# BIENNIAL STRATEGY REVIEW SYSTEM
*Chesapeake Bay Program*

Narrative Analysis

## WATER QUALITY STANDARDS ATTAINMENT AND MONITORING OUTCOME
## QUARTERLY PROGRESS MEETING: SEPTEMBER 15, 2022

OUTCOME: Continually improve the capacity to monitor and assess the effects of management actions being undertaken to implement the Bay TMDL and improve water quality. Use the monitoring results to report annually to the public on progress made in attaining established Bay water quality standards and trends in reducing nutrients and sediment in the watershed.

Summary

Progress for the water quality standards attainment and monitoring outcome is closely related to 2025 WIP outcome for implementing nutrient and sediment reduction practices to meet the Bay TMDL. The outcome is comprehensive and has several measures of success to assess progress: (1) improving the capacity to monitor, (2) attainment of tidal water quality standards related to the Bay TMDL, (3) watershed response to implementation of nutrient and sediment reduction practices, and (4) reporting of monitoring results. **Overall, the outlook for the outcome is off course, with increasing progress during the past 2 years.**

A summary of each measure of success is listed below, including current status, what we learned, and changes needed over the next 2 years.

**Improving the capacity to monitor. Outlook: Off course; Recent Progress: Increasing.** The Chesapeake Bay Program (CBP) currently lacks the capacity to meet all the monitoring requirements to fully assess the attainment of tidal water quality standards and many of the Watershed outcomes. There was progress over the past two years in preparing a report, requested by the Principals' Staff Committee (PSC), examining current monitoring and developing recommendations for the future. The report provides a blueprint for opportunities, but challenges exist to secure new investments. Support will be needed from the PSC and Management Board (MB) to identify program managers who can work together on funding opportunities.

**Attainment of tidal water quality standards. Outlook: Mixed results; Recent Progress: Decreasing**. Only 30% of tidal waters are estimated to be attaining water quality standards for the latest reporting period (2018-2020), and there has been a decline in the last two reporting periods. Long-term results (1985 – 2020) reveal attainment was about 25% in the mid-1980s and reached a high of 42% before the most recent declines caused by record river flow to the Bay delivering more nutrients and sediment. Studies have shown that the water quality response is not linear nor consistent across seasons and habitats, so the CBP is working towards developing metrics that show incremental changes in different designated uses to better inform efforts for the 2025 WIP outcome.

**Watershed response to implementation practices. Outlook: Mixed results; Recent Progress: no change**. There are mixed results for nutrient and sediment trends across the watershed for the latest reporting period (2011-2020). For example, nitrogen loads are improving at 37% of the nontidal monitoring stations, whereas 40% of the sites are degrading, and the remaining 23% have no trend. Phosphorus is improving at 44% of the sites but degrading at 23%, while sediment is improving at 18% of the sites, and degrading at 46%. Studies are improving the understanding of the factors affecting water quality response to nutrient-reduction efforts. Recent studies identified water quality improvements resulting from point source upgrades and reduced air deposition of nitrogen, but known management challenges exist in addressing nonpoint sources of nutrients in agricultural and urban lands delivered to rivers and the Bay.

**Reporting the monitoring results. Outlook: On course; Recent Progress: Increasing.** New advances are continuing in reporting the monitoring results, but more effort is needed to utilize the monitoring results to accelerate progress toward 2025 WIP's outcome and standards attainment in tidal waters. For the coming two years, the monitoring results could be used to put additional emphasis on improving water quality in shallow tidal waters that are critical for living resources (near shore and open water uses), in addition to the current focus primarily on waters in the deepest portion of the Bay. The partners need to enhance the interaction between the Water Quality Goal Implementation Team (WQ GIT), jurisdictions, and science providers to apply monitoring results to accelerate implementation and improve attainment of water quality standards. Putting a focus on using monitoring results and providing resources to enhance monitoring will require support from agencies on the Management Board.

1. Are we, as a partnership, making progress at a rate that is necessary to achieve this outcome? Would you define our **outlook** as on course, off course, uncertain, or completed? Upon what basis are you forecasting this outlook?

   How would you summarize your **recent progress** toward achieving your outcome (since your last QPM)? If you don't have an indicator, would you characterize this progress as an increase, decrease, no change, or completed? *If you have an indicator and it was updated since your last QPM, use your answer to question 16 from your Analysis and Methods document.*

   Explain any gap(s) between our actual progress and our outcome.

| | WQSAM Outcome Component | **Capacity to Monitor** | **Attainment of Tidal Water Quality Standards** | **Watershed Response to 2025 WIP** | **Report Trend Results** |
|---|---|---|---|---|---|
| Status | | | | | |
| **Outlook** | | Off Course | Mixed Results | Mixed Results | On Course |
| **Recent Progress** | | Increase | Decrease | No Change | Increase |

Table 1: Summary of outlook and recent progress for the 4 measures of success for the outcome.

The Water Quality Standards Attainment and Monitoring (WQSAM) Outcome is currently **off course,** based on **four** measures of success (table 1): (1) improving the capacity to monitor, (2) attainment of tidal water quality standards related to the Bay TMDL, (3) watershed response to implementation of nutrient and sediment reduction practices and (4) reporting trends results. More information is listed below for each measure of success.

- **Improving the Capacity to monitor: Outlook: Off course, Recent Progress: Increasing.**

  The PSC requested a report (Monitoring Report) and recommendations on how to improve Chesapeake Bay Program (CBP) monitoring networks. The Scientific Technical Assessment and Reporting (STAR) Team interacted extensively with Goal Implementation Teams (GITs) and partners currently responsible for CBP monitoring core and partner networks to produce a report providing a roadmap to address shortcomings and enhance monitoring. The 3 major findings were: (1) monitoring is critical to assess progress toward CBP outcomes, (2) monitoring is insufficient for many CBP outcomes, and (3) there are opportunities to address these shortfalls but funding remains a challenge. One major shortfall is the CBP lacks monitoring to assess water quality criteria in tidal waters, which is a requirement of the Bay TMDL. There is a need for new investments to address significant gaps in providing decision-support for existing applications. **A partnership approach is needed to address the vast scope of monitoring needs to build capacity.** Partners include federal and state agencies, local governments, academic institutions, and nongovernmental agencies. While some new investments have been made toward monitoring, there is still a funding shortfall for the CBP core networks and improving multi-partner networks.

- **Attainment of tidal water quality standards: Outlook: Mixed results, Recent Progress: Decreasing**

  The long-term estimates of attainment show small changes since the mid-1980's, so the outlook is considered to have a mixed result (Figure 1). In the most recent period analyzed (2018 – 2020), an estimated 30 % of the Chesapeake Bay and its tidal tributaries met water quality standards (Figure 1). This score is lower than the previous score of 33.1 % received during the 2017 – 2019 assessment period and marks a consecutive decline in the assessment status since the record high of 42.2% during the 2015-2017 assessment period. Two recent above-average flow years (2018 – 2019) likely played a large role in this short-term decrease, and we have not declined below the starting point of the indicator despite pressures from climate change, significant population growth, and growth of impervious surfaces, among other factors. **Additionally, no tidal segment in the Chesapeake Bay has been assessed for its full suite of dissolved oxygen, water clarity/Submerged Aquatic Vegetation (SAV), and chlorophyll *a* criteria across all seasons and designated uses.**

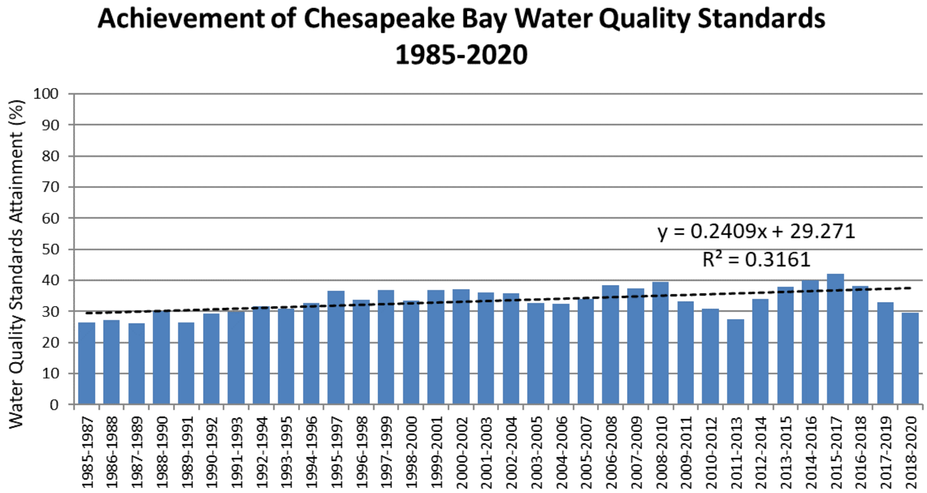


Figure 1: Estimates of attainment of water quality standards in tidal waters, 1985-2020 from the Chesapeake Bay multi-metric water quality standards indicator assessment.

- **Watershed response to implementing nutrient and sediment reduction practices for 2025 WIP: Outlook: Mixed results; Recent Progress: No change**.

The CBP partnership uses the 123 stations in the nontidal water quality network in the watershed to assess response to implementation of nutrient and sediment practices. The latest trend updated (2011-2020) revealed mixed results of 10-year trends for nitrogen, phosphorus, and sediment:

- For nitrogen, 37 % of the sites had improving trends, 40 % had degrading trends, and 23% showed no trend (Figure 2).
- For phosphorous, 44% of the sites had improving trends, 23% were degrading, and 33% had no trend.
- For sediment: 18% of the stations were improving, 46% degrading, and 36 showed no trend.

These trends are updated every two years and the previous update (2009-2018) had similar results to the 2020 update, so recent progress was considered "no change".

