**REVIEW DRAFT**

**Date:** February 5, 2015

**To:** Toxic Contaminants Work Group

Urban Stormwater Work Group

Agricultural Work Group

Wastewater Work Group

**From:** Tom Schueler, Chesapeake Stormwater Network

**Re:** Soliciting Feedback on Draft Project Work Plan:

*Summarizing Potential Benefits of Nutrient and Sediment Practices*

*to Reduce Toxic Contaminants in the Chesapeake Bay watershed*

**Request:** CSN is soliciting feedback from workgroup members on the technical scope for this work plan as well as identifying any specific research or monitoring studies that could support the project. Comments and resources are requested to be sent to watershedguy@hotmail.com **no later than Wednesday, February 18.**

**Background and Purpose of Project**

One of the key outcomes under the Toxic Contaminant Goal established in the 2014 Chesapeake Bay Watershed Agreement is to "identify which best management practices (BMPs) might provide multiple benefits of reducing nutrient and sediment pollution as well as toxic contaminants in waterways". Such multiple benefits could provide significant cost savings to the Chesapeake Bay Partnership to simultaneously meet the Bay TMDL and to reduce toxic contaminants in the environment.

The broad purpose of this one year study is to:

(1) Investigate the potential toxic contaminant reduction benefits that could be associated with the implementation of BMPs for sediment and nutrient reduction under the Bay TMDL.

(2) Provide water resource managers with better BMP data to develop more effective local TMDLs and action strategies to control toxic pollutants in the watershed.

To support this outcome, the Chesapeake Bay Trust issued an RFP on the behalf of the Chesapeake Bay Partnership, and selected the Chesapeake Stormwater Network (CSN) to perform the technical analyses on January 28, 2015. In its proposal, CSN indicated the need to get broad feedback from the many CBP workgroups involved in this issue, and solicit important research citations, resources and monitoring data from the sector work groups.

The work groups will need to make several important choices to ensure this highly interdisciplinary project will ultimately be successful. These choices are broadly outlined in the subsequent project work plan which presents proposals on how to organize the work to accomplish several tasks:

* Select priority toxins with highest environmental risk to the Bay
* Link toxic sources and pathways to BMP treatment, and
* Develop protocols to estimate potential toxic reduction by various BMPs.

**Draft Project Work Plan**

The work plan involves four major technical tasks, as follows:

**Task 1: Screening to Prioritize Toxins and BMPs For Intensive Analysis**

Under the first task, CSN will develop a technical approach to prioritize which toxic contaminants and BMPs should be targeted for further analysis, based on three screening tiers, as outlined below:

Tier 1 Screening: Identifying Toxic Contaminants with Greatest Environmental Risk.

The first tier involves prioritizing the universe of toxic contaminants based on their potential environmental risk in the Bay watershed. The degree of environmental risk is broadly defined based on three primary criteria, as previously established by CBP (2012).

(a) Relative extent of the individual toxic contaminant in the Bay watershed based on prior monitoring data that indicate it has been detected in water, sediment, and/or tissue samples, as summarized in CBP (2012).

(b) Relative severity of the human health and/or fish and wildlife impacts caused by the toxin in localized hotspots or across the entire Bay watershed.

(c) Toxins that Bay states have directly linked to water quality impairments and/or fish consumption advisories in specific receiving waters within the Bay watershed.

Based on this first tier of screening analysis, a priority list of about 30 toxic contaminants is proposed for review (Table 1), subject to review by TCWG. An additional 20 contaminants are shown (inside parentheses) that could be potentially be added to the list. It should be noted that some emerging toxic contaminants were included on the list even though data on their prevalence and risk were less certain.

*Note to Reviewers:* Ideally, to provide a realistic scope of work, CSN would like to have no more than 35 toxics on the final list, so if more are added, then we may need to remove some existing ones.

