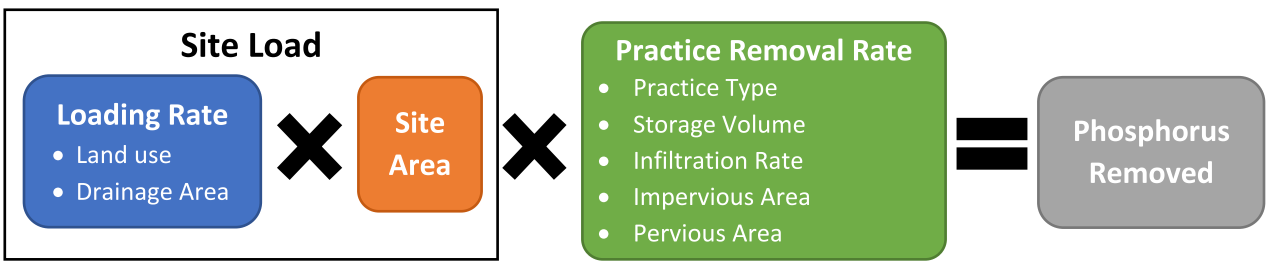
Tracking and Accounting of Stormwater Permit Programs: Operational and Municipal Separate Storm Sewer (MS4) Permits

I. Introduction

This document outlines methods used by the Vermont Department of Environmental Conservation (VTDEC) to track and account for phosphorus reductions from regulatory stormwater practices implemented under the Operational Stormwater Permits and the Municipal Separate Storm Sewer System (MS4) permit. The primary focus is on tracking and accounting of stormwater practices as described in the 2017 Vermont Stormwater Management Manual. This document also describes the methods of accounting for non-structural stormwater practices, such as street sweeping, catch basin cleaning, and leaf litter pick up used by entities subject to the MS4 permit. Tracking and accounting for practices required by the Municipal Roads General Permit are described in the MRGP tracking SOP document.

II. Accounting Method for Structural Stormwater Practices

Phosphorus reductions from structural stormwater practices are generally calculated by the product of the site area, the loading rate of the area (based on the land use type), and the removal rate of the practice.



VTDEC has based accounting methodologies on the Lake Champlain BMP Accounting and Tracking Tool, or LC BATT. LC BATT is a spreadsheet-based tool developed by EPA for the Champlain Basin to provide means to account for and track the nutrient load reductions due to implementation of stormwater and non-point source controls. While VTDEC has developed other tools tracking and accounting, the methods are largely the same.

a. Loading Rates

Loading rates for phosphorus are generally expressed in kilogram per acre per year (kg/ac/yr). To calculate a site's load, the acreage of each land use draining to a practice is multiplied by the appropriate loading rate.

Lake Champlain

Loading Rates were derived from the Lake Champlain Scenario Tool spreadsheet (TetraTech, 2015), which summarized the base load from the TMDL modeling. The total phosphorus load for each land use type was divided by the total area of that land use for each drainage area within the Lake Champlain basin, to yield an area-weighted loading rate in kilograms per acre per year. The drainage areas referred to in the TMDL are major river basins within each lake segment basin.

Some loading rates have been grouped from those originally used in the TMDL modeling. Loading rates were averaged across slopes, since this information isn't typically collected. Since many practices will drain a combination of paved roads and non-road impervious, a loading rate designated "Developed Impervious" was created as an area-weighted average of the two loading rates. For those projects were soil type by hydrologic soil group (HSG) is not available, a weighted average loading rate was calculated for developed pervious. Table 1 below shows the calculated loading rates by land use for each Lake Segment drainage area.

