# A. Category/Name/Source/Contact

(1) Category of Indicator

\_\_\_ Factors Impacting Bay and Watershed Health

\_\_\_ Restoration and Protection Efforts

\_\_\_ Watershed Health

x Bay Health

(2) Name of Indicator: Water Quality Standards Achievement

(3) Description of Dataset used:

Dissolved oxygen (DO), secchi depth, submerged aquatic vegetation (SAV) acreage, and chlorophyll *a* measurements are used to calculate standards attainment.

* For what purpose(s) were the data collected? (e.g., tracking, research, or long-term monitoring.)

Tracking, research, and long-term monitoring

* Which parameters were measured directly?
* DO concentrations are measured in-situ at surface and depth profiles across the entire Bay.
* Secchi depths are measured directly during Bay transect cruises.
  + SAV area and percent coverage is measured from photographs during the aerial surveys (after photo-interpretation).
  + Chlorophyll-a concentrations were measured in a lab using bio-matter collected from filtered water samples at fixed stations.
* Which were obtained by calculation?
  + Aggregations of photo-interpreted SAV area data to segment, zone and bay-wide levels.
  + Standards attainment for DO, water clarity, and chlorophyll *a* are calculated according to the April 2003 USEPA publication of *Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity, and Chlorophyll a for the Chesapeake Bay and Its Tidal Tributaries* (<http://www.chesapeakebay.net/content/publications/cbp_13142.pdf>) Refinements to these procedures are described in subsequent technical addenda, all of which can be downloaded from <http://www.chesapeakebay.net/publications>.

(4) Source(s) of Data:

* DO, secchi depth and chlorophyll *a* are measured by the MD Department of Natural Resources (MD mainstem and tributary data), the VA Department of Environmental Quality (VA tributary data and benthic monitoring data), Old Dominion University (VA mainstem data), Virginia Institute of Marine Sciences (VA trib data), and submitted citizen/volunteer monitoring data (VA trib data). SAV area is measured by Virginia Institute of Marine Science (VIMS).
* DO and chlorophyll *a* assessments are conducted at CBPO by Richard Tian (UMCES-CBPO). Water clarity/SAV assessments are conducted by the Maryland Department of Natural Resources (Mark Trice) and Virginia Institute of Marine Science (Dave Parrish).

Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions?

Yes.

If yes, please indicate where complete dataset can be obtained.

DO, secchi depth, and chlorophyll *a* data are located on the Chesapeake Information Management System (CIMS) data hub and can be downloaded from the CBP Water Quality Database (1984-present) webpage (<http://www.chesapeakebay.net/data/downloads/cbp_water_quality_database_1984_present>). Additional data submitted by the states from citizen science monitoring programs can be obtained by contacting Chesapeake Bay Program’s, Water Quality Database Manager (Mike Mallonee, ICPRB-CBPO).

SAV area data can be downloaded from <http://web.vims.edu/bio/sav/StateSegmentAreaTable.htm>.

DO and chlorophyll *a* assessment results can be obtain by contacting Richard Tian, CBPO’s ([rtian@chesapeakebay.net](mailto:rtian@chesapeakebay.net)). Water clarity attainment results may be obtained by contacting Dave Parrish ([parrishd@vims.edu](mailto:parrishd@vims.edu)) at VIMS or Tish Robertson ([tlrobertson@deq.virginia.gov](mailto:tlrobertson@deq.virginia.gov)) at VADEQ for the VA results and Mark Trice ([MTrice@dnr.state.md.us](mailto:MTrice@dnr.state.md.us)) at MDDNR for the MD results.

(5) Custodian of Source Data (and Indicator, if different):

* For raw data: Mike Mallonee (ICPRB-CBPO)
* For DO and chlorophyll *a* assessments: Richard Tian (UMCES-CBPO)
* For SAV acreage data: Bob Orth (VIMS) or David Wilcox (VIMS)
* For Water Clarity assessments: Dave Parrish (VIMS) (VA) or Tish Robertson (VADEQ) (VA) and Mark Trice (MDDNR) (MD)

(6) CBPO Contact:

Richard Tian (UMCES-CBPO)

**B. Communication Questions** *(complete either part 1, 2, or 3 AND part 4)*

**2. Bay Health or Watershed Health indicators only**

(7b) What is the long-term trend? (since start of data collection)

A linear trend analysis suggests a gradually increasing (i.e., improving) trend since 1985 for every 3-year assessment period.

