Technical Assistance to the Chesapeake Bay Trust

Scope #8: Assessing Benefits of Wastewater Treatment Plant Nutrient Control Upgrades on Toxic Contaminants

Background and Project Phases

The process and products of Scope #8 identify, define, quantify, and incorporate nutrient, sediment, and chemical pollutant reduction and conservation practices into the Chesapeake Bay Program (CBP) decision support system. This project evaluates potential toxic contaminant reduction benefits that could be achieved through nutrient removal upgrades at wastewater treatment plants, and supplements a similar analysis looking at the implementation of traditional nutrient and sediment nonpoint source BMPs in 2015. The CBP has an interest in better quantifying the potential toxic contaminant reductions -- with a focus on PCBs -- that can be achieved through the installation of nutrient control upgrades at wastewater treatment plants (WWTPs).

Current research on removal of urban toxic contaminants and nutrients by stormwater BMPs and WWTPs is summarized in a two-volume set of reports prepared by the Chesapeake Stormwater Network: Part 1 (2015) and the Chesapeake Stormwater Network: Report 2 (2016). The general purpose of both reviews initially identified twelve toxins associated with stormwater runoff from urban areas and BMPs that could be implemented resulting in reduction of loads to Chesapeake Bay. CSN: Part 1 focused on removal of toxins from urban stormwater sources with prescribed BMPs. In contrast, CSN: Report 2 focused on sources of toxics directly from agricultural applications or that originate from biosolids (WWTP-treated water with solids remaining) used to fertilize agricultural land. The solids contain sorbed toxics that are re-distributed on agricultural land and are, in part, the source for additional toxics that do not originate from pesticides and other chemicals used for growing crops.

This project (Scope #8 Assessing benefits of Wastewater Treatment Plant Nutrient Control Upgrades on Toxic Contaminants) extracts technical information from both the initial Part 1 and Report 2 Chesapeake Stormwater Network Reports to evaluate how technology upgrades to WWTPs benefit reduction of one or more toxic contaminants contributed by the known sources to the Bay. Selection of control upgrades to WWTPs may offer a cumulative benefit to improvement of Chesapeake Bay water quality and lend to coordinated tracking and improvements prescribed by the Bay TMDL.

The CBP is interested in quantifying potential toxic contaminant reductions for PCBs that are being or can be achieved through installation of nutrient control upgrades at WWTPs. The Maryland Department of the Environment (MDE) committed to conducting a PCB monitoring survey on pre and post-Enhanced Nutrient Removal (ENR) WWTPs in Maryland to determine if there is an increase in toxic contaminant removal efficiency from the ENR treatment technology as part of the Toxic Contaminants Policy and Prevention Work Plan for 2016/2017. This project adds to the data compiled by MDE other data available in the literature, from other watersheds, or collected by other WWTPs in the Chesapeake Bay watershed.

This project provides the CBP partnership (i.e., Chesapeake Bay Commission, Commonwealth of Virginia, Commonwealth of Pennsylvania, District of Columbia, States of Delaware, Maryland, New York, Virginia, West Virginia, and the USEPA) with available data on the toxic contaminant reduction benefits (emphasis on PCB reductions) that can be achieved through the installation of nutrient control upgrades at WWTPs in order to facilitate the Partnership's goal of considering multiple benefits when planning management scenarios. The amount of PCBs (and potentially other toxic contaminants) that enter WWTPs as well as those removed during treatment will be characterized in order to determine the environmental fate of PCBs sorbed to solids and potentially other removal mechanisms.

The Chesapeake Bay Total Maximum Daily Load (TMDL) has prompted WWTP upgrades that increased nitrogen and phosphorus removal efficiency. This project helps coordinate future WWTP upgrades as part of the Waste Load Allocation (WLA) tracking and improvement component of the TMDL. PCB sources in surface waters are known to result from sediment resuspension, non-point sources, contaminated sites, atmospheric deposition, stormwater, combined sewer outfalls, and highway and bridge runoff. Untreated water containing PCBs that enter WWTPs may originate from these sources, become concentrated and then be released if not removed during wastewater treatment. Wastewater treatment technologies often affect multiple pollutants including nutrients and organometals.

