Developing a New Chesapeake Bay Water Quality Indicator for Tracking Progress toward Bay Water Quality Standards Achievement

Chesapeake Bay Program Partnership's Management Board Draft Version

January 29, 2013 Draft
[SUBJECT TO REVIEW AND FURTHER REVISION]

The Chesapeake Bay Program (CBP) Partnership needs to develop a combined indicator to measure progress towards the achievement of the four jurisdictions' Chesapeake Bay water quality standards. As it currently stands, the Partnership chronicles the Bay's health through annual reporting of a series of individual water quality metrics. This new integrated indicator could supplement or replace the individual dissolved oxygen, water clarity and chlorophyll *a* indicators currently reported by the CBP Partnership. The indicator would be fully consistent with how Delaware, the District of Columbia, Maryland, and Virginia currently list their portion of the Bay's tidal waters and provide a means for illustrating improvements through time.

Additionally, this indicator could be used to measure progress toward the Chesapeake Bay Executive Order's water quality outcome in which 60% of segments are achieving Bay water quality standards by 2025 via the implementation of pollution reduction actions for nitrogen, phosphorus and sediment.[1] The 2009 baseline condition, as documented in the Chesapeake Bay TMDL, was 89 of 92 segments of the Chesapeake Bay and its tidal tributaries and embayments were impaired (USEPA 2010).

There are a variety of unique combinations of Chesapeake Bay water quality criteria applied, where appropriate, to each of the five tidal water designated uses within each of the 92 segments. The four tidal water jurisdictional partners –Delaware, District of Columbia, Maryland, and Virginia—and EPA work collaboratively to assess water quality standards attainment based on the criteria applicable to the designated uses (Figure 1). Each segment can have between one (e.g., Eastern Branch of the Elizabeth River which only has open water) and all five designated uses (e.g., Lower Rappahannock River which has migratory fish and spawning nursery, open-water, deep-water, deep-channel, and shallow-water bay grass designated uses) (Table 1). Furthermore, the mainstem James River segments and the District of Columbia's

[1] The Water Quality Outcome, as written on pages 4 and 22 of the Executive Order Strategy, reads as follows: **Water Quality Outcome:** Meet water quality standards for dissolved oxygen, clarity/underwater grasses and chlorophyll-a in the Bay and tidal tributaries by implementing 100 percent of pollution reduction actions for nitrogen, phosphorus and sediment no later than 2025, with 60 percent of segments attaining water quality standards by 2025. *(Current condition: 89 of the 92 segments of the Bay and its tidal waters are impaired.)* The Executive Order Strategy is available for download at: http://executiveorder.chesapeakebay.net/category/Reports-Documents.aspx.

Upper Potomac River and Anacostia River segments have applicable numeric chlorophyll *a* criteria in addition to the designated use application.

This indicator would be based on annually reported criteria assessment results, which are based on a three-year assessment period. It would combine the dissolved oxygen, water clarity and chlorophyll *a* assessment results and be reported annually as a baywide percentage of water quality standards in attainment.

There are two sets of decisions to be made by the CBP Partnership in creating this new water quality indicator:

1) how to address the fact that the CBP Partnership has not fully developed, reached agreement on, published nor adopted into the tidal water jurisdictions' water quality standards regulations a full set of criteria assessment procedures for all the applicable dissolved oxygen criteria; and

2) whether to take an area-based (or volume-based) approach versus the count of number of designated-use segments approach as the basis to reporting the water quality indicator.

The Chesapeake Bay Program Office, working with EPA Region 3's Water Protection Division and Office of Regional Counsel, as well as the CBP Partnership's Scientific, Technical Assessment and Reporting Team's (STAR) Criteria Assessment Protocols (CAP) Workgroup, explored a series of options for analysis and narrowed it down to two options and a series of recommendations. We conducted these analyses considering attainment for each segment by each of its unique tidal water designated uses (e.g., middle James River open-water) and applicable water quality criteria (e.g., chlorophyll *a*).

