ATTACHMENT 1 TO APPENDIX F

Method to Calculate Baseline Phosphorus Load (Baseline), Phosphorus Reduction Requirements and Phosphorus load increases due to development (P$_{DEVinc}$)

The methods and annual phosphorus load export rates presented in Attachments 1, 2 and 3 are for the purpose of measuring load reductions for various stormwater BMPs treating runoff from different site conditions (i.e. impervious or pervious) and land uses (e.g. commercial, industrial, residential). The estimates of annual phosphorus load and load reductions due to BMPs are intended for use by the permittee to measure compliance with its Phosphorus Reduction Requirement under the permit.

This attachment provides the method to calculate a baseline phosphorus load discharging in stormwater for the impaired municipalities subject to Lakes and Ponds TMDL. A complete list of municipalities subject to these TMDLs is presented in Appendix F, Table F-6. This method shall be used to calculate the following annual phosphorus loads:
1) Baseline Phosphorus Load for Permittees
2) Phosphorus Reduction Requirement

This attachment also provides the method to calculate stormwater phosphorus load increases due to development for the municipalities subject to the Charles River TMDL requirements and the Lakes & Ponds TMDL requirements:
3) Phosphorus Load Increases due to Development

The **Baseline Phosphorus Load** is a measure of the annual phosphorus load discharging in stormwater from the impervious and pervious areas of the impaired Lake Phosphorus Control Plan (LPCP) Area.

The **Baseline Phosphorus Pounds Reduction** referred to as the permittee's **Phosphorus Reduction Requirement** represents the required reduction in annual phosphorus load in stormwater to meet the WLA for the impaired watershed. The percent phosphorus reduction for each watershed (identified in Appendix F, Table F-6) is applied to the Baseline Phosphorus Load to calculate the Phosphorus Pounds Reduction.

The **Phosphorus load increases due to development (P$_{DEVinc}$)** is the stormwater phosphorus load increases due to development over the previous reporting period and incurred to date. Increases in stormwater phosphorus load from development will increase the permittee's baseline phosphorus load and therefore, the phosphorus reduction requirement.

Examples are provided to illustrate use of the methods. Table 1-1 below provides annual composite phosphorus load export rates (PLERs) by land use category for the Baseline Load and Phosphorus Reduction Requirement calculations. The permittee shall select the land use category that most closely represents the actual use of the watershed. For watersheds with institutional type uses, such as government properties, hospitals, and schools, the permittee shall use the commercial land use category for the purpose of calculating phosphorus loads. Table 1-2 provides annual PLERs by land use category for impervious and pervious areas. The permittee shall select the land use category that most closely represents the actual use of the watershed. For pervious areas, if the hydrologic soil group (HSG) is known, use the appropriate value. If the HSG is not known, assume HSG C/D conditions for the phosphorus load export rate. For watersheds with

institutional type uses, such as government properties, hospitals, and schools, the permittee shall use the commercial/industrial land use category for the purpose of calculating phosphorus loads. Table 1-3 provides a crosswalk table of land use codes between Tables 1-1 and 1-2 and the codes used by MassGIS.

(1) Baseline Phosphorus Load: The permittee shall calculate the **Baseline Phosphorus Load** by the following procedure:

1) Determine the total area (acre) associated with the impaired watershed;

2) Sort the total area associated with the watershed into land use categories;

3) Calculate the annual phosphorus load associated with each land use category by multiplying the total area of land use by the appropriate land use-based composite phosphorus load export rate provided in Table 1-1; and

4) Determine the Baseline Phosphorus Load by summing the land use loads.

Example 1-1 to determine Baseline Phosphorus Load:
Watershed A is 15.11 acres, with 11.0 acres of industrial area (e.g. access drives, buildings, and parking lots), 3.0 acres of medium-density residential and 4.0 acres of unmanaged wooded area.