There are longer-term trends for some of the NTN monitoring stations. Since about 1985, 67% of the stations improved for phosphorus, and 52% improved for total nitrogen. More information and results for the NTN network can be found at: USGS nutrient and sediment trends show mixed results throughout the Chesapeake Watershed | U.S. Geological Survey

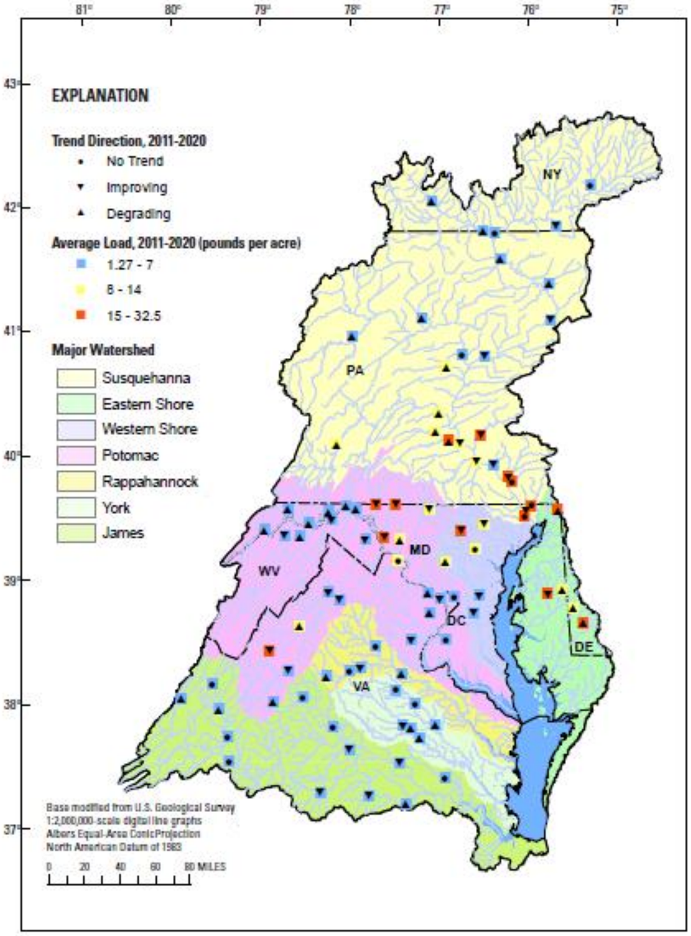


Figure 2: Map of nitrogen loads and trends from the NTN, 2011-2020

- **Report Trend Results: Outlook: On course; Recent Progress: Increasing.**

  The CBP reports results from three coordinated water quality monitoring networks. The tidal monitoring program is used to assess estimated attainment status related to water quality standards and changes in tidal water quality each year. The River Input Monitoring (RIM) Program provides annual reporting of flow, loads, and nutrient and sediment trends at 9 key sites (one site at the tidal/nontidal boundary of each major river basin). The NTN has 123 sites, and the USGS reports these trends every 2 years due to the large amount of data that must be processed. The CBP Tributary Summaries are a set of new resources that compile information from all the water quality monitoring networks (with a larger focus on tidal data) by subbasin for technical managers and planners to use as a tool to measure actual progress and transform the monitoring findings into actionable information. Examples from the various monitoring reports are available in the Appendix.

2. Looking back over the last two or more years, describe any scientific (including the impacts of climate change), fiscal, and policy-related developments that impacted your progress or may influence your work over the next two years. Have these resulted in revised needs (*e.g.,* less, more) to achieve the outcome?

*Scientific*

Scientific activities have aided the better understanding of the attainment and watershed trend results. There has been new analysis of how to explain the results and continuing support of data quality and management activities.

**Water Quality Standards Attainment:** Because of insufficient data collections relative to the information needs to assess all criteria for dissolved oxygen, SAV for water clarity, and chlorophyll, the water quality standards (WQS) indicator uses a small subset of criteria assessments and a set of scientifically based rules to produce an accounting of Bay health as defined by the TMDL.

For communication of the estimated water quality standards attainment and water quality monitoring results, we have found it **beneficial to develop metrics that show incremental progress and communicate results in multiple different ways across different platforms** (Figure 3). Figure 3 shows an example Dissolved Oxygen Criterion Attainment Deficit graph which provides an analysis over time of how close a segment came to attainment. The analysis shows that for open water segments different portions of the Potomac River showed improvement in dissolved oxygen during more recent reporting periods (upper graph of figure). Many of the deep water segments are within 10% of attaining dissolved oxygen criteria (middle graph), while the deep channel has more variable results (lower graph).

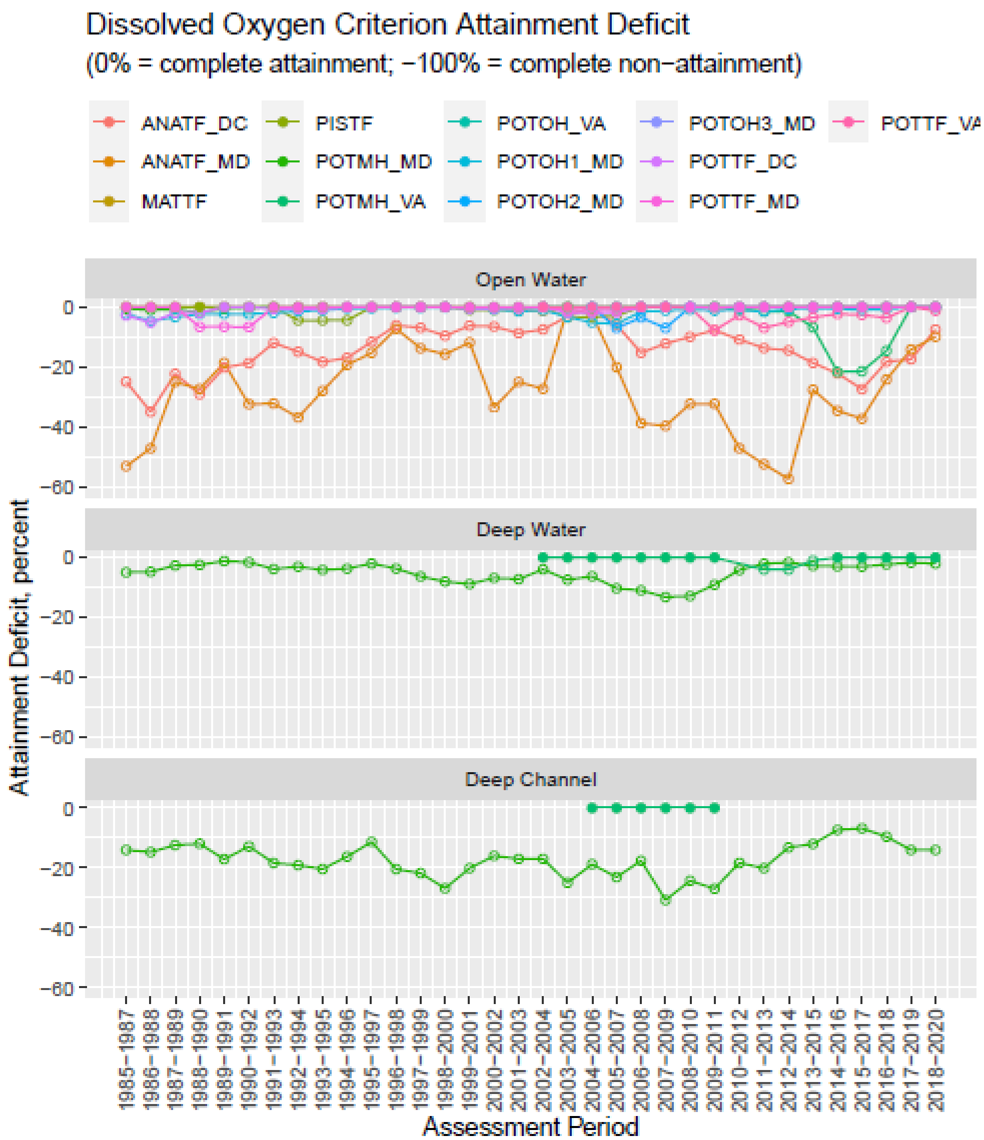


Figure 3: Dissolved Oxygen Criterion Attainment Deficit example for tidal Potomac River only.

**New monitoring & data streams:** The following innovations are the focus of active efforts in 2022 and future years to advance water quality standards attainment assessment and assessing response to management actions in the bay and watershed. They will improve and grow network data collection and interpretation operations for CBP monitoring. More details on each innovation are available in the Appendix.

- Vertical arrays of continuous water quality monitoring sensors in tidal waters of the bay
- High-temporal frequency nitrate sensors for improved tracking of river inputs from the watershed
- Small watershed monitoring with continuous water quality monitoring sensors
- 4-D interpolator tool for assessing water quality data in the tidal waters of the bay
- Community Science contributions to bay and watershed monitoring programs
- Gap-filling satellite image assessment of bay grasses in the tidal bay
- AI/ML algorithm development for SAV assessment support

Most of the CBP core monitoring networks have a long-term history of data collection lending themselves to be high value targets for use in applications such as developing and synthesizing trend analyses and model development. As part of the work to enhance the monitoring networks and produce annual products, the CBP has repeatable, published and approved protocols of data collection, sound Quality Assurance/Quality Control procedures and associated documentation, and extensive data and metadata management to support the integrity of the dataset. Challenges arise in:

- **Data Management: A challenge arises with a growing number of new water quality data streams and additional living resources data.** Additional capacity needed for effective and timely management of these new data sources. Currently, the CBP has only one data manager.
- **Quality Control: Field Audits:** Quality assurance of field and laboratory methods is important to maintaining the integrity of the water quality monitoring network's data streams. In-person, streamside field audits were put on hold for two years due to the Covid-19 pandemic. They are planned to start again in August 2022 with the goal of completing field audits of all groups collecting samples for Tier 3 data during FY23. However, capacity is again an issue as there is only one person who is tasked with coordinating and completing field audits for nine nontidal agencies, six tidal agencies, and several citizen monitoring groups while relying on additional volunteer support to complete all the audits.

