Estuarine Modeling Options for 2025 CBP Decision Making

August 27, 2021

This document is being prepared for the October 25-26, 2021 Water Quality Goal Implementation Team (WQGIT) meeting where guidance will be sought on the development of the Estuarine Model that will be used by the CBP Partnership in 2025 for the assessment of 2035 climate change impacts in the Chesapeake watershed and tidal Bay. In particular, the scope and direction in the application of fine-scale multiple tributary models in the tidal Chesapeake are options for the WQGIT's consideration.

Background

On December 17 2020 the Principals' Staff Committee met to resolve CBP's final climate Midpoint Assessment decisions. Along with approval of the modeling analysis and the loads for 2025, they agreed that "In 2025, the Partnership will consider results of updated methods, techniques, and studies and revisit existing estimated loads due to climate change to determine if any updates to those 2035 load estimates are needed." The specific recommendations from the WQGIT were:

- Develop a better understanding of the BMP responses, including new or other emerging BMPs, to climate change conditions.
- Compare the current 2025 climate change assumptions with measured climate conditions through 2024 to include: rainfall volume, intensity and distribution; air temperature, hydrology, water temperature, sea level rise, and changes in Bay stratification and circulation.
- Consider the efficacy of using projections from measured trends versus downscaled global climate model data for revised 2035 estimates.
- Improve understanding and simulation of climate change impacts to Open-Water DO segments with shallow waters.

Potential for New Planning Targets. From the Chesapeake 2010 TMDL executive summary: "The TMDL is designed to ensure that all pollution control measures needed to fully restore the Bay and its tidal rivers are in place by 2025…" Section 1.2 points out that achieving implementation in the 2025 timeline was a consensus decision: "At the October 1, 2007, meeting of the PSC, the seven watershed jurisdictions and EPA reached consensus that EPA would establish the Bay TMDL on behalf of the seven jurisdictions with a target date of 2025 when all necessary pollution control measures would be in place (CBP PSC 2007)."

During the July 9, 2018 PSC meeting the Principals' Staff Committee approved the Phase 6 Model and the resulting targets, they further agreed that, "The jurisdictions' Phase III WIP nitrogen and phosphorus planning targets will remain unchanged through 2025, recognizing that the PSC reserves the right to revisit this decision if necessary." The PSC decision indicates the possibility of planning target changes in 2025, but not the inevitability. However, a recalculation of planning targets could be triggered by the approval of a new watershed model, a demonstration that the current planning targets are insufficient to meet water quality standards, or a change in the equity/decision rules governing the planning target calculation. Should a change in planning targets be needed, it could be handled by a Phase IV WIP process or, as in the case of planning target reductions due to climate change, through the two-year milestone process.

Updating the CBP Estuarine TMDL Model to a State-of-the-Science Model

The CBP has decided to develop a state-of-the-science model of the Chesapeake Bay tidal waters using an unstructured grid. Called the Main Bay Model (MBM), it will be completed and fully operational by 2025 for the estimation of change of the Chesapeake TMDL water quality standards attainability under 2035 climate change conditions. The current Estuarine Model was successfully used and updated by the CBP for more than three decades but is unable to assess shallow water Open-Water DO TMDL segments under climate change conditions. This was largely due to insufficient understanding of shallow water processes and how to simulate them at the time of model development in combination with model processing and limitations with the model structure, i.e., a model grid too coarse to sufficiently resolve tidal shallow waters.

Dissolved oxygen (DO), chlorophyll, and water clarity/submerged aquatic vegetation are included as TMDL water quality criteria in the water quality standard regulations for Delaware, the District of Columbia, Maryland, and Virginia. The four jurisdictions must achieve all water quality standards in order to delist their Bay tidal waters currently listed as impaired, despite the headwinds of growth in the watershed and future climate change. Therefore, a state-of-the-science hydrodynamic model, based on an unstructured model grid, coupled to the current CBP water quality code (ICM), and with full assessment capability for all the Chesapeake TMDL water quality criteria is needed for the 2025 assessment of 2035 climate change risk to the Chesapeake watershed and tidal Bay. The EPA Chesapeake Bay Program Office (CBPO) released a Request for Proposal (RFA) for the MBM on August 5, 2021 and expects to initiate the work on or about December 5, 2021. The MBM development and calibration years will be limited to 2022, 2023, and 2024. The MBM will be fully operational in 2025 and ready for application to assess 2035 climate change impacts in 2025 and 2026.

Multiple Tributary Models

Augmenting the Main Bay Model (MBM) and supporting other CBP objectives are the Multiple Tributary Models (MTMs). The MTMs are at a finer scale than the MBM yet will be integrated with the MBM to fit into a cohesive whole for CBP scenarios and decision-making. If approved for funding in 2022, work on the MTMs could begin in the last quarter of 2022 and have a five-year development and application period, with three years of MTM development and calibration in 2022, 2023, and 2024 and with MTM application to the Chesapeake TMDL and local tidal water TMDLs in 2025 and 2026. The WQGIT has options on which of three to five MTMs to move forward on as described below in the section *Options for Fine-Scale Multiple Tributary Models.*

There are five major advantages to developing the MTMs including 1) improved simulation of shallow water processes, 2) resolving special issues such as the James River Chlorophyll TMDL,

3) assisting and improving all tidal Chesapeake TMDLs, 4) increasing CBP analysis capability in estimating Chesapeake climate change impacts, and 5) adhering to STAC guidance on Bay modeling.

