Appendix D. Evaluation of the Most Protective Bay Dissolved Oxygen Criteria

As outlined in the criteria assessment documentation in Section 3 and shown in Table D-1, seven different dissolved oxygen criteria are to be assessed for open-water, deep-water, and deep-channel designated uses (USEPA 2003). Using the available monitoring data, only one temporal averaging period is assessed for each designated-use type (USEPA 2003, 2007). Because the monitoring data are not available to assess all criteria or an assessment protocol has not been developed by the CBP partners and published by EPA, it raises the question of whether the assessed criteria are more or less protective of all four Chesapeake Bay designated use than the four criteria that are not able to be assessed.

Table D-1. Chesapeake Bay dissolved oxygen criteria assessed with observed data for developing the jurisdictions' the 303(d) lists and criteria that are not evaluated because of insufficient data/lack of published assessment protocols

Designated use	Instantaneous	1-day mean	7-day mean	30-day mean
Open water	Insufficient Data	No Criterion	Insufficient Data	**Assessed**
Deep water	Insufficient Data	Insufficient Data	No Criterion	**Assessed**
Deep channel	**Assessed**	No Criterion	No Criterion	No Criterion

It is difficult to comprehensively evaluate the protectiveness of the assessed criteria strictly based on monitoring data, because the unassessed criteria cannot be directly evaluated due to insufficient data or lack of published assessment protocols. A multi-partner effort is underway to develop criteria assessment protocols based on the available data, but those protocols will not be complete, peer reviewed and published until 2011 at the earliest.

The full set of 7 dissolved oxygen criteria can be assessed through direct evaluation of the Bay Water Quality Model output. The assessments will not agree precisely with the 303(d) or Bay TMDL-related criteria assessment because neither of these criteria assessments uses model outputs directly (see Section 6.2.1). However, assuming that the temporal variability of dissolved oxygen in the Chesapeake Bay is reasonably well-characterized in the Bay Water Quality model, the relative protectiveness of different criteria evaluated directly from Bay Water Quality Model output would approximate the relative protectiveness of three dissolved oxygen criteria evaluated through monitoring data.

All seven dissolved oxygen criteria were assessed using the direct outputs from a series of Bay Water Quality Model scenarios. This work was completed in November 2008 using the Phase 5.1 version of the Chesapeake Bay Watershed Model. The Bay Water Quality Model has not been modified since completion of work. Given the analysis is focused evaluating temporal variability of dissolved oxygen in the Bay Water Quality Model outputs and uses the Bay Watershed Model for generation of different loading scenario input decks, the findings are still relevant.

Figures D-1 and D-2 show the average dissolved oxygen criteria nonattainment of eight mainstem Chesapeake Bay segments for three scenarios for the 1996–1998 period. The moderate reduction scenario approximates 2009 loads and the large reduction scenario approximates the draft Bay TMDL allocation loads.
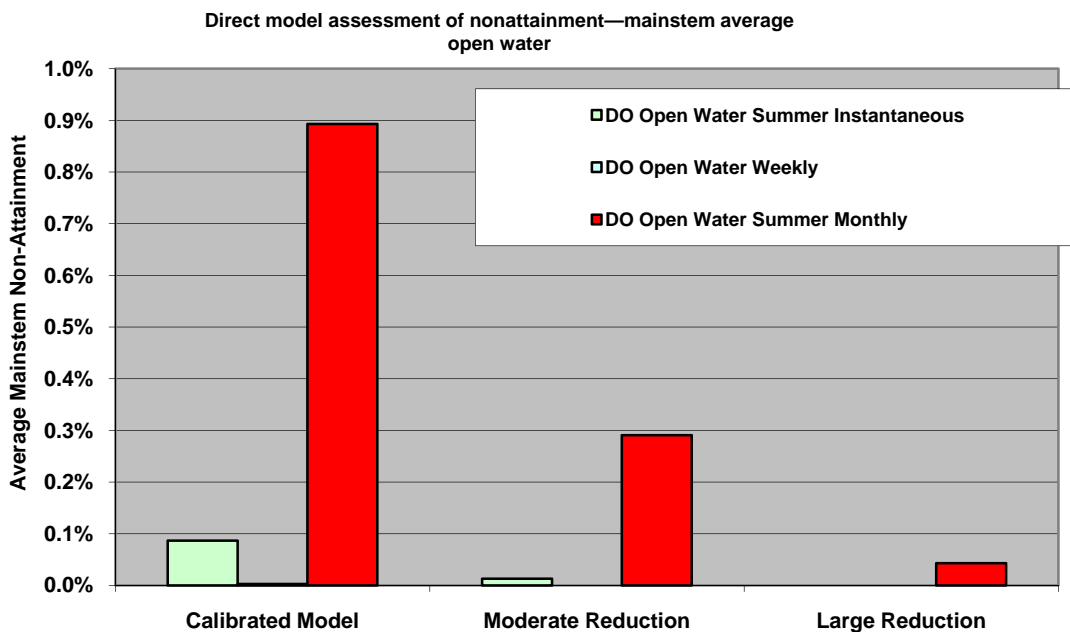
Direct model assessment of nonattainment—mainstem average open water

