Attachment 1:

Final Reports

List of Impaired Water Bodies

Water Body ID	Water Body Name
MA42-05	French River
MA51078	Jordan Pond
MA71043	Upper Mystic Lake
MA71-06	Chelsea River
MA73-16	Hawes Brook
MA73-20	Beaver Meadow Brook
MA74-15	Town River Bay
MA81-02	North Nashua River
MA81-05	Nashua River
MA82055	Grist Mill Pond
MA82056	Hager Pond
MA82A-05	Hop Brook
MA82A-07	Concord River
MA82A-15	Unnamed Tributary
MA82A-16	Unnamed Tributary
MA82B-04	Assabet River
MA82B-07	Assabet River
MA82B-14	Nashoba Brook
MA83-01	Shawsheen River
MA83-17	Shawsheen River
MA84089	Spectacle Pond
MA84A-21	Deep Brook
MA84B-04	Stony Brook
MA93-44	Saugus River

Impaired Waters Assessment for French River (MA42-05) – Final Report

Impaired Water Body

Name: French River

Location: Dudley/Webster, MA

Water Body ID: MA42-05

Impairments

French River (MA42-05) is listed under Category 5, “Waters Requiring a TMDL”, on MassDEP’s final *Massachusetts Year 2012 Integrated List of Waters* (MassDEP, 2013). French River is impaired for the following:

- (Debris/Floatables/Trash*)
- (Other flow regime alterations)
- Aquatic Macroinvertebrate Bioassessments
- Fecal Coliform

According to MassDEP’s *French and Quinebaug River Watersheds 2004-2008 Water Quality Assessment Report* (MassDEP, 2009), this segment of the French River is impaired due to (debris/floatables/trash), (other flow regime alterations), aquatic macroinvertebrate bioassessments, and fecal coliform. The report recommends conducting water quality sampling and macroinvertebrate sampling to assess the *Aquatic Life Uses* and as an upstream reference station to attempt an evaluation of the Webster WWTP discharge on the French River. Implement recommendations in Water Quality Assessment Report for the French River.

Relevant Water Quality Standards

Water Body Classification: Class B

Applicable State Regulations:

- *314 CMR 4.05 (3) (b) 6 Color and Turbidity.* These waters shall be free from color and turbidity in concentrations or combinations that are aesthetically objectionable or would impair any use assigned to this class.

- *314 CMR 4.05 (5) (a) Aesthetics.* All surface waters shall be free from pollutants in concentrations or combinations that settle to form objectionable deposits; float as debris, scum or other matter to form nuisances; produce objectionable odor, color, taste or turbidity; or produce undesirable or nuisance species of aquatic life.

- *314 CMR 4.05 (5) (c) Nutrients*. Unless naturally occurring, all surface waters shall be free from nutrients in concentrations that would cause or contribute to impairment of existing or designated uses and shall not exceed the site specific criteria developed in a TMDL or as otherwise established by the Department pursuant to 314 CMR 4.00. Any existing point source discharge containing nutrients in concentrations that would cause or contribute to cultural eutrophication, including the excessive growth of aquatic plants or algae, in any surface water shall be provided with the most appropriate treatment as determined by the Department, including, where necessary, highest and best practical treatment (HBPT) for POTWs and BAT for non POTWs, to remove such nutrients to ensure protection of existing and designated uses. Human activities that result in the nonpoint source discharge of nutrients to any surface water may be required to be provided with cost effective and reasonable best management practices for nonpoint source control.

- *314 CMR 4.05 (3)(b) 4 Bacteria.*

  - At bathing beaches as defined by the Massachusetts Department of Public Health in 105 CMR 445.010: where E. coli is the chosen indicator, the geometric mean of the five most recent samples taken during the same bathing season shall not exceed 126 colonies per 100 ml and no single sample taken during the bathing season shall exceed 235 colonies per 100 ml; alternatively, where enterococci are the chosen indicator, the geometric mean of the five most recent samples taken during the same bathing season shall not exceed 33 colonies per 100 ml and no single sample taken during the bathing season shall exceed 61 colonies per 100 ml;
  - For other waters and, during the non-bathing season, for waters at bathing beaches as defined by the Massachusetts Department of Public Health in 105 CMR 445.010: the geometric mean of all E. coli samples taken within the most recent six months shall not exceed 126 colonies per 100 ml typically based on a minimum of five samples and no single sample shall exceed 235 colonies per 100 ml; alternatively, the geometric mean of all enterococci samples taken within the most recent six months shall not exceed 33 colonies per 100 ml typically based on a minimum of five samples and no single sample shall exceed 61 colonies per 100 ml. These criteria may be applied on a seasonal basis at the discretion of the Department.

- 314 CMR 4.05 (5) (b) Bottom Pollutants or Alterations. All surface waters shall be free from pollutants in concentrations or combinations or from alterations that adversely affect the physical or chemical nature of the bottom, interfere with the propagation of fish or shellfish, or adversely affect populations of non-mobile or sessile benthic organisms.

- *314 CMR 4.05 (3)(b) Solids*. These waters shall be free from floating, suspended and settleable solids in concentrations or combinations that would impair any use assigned to this class, that would cause aesthetically objectionable conditions, or that would impair the benthic biota or degrade the chemical composition of the bottom.

- *314 CMR 4.05 (5)(e) Toxic Pollutants.* All surface waters shall be free from pollutants in concentrations or combinations that are toxic to humans, aquatic life or wildlife. For pollutants not otherwise listed in 314 CMR 4.00, the National Recommended Water Quality Criteria: 2002, EPA 822R-02-047, November 2002 published by EPA pursuant to Section 304(a) of the Federal Water Pollution Control Act, are the allowable receiving water concentrations for the affected waters, unless the Department either establishes a site specific criterion or determines that naturally occurring background concentrations are higher. Where the Department determines that naturally occurring background concentrations are higher, those concentrations shall be the allowable receiving water concentrations. The Department shall use the water quality criteria for the protection of aquatic life expressed in terms of the dissolved fraction of metals when EPA's 304(a) recommended criteria provide for use of the dissolved fraction. The EPA recommended criteria based on total recoverable metals shall be converted to dissolved metals using EPA's published conversion factors. Permit limits will be written in terms of total recoverable metals. Translation from dissolved metals criteria to total recoverable metals permit limits will be based on EPA's conversion factors or other methods approved by the Department. The Department may establish site specific criteria for toxic pollutants based on site specific considerations.

- *314 CMR 4.05 (3)(b) 1 Dissolved Oxygen*. Shall not be less than 6.0 mg/l in cold water fisheries and not less than 5.0 mg/l in warm water fisheries. Where natural background conditions are lower, DO shall not be less than natural background conditions. Natural seasonal and daily variations that are necessary to protect existing and designated uses shall be maintained.

- *314 CMR 4.05 (3)(b) 2 Temperature*. Shall not exceed 68°F (20°C) based on the mean of the daily maximum temperature over a seven day period in cold water fisheries, unless naturally occurring. Where a reproducing cold water aquatic community exists at a naturally occurring higher temperature, the temperature necessary to protect the community shall not be exceeded and the natural daily and seasonal temperature fluctuations necessary to protect the community shall be maintained. Temperature shall not exceed 83°F (28.3°C) in warm water fisheries. The rise in temperature due to a discharge shall not exceed 3°F (1.7°0C) in rivers and streams designated as cold water fisheries nor 5°F (2.8°C) in rivers and streams designated as warm water fisheries (based on the minimum expected flow for the month); in lakes and ponds the rise shall not exceed 3°F (1.7°0C) in the epilimnion (based on the monthly average of maximum daily temperature); natural seasonal and daily variations that are necessary to protect existing and designated uses shall be maintained. There shall be no changes from natural background conditions that would impair any use assigned to this Class, including those conditions necessary to protect normal species diversity, successful migration, reproductive functions or growth of aquatic organisms.

- *314 CMR 4.05 (3)(b) 3 pH*. Shall be in the range of 6.5 through 8.3 standard units but not more than 0.5 units outside of the natural background range. There shall be no change from natural background conditions that would impair any use assigned to this Class.

Site Description

Segment MA42-05 of the French River extends 2.4 miles from the dam at Mill Street in Webster (North Village) to the outfall of the Dudley/Webster Waste Water Treatment Plant (WWTP). Land use adjacent to the northern 1.1-mile portion of this segment of the French River consists of bordering wetlands and several larger industrial facilities. Residential areas and smaller commercial buildings exist along Route 12 (Main Street) east of the river. South of Peter Street in Webster the French River crosses Route 12 and traverses through a more densely developed area of residential and commercial properties. Along the final 0.4-mile portion of the segment (south of Brandon Road to the WWTP), the river again enters a less developed area and is bordered by wetlands.

Roadways under MassDOT's jurisdiction in this area consist of portions of Route 12 and Route 197. The portion of Route 12 under MassDOT jurisdiction extends from Brandon Road to south of the WWTP (outside of the segment area). Route 12 in this area is approximately 700-900 feet west of the French River. The portion of Route 197 under MassDOT jurisdiction extends westward away from the river. The closest this portion of Route 197 is to the French River is approximately 1,500 feet (Figure 2).

Stormwater along Route 197 is collected through a series of catch basins and is conveyed through a closed drainage system until it discharges into wetlands and Potash Brook, a non-impaired, National Hydrography Dataset (NHD) identified stream. Due to the fact that the stream is non-impaired and is approximately 1.5 miles upstream of French River, stormwater from Route 197 was determined to be an indirect discharge. Similarly, the section of Route 12 that is parallel to the French River is conveyed to leakoffs and outfalls that discharge to Potash Brook, traveling a significant distance before reaching French River. Stormwater at this location was also considered to be an indirect discharge.

Along the MassDOT Route 12 bridge, stormwater directly discharges into French River through independent catch basins and outfalls.

Assessment under BMP 7U

The impairments for French River have not been addressed by a TMDL. Therefore, MassDOT assessed the impairments using the approach described in BMP 7U of MassDOT's Storm Water Management Plan (*Water Quality Impaired Waters Assessment and Mitigation Plan*), which applies to impairments that have been assigned to a water body prior to completion of a TMDL. As described in MassDOT's Application of Impervious Cover Method in BMP 7U (MassDOT, 2011), impervious cover (IC) provides a measure of the potential impact of stormwater on many impairments. For this water body, MassDOT used the IC method to assess the following highway-related impairments:

- Aquatic Macroinvertebrate Bioassessments

MassDOT's Application of the Impervious Cover Method

MassDOT's Application of Impervious Cover Method in BMP 7U applies many aspects of USEPA Region I's Impervious Cover Method described in EPA's *Stormwater TMDL Implementation Support Manual* (ENSR, 2006) to MassDOT's program. This method assesses potential stormwater impacts on the impaired water and evaluates the IC reduction required to ensure that stormwater is not the cause of the impairments. Consistent with findings of EPA and others, when a watershed has less than 9% IC, MassDOT concludes that stormwater is not the likely cause of the impairment. Additional information regarding this method is provided in MassDOT's Application of IC Method document.

- *Assessment*

First, MassDOT calculated the percent IC of the water body's entire contributing watershed (total watershed upstream of the downstream end of an impaired segment) and that of the local watershed contributing to the impaired segment (referred to as the subwatershed in this analysis) to determine whether stormwater has a potential to cause the impairments of the receiving water body. The total watershed and subwatershed to the impaired water body were delineated using the USGS Data Series 451. When USGS Data Series watersheds did not delineate the subwatershed of the water body under review, the GIS shapefiles were modified by delineating to the water body based on USGS topography to add specificity. IC data was available as part of the USGS data layers Data Series 451 and MassGIS's impervious surfaces data layer. In cases where it was determined that stormwater was a potential cause of the impairment, MassDOT calculated the degree to which IC would need to be reduced in the subwatershed to meet the 9% IC target. This reduction was then applied proportionally to the area of MassDOT roadways/properties directly discharging to the water body segment to identify MassDOT's target IC reduction. The 9% IC reduction serves only as a recommended target and is not meant to imply that failing to meet the target would cause an exceedance in water quality standards. As explained in BMP 7U, MassDOT will consider a variety of factors apart from numeric guidelines, including site constraints and the magnitude of any potential exceedances in water quality standards, to determine the precise nature and extent of additional BMPs recommended for particular locations. This approach is consistent with the iterative, adaptive management BMP approach set forth in EPA guidelines.

MassDOT calculated the effective IC reduction afforded by the existing structural BMPs currently incorporated into the stormwater infrastructure of MassDOT's properties. This effective IC reduction was calculated by applying effective IC reduction rates to existing BMPs based on their size, function and contributing watershed. BMP performances were derived from EPA Region 1's *Stormwater Best Management Practices (BMP) Performance Analysis* report (EPA, 2010) and engineering judgment. More information on the approach used to calculate the effective IC reductions is described in BMP 7U. When the reduction in effective IC achieved by the existing BMPs was equal to or greater than the target reduction, no further measures were proposed. When this was not the case, MassDOT considered additional BMPs in order to meet the targeted reduction.

Using this approach, MassDOT derived the following site parameters for this segment of the French River (MA42-05):

Table 1. Site Parameter for French River (MA42-05)

Type	Parameter	Quantity	Unit of Measure
Total Watershed	Watershed Area	58,771	acres
Total Watershed	Impervious Cover (IC) Area	5,050	acres
Total Watershed	Percent Impervious	8.6	%
Subwatershed	Watershed Area	1,977	acres
Subwatershed	Impervious Cover (IC) Area	511	acres
Subwatershed	Percent Impervious	25.8	%
Subwatershed	IC Area at 9% Goal	178	acres
Subwatershed	Target Reduction % in IC	65.2	%
Reductions Applied	MassDOT's IC Area Directly Contributing to Impaired Segment	0.1	acres
Reductions Applied	MassDOT's Target Reduction in Effective IC (65.2% of DOT Directly Contributing IC)	0.04	acres

The subwatershed is greater than 9% impervious cover, indicating that stormwater likely contributes to the impairments assessed under this methodology. In order to reach the 9% target, effective IC within the subwatershed should be reduced by 65.2%. Therefore, MassDOT's target is to reduce effective IC within its own directly contributing watershed by the same percentage, or 0.04 acres.

Existing BMPs

There are no existing BMPs in the French River directly contributing watershed that are mitigating potential stormwater quality impacts prior to discharge to French River.

- *Mitigation Plan*

No mitigation of impervious surface is achieved by existing BMPs. Therefore, MassDOT considered the implementation of additional BMPs to reach the target reduction of 0.04 acres.

Based on the review of MassDOT's directly contributing drainage area, no potential BMPs have been identified that can be implemented on MassDOT property to address the impairments of French River given the site constraint of limited property. Along Route 107 limited right-of-way and residential development adjacent to the road prevent implementation of stormwater infiltration BMPs.

- *Assessment of Pathogen Impairment under BMP 7U*

MassDOT assessed the pathogen impairment using the approach described in BMP 7U of MassDOT's Storm Water Management Plan (*Water Quality Impaired Waters Assessment and Mitigation Plan*), which applies to impairments that have been assigned to a water body covered by a final TMDL. Pathogen concentrations in stormwater vary widely temporally and spatially; concentrations can vary by an order of magnitude within a given storm event at a single location (MassDEP, 2009b). Therefore, it is difficult to predict pathogen concentrations in stormwater with accuracy. Due to this difficulty, MassDOT generally will not conduct site specific assessments of loading at each location impaired for pathogens. Instead these sites are assessed based on available information on pathogen loading from highways, MassDOT actions, and information available from EPA and DEP. Based on this information MassDOT developed an approach to be consistent with relevant TMDL and permit condition requirements and an iterative adaptive management approach to stormwater management.

In addition, while there is a positive relationship between IC and pathogen loading, the relationship is not as direct as other impairments. According to the Center for Watershed Protection "…Other studies show that concentrations of bacteria are typically higher in urban areas than rural areas (USGS, 1999), but they are not always directly related to IC (CWP, 2003)." Therefore, DOT did not rely solely on the IC method to assess pathogen impairments. Instead, MassDOT reviewed its existing programs and their consistency with EPA NPDES MS4 general permit requirements and Pathogen TMDL recommendations.

Pathogens in MassDOT Discharge

A study conducted on MassDOT's South East Expressway measured bacterial concentrations in stormwater runoff (Smith, 2002). This study found a geometric mean of 186 fecal coliforms/100 ml. Concentrations of pathogens in stormwater runoff from roadways can vary widely and pathogen concentrations in runoff across the state likely deviate significantly from this stretch of roadway's specific estimate. Event mean concentrations of fecal coliform bacteria in urban stormwater from other sources ranging between 14,000 and 17,000 fecal coliform organisms/100 mL have been reported (MassDEP, 2009b). These data suggest that pathogen loading from highways may be lower than other urban areas.

Consideration of the potential sources of pathogens supports the idea that pathogens are present in lower concentrations in highway runoff since potential pathogen sources are likely to be less prevalent in the highway environment than along other urban roadways:

- <u>Illicit discharges:</u> Due to the typical setback of highways from residential and commercial developments and the stand alone nature of the drainage system, the potential for illicit discharges (e.g. sewer connections, laundry tie-ins) is much lower than in other stormwater systems. This has been confirmed by MassDOT's illicit discharge detection on many miles of urban roadways within a broad range of areas across Massachusetts. After assessment of almost 140 miles, and investigation of more than 2,500 stormwater features, MassDOT's consultant performing the broad scope reviews has found no confirmed illicit discharges.

- <u>Limited Sewer Utilities in Road Right of Ways:</u> Since DOT does not provide sewer services, many MassDOT roads do not have sewer utilities within the road's right of way; thereby eliminating the chance of cross-connections or leaking pipes as a source of pathogens into the stormwater system.

- <u>Pet waste:</u> Pets are only present on highways in rare instances. In urban residential areas pets and their associated waste are much more common. MassDOT is aware that pet waste at road side rest stops may represent a potential source of pathogens to stormwater in certain situations, and has a pet waste management program underway to address this source where necessary.

- <u>Wildlife:</u> Highways are not generally an attractive place for wildlife. Wildlife generally avoids highways and only occasionally crosses them.

The dearth of pathogen sources on highways and the relatively low concentrations of pathogens measured in the South East Expressway study together suggest that pathogen loading from stormwater runoff from highways is lower than other urban sources.

Furthermore, in almost all cases the contribution of pathogens from MassDOT to a specific water body is likely to be very small relative to other sources of pathogens in the watershed. Since MassDOT urban roadways are linear and usually cross watersheds, they represent a small fraction of the receiving water body's watershed. The water quality within these water bodies is dependent on discharge from various sources, including discharges from other stormwater systems and a large number of other factors.

Assessment

Pathogen loadings are highly variable and, as a result, quantitative assessments are challenging and of little value. Therefore, MassDOT reviewed its existing programs and their consistency with EPA NPDES MS4 general permit requirements and Pathogen TMDL recommendations.

TMDLs for pathogen impairments in Massachusetts recognize that pathogens are highly variable and difficult to address and emphasize the need for an iterative adaptive management approach to address pathogens. Examples of relevant language from these TMDLs are included below:

- "given the vast potential number of bacteria sources and the difficulty of identifying and removing them from some sources such as stormwater require an iterative process and will take some time to accomplish. While the stated goal in the TMDL is to meet the water quality standard at the point of discharge it also attempts to be clear that MassDEP's expectation is that for stormwater an iterative approach is needed…" (MassDEP, 2009a)

- "The NPDES permit does not, however, establish numeric effluent limitations for stormwater discharges. Maximum extent practicable (MEP) is the statutory standard that establishes the level of pollutant reductions that regulated municipalities must achieve. The MEP standard is a narrative effluent limitation that is satisfied through implementation of SWMPs and achievement of measurable goals."(MassDEP, 2009b)

- "Although the TMDL presents quantified WLAs for stormwater that are set equivalent to the criteria in the Massachusetts Water Quality Standards, the Phase II NPDES permits will not include numeric effluent limitations. Phase II permits are intended to be BMP based permits that will require communities to develop and implement comprehensive stormwater management programs involving the use of BMPs. Massachusetts and EPA believe that BMP based Phase II permits involving comprehensive stormwater management together with specific emphasis on pollutants contributing to existing water quality problems can be consistent with the intent of the quantitative WLAs for stormwater discharges in TMDLs."(MassDEP, 2002).

