Collaborators – Chesapeake Bay Program

- Lewis Linker – EPA – modeling coordinator
- Gary Shenk – EPA – lead for phase 5 development
- Kate Hopkins – University of Maryland – GIS analyst
- Jing Wu – University of Maryland – watershed modeler
- Sara Brandt – Chesapeake Research Consortium Fellow
- Russ Mader – NRCS – Nutrient Coordinator
- Jeff Sweeney – University of Maryland – Nutrient data analyst
- Peter Claggett – USGS – Land data manager
- Steve Preston – USGS – Monitoring coordinator

- Many, many people who participate in data gathering
Collaborators –
US Geological Survey

- Maryland Office
  - Jeff Raffensperger – Project coordinator
  - Sarah Martucci – GIS analyst
  - Joe Vrabel – software engineer
  - Angelica Gutierrez – optimization specialist
  - Gary Fisher – precipitation data collection
- Virginia Office
  - Doug Moyer – Project coordinator
  - Alan Simpson – river and reservoir morphology
  - Jen Krstolic – GIS analyst
- Pennsylvania Office
  - Mike Langland – Water quality data
- National
  - Lauren Hay – Precipitation Model
Collaborators –
State Agencies

• State Governments Supplying Data
  ▪ NY, PA, MD, DE, WV, VA, and DC

• State Governments Supplying Funding
  ▪ MD and VA (will use model for TMDLs)
Collaborators – Other

- **Penn State** –
  - Jim Lynch and Jeff Grimm
  - Atmospheric Deposition model
  - Scott Sheeder, Barry Evans and Egide Louis
    - Urban load model
- **University of Maryland**
  - Tom Fisher, Keith Eshleman –
    - Related Patuxent watershed study
- **Interstate Commission for the Potomac River Basin**
  - Ross Mandel – project coordinator
  - Julie Kiang – hydrologic model calibration support
Question 1:
The right size for segmentation
What is a reasonable size for lumping?

- Too big
  - meaningful differences are missed

- Too small
  - can’t get the data
  - can’t run the model
Phase 4 land segmentation

- Simulated on a watershed basis
- Near previous limit of computing capacity
- Headwater areas simulated in less detail
Phase 5 land segmentation

- Most counties are completely within a hydrogeomorphic region
- BMP and Crop data are not known on a finer scale in most cases
- Near the limit of computing capacity
River Simulation

What is a reasonable size for lumping?

• Too big
  ▪ meaningful differences are missed

• Too small
  ▪ can’t get the data
  ▪ can’t run the model
Phase 4 River Segmentation

• Near the previous limit of computing capacity

• Headwater regions simulated in less detail

Chesapeake Bay Program Modeling
Phase 5 River Segmentation

- Greater than 100 cfs
- Has a flow gage
- Near the limit of meaningful data
- Consistent criterion
Calibration in the Upper Susquehanna
Calibration in the Upper Susquehanna

Flow 80% NY

WQ 56% NY
Putting the land and river together
Land-Water Connection

- X 3000 acres
- X 400 acres
- X 900 acres
Logistics problem

- 310 land segments
- 17 land use types
- 5270 independent land simulations
- 930 rivers
Chesapeake Bay Program Modeling

Nutrient Application Database

Land Use Acreage Database

Physical Description Database

Process Parameter Database

Land UCI Generator
Physical Description Database

Process Parameter Database

River UCI Generator

Chesapeake Bay Program Modeling
Chesapeake Bay Program Modeling

- MET WDM
- ATDEP WDM
- PS WDM

Land variable WDM

ETM

River variable WDM

Final Output
Chesapeake Bay Program Modeling
ETM Functionality

- Time Varying Land Use
- Time Varying BMPs
- Performance under extreme weather
- Design life of BMPs
- Flexibility
Software system functionality

- Easily allows large-scale parameter adjustments during calibration
- Parallel operations easy
- Easy to add new land use types
- More easily integrated into outside databases for scenario runs
Effect of Changing Forcing Functions

Chesapeake Bay Program Modeling
Basic Hypocrisy

- Management actions affect delivery of nutrients to the Chesapeake Bay
- We can calibrate a watershed model over 17 years of observations without changing management actions
Susquehanna River at Segment 140 - Constant Anthro Forcings
Observed and Simulated versus Time
Total Nitrogen