Table 1: Lake Champlain Phosphorus Loading Rates for Developed Lands (kg/acre/year)

Lake Segment	Drainage Area	Unpaved Roads	Paved Roads	Non-Road Impervious	Developed Impervious	Developed Pervious					Forest
						HSG A	HSG B	HSG C	HSG D	Weighted Average	
South Lake B	Mettawee River	2.299	0.823	1.197	1.040	0.062	0.273	0.420	0.787	0.289	0.259
South Lake B	Poultney River	2.259	0.839	1.169	1.012	0.142	0.137	0.164	0.643	0.289	0.261
South Lake B	South Lake B DD	2.381	1.097	1.464	1.298	0.036*	0.238*	0.947	0.412*	0.947	0.131
South Lake A	South Lake A DD	2.321	0.927	1.309	1.127	0.036*	0.238*	0.250	0.374	0.373	0.132
Port Henry	Port Henry DD	2.224	0.894	1.241	1.081	0.001	0.556	0.288*	0.506	0.503	0.073
Otter Creek	Lewis Creek	2.208	0.854	0.989	0.928	0.010	0.342	0.283	0.332	0.290	0.071
Otter Creek	Little Otter Creek	2.360	0.957	1.233	1.097	0.024	n/a	0.144	0.400	0.366	0.037
Otter Creek	Otter Creek	2.115	0.818	1.150	0.998	0.100	0.276	0.271	0.398	0.292	0.248
Otter Creek	Otter Creek DD	2.272	0.881	1.095	1.005	0.036*	0.238*	0.273	0.351	0.348	0.399
Main Lake	Main Lake DD	2.081	0.877	0.933	0.914	0.001	0.043	0.288*	0.301	0.095	0.268
Main Lake	Winooski River	2.207	0.802	1.117	0.980	0.020	0.254	0.284	0.467	0.231	0.181
Shelburne Bay	Laplatte River	2.075	0.735	0.952	0.878	0.010	0.059	0.123	0.243	0.172	0.061
Burlington Bay	Burlington Bay - CSO	n/a	0.921	1.651	1.449	0.015	0.158	0.288*	0.354	0.082	0.096
Burlington Bay	Burlington Bay DD	1.939	0.750	1.369	1.215	0.001	0.058	0.288*	0.340	0.064	0.170
Malletts Bay	Lamoille River	2.034	0.810	1.138	0.986	0.037	0.213	0.438	0.547	0.228	0.069
Malletts Bay	Malletts Bay DD	2.010	0.677	0.825	0.758	0.011	0.099	0.288*	0.392	0.012	0.028
Northeast Arm	Northeast Arm DD	2.067	0.819	1.144	1.002	0.036*	0.238*	0.104	0.298	0.298	0.342
St. Albans Bay	St. Albans Bay DD	1.992	0.791	1.240	1.059	0.036*	0.049	0.194	0.412*	0.178	0.069
Missisquoi Bay	Missisquoi Bay DD	2.000	0.817	0.714	0.760	0.023	0.285	0.508	0.316	0.415	0.088
Missisquoi Bay	Missisquoi River	2.056	0.806	1.149	0.981	0.009	0.266	0.286	0.433	0.261	0.204
Isle La Motte	Isle La Motte DD	1.967	0.729	0.759	0.746	0.036*	0.024	0.084	0.076	0.077	0.069
Basin-wide		2.138	0.810	1.115	0.980	0.036	0.238	0.288	0.412	0.243	0.064

*The basin wide average of the HSG soil type was used here, as these loads were not included in the TMDL modeling.

b. Structural Treatment Practice Types and Removal Rates

The percent removal of a treatment practice is determined using BMP Performance Curves as described in the Stormwater Control Measure Nomographs and Cost Estimates produced in cooperation between EPA Regions 1 and the University of New Hampshire Stormwater Center. The curves require the physical storage of the treatment practice, expressed as inches of runoff from the contributing drainage area. Depth of storage is calculated from the impervious, pervious, and storage volume of the practice.