(8b) What is the short-term trend? (10-year trend)

A linear 10-year trend analysis suggests no significant trend since 2002 for every 3-year assessment period.

(9b) What is the current status in relation to a goal? N/A

(10b) What does this indicator tell us?

This combined indicator measures baywide attainment of water quality standards for DO, water clarity/SAV and chlorophyll *a* for each 3-year assessment period beginning in 1985.

The best available data, including water clarity assessment results from Maryland, indicate that water quality conditions from 2011-2013 indicate that about 29% (28.93) of the Bay’s tidal waters met DO, water clarity/underwater bay grasses and chlorophyll *a* standards goal. (In some years this number is subject to change once Maryland’s water clarity assessment data may be incorporated into the calculations. However, all data necessary is incorporated into this year’s analysis. No adjustments will be necessary.)

Nutrients, along with sediments, are the primary causes of impairments to the Chesapeake Bay and its tidal tributaries. To meet the objectives of the Clean Water Act, the EPA’s implementing regulations specify that states must adopt criteria that contain sufficient parameters to protect existing and designated uses. In 2003, EPA Region III developed *Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity, and Chlorophyll a for the Chesapeake Bay and Its Tidal Tributaries* (<http://www.chesapeakebay.net/content/publications/cbp_13142.pdf>). This was developed in order to achieve and maintain water quality conditions necessary to protect the aquatic living resources of the Chesapeake Bay and its tidal tributaries from the effects of nutrient and sediment pollution. Within the publication, five designated uses were identified and described, that when adequately protected, will ensure the protection of the living resources therein.

For each of the 92 Chesapeake Bay tidal management segments, a variety of unique combinations of Chesapeake Bay water quality criteria are applied, where appropriate, to each of the five tidal water designated uses. Each segment can have between one (e.g., Eastern Branch of the Elizabeth River which has only the open-water designated use) 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). Furthermore, the mainstem James River segments and the District of Columbia’s Upper Potomac River and Anacostia River segments have applicable numeric chlorophyll *a* criteria in addition to the designated use application. For a detailed outline of which designated uses and criteria apply to each of the 92 segment, refer to Table 1 of Attachment vii.b downloadable from <http://www.chesapeakebay.net/S=0/calendar/event/18751/>.

The methodology used for the calculation of the indicator considers the achievement or non-achievement of the dissolved oxygen, water clarity/underwater bay grasses, and chlorophyll a water quality standards applicable to a designated use within a segment. Rather than reporting progress only when all designated uses are met within a segment, this methodology reports when a water quality standard is met for each of the designated uses in that segment; therefore, rather than reporting on the 92 Chesapeake Bay segments used for the establishment and management of the [Chesapeake Bay Total Maximum Daily Load](http://www.epa.gov/reg3wapd/tmdl/ChesapeakeBay/tmdlexec.html) (TMDL), this methodology reports on 291 designated-use segments contained within.

This indicator uses a surface area-weighted approach, which multiplies the surface area of each of the 92 segments times the number of applicable designated uses and criteria 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 and their applicable criteria. This indicator consolidates the baywide results in the final calculations and reports percent of Bay water quality standards meeting attainment.

(11b) Why is it important to report this information?

The Chesapeake Bay Program (CBP) Partnership approved the development of this combined indicator to measure progress towards the achievement of the four jurisdictions’ Chesapeake Bay water quality standards. The indicator is 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 is being used to measure progress toward the [Chesapeake Bay Executive Order Strategy’s](http://executiveorder.chesapeakebay.net/file.axd?file=2010%2f5%2fChesapeake+EO+Strategy+Executive+Summary.pdf) water quality outcome.

