Chesapeake Bay Program
A Watershed Partnership

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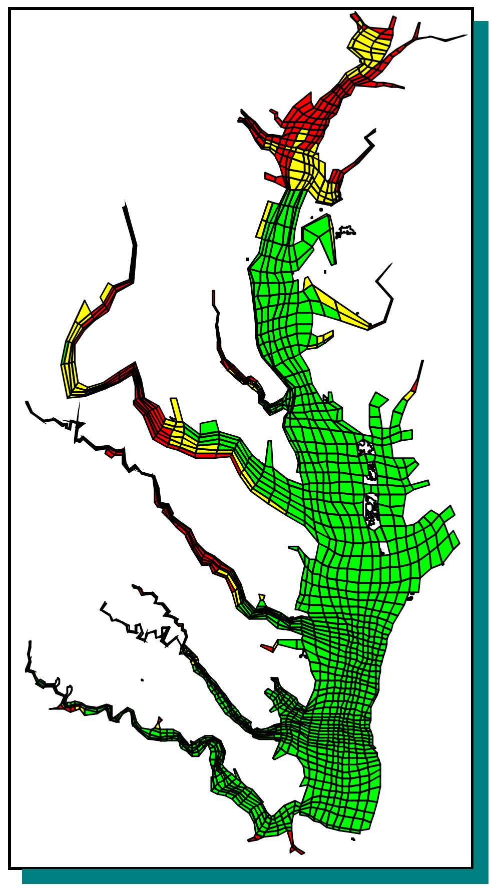
Backgrounder

Modeling the Chesapeake Bay

Environmental models are essential for simulating ecosystems that are either too large or too complex to isolate for experiments in the real world. Models allow scientists to simulate changes in an ecosystem due to changes in population, land use or pollution management. These simulations, called scenarios, allow scientists to predict positive, or negative, changes within our ecosystem due to 7management actions such as improved sewage treatment, reduced fertilizer or manure application on agricultural land or controlling urban sprawl.

Models use mathematical representations of the real world to estimate the effects of complex and varying environmental events and conditions. For example, the Chesapeake Bay Watershed Model estimates the delivery of nutrients and sediments to the Bay by simulating hydrologic and nutrient cycles, using inputs such as atmospheric nutrient deposition, precipitation, fertilizer application, and land cover or land use.



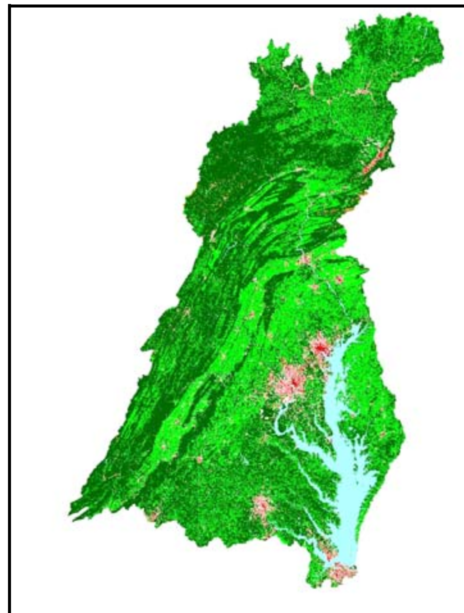
The Chesapeake Bay Estuarine model examines the effects of the loads generated by the Watershed Model on Bay water quality. The model divides the Bay into almost13,000 computational cells with an average surface area of about 1.5 square miles. The cells are stacked up to 17 layers deep in the deepest part of the Bay.

Models are one of the principal tools crucial to the Bay Program goals of reducing nutrients and sediments delivered to the Bay. In 1992, Bay Program partners agreed to reduce controllable loads of nitrogen and phosphorous delivered to the Bay by 40% of 1985 levels by the year 2000. From this goal, the Bay models were used to develop tributary nutrient allocations, or reductions, for each of the nine major tributaries in the Chesapeake watershed. In 2000, these tributary allocations became a nutrient cap, not to be exceeded even with future increases in population and growth. With the nutrient cap in place, Bay models are used to track nutrient loads to ensure the cap is not exceeded. Currently, the models are directed toward the examination of the need for further nutrient and sediment reductions to fully restore the water quality required for the Bay's living resources.

