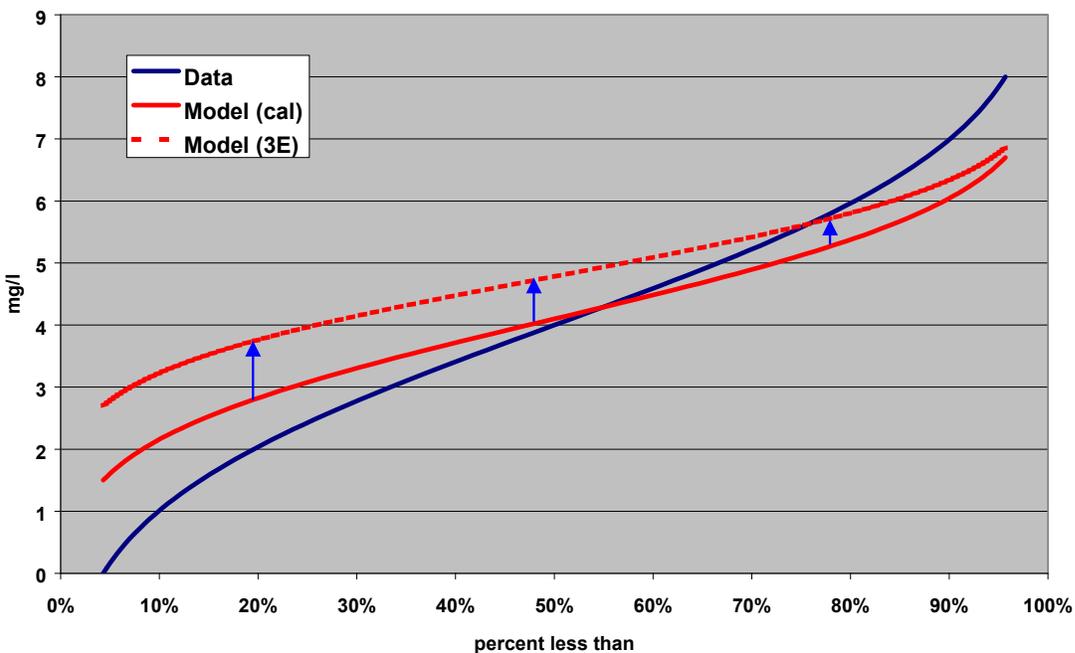


Appendix H. Criteria Assessment Procedures using Model Scenario Output with Bay Monitoring Data

Scenarios representing different nutrient and sediment loading conditions were run using the Chesapeake Bay Phase 5.3 Watershed Model (Bay Watershed Model) and the resultant model scenario output was used as input into the Chesapeake Bay Water Quality and Sediment Transport Model (Bay Water Quality Model) to evaluate the response of critical water quality parameters, specifically dissolved oxygen, water clarity, underwater bay grasses, and chlorophyll *a*. To determine whether the loading scenarios met the applicable Bay jurisdictions' Chesapeake Bay water quality standards, the Bay Water Quality Model's simulated water quality response for each variable was used to increase/decrease the corresponding observed monitoring values collected during the same 1991–2000 hydrological period. In other words, the Bay Water Quality model was used to estimate the change in Bay water quality that would result from various loading scenarios. The model-simulated change in water quality was then used to adjust the actual Chesapeake Bay water quality monitoring data. Figure H-1 provides an example of the relationship between the calibration (cal) and scenario (E3) Bay Water Quality Model outputs described above, as well as their relationship to hypothetical monitoring observations (Data) over the same 10-year period.



Source: Linker et al. 2002

Figure H-1. Frequency distribution of hypothetical observed data (blue), model calibration (solid red) and model scenario (dashed) for a designated use.

In the simplest terms, the following steps were taken to apply the Bay Water Quality Model outputs to predict Bay water quality:

1. Calibrate the Bay Water Quality Model to actual monitoring data.
2. Run a Bay Water Quality Model simulation for a given *loading scenario* (usually a management scenario resulting in lower loads relative to the calibration scenario) through the Bay Watershed and Bay Water Quality models.
3. Determine the simulated change in water quality from the calibration scenario to the given loading scenario.
4. Apply the change in water quality as predicted by the Bay Water Quality Model to the actual historical water quality monitoring data, and evaluate attainment based on this *scenario modified* data set.

In following those steps, the scenario assessment process uses both model simulated outputs and observed water quality monitoring data.

For a more detailed description of the model calibration process (Step 1 above), and the process of constructing management scenarios to simulate reduced loads to the Bay Water Quality Model (step 2 above), see Sections 5 and 6, respectively. More detailed descriptions of Steps 3 and 4 are summarized below.