Table 2: Removal Rates for the BMP Performance Curves

Depth of Runoff from Impervious Surfaces (inches)	0.1	0.2	0.4	0.6	0.8	1	1.5	2
Infiltration Basin 8.27 in/hr	59%	81%	96%	99%	100%	100%	100%	100%
Infiltration Basin 2.41 in/hr	46%	67%	87%	94%	97%	98%	100%	100%
Infiltration Basin 1.02 in/hr	41%	60%	81%	90%	94%	97%	99%	100%
Infiltration Basin 0.52 in/hr	38%	56%	77%	87%	92%	95%	98%	99%
Infiltration Basin 0.27 in/hr	37%	54%	74%	85%	90%	93%	98%	99%
Infiltration Basin 0.17 in/hr	35%	52%	72%	82%	88%	92%	97%	99%
Infiltration Trench 8.27 in/hr	50%	75%	94%	98%	99%	100%	100%	100%
Infiltration Trench 2.41 in/hr	33%	55%	81%	91%	96%	98%	100%	100%
Infiltration Trench 1.02 in/hr	27%	47%	73%	86%	92%	96%	99%	100%
Infiltration Trench 0.52 in/hr	23%	42%	68%	82%	89%	94%	98%	99%
Infiltration Trench 0.27 in/hr	20%	37%	63%	78%	86%	92%	97%	99%
Infiltration Trench 0.17 in/hr	18%	33%	57%	73%	83%	90%	97%	99%
Gravel Wetland	19%	26%	41%	51%	57%	61%	65%	66%
Wet Pond/ Constructed Wetland/ Biofiltration/ Sand Filter	14%	25%	37%	44%	48%	53%	58%	63%
Dry Pond	3%	6%	8%	9%	11%	12%	13%	14%
Grass Swale	2%	5%	9%	13%	17%	21%	29%	36%

There are a variety of names that can be used to describe a certain type of stormwater treatment practice. The table in Appendix B describes the BMP types, definitions, related performance curves and how to calculate the storage volume of each BMP based on LC BATT.

Storage Depth Calculations

In order to use the BMP Performance Curves (Table 2 B), the storage depth must be determined. The storage depth is expressed as inches of runoff from impervious surfaces. Runoff depth from impervious and pervious are calculated as follows, as modified from LC BATT:

Impervious $R_I = P$

Pervious HSG A $R_A = 0.0413 \times P^2 - 0.0118 \times P$

Pervious HSG B $R_B = 0.0652 \times P^2 - 0.0231 \times P$

Pervious HSG C $R_C = 0.2 \times P^2 - 0.0597 \times P$

Pervious HSG D $R_D = 0.2746 \times P^2 + 0.0057 \times P$

Where:

P = Precipitation in inches
R_I = Runoff from impervious areas in inches
R_A = Runoff from pervious areas with hydrologic soil group A in inches
R_B = Runoff from pervious areas with hydrologic soil group B in inches
R_C = Runoff from pervious areas with hydrologic soil group C in inches
R_D = Runoff from pervious areas with hydrologic soil group D in inches

The storage volume is calculated by the sum of the runoff depth for each land type, multiplied by the area if each land type draining to the practice.

$$V = (A_I \times R_I + A_A \times R_A + A_B \times R_B + A_C \times R_C + A_D \times R_D) \times 43560/12$$

Where:
V = Storage volume of the treatment practice in cubic feet
A_I = Impervious surface in acres
A_A = Pervious area over hydrologic soil group A
A_B = Pervious area over hydrologic soil group B
A_C = Pervious area over hydrologic soil group C
A_D = Pervious area over hydrologic soil group D

The equations above can then be substituted in.

$$V = A_I \times R_I + A_A \times (0.0413 \times R_I^2 - 0.0118 \times R_I) + A_B \times (0.0652 \times R_I^2 - 0.0231 \times R_I) + A_C \times (0.2 \times R_I^2 - 0.0597 \times R_I) + A_D \times (0.2746 \times R_I^2 + 0.0057 \times R_I) \times 3630$$

The Watershed Projects Database (WPD) and STP Calculator solve for R_I using an iterative approach. The equation can also be solved for R_I by rearranging, then solving by the quadratic equation. This solution is used to calculate storage depth in a spreadsheet.