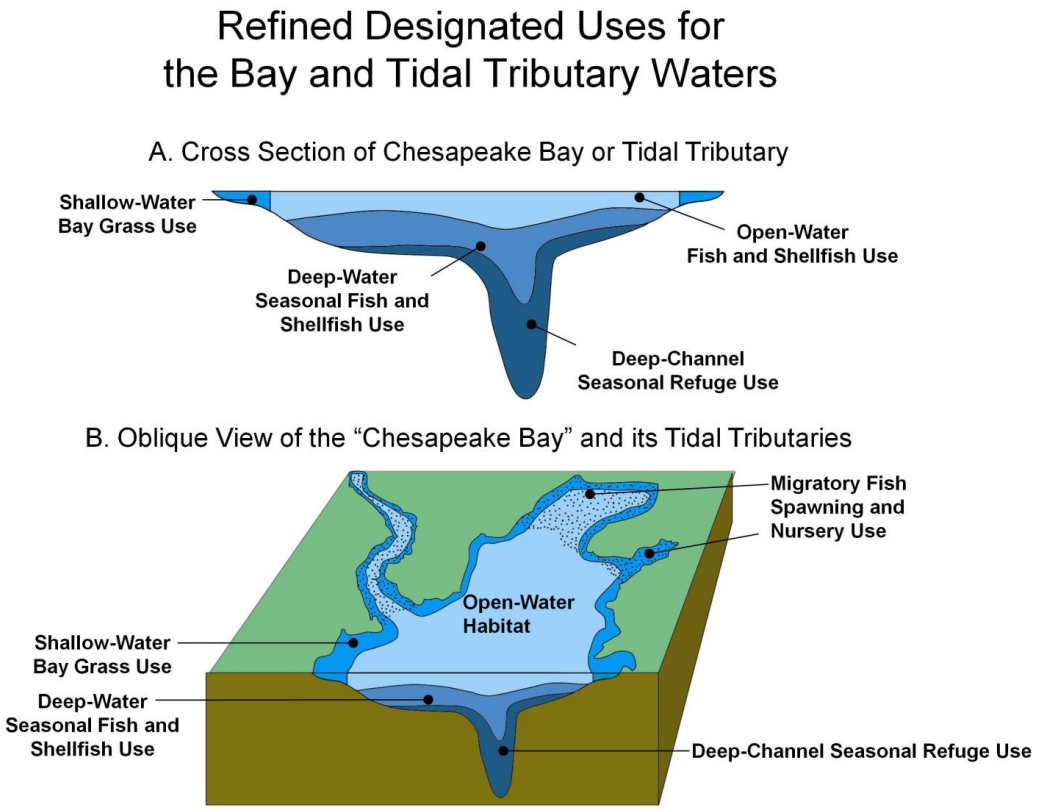

Figure 1. Conceptual illustration of the five Chesapeake Bay tidal water designated use zones.

Source: USEPA 2003a

Table 1. Tidal water designated uses by Chesapeake Bay segment

Waterbody	CBP Segments & Split Segments	Jurisdiction	Migratory Spawning & Nursery	Open Water	Deep Water	Deep Channel	Shallow Water Bay grasses	Chlorophyll-a (applies to open water)
Anacostia River	ANATF_DC	DC	X	X			X	X
Anacostia River	ANATF_MD	MD	X	X			X	
Appomattox River	APPTF	VA	X	X			X	
Back River	BACOH	MD	X	X			X	
Big Annemessex River, Lower	BIGMH1	MD	X	X			X	
Big Annemessex River, Upper	BIGMH2	MD					X	
Bohemia River	BOHOH	MD	X	X			X	
Bush River	BSHOH	MD	X	X			X	
C&D Canal	C&DOH_DE	DE	X	X				
C&D Canal	C&DOH_MD	MD	X	X			X	
Northern Chesapeake Bay, Turkey Pt. South	CB1TF1	MD	X	X			X	
Northern Chesapeake Bay, Susquehanna River and Flats	CB1TF2	MD					X	

Upper Chesapeake Bay	CB2OH	MD	X	X			X	
Upper Central Chesapeake Bay	CB3MH	MD	X	X	X	X	X	
Middle Central Chesapeake Bay	CB4MH	MD	X	X	X	X	X	
Lower Central Chesapeake Bay	CB5MH_MD	MD		X	X	X	X	
Lower Central Chesapeake Bay	CB5MH_VA	VA		X	X	X	X	
Western Lower Chesapeake Bay	CB6PH	VA		X	X		X	
Eastern Lower Chesapeake Bay	CB7PH	VA		X	X		X	
Mouth of the Chesapeake Bay	CB8PH	VA		X			X	
Chickahominy River	CHKOH	VA	X	X			X	
Mouth of the Choptank River	CHOMH1	MD	X	X			X	
Lower Choptank River	CHOMH2	MD	X	X			X	
Middle Choptank River	CHOOH	MD	X	X			X	
Upper Choptank River	CHOTF	MD	X	X				
Lower Chester River	CHSMH	MD	X	X	X	X	X	
Middle Chester River	CHSOH	MD	X	X			X	
Upper Chester River	CHSTF	MD	X	X			X	
Corrotoman River	CRRMH	VA	X	X			X	
Eastern Bay	EASMH	MD		X	X	X	X	
Eastern Branch Elizabeth River	EBEMH	VA		X				
Mouth of the Elizabeth River	ELIPH	VA		X				
Elk River, Upper	ELKOH1	MD	X	X			X	
Elk River, Lower	ELKOH2	MD					X	
Fishing Bay	FSBMH	MD	X	X			X	
Gunpowder River, Upper	GUNOH1	MD	X	X			X	
Gunpowder River, Lower	GUNOH2	MD					X	
Honga River	HNGMH	MD		X			X	
Lower James River	JMSMH	VA	X	X			X	X
Middle James River	JMSOH	VA	X	X			X	X
Mouth of the James River	JMSPH	VA		X			X	X
Upper James River	JMSTF1	VA	X	X			X	X
Upper James River	JMSTF2	VA	X	X			X	X
Lafayette River	LAFMH	VA		X				
Little Choptank River	LCHMH	MD		X			X	
Lynnhaven River	LYNPH	VA		X			X	
Magothy River	MAGMH	MD	X	X	X		X	
Manokin River, Lower	MANMH1	MD	X	X			X	
Manokin River, Upper	MANMH2	MD					X	

