# Chesapeake Bay TMDL Indicator METRIC tool

Agriculture Workgroup

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7/17/2025

# Total Maximum Daily Load (TMDL)

What management practices…

…. will reduce nitrogen, phosphorus, and sediment to levels …

…. that will achieve levels of dissolved oxygen, clarity, and chlorophyll in the Bay…

… that are supportive of living resources?

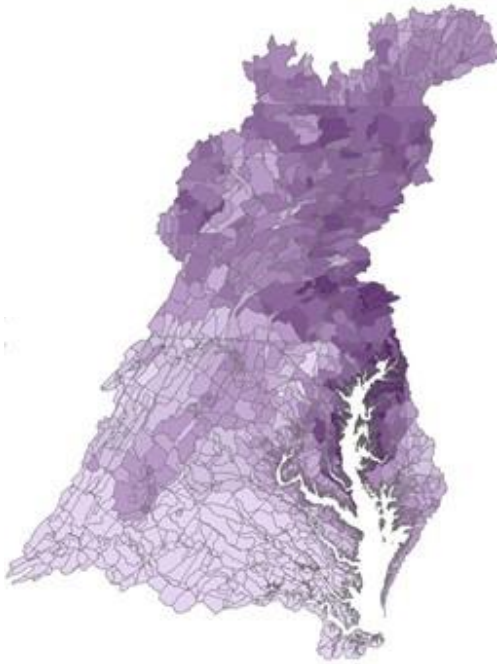


Photo credit: CBP

# Nutrient Targets

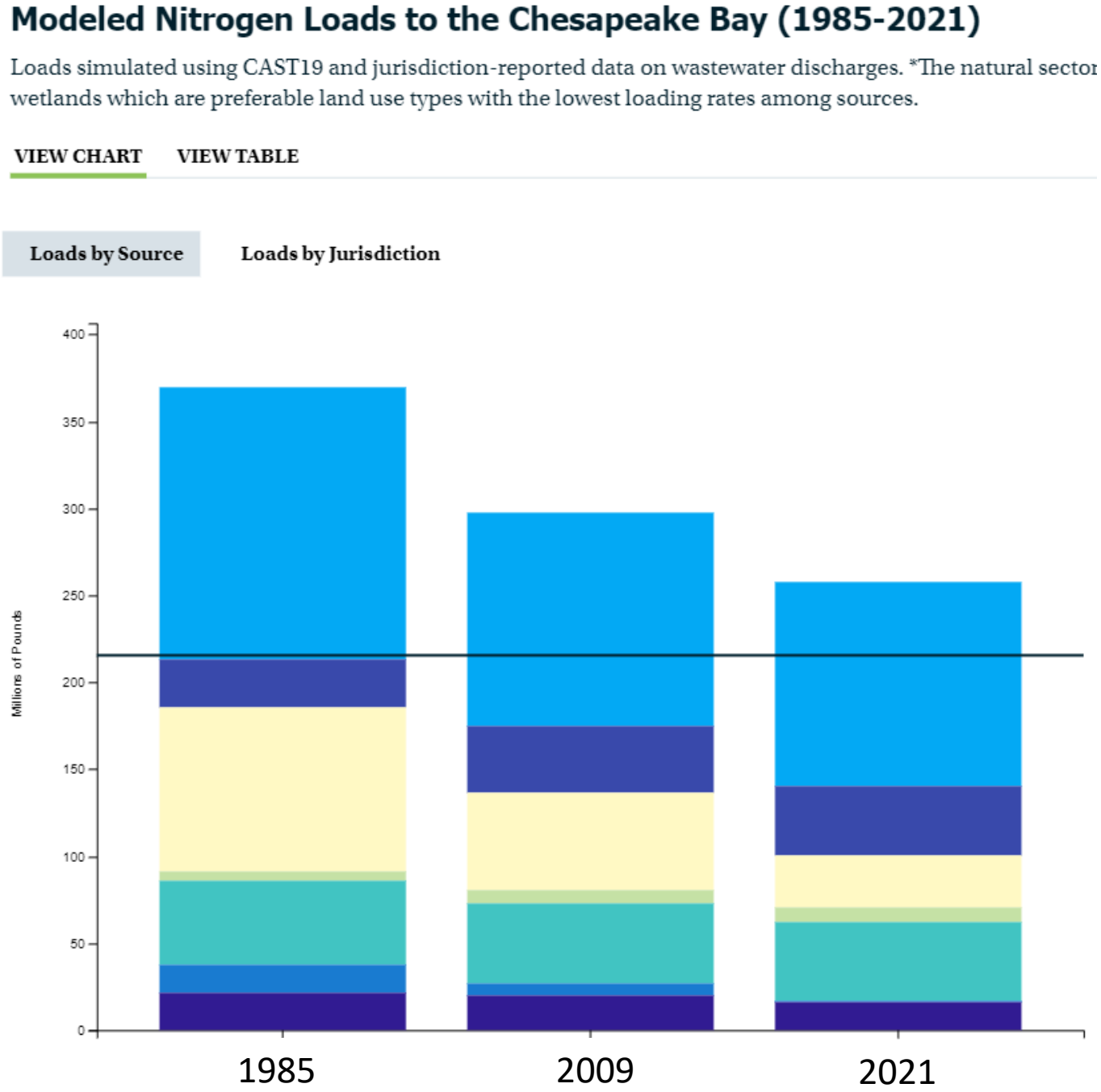
| Major | State | | 2018 Planning Targets approved by PSC | |
|---|---|---|---|---|
| Major | State | StateBasin | Nitrogen | Phosphorus |
| Potomac | DC | DC Potomac | 2.42 | 0.130 |
| Eastern Shore | DE | DE Eastern Shore | 4.55 | 0.108 |
| Eastern Shore | MD | MD Eastern Shore | 15.21 | 1.286 |
| Patuxent | MD | MD Patuxent | 3.21 | 0.301 |
| Potomac | MD | MD Potomac | 15.30 | 1.092 |
| Susquehanna | MD | MD Susquehanna | 1.18 | 0.053 |
| Western Shore | MD | MD Western Shore | 10.89 | 0.948 |
| Susquehanna | NY | NY Susquehanna | 11.53 | 0.587 |
| Eastern Shore | PA | PA Eastern Shore | 0.45 | 0.025 |
| Potomac | PA | PA Potomac | 6.11 | 0.357 |
| Susquehanna | PA | PA Susquehanna | 66.59 | 2.661 |
| Western Shore | PA | PA Western Shore | 0.02 | 0.001 |
| Eastern Shore | VA | VA Eastern Shore | 1.43 | 0.164 |
| James | VA | VA James | 25.92 | 2.731 |
| Potomac | VA | VA Potomac | 16.00 | 1.892 |
| Rappahannock | VA | VA Rappahannock | 6.85 | 0.849 |
| York | VA | VA York | 5.52 | 0.556 |
| James | WV | WV James | 0.04 | 0.005 |
| Potomac | WV | WV Potomac | 8.18 | 0.427 |

- Nutrient loads in million lbs/year
  - Watershed model (CAST) used to assess progress toward these goals



