CHAPTER 4.4 CHESAPEAKE BAY ASSESSMENT

(Note: The Federal-Interstate Chesapeake Bay Program, which is responsible for developing water quality standards and assessment protocols for Bay waters, is described in more detail in Chapter 7.6).

Assessment of Aquatic Life Use in Chesapeake Bay and Its Tidal Tributaries

<u>Summary</u>

Water quality impairments were detected throughout the Bay and its tributaries, with some important differences relative to the last assessment. Hypoxia continues to be problematic in both shallow and deeper areas, particularly during the summer months. A greater extent of deep-water and deep-channel aquatic life sub-uses are now not in attainment compared to findings from the previous assessment. While assessment of submerged aquatic vegetation (SAV) continues to find that the majority of Bay waters do not achieve the desired extent and acreage of SAV, it also shows that plant growth is improving in most segments. The total shortfall of SAV acres (relative to segment-specific goals) decreased by approximately 5% from the 2010 to the 2012 assessment. The tidal fresh segment of the Rappahannock River and the polyhaline segment of the James River saw an approximate 320% and 130% increase in SAV acres, respectively, between the growing seasons of 2008 and 2010. Benthic biological communities (e.g. worms, insects) also showed some improvement relative to findings in the 2010 report, with the aerial extent of degraded communities decreasing by 23%. Lastly, all James River segments failed their respective chlorophyll *a* standards due to the presence of algal blooms. But it is worth noting that all tidal portions of the river except for the polyhaline segment met either spring or summer criteria. It is anticipated that as nutrient and sediment pollution levels are reduced due to implementation projects, there will be continuing improvement in algal blooms, low dissolved oxygen concentrations, SAV acreage, and degraded benthic communities in Bay waters.

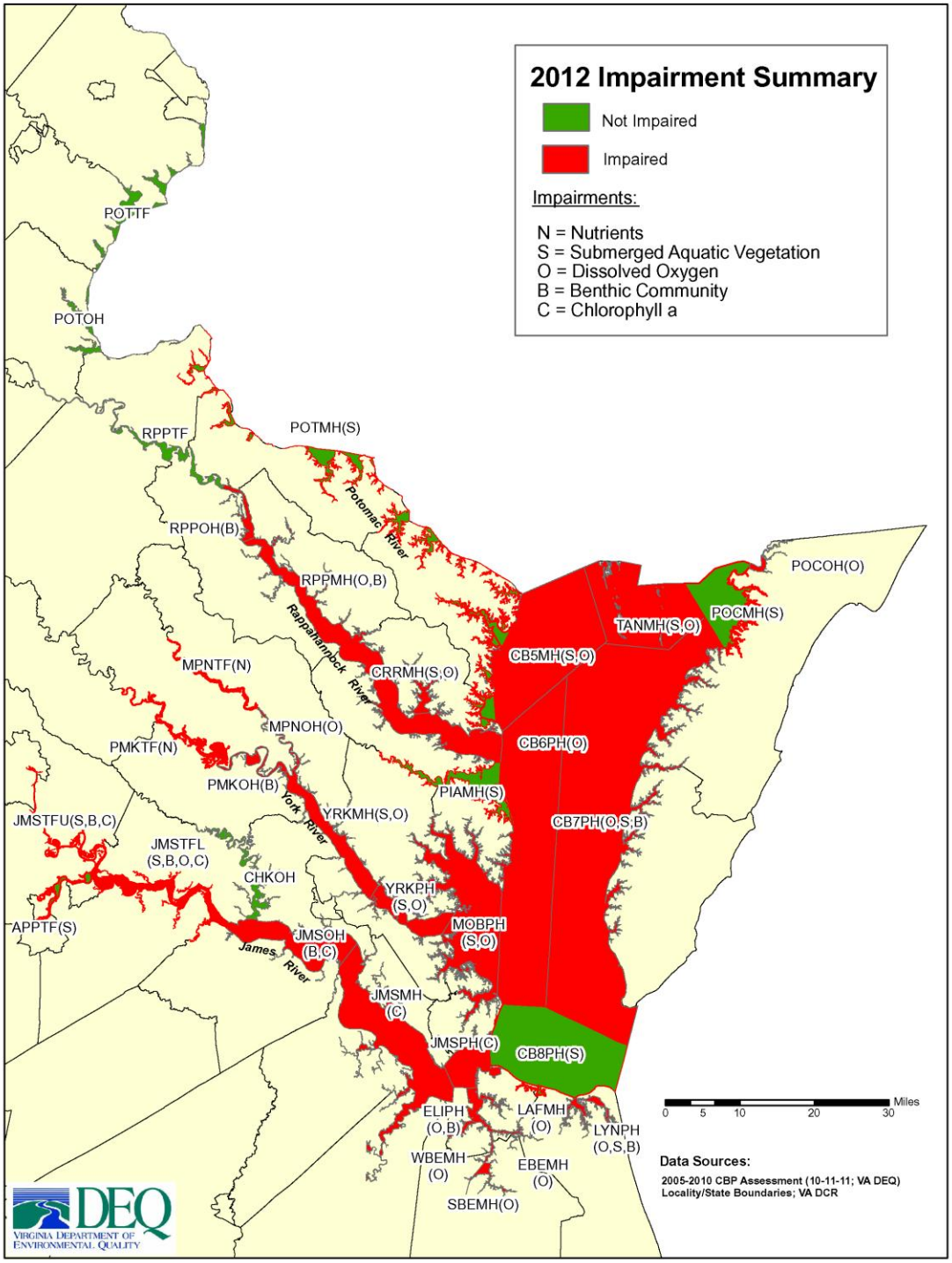
Figure 4.4-1 summarizes the current aquatic life use status for the special Bay criteria (note it does not reflect other impairments such as pH, fish tissue contaminants, or other aquatic life criteria). The only areas unimpaired are segments containing Virginia embayments in the middle and upper Potomac (POTTF, POTOH), the Chickahominy River (CHKOH) and the tidal fresh zone of the Rappahannock River (RPPTF).

Some segments, such as the tidal fresh areas of the Mattaponi (MPNTF) and Pamunkey (PMKTF), meet all assessed Bay criteria. However, these areas remain classified as impaired in the Assessment Database (ADB) because short-term criteria established for dissolved oxygen (7-day mean, 1-day mean, and instantaneous) have not been assessed. There are some data to assess these criteria, but the Chesapeake Bay Program has not yet developed an assessment protocol. Segments which were overlisted by the EPA in 1999 and currently meet all assessed criteria are assumed to be “nutrients” impaired until all dissolved oxygen criteria for all appropriate designated uses are assessed and determined to be meeting.

A few segments (e.g., the Appomattox River, the mesohaline zone of Pocomoke Sound, embayments of mainstem segment CB5MH, and the lower mainstem bay segment CB8PH) meet dissolved oxygen criteria and benthic community criteria and are impaired only due to inadequate conditions for growth of submerged aquatic vegetation. All remaining segments are impaired for dissolved oxygen, benthic macroinvertebrates, submerged aquatic vegetation, chlorophyll *a*, or some combination of these.

The following sections describe in further detail 1) aquatic life sub-uses and criteria, 2) 2012 aquatic life use assessment results and 3) future assessment refinements.

Figure 4.4-1 Impairment status of the Bay aquatic life use.



Chesapeake Bay and Tidal Tributaries Aquatic Life Uses and Criteria

The Chesapeake Bay aquatic life sub-uses described below reflect the different aquatic living resource communities living in the different areas of the Bay. Impairment of any of these sub-categories of aquatic life use is also considered an impairment of the overall aquatic life use. The overall aquatic life use also exists as a distinct designated use (i.e. distinct from the sub-uses) and is assessed with other protocols including benthic Indices of Biological Integrity (IBI), ammonia criteria, and toxicity bioassays.

Designated Uses

Migratory Fish Spawning and Nursery (MSN) Designated Use

This use exists in waters in the Chesapeake Bay and its tidal tributaries that protect the survival, growth and propagation of the early life stages of a balanced, indigenous population of anadromous, semi-anadromous, catadromous and tidal-fresh resident fish species inhabiting spawning and nursery grounds. Figure 4.4-2 illustrates this designated use and detailed geographic descriptions are in *Technical Support Document for Identification of Chesapeake Bay Designated Uses and Attainability 2004 Addendum Chesapeake Bay Program Office, Annapolis, Maryland*. The designated use extends from the beginning of tidal waters to the downriver end of spawning and nursery habitats, as determined through a composite of all targeted anadromous and semi-anadromous fish species' spawning and nursery habitats. The designated use extends horizontally from the shoreline of the body of water to the adjacent shoreline, and extends down through the water column to the bottom water-sediment interface. This use applies February 1 through May 31 and exists concurrently with the open-water use.

Shallow-Water Submerged Aquatic Vegetation (SWSAV) Designated Use

This use exists in waters in the Chesapeake Bay and its tidal tributaries that support the survival, growth and propagation of submerged aquatic vegetation (rooted, underwater bay grasses). Figure 4.4-2 illustrates this designated use and detailed geographic descriptions are in *Technical Support Document for Identification of Chesapeake Bay Designated Uses and Attainability 2004 Addendum Chesapeake Bay Program Office, Annapolis, Maryland*. This use applies April 1 through October 31 in tidal-fresh, oligohaline and mesohaline Chesapeake Bay Program segments, and March 1 through November 30 in polyhaline Chesapeake Bay Program segments and exists concurrently with the open-water use.

Open-Water (OW) Aquatic Life Designated Use

This use exists in waters in the Chesapeake Bay and its tidal tributaries that protect the survival, growth and propagation of a balanced, indigenous population of aquatic life inhabiting open water habitats. Figure 4.4-2 illustrates this designated use and detailed geographic descriptions are in *Technical Support Document for Identification of Chesapeake Bay Designated Uses and Attainability 2004 Addendum Chesapeake Bay Program Office, Annapolis, Maryland*. This designated use applies year-round but the vertical boundaries change seasonally. October 1 - May 31: the open-water aquatic life use extends horizontally from the shoreline at mean low water, to the adjacent shoreline, and extending through the water column to the bottom water-sediment interface. June 1 - September 30: if a pycnocline (i.e. a physical inhibition of mixing) is present, the open-water sub-use extends down into the water column only as far as the upper boundary of the pycnocline; otherwise, it extends to the water-sediment interface. This designated use is concurrent with the migratory fish spawning and nursery and shallow-water submerged aquatic vegetation uses in areas where these uses apply.

Deep-Water (DW) Aquatic Life Designated Use

This use exists in waters in the Chesapeake Bay and its tidal tributaries that protect the survival and growth of a balanced, indigenous population of aquatic life inhabiting deep-water habitats. Figure 4.4-2 illustrates this designated use and detailed geographic descriptions are in *Technical Support Document for Identification of Chesapeake Bay Designated Uses and Attainability 2004 Addendum Chesapeake*

Bay Program Office, Annapolis, Maryland. This designated use applies to the tidally influenced waters located between the upper and lower boundaries of the pycnocline where, in combination with bottom bathymetry and water circulation patterns, a pycnocline is present and presents a barrier to oxygen replenishment of deeper waters. In some areas, the deep-water sub-use extends from the upper boundary of the pycnocline down to the bottom water-sediment interface. This use applies June 1 through September 30.

Deep-Channel (DC) Seasonal Refuge Designated Use

This use exists in waters in the Chesapeake Bay and its tidal tributaries that protect the survival of a balanced, indigenous population of benthic infauna and epifauna inhabiting deep-channel habitats. Figure 4.4-2 illustrates this designated use and detailed geographic descriptions are in *Technical Support Document for Identification of Chesapeake Bay Designated Uses and Attainability 2004 Addendum Chesapeake Bay Program Office, Annapolis, Maryland.* This designated use applies to the tidally influenced waters at depths greater than the lower boundary of the pycnocline in areas where, in combination with bottom bathymetry and water circulation patterns, the pycnocline presents a barrier to oxygen replenishment of deeper waters. This use applies June 1 through September 30.

Applicable Criteria

Dissolved oxygen criteria protecting the described uses are shown in Table 4.4-1. The methodology for assessing monitoring data against these criteria involves spatial interpolation of fixed site monitoring results to create a 3-D picture of oxygen conditions in thousands of individual grid cells throughout the Bay. Each individual grid cell is then assessed against the criteria. In this way, the volume of water in attainment is calculated for each data collection cruise, allowing for an assessment of criteria on a spatial scale. To account for natural fluctuations over seasons and years, the individual monthly spatial assessments of a three-year time period are aggregated, allowing for an estimate of the frequency of violations. (Note that this contrasts with the six-year time period used in the assessment of DO for non-Bay waters.) The frequency and spatial extent of violations are combined to create a cumulative frequency diagram (CFD) curve, which is examined against an established reference curve.

Figure 4.4-3 shows the location of the 919 Virginia monitoring stations used for the 2012 dissolved oxygen assessment. These stations were monitored by DEQ, Old Dominion University, Virginia Institute of Marine Science, citizens groups, and municipalities. Details of the assessment procedure can be found in guidance manuals from EPA and DEQ (*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, April 2003* ; *Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity, and Chlorophyll a for the Chesapeake Bay and Its tidal Tributaries, 2004 Addendum, EPA 904-R-04-005 October 2004*; *Water Quality Assessment Guidance Manual for Y2008: 305(B)/303(D) Integrated Water Quality Report, April, 2007*; and *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 July 2007*).