Mattawoman Creek	MATTF	MD	X	X			X	
Middle River	MIDOH	MD	X	X			X	
Mobjack Bay	MOBPH	VA		X			X	
Lower Mattaponi River	MPNOH	VA	X	X				
Upper Mattaponi River	MPNTF	VA	X	X			X	
Lower Nanticoke River	NANMH	MD	X	X			X	
Middle Nanticoke River	NANOH	MD	X	X			X	
Upper Nanticoke River	NANTF_DE	DE	X	X				
Upper Nanticoke River	NANTF_MD	MD	X	X				
Northeast River	NORTF	MD	X	X			X	
Patapsco River	PATMH	MD	X	X	X	X	X	
Lower Patuxent River, Lower	PAXMH1	MD	X	X	X		X	
Lower Patuxent River, Upper	PAXMH2	MD					X	
Lower Patuxent River, Mill Creek	PAXMH3	MD					X	
Lower Patuxent River, Cuckold Creek	PAXMH4	MD					X	
Lower Patuxent River, St. Leonard Creek	PAXMH5	MD					X	
Lower Patuxent River, Island Creek	PAXMH6	MD					X	
Middle Patuxent River	PAXOH	MD	X	X			X	
Upper Patuxent River	PAXTF	MD	X	X			X	
Piankatank River	PIAMH	VA		X			X	
Piscataway Creek	PISTF	MD	X	X			X	
Lower Pamunkey River	PMKOH	VA	X	X				
Upper Pamunkey River	PMKTF	VA	X	X			X	
Lower Pocomoke River	POCMH_MD	MD	X	X			X	
Lower Pocomoke River	POCMH_VA	VA	X	X			X	
Middle Pocomoke River	POCOH_MD	MD	X	X				
Middle Pocomoke River	POCOH_VA	VA	X	X				
Upper Pocomoke River	POCTF	MD	X	X				
Lower Potomac River	POTMH_MD	MD	X	X	X	X	X	
Lower Potomac River	POTMH_VA	VA	X	X	X	X	X	
Middle Potomac River, MD Mainstem	POTOH_VA	VA	X	X			X	
Middle Potomac River, MD Port Tobacco River	POTOH1_MD	MD	X	X			X	
Middle Potomac River, MD Nanjemoy Creek	POTOH2_MD	MD	X	X			X	
Middle Potomac River	POTOH3_MD	MD	X	X			X	
Upper Potomac River	POTTF_DC	DC	X	X			X	X
Upper Potomac River	POTTF_MD	MD	X	X			X	
Upper Potomac River	POTTF_VA	VA	X	X			X	

Rhode River	RHDMH	MD	X	X			X	
Lower Rappahannock River	RPPMH	VA	X	X	X	X	X	
Middle Rappahannock River	RPPOH	VA	X	X			X	
Upper Rappahannock River	RPPTF	VA	X	X			X	
Sassafras River, Lower	SASOH1	MD	X	X			X	
Sassafras River, Upper	SASOH2	MD					X	
Southern Branch Elizabeth River	SBEMH	VA		X	X			
Severn River	SEVMH	MD	X	X	X		X	
South River	SOUMH	MD	X	X	X		X	
Tangier Sound	TAHMH_VA	VA		X			X	
Tangier Sound, MD Main Body	TANMH1_MD	MD		X			X	
Tangier Sound, MD Deal Island to Mouth of Nanticoke River	TANMH2_MD	MD					X	
Western Branch Elizabeth River	WBEMH	VA		X				
Western Branch Patuxent River	WBRTF	MD	X	X			X	
Wicomico River	WICMH	MD	X	X			X	
West River	WSTMH	MD	X	X			X	
Middle York River	YRKMH	VA	X	X			X	
Lower York River	YRKPH	VA		X	X		X	
TOTAL Number of Segments by Designated Use & Applicable Criteria			**72**	**92**	**18**	**10**	**90**	**7**

Note: This table contains additional split segments (in grey) beyond the 92 Chesapeake Bay segments strictly for purposes of applying separate water clarity criteria application depths (0.5, 1, or 2 meters) within the same Bay segment for assessing water clarity/SAV criteria attainment only (USEPA 2004).

Sources: USEPA 2003b, 2004, 2010; Code of Maryland Title 26 Subtitle 08, Chapter 2, Section 3; Code of Virginia 9 62.1-44.13 3a; Delaware Administrative Code 7401; District of Columbia Municipal Regulations Title 21, Chapter 11.

Criteria Assessment Options and Recommended Resolution

The two criteria assessment options are directly related to the question posed earlier: how to address the fact that the CBP Partnership has not fully developed, reached agreement on, published, nor adopted into the tidal water jurisdictions' water quality standards regulations a full set of criteria assessment procedures for all the applicable dissolved oxygen criteria. One option would be only assess attainment for those dissolved oxygen criteria for which criteria assessment procedures have been published and adopted into the jurisdictions' water quality standards regulations. Taking this option, however, would be completely inconsistent with the approach the four tidal water jurisdictions have taken in establishing their lists of impaired Bay tidal waters and provide the public with contradictory information.

In the course of developing the Chesapeake Bay TMDL, CBPO analysts determined that evaluation of the 30-day mean dissolved oxygen criteria was sufficient to determine attainment of the Bay's open-water and deep-water designated uses. This notion became formally known

as the Umbrella Criteria Assumption. Questions regarding the validity of the Chesapeake Bay Water Quality Sediment Transport Model (WQSTM)-based assumption by CBP partners led to the formation of the Umbrella Criteria Assessment Team to determine its validity using CBP monitoring data. The CAP workgroup is currently working towards developing recommendations based on the Umbrella Criteria Assessment Team's findings. Until recommendations are fully developed, short-term assessments procedures for dissolved oxygen continue to be lacking.

With the lack of assessment procedures in place for the short-term dissolved oxygen criteria for the various designated uses, where appropriate, Chesapeake Bay segments previously listed as impaired for dissolved oxygen will continue to be impaired until a complete set of dissolved oxygen assessment procedures are developed, agreed upon by the Partnership, and published.[2] This is in accordance with Maryland, Virginia, Delaware, and the District of Columbia's current tidal impaired waters listing approach for Chesapeake Bay segments, as published individually in their Integrated Reports and, collectively, within the 2010 Chesapeake Bay TMDL. As such, we recommend to the Partnership's Water Quality Goal Implementation Team that for those designated use criteria where a full suite of dissolved oxygen criteria assessment procedures have not yet been agreed to by the CBP Partnership, the segment is considered to be in non-attainment for that specific tidal water designated use. That is to say that since there are no published procedures for the open-water, deep-water, and migratory fish spawning and nursery designated uses assessment of the 7-day mean, 1-day mean, and instantaneous minimum dissolved oxygen criteria, where applicable, these three designated uses will continue to be considered in non- attainment because the jurisdictions cannot assess attainment for <u>all</u> the dissolved oxygen criteria applicable to these three designated uses.

