Accounting for the Effect of Conowingo Reservoir Infill on Tidal Chesapeake Water Quality

Water Quality Goal Implementation Team

September 25, 2017

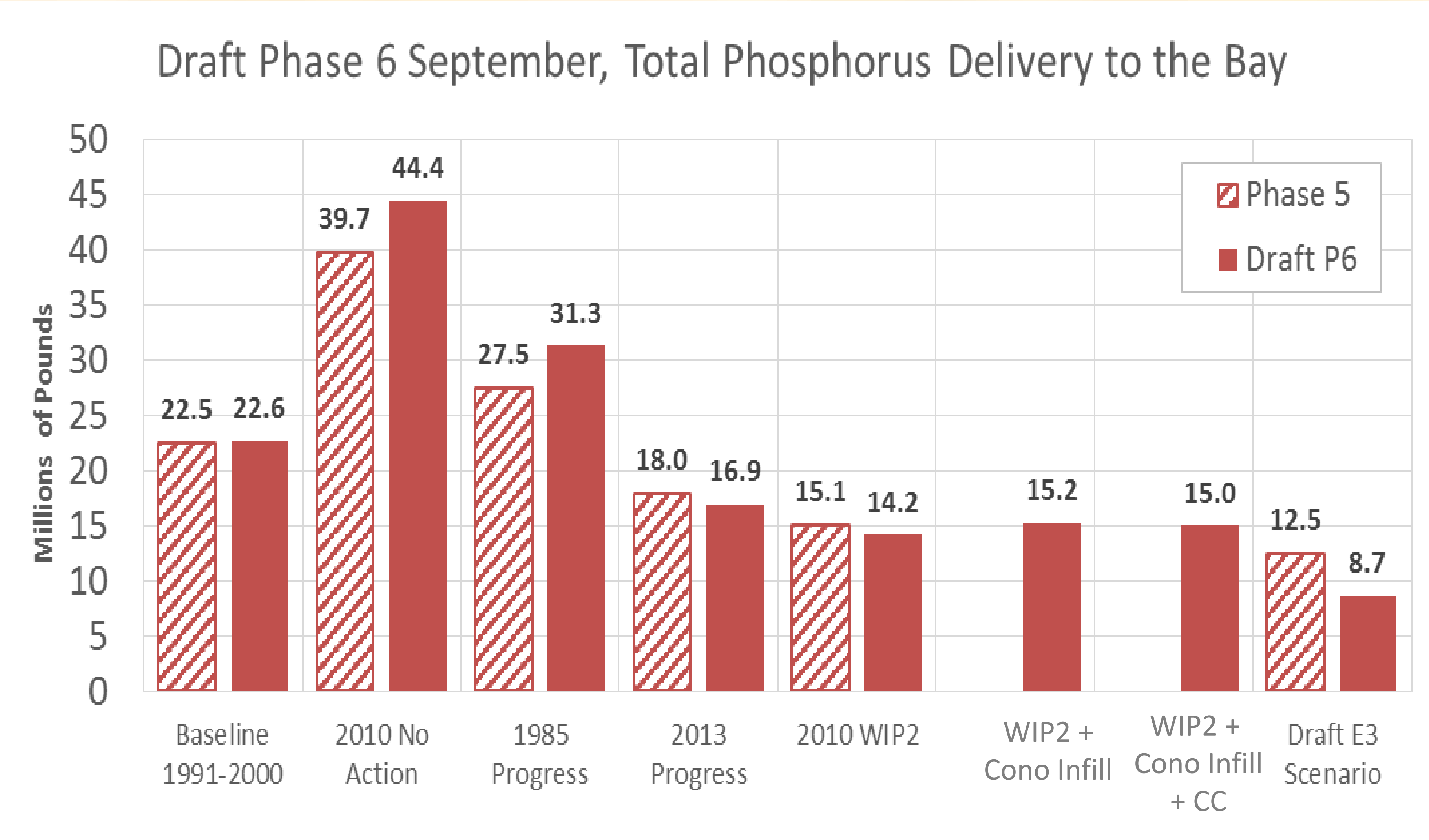
Lee Currey, MDE and Dave Montali, Tetra Tech with
Lew Linker, EPA-CBPO, Gary Shenk, USGS-CBPO and the Modeling Team

Chesapeake Bay Program
Science, Restoration, Partnership

Key Points

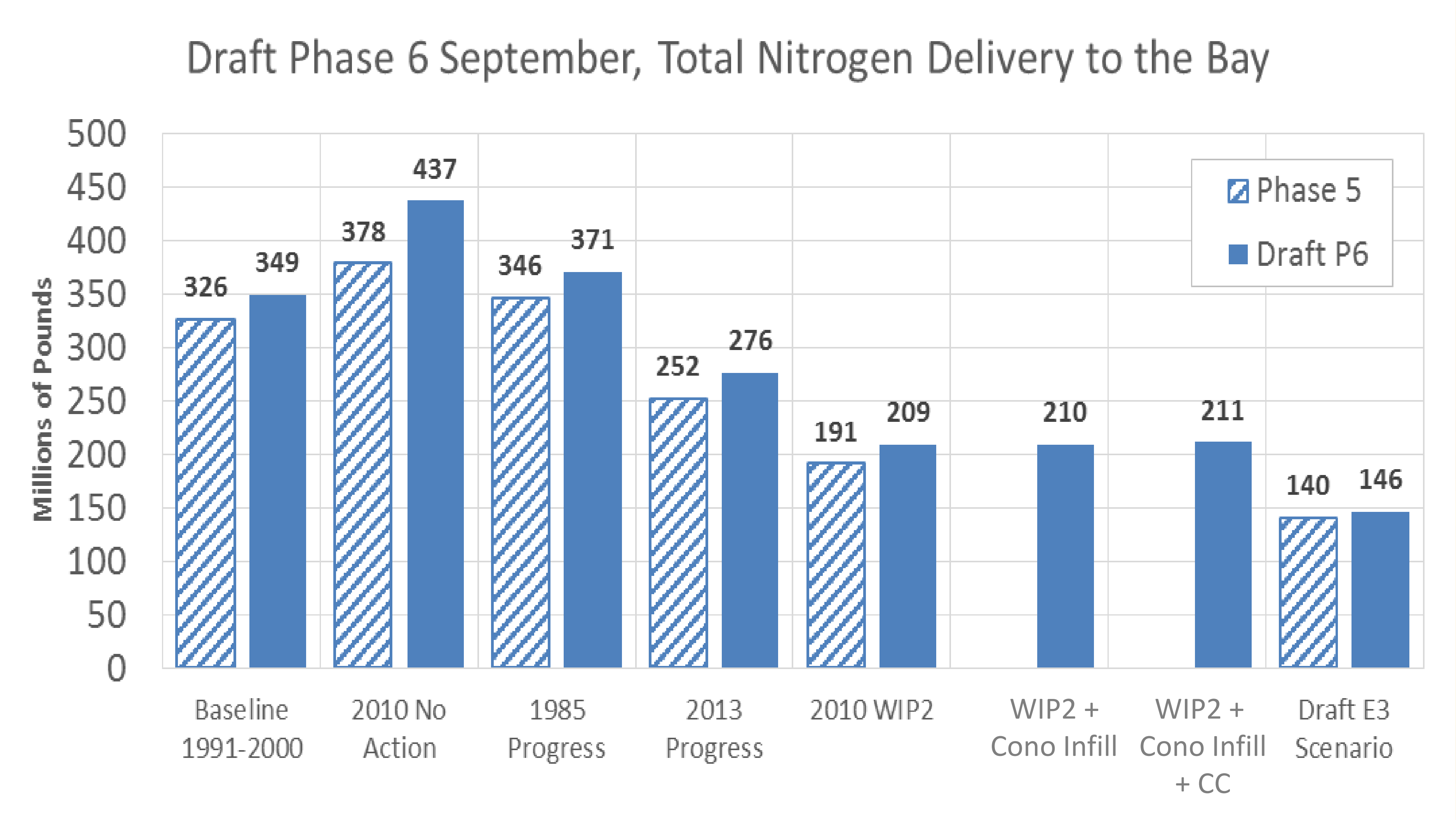
- Current Phase 6 Watershed (WS) and Water Quality and Sediment Transport (WQST) models have findings consistent with the 2010 simulations and with earlier representations of Conowingo infill's influence on Chesapeake tidal water quality.
- The technical direction and guidance from STAC and from recent Conowingo infill research was applied to the Phase 6 simulation.
- Five separate peer reviews on different aspects of the the Conowingo assessment were conducted
  http://www.chesapeakebay.net/who/group/modeling_team
- Conclusions.