The **Baseline Phosphorus Load** = (Baseline P Load $_{IND}$) + (Baseline P Load $_{MDR}$) + (Baseline P Load $_{FOR}$)

Where:
Baseline P Load $_{IND}$ = (TA$_{IND}$) x (PLER for industrial use (Table 1-1))
$\qquad$ = 11.0 acre x 1.29 lbs/acre/year
$\qquad$ = 14.2 lbs P/year

Baseline P Load $_{MDR}$ = (TA$_{MDR}$) x (PLER for medium density residential (Table 1-1))
$\qquad$ = 3.0 acre x 0.55 lbs/acre/year
$\qquad$ = 1.65 lbs P/year

Baseline P Load $_{FOR}$ = (TA$_{FOR}$) x (PLER for forest (Table 1-1))
$\qquad$ = 4.0 acre x 0.12 lbs/acre/year
$\qquad$ = 0.5 lbs P/year

Baseline Phosphorus Load = 14.2 lbs P/year + 1.65 lbs P/year + 0.5 lbs P/year
$\qquad$ = **16.4 lbs P/year**

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(2) Baseline Phosphorus Pounds Reduction (Phosphorus Reduction Requirement): The Baselines Phosphorus Reduction requirement is the amount of reduction in annual phosphorus load (in pounds) that the permittee is required to achieve in the Watershed. The permittee shall calculate the **Phosphorus Reduction Requirement** by multiplying the **Baseline Phosphorus Load** by the applicable percent phosphorus reduction for that watershed specified in Table F-6 (Appendix F).

> **Example 1-2 to determine Watershed Phosphorus Reduction Requirement:**
> Table F-6 identifies Watershed A's percent phosphorus reduction as 45%; therefore the Watershed Phosphorus Reduction Requirement is:
>
> Phosphorus Reduction Requirement   = (Baseline Phosphorus Load) x (0.45)
>   = (16.4 lbs P/year) x (0.45)
>   = **7.4 lbs P/year**

(3) Phosphorus load increases due to development (P_{DEVinc}): To estimate the increases in stormwater phosphorus load due to development in the Watershed (either PCP or LPCP Area), the permittee will use the following procedure:

1) Determine the total area of development by land use category and calculate the baseline load from that area using the composite PLERs in Table 1-1;

2) Distribute the total development area into impervious and pervious subareas by land use category;

3) Calculate the phosphorus load due to development (P_{DEV}) for each land use-based impervious and pervious subarea by multiplying the subarea by the appropriate phosphorus load export rate provided in Table 1-2; and

4) Determine the phosphorus load increase (P_{DEVinc}) by subtracting the baseline phosphorus load from the increased phosphorus load due to development.

Note: If structural BMPs are installed as part of new development, the P_{DEVinc} will be reduced by the amount of BMP load treated by that BMP as calculated in Attachment 3.

> **Example 1-3 to determine Phosphorus Load Increases:** For the same 15.11 acre Watershed A as specified in Example 1-1, a permittee has tracked development in the LPCP Area in the last year that resulted in 1.5 acres of medium density residential area and 0.5 acres of forest land being converted to high density residential impervious area as detailed below. The undeveloped MDR area is pervious area, HSG C soil and the undeveloped forest area is pervious, HSG B soil.
>
> | Land Use Category | Baseline Area (acres) | P export rate (lbs P/acre/yr)* | Baseline area unchanged (acres) | P export rate (lbs P/acre/yr)** | Developed Area converted to HDR IA (acres) | P export rate (lbs P/acre/yr)** |
> |---|---|---|---|---|---|---|
> | Industrial | 11.0 | 1.29 | No change | -- | No change | -- |
> | MDR | 3.0 | 0.55 | 1.5 | 0.21 | 1.5 | 2.32 |
> | Forest | 4.0 | 0.12 | 3.5 | 0.12 | 0.5 | 2.32 |
>
> *From Table 1-1; ** From Table 1-2
>
> The phosphorus load increase is calculated as:
>
> Baseline Load = (Baseline P Load $_{IND}$) +
>   (Baseline P Load $_{MDR}$) +
>   (Baseline P Load $_{FOR}$)
>   = **16.4 lb/year** (determined in Example 1-1)

example continued below

P_{DEV} = $(TA_{IND}$ x $PLER_{IND})+(IA_{HDR}$ x $PLER_{HDR})+(PA_{MDR}$ x $PLER_{MDR})+(PA_{FOR}$ x $PLER_{For})$
=(11.0 acres * 1.29) + (2.0 acres * 2.32) + (1.5 acres * 0.21) + (3.5 * 0.12)
= **19.6 lbs P/year**