To determine the expected effect of reduced pollutant loads on a water quality parameter such as dissolved oxygen or chlorophyll *a* (Step 3 above), the simulated parameter concentrations from the Bay Water Quality Model's calibration scenario are compared to the parameter concentrations from a given load reduction scenario. This is accomplished by relating each month's worth of values from the calibration scenario for a given location to the same month's worth of values from the load reduction scenario at the same location. The resulting *linear regression* equation represents the degree of change (in dissolved oxygen or chlorophyll *a* concentration) from the calibration scenario to the load reduction scenario. In Figure H-2, a dissolved oxygen concentration of 2 milligrams per liter (mg/L) (x axis) in the calibration scenario becomes 3.6 mg/L (y axis) in the load reduction scenario.

Regressions are generated for all Bay Water Quality Model cells that match up with the long-term Chesapeake Bay mainstem and tidal tributary water quality monitoring stations and vertical sampling locations through the water column. The regressions are generated using all Bay Water Quality Model simulated values (hourly for dissolved oxygen; daily for chlorophyll *a*) for the month when the historical monitoring observation occurred. The result is a unique linear regression equation for each monitoring location and month (Figure H-3).

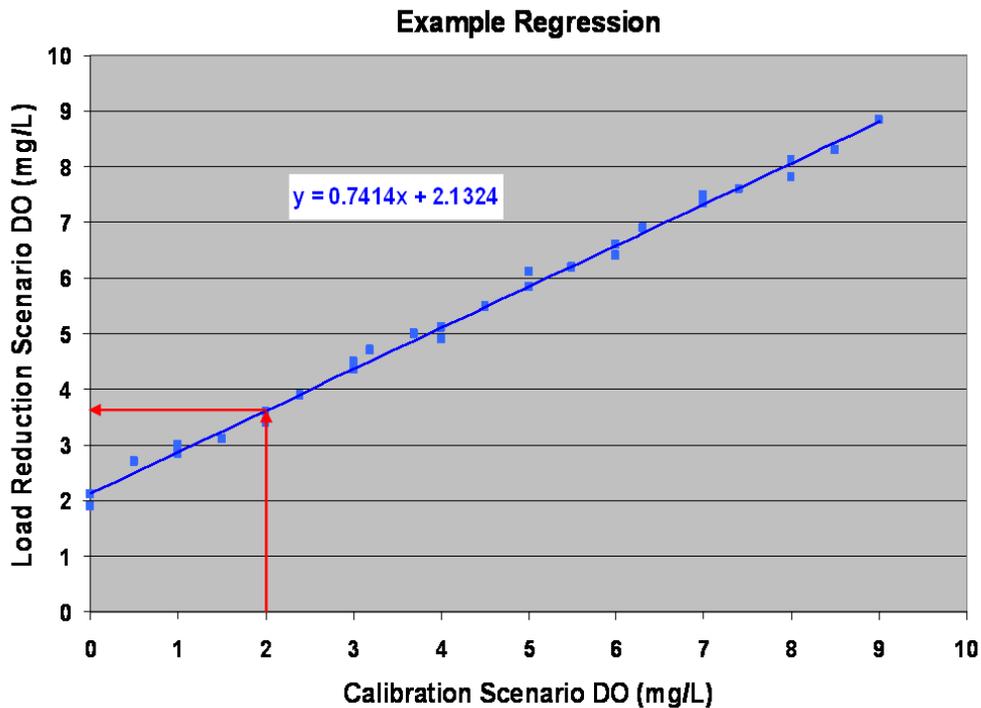


Figure H-2. Hypothetical example of a linear regression between model calibration (x axis) and scenario (y axis) data.