Phase 6 Phosphorus Loads



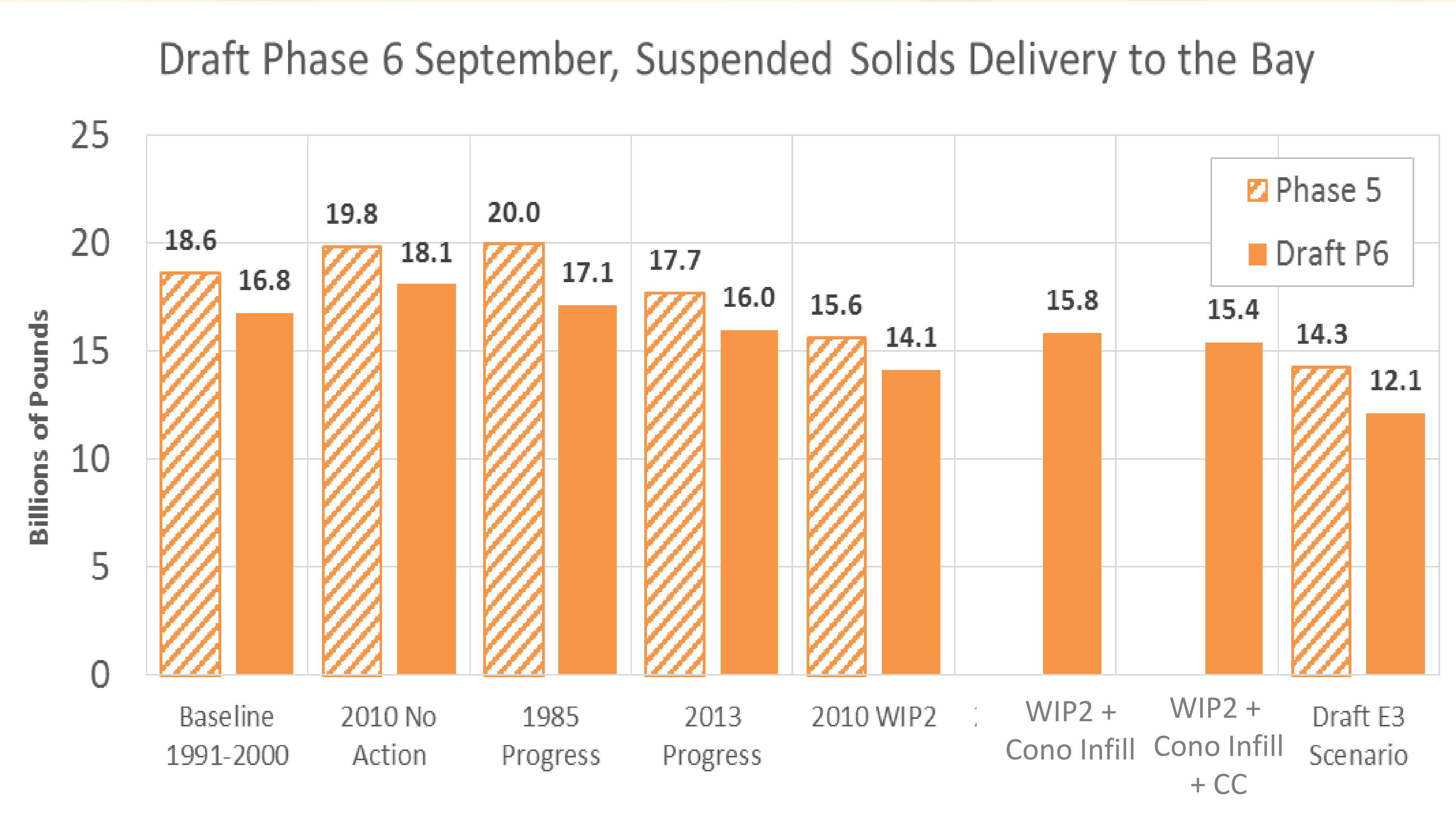
2017 September Draft Phase 6 in solid blue bars. Phase 5.3.2 in stippled bars. Units in millions of pounds.

Phase 6 Nitrogen Loads



2017 September Draft Phase 6 in solid blue bars. Phase 5.3.2 in stippled bars. Units in millions of pounds.

Phase 6 Loads Sediment Loads



2017 September Draft Phase 6 in solid blue bars. Phase 5.3.2 in stippled bars. Units in billions of pounds.

JEQ Estimated Deep Channel Nonattainment under Conowingo Infill Conditions

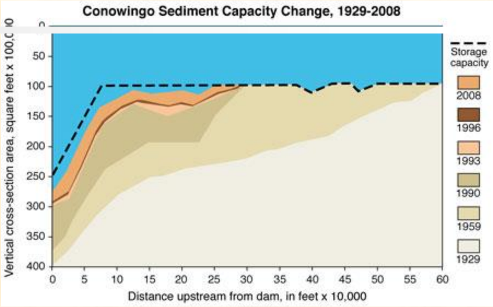
Table 1. Model-estimated level of time and space nonattainment of deep-channel dissolved oxygen (DO) in all Chesapeake Bay segments that have a deep-channel designated use. The first four scenarios (columns 2–5) are key milestone scenarios and are ordered from the highest to the lowest nutrient and sediment loads for the entire Chesapeake watershed. The nutrient and sediment scenario loads are under the scenario title and have units of millions of kilograms for total nitrogen (TN), total phosphorus (TP), and total suspended solids (TSS). The last four columns (columns 6–9) are different Conowingo infill scenarios. Deep-channel variances of 2% are applied in the central mainstem (CB4MH) and Eastern Bay (EASMH) and 16% in the lower Chester River (CHSMH). (A variance is an allowable exceedance of an established water quality standard based on the best available data on achievable water quality conditions.) The estimated degree of nonattainment of the deep-channel DO water quality standard is shown in bold type for each deep-water segment of the Chesapeake. Once attainment is estimated to be achieved, the value is shown in italic type.

Scenario CB segment	1985 Scenario 160 TN 11.2 TP 5480 TSS	2010 Scenario 119 TN 8.8 TP 3790 TSS	TMDL WIP† Scenario 87 TN 6.8 TP 3030 TSS	All Forest Scenario 24 TN 1.2 TP 610 TSS	Increase of nonattainment under Conowingo scour conditions in January storm	Increase of nonattainment under January storm conditions compared with No Storm Scenario	Increase of nonattainment under June storm conditions compared with No Storm Scenario	Increase of nonattainment under Moderate High Flow conditions
	%							
CB3MH	**17**	**5**	*0*	*0*	*0*	**1**	**1**	*0*
CB4MH	**49**	**23**	*1*	*0*	**1**	**1**	**4**	**2**
CB5MH	**17**	*0*	*0*	*0*	*0*	*0*	*0*	*0*
CHSMH	**39**	**28**	*15*	*0*	**1**	**2**	**8**	**1**
EASMH	**29**	**14**	*1*	*0*	**1**	**2**	**3**	**3**
PATMH	**42**	**18**	*0*	*0*	*0*	*0*	*0*	*0*
POTMH	**20**	*0*	*0*	*0*	*0*	*0*	*0*	*0*
RPPMH	**23**	*0*	*0*	*0*	*0*	*0*	*0*	*0*

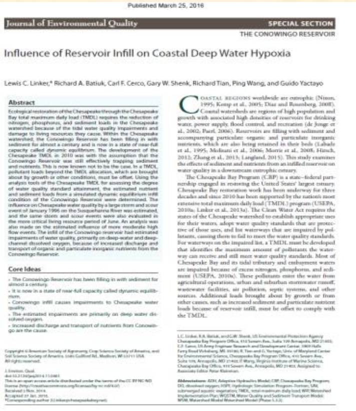
† Total maximum daily load Watershed Implementation Plan.

Brief Review of Conowingo Infill

- Conowingo is nearing dynamic equilibrium, which has reduced its ability to trap sediment and nutrients.
- Numerous research articles have documented and quantified the process and they provide estimates of changes in Conowingo transport, which are incorporated in this analysis.



Source: Graph, Michael Langland, U.S. Geological Survey


Published March 25, 2016

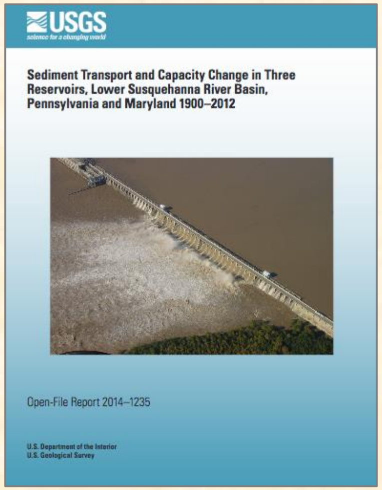
Journal of Environmental Quality — SPECIAL SECTION — THE CONOWINGO RESERVOIR

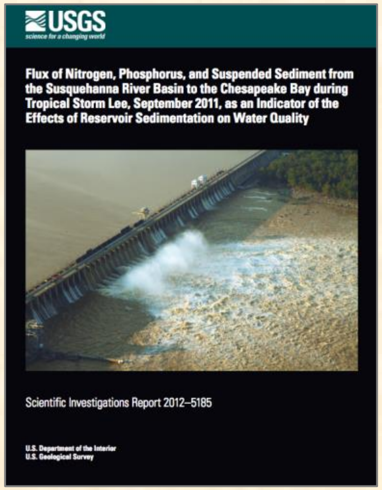
Influence of Reservoir Infill on Coastal Deep Water Hypoxia

Lewis C. Linker, Richard A. Batiuk, Carl F. Cerco, Gary W. Shenk, Richard Tian, Ping Wang, and Guido Yactayo

Abstract

Core Ideas





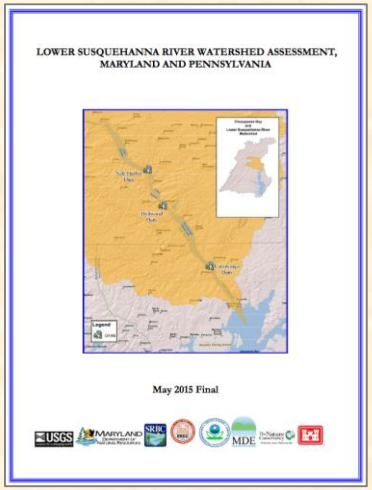

Environmental Science & Technology

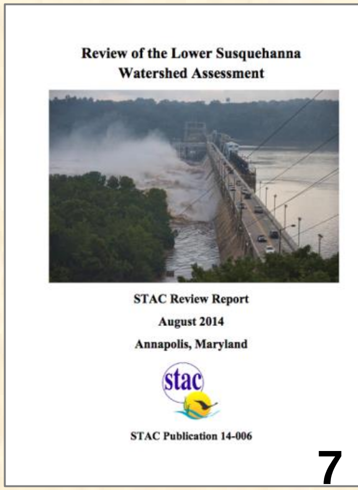
Long-Term Changes in Sediment and Nutrient Delivery from Conowingo Dam to Chesapeake Bay: Effects of Reservoir Sedimentation

