# The Chesapeake Bay Program's Watershed Model Phase 6 -- Loads and Sensitivities Webinar

***Gary Shenk***

***Olivia Devereux***

***Chesapeake Bay Program Office***

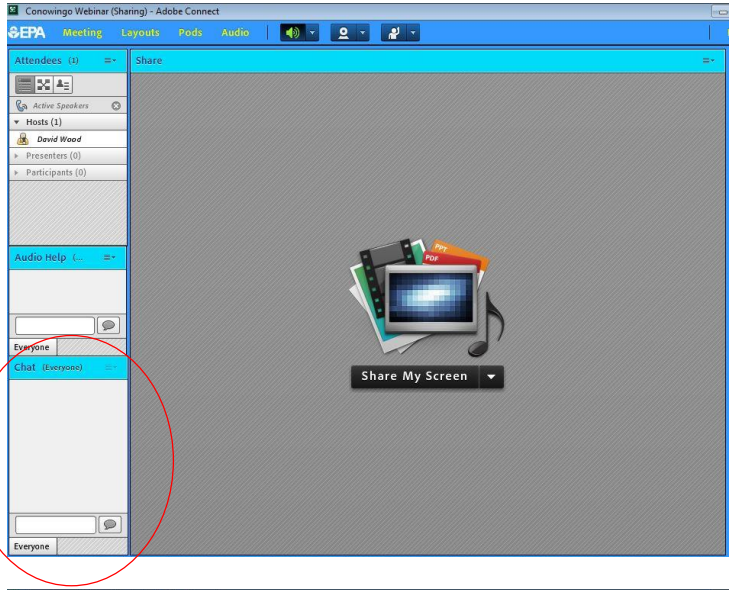
6/1/2017

# Welcome to the Phase 6 Model Review Webinar

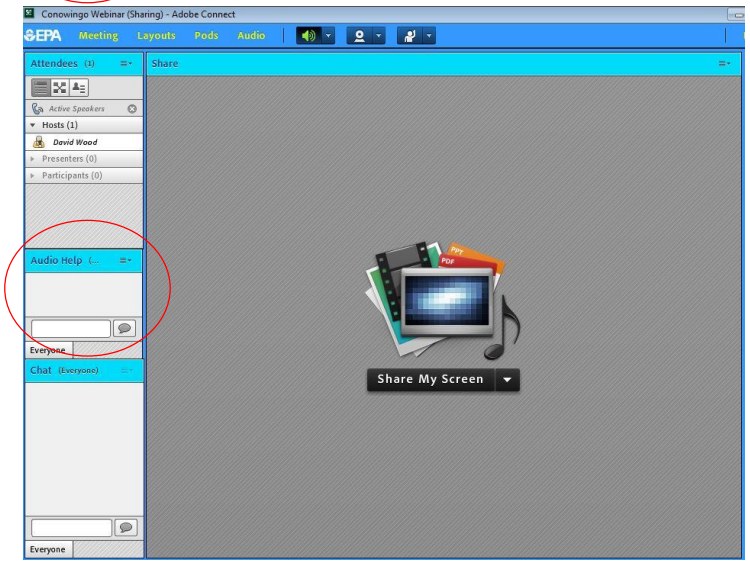
- We ARE Recording this Session
  - The recording and related resources will be available on the Chesapeake Bay Program's calendar page for today's webinar.
  - http://www.chesapeakebay.net/calendar/event/25114/

# Welcome to the Phase 6 Model Review Webinar

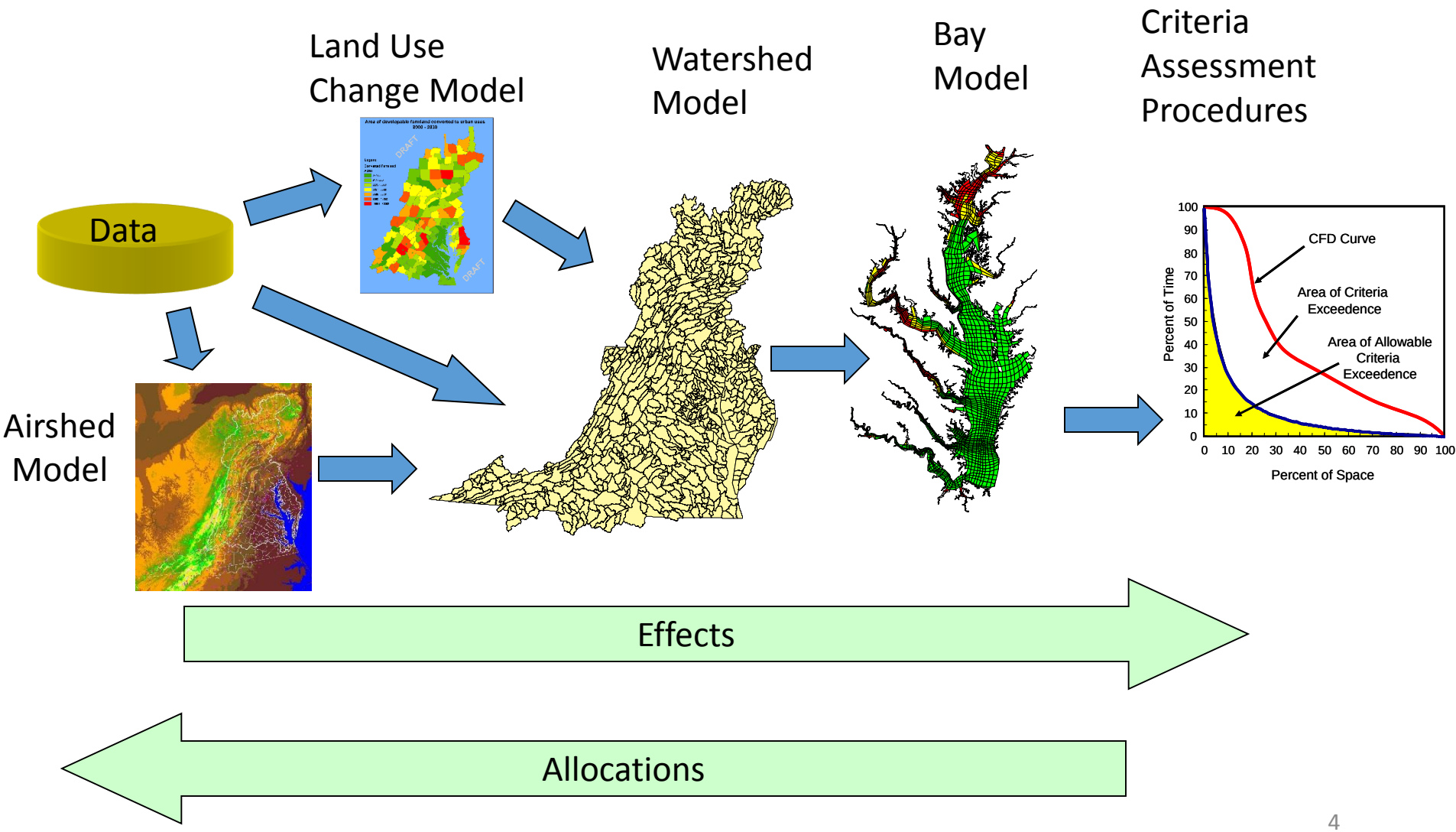
- To Ask a Question
  - Submit your question in the chat box, located in the bottom left of the screen, at any time during the webinar. We will answer as many as possible during a Q&A session following the presentation.




- For A/V Help
  - For audio or visual questions, please use the “Audio Help” box in the center-left of the screen.

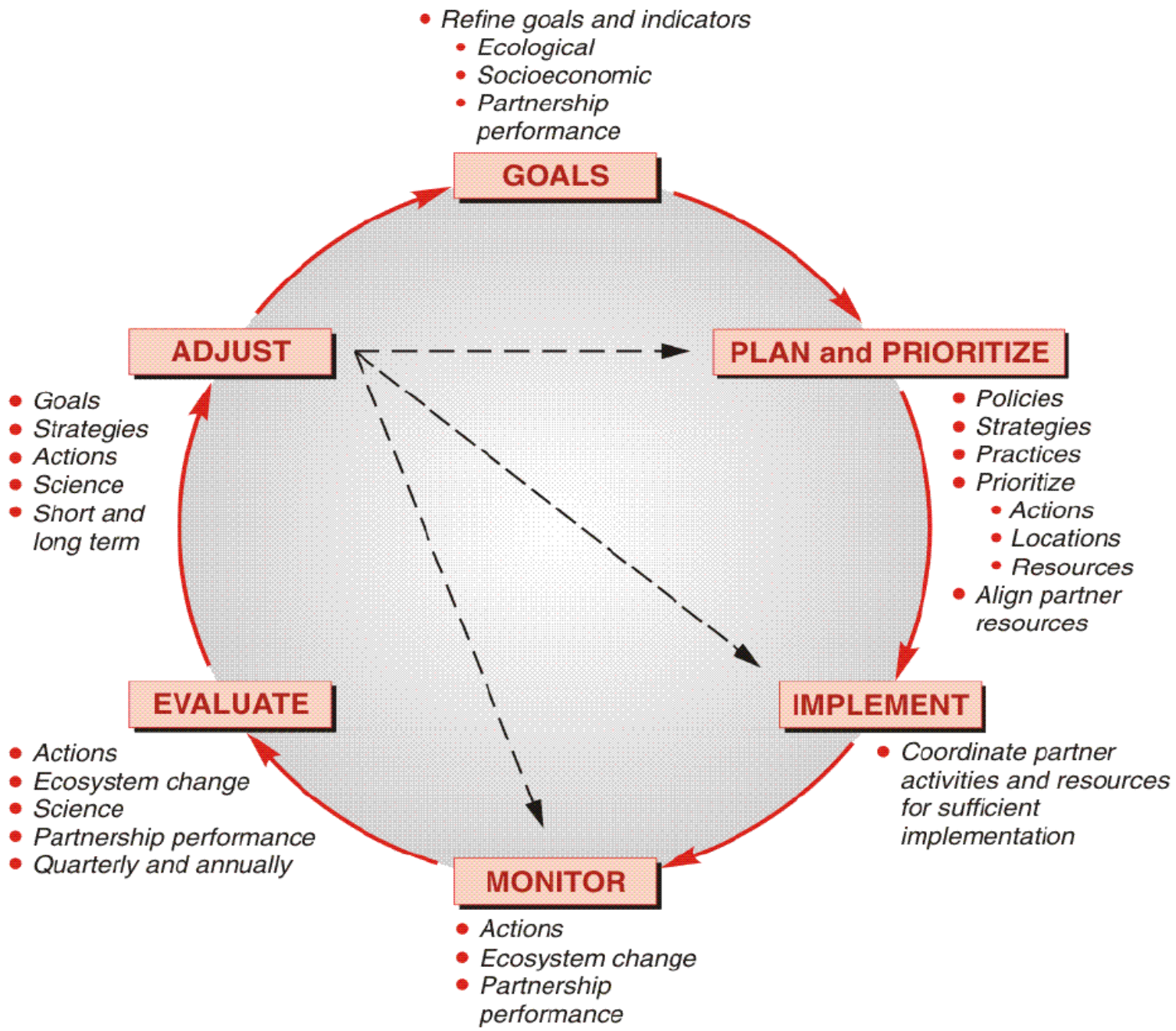


# Decision Support System

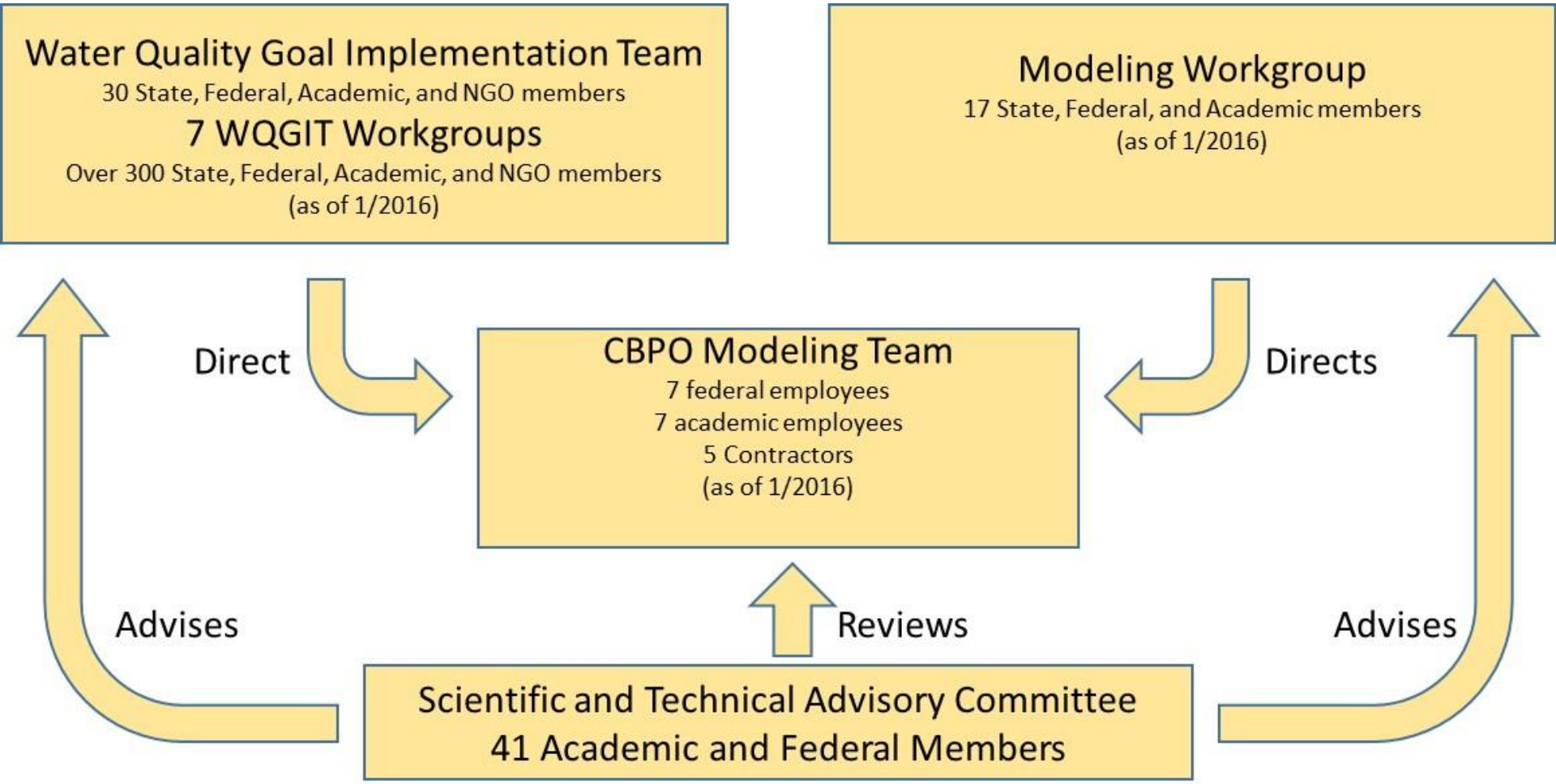


# Continual Updates to Models

| Year | Model Phase | Goal |
|---|---|---|
| 1987 | 0 | 40% reduction |
| 1992 | 2 | 40% of controllable loads |
| 1997 | 4.1 | Confirm 1992 loads |
| 2003 | 4.3 | Reallocation |
| 2010 | 5.3.0 | TMDL |
| 2011 | 5.3.2 | Phase 2 WIP targets |
| 2017 | 6.0 | Phase 3 WIP targets |




Sources: Williams et al. 2007, Levine et al. 2009.