# WIP Indicator

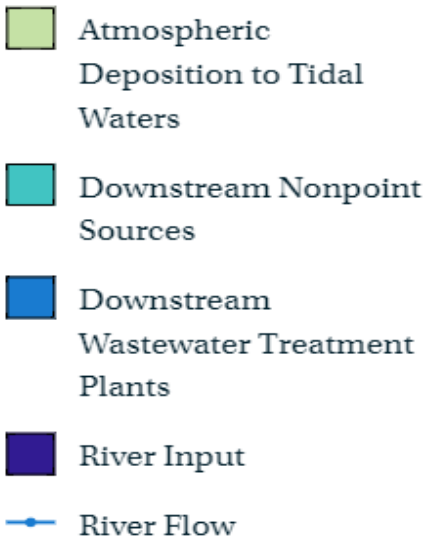
We have implemented much of the plan

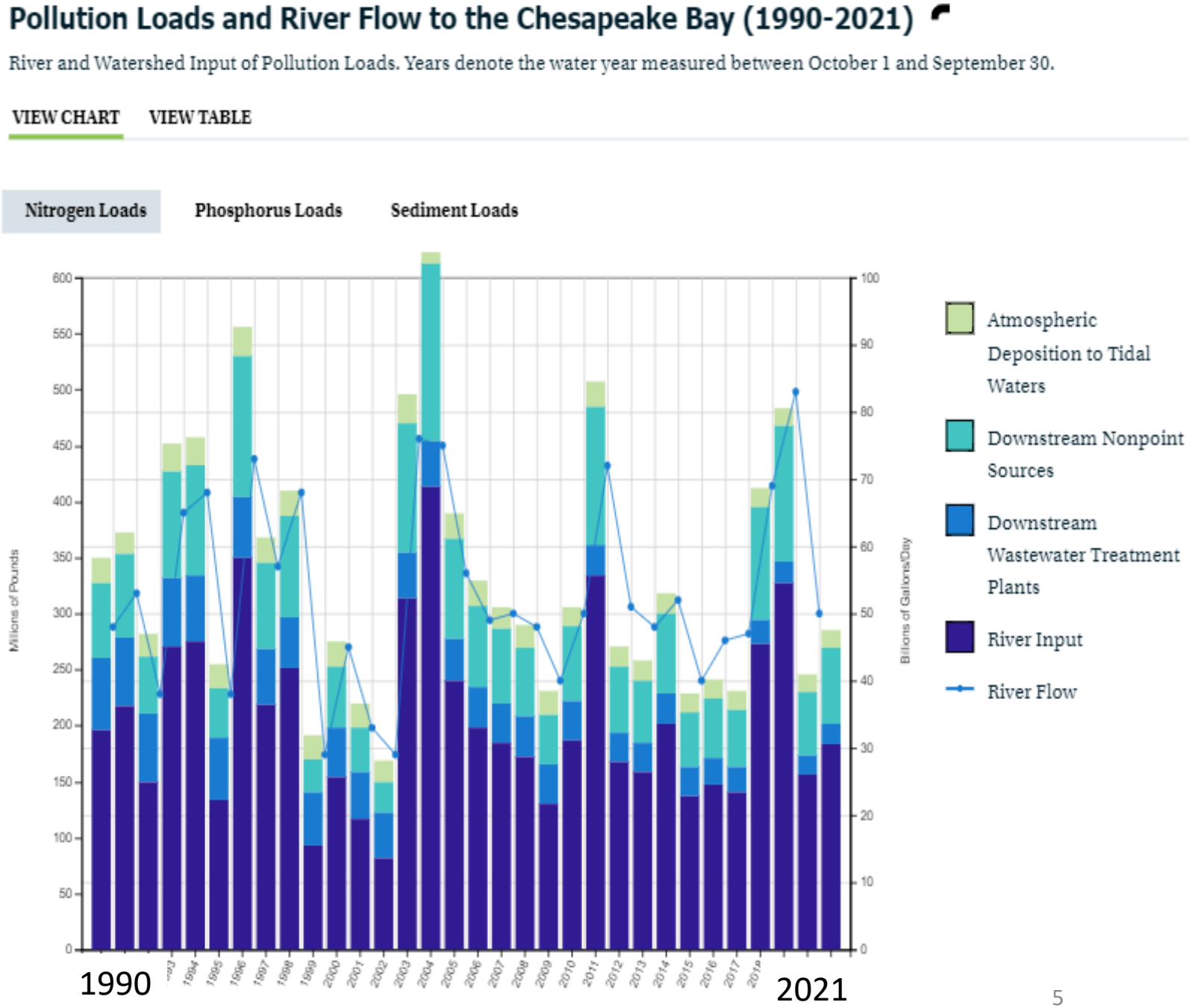




https://www.chesapeakeprogress.com/clean-water/watershed-implementation-plans

# Nontidal Load Indicator

## Extreme variability
## No Clear Trend




https://www.chesapeakeprogress.com/clean-water/water-quality

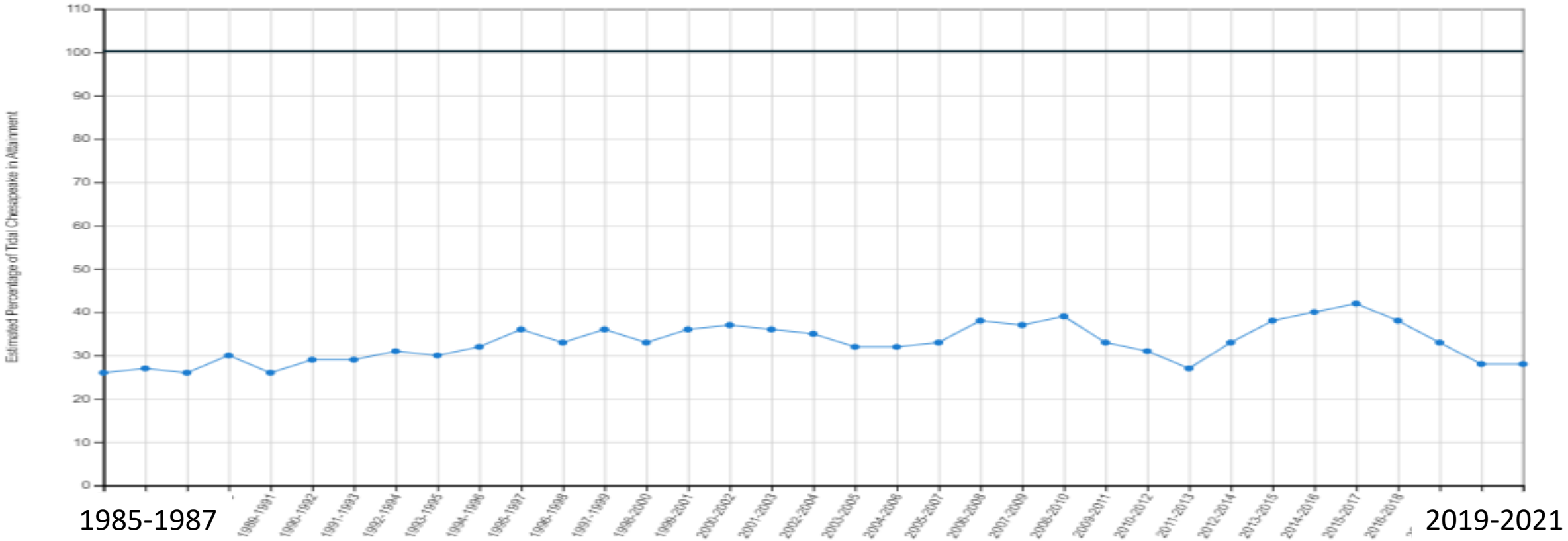
# Tidal Water TMDL Indicator

Very slow positive change

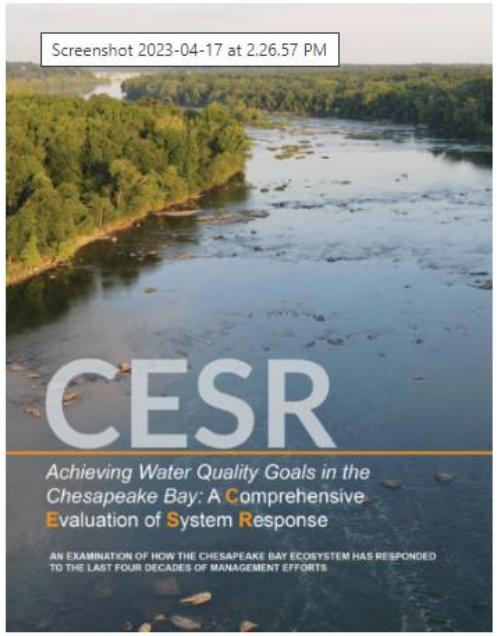
## Water Quality Standards Attainment (1985-2021)

Water quality is evaluated using three parameters: dissolved oxygen, water clarity or underwater grass abundance, and chlorophyll a (a measure of algae growth).

VIEW CHART VIEW TABLE



# STAC Comprehensive Evaluation of System Response Report

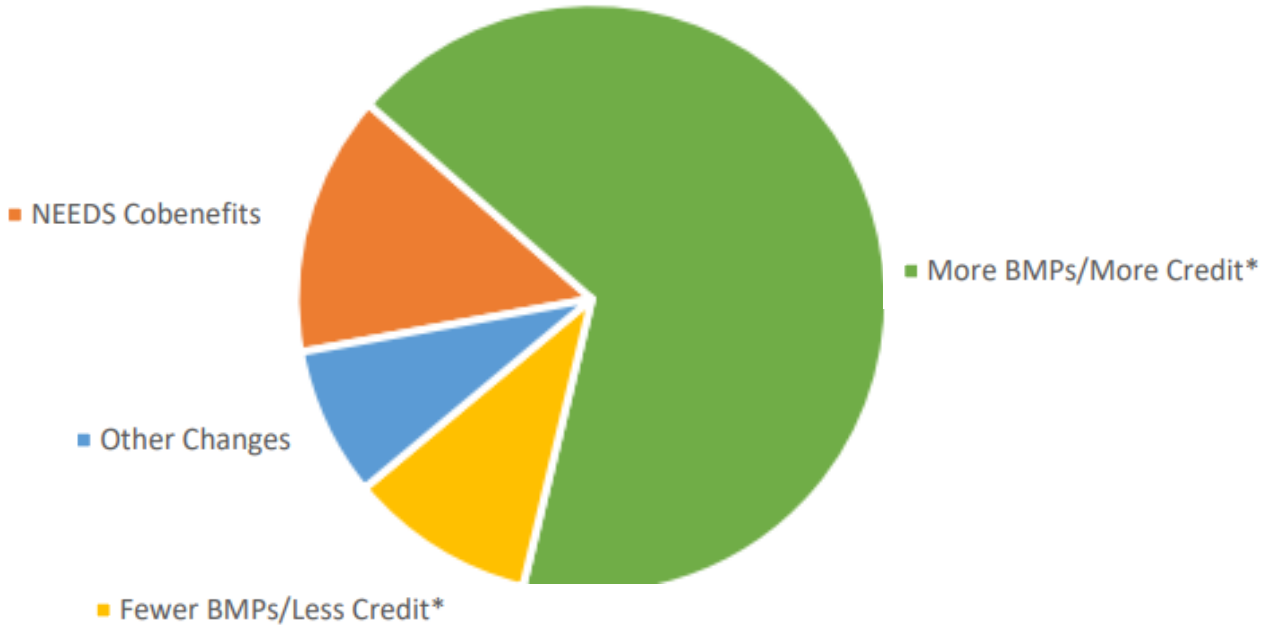



- Nonpoint source not generating enough reductions.
- *Are we getting the nitrogen and phosphorus reductions predicted by the modeling system?*

https://www.chesapeake.org/stac/cesr/

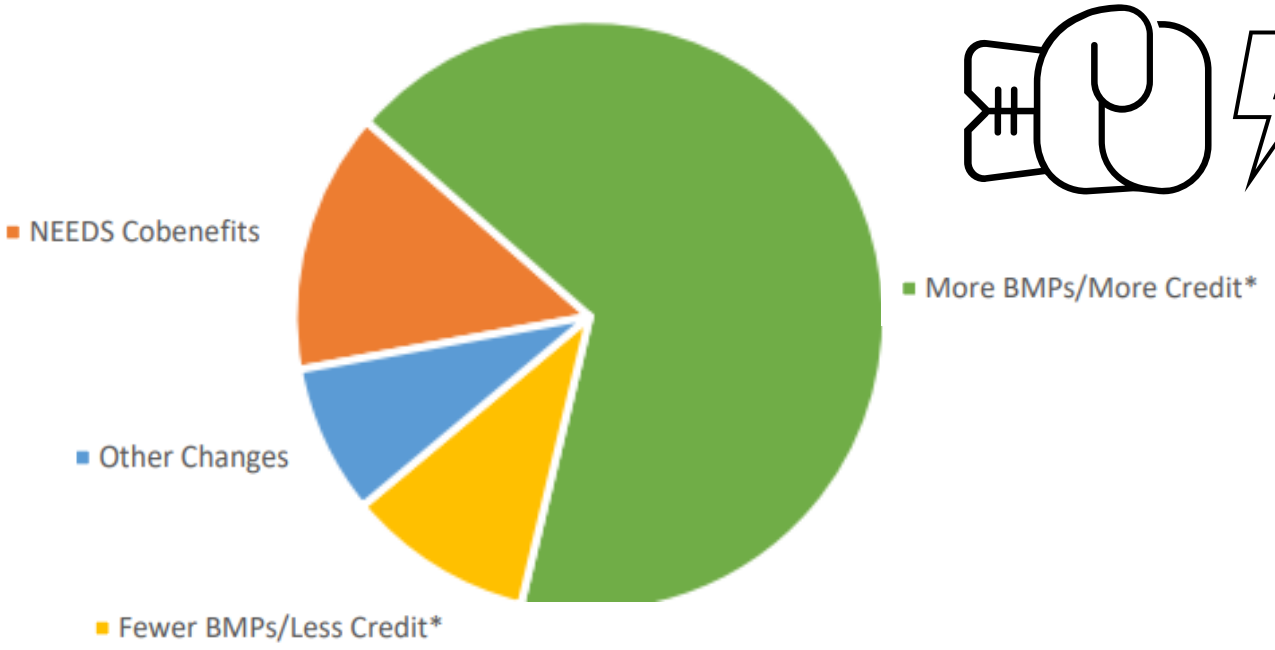
# Chesapeake Governance Study
# D.G. Webster, Dartmouth College

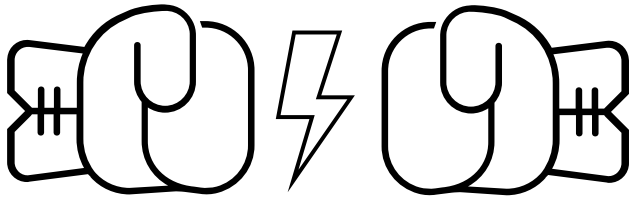
What about the watershed model (CAST) should be improved?

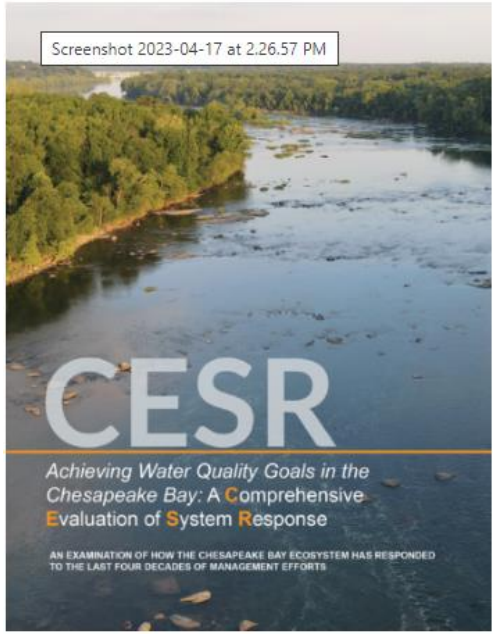



https://digitalcommons.dartmouth.edu/cgi/viewcontent.cgi?article=5309&context=facoa

# Why not use monitoring directly?






https://digitalcommons.dartmouth.edu/cgi/viewcontent.cgi?article=5309&context=facoa

Photo credit: CBP

# Natural System

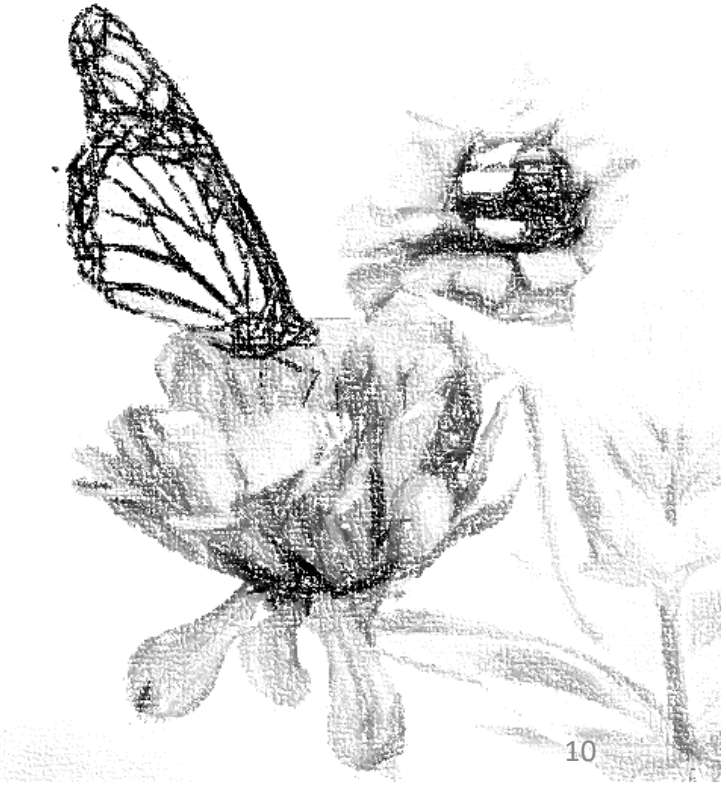
Photo credit: CBP

# Monitoring

**Reality**
***But***
**Imprecise**
**Incomplete**

# Modeling

**Precise**
**Complete**
***But***
**Not Reality**



# Indicator Development

- Long-term monitoring data
- Statistical analysis methods
- Point source data below monitoring stations
- Models with lag estimates
- Planned reductions
- Necessary reductions

- Qian Zhang (UMCES)

- Gopal Bhatt (PSU)

- Isabella Bertani (UMCES)

Zhang, Q., Shenk, G.W., Bhatt, G. and Bertani, I., 2024. Integrating monitoring and modeling information to develop an indicator of watershed progress toward nutrient reduction goals. *Ecological Indicators*, *158*, p.111357.

