Sources of Nitrogen to the Chesapeake Bay

Chesapeake Bay Watershed
- 64,000 square miles
- 11,684 miles of shoreline
- 150 major rivers and streams
- Home to over 17 million people
Reduce Nutrient Pollution Loads

As we increase implementation, we reduce loads . . .

. . . we increase achievement of water quality conditions.

### Nutrient Load (million lbs/yr)

<table>
<thead>
<tr>
<th>Year</th>
<th>Nitrogen</th>
<th>Phosphorus</th>
</tr>
</thead>
<tbody>
<tr>
<td>1985</td>
<td>350</td>
<td>100</td>
</tr>
<tr>
<td>2000</td>
<td>300</td>
<td>0</td>
</tr>
</tbody>
</table>

### DO Criteria Achievement (% water volume)

<table>
<thead>
<tr>
<th>Year</th>
<th>Chesapeake Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1985</td>
<td>50%</td>
</tr>
<tr>
<td>2000</td>
<td>70%</td>
</tr>
<tr>
<td>Chesapeake Goal</td>
<td>100%</td>
</tr>
</tbody>
</table>
Chesapeake Bay Partnership Models

INdU TS
- BMP Data
- LU Data
- Point Sources
- Septic Data
- U.S. Census Data
- Agricultural Census Data

MODEL-DERIVED
- Airshed Model
- Land Use Change Model
- Precipitation Data
- Meteorological Data
- Elevation Data
- Soil Data

SCENARIO BUILDER

WATERSHED MODEL

CHESAPEAKE BAY MODEL

MEET WQS?
- NO
- YES

ALLOCATION METHODOLOGY

Reduce/Readjust Loads to Meet Standards
CBP Modeling Tools

Interaction Tools
- NEIEN: Environmental Information Exchange Network
- CAST

Decision Models/Databases
- Chesapeake Stat
- BayTAS: Chesapeake Bay TMDL Tracking and Accounting System

Related Tools
- sparrow
Chesapeake Bay Program Partnership

- Agriculture Workgroup
- BMP Verification Committee
- Forestry Workgroup
- Land Use Workgroup
- Milestones Workgroup
- Trading and Offsets Workgroup
- Urban Stormwater Workgroup
- Wastewater Treatment Workgroup
- Watershed Technical Workgroup
- Modeling Workgroup

Model related Membership as of 7/2013 – 365 individuals
## Expert Review Panels; Planned and Active

<table>
<thead>
<tr>
<th>Agriculture</th>
<th>Urban</th>
<th>Forestry</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Nutrient Management</td>
<td>• Urban Retrofits</td>
<td>• Riparian Buffers</td>
</tr>
<tr>
<td>• Poultry Litter</td>
<td>• Performance Based Management</td>
<td>• Urban Tree Planting</td>
</tr>
<tr>
<td>• Conservation Tillage</td>
<td>• Stream Restoration</td>
<td>• Forest Management</td>
</tr>
<tr>
<td>• Cover Crop Panel</td>
<td>• LID and Runoff Reduction</td>
<td>• Urban Filter Strips and Upgraded Stream Buffers</td>
</tr>
<tr>
<td>• Manure Treatment Technologies</td>
<td>• Urban Fertilizer Management</td>
<td>• Manure Injection/Incorporation</td>
</tr>
<tr>
<td>• Animal Waste Storage Systems</td>
<td>• Erosion and Sediment Control</td>
<td>• Cropland Irrigation Management</td>
</tr>
<tr>
<td>• Manure Injection/Incorporation</td>
<td>• Illicit Discharge Elimination</td>
<td>• Urban Filter Strips and Upgraded Stream Buffers</td>
</tr>
<tr>
<td>• Cropland Irrigation Management</td>
<td>• Impervious Disconnect</td>
<td>• Floating Wetlands</td>
</tr>
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<td></td>
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<td>• MS4 Minimum Management Measures</td>
</tr>
<tr>
<td></td>
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</tbody>
</table>
Scenario Builder – model of nutrient inputs

Livestock → Pasture → Crops → Fertilizer

Manure storage practice

Image Credits:
- http://extension.tennessee.edu/lincoln/4/H/Pages/Livestock-Skillathons-929Beef_Sheep_and_Swine.aspx
- http://www.rebelwoodsranch.com
- http://www.seaburst.com
- http://pubs.ext.vt.edu/442/442-308/442-308.html
Describe Change in Load due to Actions

CBP Partnership Watershed Model

Hourly or daily values of Meteorological factors:
- Precipitation
- Temperature
- Evapotranspiration
- Wind
- Solar Radiation
- Dew point
- Cloud Cover

Constant values of anthropogenic factors:
- Land Use Acreage
- BMPs
- Fertilizer
- Manure
- Tillage
- Crop types
- Atmospheric deposition
- Waste water treatment
- Septic loads

Run for 1984-2000
Average 1991-2000
For ‘flow-normalized average annual loads’
Nitrogen Loads to the Bay by Jurisdiction

*Loads simulated using 5.3.2 version of Watershed Model and wastewater discharge data reported by Bay jurisdictions.

- New York
- Virginia
- District of Columbia
- Pennsylvania
- West Virginia
- EPA: Atmospheric Deposition to Watershed (to be reduced under Clean Air Act)
- Maryland
- Delaware
- EPA: Atmospheric Deposition to Tidal Water (to be reduced to 15.7 million lbs/yr under Clean Air Act)
Nitrogen Loads to the Bay by Source

*Loads simulated using 5.3.2 version of Watershed Model and wastewater discharge data reported by Bay jurisdictions.

