Attachment 7:

MassDOT's Nitrogen Non-TMDL Groundwater Method

Description of MassDOT's Application of Nitrogen Groundwater Method in BMP 7U

Introduction

The Massachusetts Department of Transportation (MassDOT) owns and operates stormwater collection systems along its roadways throughout Massachusetts. In urbanized areas, discharges from these stormwater collection systems are regulated under a Municipal Separate Storm Sewer Systems (MS4) National Pollutant Discharge Elimination System (NPDES) general permit issued by the United States Environmental Protection Agency (USEPA). This permit requires that MassDOT's MS4 discharges to impaired water bodies do not cause instream exceedances of water quality standards.

MassDOT has developed a NPDES Storm Water Management Plan (SWMP; MassHighway, 2009) pursuant to the requirements of its NPDES general permit. The SWMP includes several protocols used to address pollutant loading from MassDOT's stormwater discharges to the State's impaired water bodies. This report outlines one method used by MassDOT to assess the impacts that its storm water systems have on the impaired water bodies listed as Category 5 waters on MassDEP's 303(d) list.

MassDOT felt that the current protocols outlined in the SWMP to date needed to be refined to be appropriate for groundwater-controlled watersheds (herein referred to as groundwatersheds) that exist on Cape Cod, parts of southeastern Massachusetts, Martha's Vineyard and Nantucket versus the surface water-controlled watersheds that exist elsewhere in the Commonwealth. In these groundwatershed locations, coarse textured soils dominate the landscape, resulting in rapid infiltration and reduced surface runoff. Some pollutants of concern, such as nitrogen, enter groundwater and travel with little to no attenuation (White, 2003) to coastal ponds and embayments. Nitrogen has been identified as a key nutrient in coastal waters. Excess nitrogen loading to coastal ponds and embayments leads to eutrophication of these water bodies (BBNEP, 2013; MEP, 2013). In these situations, reduction of nitrogen at the source or attenuation prior to entry to groundwater is critical to reducing loading.

For those water bodies that have impairments related to elevated nitrogen inputs, are in groundwatersheds, and lack a nutrient TMDL, MassDOT will use the following assessment methodology, as modified from Best Management Practice (BMP) 7U (MassDOT, 2010) of the SWMP. For brevity, MassDOT has termed this methodology "MassDOT's Nitrogen Non-TMDL Groundwater Method." This methodology relies on research performed by the Massachusetts Estuaries Project (MEP), the United States Geological Survey (USGS), and the Buzzards Bay National Estuaries Program (BBNEP). The methodology outlined herein conservatively assumes that the entire nitrogen load from runoff that infiltrates into groundwater ultimately drains to the impaired water body (Walter et. al. 2004) without a load reduction. The methodology is summarized as follows:

1. Identify impaired water bodies with nitrogen-related impairments without TMDLs in groundwatersheds on Cape Cod and in adjacent Southeastern Massachusetts communities, and identify which of these include MassDOT property within their

watersheds. Through the MEP, USGS has completed modeling to identify the groundwatershed boundaries of impaired waters on Cape Cod, parts of southeastern Massachusetts, Martha's Vineyard, and Nantucket;. Urbanized areas are defined by the Massachusetts 2000 Urban Boundaries data layer and the 2010 U.S. census data. USEPA has provided an urbanized area GIS layer to be used for the Impaired Waters Program.

2. Conduct a desktop review and, if necessary, perform a site investigation of waters with nitrogen-related impairments in groundwatersheds to determine if there are stormwater discharges from MassDOT urbanized areas. Stormwater discharges may flow directly to the water body or may infiltrate into groundwater first before draining into the water body.
3. Assess whether the Nitrogen Target Load identified by either the MEP or BBNEP for stormwater is being met.
   - 3a. Calculate loading from MassDOT direct stormwater discharges and groundwater discharges.
   - 3b. Calculate total existing Nitrogen Load for groundwatershed and determine if MassDOT contributions are significant contributors to the load to the impaired water body or represent a negligible source. If not negligible, proceed to step 3c.
   - 3c. Calculate the relevant areal Target Load
   - 3d. Assess Target Load relative to loading from MassDOT.
4. Document the results of the assessment.
5. If BMPs are recommended as a result of the assessment conclusions, and site constraints do not appear to limit construction of additional stormwater BMPs, select BMPs suitable for nitrogen removal from stormwater runoff from MassDOT roads in urbanized areas and move forward with design.

This report is intended to describe the assessment methodology as modified from BMP 7U of the SWMP and includes detailed step-by-step instructions for each component thereof as they apply to nitrogen loadings to groundwatersheds on Cape Cod, the islands and adjacent southeastern communities dominated by coarse textured soils.

MassDOT's Nitrogen Non-TMDL Groundwater Method

MassDOT's Nitrogen Non-TMDL Groundwater Method has been developed exclusively for assessing MassDOT discharges to impaired water bodies in groundwater-controlled watersheds with nitrogen-related impairments that lack nutrient TMDLs. MassDOT has developed additional procedures for assessing compliance for other types of impaired waters across the Commonwealth of Massachusetts.

MassDOT developed a supplementary worksheet, identified as the Nitrogen Non-TMDL worksheet, to assist in performing the calculations required for each assessment and documenting the necessary information. This report provides guidance for using the Nitrogen non- TMDL Method both with and without the use of the supplementary worksheet. However, it is strongly recommended that the worksheet be used. Screenshots are included as Attachment 1 at the end of the report to illustrate various user inputs (shaded in blue) and worksheet outputs (shaded in yellow).

MassDOT's Nitrogen non-TMDL Groundwater Method uses data from draft TMDL reports, MEP reports, and BBNEP publications, and associated guidance published by MassDEP, USEPA, and BBNEP. Relevant publications can be accessed at the following URLs:

- MassDEP Draft TMDL Reports: http://www.mass.gov/eea/agencies/massdep/water/watersheds/total-maximum-daily-loads-tmdls.html#19.
- USEPA's guidance on developing, implementing, and complying with: http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/index.cfm
- MEP Reports: http://www.oceanscience.net/estuaries/reports.htm
- BBNEP Reports and Guidance: http://buzzardsbay.org

Several steps of MassDOT's Nitrogen Non-TMDL Groundwater Method require the user to perform a desktop analysis to develop an understanding of local flow patterns within the contributing groundwatershed of the subject water body and within MassDOT's right-of-way. The desktop analysis is intended to be completed in a Geographic Information System (GIS) environment in order to simultaneously analyze multiple sets of geospatial data. It is recommended that the user be familiar with GIS software before performing an assessment using the methodology described herein.

Figure 1 summarizes MassDOT's Nitrogen Non-TMDL Groundwater Method. The following sections describe in detail the steps necessary to complete an assessment of MassDOT's stormwater discharges to an impaired water body listed as Category 5 on the MassDEP 303(d) list using MassDOT's Nitrogen Non-TMDL Groundwater Method. See Attachment 1 for an example of the methodology applied to a nitrogen-impaired water body on Cape Cod and for additional background on the calculations.