Work is currently underway, under the leadership and oversight of the CBP Partnership's CAP Workgroup, to develop, submit to independent scientific peer review, seek the review and agreement of the partnership, and publish (by EPA on behalf of the larger partnership) a complete set of dissolved oxygen criteria assessment procedures. The expectation is, upon publication of these criteria assessment procedures, Delaware, District of Columbia, Maryland, and Virginia will amend, as necessary, their water quality standards regulations to adopt these criteria assessment procedures.

<u>Attainment Accounting Options and Recommended Resolution</u>

We considered the choice between a count (e.g., number of attaining segments) or weighted (e.g., by area or volume) approach in computing and reporting the water quality indicator. We determined that strictly using a count of the number of segments, be they the original 92 segments or all the 289 designated-use segments, would not be representative of the true amount of Bay tidal waters achieving water quality standards (Table 2). The shear size

[2] For the open-water, deep-water, and migratory fish spawning and nursery designated uses, there are no published procedures in place for the assessment of the 7-day mean, 1-day mean, and instantaneous minimum dissolved oxygen criteria. The Partnership is committed to working collaboratively to develop criteria assessment procedures for the remaining dissolved oxygen criteria currently without Partnership approved assessment procedures.

difference, whether measured as surface area or total volume, between the Magothy River segment and the middle central Chesapeake Bay segment is a several hundred fold. Weighting them equally by taking the count approach does not provide the public with an honest measure of how much of the Bay tidal waters are achieving water quality standards.

Table 2. Criteria attainment accounting using the count approach.

COUNT APPROACH			
289 Designated-Use Segments (making up the 92 CBP Segmentation Scheme)			
Chesapeake Bay Tidal Water Designated Use	Total Number of Designated-Use Segments	Number of Designated-Use Segments Attaining WQS	Percent Attainment
Migratory Fish Spawning and Nursery	72	0	0
Open Water – DO	92	0	0
Open Water – CHLA (spring + summer)	7	0	0
Deep Water – DO	18	0	0
Deep Channel – DO	10	1	10
Shallow-Water Bay Grasses – SAV/Water Clarity	90	27	30
Baywide Percentage of WQS Attainment	**289**	**28**	**10**

Note: As the CBP Partnership works through and reaches agreement on the remaining dissolved oxygen criteria assessment procedures, the percentage of designated-use segments attaining will increase.

Then we considered taking a volumetric approach. This approach works well for dissolved oxygen criteria whose attainment is assessed on a volume-basis. However, in the case of the water clarity/SAV and chlorophyll *a* criteria, both are assessed on a surface area-basis. We were unable to determine a method for accounting for both volume and surface area within the same metric which would have accounted for the how much of the Bay tidal waters were achieving water quality standards.

Therefore, having narrowed down the choice for the accounting approach to area, we still had to:

1) account for the area for those segments with two or more designated uses with depth (e.g., open-water, deep-water, and deep-channel); and

2) determine how to factor in the shallow-water Bay grasses designated uses which will have very small areas compared with open-water uses but are equally critical and important habitats.

The proposed solution was using the surface area of each of the 92 segments times the number of applicable designated uses for that segment. This approach factors in the relative size of each segment, ensuring we report the best available measure of how much of the Bay tidal waters were achieving water quality standards. At the same time, this approach gives equal weight to

achievement of the criteria protective of each designated use and segment, preventing any need to weigh differently the importance of restoring dissolved oxygen versus bringing back underwater bay grasses. Restoration of a fully functioning Chesapeake Bay ecosystem requires attainment of all five designated uses. The indicator consolidates the baywide results in the final calculations and reports percent of Bay water quality standards meeting attainment (Table 3).

Table 3. Criteria attainment accounting using the area-based approach.

AREA-BASED APPROACH			
289 Designated-Use Segments (contained within the 92 Chesapeake Bay segments)			
Chesapeake Bay Tidal Water Designated Use	Total Surface Area of Designated-Use Segments (km²)	Total Surface Area of Designated-Use Segment Attaining WQS (km²)	Percent Attainment
Migratory Fish Spawning and Nursery	5565101169.36	0.00	0
Open Water – DO	11660174083.95	0.00	0
Open Water – CHLA (spring + summer)	620327627.29	0.00	0
Deep Water – DO	6932558324.18	0.00	0
Deep Channel – DO	4404190644.45	83660695.00	2
Shallow-Water Bay Grasses – SAV/Water Clarity	11558645485.84	2616220341.04	23
Baywide Percentage of WQS Attainment	**40740997335.07**	**2699881036.04**	**7**

Note: As the CBP Partnership works through and reaches agreement on the remaining dissolved oxygen criteria assessment procedures, the percentage of designated-use segments attaining will increase.

Please note, however, that there can be slight variations in the total number of designated uses reported each year depending on annual climatic conditions. Since designated use boundaries between the open-water, deep-water, and deep-channel designated uses are based on the presence of a stratified water column measured by upper and lower bounds of a pycnocline, the absence of a pycnocline in a specific segment due to a fully mixed water column in a specific year due to seasonal weather conditions means one (or two) less designated uses for that year. In these cases, the total number of designated-use segments would be a number less than 289 for that year within the three-year assessment window.

Finally, this area-based criteria attainment accounting approach also directly lends itself to a visual illustration of the indicator status in a single graphic—the relative shading or different color of each individual segment would reflect the percent of all applicable designated uses in attainment with all the applicable criteria—as well as a single percentage for all Bay tidal waters. Figure 2 represents how the indicator results for each individual segment would be displayed on a baywide basis. Supplemental maps illustrating attainment status of each segment have also been developed for each of the designated uses (Appendix A). These illustrations would be used for technical and diagnostic purposes, as well as for public communication once the indicator is adopted into the current Partnership's indicator reporting

framework. As we move towards incorporating the indicator into the Partnership, we will continue to work with the CBPO's Monitoring, Indicator, Communication, and GIS teams on how to best communicate the message to the public audience.