Criteria specific to the shallow-water submerged aquatic vegetation use (SWSAV) are shown in Table 4.4-2. The criterion of “SAV Acres” was assessed in every segment. The criterion for “Water Clarity Acres” was assessed where data were available (Rappahannock, York and James River systems). The SAV Acres criterion is met by having aquatic vegetation present as measured by annual aerial photography. The Water Clarity Acres criterion is met by having sufficient water clarity present to support the potential for aquatic vegetation to grow (i.e. regardless of whether the submerged aquatic vegetation is actually present). This criterion was created because the water may be clear enough to support submerged aquatic vegetation, but it may take several years for the areas to re-populate with grasses. A detailed description of the assessment methodology can found in *Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity, and Chlorophyll a for the Chesapeake Bay and Its tidal Tributaries, 2018 Technical Support for Criteria Assessment Protocols Addendum, EPA 903-R-08-001 September 2008.*

The chlorophyll *a* criteria assessed are shown in Table 4.4-3. There are separate criteria applicable to each segment and season, and a spatial-temporal assessment is conducted using a cumulative frequency diagram (see *Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity, and Chlorophyll a for the Chesapeake Bay and Its tidal Tributaries, 2018 Technical Support for Criteria Assessment Protocols Addendum, EPA 903-R-08-001, EPA 903-R-08-001 September 2008*). If either one of the criteria (i.e. spring or summer season) is found to be failing, then the segment is assessed as failing the chlorophyll *a* standard.

Spatial Assessment Units

A general overview of the CBP segmentation scheme that is used for assessment of designated uses is shown in Figure 4.4-4. Not every designated use exists in each segment or necessarily throughout the full extent of the segments in which they exist. Details of where each designated use occurs within each of these CBP segments can be found in *Technical Support Document for Identification of Chesapeake Bay Designated Uses and Attainability, 2004 Addendum, October 2004, EPA 903-R-04-006* and *Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity, and Chlorophyll a for the Chesapeake Bay and Its tidal Tributaries, 2010 Technical Support for Criteria Assessment Protocols Addendum, EPA 903-R-10-002 May 2010*.

Figure 4.4-2 Conceptualized illustration of location of the five Chesapeake Bay tidal water designated use zones.

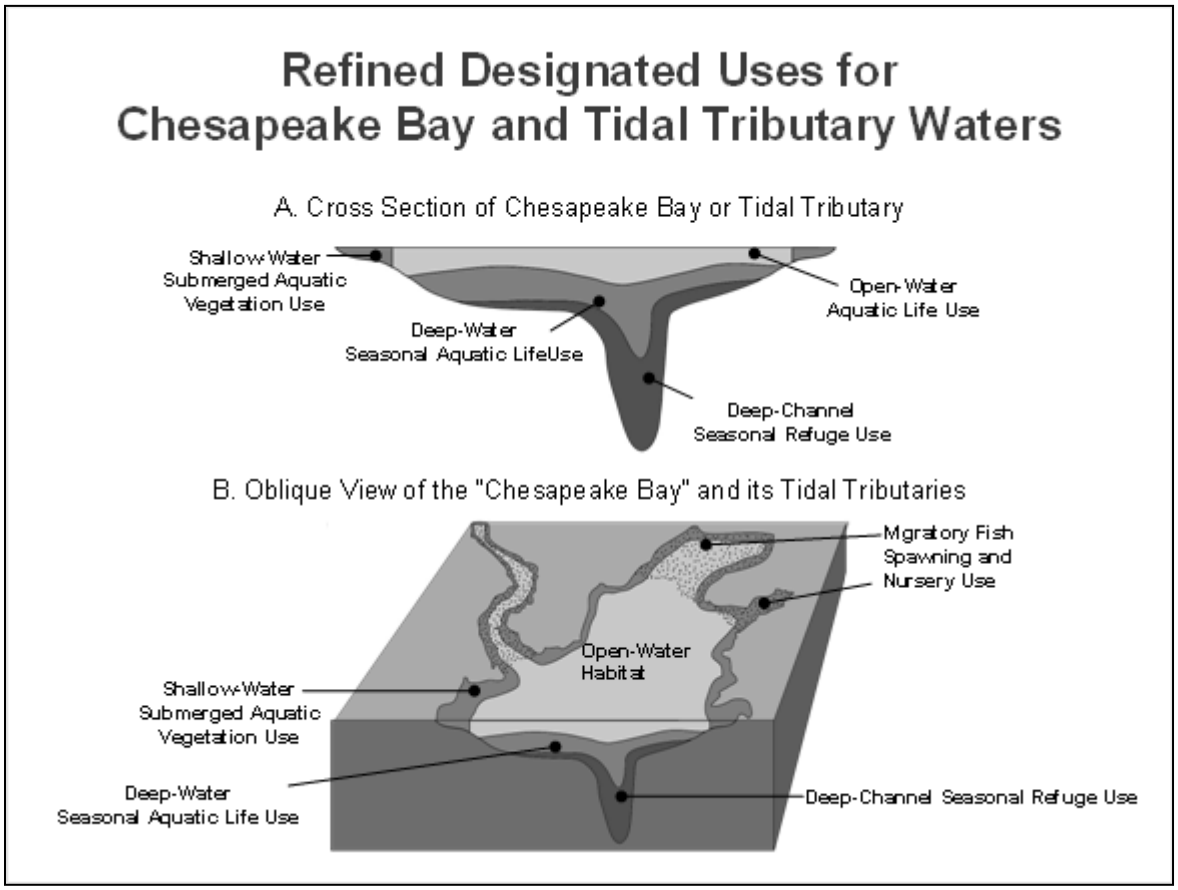


Table 4.4-1 Chesapeake Bay dissolved oxygen criteria

Designated Use	Criteria Concentration/Duration	Protection Provided	Temporal Application
Migratory fish spawning and nursery use	7-day mean $\geq$ 6 mg liter^{-1} (tidal habitats with 0-0.5 ppt salinity)	Survival/growth of larval/juvenile tidal-fresh resident fish; protective of threatened/endangered species.	February 1 - May 31
	Instantaneous minimum $\geq$ 5 mg liter^{-1}	Survival and growth of larval/juvenile migratory fish; protective of threatened/endangered species.	
	Open-water fish and shellfish designated use criteria apply		June 1 - January 31
Shallow-water bay grass use	Open-water fish and shellfish designated use criteria apply		Year-round
Open-water fish and shellfish use[1]	30-day mean $\geq$ 5.5 mg liter^{-1} (tidal habitats with 0-0.5 ppt salinity)	Growth of tidal-fresh juvenile and adult fish; protective of threatened/endangered species.	Year-round
	30-day mean $\geq$ 5 mg liter^{-1} (tidal habitats with >0.5 ppt salinity)	Growth of larval, juvenile and adult fish and shellfish; protective of threatened/endangered species.	
	7-day mean $\geq$ 4 mg liter^{-1}	Survival of open-water fish larvae.	
	Instantaneous minimum $\geq$ 3.2 mg liter^{-1}	Survival of threatened/endangered sturgeon species.[2]	
Deep-water seasonal fish and shellfish use	30-day mean $\geq$ 3 mg liter^{-1}	Survival and recruitment of bay anchovy eggs and larvae.	June 1 - September 30
	1-day mean $\geq$ 2.3 mg liter^{-1}	Survival of open-water juvenile and adult fish.	
	Instantaneous minimum $\geq$ 1.7 mg liter^{-1}	Survival of bay anchovy eggs and larvae.	
	Open-water fish and shellfish designated-use criteria apply		October 1 - May 31
Deep-channel seasonal refuge use	Instantaneous minimum $\geq$ 1 mg liter^{-1}	Survival of bottom-dwelling worms and clams.	June 1 - September 30
	Open-water fish and shellfish designated use criteria apply		October 1 - May 31

[1]Special criteria for the Mattaponi and Pamunkey rivers are 30 day mean > 4.0 mg/l ;Instantaneous minimum > 3.2 mg/l at temperatures <29°C;Instantaneous minimum > 4.3 mg/l at temperatures > 29°C.
[2] At temperatures considered stressful to shortnose sturgeon (>29°C), dissolved oxygen concentrations above an instantaneous minimum of 4.3 mg liter^{-1} will protect survival of this listed sturgeon species.

Figure 4.4-3 Monitoring stations in the Chesapeake Bay used in the 2012 assessment of dissolved oxygen

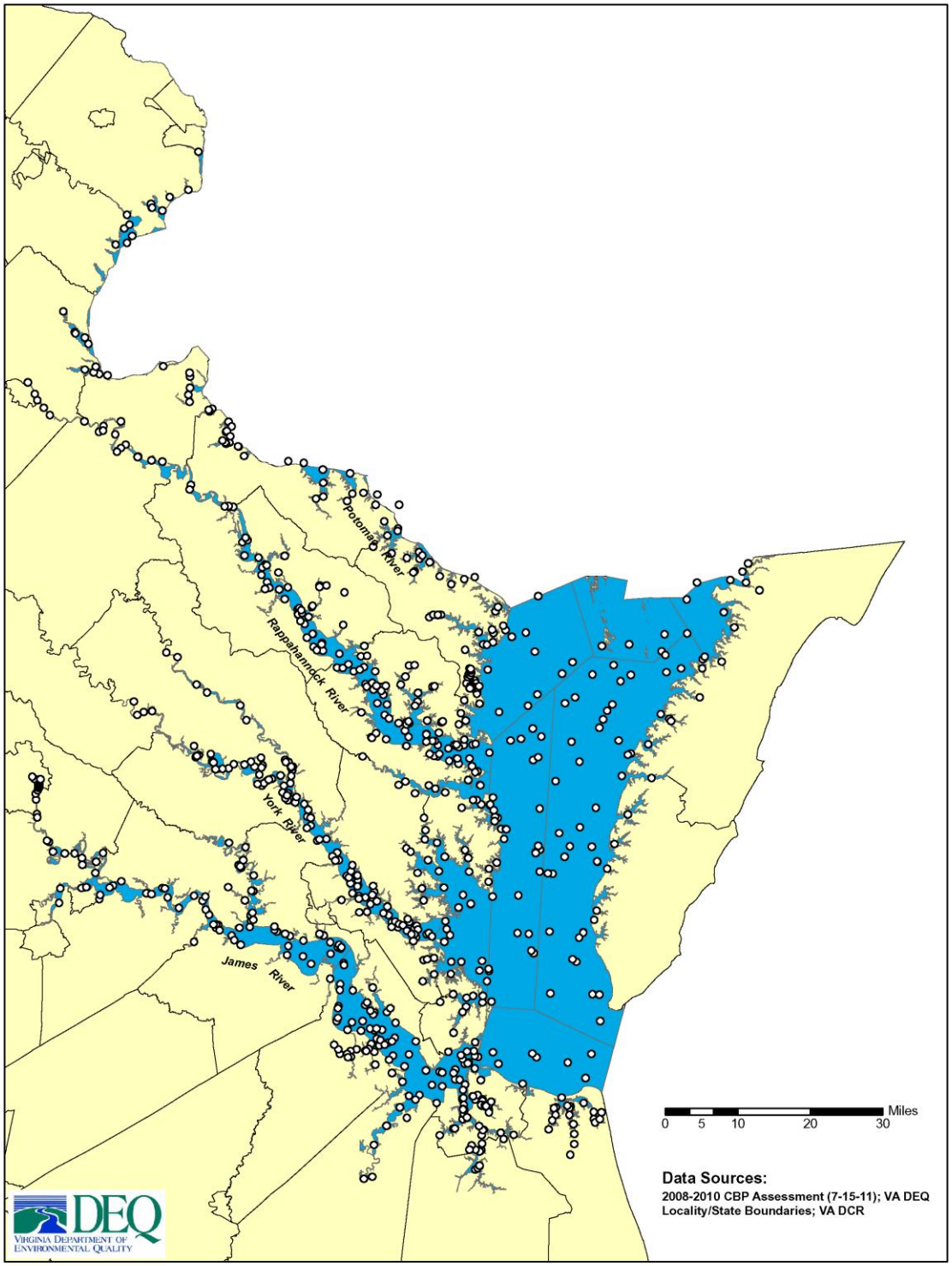


Table 4.4-2 Summary of Chesapeake Bay water clarity criteria for application to shallow-water SAV designated use habitats. Chesapeake Bay program segments are shown in Figure 4.4-2.