Qian Zhang, Robert M. Hirsch, and William P. Ball

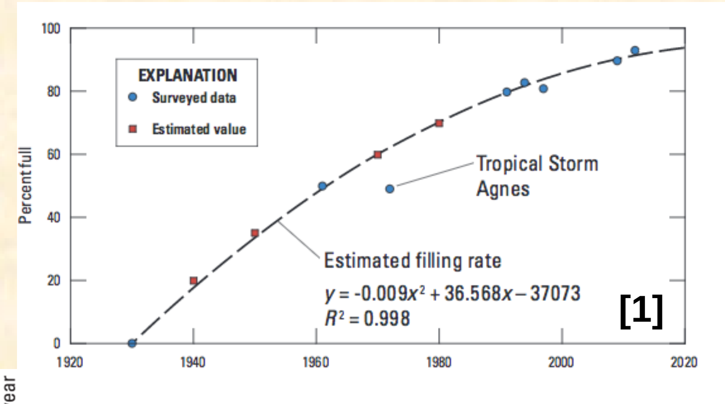
ABSTRACT

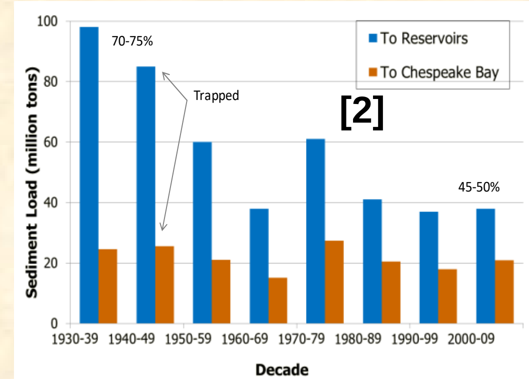
1. INTRODUCTION

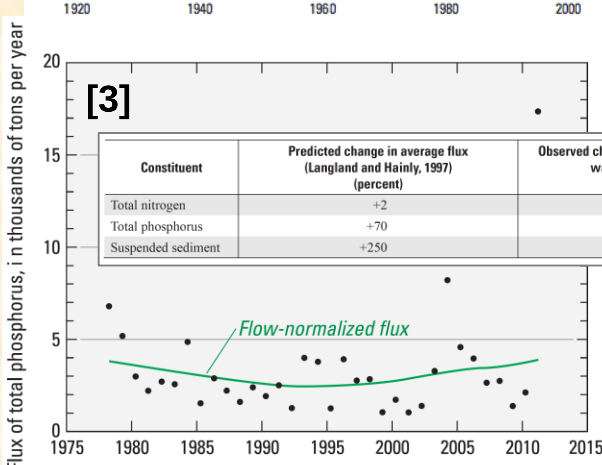




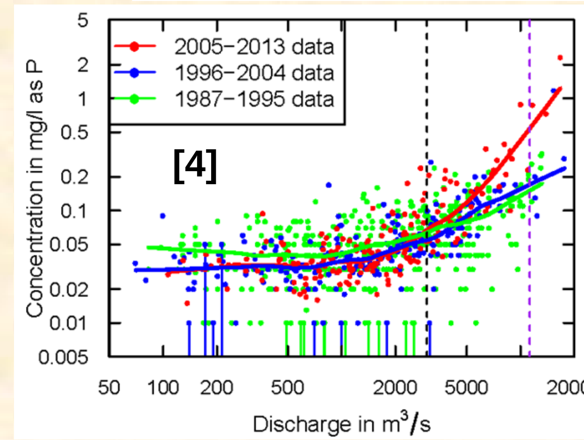
The multiple lines of evidence

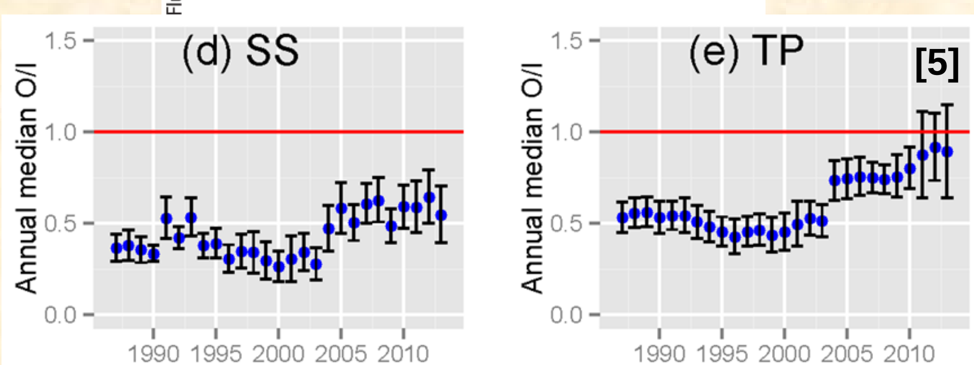


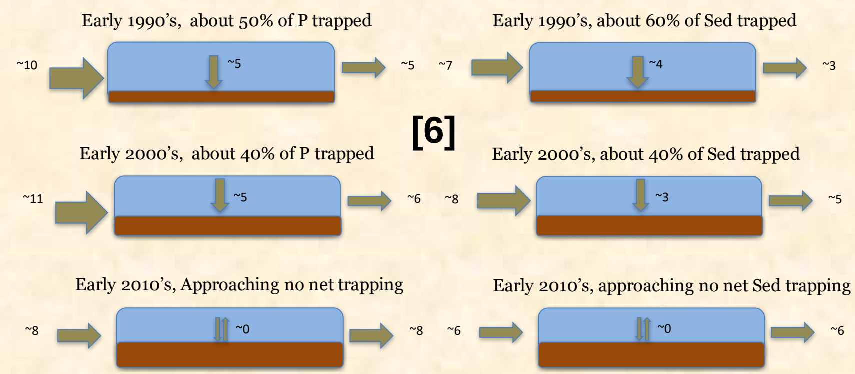




Constituent	Predicted change in average flux (Langland and Hainly, 1997) (percent)	Observed change in flow-normalized flux, water years 1996–2011 (percent)
Total nitrogen	+2	-3.2
Total phosphorus	+70	+55
Suspended sediment	+250	+97







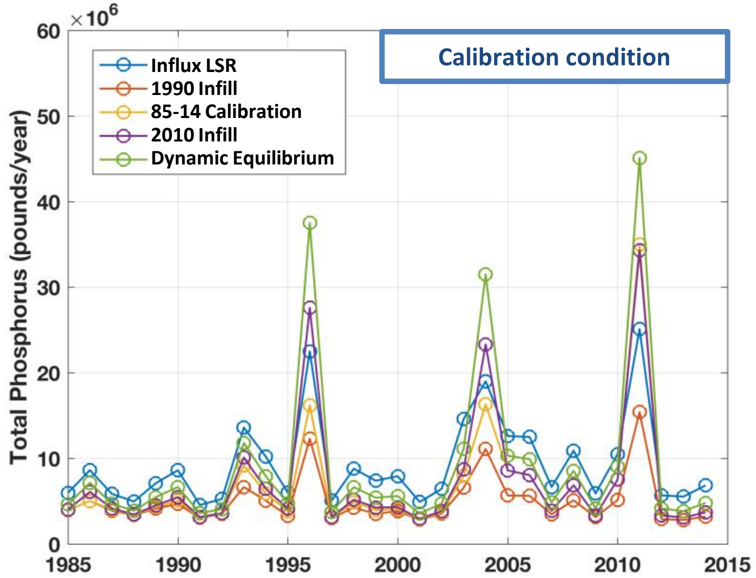
[1][2] Langland, M.J., 2009. Bathymetry and sediment-storage capacity change in three reservoirs on the lower Susquehanna River, 1996–2008: U.S. Geological Survey Scientific Investigations Report 2009–5110, 21 p.
[3] Hirsch, R.M., 2012. Flux of nitrogen, phosphorus, and suspended sediment from the Susquehanna River Basin to the Chesapeake Bay during Tropical Storm Lee, September 2011, as an indicator of the effects of reservoir sedimentation on water quality: U.S. Geological Survey Scientific Investigations Report 2012–5185, 17 p.
[4][5] Zhang, Q., Hirsch, R.M., Ball, W.P., 2016. Long-term changes in sediment and nutrient delivery from Conowingo Dam to Chesapeake Bay: Effects of reservoir sedimentation, Environ. Sci. Technol, 50(4), 1877-1886.
[6] Currey, L., 2017, Conowingo dam update, WQGIT