(12b) What detail and/or diagnostic indicators are related to this reporting level indicator?

The dissolved oxygen indicator featured at <http://www.chesapeakebay.net/indicators/indicator/dissolved_oxygen> provides information on the percent of the combined volume of open-water, deep-water and deep-channel water of the Bay and its tidal tributaries having met dissolved oxygen standards during summer months for each 3-year assessment period.

The SAV indicator featured at <http://www.chesapeakebay.net/indicators/indicator/bay_grass_abundance_baywide> provides information on progress towards the SAV restoration goal, which is to have 185,000 acres of underwater grasses in the Chesapeake Bay.

The individual component pieces (i.e., the individual surface-area assessments of standards attainment for each designated use) that, in combination, result in the baywide percentage of water quality standards meeting attainment are features at

* Dissolved Oxygen: <http://www.chesapeakebay.net/indicators/indicator/water_quality_standards_achievement_for_dissolved_oxygen_surface_area_asses>
* Chlorophyll *a*: <http://www.chesapeakebay.net/indicators/indicator/chlorophyll_a>
* Water Clarity/Underwater Bay Grasses: <http://www.chesapeakebay.net/indicators/indicator/mid_channel_water_clarity>

.**4. All indicators**

(7d) What did the most recent data show compared to the previous year?

Results for 2011-2013 indicated that 30% of the Bay was attaining water quality standards. With the availability and subsequent incorporation of Maryland’s 2011-2013 water clarity assessment data into the calculations, this percentage may change a little bit. In the meantime, these results are not significantly different from those of the previous assessment year (2010--2012) in which 31% of the Bay was attaining water quality standards.

(8d) If this was a significant increase/decrease: No.

* To what do you attribute it? N/A
* Is this educated speculation or actual cause? N/A

(9d) What is the goal, target, threshold or expected outcome for this indicator? N/A

(10d) Was a new goal, target, threshold or expected outcome established since last reporting? N/A Why? N/A

(11d) Did the methodology of data collection or analysis change from previous year(s)?

Yes, but only the case for the attainment determination of the shallow-water bay grasses designated use.

Why and how?

Water clarity assessments are only conducted on a biennial basis since the 2006-2008 listing cycle. Furthermore, water clarity assessments are only conducted for a given set of segments throughout the Bay, which rotate every three years. When water clarity assessments are not available for any segment, the attainment of the shallow water bay grasses designated use is assessed using the measured SAV acres meeting the segment-specific restoration acre goals *only*. When water clarity assessment data is available the shallow-water bay grasses designated use is considered in attainment if:

1. sufficient acres of SAV are observed within the segment; or
2. enough acres of shallow-water habitat meet the applicable water clarity criteria to support restoration of the desired SAV acreage for that segment.

Assessment of either measure, or a combination of both, serves as the basis for determining attainment or impairment of the shallow-water bay grasses designated use.

* If so, how will this improve your/our future work?

The availability of high frequency water clarity data in shallow-water that can be used in assessments provide a more comprehensive look at the water clarity conditions within a segment. Aerial SAV photography data is only indicative of existing SAV beds. Water clarity data provides an additional means of assessing in areas where the SAV restoration goal may not be met, but not as a result of insufficient water clarity conditions.

**C. Temporal Considerations**

(13) Data Collection **D**ate(s): 1985-2013

(14) Planned Update Frequency (e.g. - annual, bi-annual):

(a) Source Data:

Annual (except for water clarity assessment results which are only updated biennially beginning with the 2006-2008 listing cycle)

(b) Indicator:

Annual

(15) For annual reporting, month spatial data is available for reporting:

* Raw data is available in the spring of the following year.
* DO and chlorophyll *a* assessments are available in the spring of the following year.
* SAV data is available in the spring of the following year.
* Water Clarity assessments, when conducted, are available in the fall of the following year.

**D. Spatial Considerations**

(16) Type of Geography of Source Data (point, line polygon, other):

* DO, chlorophyll *a*, and secchi depth are all point data.
* USGS 7.5 minute quadrangle maps are used to organize the SAV mapping process; 258 quadrangles in the study area include all regions with potential for SAV growth.