(*=Observed, - = Simulated)
Susquehanna River at Segment 140 - Variable Anthro Forcings
Observed and Simulated versus Time
Total Nitrogen
(*=Observed, --=Simulated)
Variable / Steady by year in the Susquehanna (TN load)
Other p5 changes

Chesapeake Bay Program Modeling
Simulation Time

• P5 – 1984 – 2000 (calibration)
• 2001 – 2002 (verification)
Rainfall

• Better information on a 5 km grid

• Use regression of weather pattern, latitude, longitude, and altitude.
Scope

- 487 daily-data stations
- 192 hourly-data stations
Multiple linear regression (MLR) equations are developed for daily precipitation ($p$) using independent variables $x$, $y$, and $z$ from climate stations.

The general form of the MLR equation is:

$$p = b_0 + b_1 x + b_2 y + b_3 z$$
Regression is applied over each Region:
... and Weather type
Scope

- 5-km grid constructed to produce distributed data set
- Temperature and Potential ET thrown in as well
Atmospheric Deposition

- Update of data and regression methods for observed data
- Update of model predicting change due to management actions
Mean Annual Wet Deposition of Nitrate
1985 to 1999

Nitrate Deposition (kg/ha)
Better and extended data sets

- Point Source
- Water Diversions
- Septic
Better and extended data sets

- Fertilizer
- Manure
- Land Use
RESAC satellite classification for 1990 and 2000
Chesapeake Bay Program Modeling

2000 Impervious Surfaces

New York City
Chesapeake Bay Program Modeling

U.S. Census of Agriculture

1982
1987
1992
1997
2002
More land use types

- **Phase 4**
  - Forest
  - Urban
  - Hitil
  - Lotil
  - Hay
  - Pasture
  - Manure

- **Phase 5**
  - Low intensity developed
  - High intensity developed
  - Bare
  - Extractive
  - Forest
  - Harvested Forest
  - Natural Grass
  - Pasture with manure applications
  - Pasture without manure applications
  - Composite Crop with manure
  - Composite Crop without manure
  - Greenhouse / Nursery
  - Alfalfa
  - Hay with Nutrients Applied
  - Hay without Nutrients Applied
  - Water
New River Data

• Needed geomorphology of ~800 rivers
  ▪ Had data for ~200
  ▪ Developed regression curves for each region for
    • Bankfull depth
    • Bankfull width
    • Bottom depth
Chesapeake Bay Program Modeling

Piedmont Province (VA, MD, and NC)

\[ y = 5.8744x^{0.4795} \]

\[ R^2 = 0.8683 \]

Bottom width (ft) vs. Drainage Area (mi²)
Chesapeake Bay Program Modeling

Piedmont Province (VA, MD, and NC)

$y = 12.669x^{0.4492}$

$R^2 = 0.9099$
Chesapeake Bay Program Modeling

Piedmont Province (VA, MD, and NC)

\[ y = 1.8543x^{0.3017} \]

\[ R^2 = 0.8447 \]
New Reservoir Data

- Phase 4
  - Six simulated reservoirs
- Phase 5
  - Forty simulated reservoirs
Curwensville Dam Rule Curve

Date Range
- 4/23-5/8
- 11/15-12/1

Level (feet, msl)
- Winter Control
- Summer Control

Day of Year
- 1/0 to 12/25

Chesapeake Bay Program Modeling
Groundwater

- No groundwater lag in HSPF
  - Residence time days to weeks

- Attempting code modification for phase5
  - Hydrology unaffected
  - Shown ability to have a better dissolved constituent residence time
More Observations

- Phase4
  - 16 stations for flow and water quality

- Phase5
  - 70 water quality stations
  - 280 flow stations
Calibration

- Better input data
- More realistic simulation
- More observations
- Better calibration software
- More calibrators
- 5 more years of understanding
Status

- Hydrologic calibration complete
- 54% of stations have model efficiency above 0.5 for daily flow
- 79% of stations have model efficiency above 0.5 for log of daily flow