Chesapeake Bay Program Segment	SAV Acres[1]	Percent light-through-water[2]	Water Clarity Acres[1]	Temporal Application
CB5MH	7,633	22%	14,514	April 1 - October 31
CB6PH	1,267	22%	3,168	March 1 - November 30
CB7PH	15,107	22%	34,085	March 1 - November 30
CB8PH	11	22%	28	March 1 - November 30
POTTF	2,093	13%	5,233	April 1 - October 31
POTOH	1,503	13%	3,758	April 1 - October 31
POTMH	4,250	22%	10,625	April 1 - October 31
RPPTF	66	13%	165	April 1 - October 31
RPPOH	4	13	10	April 1 - October 31
RPPMH	1700	22%	5000	April 1 - October 31
CRRMH	768	22%	1,920	April 1 - October 31
PIAMH	3,479	22%	8,014	April 1 - October 31
MPNTF	85	13%	213	April 1 - October 31
MPNOH	-	-	-	-
PMKTF	187	13%	468	April 1 - October 31
PMKOH	-	-	-	-
YRKMH	239	22%	598	April 1 - October 31
YRKPH	2,793	22%	6,982	March 1 - November 30
MOBPH	15,901	22%	33,990	March 1 - November 30
JMSTF2	200	13%	500	April 1 - October 31
JMSTF1	1000	13%	2500	April 1 - October 31
APPTF	379	13%	948	April 1 - October 31
JMSOH	15	13%	38	April 1 - October 31
CHKOH	535	13%	1,338	April 1 - October 31
JMSMH	200	22%	500	April 1 - October 31
JMSPH	300	22%	750	March 1 - November 30
LYNPH	107	22%	268	March 1 - November 30
POCOH	-	-	-	-
POCMH	4,066	22%	9,368	April 1 - October 31
TANMH	13,579	22%	22,064	April 1 - October 31

1 = The assessment period for SAV and water clarity acres is the single best year in the most recent three consecutive years. When three consecutive years of data are not available, a minimum of three years within a six-year data assessment window is used.

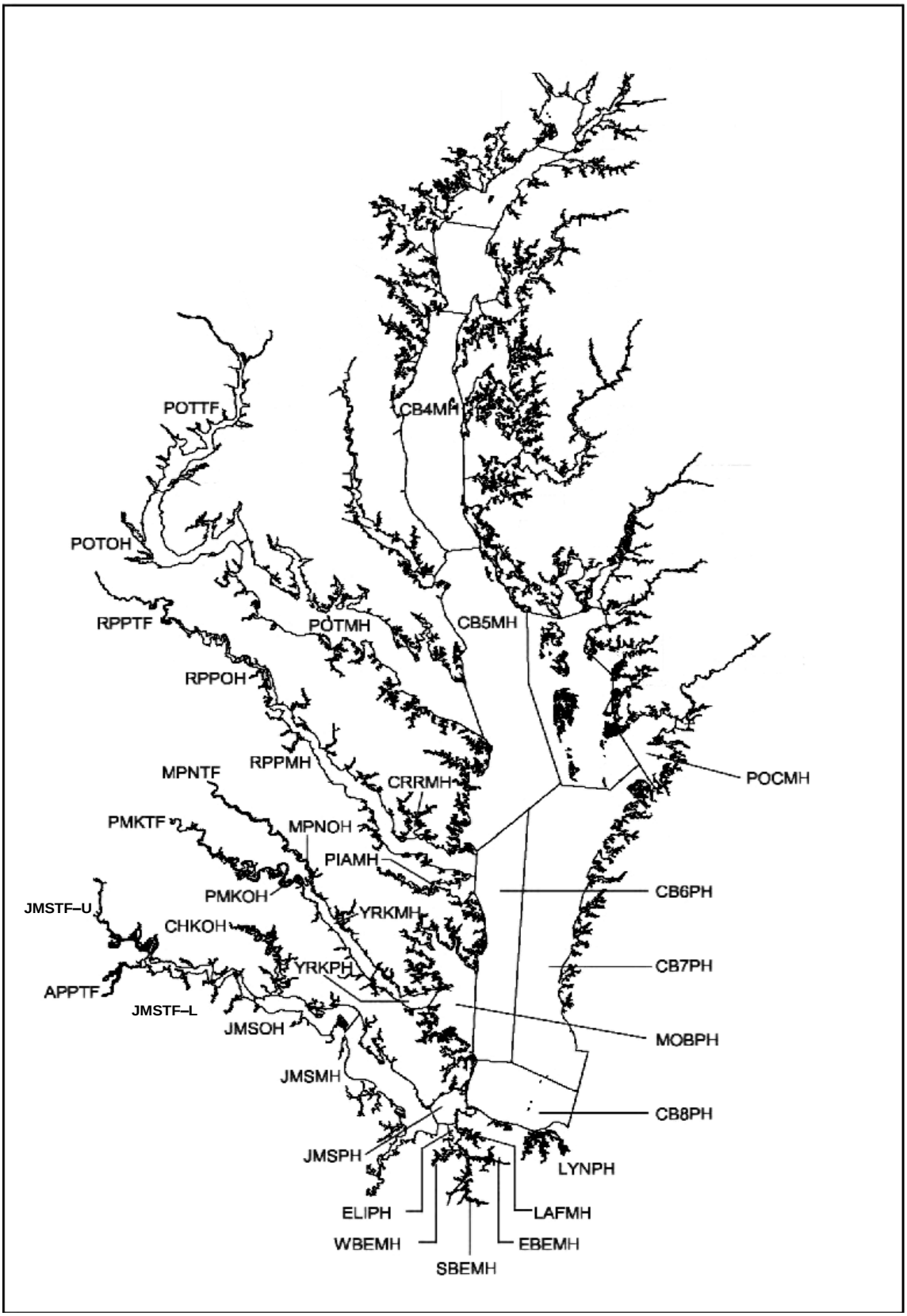
2 = Percent Light through Water = $100e^{(-KdZ)}$ where K_d is water column light attenuation coefficient and can be measured directly or converted from a measured secchi depth where K_d = 1.45/secchi depth. Z = depth at location of measurement of K_d.

Table 4.4-3 Chlorophyll *a* criteria for application to open-water designated use habitats in the James River.

Designated Use	Chlorophyll *a* (ug/l)	Chesapeake Bay Program Segment (1)	Temporal Application
Open-Water	10	JMSTFU (James Tidal Fresh Upper)	March 1 - May 31
	15	JMSTFL (James Tidal Fresh Lower)	
	15	JMSOH (James Oligohaline)	
	12	JMSMH (James Mesohaline)	
	12	JMSPH (James Polyhaline)	
	15	JMSTFU (James Tidal Fresh Upper)	July 1 - September 30
	23	JMSTFL (James Tidal Fresh Lower)	
	22	JMSOH (James Oligohaline)	
	10	JMSMH (James Mesohaline)	
	10	JMSPH (James Polyhaline)	

1) See Figure 4.4-4 for locations of these segments.

Figure 4.4-4 Chesapeake Bay dissolved oxygen and water clarity assessment segmentation.



Assessment Protocol and Criteria Updates

The assessment process has undergone three changes since the 2010 Integrated Report. The technical details of the process are provided in the EPA Criteria assessment guidance document *Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity, and Chlorophyll a for the Chesapeake Bay and Its tidal Tributaries, 2010 Technical Support for Criteria Assessment Protocols Addendum, EPA 903-R-10-002 May 2010*. The changes are summarized below:

- The computer code used to analyze vertical profiles was adjusted to account for the episodic nature of pycnoclines, steep changes in water density that represent the boundary where surface and deeper waters do not mix easily. Pycnoclines are associated with stratified waters. The degree of stratification depends on temperature, current/wind speed and other factors, so it is possible that a given vertical profile in the Bay can be stratified (exhibiting a pycnocline) during one sampling event but not the next. Prior to the correction to the protocol, the code would assign a "historical" pycnocline depth to a station if data did not demonstrate the presence of one at the time of observation. The refinement to the protocol results in a more accurate depiction of the extent and duration of the open-water, deep-water, and deep-channel uses.

- The reference curves previously used to determine non-attainment of dissolved oxygen criteria were determined to be inadequate at distinguishing "healthy" segments from "degraded" segments, and thus were refined. The biologically-based reference curves used for the assessment of open-water (summer) and deep-channel uses were replaced with default 10% curves. The benthic community dataset used to generate the reference curve used in the assessment of the deep-water use was winnowed so that the curve would represent acceptable violation rates associated with only the healthiest communities found in the Bay.

- A geometric mean is now explicitly specified to be used to calculate the seasonal means used in the assessment of chlorophyll *a* in the James River. This is consistent with how chlorophyll *a* data are conventionally analyzed by the scientific community.

Aquatic Life Sub-Use Assessment Results

<u>Open-Water Designated Assessment</u>

Figure 4.4-5 shows attainment of the 30-day mean criterion for dissolved oxygen (DO) in the open-water designated use. Exceedence rates revealed no systematic increases or decreases relative to what was observed in 2010. Overall, results are similar between the two reporting periods, with failure of the criteria observed in the majority of segments during the summer assessment period. However, in contrast to the previous three-year assessment window, more segments experienced hypoxia during the non-summer months between 2008 and 2010.

Attainment of the DO criteria was achieved in the up-river portions of most major tributaries [Appomattox (APPTF), Mattaponi (MPNTF), Pamunkey (PMKTF), and Potomac (POTTF) and (POTOH)]. Attainment of the assessed criteria is also achieved in about 15% of the mainstem Bay (i.e. segment CB8PH and the mesohaline portion of Pocomoke Sound (POCMH)). All segments of the James River except for the lower tidal fresh zone (JMSTFL) attained the assessed DO criteria, as well. The lowest excessive violation rates were found in the lower tidal segment of the James River (JMSTFL, 0.1%) and Mobjack Bay (MOBPH, 0.3%).

The highest DO violation rates occurred in the Southern and Eastern branches of the Elizabeth River—summertime exceedence rates of 58.9% and 47.6%, respectively. Additionally, during the three-year

reporting period, all three mesohaline segments of the Elizabeth experienced low dissolved oxygen concentrations during the non-summer months. These findings indicate that much of Elizabeth River experienced hypoxia of long duration and wide spatial extent between 2008 and 2010.

Figure 4.4-6 shows an evaluation of chlorophyll *a* in the James River. All segments of the James River failed to meet both spring *and* summer chlorophyll *a* criteria, which is similar to previous findings. However, almost all segments meet either one of the two seasonal criteria. Violation rates ranged from 3% to 52%, with the higher rates generally occurring up-river and during the summer.

Deep-Water Aquatic Life Designated Use Assessment

Figure 4.4-7 shows attainment of the 30-day mean criterion for dissolved oxygen in the deep-water aquatic life designated use. The deep-water criteria is attained in part of the mainstem bay (CB6PH and CB7PH) and in the mesohaline Potomac embayments (POTMH), and failed in the remaining areas (i.e. segment CB5MH of the mainstem, the lower segments of the Rappahannock and York Rivers, and the Southern branch of the Elizabeth River). Violation rates ranged from 0.8% in the lower York (YRKPH) to 8.6% in the Southern branch of the Elizabeth River (SBEMH).

Deep-Channel Designated Use Assessment

Figure 4.4-7 shows attainment status of the instantaneous criterion for dissolved oxygen (see inset box). This use exists only in relatively small areas of the Rappahannock mesohaline segment (RPPMH), the mainstem Bay segment CB5PH, and the Potomac mesohaline embayments (POTMH). The mesohaline segment of the Rappahannock (RPPMH) was determined to support the deep-channel use in the 2010 assessment, but this is now not the case.

Shallow-Water Designated Use Assessment

Figure 4.4-8 shows an evaluation of the shallow-water submerged aquatic vegetation (SWSAV) designated use. This designated use is attained if there are sufficient acres of submerged aquatic vegetation mapped by annual aerial surveys or if the water is sufficiently clear (i.e. has sufficient “water clarity” acres) so that SAV regrowth is possible. This is because lack of SAV growth may have non-pollutant causes such as insufficient propagule availability, herbivory by turtles and waterfowl, or habitat disruption by cow-nosed rays.

Full attainment of the SWSAV use is present in areas of each of the major tributary systems (James, York, Rappahannock and Potomac). Mainstem segment CB6PH and the mesohaline segments in the James (JMSMH) and the Rappahannock (RPPMH) meet the use because they are found to have sufficient water clarity even though SAV itself has not returned in sufficient acreage to attain their respective criteria. The SAV shortfalls for these segments are still presented in Figure 4.4-7.

The Bay tributaries historically have had relatively little SAV habitat in comparison to the mainstem Bay, where the largest shortfall of vegetation occurs. The open Bay areas with larger shoals had a combined shortfall of 29,937 acres for segments CB5MH, TANMH, POCMH, CB7PH, and MOBPH. Forty-seven percent (47%) of the overall sum of segment-specific SAV acreage goals was achieved. This represents 40,960 acres of SAV that must be restored before the SWSAV designated use will be met throughout the Bay and tributaries. Alternatively, sufficient water clarity must be present to potentially support this many acres of submerged aquatic vegetation.

Figure 4.4-5 Attainment of the open-water designated use (dissolved oxygen criteria) in 2012.