Services for this task will be delivered in three Phases:

- **Phase I:** develop a work plan (this document) to include quality assurance methods; perform a literature search, assess availability of data reported by permitted WWTPs before and after plant upgrades; and present on findings of the volume of available data to the Toxic Contaminants Workgroup prior to performing analyses
- **Phase II:** Analyze available data and report on pre and post-upgrade performance including categorizing changes in performance by the type of upgrade; include descriptive statistics and determine whether there is a statistically significant difference both within and across- groups of upgrade types; and estimate the amount of PCB that is retained in solids and describe the methods of solids disposal
- **Phase III:** Report preliminary findings to the Toxic Contaminants Workgroup; revise as needed and submit final report.

The final report for this project will include the following:

- Summary of data on PCB reductions resulting from WWTP upgrades available in peer-reviewed or government-sponsored literature (including the MDE study if the data is available in time for this effort)
- Summary of PCB data reported by permitted dischargers that demonstrates changes in concentrations of PCBs in effluent both within the Chesapeake Bay Watershed and in at least one other watershed in the US.
- Example mass balances for PCBs in WWTPs, to estimate the amount of PCB that is removed (e.g., by partitioning to various solid fractions) and describe the likely fate (e.g., disposal activities) of PCB in WWTP solids based on different disposal methods.
    - Low/moderate/high PCB load removal scenarios will be created based on the literature survey and the range of PCB reductions identified.
    - Describe relationships between parameters like influent PCBs, MLSS (Mixed Liquor Suspended Solids) concentrations and the PCB mass balance. Preliminary results determining these relationships may be possible by evaluating recent effectiveness monitoring data (if sufficient) collected from two upgraded WWTPs in the Chesapeake Bay watershed.
- Recommendations for how best to estimate future potential PCB reductions achieved by WWTP upgrades. Cumulative effects on PCB reduction from upgrades to multiple WWTPs will be evaluated with a benefit of coordinated tracking and improvement.
- Identification of data gaps and future research needs including additional monitoring studies if needed.

Phase I

Technical Literature Search

Given the relevance to the Bay watershed, Tetra Tech will reach out to Bay watershed jurisdictions to collect relevant data from WWTPs. Bay watershed jurisdictions will be contacted along with organizations in other watersheds known to have addressed or be addressing similar issues (e.g., Delaware estuary, Great Lakes drainages). These entities will be contacted to identify the nutrient removal technologies used by WWTPs that appear to reduce PCBs and other emerging contaminants like household personal care products and pharmaceuticals. We will start at higher levels (e.g., State NPDES contacts) and drill down to local contacts as needed to make the effort most efficient and thorough. Likewise, other areas where both nutrients and toxics or PCBs are known to be issues and where the results of this work is likely to be of joint interest (e.g., Delaware estuary) will also be targeted for data solicitation. However, other things being equal, WWTP performance should not vary much by geography, so Tetra Tech will also mine other collated data sources (e.g., EPA's ECHO system) for relevant data. Given that such data is likely to be of unknown quality (thus likely ranking lower in our data quality assessment criteria), we will also conduct an extensive literature review focused on WWTPs, particularly those that have before/after monitoring data to demonstrate the efficacy of upgrades to control nutrients on toxics removal. This literature survey will include the following:

- Collect and review general information regarding PCB and toxics removal technology from WWTPs;
- Identify and describe approaches from other areas and researchers conducting the similar evaluations of WWTPs
- Collect and review data on PCB reductions resulting from WWTP nutrient removal upgrades available in peer-reviewed or government-sponsored literature (including the MDE study if the data is available in time for this effort)
- Collect and review PCB data reported by permitted dischargers that demonstrates changes in concentrations of PCBs in effluent both within the Chesapeake Bay Watershed and in at least one other watershed in the US
- Identification of data gaps and future research needs including additional monitoring studies if needed.