# Indicator Development

- Long-term monitoring data
- Statistical analysis methods
- Point source data below monitoring stations

} Verified reductions

- Models with lag estimates
- Planned reductions
- Necessary reductions

# Indicator Development

- Long-term monitoring data
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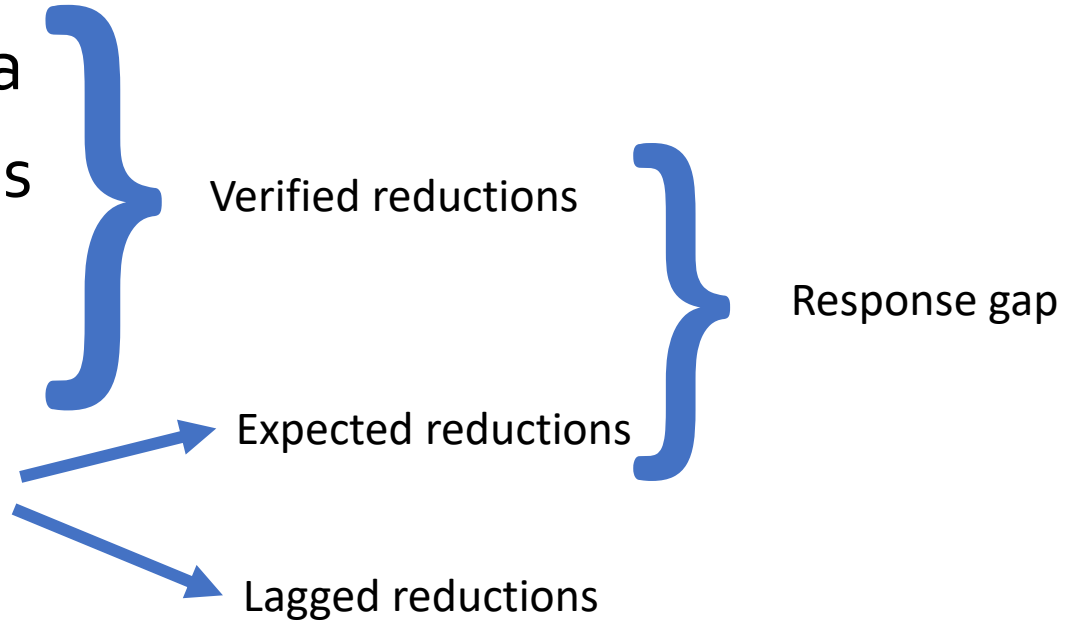


# Indicator Development

- Long-term monitoring data
- Statistical analysis methods
- Point source data below monitoring stations
- Models with lag estimates
- Planned reductions
- Necessary reductions

Planning gap

Verified reductions

Response gap

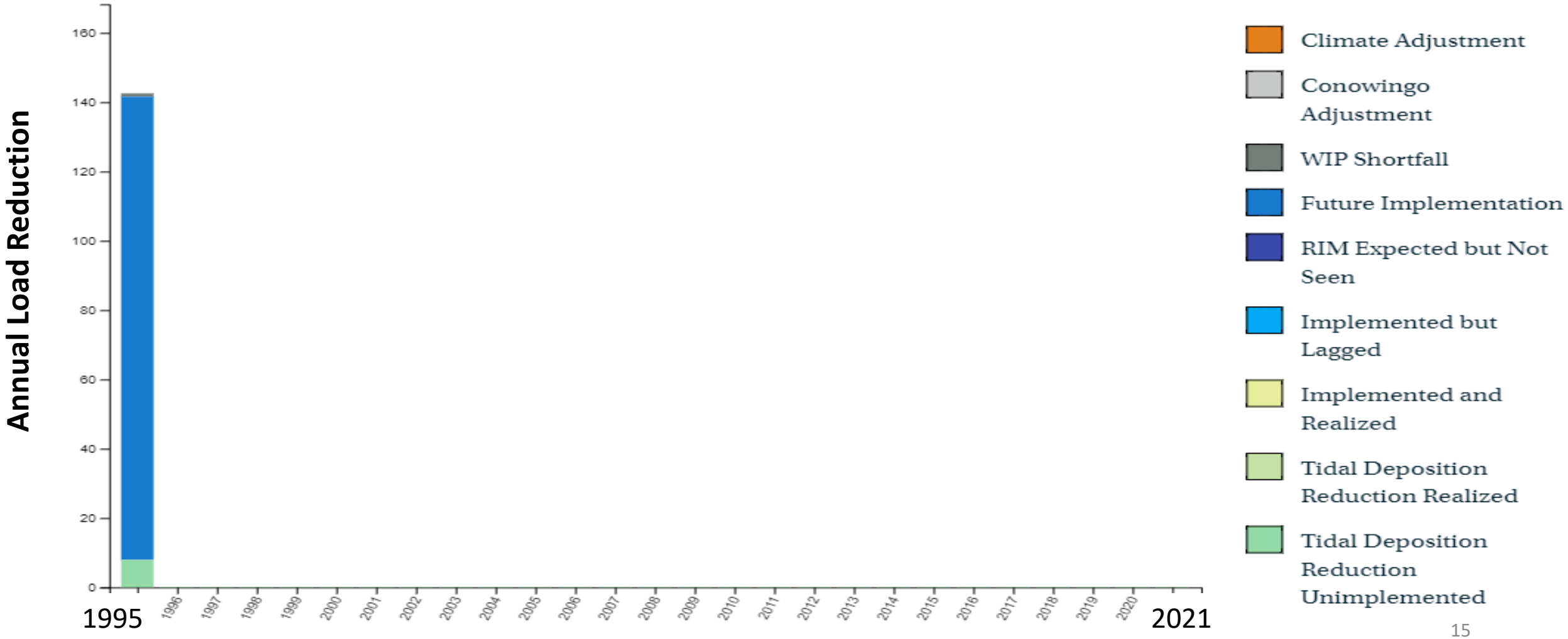
Lagged reductions

Implementation gap

# Chesapeake Bay TMDL Indicator: Total Nitrogen

This indicator combines monitored and modeled data to estimate the progress of annual pollution loading rate reductions since 1995 in response to implemented management practices.

VIEW CHART VIEW TABLE



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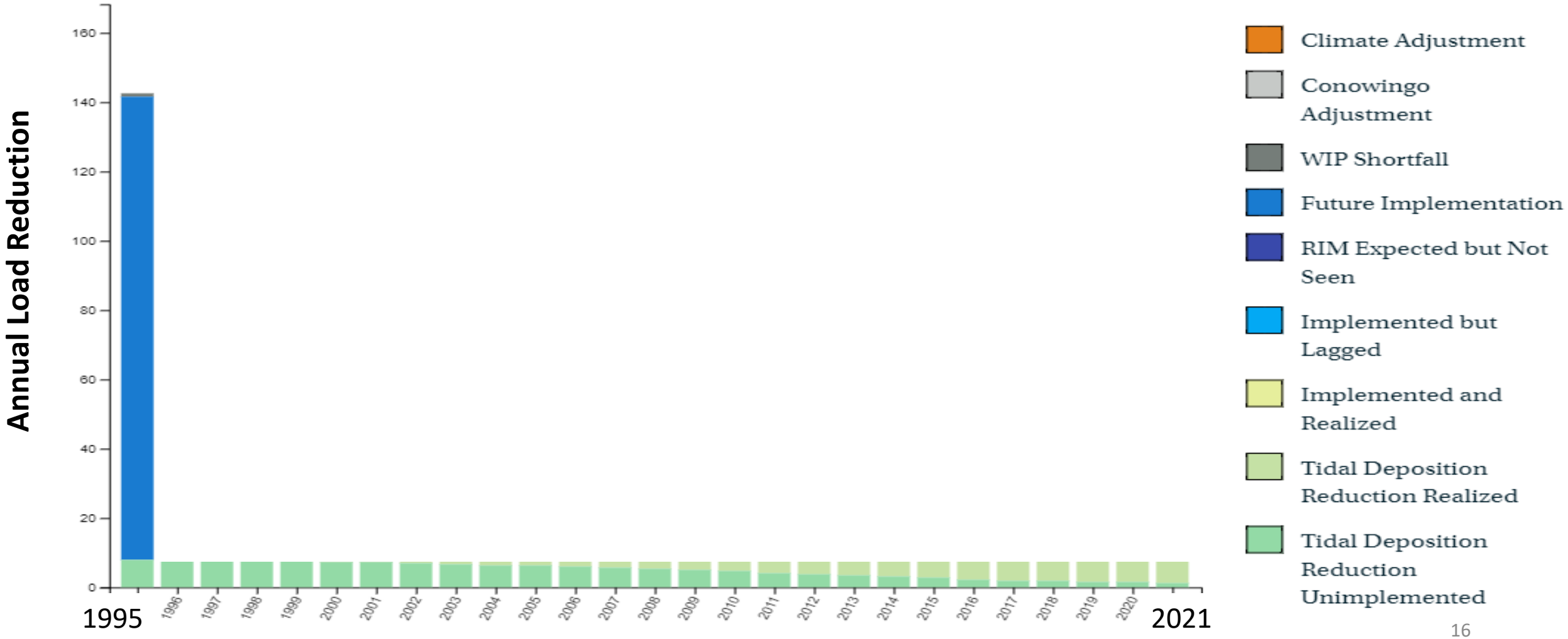

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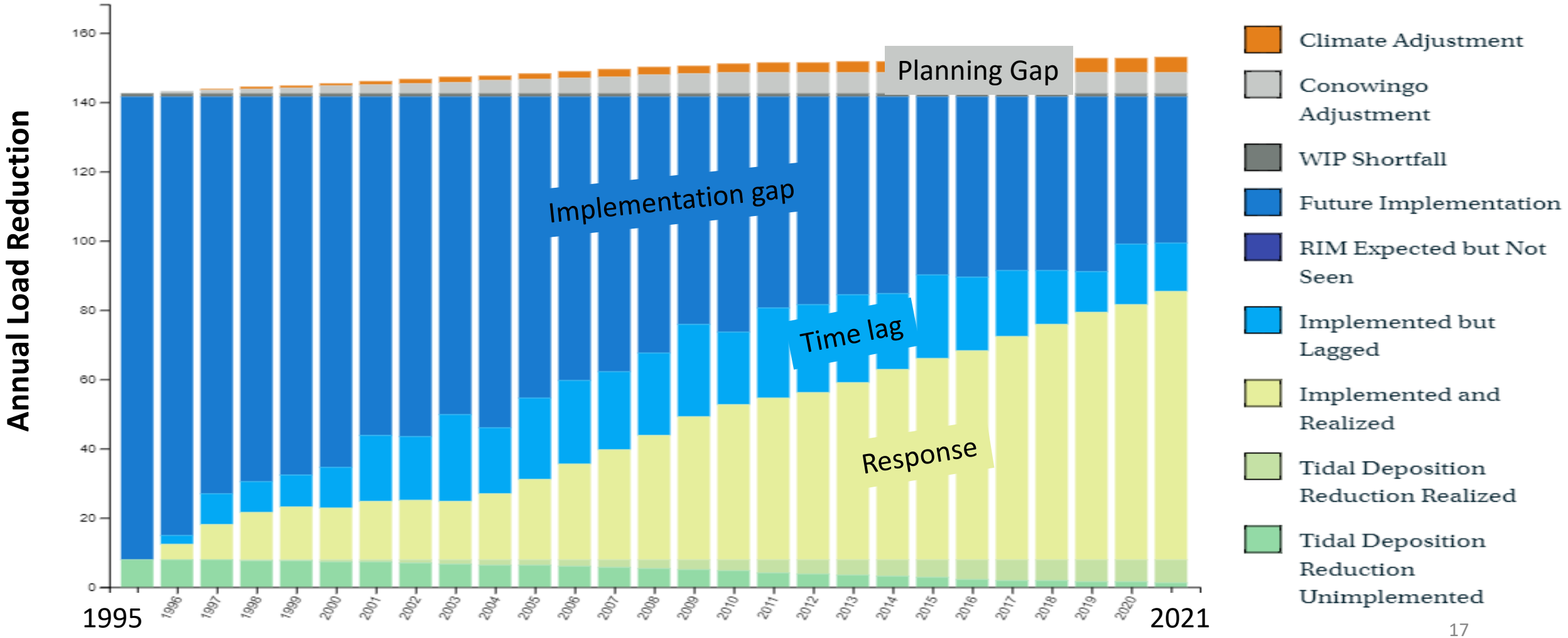

