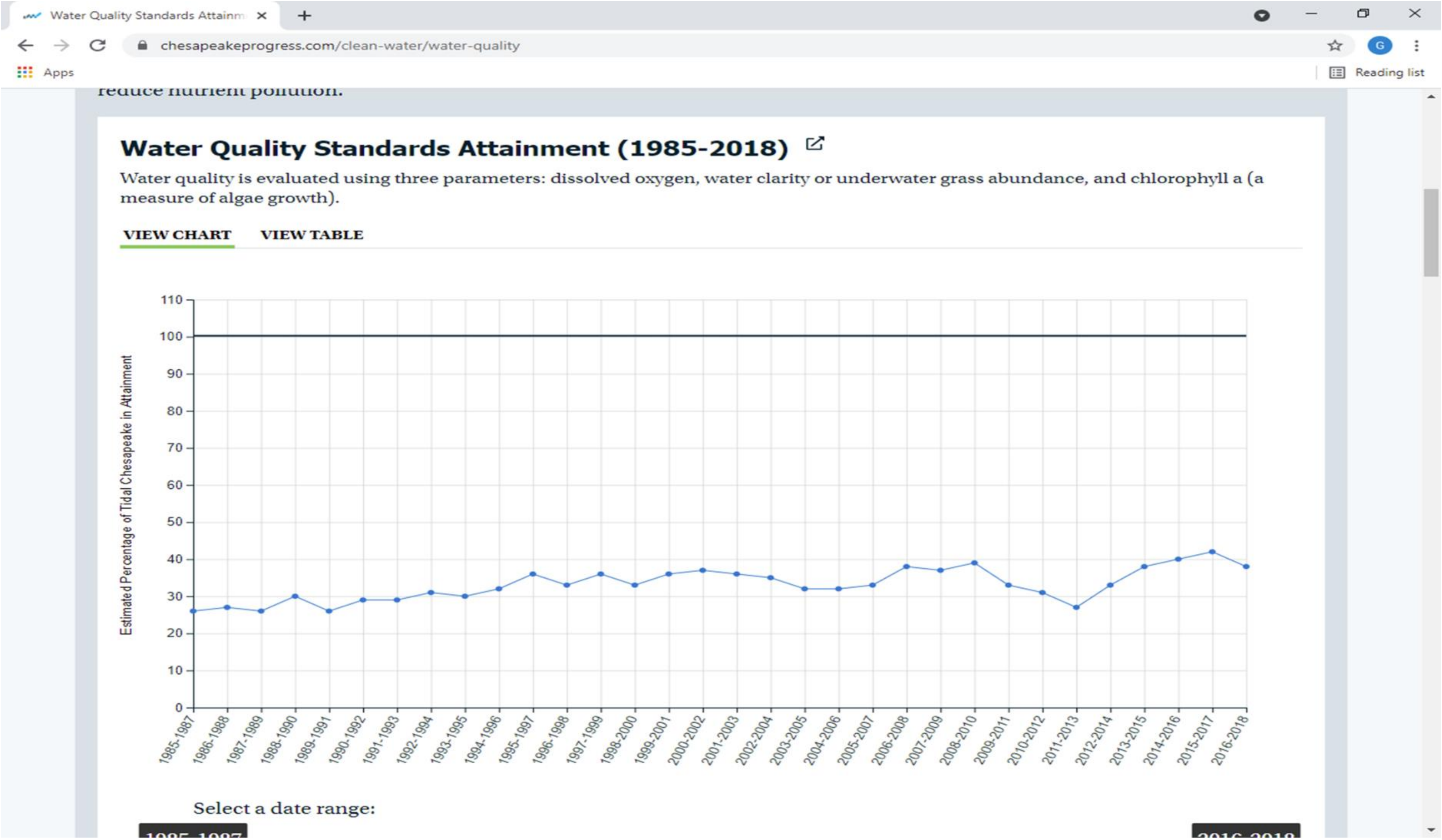
CBP Integrated Watershed TMDL indicator

Gary Shenk, Qian Zhang, Gopal Bhatt, Isabella Bertani, Chris Mason, Doug Moyer

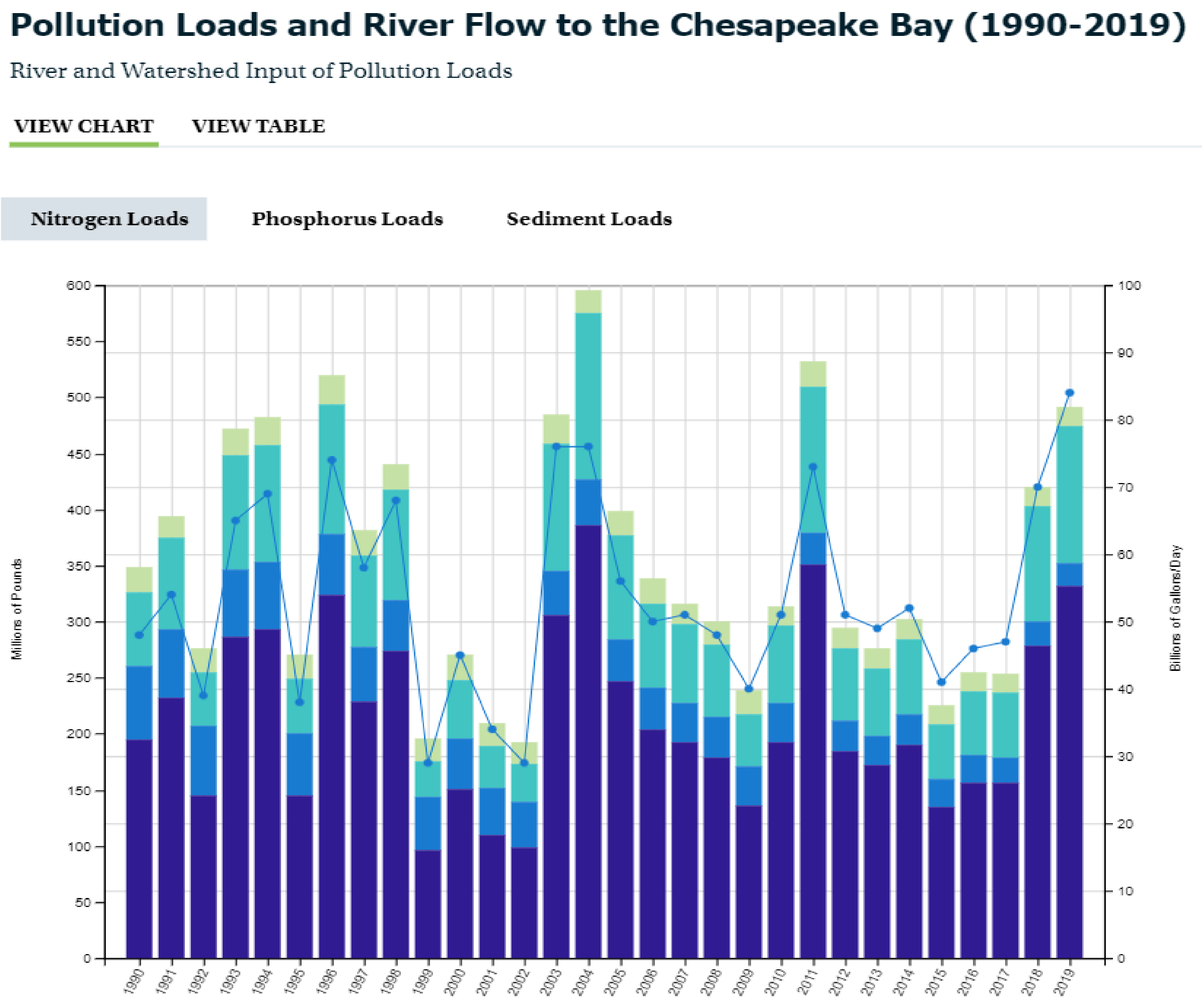
Tidal Water TMDL Indicator

Very slow positive change



Nontidal Load Indicator

Extreme variability
No Clear Trend



WIP Indicator

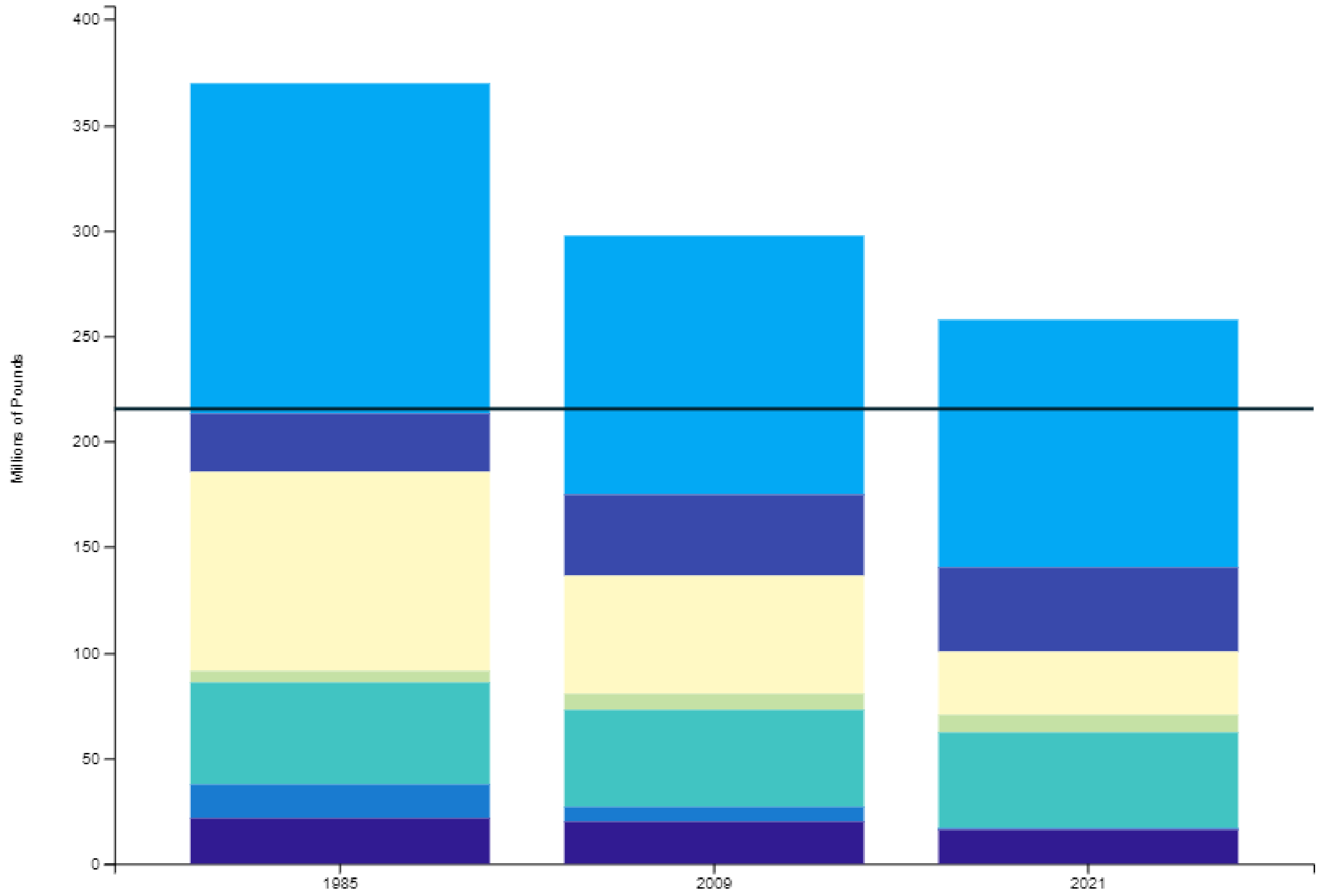
We’re almost done?

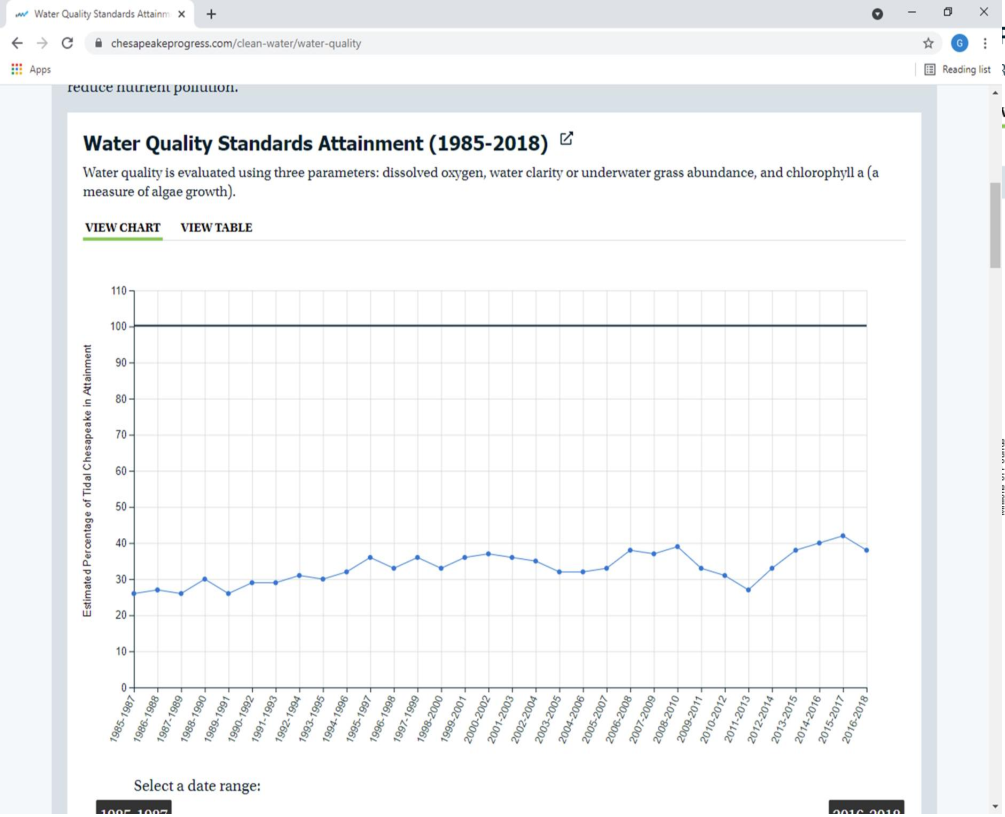
Modeled Nitrogen Loads to the Chesapeake Bay (1985-2021)

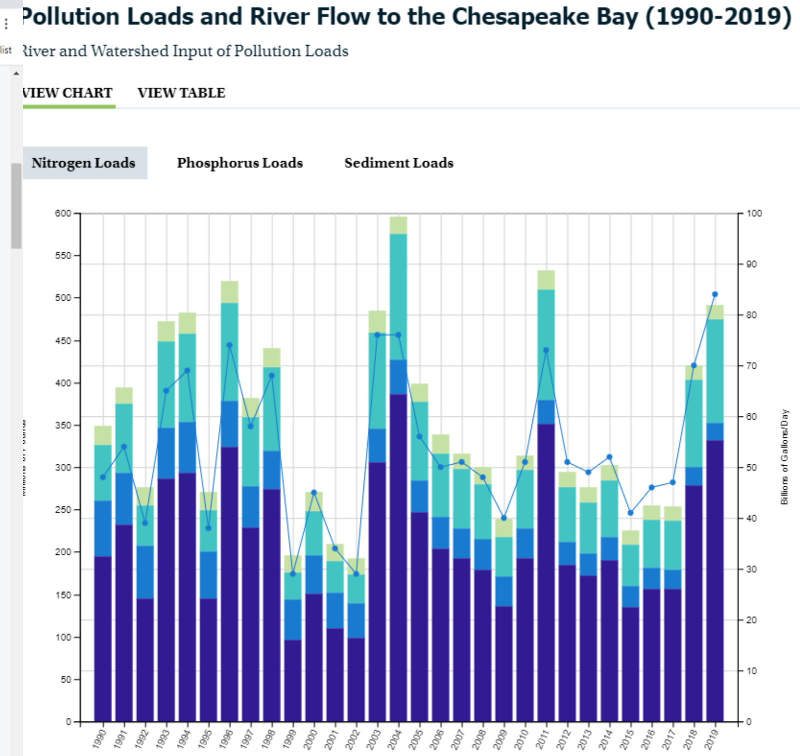
Loads simulated using CAST19 and jurisdiction-reported data on wastewater discharges. *The natural sector
wetlands which are preferable land use types with the lowest loading rates among sources.

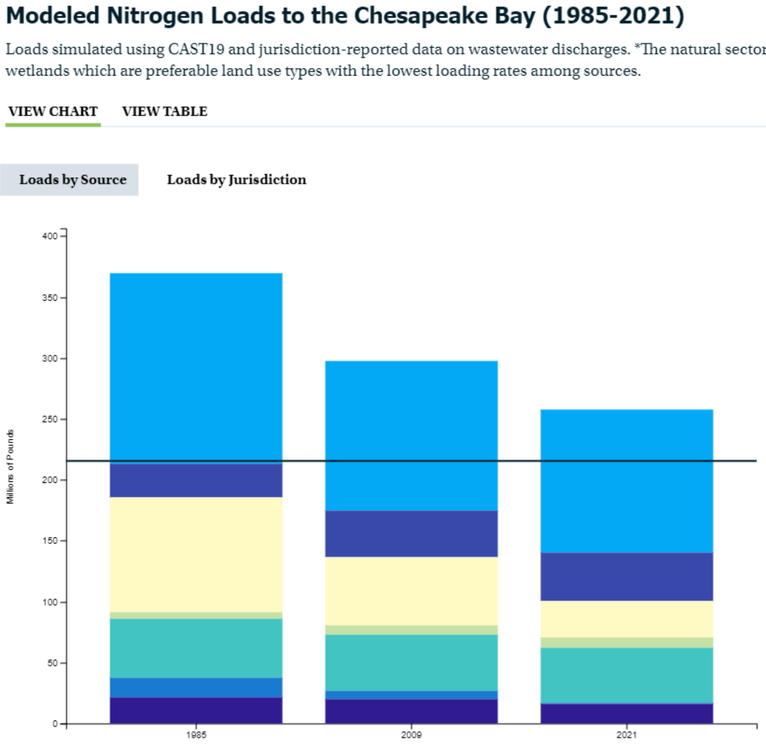
VIEW CHART **VIEW TABLE**

Loads by Source **Loads by Jurisdiction**









Ator, S.W., Blomquist, J.D., Webber, J.S. and Chanat, J.G., 2020. Factors driving nutrient trends in streams of the Chesapeake Bay watershed. *Journal of Environmental Quality*, *49*(4), pp.812-834.