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| **Table 1: Priority Contaminants to Investigate Based on Environmental Risk1** | | |
| *#* | *Toxic Category* | *Individual Contaminants* |
| 1 | PCBs | Total PCBs |
| 2 | Dioxins | Dioxin (furans) |
| 3 | PAH's | Total PAH, (benzo(a)pyrene, napthalene) 5 |
| 4 | Petroleum HC | TPH, oil and grease (benzene, toluene, xylene) 5 |
| 5a | Legacy Pesticides 2 | DDT/DDE, chlordane, heptachlor, dieldrin, diazinon3, chloropyrifos3 (mirex, aldrin) |
| 5b | Current Pesticides 2 | atrazine, simazine, metachlor, prometon, carbaryl (malathion, 2,4-D) |
| 6 | Pharmaceuticals | Caffeine, acetaminophen, carbamazepine, tetracycline |
| 7 | HPCPs | pthalates, triclosan, triclocarban (N,N-diethyltouamide, surfactants) |
| 8 | Flame Retardants | PBDE |
| 9 | Biogenic Hormones | Estradiol, estrone, testosterone (coprostanol, cholesterol) |
| 10 | Metals | Zn, Cu, Cd, Pb, Hg, (Al, Cr, Mn, Fe 4) (Chloride 6) |
| **Codes**: PCB's = Polychlorinated Biphenyls, PAH= Polycyclic Aromatic Hydrocarbons, HPCP= Household and Personal Care Products, PBDE = Polybrominated Diphenyl Ether  **Notes:**  1 As defined by the extent and prevalence of the contaminant in the Bay watershed, as well as actual impairments or fish advisories, as defined in CBP (2012).  2 Based on national assessment of prevalence in streams and groundwater (Gilliom et al, 2006)  3 While not banned like other legacy BMPs, its use has been seriously restricted since 2001.  4 While there are impairments for the metals in the watershed, they are associated with discharges from abandoned mines, and are not subject to treatment by conventional BMPs.  5 There are a dozen or more addition forms of hydrocarbons that could be listed, but these have greatest potency  6 While chloride is not a metal, it has been classified as a toxin by Environment Canada. | | |

Tier 2 Screening: Matching Toxic Sources and Pathways to BMPs in the Watershed.

The second tier of screening involves targeting where toxics are being generated in the watershed, and which pathways they tend to move through. This tier is important since it influences which land use sectors and BMPs could most effectively capture or treat individual toxins in the Bay watershed.

The screening analysis is necessarily general and simplistic, and not all compounds within a toxic contaminant category will always neatly fit within it. Despite these caveats, the screening analysis helps to define unique search terms for the literature review and to scope the subsequent BMP treatability analysis.

Tier 2 screening analysis looked at four key factors, as shown in Table 2 and described below.

*1. Primary Sector:* Most toxics tend to be associated with a specific land use sector (e.g., urban or agricultural), whereas others are dispersed across many watershed sectors (e.g., mixed). In addition, some emerging toxics of concern are generated from "point" sources, such as wastewater, feedlot or septic effluents. A good understanding of the primary sector is needed to identify the most appropriate BMP or treatment process that could be applied to each individual toxic compound.

*2. Key Watershed Sources:* Given the diversity of toxics found in the watershed, it is not surprising that there are many different sources, including atmospheric deposition, spills, applications and a variety of wastewater discharges. Some of these sources can be managed by a BMP, whereas other may not.

*3. Hydrologic Pathways*. Some toxics are primarily transported via surface water or stormwater runoff, whereas others move through groundwater. Lastly, others are discharged from different kinds of wastewater discharges. Most of the traditional BMPs are primarily designed to treat pollutants transported in agricultural and/or urban stormwater, while a smaller number are capable of reducing pollutants transported in groundwater or wastewater effluent.

*4. Landscape Position:* The relative landscape position where the toxic is discharged can have a strong influence on BMP treatability. For the screening analysis, toxics could potentially be discharged from either upland areas, the stream corridor, or into a river basin segment (e.g., wastewater effluent). With a few exceptions, most BMPs are located in upland areas. Consequently, toxics that are located further downstream are less likely to be treated by a BMP and more likely to be delivered to the main stem of the Bay

The ten toxic contaminant categories were screened according to these four factors, and the results can be found in Table 2.