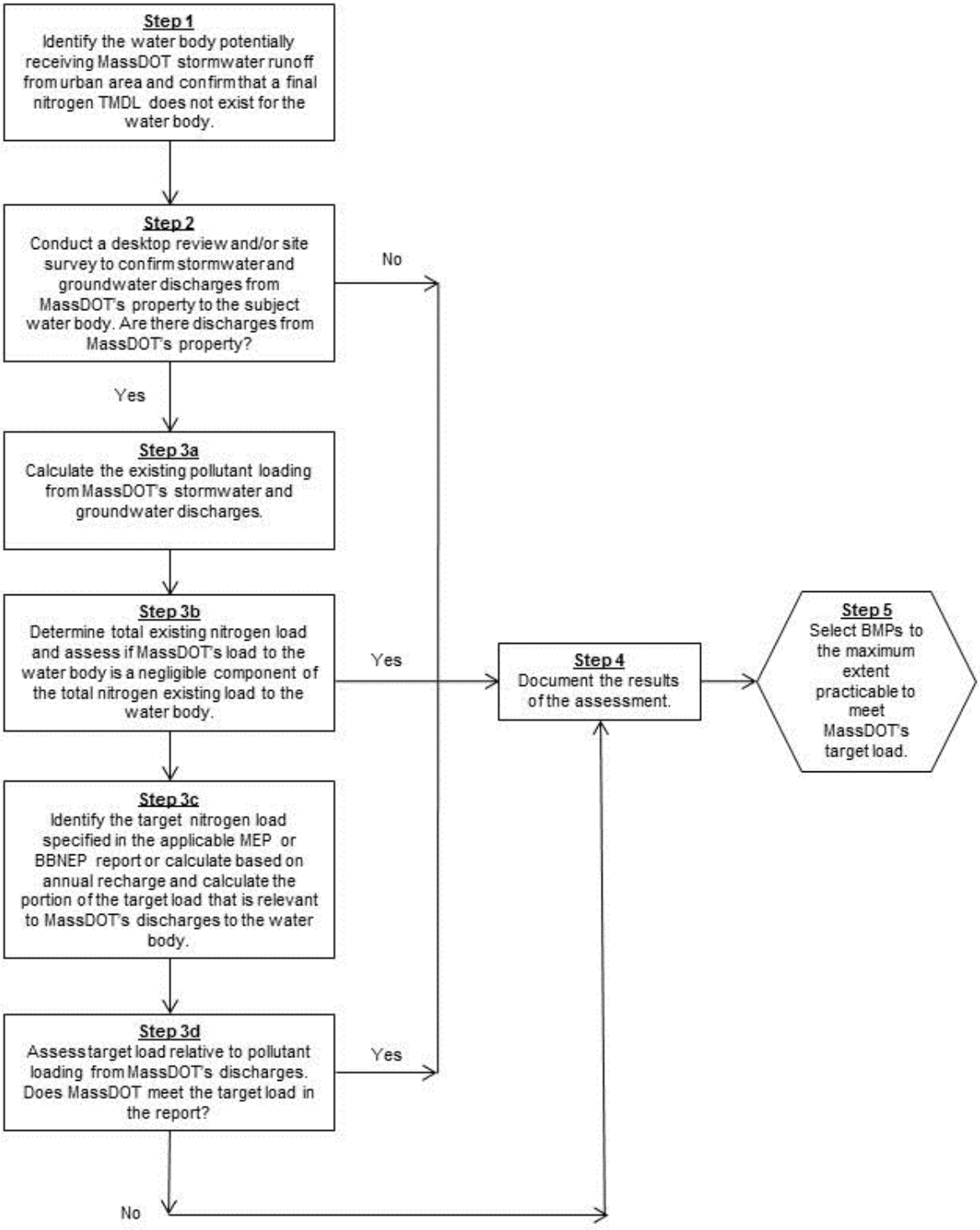

Figure 1. Flow Chart Illustrating MassDOT's Nitrogen Non-TMDL Method

Step 1. Identify Waters within Non-TMDL Groundwatersheds to Which MassDOT's Urbanized Roadways May Potentially Discharge Stormwater

Identify the impaired water body in a groundwatershed that receives stormwater from one or more of MassDOT's urbanized roadways.

Using MassDEP's most recent *Final Massachusetts Integrated List of Waters*, identify the impairment(s) of the subject water body and verify that no Nitrogen TMDL has been finalized. Review the relevant MEP, BBNEP and/or Water Quality Assessment report to verify that the impairment is nitrogen-related. Proceed to Step 2.

Step 2. Conduct Desktop Review and/or Perform a Site Survey of Waters without Nitrogen TMDLs

Perform a desktop analysis to confirm there are stormwater outlets or sheet flow from MassDOT's urban property that are within the groundwatershed of the subject water body.

Through the MEP, USGS used groundwater models to define the watersheds to nitrogen-impaired waters in southeastern Massachusetts (Walter et. al. 2004), including those areas covered by this methodology. The USGS groundwatersheds correspond to those used by the MEP and MassDEP to establish draft Nitrogen TMDLs and WLAs in the geographic areas covered by their program, as well as the nitrogen loadings included in the MEP reports. The geographic areas that are included in the MEP include those in the Cape Cod region identified at the Massachusetts Bay website at http://www.mass.gov/eea/agencies/mass-bays-program/regions/cape-cod.html . The USGS groundwatershed layers and USGS-based MEP groundwatersheds can be downloaded or obtained by contacting the agencies at the following websites. These can be accessed at the following URLs:

- www.oceanscience.net/estuaries/progress.htm - MEP
- http://www.capecodcommission.org/departments/technicalservices/GIS/mappingapplications?searched=data+sets+include&advsearch=exactphrase&highlight=ajaxSearch_highlight+ajaxSearch_highlight1 – Cape Cod Commissionhttp://water.usgs.gov/GIS/metadata/usgswrd/XML/ds451_gwcontrib_areas.xml - USGS, Groundwater Contributing areas for Cape Cod and the Plymouth-Carver Regions of Massachusetts

Some of the geographic areas covered by this methodology are located in areas that are part of the BBNEP area rather than the MEP area. Although the USGS groundwatershed delineations include areas within the BBNEP, some of these have been further refined and sub-divided by BBNEP. To determine if BBNEP has groundwatershed delineation data applicable to the water body being assessed, it is necessary to contact BBNEP through the contact information available on their webpage at http://buzzardsbay.org/gisdownload.htm

Urbanized roadways are defined as those which fall within the urbanized areas defined by the Massachusetts 2000 Urban Boundaries datalayer and the 2010 U.S. census data. USEPA provided a GIS dataset combining these urban layers and shared it with MassDOT to be used for impaired waters assessments. Additional data sources for the desktop analysis should include MassDOT construction or as-built drainage plans, aerial imagery, MassDOT outfall inventory layer, the MassDOT Survey Control and Layout Plans website to determine the extent of MassDOT property (http://www.mhd.state.ma.us/LayoutsMapping/mapping.asp?ACTION=Fullextent&ACTIVELAYER=All_LAYERS), the MassGIS Impervious Surface Layer, and any other GIS datasets which may be of use.

If the desktop analysis reveals MassDOT stormwater discharges either through overland flow or subsurface flow within the groundwatershed, then a field visit is conducted to verify if stormwater discharges exist and to confirm if MassDOT property is contributing stormwater runoff. Proceed to Step 3.

If the desktop analysis confirms that there are no stormwater discharges from MassDOT's property within the groundwatershed, then proceed to Step 4.

Step 3. Calculate Total Existing Nitrogen Load and Assess Whether Target Load for Stormwater Discharges Is Being Met

When MassDOT urbanized area drains to a water body covered by a draft Nitrogen TMDL or is impaired due to nitrogen-related impairments without TMDLs, assess whether the Target Nitrogen Load is being met through existing stormwater control measures or if additional control measures may be necessary. Note that the MassDOT urbanized area drainage may reach the target water body either through direct stormwater discharges or infiltration through groundwater. If the existing MassDOT Nitrogen Load is very small compared to the existing total nitrogen load to the water body, then the existing MassDOT Nitrogen Load may be considered negligible. This assessment will be conducted using the steps outlined below.

Step 3a. Calculate Loading from MassDOT Stormwater

This step is broken up into two parts as described below. First, calculate the estimated loading of the nitrogen from MassDOT's property to the subject water body. Then, quantify the nitrogen mitigation provided by any existing BMPs.

Calculate MassDOT's Total Estimated Pre-BMP Nitrogen Load

Delineate the pervious and impervious area of MassDOT property and the loading rates for pervious and impervious areas listed in Table 1 to calculate MassDOT's total estimated pre-BMP Nitrogen Load to the subject water body. These calculations can be performed using the Nitrogen Non-TMDL worksheet. See the example in Attachment 1 for more details. The loading rates provided in Table 1 were developed using U.S. Geological Survey (USGS) Stochastic Empirical Dilution Model (SELDM) developed to estimate downstream event mean concentrations of various pollutants based on information from the Highway Runoff Database, as well as precipitation storm flow, and water quality sampling data,. MassDOT used the USGS SELDM to estimate annual Nitrogen Loads from its property. Nitrogen loading per acre of MassDOT roadway was estimated using the precipitation datasets from Hyannis and/or New Bedford, depending on which precipitation data collection site was closest to the impaired water body being assessed. To estimate the Nitrogen Loading using SELDM, the water quality datasets for stormwater nitrogen concentrations from the Harwich and Marion sampling stations were averaged. SELDM generated loading rates are not dependent on soil types present. SELDM is a USGS peer-reviewed model based on decades of precipitation data and a robust water quality sampling program targeting highway runoff. When applying SELDM for this methodology, MassDOT selected precipitation and water quality data specific to the Cape Cod and Buzzards Bay area. Based on running SELDM with the precipitation and water quality parameters described above, MassDOT estimates the Nitrogen Loading from impervious areas and pervious areas as shown in Table 1.