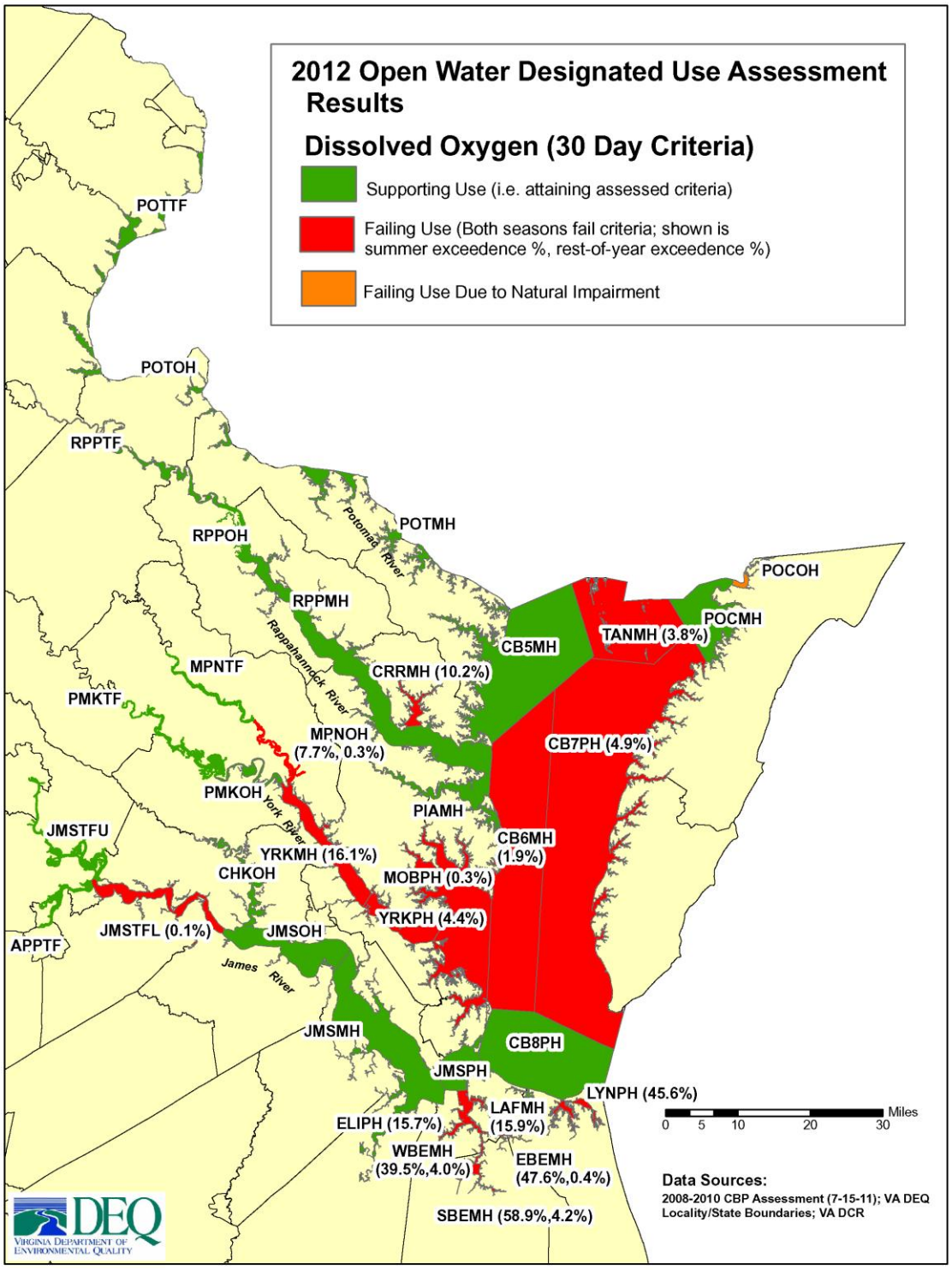


Figure 4.4-6 Attainment of the open-water designated use (chlorophyll criteria) in 2012.

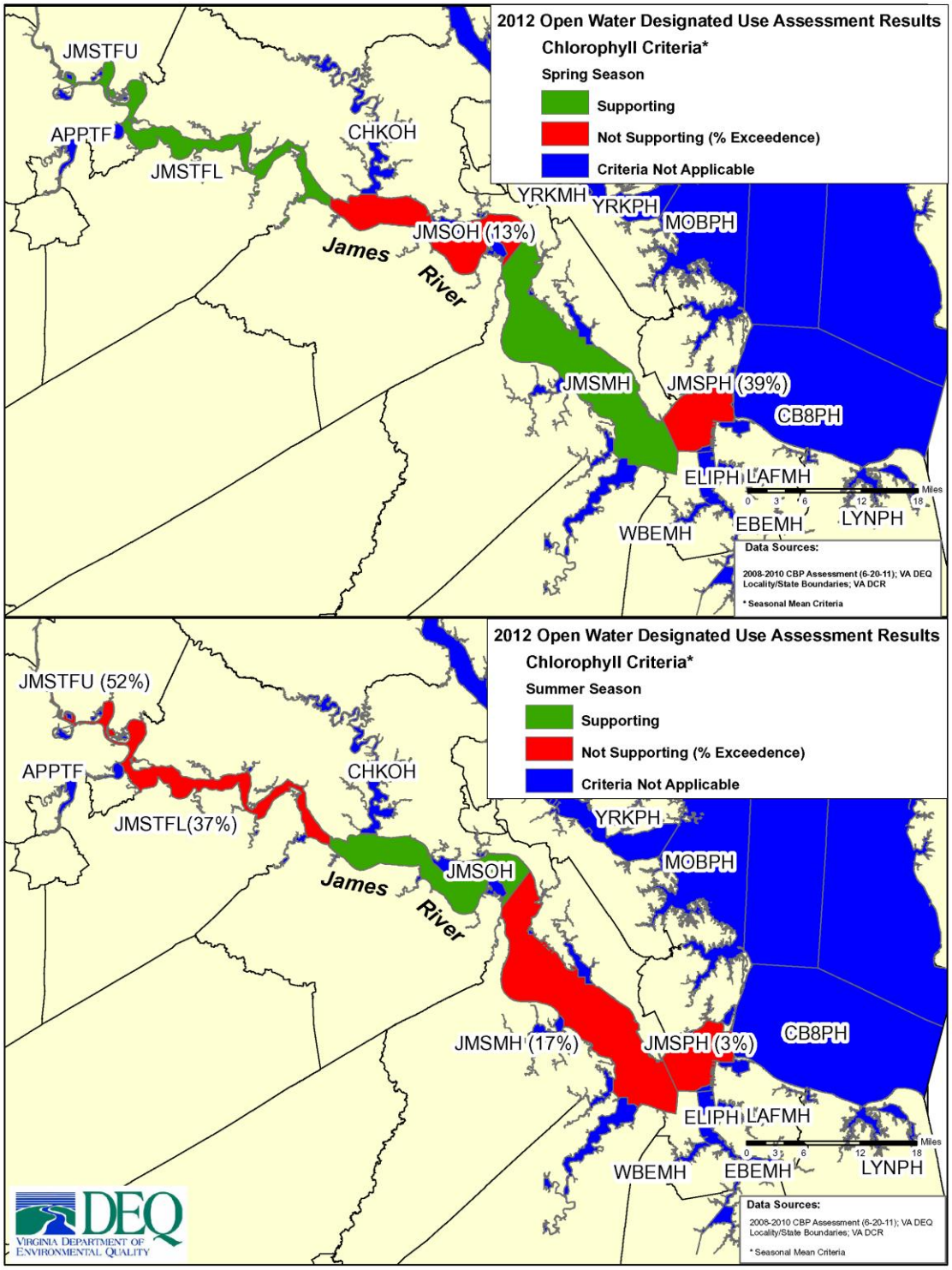


Figure 4.4-7 Attainment of the deep-water and deep-channel designated use (dissolved oxygen criteria) in 2012.

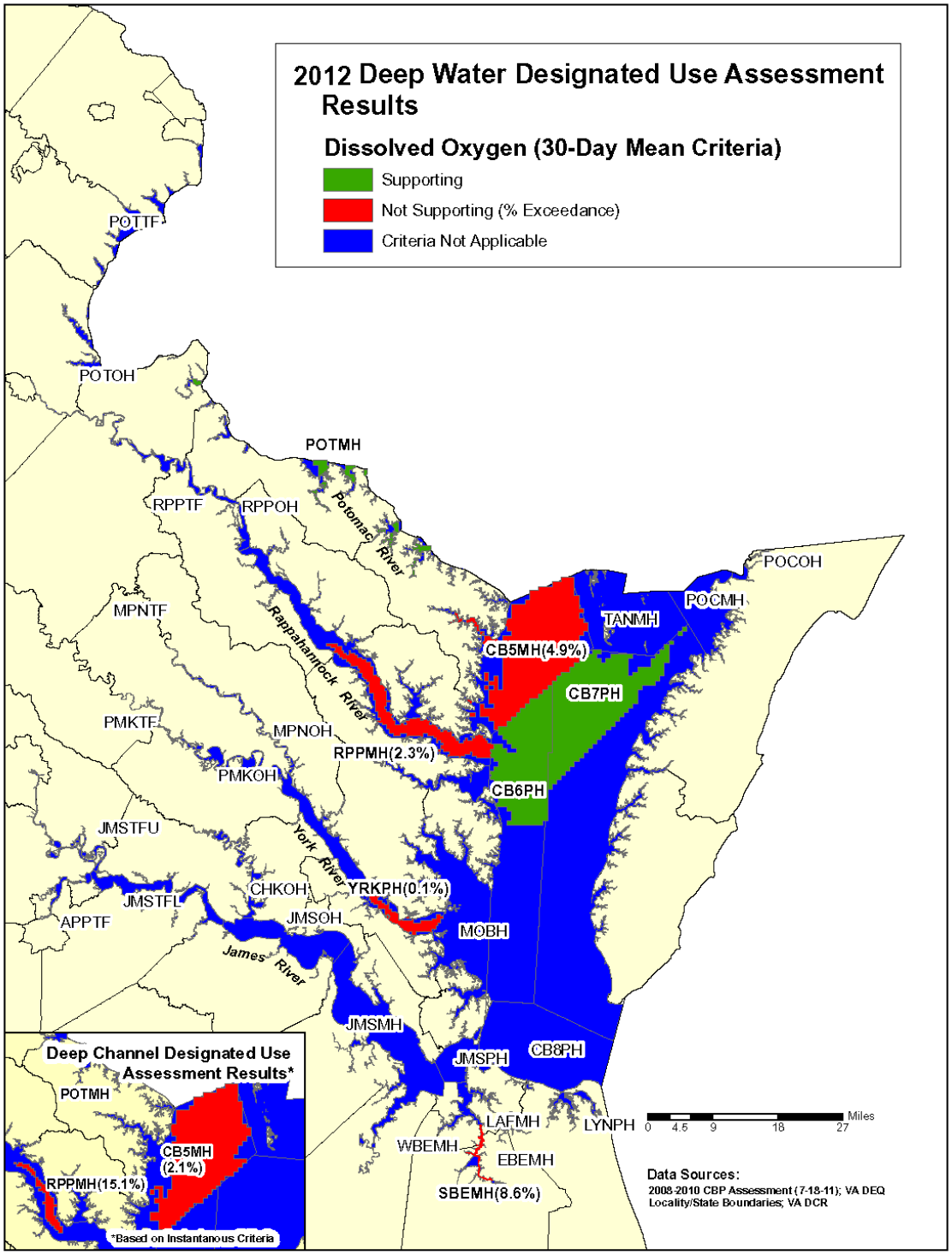
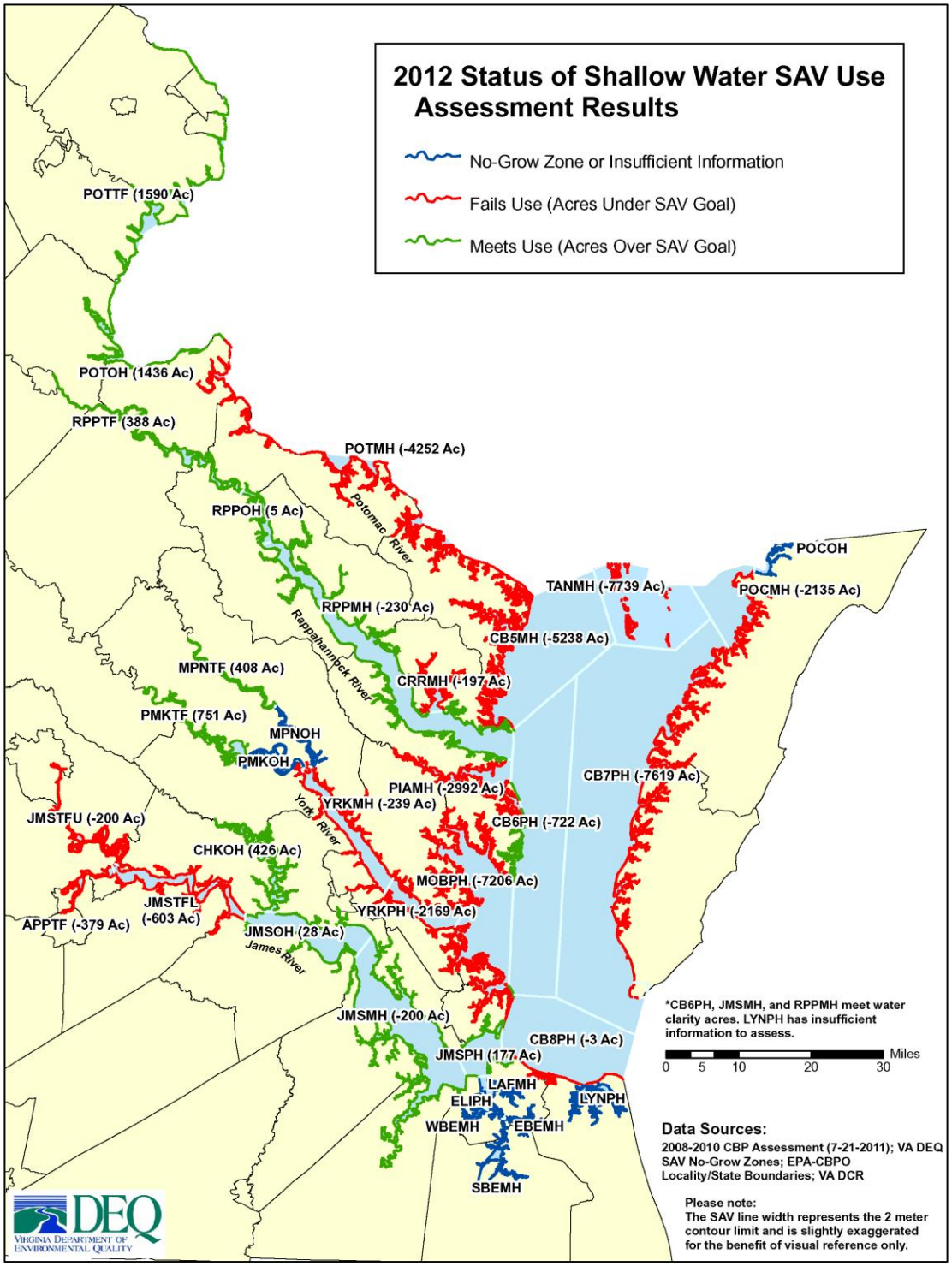


Figure 4.4-8. Attainment of the SWSAV designated use (SAV acres and water clarity acres criteria) in 2012.