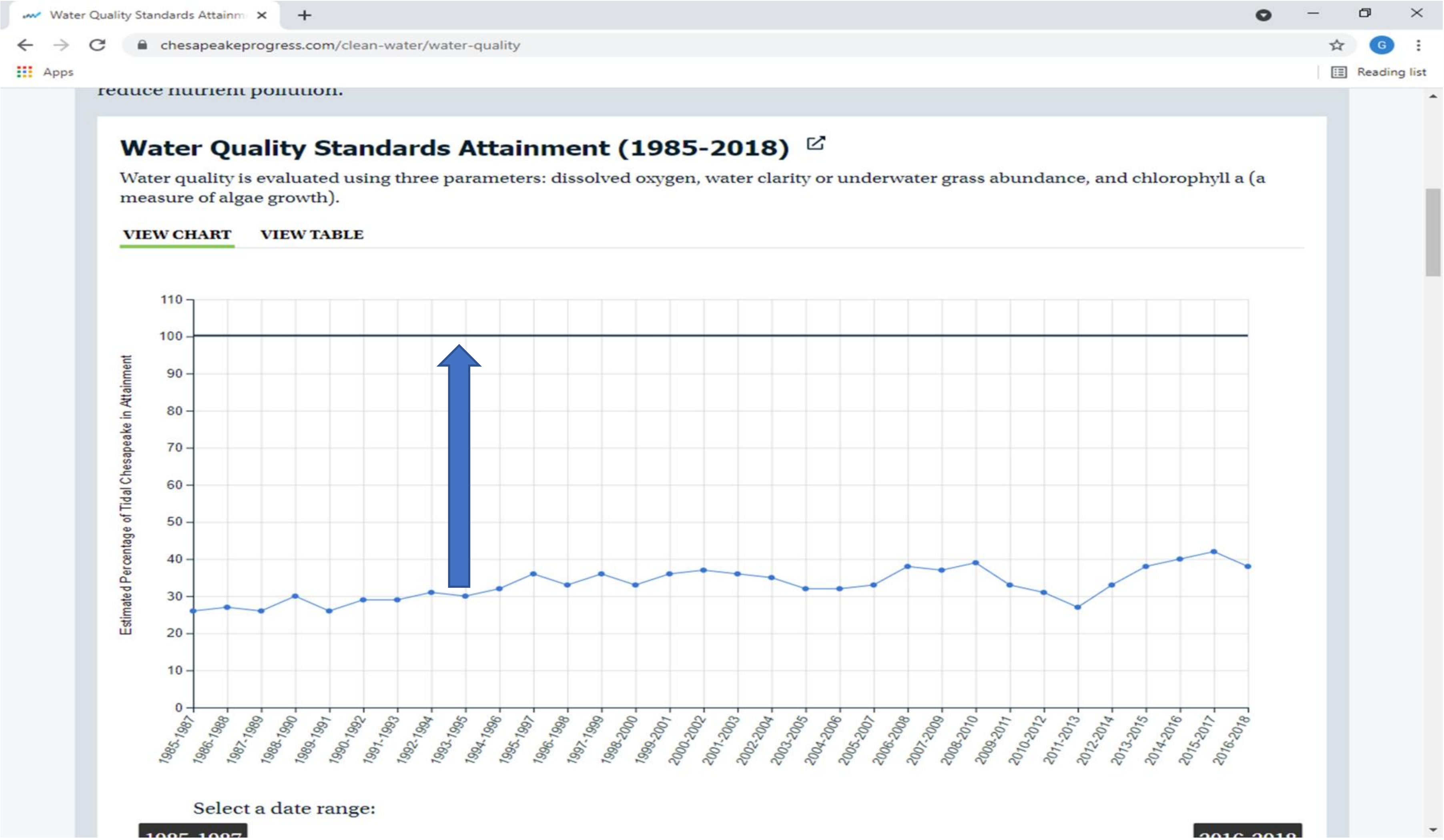
Differences due to:
Averaging periods
Lag times
Temperature effects
Errors in both estimates

Differences due to:
Normalization for flow
Lag times
Non-management factors
Errors in both estimates

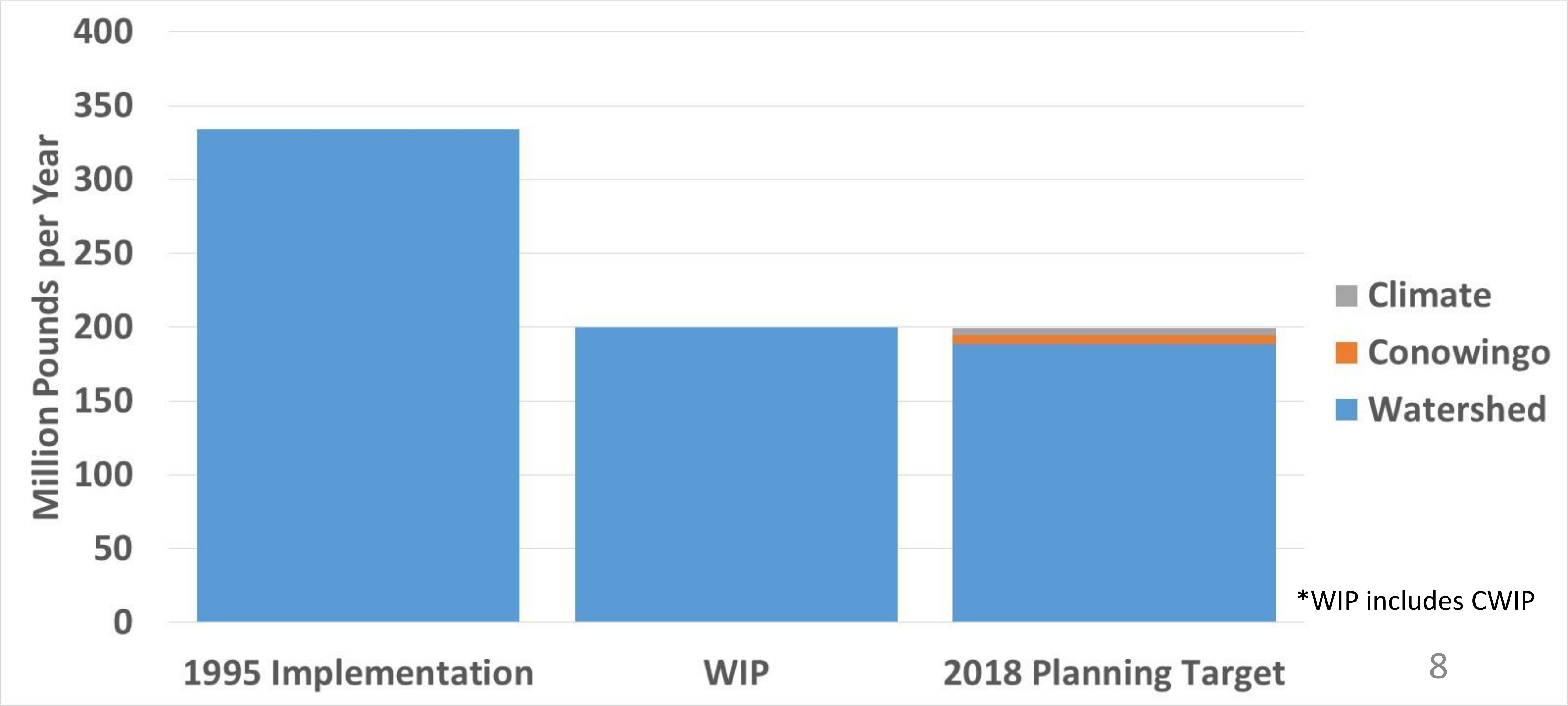
Purpose: Build an indicator that is:

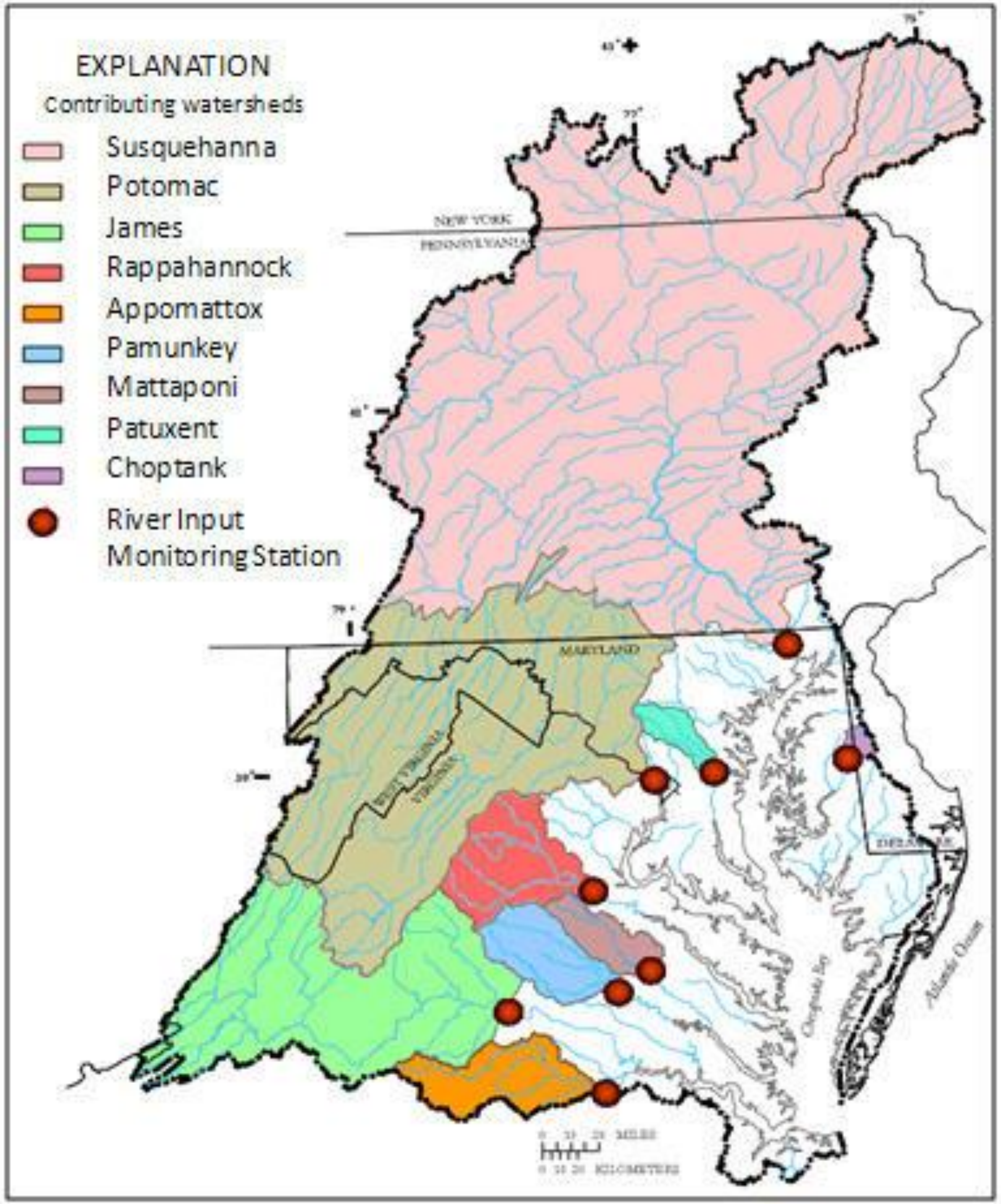
- Relevant to the TMDL
- Based on monitored changes in load to the extent possible
- Bridges monitoring and modeling by assessing lag time and other effects

TMDL question: What level of load reduction from 1995 will be necessary to meet water quality standards?



Loads required to meet TMDL Goals

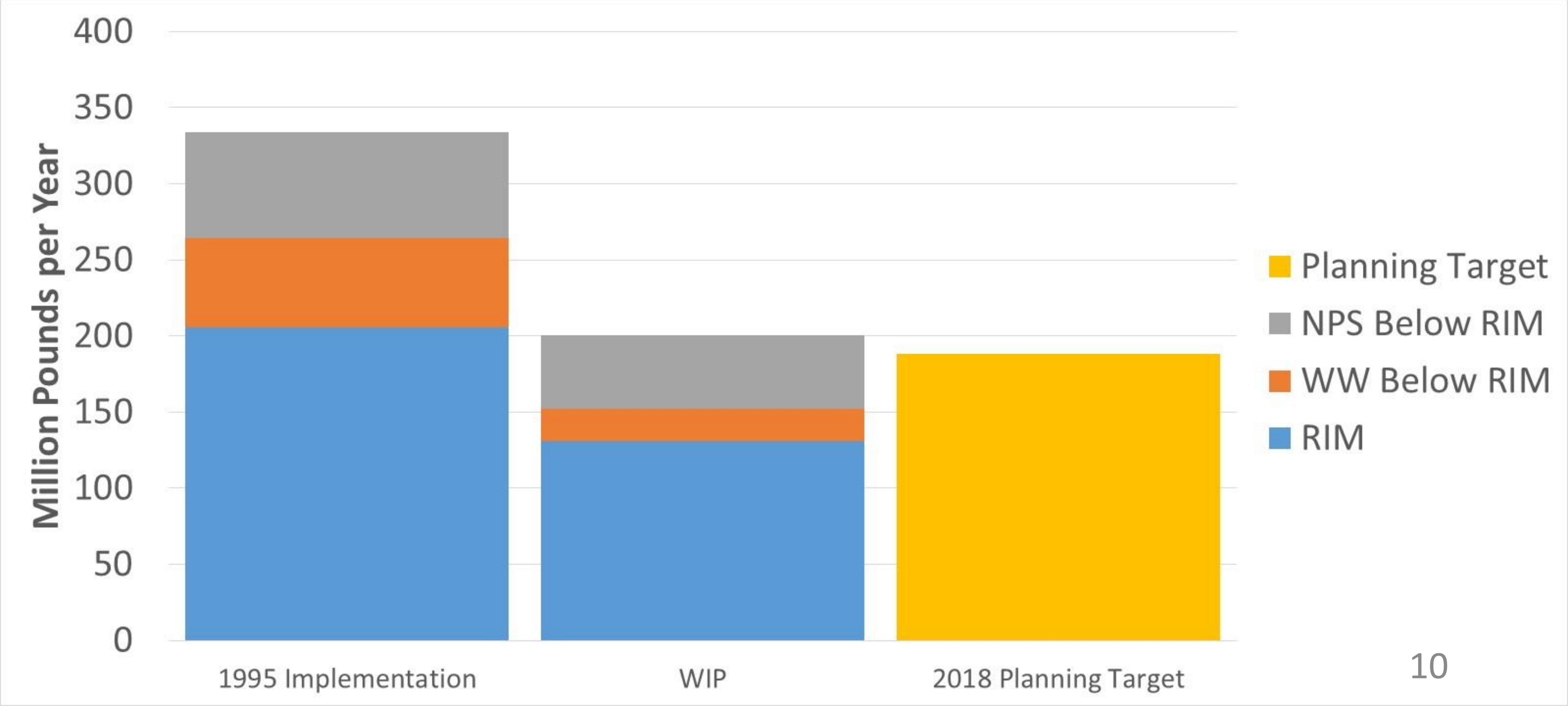




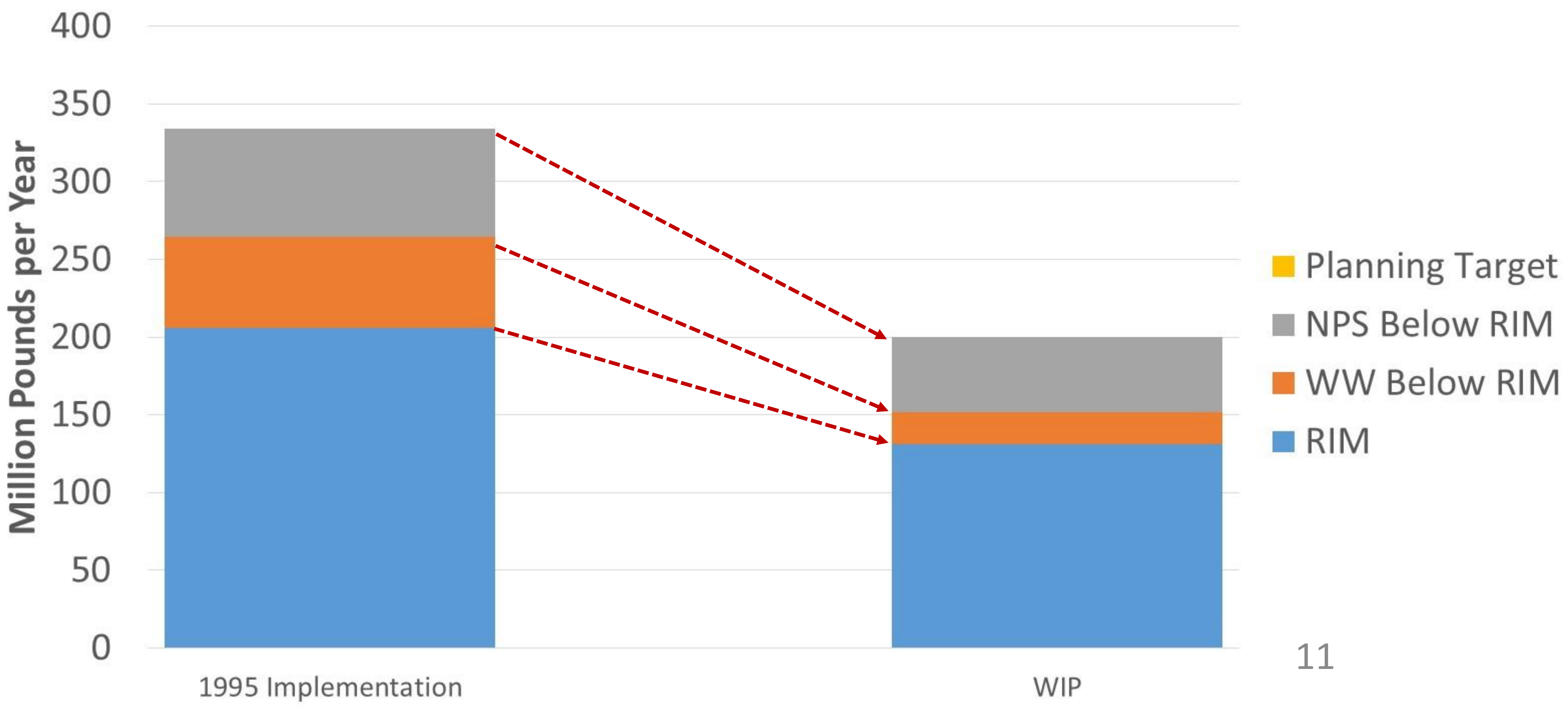
River Input Monitoring (RIM)