Table 1. Total Nitrogen Loading Rates[1] for MassDOT's Pervious and Impervious Property

	Loading Rate (lb/acre/yr)	
Location	Impervious[2]	Pervious
Cape Cod, east of Canal and Buzzards Bay East of Bourne	6.2	2.5
Wareham and areas West Towards BBNEP	6.8	2.5

[1]Developed based on USGS SELDM (Granato, G.E., 2013)
[2]Impervious loading rate for sites east of Canal and Bourne were developed using precipitation data from the Hyannis station because it was closest to the sites and most representative of the precipitation patterns in the area; because rainfall patterns near New Bedford differ from those east of the canal, for sites in Wareham and west SELDM was run with the Hyannis precipitation data, and then a second time with New Bedford precipitation data, and the loading results were averaged to obtain the loading rate shown above

Quantify the Treatment Provided by Existing BMPs

Perform a desktop analysis to identify any existing BMPs that may address stormwater from MassDOT's property to the subject water body. This may be incorporated into the desktop analysis required under Step 2. Data sources for identifying any existing BMPs should include construction or as-built plans and aerial imagery. Review design plans, as-built plans, permit applications, and any other available documentation for the following BMP-specific information:

- BMP dimensions (depth, width, length, etc.)
- Inlet structures (type, orifice size, invert elevations, etc.)
- Outlet structures (type, orifice size, invert elevations, etc.)
- Contributing groundwatershed information (size, land cover, etc.)

The data collected during the desktop analysis should subsequently be verified with a site visit. Confirm the presence, type, function, and characteristics (dimensions, inlet and outlet structures, wet or dry conditions, and working condition) of existing BMPs. Verify the drainage patterns and groundwatershed boundaries delineated during the desktop analysis and evaluate the watersheds of existing BMPs. This may be incorporated into the site visit required under Step 2.

Classify existing BMPs based on the guidance provided as Attachment 2 at the end of this report which focuses on typical MassDOT BMPs and BMPs appropriate for nitrogen removal. The guidance provides reduction rates for nitrogen based on BMP types which are used in the Nitrogen Non-TMDL worksheet.

Step 3b. Determine whether MassDOT Loads to the Impaired Water Body are Negligible

The Nitrogen TMDLs for coastal ponds and embayments suggest that septic systems and lawn fertilizer are major components of the nitrogen load (MassDEP 2013). It is possible that nitrogen loading from MassDOT roads represents a very small "negligible" amount in some groundwatersheds, which does not substantially contribute to the impairment. In these cases, removing nitrogen from DOT runoff would do little, if anything, to improve the water quality of the receiving water body.

Determine if MassDOT remaining nitrogen loads as calculated in Step 3a (which includes both direct stormwater discharges and groundwater discharges) represent a very small amount relative to the total existing Nitrogen Load (including septic) to the resource, and therefore would be considered negligible. In TMDLs established for nitrogen impaired waters in the Cape Cod area, MassDEP identifies that stormwater category specific nitrogen loads as high as 3.29% of the total nitrogen groundwatershed load were considered negligible compared to other sources (MassDEP, 2007). Based on this MassDEP published evaluation, MassDOT has determined that MassDOT property loadings less than 3.5% can be considered as negligible contributions to the resource.

The total existing Nitrogen Load (including septic) to the receiving water body can be identified from one of a number of data sources, depending on whether the water body is located within the geographic area included in the MEP or the BBNEP. The geographic areas covered by each program can be identified by reviewing each program's website, as explained in Step 2.

If the water body is located within the MEP area, the total existing nitrogen loading (including septic) can be identified from the MEP/DEP Draft Nitrogen TMDL report, a published MEP report, or MEP unpublished report/data which can be obtained by contacting the MEP. If the water body is located within the BBNEP area, the total existing nitrogen loading (including septic) can be identified from the 2013 BBNEP Comprehensive Conservation and Management Plan (BBNEP, 2013) or unpublished data, which can be obtained by contacting the BBNEP. If no published or unpublished nitrogen loading data are available, then the total nitrogen loading (including septic) can be developed by using land use loading rates (provided in Attachment 3) and MassGIS land use information (BBNEP, 2008; MassGIS, 2005).

Step 3c. Calculate the DOT Target Load

For water bodies impaired for nitrogen or with impairments related to elevated nitrogen, but without a Nitrogen TMDL, the Areal DOT Target Nitrogen Load is established using data from either the MEP or BBNEP. First, the total Target Nitrogen Load for the land use category including highways is identified. Next, the corresponding land use acreage is determined, and the Target Nitrogen Load is divided by the corresponding area to calculate a land use areal Target Nitrogen Load. Finally, the DOT acreage is multiplied by the areal target to calculate the DOT target. These steps are described below, and further illustrated in the example provided in Attachment 1.

Determine Target Nitrogen Load

If the water body is located in a geographic area covered by the MEP, review the MassDEP and MEP websites to determine if either a draft Nitrogen TMDL report or MEP report exists. If either of these reports exists, review the reports to identify the total Target Nitrogen Load for the land use category including highways. If no published report exists, contact the MEP to obtain unpublished data regarding nitrogen targets for the water body being assessed.

If the water body is located within the BBNEP area, review the BBNEP 2013 Comprehensive Conservation and Management Plan to determine if a total Target Nitrogen Load has been identified for the contributing groundwatershed area to the water body. If there is no published Target Nitrogen Load, contact BBNEP to determine if unpublished data exists that can be used.

If no published or unpublished total Target Nitrogen Load for the contributing groundwater area exists, then calculate a total Target Nitrogen Load by using a mass balance approach and a receiving water concentration target of 0.4 ppm (BBNEP, 2013). This value is based on research conducted by BBNEP and is currently the best available data for a target in-water nitrogen concentration that is protective of maintaining designated uses of coastal waters, including protection and restoration of eelgrass and benthic habitat such as shellfish beds. An alternative

target in-water concentration can be used if supported by current published data. To determine the Target Nitrogen Load in the contributing groundwater area, multiply the target concentration of 0.4 ppm by the annual recharge volume of 24 inches/year based on the BBNEP report (BBNEP, 2013) to calculate a Target Nitrogen Load in pounds per year.

After determining the total Target Nitrogen Load, determine the Target Load for stormwater runoff by subtracting out septic loads. Septic loads for each groundwatershed are identified within the draft TMDL or MEP reports for receiving waters that fall under the MEP program. For waters within the BBNEP program area, septic loads can be calculated based on the estimated number of homes and businesses within the groundwatershed area and septic flow and loading rates, all of which are available from BBNEP data at http://buzzardsbay.org/Nitrogen-loading-assumptions.htm.

The existing MEP or BBNEP data includes other non-roadway sources of stormwater runoff which may contribute significant Nitrogen Load to the receiving water which will remain in the calculated Target Load for stormwater runoff, such as golf courses and residential lawns. However, the resulting calculation will represent the best estimate of MassDOT's Target Load using available information. Many land uses typically have higher Nitrogen load contributions than roadways, such as residential land uses including fertilized lawn areas (MassDEP, 2007).

Next, calculate the target areal load for stormwater. This is calculated by dividing the applicable groundwatershed Target Load for stormwater by the corresponding area. These calculations can be performed using the Nitrogen Non-TMDL worksheet. See the example in Attachment 1 for more details.