Figure D-1. Direct model assessment of open water criteria.

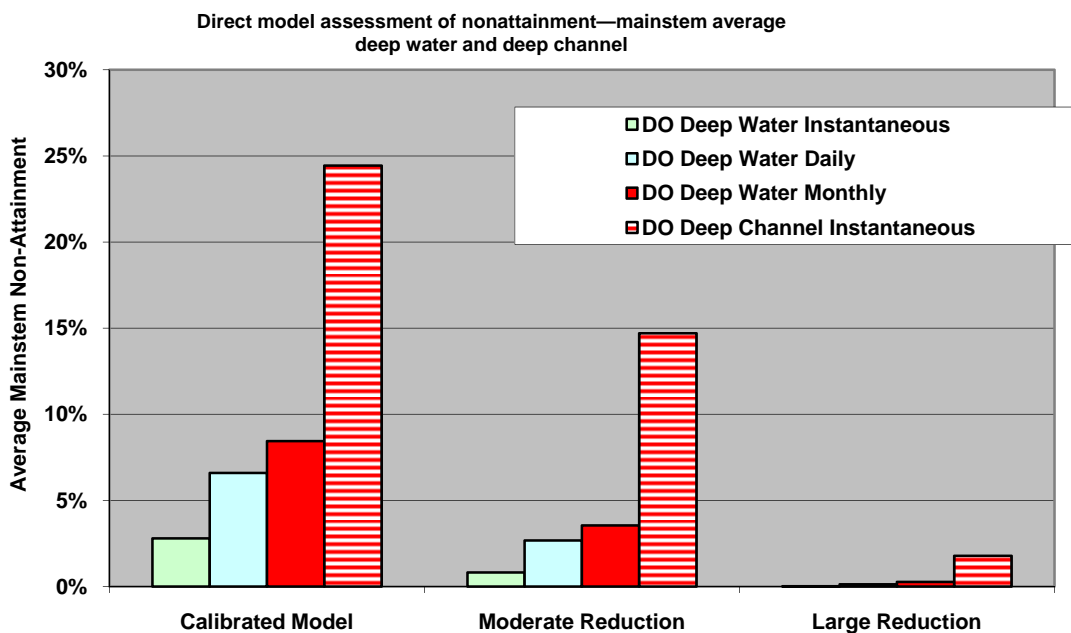**Direct model assessment of nonattainment—mainstem average deep water and deep channel**

Figure D-2. Direct model assessment of deep water and deep channel criteria.