Water Quality Goal Implementation Team
30 State, Federal, Academic, and NGO members
7 WQGIT Workgroups
Over 300 State, Federal, Academic, and NGO members
(as of 1/2016)
Modeling Workgroup
17 State, Federal, and Academic members
(as of 1/2016)
Direct
CBPO Modeling Team
7 federal employees
7 academic employees
5 Contractors
(as of 1/2016)
Directs
Advises
Reviews
Advises
Scientific and Technical Advisory Committee
41 Academic and Federal Members

# Partnership Feedback on Modeling

- **Water Quality Managers**
  - Need more **transparent and easier** to understand decision-support tools to enable successful engagement of local partners

- **Scientific and Technical Advisory Committee**
  - Multiple Models
  - Phosphorus
  - Complex Reservoir Dynamics
  - Fine-scale processes

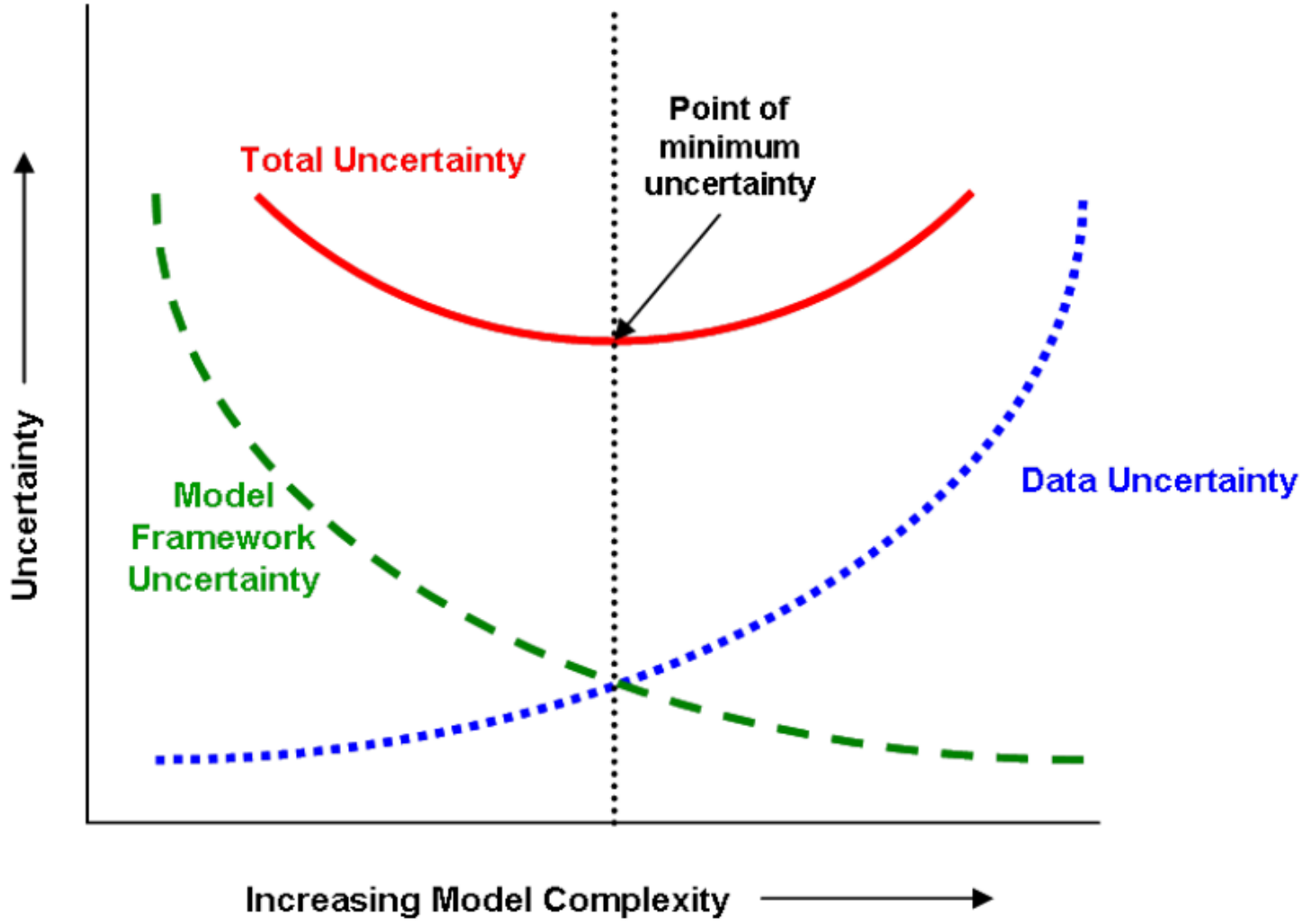
Keep it Simple!!

Include Everything!!!

# Main Prediction of the Watershed Model for decision support

- Change in Anthropogenic Load
  - BMPs
  - WWTP
  - Land use Change
  - Response to Change in inputs

- How to keep it simple and include everything?




Relationship between **model framework uncertainty** and **data uncertainty**, and their combined effect on **total model uncertainty**. Application niche uncertainty would scale the total uncertainty. Adapted from Hanna (1988) and EPA (2009a).



https://www.epa.gov/sites/production/files/2015-09/documents/mod8-saua-mod-final.pdf





# Phase 6 Model Structure

**Average Load + Δ Inputs * Sensitivity**

*

**Land Use Acres**

*

**BMPs**

*

**Land to Water**

*

**Stream Delivery**

*

**River Delivery**

**Direct Loads**

# Phase 6

# Keep It Simple

# Include Everything

**Average Load + ΔInputs * Sensitivity**

*

**Land Use Acres**

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**BMPs**

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**Land to Water**

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**Stream Delivery**

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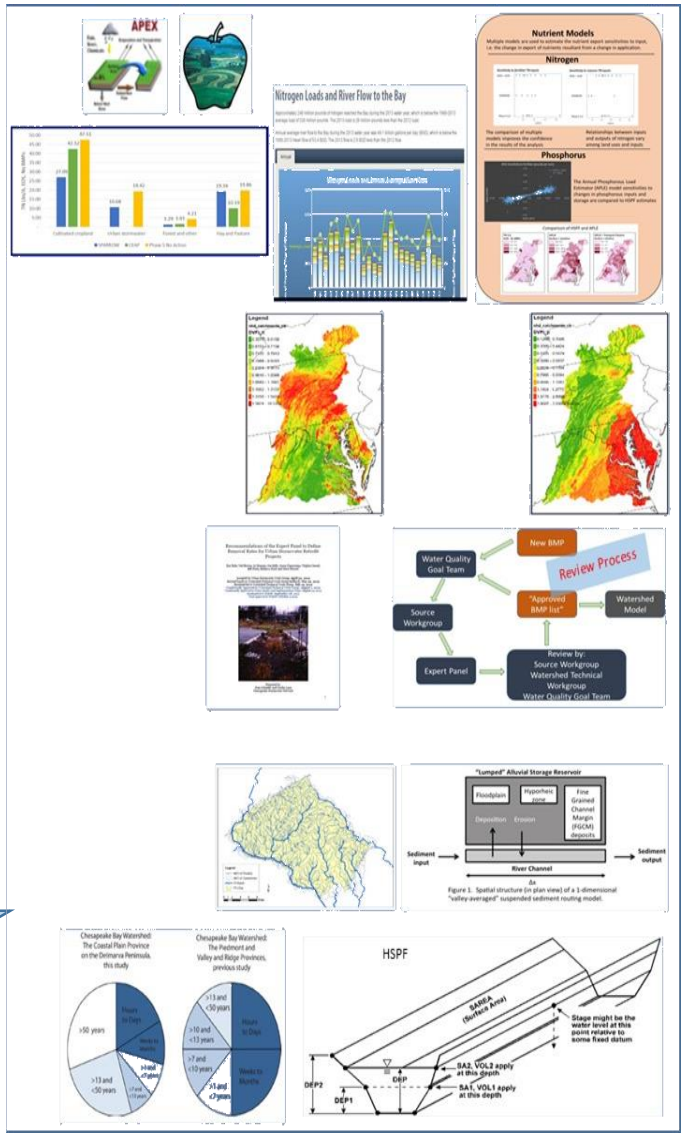
**Direct Loads**



Finished

Potentially Finished

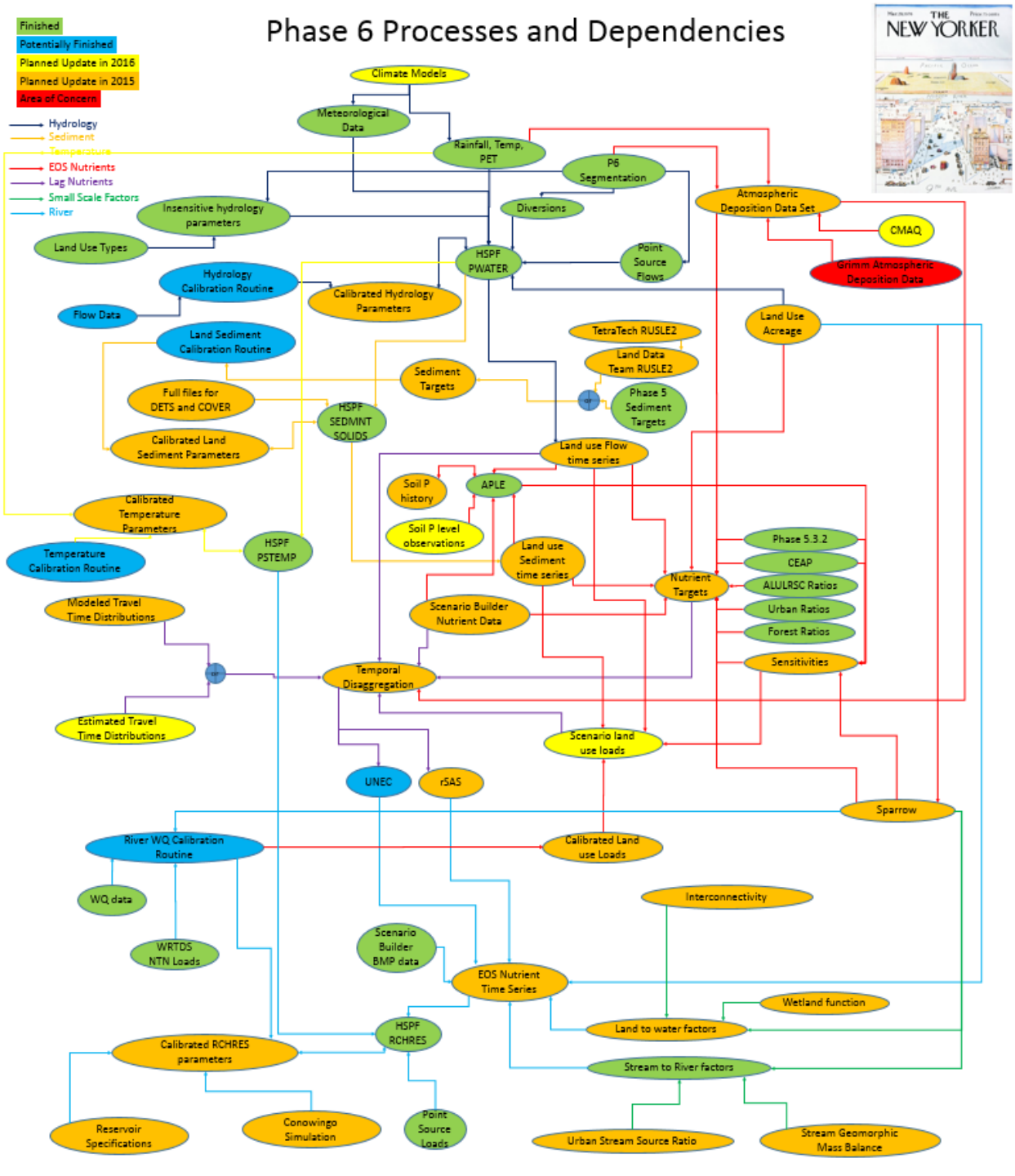
Planned Update in 2016

Planned Update in 2015

Area of Concern

Each box represents a dataset, model, or process

9/3/15







# Phase 6 Model Structure

**Average Load + ΔInputs * Sensitivity**

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**Land Use Acres**

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# Phase 6





# Phase 6 Model Structure

**Average Load + Δ Inputs * Sensitivity**

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**Land Use Acres**

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**Land to Water**

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**Stream Delivery**

*

**River Delivery**

**Direct Loads**

# Phase 6





# Phase 6 Model Documentation

Section 2: Ave Load + Section 3: Inputs * Section 4: Sensitivity

*

Section 5: Land Use

*

Section 6: BMPs

*

Section 7: Land to Water

*

Section 9: Stream Delivery

*

Section 10: River Delivery

Section 1: Overview

Section 8: Direct Loads

Section 11: Physical Setting
Section 12: Applications
Section 13: Reviews

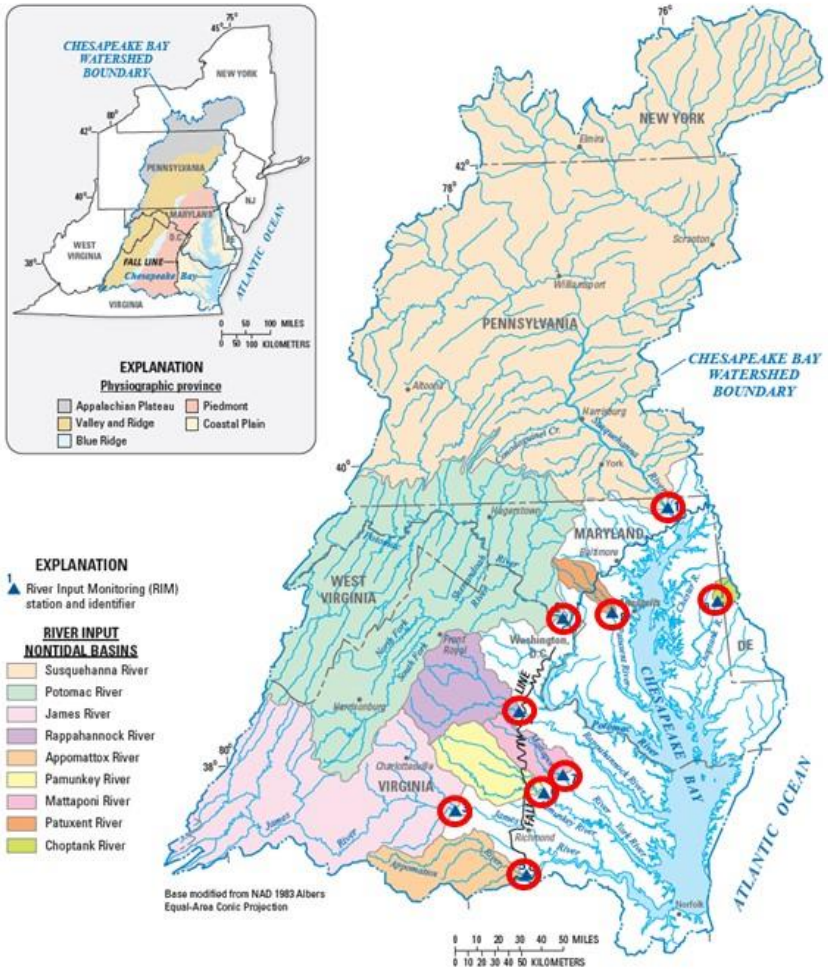
Section 14: References

# Average Loads

Average Loads – Average edge-of-small-stream loading rate for a given land use for the entire CB watershed