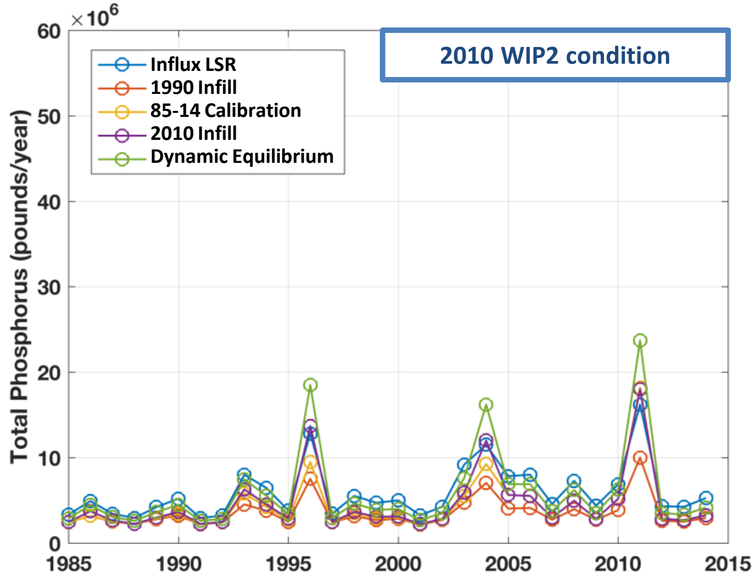
Conowingo Infill

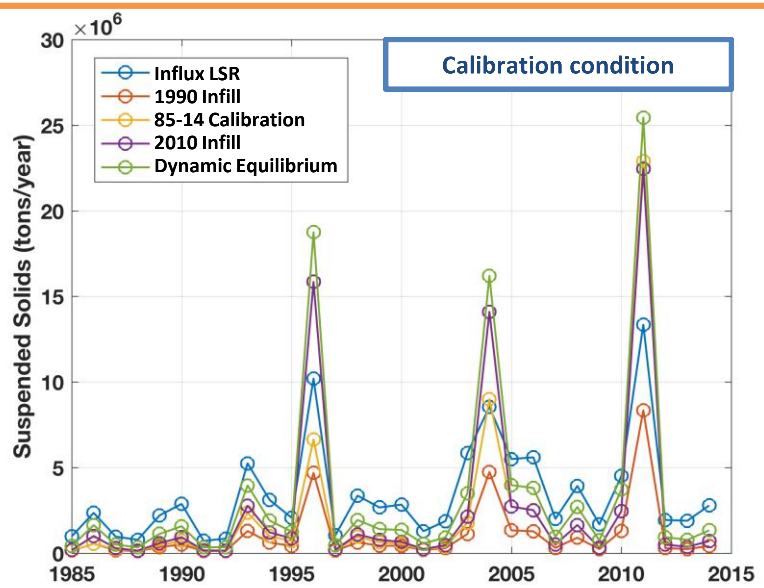
- The Modeling Workgroup, with guidance from STAC, and the recent Conowingo infill research has made four key state-of-the-science decisions for the simulation of Conowingo infill:
  - The Lower Susquehanna Reservoirs are now in the state of dynamic equilibrium (no long-term trapping) [1][2][3].
  - The information on changes the trapping capacity provided by USGS-WRTDS should be used in the the model calibration [1][2][3].
  - Constant delivery factors should be used for scenarios involving both increases or decreases in the sediment and phosphorus inputs [4].
  - Use of a flow dependent dynamic G-series response for the organic- nitrogen, phosphorus, and carbon [5].

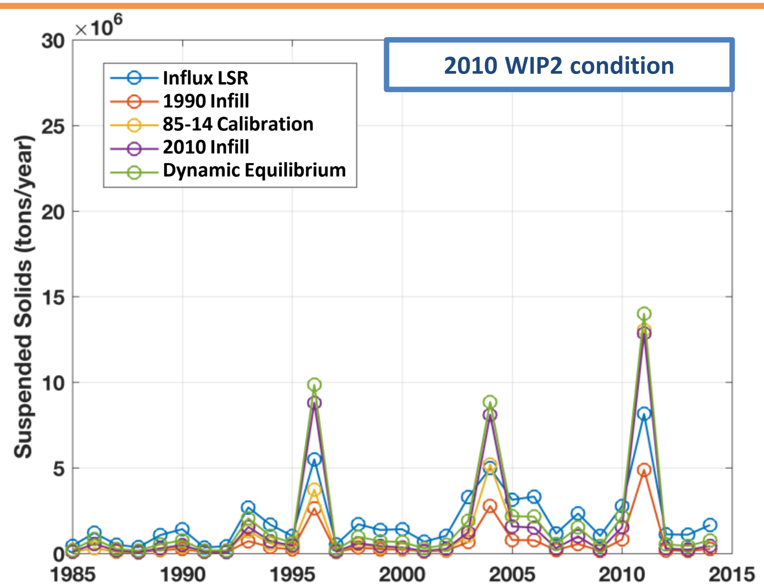
[1] Hirsch, R.M., 2012, Flux of nitrogen, phosphorus, and suspended sediment from the Susquehanna River Basin to the Chesapeake Bay during Tropical Storm Lee, September 2011, as an indicator of the effects of reservoir sedimentation on water quality: U.S. Geological Survey Scientific Investigations Report 2012–5185, 17 p.
[2] Zhang, Q., D.C. Brady, and W.P. Ball, 2013. Long-term Seasonal Trends of Nitrogen, Phosphorus, and Suspended Sediment Load from the Non-tidal Susquehanna River Basin to Chesapeake Bay, Science of the Total Environment, 452–453: 208–221
[3] Zhang, Q., R.M. Hirsch, and W. Ball. 2016a. Long-Term Changes in Sediment and Nutrient Delivery from Conowingo Dam to Chesapeake Bay: Effects of Reservoir Sedimentation. Environmental Science & Technology 50(4): 1877-1886
[4] HDR Inc. Coupled Sediment Flux Model and Conowingo Pond Mass Balance Model (2017) - http://www.chesapeakebay.net/channel_files/24718/2017-02-14_conowingo_hdr_models_2.pdf
[5] HDR Inc. Coupled Sediment Flux Model and Conowingo Pond Mass Balance Model (2017) - http://www.chesapeakebay.net/channel_files/24719/2017-04-04_conowingo_hdr_g1g2g3_2.pdf

Simulated responses for different infill conditions



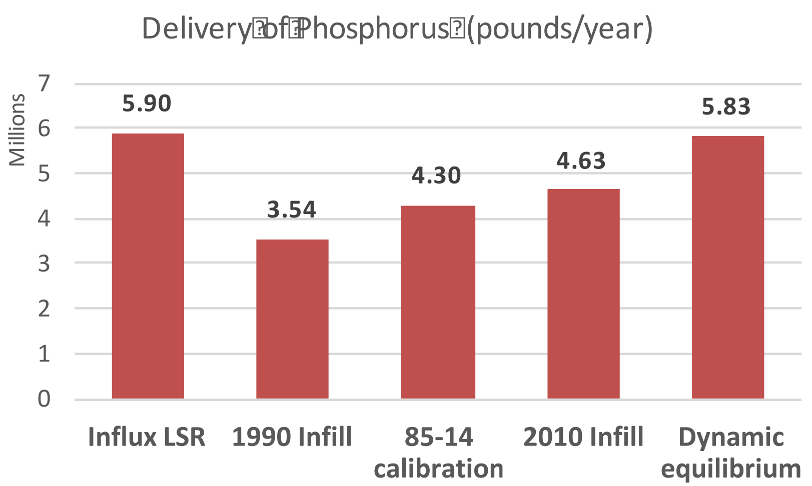


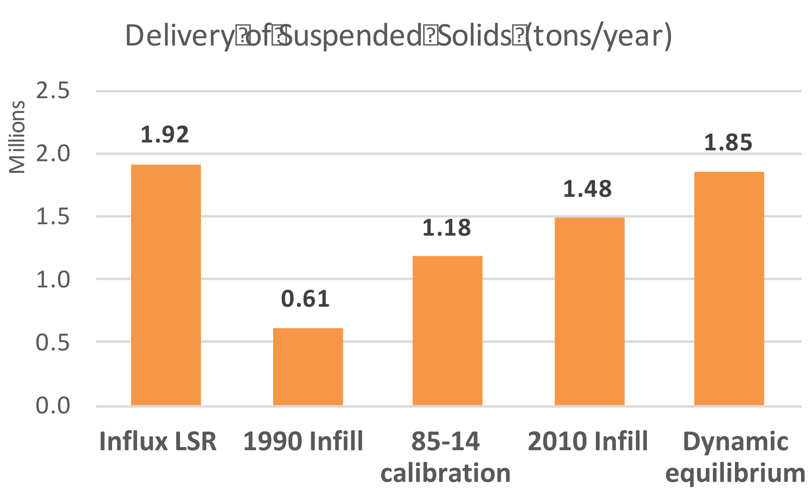




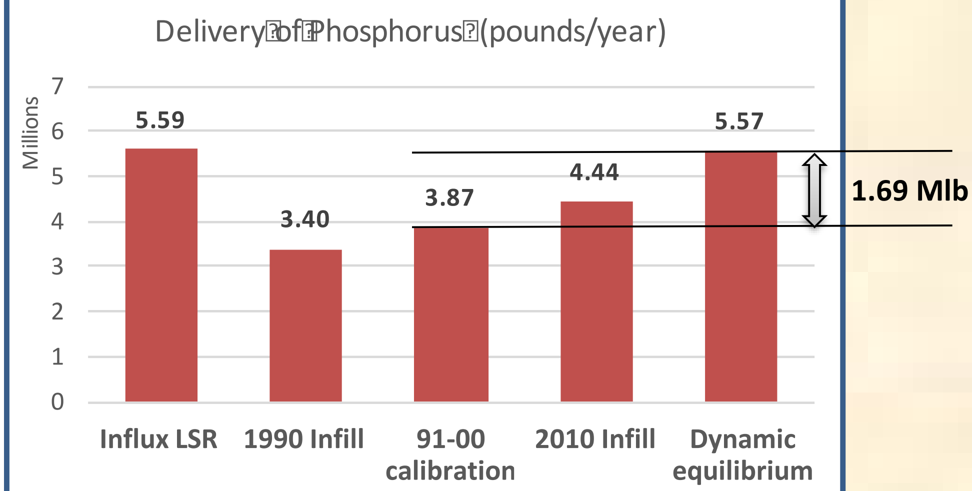
Lower Susquehanna Reservoirs – 2010 WIP2 Condition