Download Data (114.55 KB)
Analysis & Methods (127.5 KB)
Watershed Model Uses
Divide loads into contributing areas and sources

Land Use Source
Total Nitrogen

Ultimate Source
Total Nitrogen

Example from previous model version
Animal Units in the Chesapeake Watershed 2010

- Beef: 457,050
- Dairy: 846,491
- Other Cattle: 592,180
- Hogs: 173,809
- Layers: 101,333
- Pullets: 20,658
- Broilers: 405,687
- Turkeys: 258,578
- Horses: 349,498
- Sheep: 11,366
- Goats: 1,357
- Other Cattle: 592,180
- Dairy: 846,491
USGS – Sparrow
Spatial Model of Nitrogen Sources

Estimated annual yield of total nitrogen, in kg/km²
(high value in lb/ac)

- 0 - 152 (1.4)
- 152 - 221 (2.0)
- 221 - 297 (2.6)
- 297 - 398 (3.6)
- 398 - 526 (4.7)
- 526 - 683 (6.1)
- 683 - 887 (7.9)
- 887 - 1186 (11)
- 1186 - 1710 (15)
- >1710

Ator and others, USGS SIR 2011-5167
Nitrogen Source Shares

Ator and others, USGS SIR 2011-5167.
How the Watershed Model Works

Calibration Mode

Hourly or daily values of Meteorological factors:
- Precipitation
- Temperature
- Evapotranspiration
- Wind
- Solar Radiation
- Dew point
- Cloud Cover

Annual, monthly, or daily values of anthropogenic factors:
- Land Use Acreage
- BMPs
- Fertilizer
- Manure
- Tillage
- Crop types
- Atmospheric deposition
- Waste water treatment
- Septic loads

Daily flow, nitrogen, phosphorus, and sediment compared to observations over 21 years
How the Watershed Model Works

Each segment consists of 30 separately-modeled land uses:

- Regulated Pervious Urban
- Regulated Impervious Urban
- Unregulated Pervious Urban
- Unregulated Impervious Urban
- Construction
- Extractive
- Combined Sewer System
- Wooded / Open
- Disturbed Forest
- Corn/Soy/Wheat rotation (high till)
- Corn/Soy/Wheat rotation (low till)
- Other Row Crops
- Alfalfa
- Nursery
- Pasture
- Degraded Riparian Pasture
- Afo / Cafo
- Fertilized Hay
- Unfertilized Hay
  - Nutrient management versions of the above

Plus: Point Source and Septic Loads, and Atmospheric Deposition Loads

Each calibrated to nutrient and Sediment targets
How the Watershed Model Works

Precipitation

Fertilizer
Manure
Atmospheric deposition

Management filter

Runoff

Hydrology submodel
Sediment submodel
Phosphorus submodel
Nitrogen submodel

Buffers wetlands

River
Nitrogen SPARROW

Sources: On average:

- 1,090 kg/km$^2$ of N from Urban areas reach the stream
- 24% of N from fertilizer and fixation reaches streams
- Only 6% of N in manure reaches streams
- 27% of N from atmospheric deposition reaches streams

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<td>Point sources (kg/yr)</td>
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<td>0.0008</td>
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<td>0.0118</td>
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<td>5.93</td>
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RMSE=0.2892, $R^2=0.9784$, yield $R^2=0.8580$ N = 181

Ator and others, USGS SIR 2011-5167.
Nitrogen SPARROW

Fate and transport:
- Delivery to streams is greater in areas of greater groundwater flow, particularly in the Piedmont carbonate.
- Delivery to streams is less in areas with reducing conditions or greater plant uptake.
- In-stream losses are greater in smaller streams.
- In-stream losses in larger streams are greater in warmer areas.
- Losses in impoundments are likely due mainly to denitrification.

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RMSE=0.2892, \( R^2=0.9784 \), yield \( R^2=0.8580 \)

N = 181

Ator and others, USGS SIR 2011-5167.
Phosphorus SPARROW

- On average, less than 5% of applied P in fertilizer and manure reaches streams
- Urban areas yield 49 kg/km²
- Natural mineral sources are significant
- Delivery to streams is greater where runoff is more likely and in the Coastal Plain, possibly due to legacy applications or saturation
- Significant losses occur in impoundments

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<td>Sources</td>
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</tr>
<tr>
<td>Point sources (kg/yr)</td>
<td>0.877</td>
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</tr>
<tr>
<td>Urban land (km²)</td>
<td>49</td>
<td>&lt;0.0001</td>
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<tr>
<td>Fertilizer (kg/yr)</td>
<td>0.0377</td>
<td>0.0014</td>
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<tr>
<td>Manure (kg/yr)</td>
<td>0.0253</td>
<td>0.0002</td>
</tr>
<tr>
<td>Siliclastic rocks (km²)</td>
<td>8.52</td>
<td>&lt;0.0001</td>
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<tr>
<td>Crystalline rocks (km²)</td>
<td>6.75</td>
<td>0.0009</td>
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<tr>
<td>Land to Water Transport</td>
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<tr>
<td>Soil erodibility (k factor)</td>
<td>6.25</td>
<td>0.0002</td>
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<tr>
<td>Ln(% well drained soils)</td>
<td>-0.100</td>
<td>0.0019</td>
</tr>
<tr>
<td>Ln(precipitation (mm))</td>
<td>2.06</td>
<td>&lt;0.0237</td>
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<tr>
<td>Coastal Plain (% of area)</td>
<td>1.02</td>
<td>&lt;0.0001</td>
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<tr>
<td>Aquatic Decay</td>
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<tr>
<td>Impoundments</td>
<td>54.3</td>
<td>0.0174</td>
</tr>
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RMSE=0.4741
$R^2=0.9510$
yield $R^2=0.7300$
N = 184

Ator and others, USGS SIR 2011-5167.