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Dr. Brian Benham, Chair
Scientific and Technical Advisory Committee
Chesapeake Bay Program
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Brian
Dear Dr. Benham:

Thank you for the opportunity to respond to the Scientific and Technical Advisory Committee's (STAC) workshop on *Conowingo Reservoir Infill and Its Influence on Chesapeake Bay Water Quality*. The influence of Conowingo infill on Chesapeake water quality is a key aspect of the 2017 Midpoint Assessment of the Chesapeake TMDL progress, and STAC's assessment of the state of the science in quantifying the increased loads from the Conowingo once it reached dynamic equilibrium provides important support for Chesapeake Bay Program (CBP) decision making going forward.

The three major recommendations in your August 18, 2016 letter to the Management Board are addressed as follows.

Workshop Recommendation 1: Efforts to model the effects of Conowingo on net accumulation or release of nutrients and sediment from the reservoir should be evaluated based on its ability to "hindcast" data from water quality observations and statistical analyses.

Explicit simulation of the changes over time in the net transport of nutrients and sediment in the Conowingo Reservoir due to reservoir infill is a major advance of the Phase 6 simulation. The Phase 6 Model has been supported by extensive Conowingo infill monitoring, research, and applications of multiple models since 2010. The improved understanding of the infill process and its consequences for increased nutrient transport to the tidal Bay has provided the necessary support for a dynamic Phase 6 simulation of the Conowingo Reservoir that changes with infill conditions, is calibrated to long-term river monitoring stations above and below the Conowingo, and has guidance from the latest research findings.

In Phase 5 the Conowingo simulation was only a general representation of Conowingo Reservoir's long-term average behavior, and the Phase 5 simulation lacked the dynamic changes observed in the reservoir over the past several decades. In the Phase 6

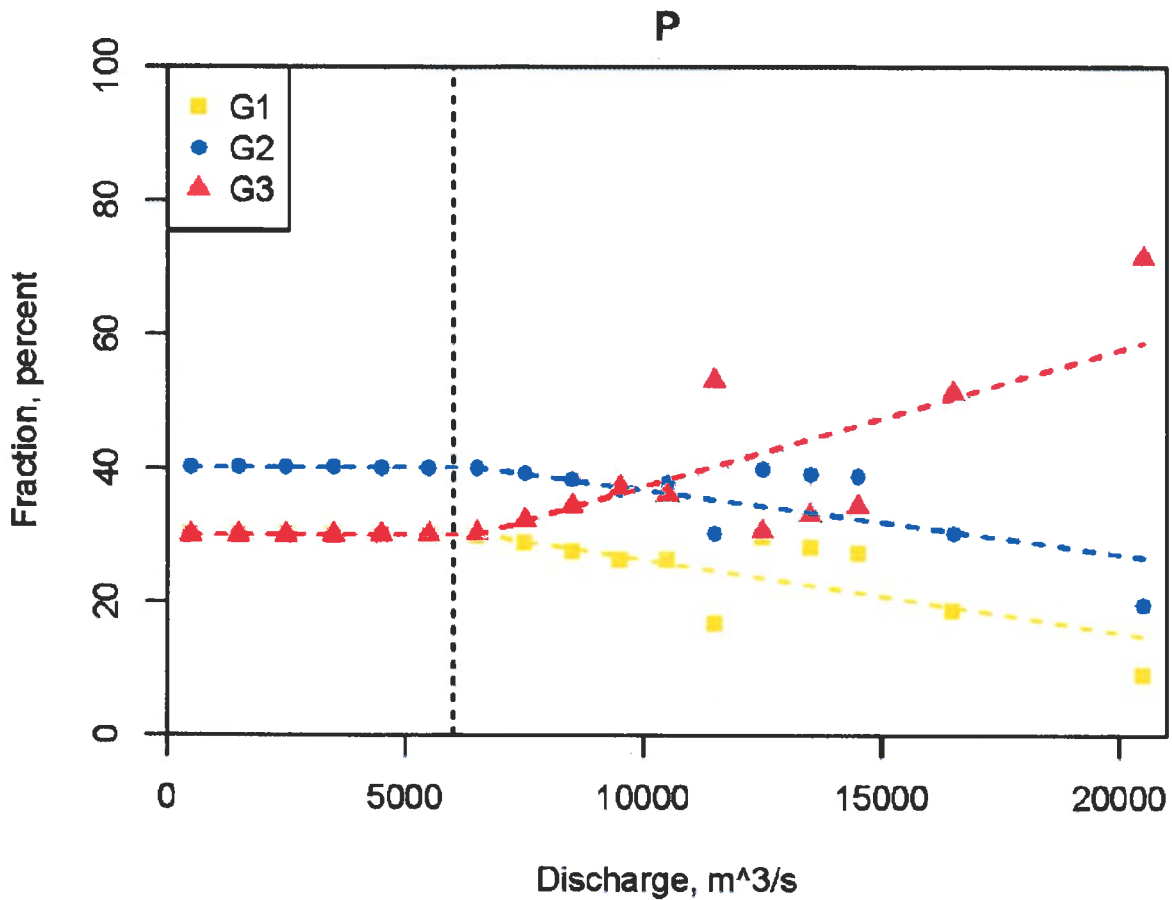
simulation of Conowingo infill, the reservoir simulation is responsive to increased infill with a reduction of particulate deposition and an increase of the potential for sediment scour (reduced critical shear stress) over the entire 1985 to 2013 Phase 6 simulation period. The Phase 6 calibrated Conowingo simulation is now fully capable in “hindcasting” data from water quality observations and statistical analyses that are consistent with a reservoir in dynamic equilibrium.