# Chesapeake Bay TMDL Indicator: Total Phosphorus

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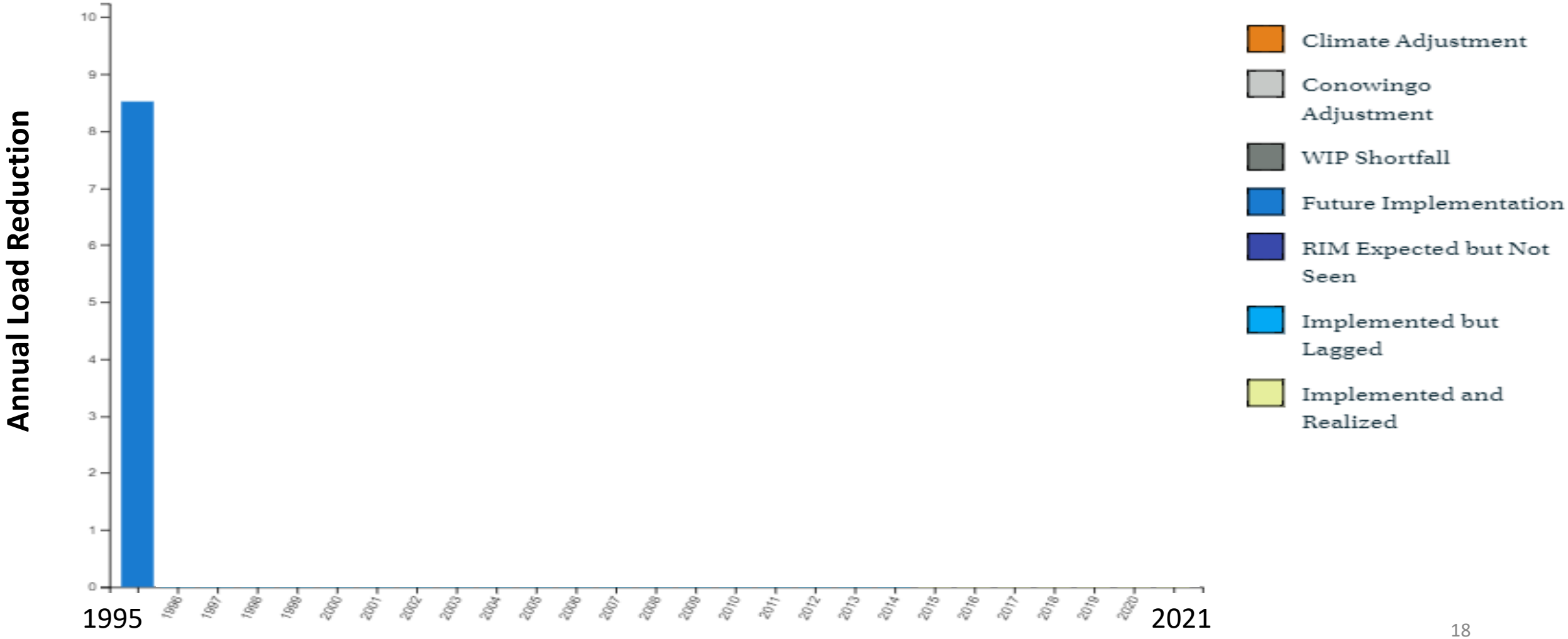
VIEW CHART VIEW TABLE



# Chesapeake Bay TMDL Indicator: Total Phosphorus

This indicator combines monitored and modeled data to estimate the progress of annual pollution loading rate reductions since 1995 in response to implemented management practices.

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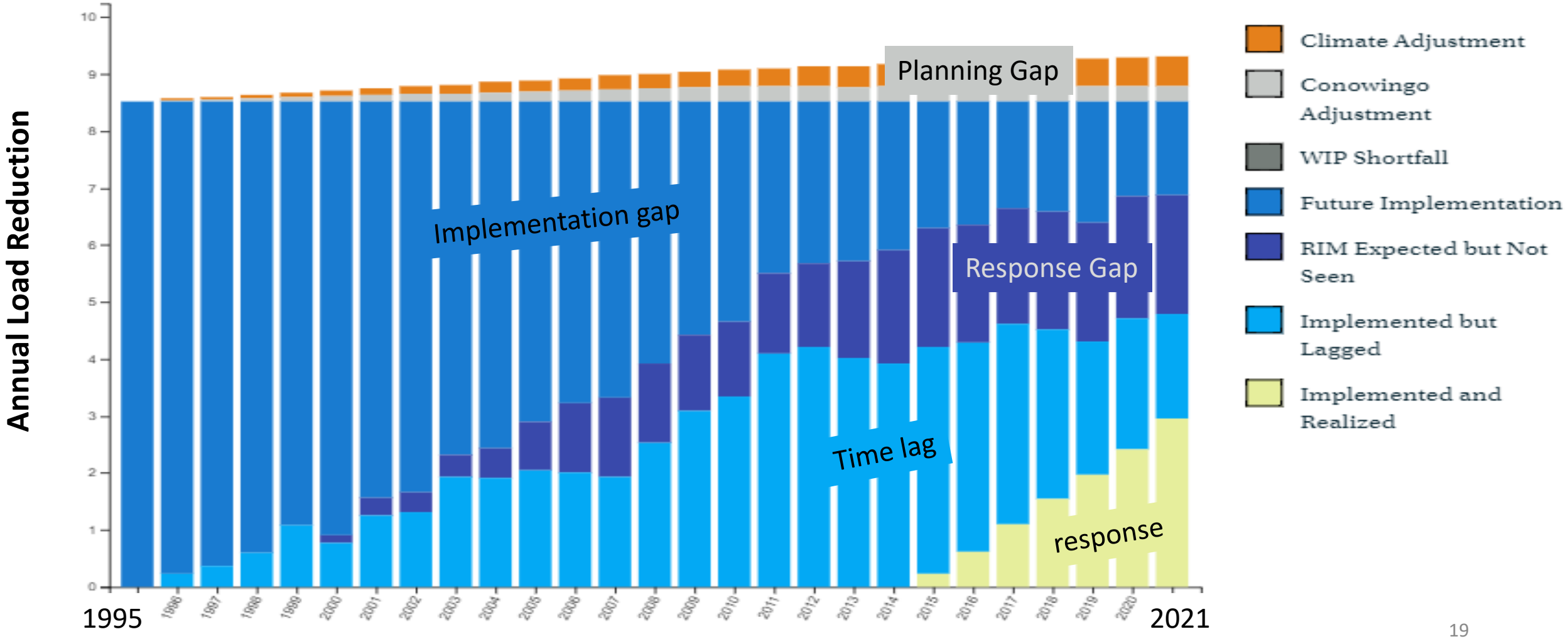


# Individual station interface

https://wqs.chesapeakebay.net/metric/

## Purpose

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 83, 66, and 66 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.

## User selection

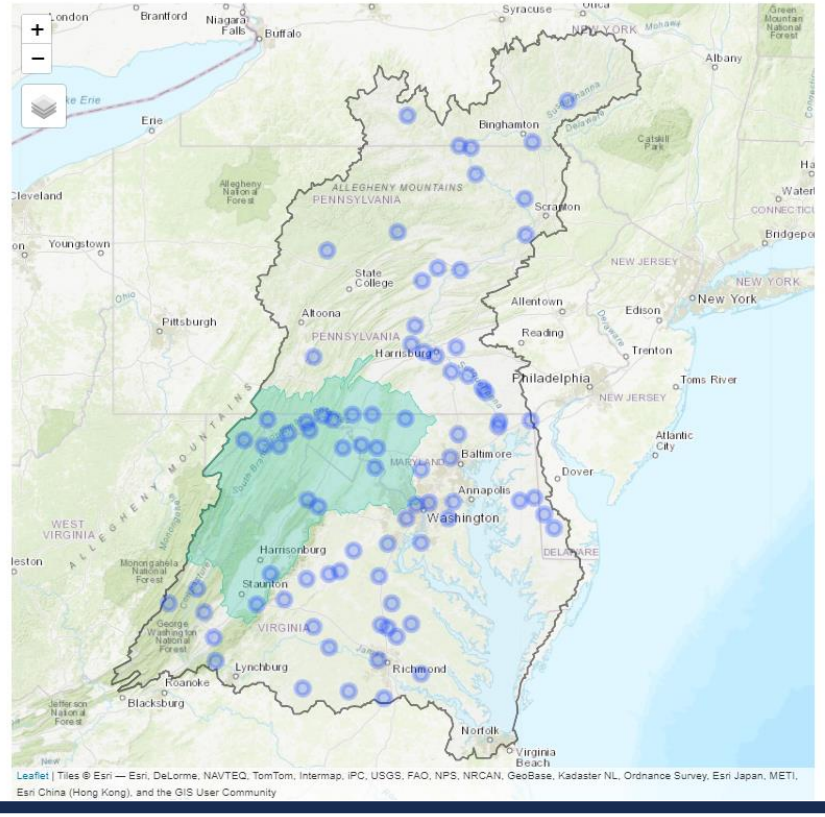
Step 1: Select the water-quality parameter:

(•) Total Nitrogen ( ) Total Phosphorus ( ) Suspended Sediment

Step 2: Select the monitoring station by clicking either Map or Table:

Map | Data Table

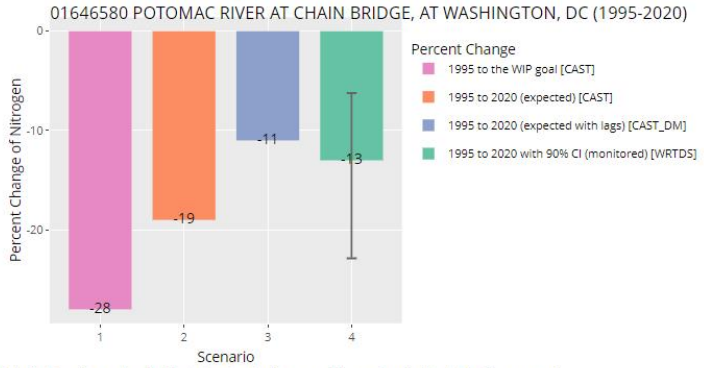
Tip: Move mouse cursor to any circle marker to show the station name.




## Results

About | Timeseries | WIP Goal | 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 About 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).

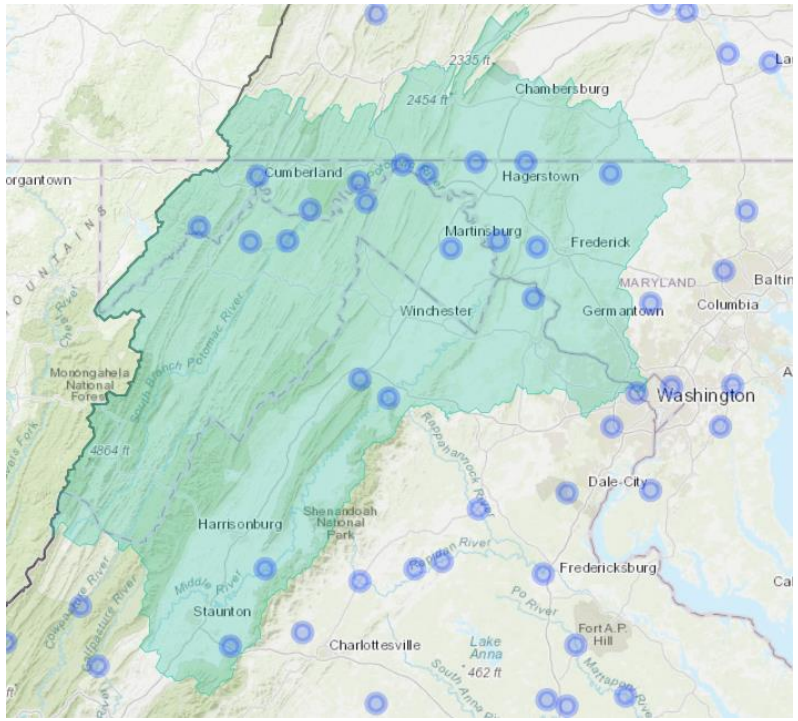
### Interpretive Text

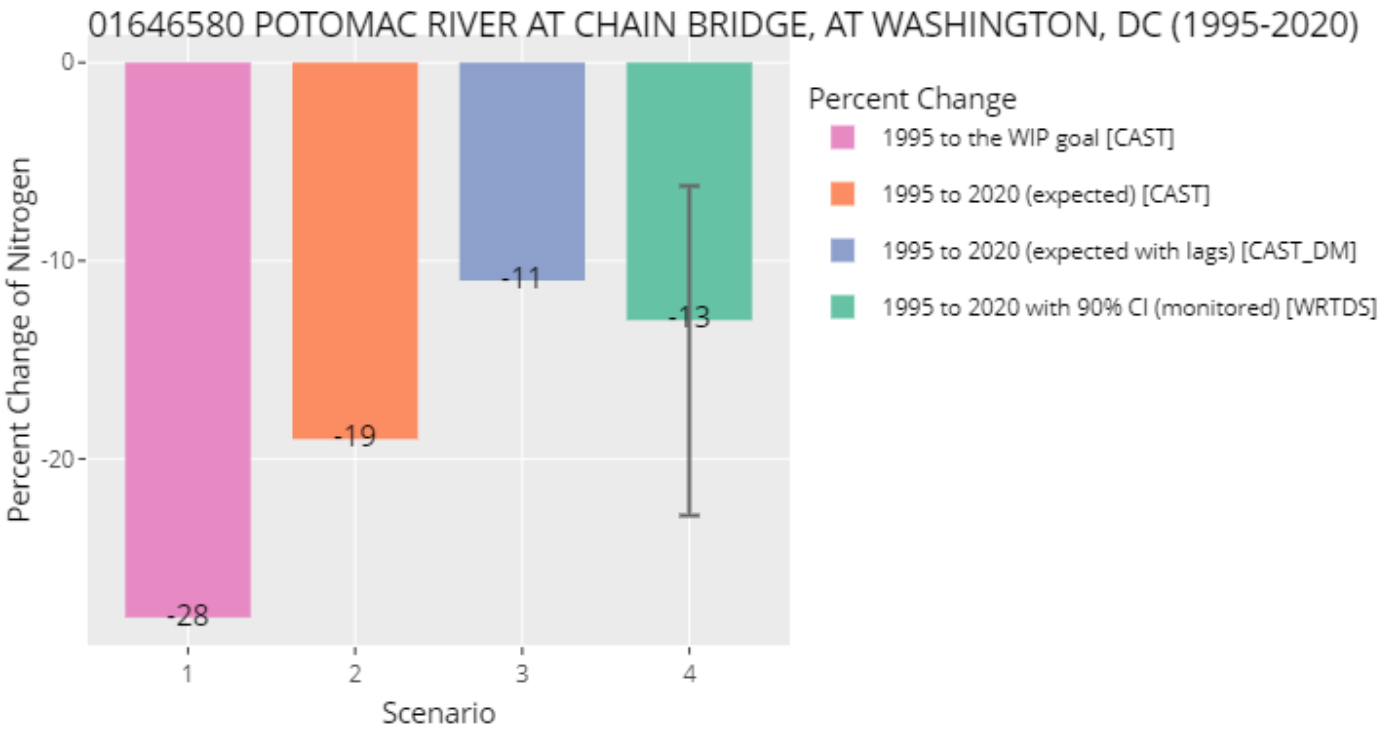
For Nitrogen at 01646580 POTOMAC RIVER AT CHAIN BRIDGE, AT WASHINGTON, DC, the period of analysis is 1995-2020.