This language clearly indicates that an iterative adaptive management approach is the appropriate way to address discharges to pathogen impaired waters. The recommendations in pathogen TMDLs for waters in Massachusetts generally require development and implementation of stormwater management programs, illicit discharge detection and elimination efforts, and in some cases installing BMPs to the maximum extent practicable.

The draft North Coastal Watershed General MS4 permit and the draft Interstate, Merrimack, and South Coastal (IMS) watershed permits contain specific requirements for compliance with pathogen TMDLs (in Appendix G). While these permits are still in draft form, MassDOT believes they represent the best available guidance on what EPA believes is appropriate for addressing stormwater discharges to pathogen-impaired waters. Section 2.2.1(c) of the permit states "For any discharge from its MS4 to impaired waters with an approved TMDL, the permittee shall comply with the specific terms of Part 2.1 of this permit. In addition, where an approved TMDL establishes a WLA that applies to its MS4 discharges, the permittee shall implement the specific BMPs and other permit requirements identified in Appendix G to achieve consistency with the WLA." Appendix G references a number of programmatic BMPs that are necessary to address pathogen loading. These cover the following general topics:

- Residential educational program
- Illicit connection identification, tracking and removal
- Pet waste management

Mitigation Plan

MassDOT implements a variety of non-structural BMP programs across their system in accordance with their existing Stormwater Management Plan (SWMP) including educational programs, illicit connection review and source control. The specific BMPs that can help reduce potential pathogen loading in the current SWMP include:

- BMP 3C-1: Drainage Connection Policy
- BMP 3C-2: Drainage Tie-In Standard Operating Procedure
- BMP 3D: Illicit Discharge Detection Review
- BMP 5H-1: Post Construction Runoff Enforcement – Illicit Discharge Prohibition
- BMP 5H-2: Post Construction Runoff Enforcement – Drainage Tie-In
- BMP 5H-3: Post Construction Runoff Enforcement – Offsite Pollution to MassHighway Drainage System
- BMP 6A-1: Source Control – 511 Program
- BMP 6A-2: Source Control – Adopt-A-Highway Program
- BMP 6C-1: Maintenance Program

MassDOT believes that existing efforts are consistent with the current and draft MS4 permit requirements and TMDL recommendations in regard to pathogens. In addition, as part of its pet waste management program, MassDOT has determined that no MassDOT rest stops are located within the sub-watershed of this waterbody. At rest stops that have been identified as being within sub-watersheds of waterbodies impaired for pathogens, MassDOT will be installing signs informing the public of the need to remove pet waste in order to minimize contributions of pathogens to the impaired waterbody, and pet waste removal bags and disposal cans will be provided.

Furthermore, MassDOT has an ongoing inspection and monitoring program aimed at identifying and addressing illicit discharges to MassDOT's stormwater management system. Any illicit discharges to MassDOT's system could contribute pathogens to impaired waters, however, MassDOT's existing Illicit Discharge Detection and Elimination (IDDE) program is aimed at identifying and addressing these contributions. District maintenance staffs are trained to conduct regular inspections of MassDOT infrastructure and note any signs of potential illicit discharges, such as dry weather flow and notable odors or sheens. Similarly, resident engineers overseeing construction projects also receive training to note any suspicious connections or flows, and report these for follow-up investigation and action as appropriate. MassDOT will continue to implement this Illicit Discharge Detection and Elimination (IDDE) training, and District staff will continue to report any suspicious flows requiring further investigation. MassDOT investigates any suspicious flows noted, and will work with owners of confirmed illicit discharges to remove these flows, and thereby minimize the possibility of pathogen contributions to receiving waters. At present, there are no suspected or known illicit discharges, or unauthorized drainage tie-ins, within the sub-watershed of this waterbody that could be contributing pathogens to the impaired waterbody.

Conclusions

MassDOT used the IC Method to assess French River for the impairments identified in MassDEP's final *Massachusetts Year 2012 Integrated List of Waters*. Results indicate that MassDOT should reduce its effective IC within its directly contributing subwatershed by 0.04 acres to achieve the targeted reduction in effective IC. MassDOT evaluated its property within the directly contributing watershed to French River to identify existing BMPs and found that no BMPs exist. This information is summarized in Table 2 below.

Table 2. Effective IC Reductions under Existing and Proposed Conditions

Parameter	Quantity	Unit of Measure
IC in Directly Contributing Watershed	0.1	acres
Target Reduction in Effective IC	0.04	acres
Effective IC Reduced by Existing BMPs	0.0	acres
Effective IC Reduced by Proposed BMPs	0.0	acres
IC Target Remaining	**0.04**	**acres**

MassDOT should reduce its effective IC within the directly contributing watershed by an additional 0.04 acres to achieve the targeted reduction in IC. However, site limitations in the French River subwatershed including limited right-of-way and residential and commercial development adjacent to MassDOT property do not allow for the construction of stormwater infiltration BMPs that would provide effective treatment of the impervious area for this location. Therefore, no further action will be taken as part of the Retrofit Initiative of the MassDOT Impaired Waters program.

MassDOT has concluded based on review of the draft North Coastal Watershed General MS4 permit, the draft Interstate, Merrimack, and South Coastal watershed permits, and pathogen TMDLs for Massachusetts waters, that the BMPs outlined in the stormwater management plan and those under consideration for reducing effective IC from MassDOT areas are consistent with its existing permit requirements. MassDOT believes that these measures achieve pathogen reductions (including fecal coliform) to the maximum extent practicable and are consistent with the intent of its existing stormwater permit and the applicable Pathogen TMDLs.

MassDOT will continue to ensure proper non-structural BMPS are being implemented within the watershed of the French River, including regular roadway and drainage system maintenance, erosion and sedimentation control, and outreach and education. Further work by MassDOT on programmed projects, which often include broader scale road layout changes, may provide additional opportunities for construction of new treatment BMPs. This is consistent with an iterative adaptive management approach to address impairments.

References

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Environmental Protection Agency (EPA). (2010). Stormwater Best Management Practices (BMP) Performance Analysis. Retrieved from: Hyperlink to EPA Stormwater BMP Performance Analysis Report

Massachusetts Department of Environmental Protection (MassDEP). (2004-2008). *French and Quinebaug River Watersheds 2004-2008 Water Quality Assessment Report* (MassDEP, 2009), Hyperlink to MassDEP French and Quinebaug River Watersheds 2004-2008 Water Quality Asessment Reports

Massachusetts Department of Environmental Protection (MassDEP). (2013). Massachusetts Year 2012 Integrated List of Waters - Final Listing of the Condition of Massachusetts' Waters Pursuant to Sections 305(b), 314 and 303(d) of the Clean Water Act. Retrieved from: Hyperlink to MassDEP 2012 Final Listing of Massachusetts Waters (303(d) list)

Massachusetts Department of Transportation (MassDOT). (2011). Description of MassDOT's Application of Impervious Cover Method in BMP 7U (MassDOT Application of IC Method).

Impaired Waters Assessment for Jordan Pond (MA51078) – Final Report

Impaired Waterbody

Name: Jordan Pond

Location: Shrewsbury, MA

Water Body ID: MA51078

Impairments

Jordan Pond (MA51078) is listed under Category 4a, "TMDL is Completed", on MassDEP's final *Massachusetts Year 2012 Integrated List of Waters* (MassDEP, 2013). Jordan Pond is impaired due to turbidity and is covered by the phosphorus TMDL, *Total Maximum Daily Loads of Phosphorus for Selected Northern Blackstone Lakes* [CN 70.1] (MassDEP, 2002).

Jordan Pond was not assessed for any designated uses in the MassDEP's *Blackstone River Watershed 2003-2007 Water Quality Assessment Report* (MassDEP, 2010).

Site Description

Jordan Pond (MA51078) is a water body in the town of Shrewsbury, Massachusetts that covers approximately 20 acres. The pond lies east of Lake Quinsigamond (MA51125). The subwatershed and total contributing watershed to Jordan Pond are the same and cover approximately 213 acres.

MassDOT's property directly contributing stormwater runoff to Jordan Pond is comprised of approximately 925 feet of Route 9 (Boston Worcester Turnpike). The roadway runs in the east to west direction, approximately 2,000 north of the pond. Route 9 is a four-lane roadway with a concrete median. Stormwater runoff from a section of Route 9 is collected in catch basins and drains to a pipe that drains down municipally-owned Svenson Road to Edgewater Avenue and then directly discharges into Jordan Pond.

Final Assessment under BMP 7R

The TMDL for Jordan Pond addresses the impairment of phosphorus. Therefore, MassDOT assessed the contribution of phosphorus from MassDOT property directly draining to this water body to address the impairment of turbidity, which the TMDL identifies as an "indicator[s] of nutrient enriched systems, better known as the process of eutrophication" (MassDEP, 2002). The assessment was completed using the approach described in BMP 7R (TMDL Watershed Review).

Existing BMPs

There are no existing BMPs in the Jordan Pond (MA51078) directly contributing watershed that are mitigating potential stormwater quality impacts prior to discharge to Jordan Pond. Thus, there is currently no TP reduction being provided.

Target Reduction

In the final report, MassDOT derived the following site parameters and target reduction for DOT's directly contributing watershed draining to Jordan Pond (MA51078) using the TMDL Method:

Table 1. Target Phosphorus Reduction – Final Report

Parameter	Quantity	Unit of Measure
Total Area	2.2	acres
Target Areal WLA	0.6	pounds/acre/year
Total Estimated Load	3.5	pounds/year
WLA for MassDOT's Directly Contributing Property	1.4	pounds/year
MassDOT's Required Load Reduction	2.1	pounds/year

Proposed BMPs

The designer's investigation confirmed that there are no existing BMPs for Jordan Pond (MA51078). Also, further investigation of MassDOT's property determined that due to site constraints and the limitations of the retrofit initiative, the construction of a BMP for the treatment of directly contributing impervious cover is not feasible for this segment.

Conclusions

To meet guidelines set forth in the TMDL for phosphorus, MassDOT should reduce its TP loading within the directly contributing watershed by 2.1 lb/yr to achieve the targeted reduction. There are currently no existing BMPs associated with direct discharges from MassDOT property into the Jordan Pond. MassDOT reviewed their property and determined that, due to the lack of available space within right of way, the placement of a BMP for the treatment of directly contributing watershed is not feasible under the Retrofit Initiative.

MassDOT will continue to identify opportunities to implement additional structural BMPs to address pollutant loading when road work is conducted under MassDOT's Programmed Projects Initiative. Work on Programmed Projects often includes broader scale road layout changes that may provide additional opportunities for construction of new treatment BMPs. This is consistent with an iterative adaptive management approach to addressing impairments. MassDOT will include an update in annual reports and biannual submittals to EPA regarding progress made towards meeting target IC reductions, plans for construction of proposed BMPs, and finalized assessments including reductions achieved by finalized BMP designs. Furthermore, MassDOT will continue to implement non-structural BMPs that reduce the impacts of stormwater.

References

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Massachusetts Department of Transportation (MassDOT). (2011). Description of MassDOT's Application of Impervious Cover Method in BMP 7R (MassDOT Application of IC Method).

Impaired Waters Assessment for Upper Mystic Lake (MA71043) – Final Report

Impaired Waterbody

Name: Upper Mystic Lake

Location: Winchester, Arlington, and Medford, MA

Water Body ID: MA71043

Impairments

Upper Mystic Lake (MA71043) is listed under Category 5, "Waters Requiring a TMDL", on MassDEP's final *Massachusetts Year 2012 Integrated List of Waters* (MassDEP, 2013). Upper Mystic Lake is impaired for the following:

- (non-native aquatic plants*)
- Dissolved oxygen saturation
- Oxygen, Dissolved

According to MassDEP's *Mystic River Watershed 20004-2008 Water Quality Assessment Report* (MassDEP, 2010), dissolved oxygen saturation was observed in surface water samples. Multiple samples from depths greater than five meters indicated that dissolved oxygen levels are lower than the Water Quality standards. It was also noted that a non-native macrophyte, *Potemegeton crispus*, is present. For these reasons, aquatic life use is impaired. In addition, this segment may have had the introduction of non-native organisms, either accidental or intentional. There are no National Pollutant Discharge Elimination Permits (NPDES) approved to discharge to the Upper Mystic Lake.

Relevant Water Quality Standards

Water Body Classification: Class B, Warm Water

Applicable State Regulations:

- 314 CMR 4.05 (5)(a) Aesthetics. All surface waters shall be free from pollutants in concentrations or combinations that settle to form objectionable deposits; float as debris, scum or other matter to form nuisances; produce objectionable odor, color, taste or turbidity; or produce undesirable or nuisance species of aquatic life.
- 314 CMR 4.05 (3)(b) 1 Dissolved Oxygen. a. Shall not be less than 6.0 mg/l in cold water fisheries and not less than 5.0 mg/l in warm water fisheries. Where natural background conditions are lower, DO shall not be less than natural background conditions. Natural seasonal and daily variations that are necessary to protect existing and designated uses shall be maintained.

Site Description

Upper Mystic Lake (MA71043) is approximately 196 acres and spans across the town lines of Winchester, Arlington, and Medford, Massachusetts. The Aberjona River is one of the major sources of Upper Mystic Lake. The lake connects with the Lower Mystic Lake via the Mystic Dam. Route 3 runs along the west side of Upper Mystic Lake. A MassDOT owned bridge is located to the northeast corner of Upper Mystic Lake, on Mystic Valley Parkway over the Aberjona River.

MassDOT's property directly contributing stormwater runoff to Upper Mystic Lake is comprised of portions of Route 3 and the Aberjona River Bridge, in Winchester (See Figures 3A, 3B and 3C). The total watershed is shown in Figure1 and the subwatershed is shown in Figure 2.

Assessment under BMP 7U

None of the impairments for Upper Mystic Lake have been addressed by a TMDL. MassDOT assessed the impairments using the approach described in BMP 7U of MassDOT's Storm Water Management Plan (*Water Quality Impaired Waters Assessment and Mitigation Plan*), which applies to impairments that have been assigned to a water body prior to completion of a TMDL. As described in MassDOT's Application of Impervious Cover Method in BMP 7U (MassDOT, 2011), impervious cover (IC) provides a measure of the potential impact of storm water on many impairments. For this water body, MassDOT used the IC method to assess the following impairments:

- Dissolved oxygen saturation
- Oxygen, Dissolved

The non-native plants impairment is not addressed in this assessment as this impairment is considered a non-pollutant and unrelated to stormwater according to the *final Massachusetts Year 2012 Integrated List of Waters*. Therefore, MassDOT has determined that further assessment of this impairment for the water bodies is not required under BMP 7U.

MassDOT's Application of the Impervious Cover Method

MassDOT's Application of Impervious Cover Method in BMP 7U applies many aspects of USEPA Region I's Impervious Cover Method described in EPA's *Stormwater TMDL Implementation Support Manual* (ENSR, 2006) to MassDOT's program. This method assesses potential stormwater impacts on the impaired water and evaluates the IC reduction necessary to attain the percent imperviousness in the watershed at which stormwater is not likely the cause of the impairments. Consistent with findings of EPA and others, when a watershed has less than 9% IC, MassDOT concludes that stormwater is not the likely cause of the impairment. Additional information regarding this method is provided in MassDOT's Application of IC Method document.

Assessment

First, MassDOT calculated the percent IC of the water body's entire contributing watershed (total watershed upstream of the downstream end of an impaired segment) and that of the local watershed contributing to the impaired segment (referred to as the subwatershed in this analysis) to determine whether stormwater has a potential to cause the impairments of the receiving water body. The total watershed and subwatershed to the impaired water body were delineated using the USGS Data Series 451. When USGS Data Series watersheds did not delineate the subwatershed of the water body under review, the GIS shapefiles were modified by delineating to the water body based on USGS topography to add specificity. IC data was available as part of the USGS data layers Data Series 451 and MassGIS's impervious surfaces data layer.

In cases where it was determined that stormwater was a potential cause of the impairment, MassDOT calculated the degree to which IC would need to be reduced in the subwatershed to meet the 9% IC target. This reduction was then applied proportionally to the area of MassDOT roadways/properties directly discharging to the water body segment to identify MassDOT's target IC reduction. The 9% IC reduction serves only as a recommended target and is not meant to imply that failing to meet the target would cause an exceedance in water quality standards. As explained in BMP 7U, MassDOT will consider a variety of factors apart from numeric guidelines, including site constraints and the magnitude of any potential exceedances in water quality standards, to determine the precise nature and extent of additional BMPs recommended for particular locations. This approach is consistent with the iterative, adaptive management BMP approach set forth in EPA guidelines.

MassDOT calculated the effective IC reduction afforded by the existing structural BMPs currently incorporated into the stormwater infrastructure of MassDOT's properties. This effective IC reduction was calculated by applying effective IC reduction rates to existing BMPs based on their size, function and contributing watershed. BMP performances were derived from EPA Region 1's *Stormwater Best Management Practices (BMP) Performance Analysis* report (EPA, 2010) and engineering judgment. More information on the approach used to calculate the effective IC reductions is described in BMP 7U. When the reduction in effective IC achieved by the existing BMPs was equal to or greater than the target reduction, no further measures were proposed. When this was not the case, MassDOT considered additional BMPs in order to meet the targeted reduction.

Using this approach, MassDOT derived the following site parameters for Upper Mystic Lake (MA71043):

Table 1. Site Parameters for Upper Mystic Lake (MA71043)

Type	Parameter	Quantity	Unit of Measure
Total Watershed	Watershed Area	17,666	acres
Total Watershed	Impervious Cover (IC) Area	6,073	acres
Total Watershed	Percent Impervious	34.4	%
Subwatershed	Subwatershed Area	1,527	acres
Subwatershed	Impervious Cover (IC) Area	390	acres
Subwatershed	Percent Impervious	25.5	%
Subwatershed	IC Area at 9% Goal	137	acres
Subwatershed	Target Reduction% in IC	64.9	%
Reductions Applied	MassDOT's IC Area Directly Contributing to Impaired Segment	8.49	acres
Reductions Applied	MassDOT's Target Reduction in Effective IC (64.9% of DOT Directly Contributing IC)	5.51	acres

*Rounding accounts for differences in calculations.

The subwatershed is greater than 9% impervious cover, indicating that stormwater likely contributes to the impairments assessed under this methodology. In order to reach the 9% target, effective IC within the subwatershed should be reduced by 64.9%. Therefore, MassDOT's target is to reduce effective IC within its own directly contributing watershed by the same percentage, or 5.51 acres.

Existing BMPs

Based on the site visit, there are no existing BMPs in the Upper Mystic Lake (MA71043) directly contributing watershed that are mitigating potential stormwater quality impacts prior to discharge to Upper Mystic Lake (MA71043).

Mitigation Plan

Because the total mitigation of impervious surface achieved by MassDOT's existing BMPs is less than the target reduction of 5.51 acres, MassDOT will consider the implementation of additional BMPs.

Conclusions

MassDOT used the IC Method to assess Upper Mystic Lake for the impairments identified in MassDEP's final Massachusetts Year 2012 Integrated List of Waters. Results indicate that MassDOT should reduce its effective IC within its directly contributing subwatershed by 5.51 acres to achieve the targeted reduction in effective IC. MassDOT evaluated its property within the directly contributing watershed to Upper Mystic Lake (MA71043) to identify existing BMPs and found that there were no existing BMPs to contribute to the target reduction in effective IC.

During the assessment it was noted that there are no feasible locations in the vicinity of the directly contributing watershed for installation of stormwater BMPs. Route 3 is primarily a residential area and the majority of the road is already curbed. Additionally, the main stormwater pipe is located on Route 3 in the vicinity where Route 3 is directly contributing stormwater. The photo below shows three outfalls into Upper Mystic Lake, including the outfall from the main stormwater pipe.

The Aberjona River Bridge drains to the Aberjona River immediately prior to confluence with Upper Mystic Lake. There are no feasible locations for a stormwater BMP near the Aberjona River Bridge due to deep outlets in the catch basins, close proximity of the Aberjona River, and lack of space.

MassDOT will continue to identify opportunities to implement additional structural BMPs to address pollutant loading when road work is conducted under MassDOT's programmed projects initiative. Work on programmed projects, which often include broader scale road layout changes, may provide additional opportunities for construction of new treatment BMPs. This is consistent with an iterative adaptive management approach to addressing impairments. MassDOT will include an update in annual reports and biannual submittals to EPA regarding progress made towards meeting target IC reductions, plans for construction of additional BMPs, and finalized assessments including reductions achieved by finalized BMP designs. Furthermore, MassDOT will continue to implement non-structural BMPs that reduce the impacts of stormwater.