Calculate DOT Target Nitrogen Load

The final calculation in this step is to determine the relevant Target Load for MassDOT. Delineate the pervious and impervious areas of MassDOT's property that contribute stormwater to the subject water body or infiltrate in to groundwater and drain to the water body to determine the total area of MassDOT property within the groundwatershed. Data sources for this delineation should include USGS groundwatershed data, construction or as-built plans, aerial imagery, the Impervious Surface datalayer downloaded from MassGIS, and other GIS datasets that may be of use. After calculating total area of MassDOT property, multiply it by the target areal load for stormwater determined above.

Step 3d. Assess Target Load Relative to Loading from MassDOT

This step analyzes the results from Steps 3a and 3c to determine if existing conditions provide enough nitrogen treatment or if more nitrogen treatment is necessary to meet the Target Load.

First, determine MassDOT's recommended Pre-BMP load reduction by subtracting the target load for MassDOT contributing property calculated in Step 3c from MassDOT's total estimated pre-BMP Nitrogen Load calculated in the first part of Step 3a.

Next, compare the treatment provided by MassDOT's existing BMPs, quantified in the second part of Step 3a, to the recommended Pre-BMP load reduction. If MassDOT's load reduction provided by existing BMPs is more than or equal to the recommended Pre-BMP load reduction, then MassDOT has met the Target Nitrogen Load for its discharges to the subject water body. If MassDOT's load reduction provided by existing BMPs is less than the recommended Pre-BMP load reduction, then opportunities for reducing the nitrogen load should be considered to meet the target.

Step 4. Document Results of Assessment

As referenced in BMP 7U of MassDOT's SWMP (MassDOT, 2010), MassDOT will include in its reports to the EPA updates on its progress in assessing and mitigating 303(d) impaired waters. This methodology, as modified from BMP 7U, will follow this same commitment and report MassDOT's progress on assessing and mitigating waters with nitrogen-related impairments and no TMDLs in groundwater-contributing watersheds.

For waters reviewed using the above methodology, document the results of the assessment in a standardized format. This should include the following at a minimum:

- the name and segment number of the impaired water body the estimated load from MassDOT;
- the applicable Target Load;
- any BMP recommendations, performance requirements, or other Performance Agreement or Memorandum of Understanding applicable to the MEP BBNEP and/or water quality assessment report; and
- a summary of MassDOT's assessment and/or mitigation plan

Any relevant calculations, documentation, data sources for the assessment, etc. should be compiled and kept on file. MassDOT's reports to the EPA should clearly document the basis of any conclusions reached as a result of the assessment regarding the need or lack of need for BMPs at specific sites.

Proceed to Step 5.

Step 5. Select, Design and Implement BMPs

If Step 3 determines that additional BMPs are necessary to meet MassDOT's Target Load and that the contribution is not negligible, MassDOT will implement additional BMPs to the maximum extent practicable and follow the BMP recommendations as described below.

First, determine whether it is practicable to construct additional BMPs to address runoff from MassDOT's contributing property to the subject water body. There are a variety of data sources that are useful for this purpose, including aerial photography, construction or as-built plans of the existing roadway and stormwater system, MassDOT Survey Control and Layout Plans website to determine the extent of MassDOT property (http://www.mhd.state.ma.us/LayoutsMapping/mapping.asp?ACTION=Fullextent&ACTIVELAYER=All_LAYERS), SSURGO-certified soils data available through MassGIS, etc. In some instances it may not be practicable under the confines of the Retrofit Program to construct additional BMPs due to site constraints such as lack of available space, presence of underground utilities, presence of incompatible soils, presence of wetlands, etc. When this is the case, report the findings to MassDOT and provide information to finalize the assessment for the water body. In the final

assessment report, thoroughly document all site constraints hindering the construction of additional BMPs.

If the installation of additional BMPs seems practicable, identify locations where BMPs may be constructed. Select BMPs that may be retrofitted into the existing roadway and stormwater infrastructure but will also provide a significant reduction in Nitrogen Loading to the subject water body. Consider the following while selecting additional BMPs:

- The estimated Nitrogen reduction efficiencies for structural BMPs based on the percent reductions assigned to each in the Nitrogen Non-TMDL worksheet;
- BMP recommendations or performance requirements for highway dischargers listed in the MEP/BBNEP report (or in other performance agreements or memoranda of understanding);
- Existing stormwater and highway infrastructure;
- The nature and extent of site constraints that may limit the scope of BMP construction;
- Any existing literature regarding appropriate BMPs for Nitrogen, including any guidance issued by the EPA or MassDEP. BMPs that are not in Appendix 2 may be used for Nitrogen removal with proper documentation of removal rates based on literature results;
- The overall magnitude of MassDOT's stormwater discharges and the degree to which its estimated Nitrogen Loads differ from the Target Load; and
- Consider stormwater BMPs for construction that are appropriate for removing Nitrogen. BMPs that provide biological uptake will remove Nitrogen effectively; therefore, bioretention areas, vegetated infiltration basins, vegetated filter strips, and gravel wetlands are typically the best BMPs to remove a portion of the Nitrogen Load. See Attachment 2, BMP Classification and Nitrogen Reduction Methodology, for more details on Nitrogen Load reductions.

Quantify the Nitrogen reductions provided by the recommended BMPs in the same manner as described for existing BMPs in Step 3a: "Quantify the Treatment Provided by Existing BMPs." First calculate an existing Nitrogen Load from the catchment area that will drain to the recommended BMP via surface water flow, then assign a Nitrogen Load reduction credit to each recommended BMP using the percent reduction values specified in Attachment 2, and finally multiply the groundwatershed Nitrogen Loads by the corresponding percent reduction values to obtain the Nitrogen Load reduction provided by each recommended BMP. These calculations can be performed using the Nitrogen Non-TMDL worksheet. See the example in Attachment 1 for more details.

Recommend additional BMPs the maximum extent practicable up to the MassDOT target. Document any site constraints or other limitations preventing MassDOT from meeting the load reduction target.

Summary

As part of its NPDES MS4 stormwater permit, MassDOT is required to address the discharge of pollutants from its stormwater systems to impaired water bodies identified in MassDEP's *Final Massachusetts Integrated List of Waters*. MassDOT's SWMP (MassHighway, 2009) identifies several methods for addressing its stormwater discharges to impaired water bodies depending on whether or not they are covered by a TMDL.

Because groundwater-controlled watersheds such as those on Cape Cod, parts of southeastern Massachusetts, Martha's Vineyard and Nantucket are characterized by coarse textured soils, stormwater rapidly infiltrates. Conservative pollutants, such as nitrogen, enter groundwater and are assumed to travel to coastal embayments without significant attenuation (White, 2003). In these situations, reduction of nitrogen at the source or attenuation prior to entry to groundwater is critical to reducing loading. This method specifically focuses on water bodies impaired for nitrogen or nitrogen-related impairments. To assess impaired water bodies that are not covered by a Nitrogen TMDL, MassDOT uses the applicable groundwatershed Target Load to compare with loading from MassDOT urbanized areas. MassDOT calculates the nitrogen loading from its property and the nitrogen load reduction provided by existing BMPs and compares the resulting values to the Target Load identified in the applicable MEP or BBNEP report, or as calculated using a mass balance approach. In cases where MassDOT's nitrogen loading exceeds the Target Load, MassDOT looks for opportunities to implement additional BMPs. This method allows MassDOT to identify locations where they are already meeting Nitrogen TMDLs for impaired waters and locations where additional BMPs should be considered.

References

Buzzards Bay National Estuary Program (BBNEP). 2008. Buzzards Bay Project - Buzzards Bay Land Use Spreadsheet. Dr. Joe Costa, last updated April 3, 2008. Available at: http://buzzardsbay.org/bbpnitro.htm

Buzzards Bay National Estuary Program (BBNEP). 2013. Comprehensive Conservation Management Plan. Action Plan 1 – Managing Nitrogen Sensitive Embayments.