$$R_I = -(3630 \times A_I - 42.834 \times A_A - 83.853 \times A_B - 216.711 \times A_C + 42.834 \times A_D) - \Big(((3630 \times A_I - 42.834 \times A_A - 83.853 \times A_B - 216.711 \times A_C + 42.834 \times A_D))^2 + 4 \times (149.919 \times A_A + 236.676 \times A_B + 726 \times A_C + 996.798 \times A_D) \times V\Big)^{1/2} / \big(2 \times (149.919 \times A_A + 236.676 \times A_B + 726 \times A_C + 996.798 \times A_D)\big)$$

c. Tracking and Accounting of Non-structural Practices

Non-structural stormwater treatment practices include street sweeping, catch basin cleaning and leaf litter pick up. DEC is currently using credits from the Massachusetts MS4 General Permit and Wisconsin Department of Environmental Protection.

Sweeper Technology	Frequency	Credit
Mechanical Broom	2/year (spring and fall)	1%
Mechanical Broom	Monthly	3%
Mechanical Broom	Weekly	5%
Vacuum Assisted	2/year (spring and fall)	2%
Vacuum Assisted	Monthly	4%
Vacuum Assisted	Weekly	8%
High Efficiency Regenerative Air-Vacuum	2/year (spring and fall)	2%
High Efficiency Regenerative Air-Vacuum	Monthly	8%
High Efficiency Regenerative Air-Vacuum	Weekly	10%
Any technology on streets with ≥17% tree cover	4X in the fall	17%

Credits based on monthly or weekly basis are assumed to be performed year-round. If sweeping is only performed during part of the year, the credit can be prorated based on the percent of the year during which sweeping takes place.

Credit is only given for an increase in street sweeping during or after the TMDL modeling period. The base year for fully credit is 2010, based on the end of the modeling period for the Lake Champlain TMDL. Credit is reduced by 10% for each year prior to 2010 that the practice commenced or increased.

Currently several towns in Chittenden County and Washington County are involved in a study with the U.S. Geological Survey (USGS) to determine the best way to give credit to municipalities who have sought to increase their level of non-structural practices. This study in Vermont is expected to be completed in the fall of 2019. The study may result in the development of a leaf management credit, for which DEC does not currently have a methodology.

III. Municipal Separate Storm Sewer System (MS4) Permit Tracking

The 2018 Municipal Separate Storm Sewer System General Permit (MS4) updated permit requires MS4 municipalities to develop and implement Phosphorus Control Plans (PCPs) to address the Lake Champlain TMDLs' developed lands waste load allocation. In addition, most MS4 municipalities were required to develop and submit Flow Restoration Plans (FRP) for stormwater impaired watersheds within their boundaries. Progress implementing FRPs are reported annually. PCP's must be submitted to the state by April 1, 2021 and their progress will be reported on annually.

Stormwater treatment systems installed under the FRPs are intended to meet flow reduction targets, however, many will also result in phosphorus reductions. Therefore, DEC plans to integrate tracking implementation of FRPs and PCPs.

Accounting for MS4 practices is consistent with Section II of this document and with the Tracking and Accounting Standard Operating Procedures of the Municipal Roads General Permit. Structural Practices are allowed credit towards the PCP targets if constructed in 2002 or later. This is somewhat earlier than the end of the TMDL modeling period in 2010 but was done to be consistent with the FRP cutoff.