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| **Table 2: Matching Toxic Sources and Pathways to BMPs in the Watershed** | | | | | |
| *Toxic Category 1* | | *Dominant*  *Sector(s)* | *Key Watershed*  *Sources* | *Hydrologic*  *Pathway* | *Landscape*  *Position* |
| 1 | PCBs | Urban | Historical/Leaks | SW | U |
| 2 | Dioxins/Furans | Mixed | Historical/Combustion | SW | SC |
| 3 | PAH's | Urban | AD, | SW | U, SC |
| 4 | Petroleum HC | Urban | AD, Spills | SW | U |
| 5 | Pesticides | Ag, Urban | Legacy, Applications | SW & GW | U |
| 6 | Pharmaceuticals | Point | Wastewater, Septic | WW, GW | SC,RS |
| 7 | HPCPs | Point | Wastewater, Septic | WW,GW | SC,RS |
| 8 | Flame Retardants | ? | ? | ? | ? |
| 9 | Biogenic Hormones | Ag, Point | Manure, AFOs, Wastewater, Septic | SW,WW,GW | U, SC |
| 10 | Metals | Urban, Ag | AD | SW & GW | U |
| **Codes**: PCB's = Polychlorinated Biphenyls, PAH= Polycyclic Aromatic Hydrocarbons, HPCP= Household and Personal Care Products, PBDE = Polybrominated Diphenyl Ether, AD = Atmospheric Deposition,  SW = Stormwater GW= Groundwater, WW = Wastewater Effluent, AFO = Animal Feeding Operation, ? = Unknown, U = Upland, SC =Stream Corridor, RS = River Segment.  1 as defined in CBP (2012). | | | | | |

*Note to Reviewers:* Would like to get to some sector-specific feedback on whether the general classifications of the four screening factors are appropriate for the ten major toxic contaminant categories are appropriate or not.

Tier 3 Screening. Identifying BMPs with Significant Potential to Achieve Toxic Reduction.

While more than 200 BMPs have been approved by the Chesapeake Bay Partnership, many of them are similar and can be grouped together. CSN analyzed the qualifying conditions and removal rates for the most frequently applied BMP groups, and found considerable variability in sediment and nutrient removal rates, and presumably, their toxic reduction potential, as well.

To start the discussion, CSN proposes that 20 major CBP-approved BMPs shown in Table 3 be targeted to determine their toxic reduction potential. CSN will consult with the TCWG, sector coordinators and workgroup chairs to review and modify the priority BMP list, as needed.

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| **Table 3. Priority List of CBP-Approved BMPs for Analysis** 1 | | |
| *Urban 1, 2* | *Agricultural 1, 2* | *Wastewater and Forestry* |
| Stormwater Retrofits | Manure Treatment Technology | Onsite Septic Systems |
| New State Stormwater Stds | Animal Waste Storage Systems | Septic Attenuation |
| Urban Nutrient Management | Manure Injection/Incorporation | Stream Buffer |
| Street Cleaning | Cropland Irrigation Mgmt |  |
| ND from Grey Infrastructure | Poultry Litter |  |
| Stream Restoration | Conservation Crops |  |
| Erosion and Sediment Control | Nutrient Management |  |
|  | Conservation Tillage |  |
| 1 Not all of the expert panels listed below have come to consensus, in these cases, CSN will directly contact the expert panel chair or facilitator to at least review any toxics data uncovered during the literature review phase.    2 CSN will work with the workgroup chairs/coordinators to prioritize which past and current expert panels would likely have the most relevance to the management of toxic contaminants, so not every expert panel will need to be fully analyzed (e.g. shoreline management, floating treatment wetlands, etc.). | | |

*Note to Reviewers:* Would like to get to some sector-specific feedback whether these BMPs are worth investigating or not, or if some alternate BMPs would be better.

*Task 1 Deliverable:* A matrix that identifies the CBP-approved BMPs that will be investigated to estimate their potential to reduce toxic contaminants.

**Task 2: Literature Search for Actual BMP Removal Data**

CSN will conduct a national literature review to identify key research on the potential toxic contaminant reductions associated with current approved BMPs for the urban, agricultural, forestry and wastewater sectors.