References

ENSR. (2006). Stormwater TMDL Implementation Support Manual for US Environmental Protection Agency Region 1. ENSR International & EPA Region 1, Boston, MA. Project No.: 10598-001-500. Retrieved from: ENSR 2006 Stormwater TMDL Implementation Support Manual for USEPA Region 1

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Massachusetts Department of Environmental Protection (MassDEP). (2010). Mystic River Watershed 2004-2008 Water Quality Assessment Report. Retrieved from: MADEP 2010 Mystic River Watershed 2004-2008 Water Quality Assessment Report

Massachusetts Department of Environmental Protection (MassDEP). (2013). Massachusetts Year 2012 Integrated List of Waters - Final Listing of the Condition of Massachusetts' Waters Pursuant to Sections 305(b), 314 and 303(d) of the Clean Water Act. Retrieved from: MADEP 2013 MA Year 2012 Integrated List of Waters

Massachusetts Department of Transportation (MassDOT). (2011). Description of MassDOT's Application of Impervious Cover Method in BMP 7U (MassDOT Application of IC Method).

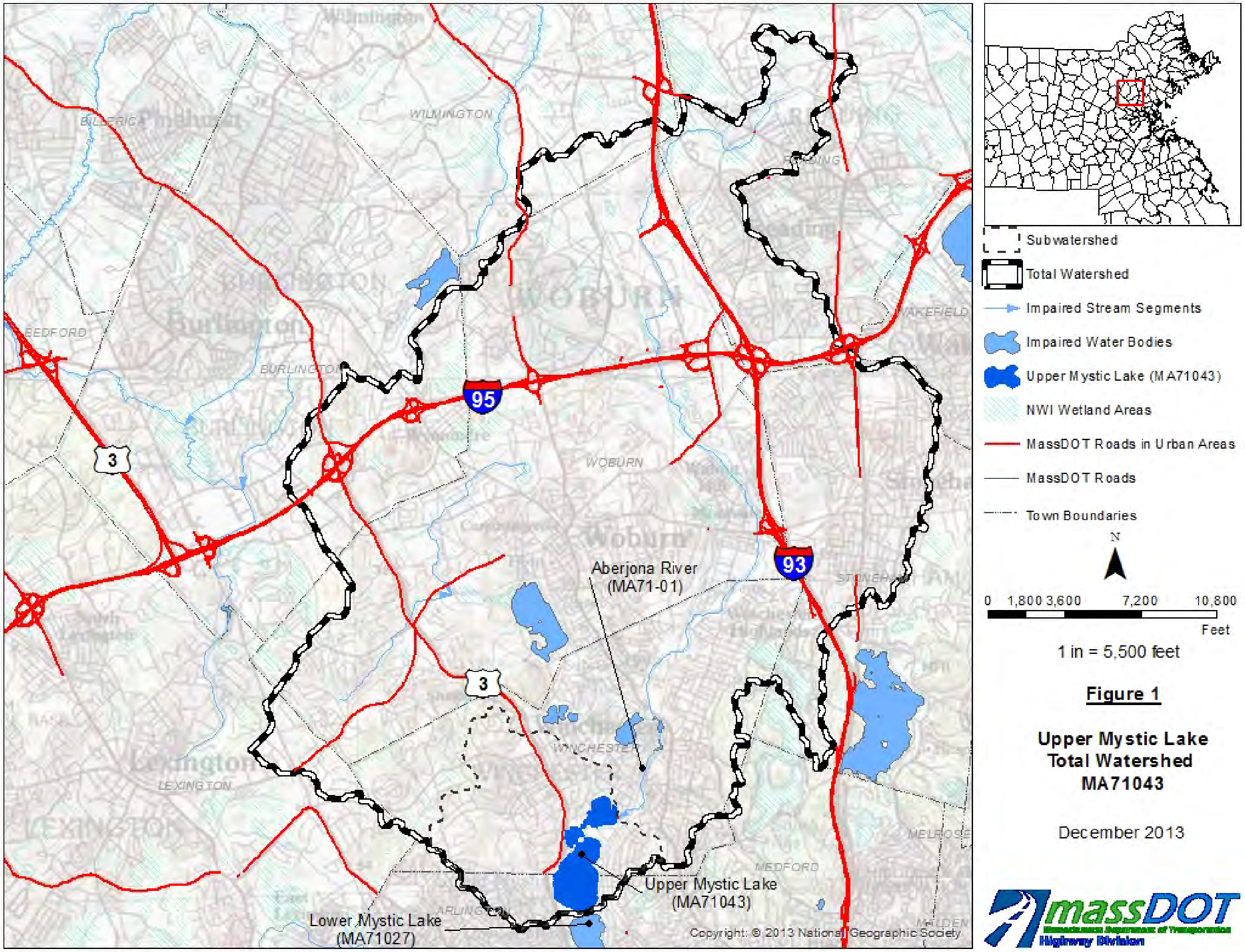


Figure 1

Upper Mystic Lake Total Watershed MA71043

December 2013

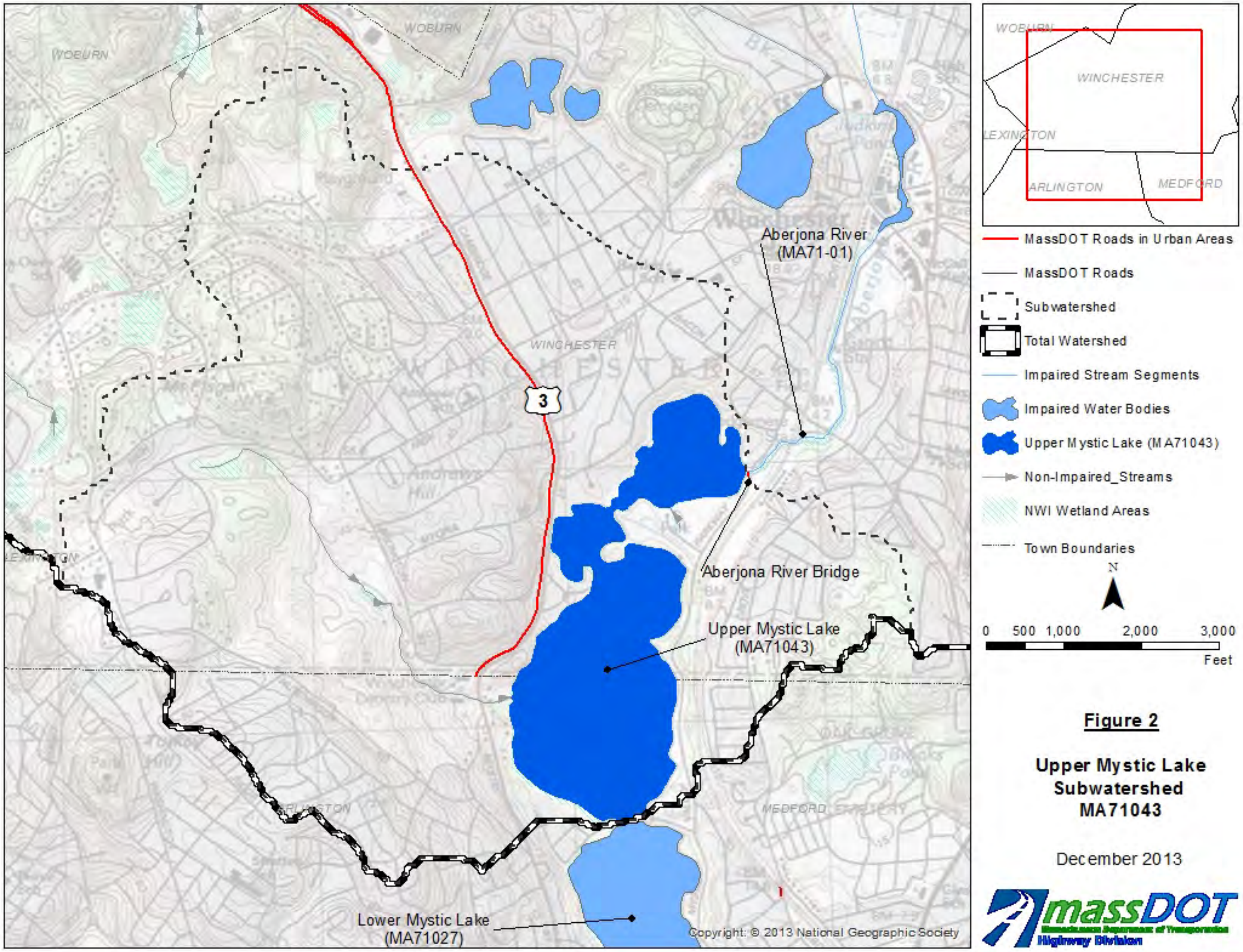
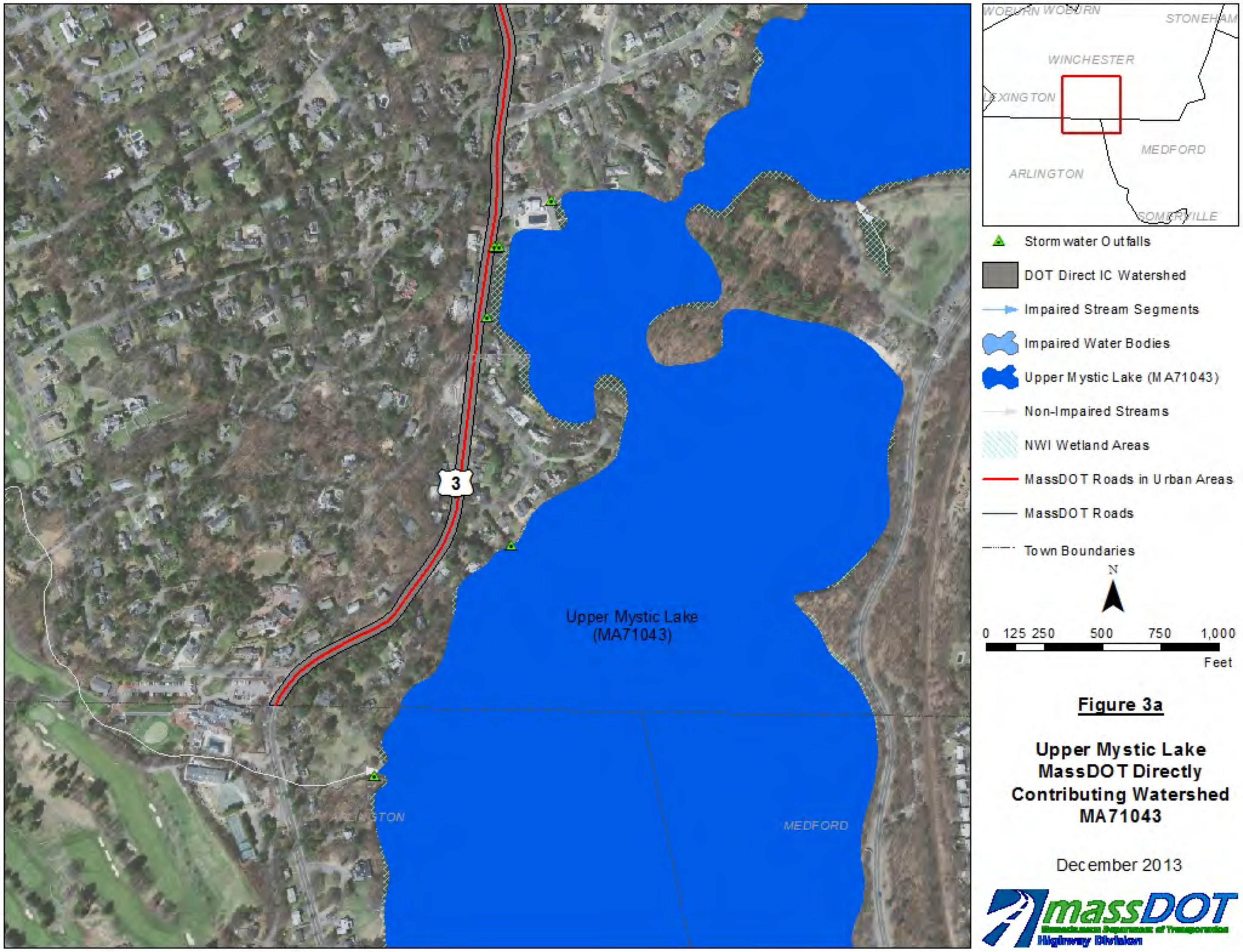


Figure 2

Upper Mystic Lake Subwatershed MA71043

December 2013



Upper Mystic Lake
(MA71043)
3
ARLINGTON
MEDFORD
WOBURN
STONEHAM
WINCHESTER
LEXINGTON
MEDFORD
ARLINGTON
SOMERVILLE
Stormwater Outfalls
DOT Direct IC Watershed
Impaired Stream Segments
Impaired Water Bodies
Upper Mystic Lake (MA71043)
Non-Impaired Streams
NWI Wetland Areas
MassDOT Roads in Urban Areas
MassDOT Roads
Town Boundaries
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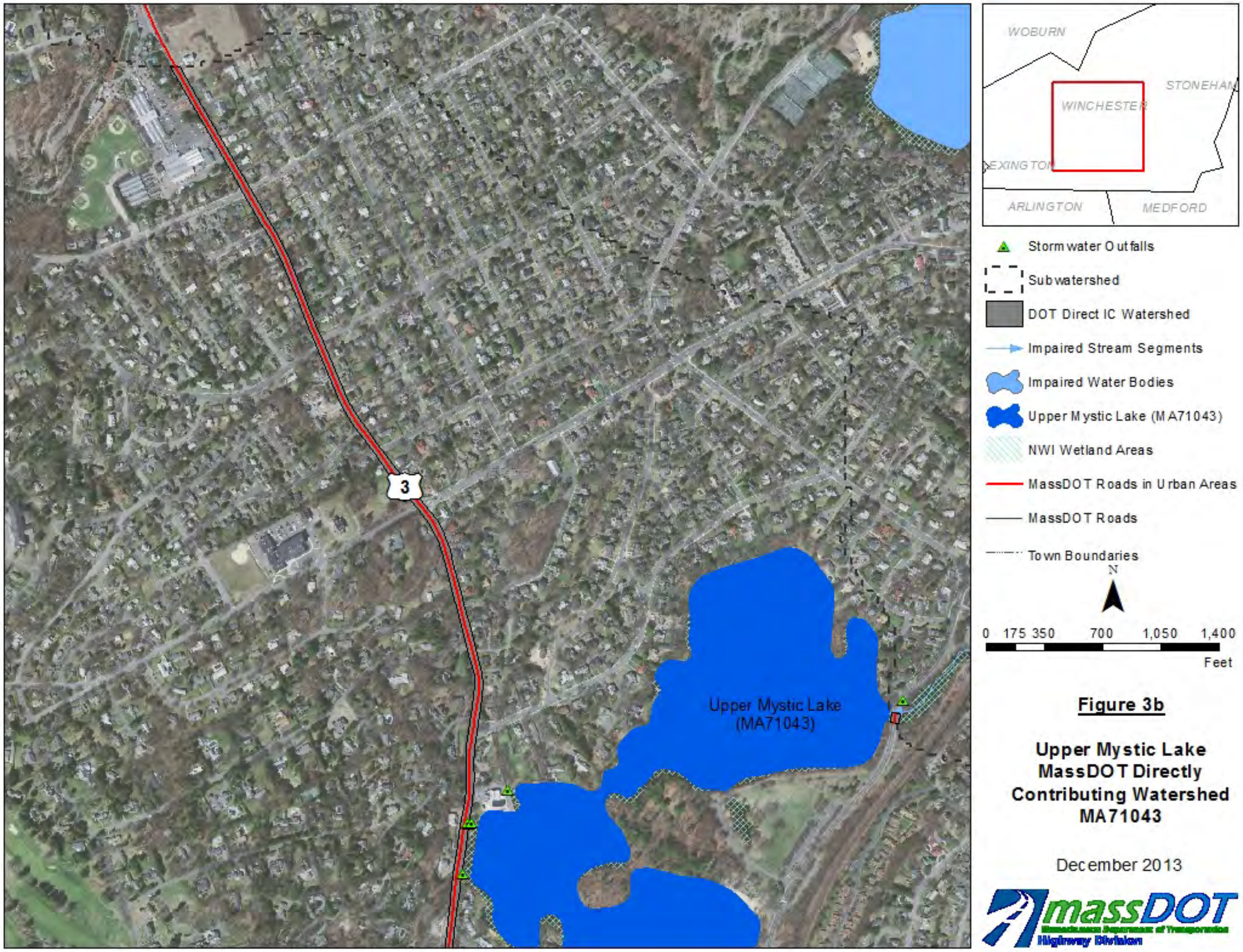
0 125 250 500 750 1,000
Feet
Figure 3a
Upper Mystic Lake
MassDOT Directly
Contributing Watershed
MA71043
December 2013


3
Upper Mystic Lake
(MA71043)
WOBURN
STONEHAM
WINCHESTER
LEXINGTON
ARLINGTON
MEDFORD
Stormwater Outfalls
Subwatershed
DOT Direct IC Watershed
Impaired Stream Segments
Impaired Water Bodies
Upper Mystic Lake (MA71043)
NWI Wetland Areas
MassDOT Roads in Urban Areas
MassDOT Roads
Town Boundaries
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Feet
Figure 3b
Upper Mystic Lake
MassDOT Directly
Contributing Watershed
MA71043
December 2013
massDOT
Massachusetts Department of Transportation
Highway Division

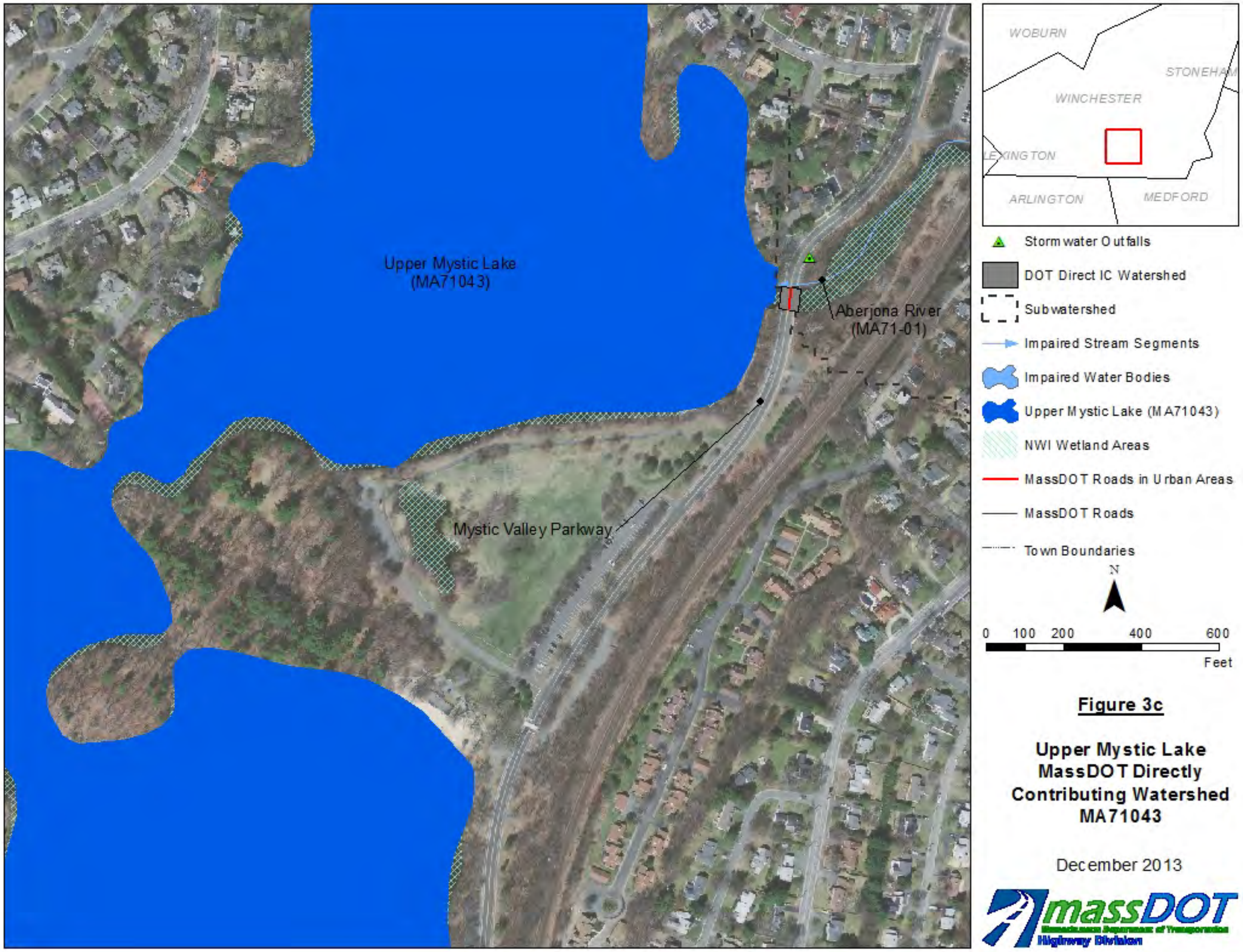

Figure 3c

Upper Mystic Lake MassDOT Directly Contributing Watershed MA71043

December 2013

Impaired Waters Assessment for Chelsea River (MA71-06) – Final Report

Impaired Water Body

Name: Chelsea River

Location: Boston, Chelsea and Revere, MA

Water Body ID: MA71-06

Impairments

The Chelsea River (MA71-06) is listed under Category 5, "Waters Requiring a TMDL", on MassDEP's final *Massachusetts Year 2012 Integrated List of Waters* (MassDEP, 2013). The Chelsea River is also covered by a draft Total Maximum Daily Load (TMDL) for pathogens according to MassDEP's *Draft Pathogen TMDL for the Boston Harbor Watershed* (MassDEP, no date).The Chelsea River is impaired for the following designated uses: aquatic life, primary contact recreation, secondary contact recreation, and aesthetics (MassDEP, 2010). The causes of these designated use impairments are listed as the following chemical, physical, and biological characteristics (MassDEP, 2013):

- Ammonia (Un-ionized)
- Fecal Coliform
- Dissolved Oxygen
- PCB in Fish Tissue
- Petroleum Hydrocarbons
- Sediment Screening Value (Exceedence)
- Taste and Odor
- Turbidity
- Other
- (Debris/Floatables/Trash*)

Relevant Water Quality Standards

Water Body Classification: Class SB

Applicable State Regulations:

- *314 CMR 4.05 (4)(b) 5 Solids*. These waters shall be free from floating, suspended and settleable solids in concentrations or combinations that would impair any use assigned to this class, that would cause aesthetically objectionable conditions, or that would impair the benthic biota or degrade the chemical composition of the bottom.
- *314 CMR 4.05 (4)(b) 6 Color and Turbidity*. These waters shall be free from color and turbidity in concentrations or combinations that are aesthetically objectionable or would impair any use assigned to this class.