Recommended Water Quality Indicator

The recommended water quality indicator for reporting on progress towards the Executive Order's water quality outcome as well as future CBP Partnership reporting of water quality restoration progress is as follows:

- The indicator will be based on an accounting of attainment of all Bay water quality criteria—dissolved oxygen, water clarity/underwater grasses, and chlorophyll *a*—applicable to the 289 designated-use segments contained within the 92 Bay segments reported for each three-year assessment period.

- The indicator will be reported annually as a baywide percentage based on the summation of the surface area of each of the designated-use segments determined to be in full attainment of all applicable criteria divided by the summation of the surface areas of the total number of designated-use segments.

- For those designated use criteria where a full suite of dissolved oxygen assessment procedures have not been agreed to by the CBP Partnership and published by EPA, those respective designated-use segments where these dissolved oxygen criteria apply will be considered to be in non-attainment.[3]

- The indicator will be graphically illustrated by coloring each of the 92 Bay segments according to the percent of applicable designated uses and criteria for that individual segment that are in attainment of all the applicable criteria.

[3] By 2015, EPA and its seven jurisdictional partners are committed to working collaboratively on developing, subjecting to independent scientific peer review, agreeing to, and then publishing criteria assessment procedures for the remaining dissolved oxygen criteria currently without Partnership approved assessment procedures.

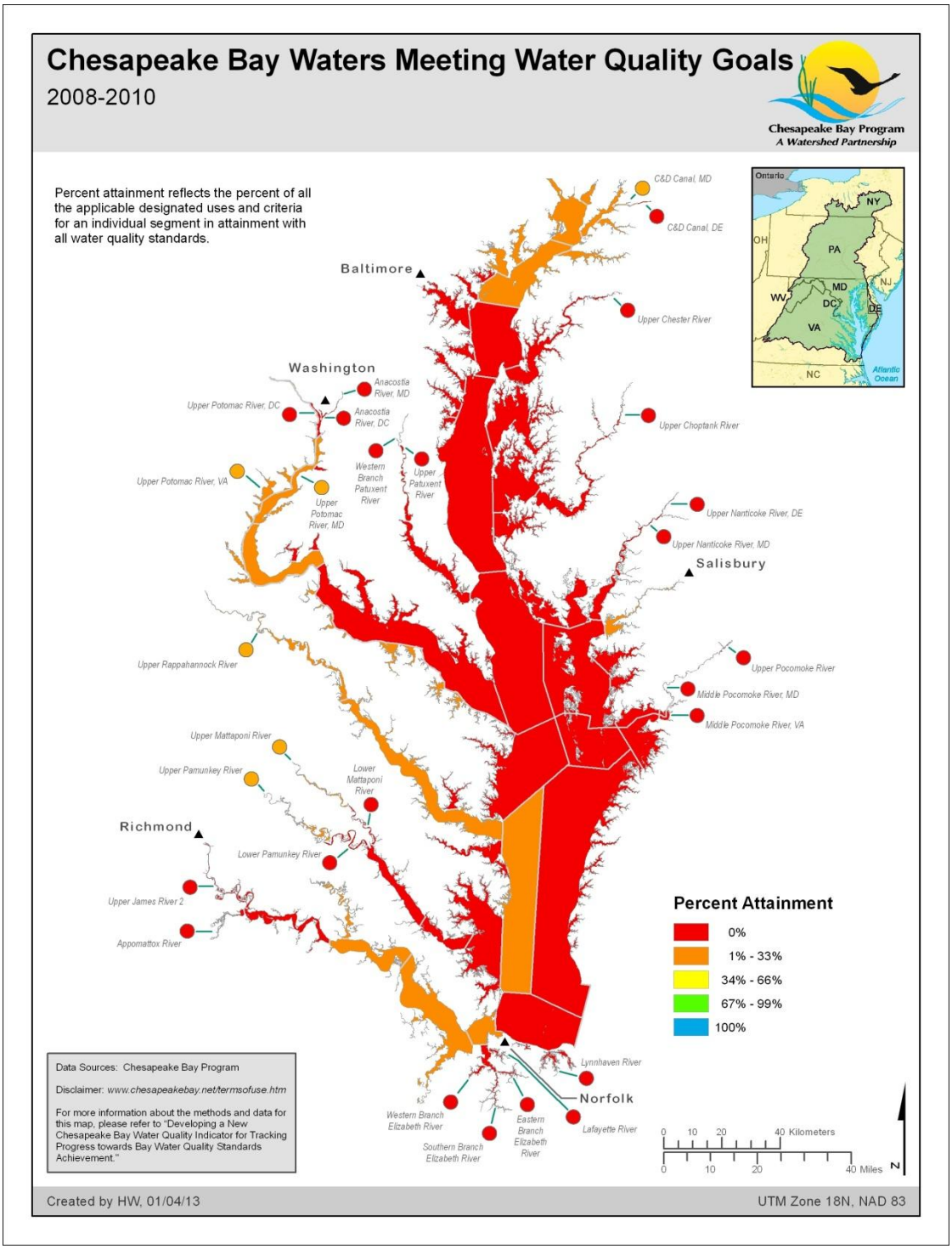

Figure 2. Visual illustration of the water quality standards indicator status, expressed as a percentage, for each of the 92 Chesapeake Bay TMDL segments (2008-2010 listing cycle). The number of water quality criteria applied varies across the 92 Bay segments based on the applicable designated uses (i.e., migratory spawning and nursery, open-water, deep-water, deep-channel, and shallow water bay grasses) and criteria (e.g., chlorophyll *a*). Percent

attainment reflects all the applicable designated uses and criteria for that individual segment which are in attainment with all water quality standards.