1. Overall reduction - comparing the baseline year of 1995 with the WIP goal:
[Bar 1] CAST estimates a reduction of 28 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 2020:
[Bar 2] CAST estimates a reduction of 19 percent in the long term from 2020 land use, inputs, and management practices.
[Bar 3] The Dynamic Watershed Model (i.e., CAST_DM) estimates that a reduction of 11 percent would have been seen by 2020, accounting for lags, sampling frequency, and other factors.
[Bar 4] The river monitoring data (i.e., WRTDS) show a reduction of 13 percent with a 90% uncertainty range of (-23%, -6%).

# Example 1: 01646580 Potomac River Total Nitrogen




Interpretive Text

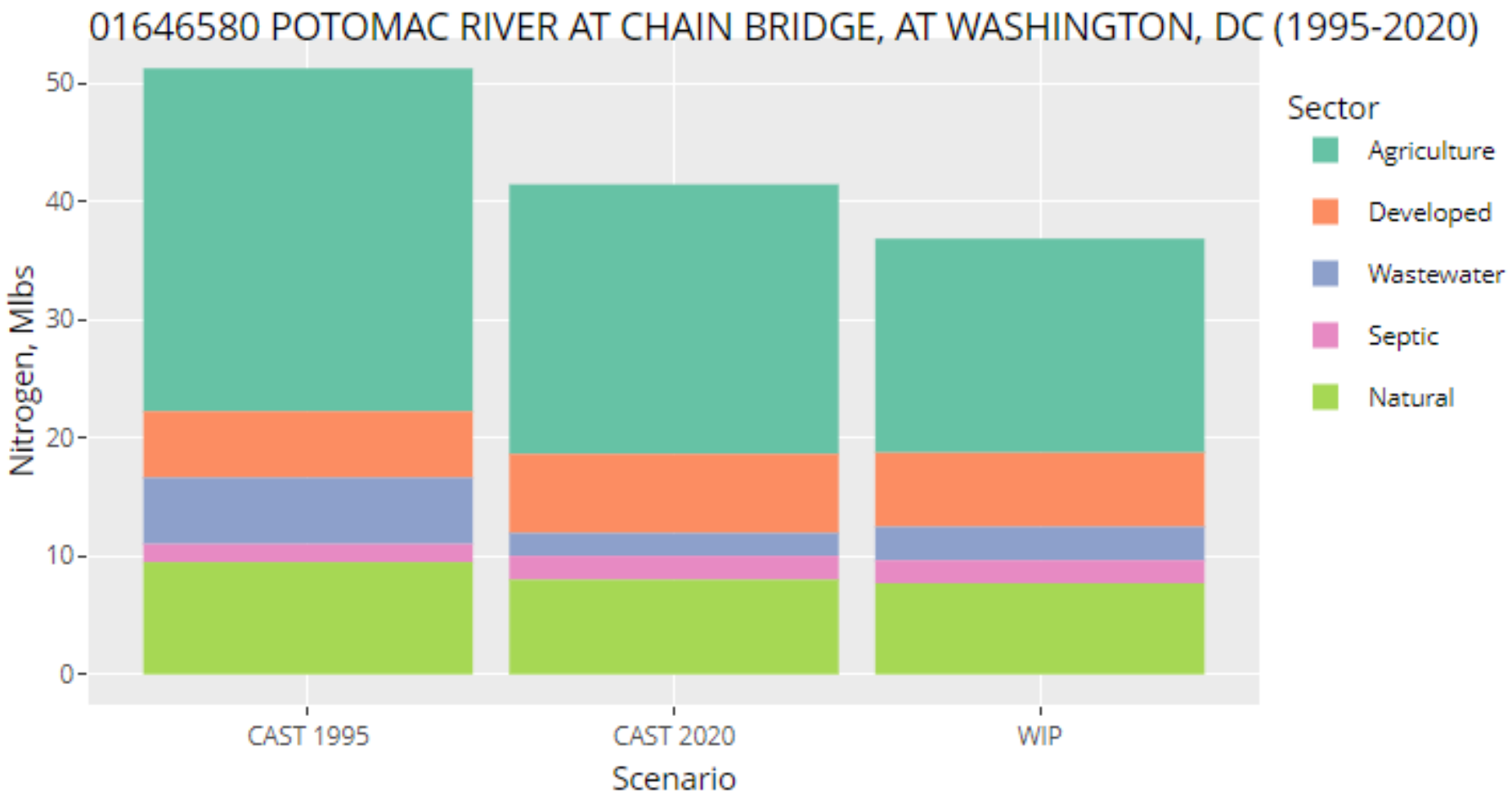
1. CAST estimates a 28 percent reduction in the long term from **implementation of the WIP** using 2025 land use and inputs.
2. CAST estimates a 19 percent reduction in the long term from **2020** land use, inputs, and management practices.
3. The Dynamic Watershed Model estimates that only a 11 percent reduction would have been seen by 2020, accounting for lags, sampling frequency, and other factors.
4. The river monitoring data show a 13 percent reduction with a 90% uncertainty range between 6 and 23 percent reduction.