Improving Simulation of Shallow Water Processes. The MTMs will be able to better simulate shallow water processes in the shallow Open-Water regions of the Bay. It is notable that the majority of the 93 Chesapeake tidal TMDL segments, also called designated uses, have only an Open-Water DO water quality standard and entirely lack Deep-Water DO and Deep-Channel DO standards. The current 2017 CBP Estuarine TMDL Model is unable to effectively simulate shallow water Open-Water DO processes under climate change conditions. Understanding of shallow water variables and processes has improved in recent years, although there is more to learn about resuspension of organic matter and sediment in shallow areas, what determines SAV success, the presence of benthic algae, and other key processes. Shallow water MTM models will help overcome known data and knowledge limitations and help CBP partners determine how best to restore and protect the Bay's extensive shallow water habitats. MTMs would also improve the ability simulate the fate of key living resources under climate change such as SAV and tidal wetlands.

Resolving Special Issues - James River Chlorophyll TMDL. The MTMs will be able to resolve special issues like the James Chlorophyll TMDL. The James River Chlorophyll TMDL is currently oriented to 2025 climate change conditions but there is an interest in updating the TMDL for climate change conditions anticipated beyond 2025. With the MTMs this can be done by taking advantage of the CBP work in the assessment of 2035 conditions. Using the updated watershed, airshed, and estuary models that will be available in 2025 and leveraging their combined analysis will provide the most complete assessment available for the James Chlorophyll TMDL at the least cost.

Assisting and Improving All Tidal Chesapeake TMDLs. Similar to the James River Chlorophyll TMDL, the MTMs will be able to bring all the TMDLs in Chesapeake tidal waters up to date and link them with the latest 2025 watershed, airshed, and estuary models. This will allow updating and integration of local tidal Bay TMDLs completely into CBP's 2025 Chesapeake TMDL. Another major advantage of the MTMs will be the ability to update of all Chesapeake tidal water TMDLs to 2035 future climate change conditions and to have them be entirely consistent among themselves and to the overall Chesapeake TMDL.

Increasing CBP Analysis Capability in Estimating Chesapeake Climate Change Impacts. The MTMs will fully integrate and dovetail into the MBM by increasing the number of CBP science teams looking into Chesapeake water quality in shallow tidal waters. Over the course of the project, multiple modeling teams will apply, in selected tributaries and at a scale finer than the MBM, the same model codes, water quality state variables, and watershed and airshed loading as the MBM but in different Bay tributaries. The MTM teams will improve Chesapeake Bay shallow water simulations of DO, chlorophyll *a*, suspended solids, and water clarity allowing CBP decision makers to better understand the impacts of alternative management strategies on water quality and living resources in the tidal Chesapeake Bay. In addition, the MTM will be able to utilize the CBP investment in shallow water continuous monitoring for the first time in the Chesapeake TMDL. The MTMs will augment the MBM investigations and simulation of shallow water processes through collaboration and coordination with the MBM team and all of the MTM teams on a quarterly basis over the entire project period. Through cross-team collaborative work, all will learn from the others in understanding and simulating the new shallow water nutrient dynamics and processes, thereby improving both the MBM and the MTMs.

Adherence to STAC Guidance on Bay Modeling. The MTMs support the recommendations by STAC in the workshop reports *Chesapeake Bay Program Modeling in 2025 and Beyond: A Proactive Visioning Workshop** and *Multiple Models for Management in the Chesapeake Bay*** which call for developing fine scale multiple models in the tidal Bay.

Options for Fine-Scale Multiple Tributary Models

The CBPO could support three to five MTMs in the Chesapeake depending on available funding. If only three MTM teams could be supported, the James and Potomac Rivers, and an Eastern Shore tributary are practical options, although the WQGIT has the option to recommend any of the three to five MTM sites. Factors to consider in choosing priority tributaries include the presence of existing tidal water TMDLs, resources under stress from climate change, i.e., SAV or tidal wetland loss with sea level rise. An additional consideration would be if the tributary has continuous shallow water monitoring sites with three to five years of data on temperature, salinity, light/turbidity, chlorophyll *a*, and DO.

* Hood, R.R., G. Shenk, R. Dixon, W. Ball, J. Bash, C. Cerco, P. Claggett, L. Harris, T.F. Ihde, L. Linker, C. Sherwood, and L. Wainger. 2019. *Chesapeake Bay Program Modeling in 2025 and Beyond: A Proactive Visioning Workshop*. STAC Publication Number 19-002, Edgewater, MD. 62 pages.

** Weller, D. E., B. Benham, M. Friedrichs, R. Najjar, M. Paolisso, P. Pascual, G. Shenk, and K. Sellner. 2013. *Multiple Models for Management in the Chesapeake Bay*. STAC Publication Number 14-004, Edgewater, MD. 37 pages.