Recommended Next Steps

- Bring the new indicator forward to the Management Board for final Partnership adoption.
- Separate from the public indicator the Partnership is recommending here, we will continue to explore a means to measure incremental progress towards the attainment of water quality standards.

References:

USEPA (U.S. Environmental Protection Agency). 2003a. *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. U.S. Environmental Protection Agency, Region 3 Chesapeake Bay Program Office, Annapolis, MD.

USEPA (U.S. Environmental Protection Agency). 2003b. *Technical Support Document for Identification of Chesapeake Bay Designated Uses and Attainability.* EPA 903-R-03-004. U.S. Environmental Protection Agency, Region 3 Chesapeake Bay Program Office, Annapolis, MD.

USEPA (U.S. Environmental Protection Agency). 2004. *Technical Support Document for Identification of Chesapeake Bay Designated Uses and Attainability–2004 Addendum.* EPA 903-R-04-006. U.S. Environmental Protection Agency, Region 3 Chesapeake Bay Program Office, Annapolis, MD.

USEPA (U.S. Environmental Protection Agency). 2010. *Chesapeake Bay Total Maximum Daily Load for Nitrogen, Phosphorus and Sediment*. U.S. Environmental Protection Agency, Region 3 Chesapeake Bay Program Office, Annapolis, MD.

Appendix A

Supplemental maps illustrating attainment status for each of the designated uses applicable criteria.

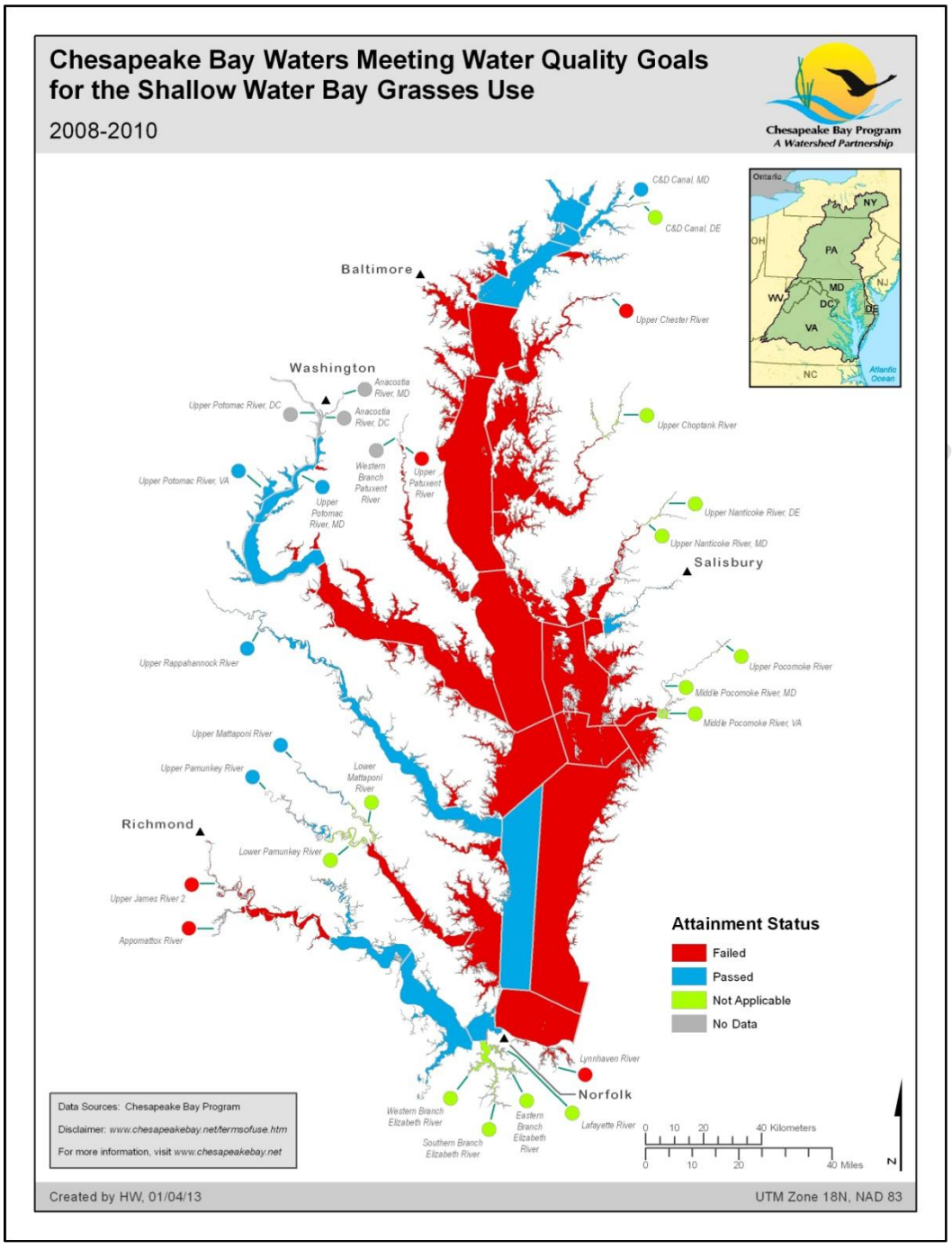

Figure 1: Attainment status of the shallow water bay grasses designated use for each of the Chesapeake Bay segments. This map contains additional split segments beyond the 92 Chesapeake Bay segments strictly for purposes of applying separate water clarity criteria

application depths (0.5, 1, or 2 meters) within the same Bay segment for assessing water clarity/SAV criteria attainment only (USEPA 2004).