Massachusetts Department of Environmental Protection (Mass DEP). 2007. Final Total Maximum Daily Load for Total Nitrogen in the Pleasant Bay System, Massachusetts (CN 244.0). Available at: http://www.mass.gov/eea/docs/dep/water/resources/n-thru-y/pbtmdl.pdf

MassDEP. 2008. Massachusetts Stormwater Handbook. February. Retrieved from: http://www.mass.gov/dep/water/laws/policies.htm#storm

MassDEP. 2013. The Massachusetts Department of Environmental Protections webpage providing access to all of the Total Maximum Daily Load reports for the state. Accessed August 20, 2013. http://www.mass.gov/eea/agencies/massdep/water/watersheds/total-maximum-daily-loads-tmdls.html

Massachusetts Estuaries Program (MEP). 2013. Massachusetts Estuaries Project Linked Watershed Embayment Approach to Determine Critical Nitrogen Loading Thresholds for the Waquoit Bay and Eel Pond Embayment System Town of Falmouth and Mashpee, Massachusetts. Available at: http://www.oceanscience.net/estuaries/report/Waquoit/Waquoit_MEP_FINAL-12MB.pdf

Massachusetts Executive Office of Geographic Information (MassGIS). 2005. Mass GIS Data – Land Use (2005). Available at: http://www.mass.gov/anf/research-and-tech/it-serv-and-support/application-serv/office-of-geographic-information-massgis/datalayers/lus2005.html

Massachusetts Highway Department (MassHighway). 2009. NPDES Storm Water Management Plan for MassHighway Owned and Operated Highways. December 23, 2009. Retrieved

from:
http://www.massdot.state.ma.us/Portals/8/docs/environmental/npdes/SWMP20091223.pdf

Massachusetts Department of Transportation (MassDOT). 2010. BMP 7R: TMDL Watershed Review. Available at:
http://www.massdot.state.ma.us/Portals/8/docs/environmental/npdes/BMP_7R_TMDL_WatershedReview.pdf

U.S. EPA. 2014. Draft MA MS4 General Permit. September.

Virginia Department of Environmental Quality. 2011. Introduction to the New Virginia Stormwater Designs Specifications

Walter, D.A., Masterson, J.P., and Hess, K.M. 2004. Ground-Water Recharge Areas and Travel times to Pumped Wells, Ponds, Streams, and Coastal Water Bodies, Cape Cod, Massachusetts, Scientific Investigations Map I-2857, 1 sheet. Available at:
http://pubs.water.usgs.gov/sim20042857

White, L. M. 2003. The Contribution of Lawn Fertilizer to the Nitrogen Loading of Cape Cod Embayments. Master's Thesis, University of Rhode Island.

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Attachment 1

Nitrogen Non-TMDL Worksheet Screenshot and Example

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Example Assessment

This example describes the step-by-step calculations needed to implement MassDOT's Nitrogen Non-TMDL Method, and how to use the Nitrogen Non-TMDL worksheet to complete these calculations. Additional description of each step in the methodology is contained within the main body of the MassDOT Nitrogen Non-TMDL Method text. The below example describes calculations and Nitrogen Non-TMDL worksheet components for Steps 3 through 5 of the methodology. Figures 2, 3 and 4 at the end of this example, provide the complete Nitrogen Non-TMDL worksheet associated with the example described below. Values with a blue highlighted box must be entered by the user, while yellow highlighted values are calculated by the spreadsheet, and white numbers are constants.

Step 3. Calculate Total Existing Nitrogen Load and Assess Whether Target Load for Stormwater Discharges Is Being Met

Step 3a. Calculate Loading from MassDOT Stormwater

This step is completed in two parts as described below. First, calculate the estimated loading of the nitrogen from MassDOT's property to the subject water body. Then, quantify the nitrogen mitigation provided by any existing BMPs.

Calculate MassDOT's Total Estimated Pre-BMP Nitrogen Load

If the Nitrogen Non-TMDL worksheet is used for the assessment, the user should have completed the input for the site name and subject impaired water body under the Site Information section at the top of the worksheet. The worksheet will assess for the pollutant total nitrogen (TN).

Site Information

Site Name	Tiny Bay
Impaired Water	MA 12345
Pollutant	Total Nitrogen

Delineate the pervious and impervious area of MassDOT property and apply the loading rates for pervious and impervious areas listed in Table 1 below to calculate MassDOT's total estimated pre-BMP Nitrogen Load to the subject water body. This calculation should be performed as follows:

$$MassDOT's \quad l \quad ated \quad - BMP \quad tant \quad (lb/yr) =$$
$$pervious \quad rea\,(\quad) \times Impervious \quad ing \quad (\quad / \quad) / yr) +$$
$$vious \quad (\quad) \times Pervious \quad ing \quad ate\,(\quad / ac / yr)$$

Table 2. Total Nitrogen Loading Rates[1] for MassDOT's Pervious and Impervious Property

	Loading Rate (lb/acre/yr)	
Location	Impervious[2]	Pervious
Cape Cod, east of Canal and Buzzards Bay East of Bourne Wareham and areas West Towards BBNEP	6.2 6.8	2.5 2.5

[1]Developed based on USGS SELDM (Granato, G.E., 2013)
[2]Impervious loading rate for sites east of Canal and Bourne were developed using precipitation data from the Hyannis station because it was closest to the sites and most representative of the precipitation patterns in the area; because rainfall patterns near New Bedford differ from those east of the canal, for sites in Wareham and west SELDM was run with the Hyannis precipitation data, and then a second time with New Bedford precipitation data, and the loading results were averaged to obtain the loading rate shown above

This calculation may be performed using the Nitrogen Non-TMDL worksheet. Refer to the section in the worksheet titled "Pre-BMP Loading Calculations for MassDOT's Contributing Property". A screenshot of this portion of the Nitrogen Non-TMDL worksheet is shown below.

Pre-BMP Loading Calculations for MassDOT's Contributing Property

Impervious Area	10.0	ac
Pervious Area	4.6	ac
Total Area	14.6	ac
Estimated Loading Rate for Impervious Area	6.2	lb/ac/yr
Estimated Loading Rate for Pervious Area	2.5	lb/ac/yr
Total Estimated Pre-BMP MassDOT Load	**73.5**	**lb/yr**

The worksheet will return values for the estimated loading rate for impervious area (lb/ac/yr), estimated loading rate for pervious area (lb/ac/yr), total estimated pre-BMP loading rate (lb/ac/yr), and total estimated pre-BMP MassDOT load (lb/yr).

Quantify the Treatment Provided by Existing BMPs

Assign a nitrogen load reduction rate to each existing BMP using the percent reduction values specified in Attachment 2 at the end of this report. Multiply the pre-BMP Nitrogen Load for the catchment area draining to that BMP calculated above by the corresponding percent reduction values to obtain the load reduction provided by each existing BMP. This calculation should be performed as follows:

$$BMP \quad ant \quad ion\ (lb/yr) = Pre - BMP \quad utant \quad (lb/yr) \times Percent \quad ction\ (\%)$$

This calculation may be performed using the Nitrogen Non-TMDL worksheet. Refer to the section in the worksheet titled "Load Reduction Provided by MassDOT BMPs under Existing Conditions." The user should input values for the following:

- BMP name
- BMP type
- soil classification of the BMP area (not required for reduction calculations)
- contributing watershed from impervious area (sf)
- contributing watershed from pervious area (sf)
- BMP surface area (sf) (if applicable)

Load Reduction Provided by MassDOT BMPs under Existing Conditions

BMP Name	BMP Type	Soil Classification	Directly Contributing Watershed IC Area (square feet)	Directly Contributing Watershed Pervious Area, Excluding BMP area (square feet)	BMP Surface Area (square feet) If Applicable	Pre-B
Sample Existing BMP 1	Oil Grit Separator	D	60,000	5,000	-	
Sample Existing BMP 2	Vegetated Filter Strip	A - Loamy Sand 2.41 in/h	18,000	1,500	2,000	
Area A	Bioretention Area/Rain Garden	A - Sand 8.27 in/hr	20,000	18,000	1,500	
Area B	Bioretention Area/Rain Garden	A - Sand 8.27 in/hr	-	-	2,000	
Area C	Bioretention Area/Rain Garden	A - Loamy Sand 2.41 in/h	4,000	2,000	2,000	
Area D	Bioretention Area/Rain Garden	A - Sand 8.27 in/hr	-	-	500	

For BMPs in series, the user must also input the impervious area remaining after nitrogen load reduction credits from the upstream BMP have been applied (sf).

