MDOT SHA AUTOMATED MODELING PROTOCOL - REVISED

Developed for Chesapeake Bay and Non-Tidal Waters

TMDL Requirements for NPDES MS4 Permit Compliance

MARYLAND DEPARTMENT OF TRANSPORTATION™

STATE HIGHWAY ADMINISTRATION

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I. INTRODUCTION

Summary

The Maryland Department of Transportation State Highway Administration (MDOT SHA) has updated the initial version of its Automated Modeling Tool (AMT) originally submitted to Maryland Department of the Environment (MDE) on June 30, 2016, to take into account changes in the modeling approach resulting from MDE comments on MDOT SHA's 2016 Annual Report, along with other modifications to improve accuracy. The most significant changes are as follows:

- Revised local TMDL baseline loads, target load reductions, and progress load reductions to reflect the percent reduction method described in MDE's guidance documents
- Improved the estimates of stormwater treatment by incorporating P_E, Runoff Depth Treated in inches, data developed from BMP research instead of using the default value of 1.0 inch and using revised ESD/Runoff Reduction (RR) and Stormwater Treatment (ST) practices removal rate curve equations
- Improved reduction calculations for stormwater retrofits by incorporating the reduction efficiencies from existing and retrofit BMP types explicitly rather than relying on the MAST rates for retrofits
- Added the ability to model load reductions by BMP

The AMT makes use of current data from several production databases to estimate pollutant load reductions for various BMPs and to adhere to approved modeling parameters defined in *Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated* (MDE 2014). The modeling tool will be used to produce planning scenarios and to track progress towards meeting nutrient (TN and TP) and sediment (TSS) pollutant load reductions for non-tidal waters and Chesapeake Bay (Bay) TMDLs.

MDE 2014 allows for alternative modeling methods to be employed to demonstrate permit compliance. The design and use of AMT adheres with MDE 2014 as stated below:

> *While different models may generate different baseline pollutant loads, the reductions from implementing water quality improvement projects will be the same because they will all be based on the approved set of CBP urban BMPs and pollutant reduction efficiencies. As a result, all models will be comparable on a percent reduction basis as long as one model is consistently used throughout the permit term.*

Although this is a custom model, it draws on BMP efficiencies, loading rates and delivery factors from MDE 2014, MAST and published Chesapeake Bay Program (CBP) BMP protocols, as follows. Pollutant loads are based on CBP loading rates by land-river segment for edge of stream (EOS) for non-tidal waters and delivered (DEL) loads for the Bay. Pollutant reductions are calculated using the revised removal rate equations from the urban stormwater retrofit Expert Panel report (Schueler and Lane, 2015) for BMPs approved for water quality treatment in MDE 2014.

Background

The 2015 MDOT SHA MS4 permit covers eleven Maryland counties that cross 84 8-digit watersheds representing larger (3rd order) rivers or streams, with 43 TMDLs written for 35 of the watersheds. This has resulted in complex load reduction modeling and tracking issues. To further complicate the modeling, these local TMDLs have been written at different times, based on monitoring data from different years. TMDLs for different pollutants in the same watershed may have a different suite of existing stormwater treatment BMPs which could also be different from the baseline BMPs used in developing the Bay TMDL.

The baseline year published on the MDE Data Center will be used for MDOT SHA's implementation planning. This usually correlates to the time period when monitoring data was collected for MDE's TMDL analysis.

When the Bay TMDL and associated watershed implementation plans (WIPs) were under development (2010-2012), MDOT SHA developed a WIP and milestone reports by modeling nutrient and sediment reductions using MAST. The complexity of modeling multiple counties, baselines and watersheds has resulted in the need for a significant number of exports of treatment data from our geodatabases, as well as a burdensome number of MAST scenarios. In addition, MAST does not currently account for the revised BMP treatment reductions from the Expert Panel report (Schueler and Lane, 2012 and revised in 2015) which were adopted by MDE in MDE 2014.