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

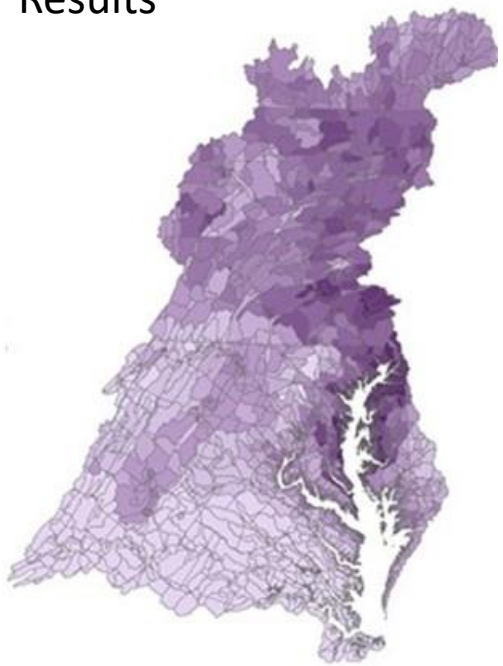
# Results:
# WIP Goal

About | Timeseries | WIP Goal | Progress | Download

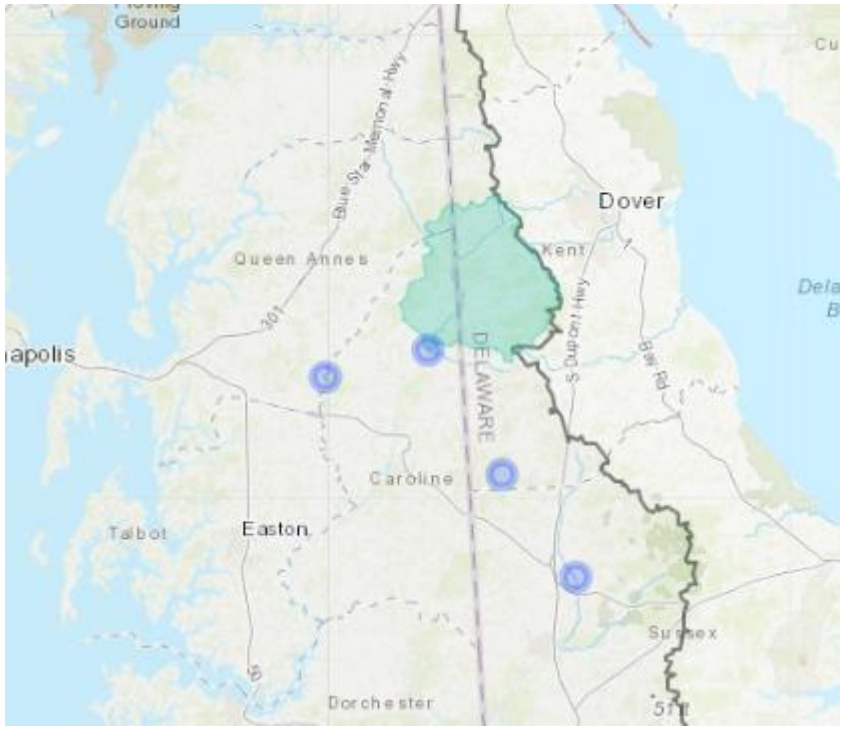
## Interactive Plot

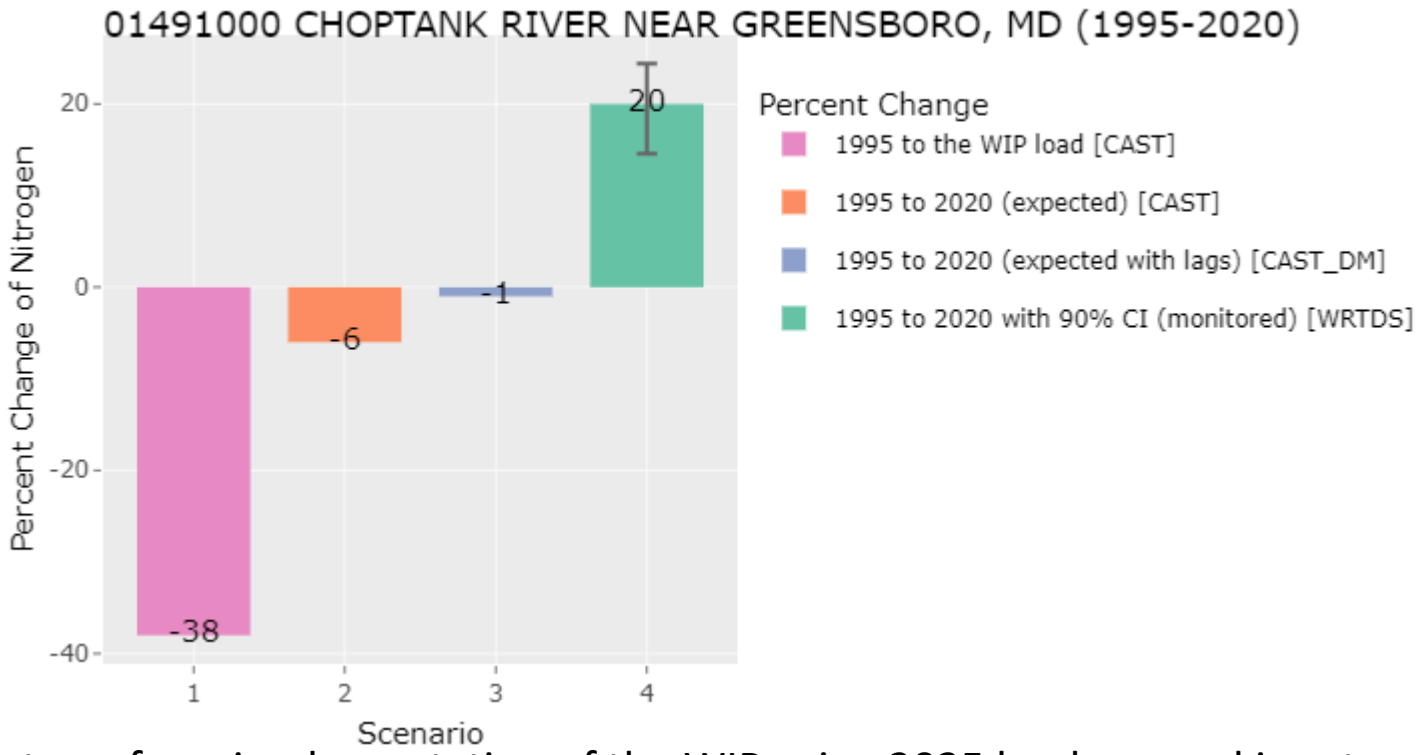



Watershed Model (CAST) Results



# 01491000 CHOPTANK RIVER NEAR GREENSBORO, MD Nitrogen



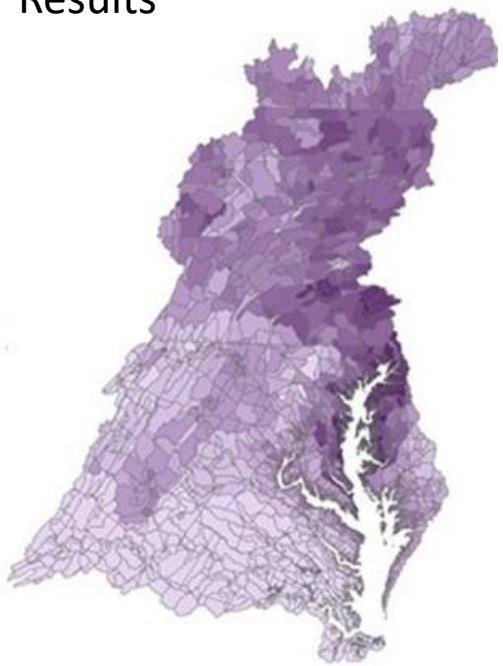

Interpretive Text

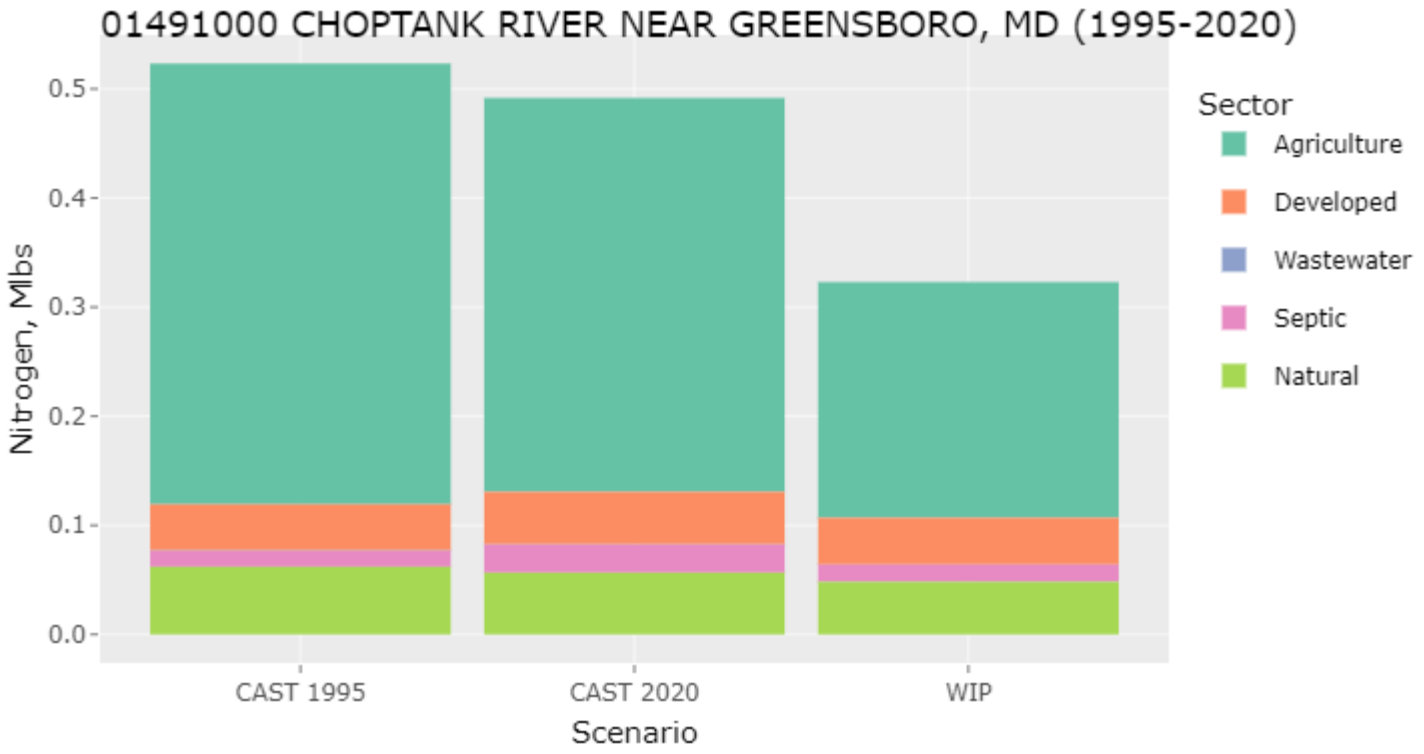
1. CAST estimates a 25 percent reduction in the long term from implementation of the WIP using 2025 land use and inputs.
2. CAST estimates a 31 percent reduction in the long term from 2020 land use, inputs, and management practices.
3. The Dynamic Watershed Model estimates that a 31 percent decrease would have been seen by 2020, accounting for lags, sampling frequency, and other factors.
4. The river monitoring data show a 32 percent reduction with a 90% uncertainty range between 28 and 37 percent reduction.

**Implication**: The observed response is opposite of what was expected over the period of 1995-2020.

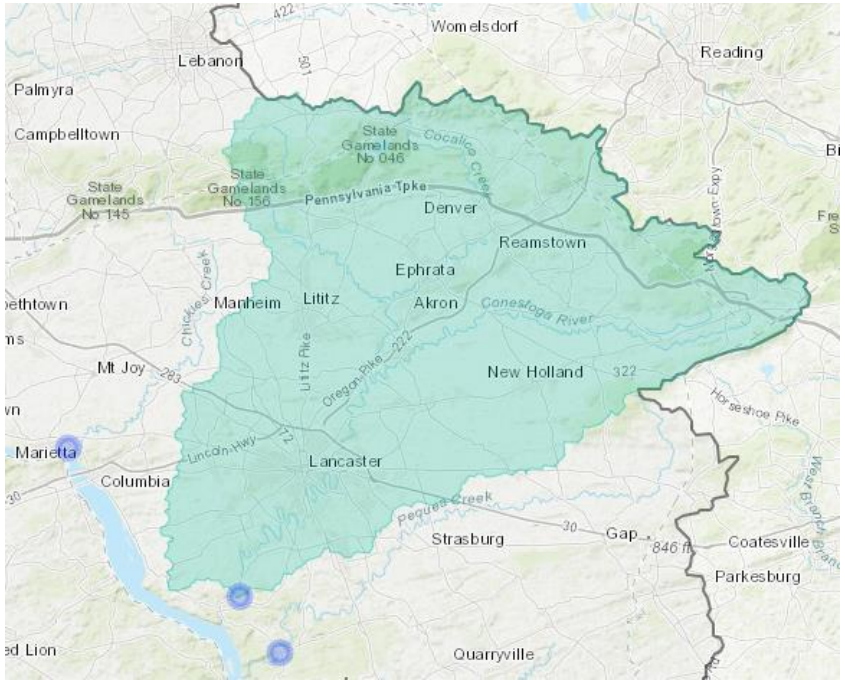
# Results:
## WIP Goal

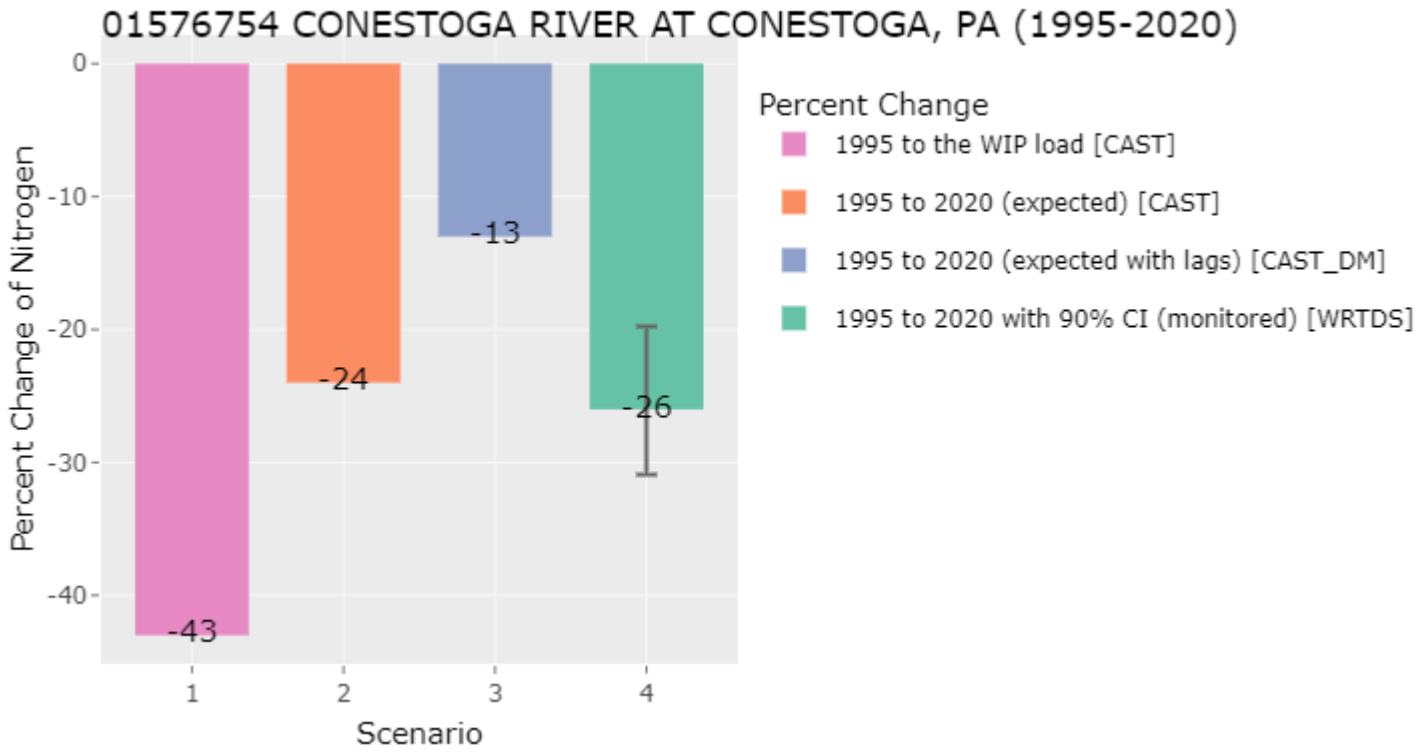
Watershed Model (CAST) Results





# 01576754 CONESTOGA RIVER AT CONESTOGA, PA - TN



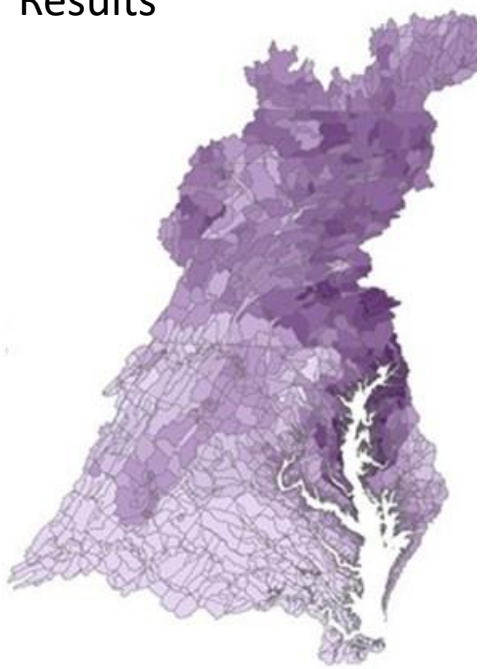

Interpretive Text

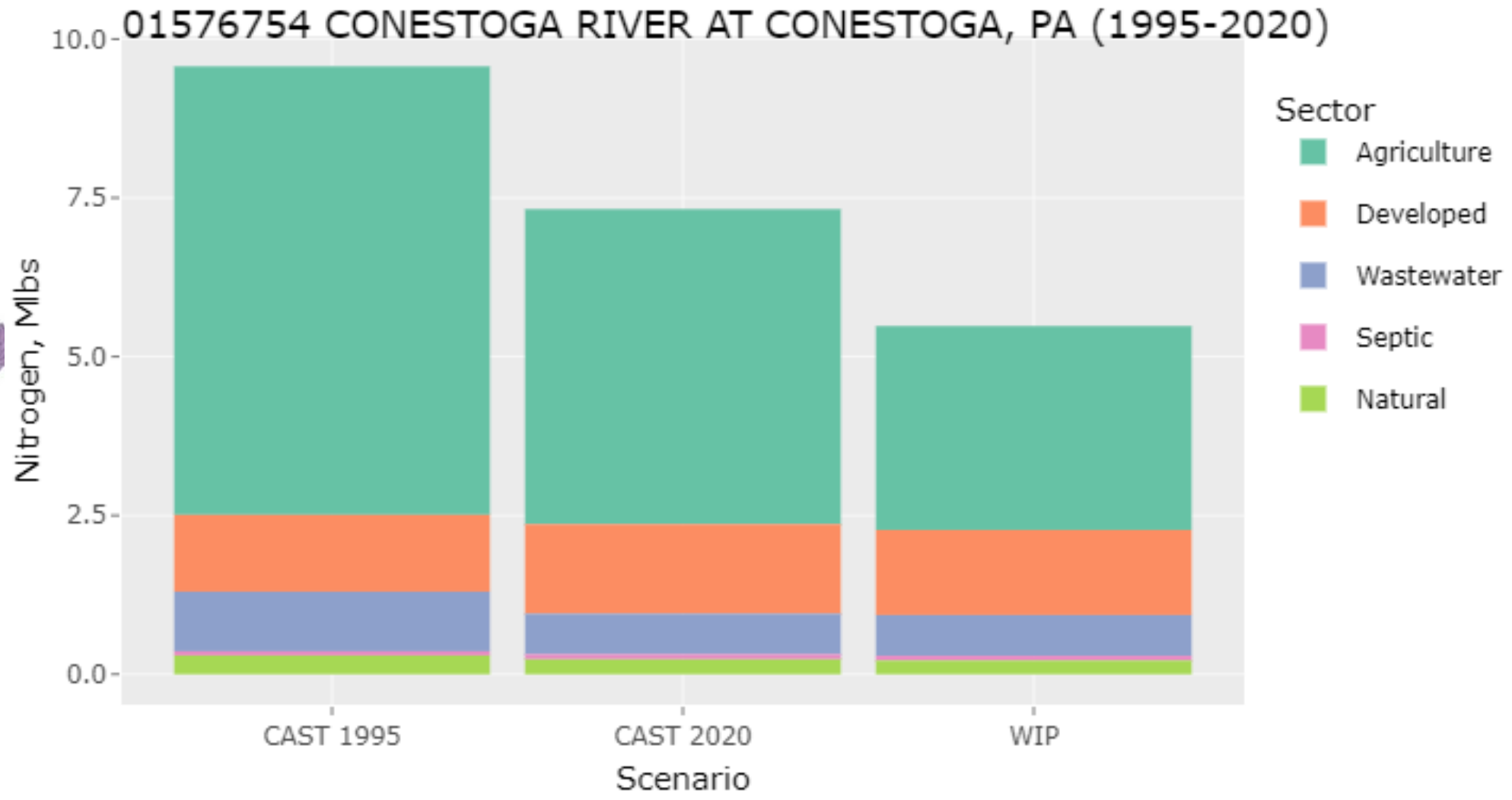
1. CAST estimates a 43 percent reduction in the long term from **implementation of the WIP** using 2025 land use and inputs.
2. CAST estimates a 24 percent reduction in the long term from **2020** land use, inputs, and management practices.
3. The Dynamic Watershed Model estimates that only a 13 percent reduction would have been seen by 2020, accounting for lags, sampling frequency, and other factors.
4. The river monitoring data show a 26 percent reduction with a 90% uncertainty range between 20 and 31 percent reduction.