- Covers most of the CB watershed
  - 80% of land
  - 60% of load
- Many large WWTP are below RIM stations

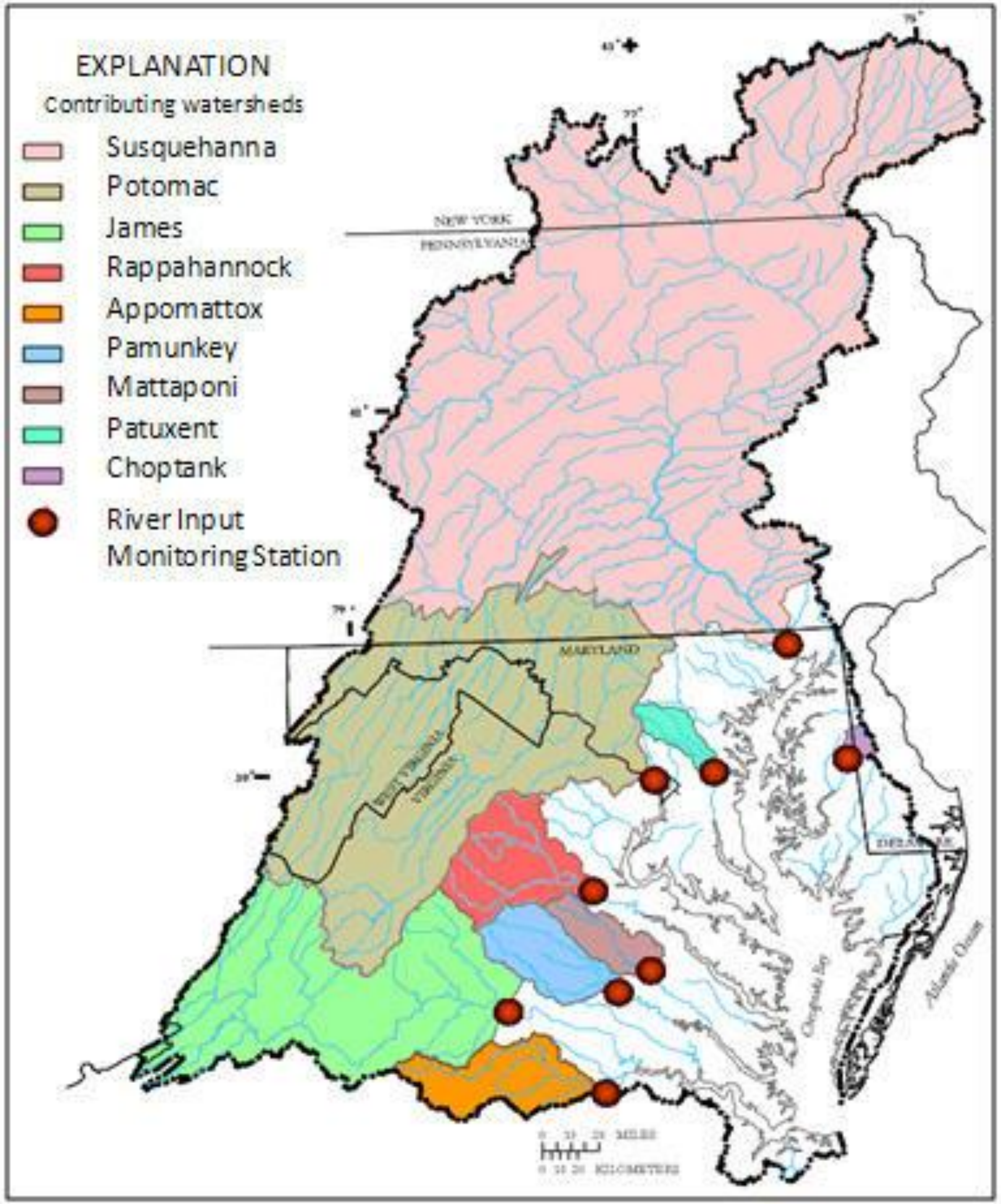
Reductions required to meet TMDL Goals

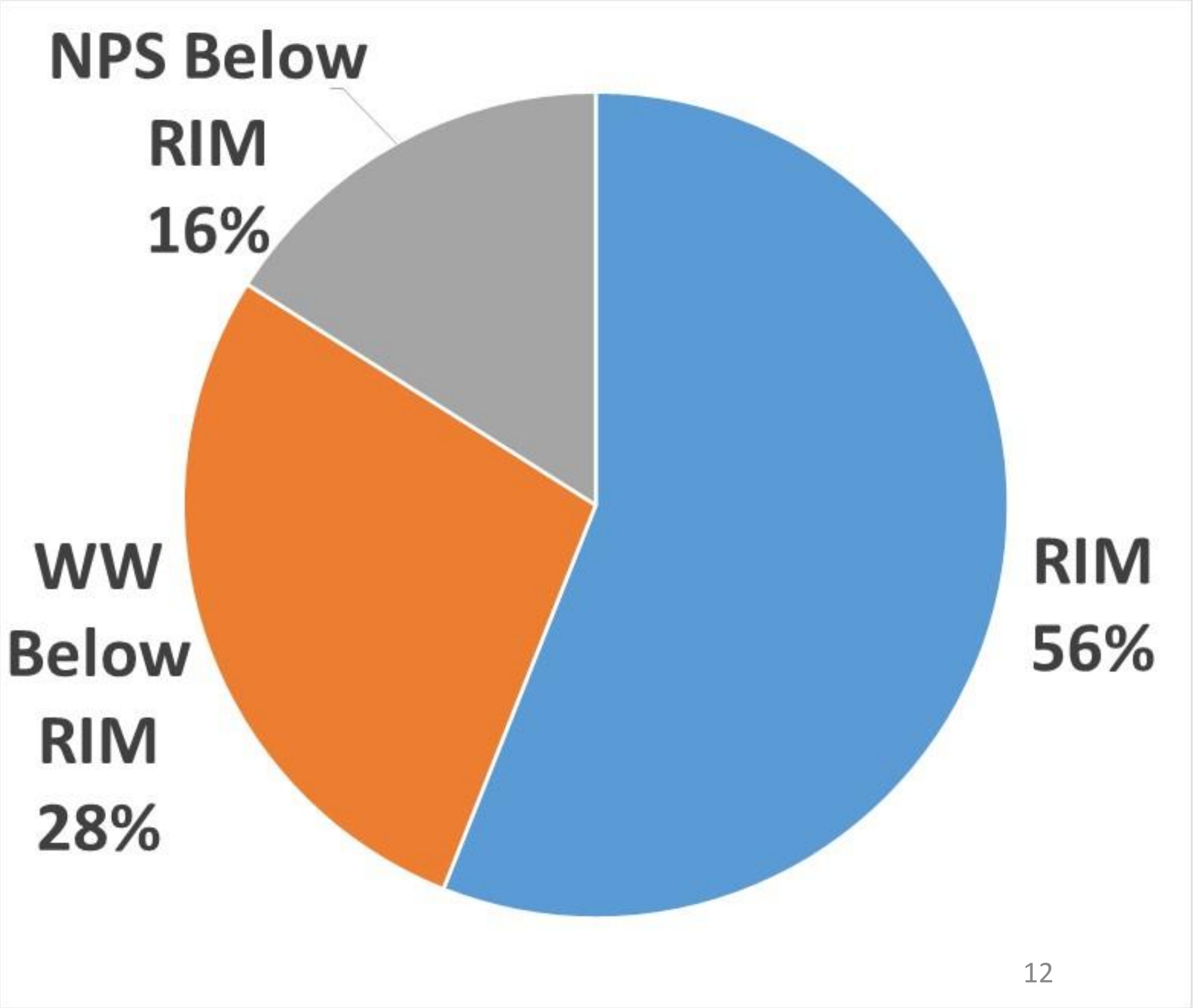


Reductions required to meet TMDL Goals

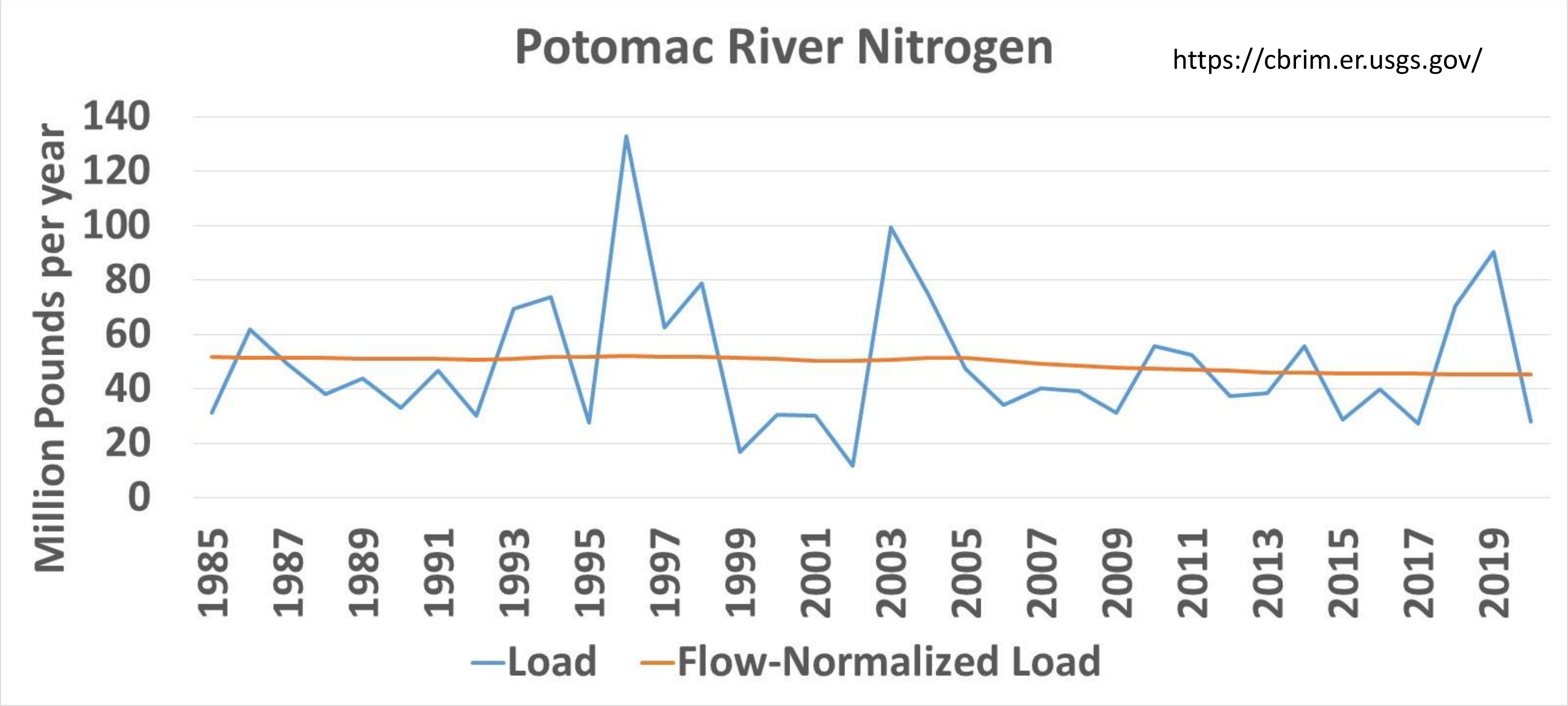


84% of Expected Reduction is Monitored

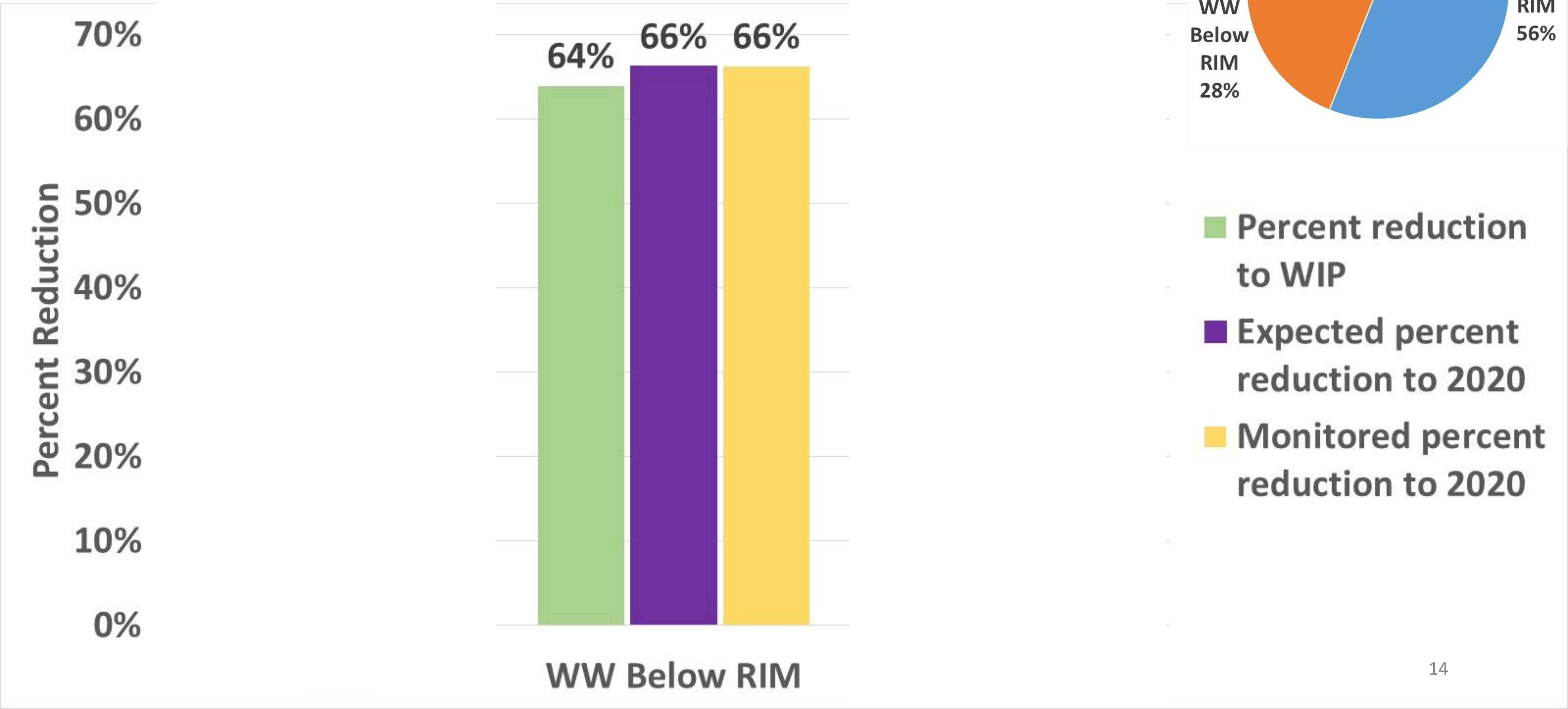


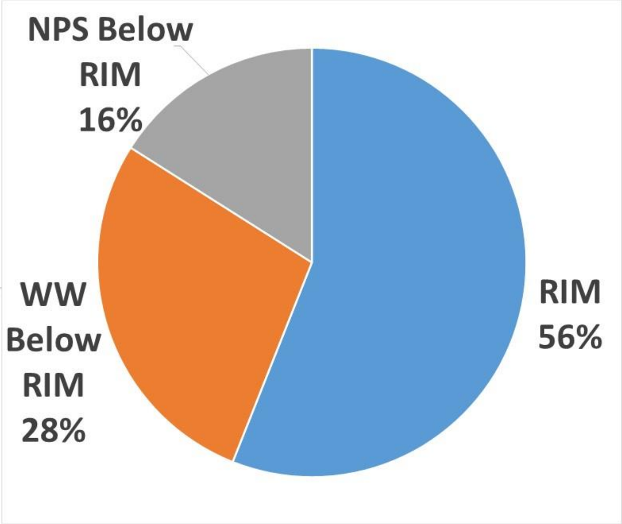


Loads and Flow-Normalized Loads

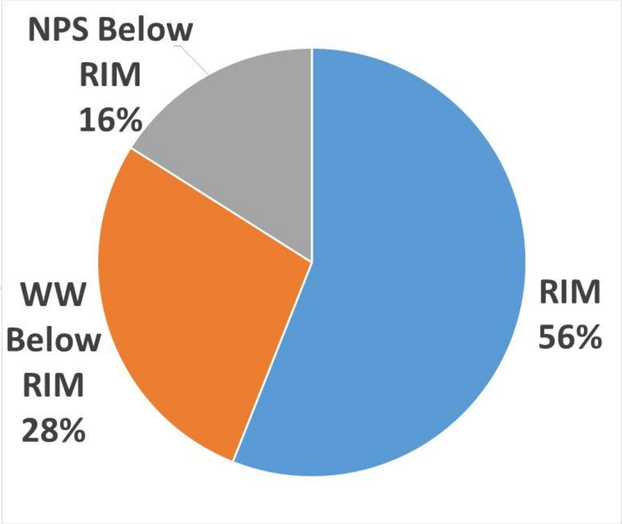


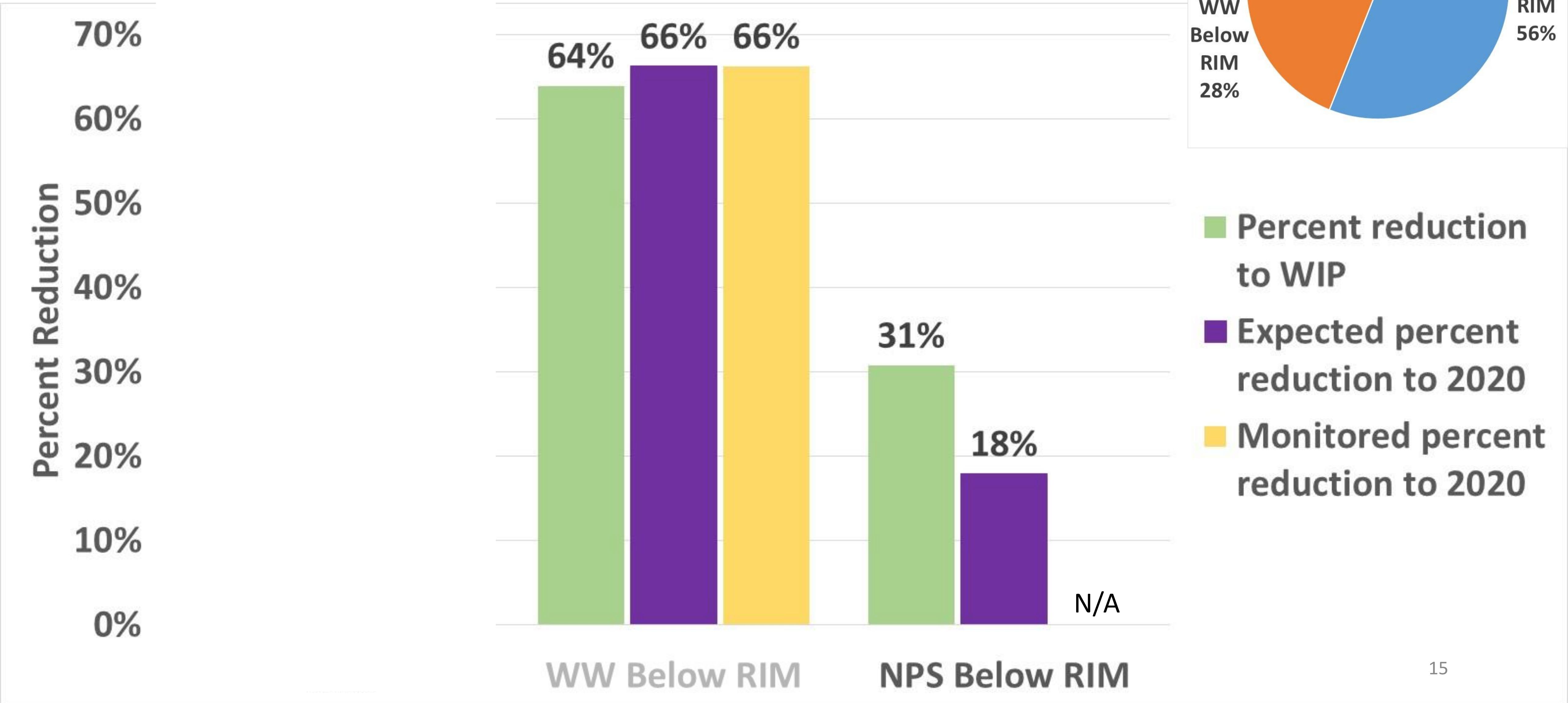
Wastewater is easy to measure and successful



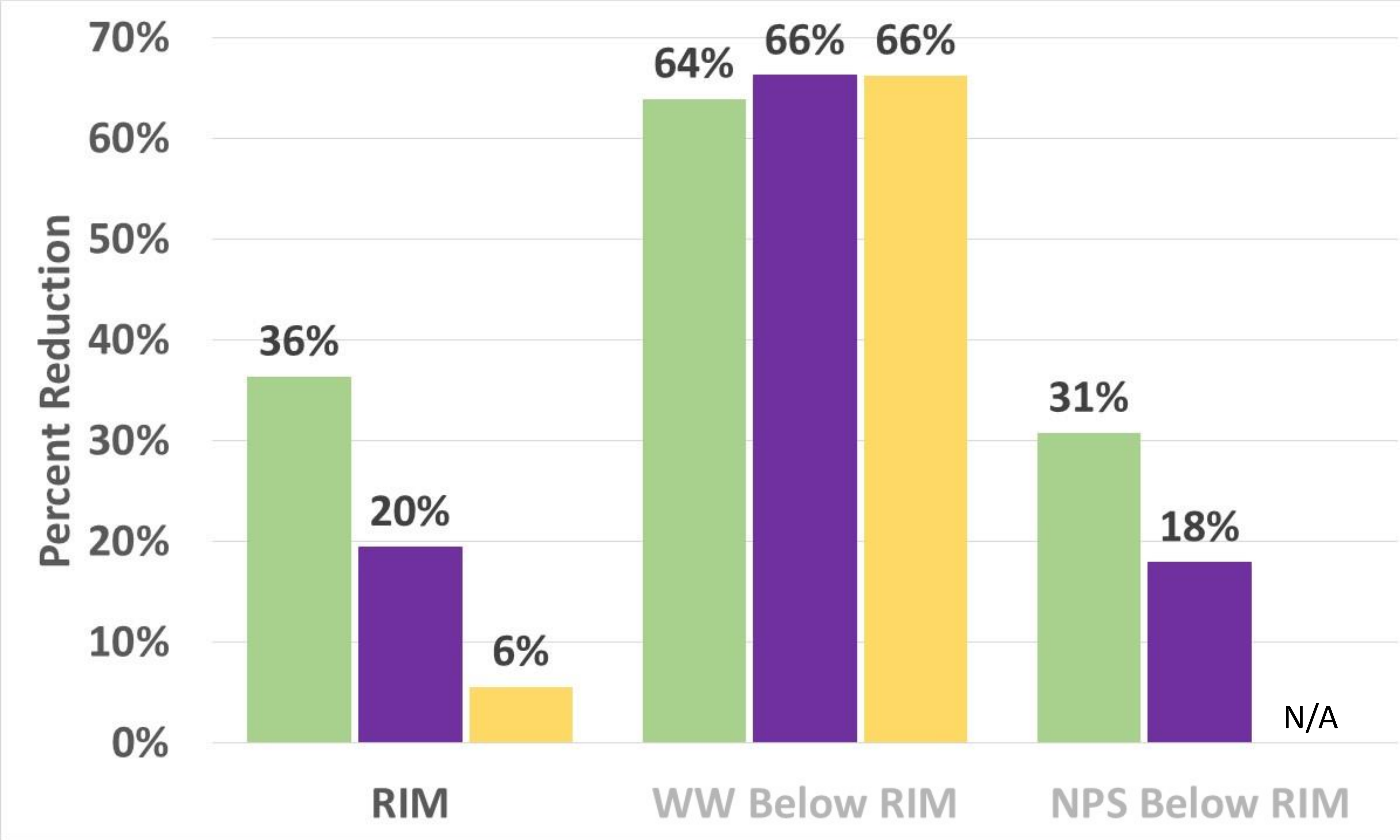


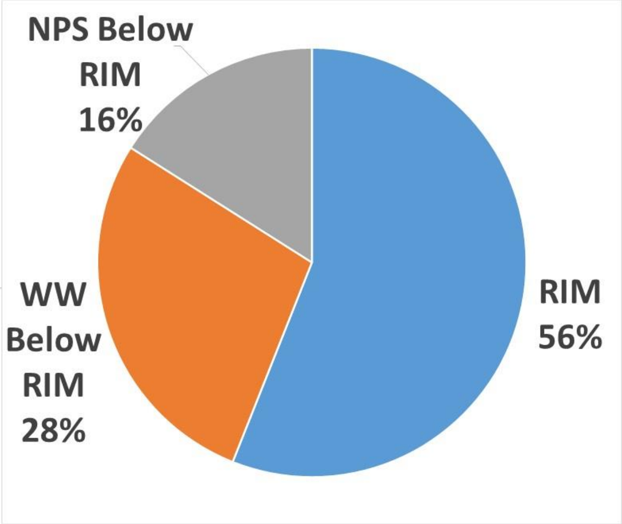
Below RIM NPS is about half implemented and is not fully monitored



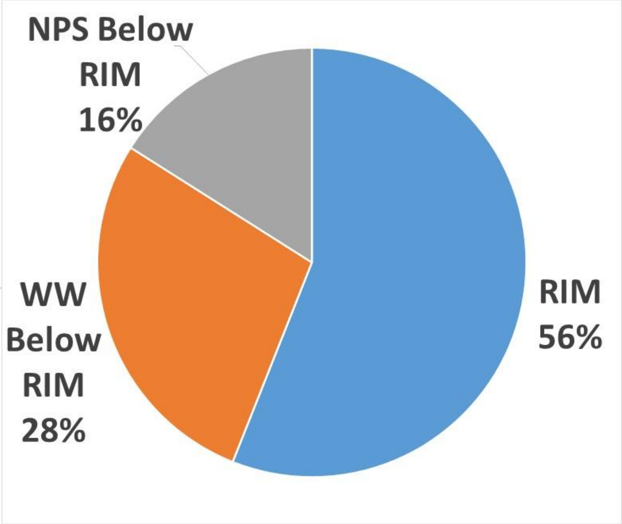


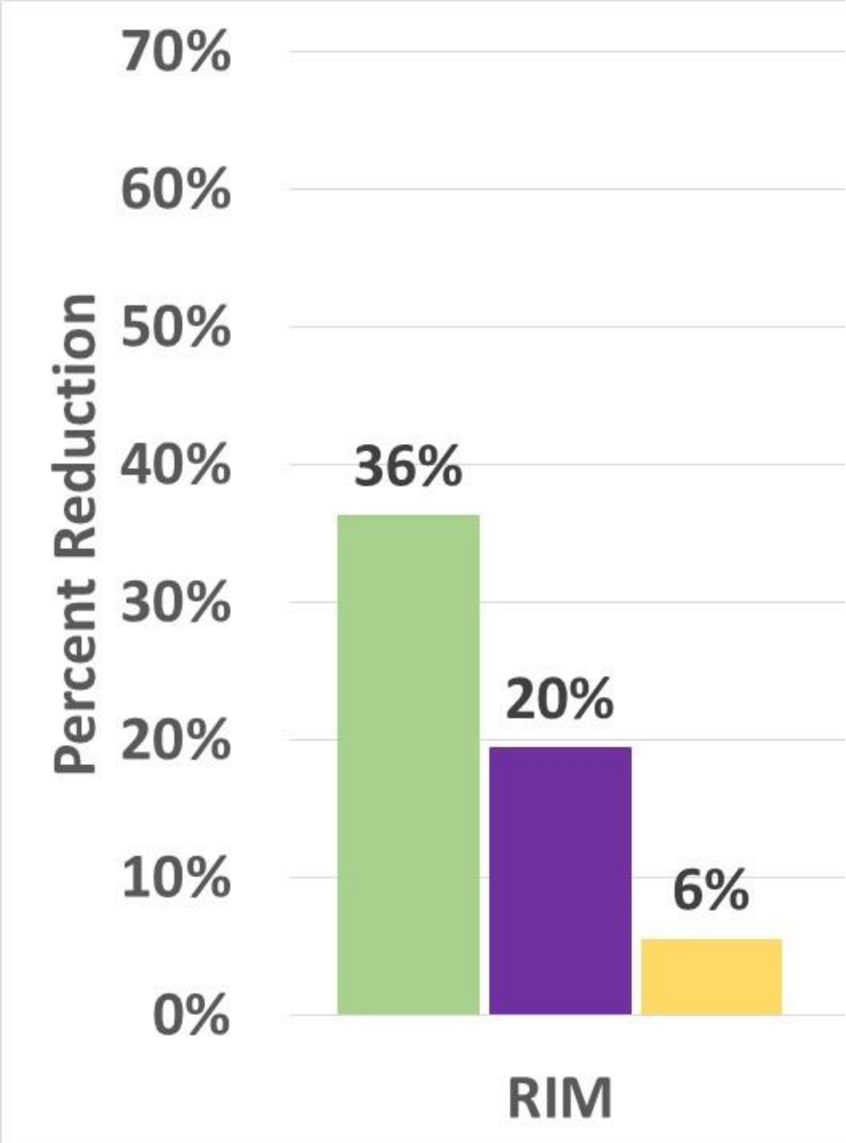