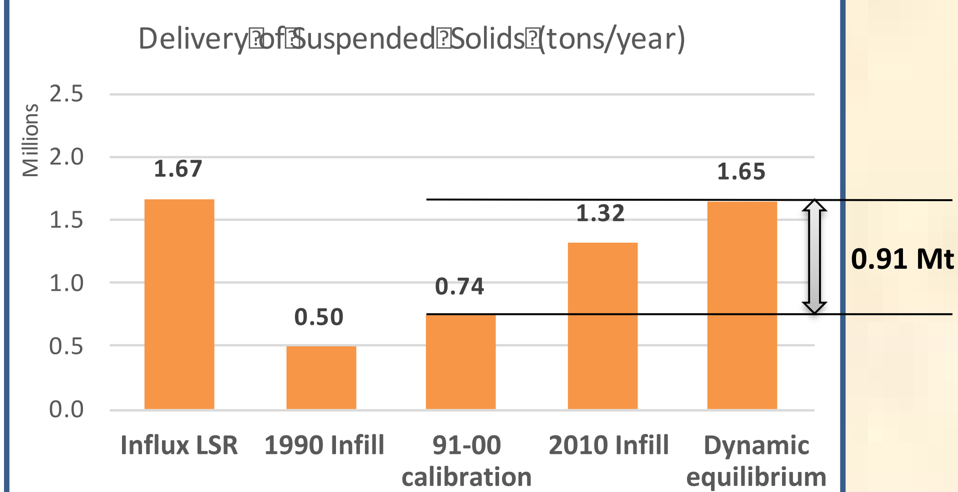
1985 – 2014





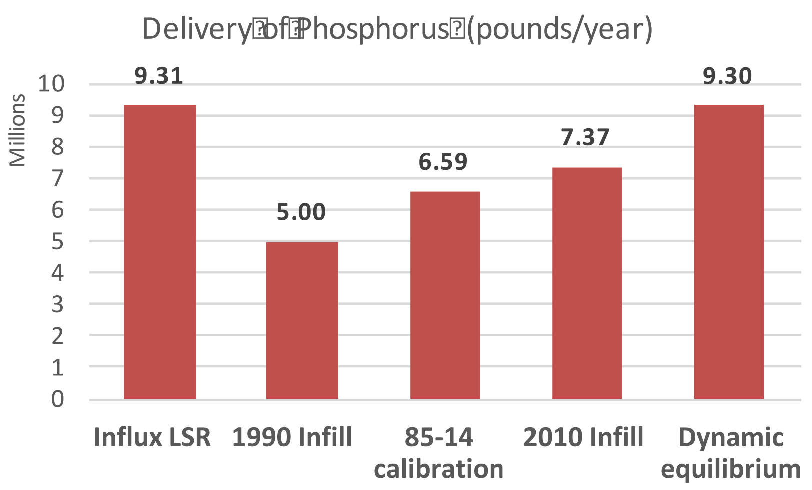
1991 – 2000

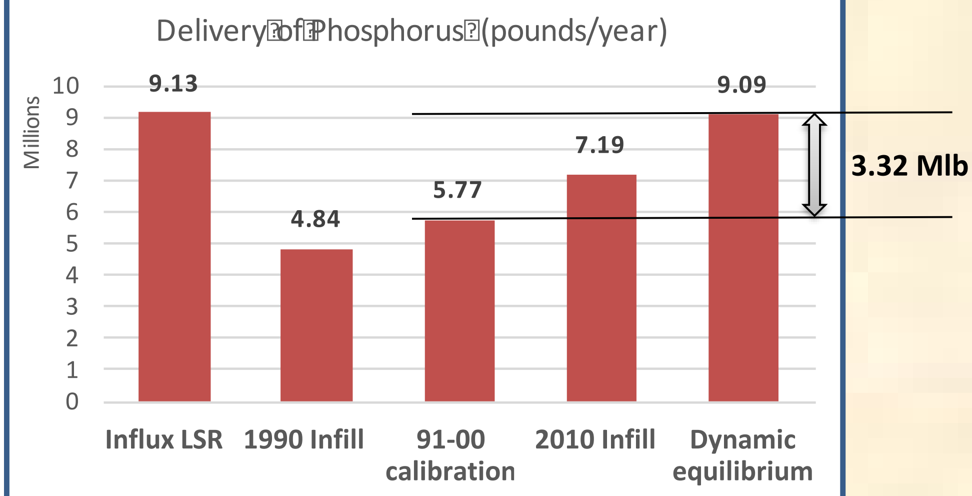


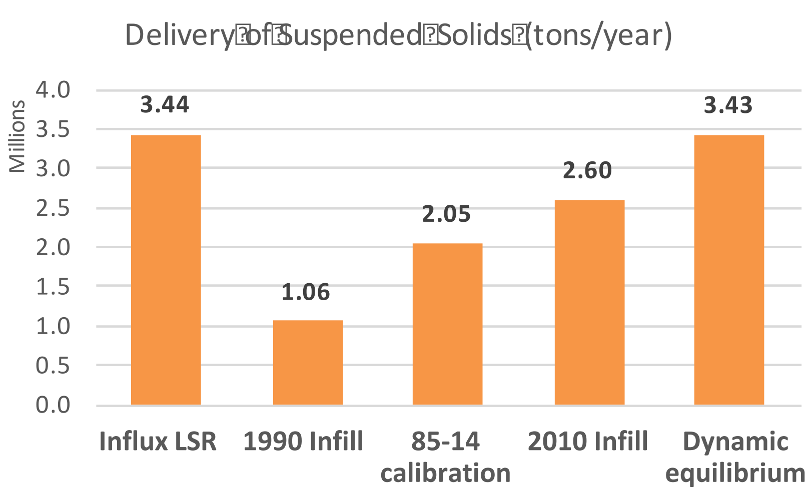


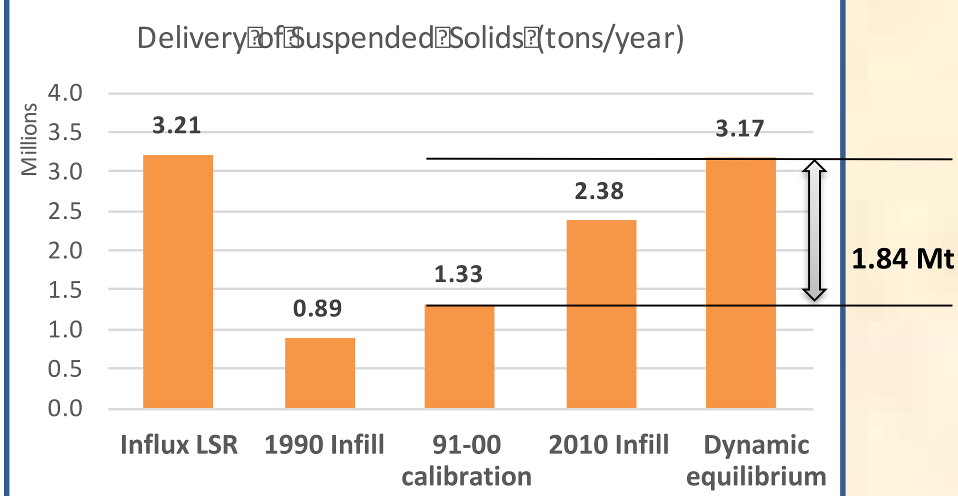
Lower Susquehanna Reservoirs – Calibration Condition