Assessing Availability and Quality of Data

Available data from the literature review including both project-specific sources and databases will be evaluated using the guidance QAPP Requirements for Secondary Data Research Projects (https://www.epa.gov/quality/quality-assurance-project-plan-requirements-secondary-data-research-projects). Results originating from federal reports or from peer-reviewed journals are expected to have been evaluated for data quality by comparison against performance criteria from companion quality assurance project plans. Results originating from other sources will be evaluated for data quality suitability based on comparison with quality assurance requirements from existing QAPPs. A statement on data quality suitability for these other data sources will be included in the Phase I report.

Presentation of Findings

The Phase I report will include data quality suitability ratings for data identified in the literature review which will be classified using a simple ranking scheme. Limitations for use of data identified from the literature survey will be reflected in this ranking scheme and contain explicit statements regarding the type of limitation(s). All procedures used to evaluate secondary data quality will culminate with statements describing data reporting, data reduction, and data validation.

Results from the literature survey meeting minimum data quality performance requirements will be used to perform the technical analyses. Instances where the intended analyses do not have an adequate amount of background data for completion represent "data gaps". The type of data required to complete the intended analysis will be identified with a recommendation for how to fill the gaps including recommendations for future monitoring.

Phase II

Tetra Tech will build appropriate analytical instruments (databases, spreadsheets) to both track the individual data sources, and manage and analyze the metadata. As data begins to be identified and collected in Phase I, it will be tracked and analyzed. It is important that Phases I and II overlap, as Phase I efforts may identify additional datasets that can be leveraged for this effort. Additionally Phase II analyses may suggest that additional or different data needs to be collected to answer the questions posed by the project.

We anticipate two major (and related/overlapping) ways of analyzing data:
1. Examining pre- and post-nutrient reduction effluent toxics data
2. Examining influent and effluent toxics data for nutrient reduction systems

Within each analytical approach, there are a number of variables likely to be significant that must be controlled in order to estimate the toxics reduction performance of a nutrient removal upgrade. A partial list of potential variables include:

- Starting system type (for pre- and post- upgrade analyses)
- Nutrient reduction system type
- Type of other unit processes (e.g., disinfection)
- Effluent nutrient concentrations
- Design flow and actual flow (and most likely, the ratio of these)
- Service area and influent characteristics
- Hydraulic retention times
- Solids retention times
- Solids processing characteristics
- Toxic contaminant

The final list of variables for which to control will depend on the size of the meta-dataset and statistical evaluations of the data. Those variables determined to be statistically significant predictors of toxics removal performance will be documented. Depending on the strength of the statistical relationship between controlling variables and toxics removal, predictive equations (e.g., based on least squares regression analysis) will be developed. Because removal of PCBs and many other toxic compounds from wastewater effluent often involves partitioning of solids, particular attention will be paid to documenting mass balances across various types and characteristics of WWTPs with the intention of documenting the final fate of the constituents. Where data allow, by-product formation will be documented.

Deliverables for Phase II that satisfy objectives for this segment of the project include the following:

- Estimates of the amount of PCB that is partitioned to solids and describe the disposal activities that are used for WWTP solids
- Recommendations for how best to estimate future potential PCB reductions achieved by WWTP upgrades.

Phase III

Tetra Tech will provide a draft report to the Toxic Contaminants Workgroup that encompasses the results of the project by summarizing the data on PCB and other toxic contaminant reductions resulting from WWTP nutrient removal upgrades available in peer-reviewed or government-sponsored literature (including the MDE study if the data is available in time for this effort) and by summarizing the PCB data reported by permitted dischargers that demonstrates changes in concentrations of PCBs in effluent both within the Chesapeake Bay Watershed and in at least one other watershed in the US. Tetra Tech will utilize the reviewed data to estimate the amount of PCB that is partitioned in solids and describe the disposal activities that are used for WWTP solids and provide recommendations for how best to estimate future potential PCB reductions achieved by WWTP upgrades. As a final part of the findings report, Tetra Tech will identify data gaps and future research needs including additional monitoring studies if needed for the analysis of the reduction of toxic contaminants particularly PCBs by nutrient reduction upgrades to WWTP.