Workshop Recommendation 2: In order to quantify the influence Conowingo infill has on Chesapeake water quality, three primary issues should be considered for modeling:

2a: Address biogeochemical processes related to sediment scour and nutrient cycling that may influence bioavailability in reservoir sediments, under variable flow ranges in the Conowingo Reservoir.

The HydroQual-HDR simulation of the Conowingo Reservoir and the UMCES assessment of particulate organics in Conowingo sediment examined mass, shear stress, and the degree of reactivity of three classes of particulate organic material. The three classes of particulate organics were a labile, or highly reactive organic material with oxidation time scales of several weeks (G1), a refractory, less reactive material with time scales of several months (G2), and an effectively inert, largely non-reactive component (G3). The UMCES research and HydroQual- HDR simulation of the G1, G2, and inert G3 particulate organics in Conowingo Reservoir sediment provided essential information to address the mobilization and relative reactivity of particulate organic nutrients from Conowingo

Specifically, the quantification of the sediment components of G1, G2, and G3 organics in Conowingo sediment were used to drive the simulation of organic scour and transport from the Conowingo Reservoir by the HydroQual-HDR Conowingo Pond Mass Balance Model (CPMBM). The CPMBM simulated fractions of G1, G2, and G3 in total organic phosphorus transported from the Conowingo are represented in the figure and table below and the associated regressions of the percent of G1, G2, and G3 in phosphorus organics with riverine flow are incorporated into the Phase 6 Model. Similar quantifications are made for organic nitrogen and carbon. Using these approaches, the simulated dissolved and organic nutrients transported from the Conowingo are well represented and reflect the observed conditions of Conowingo infill in dynamic equilibrium. In all cases, after a critical flow is reached the inert fractions of scoured particulate organic material (G3) from Conowingo increases and the fraction of the more reactive G1 and G2 components decrease.



P	For Q ≤ 6500 m ³ /s	For Q > 6500 m ³ /s
G1P, percent	30.0	-0.00109*(Q-6500) + 30
G2P, percent	40.0	-0.00095*(Q-6500) + 40
G3P, percent	30.0	+0.00204*(Q-6500) + 30

Augmenting the improved simulation of particulate nutrients under conditions of dynamic equilibrium in the Conowingo, the native HSPF simulation provided sufficient representation of dissolved phosphate (PO₄⁻) and ammonia (NH₄⁺) flux from Conowingo sediment with high flow driven sediment scour by using a model-user set flux based on observations.

