Roadside Ditch Management and the Chesapeake Bay Program Watershed Models

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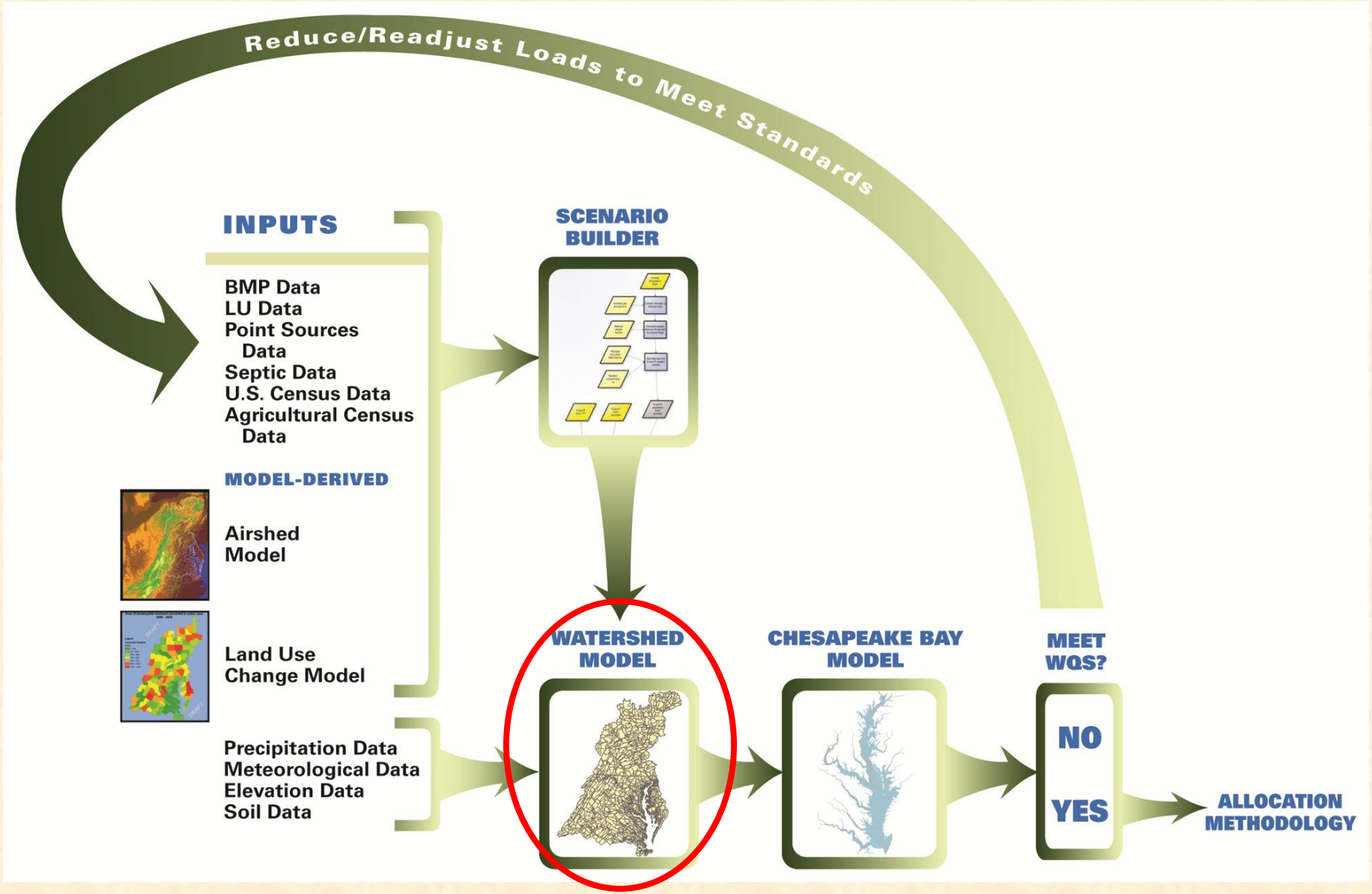
Re-plumbing the Chesapeake Watershed:
Improving roadside ditch management
to meet TMDL water quality goals
Easton, MD
October 10, 2014

Role of the Bay Partnership Models In Decision-Making



Purposes of the CBP Watershed Model

- Develop plans that meet target loads that would meet water quality standards
  - Stakeholder development of WIPs
  - WIPs are evaluated by EPA for reasonable assurance
- One of several means of accounting for progress towards goals, in addition to:
  - Annual evaluations of status and trends in implementation of BMPs, programs
  - Status and trends in monitoring data, both tidal and non-tidal

Purposes of the CBP Watershed Model

- Partner requested scenarios = what-ifs to inform implementation, direction of policy
  - Project how changes to pollution controls, land use, atmospheric deposition, and precipitation could affect flow and pollution loads to the ecosystem and how these load changes affect water quality and living resources.
  - Help assess what are the most achievable, equitable and cost-effective approaches
- Revisions to TMDL or Planning Targets
- Support research

How the Watershed Model Works

Describe Change in Load due to Actions

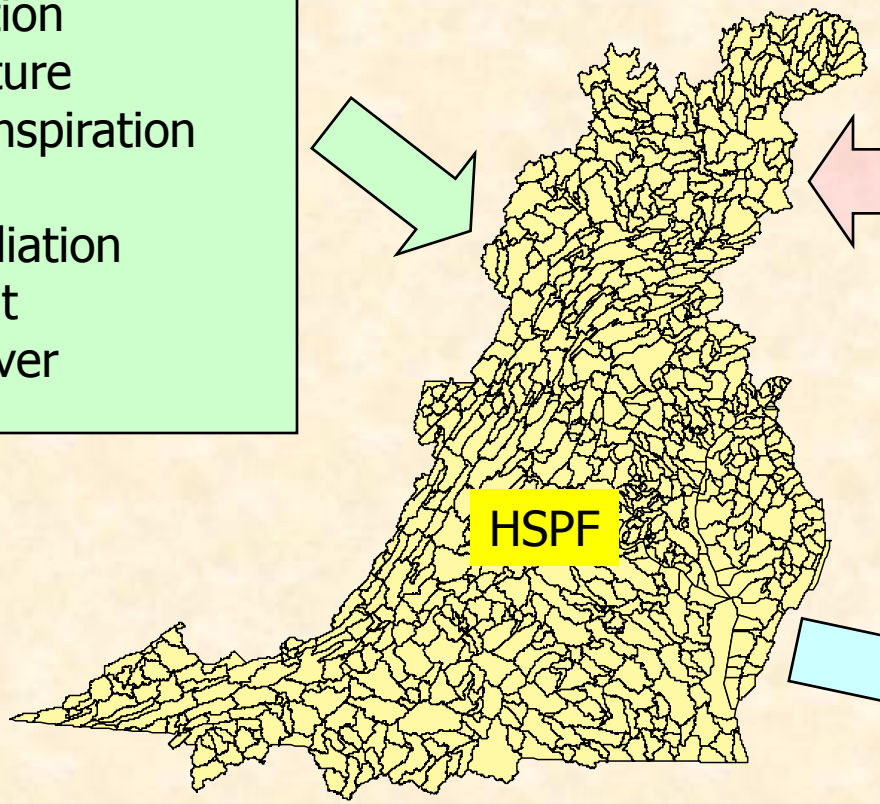
Hourly or daily values of meteorological factors:

Precipitation
Temperature
Evapotranspiration
Wind
Solar Radiation
Dew Point
Cloud Cover

From Scenario Builder

Annual, monthly or daily values of anthropogenic factors:

Land use acres
BMPs
Fertilizer
Manure
Atmospheric Deposition
Wastewater Loads
AFO-CAFO, Septic Loads



Average annual flow-normalized loads (1991-2000)