As described in Section II, MDOT SHA is managing restoration BMP data associated with planning, design, construction, inspection, maintenance and credit verification through spatial geodatabases and a Microsoft Access database. Depending upon where the BMP is in the project development process, different levels of data and tracking are required. Also, the level of effort over the initial eleven Phase I and II counties has resulted in extensive and complex data tracking, which is anticipated to increase with MDE's determination that five additional county jurisdictions will fall under the new Phase II permit. Developing and preparing input data for model runs was proving to be overwhelming and fraught with error. In order to reduce the effort, improve the data management process and increase accuracy, MDOT SHA developed the AMT that uses scripts within a Geographical Information System (GIS) to extract BMP treatment data from multiple sources and then apply algorithms derived from MAST and MDE guidance documents to calculate loads and load reductions.

This model has multiple benefits:

- Uses MDOT SHA production stormwater infrastructure and restoration BMP databases for the most up-to-date source of constructed, under-design and future BMPs at any given time

- Allows flexibility to easily develop, test and adjust planning scenarios at the Bay and non-tidal watershed levels

- Utilizes the latest MAST loading and MDE 2014 load reduction data. Revisions to these parameters can be made within the AMT easily

- By including loads in a table by land-river segment and land use, the AMT provides the ability to assess the effects of potential 2017 changes in the Phase 6 Chesapeake Bay Watershed Model with a table modification, so that MDOT SHA can quickly determine if changes in restoration strategies or approaches would be warranted

Modeling Approach

For both the Chesapeake Bay TMDL and local TMDLs, the modeling approach is based on MDE's guidance (MDE 2014, MDE 2014b) regarding the process for determining whether WLA requirements have been met:

> *"… it is recommended that local jurisdictions demonstrate their progress towards achieving SW-WLAs by comparing reduction percentages rather than absolute loads."*

It is understood that by using this approach the absolute loads listed in the TMDL and the loads modeled by MDOT SHA will vary, because the modeling used to develop the TMDL is different from what is currently available. Demonstrating progress by percent reduced will allow MDOT SHA to meet the TMDL based on the best and most accurate data available on land use, loading rates, and treatment, as follows.

Land Use

MDOT SHA's land use and impervious area spatial data are currently based on analysis of aerial imagery dated 2011. This is consistent with the baseline for the Bay TMDL, but it poses a challenge for modeling local TMDLs. TMDL dates published by MDE on the TMDL Data Center (MDE 2014c) range from 2000 to 2010. Accurate MDOT SHA data for land use prior to 2011 is under review by MDOT SHA; so, baseline loads are currently modeled using 2011 land use but in the future we may have the ability to model using baselines consistent with TMDL dates. Using 2011 baselines is likely to overstate the amount of land area and imperviousness compared to the TMDL analysis, which will lead to a higher restoration requirement; in other words, a conservative approach.

Loading Rates

Loading rates have been calculated at the most detailed level feasible: the land-river segments from the Chesapeake Bay model / MAST. Untreated loads and acres, per land-river segment, were derived from a No BMPs scenario in MAST at the Maryland statewide geographic scale using 2010 conditions, to correspond with MDOT SHA's as-of date for land use.

Treatment

MDOT SHA has committed significant resources to researching and updating BMP and other treatment data to the point where as-built or implementation dates are considered accurate enough for TMDL modeling and calculation of baseline treated loads for Bay and local TMDLs. Pollutant removal rates in the AMT are based on revised ESD/Runoff Reduction (RR) and Stormwater

Treatment (ST) removal rate curve equations (Schueler and Lane, 2013) and Expert Panel reports (Schueler and Lane, 2015) from the Bay Program.

Calibration

Baseline load and target reductions translated to AMT modeling methodologies will allow MDOT SHA to accurately compare progress and planned load reductions to the target.

