Future Growth from Developed Lands in the Lake Champlain Basin

Stormwater Management Program, VTDEC, June 23rd, 2015

In order to inform the future growth allocation in the Lake Champlain TMDL the Vermont Department of Environmental Conservation (VTDEC) has undertaken an analysis of some of the factors that affect increased loads from the addition of impervious surfaces in the basin over the next 20 years.

Permitted Impervious Growth

An analysis was undertaken to estimate the rate of impervious area growth under the Vermont Stormwater Permitting program for the period of 2005-2014, based on information taken from the Stormwater Management Database on January 28, 2015.

The Department estimates that, on average, an additional 233 acres of impervious is permitted under the state stormwater permitting program every year. The highest rate of impervious creation occurred in 2005-2008, before attenuating somewhat in recent years. The lake segments with smaller drainage areas represented both extremes. Port Henry, South Lake A, and South B have the lowest rate of growth as they are largely undeveloped, while St Albans Bay and Burlington Bay have more urban areas and saw the highest rate of growth. The Lake Champlain Basin Program 2011 impervious surface layer was used to estimate the total impervious cover in the basin for calculation of the percentage growth rate.

The stormwater management database does not currently differentiate between new impervious or re-developed impervious. A sampling of stormwater permits in the study period suggests that approximately 10% of the impervious permitted is due to redevelopment, rather than new construction, and therefore does not constitute a net increase in phosphorus load.

Table 1: New Permitted Impervious by Lake Segment, 2005-2014

Lake Segment	Newly Permitted Impervious - Operational (acres)										Average Annual Permitted Impervious (acres)	New Impervious Multiplier	Total Impervious LCBP 2011 (acres)	% Average Annual New Impervious
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014				
01. South Lake B	0.8	2.3	7.2	4.7	1.0	1.3	3.0	3.2	0.1	1.5	2.5	0.9	4026.3	0.06%
02. South Lake A	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.9	630.6	0.02%
03. Port Henry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	218.1	0.00%
04. Otter Creek	63.4	33.7	53.6	37.4	41.7	29.2	12.7	34.9	53.6	22.4	38.3	0.9	13051.5	0.26%
05. Main Lake	103.7	96.5	144.0	94.1	93.2	69.3	65.9	51.9	52.9	55.7	82.7	0.9	17890.1	0.42%
06. Shelburne Bay	20.9	13.3	41.4	15.0	12.8	9.7	19.4	10.0	15.2	25.7	18.3	0.9	2878.8	0.57%
07. Burlington Bay	23.4	11.1	0.0	0.6	3.0	19.1	12.5	9.4	0.0	2.2	8.1	0.9	1206.5	0.61%
09. Malletts Bay	27.4	24.5	95.4	98.4	33.8	23.6	50.2	23.2	11.5	36.2	42.4	0.9	9735.1	0.39%
10. Northeast Arm	0.0	0.0	1.0	3.7	7.3	6.1	0.0	0.5	2.1	4.1	2.5	0.9	1570.0	0.14%
11. St. Albans Bay	9.6	75.8	5.6	28.0	29.4	8.1	6.5	3.1	3.0	1.4	17.0	0.9	1837.4	0.83%
12. Missisquoi Bay	28.4	18.5	7.3	18.6	24.7	16.5	38.9	16.2	15.8	14.9	20.0	0.9	7223.8	0.25%
13. Isle La Motte	0.0	6.5	1.5	0.0	0.0	0.0	0.0	2.0	1.4	0.0	1.1	0.9	508.9	0.20%
Total	**277.6**	**283.4**	**357.0**	**300.5**	**246.9**	**183.0**	**208.9**	**154.3**	**155.6**	**164.0**	**233.1**	**0.9**	**60777.2**	**0.35%**