**Strategic Science & Research Framework (SSRF):** The development of the CBP's Strategic Science and Research Framework (SSRF), led by STAR, has been very successful in tracking the science needs across the Bay program's Watershed Agreement goal- and outcome-focused management efforts, identifying overlapping interests between teams, and engaging additional science providers to provide capacity addressing identified science needs. A Science Needs Database was recently developed that is publicly available and provides an up-to-date list of science needs from across the partnership. With over 170 needs identified in the database, the focus for STAR is now turned to finding additional resources to increase capacity needed to address the growing list of science needs. **Expanded capacity to address the science priorities of the CBP partnership requires the engagement of the broader scientific community to** (1) translate and disseminate existing science and (2) inspire and implement additional research tackling new science needs providing decision-support to inform management of the Chesapeake Bay and its watershed.

*Fiscal*

**Funding for monitoring:** Fixed and reduced funding levels of the Federal and State water quality monitoring program funding sources **have negatively impacted the CBP partnership's ability to evaluate status and assess progress toward achieving water quality targets associated with implementing WIPs to achieve the Bay TMDL**. There is an implicit assumption that Federal funding provides a substantial foundation for States to leverage to meet their monitoring requirements and that States will address cost of living adjustments needed to round out the capacity over time. However, since 2009, Federal investment to jurisdictional partner grants supporting the monitoring programs increased initially then leveled off in recent years. Without increased investments reflecting an annual rise in cost-of-living effects on the monitoring programs budgets, some States are struggling with covering the annual cost-of-living effects on sustaining the existing sampling, analysis and reporting programs. Additionally, costs of supplies needed for sampling collection and laboratory processing and analysis have increased due to inflation. Some supplies have become unavailable due to supply chain issues, leading to costly substitutions becoming necessary to continue the sampling program. The result is reduced buying power with **fewer dollars available to support monitoring functions of sample collection across existing**

**network stations, sample processing, quality assurance (QA), data management, analysis, and reporting**. Further, there has been limited opportunity available in recent years for program growth to meet additional information needs requested by the partnership.

A partnership approach is needed to invest in the vast scope of monitoring needs to sustain and enhance the different aspects of our monitoring networks. Partners include federal and state agencies, local governments, academic institutions, and nongovernmental agencies (Figure 4). The Monitoring Report developed recommendations and cost estimates to address development, maintenance, and improvement of CBP core networks. The menu was designed to help CBP partners choose where they can support individual items that will collectively improve monitoring toward multiple outcomes.

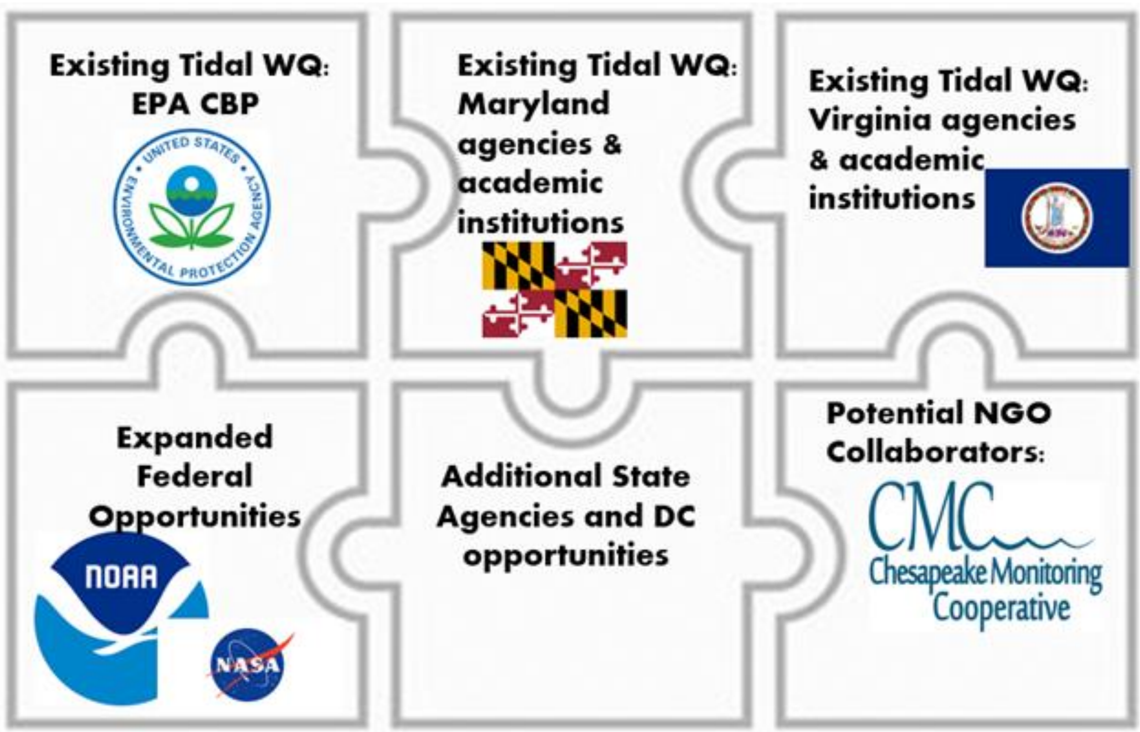


Figure 4: EPA, NOAA, and agencies and institutions in MD and VA are collaborating on estuary monitoring. These existing partners, interacting with additional collaborators, could enhance monitoring for water quality criteria, SAV, and potentially fish-habitat assessments.

**Match funding for monitoring:** Historically monitoring support from the Federal side to the State water quality monitoring program grants needed to be matched with complementary forms of monitoring match by the State. Over 10 years ago, EPA implemented a change in policy allowing States to match monitoring funding using non-monitoring restoration project efforts. The 1:1 Federal:State match formula of the 117e grant leads to an expectation that produces $2 of total monitoring for every $1 invested by EPA. However, when a State chooses to match the Federal contribution with non-monitoring programs dollars, the total monitoring output per dollar invested by EPA declines. Today, **because of the existing EPA policy on allowable match that the States are using to receive federal funds, the CBP is getting less than 100% of the expected monitoring specific output from its investments.** A change in EPA policy about allowable matching funds could be used to improve monitoring capacity for the Chesapeake Bay Program partnership. States could also re-evaluate their policies for how they apply match funding within and across their agencies that will best leverage the available funding to the States from the Federal government to support monitoring needs evaluating the Water Quality Standards Attainment outcome and other Bay Agreement outcomes. It is noteworthy that States are starting to look at their grant formulas (e.g., Maryland) and working toward improving the monitoring-to-monitoring match applications in their grants.

*Policy*

**Accelerating attainment of water quality standards.** The current partnership approach is to focus implementation of nutrient and sediment reduction practices in places that will improve waters in the deepest portion of the Bay. The CBP developed a "most-effective basins" map to guide practices to watershed areas that will provide the greatest benefit towards achieving the deep channel habitat goals. The rationale is if these waters, which are some of the most degraded, are improved, the rest of the tidal waters will also see benefits.

Given the slow improvement in these deep waters (Figure 3), there have been discussions of identifying additional tidal waters where attainment of standards can be accelerated. These discussions have focused on shallow and open waters, which are important for living resources. The CBP has an opportunity to use the tidal and watershed water quality monitoring results to consider policies to expand the places for focusing nutrient and sediment reduction practices affecting change in these other habitats.

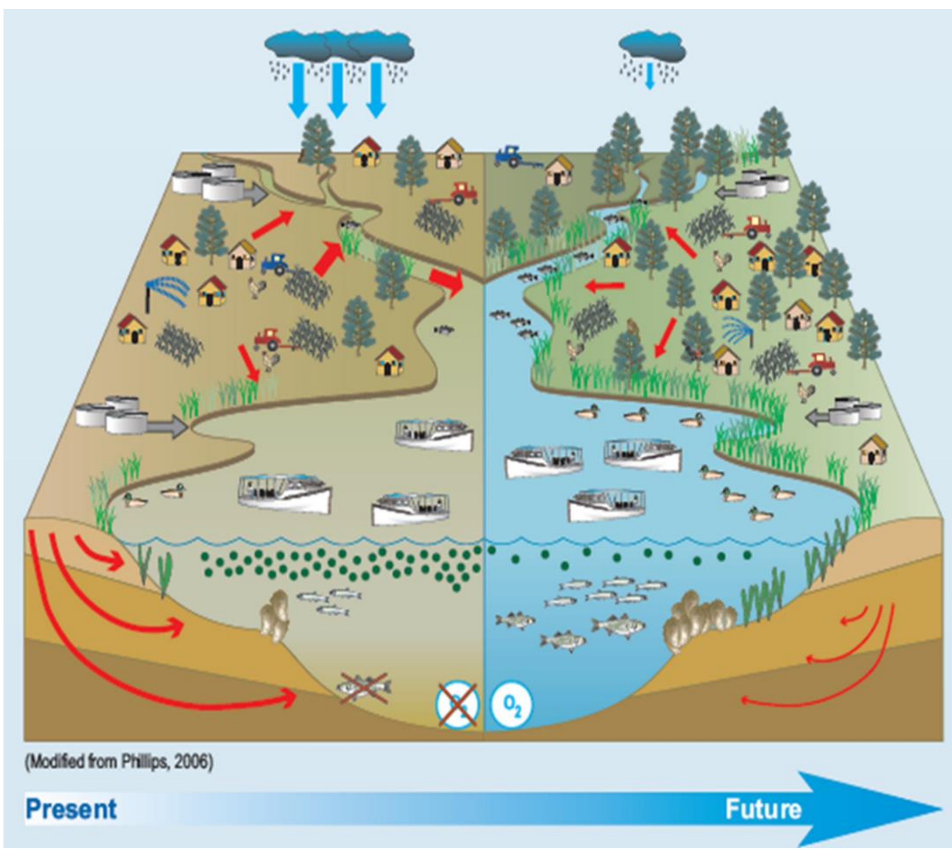


Figure 5: Conceptual diagram of current and future conditions in the Chesapeake Bay. Restoration efforts to reduce nutrient and sediment to the Bay and projected to improve dissolved oxygen for fisheries and water clarity for SAV.

