September 7, 2017

Briefing Paper on Soil Phosphorus Data Concerns, Partnership Responses, and Proposed Paths Forward for Management Board Consideration and Decision

Since 2012, the Chesapeake Bay Program (CBP) Partnership has been working on the recommended refinements to the Phase 6 suite of modeling tools, as part of the Chesapeake Bay TMDL's Midpoint Assessment, to improve confidence and transparency, and to adopt a simplified, multiple model approach: http://www.chesapeakebay.net/who/group/modeling_team . These refinements reflect over 5 years of meetings, conference calls, and smaller group discussions between the Modeling Workgroup, the Water Quality Goal Implementation Team (WQGIT), and its Source Sector Workgroups. These model refinements were based directly on recommendations coming forth from workgroups[1], workshops[2], symposiums[3], and independent scientific peer reviews[4][5] sponsored by the Partnership's Scientific and Technical Advisory Committee (STAC) and the Agriculture Workgroup (AgWG), as well as the University of Maryland Wye Research and Education Center.

Prior to finalizing the Phase 6 modeling tools in Fall 2017, the Partnership undertook a two-month fatal flaw review of the tools (June 1 – July 31, 2017). A Phase 6 modeling review strategy document (http://www.chesapeakebay.net/channel_files/25113/phase_6_approval_process_final_5-9-17.pdf) was approved by the WQGIT during their May 8 conference call and distributed to its Source Sector Workgroups and other Partnership groups to help guide the fatal flaw review process (see Appendix A for the fatal flaw definition).

The Chesapeake Bay Program Office (CBPO) received 115 comments from partners and stakeholders, with perhaps 80 unique comments (some are duplicates from multiple sources) as a result of this fatal flaw review period. During their August 28 WQGIT conference call, the WQGIT agreed to the proposed resolutions on all comments received during the Phase 6 fatal flaw review period, with the exception of two issues related to soil phosphorus, representing about 15 comments.

Incorporating Soil Phosphorus into the Phase 6 Model

The concerns raised in this document are regarding the Phase 6 model refinements to simulate soil phosphorus concentrations. The Phase 6 method to simulate phosphorus on agricultural lands has been developed over the past five years with significant existing research and the Partnership's existing model. The approach includes the use of observed agricultural phosphorus soils data, where available, and the application of the Annual Phosphorus Loss Estimator (APLE) model and Baysian statistics to assign soil phosphorous concentrations across all agricultural land uses through time. The CBP

[1] 2014 A Review of Agricultural P-dynamics in the Chesapeake Bay Watershed Model: A Workgroup Report from the Chesapeake Bay Program Scientific and Technical Advisory Committee: http://www.chesapeake.org/pubs/327_Staver2014.pdf

[2] 2013 Building a Better Bay Model: A Workshop for Agricultural Partners: http://www.chesapeakebay.net/channel_files/20725/building_a_better_bay_model_a_workshop_for_agriculture_partners_annotated_051713.pdf

[3] 2015 The State of the Science of Phosphorus Symposium Proceedings: https://sera17dotorg.files.wordpress.com/2015/02/phosphorus-symposium-proceedings-1-30-15.pdf

[4] 2017 Scientific and Technical Advisory Committee Chesapeake Bay Watershed Model Phase 6 Review: http://www.chesapeake.org/pubs/379_Easton2017.pdf

[5] 2016 Scientific and Technical Advisory Committee Review of Nutrient Input Estimation for the Chesapeake Bay Watershed Model: http://www.chesapeake.org/pubs/358_Yagow2016.pdf

Partnership and its relevant committees approved the method and APLE model to simulate soil phosphorus concentrations.

The benefits of applying the APLE Model in Phase 6 and simulating soil phosphorus concentrations are as follows:

- Adding soil phosphorus allows agricultural lands to take significant credit for managing phosphorus inputs.
- The use of APLE allows the Partnership to differentiate between areas of high soil phosphorus and low soil phosphorus.
- APLE was recommended by STAC. By using APLE, the Partnership is taking advantage of the best available scientific knowledge.

Phase 6 Fatal Flaw Review: Soil Phosphorus Issues and Concerns

ISSUE I: ***Delaware expressed concerns that there is an inequity between modeling soils data between the agricultural and urban sectors***. Delaware contends that the APLE simulation on agricultural land is inequitable with the developed sector. Delaware is requesting that soil samples and relative load should be simulated in a similar fashion in both sectors; using either the Phase 5 Watershed Model or APLE method.

