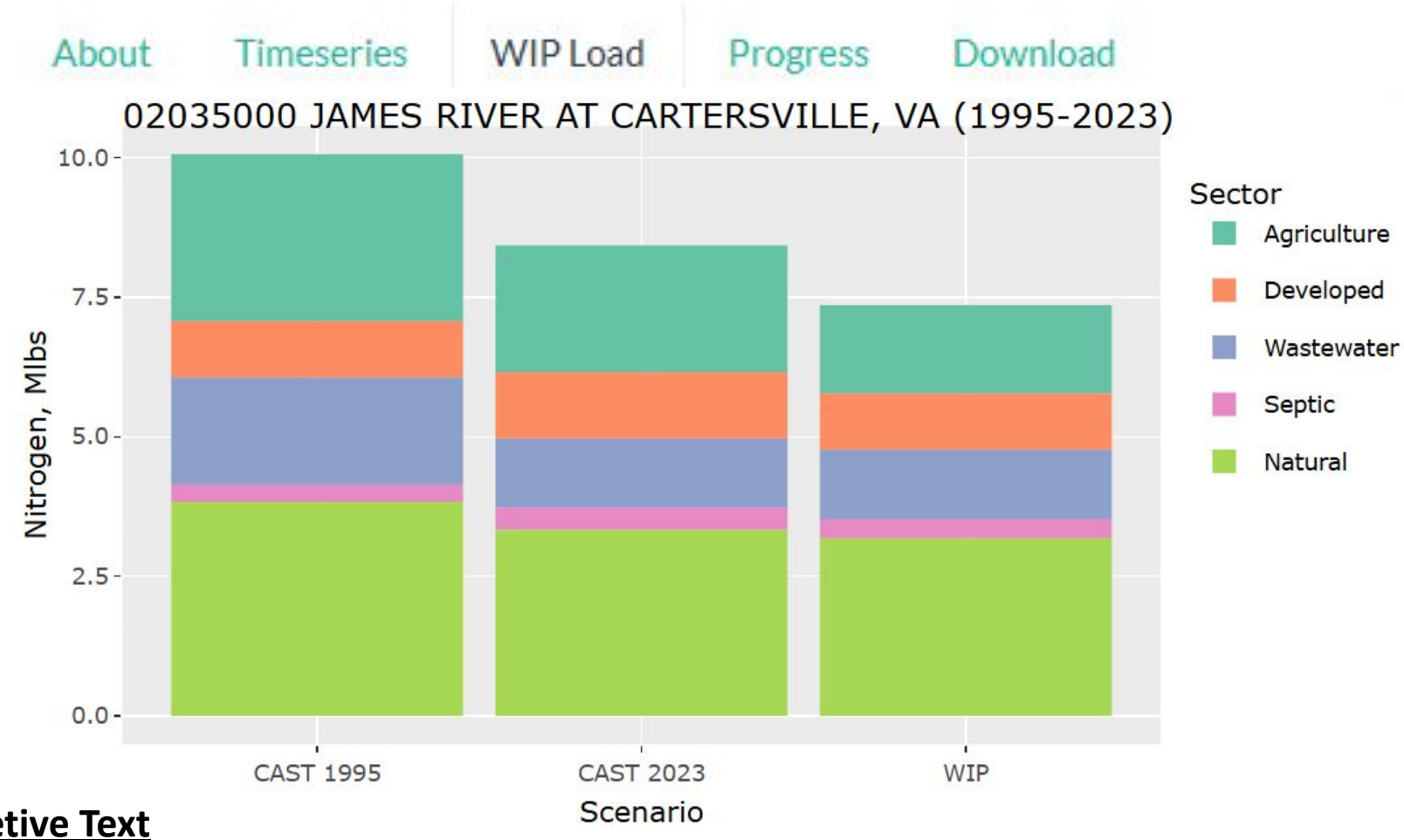
1. Monitoring and dynamic modeling trends show increases since the 1995 baseline year. CAST model trends show a decrease.
2. WIP load refers to the expected long-term load once the watershed implementation plans are fully implemented. Derived using Phase 6 land-river segments that map onto Nontidal Network watersheds.

Implication: The observed response is as expected over the period of 1995-2023 relative to the dynamic watershed model.