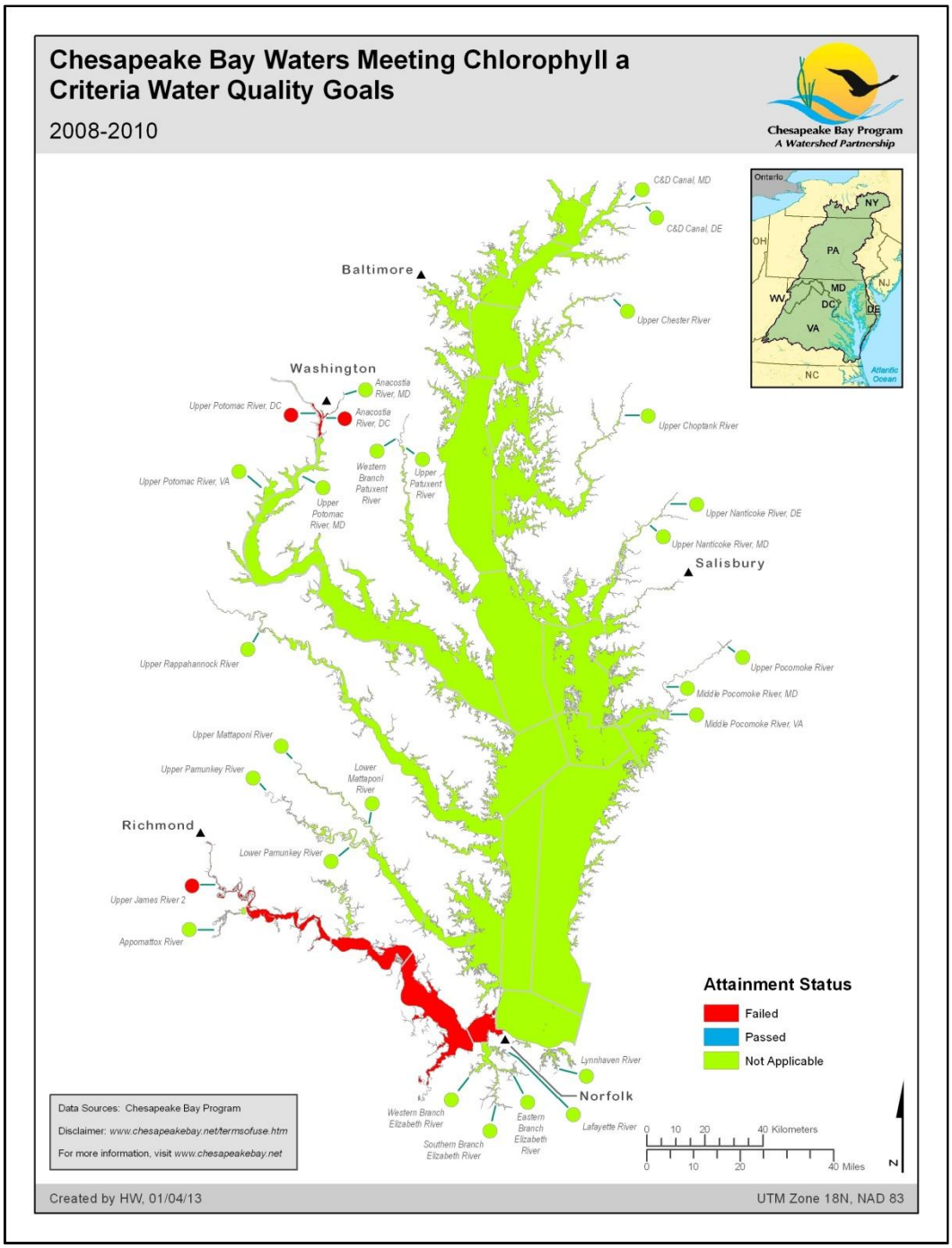

Figure 2: Attainment status of the chlorophyll *a* numeric criteria as applied as to the open-water designated use of the James and Anacostia Rivers of Chesapeake Bay.

