TECHNICAL MEMORANDUM

TO: Chesapeake Bay Program Wastewater Treatment Workgroup
FROM: Maryland Department of the Environment
SUBJECT: Proposed supplemental indicator for reporting point source progress
DATE: September 4, 2013

1.0 INTRODUCTION

This proposal is for a supplemental indicator that will address several shortcomings of the annual progress scenario in the wastewater sector. It is not intended to replace the current progress reporting methodology, but will instead provide watershed managers with an additional tool for making informed management decisions

This project was initiated by the state of Maryland in the belief that the Bay Model results from its annual Progress scenarios do not accurately reflect the progress of implementation measures in the state's wastewater sector. These scenarios fail to control for the confounding effects of rainfall variability on wastewater and they are also assembled in a way that shows a lag time between the actual and modeled start-ups of wastewater treatment upgrades. As a result, it has been very difficult for Maryland to quantify, in pounds reduced per year, the benefit of these upgrades toward meeting the state's Chesapeake Bay targets.

The supplemental indicator described below, was developed to account for these issues, and was designed to be as simple and transparent as possible. While it would be feasible to develop a more accurate model of rainfall-normalized wastewater treatment plant (WWTP) performance, many of these enhancements would come at the cost of ease and clarity, rendering it more difficult to compute and to explain to stakeholders.

1.1 Background

The annual progress scenario is the definitive measure of achievement toward the Chesapeake Bay planning targets and milestones. This scenario is not an estimate of how much pollution reaches the Chesapeake Bay annually, but instead serves as a management tool for tracking annual implementation and understanding the impacts of management actions. The most accurate estimate of *actual* annual nutrient loads to the Bay, on the other hand, is calculated and reported through the Nitrogen Loads and River Flows to the Bay Indicator. (CBP, Reducing Nitrogen Pollution)

The methodology for developing the annual progress scenario diverges from an estimate of actual annual delivered loads due to many of its underlying assumptions, but two of the major differences are that:

1) Indicator loads for every sector except wastewater, are estimated using average weather conditions

2) Pollution removal practices, in all but the wastewater sector, are applied in the progress scenario during the same year that they are completed, without considering *time to maturity*

Both of these assumptions are instrumental in defining the progress scenario's appropriateness as a management tool. The first assumption normalizes for the effects of annual weather variation, which can more than double actual loadings to the Bay from one year to the next (CBP, Nitrogen Loads and River Flow to the Bay). Without controlling for this, it would be impossible to parse the effects of management actions from the higher-magnitude, weather-driven fluctuations.

The second assumption is critical for crediting purposes. EPA guidelines state that credit must be given to all practices that are installed by 2025 (Early), so that a practice completed in 2025 must be credited that same year. Logically, this standard should apply to any practice completed in any year, be it 2025, 2017 of 2014. Under this rule, nutrient removal best management practices (BMPs), are not credited based on performance, and are not required to fully mature before being completely counted in the model. If a performance-based standard were adopted instead, a practice that involves planting trees might need to be completed ten years before the planning target year in order to achieve full credit. A policy like this would be very difficult to implement and would fundamentally change how TMDL achievement is assessed. More importantly, it would stand in direct contradiction to the initial directive.

As mentioned above, the notable exception to these assumptions is in the wastewater sector, where annual weather affects loads and reduction credit is not awarded based implementation. This paper proposes a methodology for developing a supplemental indicator that estimates wastewater loads in a manner that is better aligned with how other sectors are reported. In doing so, this revised methodology should provide a more robust measure of annual progress toward wastewater targets, and thus serve as a better measure of overall TMDL achievement. The proposal has two distinct components:

1) The adoption of a multi-year average flow estimate to mimic average weather conditions

2) The reporting of two wastewater BMPs:
    a. Upgrades to wastewater treatment processes
    b. Separation of combined sewers systems

2.0 CONTROLLING FOR WEATHER VARIABILITY

Excerpts from the Chesapeake Bay Program's webpage describing the Reducing Nitrogen Pollution Indicator:

> *"The Model estimates pollution from...sources such as agriculture or urban runoff using average weather conditions. This allows managers to understand trends in efforts to implement pollution reduction actions."*

"The Chesapeake Bay Program Watershed Model uses actual wastewater discharge data, which is influenced by annual weather conditions, to estimate wastewater pollution."