Baseline

Baseline loads have been calculated in two steps: first, to model the untreated load, and next, to apply treatment as of the baseline year for each TMDL. Untreated baseline loads were modeled by multiplying MDOT SHA pervious and impervious acres by land-river segment using MDOT SHA spatial data with loading rates calculated as described above. Load reductions from baseline BMPs were calculated from MDOT SHA database information, then applied to the untreated load to determine the treated baseline load.

Load Reduction

In order to show that TMDL goals are being met, the reduction target and WLA for each TMDL is calculated based on MDOT SHA data. The reduction target is calculated by applying percent reduction as published in the TMDL to the calibrated treated baseline load. The modeled WLA is calculated by subtracting the calibrated reduction target from the calibrated treated baseline load.

Model Structure

The AMT consists of three elements:

Database / Scripts
Several databases are the repository for the treatment data needed to calculate load reductions from baseline and restoration BMPs. The data are exported for further analysis. Additional information is calculated directly with scripts that make calculations from the data prior to export. One example is the use of P_E to calculate the removal rate for each BMP.

Lookup Tables
Lookup tables are used for data that are not necessarily attributes for a BMP, but which are needed for loading calculations, and which will not change often. Loading rates per land-river segment are an example.

Spreadsheet / Worksheets
Calculations of treatment and load reductions for each TMDL are made in a spreadsheet, with worksheets for each combination of TMDL watershed and pollutant.

Pollutant Reduction Planning Scenarios

For planning and reporting purposes, MDOT SHA needs to be able to track implementation status against the permit and TMDL goals. Status is based on progress in planning, design, and construction of structural, ESD, and alternative BMPs, including operational practices such as inlet cleaning. As described in Section II, this information is stored in databases with the project development status identified as completed, under construction or in-design for each restoration BMPs. This allows MDOT SHA to assess pollutant reduction progress in near real time and plan BMPs needed to meet the remaining reduction goal. The database queries status and built dates allowing MDOT SHA to group the amount of unit treatment based on project phase:

Completed BMPs
Queries TMDL geospatial database using statuses that depict a functioning, built site.

Under Construction or Design
Queries TMDL geospatial database using statuses that depict sites currently in design and construction phases.

Future BMPs
Determined through a query that evaluates the delta between completed, under construction, or in design projects compared to estimates for planned projects derived from the non-spatial Task Management Access database, which would prevent over counting.

II. DATA SOURCES

Databases

Restoration BMPs

The core of the AMT is the databases, both spatial and tabular, which MDOT SHA uses to manage its restoration BMPs from planning through compliance reporting, as follows:

TMDL Database
Structural and ESD restoration BMPs and alternative BMPs that are completed, under construction, or in-design are stored within a geospatial data management system. This geodatabase includes spatial locations and drainage areas for stormwater treatment. The database also contains tables with and operational information for alternative load reduction BMPs, along with regulatory information. Each BMP type has individual attributes, design criteria, inspection criteria, pollutant load reduction potential, establishment, verification and maintenance requirements that are addressed in the data management system.

NPDES Database
New development and restoration BMPs that are structural and ESD stormwater controls are housed in a separate geodatabase that also contains structures built in association with highway projects. This is MDOT SHA's traditional NPDES MS4 geodatabase with all MDOT SHA storm

sewer system assets. This database is not linked directly to the AMT. Prior to model runs, relevant restoration treatment data will be exported into the TMDL Database.

<u>Task Management Database</u>
Future projects are stored within a non-spatial MS Access database. For these projects, the database includes information on the type of planned restoration, target watershed, amount of anticipated credit and target milestone year.