Estuarine Benthic Bioassessment

Support status of the general aquatic life use as indicated by benthic community health throughout Chesapeake Bay and its tidal tributaries was performed in cooperation with EPA Region III, EPA Chesapeake Bay Program, Maryland Department of the Environment, Maryland Department of Natural Resources, and the Virginia Department of Environmental Quality. This section describes the assessment protocol and summarizes the key results. Technical details of statistical methods were previously described in *2006 303(D) Assessment Methods For Chesapeake Bay Benthos, Final Report Submitted to Virginia Department of Environmental Quality, Roberto J. Llansó, Jon H. Vølstad, Versar Inc., Daniel M. Dauer, Michael F. Lane, Old Dominion University, September 2005*.

The overall assessment protocol is conducted in three phases as shown in Figure 4.4-9. Table 4.4-4 shows the possible outcome scenarios from the three phases of the protocol.

Phase I examines if the sample size satisfies the requirements of the statistical method (N ≥ 10) during the six-year assessment window. Phase II consists of the aquatic life use assessment based on a comparison of Benthic Index of Biotic Integrity (B-IBI) scores between reference conditions and the assessment data utilizing a "percent degraded area" statistical methodology. Phase II can result in one of two possible outcomes: (1) the segment is not impaired for aquatic life use due to benthic community status (note that the segment may still be impaired for aquatic life use due to failure of the other Chesapeake Bay aquatic life use sub-categories), or (2) the segment fails to support aquatic life use due to benthic community status and is assessed as impaired.

Phase III consists of the identification of probable causes of benthic impairment of the waterbody segment based upon benthic stressor diagnostic analyses. It is a two step procedure that involves (1) Site Classification, and (2) Segment Characterization.

1) Site classification: The first step is to assign probable sources of benthic degradation to each individual "degraded" benthic sample. For the purpose of these diagnostic analyses, a sample is considered degraded if the B-IBI score is less than 2.7.

<u>Site Classification - Step 1a</u>: The application of a formal statistical linear discriminant function calculates the 'inclusion probability' of each degraded site belonging to a 'contaminant caused' group or an 'other causes' group, based upon its B-IBI score and associated metrics. If a site is assigned to the 'Contaminant' Group with a probability ≥ 0.9, this site is considered impacted by contaminated sediment and no further classification is required.

<u>Site Classification - Step 1b</u>: If a site is classified as degraded due to 'other causes' (*i.e.*, not contaminant-related), an evaluation of the relative abundance (and/or biomass) of the benthos is examined. Scores for both abundance and biomass are considered to be bipolar for the Chesapeake Bay Benthic IBI. For either metric; a high score of 5, indicating desirable conditions, falls in the mid-range of the abundance/biomass distributions, while a low score of 1, indicating undesirable conditions, can result either from insufficient abundance/biomass or excessive abundance/biomass. The scoring thresholds for these two metrics vary with habitat type (salinity regime and substrate type). In this process, a site is classified as degraded by "low dissolved oxygen" if the abundance (and/or biomass) metric scores a 1 due to insufficient abundance (and/or biomass). Alternatively, if the abundance (and/or biomass) metric scores a 1 because of excessive abundance (and/or biomass) the site is classified as degraded by "eutrophication".

1) Segment classification: The assignment of probable causes of benthic degradation for the overall segment is accomplished using a 25% rule. If the percent of total sites in a segment impacted by a single cause (i.e. sediment contaminants, low dissolved oxygen, or eutrophication) exceeds 25%, then that cause is assigned. If no causes exceed 25%, the cause is considered unknown. In the ADB

database, the cause(s) are identified as a suspected (vs. verified) cause of benthic community degradation.

Figure 4.4-9 Estuarine Benthic Bioassessment Protocol

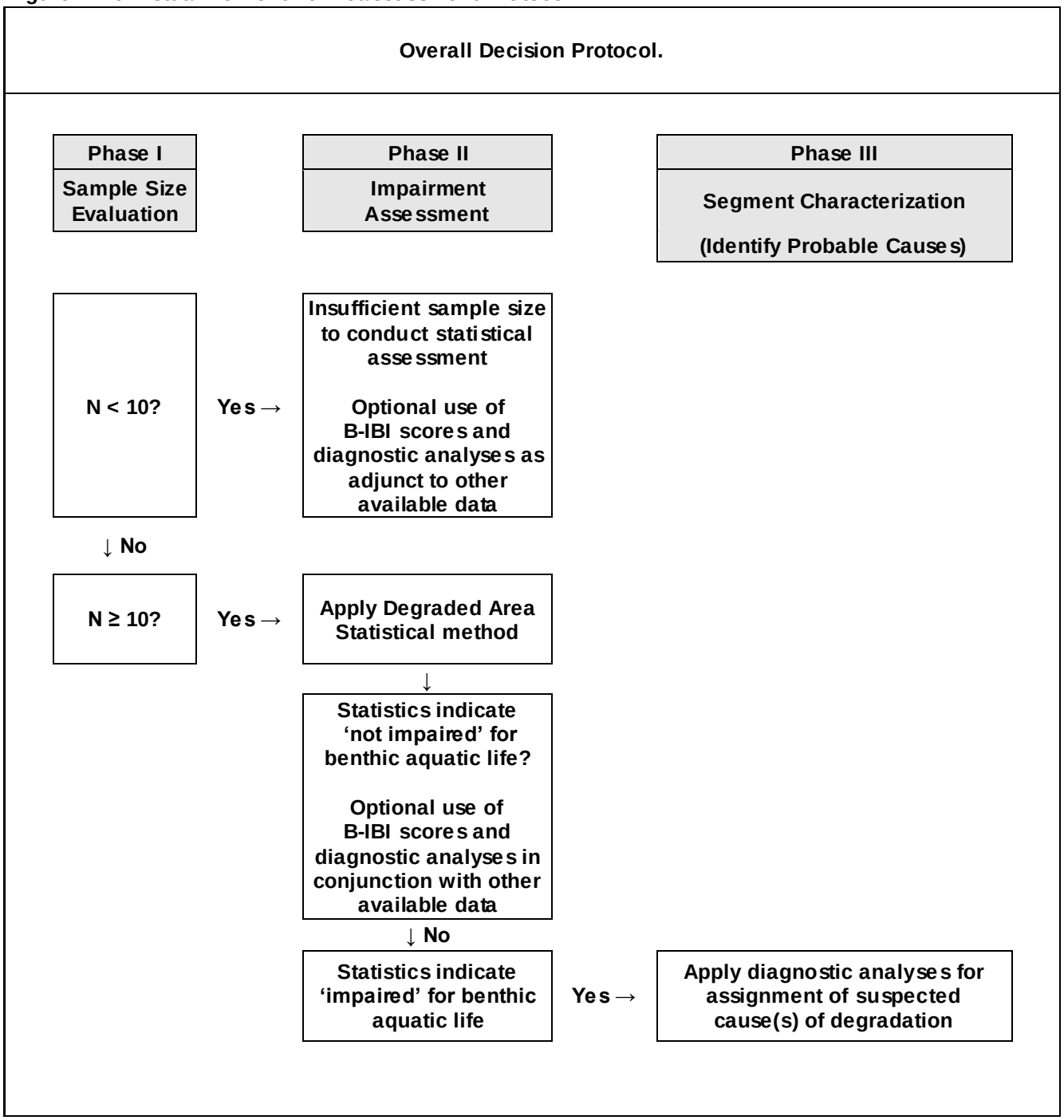


Table 4.4- 4 Outcome scenarios from benthic biological assessment. From: 2006 303(D) Assessment Methods For Chesapeake Bay Benthos, Final Report Submitted to: Virginia Department of Environmental Quality, Roberto J. Llansó, Jon H. Vølstad Versar, Inc., Daniel M. Dauer Michael F. Lane, Old Dominion University, September 2005

n>=10 - sufficient sample size for assessment					
	Impairment Analysis		**Stressor Diagnostic Analyses**		
Scenario	**CL-L ($P-P_0$) (Table 3 of VERSAR Technical Report)**	**Impaired: Degraded Area method? (Table 3 of VERSAR Technical Report)**	**Samples with contaminant Posterior Prob. *p*>= 0.90; % of Total (Table 5 of VERSAR Technical Report)**	**Degraded Samples with excessive Abundance/Biomass; % of Total w/o Cont. (Table 5 of VERSAR Technical Report)**	**Degraded Samples with Insufficient Abundance/Biomass; % of Total w/o Cont. (Table 5 of VERSAR Technical Report)**
1	≤0	No	review as supplemental info	review as supplemental info	review as supplemental info
• A small, non-significant fraction of IBI scores are within or below the lower range of the reference distribution so water quality conditions in this segment support the benthic community (no impairment). • Where community samples are degraded, the stressor analyses may provide information that supports other assessment data.					
2	>0	Yes	≤ 25% of Total Samples	≤ 25% of Total Samples	≤ 25% of Total Samples
• A large, significant fraction of IBI scores are within or below the lower range of the reference distribution, so water quality conditions in this segment do not support the benthic community (impaired condition). • Stressor diagnostic analyses do not suggest dominant stressors affecting community composition. Cause of degradation is "unknown".					
3	>0	Yes	> 25% of Total Samples	≤ 25% of Total Samples	≤ 25% of Total Samples
• A large, significant fraction of IBI scores are within or below the lower range of the reference distribution, so water quality conditions in this segment do not support the benthic community (impaired condition). • Stressor diagnostic analyses suggest sediment contaminants as a likely pollutant affecting benthic community structure.					
4	>0	Yes	> 25% of Total Samples	> 25% of Total Samples	≤ 25% of Total Samples
• A large, significant fraction of IBI scores are within or below the lower range of the reference distribution, so water quality conditions in this segment do not support the benthic community (impaired condition). • Stressor diagnostic analyses suggest sediment contaminants as a likely pollutant affecting benthic community structure. Observation of high biomass or abundance is indicative of eutrophic conditions as an additional stressor affecting the benthic community.					
5	>0	Yes	> 25% of Total Samples	≤ 25% of Total Samples	> 25% of Total Samples
• A large, significant fraction of IBI scores are within or below the lower range of the reference distribution, so water quality conditions in this segment do not support the benthic community (impaired condition). • Stressor diagnostic analyses suggest sediment contaminants as a likely pollutant affecting benthic community structure. Samples observed with low biomass or abundance is indicative of low dissolved oxygen as an additional stressor affecting the benthic community.					
6	>0	Yes	≤ 25% of Total Samples	> 25% of Total Samples	≤ 25% of Total Samples
• A large, significant fraction of IBI scores are within or below the lower range of the reference distribution, so water quality conditions in this segment do not support the benthic community (impaired condition). • Stressor diagnostic analyses do not suggest sediment contaminants as a stressors affecting community composition. Samples observed with high biomass or abundance is indicative of eutrophic conditions (excessive nutrients) as a stressor affecting the benthic community.					
7	>0	Yes	≤ 25% of Total Samples	> 25% of Total Samples	> 25% of Total Samples
• A large, significant fraction of IBI scores are within or below the lower range of the reference distribution, so water quality conditions in this segment do not support the benthic community (impaired condition). • Stressor diagnostic analyses do not suggest sediment contaminants as stressor affecting community composition. Samples observed with high biomass or abundance are indicative of eutrophic conditions within the segment while other samples observed with low biomass or abundance are indicative of low dissolved oxygen as another stressor within the segment.					
8	>0	Yes	≤ 25% of Total Samples	≤ 25% of Total Samples	> 25% of Total Samples

Table 4.4- 4 Outcome scenarios from benthic biological assessment. From: 2006 303(D) Assessment Methods For Chesapeake Bay Benthos, Final Report Submitted to: Virginia Department of Environmental Quality, Roberto J. Llansó, Jon H. Vølstad Versar, Inc., Daniel M. Dauer Michael F. Lane, Old Dominion University, September 2005					
• A large, significant fraction of IBI scores are within or below the lower range of the reference distribution, so water quality conditions in this segment do not support the benthic community (impaired condition). • Stressor diagnostic analyses do not suggest sediment contaminants as a stressor affecting community composition. Samples observed with low biomass or abundance is indicative of low dissolved oxygen as a stressor affecting the segment.					
9	>0	Yes	> 25% of Total Samples	> 25% of Total Samples	> 25% of Total Samples
• A large, significant fraction of IBI scores are within or below the lower range of the reference distribution, so water quality conditions in this segment do not support the benthic community (impaired condition). • Stressor diagnostic analyses suggest sediment contaminants as a likely pollutant affecting benthic community structure. Samples observed with high biomass or abundance are indicative of eutrophic conditions within the segment while other samples observed with low biomass or abundance are indicative of low dissolved oxygen as an additional stressor within the segment.					
n<10 – small sample size, insufficient for analysis					
1	n/a	Unknown, Not Assessed	review as supplemental info	review as supplemental info	review as supplemental info
• There are too few samples to define the confidence interval of benthic sample IBIs, so in this segment – the biological community condition is unknown. • Where community samples are identified as degraded, information from the stressor diagnostic analyses may provide supplemental information that may support other assessment data.					