"The influence of weather, rain and snowfall can be quite large and can influence wastewater loads more than the restoration efforts in any single year."

2.1 Purpose

Using the Reducing Pollution Indicators for tracking annual wastewater progress, it is difficult to discern short- and medium-term trends in annual loads. This is because wastewater loads in the model are influenced by annual weather variability, which can mask the benefits of restoration efforts. Wastewater is unique in this aspect, since all the other sectors are modeled using average weather conditions.

Currently, discharge monitoring report (DMR) data is used for reporting annual wastewater progress loads. For Maryland, the annual load of a pollutant is a function of the average discharge concentration for the year and the average daily flow. During years of abnormally high rainfall, extraneous flows to collection systems, known as inflow and infiltration (I/I), increase wastewater flows to treatment plants, which generally cause an overall surge in loads. The green line in *Figure 1* shows thirteen years of effluent discharges at major municipal treatment plants in Maryland. The blue dashed line shows average annual rainfall over that same period. A comparison of these two lines illustrates that during unusually wet years, such as 2003, 2004 and 2010, there is a corresponding increase in wastewater flows.

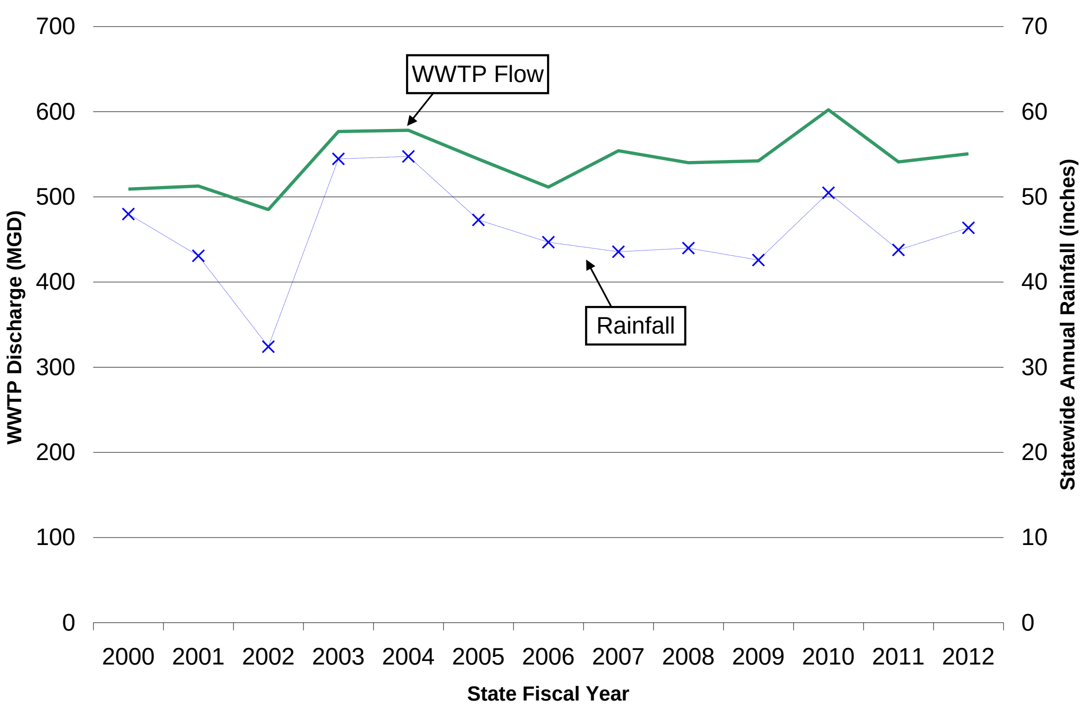

Figure 1 – Flows from Maryland major municipal facilities by year

These flows, in turn, correspond to higher wastewater loads during those same years. The red line in *Figure 2* represents the total nitrogen loads from major municipal treatment plants over the same period. The blue line represents rainfall, and during the same high-rainfall years mentioned above, there are spikes in nitrogen loads.