Results: WIP Goal

Watershed Model (CAST) Results





Interpretive Text

1. CAST: Expected load in the long term - computed using the Chesapeake Bay Program Watershed Model. Scenarios are for 1995 and 2023.
2. WIP load refers to the expected long-term load once the watershed implementation plans are fully implemented.

Implication: Total load reduction is closer to the goal with reductions the Ag and Wastewater sectors. WIP includes more expected reductions from Ag sector.

4

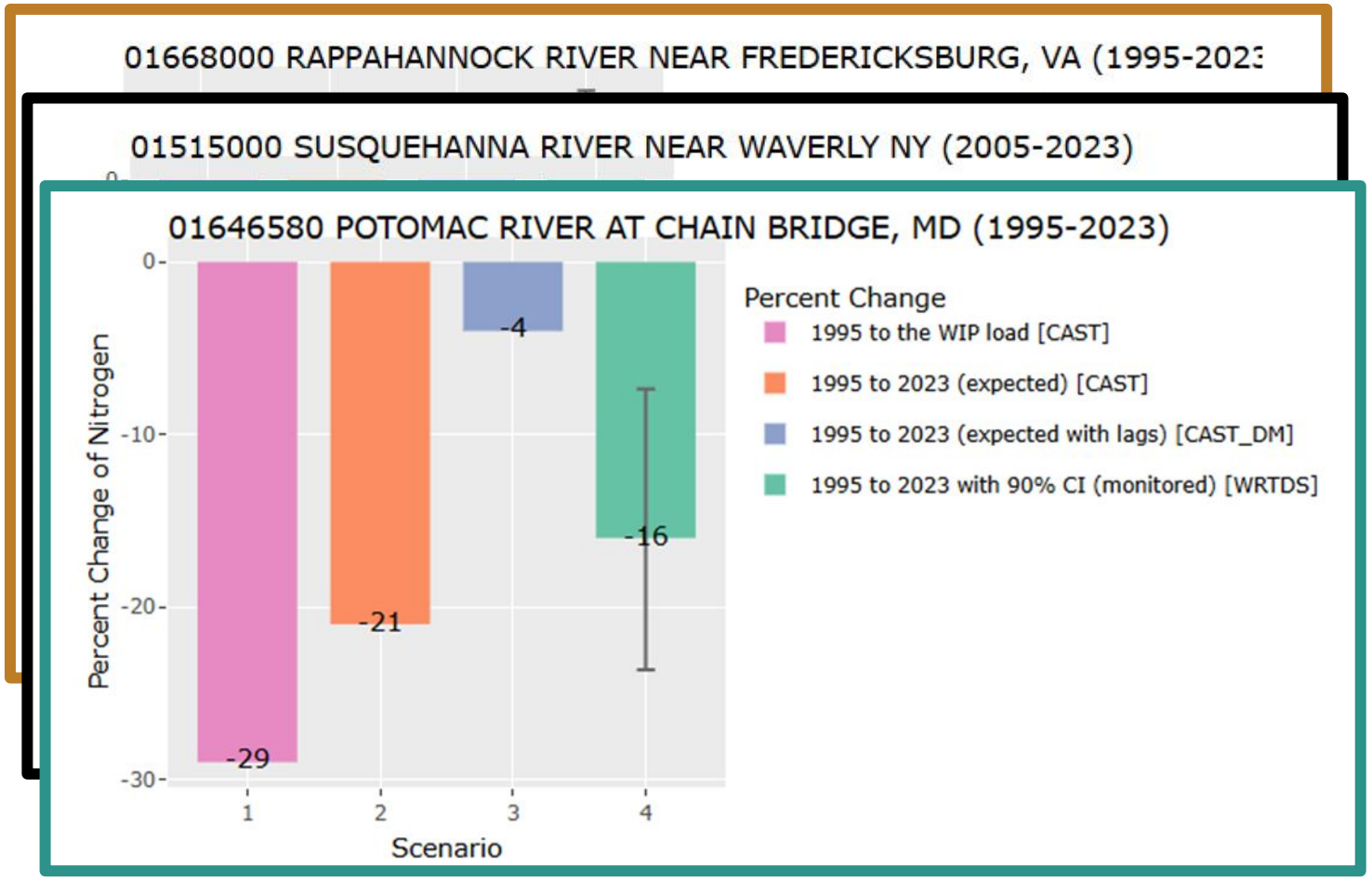
Summary

How do the monitoring and modeling results compare?