**CBP Climate Directive:** The CBP continues to try and better understand the impacts of climate change on our capacity to achieve all our goals and outcomes. Gaining a better understanding of these impacts may influence where and what we need to monitor, and the analyses to be conducted. A better understanding is needed on how climate change will directly affect water quality and determine if it will limit the ability to attain water quality standards and degree of limitation as a function of the stressor acting on the system. In the watershed, we need to further explain how climate change may affect the response of water quality to assess the impact of nutrient-reduction efforts. Linkages with other outcomes and targets (e.g., blue crab abundance or SAV restoration) requires more evaluation on how water quality and climate factors may be affecting progress towards achieving our goals.

**Communication of water quality standards attainment:** As we near 2025, there will be challenges in communicating that management practices to restore the estuary are to be in place by 2025, but full water quality standards attainment for dissolved oxygen, SAV/water clarity and chlorophyll *a* is not expected to reach 100% by 2025. However, questions may arise why water quality standards are not being met when they would be expected to be. It further needs to be better recognized and communicated that the multi-metric water quality standards attainment indicator does not incorporate a full suite of criteria assessments necessary for a complete accounting that reflects the status of water quality standards attainment. Under existing assessment protocols, the monitoring programs have not had the capacity to make effective assessments of over half of the more than 1000 decisions needed to complete the accounting for a single 3-year assessment of the Chesapeake Bay dissolved oxygen, SAV/clarity and chlorophyll *a* criteria.

3. Based on the red/yellow/green analysis of the actions described in your logic and action plan, summarize what you have learned over the past two years of implementation.

The four components presented in question 1 correspond closely to the four factors in our Logic and Action Plan.

***Factor 1:*** *Sustaining and enhancing monitoring in tidal and nontidal waters*

The 2021-22 review of the monitoring program requested by the PSC, and the associated summary report, identified several insights into the operations and management of the existing CBP core monitoring networks and gap filling needs to provide missing decision-support to supporting outcome assessment under the Chesapeake Bay Watershed Agreement. The **report included recommendations and cost estimates needed to address shortfalls, maintenance, and enhancements of CBP core networks** including the tidal and nontidal water quality networks. The challenge for the next two years will be to identify funding opportunities to address monitoring shortfalls and enhancements identified in the report recommendations.

***Factor 2:*** *Improved analysis and reporting of attainment and trends results*

Analysis and synthesis of water quality data are essential to understanding and communicating attainment of water quality standards and trends in tidal and nontidal waters that support decision-making for the 2025 WIP outcome. STAR works with multiple science providers to produce an extensive amount of analysis and to report and publish water quality status and trends. Some highlights include progress towards a new 4-dimensional space-time water quality interpolator, more analysis of attainment in different designated uses, summary documents on factors affecting trends, and development of 12 Tributary Summaries. The tributary summaries contain a wealth of findings for 12 different portions of the Bay, combining information on attainment of standards, tidal trends and watershed trends and characteristics. The Integrated

Trends Analysis Team (ITAT) produces complementary information to the Tributary Summaries, which can be found on the ITAT webpage and on the interactive baytrends map app. The USGS updated watershed trends through 2020, which includes an updated story map of the results.

***Factor 3:*** *Improved understanding and communication of the factors affecting the water quality and influence of management practices.*

The STAR team in partnership with federal agencies, academic institutions and the states, has made progress in analyzing and communicating factors affecting the water quality.

Multiple reports and synthesis products were produced to better understand changes in the tidal waters and attainment of standards. The tidal water quality standards indicator showed a third consecutive year of degrading results, but studies have shown that tidal water quality response to nutrient load reductions and other forcing factors is not necessarily linear or consistent across the seasons. These types of findings are documented now in the Tributary Summaries and in recent scientific studies in the tidal waters, which can be found on the ITAT Webpage. Work is still needed to effectively communicate results from these scientific studies in ways that can aid implementation decisions. Innovations in data collection and their initial deployment and operation now in the bay occurred in this period, including new vertical continuous profiler deployments, and interpretation is underway to use this data for water quality standards attainment assessments. There needs to be an active effort to advance their application to improve and grow network data collection and interpretation operations.

New interpretations of watershed information supplied more insights into the factors affecting nutrient trends. Recent studies identified water quality improvements resulting from point source upgrades and reduced air deposition of nitrogen, but management challenges are recognized in addressing nonpoint sources of nutrients in agricultural and urban lands delivered to rivers and the Bay. The information was summarized in a fact sheet produced by USGS and UMCES. Fact Sheet Summarizes Nutrient Trends and Drivers in the Chesapeake Watershed | U.S. Geological Survey (usgs.gov).

USGS also interacted with stakeholders in each state and DC to identify their priority science questions and presented summaries for each question. Summarizing Scientific Findings for Common Stakeholder Questions to Inform Nutrient and Sediment Management Activities in the Chesapeake Bay Watershed | U.S. Geological Survey (usgs.gov)

Findings from these analyses were communicated to jurisdictions through a series of presentations and meetings. Each jurisdiction is different so instead of grouped technical meetings, a more organic approach was taken by designating a USGS point of contact for each jurisdiction. They interacted with respective regulatory and conservation groups to enhance communication of the factors affecting trends on decisions toward nutrient practices for the 2025 WIP outcome (Figure 6). Interactions with stakeholders focused on common questions of resource managers and how science could help additional priorities and individual local projects allowing USGS to build a relationship. Developing a more structured management outreach framework is the desired approach moving forward and is continuing to produce positive results.

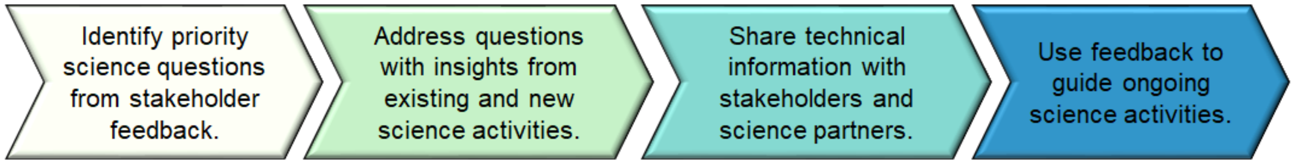


Figure 6: USGS approach for interacting with stakeholder and research community.

The communication of these results with federal, state, and local stakeholders increased over the past two years. **However, application of the monitoring results for water quality decision making remains limited and is still a challenge.** Progress toward implementing nutrient and sediment reduction practices is still based on modeling tools, principally CAST. Therefore jurisdictions, DC, and EPA focus on these modeling tools under the TMDL framework to address the 2025 WIP outcome. The WQ GIT is considering more emphasis on using monitoring since the 2025 WIP outcome also contains statements on making progress toward attaining water quality standards.

***Factor 4:*** *Improve understanding of multiple benefits between water quality practices and other CBP outcomes*

The existing CBP core networks have primarily focused on assessing water quality standards in the estuary, and changes in nutrient and sediment conditions in the watershed. The water quality monitoring programming remains a partnership priority due to regulatory mandates of the Clean Water Act. However, CBP partners further have a commitment outlined in the 2014 Watershed Agreement to assess progress toward achieving the Agreement outcomes. There is **a need to continue refining analyses that improve understanding of major drivers of water quality and living resource change and to better distinguish the response of impacted resources around the watershed, within and across tidal tributaries, and along the mainstem Bay.** Enhancements will put the CBP in a better position to address questions about drivers of observed water quality and living resources changes and effectively target the next cycle of analysis to address management concerns.

A vast amount of science is required to understand these major drivers. The Strategic Science and Research Framework (SSRF) was developed to increase the amount of science for the CBP. **The full breath of the more than 170 science needs identified in the Science Needs Database currently cannot be addressed with existing CBP Office capacity**, so we continue to engage federal and state agencies and nonprofits to expand science capacity. Future efforts will focus on promoting the use of SSRF in MB member strategic decision making and funding proposals to maintain progress towards enhancing science for CBP outcomes.

Finally, several partners have been working together on a science-based approach targeting resources to address multiple Watershed Agreement outcomes. The USGS is working with the CBP Office, USEPA, NOAA, and the Chesapeake Conservancy to provide science-based information that can be considered by agencies and organizations for a more strategic approach to targeting resources. The objective of the targeting effort is to organize science-based information so agencies and organizations can better target resources to the places, and towards the types of activities, that accelerate progress for multiple CBP outcomes and provide more local benefits. The information is organized around several topics (Figure 7) based on the goals of the Chesapeake Bay Watershed Agreement: (1) accelerate water quality improvements, (2) improve fish, wildlife populations and habitats, (3) expand land-conservation efforts, and (4) increase benefits to people, with all topics considering opportunities to enhance climate resiliency (Figure 7).