P_{DEVinc} = P_{DEV} – Baseline Load
= 19.6 – 16.4
= **3.2 lbs/year**

Table 1-1. Annual composite phosphorus load export rates

Land Cover	Composite PLERs, lb/ac/yr	Composite PLERs, kg/ha/yr
Commercial	1.16	1.30
Industrial	1.29	1.45
High Density Residential	1.07	1.20
Medium Density Residential	0.55	0.62
Low Density Residential	0.37	0.41
Freeway	0.78	0.88
Open Space	0.33	0.37
Agriculture	0.45	0.50
Forest	0.12	0.13

Table 1-2: Proposed average annual distinct P Load export rates for use in estimating P Load reduction credits the MA MS4 Permit

Phosphorus Source Category by Land Use	Land Surface Cover	P Load Export Rate, lbs/acre/year	P Load Export Rate, kg/ha/yr
Commercial (Com) and Industrial (Ind)	Directly connected impervious	1.78	2.0
	Pervious	See* DevPERV	See* DevPERV
Multi-Family (MFR) and High-Density Residential (HDR)	Directly connected impervious	2.32	2.6
	Pervious	See* DevPERV	See* DevPERV
Medium -Density Residential (MDR)	Directly connected impervious	1.96	2.2
	Pervious	See* DevPERV	See* DevPERV
Low Density Residential (LDR) - "Rural"	Directly connected impervious	1.52	1.7
	Pervious	See* DevPERV	See* DevPERV
Highway (HWY)	Directly connected impervious	1.34	1.5
	Pervious	See* DevPERV	See* DevPERV
Forest (For)	Directly connected impervious	1.52	1.7
	Pervious	0.13	0.13
Open Land (Open)	Directly connected impervious	1.52	1.7
	Pervious	See* DevPERV	See* DevPERV
Agriculture (Ag)	Directly connected impervious	1.52	1.7
	Pervious	0.5	0.5
*Developed Land Pervious (DevPERV)- Hydrologic Soil Group A	Pervious	0.03	0.03
*Developed Land Pervious (DevPERV)- Hydrologic Soil Group B	Pervious	0.12	0.13
*Developed Land Pervious (DevPERV) - Hydrologic Soil Group C	Pervious	0.21	0.24
*Developed Land Pervious (DevPERV) - Hydrologic Soil Group C/D	Pervious	0.29	0.33
*Developed Land Pervious (DevPERV) - Hydrologic Soil Group D	Pervious	0.37	0.41

Table 1-3: Crosswalk of MassGIS land-use categories to land-use groups for P Load Calculations

Mass GIS Land Use LU_CODE	Description	Land Use group for calculating P Load - 2013/14 MA MS4
1	Crop Land	Agriculture
2	Pasture (active)	Agriculture
3	Forest	Forest
4	Wetland	Forest
5	Mining	Industrial
6	Open Land includes inactive pasture	open land
7	Participation Recreation	open land
8	spectator recreation	open land
9	Water Based Recreation	open land
10	Multi-Family Residential	High Density Residential
11	High Density Residential	High Density Residential
12	Medium Density Residential	Medium Density Residential
13	Low Density Residential	Low Density Residential
14	Saltwater Wetland	Water
15	Commercial	Commercial
16	Industrial	Industrial
17	Urban Open	open land
18	Transportation	Highway
19	Waste Disposal	Industrial
20	Water	Water
23	cranberry bog	Agriculture
24	Powerline	open land
25	Saltwater Sandy Beach	open land
26	Golf Course	Agriculture
29	Marina	Commercial
31	Urban Public	Commercial
34	Cemetery	open land
35	Orchard	Forest
36	Nursery	Agriculture
37	Forested Wetland	Forest
38	Very Low Density residential	Low Density Residential
39	Junkyards	Industrial
40	Brush land/Successional	Forest