Lookup Tables

Several lookup tables are incorporated in the AMT to provide input parameters for model calculations, as follows:

- LOADING RATE LOOKUP TABLE provides pollutant loading rates by land use
- BMP EFFICIENCIES AND LOAD REDUCTION LOOKUP TABLE provides BMP efficiencies
- UNTREATED BASELINE LOADS LOOKUP TABLE is used to define MDOT SHA baseline loads

LOADING RATE LOOKUP TABLE

This table provides untreated loading rates (lb/ac) for each land-river segment. This is the basis for calculating baseline loads and restoration load reductions. It is calculated using MAST data as follows:

- Run a No BMPs scenario in MAST at the Maryland statewide geographic scale using “2010, revised 10/2014” Initial Conditions and “2010 Loads” Processed Water Base Data
- Export loads from MAST scenario into Excel workbook. 2010 MAST land use acres and loads for the loading rate calculations to correspond with 2011 MDOT SHA ROW and impervious land use data
- Export “Source Data” file from MAST documentation to obtain land-river segment data from Geographic References tab in order to identify land-river segments within a particular local TMDL 8-digit watershed
- Create 2 pivot tables to display Sum of Acres and TN/TP/TSS EOS and DEL loads by land-river segment filtered to 1) SHA Phase I/II MS4 Impervious land use, and 2) SHA Phase I/II MS4 Pervious land use
- Calculate loading rates per land-river segment from impervious and pervious pivot tables described above using the following equations:
    - MDOT SHA impervious loading rates = $\frac{TN/TP/TSS\ EOS\ or\ DEL\ impervious\ loads}{Impervious\ acres}$

- MDOT SHA pervious loading rates = $\frac{TN/TP/TSS\ EOS\ or\ DEL\ pervious\ loads}{Pervious\ acres}$

The result is two lookup tables for loading rates for impervious and pervious land use in each land-river segment.

BMP EFFICIENCIES AND LOAD REDUCTION LOOKUP TABLE

This table is used in conjunction with planned structural and ESD stormwater control BMP efficiencies (RR and ST) and planned alternative BMPs (e.g. stream restoration, catch basin cleaning, and street sweeping) and was created following MDE 2014a. The BMP efficiencies in the lookup table are used in conjunction with the loads developed for each 8-digit watershed to determine specific amount-removed for individual BMP types within an 8-digit watershed.

UNTREATED BASELINE LOADS LOOKUP TABLE

This table is based on calculated baseline loads from the loading rate lookup table and MDOT SHA land use data.

- Intersect GIS layers for MDOT SHA ROW and impervious cover with land-river segments from MAST data to calculate the MDOT SHA area in each TMDL watershed

- Untreated baseline loads were modeled by multiplying MDOT SHA pervious and impervious acres by land-river segment using MDOT SHA spatial data with loading rates calculated by land-river segment

- Create a pivot table of land-river segment untreated baseline loads table showing the sum of TN/TP/TSS EOS loads by 8-digit watershed/land-river segment

For local untreated baseline loads, local TMDLs are defined at various scales including multi-8-digit watersheds, 8-digit watershed, and subwatershed (i.e., smaller than 8-digit watershed scale). Untreated baseline loads were modeled with different procedures for local TMDLs defined at the 8-digit watershed scale (including whole land-river segments) and those defined at a smaller, subwatershed scale (including partial land-river segments).

MDOT SHA baseline TN/TP/TSS EOS loads for all statewide 8-digit watersheds are included in this pivot table. Therefore, if a new nutrient or sediment TMDL at the 8-digit watershed scale comes online, MDOT SHA will have untreated baseline loads calculated at the ready. For TMDLs that area a subset of an 8-digit watershed, additional manual processing is needed.

III. MODEL DESCRIPTION

Data Export

The outcome / output of the automated modeling process is the creation of a series of data tables which are imported into Excel workbooks. The output is essentially a list of every BMP within MDOT SHA's databases and the summary of total reductions (nutrients and sediments) for each individual BMP generated on demand. The amount of pollutant removal attributed to each BMP type is calculated within the AMT based on the procedures described below.