- *314 CMR 4.05 (4)(b) 7 Oil and Grease.* These waters shall be free from oil and grease, petrochemicals and other volatile or synthetic organic pollutants.
- *314 CMR 4.05 (4)(b) 8 Taste and Odor.* None in such concentrations or combinations that are aesthetically objectionable, that would impair any use assigned to this class, or that would cause tainting or undesirable flavors in the edible portions of aquatic life.
- *314 CMR 4.05 (5)(a) Aesthetics.* All surface waters shall be free from pollutants in concentrations or combinations that settle to form objectionable deposits; float as debris, scum or other matter to form nuisances; produce objectionable odor, color, taste or turbidity; or produce undesirable or nuisance species of aquatic life.
- *314 CMR 4.05 (5)(b) Bottom Pollutants or Alterations*. All surface waters shall be free from pollutants in concentrations or combinations or from alterations that adversely affect the physical or chemical nature of the bottom, interfere with the propagation of fish or shellfish, or adversely affect populations of non-mobile or sessile benthic organisms.
- *314 CMR 4.05 (4)(b) 1 Dissolved Oxygen.* Shall not be less than 5.0 mg/l. Seasonal and daily variations that are necessary to protect existing and designated uses shall be maintained. Where natural background conditions are lower, DO shall not be less than natural background.
- 315 CMR 4.05 (4)(b) 2 Temperature.
  - a. Shall not exceed 85°F (29.4°C) nor a maximum daily mean of 80°0F (26.7°C), and the rise in temperature due to a discharge shall not exceed 1.5°F (0.8°C) during the summer months (July through September) nor 4°0F (2.2°0C) during the winter months (October through June);
  - b. there shall be no changes from natural background that would impair any uses assigned to this class including those conditions necessary to protect normal species diversity, successful migration, reproductive functions or growth of aquatic organisms;
- *314 CMR 5.04 (4)(b) 3 pH.* Shall be in the range of 6.5 through 8.5 standard units and not more than 0.2 standard units outside of the natural background range. There shall be no change from natural background conditions that would impair any use assigned to this Class.
- *314 CMR 4.05 (4)(b) 4 Bacteria.*
  - a. Waters designated for shellfishing shall not exceed a fecal coliform median or geometric mean MPN of 88 organisms per 100 ml, nor shall more than 10% of the samples exceed an MPN of 260 per 100 ml or other values of equivalent protection based on sampling and analytical methods used by the Massachusetts Division of Marine Fisheries and approved by the National Shellfish Sanitation Program in the latest revision of the Guide For The Control of Molluscan Shellfish (more stringent regulations may apply, see 314 CMR 4.06(1)(d)(5));
  - b. at bathing beaches as defined by the Massachusetts Department of Public Health in 105 CMR 445.010, no single enterococci sample taken during the bathing season shall exceed 104 colonies per 100 ml and the geometric mean of the five most recent samples taken within the same bathing season shall not exceed 35 enterococci colonies per 100 ml. In non bathing beach waters and bathing beach waters during the non bathing season, no single enterococci sample shall exceed 104 colonies per 100 ml and the geometric mean of all of the samples taken during the most recent six months typically based on a minimum of five samples shall not exceed 35 enterococci colonies per 100 ml. These criteria may be applied on a seasonal basis at the discretion of the Department;
- *314 CMR 4.05 (5)(c) Nutrients.* Unless naturally occurring, all surface waters shall be free from nutrients in concentrations that would cause or contribute to impairment of existing or designated

uses and shall not exceed the site specific criteria developed in a TMDL or as otherwise established by the Department pursuant to 314 CMR 4.00. Any existing point source discharge containing nutrients in concentrations that would cause or contribute to cultural eutrophication, including the excessive growth of aquatic plants or algae, in any surface water shall be provided with the most appropriate treatment as determined by the Department, including, where necessary, highest and best practical treatment (HBPT) for POTWs and BAT for non POTWs, to remove such nutrients to ensure protection of existing and designated uses. Human activities that result in the nonpoint source discharge of nutrients to any surface water may be required to be provided with cost effective and reasonable best management practices for nonpoint source control.

- *314 CMR 4.05 (5)(e) Toxic Pollutants.* All surface waters shall be free from pollutants in concentrations or combinations that are toxic to humans, aquatic life or wildlife. For pollutants not otherwise listed in 314 CMR 4.00, the National Recommended Water Quality Criteria: 2002, EPA 822R-02-047, November 2002 published by EPA pursuant to Section 304(a) of the Federal Water Pollution Control Act, are the allowable receiving water concentrations for the affected waters, unless the Department either establishes a site specific criterion or determines that naturally occurring background concentrations are higher. Where the Department determines that naturally occurring background concentrations are higher, those concentrations shall be the allowable receiving water concentrations. The Department shall use the water quality criteria for the protection of aquatic life expressed in terms of the dissolved fraction of metals when EPA's 304(a) recommended criteria provide for use of the dissolved fraction. The EPA recommended criteria based on total recoverable metals shall be converted to dissolved metals using EPA's published conversion factors. Permit limits will be written in terms of total recoverable metals. Translation from dissolved metals criteria to total recoverable metals permit limits will be based on EPA's conversion factors or other methods approved by the Department. The Department may establish site specific criteria for toxic pollutants based on site specific considerations.

Site Description

The Chelsea River (MA71-06) is approximately 2.5 miles long (0.39 square miles) and extends from the confluence with Mill Creek (MA71-08) along the Chelsea and Revere boundary south to the confluence with Boston Inner Harbor in Chelsea and East Boston (**Figure 1**). The Chelsea River is highly impacted by the surrounding industrial oil storage and distribution facilities along Route 1A. Accidental releases and spills from these facilities are attributed as sources of petroleum measured in the river (MassDEP, 2010). Stormwater from the highly urbanized watershed in Revere, Chelsea, and East Boston is also attributed as a source of the impairments to the Chelsea River (MassDEP, 2010).

The Chelsea River watershed is approximately 2.7 square miles of dense urban and industrial land use. The subwatershed that directly contributes to the Chelsea River segment is approximately 1.3 square miles (**Figure 1**). There are municipal storm sewers and combined sewer systems throughout most of the developed area surrounding the Chelsea River. The subwatershed was delineated for this impaired waters assessment with the USGS Data Series 451 subbasin data, the Chelsea sewer map (Weston & Sampson, no date), and Boston Water and Sewer Commission GIS data. The USGS subbasin data was modified to remove the drainage areas that are connected to the combined sewer system that discharges to POTWs. All of the areas that have storm sewers with outfalls into the Chelsea River are included in the Chelsea River subwatershed.

MassDOT's property that directly contributes stormwater runoff to the Chelsea River (MA71-06) consists of approximately 1.5 miles (15.1 acres) of Route 1A in Boston and Revere and approximately 0.95 miles (5.7 acres) of Eastern Avenue in Chelsea (**Figure 2**). Stormwater runoff from Eastern Avenue drains into the Chelsea municipal separate storm sewer system (MS4) and subsequently discharges directly into the Chelsea River through one of MS4 outfalls. Stormwater runoff from portions of Route 1A in Boston and Revere discharge directly to the Chelsea River. Two of the three MassDOT outfalls to the Chelsea River from Route 1A discharge from property beyond the MassDOT right-of-way. One of the outfalls, located near Tomesello Way, discharges to a drainage channel approximately 300 feet north of Tomesello Way that flows to the Chelsea River.

Assessment under BMP 7U

None of the following impairments for the Chelsea River have been addressed by an approved TMDL. Therefore, MassDOT assessed the impairments using the approach described in BMP 7U of MassDOT's Storm Water Management Plan (*Water Quality Impaired Waters Assessment and Mitigation Plan*), which applies to impairments that have been assigned to a water body prior to completion of a TMDL. As described in MassDOT's Application of Impervious Cover Method in BMP 7U (MassDOT, 2011), impervious cover (IC) provides a measure of the potential impact of stormwater on many impairments. For this water body, MassDOT used the IC method to assess the following impairments:

- Ammonia (Un-ionized)
- Dissolved Oxygen
- Petroleum Hydrocarbons
- Taste and Odor
- Turbidity

According to MassDEP's final Massachusetts Year 2012 Integrated List of Waters, the impairment of debris/floatables/trash are not caused by pollutants (MassDEP, 2013); therefore, these impairments are not considered further.

MassDOT concluded that the impairment for PCBs is unrelated to storm water runoff. The Nationwide Urban Runoff Program (NURP) conducted by the EPA found that PCB was detected in less than 1% of stormwater samples collected (EPA, 1983). Therefore, MassDOT concluded that stormwater runoff from its roadways does not contribute to the impairments of PCBs.

The impairment for fecal coliform is assessed separately in the section titled, Assessment of Pathogen Impairment.

MassDOT's Application of the Impervious Cover Method

MassDOT's Application of Impervious Cover Method in BMP 7U applies many aspects of USEPA Region I's Impervious Cover Method described in EPA's *Stormwater TMDL Implementation Support Manual* (ENSR, 2006) to MassDOT's program. This method assesses potential stormwater impacts on the impaired water and evaluates the IC reduction necessary to attain the percent imperviousness in the watershed at which stormwater is not likely the cause of the impairments. Consistent with findings of EPA and others, when a watershed has less than 9% IC, MassDOT concludes that stormwater is not the likely cause of the impairment. Additional information regarding this method is provided in MassDOT's Application of IC Method document.

Assessment

First, MassDOT calculated the percent IC of the water body's entire contributing watershed (total watershed upstream of the downstream end of an impaired segment) and that of the local watershed contributing to the impaired segment (referred to as the subwatershed in this analysis) to determine whether stormwater has a potential to cause the impairments of the receiving water body. The total watershed and subwatershed to the impaired water body were delineated using the USGS Data Series 451. When USGS Data Series watersheds did not delineate the subwatershed of the water body under review, the GIS shapefiles were modified by delineating to the water body based on USGS topography to add specificity. IC data was available as part of the USGS data layers Data Series 451 and MassGIS's impervious surfaces data layer. In cases where it was determined that stormwater was a potential cause of the impairment, MassDOT calculated the degree to which IC would need to be reduced in the subwatershed to meet the 9% IC target. This reduction was then applied proportionally to the area of MassDOT roadways/properties directly discharging to the water body segment to identify MassDOT's target IC reduction. The 9% IC reduction serves only as a recommended target and is not meant to imply that failing to meet the target would cause an exceedance in water quality standards. As explained in BMP 7U, MassDOT will consider a variety of factors apart from numeric guidelines, including site constraints and the magnitude of any potential exceedances in water quality standards, to determine the precise nature and extent of additional BMPs recommended for particular locations. This approach is consistent with the iterative, adaptive management BMP approach set forth in EPA guidelines.

MassDOT calculated the effective IC reduction afforded by the existing structural BMPs currently incorporated into the stormwater infrastructure of MassDOT's properties. This effective IC reduction was calculated by applying effective IC reduction rates to existing BMPs based on their size, function and contributing watershed. BMP performances were derived from EPA Region 1's *Stormwater Best Management Practices (BMP) Performance Analysis* report (EPA, 2010) and engineering judgment. More information on the approach used to calculate the effective IC reductions is described in BMP 7U. When the reduction in effective IC achieved by the existing BMPs was equal to or greater than the target reduction, no further measures were proposed. When this was not the case, MassDOT considered additional BMPs in order to meet the targeted reduction.

Using this approach, MassDOT derived the following site parameters for the Chelsea River (MA71-06):

Table 1. Site Parameters for Chelsea River (MA71-06)

Type	Parameter	Quantity	Unit of Measure
Total Watershed	Watershed Area	1,746	acres
Total Watershed	Impervious Cover (IC) Area	1,201	acres
Total Watershed	Percent Impervious	68.8	%
Subwatershed	Subwatershed Area	824	acres
Subwatershed	Impervious Cover (IC) Area	633	acres
Subwatershed	Percent Impervious	76.8	%
Subwatershed	IC Area at 9% Goal	74	acres
Subwatershed	Target Reduction % in IC	88.3	%
Reductions Applied to DOT Direct Watershed	MassDOT's IC Area Directly Contributing to Impaired Segment	20.8	acres
Reductions Applied to DOT Direct Watershed	MassDOT's Target Reduction in Effective IC (88.3% of DOT Directly Contributing IC)	18.4	acres

The subwatershed is greater than 9% impervious cover, indicating that stormwater likely contributes to the impairments assessed under this methodology. In order to reach the 9% target, effective IC within the subwatershed should be reduced by 88.3%. Therefore, MassDOT's target is to reduce effective IC within its own directly contributing watershed by the same percentage, or 18.4 acres.

Existing BMPs

There are no existing BMPs in the Chelsea River (MA71-06) directly contributing watershed that are mitigating potential stormwater quality impacts prior to discharge to the Chelsea River.

Mitigation Plan

Because there are no existing BMPS, the total mitigation of impervious surface achieved by MassDOT's existing BMPs is less than the target reduction of 18.4 acres. Therefore, MassDOT considered the implementation of additional BMPs.

Assessment of Pathogen Impairment

MassDOT assessed the pathogen impairment using the approach described in BMP 7U of MassDOT's Storm Water Management Plan (*Water Quality Impaired Waters Assessment and Mitigation Plan*), which applies to impairments that have been assigned to a water body prior to completion of a TMDL. Pathogen concentrations in stormwater vary widely temporally and spatially; concentrations can vary by an order of magnitude within a given storm event at a single location (MassDEP, 2009b). Therefore, it is difficult to predict pathogen concentrations in stormwater with accuracy. Due to this difficulty, MassDOT generally will not conduct site specific assessments of loading at each location impaired for pathogens. Instead these sites are assessed based on available information on pathogen loading from highways, MassDOT actions, and information available from EPA and DEP. Based on this information MassDOT developed an approach to be consistent with relevant TMDL and permit condition requirements and an iterative adaptive management approach to stormwater management.

In addition, while there is a positive relationship between IC and pathogen loading, the relationship is not as direct as other impairments. According to the Center for Watershed Protection "…Other studies show that concentrations of bacteria are typically higher in urban areas than rural areas (USGS, 1999), but they are not always directly related to IC (CWP, 2003)." Therefore, DOT did not rely solely on the IC method to assess pathogen impairments. Instead, MassDOT reviewed its existing programs and their consistency with EPA NPDES MS4 general permit requirements and Pathogen TMDL recommendations.

Pathogens in MassDOT Discharge

A study conducted on MassDOT's South East Expressway measured bacterial concentrations in stormwater runoff (Smith, 2002). This study found a geometric mean of 186 fecal coliforms/100 ml. Concentrations of pathogens in stormwater runoff from roadways can vary widely and pathogen concentrations in runoff across the state likely deviate significantly from this stretch of roadway's specific estimate. Event mean concentrations of fecal coliform bacteria in urban stormwater from other sources ranging between 14,000 and 17,000 fecal coliform organisms/100 mL have been reported (MassDEP, 2009b). These data suggest that pathogen loading from highways may be lower than other urban areas.

Consideration of the potential sources of pathogens supports the idea that pathogens are present in lower concentrations in highway runoff since potential pathogen sources are likely to be less prevalent in the highway environment than along other urban roadways:

- Illicit discharges: Due to the typical setback of highways from residential and commercial developments and the stand alone nature of the drainage system, the potential for illicit discharges (e.g. sewer connections, laundry tie-ins) is much lower than in other stormwater systems. This has been confirmed by MassDOT's illicit discharge detection on many miles of urban roadways within a broad range of areas across Massachusetts. After assessment of almost 140 miles, and investigation of more than 2,500 stormwater features, MassDOT's consultant performing the broad scope reviews has found no confirmed illicit discharges.

- Limited Sewer Utilities in Road Right of Ways: Since DOT does not provide sewer services, many MassDOT roads do not have sewer utilities within the road's right of way; thereby eliminating the chance of cross-connections or leaking pipes as a source of pathogens into the stormwater system.
- Pet waste: Pets are only present on highways in rare instances. In urban residential areas pets and their associated waste are much more common. MassDOT is aware that pet waste at road side rest stops may represent a potential source of pathogens to stormwater in certain situations, and has a pet waste management program underway to address this source where necessary.
- Wildlife: Highways are not generally an attractive place for wildlife. Wildlife generally avoids highways and only occasionally crosses them.

The dearth of pathogen sources on highways and the relatively low concentrations of pathogens measured in the South East Expressway study together suggest that pathogen loading from stormwater runoff from highways is lower than other urban sources.

Furthermore, in almost all cases the contribution of pathogens from MassDOT to a specific water body is likely to be very small relative to other sources of pathogens in the watershed. Since MassDOT urban roadways are linear and usually cross watersheds, they represent a small fraction of the receiving water body's watershed. The water quality within these water bodies is dependent on discharge from various sources, including discharges from other stormwater systems and a large number of other factors.

Assessment

Pathogen loadings are highly variable and, as a result, quantitative assessments are challenging and of little value. Therefore, MassDOT reviewed its existing programs and their consistency with EPA NPDES MS4 general permit requirements and Pathogen TMDL recommendations.

