Review of modeling advice

Prior STAC Recommendations

The Chesapeake Bay Program (CBP) Partnership's Scientific and Technical Advisory Committee (STAC) provides independent scientific and technical guidance in various ways, including technical reports and position papers, organizing reviews of CBP projects and products, and technical workshops. STAC serves as a liaison between the scientific community and the CBP. Through professional and academic contacts and organizational networks of its 38 members, STAC ensures close collaboration among and between the various research institutions and management agencies represented in the Chesapeake Bay watershed. STAC (in conjunction with the Chesapeake Research Consortium) has assembled independent review panels with appropriate expertise to conduct several iterative reviews of the current models and their constituent components. For a STAC-sponsored peer review, reviewers are asked to prepare a report of their findings, typically in response several charge questions for each request.

All STAC review and workshop reports can be found on the STAC publication page.

Watershed Model (Phase 6, 2017)

Report Accessible At: http://www.chesapeake.org/pubs/379_Easton2017.pdf

For the 2017 Mid-Point Assessment of the TMDL, the CBP's Modeling Workgroup requested that STAC review the partnership's Phase 6 version of the Chesapeake Bay Watershed Model (P6 WSM, here). P6 is the most recent of a series of increasingly refined versions of the Chesapeake Bay Watershed Model (WSM) developed since 1982. Different versions of the model have been operational for more than three decades. However, the P6 WSM is a major departure from previous deterministic and mechanistic versions, specifically in a new approach to water quality simulation that relies on integration of multiple models for different biogeochemical processes in the watershed. This STAC-sponsored review placed particular emphasis on the new multiple model aspects of the watershed simulation, which stemmed from recommendations from several previous STAC workshops and reviews on earlier versions of the model.

In addition to addressing twelve main charge questions, the review panel was also encouraged to make recommendations for future work by the CBP partnership that built on the questions or were related to the scientific or management issues raised in the review. A panel of eleven individuals with appropriate expertise in management-focused watershed modeling, nutrient dynamics, lag time estimation, and large scale sediment modeling was formed in August 2016.

Overall, the panel was favorably impressed with the integrated P6 WSM framework. Recommendations focus largely on future actions such as a suggestion for the CBP to more fully exploit the multiple model framework and incorporate estimates of uncertainty into the output. Other recommendations are for better justification and documentation of approaches taken.

The summary recommendations identified by the panel relevant to this workshop are:

- An accuracy or skill assessment of the underlying individual models used in the multiple model approach is warranted to better constrain model uncertainty.

- The panel encourages the CBP to transition from a multi-level model approach (e.g., several models providing a single point of input to the larger watershed model, which results in a single model realization) to a true ensemble model approach, which would allow for a Bayesian model analysis and a more thorough quantification of uncertainties.
- Uncertainty analyses should be developed for each P6 WSM model component; the panel believes this would be a natural extension of the ensemble model approach.
- Use of expert panels for establishing BMP (best management practices) efficiencies should develop an explicit basis/approach to evaluating and applying uncertainty.
- The CBP should commit to a process for improving the model's capability to represent processes of particle transport, storage, and reworking in the Chesapeake Bay watershed, as the Revised Universal Soil Loss Equation 2 (RUSLE2) foundation is questionable at the river basin scale.
- The CBP should encourage the development of sub-models that attempt to down-scale the watershed models while also exploring process-based mechanisms affecting water quality to help inform local decisions to target conservation and manage inputs.

Report on the previous STAC review of the Watershed Model (Phase 5, 2008) is accessible at: http://www.chesapeake.org/pubs/2ndphasevreportfinal.pdf

Water Quality and Sediment Transport Model (Estuarine Model)

Report to be released mid-January 2018

Similarly to the Watershed Model, the CBP's Modeling Workgroup also requested that STAC conduct an independent review of the scientific credibility and utility of the 2017 version of the Chesapeake Bay Water Quality and Sediment Transport Model (WQSTM) for the 2017 Mid-Point Assessment.

In general, the approaches taken and changes made to the 2010 version of the model (Cerco et. al. 2010) were judged to be sufficiently scientifically defensible and appropriate for preliminary application for the Mid-Point Assessment. The Panel's main findings and recommendations are summarized below; more detail on each topic is presented in the body of the report. Additionally, the panel also outlines multiple modifications and updates that must be made as soon as possible to ensure that an improved estuarine model can be successfully recalibrated and its key elements introduced and reviewed in time for its use to re-compute the Chesapeake Bay TMDL in 2025.

- The representation of organic matter in the water column to more easily couple pelagic and benthic organic matter cycling is appropriate and defensible, however, an analysis of the residuals between the 2010 model and current model version to determine if the new formulation significantly shifts organic matter cycling spatially in the Bay (that is, does the new formulation change the spatial distribution of organic matter diagenesis in the Bay?) is recommended.
- The panel agrees that the Conowingo Reservoir is rapidly approaching or has effectively reached a state of "dynamic equilibrium" – and understands that the P6 model has been modified based on the CBP's best current understanding of declining reservoir performance due to reservoir infilling and that the current modeling of the Conowingo loads is satisfactory for use in the mid-term.

However, in addition to the need for complete and comprehensive documentation the panel believes that modeling improvements are likely to be needed in the future, and therefore recommends further review of this aspect of the model before the intended 2025 implementation of final watershed plans.