(17) Acceptable Level of Spatial Aggregation (e.g. - county, state, major basin, tributary basin, HUC):

* DO and SAV data are aggregated to 92 tidal water segments for the Chesapeake Bay (2008 revised Chesapeake Bay Program segmentation scheme: <http://www.chesapeakebay.net/content/publications/cbp_47637.pdf>).
* Chlorophyll a data are aggregated to the 7 tidal water segments for which numeric criteria apply.
* Water clarity data are aggregated to each tidal water segment where the shallow-water monitoring (i.e., continuous monitoring) is active.

(18) Are there geographic areas with missing data? Yes

If so, where?

POTOH2\_MD and POTOH3\_MD and HNGMH were not assessed for attainment of dissolved oxygen criteria due to insufficient data.

POTMH\_VA was not assessed for attainment of the deep-water and deep-channel designated uses for dissolved oxygen criteria due to insufficient data.

In areas that cannot be assessed due to lack of bathymetry data or insufficient data (i.e., “NoData”), the designated use for that segments is treated as out of attainment.

(19) The spatial extent of this indicator best described as:

(a) Chesapeake Bay (estuary) x\_

(b) Chesapeake Bay Watershed \_\_\_

(c) Other (please describe): \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Please submit any appropriate examples of how this information has been mapped or otherwise portrayed geographically in the past.

Throughout the development of this indicator, attainment status for each of the designated uses was mapped. These maps are contained within Attachments vii.a and vii.b, which were presented to the Management Board. These attachments may be downloaded from <http://www.chesapeakebay.net/S=0/calendar/event/18751/>.

(20) Can appropriate diagnostic indicators be represented geographically? Yes.

**E. Data Analysis and Interpretation: (**Please provide appropriate references and location of documentation if hard to find.)

(21) Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates? (i.e., how well do the data represent the phenomenon?)

Yes. An extensive technical review of the assumptions drawn, the data selected to be used, data interpretation, the methods employed and all supporting information and conclusions was conducted by state, federal and non-government organization partners through the development of this indicator.

Specifically, 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. Final recommendations were reviewed and approved by members of the Criteria Assessment Protocols Workgroup (CAP), the Tidal Monitoring and Analysis Workgroup (TMAW), the Water Quality Goal Implementation Team (WQGIT), and the Management Board.

Materials presented to the Management Board, including a brief write-up of methods may be found at <http://www.chesapeakebay.net/S=0/calendar/event/18753/>. Further development of the indicator as recommended by the Management Board led to the derivation of all final assumptions being used in the calculation of the water quality standards indicator. These are stated in the presentation which can be found at <http://www.chesapeakebay.net/S=0/calendar/event/18754/>.

(22) What is the process by which the raw data is summarized for development and presentation of the indicator?

The published dissolved oxygen criteria assessment methodology currently used for assessing Chesapeake Bay water quality criteria attainment involves the use of cumulative frequency distribution (CFD) curves in a 2D space of percent time and percent space to determine the volumetric extent of compliance. The procedure for assessing dissolved oxygen criteria attainment is described in detail in Appendix A of the September 2008 water quality criteria addendum: *Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and Its Tidal Tributaries 2008 Technical Support for Criteria Assessment Protocols Addendum* (<http://www.chesapeakebay.net/content/publications/cbp_47637.pdf>).

In 2004, Virginia and the District of Columbia adopted numerical chlorophyll *a* criteria for application in the tidal James River and across the District’s jurisdictional tidal waters. In 2007, EPA provided states guidance for the assessment of chlorophyll *a* criteria through the publication of *Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and Its Tidal Tributaries: 2007 Chlorophyll Criteria Addendum* (<http://www.chesapeakebay.net/content/publications/cbp_20138.pdf>). The published chlorophyll *a* criteria assessment methodology currently used for assessing Chesapeake Bay water quality criteria attainment involves the use of cumulative frequency distribution (CFD) curves in a 2D space of percent time and percent space to determine the volumetric extent of compliance.