The Nitrogen Non-TMDL worksheet will return values for the following:

- Pre-BMP Nitrogen Load (lb/yr)
- Percent load reduction provided by the BMP (based on values identified in Attachment 2)
- Total load reduction provided by the BMP (lb/yr)
- Post-BMP Nitrogen Load (lb/yr)
- Total Load Reduction (lbs/year) for all BMPs entered
- Total Post-BMP Load (lbs/year)

Load Reduction Provided by MassDOT BMPs under Existing Conditions

BMP Name	Pre-BMP Load (lb/yr)	Load Reduction %	Load Reduction (lbs/yr)	Post-BMP Load (lbs/yr)	Comments
Sample Existing BMP 1	8.83	0%	0.00	8.83	Oil grit separator treating runoff from Route 499 from STA 6+30 to STA 10+65
Sample Existing BMP 2	2.76	0%	0.00	2.76	Vegetated filter strip along southbound shoulder of Route 499 from STA 5+10 to STA 5+90
Sample Series - Bioretention Area A	3.97	42%	1.67	2.30	
Sample Series - Bioretention Area B	2.41	42%	1.01	1.40	
Sample Series - Bioretention Area C	2.20	42%	0.92	1.28	
Sample Series - Bioretention Area D	1.30	42%	0.55	0.76	
		Total	4.2	lb/yr	

MassDOT:
For BMP in series, if any additional impervious and/or pervious area contributes to one of the BMPS in the serie, the Pre-BMP load swill be calculated using any new directly contributing pervious or impervious watershed area multiplied by the load rates plus the remaining BMP load from the upstream BMP.

MassDOT:
For BMP in series, the Pre-BMP Load will equal the resulting load (Post-BMP Load) from the upstream BMP.

If there are existing BMPs owned by MassDOT that receive stormwater from non-MassDOT property, calculate the nitrogen load reduction provided by these BMPs using the same methodology as described above but include both MassDOT and non-MassDOT area in the watershed to determine the percent of nitrogen removal the BMP provides. Then use this percentage removal to determine the nitrogen reduction specifically for MassDOT property. These calculations can be performed using the Nitrogen Non-TMDL worksheet. Refer to the section titled "Credit for Non-MassDOT Property Treated by Existing MassDOT BMPs."

The Nitrogen Non-TMDL worksheet summarizes the nitrogen load reduction provided by existing BMPs in the "MassDOT's Load Reduction Summary" section of the worksheet shown in Figure 2.

Step 3b. Determine whether MassDOT Loads to the Impaired Water Body are Negligible

Determine if MassDOT remaining Nitrogen Loads as calculated in Step 3a (which includes both direct stormwater discharges and groundwater discharges) represent a very small amount relative to the total existing Nitrogen Load to the receiving water. In TMDLs established for nitrogen impaired waters in the Cape Cod area, MassDEP identifies that category specific nitrogen loads as high as 3.29% of the total Nitrogen groundwatershed load were considered negligible compared to other sources (MassDEP, 2007). Based on this MassDEP published evaluation, MassDOT has determined that MassDOT property loadings less than 3.5% can be considered as negligible contributions to the resource. The total Nitrogen Load to the receiving water body can be identified in either published or unpublished reports by the MEP or BBNEP, as explained in the main body of the MassDOT Nitrogen Non-TMDL Groundwater Method text. If no published or unpublished nitrogen loading data exists, then the BBNEP land use loading rates and MassGIS land use information can be used to calculate the total existing Nitrogen Load (BBNEP, 2008; MassGIS,

2005) as explained in the main body of the text. Land Use Loading rates are provided in Attachment 3.

The worksheet automatically returns this calculation when the total existing load to the water body is entered under the Load Calculations section. A screen shot of this portion of the worksheet is provided below.

Total Existing Load to Water Body	109803 lb/yr
Percent of Total Existing Load that is from MassDOT Property	0.07%

If the MassDOT Nitrogen Load is considered negligible, the assessment is complete at this step and the results can be documented.

Step 3c. Calculate the DOT Target Load

Nitrogen Determine Target Nitrogen Load

Identify the total Target Nitrogen Load (pounds/year) for the land use category including highway by reviewing published or unpublished MEP or BBNEP data if it exists. Published data may be provided in the draft TMDL report, MEP reports or the BBNEP 2013 Comprehensive Conservation and Management Plan (BBNEP, 2013). Unpublished data may be obtained by contacting MEP or BBNEP. If no MEP or BBNEP data exist, multiply the target concentration of 0.4 ppm by the annual recharge volume of 24 inches/year for the geographic area, based on the BBNEP report (BBNE,2013), to calculate a Target Nitrogen Load in pounds per year. The target concentration of 0.4 ppm is equivalent to 0.000024943 pounds per cubic foot. The equation to calculate the Target Nitrogen Load based on this concentration and the annual recharge volume is below:

$$Target\quad en\quad (\quad ds/\quad) =$$

$$Contributing\quad dwath\quad ed\quad (\quad .Ft.)$$
$$\times\quad oncentration\quad 0.000024943\ (\quad /\quad 3)$$
$$\times\ h\quad rge\quad 2(\ t/\quad)$$

After determining the total Nitrogen Load, determine the Target Load for stormwater runoff by subtracting out septic loads. Septic loads for each groundwatershed are identified within the draft TMDL or MEP reports for receiving waters that fall under the MEP program. For waters within the BBNEP program area, septic loads can be calculated based on the estimated number of homes and businesses within the groundwatershed area and septic flow and loading rates, all of which are available from BBNEP data at http://buzzardsbay.org/Nitrogen-loading-assumptions.htm. The calculation for the Target Load for Stormwater Runoff is below:

$$= \quad \boldsymbol{unoff}\left(\boldsymbol{lbs}/_{\boldsymbol{yr}}\right) \quad (\quad + \boldsymbol{Septic})\left(\boldsymbol{lb}/_{\boldsymbol{yr}}\right)$$
$$- \quad \left(\boldsymbol{lb}/_{\boldsymbol{yr}}\right)$$

After determining the Target Nitrogen Load for stormwater runoff, use the corresponding land use area (typically the entire groundwatershed minus the impaired water body's area) to calculate the Land Use Areal Target Load as follows:

$$real \quad (\ /ac/yr) = \frac{Target \quad rom \quad (\ /\ )}{Groundwath \quad d \quad (ac) - Waterbodies \quad (\quad ac)}$$

These calculations may be performed using the Nitrogen Non-TMDL worksheet. Refer to the section in the worksheet titled "Load Calculations." A screenshot of this portion of the Nitrogen Non-TMDL worksheet is shown below.

Target Load Calculations

Target Threshold Watershed Load (Land Use + Septic)	22594	lb/yr
Target Load from Septic	7856	lb/yr
Target Load from Land Use	14738	lb/yr
Groundwatershed Area	11686.342	ac
Waterbodies Area	1875.4	ac
Land Use Area	9810.9	ac
Land Use Areal Target Load	**1.50**	**lb/ac/yr**

Calculate MassDOT Target Nitrogen Load

Next, calculate the relevant Target Load for MassDOT. Enter the impervious and pervious area (in acres) in the section in the worksheet titled "Pre-BMP Loading Calculations for MassDOT's Contributing Property." The contributing property includes both direct discharges from urban MS4 areas as well as groundwater discharge from urban MS4 areas. The worksheet will return values for total area (ac). A screenshot of this portion of the Nitrogen Non-TMDL worksheet is shown below.

Pre-BMP Loading Calculations for MassDOT's Contributing Property

Impervious Area	10.0	ac
Pervious Area	4.6	ac
Total Area	14.6	ac

Multiply the areal Target load by the total area of MassDOT's property that contributes stormwater directly to the subject water body or to groundwater to obtain the Target Load for MassDOT's contributing property. This calculation should be performed as follows:

$$\begin{aligned} &Target \quad or \quad assDOT\ (lb/\ \ ) \\ &= Land \quad real \quad (lb/\ \ /\ \ ) \\ &\times Total \quad rea \quad DOT's \quad ontributing \quad rty \quad cluding\ h \quad arge \quad undwater\ (\ \ ) \end{aligned}$$

This calculation may be performed using the Nitrogen Non-TMDL worksheet. Refer to the section in the worksheet titled "Loading from MassDOT's Contributing Property."

