Development of the Chesapeake Bay Program’s Watershed Model for 2017

Gary Shenk – USGS - Chesapeake Bay Program
9/20/16

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Preliminary Information-Subject to Revision.
Not for Citation or Distribution
Chesapeake Bay Program Partnership

- Federal agencies
  - Environmental Protection Agency (EPA)
  - US Department of Agriculture (USDA)
  - US Forest Service (USFS)
  - US Geological Survey (USGS)
  - US Fish and Wildlife Service (USFWS)
  - And more

- State agencies
  - Natural Resources/Environmental departments
  - Agricultural departments
  - Parks and Recreation groups
  - Fish and Wildlife agencies

- Local Governments

DNREC
MDA
DDA
DCR
DNR
MDE
DEQ
DEP
DEC
DDA
DAF
DCNR
DEQ
DNREC
DCR
PDA
MDE
MDA
DNREC
Chesapeake Bay Program Partnership

• Non-profit organizations
  • Chesapeake Bay Foundation
  • Center for Watershed Protection
  • Ducks Unlimited
  • National Fish and Wildlife Foundation
  • And more

• Academic institutions
  • Land grant universities
  • Cooperative Extension programs
  • Sea Grant programs
  • Research centers and consortiums
  • And more
1960s 1980s 2000s

1970s 1990s 2010s

TMDL 2010 accountability
TMDL Timeline

• 1999 – Lawsuit by American Canoe Association and American Littoral Society

• 2010 – TMDL put in place

• 2017 MidPoint Assessment
  • 60% of the management practices implemented
  • Mid-Course Correction?

• 2025 TMDL Goal Date
  • 100% of the management practices implemented
Model Timeline

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• 2025 TMDL Goal Date
  • 100% of the management practices implemented

1980s – Phase 0, Phase 1

1990s – Phase 2, Phase 4

2000s – Phase 4 versions

2010 – Phase 5

2017 – Phase 6
Chesapeake Bay Program

Model related Membership as of 7/2013 – 365 individuals

- 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
- Scientific, Technical Assessment & Reporting
- Modeling Workgroup

Citizen’s Advisory Committee
- Local Government Advisory Committee
- Scientific & Technical Advisory Committee
- Management Board
- Chesapeake Executive Council
- Principals Staff Committee
- Independent Evaluator

Goal Implementation Teams
- Sustainable Fisheries
- Protect & Restore Vital Habitats
- Protect & Restore Water Quality
- Maintain Healthy Watersheds
- Foster Chesapeake Stewardship
- Enhance Partnering & Leadership
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
Partnership Feedback on Modeling

• **Water Quality Managers**
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  - Fine-scale processes

Keep it Simple!!
Include Everything!!
Model Complexity

• Von Neumann: With four parameters I can fit an elephant, and with five I can make him wiggle his trunk.

“Drawing an elephant with four complex parameters” by Jurgen Mayer, Khaled Khairy, and Jonathon Howard, Am. J. Phys. 78, 648 (2010), DOI:10.1119/1.3254017
Phase 6 Model Structure

Average Load + \( \Delta \) Inputs * Sensitivity

- Land Use Acres
- BMPs
- Land to Water
- Stream Delivery
- River Delivery

Phase 6

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Keep It Simple

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* Land Use Acres
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Include Everything

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## Use of Multiple Models for Nitrogen Export Rate

<table>
<thead>
<tr>
<th>Sector</th>
<th>Crop</th>
<th>Pasture/Hay</th>
<th>Developed</th>
<th>Natural</th>
</tr>
</thead>
<tbody>
<tr>
<td>CBP Phase 5 model</td>
<td>47.5</td>
<td>19.9</td>
<td>19.4</td>
<td>4.2</td>
</tr>
<tr>
<td>USDA-CEAP Model</td>
<td>42.5</td>
<td>10.2</td>
<td>Not used</td>
<td>1.6</td>
</tr>
<tr>
<td>USGS- SPARROW Model</td>
<td>22.9</td>
<td>10.2</td>
<td>8.9</td>
<td>0.4</td>
</tr>
<tr>
<td>Average Ratio to Crop Rate</td>
<td>1.00</td>
<td>0.37</td>
<td>0.40</td>
<td>0.05</td>
</tr>
</tbody>
</table>
Contributions from new research

- Lidar over 166,000 km²
- Regression of Stream mass balance against morphology

Preliminary work on stream mass balance
Collaborative Stakeholder Processes

Protocol to Add/Modify BMPs

New/Revised BMP

Water Quality GIT

Source Workgroup

Expert Panel

Watershed Model

“Approved BMP list”

Review by:
Source Workgroups
Watershed Technical Workgroup
Water Quality GIT
Phase 6 Model Structure

Phase 6

Average Load + $\Delta$ Inputs * Sensitivity

- Land Use Acres
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- Land to Water
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Stakeholder Science

• Transparent science is more palatable to stakeholders
• Multiple lines of evidence has scientific support

... but does it work?