**Implication**: The observed response is greater than expected over the period of 1995-2020.

# Results:
## WIP Goal

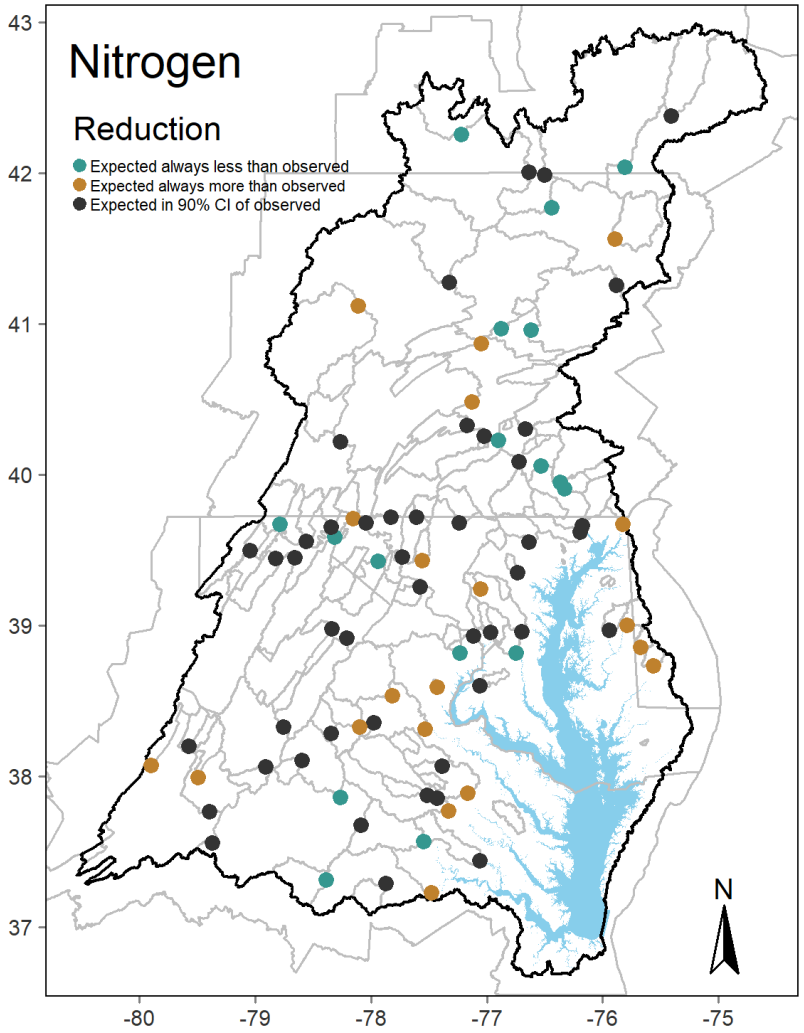
Watershed Model (CAST) Results

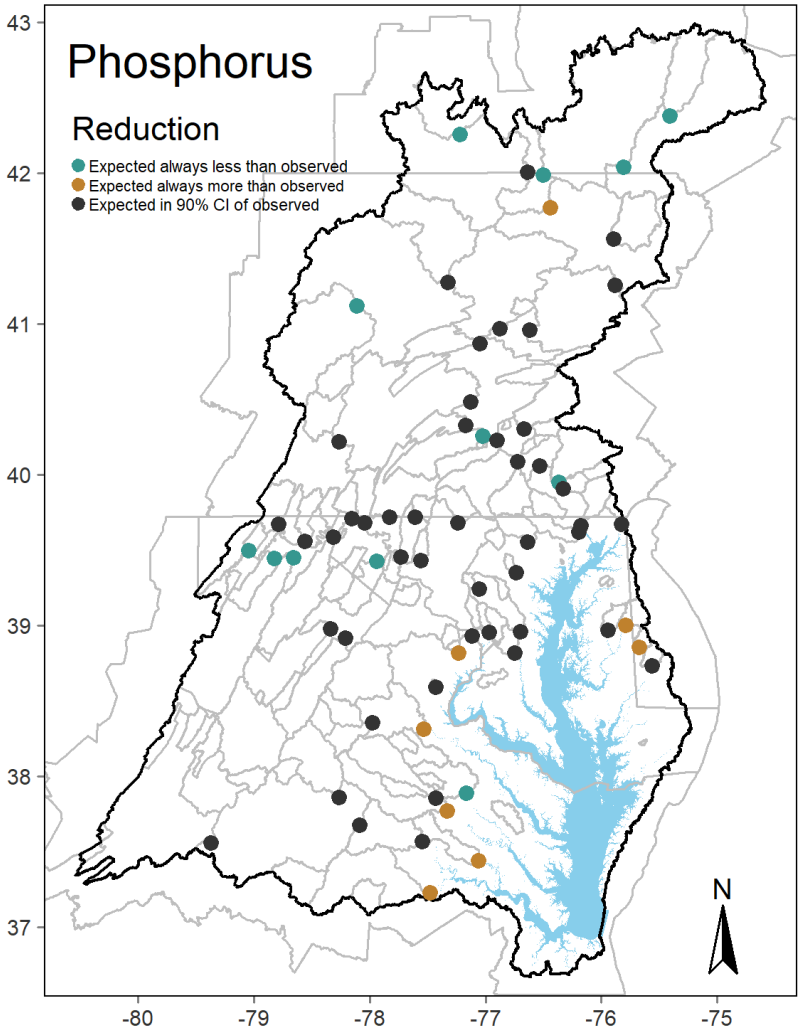


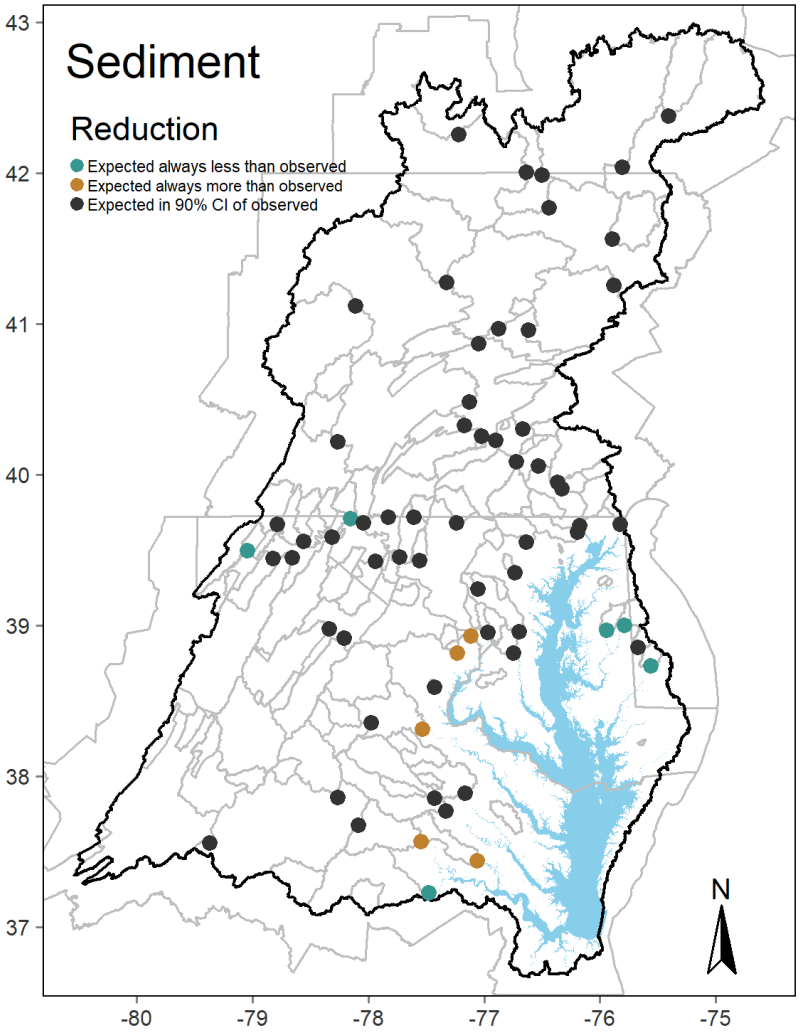


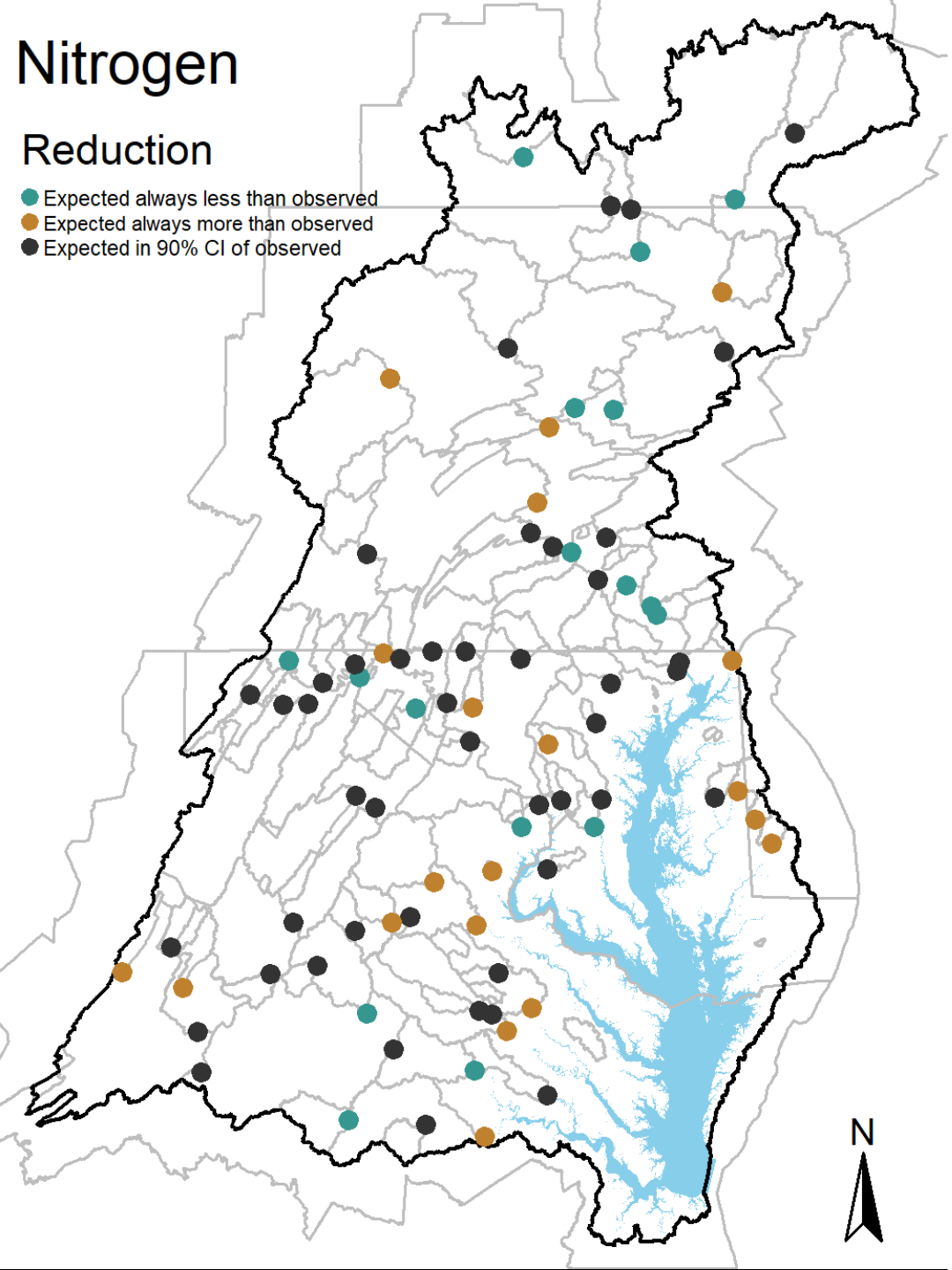
# All stations

- 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





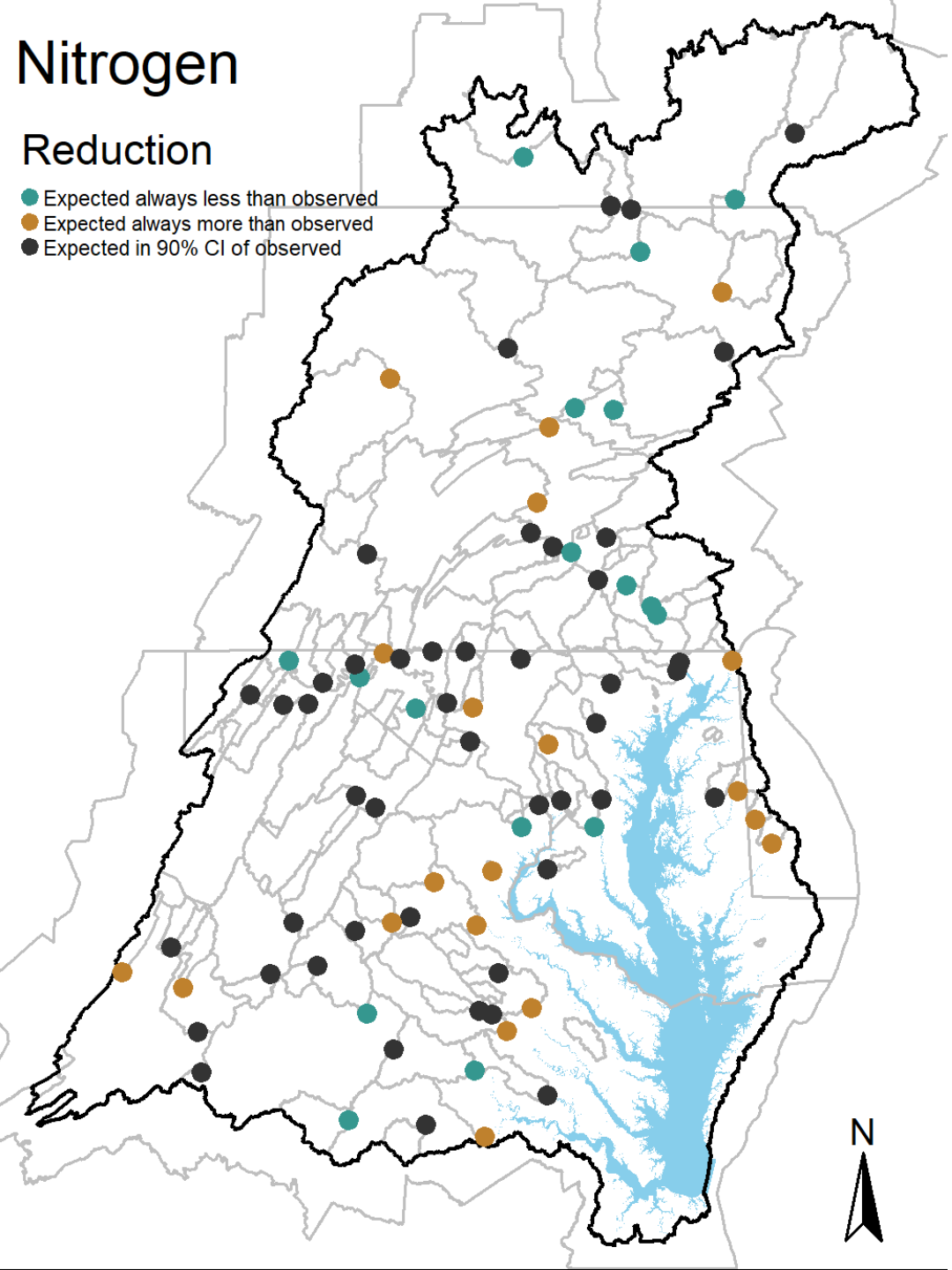

- Model within the error range of the observed trend
- Model showing greater reduction; doing worse than expected
- Data showing greater reduction; doing better than expected

About a third in each category

Potential Patterns:

Coastal plain worse than expected?

larger rivers better predicted?




- 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

Next Step: Why?

Machine Learning approaches