Loading from MassDOT's Contributing Property

Target Load for MassDOT's Contributing Property	21.90 lb/yr

Step 3d. Assess Target Load Relative to Loading from MassDOT

First, determine MassDOT's recommended Pre-BMP load reduction by subtracting the Target Load for MassDOT contributing property calculated in Step 3c from MassDOT's total estimated pre-BMP Nitrogen Load calculated in the first part of Step 3a. This calculation should be performed as follows:

$$\begin{aligned} \text{Recommended} \quad &re - \quad \text{Load R}\ duc \quad (lb/yr) \\ &= Total \quad ated \quad - BMP \quad (lb/yr) \\ &- Target \quad assDOT' \quad ontributing \quad rty\ (\ \ /yr) \end{aligned}$$

The worksheet automatically returns this calculation when Steps 3a and 3c are performed. This portion of the worksheet is shown in the screenshot below.

Loading from MassDOT's Contributing Property

Total Estimated MassDOT Load (calculated above)	73.50 lb/yr
Target Load for MassDOT's Contributing Property	21.90 lb/yr
MassDOT's Recommended Load Reduction	**51.60 lb/yr**

Next, compare the treatment provided by MassDOT's existing BMPs, quantified in the second part of Step 3a, to the recommended Pre-BMP load reduction. If MassDOT's load reduction provided by existing BMPs is more than or equal to the recommended Pre-BMP load reduction, then MassDOT meets the Nitrogen Target goal for its discharges to the subject water body. If MassDOT's load reduction provided by existing BMPs is less than the recommended Pre-BMP load reduction, then opportunities for reducing the Nitrogen Load should be considered. For example, a vegetated filter strip or a gravel wetland could be constructed to intercept flow prior to discharging to the water body.

To determine MassDOT's final recommended load reduction, subtract the load reduction provided by existing BMPs from the recommended Pre-BMP load reduction. This value is the remaining Nitrogen Load that recommended BMPs should aim to treat and is automatically calculated in the last line of the section. This portion of the worksheet is shown in the screenshot below.

MassDOT's Load Reduction Summary		
Reduction provided by Existing BMPs	4.2	lb/yr
Credit for Non-MassDOT Property Treated by MassDOT BMPs	0.0	lb/yr
Reduction Provided by Proposed BMPs	0.4	lb/yr
Reduction provided by Existing and Proposed BMPs	**4.6**	**lb/yr**
Remaining MassDOT Load taking BMPs into account	68.9	lb/yr
MassDOT's Recommended Load Reduction	**47.0**	**lb/yr**

Refer to the section in the Nitrogen Non-TMDL worksheet titled "Loading from MassDOT's Contributing Property" for assistance in this determination. Since calculations for these items are based upon previous calculations, no input is required from the user.

Step 4. Document Results of Assessment

In this step the results of the assessment are documented in a standardized format. There are no calculations specific to Step 4; refer to the main body of the methodology text for an explanation of this step.

Step 5. Select, Design and Implement BMPs

Quantify the nitrogen reductions provided by the recommended BMPs in the same manner as described for existing BMPs in Step 3a: "Quantify the Treatment Provided by Existing BMPs." First calculate an existing Nitrogen Load from the catchment area that will drain to the recommended BMP, then assign a Nitrogen Load reduction credit to each recommended BMP using the percent reduction values specified in Attachment 2, and finally multiply the watershed nitrogen loads by the corresponding percent reduction values to obtain the nitrogen load reduction provided by each recommended BMP. Below is a screenshot of the worksheet that will assist in the recommended BMP calculations.

Sum the Nitrogen Load reductions provided by the recommended BMPs and compare to MassDOT's recommended load reduction calculated in Step 3c. As described in Step 3b, the worksheet summarizes the Nitrogen Load reductions provided by existing and recommended BMPs in the "MassDOT's Load Reduction Summary" section of the worksheet. If possible, the Nitrogen Load reduction provided by the existing and recommended BMPs should equal or exceed MassDOT's recommended load reduction. Considering site-specific limitations, this may not be possible.

MassDOT's Load Reduction Summary		
Reduction provided by Existing BMPs	4.2	lb/yr
Credit for Non-MassDOT Property Treated by MassDOT BMPs	0.0	lb/yr
Reduction Provided by Proposed BMPs	0.4	lb/yr
Reduction provided by Existing and Proposed BMPs	**4.6**	**lb/yr**
Remaining MassDOT Load taking BMPs into account	68.9	lb/yr
MassDOT's Recommended Load Reduction	**47.0**	**lb/yr**

Site Information

Site Name	Tiny Bay	Input
Impaired Water	MA 12345	Calculated
Pollutant	Total Nitrogen	

NOTE: This spreadsheet has been designed for units consisting of pounds (lb), acres (ac), and years (yr). For all other units, please convert.

1 acre = 43,560 square feet
1 hectare = 2.47105381 acres
1 kilogram = 2.20462262 pounds

Pre-BMP Loading Calculations for MassDOT's Contributing Property

Impervious Area	10.0	ac
Pervious Area	4.6	ac
Total Area	14.6	ac
Estimated Loading Rate for Impervious Area	6.2	lb/ac/yr
Estimated Loading Rate for Pervious Area	2.5	lb/ac/yr
Total Estimated Pre-BMP MassDOT Load	**73.5**	**lb/yr**

Target Load Calculations

Target Threshold Watershed Load (Land Use + Septic)	22594	lb/yr
Target Load from Septic	7856	lb/yr
Target Load from Land Use	14738	lb/yr
Groundwatershed Area	11686.342	ac
Waterbodies Area	1875.4	ac
Land Use Area	9810.9	ac
Land Use Areal Target Load	**1.50**	**lb/ac/yr**
Total Existing Load to Water Body	103803	lb/yr
Percent of Total Existing Load that is from MassDOT Prope	0.07%	

MassDOT:
If no published or unpublished data exists, use using a mass balance approach and a receiving water concentration target of 0.4 ppm (BBNEP, 2013)

Page No.	Notes
p. 13 (Executive Summary)	28.073 kg/day - Target Threshold Watershed Load Table ES-2 for Bay system without Eel Pond or Childs River (must convert from kg/day to lb /yr).
p. 195	9.761 kg/day - Table VIII-2 This includes Septic only, data for Bay system without Eel Pond (must convert from kg/day to lb /yr)
	Target Land Use Load = Target Threshold Watershed Load - Target Septic Load
	Area calculated from GIS groundwatershed
	Area calculated from GIS (convert m2 to acres)
	Land Use Area = groundwatershed area - waterbodies area

Page	Notes
(Executive Summary)	136.46 kg/day - Table ES-1 - total existing load for Bay system without Eel Pond or Childs Pond

MassDOT:
If no published or unpublished data is available, calculate using Land use info from MassGIS and BBNEP land use load rates.

Loading from MassDOT's Contributing Property

Total Estimated MassDOT Load (calculated above)	73.50	lb/yr
Target Load for MassDOT's Contributing Property	21.90	lb/yr
MassDOT's Recommended Load Reduction	**51.60**	**lb/yr**

MassDOT's Load Reduction Summary

Reduction provided by Existing BMPs	4.2	lb/yr
Credit for Non-MassDOT Property Treated by MassDOT BM	0.0	lb/yr
Reduction Provided by Proposed BMPs	0.4	lb/yr
Reduction provided by Existing and Proposed BM	**4.6**	**lb/yr**
Remaining MassDOT Load taking BMPs into account	68.9	lb/yr
MassDOT's Recommended Load Reduction	**47.0**	**lb/yr**

Figure 2: Screenshot from Nitrogen Non-TMDL worksheet showing MassDOT's Nitrogen Loading Calculations