TMDLs for pathogen impairments in Massachusetts recognize that pathogens are highly variable and difficult to address and emphasize the need for an iterative adaptive management approach to address pathogens. Examples of relevant language from these TMDLs are included below:

- "given the vast potential number of bacteria sources and the difficulty of identifying and removing them from some sources such as stormwater require an iterative process and will take some time to accomplish. While the stated goal in the TMDL is to meet the water quality standard at the point of discharge it also attempts to be clear that MassDEP's expectation is that for stormwater an iterative approach is needed…" (MassDEP, 2009a)
- "The NPDES permit does not, however, establish numeric effluent limitations for stormwater discharges. Maximum extent practicable (MEP) is the statutory standard that establishes the level of pollutant reductions that regulated municipalities must achieve. The MEP standard is a narrative effluent limitation that is satisfied through implementation of SWMPs and achievement of measurable goals."(MassDEP, 2009b)
- "Although the TMDL presents quantified WLAs for stormwater that are set equivalent to the criteria in the Massachusetts Water Quality Standards, the Phase II NPDES permits will not include numeric effluent limitations. Phase II permits are intended to be BMP based permits that will require communities to develop and implement comprehensive stormwater management programs involving the use of BMPs. Massachusetts and EPA believe that BMP based Phase II permits involving comprehensive stormwater management together with specific emphasis on pollutants contributing to existing water quality problems can be consistent with the intent of the quantitative WLAs for stormwater discharges in TMDLs." (MassDEP, 2002).

This language clearly indicates that an iterative adaptive management approach is the appropriate way to address discharges to pathogen impaired waters. The recommendations in pathogen TMDLs for waters in Massachusetts generally require development and implementation of stormwater management programs, illicit discharge detection and elimination efforts, and in some cases installing BMPs to the maximum extent practicable.

The draft North Coastal Watershed General MS4 permit and the draft Interstate, Merrimack, and South Coastal (IMS) watershed permits contain specific requirements for compliance with pathogen TMDLs (in Appendix G). While these permits are still in draft form, MassDOT believes they represent the best available guidance on what EPA believes is appropriate for addressing stormwater discharges to pathogen-impaired waters. Section 2.2.1(c) of the permit states "For any discharge from its MS4 to impaired waters with an approved TMDL, the permittee shall comply with the specific terms of Part 2.1 of this permit. In addition, where an approved TMDL establishes a WLA that applies to its MS4 discharges, the permittee shall implement the specific BMPs and other permit requirements identified in Appendix G to achieve consistency with the WLA." Appendix G references a number of programmatic BMPs that are necessary to address pathogen loading. These cover the following general topics:

- Residential educational program
- Illicit connection identification, tracking and removal
- Pet waste management

Mitigation Plan

MassDOT implements a variety of non-structural BMP programs across their system in accordance with their existing Stormwater Management Plan (SWMP) including educational programs, illicit connection review and source control. The specific BMPs that can help reduce potential pathogen loading in the current SWMP include:

- BMP 3C-1: Drainage Connection Policy
- BMP 3C-2: Drainage Tie-In Standard Operating Procedure
- BMP 3D: Illicit Discharge Detection Review
- BMP 5H-1: Post Construction Runoff Enforcement – Illicit Discharge Prohibition
- BMP 5H-2: Post Construction Runoff Enforcement – Drainage Tie-In
- BMP 5H-3: Post Construction Runoff Enforcement – Offsite Pollution to MassHighway Drainage System
- BMP 6A-1: Source Control – 511 Program
- BMP 6A-2: Source Control – Adopt-A-Highway Program
- BMP 6C-1: Maintenance Program

In addition, the structural BMPs that will be considered to reduce the IC will also have the effect of reducing pathogen loads.

MassDOT believes the existing and proposed efforts are consistent with the current and draft MS4 permit's requirements and TMDL recommendations. MassDOT's existing stormwater management plan outlines BMPs that include education and illicit discharge detection and elimination. MassDOT will be implementing a pet waste management program at its rest stops that have discharges to pathogen impaired waters.

Target Reduction

MassDOT worked with design consultants to identify locations suitable for the construction of BMPS to treat the directly contributing IC for Chelsea River. Further investigation of the MassDOT's property determined that due to site constraints and a shallow seasonal high groundwater table, the construction of a BMP for the treatment of directly contributing cover is not feasible for this segment.

Conclusions

MassDOT used the IC Method to assess the Chelsea River (MA71-06) for the impairments identified in MassDEP's final *Massachusetts Year 2012 Integrated List of Waters*. Results indicate that MassDOT should reduce its effective IC within its directly contributing subwatershed by 18.4 acres to achieve the targeted reduction in effective IC. MassDOT evaluated its property within the directly contributing watershed to the Chelsea River to identify existing BMPs and found that no BMPs exist to reduce effective IC. This information is summarized in Table 2 below.

Table 2. Effective IC Reductions under Existing &Proposed Conditions

Parameter	Quantity	Unit of Measure
IC in Directly Contributing Watershed	20.8	acres
Target Reduction in Effective IC	18.4	acres
IC Effectively Reduced by Existing BMPs	0	acres
IC remaining to mitigate with Proposed BMPs	18.4	acres

MassDOT should reduce its effective IC within the directly contributing watershed by an additional 18.4 acres to achieve the targeted reduction in IC. However, design consultants further investigated the property to identify locations suitable for construction of BMPs to treat directly contributing IC as part of MassDOT's Impaired Waters Retrofit Initiative. The design consultants determined that it was not feasible to construct BMPs due to a shallow seasonal high groundwater table and other site limitations.

MassDOT has concluded based on review of the draft North Coastal Watershed General MS4 permit, the draft Interstate, Merrimack, and South Coastal watershed permits, and pathogen TMDLs for Massachusetts waters, that the BMPs outlined in the stormwater management plan and those under consideration for reducing effective IC from MassDOT areas are consistent with its existing permit requirements. MassDOT believes that these measures achieve pathogen reductions (including fecal coliform) to the maximum extent practicable and are consistent with the intent of its existing stormwater permit and the applicable Pathogen TMDLs.

Furthermore, MassDOT will continue to identify opportunities to implement additional structural BMPs to address pollutant loading when road work is conducted under MassDOT's programmed projects initiative. Work on programmed projects, which often include broader scale road layout changes, may provide additional opportunities for construction of new treatment BMPs. This is consistent with an iterative adaptive management approach to addressing impairments. MassDOT will include an update in annual reports and biannual submittals to EPA regarding progress made towards meeting target IC reductions, plans for construction of additional BMPs, and finalized assessments including reductions achieved by finalized BMP designs. MassDOT will continue to implement non-structural BMPs that reduce the impacts of stormwater.

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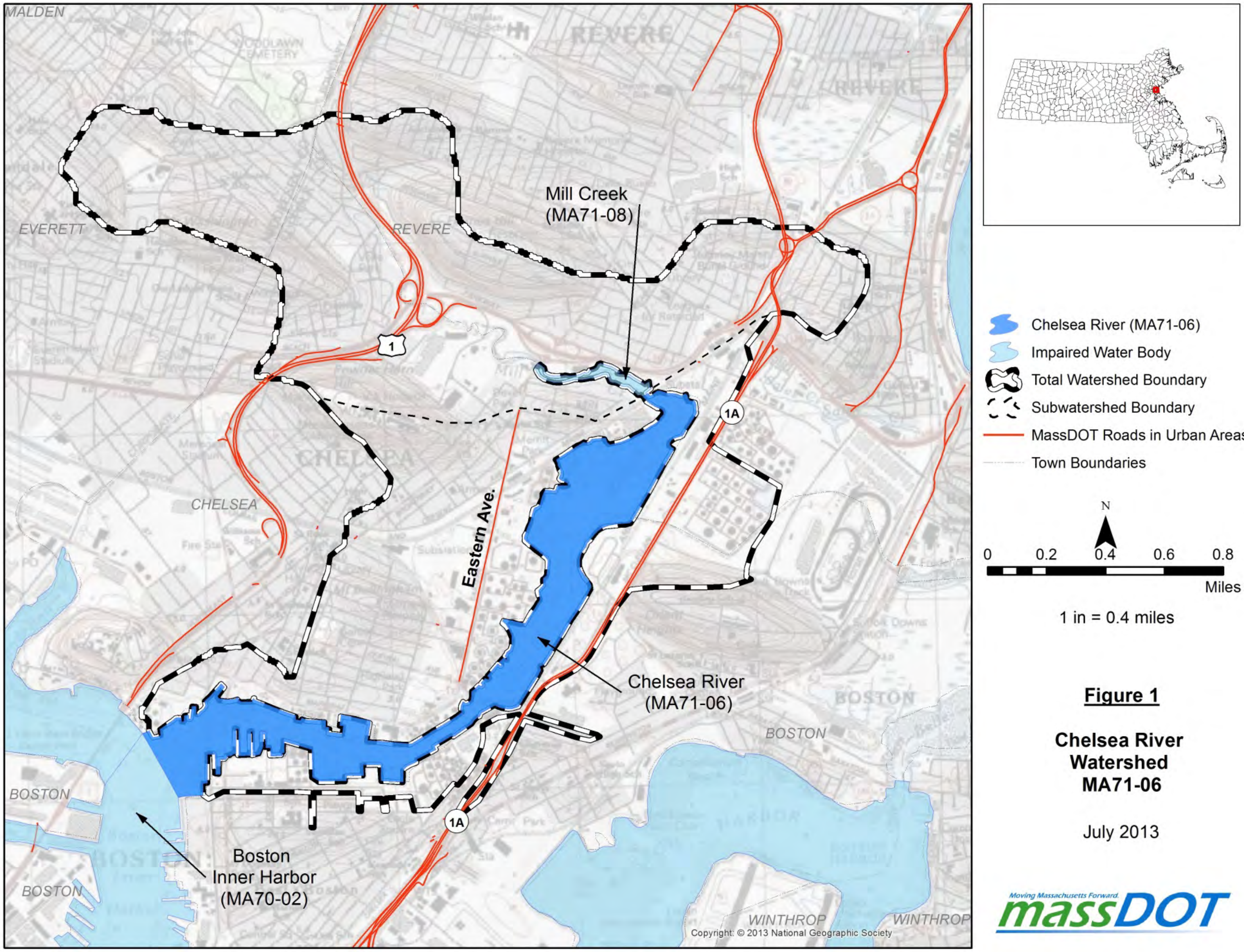

Figure 1

Chelsea River Watershed MA71-06

July 2013

Moving Massachusetts Forward. massDOT

Legend

- MassDOT Outfall
- City of Chelsea Outfall
- Boston Water and Sewer Outfall
- Chelsea River (MA71-06)
- Subwatershed Boundary
- DOT Directly Contributing Watershed
- MassDOT Roads in Urban Areas
- Town Boundaries

N

0 490 980 1,470 1,960 Feet

1 inch = 1,000 feet

Figure 2

Chelsea River
MA71-06
Directly Contributing
MassDOT Watershed

July 2013

Moving Massachusetts Forward. massDOT

Impaired Waters Assessment for Hawes Brook (MA73-16) – Final Report

Impaired Water Body

Name: Hawes Brook

Location: Norwood, MA

Water Body ID: MA73-16

Impairments

Hawes Brook (MA73-16) is listed under Category 5, "Waters Requiring a TMDL", on MassDEP's final *Massachusetts Year 2012 Integrated List of Waters* (MassDEP, 2013). Hawes Brook is impaired for the following:

- Escherichia coli
- fecal coliform
- taste and odor
- (debris/floatables/trash*)

According to MassDEP's *Neponset River Watershed 2004 Water Quality Assessment Report* (MassDEP, 2010), Hawes Brook is impaired for primary contact recreational use due to the presence of Escherichia coli. It supports secondary contact recreational use and is not assessed for aquatic life, fish consumption and aesthetics. Hawes Brook is also included in MassDEP's *Total Maximum Daily Loads (TMDL) of Bacteria for Neponset River Basin* (MassDEP, 2002).

Relevant Water Quality Standards

Water Body Classification: Class B

Applicable State Regulations:

- *314 CMR 4.05 (3)(b) 8 Taste and Odor*. None in such concentrations or combinations that are aesthetically objectionable, that would impair any use assigned to this Class, or that would cause tainting or undesirable flavors in the edible portions of aquatic life.
- 314 CMR 4.05 (3)(b) 4 *Bacteria*.
  - a. At bathing beaches as defined by the Massachusetts Department of Public Health in 105 CMR 445.010: where E. coli is the chosen indicator, the geometric mean of the five most recent samples taken during the same bathing season shall not exceed 126 colonies per 100 ml and no single sample taken during the bathing season shall exceed 235 colonies per 100 ml; alternatively, where enterococci are the chosen indicator, the geometric mean of the five most recent samples taken during the same bathing season shall not exceed 33 colonies per 100 ml and no single sample taken during the bathing season shall exceed 61 colonies per 100 ml;

– b. For other waters and, during the non bathing season, for waters at bathing beaches as defined by the Massachusetts Department of Public Health in 105 CMR 445.010: the geometric mean of all E. coli samples taken within the most recent six months shall not exceed 126 colonies per 100 ml typically based on a minimum of five samples and no single sample shall exceed 235 colonies per 100 ml; alternatively, the geometric mean of all enterococci samples taken within the most recent six months shall not exceed 33 colonies per 100 ml typically based on a minimum of five samples and no single sample shall exceed 61 colonies per 100 ml. These criteria may be applied on a seasonal basis at the discretion of the Department;

Site Description

Hawes Brook (MA73-16) begins at the outlet of Ellis Pond in Norwood and extends approximately 1.1 miles to its confluence with the Neponset River in Norwood as shown in Figure 1. This entire segment of stream is classified as impaired according to the *Neponset River Watershed 2004 Water Quality Assessment Report*. The land use within the Hawes Brook total watershed and subwatershed is a combination of residential, forested, and commercial. The Hawes Brook subwatershed is shown in Figure 2.

MassDOT’s property that directly contributes stormwater runoff to Hawes Brook is comprised of an approximately 1.2 mile section of Route 1A from Willett Street in Walpole north to Hillshire Lane in Norwood as described below (Figure 3). Stormwater runoff from this portion of Route 1A is directed through storm drains that discharge directly into Hawes Brook on the downstream side of the Route 1A bridge over Hawes Brook (Figure 3).

Route 1A has curbs and catch basins that are connected to trunk lines that discharge directly into Hawes Brook from the south through a 24-inch concrete pipe and from the north through an 18-inch concrete pipe. The DOT right-of-way along this section of Route 1A is 50 feet in width. The land adjacent to Route 1A is primarily high density residential; although an area near the Hawes Brook crossing is commercial and has considerable impervious cover due to parking areas.

Assessment under BMP 7U

Only the impairments to Hawes Brook that are caused by bacteria have been addressed by a TMDL (MassDEP, 2002). MassDOT assessed the non-bacteria related impairments using the approach described in BMP 7U of MassDOT’s Storm Water Management Plan (*Water Quality Impaired Waters Assessment and Mitigation Plan*), which applies to impairments that have been assigned to a water body prior to completion of a TMDL. As described in MassDOT’s Application of Impervious Cover Method in BMP 7U (MassDOT, 2011), impervious cover (IC) provides a measure of the potential impact of stormwater on many impairments. For this water body, MassDOT used the IC method to assess the following impairments:

- taste and odor

According to the final *Massachusetts Year 2012 Integrated List of Waters*, debris/floatables/trash is considered a non-pollutant and unrelated to stormwater. Therefore, MassDOT has determined that further assessment of this impairment for the water body is not required under BMP 7U.

The impairments for Escherichia coli and fecal coliform are assessed separately in the section titled Assessment of Pathogen Impairment.

MassDOT's Application of the Impervious Cover Method

MassDOT's Application of Impervious Cover Method in BMP 7U applies many aspects of USEPA Region I's Impervious Cover Method described in EPA's *Stormwater TMDL Implementation Support Manual* (ENSR, 2006) to MassDOT's program. This method assesses potential stormwater impacts on the impaired water and evaluates the IC reduction necessary to attain the percent imperviousness in the watershed at which stormwater is not likely the cause of the impairments. Consistent with findings of EPA and others, when a watershed has less than 9% IC, MassDOT concludes that stormwater is not the likely cause of the impairment. Additional information regarding this method is provided in MassDOT's Application of IC Method document.

Assessment

First, MassDOT calculated the percent IC of the water body's entire contributing watershed (total watershed upstream of the downstream end of an impaired segment) and that of the local watershed contributing to the impaired segment (referred to as the subwatershed in this analysis) to determine whether stormwater has a potential to cause the impairments of the receiving water body. The total watershed and subwatershed to the impaired water body were delineated using the USGS Data Series 451. When USGS Data Series watersheds did not delineate the subwatershed of the water body under review, the GIS shapefiles were modified by delineating to the water body based on USGS topography to add specificity. IC data was available as part of the USGS data layers Data Series 451 and MassGIS's impervious surfaces data layer.

In cases where it was determined that stormwater was a potential cause of the impairment, MassDOT calculated the degree to which IC would need to be reduced in the subwatershed to meet the 9% IC target. This reduction was then applied proportionally to the area of MassDOT roadways/properties directly discharging to the water body segment to identify MassDOT's target IC reduction. The 9% IC reduction serves only as a recommended target and is not meant to imply that failing to meet the target would cause an exceedance in water quality standards. As explained in BMP 7U, MassDOT will consider a variety of factors apart from numeric guidelines, including site constraints and the magnitude of any potential exceedances in water quality standards, to determine the precise nature and extent of additional BMPs recommended for particular locations. This approach is consistent with the iterative, adaptive management BMP approach set forth in EPA guidelines.

MassDOT calculated the effective IC reduction afforded by the existing structural BMPs currently incorporated into the stormwater infrastructure of MassDOT's properties. This effective IC reduction was calculated by applying effective IC reduction rates to existing BMPs based on their size, function and contributing watershed. BMP performances were derived from EPA Region 1's *Stormwater Best Management Practices (BMP) Performance Analysis* report (EPA, 2010) and engineering judgment. More information on the approach used to calculate the effective IC reductions is described in BMP 7U. When the reduction in effective IC achieved by the existing BMPs was equal to or greater than the target reduction, no further measures were proposed. When this was not the case, MassDOT considered additional BMPs in order to meet the target reduction.

Using this approach, MassDOT derived the following site parameters for Hawes Brook (MA73-16):

Table 1. Site Parameters for Hawes Brook (MA73-16)

Type	Parameter	Quantity	Unit of Measure
Total Watershed	Watershed Area	5,558	acres
Total Watershed	Impervious Cover (IC) Area	943	acres
Total Watershed	Percent Impervious	17.0	%
Subwatershed	Watershed Area	628	acres
Subwatershed	Impervious Cover (IC) Area	181	acres
Subwatershed	Percent Impervious	28.8	%
Subwatershed	IC Area at 9% Goal	57*	acres
Subwatershed	Target Reduction % in IC	68.5	%
DOT Direct Watershed	MassDOT's IC Area Directly Contributing to Impaired Segment	4.2	acres
Reductions Applied to DOT Direct Watershed	MassDOT's Target Reduction in Effective IC (68.5% of DOT Directly Contributing IC)	2.9	acres

*Rounding accounts for differences in calculations

The subwatershed is greater than 9% impervious cover, indicating that stormwater likely contributes to the impairments assessed under this methodology. In order to reach the 9% target, effective IC within the subwatershed should be reduced by 68.5%. Therefore, MassDOT's target is to reduce effective IC within its own directly contributing watershed by the same percentage, or 2.9 acres.

Existing BMPs

There are no existing BMP's associated with DOT's Directly Contributing IC to Hawes Brook.

Mitigation Plan

Because there is currently no mitigation of the directly contributing MassDOT IC, MassDOT considered the implementation of BMPs.

Due to the limited right-of-way, the high density of development along Route 1A, and the lack of available land near the directly discharging outfalls of the existing storm drainage system, no structural BMPs or diversionary techniques can be employed to effectively reduce IC from MassDOT property that directly contributes stormwater runoff to Hawes Brook.

Assessment of Pathogen Impairment under BMP 7R

MassDOT assessed the pathogen impairment using the approach described in BMP 7R of MassDOT's Storm Water Management Plan (*TMDL Watershed Review*), which applies to impairments that have been assigned to a water body covered by a final TMDL. Pathogen concentrations in stormwater vary widely temporally and spatially; concentrations can vary by an order of magnitude within a given storm event at a single location (MassDEP, 2009b). Therefore, it is difficult to predict pathogen concentrations in stormwater with accuracy. Due to this difficulty, MassDOT generally will not conduct site specific assessments of loading at each location impaired for pathogens. Instead these sites are assessed based on available information on pathogen loading from highways, MassDOT actions, and information available from EPA and DEP. Based on this information MassDOT developed an approach to be consistent with relevant TMDL and permit condition requirements and an iterative adaptive management approach to stormwater management.