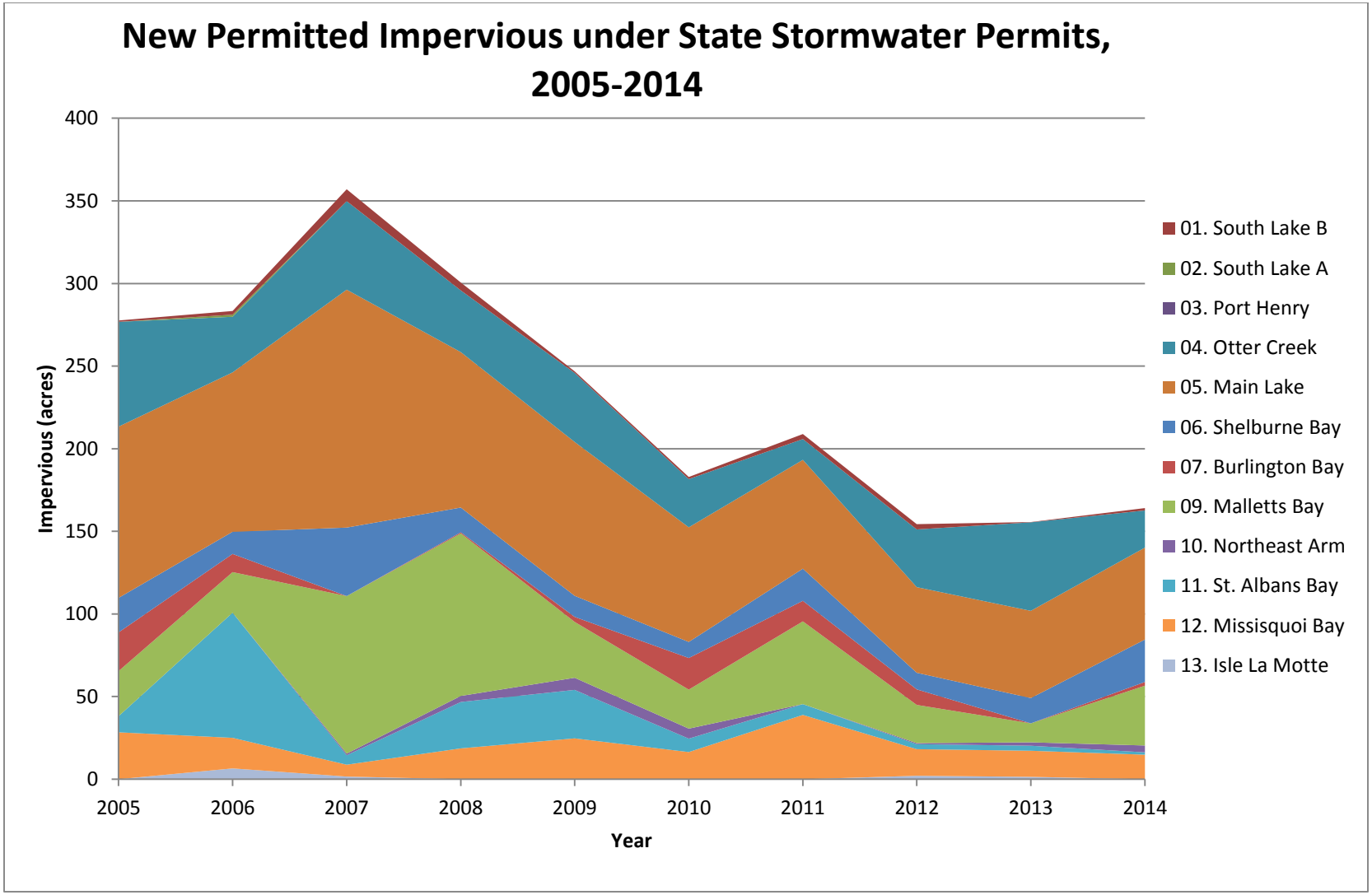

Figure 1: New Impervious Permitted under the Vermont Stormwater Program, 2005-2014

Unpermitted Impervious Growth

In addition to the new impervious that is subject to operational stormwater permitting, there are projects that do not trigger state permitting thresholds. As it is unpermitted, data is lacking on the growth of impervious in this category. Consequently, estimating basin-wide future growth from sub-jurisdictional impervious is difficult. A few limited studies have been undertaken in a few watersheds in relation to municipalities' future growth commitments under the stormwater TMDLs. South Burlington estimated 0.36% annual growth in non-jurisdictional impervious Centennial Brook (excluding Burlington impervious). Winooski estimated 0.15% annual growth in non-jurisdictional impervious Morehouse Brook between 2004 and 2010. Both communities represent more developed areas of the basin, and no estimates exist for the majority of Lake Champlain communities, which are typically less developed. For the purposes of this exercise, it was assumed that the growth rate of sub-jurisdictional impervious is equal to the jurisdictional impervious. While there is significant uncertainty surrounding this estimate, the limited sub-jurisdictional growth estimates are within the range of values for permitted impervious. In addition, nearly half of the construction permits issued by VTDEC are not associated with an operational permit, suggesting that there is significant sub-jurisdictional development occurring.