How the Watershed Model Works

Precipitation

Fertilizer
Manure
Atmospheric deposition

Management filter

Runoff

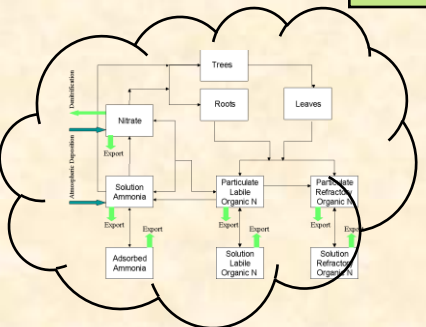
River

Hydrology sub-model

Sediment sub-model

Phosphorus sub-model

Nitrogen sub-model



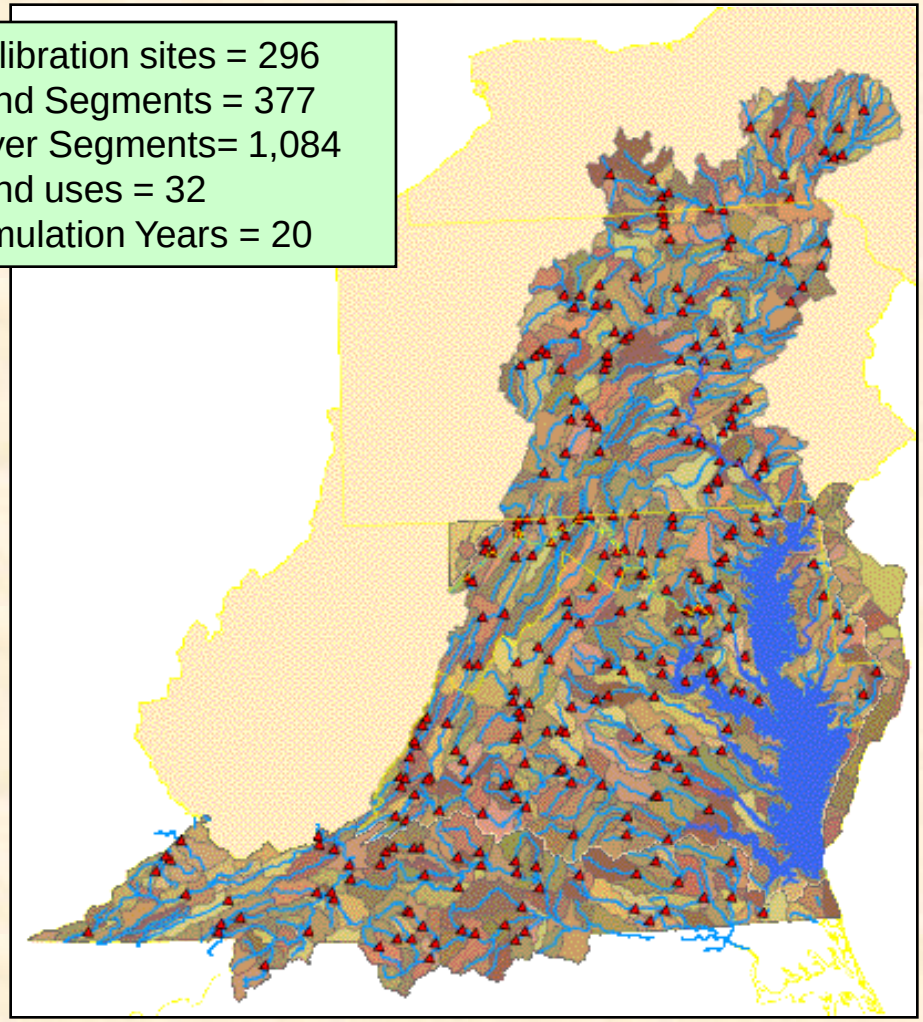
hourly

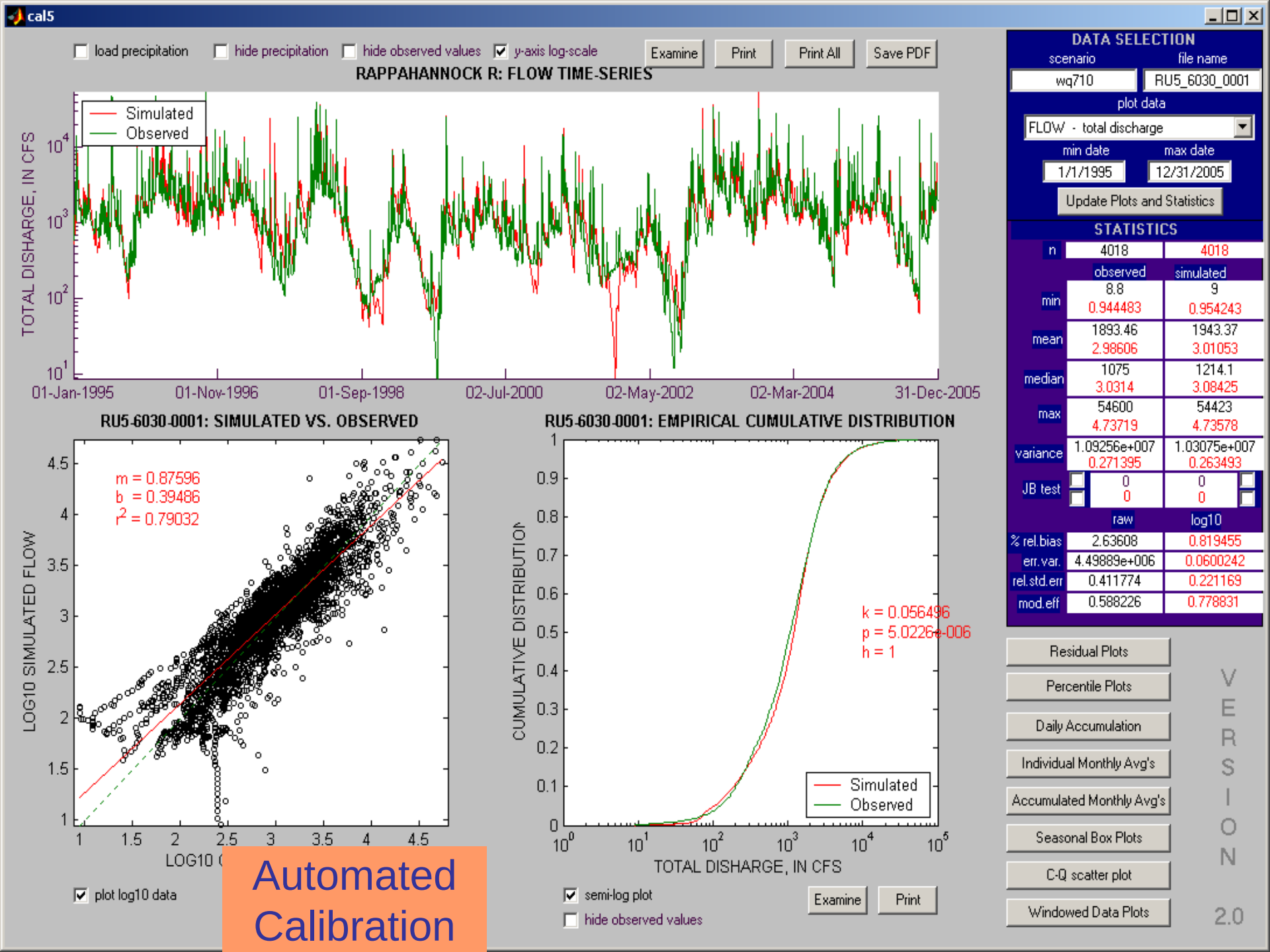
How the Watershed Model Works

Calibration

Phase 5 Segmentation and Calibration Sites

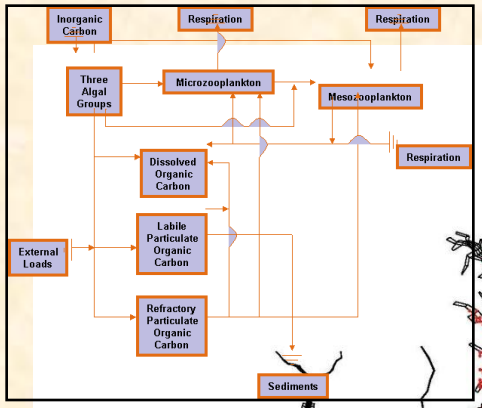
Calibration sites = 296
Land Segments = 377
River Segments= 1,084
Land uses = 32
Simulation Years = 20

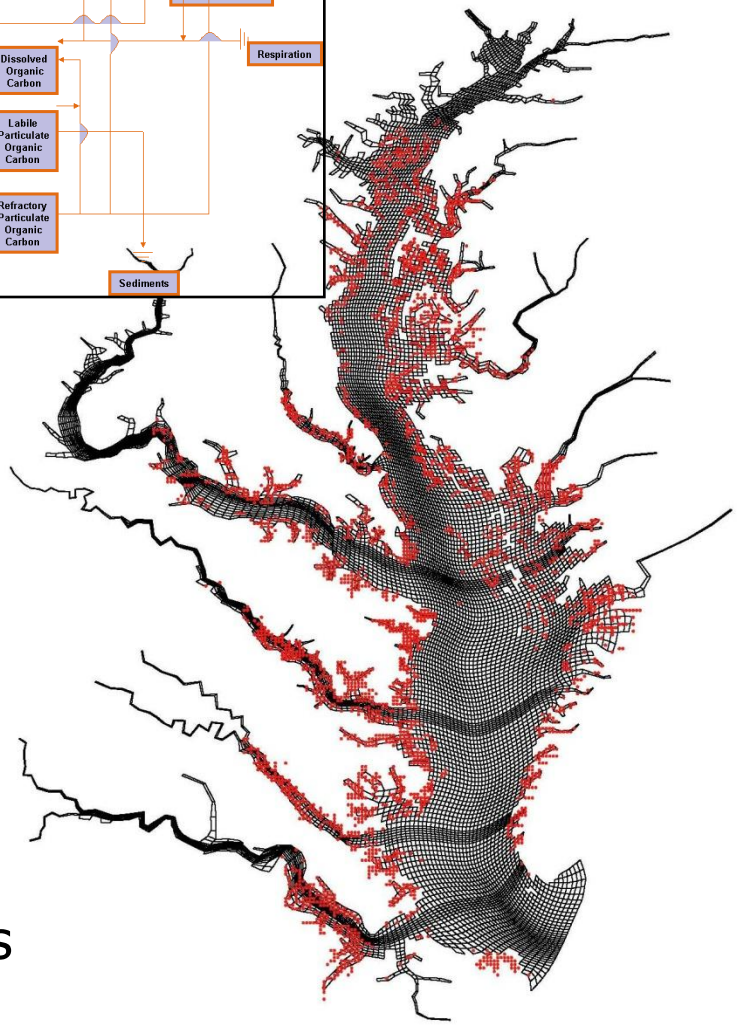



cal5
load precipitation
hide precipitation
hide observed values
y-axis log-scale
Examine
Print
Print All
Save PDF
RAPPAHANNOCK R: FLOW TIME-SERIES
Simulated
Observed
TOTAL DISHARGE, IN CFS
01-Jan-1995
01-Nov-1996
01-Sep-1998
02-Jul-2000
02-May-2002
02-Mar-2004
31-Dec-2005
RU5-6030-0001: SIMULATED VS. OBSERVED
m = 0.87596
b = 0.39486
r2 = 0.79032
LOG10 SIMULATED FLOW
plot log10 data
RU5-6030-0001: EMPIRICAL CUMULATIVE DISTRIBUTION
k = 0.056496
p = 5.0226e-006
h = 1
CUMULATIVE DISTRIBUTION
TOTAL DISHARGE, IN CFS
semi-log plot
hide observed values
Examine
Print
DATA SELECTION
scenario
wq710
file name
RU5_6030_0001
plot data
FLOW - total discharge
min date
1/1/1995
max date
12/31/2005
Update Plots and Statistics
STATISTICS
n 4018 4018
observed simulated
min 8.8 9
0.944483 0.954243
mean 1893.46 1943.37
2.98606 3.01053
median 1075 1214.1
3.0314 3.08425
max 54600 54423
4.73719 4.73578
variance 1.09256e+007 1.03075e+007
0.271395 0.263493
JB test 0 0
0 0
raw log10
% rel.bias 2.63608 0.819455
err.var. 4.49889e+006 0.0600242
rel.std.err 0.411774 0.221169
mod.eff 0.588226 0.778831
Residual Plots
Percentile Plots
Daily Accumulation
Individual Monthly Avg's
Accumulated Monthly Avg's
Seasonal Box Plots
C-Q scatter plot
Windowed Data Plots
VERSION 2.0
Automated Calibration