Enhanced targeting of resources will accelerate progress toward multiple CBP outcomes and increase the return on funding investments by providing more benefits to the people, fish, and wildlife across the Bay and its watershed. More information on these targeting tools can be found at: [A Science-Based Approach for Targeting Resources to Achieve Multiple Chesapeake Outcome | U.S. Geological Survey (usgs.gov)]

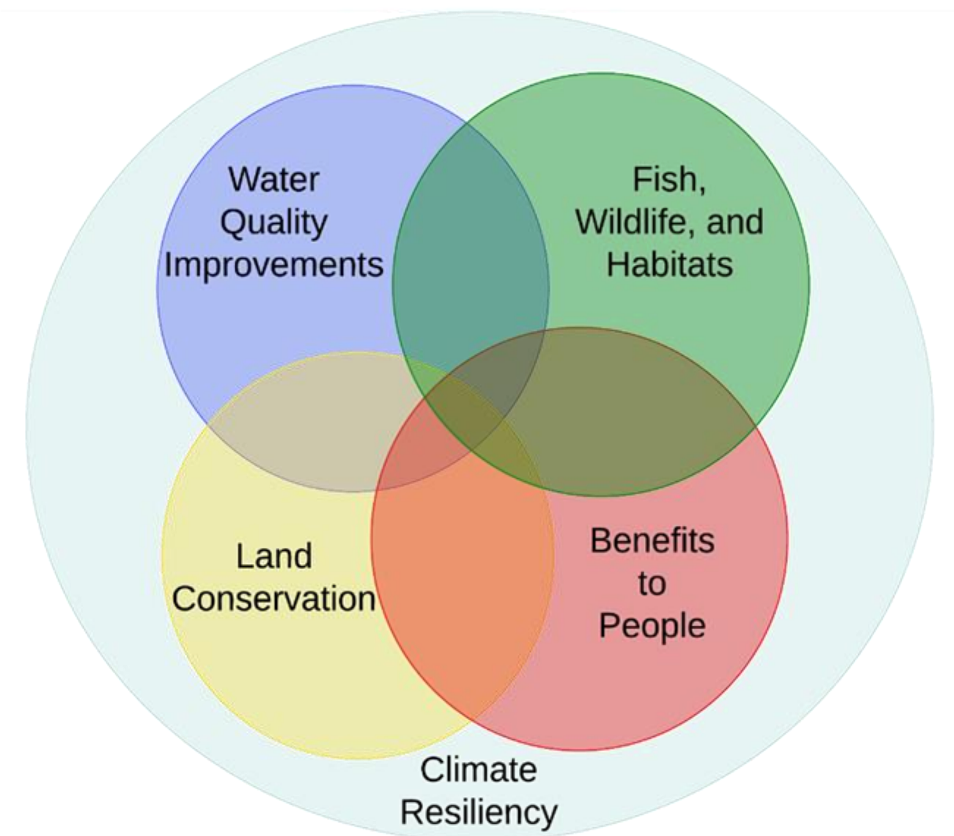


Figure 7: topics for targeting tools to help address multiple CBP Watershed Outcomes.

4. Based on what you have learned through this process and any new developments or considerations described in response to question #2, how will your work change over the next two years? If we need to accelerate progress towards achieving our outcome, what steps are needed, and in particular, what specific actions or needs are beyond the ability of your group to meet and, therefore, you need the assistance of the Management Board to achieve?

***Factor 1:*** *Sustaining and enhancing Monitoring in tidal and nontidal waters*

The CBP plans to have an initial "Kick-off" meeting in October 2022 of monitoring program managers to identify their interest in different investments to address shortfalls and enhance existing CBP core networks based on the 2022 PSC Monitoring Review Report. More detailed discussions will be coordinated with these members through the STAR Integrated Monitoring Networks (IMN) Workgroup.

**We request MB member institutions involved in monitoring support to maintain existing support levels and work as a partnership to enhance existing CBP core networks.** There is no single funding source available to enhance the existing CBP core networks or establish new networks to support monitoring for water quality attainment or monitoring for response to practices being implemented for the TMDLs. Pursuing funds for monitoring investments will require a long-term effort of increased collaboration between federal, state, academic and local monitoring programs. **We need assistance identifying agency staff to participate in partnership meetings to address priority programming needs** to ensure we have appropriate staff at the "Kick-off" meeting, and **request staff commit to future discussions on financing strategies for the monitoring networks.**

***Factor 2:*** *Improved analysis and reporting of attainment and trends results*

As part of the work to enhance the monitoring networks, analysis and synthesis need to be concurrently improved and new protocols need to be adopted and accepted to support assessment. We currently have segment-level trend results for attainment, but these have not been widely communicated. These results can inform options to accelerate progress for attainment in tidal waters important for living resources in open water and shallow water. **We request the MB to support more in-depth analyses of attainment of water quality standards.**

***Factor 3:*** *Improved understanding and communication of the factors affecting the water quality and influence of management practices.*

STAR and its science providers will supply more information on the options to accelerate attainment of water quality standards in shallow tidal waters important for living resources and people. Close interaction will be needed to consider policy implications for the Most Effective Basins (MEB) that are currently focused on improving tidal waters in the deepest portions of the Bay (Figure 8). Additional areas would have to be considered for nutrient and sediment reduction practices to improve shallow tidal waters (red box on Figure 8).

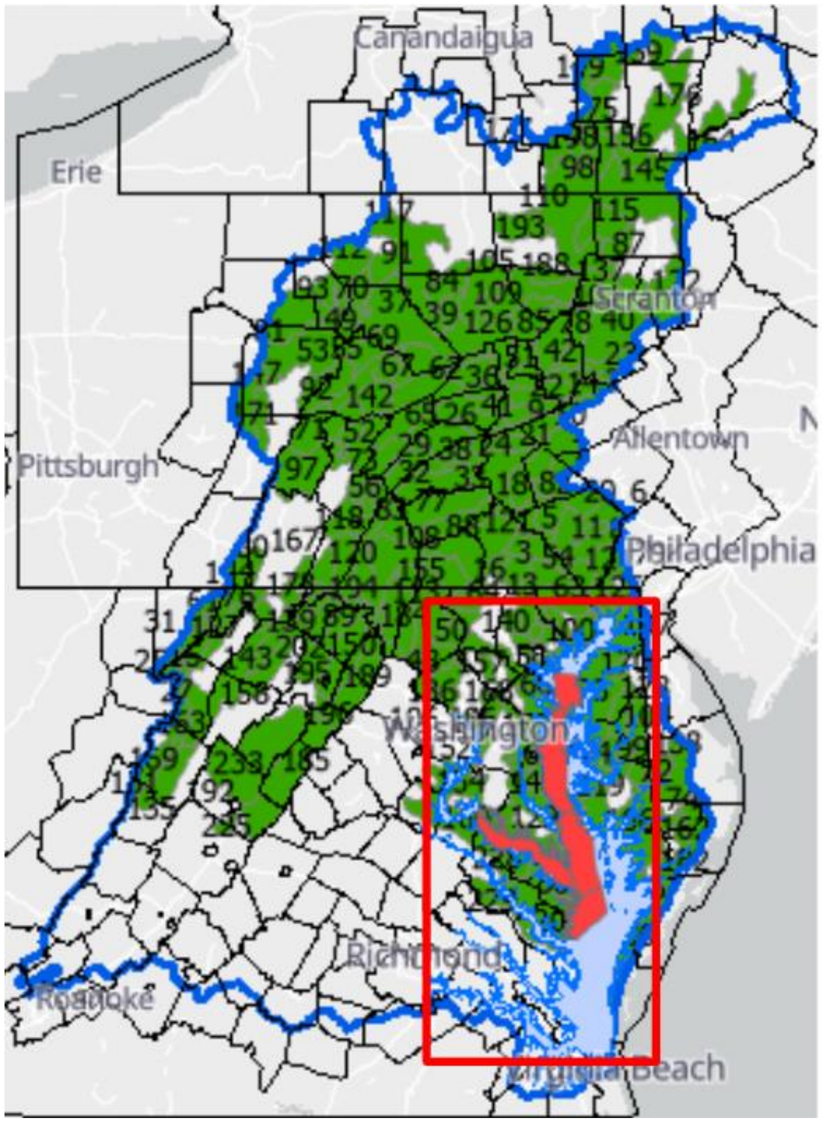


Figure 8: Most effective basins and disadvantaged communities 2022. The areas in green represent the most effective basins (MEB) as of 2022, which include the criteria for agriculture, disadvantaged communities, and infrastructure. The numbers represent the rank label of each basin, and the red areas in the Bay represent the TMDL planning target segments.

Recently, groups working on the 2025 WIP outcome and the WQSAM outcomes have started exploring options for increasing collaborations. Both teams (STAR and the WQ GIT) envision building new, complementary actions in their revised Logic and Action Plans (LAPs) to align more and improve the sharing and application of the monitoring data and interpretations from the WQSAM outcome with the 2025 WIP outcome to better inform subsequent implementation plan development. Additional joint meetings are planned between science providers and jurisdictions to apply monitoring results for progress toward the 2025 WIP outcome. To support this collaboration, we will continue the course for producing tidal, nontidal, and RIM assessments, Tributary summaries, and other reports to inform implementation targets of practices and understand the status and change through time for Chesapeake Bay dissolved oxygen, SAV/Water Clarity and Chlorophyll a water quality standards attainment.

**We request the jurisdictional members of the MB and the WQGIT commit to using monitoring results to accelerate progress towards the 2025 WIP outcomes and attaining water quality standards.** The findings about the factors affecting trends in both nontidal and tidal waters have had limited use by most jurisdictions in decision-making. Enhanced collaboration is needed to share and apply monitoring results to achieve a close connection between 1) implementing nutrient and sediment reduction practices, 2) improve water quality in the watershed, 3) reduce loads in the Bay, and 4) increase progress towards attainment of water quality standards for dissolved oxygen, SAV/water clarity and chlorophyll *a* in tidal waters.

**Factor 4:** *Improve understanding of multiple benefits between water quality practices and other CBP outcomes*

The CBP better understands the science needs across the partnership and continues to provide a strategic approach to partner resources to address operational and fundamental science needs and report on the science. Science providers have evolved their efforts to address CBP science priorities, but the advancement of technology, the change in climate conditions, the increase in land use change, etc., has amplified the amount of science needs within the CBP that need to be addressed to assess progress towards the outcomes established in the Chesapeake Bay Watershed Agreement. CBP Office does not have the capacity to fulfil all the science needs, so we need to expand science capacity through our partners. **We request MB members to use the SSRF and its Science Needs Database to guide and support jurisdictional grants and proposals development, and strategic management planning.** MB members may align their priorities with the science needs of the CBP to leverage resources and advance their objectives coincident with those of the 2014 Watershed Agreement.

The USGS has initiated an effort to take a more comprehensive approach for targeting resources, working with several partners including the USEPA (CBP office, Office of Research and Development, and Region 3) and the Chesapeake Conservancy. The objective is to develop a strategic, science-based approach to better target federal and state resources to places, and towards the types of activities that accelerate progress for multiple outcomes (Figure 7). CBP and partners will also continue to explore and explain nontidal water quality changes and the factors affecting watershed response to the focused practices. **We request the MB to support more application of actions providing benefits to multiple outcomes from targeted water quality improvement practices.**

5. What steps are you taking, or do you recommend, to ensure your actions and work will be equitably distributed and focused in geographic areas and communities that have been underserved in the past?