Estimate Total Non-point Source

***Modeling Workgroup***



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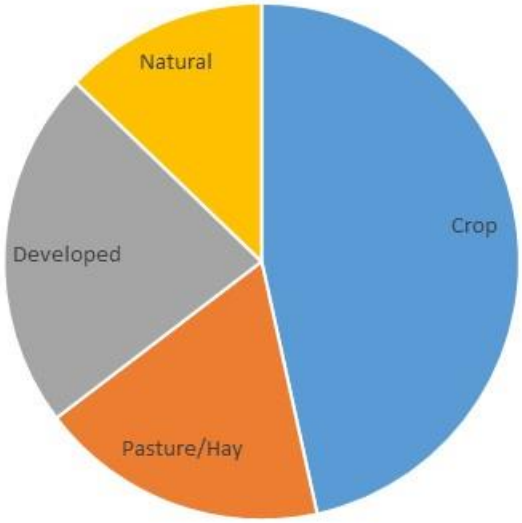
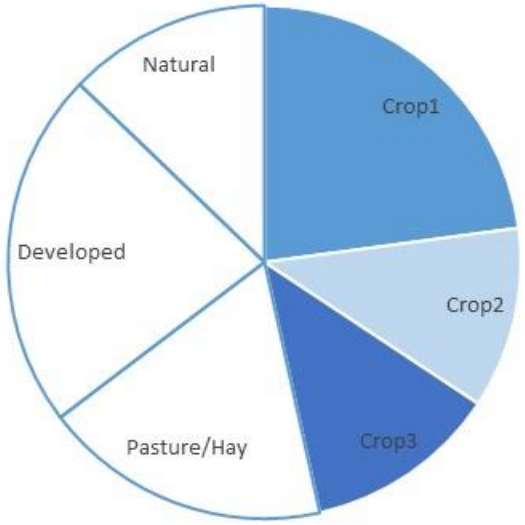



Divide into Broad Classes

***Modeling Workgroup***

# Average Loads

Average Loads – Average edge-of-small-stream loading rate for a given land use for the entire CB watershed




Split Classes into individual land uses

***WQGIT Workgroups***

# Average Loads

Average Loads – Average edge-of-small-stream loading rate for a given land use for the entire CB watershed

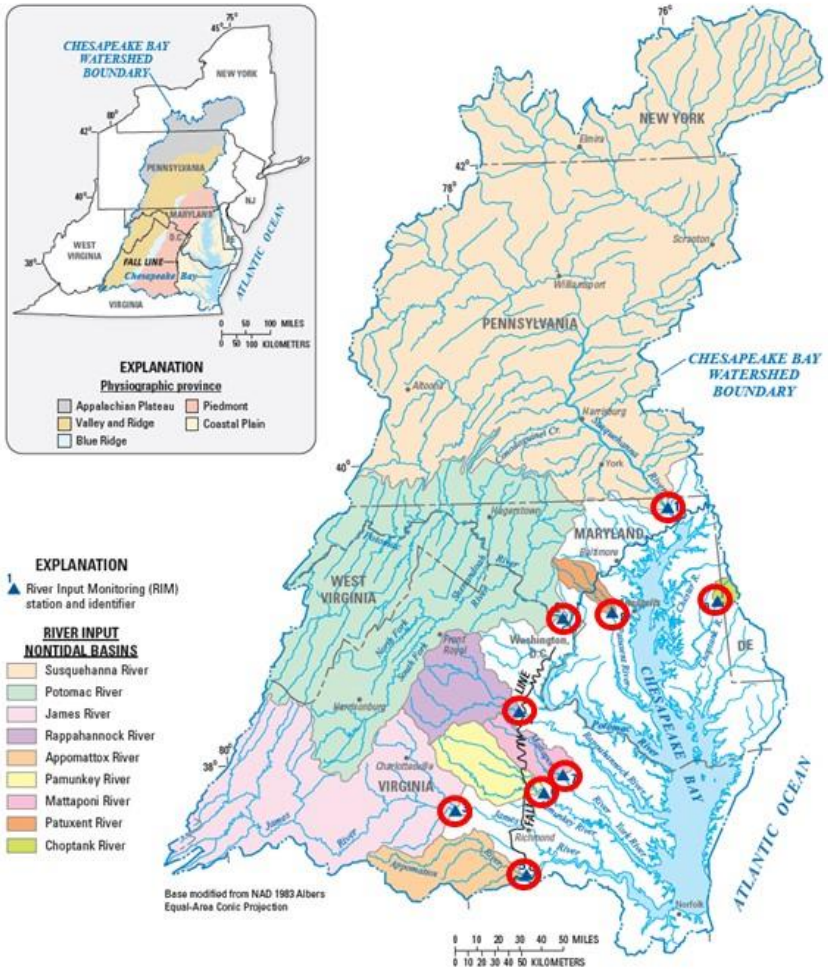
Estimate Total Non-point Source

***Modeling Workgroup***

Monitoring Data

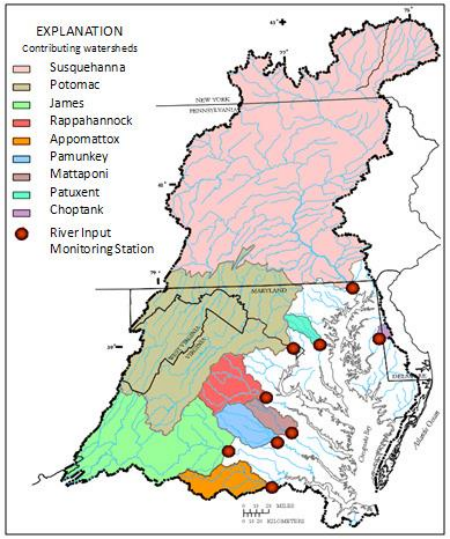
subtract point source

divide by transport



# Watershed Land Loads

- Monitored loads at RIM stations 1990-2014, averaged
- Subtract out:
  - BMP effects
  - River attenuation effects
  - Waste water
  - Animal feeding space
  - Riparian pasture direct deposition
  - Atmospheric deposition to water
  - Septic
  - Rapid infiltration basins
  - Small stream attenuation effects



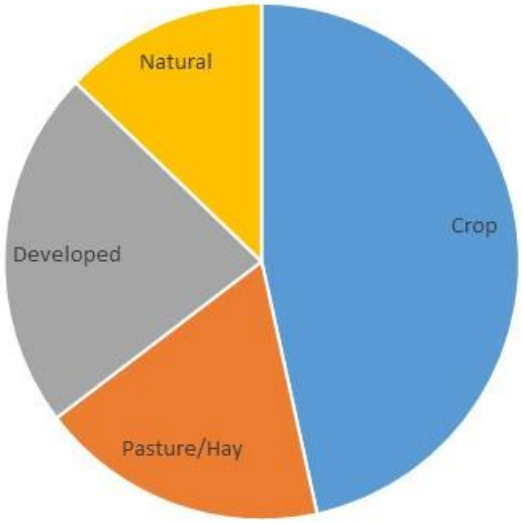

- Leaves edge-of-stream loads to distribute to land

# Draft Phase 6 Values

| Component | Total Nitrogen | | Total Phosphorus | |
|---|---|---|---|---|
| | Factor (%) or Amount (million pounds per year) | Load (million pounds per year) | Factor (%) or Amount (million pounds per year) | Load (million pounds per year) |
| Monitored Load at Rim Stations | NA | 210.3 | NA | 13.8 |
| BMP Effects Removed | 15.6 | 226.5 | 1.5 | 15.3 |
| River Attenuation Removed | 74.7% | 270.6 | 86.9% | 19.3 |
| Wastewater Removed | 30.8 | 239.8 | 5.2 | 14.1 |
| Animal Feeding Space Removed | 18.2 | 221.7 | 0.7 | 13.3 |
| Riparian Pasture Deposition Removed | 5.8 | 215.9 | 1.8 | 11.6 |
| Atm. Deposition on Water Removed | 6.5 | 209.4 | 0.2 | 11.3 |
| Septic Systems Removed | 5.9 | 203.5 | NA | 11.3 |
| Rapid Infiltration Basin | 0.1 | 203.5 | 0.002 | 11.3 |
| Small Stream Attenuation Removed | 89.3% | 219.7 | 88.2% | 10.0 |
| Global Edge of Small Stream Load | NA | 227.9 | NA | 12.8 |

# Average Loads

Average Loads – Average edge-of-small-stream loading rate for a given land use for the entire CB watershed




Divide into Broad Classes

***Modeling Workgroup***

Multiple models

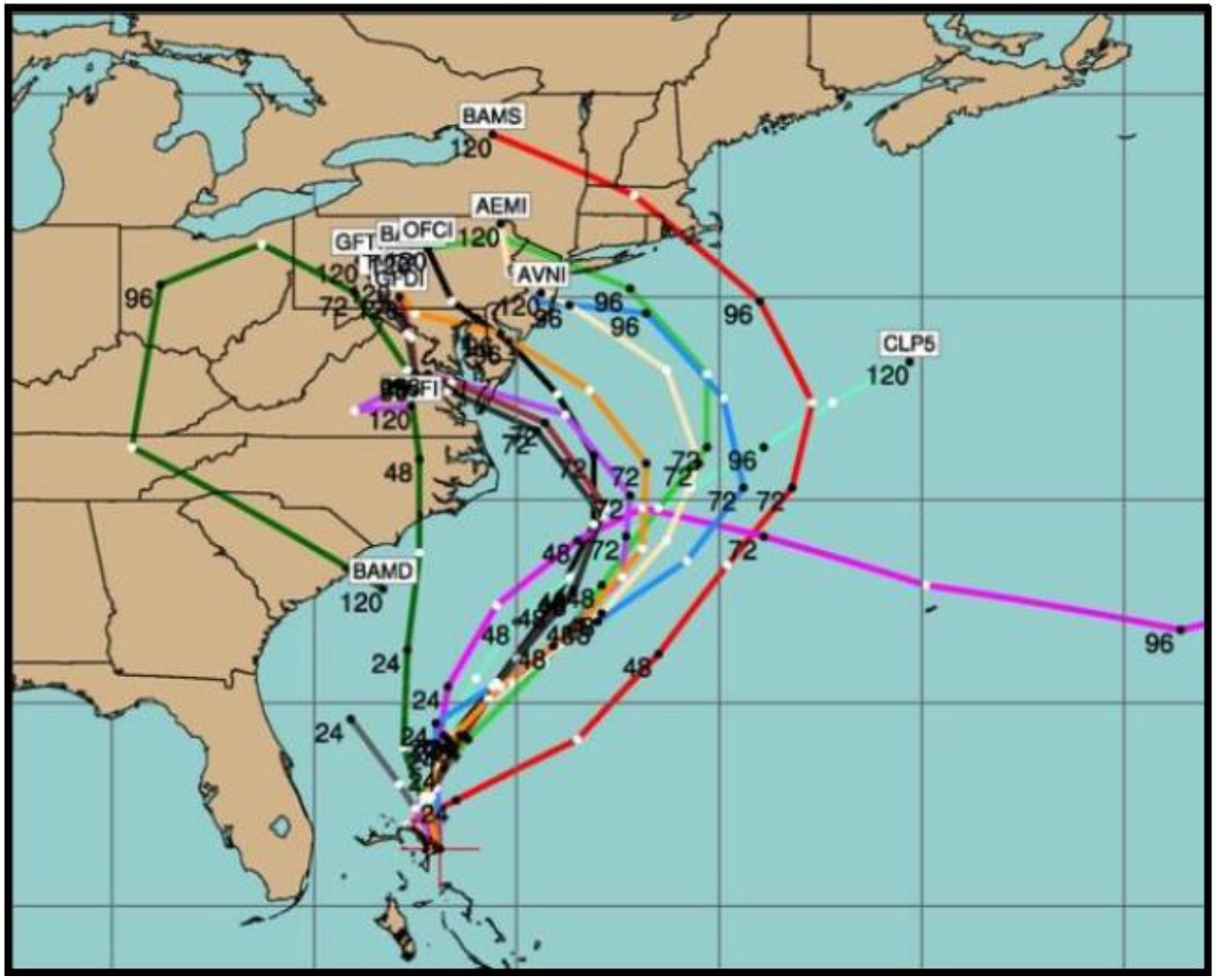
*Phase 5.3.2*

*Sparrow*

*CEAP*

# STAC Guidance

## Multiple Models for Management in the Chesapeake Bay



# Use of Multiple Models for Nitrogen Export Rate

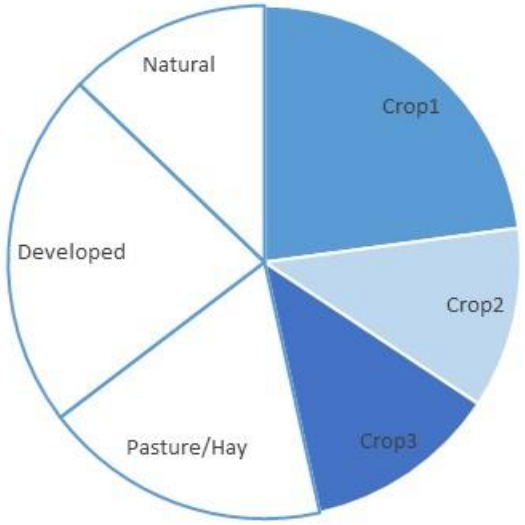
| Land class | Crop | Pasture/Hay | Developed | Natural |
|---|---|---|---|---|
| Acres | 2,620,895 | 4,535,321 | 2,690,480 | 21,458,991 |
| P532 No BMP Loading Rate (pounds per acre per year) | 47.51 | 14.95 | 16.80 | 4.21 |
| CEAP Loading Rate (pounds per acre per year) | 42.52 | 10.19 | Not used | 1.61 |
| SPARROW Loading Rate with BMP effects removed (pounds per acre per year) | 22.35 | 7.30 | 8.35 | 0.40 |
| Average Ratio to Cropland Rate | 1.00 | 0.29 | 0.36 | 0.05 |
| Average Land class Loading Rate (pounds per acre per year) | **38.22** | **11.22** | **13.90** | **1.84** |
| Total Land class Load (million pounds per year) | **100.16** | **50.88** | **37.39** | **39.45** |

# Use of Multiple Models for Phosphorus Export Rate

| Land class | Crop | Pasture/Hay | Developed | Natural |
|---|---|---|---|---|
| Acres above RIM stations | 2,620,895 | 4,535,321 | 2,690,480 | 21,458,991 |
| P532 Loading Rate (pounds per acre per year) | 2.23 | 1.48 | 1.22 | 0.12 |
| CEAP Loading Rate (pounds per acre per year) | 3.12 | 1.29 | Not used | 0.10 |
| SPARROW Loading Rate with BMP effects removed (pounds per acre per year) | 0.94 | 0.22 | 0.34 | 0.06 |
| Average Ratio to Crop Rate | 1.00 | 0.44 | 0.46 | 0.05 |
| Average Land class Loading Rate (phosphorus pounds per acre per year) | 1.87 | 0.81 | 0.85 | 0.09 |
| Total Land class Load (million pounds per year) | 4.89 | 3.69 | 2.38 | 1.98 |

# Average Loads

Average Loads – Average edge-of-small-stream loading rate for a given land use for the entire CB watershed