Selection of Pollutant Removal Efficiency

Vermont's Stormwater Standards

The Vermont Stormwater Management Manual currently describes five stormwater treatment standards:

- Water Quality (WQ_v): treatment of the 90th percentile rain storm in an approved water quality practice. Under the 2002 Manual, the target rainstorm is 0.9" statewide, but DEC is proposing to raise this to 1.0".
- Recharge (Re_v): This is the minimum portion of the water quality volume that must be infiltrated. The recharge factor is based on soil type. Recharge is waived for hydrologic soil group D soils.
- Channel Protection (CP_v): 12 or 24 hour detention of the 1 year storm.
- Overbank Flood Protection (Q_{10}): Control the post-developed peak discharge from the 10 year storm to 10 year predevelopment rates.
- Extreme Flood Protection (Q_{100}): Control the post-developed peak discharge from the 100 year storm to 100 year predevelopment rates. This standard is only applicable to those projects that create at least 10 acres of impervious, and is therefore not often required.

A typical site subject to a stormwater permit must address at least the first four treatment standards. Designers typically tend to favor practices that can address more than one standard, as it reduces the total amount of area on the site that is dedicated to stormwater management. The channel protection and overbank flood protection standards generally requires detention of significant volumes on all but the sandiest of soils. Under the 2002 stormwater manual, a popular strategy has been to design a pond

with a permanent pool and extended detention that can meet the water quality standard as well as the larger standards as well within the same footprint.

Soil Distribution of Permits in the Lake Champlain Basin

Soil hydrologic group is important factor in determining what types of BMPs are appropriate on a given site. Practices that are able to infiltrate generally can achieve higher pollutant removal efficiencies than those that do not. Soils classified as hydrologic soil group A or B are generally conducive to infiltration based practices, whereas C and D soils have limited to no infiltration capacity. Based on an intersection of the stormwater permits point layer with the soils coverage for the state, the relative distribution of stormwater permits by soil group was approximated for the basin. The basin is dominated by C and D soils, but due to the tendency for development to cluster in river valleys where sandier soils are present, the distribution of permits amongst soil classes is more evenly distributed.