Bay Water Quality Model

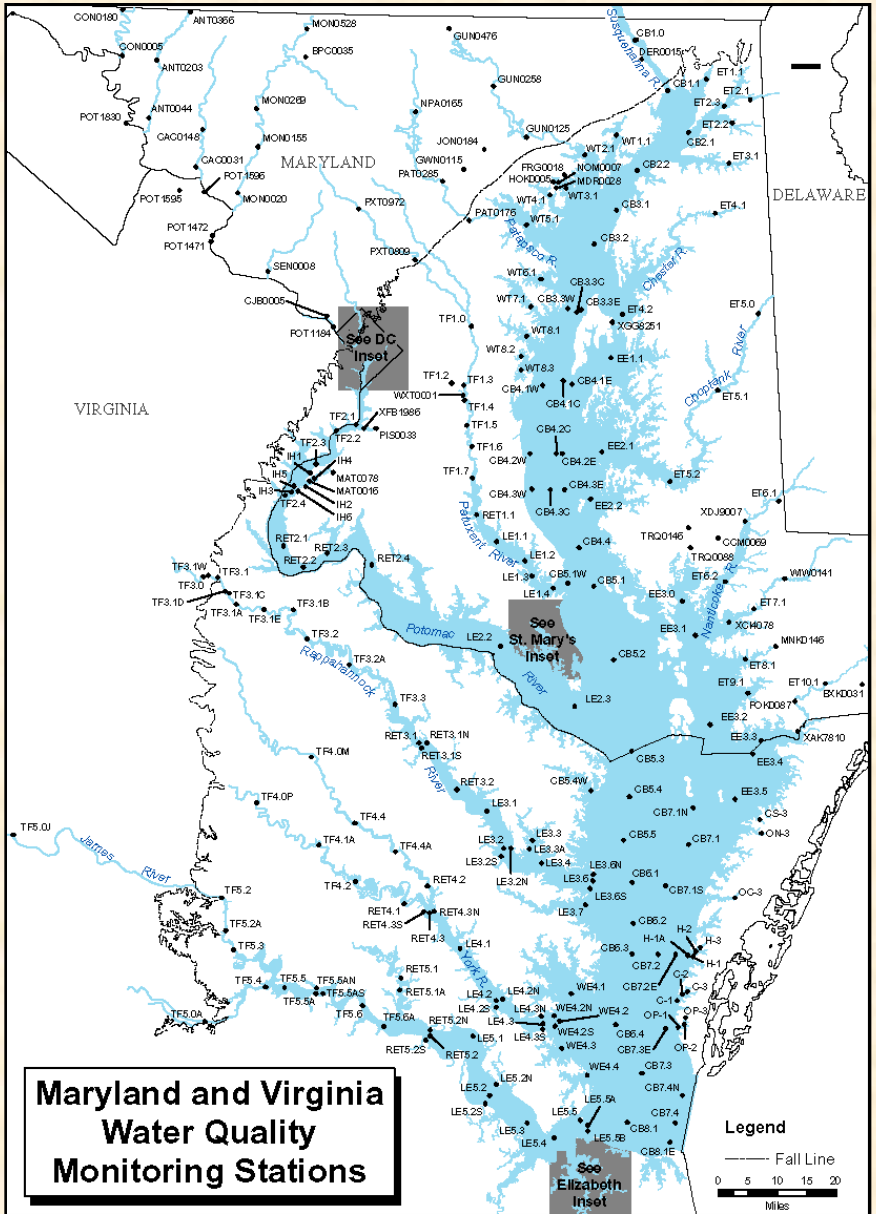
- 57,000 cells
- Predicts changes in water quality due to changes in nitrogen, phosphorus, and sediment
  - Dissolved Oxygen
  - Clarity
  - Chlorophyll (algae)
- Also simulates shellfish, submerged aquatic vegetation



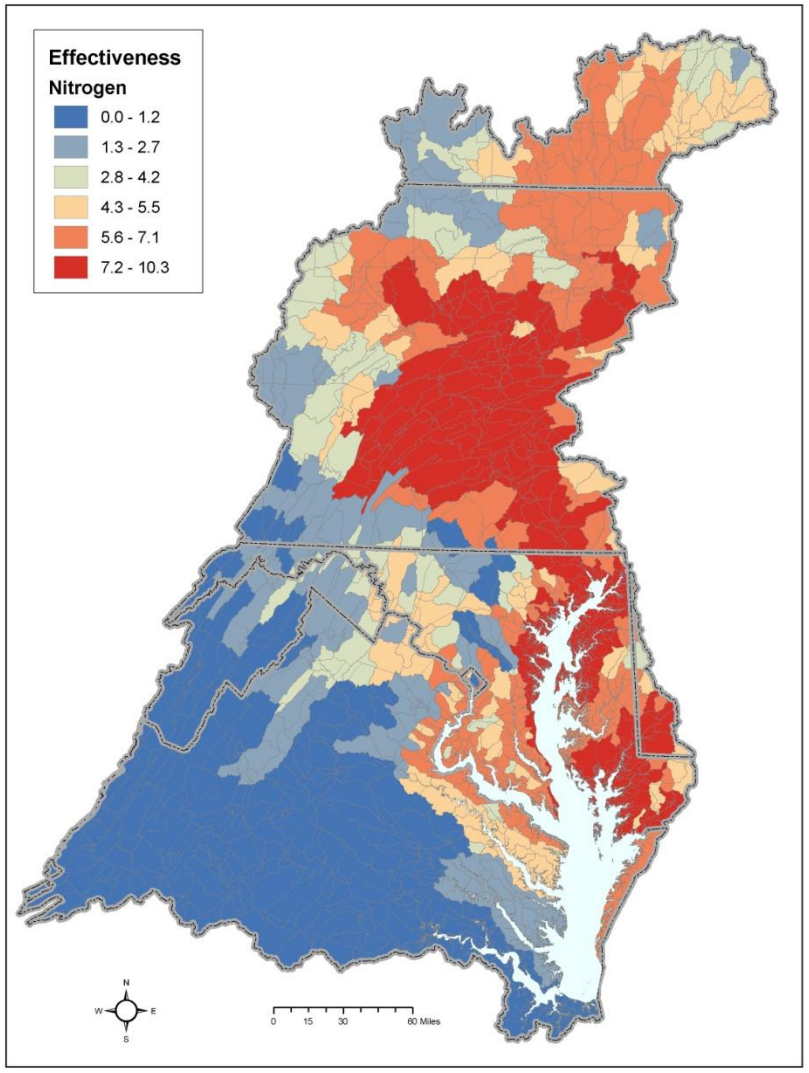


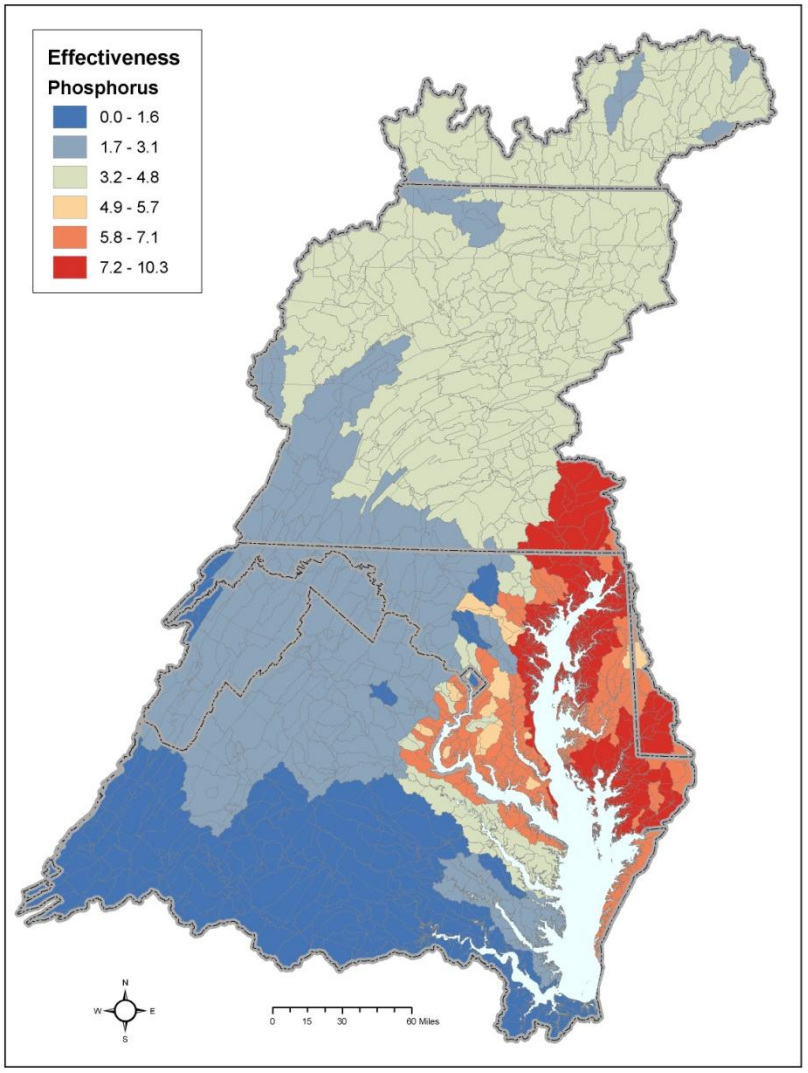
Developed by U.S. Army Corps of Engineers