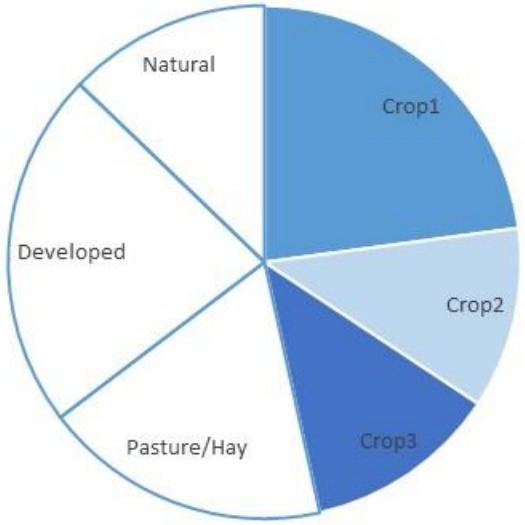

Split Classes into individual land uses

***WQGIT Workgroups***

Multiple lines of evidence to develop ratios

- for example silage is 16% higher than grain

# Average Loads




Perform this process for all nitrogen classes

Perform this process for phosphorus in the developed and natural land classes

# Split classes into individual land uses – Crop Nitrogen

| Land class | Land Use | Acres | Loading Rate Ratio | Loading Rate (lb/ac/yr) |
|---|---|---|---|---|
| Cropland | Double Cropped Land | 165,396 | 0.79 | 30.87 |
| | Full Season Soybeans | 282,456 | 0.71 | 27.74 |
| | Grain with Manure | 389,811 | 1.4 | 54.7 |
| | Grain without Manure | 451,318 | 1 | 39.07 |
| | Other Agronomic Crops | 417,838 | 0.45 | 17.58 |
| | Silage with Manure | 392,156 | 1.62 | 63.3 |
| | Silage without Manure | 69,204 | 1.16 | 45.33 |
| | Small Grains and Grains | 291,677 | 0.84 | 32.82 |
| | Specialty Crop High | 35,525 | 1.34 | 52.36 |
| | Specialty Crop Low | 125,509 | 0.31 | 12.11 |

# Split classes into individual land uses – Crop Nitrogen

| Land class | Land Use | Acres | Loading Rate Ratio | Loading Rate (pounds per acre per year) |
|---|---|---|---|---|
| Pasture | Ag Open Space | 140,316 | 0.43 | 5.07 |
| | Legume Hay | 728,148 | 0.74 | 8.72 |
| | Other Hay | 1,294,306 | 1.04 | 12.26 |
| | Pasture | 2,372,549 | 1 | 11.78 |

# Split classes into individual land uses – Crop Nitrogen

| Land class | Land Use | Acres | Loading Rate Ratio | Loading Rate (pounds per acre per year) |
|---|---|---|---|---|
| Developed | Buildings and Other | 39,580 | 0.81 | 18.08 |
| | Construction | 1,516 | 1.19 | 26.8 |
| | Roads | 10,849 | 1.02 | 22.87 |
| | Tree Canopy over Impervious | 4,466 | 0.91 | 20.49 |
| | Tree Canopy over Turfgrass | 15,934 | 0.38 | 8.53 |
| | Turf Grass | 29,800 | 0.5 | 11.19 |

These rates apply across the three management categories of Non-regulated, MS4, and Combined Sewer

# Split classes into individual land uses – Crop Nitrogen

| Land class | Land Use | Acres | Loading Rate Ratio | Loading Rate (pounds per acre per year) |
|---|---|---|---|---|
| Natural | CSS Forest | 25,062 | 1 | 1.68 |
| | CSS Mixed Open | 11,193 | 1.46 | 2.45 |
| | Harvested Forest | 264,474 | 7.07 | 11.88 |
| | Headwater or Isolated Wetland | 350,820 | 1 | 1.68 |
| | Mixed Open | 895,240 | 1.46 | 2.45 |
| | Non-tidal Floodplain Wetland | 397,778 | 1 | 1.68 |
| | True Forest | 19,550,675 | 1 | 1.68 |

# Split classes into individual land uses – Crop Phosphorus

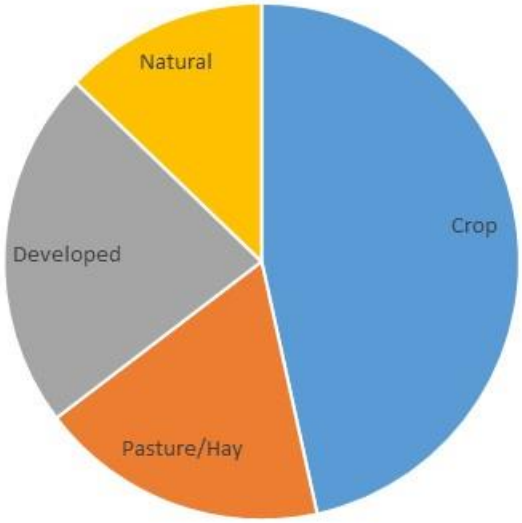
| Target Land class | Land Use | Acres | Loading Rate Ratio | Loading Rate (pounds per acre per year) |
|---|---|---|---|---|
| Developed | Buildings and Other | 39580 | 0.83 | 0.69 |
| | Construction | 1516 | 3.89 | 3.21 |
| | Roads | 10849 | 1.04 | 0.86 |
| | Tree Canopy over Impervious | 4466 | 0.91 | 0.75 |
| | Tree Canopy over Turfgrass | 15934 | 0.79 | 0.65 |
| | Turf Grass | 29800 | 1.04 | 0.86 |

These rates apply across the three management categories of Non-regulated, MS4, and Combined Sewer

# Split classes into individual land uses – Crop Phosphorus

| Target Land class | Land Use | Acres | Loading Rate Ratio | Loading Rate (pounds per acre per year) |
|---|---|---|---|---|
| Natural | CSS Forest | 25062 | 1 | 0.08 |
| | CSS Mixed Open | 11193 | 5.69 | 0.43 |
| | Harvested Forest | 264474 | 3.12 | 0.24 |
| | Headwater or Isolated Wetland | 350820 | 1 | 0.08 |
| | Mixed Open | 895240 | 5.69 | 0.43 |
| | Non-tidal Floodplain Wetland | 397778 | 1 | 0.08 |
| | True Forest | 19550675 | 1 | 0.08 |

# Average Loads




The Agricultural Land Use Loading Rate Subgroup determined that the phosphorus export rate for cropland and pasture land uses is a function of the soil P storage and landscape properties rather than land use.

# Split classes into individual land uses – Crop Phosphorus

| Target Land class | Land Use | Acres | Loading Rate Ratio | Loading Rate (pounds per acre per year) |
|---|---|---|---|---|
| Cropland | Double Cropped Land | 165396 | 1* | 1.87* |
| | Full Season Soybeans | 282456 | | |
| | Grain with Manure | 389811 | | |
| | Grain without Manure | 451318 | | |
| | Other Agronomic Crops | 417838 | | |
| | Silage with Manure | 392156 | | |
| | Silage without Manure | 69204 | | |
| | Small Grains and Grains | 291677 | | |
| | Specialty Crop High | 35525 | | |
| | Specialty Crop Low | 125509 | | |

*At the direction of the Agriculture Land Use Loading Rate Subgroup, the entire crop category was treated as a single unit. The weighted average of all crop types is 1.87 lbs/acre. They are differentiated by inputs and sensitivities as described in sections 3 and 4.*

# Split classes into individual land uses – Crop Phosphorus

| Target Land class | Land Use | Acres | Loading Rate Ratio | Loading Rate (pounds per acre per year) |
|---|---|---|---|---|
| Pasture | Ag Open Space | 140316 | 1 | .81 |
| | Legume Hay | 728148 | | |
| | Other Hay | 1294306 | | |
| | Pasture | 2372549 | | |





# Phase 6 Model Structure

**Average Load + Δ Inputs * Sensitivity**

*

**Land Use Acres**

*

**BMPs**

*

**Land to Water**

*

**Stream Delivery**

*

**River Delivery**

**Direct Loads**

# Phase 6

# Sensitivity

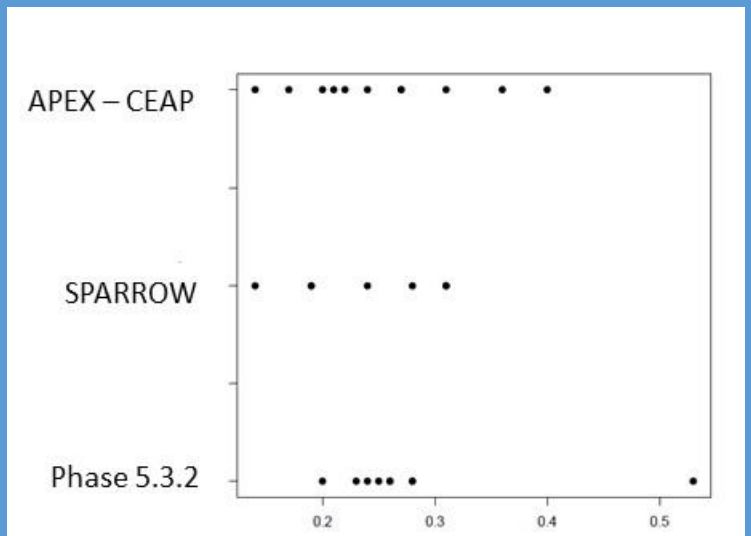
- **Sensitivity is defined as the change in export load per change in input load**.

- Absolute Sensitivity = $\frac{\text{Change in output}}{\text{Change in input}}$

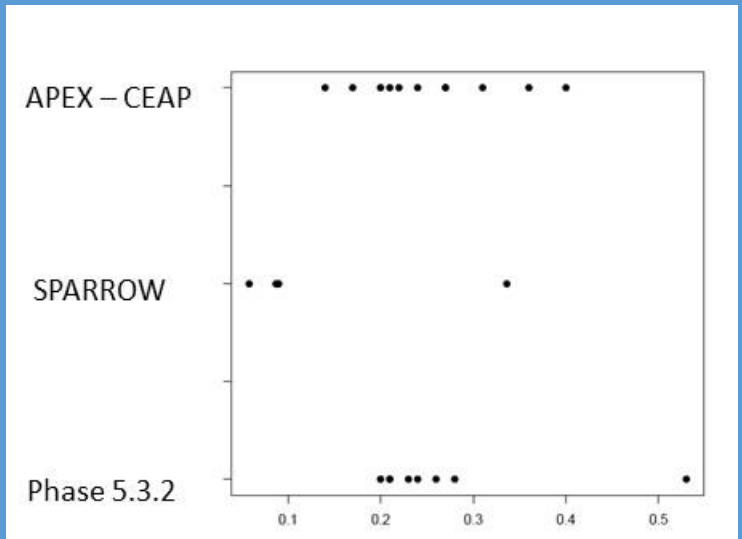
- Relative Sensitivity = $\frac{\text{Percent Change in output}}{\text{Percent Change in input}}$

# Nitrogen Sensitivity

***Definition – Average Change in export per change in input***




Commercial Fertilizer

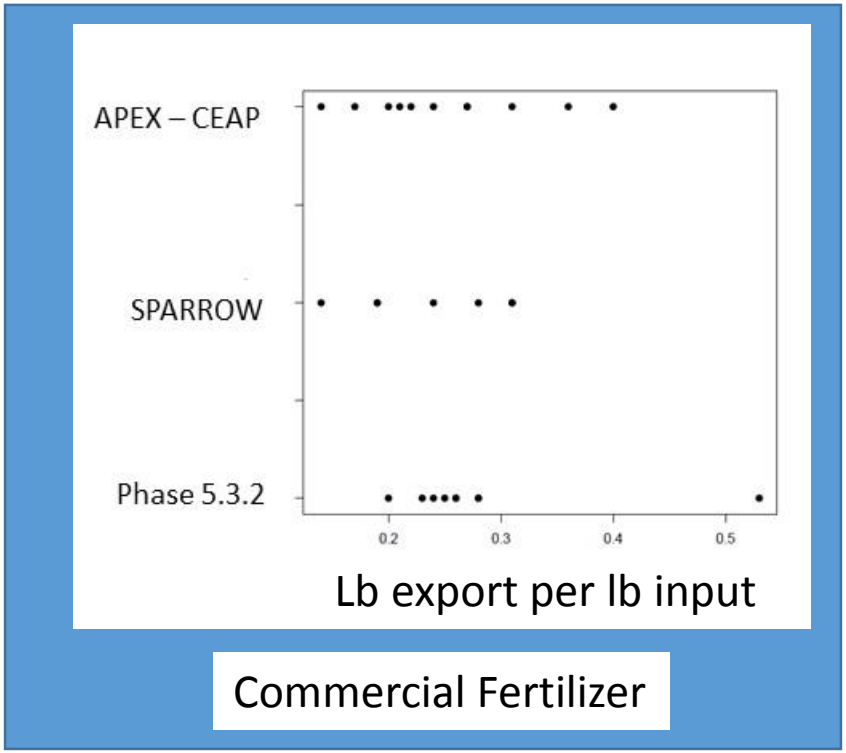



Manure

**Multiple Model comparison – All in general agreement on the average effect**

# Nitrogen Sensitivity

***Definition – Average Change in export per change in input***




**Modeling Workgroup Decision:**

***Use Phase 5.3.2 for global sensitivities***

- Supported by CEAP and SPARROW results
- Answers the right question
  - ***Change*** in export per ***change*** in input
- No direct access to APEX-CEAP
- Sparrow had different land use classifications

# Sensitivity Runs

- Use Phase 5.3.2
- Base scenario 1997 No Action

- Adjust: Fertilizer, Manure, Atdep, Crop Uptake, Fixation, and Crop Cover
- By: -60% -30% 0% +30% +60%

- Constituents: TN, NO3, NH3, and ORGN
- Land Uses
  - Hightill with manure
  - Hightill without manure
  - Hay without nutrients
  - Alfalfa
  - Pasture
  - Pervious developed
  - Impervious developed
  - Forest

# Sensitivity of Phase 5 Hightill with Manure land use

| | NH3 | NO3 | ORGN |
|---|---|---|---|
| **Atmospheric Deposition** | 0.01 | 0.226 | 0.083 |
| **Fertilizer** | 0.018 | 0.19 | 0.073 |
| **Manure** | 0.005 | 0.067 | 0.104 |
| **Fixation** | 0.01 | 0.19 | 0.101 |
| **Crop Uptake** | 0 | -0.057 | 0 |
| **Vegetative Cover** | -0.012 | 0.012 | -0.404 |

Sensitivities are modified according to relative loading rates

Adjust by load ratio => $\frac{\text{Phase 6 Grain with Manure}}{\text{P5.3.2 Hightill with Manure}} = 0.931$

Adjusted GWM = Hightill sensitivity * 0.931


**Average Load + ΔInputs * Sensitivity**

Source: http://www.androidauthority.com/best-android-calculator-apps-577878/


**Average Load + ∆Inputs * Sensitivity**

N Load from grain without manure =

54.7 + 0.262 * (fertilizer – 106) lbs

+ 0.297 * (atmospheric deposition – 13.2) lbs

- 0.053 * (uptake – 81.2) lbs

- 0.376 * (cover – 0.66) percent

Source: http://www.androidauthority.com/best-android-calculator-apps-577878/





# Phase 6 Model Structure

**Spatially differentiated by Transport**
**1/20/17 Webinar**

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**BMPs**

*

**Land to Water**

*

**Stream Delivery**

*

**River Delivery**

Direct Loads

# Phase 6

# STAC Guidance on Phosphorus

**A Review of Agricultural P-dynamics in the Chesapeake Bay Watershed Model**

"…output from CBWM [indicated] major reductions in P losses from cropland on the Maryland Eastern Shore that seemed to be inconsistent with research findings and monitoring data in the region."