   Current efforts:

   - STAR launched the Chesapeake Bay Program Science Needs Database as a resource to document and track science needs, including the Diversity Outcome science needs, and engage a more diverse cohort of science providers. Several CBP GITs have used the database to consider GIT funded proposals to benefit underserved communities.
   - Under the science-based approach for targeting, information specific to underserved communities has been developed including a map for the watershed (Figure 9).
   - Partnered with UMBC ICARE Program (Interdisciplinary Consortium for Applied Research in the Environment), connecting professional scientists in the CBP with faculty and students to be mentors in the Master student's research. The UMBC ICARE program is a 2-year interdisciplinary degree program with a mission of diversity, equity, inclusion, and justice

combined with research focused on improving the health of Baltimore harbor as a socioecosystem.

- Serving on Academic Advisory Boards of UMBC ICARE and MD Sea Grant where guiding proposal developments and research activities are inclusive of Diversity, Equity, Inclusion and Justice (DEIJ) considerations.
- Coordinating with EPA and USGS to establish a Memorandum of Understanding (MOU) with UMBC, a Minority Serving Institution (MSI). One objective is to cooperate on potential joint projects between EPA, USGS, and UMBC that create opportunities for UMBC students to collaborate with CBP staff/partners on CBP science needs.
- The Chesapeake Monitoring Cooperative (CMC) has begun a multiple year project to:
    - Develop case studies on how CMC data is utilized at the local level by a diverse range of stakeholders.
    - Engage underrepresented communities through a variety of techniques to identify community interests, barriers, and intersections of common data needs and understanding.
    - Connect identified data needs of underrepresented communities to data within the CMC's existing network.
    - Develop and deliver mechanisms and resources to engage underrepresented communities in monitoring programs.
    - Provide funding for equipment or equipment loan programs, training and monitoring oversight in order to meet the data use needs identified.

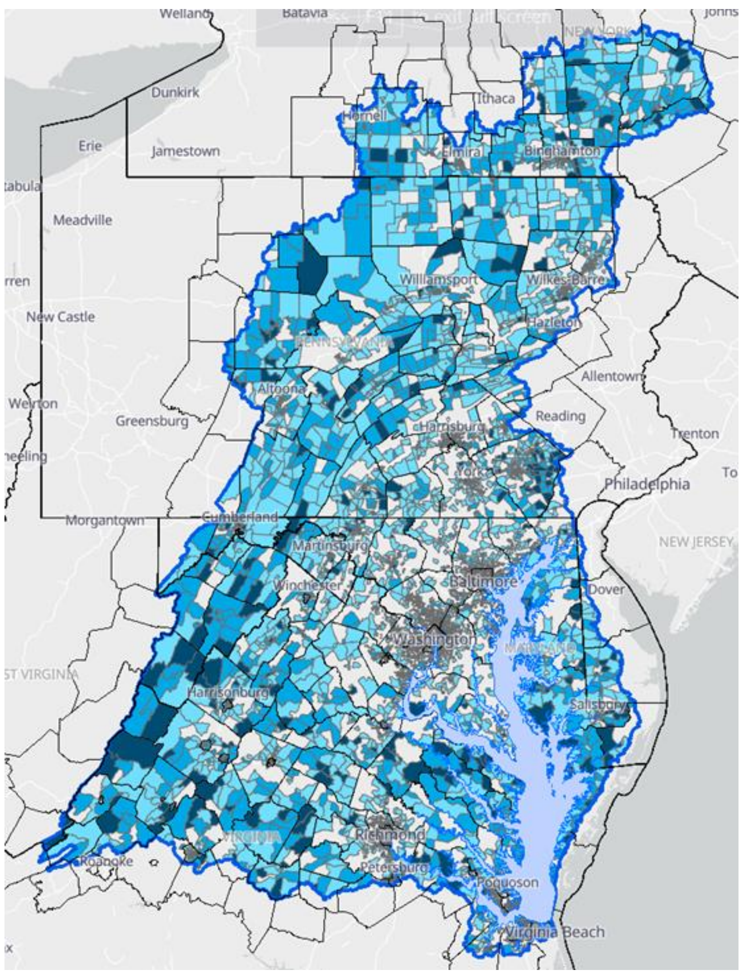

Figure 9: The location of census block groups that meet one or more of 6 demographic variables selected from the American Community Survey: percent low-income, percent in linguistic isolation, percent unemployment, percent of individuals over 25 with less education than a high school degree, percent of individuals under age 5 as a fraction of the population, and percent of individuals over age 64 as a fraction of the population. Communities that meet one of the above criterion are shown in light blue, those that meet two of the criteria are shown in a medium blue; and those that meet three or more of the criteria are shown in dark blue.

Recommended efforts:

- Continue current efforts listed above.
- Continue to engage a larger breadth of science providers around CBP science needs, including continued outreach and networking with Historically Black Colleges and Universities (HBCUs) and other MSIs.
- Increase capacity to monitor by engaging underrepresented communities in monitoring activities aligned with collected data identified under the science needs in the CBP Science Needs Database.
- Continue to inform targeting of practices for underrepresented communities.

## APPENDIX

Question 1: Are we, as a partnership, making progress at a rate that is necessary to achieve this outcome? Would you define our **outlook** as on course, off course, uncertain, or completed?  Upon what basis are you forecasting this outlook?

How would you summarize your **recent progress** toward achieving your outcome (since your last QPM)? If you don't have an indicator, would you characterize this progress as an increase, decrease, no change, or completed?

Overall, the Water Quality Standards Attainment and Monitoring Outcome is **off course**. Tidal monitoring has been recognized as insufficient to fully assess water quality standards since the criteria were established in 2003. Data collection in the Bay has declined during the history of the program associated with fewer annual cruises and/or reduced data collections per station and seasons. Nontidal monitoring grew from 2010-2012 and has maintained a network of about 125 sites across the watershed for the last decade. However, annual funding shortfalls and a major monitoring gap in the Coastal Plain region limits assessments of nitrogen and phosphorus pollution entering tidal waters. Although we have made improvements in the breadth of communication of the estimated water quality standards attainment and tidal and nontidal water quality monitoring trends, more effort is needed to better communicate analysis results generated with new and improved assessment methods, and to get the monitoring data and their translation, interpretation and synthesis utilized by the jurisdictions for 2-year milestone development.

**Capacity to Monitor:**

The watershed (nontidal) monitoring network was established through an MOU in 2004 and operates at "adequate" levels to support management information needs. The network currently has 123 stations and peaked at 125 stations, but every year there are risks of losing stations. The tidal water quality monitoring network has only ever operated at a "marginal" level with respect to collecting data necessary to evaluate all applicable criteria in the water quality standards (WQS) for dissolved oxygen, SAV & water clarity, and chlorophyll-a, in all applicable seasons, across all 92 tidal segments and their respective designated uses associated with the TMDL.

Based on the water quality criteria, there are over 1000 decision points that need to be monitored to fully assess dissolved oxygen, SAV/water clarity and Chlorophyll a standards through targeted actions identified in the WIPs under the TMDL requirements. Over 500 decision points are not able to be monitored and assessed with current CBP monitoring capacity. Without this information, the CBP cannot produce a full accounting of the status of the bay defined by the criteria and provide a full assessment of progress towards attainment of water quality standards (Figure A1).

**Report Trend Results:** Examples of the trend reports are described below.
*Example – Water Quality Standards Attainment Indicator:*

The water quality standards attainment indicator is an integrated metric used to estimate standards attainment using a scientifically based rule set to address data gaps. Indicator output is used to track progress across five designated uses (Figure A1), and criteria that can be analyzed until monitoring and assessment capacity gaps completing a full assessment care in place. The indicator allows for an overview of bay-wide progress and change over time and is a useful starting point in gauging water quality before examining the more detailed trend maps or Tributary Summaries described below.

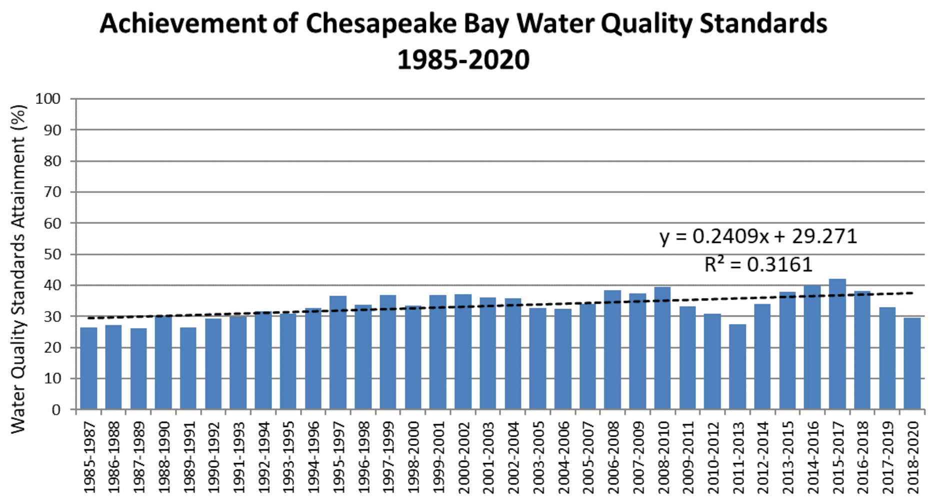


Figure A1. 1985-2020 Water Quality Standards Attainment Indicator results used to track progress on bay health.

*Example – Tidal Trends:*

Annual tidal trends results are generated for long- and short-term, both observed and flow-adjusted. The following map (Figure A2) depicts the short-term (most recent 10-years) observed trends for summer bottom dissolved oxygen.