2b: Ensure representation of effects of Conowingo inputs to Chesapeake Bay for the full range of flow conditions including ‘extreme’ high-flow events.

The representation of the effects of Conowingo inputs to the tidal Chesapeake Bay for the full range of flow conditions including ‘extreme’ high-flow events was done using WRTDS guidance over the full range of flows, which were augmented with observations during the extreme high flow events to further guide the Phase 6 simulation of the Conowingo Reservoir. Decreased deposition over time with increasing infill was

consistent with WRTDS and other observations (Zhang et al., 2016a; 2016b; Langland, 2015). In addition, scour was calibrated with the critical shear stress of bottom scour from the Conowingo Reservoir increasing over time with increased infill. The approaches of decreased particle deposition and increased bottom critical shear stress with infill demonstrably improved the simulation's agreement with observation and was entirely consistent with reservoir infill theory and the recommendations of the STAC Conowingo workshop. In addition to the calibration for Conowingo, an enhanced one-dimensional HEC-RAS2 model of Lake Clarke and Lake Aldred was applied to estimate sediment inflows to the Conowingo Reservoir and improving the overall input output mass balance over all flow conditions.

2c: Improve representation of reactivity of particulate organic matter in Conowingo outflow.

The 2017 version of the WQSTM included the full explicit simulation of labile, reactive, and relatively unreactive particulate organics (G1, G2, G3, respectively) in the simulated WQSTM water column for the first time, which significantly improved the representation of particulate organic material throughout the model domain.

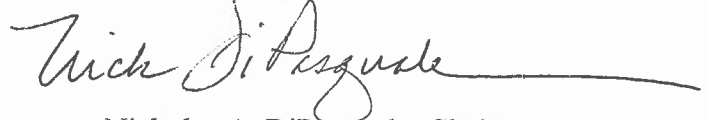
In addition, to further address the fate of the particulate organic phosphorus, particulate inorganic phosphorus and particulate organic nitrogen scoured from the Conowingo and transported to tidal water, core studies with tidal Chesapeake sediments were conducted by UMCES. The tidal water sediment core studies provided insight as to what changes in nutrient flux would be expected from sediment cores that were capped by an influx of Conowingo sediment, similar to what would occur during scour from Conowingo during extreme high flows. A collection of cores from different regions of the upper Bay confirmed that the simulated flux behavior of the WQSTM in the upper Bay downstream of Conowingo discharge was consistent with observations.

Workshop Recommendation 3: Moving forward, an effort should be made to link the sediment transport and biogeochemical models in the 2010 Water Quality and Sediment Transport Model (WQSTM) to enhance modeling of the transport and fate of organic nutrients in the tidal Bay.

The Modeling Workgroup fully agrees that the next generation of tidal water quality and sediment transport model should have fully linked and integrated sediment transport and biogeochemical models. This is an active area of simulation research, and examples of the linkage of simulated sediment transport and sediment/water column biogeochemical processes are now operational, such as in the CPMBM used in the current Conowingo study. The linkage could be particularly important in regions of high estuarine deposition of sediment and particulate nutrients, with subsequent nutrient outflux determined by the presence and extent of bottom water hypoxia. Opportunities for examining the potential for this linkage will be in the January 2018 STAC workshop *Chesapeake Bay Program Modeling Beyond 2018: A Proactive Visioning Workshop*.

In closing, on behalf of the Management Board, please extend my thanks to the workshop steering committee and participants for their time and effort in developing the report *Conowingo Reservoir Infill and Its Influence on Chesapeake Bay Water Quality*. We remain, as always, very appreciative of STAC's role in providing independent reviews and guidance for improving our management of the Chesapeake Bay TMDL and restoration effort.

Most sincerely,



Nicholas A. DiPasquale, Chair
Management Board

Ec: Management Board Members
Water Quality Goal Implementation Committee Members
Modeling Workgroup Members

References

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