For both open-water and deep–water designated uses, the 30-day mean criteria had the highest nonattainment in all three scenarios (Figures D-1 and D-2). The 30-day mean open-water and deep-water criteria are, therefore, protective of the other two non-assessed dissolved oxygen criteria (open-water 7-day and instantaneous minimum, deep-water 1-day mean and

instantaneous minimum) on average for the mainstem Bay segments. The deep–channel designated use has only one dissolved oxygen criterion, and it is currently assessed using monitoring data. The deep-channel criterion is also more protective, based on the levels of nonattainment recorded in Figures D-1 and D-2, than the deep-water and open-water criteria.

Looking at the results of individual designated uses strengthens these findings considerably. Using the criteria nonattainment percentages for the moderate reduction scenario and the 1996–1998 assessment period, the 30-day mean, 7-day mean, and instantaneous minimum criteria are compared across 53 of the 92 Bay segments with the open–water designated use. During the 1996-1998 assessment period, these 53 segment did not attain all three open-water criteria. In all 53 segments, the 30-day mean criterion had the highest nonattainment percentage compared to the 7-day mean and 1-day mean criteria (Table D-1). In the 16 Bay segments that did not attain all three deep water criteria during the same three year period, the 30-day mean deep-water criterion had the highest nonattainment percentage in all 16 segments compared with the deep-water 1-day mean and instantaneous minimum criteria (Table D-2).

Given this is direct assessment of the Bay Water Quality Model output using inputs from the Phase 5.1 Bay Watershed Model and that the water quality criteria and assessment protocols that existed in 2008, the nonattainment values will not match with nonattainment in other parts of this document.

Table D-2. Comparison of open–water dissolved oxygen 30-day mean, 7-day mean and instantaneous criteria for the moderate reduction scenario and the 1996–1998 assessment period across Bay segments for identification of the most protection criterion.

Ches Bay Segment	30-day mean	7-day mean	Instantaneous minimum	Most protective criterion
BI2MH	3.56%	0.43%	0.00%	30-day mean
C11TF	0.02%	0.00%	0.00%	30-day mean
CB1TF	0.03%	0.00%	0.00%	30-day mean
CB2OH	1.48%	0.00%	0.10%	30-day mean
CB5MH	0.01%	0.00%	0.00%	30-day mean
CB6PH	0.24%	0.00%	0.00%	30-day mean
CB7PH	0.57%	0.00%	0.00%	30-day mean
CDDOH	24.87%	20.59%	19.19%	30-day mean
CHOMH1	7.24%	1.96%	2.53%	30-day mean
CHOMH2	34.10%	28.45%	25.47%	30-day mean
CHOOH	28.04%	24.18%	23.20%	30-day mean
CHOTF	20.32%	14.31%	13.96%	30-day mean
CHSMH	0.65%	0.00%	0.12%	30-day mean
CHSOH	46.68%	36.62%	34.53%	30-day mean
CHSTF	63.24%	60.63%	57.21%	30-day mean
CMDOH	48.35%	41.64%	37.15%	30-day mean
CNDOH	35.86%	30.44%	27.75%	30-day mean
CRRMH	0.25%	0.00%	0.00%	30-day mean
DCATF	2.67%	0.09%	0.29%	30-day mean
EBEMH	1.19%	0.00%	0.00%	30-day mean
EL1OH	9.96%	3.44%	4.14%	30-day mean