Appendix B. Stormwater Treatment Practice Types and Storage Volume Equations

STP Type	Description	STP Calculator Curve	Method for Calculating Design Storage Volume (DSV)
Infiltration Trench	Provides storage of runoff using the void spaces within the soil/sand/gravel mixture within the trench for infiltration into the surrounding soils.	Infiltration Trench	DSV = void space volumes of stone and sand layers DSV = $(A_{trench} \times D_{stone} \times n_{stone}) + (A_{trench} \times D_{sand} \times n_{sand})$
Subsurface Infiltration	Provides storage of runoff using the combination of storage structures and void spaces within the washed stone within the system for infiltration into the surrounding soils.	Infiltration Trench	DSV = storage volume of storage units and void space of backfill materials. Example for subsurface galleys backfilled with washed stone: DSV = $(L \times W \times D)_{galley} + (A_{backfill} \times D_{stone} \times n_{stone})$
Surface Infiltration	Provides storage of runoff through surface ponding (e.g., basin or swale) for subsequent infiltration into the underlying soils.	Surface Infiltration	DSV = volume of storage structure before bypass. Example for linear trapezoidal vegetated swale. DSV = $(L \times ((W_{bottom}+W_{top@Dmax})/2) \times D)$
Rain Garden/ Bioretention (no underdrains)	Provides storage of runoff through surface ponding and possibly void spaces within the soil/sand/washed stone mixture that is used to filter runoff prior to infiltration into underlying soils.	Surface Infiltration	DSV = Ponding water storage volume and void space volumes of soil filter media. Example for raingarden: DSV = $(A_{pond} \times D_{pond}) + (A_{soil} \times D_{soil} \times n_{soil\ mix})$
Rain Garden/ Bioretention (w/underdrain)	Provides storage of runoff by filtering through an engineered soil media. The storage capacity includes void spaces in the filter media and temporary ponding at the surface. After runoff passes through the filter media it discharges through an under-drain pipe.	Bioretention	DSV = Ponding water storage volume and void space volume of soil filter media. DSV = $(A_{bed} \times D_{ponding}) + (A_{bed} \times D_{soil} \times n_{soil})$
Gravel Wetland	Provides surface storage of runoff in a wetland cell that is routed to an underlying saturated gravel internal storage reservoir (ISR). Outflow is controlled by an orifice that has its invert elevation equal to the top of the ISR layer and provides retention of at least 24 hrs.	Gravel Wetland	DSV = pretreatment volume + ponding volume + void space volume of gravel ISR. DSV = $(A_{pretreatment} \times D_{Pretreatment}) + (A_{wetland} \times D_{ponding}) + (A_{ISR} \times D_{gravel} \times n_{gravel})$

Porous Pavement with infiltration	Provides filtering of runoff through a filter course and temporary storage of runoff within the void spaces of a subsurface gravel reservoir prior to infiltration into subsoils.	Infiltration Trench	DSV = void space volumes of gravel layer DSV = ($A_{pavement}$ x D_{stone} x n_{stone})
Porous pavement w/ impermeable underlining or underdrain	Provides filtering of runoff through a filter course and temporary storage of runoff within the void spaces prior to discharge by way of an underdrain.	Porous Pavement	Depth of Filter Course = D_{FC}
Sand Filter w/underdrain	Provides filtering of runoff through a sand filter course and temporary storage of runoff through surface ponding and within void spaces of the sand and washed stone layers prior to discharge by way of an underdrain.	Sand Filter	DSV = pretreatment volume + ponding volume + void space volume of sand and washed stone layers. DSV = ($A_{pretreatment}$ x $D_{preTreatment}$) + (A_{bed} x $D_{ponding}$) + (A_{bed} x D_{sand} x n_{sand}) + (A_{bed} x D_{stone} x n_{stone})
Wet Pond	Provides treatment of runoff through routing through permanent pool.	Wet Pond	DSV= Permanent pool volume prior to high flow bypass DSV=A_{pond} x D_{pond} (does not include pretreatment volume)
Extended Dry Detention Basin	Provides temporary detention storage for the design storage volume to drain in 24 hours through multiple outlet controls.	Dry Pond	DSV= Ponding volume prior to high flow bypass DSV=A_{pond} x D_{pond} (does not include pretreatment volume)
Grass Conveyance Swale	Conveys runoff through an open channel vegetated with grass. Primary removal mechanism is infiltration.	Grass Swale	DSV = Volume of swale at full design flow DSV=L_{swale}x $A_{crossect. swale}$
Footnotes:			
DSV= Design Storage Volume = physical storage capacity to hold water			
VSV=Void Space Volume			
L= length, W= width, D= depth at design capacity before bypass, n=porosity fill material, A= average surface area for calculating volume			
Infiltration rate = saturated soil hydraulic conductivity			