Table 4.4-5a shows the estuarine benthic bioassessment results for 2012. Each segment is indicated as impaired or not impaired, and the suspected source of impairment and miscellaneous statistics are provided. Table 4.4-5b identifies the corresponding waterbodies for each segment ID's. The assessment segmentation for benthic health is slightly different than that used for the other Bay criteria. For benthos, segments consist of only the mainstem of major tidal tributaries (this also means the segmentation is according to named waterbodies). For example, the mesohaline James CBP segment (JMSMH in figure 4.4-3) is sub-divided into a "mainstem" James River assessment segment (i.e. JMSMHa of Table 4.4-5b) and a separate Nansemond River benthic assessment segment (i.e. JMSMHb of Table 4.4-5b). Each of these sub-segments has a separate benthic assessment result as shown in Figure 4.4-10.

Figure 4.4-10 shows a map of the results presented in Table 4.4-5a. Approximately 975 square miles of the estuarine aquatic life use is impaired as indicated by the benthic community assessment. This represents 77% of the total assessed Bay waters. The absolute impaired area is smaller than the impaired area in the 2010 report (1090 sq. miles) because the mesohaline portions of the York and James Rivers and the Corrotoman River, which were previously impaired, were assessed as unimpaired for the current assessment. However, there were more segments that had insufficient data (having less than ten samples) for assessment this cycle. It should also be noted that the total Bay system area impaired for benthics reported in Chapter 4.2 may be slightly higher than these numbers because the figures presented above do not include impairments identified by the National Coastal Assessment sampling program.

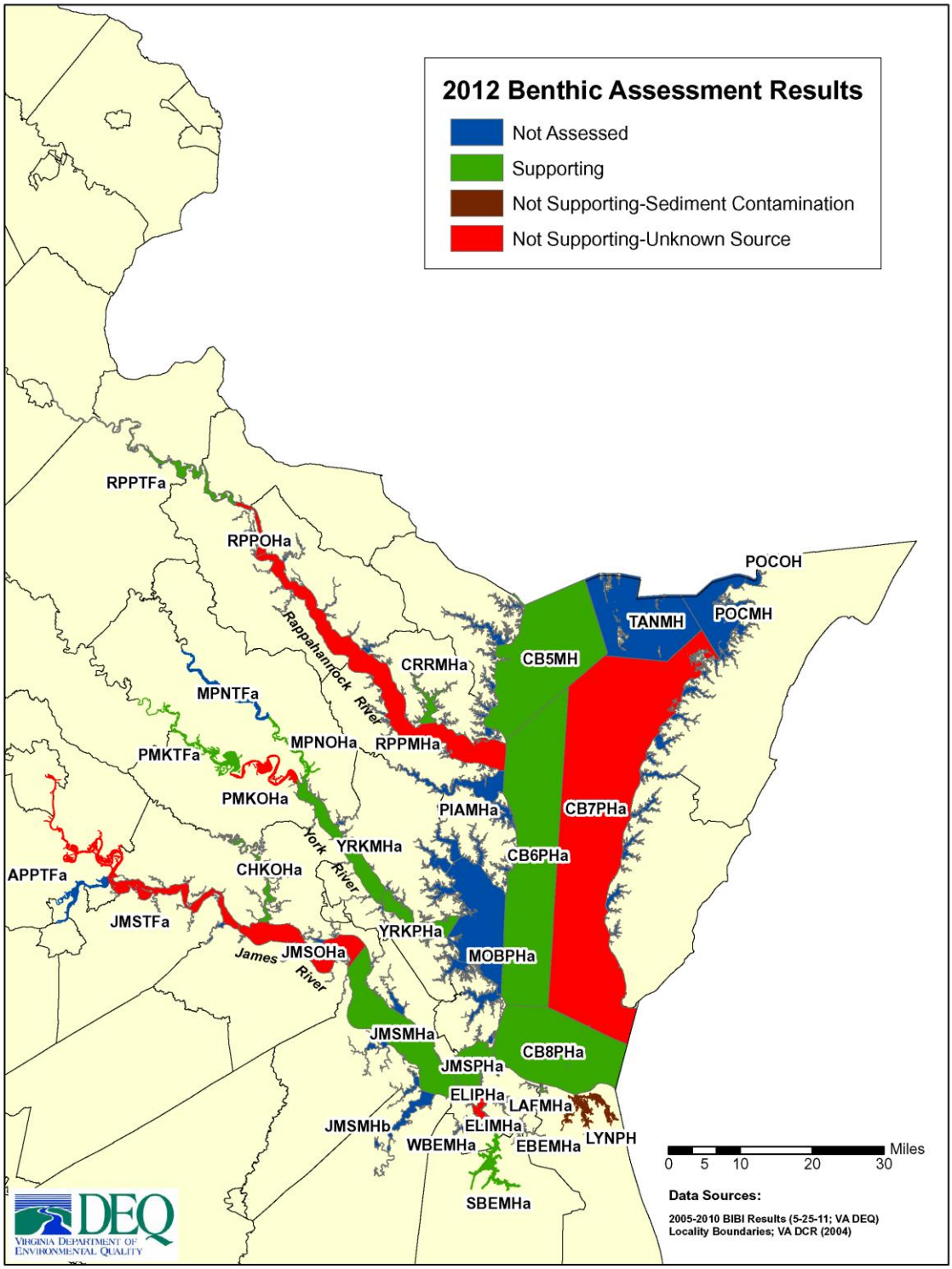
The analyses performed cannot determine the source of benthic community degradation for most of the assessed segments. Sediment contaminants are a suspected source of degradation for only the Lynnhaven River segment (LYNPH). Low dissolved oxygen is not implicated as a source in any impaired segment. This contrasts with the 2010 assessment, which found that low DO was the suspected cause of impairment for the Corrotoman River (CRRMH), which is currently unimpaired for benthics.

Table 4.4- 5a. Estuarine Benthic Analysis

Segment	Impaired (Y/N)	Mean B-IBI	Sample Size	% of Total Samples with contaminant Posterior Prob. (*p*>= 0.90)	% of Total Degraded Samples with excessive Abundance/Biomass (w/o Contaminants)	% of Total Degraded Samples with Insufficient Abundance/Biomass (w/o Contaminant)	Suspected Sources of Degradation
CB5MH	NO	2.9	20	6%	0%	0%	NA
CB6Pha	NO	3.2	24	0%	0%	12.5%	NA
CB7Pha	**YES**	3.1	67	2%	0%	11%	Unknown
CB8Pha	NO	3.1	14	7%	0%	0%	NA
CHKOHa	NO	2.9	10	0%	0%	0%	NA
CRRMHa	NO	2.0	17	27%	0%	33%	NA
EBEMHa	NA	2.4	5	50%	0%	0%	NA
ELIMHa	**YES**	2.2	35	24%	0%	0%	Unknown
ELIPHa	**YES**	2.6	15	7%	0%	13%	Unknown
JMSMHa	NO	2.7	74	9%	0%	4%	NA
JMSMHb	NA	2.6	9	33%	0%	0%	NA
JMSOHa	**YES**	2.5	26	27%	0%	0%	Unknown
JMSPHa	NO	3.0	22	9%	0%	0%	NA
JMSTFa	**YES**	3.0	27	0%	0%	0%	Unknown
LAFMHa	NA	2.6	9	22%	0%	0%	NA
LYNPHa	**YES**	2.1	177	28%	5%	13%	Unknown
MOBPHa	NA	3.3	8	0%	0%	0%	NA
MPNOHa	NO	3.2	11	18%	0%	9%	NA
MPNTFa	NA	2.3	2	0%	0%	0%	NA
PIAMHa	NA	1.7	5	67%	0%	33%	NA
PMKOHa	**YES**	3.0	21	20%	0%	5%	Unknown
PMKTFa	NO	3.3	12	0%	0%	0%	NA
POCMH	NA	2.5	7	0%	0%	50%	NA
POCOH	NA	2.7	1	0%	0%	0%	NA
RPPMHa	**YES**	2.2	124	17%	0%	19%	Unknown
RPPOHa	**YES**	2.2	16	25%	0%	0%	Unknown
RPPTFa	NO	3.1	10	0%	0%	0%	NA
SBEMHa	NO	2.2	12	50%	0%	0%	NA
TANMH	NA	3.6	7	0%	0%	0%	NA
WBEMHa	NA	2.3	9	44%	0%	11%	NA
YRKMHa	NO	2.5	75	19%	0%	3%	NA
YRKPHa	NO	2.4	35	23%	0%	9%	NA

Table 4.4- 5b Segment ID's and corresponding waterbody.	
Segment	**Waterbody**
APPTFa	Appomattox River, Mainstem of APPTF
MPNOHa	Mattaponi River, mainstem of MOBPH
MPNTFa	Mattaponi River, mainstem of MPNTF
CB5MH	Maryland/Virginia mainstem
CB6PHa	Virginia Bay, mainstem of CB6PH
CB7PHa	Virginia Bay, mainstem of CB7PH
CB8PHa	Virginia Bay, mainstem of CB8PH
EBEMHa	Elizabeth River Eastern Branch
ELIMHa	Elizabeth River, mainstem of ELIMH
ELIPHa	Elizabeth River, mainstem of ELIPH
JMSMHa	James River, mainstem of JMSMHa
JMSMHb	Nansemond River
JMSOHa	James River, mainstem of JMSOHa
JMSPHa	James River, mainstem of JMSPH
POCMH	Pocomoke Sound
POCOH	Pocomoke River
POCTF	Pocomoke River
MPNOHa	Mattaponi River, mainstem of MOBPH
MPNTFa	Mattaponi River, mainstem of MPNTF
PMKOHa	Pamunkey River, Mainstem of PMKOH
SBEMHa	Elizabeth River Southern Branch, mainstem of SBEMH
WBEMHa	Elizabeth River Western Branch, mainstem of WBEMH
JMSTFa	James River, mainstem of JMSTF
LAFMHa	Lafayette River
MOBPHa	Mobjack Bay
TANMH	Tangier Sound
POCMH	Pocomoke Sound
POCOH	Pocomoke River
POCTF	Pocomoke River
RPPMHa	Rappahannock River, mainstem of RPPMH
RPPMHd	Robinson Creek
RPPMHm	Totuskey Creek
RPPOHa	Rappahannock River
RPPTFa	Rappahannock River, mainstem of RPPTF
TANMH	Tangier Sound
YRKMHa	York River, mainstem of YRKMH
YRKMHb	Queen Creek
YRKPHa	York River, mainstem of YRKPH

Figure 4.4-10 2012 Estuarine Benthic Biological Assessment.



Chesapeake Bay and Tributaries Aquatic Life Use and Sub-use Listing

The Integrated Report listing methodology addresses the goals of maintaining continuity with previous methodologies, accurately reflecting the assessment results of new uses and criteria and—more importantly--protecting and restoring aquatic life. The listing methodology for the new aquatic life use sub-categories was developed by a Water Quality Criteria Assessment Workgroup involving EPA Region III, EPA Chesapeake Bay Program, Maryland Department of the Environment, Maryland Department of Natural Resources, and the Virginia Department of Environmental Quality. The workgroup's efforts will continue through future modifications as necessary to assure Bay-wide consistency. The main rules for designated use attainment categorization are:

- Aquatic life use is listed as impaired and having a TMDL (i.e. category 4A) if any aquatic life sub-use (i.e. SWSAV, MSN, OW, DW, DC) is not supported. The sub-use impairment cause (e.g. dissolved oxygen, aquatic vegetation, or chlorophyll-a) is designated as both the sub-use and the aquatic life use impairment cause.