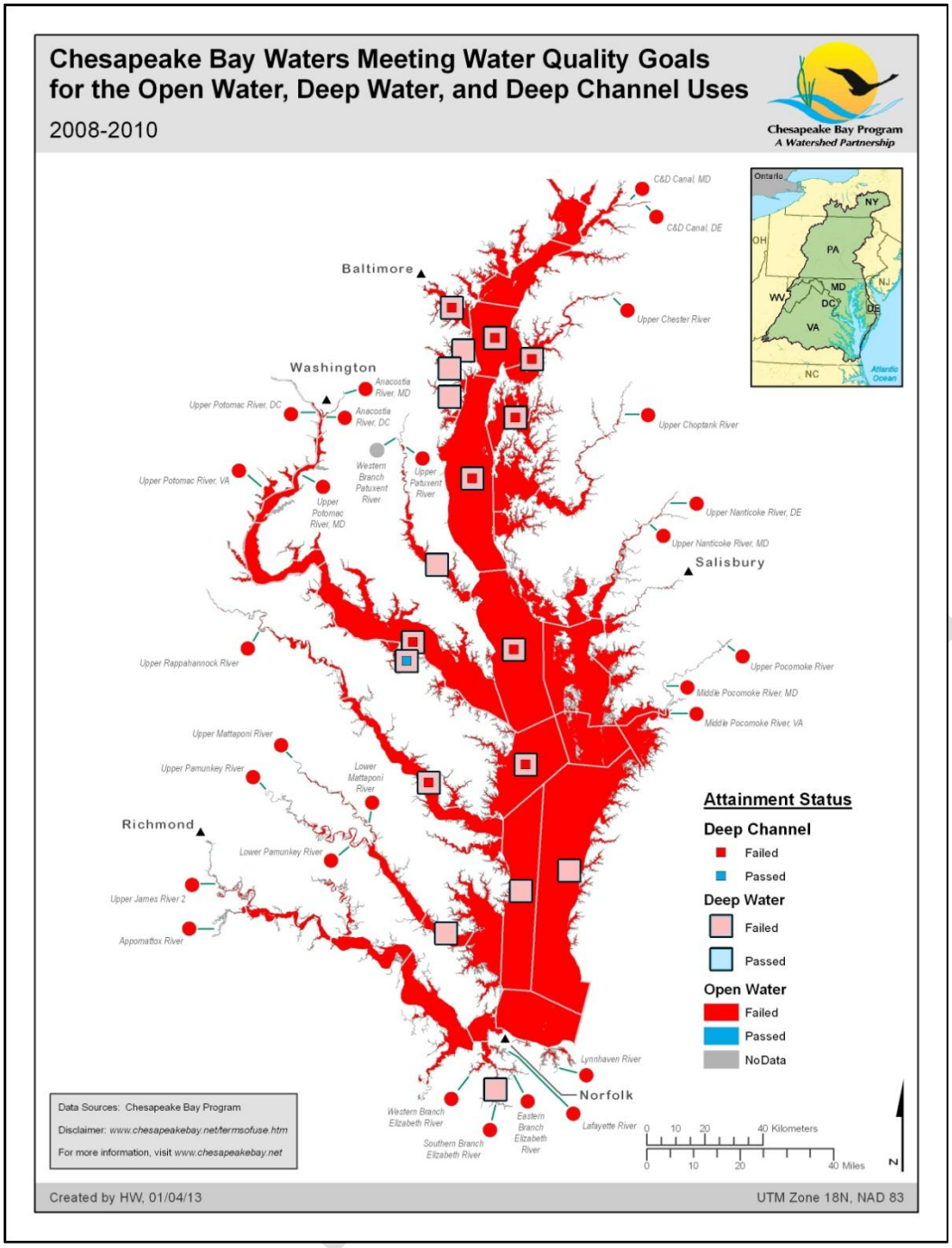

Figure 3: Attainment status of the open-water, deep-water, and deep channel designated uses for each of the Chesapeake Bay segments.

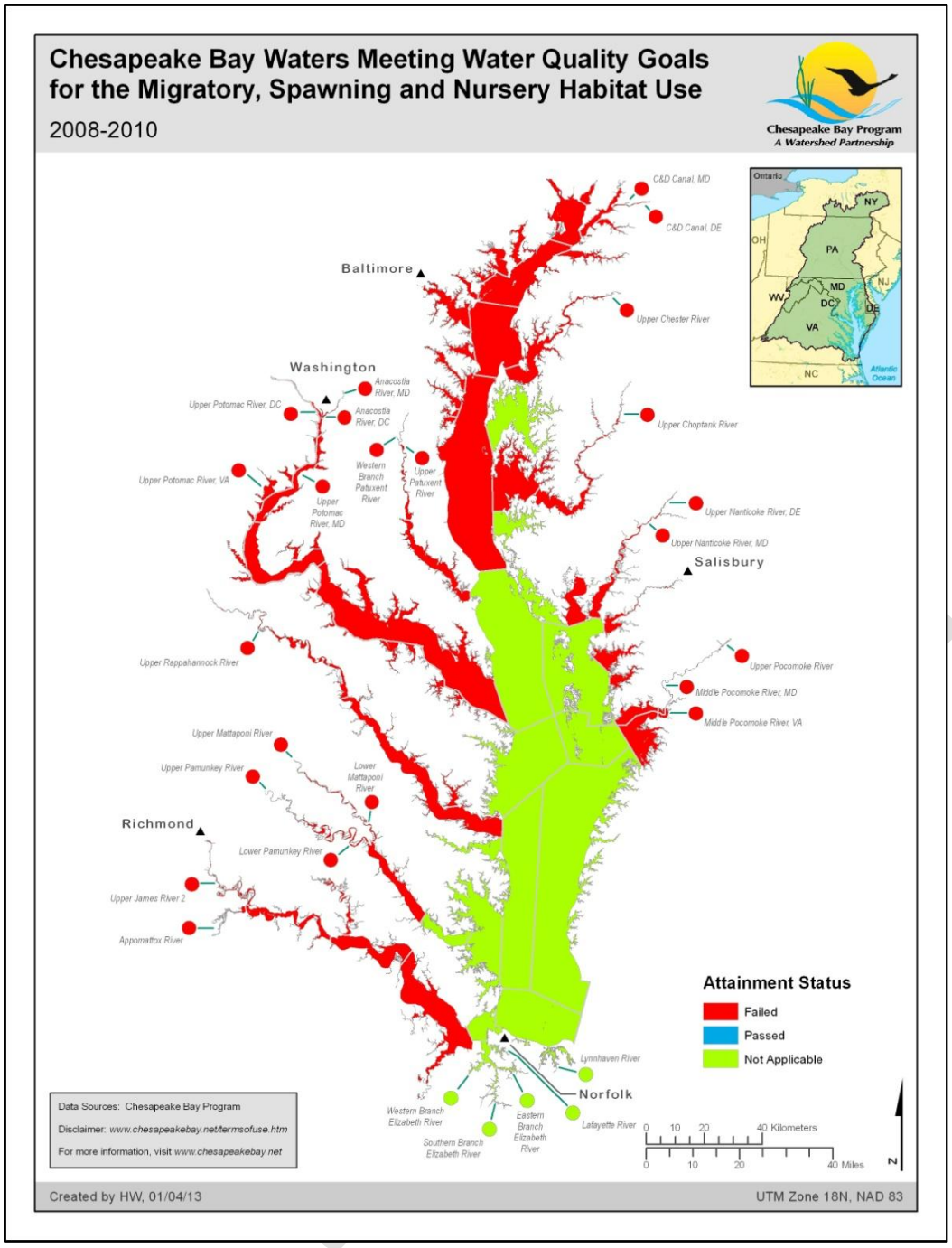

Figure 4: Attainment status of the migratory spawning and nursery designated use for each of the Chesapeake Bay segments.