The target will be any actual toxic contaminant loading rates and/or BMP efficiencies that currently exist in the literature. Based on prior experience, it is anticipated that the available monitoring data will be fairly limited, with the possible exception of trace metals, some pesticides, PAH's and petroleum hydrocarbons.

CSN will document the actual toxic loading rates and BMP removal efficiencies that are discovered, and will assign each a degree of confidence, based on the data source characterization methods outlined in the CBP BMP Review Protocol (WQGIT, 2014).

For the urban sector, the search will involve an analysis of all toxic contaminants in the current version of the *National Urban Stormwater Quality Database*, toxic removal rates as provided in the most recent editions of the *International Urban Stormwater BMP database*, as well as review of existing and draft urban BMP expert panel reports and their supporting citations (more than 1,500 BMP research studies). These efforts will be supplemented by an internet search for key research studies on toxic reduction by target BMPs.

The same approach will be used for the other sectors, and will be further supplemented by interviewing sector coordinators, expert panel chairs, and support consultants (e.g., CWP, Tetra Tech, VA Tech), and reviewing existing expert panel reports.

CSN will also look at summary literature reviews on the impact of wastewater treatment processes on pharmaceuticals, personal care products and biogenic hormones, such as has been recently published by the Water Environment Research Federation.

*Task 2 Deliverable:* Technical memo that summarizes available scientific literature on actual loading rates and BMP removal rates for toxic contaminants.

**Task 3: Develop and Apply Protocol to Estimate or Infer Toxic Removal Rates for BMPs.**

It is anticipated that there will be little or no actual monitoring data on BMP removal for most toxic contaminants, and consequently, removal rates will need to be estimated based on similarities in the chemical properties of the toxicant, in relation to either sediment, phosphorus or nitrogen removal rates. These three pollutants span a continuum of potential removal potential.

For example, sediment tends to have the highest removal rates because its particles are relatively easy to settle out or filter through a medium, under most conditions. Total phosphorus, on the other hand, has an intermediate removal rate, since it is commonly found in roughly equal particulate and soluble fractions. While the particulate fraction is subject to settling or filtering, removal of the soluble fraction requires further biological uptake and/or adsorption to solids/carbon. Lastly, total nitrogen usually has the lowest removal rates, as the various nitrogen species often require specific environmental conditions for microbial communities to be transformed into N gas.

Therefore, under this task, CSN will conduct a review to define the basic characteristics and/or behavior of each toxic contaminant to determine if they can be directly linked to similar properties for sediment, phosphorus and nitrogen, and therefore be assumed to have comparable removal potential.

This approach is best exemplified by toxic contaminants that have "sediment-like characteristics" and would tend to utilize the same sediment removal mechanisms that operate in a particular BMP. Sediment-like characteristics may include one or more of the following:

* A high affinity to bind or adsorb to sediment or organic carbon particles
* Fund in a particulate form and associated with a larger particle size diameter.
* A low Henry's Law constant (KH)
* A high soil organic carbon-water partition coefficient (KOC) (i.e., hydrophobic)
* Low solubility in water
* Long half-life for transformation
* Other physical or chemical factors to consider ?

In general, data on partition coefficients and other characteristics are readily available for most toxic compounds from chemical databases (e.g., www.pesticideinfo.org) or literature reviews (e.g., Appendix 2 of Gilliom et al, 2006). Based on this data, CSN will then determine if the toxic contaminant acts in the same general manner as a sediment particle, and therefore should be expected to have the same sediment reduction potential associated with the BMP.

The other end of the removal spectrum involves toxic contaminants with "nitrogen-like" characteristics that require unique removal mechanisms and environmental conditions to achieve high removal levels. A toxic contaminant that acts in "nitrogen-like" manner may include one or more of the following characteristics:

* A low affinity to bind, adsorb or otherwise attach to sediment or organic carbon particles
* Primarily found in soluble forms and/or low molecular weight
* A high Henry's Law constant (KH)
* A low soil organic carbon-water partition coefficient (KOC) (i.e., hydrophilic)
* Highly soluble in water
* Moderate to short half-life for transformation, often requiring soil- or phyto-bioremediation.
* Other physical or chemical factors to consider ?