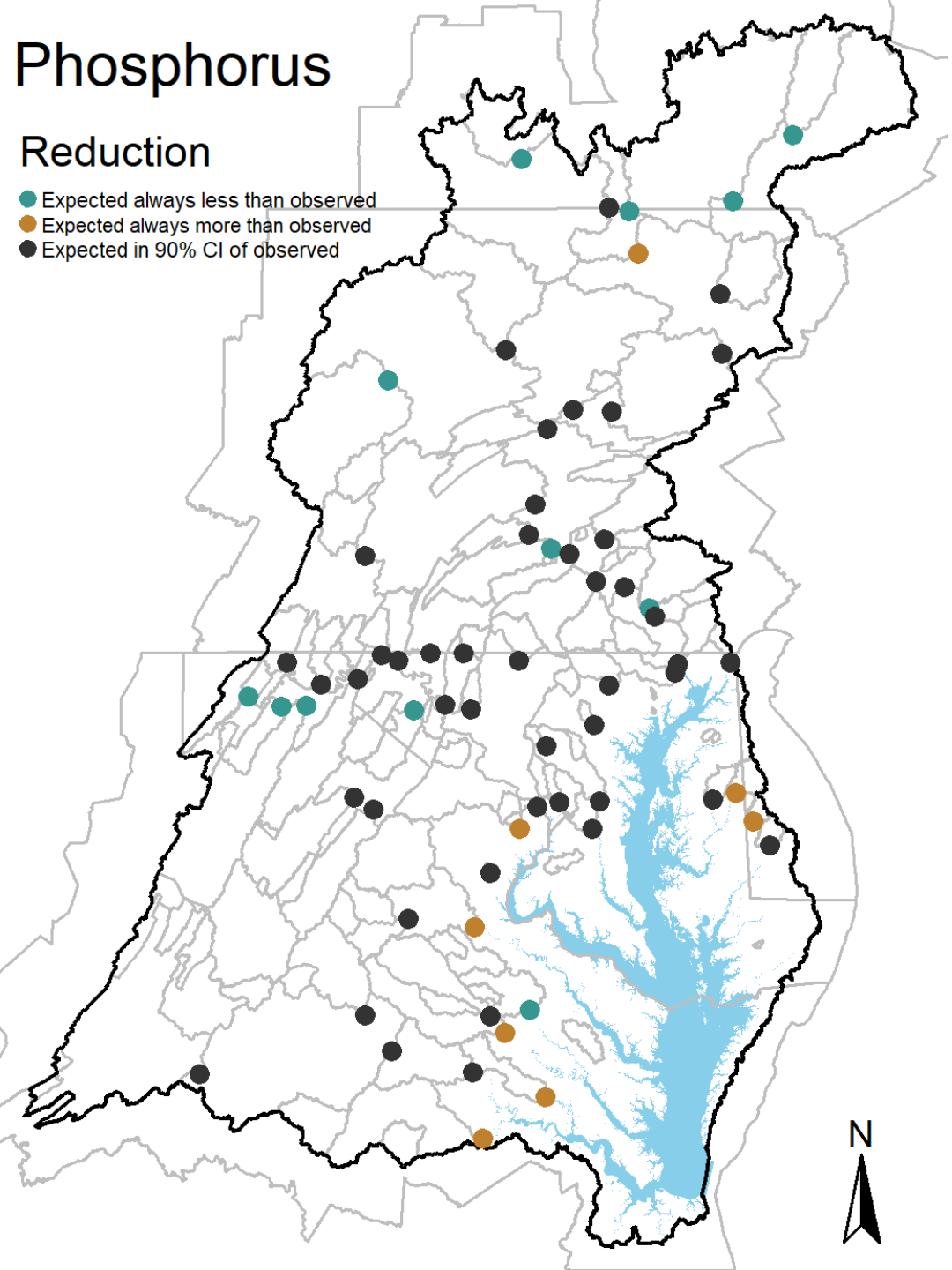
Robert Sabo (EPA ORD)

Qian Zhang (UMCES)

Bayesian Approach as part of Phase 7

Isabella Bertani (UMCES)





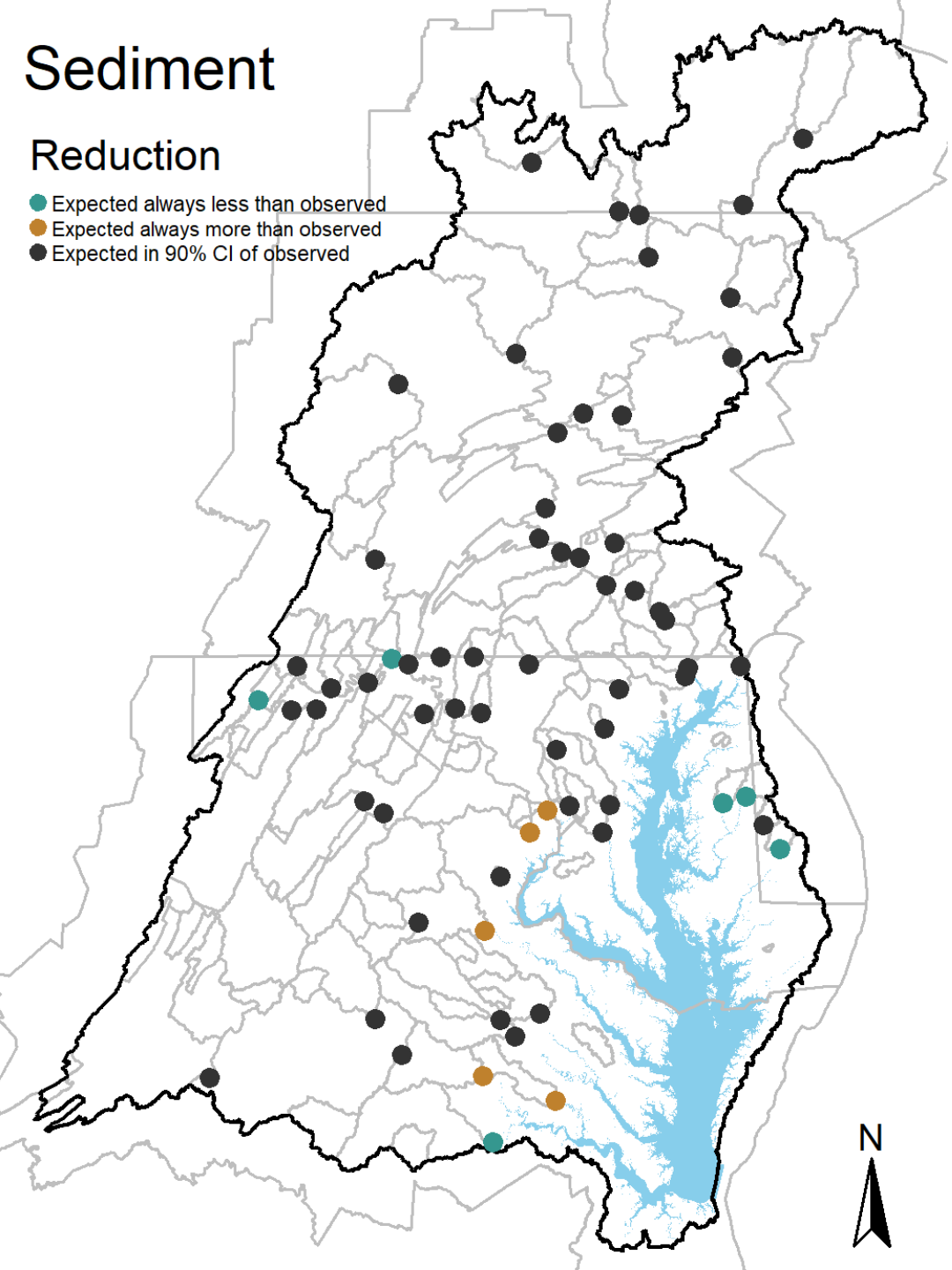

- Model within the error range of the observed trend
- Model showing greater reduction; doing worse than expected
- Data showing greater reduction; doing better than expected

More in the accurate category

Potential Patterns:

Coastal plain worse than expected?

all others better than expected?




- 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

Most in the accurate category

Potential Patterns:

southern piedmont worse than expected?

eastern shore better than expected?

https://metric.chesapeakebay.net/metric/

# Reception and Uses

- Significant interest from across the CBP (15th presentation!)

- 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?