Data analyses will be presented with supporting statistics (as described in Phase II); however, the data analyses will also be synthesized into practical implications and will be clearly communicated in Discussion and Conclusions sections of the report.

Tetra Tech Team Roles and Responsibilities

Tetra Tech has assembled a team with substantial experience in nutrient reduction from wastewater treatment plants (WWTPs) and related toxics reductions, especially PCBs (Figure 1). Our team has experience identifying and source tracking PCBs through stormwater and from legacy sources. We are well versed in evaluating BMP technology costs and reductions in PCB concentrations that input to WWTPs. Mr. Rob Plotnikoff, proposed as project manager, served as the key scientist for designing toxics reduction strategy (including PCBs) and selection process for BMPs targeting specific toxics in Puget Sound initiatives endorsed by the Washington Department of Ecology (WDOE) and the Northwest Indian Fisheries Commission (NWIFC). Mr. Victor D'Amato has a variety of applicable experience including WWTP nutrient reduction design, assessment and process optimization; multiple nutrient reduction planning and implementation projects within the Chesapeake Bay and other watersheds across the United States; and a long history of experience in environmental technology evaluation and development, including designing and executing numerous studies quantifying the treatability of a range of toxic compounds. Mr. Marcus Bowersox is an aquatic toxicologist that has considerable experience in literature survey and assembling information on current knowledge of collection and analysis of toxics, as well as synthesis of the pertinent information to achieve project goals. Mr. Bowersox also has extensive experience regarding the toxicity and bioavailability of the contaminants of concern, particularly PCBs, based on past project experience using ecological risk assessments.

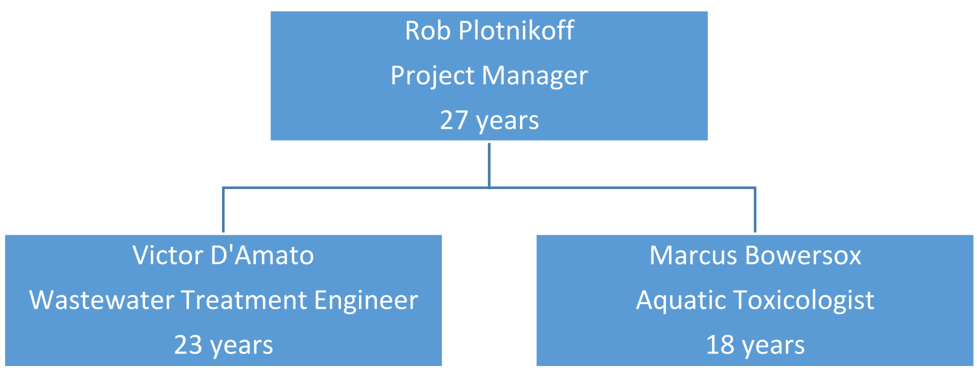

Figure 1. Years of Experience in Nutrient and Toxics Control through Wastewater Treatment Plant Design and Implementation of BMPs to achieve Toxics Reduction for Proposed Team Members

References

Chesapeake Stormwater Network: Report 1. 2015. Potential Benefits of Nutrient and Sediment Practices to reduce Toxic Contaminants in the Chesapeake Bay Watershed, Part 1: Removal of Urban Toxic Contaminants. Prepared for Toxics Workgroup, Chesapeake Bay Partnership. http://chesapeakestormwater.net/2016/03/urban-toxic-contaminants-in-the-chesapeake-bay/.

Chesapeake Stormwater Network: Report 2. 2016. Potential Benefits of Nutrient and Sediment Practices to reduce Toxic Contaminants in the Chesapeake Bay Watershed, Report 2: Removal of Toxic Contaminants from the Agriculture and Wastewater Sectors. Prepared for Toxics Workgroup, Chesapeake Bay Partnership. http://chesapeakestormwater.net/2016/03/urban-toxic-contaminants-in-the-chesapeake-bay/.