- Waters previously listed as impaired (i.e. category 5A) for aquatic life use because of low dissolved oxygen or nutrients will remain in category 4A until all applicable criteria for aquatic life sub-uses are assessed. This "carry-forward" of previous impairments will be listed as aquatic life use impairment due to dissolved oxygen cause (if previous listing was for dissolved oxygen) or "biological indicators/nutrient enrichment" cause (if "nutrients" was the cause listed previously). All applicable dissolved oxygen criteria must be assessed and attained in order for a DO-related sub-use (i.e. MSN, OW, DW, DC) to be fully supported. If only a sub-set of applicable dissolved oxygen criteria are attained (e.g. only the 30-day criteria) and remaining criteria (e.g. 7-day, instantaneous) are un-assessed, the sub-use will be listed as having "insufficient data".

- The shallow-water submerged aquatic vegetation (SWSAV) use is fully supporting if any of the criteria for this use is met. For example, if sufficient water clarity is present (i.e. "Water Clarity Acres" criterion is met), then the SWSAV designated use is supported regardless of the presence or absence of sufficient submerged aquatic vegetation (i.e. "SAV Acres" criterion is not met). This is because there can be many non-pollutant causes for the lack of SAV acres such as lack of propagule availability, herbivory by turtles, waterfowl, etc. or habitat disruption by cow-nosed rays.

Aquatic Life Use Assessment and Listing Results

Table 4.4-6 presents aquatic life designated use and sub-use support for the Chesapeake Bay and its tidal tributaries. The Deep Water Aquatic Life Use subcategory (DW), Deep Channel Aquatic Life Use subcategory (DC), Shallow Water Aquatic Life Use subcategory (SWSAV), and Aquatic Life Use sizes in this chapter may be different than reported in other chapters or summarized from the Assessment Data Base (ADB v2.2.0). This is because of the complex spatial nature of the Bay uses and limitations of reporting capability of ADB. A few of the confounding issues and differences between results in this chapter and area summarizations in other chapters created from ADB are listed below.

- The area of DW and DC is inaccurate in ADB. Area of DW and DC reported in this chapter vary in square mileage size within assessment units and between reporting periods due to the naturally varying depth of pycnoclines. However, DW and DC area ADB can only be reported as existing throughout the complete assessment unit.

- The area of SWSAV use is inaccurate in ADB. The SWSAV designated use exists only within the area defined by the SAV acres criteria. For example, CBP Segment CB5PH has an SAV acres criterion of 7,633 acres (see Table 4.4-2) therefore the area of SWSAV designated use for this segment is 7,633 acres (i.e. 11.9 square miles). However, within ADB the size of SWSAV use within

this segment can only be reported as the complete area of the assessment unit (i.e. 215 square miles). The figures reported in this chapter are therefore more accurate.

- Related to the above, the area of impairment for aquatic life use within ADB is often incorrect. For example, segment CB8PH failed the SWSAV use, so the segment also fails the aquatic life use. The area of SWSAV use within this segment is only 11 acres (0.02 square miles), making the accurate area of aquatic life use impairment only 0.02 square miles. However, within ADB the area of aquatic life use can only be reported as the complete area of the assessment unit (48.4 square miles). The figures for impairment area reported in this chapter are more accurate than what appears in ADB.

- This chapter reports only the aquatic life use and sub-use impairments due to dissolved oxygen, water clarity, chlorophyll, and benthic community assessments. Some waters have met all the assessed criteria for these parameters, but may be impaired in ADB for aquatic life due to other parameters (e.g. pH, chloride, bacteria, toxics, etc.). Aquatic life use impairments due to these other parameters are not reported in this chapter.

Table 4.4-6 shows that a total of 1783 sq. miles (82% of the total area) of the Bay and tributaries is impaired for the aquatic life use due to oxygen, water clarity, chlorophyll, or benthic community assessment. The open-water sub-use has the largest area of impairment (1465 sq. miles) and thus is the largest contributor to overall aquatic life use non-attainment. Sixty-seven percent (67%) of the areal extent of this sub-use is impaired. The extent of the deep-water sub-use that is impaired is 46% (238 sq. miles) of the assessed area, and 100% of the deep channel sub-use extent is impaired (164 sq. miles). The smallest Bay designated use by area, the shallow-water submerged aquatic vegetation use, is 53% impaired (64 sq. miles). The complete area of Migratory Fish Spawning and Nursery was not assessed in 2012 due to lack of an approved assessment method.

Table 4.4-7 presents the cause of impairment of the designated uses. The majority of impairment is due to dissolved oxygen depletion. As shown in the 2010 report, dissolved oxygen impairment was not limited to deeper waters, but many areas of generally more shallow waters, relatively well mixed, or close to inputs of oxygen rich oceanic waters also have impaired conditions for dissolved oxygen. The second largest cause for impairment is degraded benthic macroinvertebrate communities, as determined by biological integrity assessments. Most of this impairment is due to unknown causes. (see Figure 4.4-10). The third largest cause of impairment is excessive levels of chlorophyll *a*. The smallest cause of impairment is lack of sufficient submerged aquatic vegetation. The lack of submerged aquatic vegetation has been generally attributed to overall declines in water clarity throughout the Chesapeake Bay and tributaries.

Table 4.4-8 shows the designated uses, detailed criteria assessment results, and listing category for each CBP program segment.

Table 4.4-6. 2012 Chesapeake Bay and Tributaries aquatic life use status for oxygen, water clarity, chlorophyll and benthic impairments (Units: Square miles)

Designated Use	Total Size Assessed	Size Supporting (Category 2C)	Size Impaired (Category 5 or 4A)	Size Not Assessed	Size with Insufficient Info (Category 3B)	Size Classified as Naturally Impaired
Aquatic Life Use (ALUS)	2,173	53	2117	0	0	3
Open Water Aquatic Life (OW-ALUS)	2,173	703	1,465	0	0	3
Deep Water	516	13	238	0	265	0

Designated Use	Total Size Assessed	Size Supporting (Category 2C)	Size Impaired (Category 5 or 4A)	Size Not Assessed	Size with Insufficient Info (Category 3B)	Size Classified as Naturally Impaired
Aquatic Life (2) (DW-ALUS)						
Deep-Channel Seasonal Refuge (2) (DC-ALUS)	164	0	164	0	0	0
Shallow Water Submerged Aquatic Vegetation (2) (SWSAV)	121*	57 **	64***	0	0.2	0
Migratory Fish Spawning and Nursery Aquatic Life (MSN)	0	0	0	0	351	0

1) Some portion of this mileage may be not supporting the aquatic life use due to parameters other than oxygen, water clarity, chlorophyll or benthic community (e.g. chloride, pH).
2) These numbers may not correspond with sizes reported in the Executive Summary or other chapters because of limitations and usage as described in chapter text. They are reported here for tracking changes in the sizes of these impairments between reporting periods.
* This is the sum total SAV criteria (in square miles) for all CBP segments.
** This is the sum total of SAV coverage (in square miles) observed in any single best year of the most recent 3 years, not exceeding segment-specific goals.
*** This is the difference between total SAV criteria and the SAV coverage observed in any single best year of the most recent 3 years.

Table 4.4-7 Chesapeake Bay impairment causes by impacted area (Units: Square miles)

Impairment Cause	Total Size
OXYGEN DEPLETION (1)	1,605
BIOLOGIC INTEGRITY (BIOASSESSMENTS)	834
CHLOROPHYLL-A	203
AQUATIC PLANTS (MACROPHYTES) (1)	64

1) These numbers may not correspond with sizes reported in the Executive Summary or other chapters because of limitations and usage as described in chapter text. They are reported here for tracking changes in the sizes of these impairments between reporting periods.

Table 4.4-8. Data assessment results and assessment determination by CBP segment and designated use.

Legend

Data Assessment Results

Cell Shading	Analysis Result
	Criteria Not Applicable
	Insufficient Data or lack of approved methods to assess criteria
	Attainment of Criteria
	Non-Attainment of Criteria

Use Assessment Category	Description
5D	The water quality standard is not attained for one or more designated uses. There is a TMDL for some impairment(s) related to this designated use, but not all the impairments. Thus, the water is in need of a TMDL.
4A	The water quality standard is not attained but there is a TMDL for known impairments.
3B	Some data exists but is insufficient to determine attainment of designated uses.
2C	Waters are supporting all of the uses for which they are monitored, and there is also a TMDL.

Miscellaneous

ALUS RESULT: The assessment determination for Aquatic Life Use in this row includes benthos criterion assessment result, plus impairments for the aquatic life use subcategories within the segment, plus the "worst case" use assessment category from aquatic life use subcategories within the segment.

MSN: Migratory Spawning and Nursery Aquatic Life Use Subcategory.

OW: Open Water Aquatic Life Use Subcategory.

DW: Deep Water Aquatic Life Use Subcategory.

SWSAV: Shallow Water Aquatic Life Use Subcategory.

Spring: Spring Time assessment period. For chlorophyll criterion this is March through May. For MSN dissolved oxygen criteria this is February through May.

Summer: Summer Time assessment period. For dissolved oxygen this is June - September. For Chlorophyll this is July - September.

ROY: Non-Summer "Rest of Year" assessment period. For dissolved oxygen this is Oct. - May. For Chlorophyll this is March-May.

30D: 30- Day Dissolved Oxygen Criterion.

7D: 7- Day Dissolved Oxygen Criterion.

1D: 1 Day Mean Dissolved Oxygen Criterion.

IM: Instantaneous Minimum Dissolved Oxygen Criterion.

SAV: Submerged Aquatic Vegetation.

WC: Water Clarity.

Chl: Numeric Chlorophyll Criterion. Numeric Chlorophyll criterion is applicable only to James River. Narrative criterion applies to remaining Bay and Tidal Tributaries.

		Data Assessment Results Presented by Subcategory									Assessment Determination		
		Dissolved Oxygen					SAV						
Bay Segment	Designated Use (1)	Time Period	30D	7D	1D	IM	SAV Acres	WC Acres	Chl	Benthos (2)	Assessment Decision	Impairments (2)	Use Assessment Category
APPTF	**ALUS RESULT**										**Fails but has TMDL**	**Aquatic Vegetation**	**4A**
APPTF	MSN	Spring									Insufficient Information		3B
APPTF	OW	ROY									Meets		2C
		Summer											
APPTF	SWSAV										**Fails but has TMDL**	Aquatic Vegetation	4A
CB5MH	**ALUS RESULT**										**Fails but has TMDL**	**Aquatic Vegetation, Dissolved Oxygen**	**4A**
CB5MH	DC	Summer									Fails but has TMDL	Dissolved Oxygen	4A
CB5MH	DW	Summer									Fails but has TMDL	Dissolved Oxygen	4A
CB5MH	OW	ROY									Insufficient Data - Previously Listed		3B (3)
		Summer											

		Data Assessment Results Presented by Subcategory									Assessment Determination		
		Dissolved Oxygen					SAV						
Bay Segment	Designated Use (1)	Time Period	30D	7D	1D	IM	SAV Acres	WC Acres	Chl	Benthos (2)	Assessment Decision	Impairments (2)	Use Assessment Category
CB5MH	SWSAV										Fails but has TMDL	Aquatic Vegetation	4A
CB6PH	**ALUS RESULT**										**Fails but has TMDL**	**Dissolved Oxygen**	**4A**
CB6PH	DW	Summer									Insufficient Data - Previously Listed		3B (3)
CB6PH	OW	ROY									Fails but has TMDL	Dissolved Oxygen	4A
		Summer											
CB6PH	SWSAV										Meets		2C
CB7PH	**ALUS RESULT**										**Fails but has TMDL**	**Aquatic Vegetation, Dissolved Oxygen, Benthic Community**	**5D (2)**
CB7PH	DW	Summer									Insufficient Data - Previously Listed		3B (3)
CB7PH	OW	ROY									Fails but has TMDL	Dissolved Oxygen	4A
		Summer											
CB7PH	SWSAV										Fails but has TMDL	Aquatic Vegetation	4A
CB8PH	**ALUS RESULT**										**Fails but has TMDL**	**Aquatic Vegetation**	**4A**
CB8PH	OW	ROY									Meets		2C (4)
		Summer											
CB8PH	SWSAV										Fails but has TMDL	Aquatic Vegetation	4A
CHKOH	**ALUS RESULT**										**Meets**		**2C**
CHKOH	MSN	Spring									Insufficient Data		3B
CHKOH	OW	ROY									**Meets**		2C
		Summer											
CHKOH	SWSAV										Meets		2C
CRRMH	**ALUS RESULT**										**Fails but has TMDL**	**Dissolved Oxygen, Aquatic Vegetation**	**4A**
CRRMH	OW	ROY									Fails but has TMDL	Dissolved Oxygen	4A
		Summer											
CRRMH	SWSAV										Fails but has TMDL	Aquatic Vegetation	4A
EBEMH	**ALUS RESULT**										**Fails but has TMDL**	**Dissolved Oxygen**	**4A**
EBEMH	OW	ROY									Fails but has TMDL	Dissolved Oxygen	4A
		Summer											
ELIPH	**ALUS RESULT**										**Fails but has TMDL except for benthics**	**Benthic Community, Dissolved Oxygen**	**5D (2)**
ELIPH	OW	ROY									Fails but has TMDL	Dissolved Oxygen	4A
		Summer											
JMSMH	**ALUS RESULT**										**Fails but has TMDL**	**Dissolved Oxygen,Chlorophyll-a**	**4A**
JMSMH	MSN	Spring									Insufficient Data		3B
JMSMH	OW	ROY									Fails but has	Chlorophyll-a	4A