- The approach taken for assessing the impact of future sea level rise (SLR) is appropriate for preliminary application. The results showing that SLR reduces hypoxia are in general agreement with those obtained in previous studies (Irby et al. 2017); however, there is an inconsistency in the impact of SLR on upper Bay bottom salinity estimates between the current simulation and previously published literature. The Review Panel recommends further investigation as to the cause of this inconsistency.

- The approach taken for estimating the impacts of future temperature changes on summer hypoxic volume in Chesapeake Bay is satisfactory for preliminary application. However, the Panel has some reservations about the climate change modeling protocol for long-term management use. Climate linked processes and metrics should be re-examined (e.g., oxygen solubility, phytoplankton growth rate-temperature relationships, and metrics for the characterization of hypoxic volume).

- Although initial results suggest that wetland loss is not a concern for impacts on water quality standards attainment (i.e., oxygen concentrations), the CBP should give serious consideration to the issue of whether the SLAMM (Sea Level Affecting Marshes Model) approach an accurate assessment on the impacts of wetlands loss in shallow waters. In the future, a more mechanistic and dynamic treatment of wetland accretion and erosion may be helpful, and it would be more useful to consider the difference of various wetland types regarding to the ecological consequences.

- The oyster module appears to use the best and most freely available data for estimating the oyster populations among natural reefs, sanctuaries, and aquaculture leases. The approach for parameterizing factors in the model is certainly defensible, especially given the apparent lack of detailed information on farm sites and culture practices. Conclusions of Cerco and Noel (2007) align well with several other studies that suggest oyster beds (e.g., sanctuaries and wild stocks) can have a meaningful impact on water quality in Chesapeake Bay but that point and non-point sources of nitrogen must be reduced to curb system-wide eutrophication.

Report on the previous STAC review of the water clarity and SAV components of the WQSTM are accessible at: http://www.chesapeake.org/pubs/236_2010.pdf

STAC Workshop: Modeling in the Chesapeake Bay Program: 2010 and Beyond

Report Accessible At: http://www.chesapeake.org/pubs/modbay2010report.pdf

STAC, with the support of the CBP Modeling Subcommittee and the Chesapeake Community Modeling Program (CCMP), sponsored a workshop in early 2006 to explore the challenges and opportunities likely to face CBP modeling efforts in the next 5-10 years, and formulate recommendations to help plan for the future and maximize the utility, scientific rigor, and openness of modeling efforts.

There were several recurring themes and areas of clear consensus. The strongest was that CBP model codes, model predictions, model forcing data, and model loading data should be made more accessible to the Chesapeake Bay modeling community. More attention also needed to be paid to documentation, independent verification, and sensitivity testing. There was also clear consensus that living resources modeling should be a very high priority, not only for analysis of past and present conditions, but also for predicting both a restored Bay and the trajectory by which it may be reached. There was a consensus that more effective interactions between monitoring and modeling were needed in specific areas, some involving new modeling efforts and some involving changes to the monitoring programs to better support modeling needs. A clear vision for development of the next major version of the watershed model was presented, interactions with meteorological and atmospheric transport models were encouraged, and modeling the effects of long term changes in population, land use, and/or climate change was strongly recommended. Specific recommendations resulting from this workshop are further summarized in the report.

Most of these recommendations have been addressed to a large extent in the 2017 models. Model codes, predictions, and forcing data have been made available to partners. Documentation has improved. Sensitivity testing has become a larger part of standard operations and multiple models have contributed to independent validation of results. Living resources modeling has been improved, although only at lower trophic levels. Monitoring has been realigned and improved, particularly in the watershed. Participants in the current workshop should note that while not all recommendations were followed and few have been carried out to the fullest extent possible, recommendations from STAC workshops have weight within the Chesapeake Bay Program and influence model development significantly.

National Research Council (NRC)

https://www.nap.edu/catalog/13131/achieving-nutrient-and-sediment-reduction-goals-in-the-chesapeake-bay

Even though they were not specifically asked about modeling, the NAS panel felt that it was important to make the following recommendation:

"**Establishing a Chesapeake Bay modeling laboratory would ensure that the CBP would have access to a suite of models that are state-of-the-art and could be used to build credibility with the scientific, engineering, and management communities.** The CBP relies heavily on models for setting goals and evaluating nutrient control strategies; thus, the models are essential management tools that merit substantial investment to ensure that they can fulfill present and future needs. Currently, only a few technical professionals are fully knowledgeable of the details of the models and their development. The models are not widely used outside the CBP and, therefore, are unfamiliar to the broader scientific community. Credibility of the models is essential if the CBP goals and strategies are to be accepted and have widespread support. A Chesapeake Bay modeling laboratory would bring together academic scientists and engineers with CBP modelers to examine various competing models with similar objectives and work to enhance the quality of the simulations. An important component of the work of a modeling laboratory would be the integration of monitoring with modeling efforts. Joint research

investigations focused on evaluating the success of the Bay recovery strategies could be centered in the laboratory, such as studies on the role of lag times in the observed pollutant loads and Bay responses. A close association with a research university would bring both critical review and new ideas. A laboratory could also facilitate improvements to the models to support the 2017 reevaluation of the TMDL and the WIPs."

To a large extent, the goals of this recommendation have been met for the watershed model. There is a large group of stakeholders that contribute to the development of the watershed model and its inputs. Directions from the stakeholders are implemented by a large and diverse technical team at the Chesapeake Bay Program Office to create the watershed model. The model is run over a web interface by hundreds of users. The current estuarine model does not have a large community of users, but does have stakeholder involvement in its development. Workshop participants may want to consider how the goals of this recommendations of a large user group could be met with an appropriate structure.