For each BMP facility where impervious/pervious loading rates are used, pollutant reduction is calculated by determining the removal in pounds per unit. The logic uses lookup tables to multiply loading rate by BMP efficiency and area of treatment:

<u>Step 1: Calculate Load Removed for Each BMP and Land Use</u>:

1A. Look up specific land use (impervious/pervious) loading rates for TN EOS/DEL, TP EOS/DEL, and TSS EOS/DEL from LOADING RATE LOOKUP TABLE

1B. Derive or look up BMP efficiency rates for each BMP based on each individual BMP type, detailed for each BMP type in the following sections

1C. Multiply loading rates by BMP efficiency rates to find removal in lb/unit of each BMP within the specific county or-watershed

<u>Step 2: Calculate Pollutant Pounds Removed by Each BMP</u>

2A. Multiply removal lb/unit calculated in 1C by the BMP impervious/pervious area treated

For load reduction BMPs such as streams, outfall stabilizations, inlet cleaning, and street sweeping, the model uses project specific data when available, and rates provided by MDE 2014 for planning level data.

<u>Step 3: Extract Data for Filtering Results</u>

3A. Extract Built Date, Status, County, and other MDOT SHA operational fields

The data tables describing BMP pollutant removal are used in subsequent spreadsheet analysis (described below) to aggregate reductions by TMDL watershed, by baseline / restoration classification, or other parameters to assist MDOT SHA staff in planning and tracking progress. Treatment Calculation Details

New Stormwater Efficiency BMPs

Load reductions are modeled per facility using RR/ST curves (see tables below) and facility P_E. P_E is captured from design plans, and ultimately, as-builts for new restoration projects, and assumed 1.0 inch for programmed facilities where the information is unknown. This component of the modeling is an enhancement from the original AMT where a P_E assumption of 1.0 inch was used for all facilities.

RR and ST Removal Rate Curve Equations (Schueler and Lane, 2013):

TP	RR	$y = 0.0304x^5 - 0.2619x^4 + 0.9161x^3 - 1.6837x^2 + 1.7072x - 0.0091$
	ST	$y = 0.0239x^5 - 0.2058x^4 + 0.7198x^3 - 1.3229x^2 + 1.3414x - 0.0072$
TN	RR	$y = 0.0308x^5 - 0.2562x^4 + 0.8634x^3 - 1.5285x^2 + 1.501x - 0.013$
	ST	$y = 0.0152x^5 - 0.131x^4 + 0.4581x^3 - 0.8418x^2 + 0.8536x - 0.0046$
TSS	RR	$y = 0.0326x^5 - 0.2806x^4 + 0.9816x^3 - 1.8039x^2 + 1.8292x - 0.0098$
	ST	$y = 0.0304x^5 - 0.2619x^4 + 0.9161x^3 - 1.6837x^2 + 1.7072x - 0.0091$

Removal rates for a P_E of 1.0 inch using these curve equations are slightly higher than removal rates for a P_E of 1.0 inch using the curves presented in MDE 2014 because the curve equations presented above were revised by Schueler and Lane (2015). Alternatively, above 1.0 inch treatment removal rates are slightly lower than removal rates presented in MDE 2014. The curves presented in MDE's Guidance are from the original publication by Schueler and Lane in 2012 defining removal rates for New SW BMPs.

All the examples shown below have been made with the assumption that the built date is after the TMDL date so that they all represent reductions that can be applied to restoration credit.

Example 1

A bioswale and sand filter each treating 0.5 acres of impervious area and 0.8 acres of pervious area in the Anne Arundel County portion of the Little Patuxent River watershed. The facilities fall within the land-river segment: A24003XU2_4270_4650 and have a P_E value of 1.5. The Little Patuxent watershed has a TMDL for sediment with a baseline year of 2005. Using the steps outlined above, the sediment load removed for each land use and BMP is derived, as follows:

1A. Loading rate lookup value is queried by land-river segment for SHA MS4 Phase I/II Impervious and SHA MS4 Phase I/II Pervious.