Water clarity acres are calculated from the most recent consecutive three-year period of available shallow-water monitoring water clarity data. The general methodology is described in Appendix E of the September 2008 water quality criteria addendum: *Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and Its Tidal Tributaries 2008 Technical Support for Criteria Assessment Protocols Addendum* (<http://www.chesapeakebay.net/content/publications/cbp_47637.pdf>).

ArcGIS geodatabase in a Universal Transverse Mercator (UTM) Zone 18 projection was used to calculate area in square meters for all SAV beds. These areas are summarized in tables by USGS 7.5 minute quadrangle, Chesapeake Bay Program and Delmarva Peninsula coastal bay segments, zone, and by state. Segment and zone totals were calculated using an overlay operation of segment and zone regions on the SAV beds.

For the presentation of this indicator, we assumed that attainment of the open-water dissolved oxygen criterion can serve as an “umbrella” assessment protective of the remaining dissolved oxygen criteria in each designated use. In this way, we are able to fully assess attainment across all segments, uses and criteria using the following criteria for making impairment status determinations:

* Migratory Fish and Spawning Nursery Habitat: applied the 6 mg/L 7-day mean DO criterion as a 30-day mean
* Open-Water Fish and Shellfish Habitat: 5 mg/L 30-day mean DO criteria,
* Deep-Water Seasonal Fish and Shellfish Habitat: 3 mg/L 30-day mean DO criteria,
* Deep-Channel Seasonal Refuge Habitat: 1 mg/L instantaneous minimum DO criteria
* Shallow-Water Bay Grasses Habitat:

When water clarity assessment data is available the shallow-water bay grasses designated use is considered in attainment if:

1. sufficient acres of SAV are observed within the segment; or
2. enough acres of shallow-water habitat meet the applicable water clarity criteria to support restoration of the desired SAV acreage for that segment.

* Assessment of either measure, or a combination of both, serves as the basis for determining attainment or impairment of the shallow-water bay grasses designated use.
* Chlorophyll *a* numeric criteria as it applied to the open-water designated use for the mainstem James River segments and the District of Columbia’s Upper Potomac River and Anacostia River segments:
  + James River segments:
    1. Criteria attainment assessed during spring (Mar1-May31) and summer (Jun1-Sep30) seasons; both seasons must be meeting the standards for the segment to be in attainment.
  + District of Columbia’s Upper Potomac River and Anacostia River segments:
    1. Criteria attainment only assessed during the summer (Jun1-Sep30) season.

Impairment determinations were then summarized for every applicable designated use and criteria contained within each of the 92 segments. Using a surface area-weighted approach, which multiplies the surface area of each of the 92 segments times the number of applicable designated uses and criteria for that segment, this indicator 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. Final calculations represent the baywide percent of Bay water quality standards meeting attainment.

(23) Are any tools required to generate the indicator data (e.g. - Interpolator, watershed model)

* Interpolator and FORTRAN programs to determine the volumetric extent of compliance of DO and chlorophyll *a* standards.
* ArcGIS used to calculate area in square meters for all SAV beds.
* ArcGIS used to calculate water clarity acres for segments containing shallow-water monitoring data.

(24) *Are the computations* widely accepted as scientifically sound? Yes.

(25) Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

Yes, the Chesapeake Bay Program’s interpolator (Vol3D461) was used to interpolate DO and chlorophyll *a* the data within each segment; ArcGIS was used to interpolate water clarity data.

(26) Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the desired state of the environment? (health/stressors only)

Yes. Water quality criteria for the Chesapeake Bay and its tidal tributaries used for the assessment of water quality standards have been developed and are available at <http://www.chesapeakebay.net/content/publications/cbp_13142.pdf>.

**F. Data Quality: (**Please provide appropriate references and location of documentation if hard to find.)

(27) Were the data collected according to an EPA-approved Quality Assurance Plan?

Yes, methods are described in the Quality Assurance Project Plan (QAPP) on file for the EPA grant. Documentation is available at <http://www.chesapeakebay.net/about/programs/qa/tidal>.