# STAC Recommendations […]

- **Track drawdown and buildup of soil P reservoirs by segment as a source of P runoff**
- **Get better manure, fertilizer, application method, and soil P data**
- **Account for management (method, timing, tillage, etc)**


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Chesapeake College
MARYLAND GRAIN PRODUCERS UTILIZATION BOARD
CHESAPEAKE BAY FOUNDATION
SAVE THE BAY
UNIVERSITY OF MARYLAND EXTENSION
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Agenda
Presenters
Location
Hosts
The State of the Science of Phosphorus
This symposium drew 350 attendees seeking to better understand the current state of science surrounding phosphorus transport, soil dynamics, legacies, modeling, and its impact on water quality. Experts on the science of phosphorus from across the country were featured on the program.
Visit the Phosphorus Symposium playlist to watch presentations by selecting individual sessions or play all for continuous play of the program. Proceedings are also available in PDF format to download.
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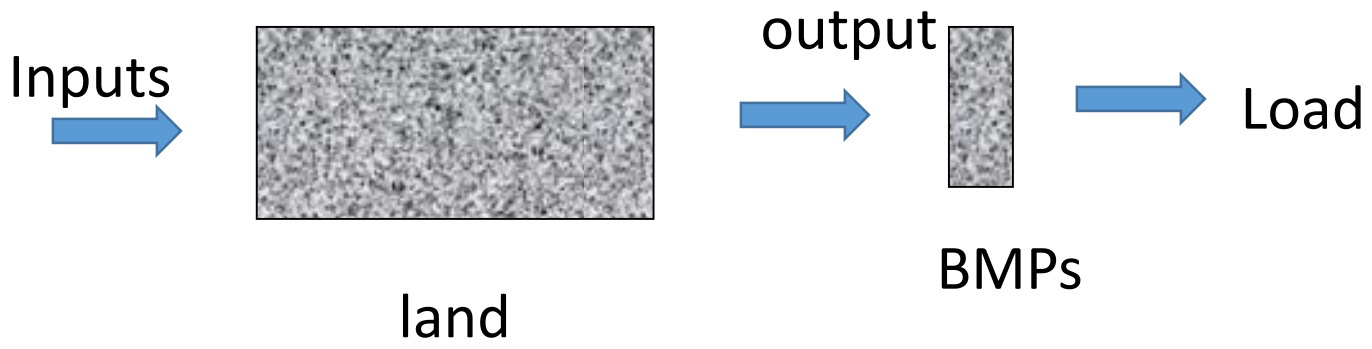
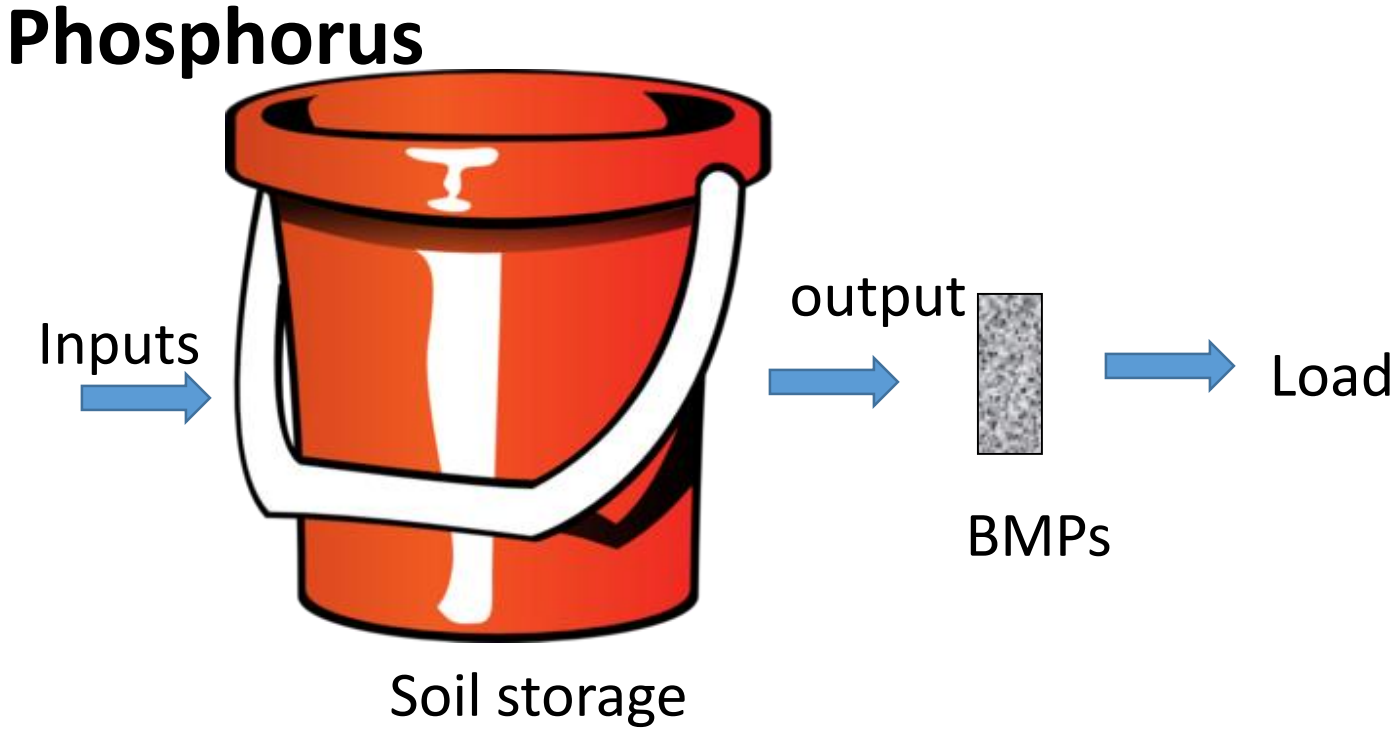
# Nitrogen Conceptual Model

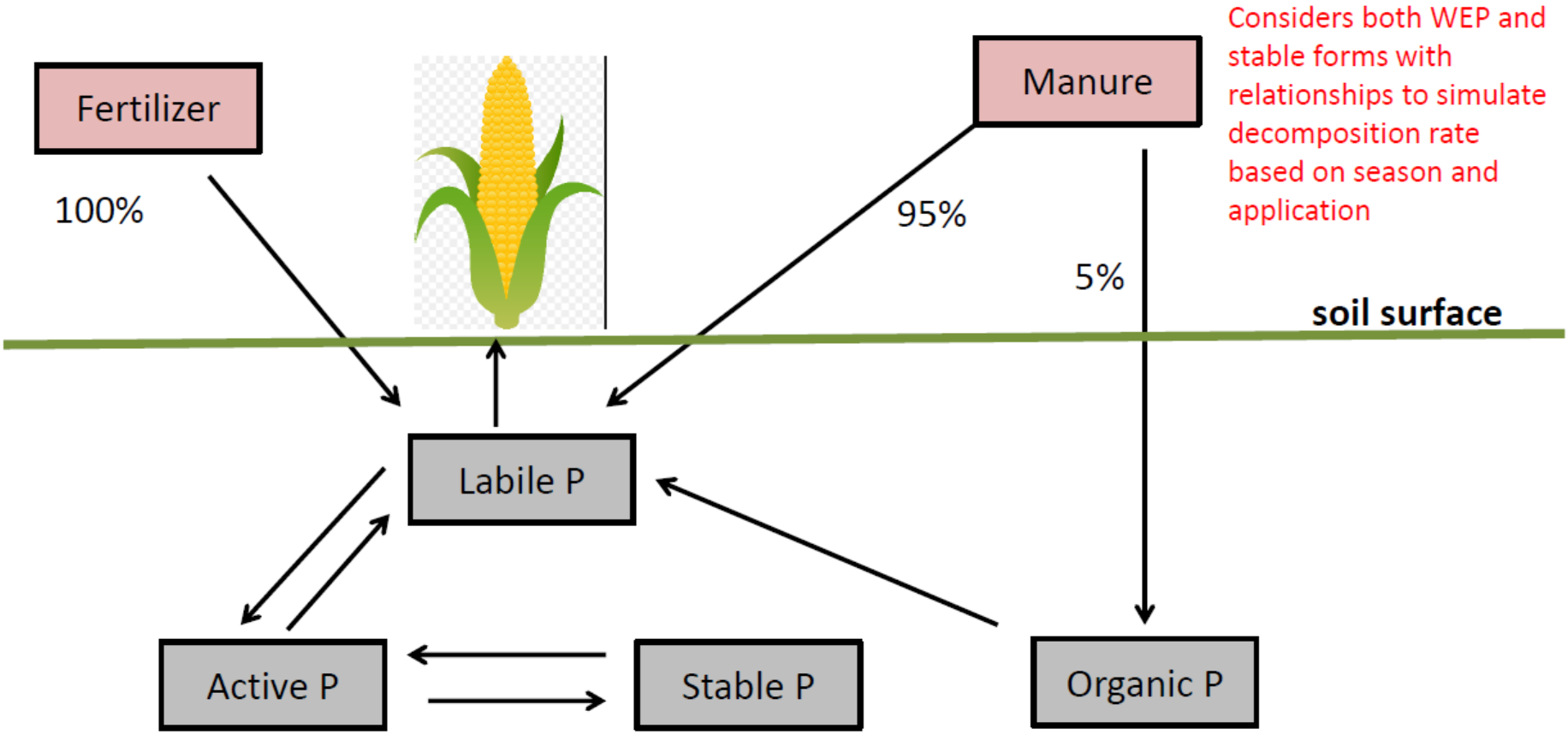



1 lb reduction in fertilizer is about a quarter lb reduction in output

# Phosphorus Conceptual Model



# Diagram of APLE Nutrient Sources and Soil Pools




**Equations to estimate Manure runoff P, Fertilizer runoff P, Sediment P loss, and Dissolved Soil P runoff**



*(Adapted from Vadas, et al. 2007)*

# APLE Hightill Landuse Sensitivities

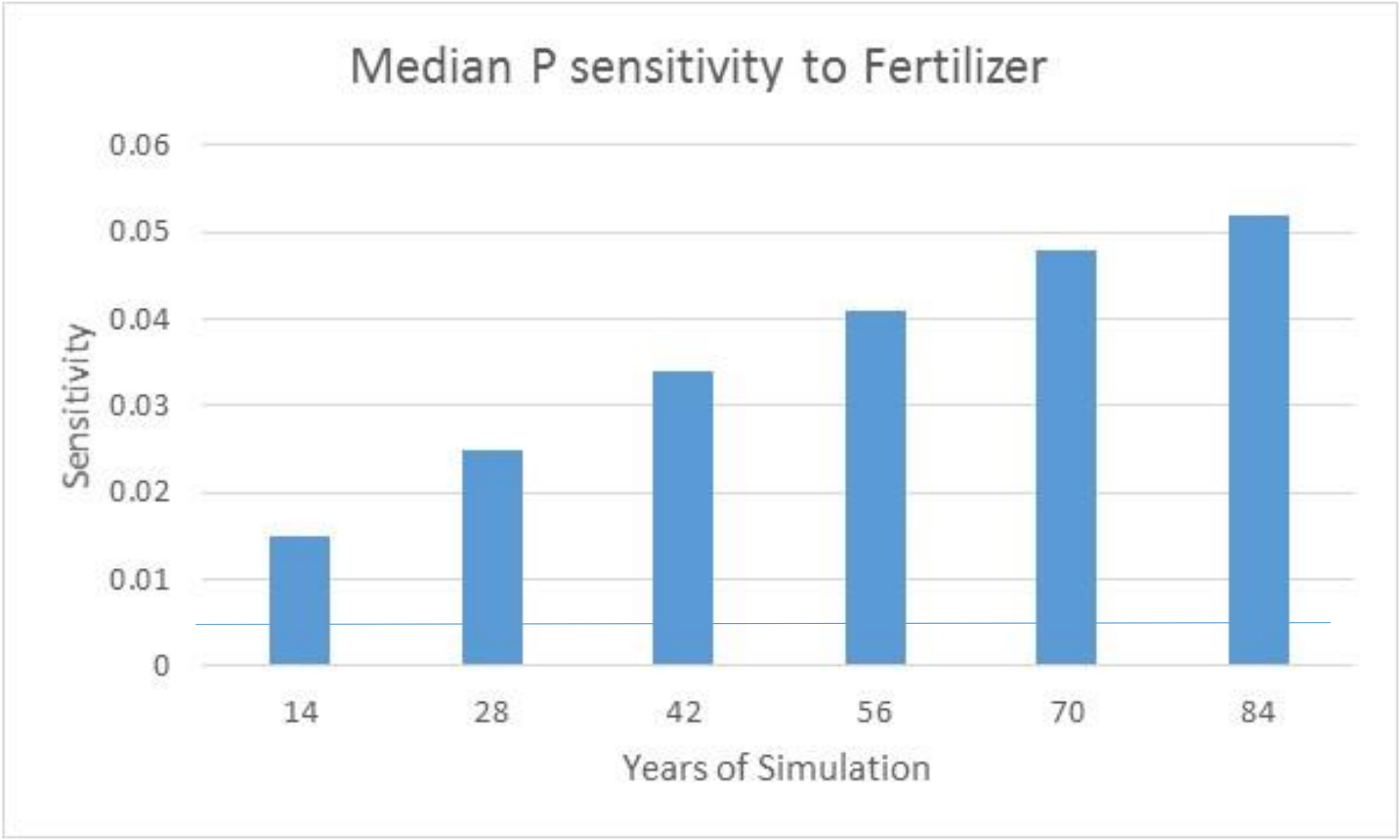
| Input | Input Unit | Average Slope | Median Slope | Median $S_R$ | Relative Sensitivity |
|---|---|---|---|---|---|
| Soil P | ppm | 0.017 | 0.015 | 0.696 | Moderately sensitive |
| Sediment Washoff | ton/ac | 0.181 | 0.168 | 0.633 | Moderately sensitive |
| Runoff | Inches | 0.064 | 0.057 | 0.403 | Moderately sensitive |
| Water Extractable P | lbs/acre | 0.021 | 0.018 | 0.187 | Slightly sensitive |
| Manure | lbs/acre | 0.008 | 0.007 | 0.111 | Slightly sensitive |
| Fertilizer | lbs/acre | 0.005 | 0.004 | 0.068 | Slightly sensitive |
| Uptake | lbs/acre | 0.000 | 0.000 | 0.000 | Insensitive |

Requires estimate of soil P

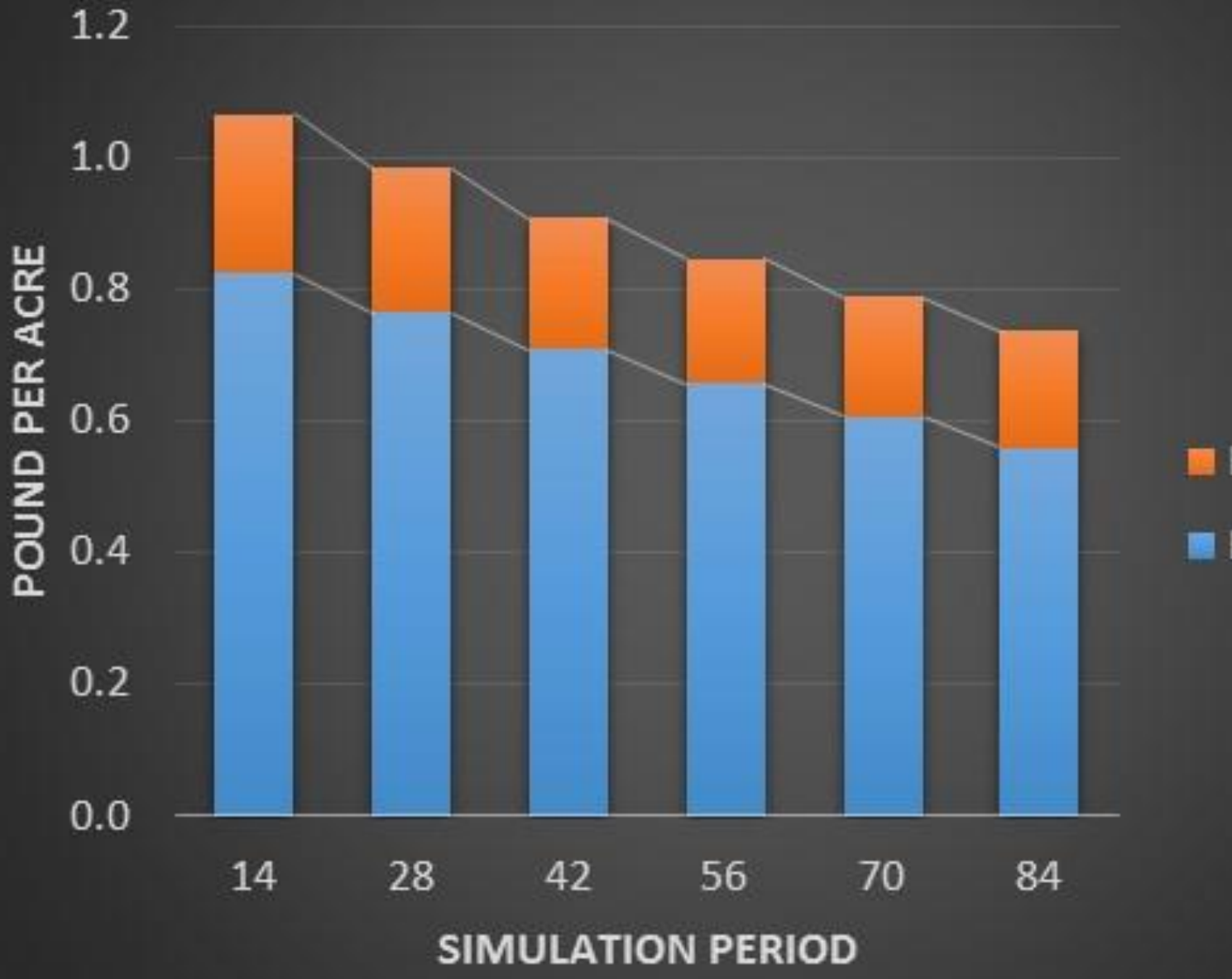
# What determines P loads in a given year?