Above RIM is about half implemented, but monitoring shows only a small reduction





Why are monitoring and modeling not showing the same thing?



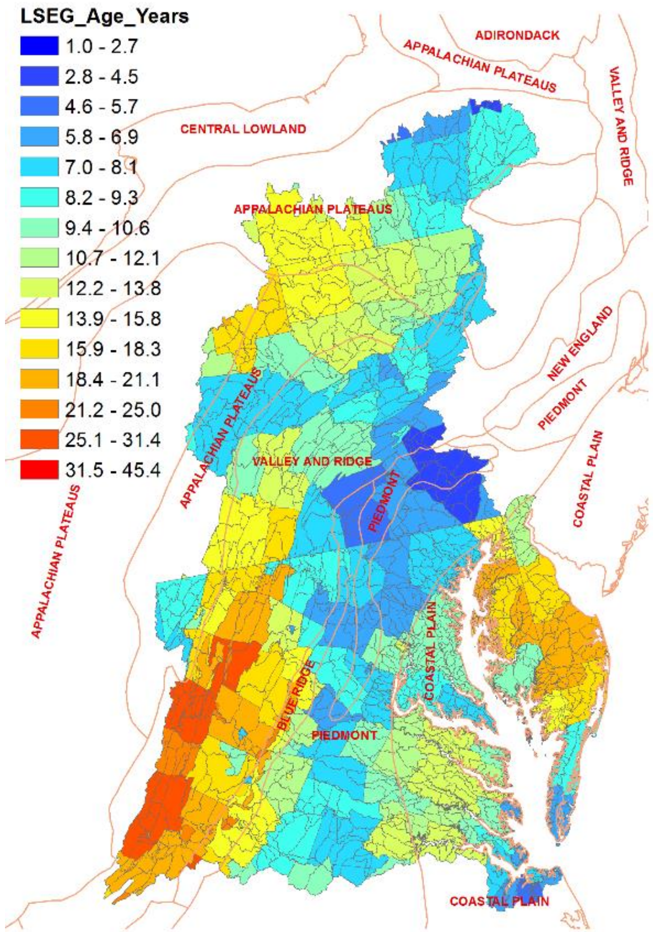


- Uncertainty in CAST
  - BMPs implemented
  - BMP effectiveness
  - Nutrient applications
  - Watershed response
- Uncertainty in “monitored” loads
- Lag time
- Competing factors such as
  - Climate change
  - Conowingo

Ator, S.W., Blomquist, J.D., Webber, J.S. and Chanat, J.G., 2020. Factors driving nutrient trends in streams of the Chesapeake Bay watershed. *Journal of Environmental Quality*, *49*(4), pp.812-834.

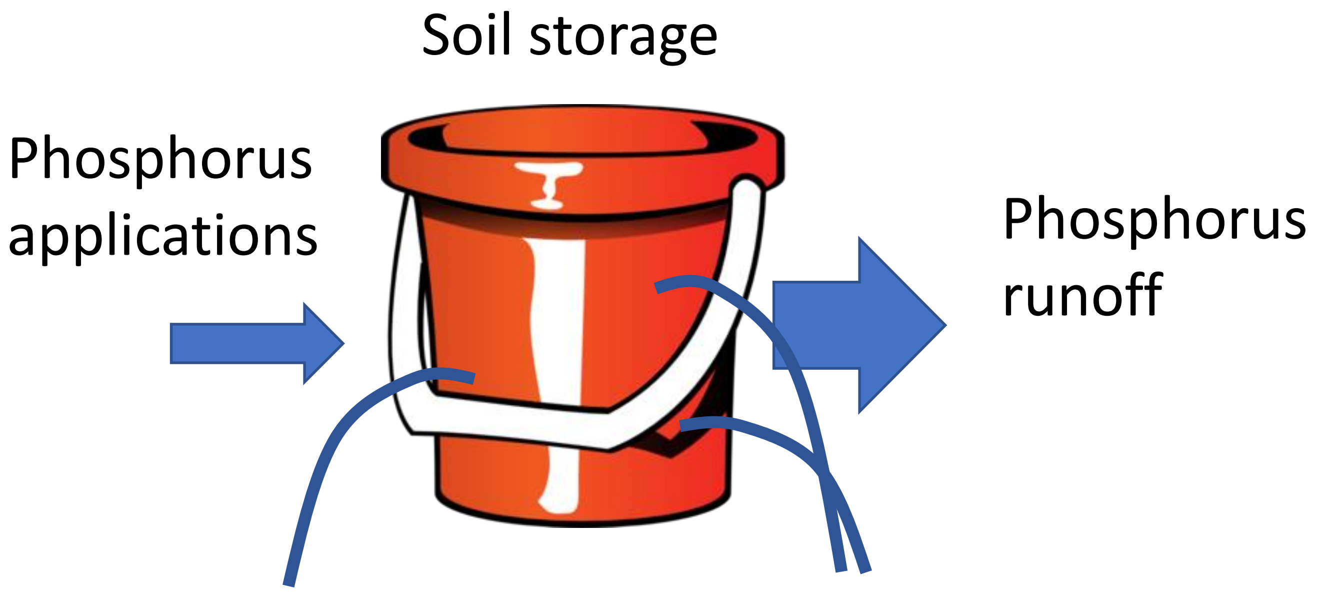
Lag times

Nitrate in groundwater



Phase 6 CAST documentation

Phosphorus in soils



Conowingo effect

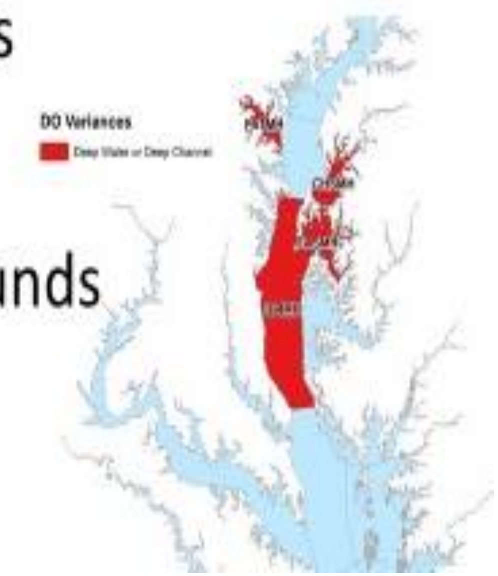
2017/2018 Presentations
to WQGIT, MB, and PSC

