Chesapeake Bay Program
SCIENTIFIC AND TECHNICAL ADVISORY COMMITTEE
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January 24, 2017

RE: STAC Review of the Generalized Additive Model (GAM) Approach for Water Quality Trends in Tidal Waters

Nicholas DiPasquale, Chair, Chesapeake Bay Program Management Board
U.S. Environmental Protection Agency
410 Severn Avenue, Suite 109
Annapolis, MD 21403

Cc: Management Board; Scientific Technical Assessment and Reporting (STAR); STAR Integrated Trends Analysis Team (ITAT); Water Quality Goal Implementation Team

Dear Director DiPasquale,

I am pleased to provide you with the attached STAC report entitled *Scientific and Technical Advisory Committee Review of the Generalized Additive Model (GAM) Approach for Water Quality Trends in Tidal Waters* for your consideration. This report outlines the findings and recommendations from the Chesapeake Bay Program (CBP)-requested and STAC-sponsored independent review of the approach for applying Generalized Additive Models (GAMs) in Chesapeake Bay tidal waters.

As an outcome from a 2014 STAC workshop ("Estimating Land Management Effects on Water Quality Status and Trends"), GAMs were presented as a statistical technique with the flexibility to represent the long-term patterns now being observed with 30 years of water quality data in Chesapeake Bay, and to explore environmental factors that may affect those trends. The review panel was tasked with assessing several methods tested and assumptions made in the GAM approach as implemented in an R package, with the goal of providing a temporally and spatially consistent standardized method for annual reporting of trends in tidal water quality. During this review, the charge was to 1) address ten main questions on the scientific and management issues raised in the documentation, and 2) make recommendations for future work by the CBP that would further strengthen this approach, or that are related to the scientific or management issues raised in the review. A panel of four individuals with appropriate expertise in applied environmental statistics, long term water quality monitoring, and generalized additive models, was formed in September, and the team conducted their review of the provided documentation and R package over the past few months.

The body of this report synthesizes reviewer responses to each of the charge questions. Reviewers also commented on the clarity of the documentation, and came together to provide consensus feedback on the positive aspects of the proposed approach. The panel's overall assessment finds that the addition of the Mixed GAM Computation Vehicle (*mgcv*)

implementation of GAMs to the toolbox for tidal water quality trends analysis in the Chesapeake Bay is an excellent decision – making particular note that *mgcv* is a transparent, flexible, robust, and well supported approach. The panel identified key areas for exploration moving forward, as well as alternatives for consideration. Several suggestions also emerged for future analyses, including:

- an assessment of who the intended users of the R package are (and a corollary - what level of statistical knowledge and experience is required for successful application of the package);
- the degree to which the implementation will focus on automating the *mgcv* application;
- alternative approaches for calculating percent change in water quality over extended periods and for handling censored data; and
- an added emphasis on residual diagnostics of the fitted GAM models.

We hope the Management Board, Goal Implementation Teams, and various workgroups find the recommendations outlined in this review report to be useful, and we look forward to your feedback. STAC respectfully requests a written response from STAR's Integrated Trends Analysis Team by April 24, 2017.

Please direct any questions you may have about this report and its recommendations to Rachel Dixon, Coordinator of the Chesapeake Bay Program's Scientific and Technical Advisory Committee, and Hugh Ellis (Johns Hopkins University), chair of the review panel.

On behalf of the entire STAC, thank you again for your consideration, and we welcome any opportunity to continue to work with you on this matter.

Sincerely,

Lisa Wainger
Chair, Chesapeake Bay Program's Scientific and Technical Advisory Committee