Considerations:

- There is some "Home and Garden" soil phosphorus data available in the existing data.
- The Partnership's approved Urban Nutrient Management BMP Expert Panel Report determined that high soil phosphorus levels were only one of eleven factors which determine phosphorus runoff from pervious, developed land.
- Urban pervious lands have much different phosphorus inputs than crop land. For example, only half of urban turf in the Bay watershed is fertilized, and no urban lands receive any manure applications (like their agricultural counterparts).
- APLE is not a peer-reviewed, calibrated tool for urban soils, and should not be used for estimating runoff from urban soils. No known model exists to simulate urban phosphorus runoff based upon soil phosphorus data.
- The APLE model does not change the total load within a sector but only changes its geographic distribution.
- Phosphorus concentrations in developed runoff are well-understood, and monitoring data suggest they are very consistent across the nation and in the Bay watershed. Additional information on urban phosphorus can be found in Appendix B.
- Simply applying agricultural methods to developed lands is not scientifically valid, since no such method exists at this point, and it would have little or no aggregate effect on the load balance between the agricultural and developed sectors.
- Removing the modeling approach for soil phosphorus in the Phase 6 Watershed Model would actually have a detrimental effect:
    - It would limit agricultural management practice effects and Delaware loads would likely increase.

ISSUE II: ***Several jurisdictions and at-large members expressed concerns about the soil phosphorus data quality, uncertainty, and the APLE process***. The extent of observed agricultural phosphorus soils data available for individual counties and years across the watershed is highly variable. Some counties have hundreds of samples, others have only a few. There are also concerns about the uncertainty of the

data due to differences in lab techniques, extraction methods, lab equipment, etc. Finally, there are concerns about the appropriateness of the APLE process to apply these data to all agricultural land uses in each county through time. Together, these concerns raise questions as to the accuracy, reliability, and representativeness of the resulting soil phosphorus concentrations used in the model. Given these concerns, Delaware Department of Natural Resources and Environmental Control and Delaware Department of Agriculture have requested that the use of the APLE model and the method of simulating phosphorus on agricultural lands be removed from the Partnership's Phase 6 suite of modeling tools, reverting back to the Phase 5 approach where soil phosphorus concentrations were not explicitly simulated.

Considerations:

- Removing the modeling approach for soil phosphorus in the Phase 6 Watershed Model would have a detrimental effect on the calibration and the Partnership-approved Midpoint Assessment schedule.
- While the data is imperfect, the methods to incorporate the data reflect the recommendations of regional and national experts in soil phosphorus, and the decisions of the Partnership.
- The 2014 STAC Report specifically recommended changes to the Phase 5 modeling approach to better simulate soil phosphorus concentrations, which have the potential to contribute to watershed P losses well into the future.

Recommended Path Forward to Address Concerns on Soil Phosphorus Data & Methods

During the August 28 WQGIT conference call, CBPO staff presented a recommended path forward to address the concerns on soil phosphorus data and simulation methods:

- **Near-term: Data Uncertainty**. As part of the states' submission of their soil phosphorus data to the CBPO, states were also expected to conduct a quality assurance/quality control of that data. However, in response to states expressing concerns over data uncertainty (e.g., differences in lab techniques and/or extraction methods), the WQGIT approved that states be provided with the opportunity to individually review and request a change to the standard deviation value from a given soil phosphorus data source. This information was due to the CBPO by September 1 and all states except Virginia chose to alter their respective standard deviations following the review of their soil phosphorus data. These changes will be factored into the Phase 6 Watershed Model.

- **Mid-term: Future Data Collection**. There was general Partnership agreement that continuing to collect soil phosphorus data and improving assumptions behind that data collection and use is a worthwhile effort. States can continue to submit agricultural soil phosphorus data to the CBPO to be incorporated into each two-year milestone period, following Partnership-approved protocols.

- **Long-term: STAC Workshop**. Both the AgWG and the USWG were supportive of submitting a STAC workshop proposal to investigate the impact of soil phosphorus on urban runoff for future versions of the Partnership's Watershed Model. While no specific action was taken by the WQGIT on this recommendation, there was general consensus that additional research was needed on the soil phosphorus issue across all sectors.

Partnership Decisions to Date on the Use of APLE and Soil Phosphorus Data in the Phase 6 Model

Over the past several years, the Partnership has (1) developed an approach for modeling phosphorus soil loadings; (2) requested and received phosphorus soils data from the jurisdictions; and (3) developed Baysian statistical approaches for addressing phosphorus soil data uncertainties. These approaches were vetted and approved by the AMS and AgWG in Spring 2017.