1985 – 2014	1991 – 2000

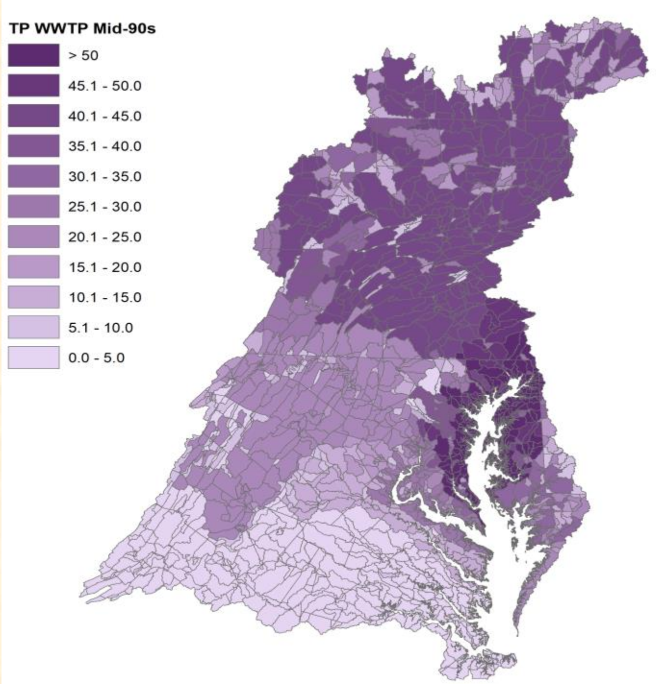


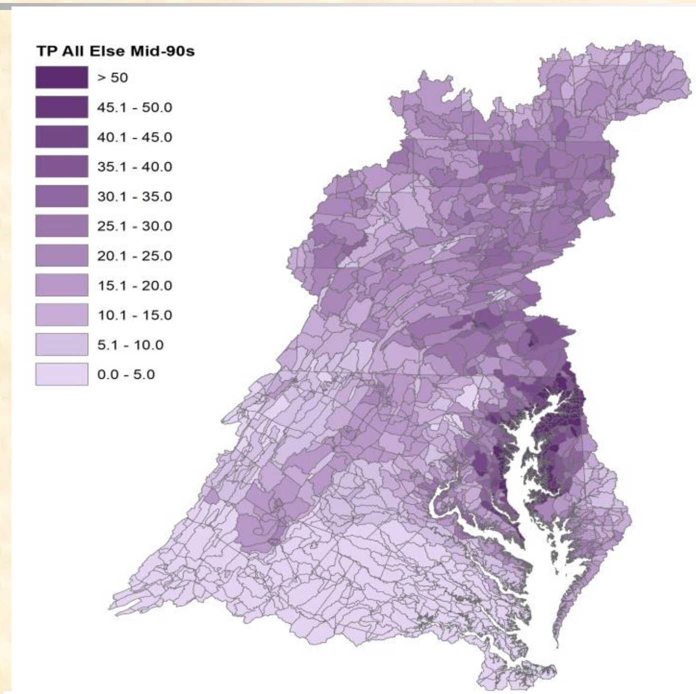


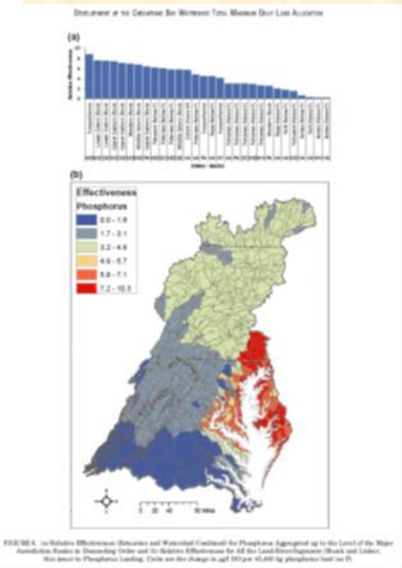


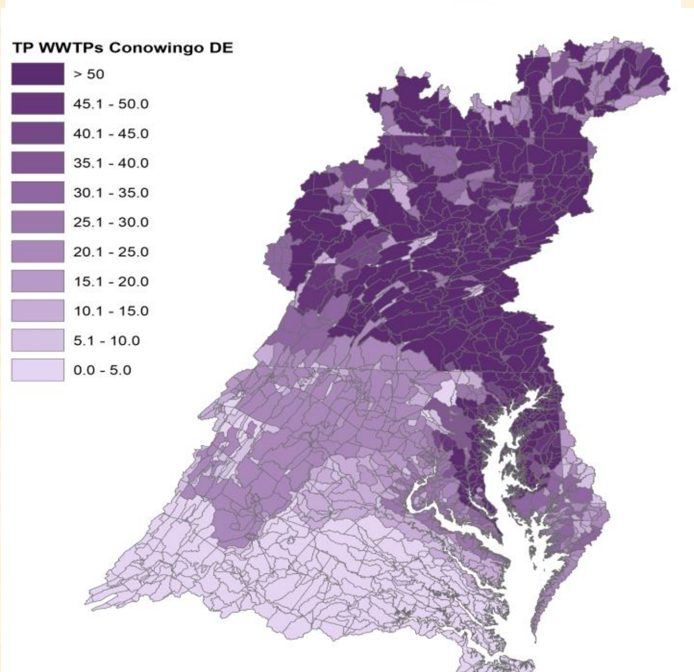


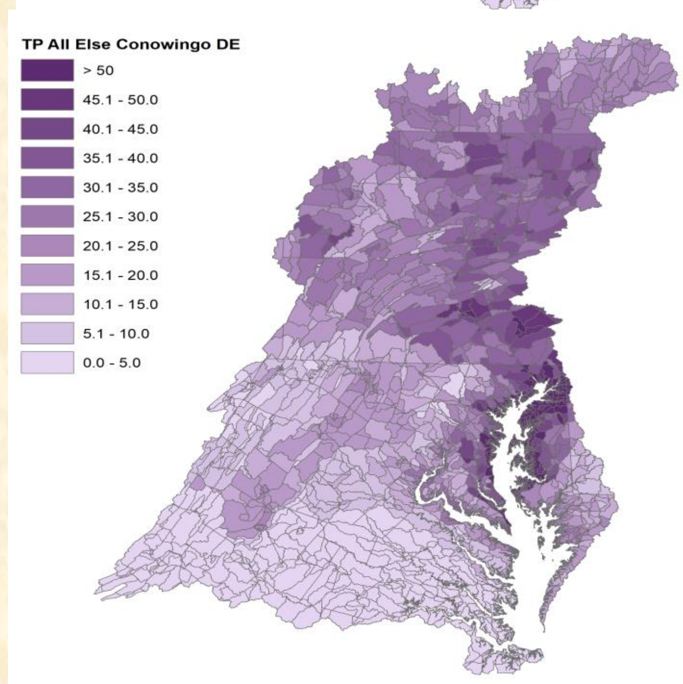
How the TP transport factors have changed by Conowingo Infill