Loading Rates for Example 1, Step 1A		
Land-River Segment	**MAST Land Use**	**TSS-EOS lb/ac**
A24003XU2_4270_4650	SHA Phase I/II MS4 Impervious	495.3
A24003XU2_4270_4650	SHA Phase I/II MS4 Pervious	75.9

1B. BMP efficiency value is derived for each BMP type using the revised curves from Schueler and Lane (2015). In this case the efficiencies for sediment removal are used with 1.5 inch treatment over the impervious area:

BMP Efficiencies for Example 1, Step 1B		
BMP Type	**BMP Category**	**TSS Removal**
Bioswale	RR	82%
Sand Filter	ST	76%

1C. Multiply loading rates by BMP efficiencies to obtain reduction by lb/unit:

Results for Example 1, Step 1C					
BMP Type	**Land use**	**TSS-EOS lb/unit**	**TSS Removal Efficiency**	**Calculation**	**TSS Reduction (lb/unit)**
Bioswale	Impervious	495.3	82%	495.3 * 82%	406.1
	Pervious	75.9	82%	75.9 * 82%	62.2
Sand Filter	Impervious	495.3	76%	495.3 * 76%	376.4
	Pervious	75.9	76%	75.9 * 76%	57.7

2. Multiply reduction by lb/unit by units treated by BMP. In this case the units treated are acres of impervious and pervious.

Results for Example 1, Step 2					
BMP Type	**Land use**	**TSS Reduction (lb/unit)**	**Unit Treated (Acres)**	**Calculation**	**TSS Reduction (lb)**
Bioswale	Impervious	406.1	0.5	406.1*0.5	203.1
	Pervious	62.2	0.8	62.2*0.8	49.8
Sand Filter	Impervious	376.4	0.5	376.4*0.5	188.2
	Pervious	57.7	0.8	57.7*0.8	46.2
				Total	**487.3**

For these two facilities, 487.3 pounds of sediment are removed annually, counting as progress towards the local sediment TMDL for Little Patuxent watershed.

DEL loads are calculated in the same manner, but with the appropriate loading rates to track progress towards the Chesapeake Bay TMDL.

Stormwater Retrofits

Stormwater retrofit BMPs use the same modeling process applied to new efficiency BMPs, but before and after specifications are used to determine the net number of pounds reduced by a facility for each nutrient. The previous conditions are subtracted from the proposed conditions to provide the delta of nutrient reduction provided by the facility. If the facility was providing some water quality prior to being retrofit, its prior treatment will also be counted towards the baseline.

Tree Plantings and Impervious Removal

For tree plantings and impervious surface removal, BMP efficiencies are derived from table '3.E. Alternative Urban BMPs' from MDE's Guidance 2014. The pervious loading rate for the land-river segment is used alongside the efficiency to calculate the amount of nutrient reduced by the facility.

Example 2

A tree planting project has an area of 1.65 acres in the Catoctin Creek watershed in Frederick County. The Catoctin Creek watershed has a TMDL for sediment with a baseline year of 2000 and a TMDL for phosphorus with a baseline year of 2009. Using the steps outlined above, the sediment load removed for the BMP is derived:

1A. Loading rate lookup value is queried by land-river segment for SHA MS4 Phase I/II Pervious.

Loading Rates for Example 1, Step 1A		
Land-River Segment	**MAST Land Use**	**TSS-EOS lb/ac**
B24021PM1_4000_4290	SHA Phase I/II MS4 Pervious	339.63

1B. BMP efficiency lookup value is queried for each BMP type. In this case the efficiencies for sediment removal are used for Reforestation on Pervious Urban:

BMP Efficiencies for Example 1, Step 1B		
BMP Type	**BMP Category**	**TSS Removal**
FPU	Alternative	57%

1C. Multiply loading rates by BMP efficiencies to obtain reduction by lb/unit:

Results for Example 1, Step 1C					
BMP Type	**Land use**	**TSS-EOS lb/unit**	**TSS Removal Efficiency**	**Calculation**	**TSS Reduction (lb/unit)**
Tree Planting	Pervious	339.63	57%	339.63 * 57%	193.59

2. Multiply reduction by lb/unit by units treated by BMP. In this case the units treated are acres of impervious and pervious.