Tidal Water Monitoring Network



Relative Effect of a Pound of Excess Nutrients on Bay Water Quality



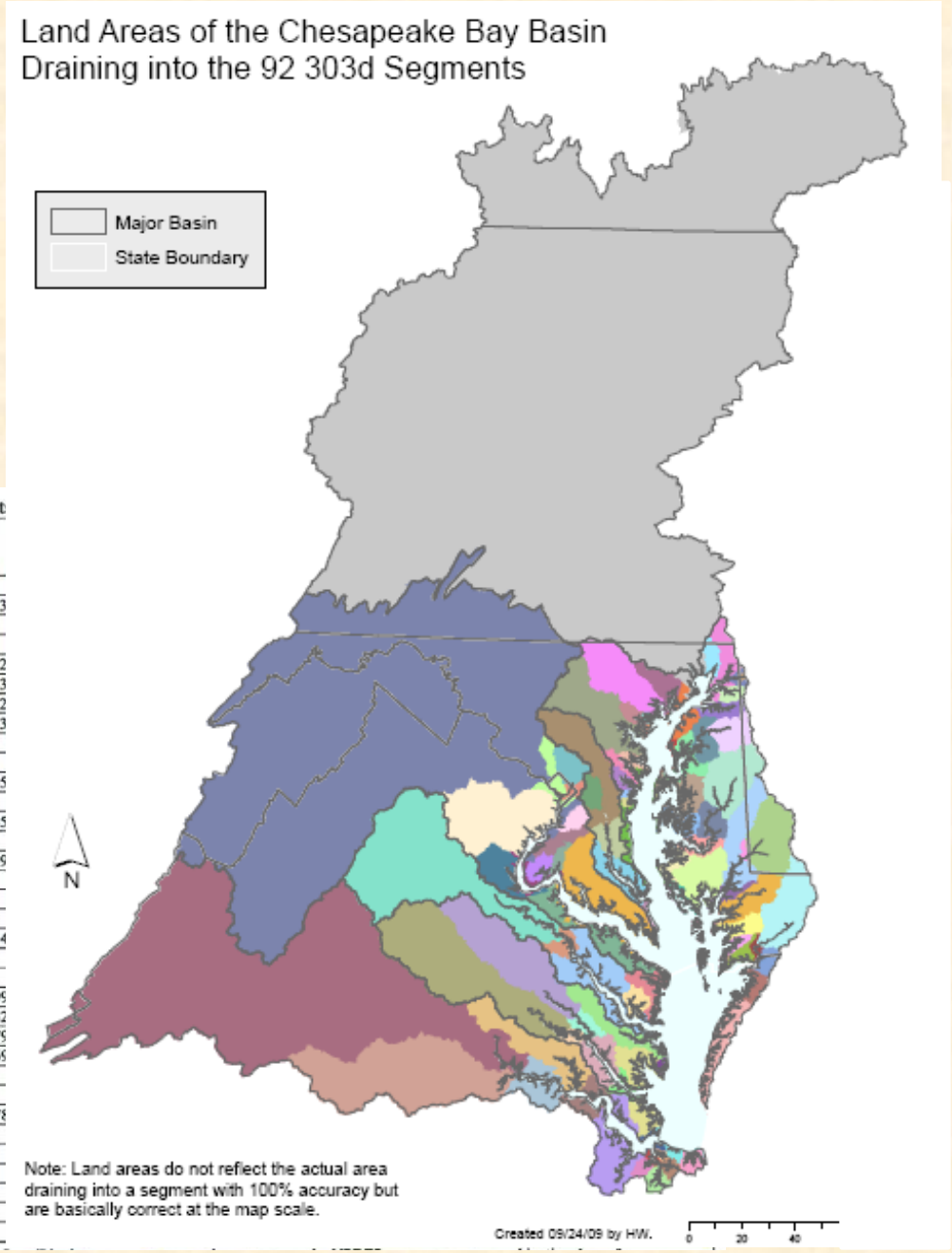


Jurisdictions' Watershed Implementation Plans

92 Individual TMDLs

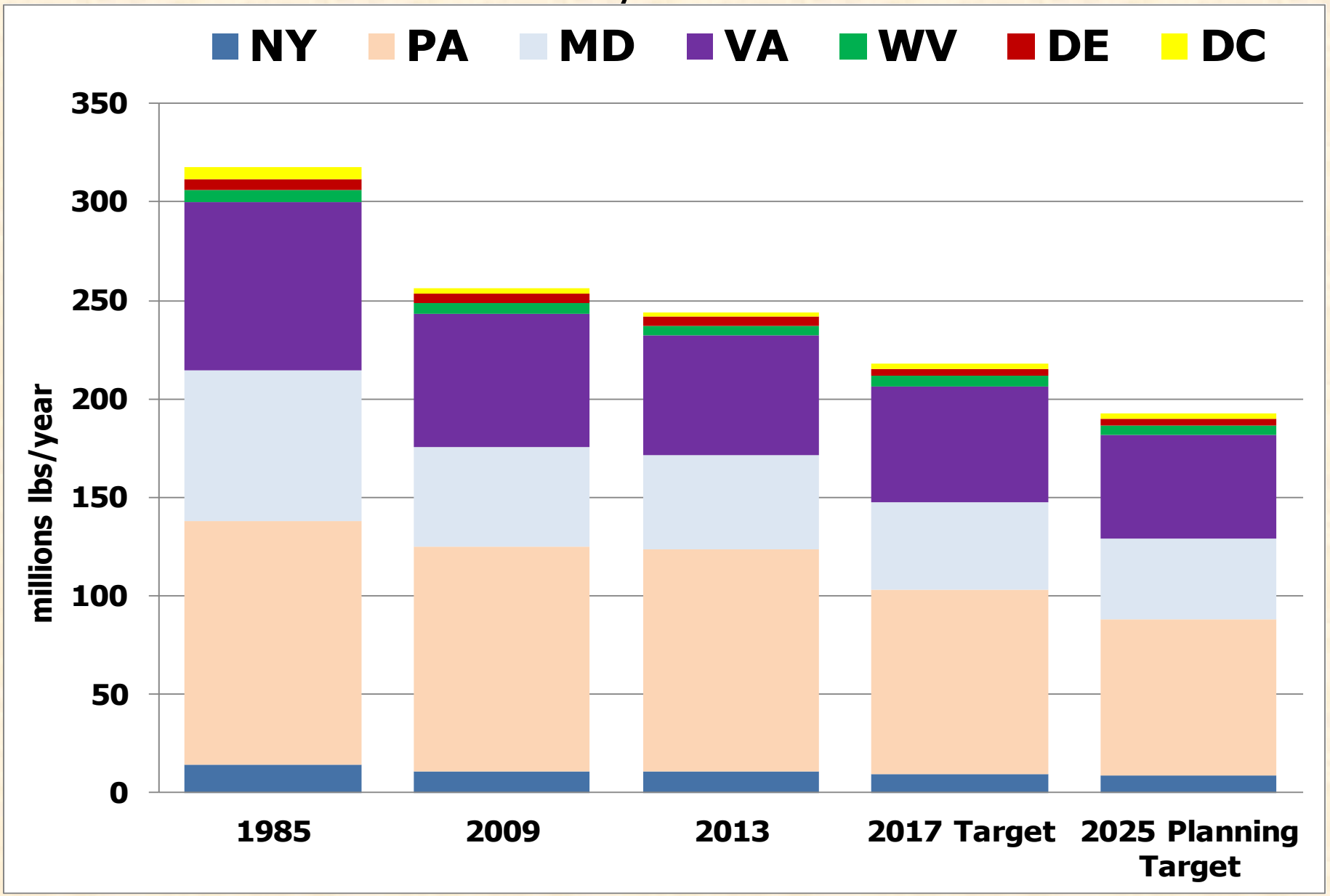
Table B2. Format for Submitting Phase I Watershed Implementation Plan Output

St.	Maj. Basin	Impaired Segment Drainage	Unique Code	Source Sector[b]	Type[c]	NPDES Permit
MD	W. Shore	PAXTF	MWPTF	Agriculture-CAFO	Agg. WLA	
				Agriculture-CAFO	Ind. WLA	MD356913
				Agriculture	LA	
				Subtotal: Agriculture		
				Wastewater: POTW#1	Ind. WLA	MD012452
				Wastewater: POTW#2	Ind. WLA	MD013943
				Wastewater: Indus #1	Ind. WLA	MD821672
				Wastewater: Indus #2	Ind. WLA	MD853653
				Subtotal: Wastewater		
				Onsite	LA	
				Urb/Suburb Runoff: MS4	Agg. WLA	MD546195
				Urb/Suburb Runoff: Non-MS4	LA	
				Urb/Suburb Runoff: MS4	Ind. WLA	MD892645
				Industrial Stormwater	Agg. WLA	
				Industrial Stormwater	Ind. WLA	MD246139
				Construction	Agg WLA	
				Subtotal: Urb/Suburb		
				Forest	LA	
MD	W. Shore	SEVMH	MWSeM	Agriculture-CAFO	Agg. WLA	MD382614
				Agriculture	LA	
				Subtotal: Agriculture		
				Wastewater: POTW#1	Ind. WLA	MD083695
				Wastewater: POTW#2	Ind. WLA	MD054732
				Wastewater: Indus #1	Ind. WLA	MD836675
				Wastewater: Indus #2	Ind. WLA	MD854465
				Subtotal: Wastewater		
				Onsite	LA	
				Urb/Suburb Runoff: MS4	Agg. WLA	MD588578
				Urb/Suburb Runoff: Non-MS4	LA	
				Subtotal: Urb/Suburb		
				Forest	LA	
	...					
MD	W. Shore			Reserve for Growth	WLA/LA	
MD	**W Shore**		**MW**	**Total**		