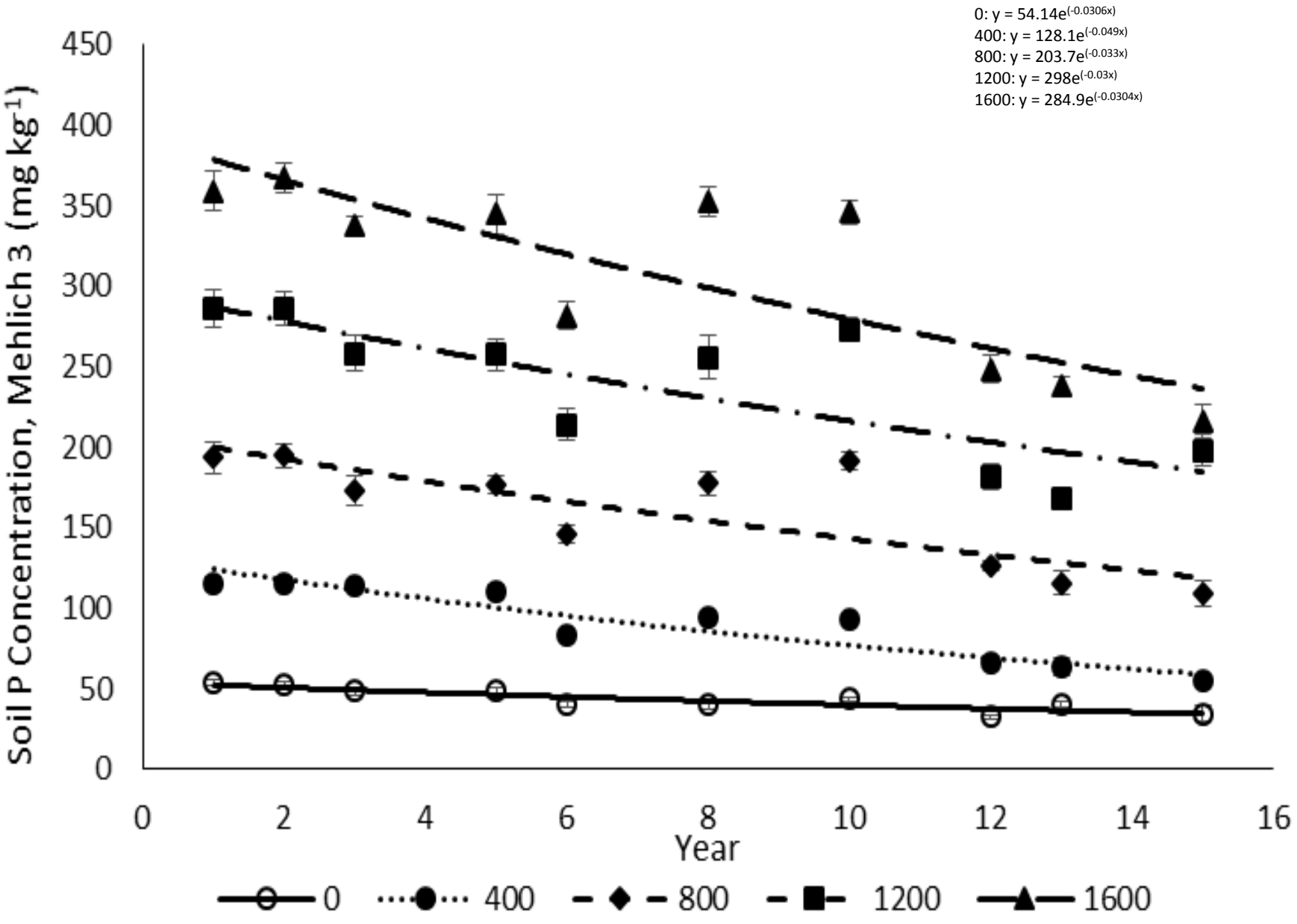
- Soil Storage
- Sediment Washoff
- Stormwater Runoff
- Water Extractable P Applications
- Manure
- Fertilizer
- Uptake

# Different Simulation Periods to Evaluate Sensitivities



# Frederick VA – Phosphorus Loss






From Frank Coale

# What determines P loads in a given year?

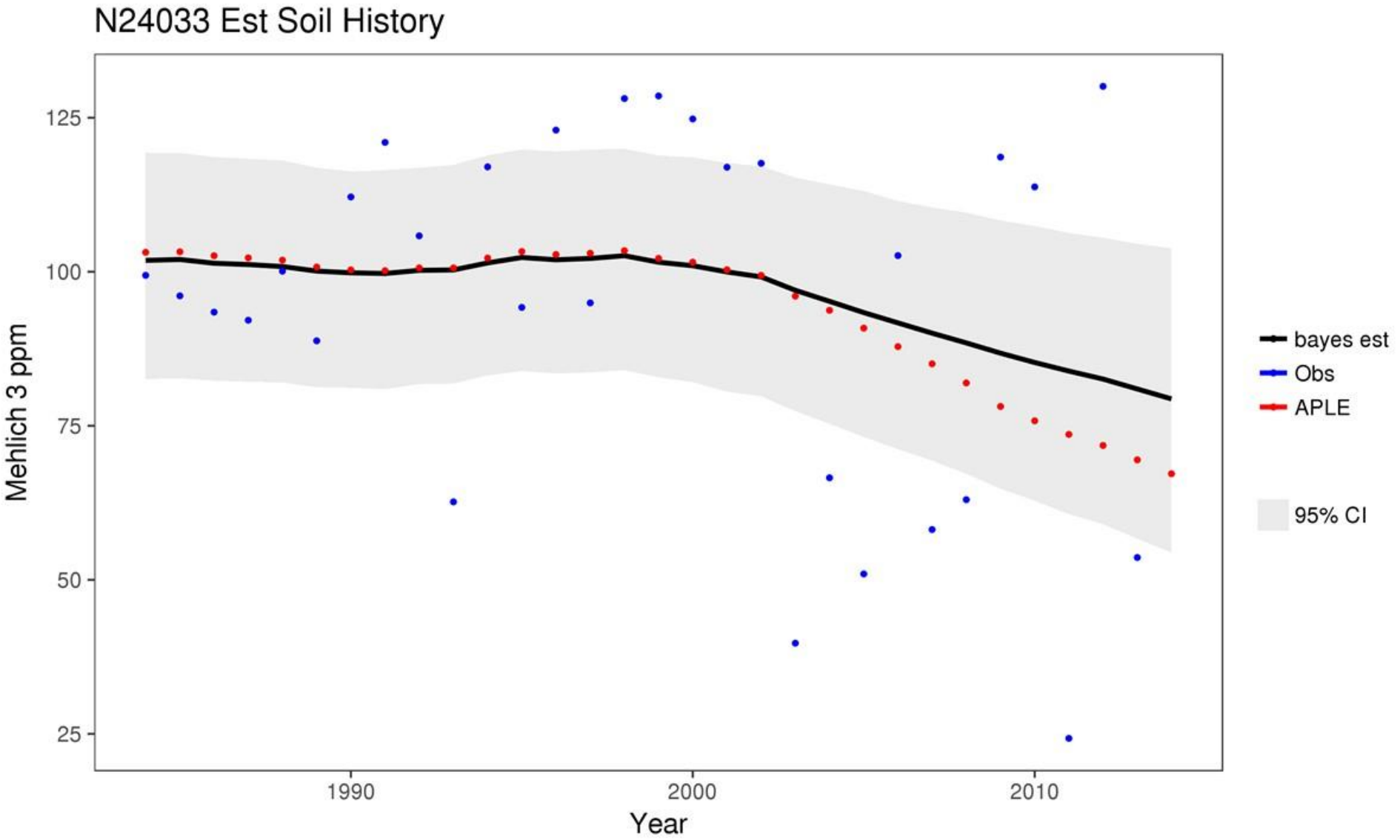
- Soil Storage
- Sediment Washoff
- Stormwater Runoff
- Water Extractable P Applications
- Manure
- Fertilizer
- Uptake

**Soil Storage is the history of applications and uptake over time. The current year's applications are not very important**

# APLE Hightill Landuse Sensitivities using Constant Mehlich 3 Soil P

| Input | Input Unit | Average Slope | Median Slope | Median $S_R$ | Relative Sensitivity |
|---|---|---|---|---|---|
| Soil P | ppm | 0.017 | 0.015 | 0.696 | Moderately sensitive |
| Sediment Washoff | ton/ac | 0.181 | 0.168 | 0.633 | Moderately sensitive |
| Runoff | Inches | 0.064 | 0.057 | 0.403 | Moderately sensitive |
| Water Extractable P | lbs/acre | 0.021 | 0.018 | 0.187 | Slightly sensitive |
| ~~Manure~~ | ~~lbs/acre~~ | ~~0.008~~ | ~~0.007~~ | ~~0.111~~ | ~~Slightly sensitive~~ |
| ~~Fertilizer~~ | ~~lbs/acre~~ | ~~0.005~~ | ~~0.004~~ | ~~0.068~~ | ~~Slightly sensitive~~ |
| ~~Uptake~~ | ~~lbs/acre~~ | ~~0.000~~ | ~~0.000~~ | ~~0.000~~ | ~~Insensitive~~ |

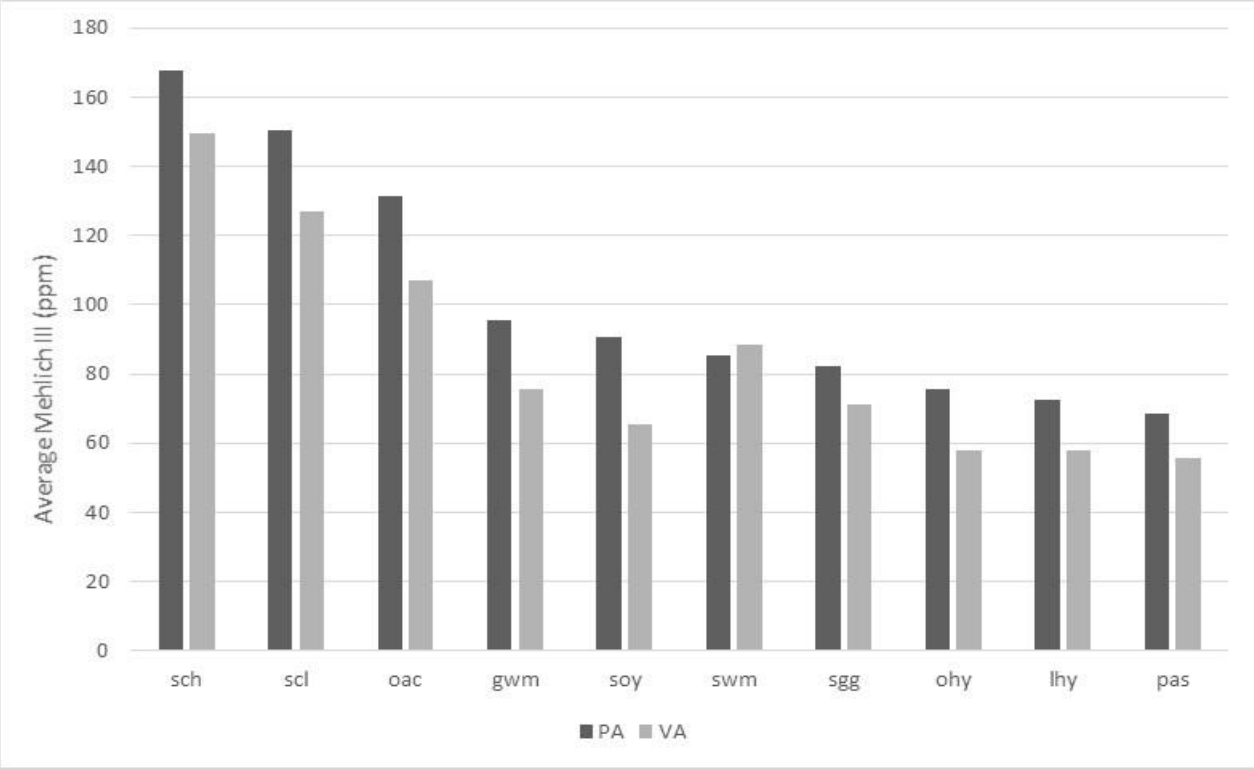
Requires estimate of soil P




Double Crops in Prince George's County, Maryland

# Additional Notes for soil P

- Soil P is shared among major crops in a county to account for rotations
- Soil P for other ag land uses are set based on ratios derived from soil P data.