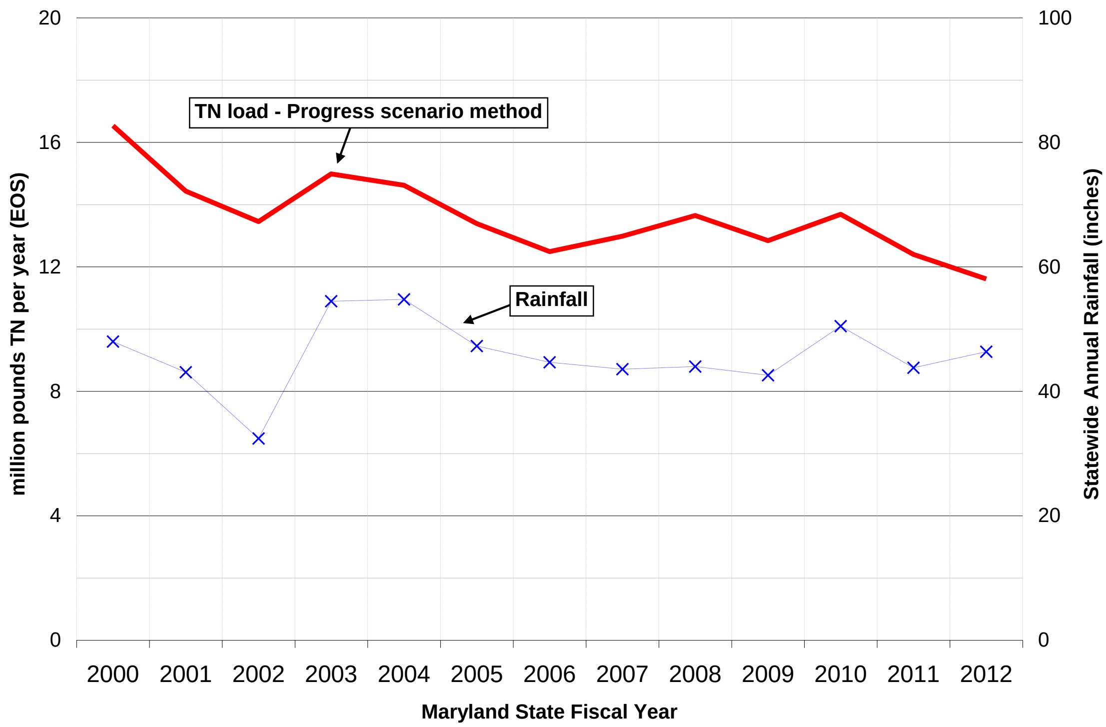

Figure 2 – Loads from Maryland major municipal facilities by year

2.2 Proposed Methodology

For the supplemental indicator, MDE proposes using a rolling ten-year average flow at municipal facilities, instead of a one-year flow. This long-term average will better simulate average weather conditions and reduce the impact of annual variability. A ten-year averaging period was chosen instead of a three- or a five-year period based on an analysis of 35 years of flow data. At ten years, the effects of wet weather were determined to be much lower than they were at either of the other proposed time periods. Also, a rolling average was found to work better than a fixed average, since it captures the gradual increase in flows over time due to additional sewer connections.

Because the flow will be representative of the average number of connections during the entire averaging period, this figure must be adjusted to bring it in line with the number of connections in the reporting year. A population adjustment factor, applied to the ten-year average flow, will be computed using population data from the county where the facility is located. The factor will be calculated as the population of the county during the reporting year divided by the population of the county during the midpoint of the averaging period (see *Equation 1*). Since this method uses a ten-year average, the midpoint population will be the average of the county populations in the fifth and sixth years of the averaging period. In order to maintain a standard dataset across the watershed, all county population estimates will be obtained from the United States Census Bureau website. The Census Bureau publishes these estimates annually. (USCB)

$$\textit{Population adjustment factor} = \frac{\textit{Current County Population}}{\textit{County population at midpoint of averaging period}}$$

Equation 1 – Population adjustment factor equation

Incorporating the population adjustment factor yields *Equation* 2, the final equation for calculating the normalized flow at a municipal wastewater treatment plant in the arbitrary reporting year of 2010.