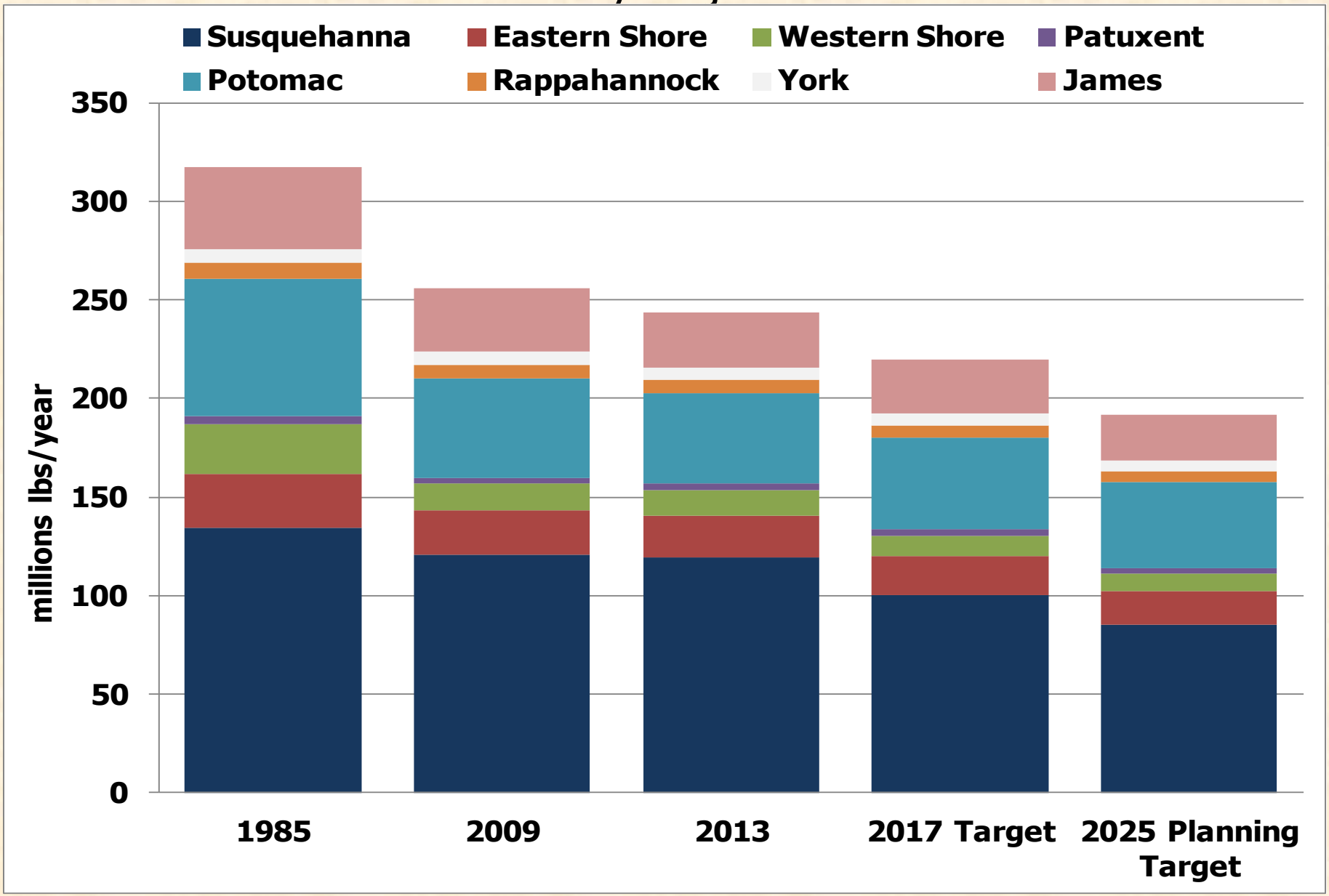
Nitrogen Loads Delivered to the Bay

By Jurisdiction



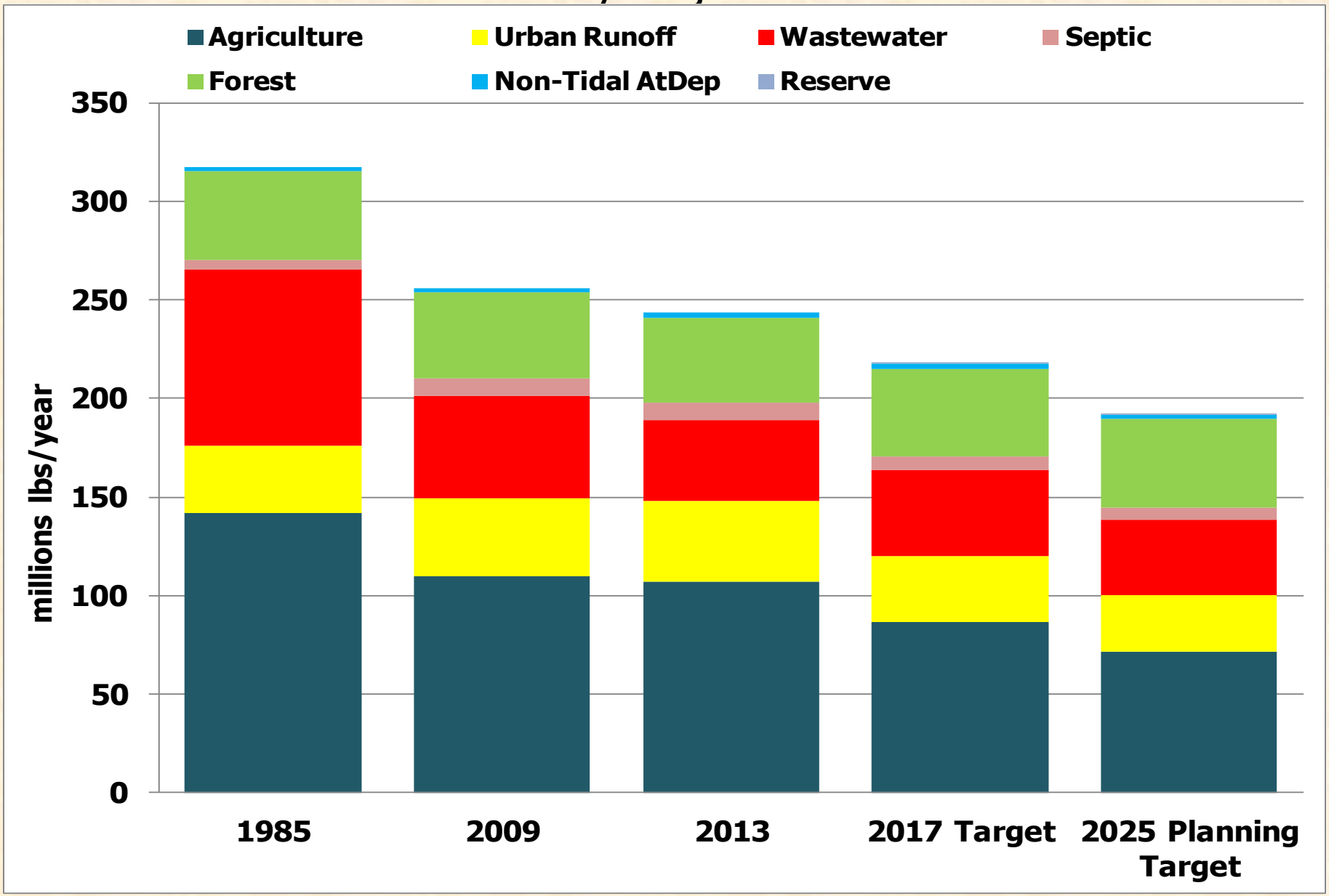
Nitrogen Loads Delivered to the Bay

By Major Basin



Nitrogen Loads Delivered to the Bay

By Major Source



Chesapeake Bay Watershed Model
Agricultural Practice Groups

Nutrient Management

- Nutrient Management
- Decision Agriculture
- Enhanced Nutrient Management

Conservation Tillage

- Continuous No-Till
- High-Residue Tillage
- Other Conservation Tillage

Cover Crops

- Cover Crops and Commodity Cover Crops
  - Early, standard, late-planting
  - Species
  - Seeding method

Pasture Grazing Practices

- Alternative Watering Facilities
- Stream Access Control with Fencing
- Prescribed Grazing
- Precision Intensive Rotational Grazing
- Horse Pasture Management

Other Agricultural Practices

- Forest Buffers
- Wetland Restoration
- Land Retirement
- Grass Buffers
- Tree Planting
- Carbon Sequestration/Alternative Crops
- Conservation Plans/SCWQP
- Animal Waste Management Systems
- Barnyard Runoff Control
- Mortality Composters
- Manure Transport
- Water Control Structures
- Non-Urban Stream Restoration
- Poultry and Swine Diet & Feed, Genetics
- Dairy Precision Feeding and/or Forage Management
- Ammonia Emissions Reductions

Chesapeake Bay Watershed Model
Practices on Developed Lands

Stormwater Management

- Wet Ponds and Wetlands
- Dry Detention Ponds and Hydrodynamic Structures
- Dry Extended Detention Ponds
- Infiltration Practices
- Filtering Practices
- Urban Stormwater Retrofit
- SW Performance Standards

Septic BMPs

- Septic Connections
- Septic Denitrification
- Septic Pumping

Other Urban/Suburban Practices

- Forest Conservation
- Impervious Surface and Urban Growth Reduction
- Forest Buffers
- Tree Planting
- Grass Buffers
- Stream Restoration
- Erosion and Sediment Control
- Fertilizer Management
- Street Sweeping
- Abandoned Mine Reclamation
- Dirt and Gravel Road Erosion and Sediment Controls
- Shoreline Erosion Control

Ditch Management in the CBP Watershed Model

- Forest + Agricultural + Stormwater BMPs
  - Dirt and Gravel Road Erosion & Sediment Control
- Agricultural BMPs
  - Drainage Water Control Structures on Eastern Shore ditch network to keep water on the landscape = irrigation
  - Wetland Restoration = LIDAR to detect slight elevation differences to reveal best places for floodplain restoration
  - Ditch Filters = Cropland drainage phosphorus-sorbing materials
- Stormwater BMPs
  - Vegetated Open Channels
  - Bio-swales = dry swale with under-drain

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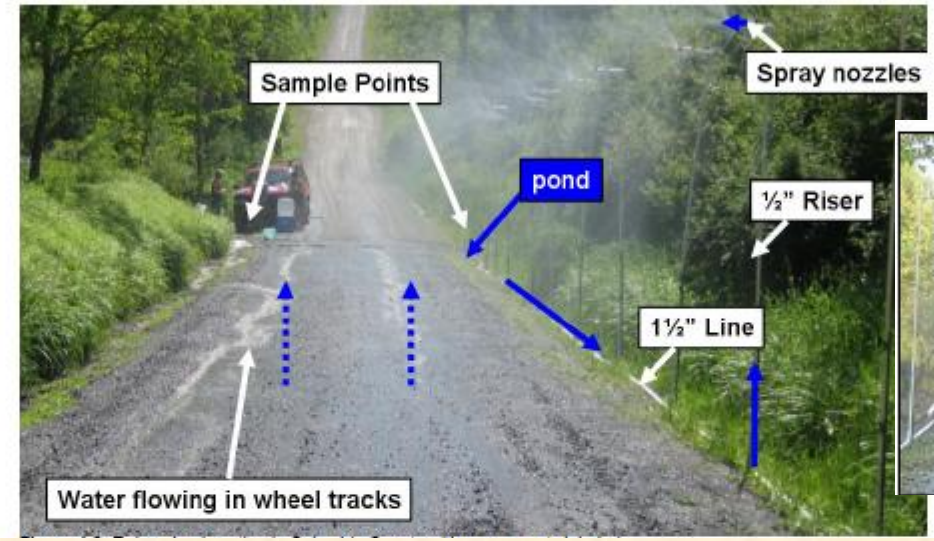
Ditch Management in the CBP Watershed Model