# Additional Notes for P sensitivities

- Pasture sensitives are set through a similar process with APLE
- The results are consistently lower, reflecting lower pasture loads.
- Runoff coefficients are relatively higher reflecting application methods

# Non-Agricultural P sensitivities

- Sensitivities are little used as applications, sediment washoff, and stormwater runoff are not changed in scenarios generally
- Sensitivities supplied for developed based on the urban nutrient management panel recommendations
- Natural areas use scaled pasture sensitivities





# Phase 6 Model Structure

**Average Load + Δ Inputs * Sensitivity**

*

**Land Use Acres**

*

**BMPs**

*

**Land to Water**

*

**Stream Delivery**

*

**River Delivery**

**Direct Loads**

# Phase 6


**Average Load + ΔInputs * Sensitivity**

Sensitivities modified by phase 5 – phase 6 translation of 0.862

Source: http://www.androidauthority.com/best-android-calculator-apps-577878/


**Average Load + ∆Inputs * Sensitivity**

P Load from grain without manure =

1.87 + 0.013 * (Mehlich – 98.2) ppm
+ 0.144 * (storm runoff - 6.73) inches
+ 0.049 * (sediment loss - 4.75) tons
+ 0.015 * (WEP – 14.3) lbs

Sensitivities modified by phase 5 – phase 6 translation of 0.862

Source: http://www.androidauthority.com/best-android-calculator-apps-577878/





# Phase 6 Model Structure

**Spatially differentiated by Transport**
**1/20/17 Webinar**

*

**BMPs**

*

**Land to Water**

*

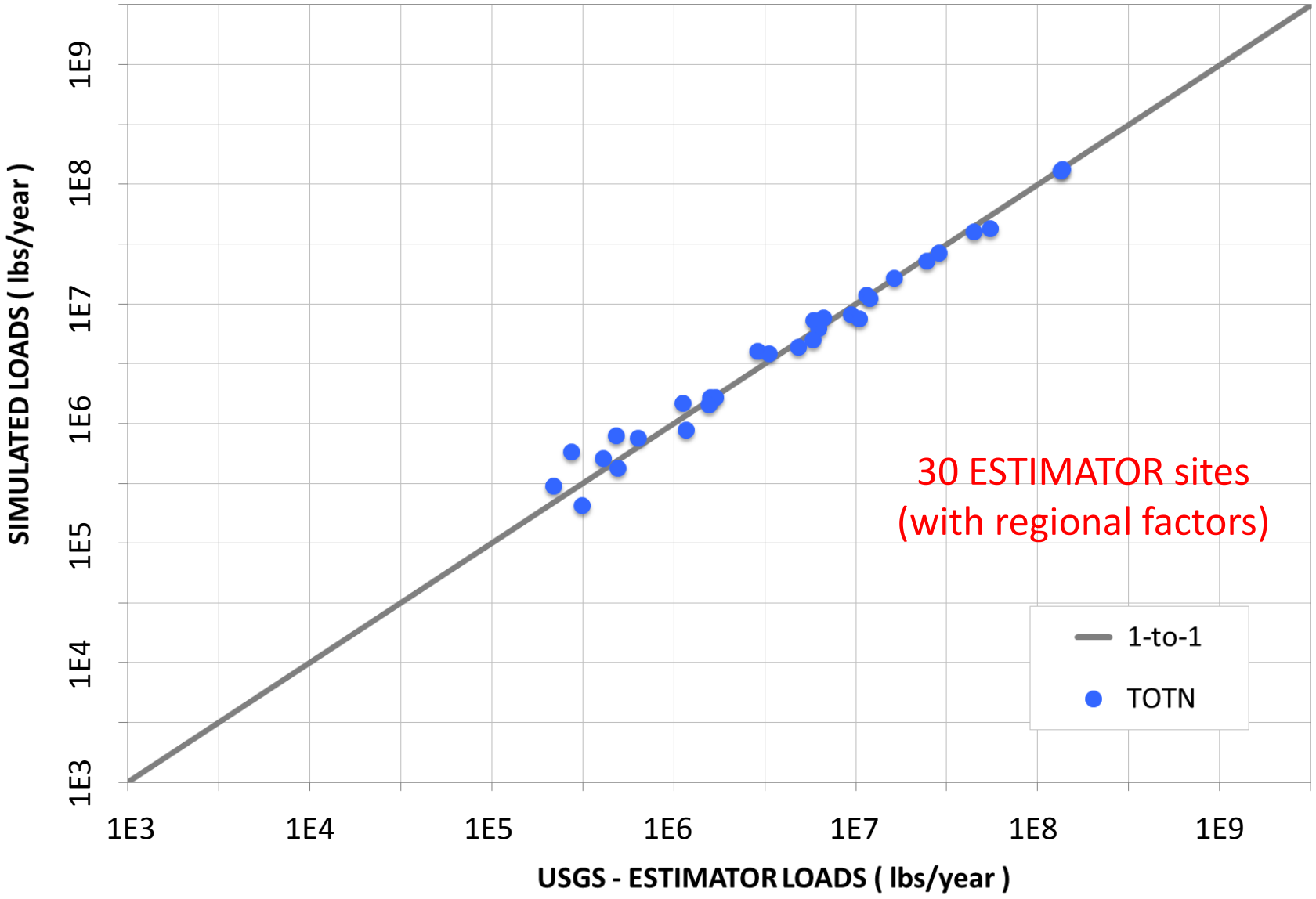
**Stream Delivery**

*

**River Delivery**

Direct Loads

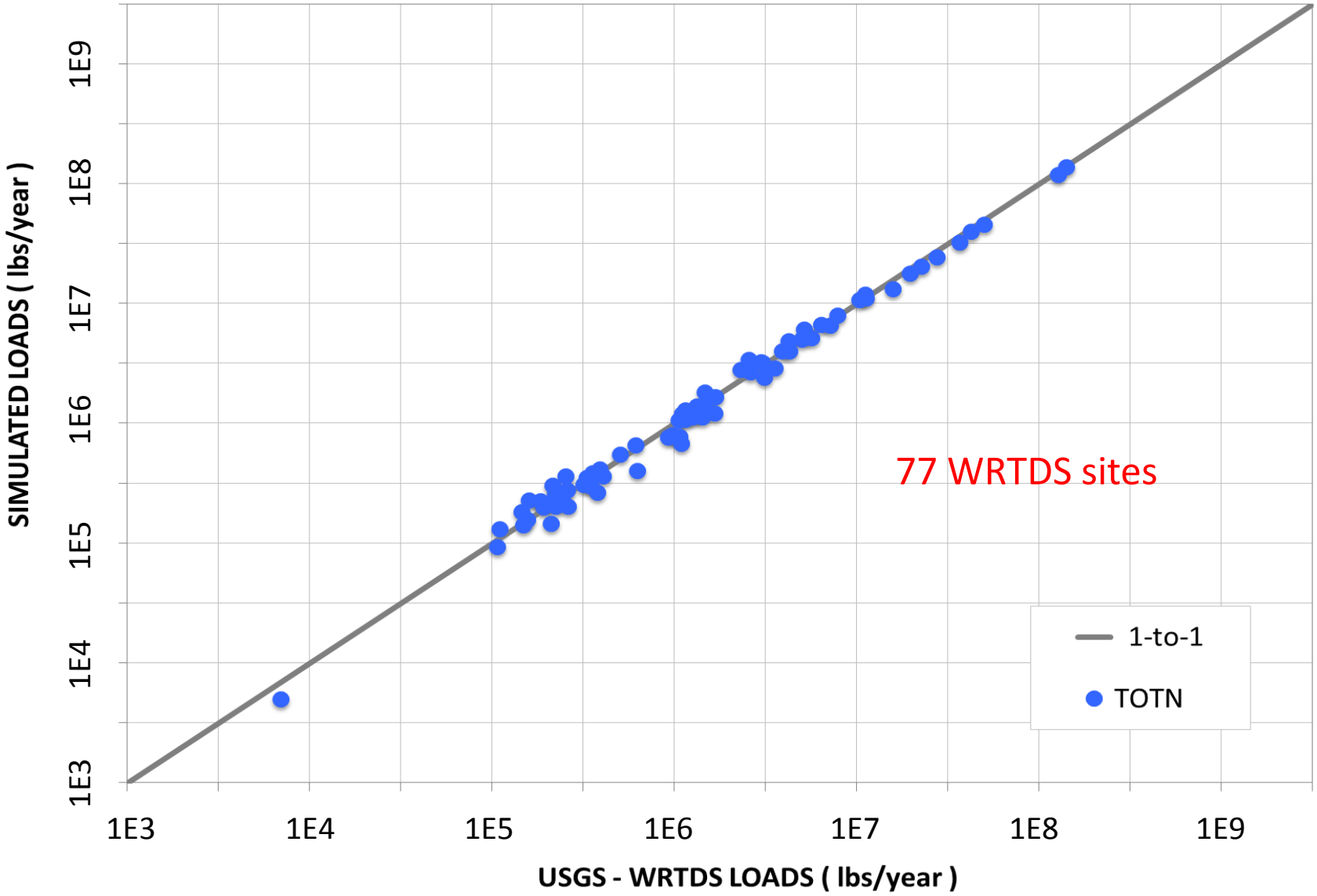
Phase 6

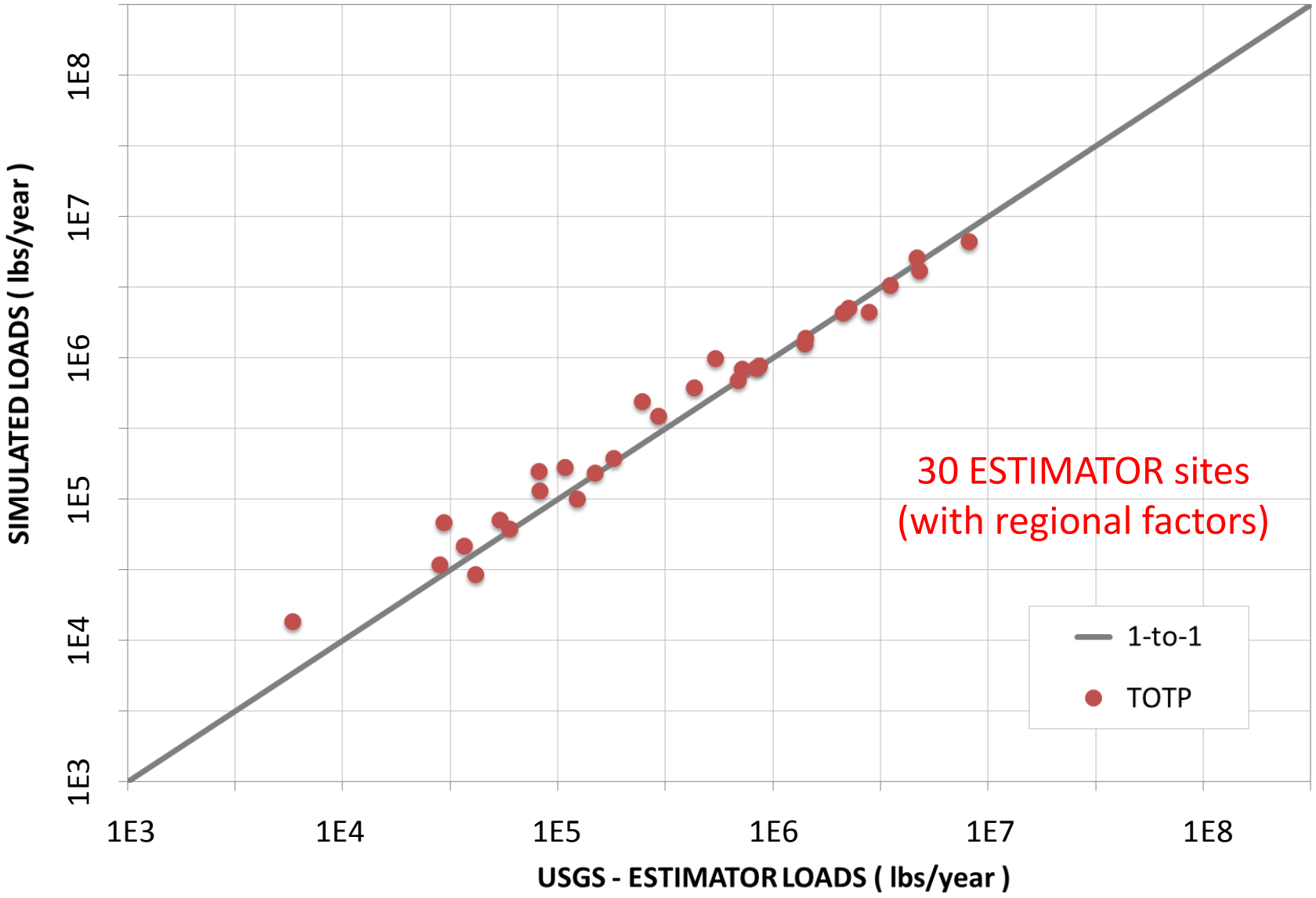

SIMULATED LOADS ( lbs/year )
1E3
1E4
1E5
1E6
1E7
1E8
1E9
USGS - ESTIMATOR LOADS ( lbs/year )
1E3
1E4
1E5
1E6
1E7
1E8
1E9
30 ESTIMATOR sites
(with regional factors)
1-to-1
TOTN

DRAFT G

*Revised inputs, model refinements, and calibration methods*

NITROGEN

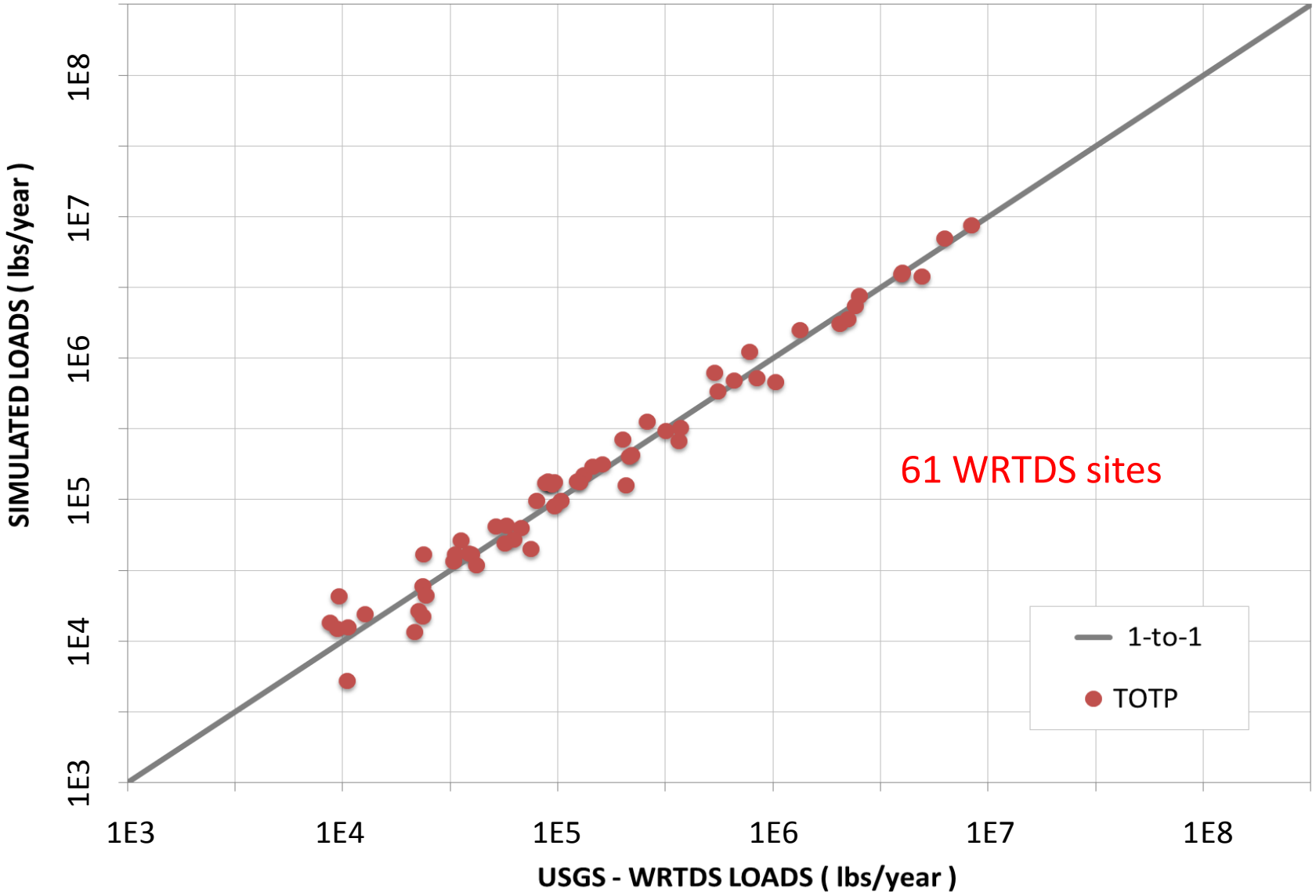



SIMULATED LOADS ( lbs/year )
1E8
1E7
1E6
1E5
1E4
1E3
1E3
1E4
1E5
1E6
1E7
1E8
USGS - ESTIMATOR LOADS ( lbs/year )
30 ESTIMATOR sites
(with regional factors)
1-to-1
TOTP