$$\textit{Adjusted 2010 Flow} = \textit{Average flow from 2001 to 2010} \times \textit{Population adjustment factor}$$

Equation 2 – Flow Normalization Equation (2010 reporting year)

The supplemental indicator will report a facility's pollutant discharge concentrations in the same manner as the Reducing Pollution Indicators—the annual reported concentration will be the average, flow-weighted concentration from the monthly DMRs for that year. An analysis of historic Maryland data shows that statewide, concentrations have decreased steadily since 2000 at the significant municipal plants, reflecting improvements in wastewater treatment processes. These annual concentrations serve as a good indicator of statewide treatment performance. Concerns have been raised that concentrations respond significantly to rainfall, but these data show only minimal effects from dilution, especially when compared to the outsize influence of inflow and infiltration on flow.

Under the proposed supplemental indicator, industrial facilities would continue to measure progress with a one-year flow. Analysis of Maryland's industrial data has shown no significant correlation between rainfall and annual discharge volumes. While there is significant year-to-year fluctuation in these loads, this variation reflects the effects of treatment performance and economic activities rather than the climate. Switching the indicator to a multi-year average flow for these facilities would mask the important trends in industrial data.

2.3 Results

The dashed black line in *Figure 3* shows the major municipal TN load from 2000 to 2012 using the proposed supplemental indicator. Compared with the progress scenario results, the proposed supplemental indicator shows less dramatic fluctuations corresponding to variations in rainfall, illustrating the steady downward trend in loads in response to wastewater treatment process improvements.

One important difference between the two indicators is highlighted in the years 2008 and 2010. The progress scenario results spike in both years, for different reasons—in 2008 they increase because of process problems at two of the state's largest WWTPs and in 2010 they increase due to higher-than-average rainfall. From a management perspective, the 2008 peak is much more important than the 2010 peak since the 2008 deviation was caused by controllable processes and not exogenous climatic events. Without dissecting the underlying data though, it would be impossible to determine the cause of either one these spikes. On the other hand, the supplemental indicator only peaks in 2008 when the process problems occurred. By minimizing the effects of weather variability, this indicator therefore provides a much more useful measure of plant performance.