Compare
Heavily-Calibrated Process Model
Lightly-Calibrated Stakeholder Model
Dauphin County Summary Results

**Description:** Inseg base loads
**Initial Conditions:** 2017, revised: 4/2016
**Date Created:** 5/4/2016 10:25:23 AM

### Total Loads

<table>
<thead>
<tr>
<th>Load Type</th>
<th>Lbs Nitrogen Edge of Stream</th>
<th>Lbs Nitrogen Delivered</th>
<th>Lbs Phosphorus Edge of Stream</th>
<th>Lbs Phosphorus Delivered</th>
<th>Lbs Sediment Edge of Stream</th>
<th>Lbs Sediment Delivered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landuse</td>
<td>6,513,592.7</td>
<td>5,271,385.8</td>
<td>107,695.9</td>
<td>76,354.8</td>
<td>137,419,842.9</td>
<td>53,823,104.8</td>
</tr>
<tr>
<td>Septic</td>
<td>141,079.6</td>
<td>114,690.5</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Waste Water and Combined Sewer Output</td>
<td>1,487,025.4</td>
<td>1,236,710.8</td>
<td>216,146.1</td>
<td>83,354.6</td>
<td>12,325,864.3</td>
<td>4,827,560.2</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td><strong>8,141,697.7</strong></td>
<td><strong>6,622,787.1</strong></td>
<td><strong>414,142.0</strong></td>
<td><strong>159,709.4</strong></td>
<td><strong>149,745,707.2</strong></td>
<td><strong>58,650,765.0</strong></td>
</tr>
</tbody>
</table>

### Total Annualized Costs

<table>
<thead>
<tr>
<th>Sector</th>
<th>Total Annualized Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban Land</td>
<td></td>
</tr>
<tr>
<td>Septic</td>
<td></td>
</tr>
<tr>
<td>Agricultural</td>
<td></td>
</tr>
<tr>
<td>Forest</td>
<td></td>
</tr>
<tr>
<td>Transportation</td>
<td></td>
</tr>
<tr>
<td>Marine</td>
<td></td>
</tr>
<tr>
<td>Lands Use</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
</tr>
</tbody>
</table>
Screenshots – Agriculture

Comment field to put consistent information that explains rationale behind numbers. Helps manage the large amount of information.
On Line Version -- BayFAST

York City Location

When you are finished editing your parcel, please click off the parcel to deselect it and save the edits.

Save  Reset  Cancel
Howard County (BayFAST)

- Seven Local TMDLs:
  - Baltimore Harbor
  - Little Patuxent
  - Patapsco LNB
  - Upper Patuxent
  - Rocky Gorge
  - Triadelphia

William Frost, PE, D.WRE, Senior Water Resources Engineer, KCI Technologies, Inc.
Megan Crunkleton, CE, Project Scientist, KCI Technologies, Inc.
OPTIMIZATION Calculation Engine

Users input objectives, tool outputs BMPs in the plan that maximize effectiveness at minimum cost.

* Still in vaporware stage
CAST = WSM = Scenario Builder

Data
- BMPs
- Land cover
- Nutrient availability
- Census of Agriculture
- Physical characteristics

Logic Engines
- Land use calculator
- BMP location
- BMP effect
- Nutrient Application
- Sensitivity to Nutrient Input
- Watershed Processes

Tools
- Temporal watershed model
- Static Watershed Model
- CAST Casttool.org
- Optimization Engine

Products
- Load to Estuarine model
- Calibration
- Climate change
- Lag Times
- Chesapeake Bay Program Accounting
- Stakeholder Planning
- Stakeholder Planning
Extensive partnership involvement...

...Which Leads to a robust model of the watershed

...Leads to collaborative thinking...