Performance Assessment

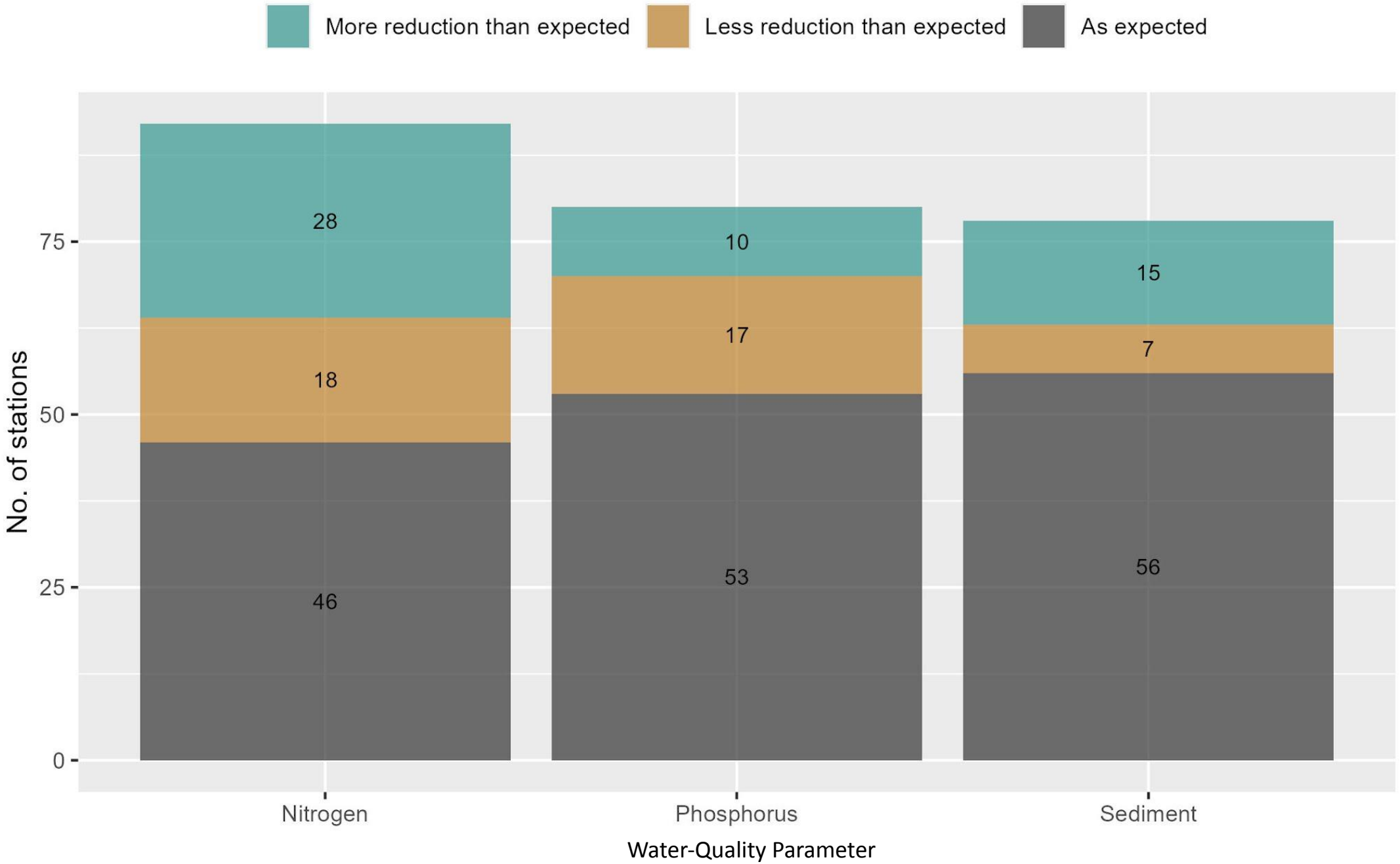
How accurate are model predictions and is the watershed performing better than expected for NTN catchments?