**If no, complete questions 28a – 28d:**

(28a) Is the sampling design and/or monitoring plan and/or tracking system used to collect the data over time and space based on sound scientific principles? N/A

(28b) What documentation clearly and completely describes the underlying sampling and analytical procedures used? N/A

(28c) Are the sampling and analytical procedures widely accepted as scientifically and technically valid? N/A

(28d) To what extent are the procedures for quality assurance and quality control of the data documented and accessible? N/A

(29) Are the descriptions of the study or survey design clear, complete, and sufficient to enable the study or survey to be reproduced?

Yes, methods are described in the Quality Assurance Project Plan (QAPP) on file for the EPA grant. Documentation is available at <http://www.chesapeakebay.net/about/programs/qa/tidal>.

(30) Were the sampling and analysis methods performed consistently throughout the data record?

Beginning with the 2005-2007 3-year assessment period, ancillary data provided by the states are included for the assessment of DO criteria. Ancillary data did not exist prior to 2007, therefore is not included for analyses going back to 1985. Furthermore, since 2003, improvements in the development of the underlying biological reference curves used for the assessment of DO criteria haveresulted in modified reference curves. In addition, the logic of pycnocline application for determination of designated uses was corrected, in order to allow for episodic occurrence of deep-water and deep-channel designated uses. These refinements are described in the Technical Addendum published in May 2010 and are available at <http://www.chesapeakebay.net/content/publications/cbp_51366.pdf>.

Some technical improvements (e.g., photo-interpretation tools) were made over the 26 years of the annual SAV survey in Chesapeake Bay. Surveyors and analysts have carefully evaluated the effect of methodological changes along the way and made corrections to adjust for any known effects. The quality assurance project plan for the EPA grant to the Virginia Institute of Marine Sciences describes data collection, analysis, and management methods. This is on file at the U. S. Environmental Protection Agency Chesapeake Bay Program Office (contact: EPA grant project officer, Mike Fritz (fritz.mike@epa.gov). The VIMS web site at <http://www.vims.edu/bio/sav/> provides this information as well. Metadata are included with the data set posted at the VIMS web site (<http://www.vims.edu/bio/sav/metadata/beds11.html>).

Revisions to the water clarity acres assessment methodology were implemented in 2008 and are outlined in Chapter 4 of the September 2008 water quality criteria addendum: *Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and Its Tidal Tributaries 2008 Technical Support for Criteria Assessment Protocols Addendum* (<http://www.chesapeakebay.net/content/publications/cbp_47637.pdf>).

(31) If datasets from two or more agencies are merged, are their sampling designs and methods comparable?

Yes, methods are described in the Quality Assurance Project Plan (QAPP) on file for the EPA grant. Documentation is available at <http://www.chesapeakebay.net/about/programs/qa/tidal>.

(32) Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Uncertainty measurements/estimates are available for the underlying data. Methods are described in the Quality Assurance Project Plan (QAPP) on file for the EPA grant. Documentation is available at <http://www.chesapeakebay.net/about/programs/qa/tidal>.

(33) Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Yes. DO, chlorophyll *a* and water clarity are variable both spatially and temporally. The interpolation method used for each of these parameters to determine the spatial variability has inherent errors that add to the uncertainty of estimating measurements in large areas of the Bay. Moreover, the interpolations have inherent errors in that they are a composite of monthly data and the sampling of different parts of the Bay occurs over different times of the month. Therefore, there are limitations to how the data can be applied and interpreted both spatially and temporally

(34) Are there noteworthy limitations or gaps in the data record? Please explain.

Noteworthy gaps only apply to the underlying SAV acreage data– due to funding constraints, no SAV survey was conducted in 1988. For further detail on SAV spatial gaps since 1988, refer to the analysis and methods documentation for SAV available for download at <http://www.chesapeakebay.net/indicators/indicator/bay_grass_abundance_baywide>.

**G. Additional Information (optional)**

(35) Please provide any other information about this indicator you believe is necessary to aid communication and any prevent potential misrepresentation. N/A