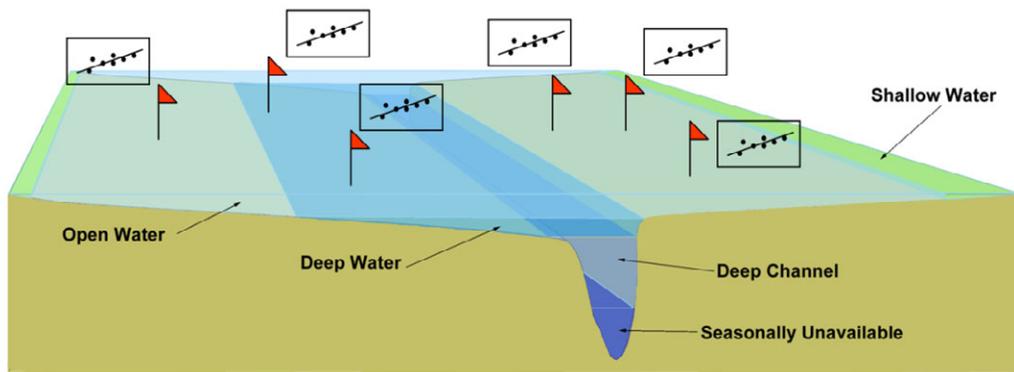
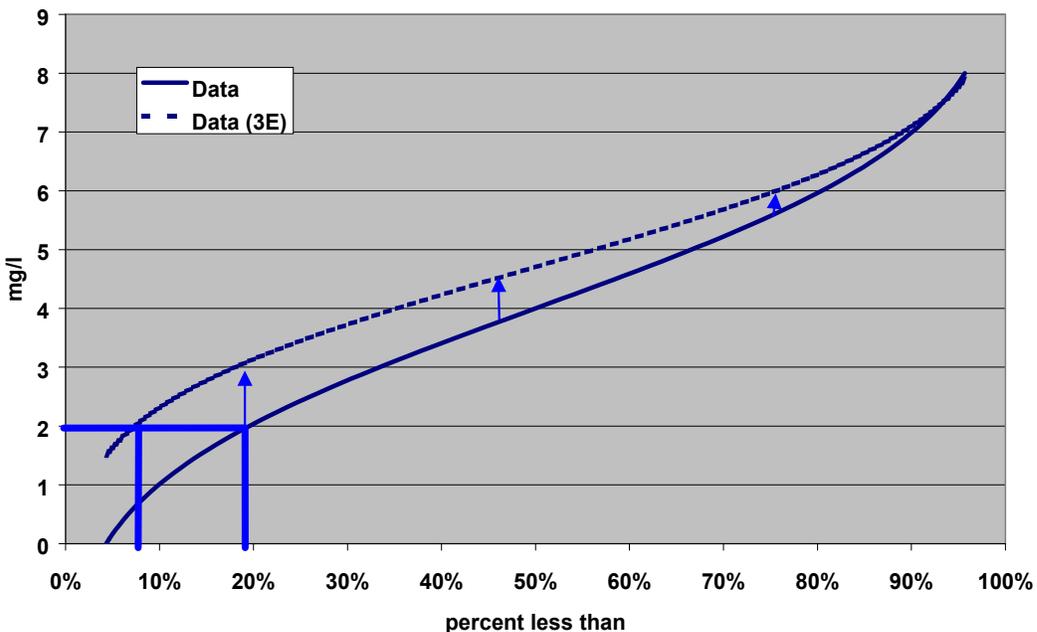


Figure H-3. Individual regression equation generated for each monitoring station location and month.

Once the relationship between the calibration and a given loading scenario is established, that relationship is used to generate a *scenario-modified* value for each observation in the historical monitoring data set spanning 1991–2000 (step 4 above). Those scenario-modified values represent an estimate of the concentration that would have been observed under the conditions of nutrient and sediment management represented by the scenario. In that manner, each observed concentration for dissolved oxygen or chlorophyll *a* in the 1991–2000 data set is replaced with a scenario-modified concentration for the same sampling location and date.

Figure H-4 illustrates the modification of hypothetical historical monitoring data using a regression generated with the described procedure. The result is shown on a frequency plot so that changes in the prediction of attainment can be seen. The perpendicular blue lines in the lower-left portion of the graph illustrate the predicted change in dissolved oxygen from the hypothetical historical monitoring data (solid line) to the E3 scenario (dashed line). In this case, the incidence of dissolved oxygen concentrations less than 2.0 mg/L is predicted to decrease from 20 percent to 10 percent.

For a full discussion of this procedure, see *A Comparison of Chesapeake Bay Estuary Model Calibration With 1985-1994 Observed Data and Method of Application to Water Quality Criteria* (Linker et al. 2002).



Source: Linker et al. 2002

Figure H-4. Frequency distribution of hypothetical summer DO concentrations, as observed (solid blue line) and as simulated using a regression equation generated from water quality model scenarios.

Reference

Linker, L., G. Shenk, P. Wang, C. Cerco, A. Butt, P. Tango, and R. Savage. 2002. *A Comparison of Chesapeake Bay Estuary Model Calibration with 1985–1994 Observed Data and Method of Application to Water Quality Criteria*. Chesapeake Bay Program Modeling Subcommittee Report. U.S. Environmental Protection Agency, Chesapeake Bay Program Office, Annapolis, MD.