		Data Assessment Results Presented by Subcategory									Assessment Determination		
		Dissolved Oxygen					SAV						
Bay Segment	Designated Use (1)	Time Period	30D	7D	1D	IM	SAV Acres	WC Acres	Chl	Benthos (2)	Assessment Decision	Impairments (2)	Use Assessment Category
		Summer									TMDL		
JMSMH	SWSAV										Meets		2C
JMSOH	**ALUS RESULT**										**Fails but has TMDL except for benthics**	**Benthic Community, Chlorophyll-a**	**5D (2)**
JMSOH	MSN	Spring									Insufficient Data		3B
JMSOH	OW	ROY									Fails but has TMDL	Chlorophyll-a	4A
		Summer											
JMSOH	SWSAV										Meets		2C
JMSPH	**ALUS RESULT**										**Fails but has TMDL**	Chlorophyll-a	**4A**
JMSPH	OW	ROY									F Fails but has TMDL	Chlorophyll-a	4A
		Summer											
JMSPH	SWSAV										Meets		2C
JMSTF1 - Lower	**ALUS RESULT**										**Fails but has TMDL except for benthics**	**Benthic Community, Dissolved Oxygen, Chlorophyll-a, Aquatic Vegetation**	**5D (2)**
JMSTF1 - Lower	MSN	Spring									Insufficient Data		3B
JMSTF1 - Lower	OW	ROY									Fails but has TMDL	Dissolved Oxygen, Chlorophyll-a	4A
		Summer											
JMSTF1 - Lower	SWSAV										Fails but has TMDL	Aquatic Vegetation	4A
JMSTF2 - Upper	**ALUS RESULT**										**Fails but has TMDL except for benthics**	**Benthic Community, Chlorophyll-a, Aquatic Vegetation**	**5D (2)**
JMSTF2 - Upper	MSN	Spring									Insufficient Data		3B
JMSTF2 - Upper	OW	ROY									Fails but has TMDL	Chlorophyll-a	4A
		Summer											
JMSTF2 - Upper	SWSAV										Fails but has TMDL	Aquatic Vegetation	4A
LAFMH	**ALUS RESULT**										**Fails but has TMDL**	**Dissolved Oxygen**	**4A**
LAFMH	OW	ROY									Fails but has TMDL	Dissolved Oxygen	4A
		Summer											
LYNPH	ALUS RESULT										**Fails but has TMDL except for benthics**	Aquatic Vegetation, Benthic Community, Dissolved Oxygen	5D (2)
LYNPH	OW	ROY									Fails but has TMDL	Dissolved Oxygen	4A
		Summer											
LYNPH	SWSAV										Fails but has TMDL	Aquatic Vegetation	4A
MOBPH	**ALUS RESULT**										**Fails but has TMDL**	**Aquatic Vegetation, Dissolved Oxygen**	**4A**
MOBPH	OW	ROY									Fails but has	Dissolved Oxygen	4A

		Data Assessment Results Presented by Subcategory									Assessment Determination		
		Dissolved Oxygen					SAV						
Bay Segment	Designated Use (1)	Time Period	30D	7D	1D	IM	SAV Acres	WC Acres	Chl	Benthos (2)	Assessment Decision	Impairments (2)	Use Assessment Category
		Summer									TMDL		
MOBPH	SWSAV										Fails but has TMDL	Aquatic Vegetation	4A
MPNOH	**ALUS RESULT**										**Fails but has TMDL**	**Dissolved Oxygen**	**4A**
MPNOH	MSN	Spring									Insufficient Data		3B
MPNOH	OW	ROY									Fails but has TMDL	Dissolved Oxygen	4A
		Summer											
MPNTF	**ALUS RESULT**										**Fails but has TMDL**	**"Nutrients" Overlist**	**4A**
MPNTF	MSN	Spring									Insufficient Data		3B
MPNTF	OW	ROY									Insufficient Data - Previously Listed		3B (3)
		Summer											
MPNTF	SWSAV										Meets		2A
PIAMH	**ALUS RESULT**										**Fails but has TMDL**	**Aquatic Vegetation**	**4A**
PIAMH	OW	ROY									Meets		2C
		Summer											
PIAMH	SWSAV										Fails but has TMDL	Aquatic Vegetation	4A
PMKOH	**ALUS RESULT**										**Fails but has TMDL except for benthics**	**Benthic Community**	**5D (2)**
PMKOH	MSN	Spring									Insufficient Data		3B
PMKOH	OW	ROY									Insufficient Data - Previously Listed		3B (3)
		Summer											
PMKTF	**ALUS RESULT**										Fails but has TMDL	**"Nutrients" Overlist**	**4A**
PMKTF	MSN	Spring									Insufficient Data		3B
PMKTF	OW	ROY									Insufficient Data - Previously Listed		3B (3)
		Summer											
PMKTF	SWSAV										Meets		4A
POCMH	**ALUS RESULT**										**Fails but has TMDL**	**Aquatic Vegetation**	**4A**
POCMH	OW	ROY									Meets		2C (4)
		Summer											
POCMH	SWSAV										Fails but has TMDL	Aquatic Vegetation	4A
POCOH	**ALUS RESULT**										**Fails but does not require TMDL**	**Dissolved Oxygen**	**4C**
POCOH	MSN	Spring									Insufficient Data		3B
POCOH	OW	ROY									Natural Impairment	Dissolved Oxygen	4C
		Summer											
POTMH	**ALUS RESULT**										**Fails but has TMDL**	**Aquatic Vegetation**	**4A**

		Data Assessment Results Presented by Subcategory									Assessment Determination		
		Dissolved Oxygen					SAV						
Bay Segment	Designated Use (1)	Time Period	30D	7D	1D	IM	SAV Acres	WC Acres	Chl	Benthos (2)	Assessment Decision	Impairments (2)	Use Assessment Category
POTMH	DC	Summer									Meets		2C
POTMH	DW	Summer									Meets		2C (4)
POTMH	MSN	Spring									Insufficient Data		3B
POTMH	OW	ROY									Meets		2C (4)
		Summer											
POTMH	SWSAV										Fails but has TMDL	Aquatic Vegetation	4A
POTOH	**ALUS RESULT**										**Meets**		**2C (4)**
POTOH	MSN	Spring									Insufficient Data		3B
POTOH	OW	ROY									Meets		2C (4)
		Summer											
POTOH	SWSAV										Meets		2C
POTTF	**ALUS RESULT**										**Meets**		**2C (4)**
POTTF	MSN	Spring									Insufficient Data		3B
POTTF	OW	ROY									Meets		2C (4)
		Summer											
POTTF	SWSAV										Meets		2C
RPPMH	**ALUS RESULT**										**Fails but has TMDL except for benthics**	**Dissolved Oxygen, Benthic Community**	**5D (2)**
RPPMH	DC	Summer									Fails but has TMDL	Dissolved Oxygen	4A
RPPMH	DW	Summer									Fails but has TMDL	Dissolved Oxygen	4A
RPPMH	MSN										Insufficient Data		3B
RPPMH	OW	ROY									Insufficient Data		3B
		Summer											
RPPMH	SWSAV										Meets		2C
RPPOH	**ALUS RESULT**										**Fails but has TMDL**	**Benthic Community**	**5F (2)**
RPPOH	MSN	Spring									Insufficient Data		3B
RPPOH	OW	ROY									Meets		2C (4)
		Summer											
RPPOH	SWSAV										Meets		2C
RPPTF	**ALUS RESULT**										**Meets**		**2C (4)**
RPPTF	MSN	Spring									Insufficient Data		3B
RPPTF	OW	ROY									Meets		2C
		Summer											
RPPTF	SWSAV										Meets		2C
SBEMH	**ALUS RESULT**										**Fails but has TMDL**	**Dissolved Oxygen**	**4A**
SBEMH	DW	Summer									Fails but has TMDL	Dissolved Oxygen	4A

		Data Assessment Results Presented by Subcategory									Assessment Determination		
		Dissolved Oxygen					SAV						
Bay Segment	Designated Use (1)	Time Period	30D	7D	1D	IM	SAV Acres	WC Acres	Chl	Benthos (2)	Assessment Decision	Impairments (2)	Use Assessment Category
SBEMH	OW	ROY									Fails but has TMDL	Dissolved Oxygen	4A
		Summer											
TANMH	**ALUS RESULT**										**Fails but has TMDL**	**Aquatic Vegetation, Dissolved Oxygen**	**4A**
TANMH	OW	ROY									Fails but has TMDL	Dissolved Oxygen	4A
		Summer											
TANMH	SWSAV										Fails but has TMDL	Aquatic Vegetation	4A
WBEMH	**ALUS RESULT**										**Fails but has TMDL**	**Dissolved Oxygen**	**4A**
WBEMH	OW	ROY									Fails but has TMDL	Dissolved Oxygen	4A
		Summer											
YRKMH	**ALUS RESULT**										**Fails but has TMDL**	**Dissolved Oxygen, Aquatic Vegetation**	**4A**
YRKMH	MSN	Spring									Insufficient Data		3B
YRKMH	OW	ROY									Fails but has TMDL	Dissolved Oxygen	4A
		Summer											
YRKMH	SWSAV										Fails but has TMDL	Aquatic Vegetation	4A
YRKPH	**ALUS RESULT**										**Fails but has TMDL**	**Dissolved Oxygen, Aquatic Vegetation**	**4A**
YRKPH	DW	Summer									Fails but has TMDL	Dissolved Oxygen	4A
YRKPH	OW	ROY									Fails but has TMDL	Dissolved Oxygen	4A
		Summer											
YRKPH	SWSAV										Fails but has TMDL	Aquatic Vegetation	4A

1) The Migratory Spawning and Nursery Use, Deep Water, and Deep Channel uses do not necessarily exist throughout the entire CPB segment (see boundaries in U.S. Environmental Protection Agency, 2004, Technical Support Document for Identification of Chesapeake Bay Designated Uses and Attainability 2004 Addendum, Chesapeake Bay Program Office, Annapolis, Maryland).

2) Benthic community assessment and impairment in this table are for mainstem portion of these CBP segments only. Tributaries to these segments are assessed as separate units and may have differing benthic community assessment or impairment as shown in the Benthic Assessment Results section of this chapter. ALUS category assignations based on these benthic assessments also applies only to the mainstem portion of these CBP segments. Additionally, because the Bay TMDL does not address benthic impairments, the ALUS for waters impaired for benthics will be classified as category 5D or 5F.

3) This OW category 3B applies only to assessment units within this CBP segment which have been previously impaired for dissolved oxygen due to EPA overlisting or D.O. standard violations (i.e. Mainstem Chesapeake Bay, Mattaponi, Pamunkey, York, James, Elizabeth R. and Branches). These mainstem Bay assessment units shall remain as insufficient data until all DO criteria are assessed. Category 2C will be assigned to assessment units within this CBP segment which have never been listed for dissolved oxygen impairment.

4) This ALUS, OW, DW, DC category 2C applies only to assessment units within this CBP segment never listed impaired previously. Category 3B should be assigned to assessment units which were impaired for dissolved oxygen prior to 2006 due to EPA overlisting or D.O. standard violations until all applicable dissolved oxygen criteria have been assessed and attained.

Future Assessment Refinements

This is the fourth report to present assessment of the recently developed designated uses in the Chesapeake Bay and its tidal tributaries. Much progress has been made in developing realistic and appropriate designated uses, associated criteria, and assessment protocols for the Chesapeake Bay and its tidal tributaries. Continued refinement for future assessments is summarized below. To ensure consistency throughout the multi-State Chesapeake Bay system, most of these issues will be resolved through the Water Quality Criteria Assessment Workgroup involving EPA Region III, EPA Chesapeake Bay Program, Maryland Department of the Environment, Maryland Department of Natural Resources and the Virginia Department of Environmental Quality.

Assessment of currently un-assessed designated uses and criteria

Of the five aquatic life sub-uses, this chapter reports only on conditions for the open-water, deep-water, deep-channel, and shallow-water submerged aquatic vegetation subuses. It is anticipated that future reports will assess the remaining aquatic life sub-use of "Migratory and Spawning Fish". Also, only a limited suite of dissolved oxygen criteria for each sub-use were assessed, these being 30-Day average for dissolved oxygen in open- and deep-water uses and the instantaneous minimum for the deep-channel use. Many other dissolved oxygen criteria were not assessed (e.g. 7-day, 1-day, and instantaneous minimum criteria). These limitations on assessments of designated uses and criteria are due to the lack of EPA-approved assessment protocols.

Refinements to assessment protocols

While DEQ believes the protocols performed for this assessment are valid, the following issues may be examined in more detail for future assessments:

a. Refinements in spatial interpolation tools.

Part of the assessment protocol involves spatial interpolation of data to create a 3-dimensional depiction of oxygen conditions throughout a waterbody segment. The software used for performing this step in this assessment may be refined and updated to enhance interpolation for future assessments.

b. Refinements in statistical determination of attainment.

Data are assessed after interpolation for criteria exceedences using a reference curve to determine waterbody attainment. The assessment was based on either EPA-published reference curves or used a default 10% reference curve if a published one was not available for a specific aquatic life sub-category (e.g. deep water). It is possible that new reference curves developed by EPA could be adopted into Virginia water quality standards and used in future assessments. Also, there may be future efforts to explicitly incorporate statistical measures of uncertainty into the reference curve attainment process.