Estimated Loads to the Bay with Conowingo Dam and Reservoir at Infill Conditions

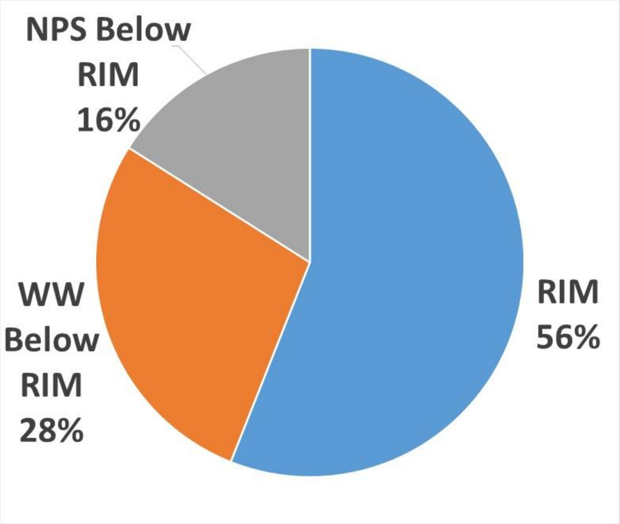
Additional Nitrogen Load: 13 million pounds

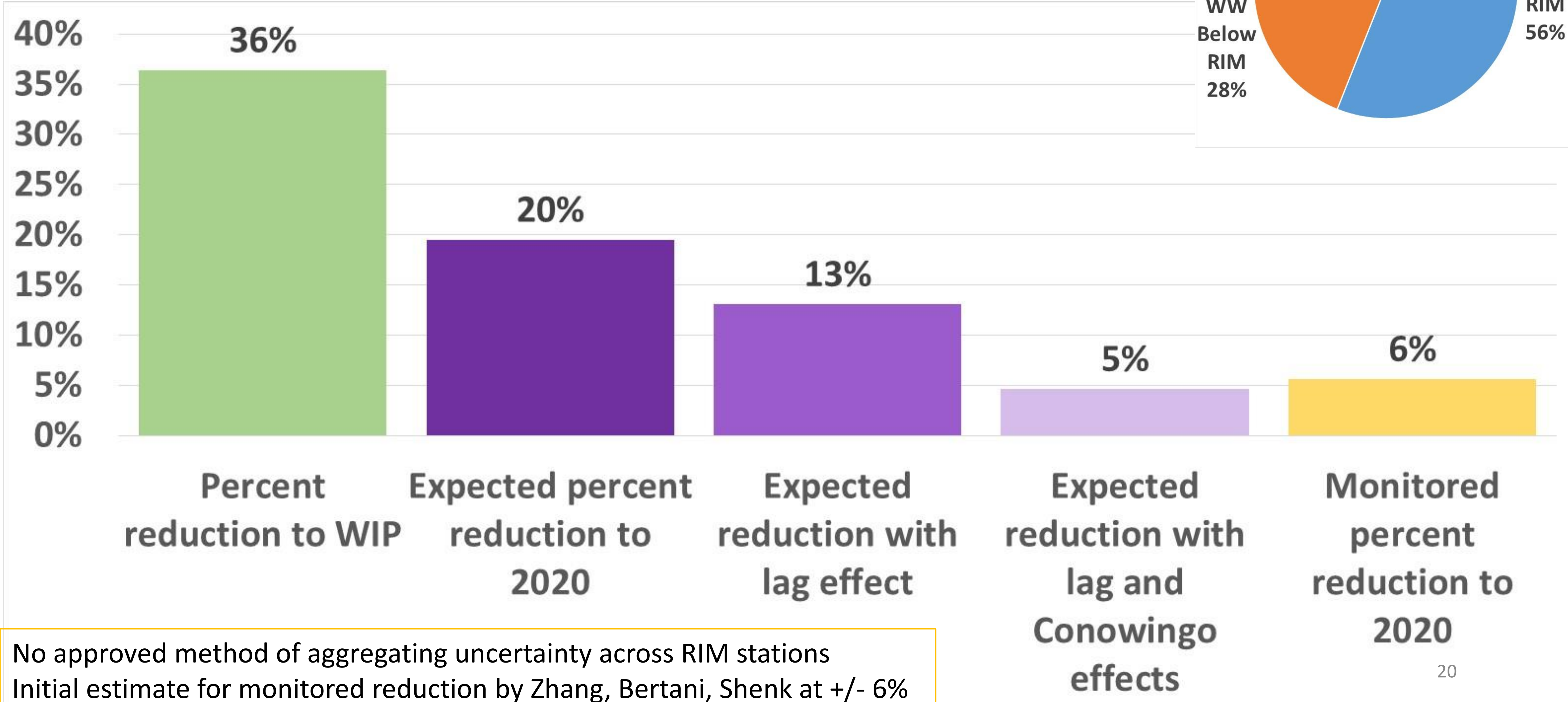
+

Additional Phosphorus Load: 1.8 million pounds



Lags and Conowingo account for major differences between Modeling and Monitoring





No approved method of aggregating uncertainty across RIM stations
Initial estimate for monitored reduction by Zhang, Bertani, Shenk at +/- 6%

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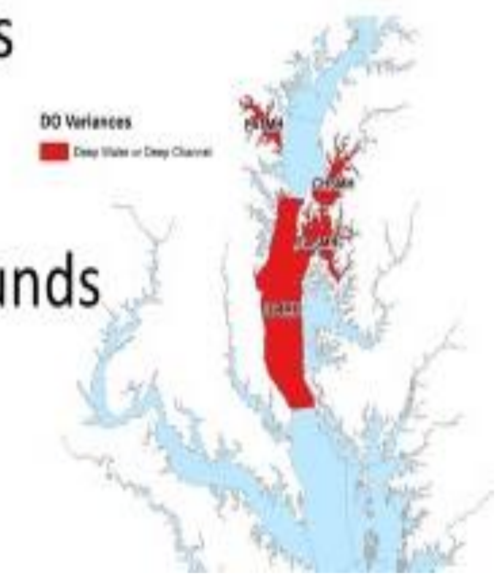
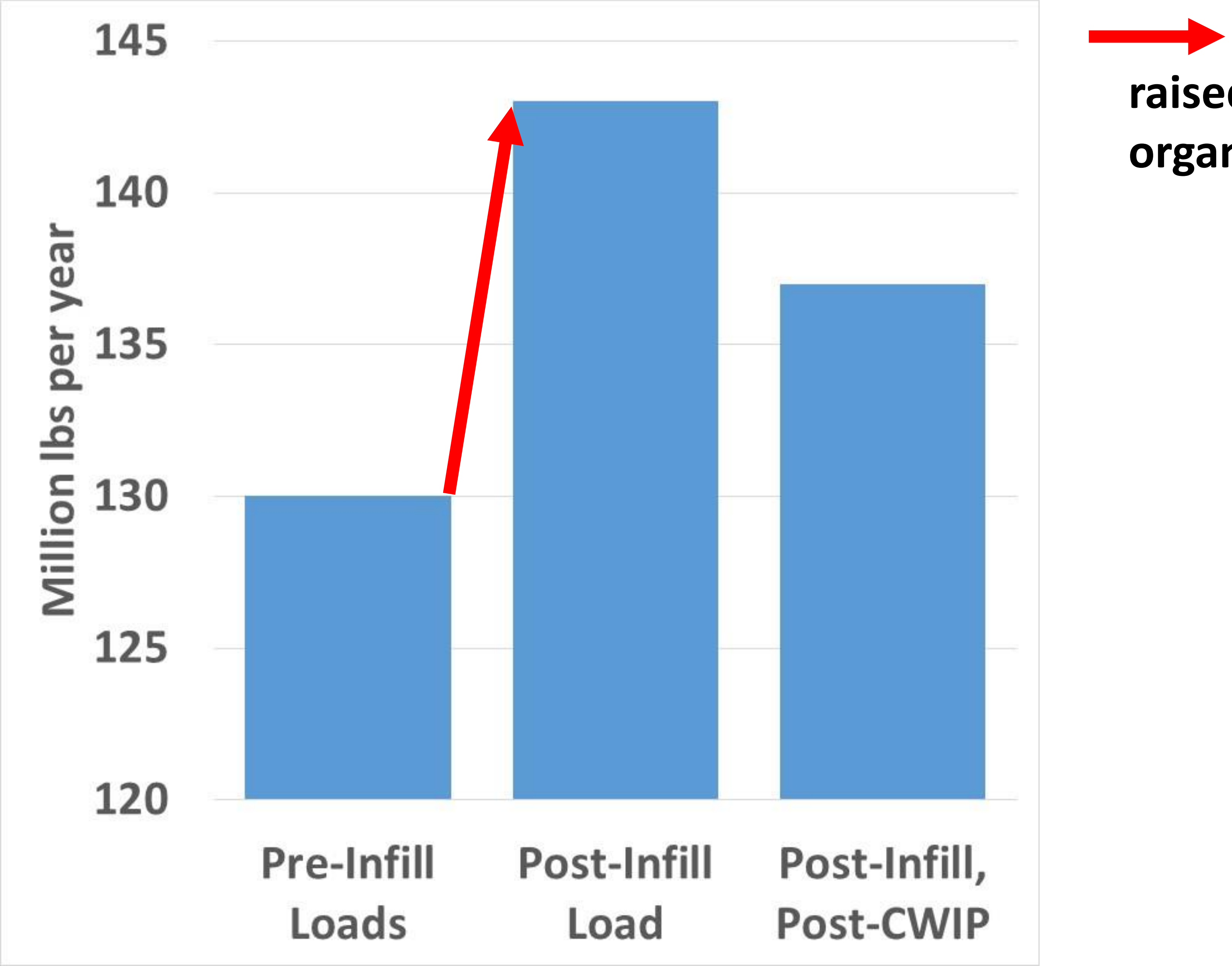


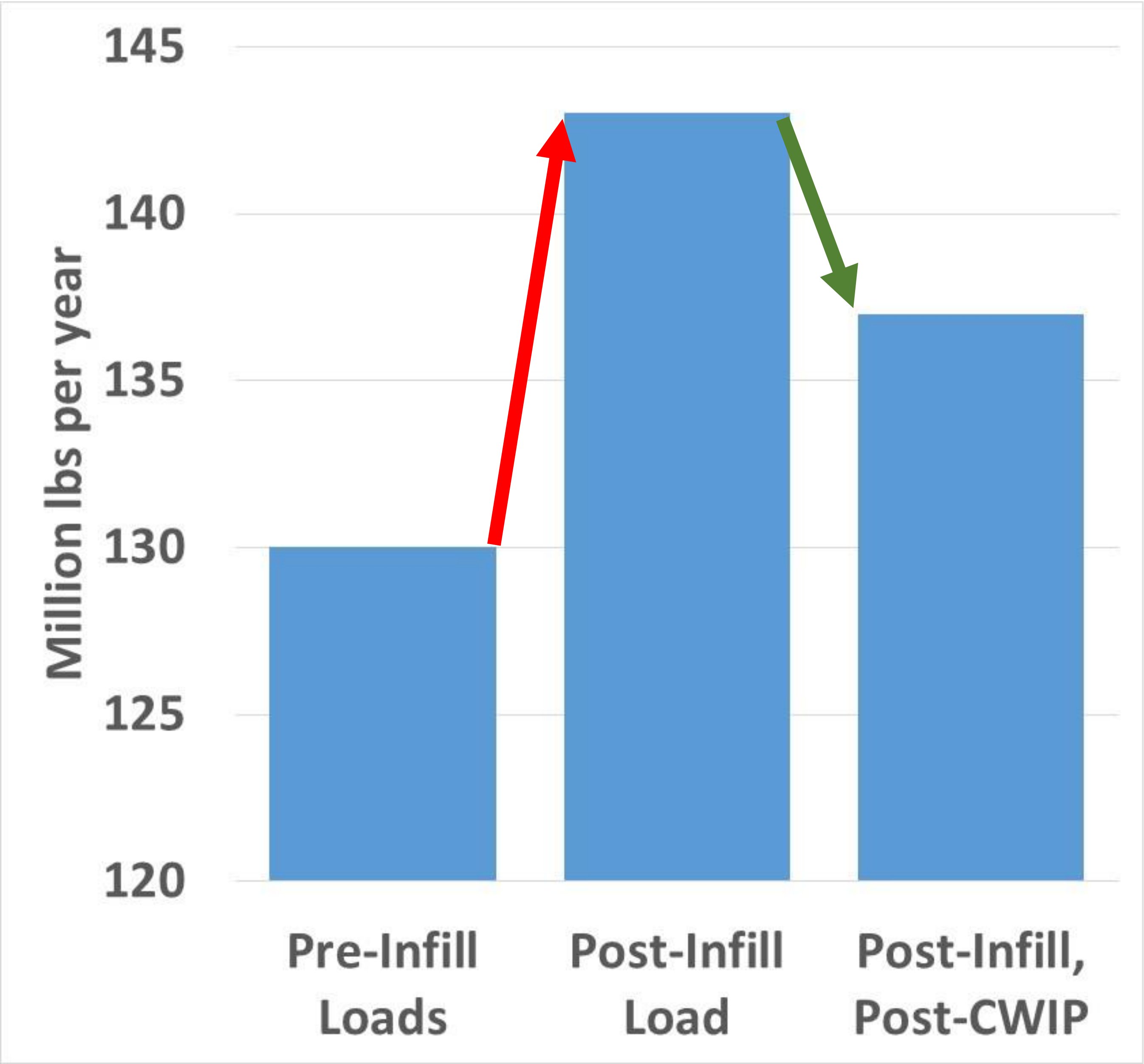
HOWEVER: These are less bioavailable nutrients and its delivery to Bay is dependent on large storm events. Reduction equivalent to 6 million pounds of Nitrogen and 0.26 million pounds of Phosphorus

Conowingo infill raises the assimilative capacity



All else being equal, Conowingo raised loads by 13 million (mostly organic and non-summer) lbs

Conowingo infill raises the assimilative capacity



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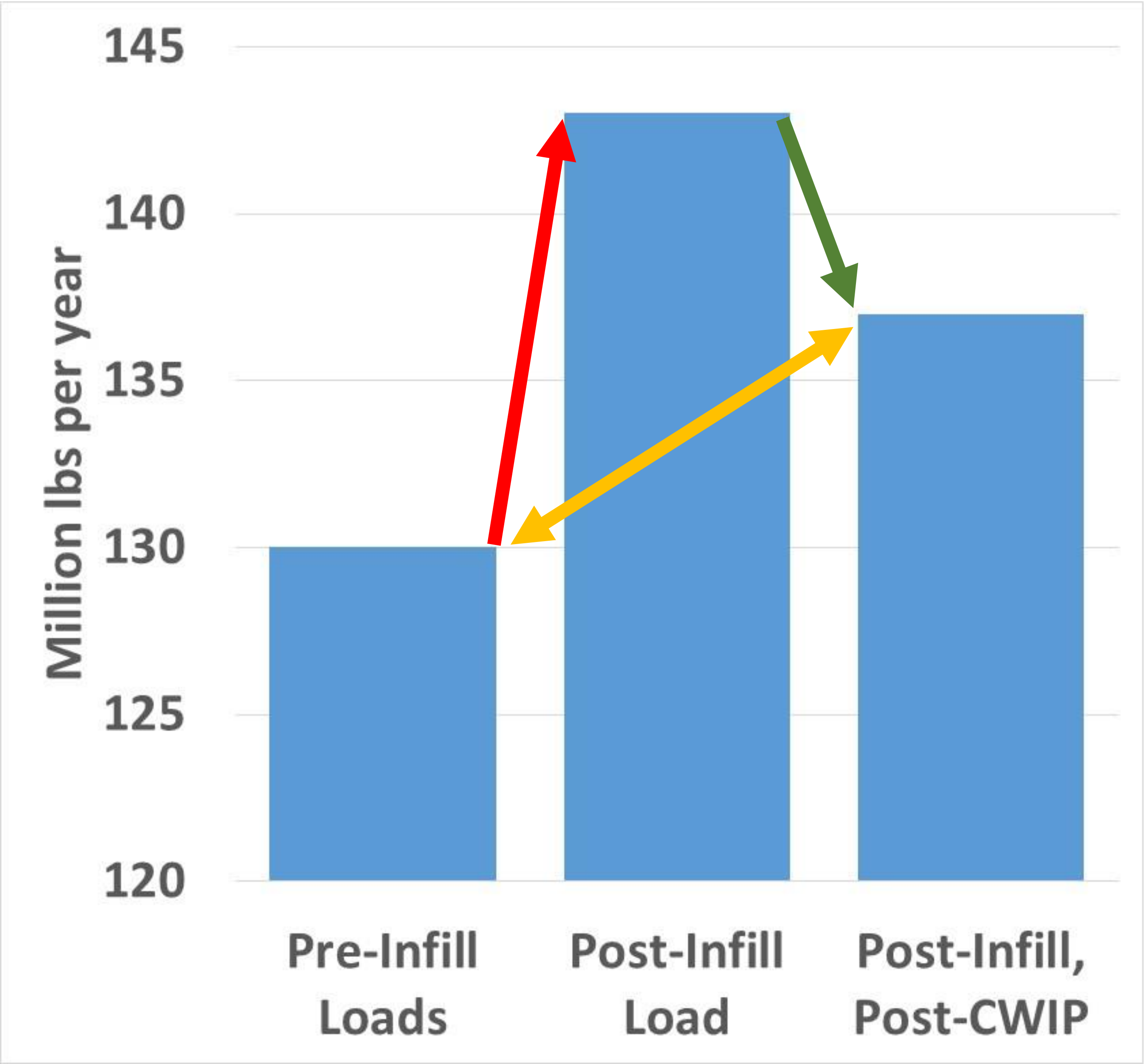
The infill effect can be removed by a watershed reduction of 6 million (more inorganic and summer) lbs

Conowingo infill raises the assimilative capacity



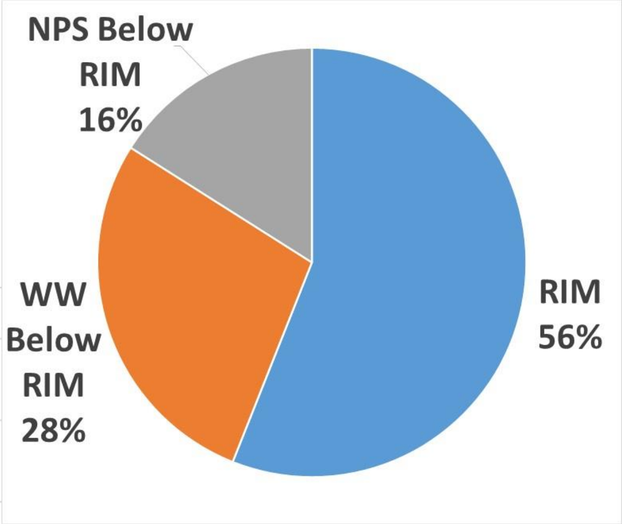
All else being equal, Conowingo raised loads by 13 million (mostly organic and non-summer) lbs