In addition, while there is a positive relationship between IC and pathogen loading, the relationship is not as direct as other impairments. According to the Center for Watershed Protection "…Other studies show that concentrations of bacteria are typically higher in urban areas than rural areas (USGS, 1999), but they are not always directly related to IC (CWP, 2003)." Therefore, DOT did not rely solely on the IC method to assess pathogen impairments. Instead, MassDOT reviewed its existing programs and their consistency with EPA NPDES MS4 general permit requirements and Pathogen TMDL recommendations.

Pathogens in MassDOT Discharge

A study conducted on MassDOT's South East Expressway measured bacterial concentrations in stormwater runoff (Smith, 2002). This study found a geometric mean of 186 fecal coliforms/100 ml. Concentrations of pathogens in stormwater runoff from roadways can vary widely and pathogen concentrations in runoff across the state likely deviate significantly from this stretch of roadway's specific estimate. Event mean concentrations of fecal coliform bacteria in urban stormwater from other sources ranging between 14,000 and 17,000 fecal coliform organisms/100 mL have been reported (MassDEP, 2009b). These data suggest that pathogen loading from highways may be lower than other urban areas.

Consideration of the potential sources of pathogens supports the idea that pathogens are present in lower concentrations in highway runoff since potential pathogen sources are likely to be less prevalent in the highway environment than along other urban roadways:

- Illicit discharges: Due to the typical setback of highways from residential and commercial developments and the stand alone nature of the drainage system, the potential for illicit discharges (e.g. sewer connections, laundry tie-ins) is much lower than in other stormwater systems. This has been confirmed by MassDOT's illicit discharge detection on many miles of urban roadways within a broad range of areas across Massachusetts. After assessment of almost 140 miles, and investigation of more than 2,500 stormwater features, MassDOT's consultant performing the broad scope reviews has found no confirmed illicit discharges.
- Limited Sewer Utilities in Road Right of Ways: Since DOT does not provide sewer services, many MassDOT roads do not have sewer utilities within the road's right of way; thereby eliminating the chance of cross-connections or leaking pipes as a source of pathogens into the stormwater system.
- Pet waste: Pets are only present on highways in rare instances. In urban residential areas pets and their associated waste are much more common. MassDOT is aware that pet waste at road side rest stops may represent a potential source of pathogens to stormwater in certain situations, and has a pet waste management program underway to address this source where necessary.
- Wildlife: Highways are not generally an attractive place for wildlife. Wildlife generally avoids highways and only occasionally crosses them.

The dearth of pathogen sources on highways and the relatively low concentrations of pathogens measured in the South East Expressway study together suggest that pathogen loading from stormwater runoff from highways is lower than other urban sources.

Furthermore, in almost all cases the contribution of pathogens from MassDOT to a specific water body is likely to be very small relative to other sources of pathogens in the watershed. Since MassDOT urban roadways are linear and usually cross watersheds, they represent a small fraction of the receiving water body's watershed. The water quality within these water bodies is dependent on discharge from various sources, including discharges from other stormwater systems and a large number of other factors.

Assessment

Pathogen loadings are highly variable and, as a result, quantitative assessments are challenging and of little value. Therefore, MassDOT reviewed its existing programs and their consistency with EPA NPDES MS4 general permit requirements and Pathogen TMDL recommendations.

TMDLs for pathogen impairments in Massachusetts recognize that pathogens are highly variable and difficult to address and emphasize the need for an iterative adaptive management approach to address pathogens. Examples of relevant language from these TMDLs are included below:

- "given the vast potential number of bacteria sources and the difficulty of identifying and removing them from some sources such as stormwater require an iterative process and will take some time to accomplish. While the stated goal in the TMDL is to meet the water quality standard at the point of discharge it also attempts to be clear that MassDEP's expectation is that for stormwater an iterative approach is needed…" (MassDEP, 2009a)
- "The NPDES permit does not, however, establish numeric effluent limitations for stormwater discharges. Maximum extent practicable (MEP) is the statutory standard that establishes the level of pollutant reductions that regulated municipalities must achieve. The MEP standard is a narrative effluent limitation that is satisfied through implementation of SWMPs and achievement of measurable goals."(MassDEP, 2009b)
- "Although the TMDL presents quantified WLAs for stormwater that are set equivalent to the criteria in the Massachusetts Water Quality Standards, the Phase II NPDES permits will not include numeric effluent limitations. Phase II permits are intended to be BMP based permits that will require communities to develop and implement comprehensive stormwater management programs involving the use of BMPs. Massachusetts and EPA believe that BMP based Phase II permits involving comprehensive stormwater management together with specific emphasis on pollutants contributing to existing water quality problems can be consistent with the intent of the quantitative WLAs for stormwater discharges in TMDLs." (MassDEP, 2002).

This language clearly indicates that an iterative adaptive management approach is the appropriate way to address discharges to pathogen impaired waters. The recommendations in pathogen TMDLs for waters in Massachusetts generally require development and implementation of stormwater management programs, illicit discharge detection and elimination efforts, and in some cases installing BMPs to the maximum extent practicable.

Unlike other TMDLs that establish pollutant load allocations based on mass per time, many bacteria and pathogen TMDLs in Massachusetts establish bacterial TMDLs that are concentration based and equivalent to the MassDEP water quality standard for the receiving water body. This requirement therefore requires that at the point of discharge to the receiving water, all sources include bacteria concentrations that are equal or less than the MassDEP water quality standard for the receiving water body.

The draft North Coastal Watershed General MS4 permit and the draft Interstate, Merrimack, and South Coastal (IMS) watershed permits contain specific requirements for compliance with pathogen TMDLs (in Appendix G). While these permits are still in draft form, MassDOT believes they represent the best available guidance on what EPA believes is appropriate for addressing stormwater discharges to pathogen-impaired waters. Section 2.2.1(c) of the permit states "For any discharge from its MS4 to impaired waters with an approved TMDL, the permittee shall comply with the specific terms of Part 2.1 of this permit. In addition, where an approved TMDL establishes a WLA that applies to its MS4 discharges, the permittee shall implement the specific BMPs and other permit requirements identified in Appendix G to achieve consistency with the WLA." Appendix G references a number of programmatic BMPs that are necessary to address pathogen loading. These cover the following general topics:

- Residential educational program
- Illicit connection identification, tracking and removal
- Pet waste management

In addition to the generic recommendations provided in the draft MS4 permits for Massachusetts, the Neponset River TMDL report (pages 38-39) recommends the following specific BMPs to address elevated fecal coliform levels in the watershed:

- Identification and elimination of illicit sources
- Increased frequency of street sweeping and catch basin cleaning
- Public education programs
- Adoption of pet waste pick up laws
- Diversion of runoff to pervious areas for infiltration where possible

The TMDL report also indicates that structural BMPs may be appropriate to address runoff from impervious areas in instances where fecal coliform concentrations cannot be reduced by other means.

The following BMPs are specifically identified as being ongoing and/or planned in order to meet the bacteria TMDL for the Neponset River:

- Watershed resident education
- Additional monitoring

Mitigation Plan

MassDOT implements a variety of non-structural BMP programs across their system in accordance with their existing Stormwater Management Plan (SWMP) including educational programs, illicit connection review and source control. The specific BMPs that can help reduce potential pathogen loading in the current SWMP include:

- BMP 3C-1: Drainage Connection Policy
- BMP 3C-2: Drainage Tie-In Standard Operating Procedure
- BMP 3D: Illicit Discharge Detection Review
- BMP 5H-1: Post Construction Runoff Enforcement – Illicit Discharge Prohibition
- BMP 5H-2: Post Construction Runoff Enforcement – Drainage Tie-In
- BMP 5H-3: Post Construction Runoff Enforcement – Offsite Pollution to MassHighway Drainage System
- BMP 6A-1: Source Control – 511 Program

- BMP 6A-2: Source Control – Adopt-A-Highway Program

BMP 6C-1: Maintenance ProgramMassDOT believes that existing efforts are consistent with the current and draft MS4 permit requirements and TMDL recommendations in regard to pathogens. MassDOT has documented the locations of its stormwater outfalls. In addition, as part of its pet waste management program, MassDOT has determined that no MassDOT rest stops are located within the sub-watershed of this water body. At rest stops that have been identified as being within sub-watersheds of water bodies impaired for pathogens, MassDOT will be installing signs informing the public of the need to remove pet waste in order to minimize contributions of pathogens to the impaired water body, and pet waste removal bags and disposal cans will be provided.

Although the TMDL report also identifies that depending on the success of non-structural BMPs structural BMPs may become appropriate to address runoff from impervious areas, MassDOT feels that it is not a beneficial approach to implement these BMPs in advance of other ongoing BMP efforts identified in the watershed, given the documented variability of pathogen concentrations in highway runoff, and the low probability of achieving substantial gains towards meeting the TMDL with solely implementing IC reductions and controls.

Furthermore, MassDOT has an ongoing inspection and monitoring program aimed at identifying and addressing illicit discharges to MassDOT's stormwater management system. Any illicit discharges to MassDOT's system could contribute pathogens to impaired waters, however, MassDOT's existing Illicit Discharge Detection and Elimination (IDDE) program is aimed at identifying and addressing these contributions. District maintenance staff is trained to conduct regular inspections of MassDOT infrastructure and note any signs of potential illicit discharges, such as dry weather flow and notable odors or sheens. Similarly, resident engineers overseeing construction projects also receive training to note any suspicious connections or flows, and report these for follow-up investigation and action as appropriate. MassDOT will continue to implement this Illicit Discharge Detection and Elimination (IDDE) training, and District staff will continue to report any suspicious flows requiring further investigation. MassDOT investigates any suspicious flows noted, and will work with owners of confirmed illicit discharges to remove these flows, and thereby minimize the possibility of pathogen contributions to receiving waters. At present, there are no suspected or known illicit discharges, or unauthorized drainage tie-ins, within the sub-watershed of this water body that could be contributing pathogens to the impaired water body.

Conclusions

MassDOT used the IC Method to assess Hawes Brook for the impairments identified in MassDEP's final *Massachusetts Year 2012 Integrated List of Waters*. Results indicate that MassDOT would need to reduce its effective IC within its directly contributing subwatershed by 2.9 acres to achieve the target reduction in effective IC. MassDOT evaluated its property within the directly contributing watershed to Hawes Brook and found no existing BMPs or feasible areas to construct BMPs. The limited right-of-way, high development density, and limited area near the directly discharging stormwater outfalls make the implementation of BMPs infeasible.

Regarding the pathogen impairment of Hawes Brook, MassDOT has concluded, based on review of the draft North Coastal Watershed General MS4 permit; the draft Interstate, Merrimack, and South Coastal watershed permits, and pathogen TMDLs for Massachusetts waters; and the Final Bacteria TMDL for this impaired water body segment, that the BMPs outlined in MassDOT's stormwater management plan are consistent with its existing permit requirements. MassDOT believes that these measures achieve pathogen reductions (including fecal coliform) to the maximum extent practicable and are consistent with the intent of its existing stormwater permit and the applicable Pathogen TMDLs. As stated previously, pathogen loadings are highly variable and although there is potential for stormwater runoff from DOT roadways to be a contributing source it is unlikely to warrant action relative to other sources of pathogens in the watershed.

MassDOT will continue to identify opportunities to implement additional structural BMPs to address pollutant loading when road work is conducted under MassDOT's programmed projects initiative. Work on programmed projects, which often include broader scale road layout changes, may provide additional opportunities for construction of new treatment BMPs. This is consistent with an iterative adaptive management approach to addressing impairments. MassDOT will include an update in annual reports and biannual submittals to EPA regarding progress made towards meeting target IC reductions, plans for construction of additional BMPs, and finalized assessments including reductions achieved by finalized BMP designs. Furthermore, MassDOT will continue to implement non-structural BMPs that reduce the impacts of stormwater.

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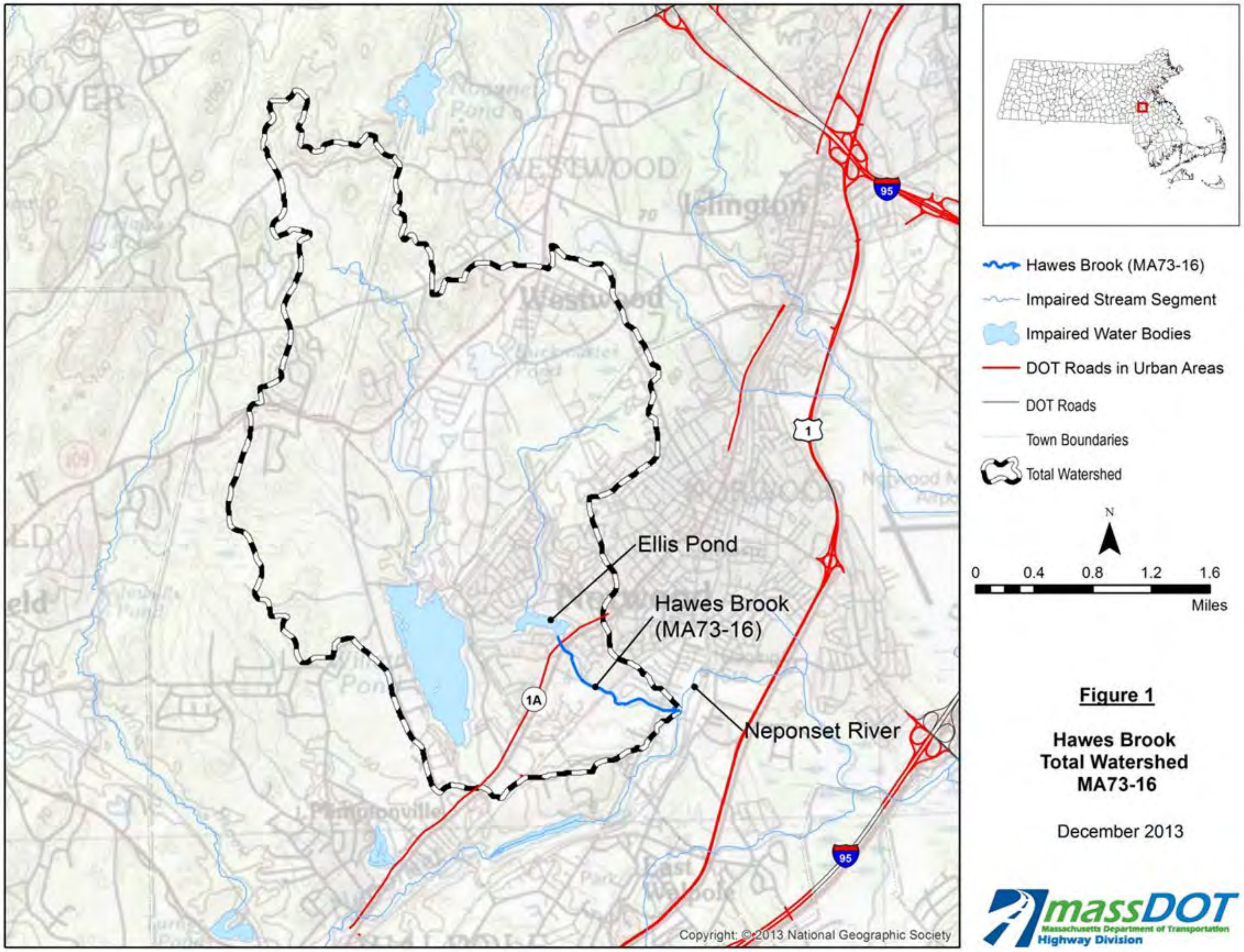