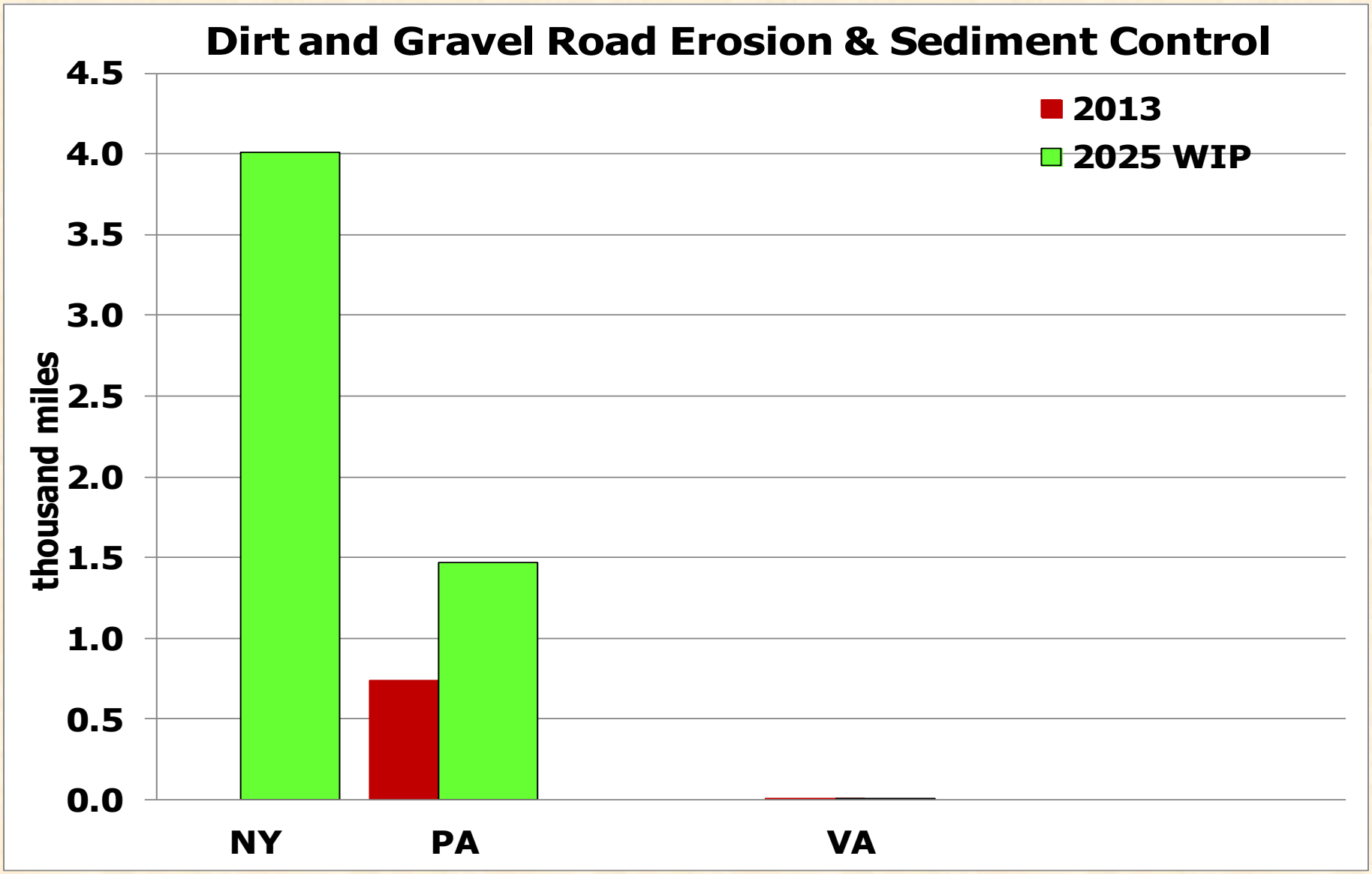
- Dirt and Gravel Road Erosion & Sediment Control
  - "Environmentally Sensitive Maintenance Practices for Unpaved Roads: Sediment Reduction Study", June 30, 2008
    - Prepared for Chesapeake Bay Commission
      by Dr. Barry E. Scheetz, Steven M. Bloser
      Center for Dirt and Gravel Road Studies, The Pennsylvania State University, University Park, PA



Ditch Management in the CBP Watershed Model

- Dirt and Gravel Road Erosion & Sediment Control
  - Driving Surface Aggregate + Raising the Roadbed
    - E&S through driving surface aggregates (DSA) such as durable and erosion resistant road surface and raising road elevation to restore natural drainage patterns
  - DSA with Outlets
    - E&S through the use of DSA + additional drainage outlets; creating new outlets in ditch-line to reduce channelized flow
  - Outlets Only
    - E&S through the use of additional drainage outlets

Ditch Management
BMP Implementation and Targets



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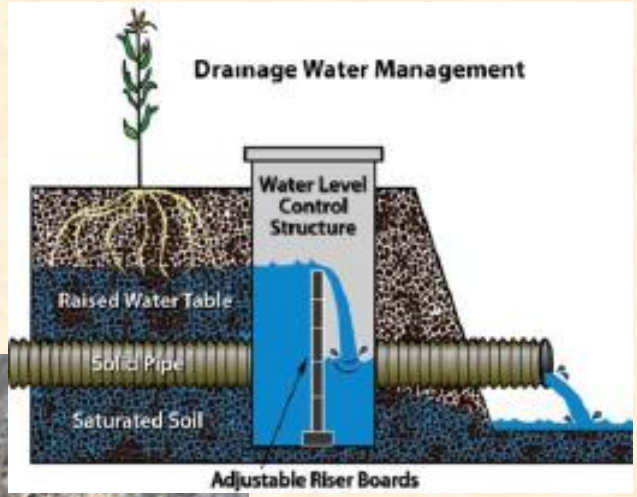
Ditch Management in the CBP Watershed Model

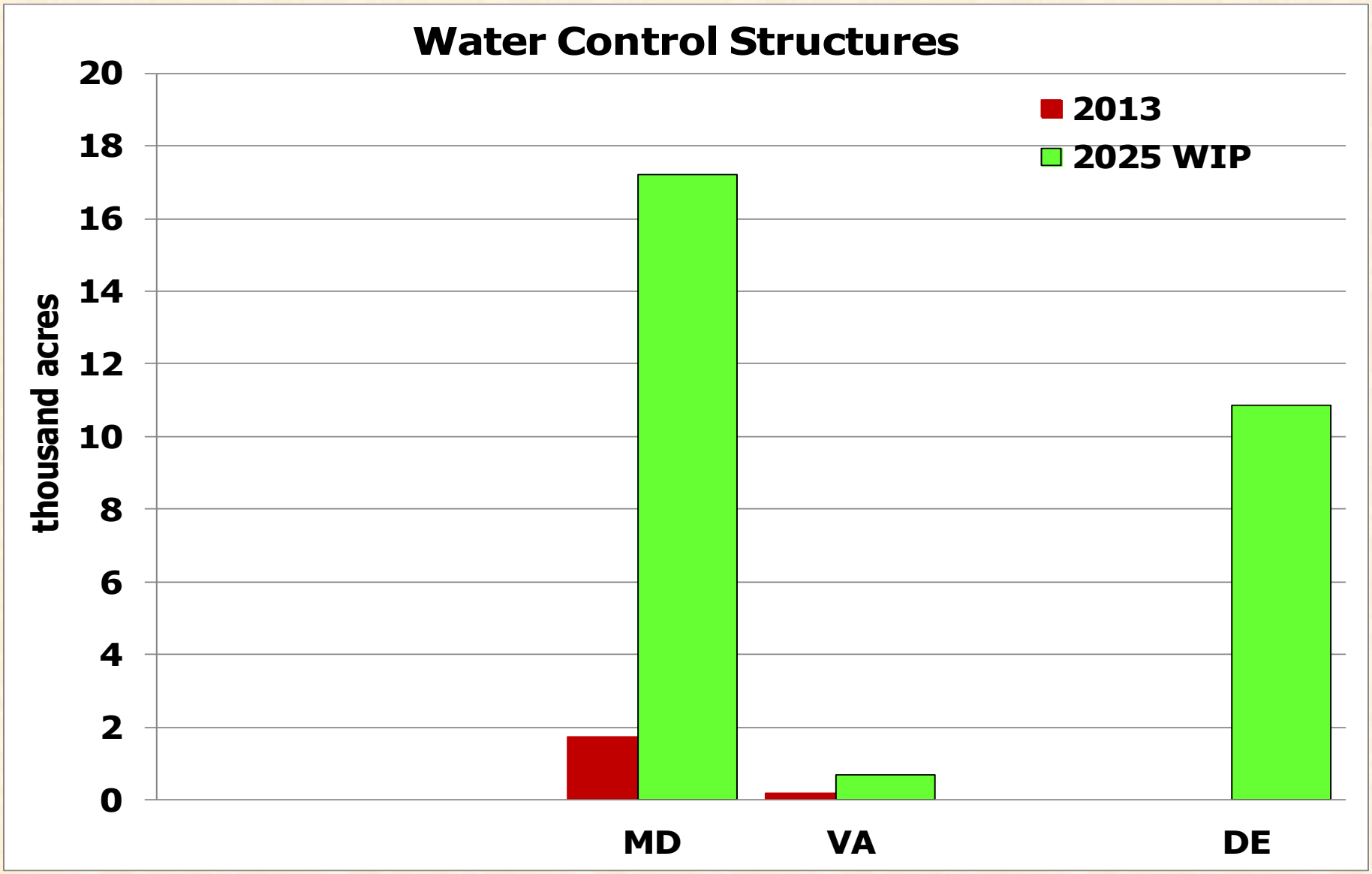
- Drainage Water Control Structures
  - Install and manage boarded gate systems in the surface drainage ditches = flashboard risers at the ditch outlet



Ditch Management in the CBP Watershed Model

- Drainage Water Control Structures
  - Applies to cropland nitrogen in CBWSM
  - Nitrogen load reduction occurs as the result of:
    1) Volume flow reduction = water conservation
    2) Nitrogen concentration reduction through de-nitrification
    3) Management of water table levels can have crop production benefits = yield

Ditch Management
BMP Implementation and Targets



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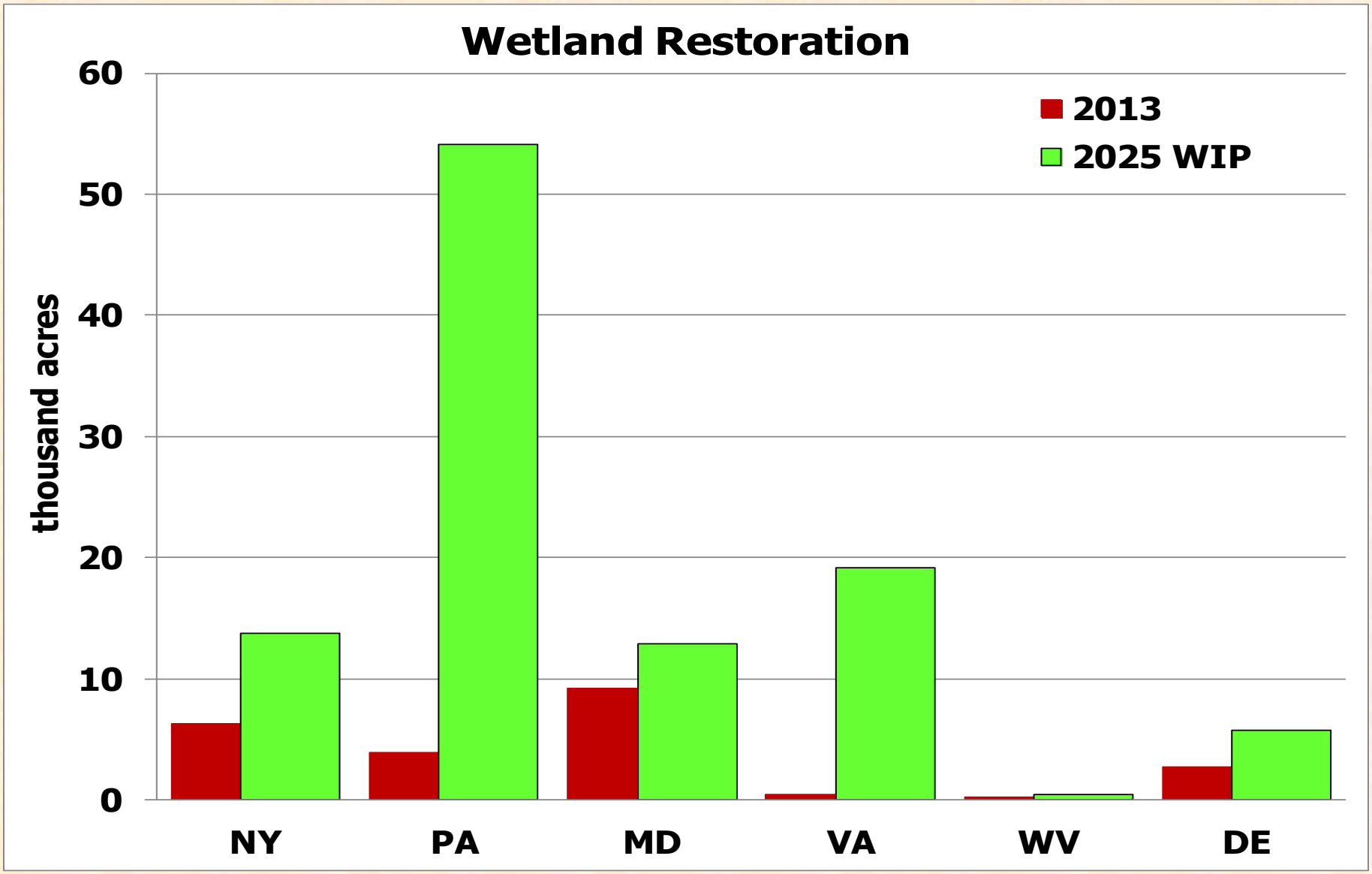
Ditch Management in the CBP Watershed Model