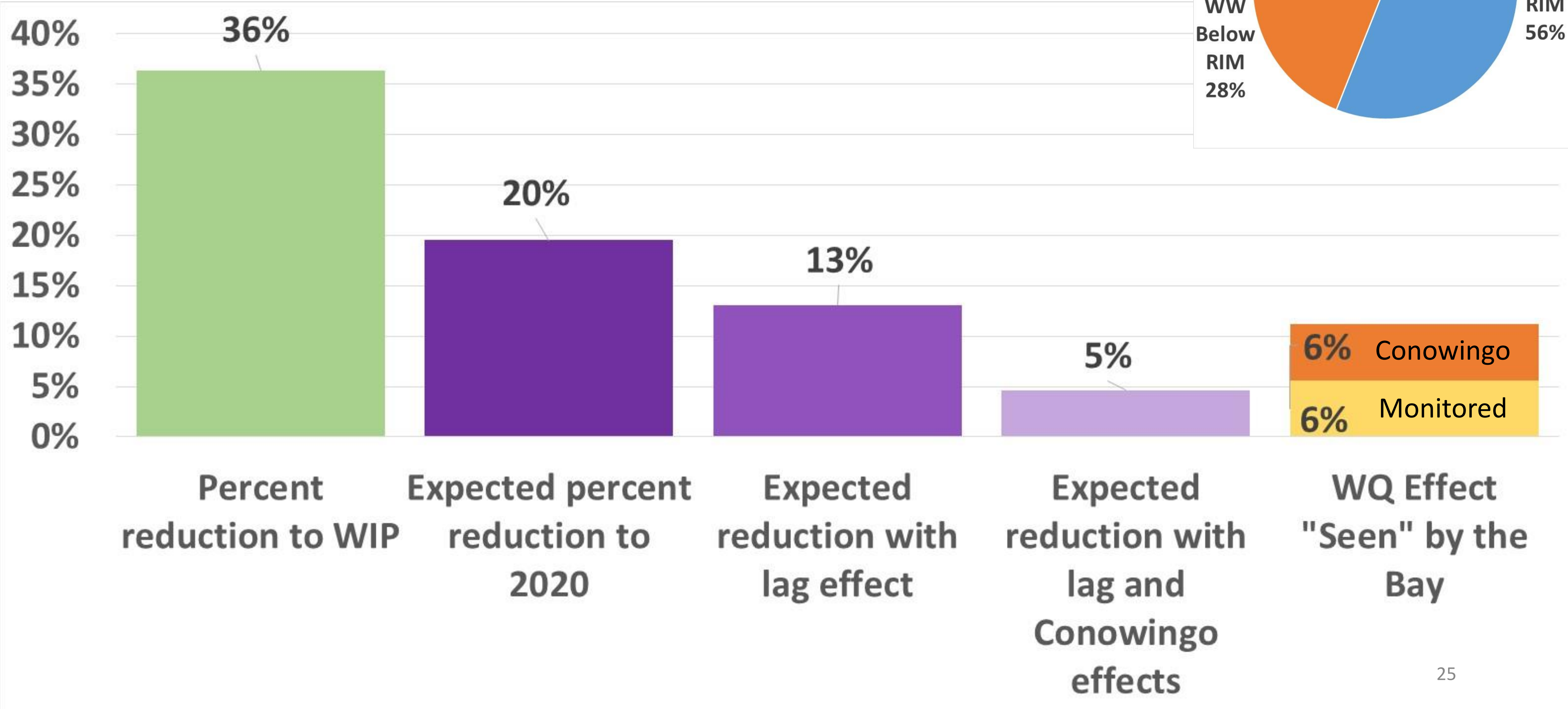
The infill effect can be removed by a watershed reduction of 6 million (more inorganic and summer) lbs

The TMDL water quality is equivalent at 130 pre-infill and 137 post-infill

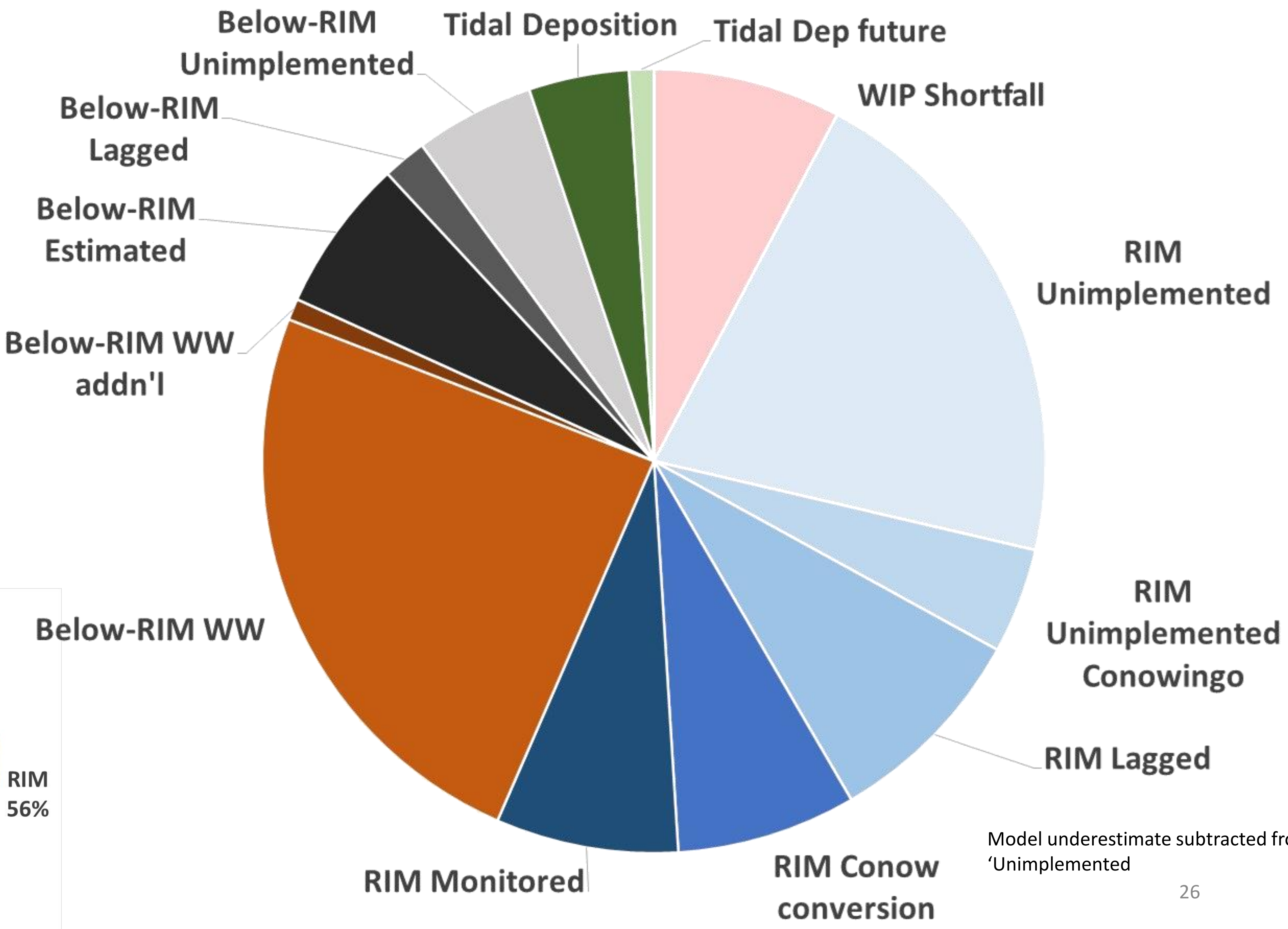
The water quality change "Seen" by the Bay is greater than the monitoring results by 7 million pounds because of the infill effect

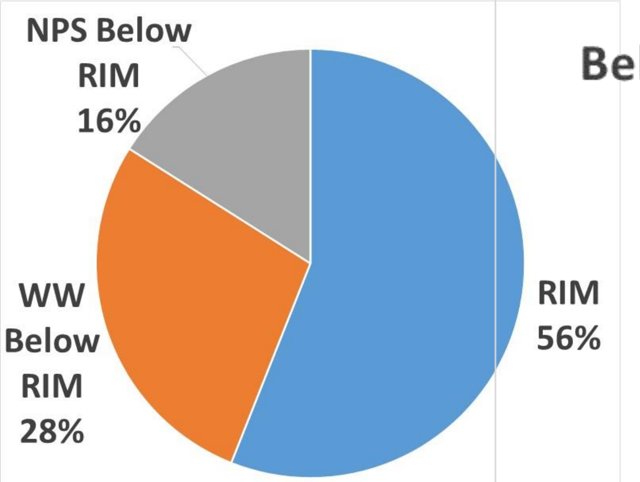
Lags and Conowingo account for major differences between Modeling and Monitoring





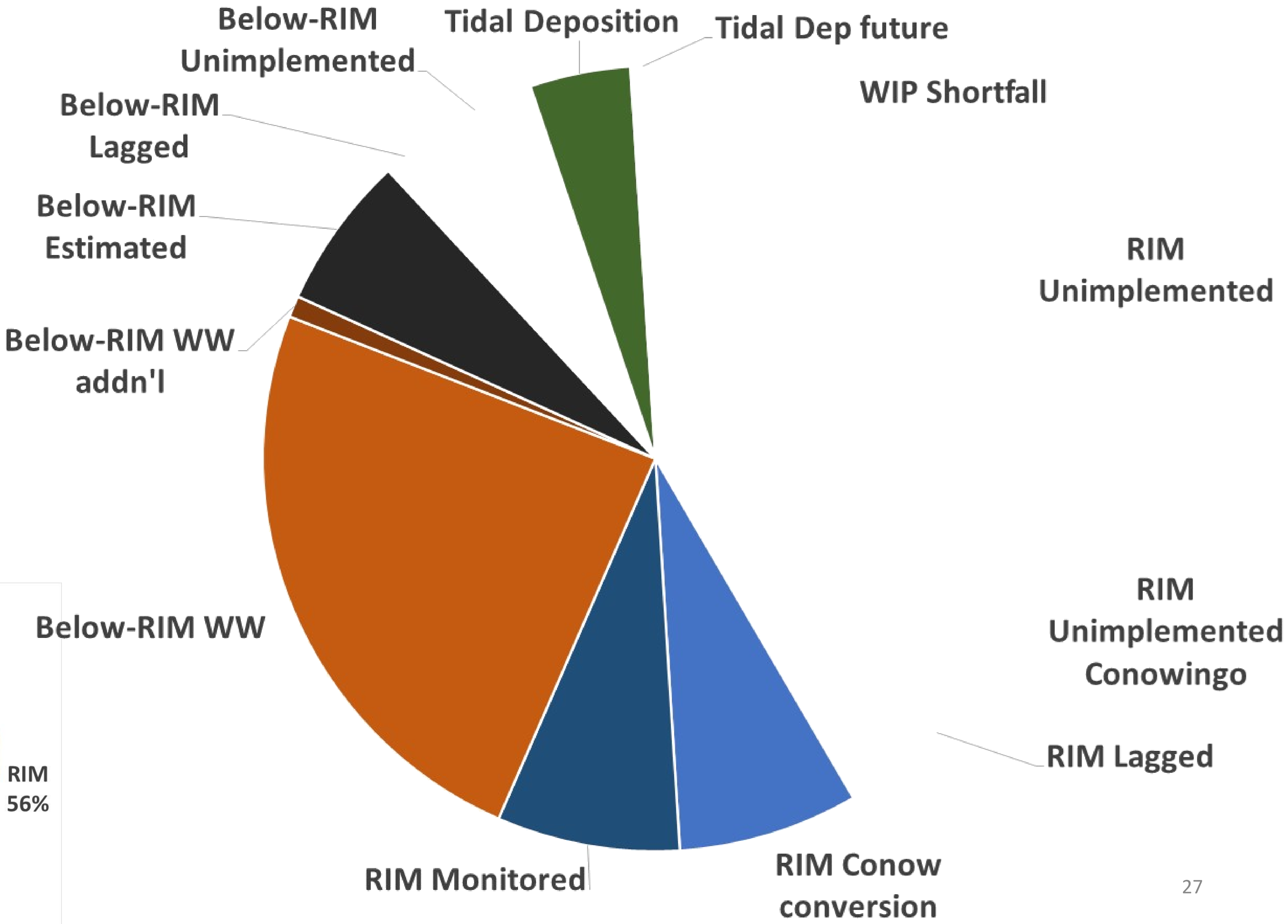
Putting it all together

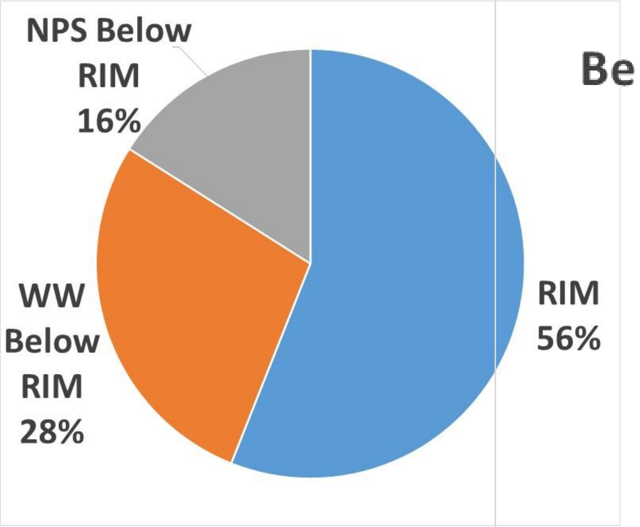




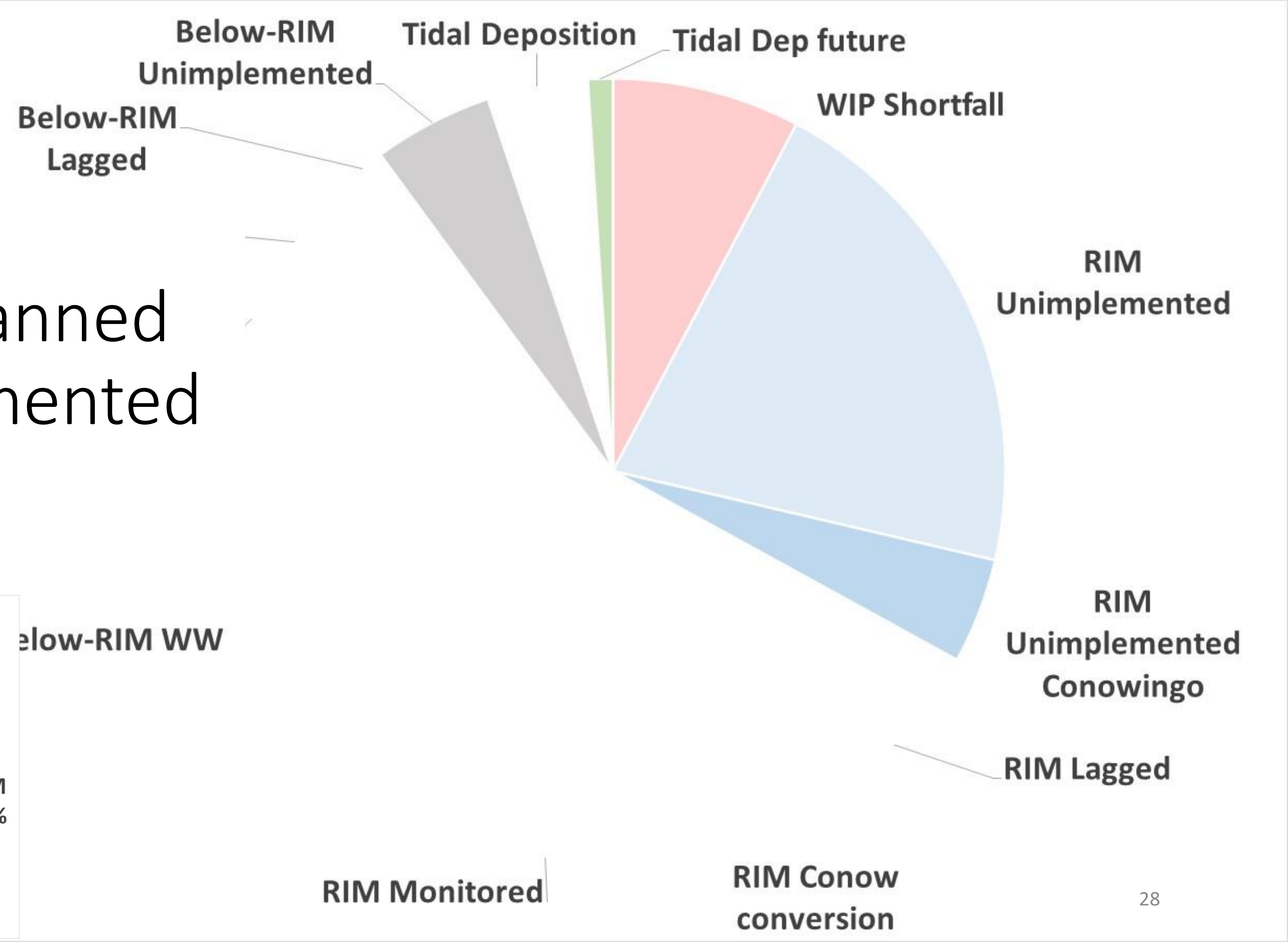
Model underestimate subtracted from 'Unimplemented

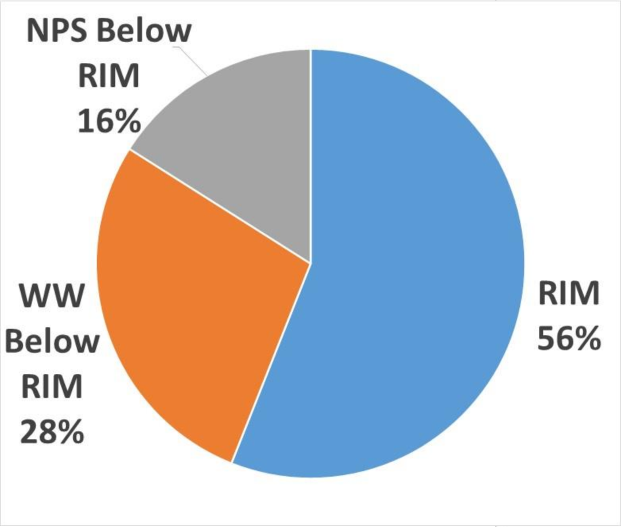
The bay has seen 51% of needed reductions