- Less Reduction Than Expected
- As Expected
- More Reduction Than Expected



Comparing dynamic watershed model (blue bar; loads with lags)

Monitored reduction vs. expected reduction with lags



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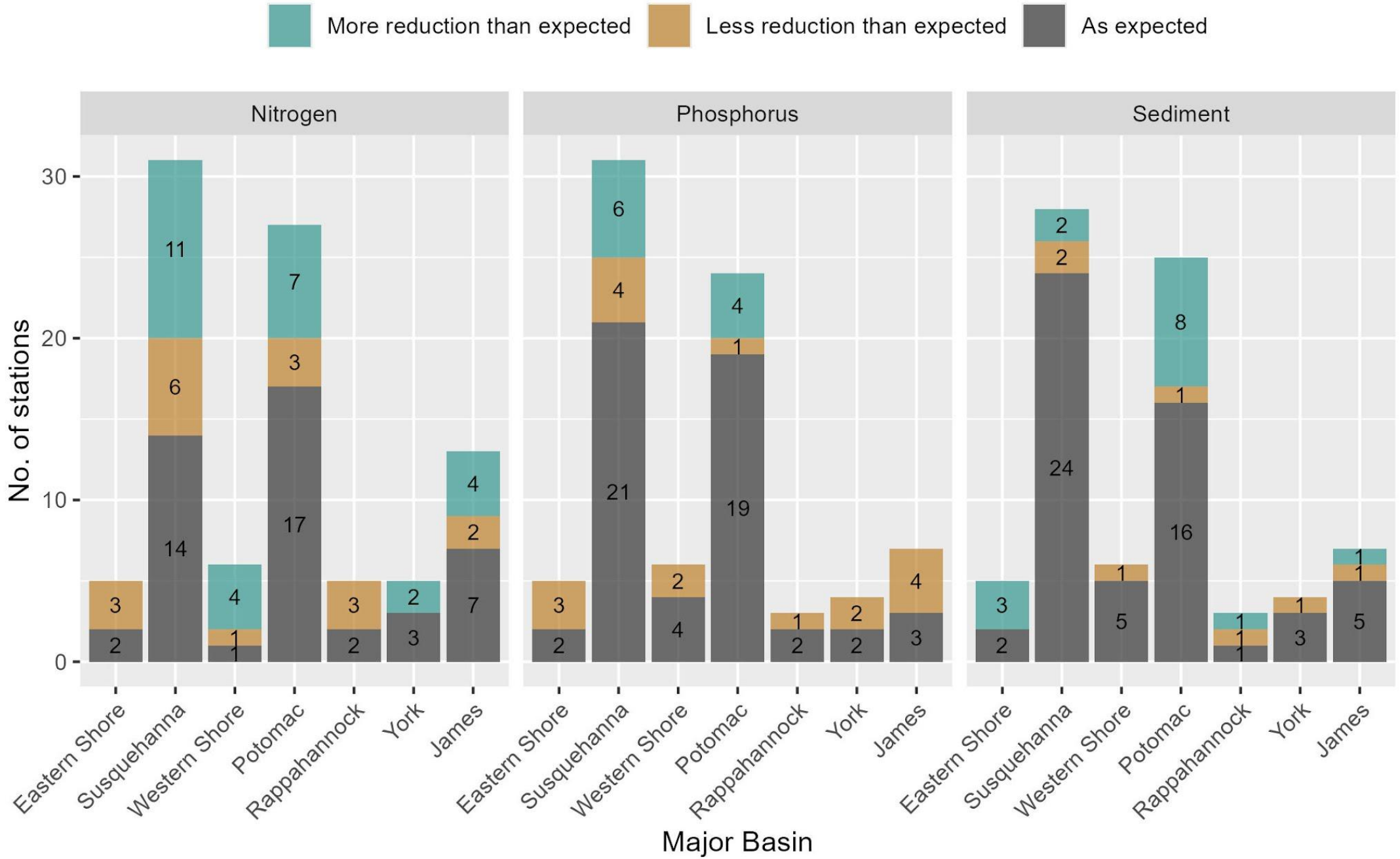
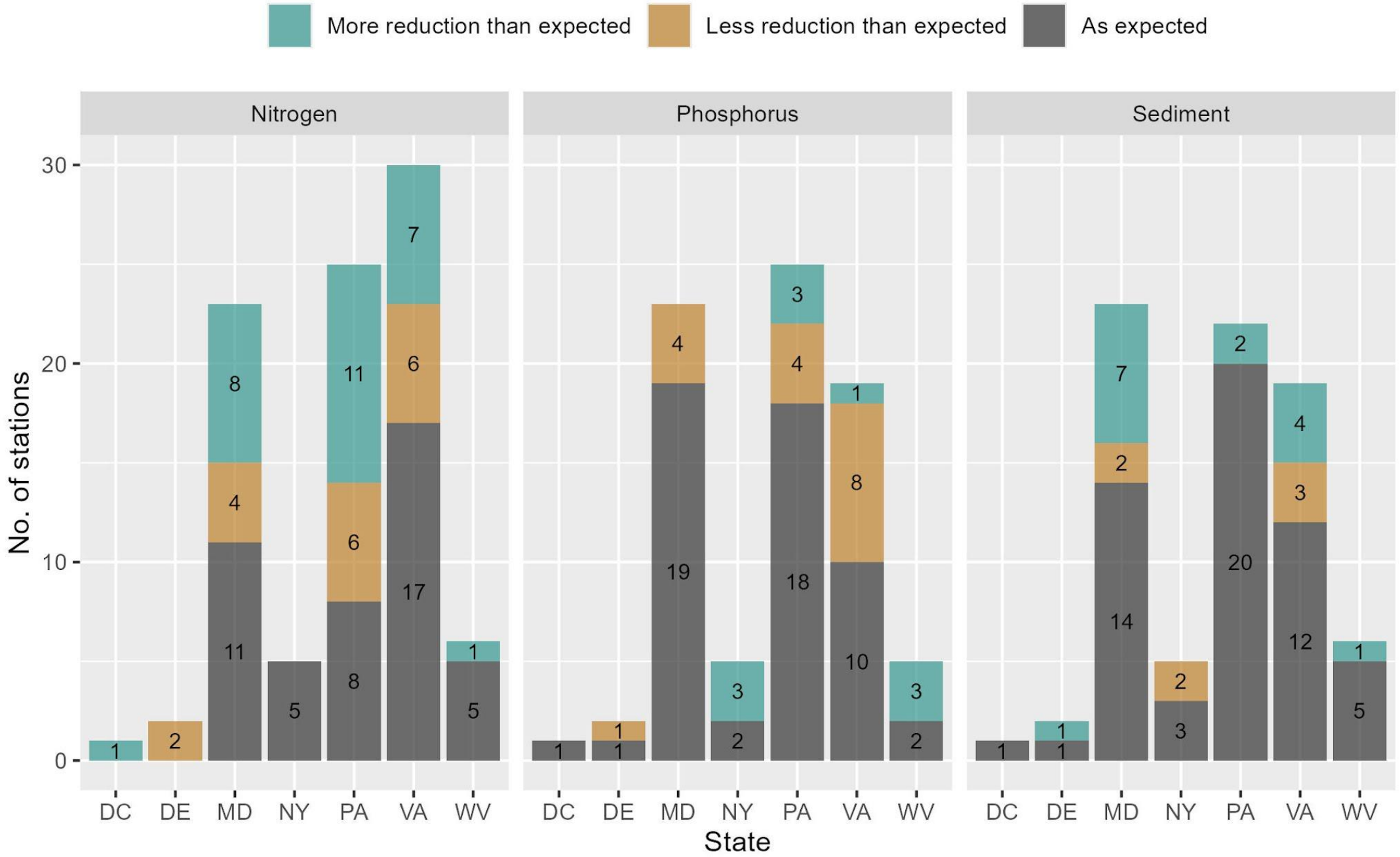
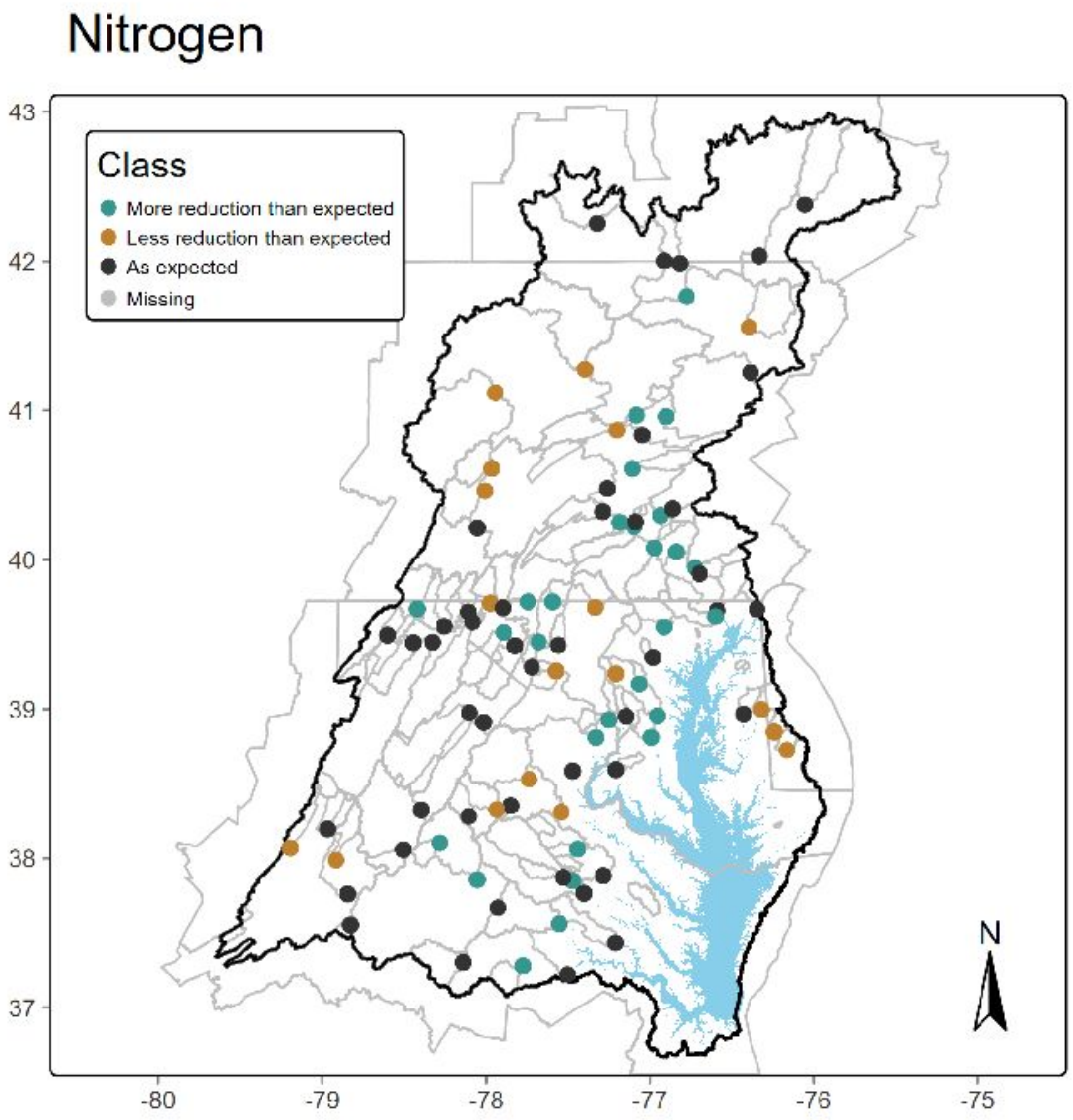