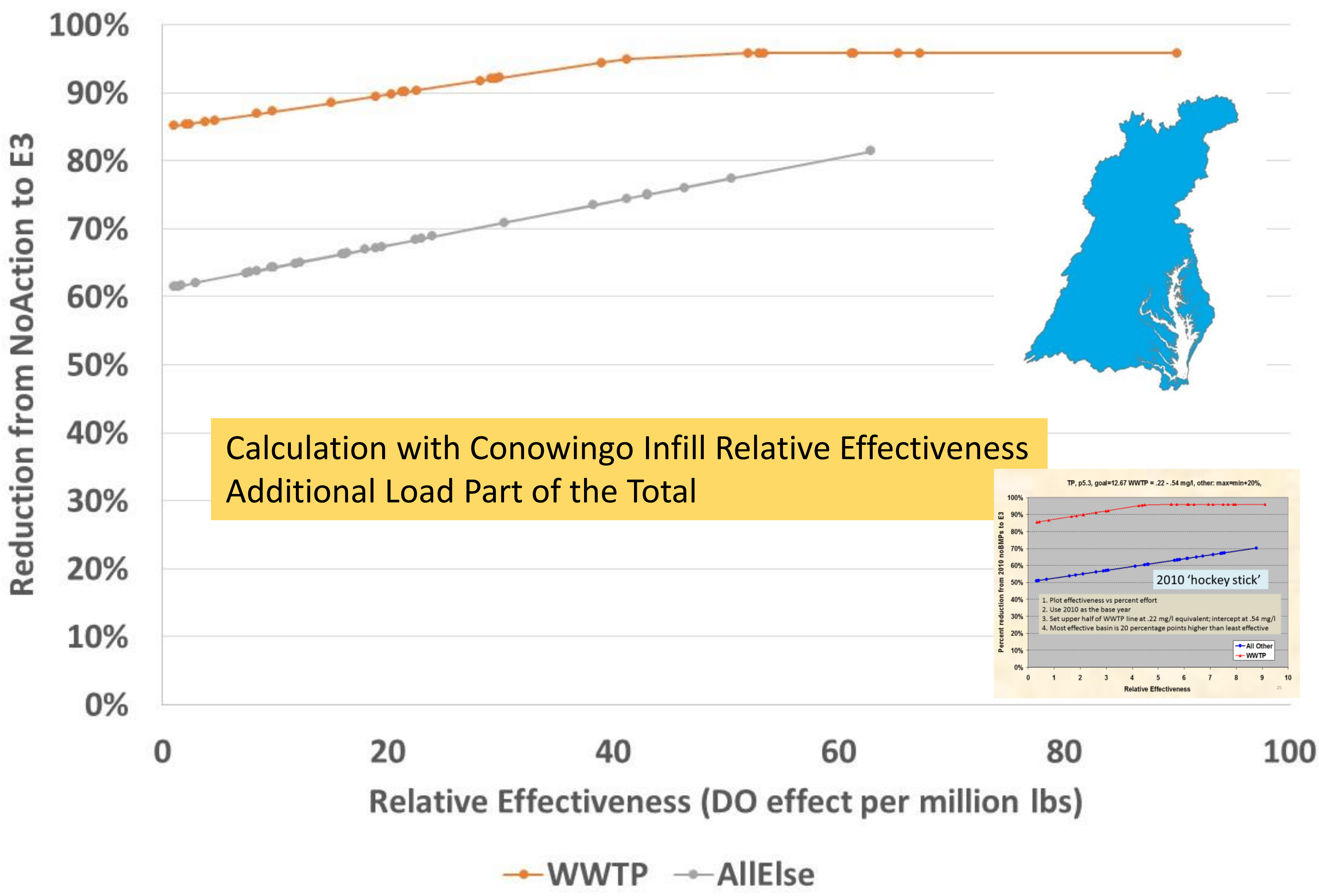


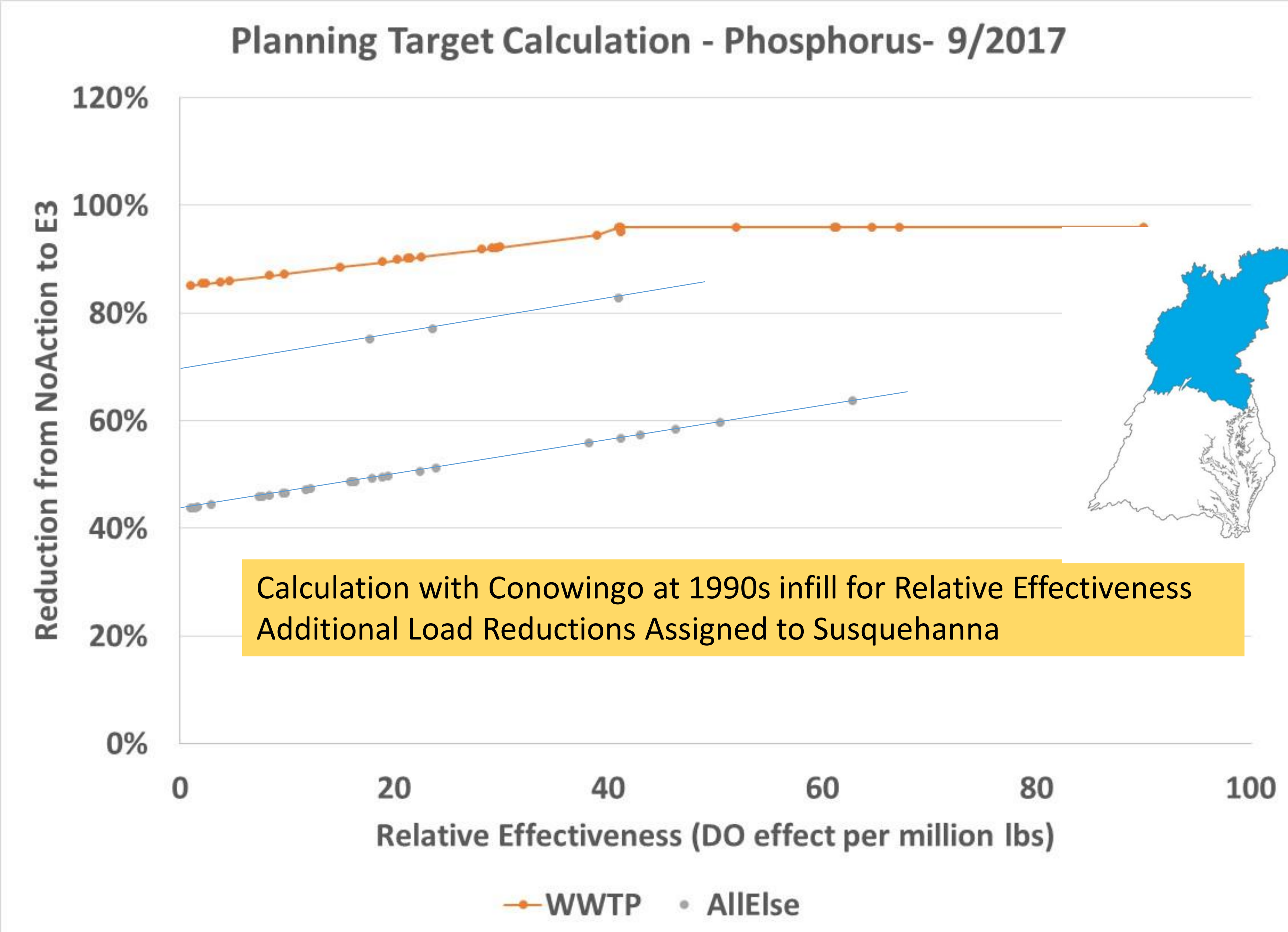


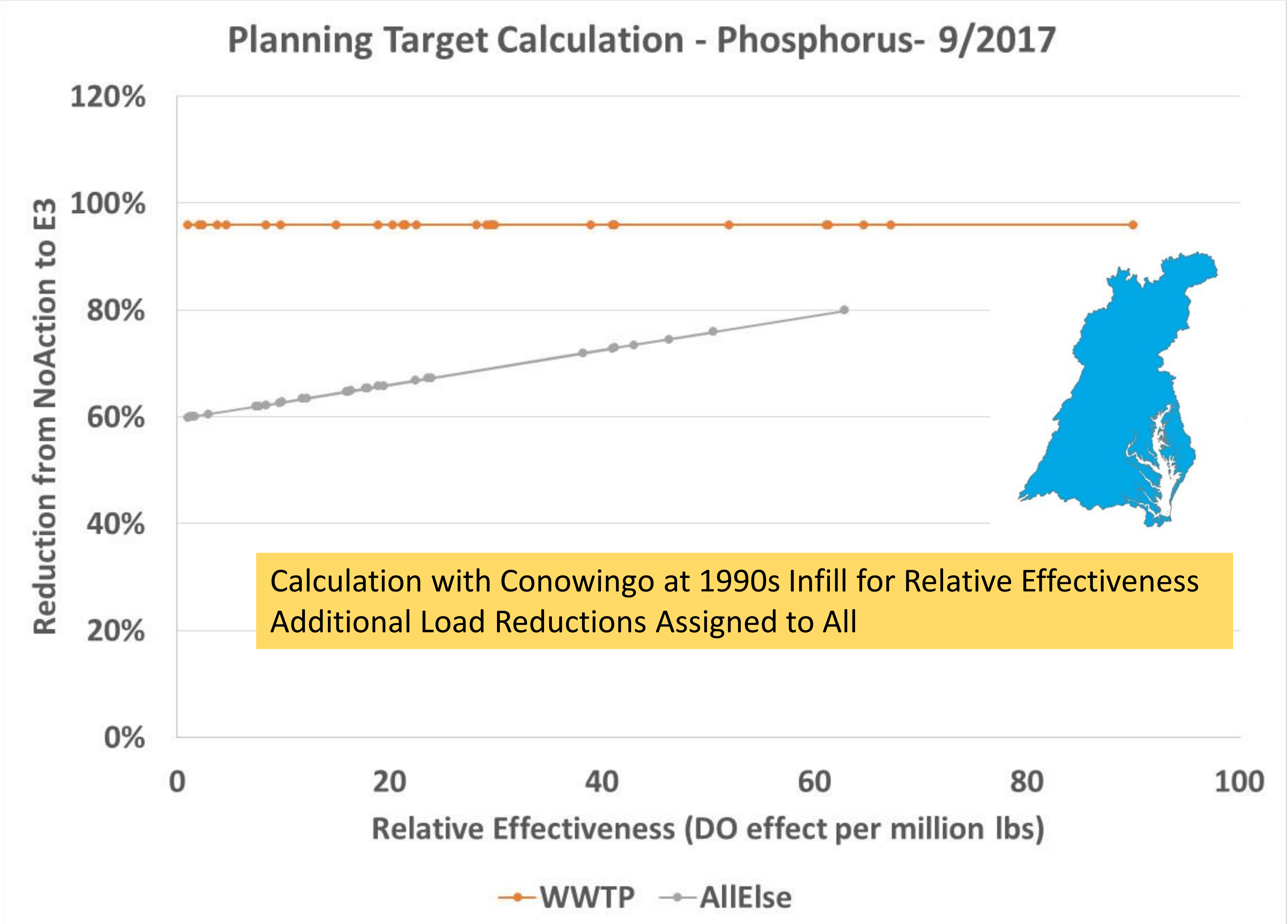




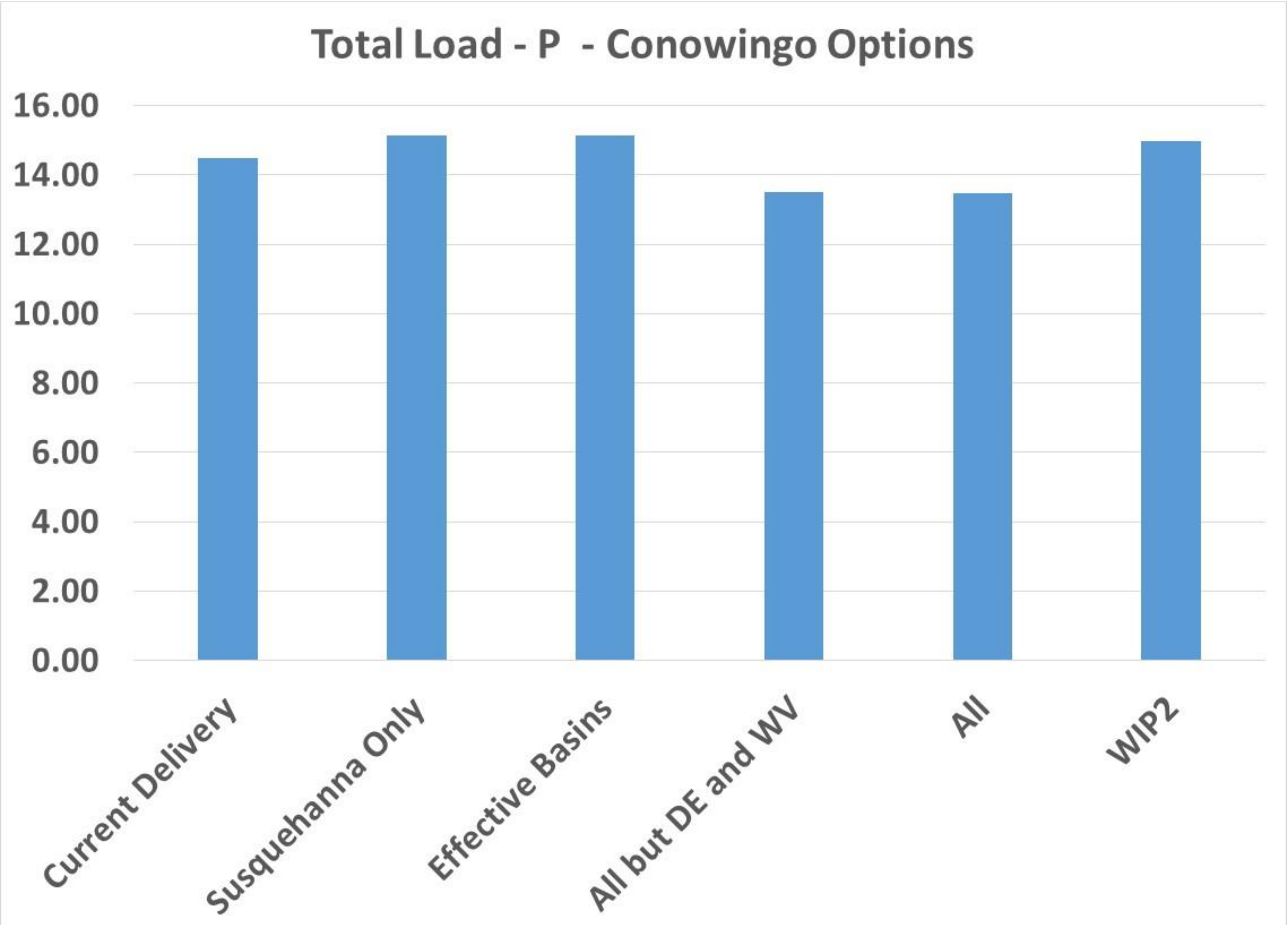
Planning Target Calculation - Phosphorus- 9/2017