- Wetland Restoration
  - Applies to agricultural nutrients and sediment in CBWSM
  - Re-establishes the natural hydraulic condition in a field that existed prior to the installation of subsurface or surface drainage.
    - Projects may include restoration, creation and enhancement acreage.
      - Wetland Reserve Program
      - Conservation Reserve Enhancement Program
      - Conservation Securities Program
      - Rural Legacy
      - Growing Greener
      - Partners for Fish and Wildlife

Ditch Management
BMP Implementation and Targets



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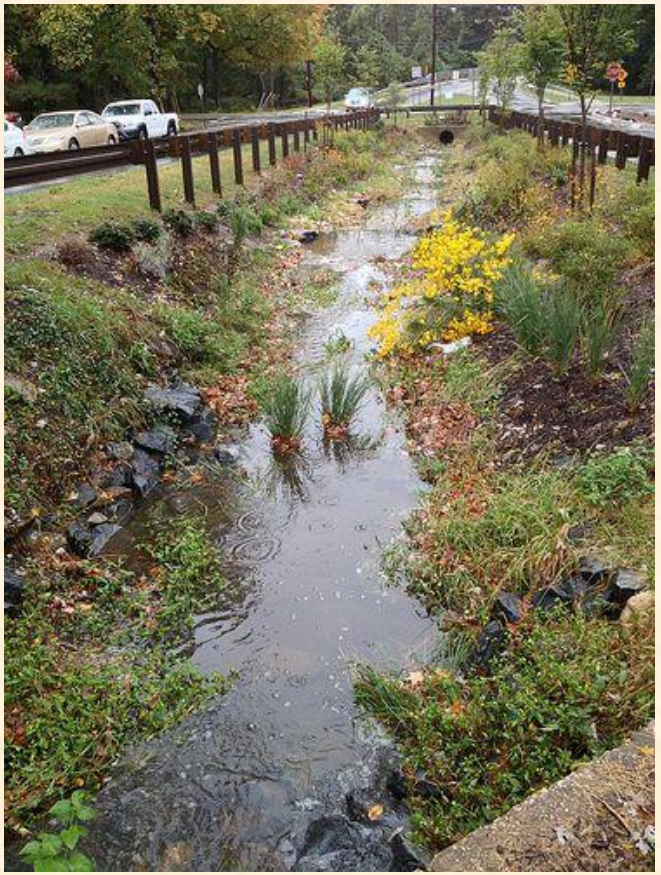
Ditch Management in the CBP Watershed Model

- Vegetated Open Channels
  - Practices that provide treatment as stormwater is conveyed, including bioswales (biofilters, grass swales, or water quality swales



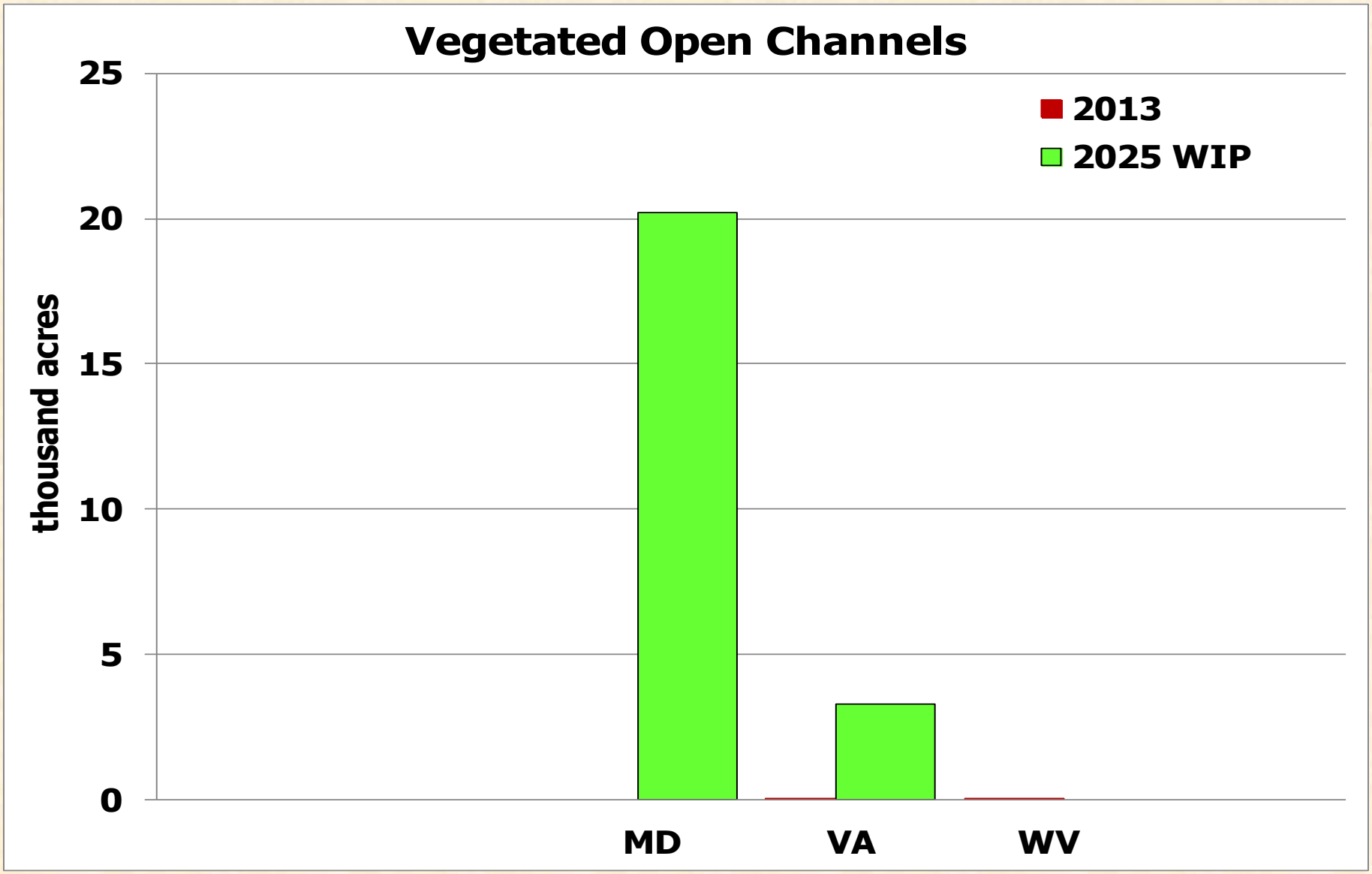
Ditch Management in the CBP Watershed Model

- Vegetated Open Channels
  - Applies to urban stormwater nutrients and sediment in CBWSM
  - Runoff passes through either vegetation in the channel (grass in a dry swale), subsoil matrix, and/or is infiltrated into the underlying soils

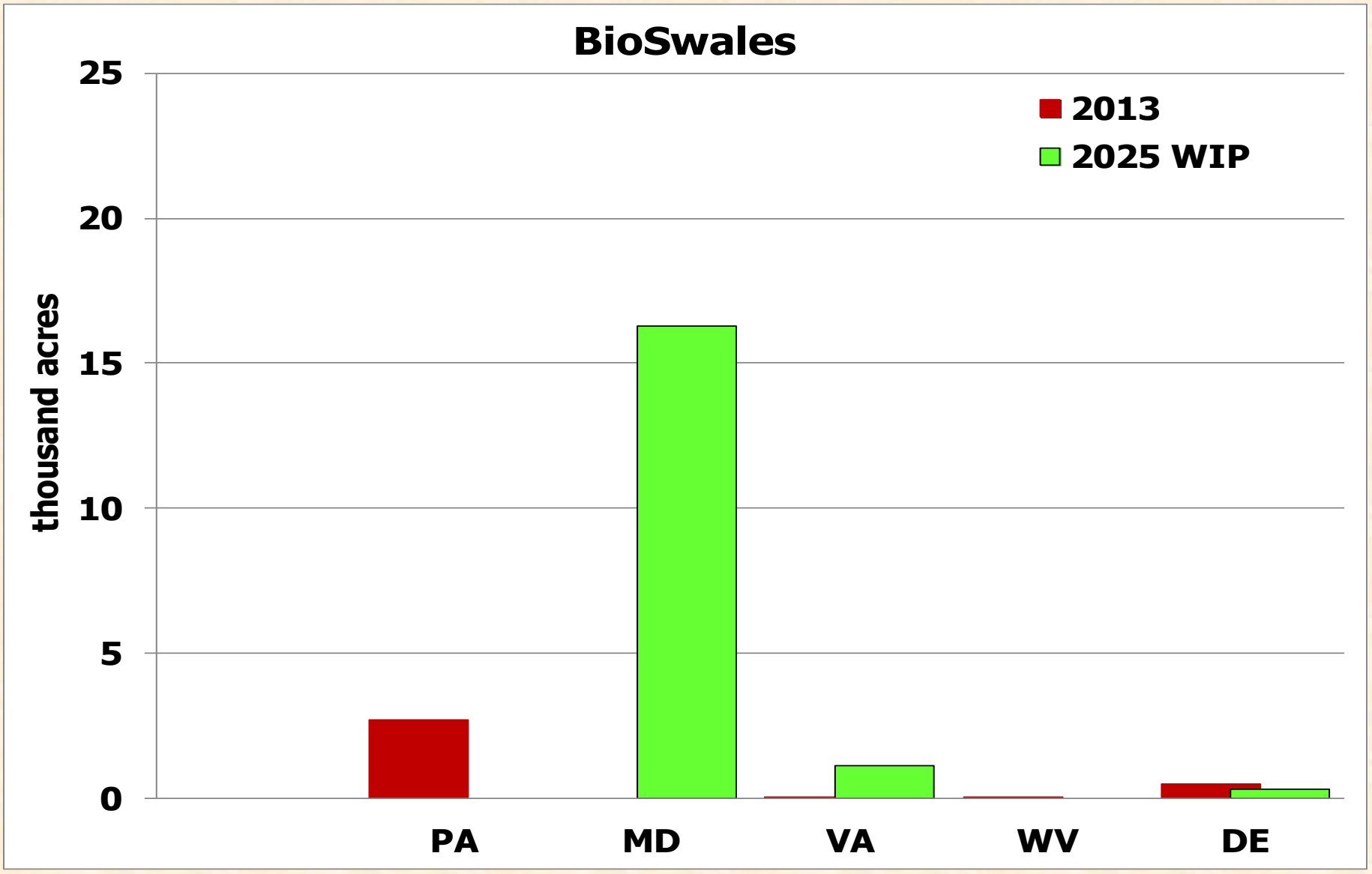
Ditch Management in the CBP Watershed Model