Building a Better Bay Model, May 22, 2013

On May 22-23, 2013, the Partnership and Bay watershed agricultural community convened a *Building a Better Bay Model* workshop to discuss proposed refinements to the Phase 6 suite of modeling tools for the agricultural sector. The AMS prioritized the recommendations from the *Building a Better Bay Model* workshop, noting soils data as a high priority:
http://www.chesapeakebay.net/channel_files/19189/agwg_ams_workshop_recommendations_and_tasks_092413.pdf

Recommendations for Chesapeake Bay Program Partnership Phase 6.0 Models

From Building a Better Bay Model: A Workshop for Agriculture Partners, May 22-23, 2013

Prioritized by the Agriculture Workgroup's Agricultural Modeling Subcommittee on September 12, 2013

Priority	Task Category	Task	Line Reference in Detailed Recommendations Sheet
High Priority Tasks	Soils	Characterize how legacy nutrients (especially legacy P) impact nutrient losses from agricultural lands.	59,60,61,62
	Soils	Incorporate soil and nutrient content data into the next version of the Watershed Model. Soils test data is available in annual reports from Maryland and Deleware and in nutrient management plans.	55,56,58
	Manure	Collect and analyze data from industry sources on animal populations, manure and nutrients produced, and mortality rates to update Scenario Builder assumptions. Some sources include: Milk Processor Surveys; Dairy, Calves and Heifers Association; National Pork Board Environmental Committee; Pig Production Environmental Footprint Calculator; Iowa State University; Virginia Tech; Poultry Growers Association	33,34,35,36,38,39,42,44,51

STAC's 2014 Workgroup Report entitled, "A Review of Agricultural P-dynamics in the Chesapeake Bay Watershed Model". http://www.chesapeake.org/pubs/327_Staver2014.pdf

STAC approved the formation of a workgroup of scientists following its September 2011 quarterly meeting to work with CBP modelers to investigate how phosphorus transport from cropland was simulated in the Partnership's Watershed Model. The workgroup developed recommendations for better accounting for soil phosphorus and the effects of how phosphorus applications are managed in the simulation process, along with several general phosphorus modeling recommendations, and also identified future data needed to improve phosphorus transport modeling within the Watershed Model. The Partnership's Management Board responded to the STAC workshop report on March 9, 2015, which was overall supportive of the workgroup's recommendations, including the confirmation of the Modeling Workgroup's evaluation of the use of APLE and soil phosphorus data in Phase 6. As a result of the subsequent discussions, the Partnership made the determination that APLE was an appropriate model for phosphorus losses and for use in the Phase 6 Watershed Model.

Independent Scientific Peer Review of the Phase 6 Model

In 2016, the Partnership's Modeling Workgroup requested a detailed and in-depth independent scientific peer review of the Phase 6 Watershed Model be sponsored by STAC. In response, STAC convened a panel of nationally recognized experts in the appropriate fields of watershed modeling to carry out this review. In the panel's final report distributed widely to partners on September 1st by STAC staff, the panel's detailed findings and recommendations did not document any concerns with how soil

phosphorus on agricultural lands was being simulated using the APLE model. The report can be accessed here: http://www.chesapeake.org/pubs/379_Easton2017.pdf

June 7, 2016 Webinar: The CBPO's Modeling Team provided the AgWG with a webinar describing the beta version of the Phase 6 Model, including links to draft documentation, and a description of the use of APLE and soil phosphorus data. The webinar presentation can be accessed here: http://www.chesapeakebay.net/channel_files/23301/2016_07_20_phase_6_beta_agwg_garyshenk.pdf

March 13, 2017 Decision: The AMS agreed to move forward with using the Bayesian model approach developed by Andrew Sommerlot for representing soil phosphorus history in the Phase 6 model.

March 16, 2017 Decision: The AgWG approved the AMS recommendation to simulate soil phosphorus history by using a mass balance modeling approach combining APLE and soil test data. This decision was made with Pennsylvania abstaining.

August 3, 2017: The AgWG held a special Phase 6 review in-person meeting at the Fish Shack to address comments and questions with the CBPO Modeling team, at which time the phosphorus modeling questions were discussed.

August 17, 2017: The AgWG held an extended monthly meeting conference call, at which time an ad hoc committee was formed to further discuss and evaluate P modeling for Phase 6.

August 21, 2017: The ad hoc committee held a conference call and was not able to reach consensus on any recommendations for the AgWG.

August 24, 2017: The AgWG held a second special conference call meeting to make a recommendation to the WQGIT on phosphorus modeling, but no consensus was achieved on any recommendations.

August 28, 2017: The AgWG provided its report to the WQGIT.

August 28, 2017: The WQGIT did not reach consensus on whether these comments constitute "fatal flaws" as defined by the Partnership, nor did the WQGIT reach consensus on how to resolve these comments.