Monitored reduction vs. expected reduction with lags



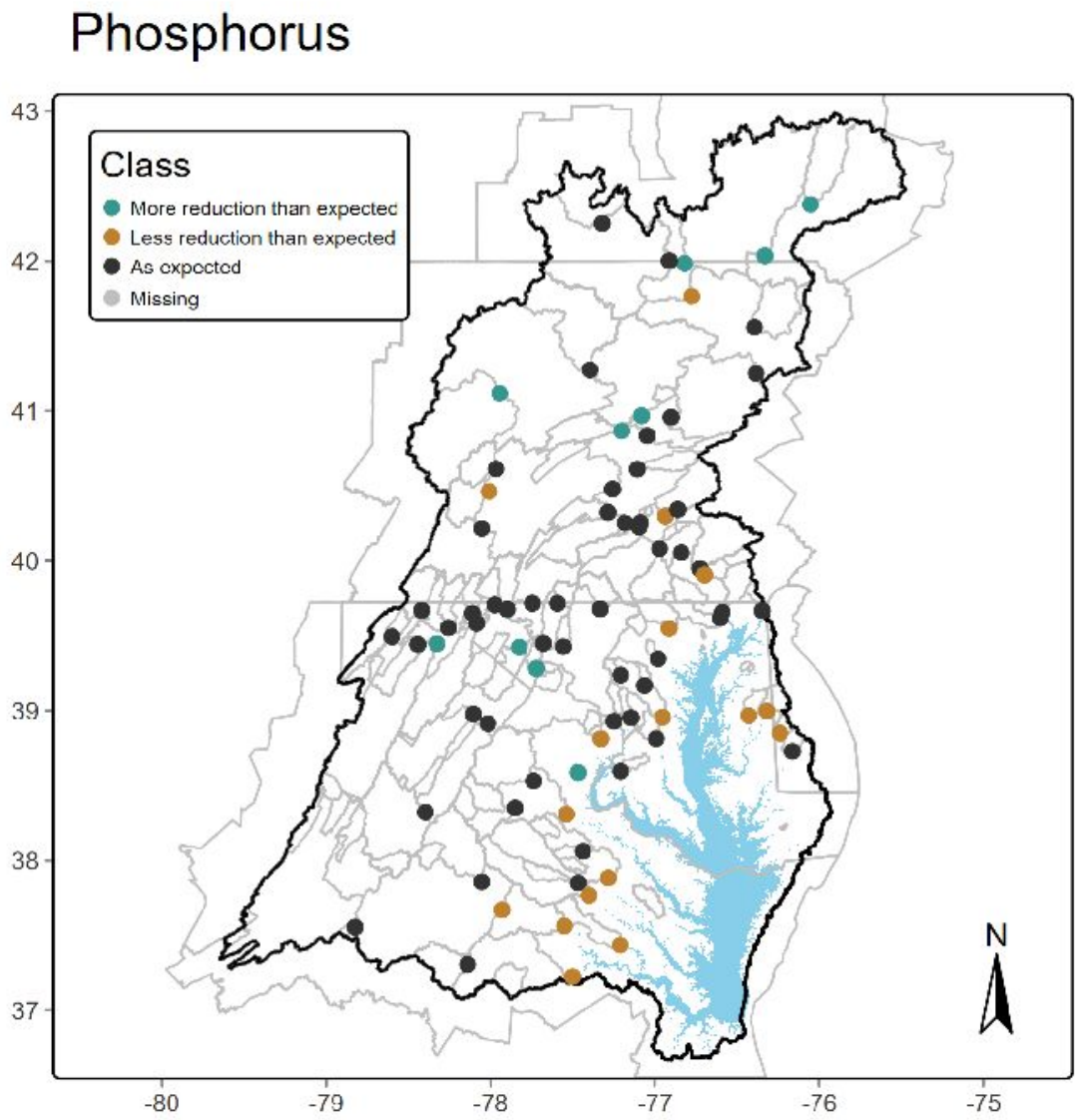


- Model within the error range of the observed trend
- Model showing greater reduction; doing worse than expected
- Data showing greater reduction; doing better than expected

Half of stations as expected

Potential Patterns:
-Coastal plain worse than expected?
-Larger rivers better than predicted?

Next Step: Why?