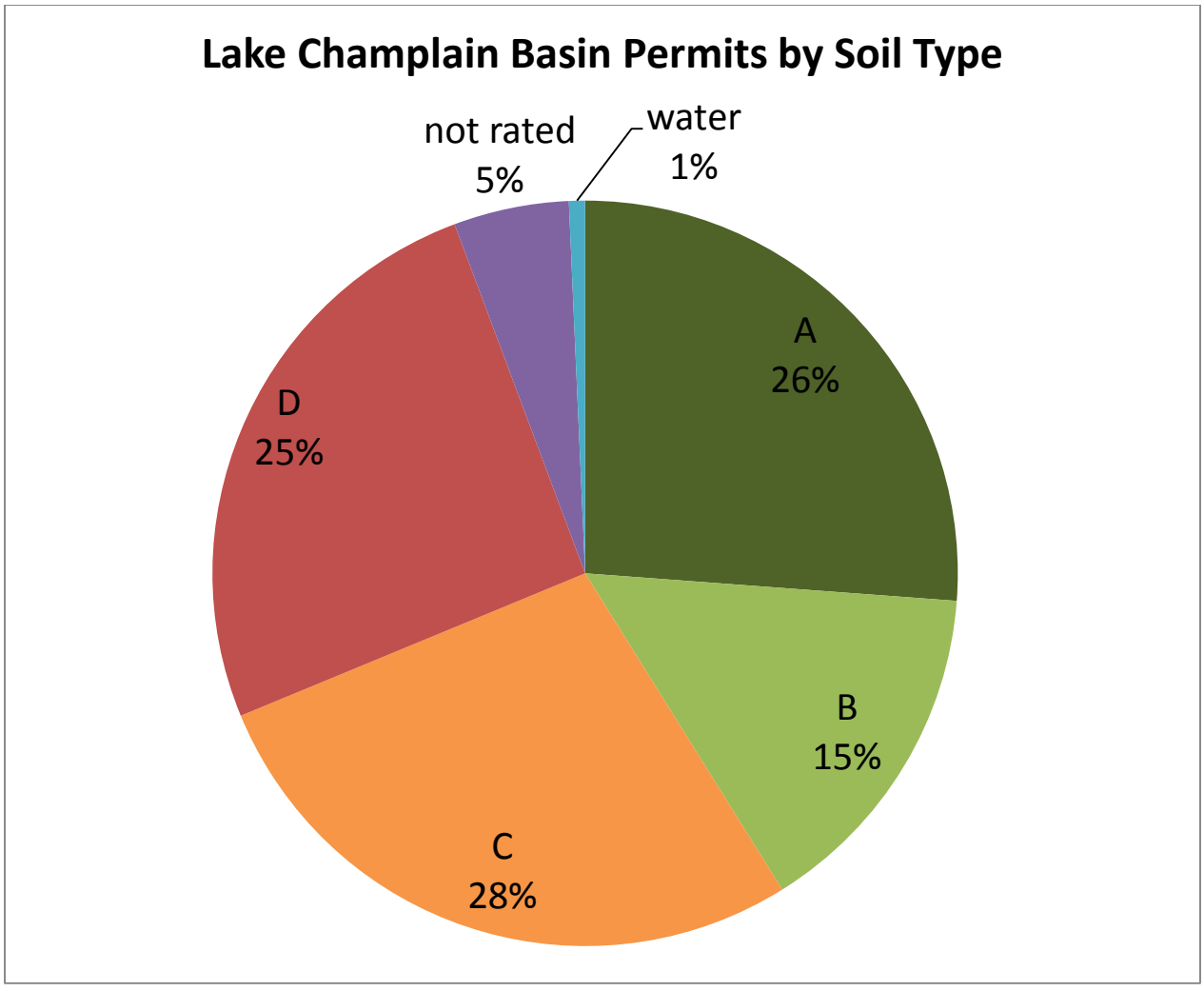

Figure 2: Percent Area by Hydrologic Soil Group in the Lake Champlain Basin

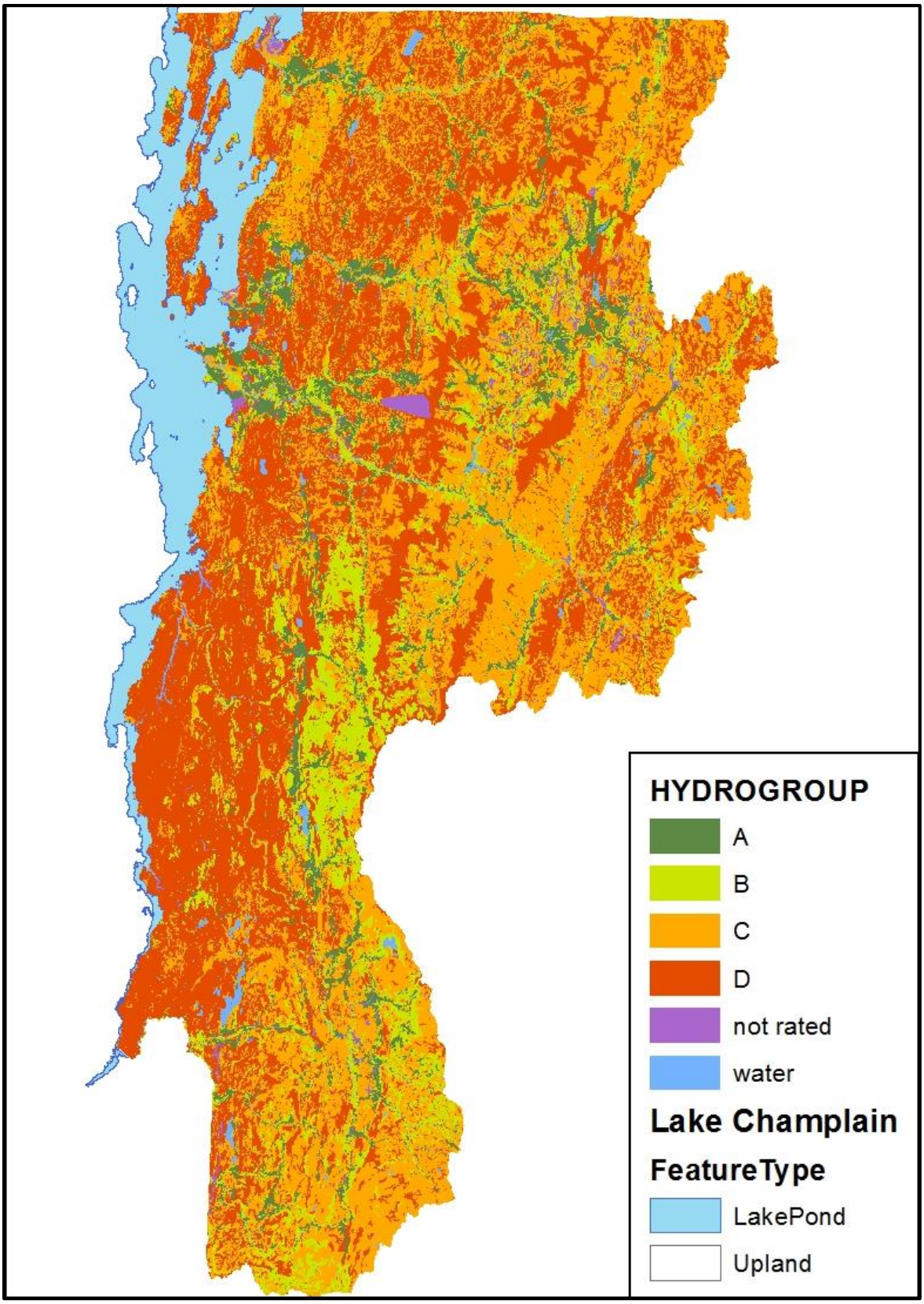

Figure 3: Geographic Distribution of Hydrologic Soil Group in the Lake Champlain Basin

Average BMP Removal Efficiency

Based on the current distribution of stormwater permits currently, two average pollutant removal efficiencies were examined (Table 2). For all scenarios the EPA BMP pollutant removal curves were used. BMP removal efficiencies were based on treatment of the first of inch of runoff through the respective BMP. It is acknowledged that many permitted sites will treat more than the first inch of runoff, but the additional pollutant removal above one inch is usually minimal. The bulk of the phosphorus removal will be accomplished by the Water Quality and Recharge standards. Both scenarios assume that hydrologic soil groups A & B will utilize infiltration practices to meet these standards, with a phosphorus removal efficiency of 94% for practices with a 1.0" capacity. An average efficiency was calculated based on the distribution of permits by soil type.

Standard Treatment Scenario

In the standard treatment scenario, treatment of the water quality and recharge standards is assumed to be met with a wet pond. According to EPA's estimates, a wet pond treating one inch of runoff provides 53% phosphorus reduction. The recharge factors are 0.1 and 0 for C and D soils, respectively. Recharge on C soils is often met through the use of disconnection credits. Assuming the ratio of disconnected impervious to pervious area is 1:1, the removal efficiency for C soils is 49% (draft Mass MS4 permit). If a C soil site must disconnect 10% of their impervious, then the site-wide phosphorus reduction from the recharge standard would be 4.9%, for a total P reduction of 57.9% when added to the performance of the wet pond. Soils that were rated "water" or "not rated" were assigned reduction efficiencies as if they were D soils.

Enhanced Phosphorus Removal Scenario

The second scenario uses biofiltration, a higher P removal practice to meet the water quality standard, in place of the wet ponds on C & D soils. Based on EPA's BMP performance curves, a biofiltration with a 1.0" volume can achieve 76% phosphorus removal. The tradeoff between higher pollutant removal is generally larger overall BMP footprint on the site, since the filter is not able to meet the channel protection or overbank flood standards and an additional BMP will be required.