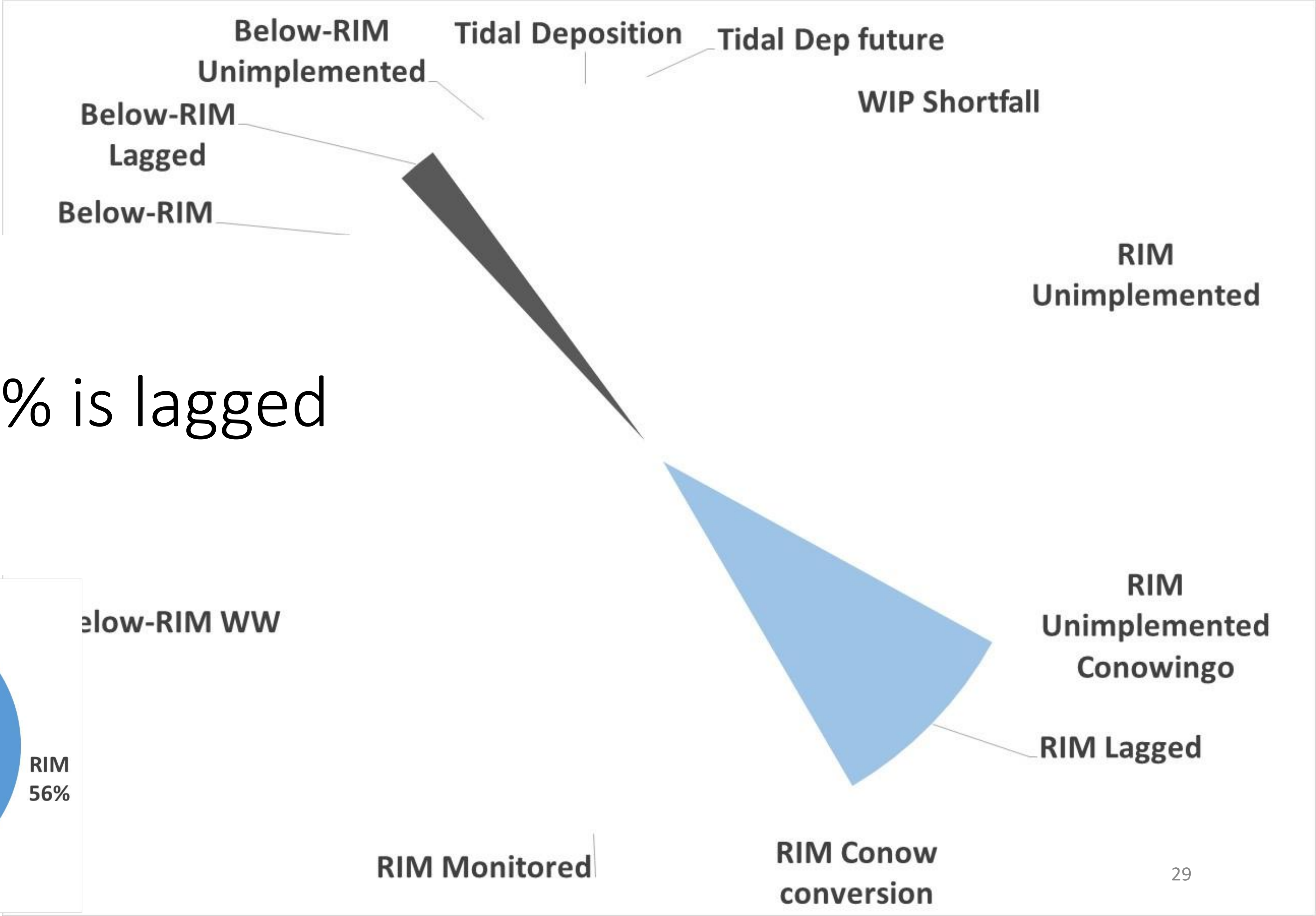


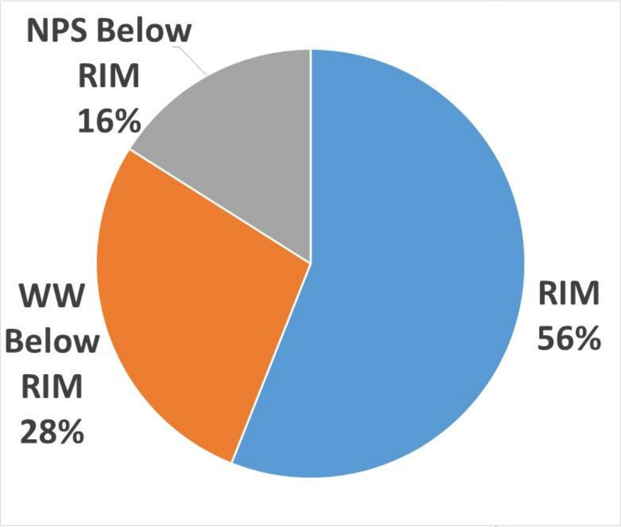
39% is unplanned or unimplemented



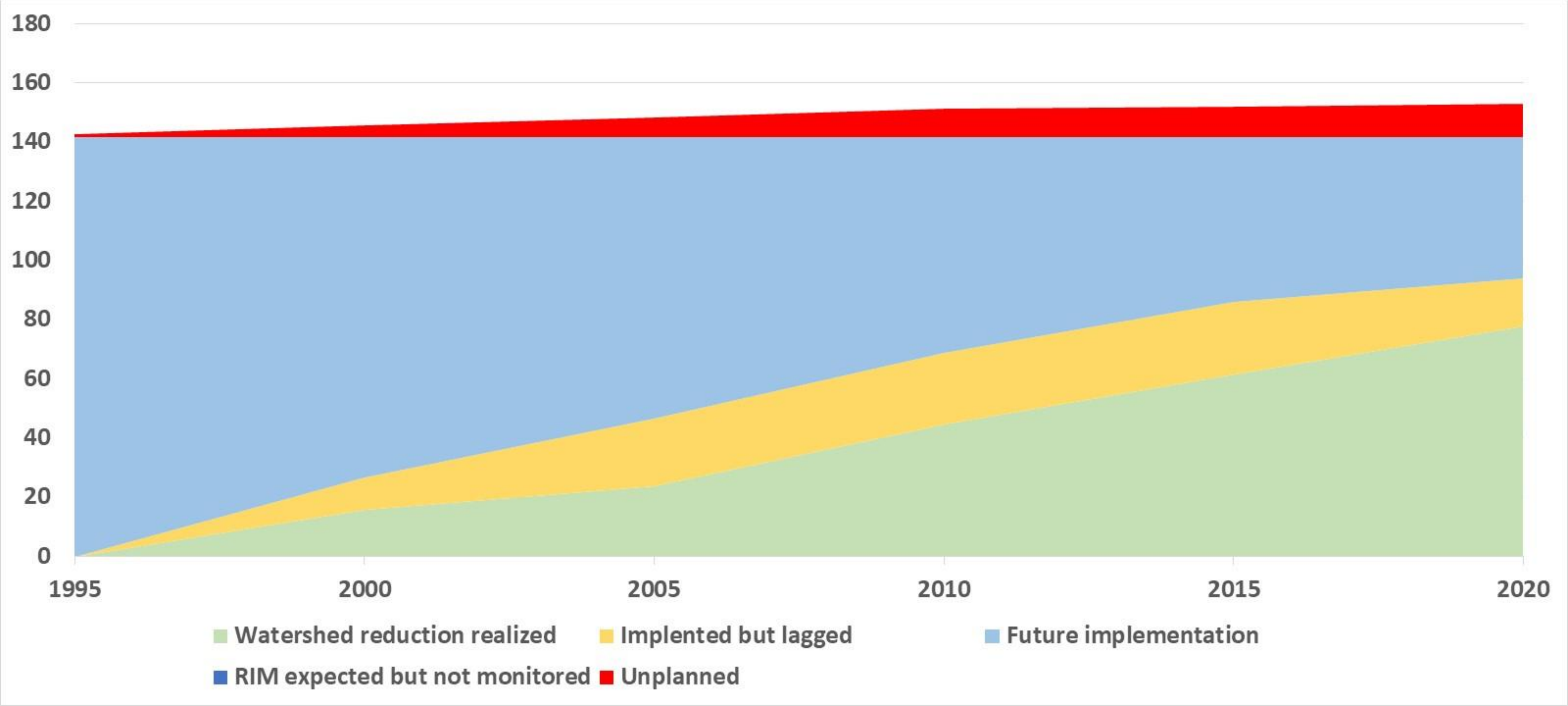


10% is lagged


Below-RIM Unimplemented
Tidal Deposition
Tidal Dep future
WIP Shortfall
Below-RIM Lagged
Below-RIM
RIM Unimplemented
elow-RIM WW
RIM Unimplemented Conowingo
RIM Lagged
RIM Monitored
RIM Conow conversion


NPS Below RIM 16%
WW Below RIM 28%
RIM 56%

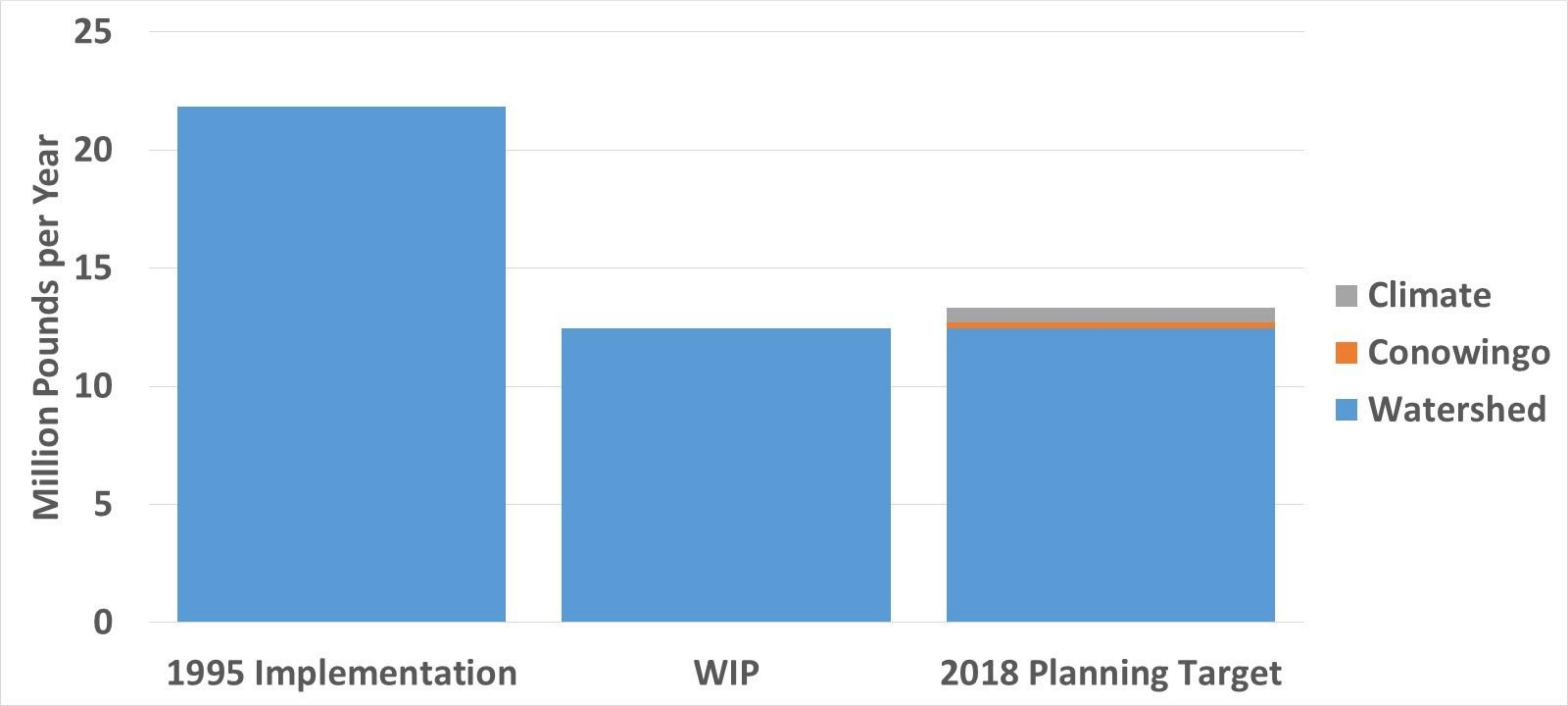
Proposed Public Indicator



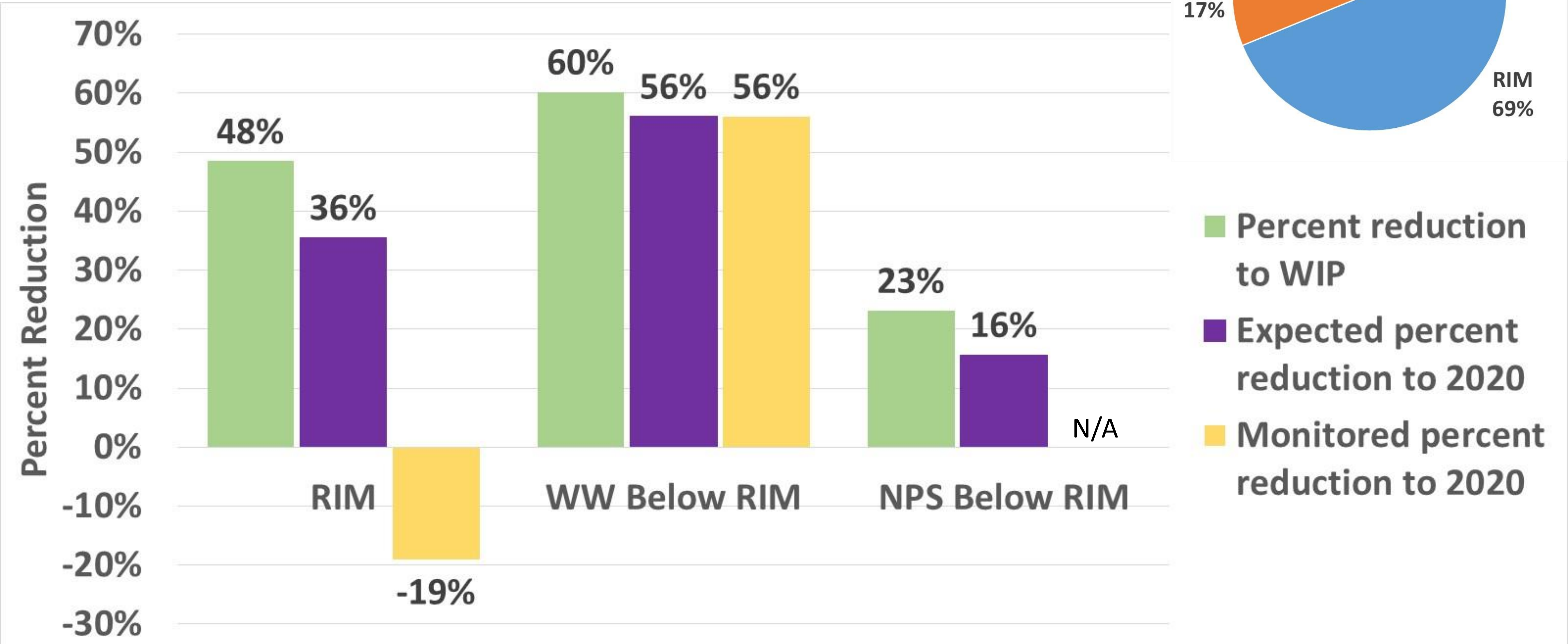
Partnership Product for Data Dashboard

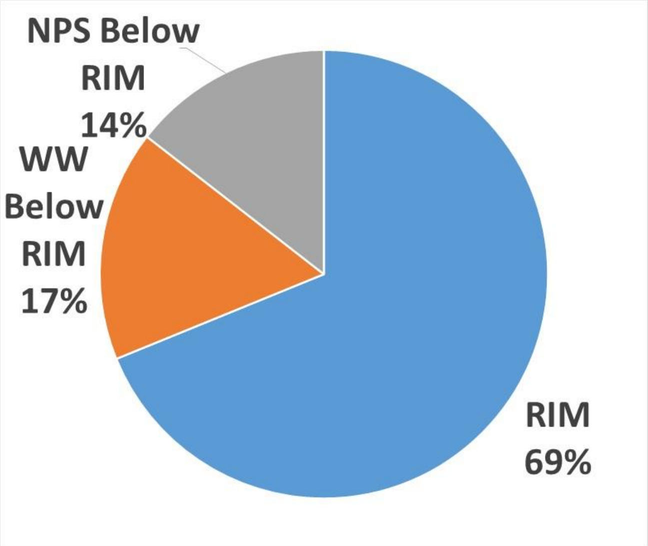
Category	1995	2000	2005	2010	2015	2020
WIP Shortfall	0.9	3.8	6.6	9.4	10.2	11.1
RIM Unimplemented	68.3	53.6	45.4	31.1	28.0	32.1
RIM Unimplemented Conowingo	6.7	6.7	6.7	6.7	6.7	6.7
RIM Expected but not monitored	0.0	0.0	0.0	0.0	0.0	0.0
RIM Lagged	0.0	8.9	17.9	19.3	20.2	13.2
RIM Conowingo Conversion	0.0	4.0	8.3	11.8	11.8	11.4
RIM Monitored	0.0	1.9	-3.3	6.0	8.3	11.6
Below-RIM PS Implemented	0.0	11.2	17.6	20.6	30.0	38.8
Below-RIM PS Unimplemented	37.4	26.2	19.9	16.8	7.4	-1.4
Below-RIM Estimated	0.0	-1.8	-0.6	2.8	6.3	9.7
Below-RIM Lagged	0.0	1.9	5.1	5.1	4.2	2.8
Below-RIM Unimplemented	21.4	21.3	17.0	13.5	10.9	8.9
Tidal Deposition Reduction Realized	0.0	0.5	1.7	3.3	5.2	6.4
Tidal Deposition Reduction Unrealized	7.9	7.5	6.2	4.6	2.7	1.6