Ches Bay Segment	30-day mean	7-day mean	Instantaneous minimum	Most protective criterion
ELIPH	27.51%	16.54%	13.56%	30-day mean
ELKOH	9.13%	2.93%	3.77%	30-day mean
FSBMH	8.13%	2.35%	2.83%	30-day mean
HNGMH	1.09%	0.00%	0.13%	30-day mean
JMSPH	1.07%	0.00%	0.00%	30-day mean
JMSTF	0.22%	0.00%	0.13%	30-day mean
JMSTFL	0.27%	0.00%	0.17%	30-day mean
LCHMH	10.24%	6.17%	7.01%	30-day mean
MA1MH	0.55%	0.00%	0.00%	30-day mean
MAGMH	3.74%	0.00%	0.00%	30-day mean
MANMH	0.48%	0.00%	0.00%	30-day mean
MD5MH	0.01%	0.00%	0.00%	30-day mean
MOBPH	1.26%	0.00%	0.02%	30-day mean
NANMH	5.70%	3.09%	3.95%	30-day mean
NANOH	0.04%	0.00%	0.00%	30-day mean
PAXOH	10.68%	0.49%	0.03%	30-day mean
PAXTF	0.95%	0.00%	0.00%	30-day mean
PIAMH	1.93%	0.00%	0.00%	30-day mean
PO1OH	3.83%	0.00%	0.04%	30-day mean
POCMH	1.14%	0.03%	0.41%	30-day mean
POTOH	3.55%	0.00%	0.03%	30-day mean
SA1OH	10.46%	1.28%	1.36%	30-day mean
SA2OH	8.85%	1.54%	2.19%	30-day mean
SASOH	9.95%	1.27%	1.81%	30-day mean
SEVMH	4.38%	0.77%	1.54%	30-day mean
TA1MH	11.93%	6.99%	7.39%	30-day mean
TA2MH	1.20%	0.00%	0.00%	30-day mean
TAMMH	11.34%	6.50%	7.00%	30-day mean
TANMH	12.85%	6.76%	6.66%	30-day mean
TAVMH	15.43%	7.17%	5.76%	30-day mean
VPCMH	1.62%	0.08%	0.59%	30-day mean
YRKMH	7.42%	2.89%	3.19%	30-day mean

Table D-3. Comparison of deep–water dissolved oxygen 30-day mean, 1-day mean and instantaneous criteria for the moderate reduction scenario and the 1996–1998 assessment period across Bay segments for identification of the most protection criterion.

Ches Bay Segment	30-day mean	1-day mean	Instantaneous minimum	Most protective criterion
CB3MH	1.86%	0.60%	0.29%	30-day mean
CB4MH	11.45%	10.21%	3.00%	30-day mean
CB5MH	2.22%	1.55%	0.01%	30-day mean
CB7PH	2.21%	0.99%	0.77%	30-day mean
CHSMH	14.31%	12.37%	6.60%	30-day mean
EASMH	18.11%	16.84%	9.91%	30-day mean
MD5MH	6.08%	5.52%	0.01%	30-day mean
PA1MH	0.11%	0.00%	0.00%	30-day mean
PA2MH	8.11%	7.82%	3.44%	30-day mean
PATMH	29.12%	27.75%	19.75%	30-day mean
PAXMH	0.63%	0.00%	0.10%	30-day mean
POMMH	0.08%	0.00%	0.00%	30-day mean
POMMH	0.08%	0.00%	0.00%	30-day mean
POTMH	0.08%	0.00%	0.00%	30-day mean
RPPMH	0.01%	0.00%	0.00%	30-day mean
SBEMH	42.50%	35.44%	22.34%	30-day mean

EPA used direct assessment of Bay Water Quality Model outputs to document that the three dissolved oxygen criteria that are currently assessed—open-water 30 day mean, deep-water 30 day mean and deep-channel instantaneous minimum—are the most restrictive criteria. These three criteria, applied during the summer period, are protective of the other four dissolved oxygen criteria across all four designated uses, across a range of nutrient reduction scenarios, and in all areas of the Chesapeake Bay and its tidal tributaries and embayments.

References

USEPA (U.S. Environmental Protection Agency). 2003. *Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll* a *for the Chesapeake Bay and Its Tidal Tributaries*. EPA 903-R-03-002. Region 3 Chesapeake Bay Program Office, Annapolis, MD.

USEPA (U.S. Environmental Protection Agency). 2007. *Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and Its Tidal Tributaries–2007 Addendum*. EPA 903-R-07-003. CBP/TRS 285-07. Region 3 Chesapeake Bay Program Office, Annapolis, MD.