Table 2: Average Phosphorus Removal Efficiency of the Vermont State Stormwater Manual

HYDROGROUP	% of Permits	Phosphorus Removal Efficiency	
		Standard Treatment Scenario	Enhanced Treatment Scenario
A	26.2%	94.0%	94.0%
B	15.0%	94.0%	94.0%
C	27.6%	57.9%	80.9%
D	25.5%	53.0%	76.0%
not rated [1]	5.0%	53.0%	76.0%
water	0.7%	53.0%	76.0%
Average Removal Efficiency		**71.2%**	**84.8%**

(1) Not rated: these soils are most often urban or fill soils and some alluvial deposits. They are generally not considered suitable for infiltration.

Redevelopment Standard

Under the proposed revised Vermont Stormwater Manual, redeveloped projects must either reduce the existing impervious by 25%, provide treatment equivalent to 25% of the WQv, or some combination of the two. For purposes of this analysis, a credit equal to the Water Quality removal efficiency on 25% of the estimated redeveloped impervious was applied.

Retrofit Treatment Efficiency

For purposes of this exercise, it is assumed that retrofit sites will be able to achieve the same phosphorus removal efficiency as newly developed sites. In reality, retrofits sites tend to have many more site constraints than new development, so it is possible that more acres of impervious will need to be retrofitted in order to offset the calculated impervious, based on how the treatment standards on developed sites are structured.

Load Estimation

Loading rates were taken from the Lake Champlain Scenario Tool (2015). The net increase in load was calculated by subtracting the forest load from the impervious load. For permitted impervious, the average phosphorus removal efficiency was applied to the impervious load. For unpermitted impervious, no removal efficiency was applied, as it is assumed these sites will not receive treatment. For both types of impervious, the forest load for the same area was then subtracted to yield the net increase in phosphorus load for the development.

Table 3: Delivered Phosphorus Load from Future Development

Lake Segment	Increase in Delivered P Load from Permitted Impervious (kg/year)		Increase in Delivered P from Unpermitted Impervious (kg/year)
	71.2% BMP P Removal Efficiency	84.8% BMP P Removal Efficiency	
01. South Lake B	0.3	0.1	1.7
02. South Lake A	0.0	0.0	0.1
03. Port Henry	0.0	0.0	0.0
04. Otter Creek	4.1	1.5	20.0
05. Main Lake	12.7	5.2	59.1
06. Shelburne Bay	2.8	1.4	11.3
07. Burlington Bay	2.2	1.0	9.0
09. Malletts Bay	6.8	3.5	27.3
10. Northeast Arm	0.3	0.1	1.9
11. St. Albans Bay	3.6	1.9	14.3
12. Missisquoi Bay	2.9	1.1	14.1
13. Isle La Motte	0.2	0.1	0.7
TOTAL	**35.9**	**15.9**	**159.3**

Limitations

The most important source of uncertainty in the analysis is the lack of information on sub-jurisdictional impervious, as it constitutes the majority of the phosphorus increase.

There are several programs not accounted for here that provide protection to water resources without requiring a stormwater permit, including:

- MS4 post-construction stormwater controls: MS4 entities are required by permit to have post construction stormwater controls on projects that do not meet the state jurisdictional thresholds, but disturb more than an acre of land during construction. Some municipalities voluntarily regulate projects even below the statutory requirement.
- Act 250 permits: Permit conditions vary but may include buffers, land conservation, or stormwater BMPs to offset the impacts of development that require Act 250 permit coverage.
- Shoreland Permits: Limits clearing and impervious surface within 250 feet of lakes 10 acre or larger.
- Wetland Permits: Wetland regulations require avoidance and minimization of development in wetlands and their buffers.

The analysis also assumes that the Vermont's current operational permitting thresholds will remain unchanged. As a result of H.35 the Department is committed to evaluating whether the threshold should be lowered to one half acre of impervious. If the Department were to expand its jurisdictional coverage, a higher proportion of new impervious would receive treatment, and then the net increase in phosphorus from these areas would be less.

References

Environmental Protection Agency. (2014). Appendix F Attachment 3. In *Draft Massachusetts Small MS4 General Permit*. Retrieved from http://www.epa.gov/region1/npdes/stormwater/MS4_MA.html.

TetraTech, Inc. (2015). BMP Scenario Tool to Support Selection of the TMDL allocations for the Lake Champlain Phosphorus TMDL. (Version ScenarioTool 05-14-15.xlsm).