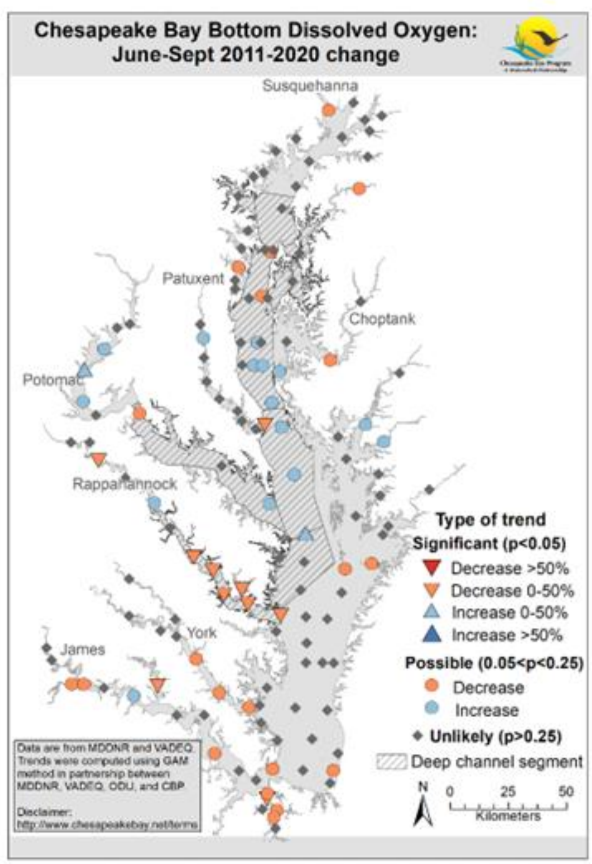

Figure A2. Bottom dissolved oxygen trends for Chesapeake Bay and its tidal tributaries, 10-year trends, 2011-2020.

*Example – Nontidal Trends:* The following map (Figure A3) depicts total nitrogen load (pounds per acre) and trends in loads, 2011-20, for selected monitoring stations.

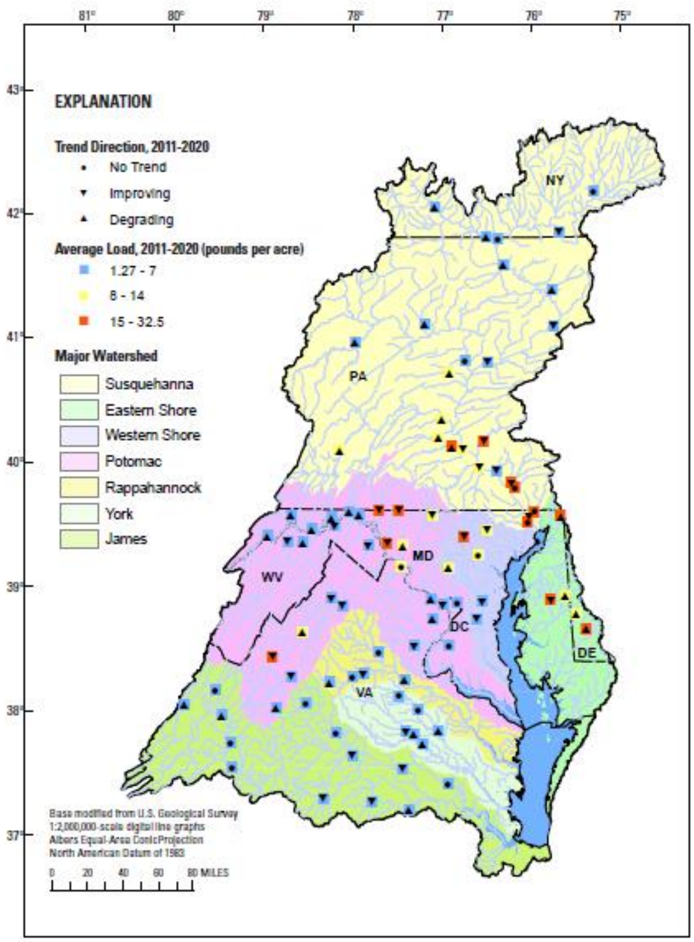


Figure A3. Chesapeake Bay watershed nontidal network monitoring results: Total nitrogen load (pounds per acre) and trends in loads, decadal patterns, 2011-2020.

*Example – Tributary Summaries:*

The Chesapeake Bay Program and its partners produce tributary basin summaries for the Bay's 12 major tributaries using tidal monitoring data from more than 130 monitoring stations throughout the mainstem and tidal portions of the Bay. These reports use water quality sample data to summarize 1) how tidal water quality (TN, TP, DO, Chlorophyll a, Secchi Depth) has changed over time, 2) how and which factors may influence water quality change over time, and 3) recent research connecting observed changes in aquatic conditions to its drivers. The tributary summaries may be used as a tool effectively communicate the data and trends and drive the direction for future management actions to support progress in water quality attainment. The following graph (Figure A4) represents information in the Potomac Tributary comparing trends in station-level DO concentrations to the computed DO criterion status for a recent assessment period.

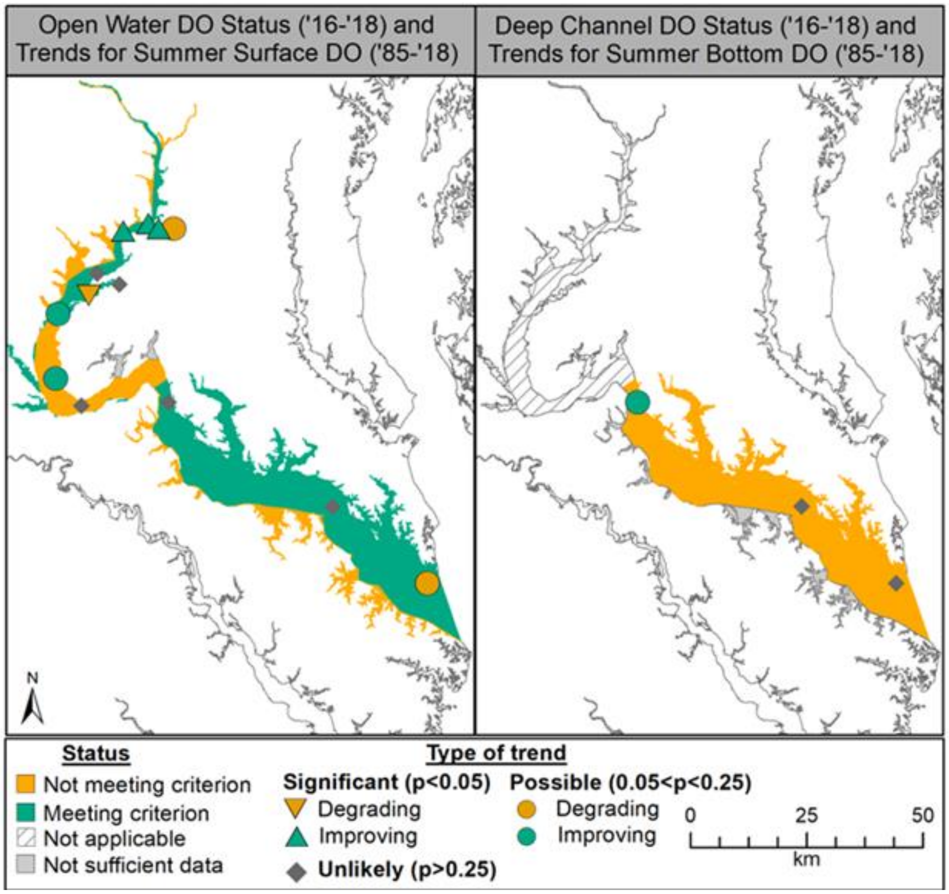


Figure A4. Tributary Summary example graphic of Potomac River water quality showing summer surface dissolved oxygen (left pane), summer bottom dissolved oxygen (right pane) for the period 2016-2018, and each provides and overlay with water quality standards attainment assessment pattern and trend results (1985-2018).

2. Looking back over the last two or more years, describe any scientific (including the impacts of climate change), fiscal, and policy-related developments that impacted your progress or may influence your work over the next two years. Have these resulted in revised needs (*e.g.,* less, more) to achieve the outcome?

*Scientific*

**New monitoring & data streams:** The following innovations are the focus of active efforts in 2022 to advance water quality standards attainment assessment and assessing response to management actions in the bay and watershed. They will improve and grow network data collection and interpretation operations for CBP monitoring:

- Vertical arrays of continuous water quality monitoring sensors
    - Short-duration dissolved oxygen criteria are an explicit subset of criteria evaluations necessary to support water quality standards attainment assessment for the tidal waters of Chesapeake Bay. The 7-day mean, 1-day mean, and instantaneous minimum dissolved

oxygen criteria are largely unmonitored and unavailable as complete data for any of the 92 bay segments. Dissolved oxygen, salinity and temperature data are needed to simultaneously characterize habitats (open water, deep water, and deep channel designated uses) to apply habitat-specific dissolved oxygen criteria thresholds to the time series in the analysis. Fixed-depth continuous monitoring sensor arrays located in shallow water offer an opportunity for subsegment evaluation of bay health (USEPA 2017).