Load Reduction Provided by MassDOT BMPs under Existing Conditions

BMP Name	BMP Type	Soil Classification	Directly Contributing Watershed IC Area (square feet)	Directly Contributing Watershed Pervious Area, Excluding BMP area (square feet)	BMP Surface Area **If Applicable** (square feet)	Pre-BMP Load (lb/yr)	Load Reduction %	Load Reduction (lbs/yr)	Post-BMP Load (lbs/yr)
Sample Existing BMP 1	Oil Grit Separator	D	60,000	5,000	-	8.83	0%	0.00	8.83
Sample Existing BMP 2	Vegetated Filter Strip	A - Loamy Sand 2.41 in/h	18,000	1,500	2,000	2.76	0%	0.00	2.76
Sample Series - Bioretention Area A	Bioretention Area/Rain Garden	A - Sand 8.27 in/hr	20,000	18,000	1,500	3.97	42%	1.67	2.30
Sample Series - Bioretention Area B	Bioretention Area/Rain Garden	A - Sand 8.27 in/hr	-	-	2,000	2.41	42%	1.01	1.40
Sample Series - Bioretention Area C	Bioretention Area/Rain Garden	A - Loamy Sand 2.41 in/h	4,000	2,000	2,000	2.20	42%	0.92	1.28
Sample Series - Bioretention Area D	Bioretention Area/Rain Garden	A - Sand 8.27 in/hr	-	-	500	1.30	42%	0.55	0.76
							Total	4.2	lb/yr

MassDOT:
For BMP in series, if any additional impervious and/or pervious area contributes to one of the BMPS in the serie, the Pre-BMP load swill be calculated using any new directly contributing pervious or impervious watershed area multiplied by the load rates plus the remaining BMP load from the upstream BMP.

MassDOT:
For BMP in series, the Pre-BMP Load will equal the resulting load (Post-BMP Load) from the upstream BMP.

Figure 3: Screenshot from Nitrogen Non-TMDL worksheet Showing Nitrogen Load Reduction Calculations for Existing BMPs

Load Reduction Provided by MassDOT BMPs under Proposed Conditions

BMP Name	BMP Type	Soil Classification	Directly Contributing Watershed IC Area (square feet)	Directly Contributing Watershed Pervious Area, Excluding BMP area (square feet)	BMP Surface Area (square feet)	Pre-BMP Load (lb/yr)	Load Reduction %	Load Reduction (lbs/yr)	Post-BMP Load (lbs/yr)
Sample Proposed BMP 1	Extended Detention Basin	C - Sandy Clay Loam - 0.1	10,000	2,500	3,000	1.74	15%	0.26	1.48
Sample Proposed BMP 2	Bioretention Area/Rain Garden	B - Loam 0.52 in/hr	2,000	1,500	1,000	0.43	42%	0.18	0.25
							Total	0.4	lb/yr

Figure 4: Screenshot from Nitrogen Non-TMDL worksheet Showing Nitrogen Load Reduction Calculations for Proposed BMPs

Attachment 2

BMP Classification and Nitrogen Reduction Methodology

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BMP Classification and Nitrogen Reduction Methodology

This attachment provides information to classify existing BMPs identified on MassDOT property and provides the reduction rates for Nitrogen based on BMP type used in the Nitrogen Non-TMDL worksheet. This attachment can also be used as guidance for the selection of conceptual BMPs.

Characterizing Existing BMPs

Using the data obtained through the desktop analysis and field verification, characterize existing BMPs according to approximate type. For groundwatersheds contributing to waters with nitrogen impairments, or with impairments related to elevated nitrogen, different types of BMPs may be needed to achieve water quality improvements by removing nitrogen than those typically utilized in the rest of the state for TSS treatment or volume control. Although infiltration BMPs are effective for TSS removal and volume control, they are not as effective at removing nitrogen. BMPs designed to include anoxic environments (saturated zones) and that utilize biological uptake and/or dentrification, such as gravel wetlands and bioretention / rain gardens, are those that can more effectively reduce nitrogen loading from stormwater. According to recent research documented in the *University of New Hampshire (UNH) Stormwater Center 2012 Biennial Report*, gravel wetlands provide an estimated 75% reduction in nitrogen loading and bioretention / rain gardens provide an estimated 42% reduction.

Although gravel wetlands and bioretention / rain gardens provide relatively higher levels of nitrogen removal than other BMPs, they currently may not be very common on MassDOT property. Infiltration BMPs are commonly implemented on MassDOT roadways. MassDOT classifies infiltration basins and infiltration trenches as infiltration BMPs. Infiltration BMPs are designed to infiltrate runoff and therefore mimic the ability of undeveloped vegetated soils to absorb stormwater runoff. This serves to reduce runoff volumes and rates, remove pollutants as water is absorbed in the soils, and restore base flows to the receiving water body. Infiltration BMPs provide some of the highest pollutant load reduction credits for TP, TSS, and Zn, although published removal rates for total nitrogen are generally lower (VA DEQ, 2011).

Additional BMPs that may be currently in place on MassDOT property that provide TP, TSS, and Zn removal and provide some level of total nitrogen removal under the Nitrogen Non-TMDL Groundwater Method include: constructed stormwater wetlands; wet detention basins; extended detention basins, and water quality swales with check dams.

The first step in assigning a nitrogen reduction credit to an existing BMP should be to consult the current EPA MS4 draft or final permit for Massachusetts regarding Nitrogen removal credits for BMPs. Currently, these reduction credits are explained in Appendix H, Attachment 1 of the draft MS4 permit for Massachusetts. Appendix H, Attachment 1 provides guidance regarding Nitrogen removal credits for bioinfiltration systems as well as water quality treatment and infiltrating BMPs.

For two BMPs that do not meet the definitions associated with the EPA MS4 guidance document, Table 2-1 provides removal credit guidance for other BMPs assuming they are appropriately designed to treat the required water quality volume as identified in the *UNH Stormwater Center 2012 Biennial Report.* Using the descriptions provided by these reference documents, each existing BMP should be classified and assigned a percentage of annual nitrogen removal based on BMP type using the table's removal efficiencies. Removal rates summarized in Table 2-1 assume that existing BMPs are appropriately sized to treat the water quality volume and that the BMPs are designed and maintained in accordance with the cited reference document.

If BMPs are present or proposed that are not listed in Table 2-1 and do not meet the definitions of BMPs in the US EPA MS4 guidance, then published literature values for nitrogen removal rates should be referenced and documented in the impaired water assessment/BMP design documents to support the assigned nitrogen removal credit.

Table 2-1. Nitrogen Removal Rates for Structural Storm Water BMPs

BMP Type	BMP Nitrogen Load Reduction Credits	
	Reduction Rate	Data Source Notes
Bioinfiltration BMPs	Refer to Draft US EPA MS Permit for MA	1
Infiltration BMPs	Refer to Draft US EPA MS Permit for MA	1
Treatment BMPs	Refer to Draft US EPA MS Permit for MA	1
Tree Filters	1-3%	2a
Wet Detention Basin	25%	2a, 2b

Data Source Notes:

1. U.S. EPA. 2014. Draft MA MS4 General Permit.

2. University of New Hampshire Stormwater Center. October 2012. 2012 Biennial Report.
   a. Load reductions for Total Nitrogen assumed to be similar to that for Dissolved Inorganic Nitrogen (NO_3-N).
   b. Assumes Nitrogen Load reductions equal to those for wet ponds.

Attachment 3

Nitrogen Loading Rates

Nitrogen Loading Lookup Table	
Land use type	MEP N loading (lb/ac)
Cropland	9.1
Pasture	4.46
Forest	0.45
Non-forested wetland	0.45
Open land	1.08
Participatory recreation	23.83
Spectator recreation	26.14
Water based recreation	9.73
R0: residential multi-family	19.7
R1: Residential- <1/4 acre lots	19.7
R2: Residential- <1/4-1/2 acre lots	19.7
R3: Residential- <1/2 acre lots	19.7
Salt marsh	9.82
Commercial	6.76
Industrial	13.5
Urban open	1.08
Transportation (maj. highways)	13.7
Water (ponds, other freshwater)	9.73
Woody perennial (bogs, orchards, etc.)	6.16
Cranberry Bog (part of #21	6.16
Golf (part of #7)	23.83
Urban Public (part of #17)	13.5
Cemeteries (part of #17)	1.08
Nursery (part of #21)	4.46
Est. paved/roof rate	10.1

1) Loading rates are based "buzzbaylanduse.xlxs". Prepared by Dr. Joe Costa, Buzzards Bay Project.

2) For land use categories in which loading rates were not provided, the most conservative loading rate for most similar land use was applied.