A toxic contaminant with many of the above characteristics can be considered to act in a similar fashion to nitrogen, and have a correspondingly lower BMP removal rate. Toxic contaminants with intermediate characteristics would be presumed to act in the same general manner as total phosphorus.

Based on this analysis, CSN will make an initial estimate of the potential BMP reduction that could be achieved for each priority toxic contaminant. If actual values cannot be computed, a semi-quantitative estimate will be derived for the contaminant (e.g., high, moderate, low, uncertain, or negative). Where technically supported, these rankings may include with quantitative threshold values for the removal rate removal rate (e.g., greater than 50%. etc).

*Note to Reviewers*: Need some guidance during the project about how "quantitative" the numbers should be. Some users will request rather precise removal estimates for actual BMP accounting in local TMDLs (e.g., 50%), but also a risk that these "interim" values take on a life of their own and provide a false sense of precision

Along with the potential BMP reduction for each toxin, CSN will also evaluate the treatability of the toxin and the long-term reliability of BMP removal. The treatability variable reflects whether the toxin can actually be captured within a BMP, based on its source, landscape position or hydrologic pathway. The long-term reliability factor looks at the potential risk that toxics trapped in BMP sediments, media or vegetation could be re-suspended or re-mobilized into the environment. This risk is particularly acute for toxicants with long half lives. CSN will also briefly examine the potential for bioaccumulation of toxins within fish and wildlife that may inhabit the certain BMPs, and outline any issues related to BMP sediment monitoring or testing to ensure safe disposal during maintenance activities.

**Task 4. Final Project Report**

The BMP toxic reduction estimates will be presented in graphical and tabular form, and a draft final report will be prepared that synthesizes the key findings, identifies the most promising BMPs for toxic reduction, and recommends the most important management actions to reduce sediment, nutrient and toxics to the Bay.

Where possible, the report will assess whether it is feasible to effectively use BMPs to get below toxic action levels or benchmarks for water, sediment and tissue, using the current best estimates of the toxic loading and BMP removal rates. The draft report will also discuss additional BMPs that may need to be investigated (beyond those that are currently approved in the Bay TMDL) in order to better manage toxic contaminants in the watershed, such as soil bioremediation and industrial pollution prevention.

*Deliverable Product*. Based on comments and interaction from the TCWG and other Bay workgroups, CSN will produce a final technical report and make a final presentation to the CBP partnership.

**Schedule:**

The proposed schedule for the project is outlined in Table 4 below.

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| **Table 4. Proposed Schedule For Project** | |
| **Task** | **Deadline** |
| Commence Project | 2/1/2015 |
| Develop Project Work Plan For TCWG Comment | 3/1/2015 |
| Solicit Additional Input from USWG, AGWG and WWWG | 3/15/2015 |
| Launch Literature Review and Database Analysis | 4/1/2015 |
| First Progress Report to CBT and TCWG Chair | 5/1/2015 |
| Provide First Draft of Technical Memos for TCWG Review | 9/15/2015 |
| Second Progress Report to CBT and TCWG Chair | 9/15/2015 |
| Present Initial Findings to TCWG and Sector Work Groups | 10/2015 |
| Incorporate Comments into Draft Final Report | 11/1/15 |
| Toxic Contaminants Management Strategy | 11/15/2015 |
| Deliver Final Project Report to CBT | 12/1/2o15 |

**References Cited**

Chesapeake Bay Program (CBP). 2012. Technical Report: Toxic contaminants in the Chesapeake Bay and its watershed: extent and severity of occurrence and potential biological effects. US EPA, USGS and US FWS. Annapolis, MD.

Gilliom, R., et al. 2006. The quality of our nation's waters: pesticides in the nation's streams and groundwater, 1992-2001. National Water Quality Assessment Program. U.S. Geological Survey Circular 1291.

Water Quality Goal Implementation Team (WQGIT). 2014. Protocol for the development, review and approval of loading and effectiveness estimates for nutrient and sediment controls in the Chesapeake Bay Watershed Model. US EPA Chesapeake Bay Program. Annapolis, MD.