Models produce estimates, not perfect forecasts. They reduce, but do not eliminate, uncertainty in environmental decision making. Used properly, they are a tool that can assist in developing nutrient and sediment reductions that are most protective of the environment, while being equitable, achievable and cost effective

The Watershed Model

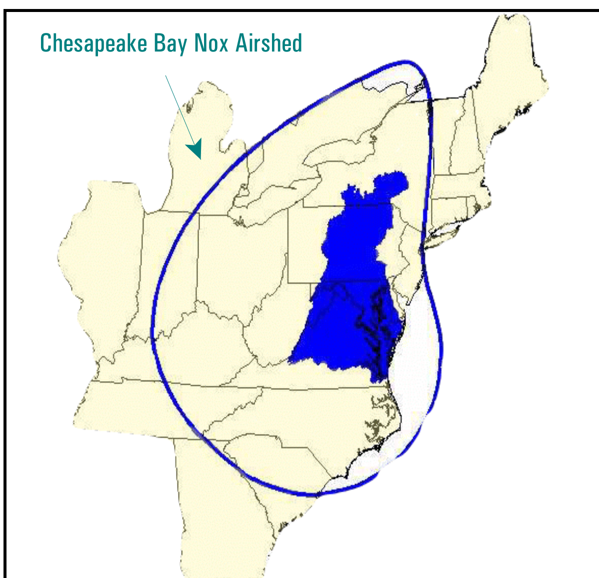
The Watershed model divides the 64,000 square mile Chesapeake Bay drainage basin into 94 model segments. Each segment contains information generated by a hydrologic submodel, a nonpoint source submodel and a river submodel. The hydrologic submodel uses rainfall, evaporation and meteorological data to calculate runoff and subsurface flow for all the basin land uses including forest, agricultural and urban lands. The surface and subsurface flows ultimately drive the nonpoint source submodel, which simulates soil erosion and the pollutant loads from the land to the rivers. The river submodel routes flow and associated pollutant loads from the land through lakes, rivers and reservoirs to the Bay.



The Chesapeake Bay Watershed Model divides the Bay's 64,000 square mile drainage basin into 94 model segments.

The Estuary Model

The estuarine model, commonly referred to as the water quality model, examines the effects of the loads generated by the Watershed Model on Bay water quality. In the Estuary Model, the Bay is represented by almost 13,000 computational cells which average six miles long, two miles wide and five feet deep. The cells are stacked up to 17 layers in the deepest areas of the Bay. The Estuary Model is built on two submodels: the hydrodynamic submodel and the water quality submodel. The hydrodynamic submodel simulates the mixing of estuarine waters with coastal ocean waters, and the mixing of water within the Chesapeake. The water quality submodel calculates the chemical and physical dynamics of the Chesapeake.



The Chesapeake Bay airshed covers an area 6.5 times larger than its watershed. The Bay Airshed Model divides this area into 22,000 cells, each measuring twenty kilometers square.

The Airshed Model

The Airshed Model (Regional Acid Deposition Model - RADM) tracks nitrogen emissions from all sources in the airshed. The model is three-dimensional; it simulates movement both vertically and horizontally across a region. The Airshed Model covers the eastern United States from Texas and North Dakota eastward to Maine and Florida with 22,000 cells. Each cell measures eighty kilometers square. Stacked up, the cells make fifteen vertical layers reaching about fifteen kilometers high. The airborne nutrient loads are transported by the Airshed Model and linked to the Watershed Model through deposition to land surfaces and to the Estuary Model through deposition to the water surfaces of the tidal Bay.