- Model within the error range of the observed trend
- Model showing greater reduction; doing worse than expected
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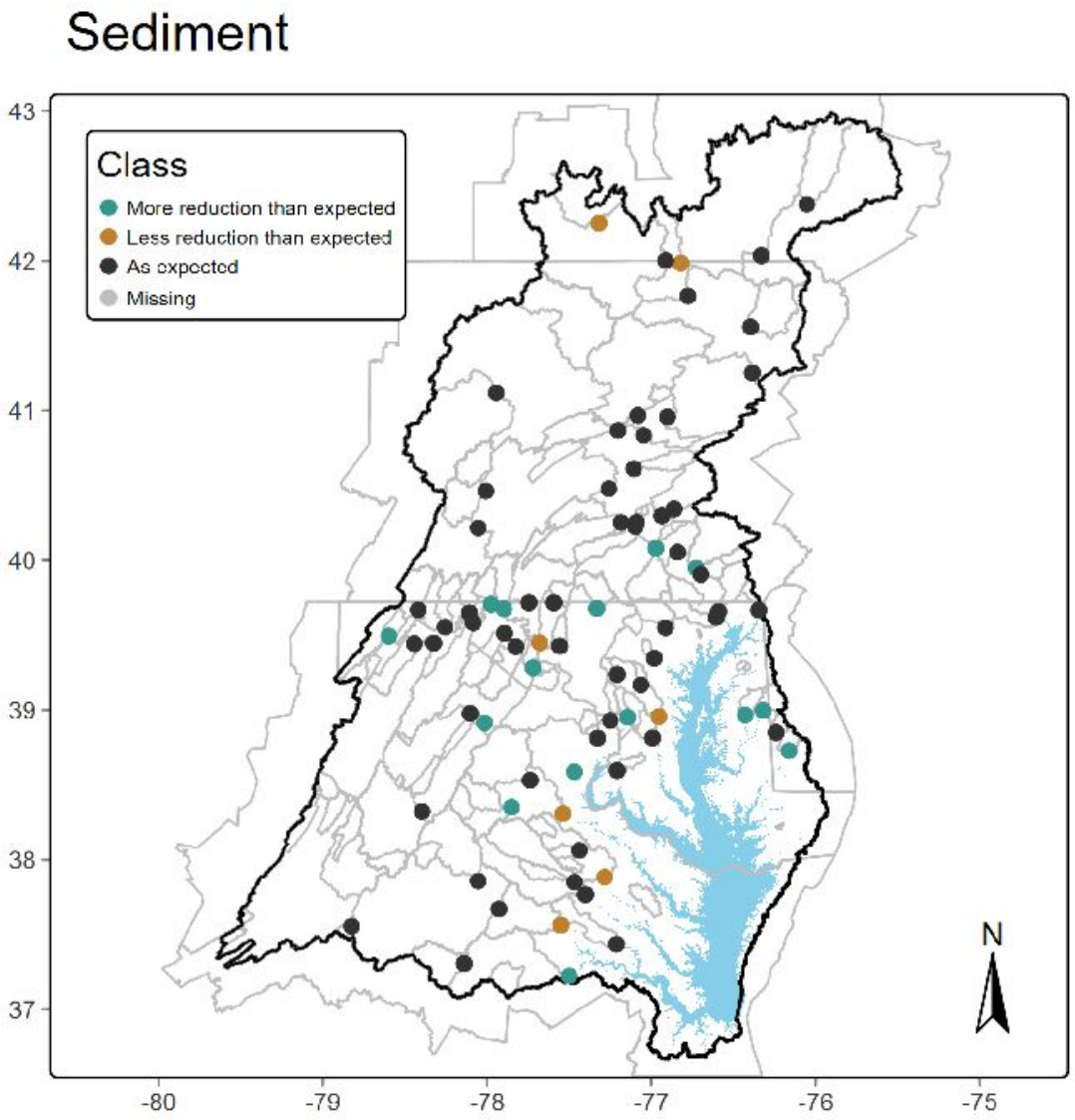
More in the as expected/accurate category
-Matches do not imply better model performance due to wider confidence intervals for P

Potential Patterns:
-Coastal Plain worse than expected?
-Some in Valley & Ridge and Appalachian Plateau better than expected?

Next Step: Why?



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Potential Patterns:
-Southern Piedmont is mixed?
-Eastern shore better than expected?

Next Step: Why?

5

Reception and Uses

Significant interest from across the CBP

Many presentations to different audiences and partners.

Check out our blog here!

Additional outreach is being planned.

Facilitates conversations comparing modeled and monitored outcomes

Have we implemented enough?

Are we seeing the expected results?

How does my watershed compare to similar watersheds?

Invites research questions

Why are we seeing lower response in phosphorus?

Are there similar responses for similar watersheds?

What is happening in specific watersheds?

Thank You!

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