Results for Example 1, Step 2					
BMP Type	**Land use**	**TSS Reduction (lb/unit)**	**Unit Treated (Acres)**	**Calculation**	**TSS Reduction (lb)**
Tree Planting	Pervious	193.59	1.65	193.59*1.65	319.42
				Total	**319.42**

For this facility, 319.42 pounds of sediment are removed annually, counting as progress towards the local sediment TMDL for Catoctin Creek watershed.

DEL loads are calculated in the same manner, but with the appropriate loading rates to track progress towards the Chesapeake Bay TMDL.

Stream Restoration

Load reductions are calculated per project by the stream restoration design team during the design process. For projects where MDOT SHA design teams have not provided project level load reduction information, interim rates based on MDE 2014 will be used. Currently, Coastal/Non Coastal lbs/lf removed were used for all stream restoration projects until project specific load reductions are migrated into the database. As designs progress and project-level information is available, load reductions based on stream design protocols will be incorporated.

Example 3

A stream restoration project is estimated to treat 2,000 linear feet in the Double Pipe Creek watershed in Frederick County. The Double Pipe Creek watershed has a TMDL for sediment with a baseline year of 2000 and a TMDL for phosphorus with a baseline year of 2009. Using the steps outlined above, the phosphorus load removed for the BMP is derived:

1A. Loading rate lookup value is not required for load reduction BMPs such as this one. Reductions are based on a fixed amount of pollutant removed instead of a percentage of the load delivered to the BMP. Therefore, the first step in this analysis is the same as the second step in Example 1.

1B. BMP load reduction is queried for stream restoration. In this case, the project is not far enough along in design to estimate reductions from the Expert Panel protocols (Schueler and Stack, 2014) so the interim rate per linear foot is used.

BMP Load Reduction for Example 2, Step 1B	
BMP Type	**TP Removal (lb/LF)**
Stream Restoration	0.068

1C. It is also not necessary to determine reduction by lb/unit by multiplying loading rates by BMP efficiencies. This reduction factor is given in the lookup table.

2. Multiply reduction by lb/unit by units treated by BMP. In this case the units treated are linear feet of restoration.

Results for Example 1, Step 2				
BMP Type	**TP Reduction (lb/unit)**	**Unit Treated (LF)**	**Calculation**	**TP Reduction (lb)**
Stream Restoration	0.068	2,000	2,000* 0.068	136.0
			Total	**136.0**

For this project, 136.0 pounds of phosphorus are removed annually, counting as progress towards the local phosphorus TMDL for Double Pipe Creek watershed.

Outfall Stabilization

Outfall stabilization projects are expected to have project-specific load reduction information available at the time the facility is built. For planning purposes, MDOT SHA has incorporated its own research on load reductions from outfall stabilization. Based on the results, the assumption for linear feet of treatment provided by planned outfall projects was doubled to 400 linear feet of stream restoration credit as opposed to the maximum of 200 linear feet in MDE 2014. Based on initial research by the stream and outfall teams and individual project results, this is still believed to be a conservative estimate. This number will be adjusted in the future as more project specific data will help determine planning estimates.

GIS Data Processing

Once the calculated load reduction for each facility is determined through the automated script, all treatment data is joined to a point file based on BMP location. This layer is subsequently intersected with TMDL polygons provided on MDE's TMDL Data Center website in order to apply the appropriate treatment to each TMDL. The resulting table lists every BMP within a TMDL along with the load reductions for each facility. Subsequent spreadsheet analysis defined below applies filtering and queries to the data, providing a dynamic view of MDOT SHA's treatment scenarios within a local TMDL.

Bay TMDL Modeling

For Bay TMDL modeling, the sum of load reductions from all MDOT SHA BMPs within MS4 jurisdictions will be compared to reduction goals when developed by MDE.