Phosphorus Reductions

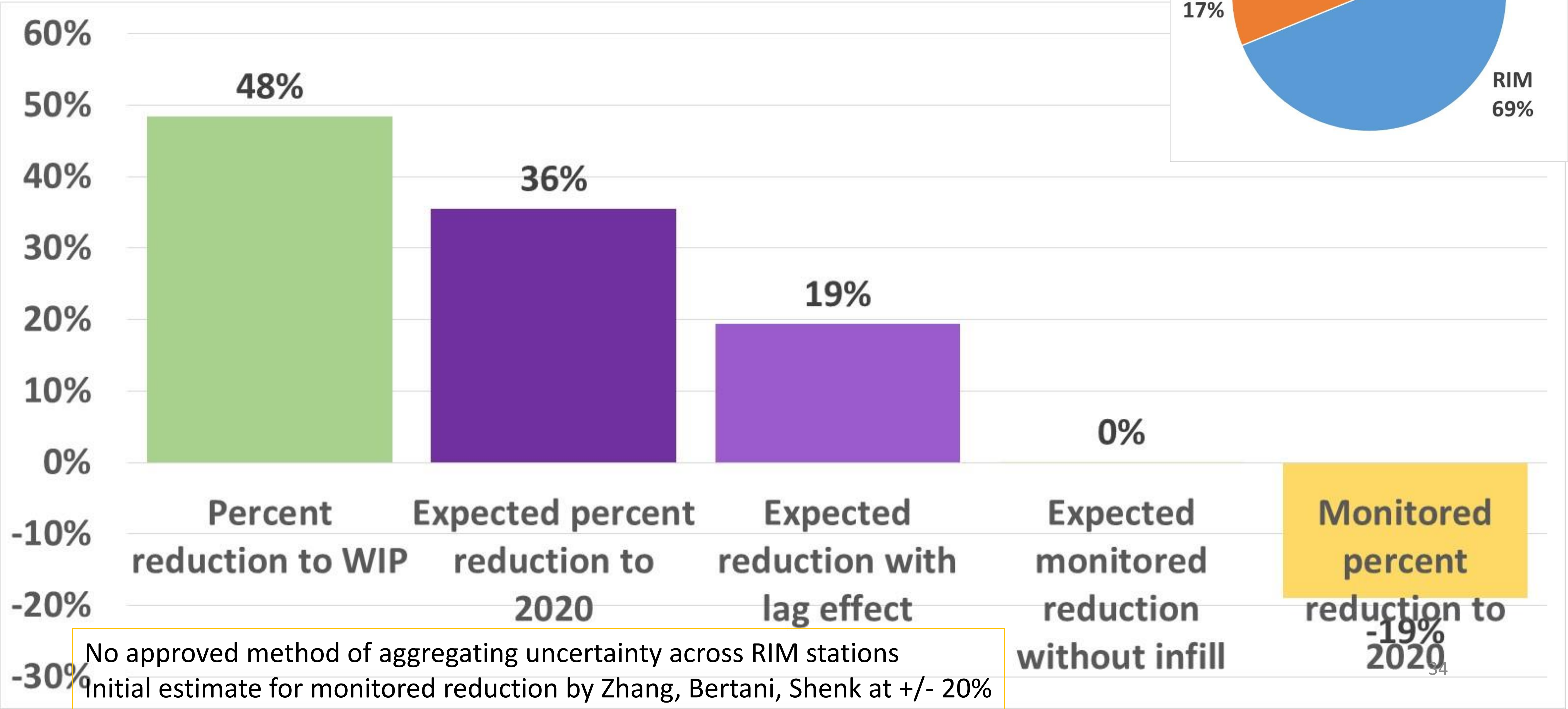


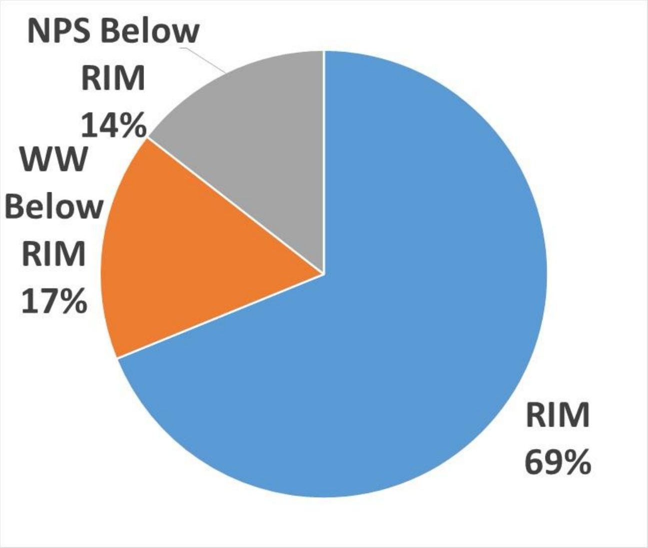
Phosphorus is mostly implemented, but monitoring results show increases





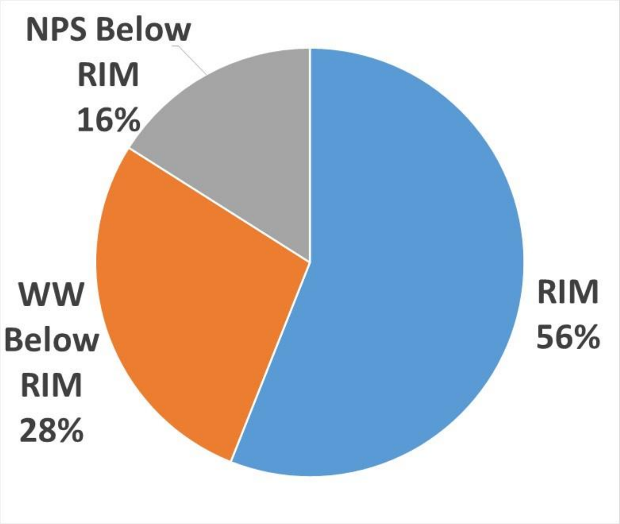
Lags and Conowingo account for more than half of the difference

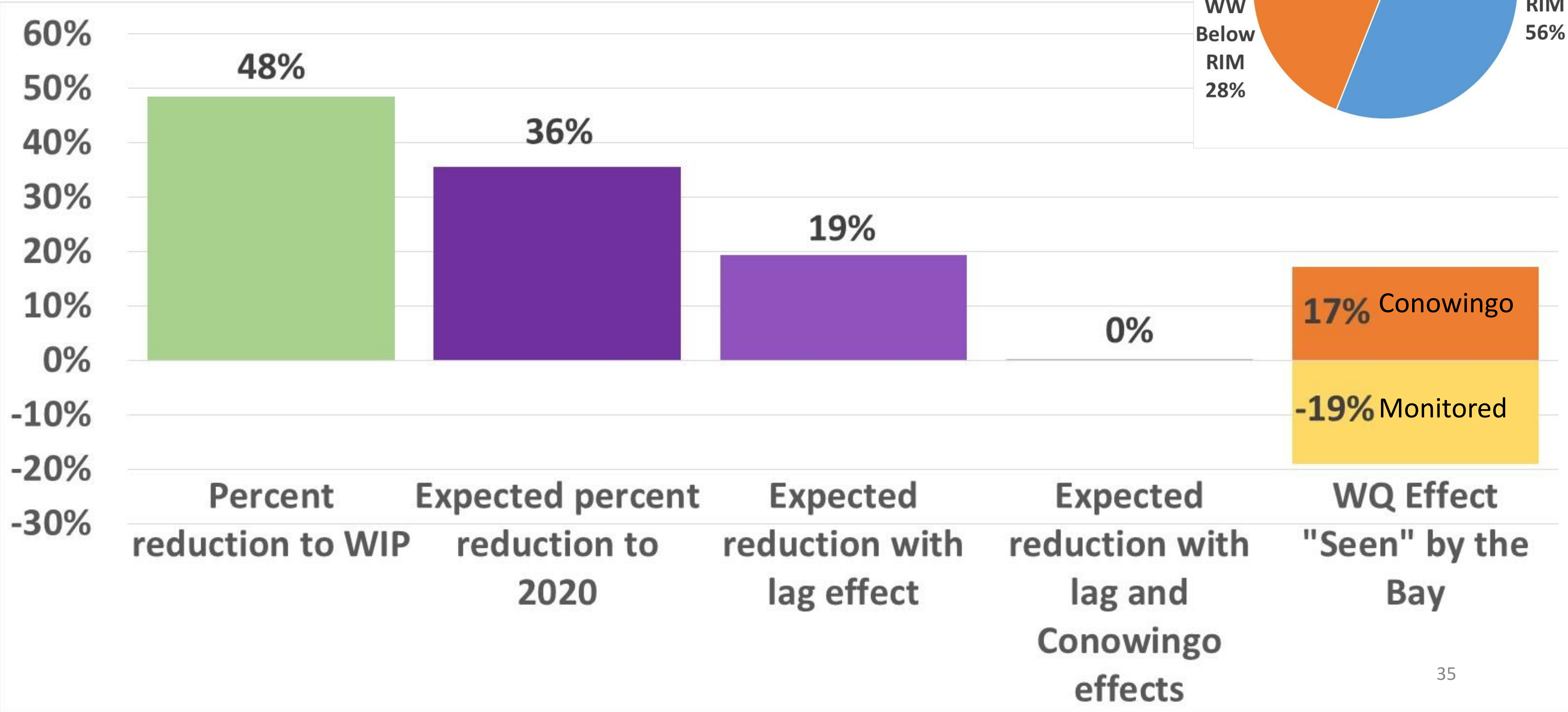




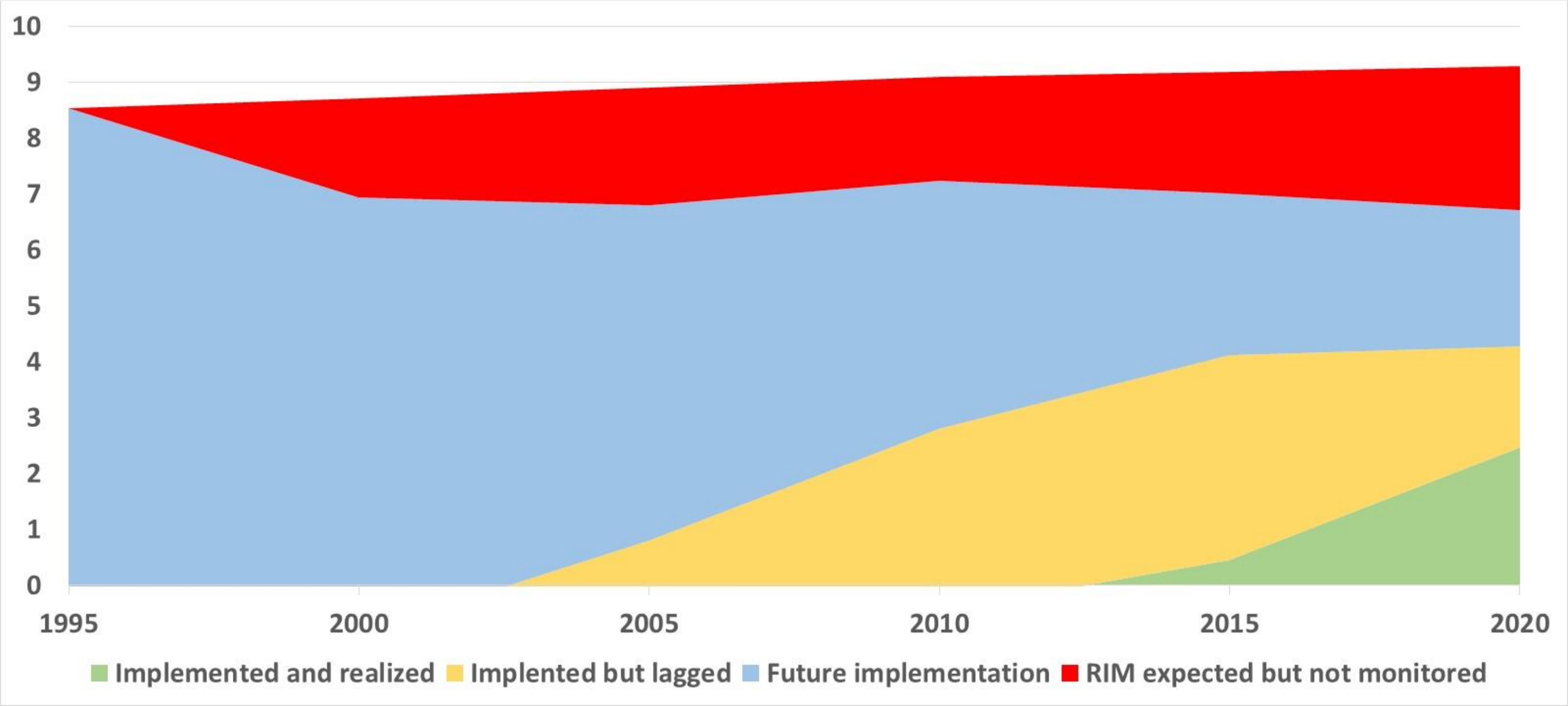
No approved method of aggregating uncertainty across RIM stations
Initial estimate for monitored reduction by Zhang, Bertani, Shenk at +/- 20%

Lags and Conowingo account for major differences between Modeling and Monitoring





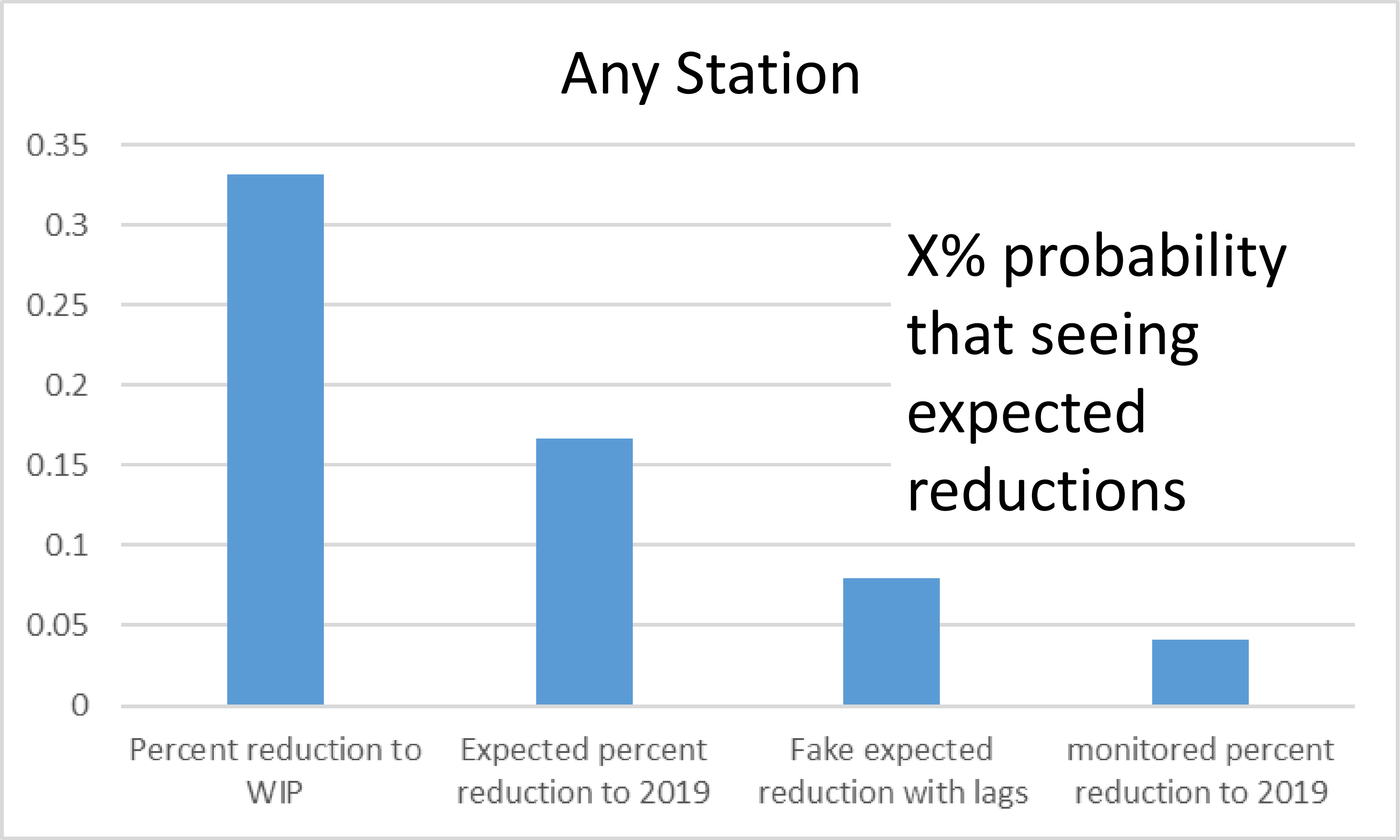
Proposed Public Indicator - Phosphorus



Partnership Product for Data Dashboard

Category	1995	2000	2005	2010	2015	2020
WIP Shortfall	-0.87	-0.68	-0.50	-0.31	-0.21	-0.11
RIM Unimplemented	6.33	5.76	4.28	3.27	2.18	1.85
RIM Unimplemented Conowingo	0.14	0.14	0.14	0.14	0.14	0.14
RIM Expected but not monitored	0.00	1.77	2.10	1.86	2.18	2.58
RIM Lagged	0.00	1.00	2.26	3.17	3.45	2.15
RIM Conowingo Conversion	0.00	0.71	1.62	2.98	2.89	2.29
RIM Monitored	0.00	-2.93	-3.94	-4.94	-4.38	-2.54
Below-RIM PS Implemented	0.00	0.26	0.32	0.84	1.25	1.46
Below-RIM PS Unimplemented	1.57	1.30	1.25	0.73	0.32	0.11
Below-RIM Estimated	0.00	0.48	0.87	0.66	0.70	1.26
Below-RIM Lagged	0.00	-0.40	-0.33	0.10	0.21	-0.34
Below-RIM Unimplemented	1.36	1.28	0.82	0.60	0.46	0.44

Future Work


Any Station
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
X% probability that seeing expected reductions
Percent reduction to WIP
Expected percent reduction to 2019
Fake expected reduction with lags
monitored percent reduction to 2019

Summary

- Indicator summarizes N and P progress toward the TMDL
  - Implemented and realized
  - Implemented but unrealized due to lag
  - Implemented but unrealized due to uncertainty
  - Not implemented
- More detailed products for Watershed Data Dashboard
  - Tables for RIM
  - Individual nontidal network Station analyses