Appendix A

Fatal Flaw Definition

The WQGIT approved the Phase 6 model review document on May 8,2017 which included the following definition of a fatal flaw comment:

– A fatal flaw is defined as a significant impediment, based on a weight of evidence approach, of the ability of the partnership to establish reasonable planning targets or evaluate progress toward achieving the planning targets or meet the conditions of EPA's "Interim Expectations for the Phase III Watershed Implementations Plans," dated January 19, 2017 due to:

- A calculation or method that does not follow the documented final decisions of the CBP partnership
- A calculation or method, or combinations thereof, that produce illogical results that result in significant impediment
- The omission of data submitted by the CBP partnership by established deadlines
- The overall failure of the model calibration to match observed flows and loads when compared to the level of performance in previous models

A comment is not considered a fatal flaw if it is:

- A disagreement with a final decision that has been made by the partnership
- A disagreement with a scientific or technical method or product in favor of another method or product
- A failure to match loads for particular monitoring station(s) or constituent(s)
- A disagreement with a planning target

Appendix B

Technical Documentation for Phosphorus Loads from the Urban Sector

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Chesapeake Stormwater Network Executive Director

Over the last several years, the Chesapeake Bay Program's Urban Stormwater Work Group developed a technically credible approach on how phosphorus loads are simulated in the Phase 6 Chesapeake Bay watershed model. While this approach differs from the one taken by the agricultural sector, it reflects the unique phosphorus sources, inputs and dynamics of the urban sector, and is based on three recent scientific and technical reports that have been approved by the partnership (UNM EP, 2013, Sample et al, 2015 and Tetra Tech, 2015). Some of the key findings from the urban sector P review are provided below:

Urban pervious lands have much different P inputs than crop land. For example, only half of urban turf in the Bay watershed is fertilized, and no urban lands receive any manure applications (like their agricultural counterparts). Indeed, while some lawns are fertilized, the P inputs are now historically very low. P fertilizer inputs have dropped sharply in recent years in response to state laws that have limited P content in urban lawn fertilizer in MD, VA, DC and NY. One consequence of these laws, is that it prompted an industry phase out of P in lawn fertilizer, which resulted in an 85% decline in non-farm fertilizer sales in the state of DE (Table 7, p. 17, UNM EP, 2013).

The urban sector has many other sources of P inputs than fertilizer and manure. These include atmospheric deposition, leaf drop from tree canopy, lawn biomass, soil erosion, urban stream bank erosion and discharges from grey infrastructure. For a comprehensive review of these sources, please see Sample et al (2015).

Phosphorus concentrations in urban runoff are well understood and very consistent across the Bay watershed and the nation. The National Stormwater Quality Database provides an empirical basis to examine urban phosphorus dynamics and contains a statistical analysis of more than 7,000 individual monitored storm events (Pitt, 2014). Two recent research summaries found that event mean concentrations (EMCs) of phosphorus are very consistent along the range of urban land uses in the watershed (Tetra Tech, 2014 and Figure 4 of Sample et al, 2015). Consequently, the urban sector has high confidence that the estimates of phosphorus loads from both impervious and pervious lands in the Phase 6 watershed model are consistent with observed runoff monitoring data. More documentation on the methods for simulating P loading rates in developed lands in the Phase 6 model can be found in Chapter 2.2.4.1.1 on page 2-13.

Soil P levels do not appear to be a major factor influencing the variability in P loss from urban land. The Urban Nutrient Management Expert Panel (UNM EP) (2013) looked into how P loss was simulated from urban pervious land (see Figure 3 in the Panel report) and found that high soil P was only one of 11 risk factors influencing P loss from pervious land. They recommended that a high risk/low risk be assigned to pervious lands to determine nutrient reduction credit for written urban nutrient management plans.

The APEL model was developed exclusively for crop and pasture land, and has no applicability to the urban sector. Soil P testing is not commonly undertaken in urban areas (usually only when UNM plans

are written) and there is no comprehensive geographic database of urban soil P values in the watershed that could be used for any other Soil P model.

The urban sector is somewhat surprised that this sector equity issue has come up at such a late hour, since neither the CBP agricultural or modeling workgroup has brought it to our attention. It is our understanding that the APEL model does not change the total load within a sector but only changes its geographic distribution. Consequently, we contend that the lack of an explicit soil P model in the urban sector does not creates any sector inequity and does not rise to the standard of a fatal flaw in the Phase 6 watershed model review.

The Urban Stormwater Work Group has indicated its willingness to participate in future STAC workshop on this topic should it be organized.

References:

Pitt, B. 2014. Current edition of the national stormwater quality database. University of Alabama.

Sample, D. et al. 2015. The Peculiarities of Pervious Cover: A research synthesis on allocating pollutant loads to urban land uses in the Chesapeake Bay. A STAC Workshop report. STAC Publication 15-001

Tetra Tech, Inc. 2015. Urban Land Use Loading Literature Review: Task Summary and Results. Technical Memo Prepared for Urban Stormwater Work Group of the Chesapeake Bay Program Partnership. Annapolis, MD.

Urban Nutrient Management Expert Panel (UNM EP). 2013. Recommendations of the expert panel to define removal rates for urban nutrient management. Final panel report. Approved by Water Quality Goal Implementation Team. March, 2013.