Spreadsheet Analysis

Treatment and Load Reduction Pivot Tables

The scripts described above result in a raw data export which lists load reductions for each facility found within a MDOT SHA local TMDL. A series of pivot tables are created in an Excel workbook from the data export generated by the AMT to calculate the sum of treatment and sum of load reductions by TMDL pollutant and level of treatment (i.e., baseline, progress, and future). Because baseline dates vary by TMDL, separate pivot tables must be created in order to isolate the treatment from a subset of BMPs by built date. Therefore, multiple pivot tables are required per TMDL pollutant to accurately calculate load reductions per level of treatment.

AMT functionality varies by TMDL pollutant, as follows:

<u>TP AMT result:</u> sum of treatment and sum of TP EOS lbs/yr removed by treatment level

<u>TSS AMT result:</u> sum of treatment and sum of TSS EOS lbs/yr removed by treatment level

PCBs AMT result: sum of treatment and sum of TSS EOS lbs/yr removed by treatment level. TSS EOS lbs/yr removed is then converted to g/yr removed and then multiplied by the average sediment tPCB concentration from the TMDL document to calculate load reduction in PCB g/yr (SHA, 2016).

Bacteria AMT result: sum of treatment by treatment level is used in the WTM and described in the Bacteria Modeling Protocol to calculate bacteria load reductions from stormwater BMPs (SHA, 2016).

The following pivot table filters are applied per TMDL pollutant:

Baseline Pivot Tables:

Pollutant: varies by TMDL

Baseline year: varies by TMDL

BMP type:

- TP and TSS: Excludes BMPs coded as XDED, XDPD, XOGS, XOTH, or blank
- PCB: Excludes tree planting, outfall stabilization, and stream restoration in addition to BMPs coded as XDED, XDPD, XOGS, XOTH, or blank
- Bacteria: Excludes tree planting, impervious surface reduction, grass swales, outfall stabilization, and stream restoration in addition to BMPs coded as XDED, XDPD, XOGS, XOTH, or blank

Status: BMPs coded as construction complete

Built date: BMPs with a built date before July 1 of the baseline year (e.g., For a TMDL with a baseline year of 2005: BMPs before 7/1/2005 are filtered)

Progress Pivot Tables:

Pollutant: varies by TMDL

Baseline year: varies by TMDL

BMP type:

- TP and TSS: Excludes BMPs coded as XDED, XDPD, XOGS, XOTH, or blank
- PCB: Excludes tree planting, outfall stabilization, and stream restoration in addition to BMPs coded as XDED, XDPD, XOGS, XOTH, or blank

- Bacteria: Excludes tree planting, impervious surface reduction, grass swales, outfall stabilization, and stream restoration in addition to BMPs coded as XDED, XDPD, XOGS, XOTH, or blank

Construction purpose: Restoration BMPs (excludes new development BMPs)

Status: BMPs coded as construction completed

Built date: BMPs with a built date between the TMDL baseline year and end of current fiscal year (e.g., FY17 progress BMPs for a TMDL with a baseline year of 2005: BMPs between 7/1/2005 and 6/30/2017)

Future BMP Pivot Tables:

Pollutant: varies by TMDL

BMP type:

- TP and TSS: Excludes BMPs coded as XDED, XDPD, XOGS, XOTH, or blank

- PCB: Excludes tree planting, outfall stabilization, and stream restoration in addition to BMPs coded as XDED, XDPD, XOGS, XOTH, or blank

- Bacteria: Excludes tree planting, impervious surface reduction, grass swales, outfall stabilization, and stream restoration in addition to BMPs coded as XDED, XDPD, XOGS, XOTH, or blank

Construction purpose: Restoration BMPs (excludes new development BMPs)

Status: BMPs coded as under construction, proposed, in design concept, potential, and planned

Fiscal year: 2017 and after, excluding blanks

IV.REFERENCES

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