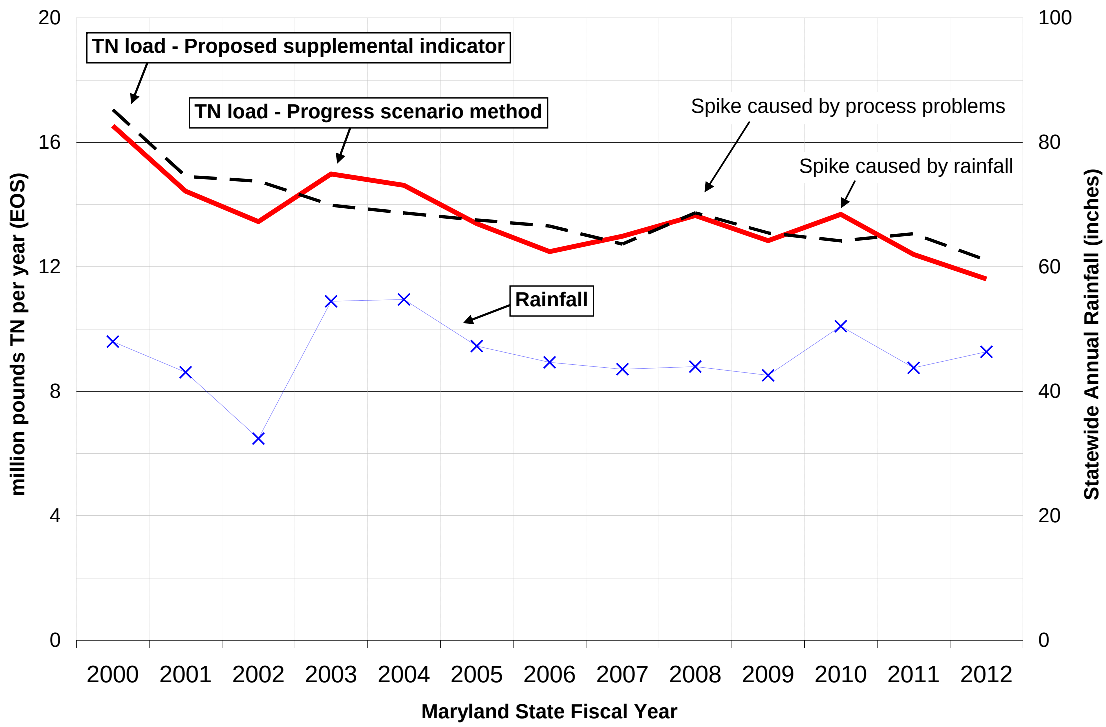

Figure 3 – Actual and adjusted loads from Maryland major municipal facilities by year

3.0 ELIMINATING IMPLEMENTATION LAG TIME

From EPA's November 4, 2009, "Expectation Letter" to the Chesapeake Bay Program's (CBP) Principal's Staff Committee:

> *"The second element of [the accountability] framework is the milestones that will identify specific actions and controls to be implemented by the jurisdictions within two-year increments to reach the Chesapeake Executive Council's goal that all practices necessary for restored Bay water quality be in place as soon as possible, but no later than 2025. These two-year milestones will result in nutrient and sediment reductions on schedule with targets identified in the Watershed Implementation Plans"*

3.1 Purpose

EPA's expectation for the six states within the Chesapeake Bay watershed, and for Washington, DC, is that they will fully implement their WIPs by the end of 2025. These WIPs, in turn, were developed to ensure, that when fully implemented, water quality standards will be achieved in the Bay. There is an important distinction here, between WIP implementation, which is required to be completed by a fixed deadline, and water quality attainment, which is expected to occur after full implementation. Given the direction above, a measure of whether or not the jurisdictions have met the deadlines prescribed in the WIP can only be assessed based on implementation.

Because implementation is how WIP achievement is measured, it follows logically that pollution reduction practices must be credited toward annual progress based on implementation—not performance. Thus, anything that is "on the ground" by 2025 should be fully credited toward WIP achievement.

This is how nonpoint source practices are currently applied in the model. Annual progress is computed based on what practices have been installed, without regard to their maturation time. It is understood that an acre of riparian forest buffer, planted in a given year, will not perform optimally until several years later, once the saplings have grown into trees. The model however, makes no distinction between a field of saplings and a fully-developed forest. Each one is considered an installed acre of forest buffer, and each one is fully credited toward annual progress. Ongoing verification is required, and practices may be removed from the model if they are not being maintained, but in terms of startup, all practices receive credit as soon as they are put on the ground.

This method for immediately crediting practices, without regard to maturity or performance, is applied to every sector except wastewater. For wastewater improvements, credit is based on performance instead of implementation. The performance of each plant is measured as the average concentration from that plant during the reporting year, so a plant that upgrades during a given reporting year is evaluated based on its performance for the periods both before and after the upgrade. Thus, even if by the end of the year, it is performing at the treatment levels expected after the upgrade, it might be reported to the model as operating at pre-upgrade treatment levels. This poses a problem, since an upgrade installed during the final year of an evaluation period might not get credit during that period, and a municipality would risk not achieving its WIP implementation targets, despite having ample implementation.

3.2 Proposed Methodology

For the proposed supplemental indicator, wastewater pollutant removal practices would be credited in the same way as for nonpoint sources—during the year that they are installed. This would involve jurisdictions reporting wastewater treatment upgrades to the Bay Program as they would for any other BMP. A reported upgrade would result in the concentration for the facility being changed, during that one reporting year, to the concentration that the facility is required to achieve under its post-upgrade permit. In

Maryland, this would mean that any facility that upgrades during a given year would calculate that year's loading with a concentration value of 4.0 mg/L. The following year, the reported concentration would revert to the annual DMR concentration. Just as nonpoint source BMPs are expected to undergo post installation validation, wastewater treatment upgrades would be validated annually though their subsequent DMRs.

In the event that a facility is already reporting a pollutant concentration below its post-upgrade limit, the DMR concentration would be reported in the supplemental indicator. For instance, a WWTP in Maryland that installs an enhanced nutrient removal (ENR) process in 2015 and shows a concentration of 3.75 mg-TN/L for that reporting year, will report its TN effluent concentration as 3.75 mg/L and not 4.0 mg/L. This will prevent any erroneous load increases when a facility, which is already discharging at low nutrient levels, upgrades to ENR.