Figure 1

Hawes Brook Total Watershed MA73-16

December 2013

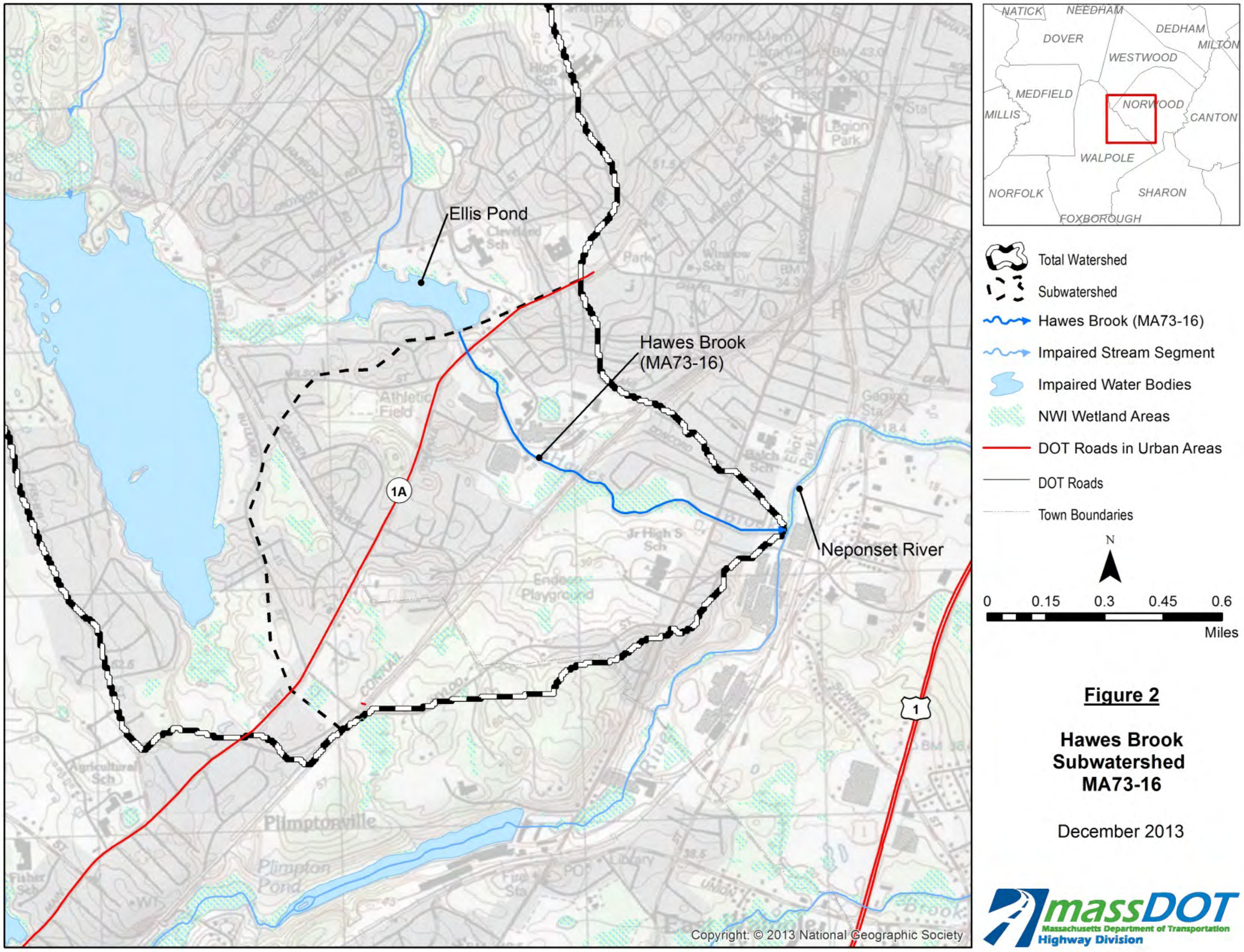

Figure 2

Hawes Brook Subwatershed MA73-16

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Highway Division

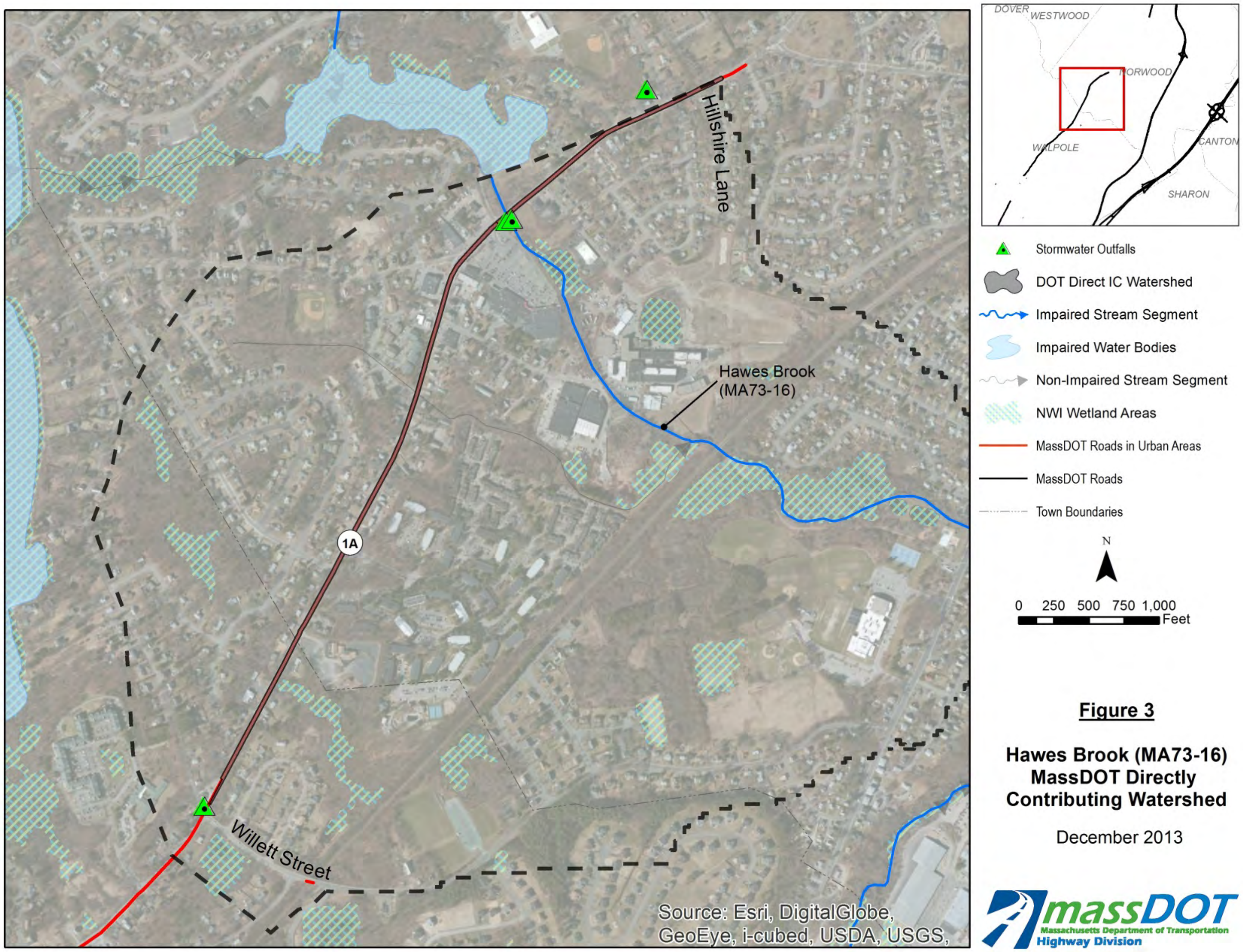

Figure 3

Hawes Brook (MA73-16)
MassDOT Directly
Contributing Watershed

December 2013

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Highway Division

Impaired Waters Assessment for Beaver Meadow Brook (MA73-20) – Final Report

Impaired Waterbody

Name: Beaver Meadow Brook

Location: Canton and Stoughton, MA

Water Body ID: MA73-20

Impairments

Beaver Meadow Brook (MA73-20) is listed under Category 5, "Waters Requiring a TMDL", on MassDEP's final *Massachusetts Year 2012 Integrated List of Waters* (MassDEP, 2013). Beaver Meadow Brook (MA73-20) is impaired for the following:

- dissolved oxygen

Beaver Meadow Brook (MA73-20) falls under the jurisdiction of MassDEP's *TMDLs of Bacteria for Neponset River Basin* (MassDEP, 2002). Beaver Meadow Brook (MA73-20) was impaired for fecal coliform based on MassDEP's final *Massachusetts Year 2010 Integrated List of Waters* (MassDEP, 2011); however, fecal coliform has since been removed from the list "based on new assessment" (MassDEP, 2013). According to MassDEP's *Neponset River Watershed 2004 Water Quality Assessment Report* (MassDEP, 2010), Beaver Meadow Brook (MA73-20) supports primary and secondary contact recreational uses.

Relevant Water Quality Standards

Water Body Classification: Class B

Applicable State Regulations:

- *314 CMR 4.05 (3)(b) 1 Dissolved Oxygen*. Shall not be less than 6.0 mg/l in cold water fisheries and not less than 5.0 mg/l in warm water fisheries. Where natural background conditions are lower, DO shall not be less than natural background conditions. Natural seasonal and daily variations that are necessary to protect existing and designated uses shall be maintained.

Site Description

Segment MA73-20 of the Beaver Meadow Brook begins at the outlet of Glenn Echo Pond in Stoughton and continues approximately 3.3 miles to the inlet of Bolivar Pond in Canton. Refer to Figure 1 for the total and subwatershed (which are the same) of Beaver Meadow Brook (MA73-20).

MassDOT's property directly contributing stormwater runoff to the Beaver Meadow Brook (MA73-20) is comprised of a portion of Rte 138 (Turnpike Street in Canton and Washington Street in Stoughton), as shown in Figure 2. The Rte 138 directly contributing area starts on Turnpike Street approximately 550 feet uphill of the brook, continues south to the brook then continues uphill approximately 650 feet. Runoff from this section of Rte 138 is collected in catch basins in the vicinity of the brook, which discharge via an outfall to the brook.

Rte 138 crosses over two non-impaired streams that merge with Beaver Meadow Brook (MA73-20). One of the streams is located approximately 1,400 feet north of Beaver Meadow Brook (where Beaver Meadow Brook crosses under Rte 138) and merges with the brook downsteam of Rte 138; the other stream is located approximately 1,000 feet south of Beaver Meadow Brook (where the brook crosses under Rte 138) and merges with Beaver Meadow Brook upstream of Rte 138 (see Figure 2). Neither stream is impaired and both streams flow through wetlands upstream of the confluence with Beaver Meadow Brook (Figure 2). Runoff from Rte 138 that drains to both stream segments is considered indirect drainage to Beaver Meadow Brook.

In the vicinity of Rte 138 in this area, MassDOT owns only Rte 138 and minimal to no property surrounding the roadway. The approach roadways are owned and operated by the respective towns.

Assessment under BMP 7U

The dissolved oxygen impairment listed for Beaver Meadow Brook is potentially linked to stormwater runoff and has not been addressed by a TMDL. Therefore, MassDOT assessed this impairment using the approach described in BMP 7U of MassDOT's Storm Water Management Plan (*Water Quality Impaired Waters Assessment and Mitigation Plan*), which applies to impairments that have been assigned to a water body prior to completion of a TMDL. As described in MassDOT's Application of Impervious Cover Method in BMP 7U (MassDOT, 2011), impervious cover (IC) provides a measure of the potential impact of stormwater on many impairments. For this water body, MassDOT used the IC method to assess the following impairments:

- dissolved oxygen

The following sections describe the methodology used by MassDOT to assess the one impairment potentially linked to stormwater that has not been addressed by a TMDL.

MassDOT's Application of the Impervious Cover Method

MassDOT's Application of Impervious Cover Method in BMP 7U applies many aspects of USEPA Region I's Impervious Cover Method described in EPA's *Stormwater TMDL Implementation Support Manual* (ENSR, 2006) to MassDOT's program. This method assesses potential stormwater impacts on the impaired water and evaluates the IC reduction necessary to attain the percent imperviousness in the watershed at which stormwater is not likely the cause of the impairments. Consistent with findings of EPA and others, when a watershed has less than 9% IC, MassDOT concludes that stormwater is not the likely cause of the impairment. Additional information regarding this method is provided in MassDOT's Application of IC Method document.

Assessment

First, MassDOT calculated the percent IC of the water body's entire contributing watershed (total watershed upstream of the downstream end of an impaired segment) and that of the local watershed contributing to the impaired segment (referred to as the subwatershed in this analysis) to determine whether stormwater has a potential to cause the impairments of the receiving water body. The total watershed and subwatershed to the impaired water body were delineated using the USGS Data Series 451. When USGS Data Series watersheds did not delineate the subwatershed of the water body under review, the GIS shapefiles were modified by delineating to the water body based on USGS topography to add specificity. IC data was available as part of the USGS data layers Data Series 451 and MassGIS's impervious surfaces data layer.

In cases where it was determined that stormwater was a potential cause of the impairment, MassDOT calculated the degree to which IC would need to be reduced in the subwatershed to meet the 9% IC target. This reduction was then applied proportionally to the area of MassDOT roadways/properties directly discharging to the water body segment to identify MassDOT's target IC reduction. The 9% IC reduction serves only as a recommended target and is not meant to imply that failing to meet the target would cause an exceedance in water quality standards. As explained in BMP 7U, MassDOT will consider a variety of factors apart from numeric guidelines, including site constraints and the magnitude of any potential exceedances in water quality standards, to determine the precise nature and extent of additional BMPs recommended for particular locations. This approach is consistent with the iterative, adaptive management BMP approach set forth in EPA guidelines.

MassDOT calculated the effective IC reduction afforded by the existing structural BMPs currently incorporated into the stormwater infrastructure of MassDOT's properties. This effective IC reduction was calculated by applying effective IC reduction rates to existing BMPs based on their size, function and contributing watershed. BMP performances were derived from EPA Region 1's *Stormwater Best Management Practices (BMP) Performance Analysis* report (EPA, 2010) and engineering judgment. More information on the approach used to calculate the effective IC reductions is described in BMP 7U. When the reduction in effective IC achieved by the existing BMPs was equal to or greater than the target reduction, no further measures were proposed. When this was not the case, MassDOT considered additional BMPs in order to meet the targeted reduction.

Using this approach, MassDOT derived the following site parameters for Beaver Meadow Brook:

Table 1. Site Parameters for Beaver Meadow Brook (MA73-20)

Type	Parameter	Quantity	Unit of Measure
Total and Subwatershed	Watershed Area	1,829	acres
Total and Subwatershed	Impervious Cover (IC) Area	328	acres
Total and Subwatershed	Percent Impervious	18.0	%
Total and Subwatershed	IC Area at 9% Goal	165	acres
Total and Subwatershed	Target Reduction% in IC	49.8	%
Reductions Applied	MassDOT's IC Area Directly Contributing to Impaired Segment	1.2	acres
Reductions Applied	MassDOT's Target Reduction in Effective IC (49.8% of DOT Directly Contributing IC)	0.6	acres

The subwatershed is greater than 9% impervious cover, indicating that stormwater likely contributes to the impairments assessed under this methodology. In order to reach the 9% target, effective IC within the subwatershed should be reduced by 49.8%. Therefore, MassDOT's target is to reduce effective IC within its own directly contributing watershed by the same percentage, or 0.6 acres.

Existing BMPs

Based on the site visit, there are no existing BMPs in the Beaver Meadow Brook directly contributing watershed that are mitigating potential stormwater quality impacts prior to discharge to Beaver Meadow Brook.

Mitigation Plan

Because there is no mitigation of impervious cover achieved by existing MassDOT BMPs to meet the target reduction of 0.6 acres, MassDOT considered the implementation of BMPs.

Conclusions

MassDOT used the IC Method to assess Beaver Meadow Brook for the impairments identified in MassDEP's final *Massachusetts Year 2012 Integrated List of Waters*. Results indicate that MassDOT should reduce its effective IC within its directly contributing subwatershed by 0.6 acres to achieve the targeted reduction in effective IC. MassDOT evaluated its property within the directly contributing watershed to Beaver Meadow Brook to identify existing BMPs and found that no BMPs exist to reduce effective IC. This information is summarized in Table 2 below.

Table 2. Effective IC Reductions under Existing &Proposed Conditions

Parameter	Quantity	Unit of Measure
IC Directly Contributing Watershed	1.2	acres
Target Reduction in Effective IC	0.6	acres
IC Effectively Reduced by Existing BMPs	0	Acres
IC Remaining to Mitigate with Proposed BMPs	0.6	acres

MassDOT should reduce its effective IC within the directly contributing watershed by 0.6 acres to achieve the targeted reduction in IC. However, the site constraints and limited right-of-way area indicate that the construction of stormwater infiltration BMPs along the directly contributing MassDOT roadways is infeasible. Therefore, no further action will be taken as part of the Retrofit Initiative of the MassDOT Impaired Waters program.

MassDOT will continue to identify opportunities to implement additional structural BMPs to address pollutant loading when road work is conducted under MassDOT's programmed projects initiative. Work on programmed projects, which often include broader scale road layout changes, may provide additional opportunities for construction of new treatment BMPs. This is consistent with an iterative adaptive management approach to addressing impairments. MassDOT will include an update in annual reports and biannual submittals to EPA regarding progress made towards meeting target IC reductions, plans for construction of additional BMPs, and finalized assessments including reductions achieved by finalized BMP designs. MassDOT will also continue to implement non-structural BMPs that reduce the impacts of stormwater.

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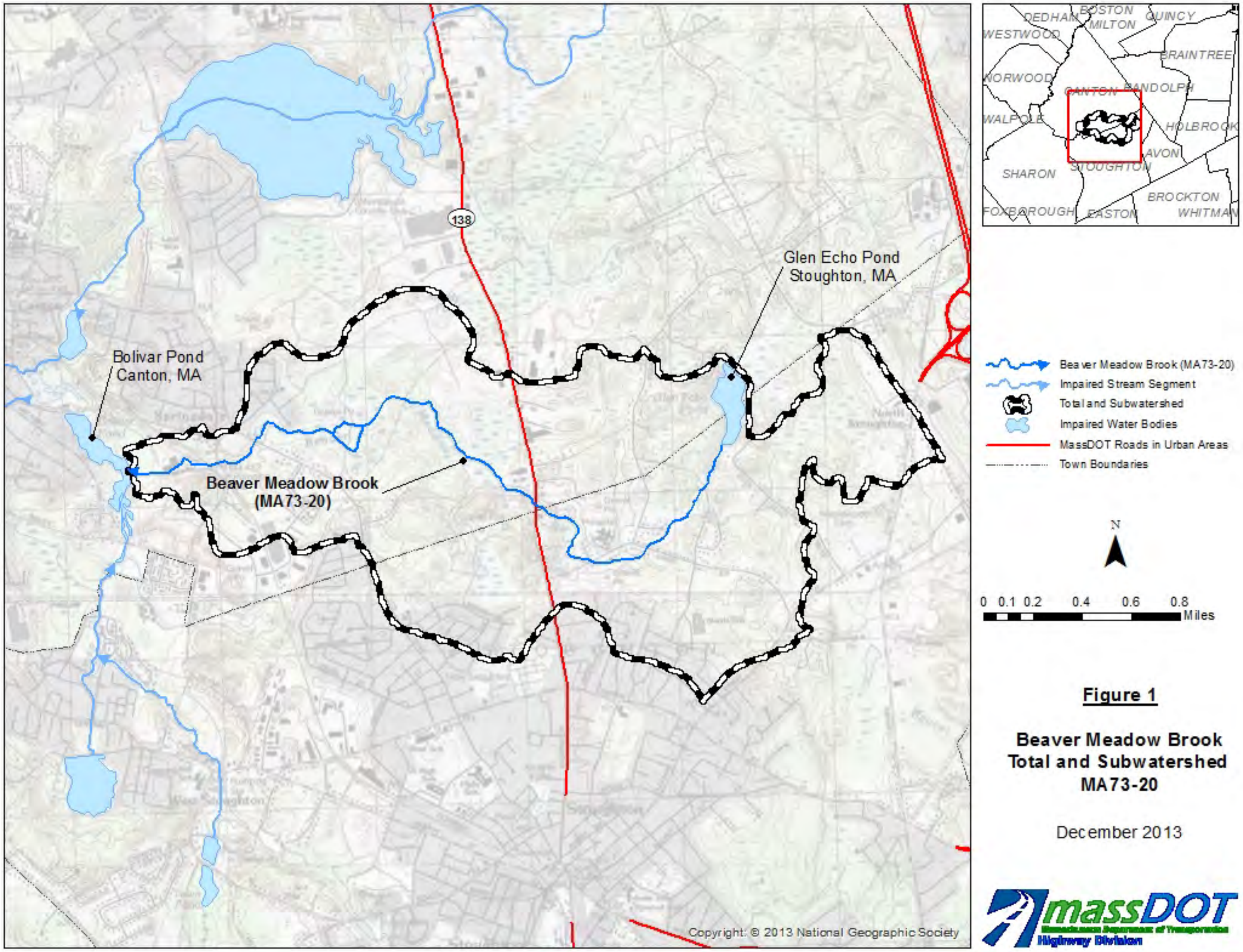

Figure 1

Beaver Meadow Brook Total and Subwatershed MA73-20

December 2013

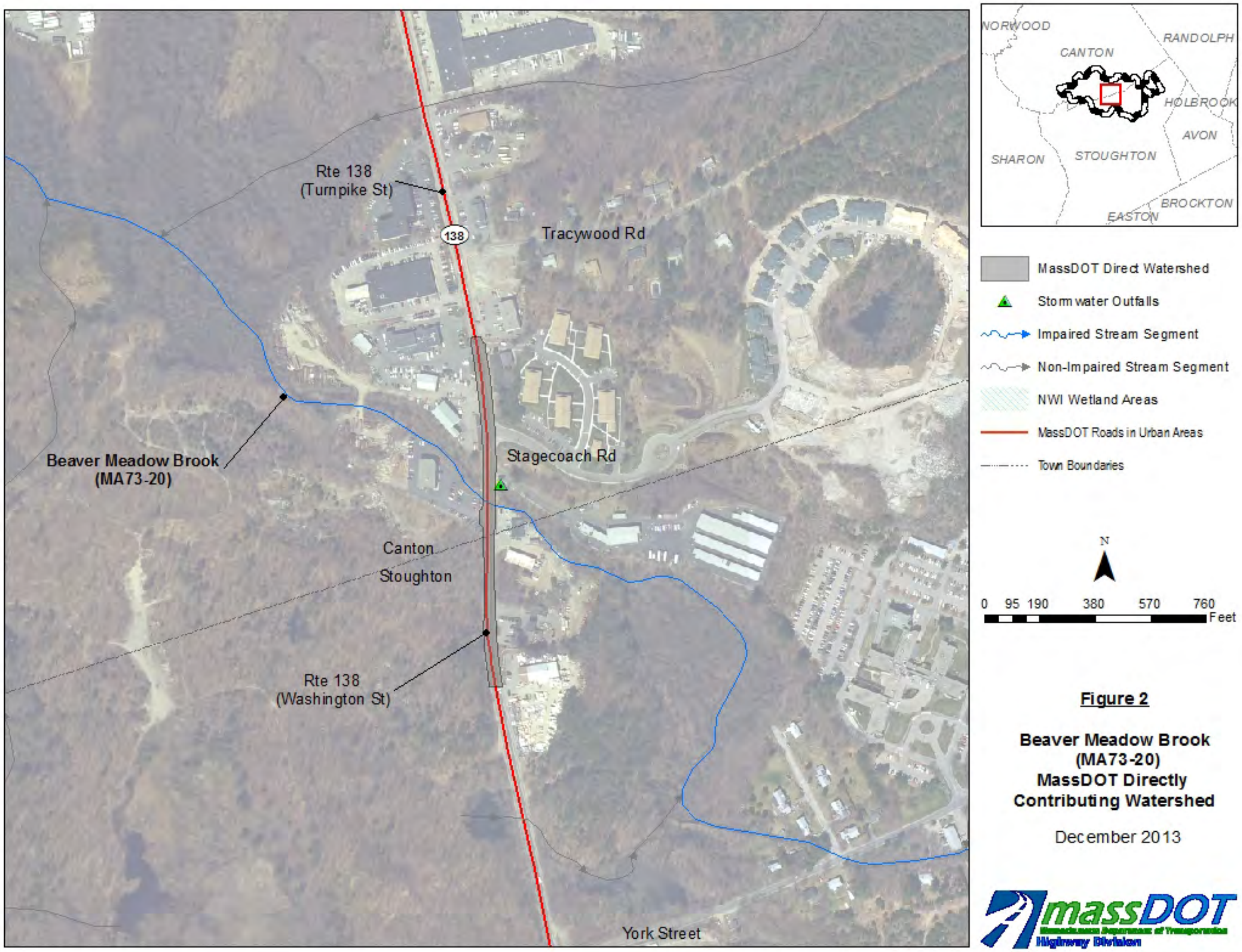

Figure 2

Beaver Meadow Brook (MA73-20) MassDOT Directly Contributing Watershed

December 2013

12/08/2013

Impaired Waters Assessment for Town River Bay (MA74-15) – Final Report

Impaired Water Body

Name: Town River Bay

Location: Quincy, MA

Water Body ID: MA74-15

Impairments

Town River Bay (MA74-15) is listed under Category 5, "Waters Requiring a TMDL", on MassDEP's final *Massachusetts Year 2012 Integrated List of Waters* (MassDEP, 2013). Town River Bay is impaired for the following:

- Fecal Coliform
- Oxygen, Dissolved
- PCB in Fish Tissue
- Other (Not Specified)

According to MassDEP's *Weymouth and Weir River Basin 2004 Water Quality Assessment Report* (MassDEP, 2010), Town River Bay is a 0.46 square mile body of water, covering the area from the headwaters at the Route 3A bridge in Quincy to the mouth at Weymouth Fore River between Shipyard and Germantown Points, in Quincy. Town River Bay is impaired for PCB, fecal coliform, and dissolved oxygen from possible causes such as unspecified urban stormwater and other unknown sources.