- Vegetated Open Channels
  - Category 1: Open channel in C or D soils without underdrain
  - Category 2: Open channel in A or B soils without underdrain
  - Category 3: Open channel in A or B soil with underdrain; design with complete infiltration like bioswale;
  - Other Benefits
    - Aesthetic – may replace open ditch systems
    - Treat heavy metals

Ditch Management
BMP Implementation and Targets



Ditch Management
BMP Implementation and Targets



BMP Protocol
Practices and Programs Credited

- There is a lot of interest in getting water quality credit for practice types that are not currently in the Bay Model – although the vast majority are credited, typically as sub-sets of BMP groupings.
- The Chesapeake Bay Program partnership needed a procedure for evaluating these practices.
  - "Protocol for the Development, Review, and Approval of Loading and Effectiveness Estimates for Nutrient and Sediment Controls in the Chesapeake Bay Watershed Model"

    http://www.chesapeakebay.net/documents/Nutrient-Sediment_Control_Review_Protocol_v7.14.2014.pdf

BMP Protocol
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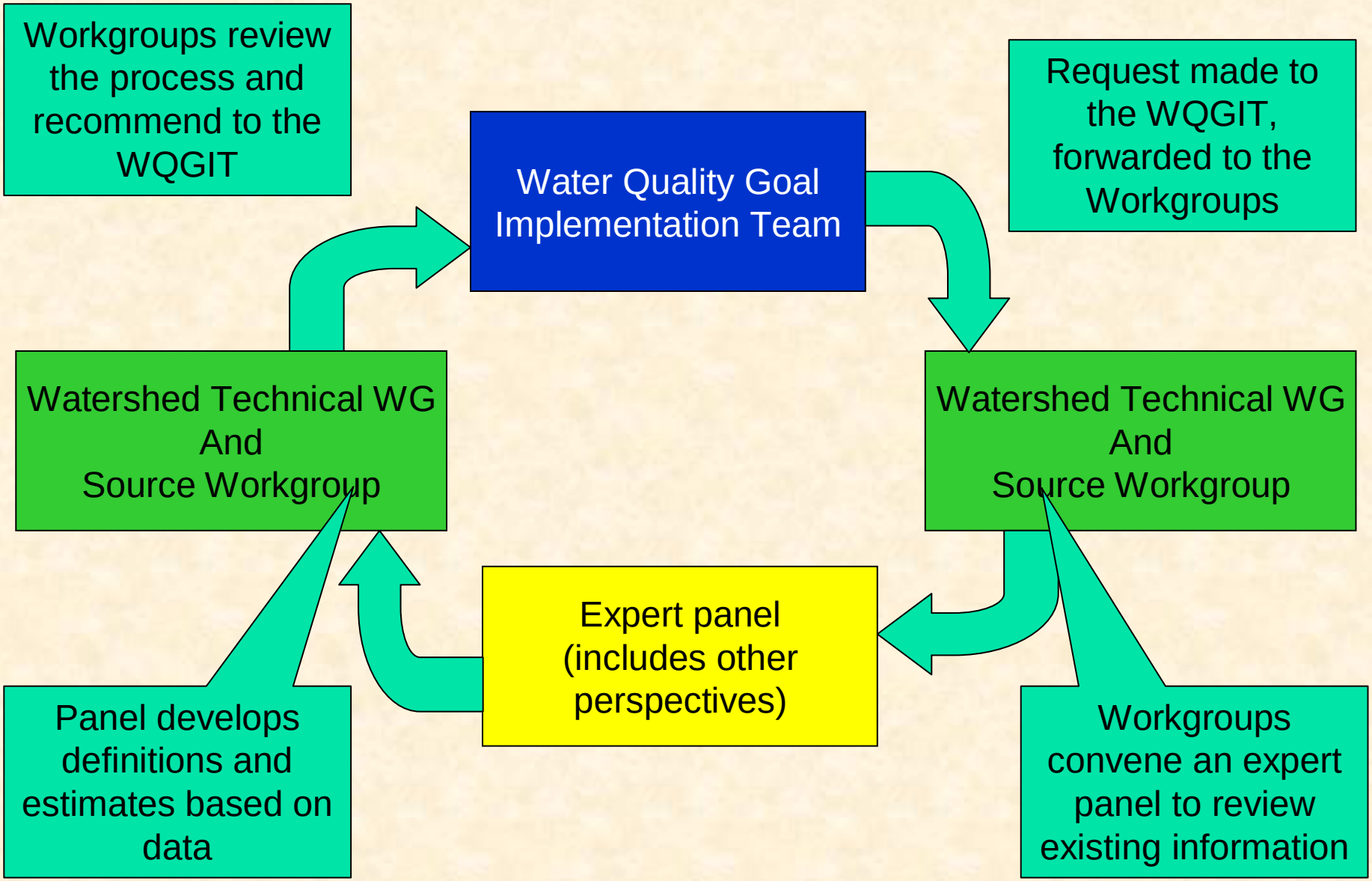
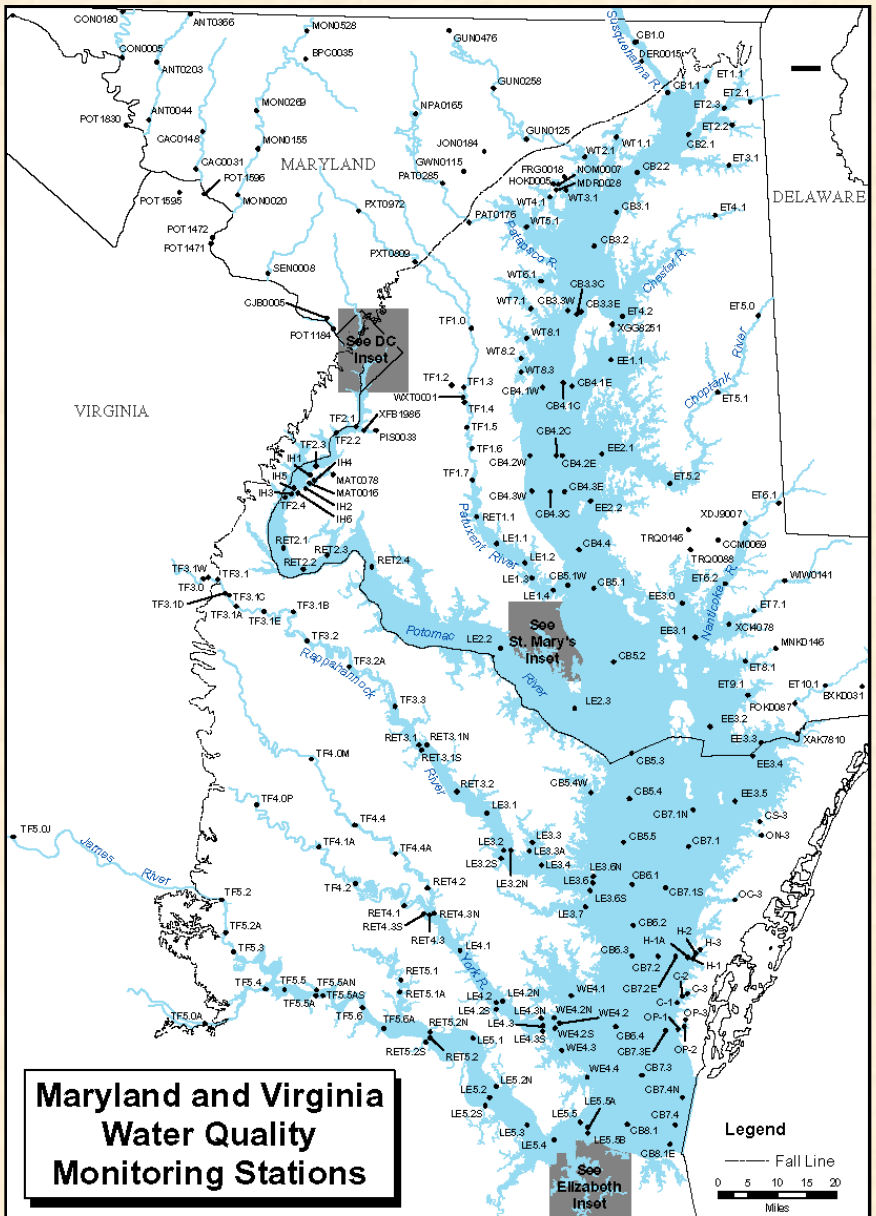


Practices and Programs Credited

- A great deal of professional judgment is still required to extrapolate our current knowledge of [BMP] into broadly accurate estimates of water pollution abatement in response to [BMP] implementation, restoration . . . and to account for natural site variability.

Practices and Programs Credited
Tidal Water Monitoring Network



It's important to "credit" the benefits of restoration efforts in the model, but what moves us closer to meeting water quality standards – and removing the Bay from the list of impaired waters – is all on-the-ground implementation that reduces nutrient and sediment loads.