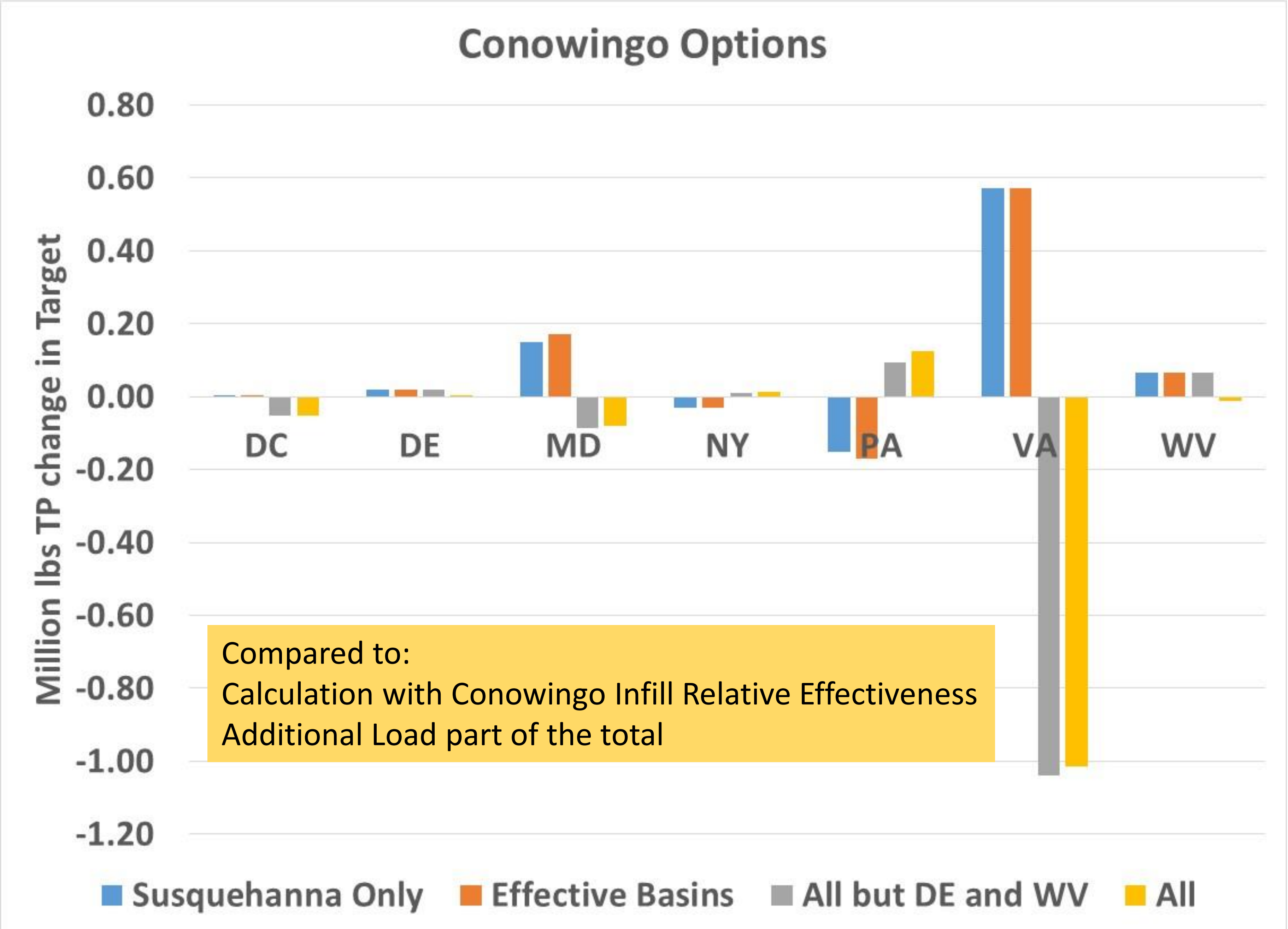


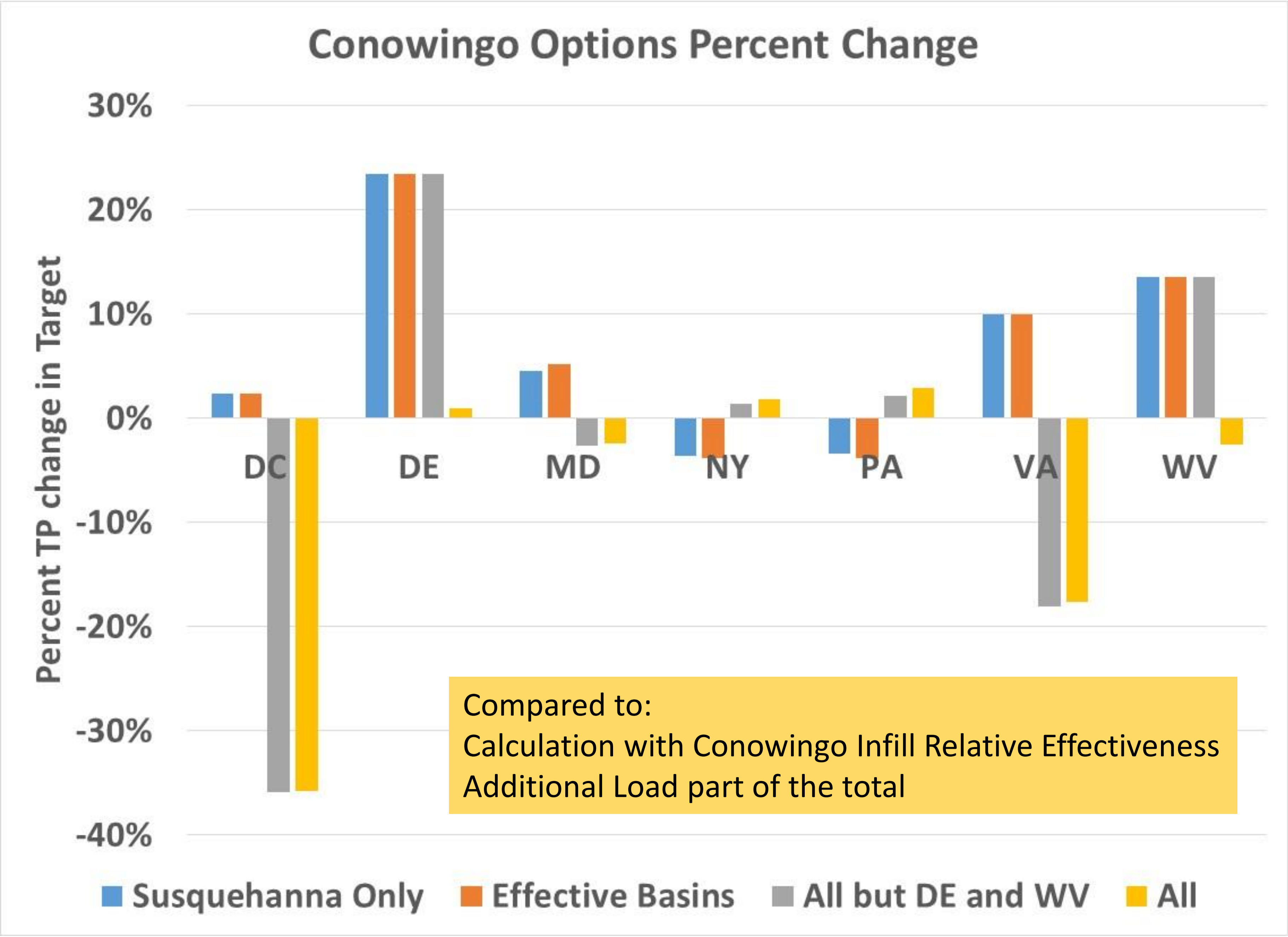

Planning Target Calculation - Phosphorus- 9/2017
120%
100%
80%
60%
40%
20%
0%
Reduction from NoAction to E3
0
20
40
60
80
100
Relative Effectiveness (DO effect per million lbs)
WWTP
AllElse
Calculation with Conowingo at 1990s infill for Relative Effectiveness
Additional Load Reductions Assigned to Susquehanna



Planning Target Calculation - Phosphorus- 9/2017
120%
100%
80%
60%
40%
20%
0%
Reduction from NoAction to E3
0
20
40
60
80
100
Relative Effectiveness (DO effect per million lbs)
Calculation with Conowingo at 1990s Infill for Relative Effectiveness
Additional Load Reductions Assigned to All
WWTP
AllElse


Total Load - P - Conowingo Options
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Current Delivery
Susquehanna Only
Effective Basins
All but DE and WV
All
WIP2


Conowingo Options
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
-1.20
Million lbs TP change in Target
DC
DE
MD
NY
PA
VA
WV
Compared to:
Calculation with Conowingo Infill Relative Effectiveness
Additional Load part of the total
Susquehanna Only
Effective Basins
All but DE and WV
All


Conowingo Options Percent Change
30%
20%
10%
0%
-10%
-20%
-30%
-40%
Percent TP change in Target
DC
DE
MD
NY
PA
VA
WV
Compared to:
Calculation with Conowingo Infill Relative Effectiveness
Additional Load part of the total
Susquehanna Only
Effective Basins
All but DE and WV
All

Conclusions:

- The 2017 CBP Models have Conowingo infill findings consistent with the 2010 CBP Models.
- The increase of about 1.5 million pounds phosphorus is consistent with the previous analyses (2 million pounds) going back to 2015 [1].
- The current best estimates of the increase in net transport of phosphorus loads to the Chesapeake due to Conowingo infill is about 1.5 million pounds which results in an estimated ~1% increase in nonattainment of the Deep Channel DO water quality standard under WIP levels of nutrient loads.
- The results shown were based on the Draft Phase 6 Watershed Model of September 2017 with all input changes recommended by the CBP partners

[1] Linker, L.C., Batiuk, R.A., Cerco, C.F., Shenk, G.W., Tian, R., Wang, P., Yactayo, G., 2016. Influence of Reservoir Infill on Coastal Deep Water Hypoxia. Journal of Environmental Quality, 45: 887-893