For states that do not require facilities to meet a maximum concentration, but instead only require them to achieve cap loads, the post-upgrade concentration would be calculated so that at the reported adjusted flow for that year, the facility would discharge at its load limit. This calculation is shown in *Equation* 3. Again, like with the concentration based limits, this change would only take effect if the facility's reported load exceeds its cap load.

$$\textit{Concentration in upgrade year (mg/L)} = \frac{\textit{Load Cap (lbs/yr)}}{\textit{Adjusted flow for upgrade year (MGD)} \times \textit{days per year} \times \textit{Conversion factor (lbs-L/MG-mg)}}$$

Equation 3 – Calculating the upgrade year concentration at a facility with no concentration limit

Like any other BMP, no jurisdiction would be required to report WWTP upgrades. Reporting upgrades would allow a jurisdiction to get an immediate one-time, one-year credit for their BMP, however, a jurisdiction that opts not to report a startup would still receive credit through DMR data after a typical one-year lag time.

Since no large facilities have upgraded to ENR in Maryland, it is unnecessary to apply this methodology to historical data as was done for the rainfall normalization methodology. However, for the facilities that have already been upgraded, DMR data have shown that in the month following ENR startup, TN effluent concentrations have, on average, achieved the facilities' post-upgrade permit requirements. Thus, even if a maturation time was applied to all BMPs, the maturation period of an ENR upgrade would be significantly less than one year.

4.0 CREDITING FLOW REDUCTION BMPs

The previous section focused on applying treatment upgrades in the supplemental indicator. Within the indicator, a treatment upgrade is a wastewater BMP that works by reducing nutrient effluent concentrations. There is another mechanism through which a wastewater practice can decrease pollutant loads—by reducing flow. This is what happens through combined sewer system (CSS) separation. When a CSS is separated, stormwater flows that were formerly directed to the plant are now diverted to surface waters. While urban stormwater loads will increase, there should be a decrease at the WWTP.

Using a ten-year averaging period to represent WWTP outflow, the effects of these flow reduction BMPs are significantly damped. In this case, the long term flow trends end up masking any of the benefit recent collection system improvements.

4.1 Proposed Methodology

To show the effects of these projects, this indicator will allow jurisdictions to report sewer separation BMPs as they would ENR upgrades or any other BMP. Reporting this flow reduction BMP would be up to the discretion of the jurisdiction. The BMP would be implemented by replacing the ten-year rolling average with a three-year rolling average. This would make the annual flow figures much more responsive to recent flow trends, highlighting the effects of flow reduction projects.

Following the completion of CSS projects, the three-year rolling averaging period would continue until there are three years of post-CSS separation data. Once this has happened, the averaging period would increase in each subsequent reporting year, until the averaging period includes ten years of data. At this point, the facility would return to a 10-year rolling average.

It is possible that WWTP flow reductions can be achieved through other means, such as I/I reduction projects. If a program results in significant and ongoing flow reductions to a facility, then for the purposes of the supplemental indicator, it can be considered as a flow reduction BMP to that facility, and be treated in the same manner as CSS separation.

5.0 CONCLUSION

The supplemental indicator described in this document was developed as a tool for understanding the effects of wastewater management actions. It addresses two aspects of the annual progress scenario that are inconsistent between wastewater and all of the other sectors: that wastewater loads are affected by annual weather fluctuations and that wastewater BMPs are not immediately credited to the model.

The proposed supplemental indicator is similar to the progress reporting methodology, but with three key changes:

1) Municipal flows will be estimated using a 10-year, population adjusted, rolling average flow. Industrial flows will remain unchanged.
2) ENR upgrades will be credited as concentration reduction BMPs in the year that they occur.
3) Sewer separation will be treated as a flow reduction BMP, and credit will be given by reducing a WWTP's flow averaging period from ten to three years.

By making these adjustments, the supplemental indicator should provide watershed managers with a valuable, internally-consistent tool for understanding wastewater trends

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