  - A group of federal, state, and academic partners through the Hypoxia Collaborative Team, a new CBP workgroup, were formed to develop a hypoxia monitoring network that considers data needs to fill gaps for unassessed water quality criteria, fish habitat assessment, and model development calibration and verification. The formation of the group was possible due to the success of pilot study to collect high temporal frequency data throughout the water column. NOAA and EPA are exploring partnership opportunities to build out a 10-array system with station locations based on recommendations from the Collaborative.
- High-temporal frequency nitrate sensors
  - Continuous monitoring of water quality in the watershed reduces the uncertainty estimates for loads and tracks conditions unavailable from the monthly routine or quarterly storm samples. Continuous monitoring sensor suites are used to simultaneously track dissolved oxygen, conductivity, temperature, pH, coincident with continuous river flow measures, but now offer nutrient concentration tracking at high temporal density. Nitrate is a primary nutrient for algae in the bay and is the target of management actions to control nutrient pollution to the bay. Application of continuous nitrate sensors to monitoring sites will reduce the uncertainty and estimation of loads and increase the pace of detecting load responses to management actions targeting nitrogen, specifically nitrate.
- 4-D interpolator tool for assessing water quality data
  - Coincident with the development of the new vertical arrays of continuous water quality monitoring sensors is the need for a tool to use the data to improve water quality criteria attainment assessments. A 2008 CBP-STAC Workshop posed the question regarding feasibility of supporting this assessment with 4-dimensional (4-D) interpolation, and the consensus was that there was insufficient information. The Bay Oxygen Research Group (BORG), a new CBP workgroup, re-evaluated the state of science on 4-D interpolation, and agreed it was now feasible and multiple options for approaches were available to address the issue. Development of the methods are underway, and the development of the tool and implementation will continue for the next 2 – 3 years.
- Community Science
  - The maturation of the Chesapeake Monitoring Cooperative (CMC) has demonstrated the utility and the importance of citizen science and alternative monitoring data complementing the traditional long-term water quality monitoring program and other monitoring efforts. Investments in community science have helped generate new data streams that can support enhanced analyses of Bay health and reduce the uncertainties of present assessments. In March of 2022, the CMC Chesapeake Data Explorer database (https://cmc.vims.edu/#/home) had over 500,000 data points of known integrity, integrity being a long-standing challenge to the otherwise limited utility of secondary datasets. The jurisdictions signed an MOU in 2018 supporting the use of data as available, but more engagement is needed between the jurisdictions and the CMC to integrate citizen science and nontraditional partner data into state assessment programs.
  - CMC faces challenges of sustaining community scientists' engagement in data collection to support these assessments. Volunteer retention for monitoring is about 1 to 3 – 5 years, so the program has been built to account for this turnover. However, some of the

data is collected on private property or not easily accessed sites, so once a person stops monitoring data at the location, the data record can no longer continue. Programmatically, there is a similar challenge because groups may receive a grant for 2 – 3 years for their monitoring program, but many groups do not have sustained funding to support data collection after the grant ends. These challenges cause spatial and temporal gaps in the monitoring data captured in the CMC Data Explorer. The CMC has worked to overcome some of these challenges, but it takes extensive effort at the Service Provider level to continually train and manage new people leading to a more variable flux of data compared to State and Federal programs.

    - For community science monitoring data to be used in Chesapeake Bay assessments, the group must meet Tier 3 monitoring protocols. Tier 1-3 community science data collections are all data with known integrity; however, Tier 3 has the quality assurance/quality control programming comparable to EPA supported monitoring programs in the Bay. Tier 1 protocols have lower rigor and greater uncertainty, and Tier 2 protocols have high integrity with QA but may not fit into any regulatory level assessment available. Promoting Tier 1 or 2 monitoring groups to Tier 3 has increased in difficulty because of rising lab costs and specifically the requirements to do 10% field blanks and duplicate samples with the lab analysis. The blanks and duplicates alone can cost upwards to $7,000 for the programs that monitor a lot of stations (30+) causing vulnerabilities in sustainable funding for these community science programs. These added costs make it even more difficult to improve capacity of underrepresented communities which do not have the capacity or resources to apply for grants to start or support local monitoring programs. In addition to providing equipment for underrepresented and environmental justice communities, it is important to provide direct financial incentives to increase participation, build in opportunities for networking and skill building, and increase science literacy. Without increased investment in the Chesapeake Monitoring Cooperative, monitoring cuts in other community programs will need to be redistributed to these incentive programs or there will continue to be a lack of representation of those who have been traditionally excluded from the Chesapeake Bay environmental field.

- High resolution satellite imagery of the Bay
    - Aerial imagery collected by fixed wing aircraft has been used to measure and track Chesapeake Bay SAV since 1975. Publicly available satellite imagery has been widely accessible for decades (e.g., Landsat), however, pixel resolution was a limitation for effective, efficient and reliable characterization of SAV cover and therefore of limited use. Recently, new satellite image sources are producing publicly available imagery with improved pixel resolution (e.g., PLANET Scope 4$m^2$ resolution, Digital Globe 1$m^2$). This is closer to the sub-meter resolution of the fixed wing aircraft data and, when aerial flight paths could not be covered on an ideal schedule in a year due to weather or other factors, newer satellite images that have SAV detection visible have been sufficient to help backfill estimates of SAV cover.
    - Satellite image use has been opportunistic during these backfill efforts. Any consideration for a complete dependency on satellite based SAV assessment in the program needs to address key monitoring issues including 1) baywide coverage, 2) effective targeting of specific areas in space and across time, 3) be affordable, and 4) be accessible. The 2021 STAC-sponsored workshop "Exploring Satellite Image Integration for the Chesapeake Bay SAV Monitoring Program" was used to evaluate details of options and opportunities for commercial satellite imagery (CSI) with meter-scale resolution comparable to the aerial image data collections could be engaged to provide support for the annual baywide SAV survey. Workshop findings indicated CSI could provide viable local estimates of SAV cover directly comparable to aerial image

assessment approaches used today. However, a follow-up study to test implementation of a full bay monitoring program with CSI identified a series of challenges remaining (such as efficient and effective tasking to get needed imagery at appropriate times and places for assessment) before making such a data source transition.
    - Research is tackling the challenges of effective CSI accessibility, interpretability, reliability and dependability necessary to transition protocols from research phase into an annual, functional operational SAV monitoring program. Innovation is being targeted for testing on spring SAV resources (i.e., *Zannachellia*) as an extension of proof of concept from local area assessment to a viable, regional monitoring programming option.
- AI/ML Algorithm Development
    - The Annual Chesapeake Bay SAV monitoring program has produced estimates of baywide cover by hand mapping SAV beds since 1974. New computer-based image interpretation methods are evolving to interpret images for target resources like SAVs in Chesapeake Bay. AI/ML algorithm development is proving to be capable of mapping SAV resources in diverse estuaries with and satellite image sources (e.g., Coffer et al. 2020, Performance across WorldView-2 and RapidEye for reproducible seagrass mapping https://www.sciencedirect.com/science/article/pii/S0034425720304065).
    - Algorithm calibration and verification is needed for the highly variable and frequently turbid conditions in tidal waters of Chesapeake Bay. Algorithm development for mapping SAV in connection with availability and accessibility of new high resolution satellite image resources provide us with few remaining challenges to conducting regional SAV assessment with a new set of tools in the years ahead. Support for algorithm development that addresses remaining hurdles supporting a complete assessment process are necessary to move the CBP from research proof-of-concept into annual monitoring program operational mode with this technology.
    - AI/ML algorithms are already being used in research mode to characterize key water quality parameters in Chesapeake Bay including chlorophyll a (Gilerson et al. 2021 https://www.spiedigitallibrary.org/conference-proceedings-of-spie/11752/117520B/Estimation-of-chlorophyll-a-concentration-in-complex-coastal-waters-from/10.1117/12.2588004.short?SSO=1&tab=ArticleLink) and water clarity (Tomlinson et al. 2019). Time series assessments are available for chlorophyll and water clarity related conditions (He et al. 2021 and Turner et al. 2021 respectively). Here again, CBP program work remains to assess the ability of such research output to address data gaps and establish a protocol suitable for adoption into an operational, annual monitoring program.

**Tidal nutrient limitation:** Understanding the temporal and spatial roles of nutrient limitation on phytoplankton growth is necessary for developing successful management strategies. New analyses of historical data from nutrient bioassay experiments and data from the Partnership's long-term water quality monitoring program have led to the development of new empirical approaches for predicting nutrient limitation in the tidal waters (Figure A5). These new tools revealed enhanced nutrient limitation in the mainstem and three major tributaries after decades of nutrient reduction. However, collection and analysis of new bioassay data in the mainstem of the Bay and its tributaries is essential for better understanding the temporal and spatial patterns of nutrient limitation.

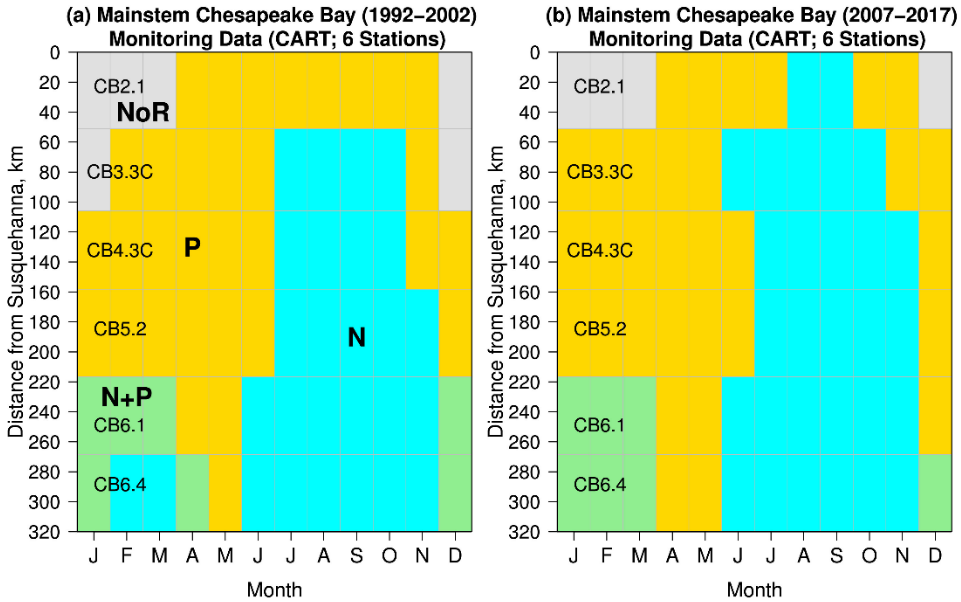


Figure A5. Predicted nutrient limitation maps for the mainstem Chesapeake Bay, comparing two decadal periods: (a) 1992–2002 and (b) 2007–2017.