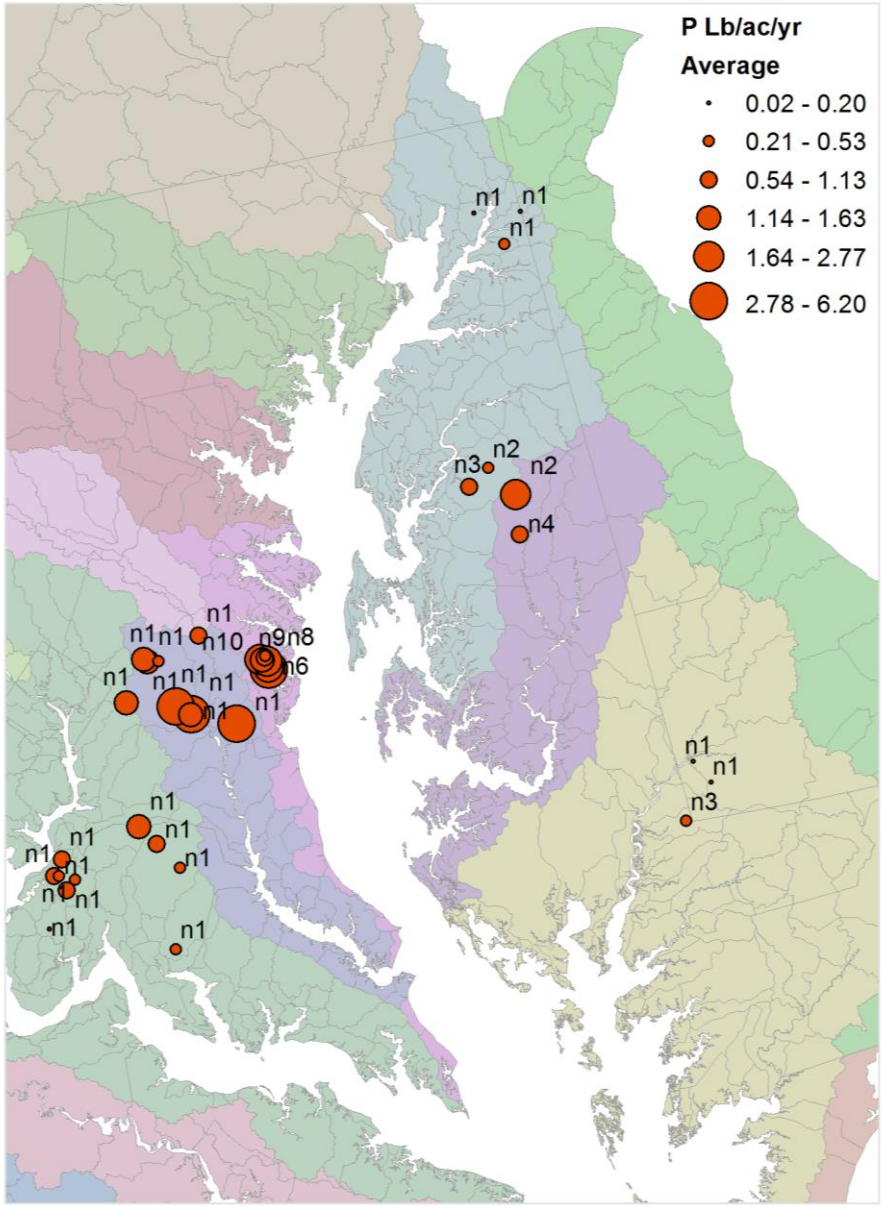
DRAFT G

*Revised inputs, model refinements, and calibration methods*

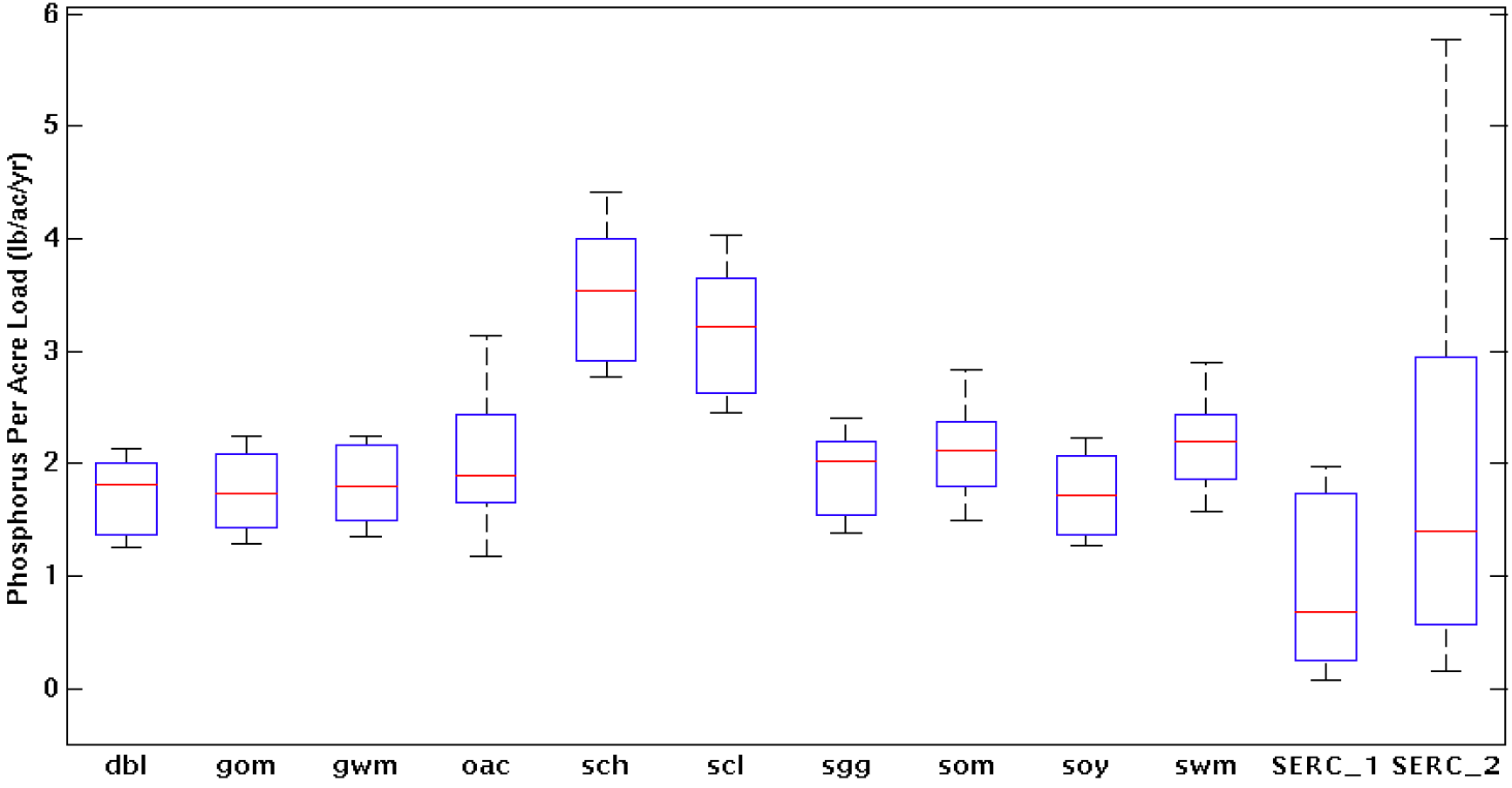
PHOSPHORUS



# Annual Phosphorus Runoff



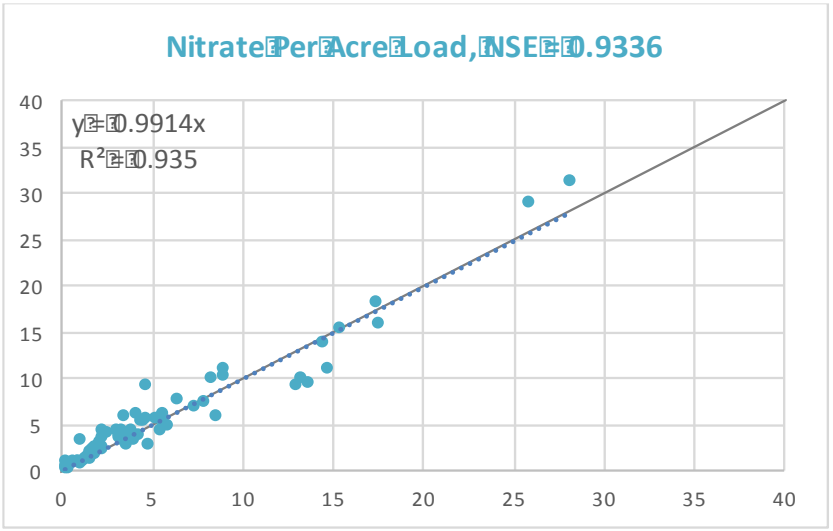

| Major/Minor Basin | Nobs |
|---|---|
| Eastern Shore of Chesapeake Bay | 19 |
| Upper Eastern Shore | 8 |
| Middle Eastern Shore, including Choptank River | 6 |
| Lower Eastern Shore | 5 |
| Western Shore of Chesapeake Bay | 71 |
| Lower Western shore | 71 |
| Patuxent River Basin | 9 |
| Patuxent River below Bowie, Maryland | 9 |
| Potomac River Basin | 10 |
| Lower Potomac River, below Chain Bridge | 10 |

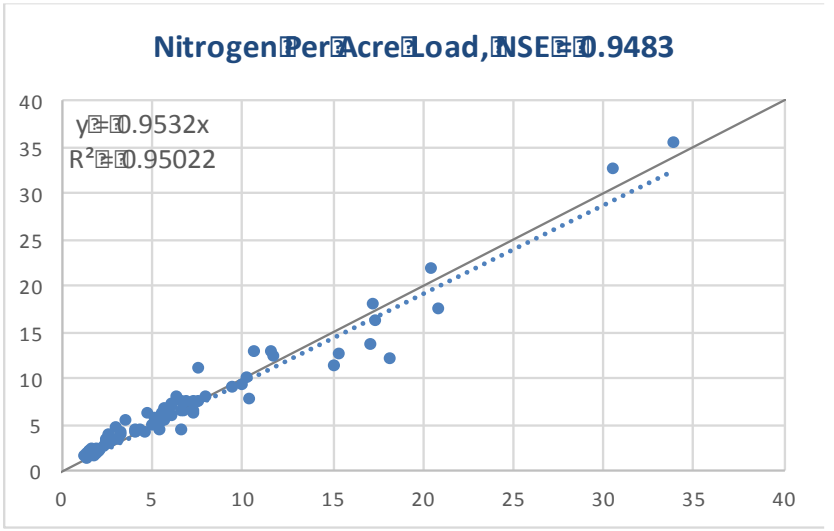


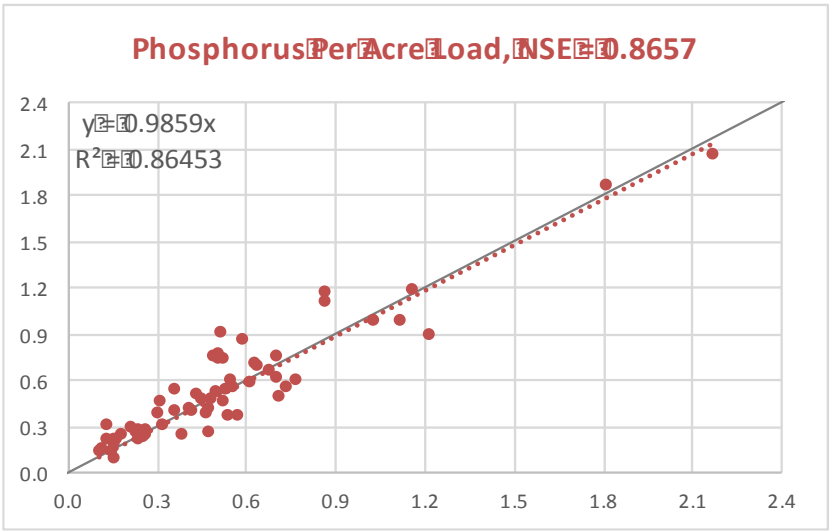

SERC_1 – phosphorus per watershed acres

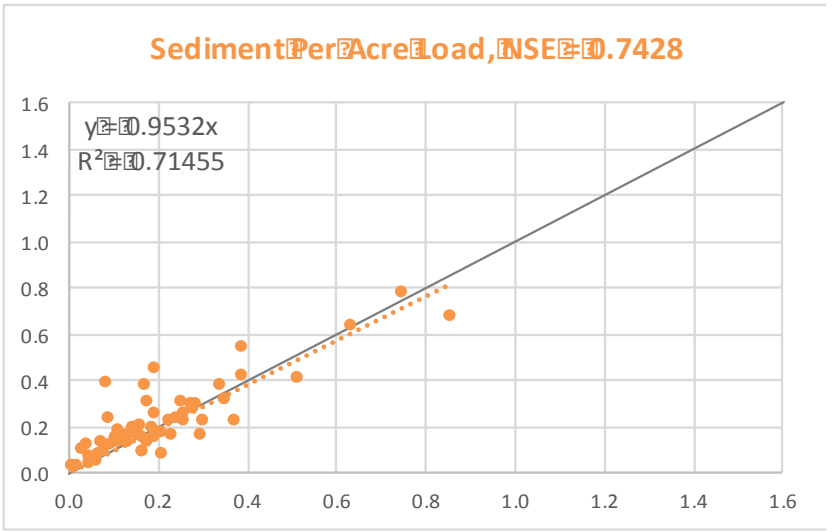
SERC_2 – phosphorus per non-natural acres

# Draft Phase 6 – geographic efficiencies




Simulated Per Acre Load

WRTDS Per Acre Load

# Summary of geographic efficiencies

| Constituents | **Phase 5** | **Draft Phase 6** |
|---|---|---|
| Nitrate | 0.8284 | 0.9336 |
| Nitrogen | 0.8704 | 0.9483 |
| Phosphorus | 0.6321 | 0.8657 |
| Sediment | -0.0770 | 0.7428 |

# Summary

- The CBP partnership built the Phase 6 model using a simplified structure
- Load differences between land uses are based on multiple models and multiple lines of evidence and calculated from monitoring data
- Load differences within land uses are determined by differences in inputs multiplied by coefficients.
- The resulting model is better able to match spatial differences in monitored stream loads.

# Access to Overview of the Integrated Air Watershed and Bay Models Webinar Recording

A recording of this webinar along with the presentation will be posted to the following page on the Chesapeake Bay Program Partnership's website:

**Phase 6 Model Overview Webinar Calendar Page:**
http://www.chesapeakebay.net/calendar/event/25114/

# The final Phase 6 Webinar

**Phase 6 Physical Transport Webinar**
June 20, 2017 1:00 – 3:00 pm
Adobe Connect: https://epawebconferencing.acms.com/mpawebinars
Webinar Calendar Page:
http://www.chesapeakebay.net/calendar/event/25116/
Webinar Leads: Gary Shenk and Gopal Bhatt
This webinar will review in detail the processes of riverine and small stream transport as well as the attenuation of nutrient and sediment loads.

# Questions and Answers Session

- To Ask a Question
  - Submit your question in the chat box, located in the bottom left of the screen.