Town River Bay is included in the Draft Pathogen TMDL Report for the Boston Harbor Watershed (MassDEP, no date).

Sprague Energy has a National Pollutant Discharge Elimination Permit (NPDES) to discharge treated stormwater to Town River Bay from outfall 001.

Relevant Water Quality Standards

Water Body Classification: Class SB, Shellfishing

Applicable State Regulations:

- 314 CMR 4.05 (4)(b) 4 Bacteria.
  a. Waters designated for shellfishing shall not exceed a fecal coliform median or geometric mean MPN of 88 organisms per 100 ml, nor shall more than 10% of the samples exceed an MPN of 260 per 100 ml or other values of equivalent protection based on sampling and

analytical methods used by the Massachusetts Division of Marine Fisheries and approved by the National Shellfish Sanitation Program in the latest revision of the Guide For The Control of Molluscan Shellfish (more stringent regulations may apply, see 314 CMR 4.06(1)(d)(5));
b. at bathing beaches as defined by the Massachusetts Department of Public Health in 105 CMR 445.010, no single enterococci sample taken during the bathing season shall exceed 104 colonies per 100 ml and the geometric mean of the five most recent samples taken within the same bathing season shall not exceed 35 enterococci colonies per 100 ml. In non bathing beach waters and bathing beach waters during the non bathing season, no single enterococci sample shall exceed 104 colonies per 100 ml and the geometric mean of all of the samples taken during the most recent six months typically based on a minimum of five samples shall not exceed 35 enterococci colonies per 100 ml. These criteria may be applied on a seasonal basis at the discretion of the Department;

- 314 CMR 4.05 (4)(b) 1 Dissolved Oxygen. Shall not be less than 5.0 mg/l. Seasonal and daily variations that are necessary to protect existing and designated uses shall be maintained. Where natural background conditions are lower, DO shall not be less than natural background.

- 314 CMR 4.05 (5)(e) Toxic Pollutants. All surface waters shall be free from pollutants in concentrations or combinations that are toxic to humans, aquatic life or wildlife. For pollutants not otherwise listed in 314 CMR 4.00, the National Recommended Water Quality Criteria: 2002, EPA 822R-02-047, November 2002 published by EPA pursuant to Section 304(a) of the Federal Water Pollution Control Act, are the allowable receiving water concentrations for the affected waters, unless the Department either establishes a site specific criterion or determines that naturally occurring background concentrations are higher. Where the Department determines that naturally occurring background concentrations are higher, those concentrations shall be the allowable receiving water concentrations. The Department shall use the water quality criteria for the protection of aquatic life expressed in terms of the dissolved fraction of metals when EPA's 304(a) recommended criteria provide for use of the dissolved fraction. The EPA recommended criteria based on total recoverable metals shall be converted to dissolved metals using EPA's published conversion factors. Permit limits will be written in terms of total recoverable metals. Translation from dissolved metals criteria to total recoverable metals permit limits will be based on EPA's conversion factors or other methods approved by the Department. The Department may establish site specific criteria for toxic pollutants based on site specific considerations.

Site Description

Town River Bay (MA74-15) covers an 0.46 square miles, stretching from its headwaters at the Route 3A bridge in Quincy to the mouth at the Weymouth Fore River between Shipyard and Germantown Points, in Quincy. The headwaters are located at the confluence of Town Brook and Town River Bay (MA74-15). Town Brook is also classified impaired according to the Weymouth and Weir River Basin 2010 Water Quality Assessment Report, but is not the subject of this assessment.

Figure 1 shows the total watershed and Figure 2 shows the subwatershed. The total watershed contains portions of I-93, Route 3, Burgin Parkway, Washington Street bridge (in Braintree), North Main Street (in Randolph), Randolph Avenue (in Quincy), Ponkapoag Trail Bridge (in Milton), and Route 24. MassDOT roadways in the subwatershed include portions of I-93, Route 3, Granite Street (in Braintree), and the Washington Street bridge (in Braintree). The subwatershed also includes Town Brook (MA74-09) and Old Quincy Reservoir (MA7401), both of which are impaired, but not the subject of this assessment. The MassDOT owned roadways in the subwatershed discharge directly to Town Brook (MA74-09), which drains into Town River Bay (MA74-15), with the exception of the Route 3A Bridge. This MassDOT property crosses over the headwaters of Town River Bay and drains directly to it (See Figure 3).

Assessment under BMP 7U

None of the impairments for Upper Mystic Lake have been addressed by a TMDL. MassDOT assessed the impairments using the approach described in BMP 7U of MassDOT's Storm Water Management Plan (*Water Quality Impaired Waters Assessment and Mitigation Plan*), which applies to impairments that have been assigned to a water body prior to completion of a TMDL. As described in MassDOT's Application of Impervious Cover Method in BMP 7U (MassDOT, 2011), impervious cover (IC) provides a measure of the potential impact of storm water on many impairments. For this water body, MassDOT used the IC method to assess the following impairments:

- Fecal Coliform
- Oxygen, Dissolved
- PCB in Fish Tissue
- Other (Not Specified)

The non-native plants impairment is not addressed in this assessment as this impairment is considered a non-pollutant and unrelated to stormwater according to the *final Massachusetts Year 2012 Integrated List of Waters*. Therefore, MassDOT has determined that further assessment of this impairment for the water bodies is not required under BMP 7U.

MassDOT's Application of the Impervious Cover Method

MassDOT's Application of Impervious Cover Method in BMP 7U applies many aspects of USEPA Region I's Impervious Cover Method described in EPA's *Stormwater TMDL Implementation Support Manual* (ENSR, 2006) to MassDOT's program. This method assesses potential stormwater impacts on the impaired water and evaluates the IC reduction necessary to attain the percent imperviousness in the watershed at which stormwater is not likely the cause of the impairments. Consistent with findings of EPA and others, when a watershed has less than 9% IC, MassDOT concludes that stormwater is not the likely cause of the impairment. Additional information regarding this method is provided in MassDOT's Application of IC Method document.

Assessment

First, MassDOT calculated the percent IC of the water body's entire contributing watershed (total watershed upstream of the downstream end of an impaired segment) and that of the local watershed contributing to the impaired segment (referred to as the subwatershed in this analysis) to determine whether stormwater has a potential to cause the impairments of the receiving water body. The total watershed and subwatershed to the impaired water body were delineated using the USGS Data Series 451. When USGS Data Series watersheds did not delineate the subwatershed of the water body under review, the GIS shapefiles were modified by delineating to the water body based on USGS topography to add specificity. IC data was available as part of the USGS data layers Data Series 451 and MassGIS's impervious surfaces data layer.

In cases where it was determined that stormwater was a potential cause of the impairment, MassDOT calculated the degree to which IC would need to be reduced in the subwatershed to meet the 9% IC target. This reduction was then applied proportionally to the area of MassDOT roadways/properties directly discharging to the water body segment to identify MassDOT's target IC reduction. The 9% IC reduction serves only as a recommended target and is not meant to imply that failing to meet the target would cause an exceedance in water quality standards. As explained in BMP 7U, MassDOT will consider a variety of factors apart from numeric guidelines, including site constraints and the magnitude of any potential exceedances in water quality standards, to determine the precise nature and extent of additional BMPs recommended for particular locations. This approach is consistent with the iterative, adaptive management BMP approach set forth in EPA guidelines.

MassDOT calculated the effective IC reduction afforded by the existing structural BMPs currently incorporated into the stormwater infrastructure of MassDOT's properties. This effective IC reduction was calculated by applying effective IC reduction rates to existing BMPs based on their size, function and contributing watershed. BMP performances were derived from EPA Region 1's *Stormwater Best Management Practices (BMP) Performance Analysis* report (EPA, 2010) and engineering judgment. More information on the approach used to calculate the effective IC reductions is described in BMP 7U. When the reduction in effective IC achieved by the existing BMPs was equal to or greater than the target reduction, no further measures were proposed. When this was not the case, MassDOT considered additional BMPs in order to meet the targeted reduction.

Using this approach, MassDOT derived the following site parameters for Town River Bay (MA74-15):

Table 1. Site Parameters for Town River Bay (MA74-15)

Type	Parameter	Quantity	Unit of Measure
Total Watershed	Watershed Area	12,561	acres
Total Watershed	Impervious Cover (IC) Area	3,367	acres
Total Watershed	Percent Impervious	26.8	%
Subwatershed	Subwatershed Area	3,760	acres
Subwatershed	Impervious Cover (IC) Area	1,466	acres
Subwatershed	Percent Impervious	39.0	%
Subwatershed	IC Area at 9% Goal	338.4*	acres
Subwatershed	Target Reduction% in IC	76.9	%
Reductions Applied	MassDOT's IC Area Directly Contributing to Impaired Segment	0.08	acres
Reductions Applied	MassDOT's Target Reduction in Effective IC (76.9% of DOT Directly Contributing IC)	0.07*	acres

*Rounding accounts for differences in calculations.

The subwatershed is greater than 9% impervious cover, indicating that stormwater likely contributes to the impairments assessed under this methodology. In order to reach the 9% target, effective IC within the subwatershed should be reduced by76.9%. Therefore, MassDOT's target is to reduce effective IC within its own directly contributing watershed by the same percentage, or 0.07 acres.

Existing BMPs

Based on the site visit, there are no existing BMPs in the Town River Bay (MA74-15) directly contributing watershed that are mitigating potential stormwater quality impacts prior to discharge to Town River Bay (MA74-15).

Mitigation Plan

Based on the review of MassDOT's directly contributing drainage area, no BMPs have been identified that can be implemented on MassDOT property to address the impairments of Town River Bay due to site constraints. The Route 3A Bridge is owned by MassDOT, but the roadways on either side of the bridges are not owned by MassDOT. Therefore, there is no land available to implement stormwater infiltration BMPs to mitigate the effect of the bridge stormwater runoff.

Conclusions

MassDOT should reduce its effective IC within the directly contributing watershed by an additional 0.065 acres to achieve the targeted reduction in IC. However, the site constraints and limited right-of-way area indicate that the construction of stormwater infiltration BMPs along the directly contributing MassDOT roadways is infeasible. Therefore, no further action will be taken as part of the Retrofit Initiative of the MassDOT Impaired Waters program.

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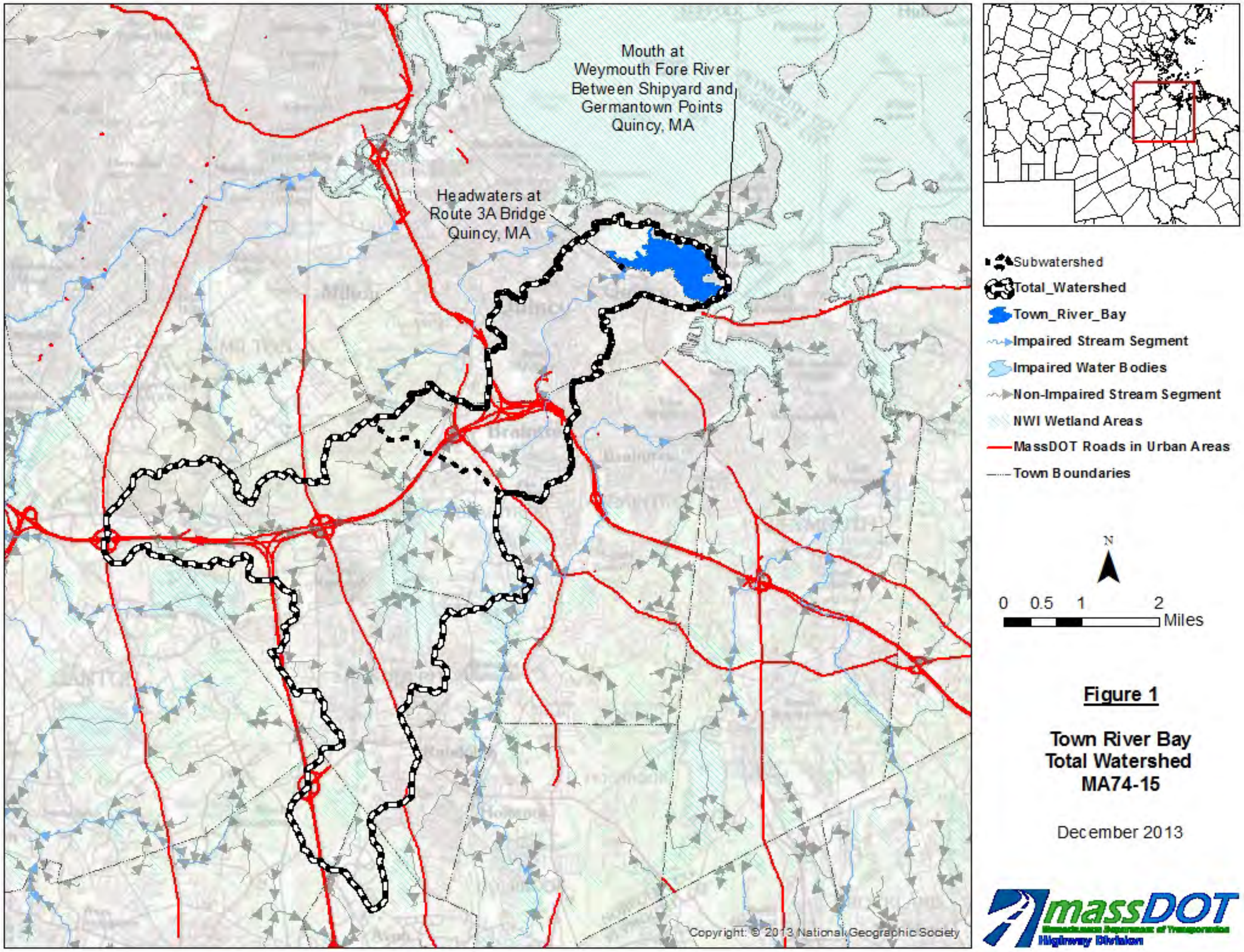

Figure 1

Town River Bay
Total Watershed
MA74-15

December 2013

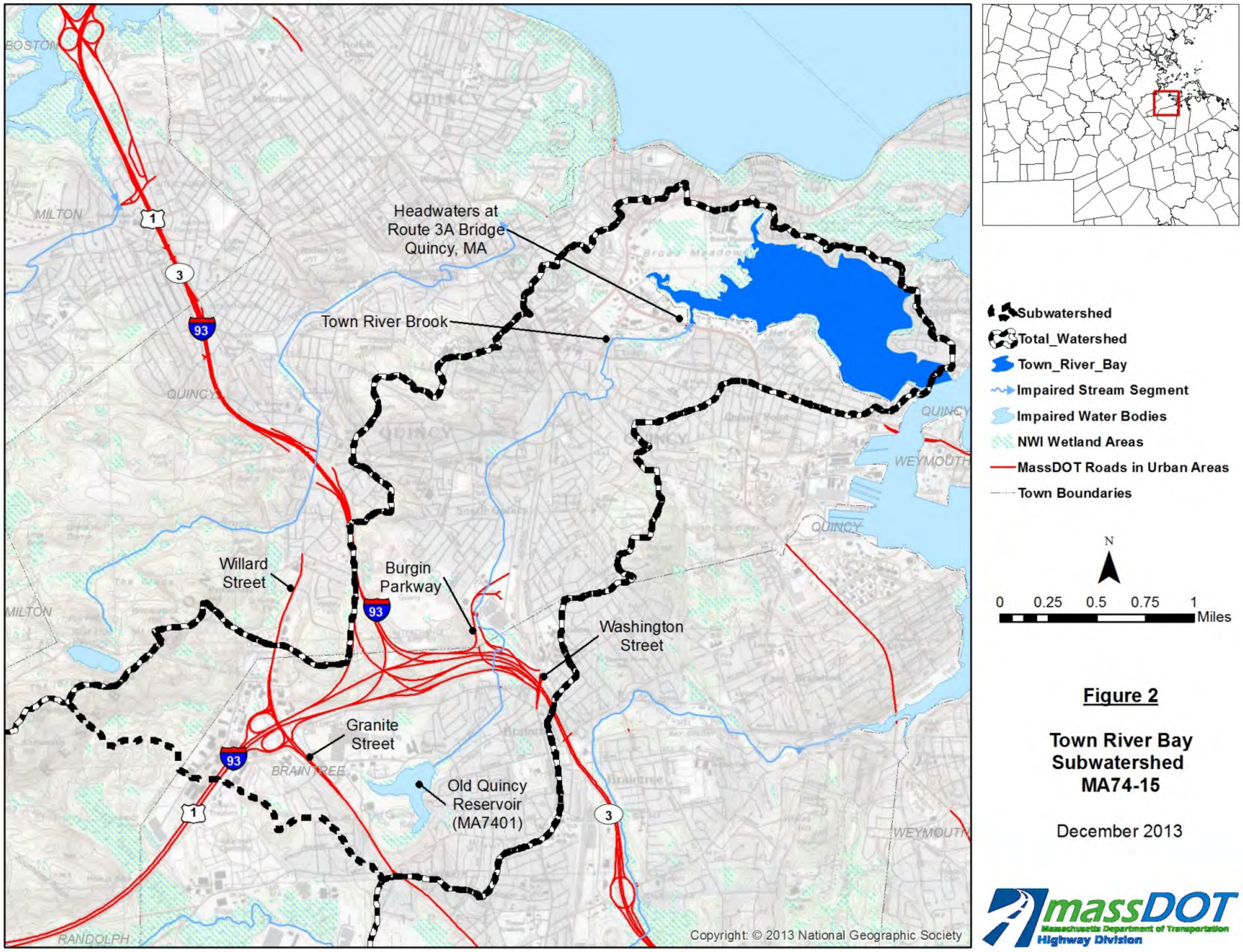

Figure 2

Town River Bay Subwatershed MA74-15

December 2013

Figure 3

Town River Bay
MA74-15
MassDOT Directly Contributing Watershed

December 2013

Impaired Waters Assessment for North Nashua River (MA81-02)

Impaired Water Body

Name: North Nashua River

Location: Fitchburg and Leominster, Massachusetts

Water Body ID: MA81-02

Impairments

The North Nashua River (MA81-02) is listed under Category 5, "Waters Requiring a TMDL", on MassDEP's Final *Massachusetts Year 2012 Integrated List of Waters* (MassDEP, 2013). The causes for the North Nashua River impairment are listed as the following:

- Ambient Bioassays – Chronic Aquatic Toxicity
- Aquatic Macroinvertebrate Bioassessments
- Escherichia coli

According to the MassDEP's *Nashua River Watershed 2003 Water Quality Assessment Report* (MassDEP, 2008) the North Nashua River (MA81-02) is impaired for the aquatic life use due to aquatic macroinvertibrate bioassessments and ambient bioassay – chronic toxicity and is impaired for the primary contact recreation use and secondary contact recreation use due to Escherichia coli. The North Nashua River (MA81-02) is also covered by a Draft Total Maximum Daily Load (TMDL) for Pathogens according to MassDEP's *Draft Pathogen TMDL for the Nashua River Watershed* (MassDEP, No Date) and as part of a protective Draft TMDL for the Nutrient Phosphorus according to *MassDEP's Draft Nashua River, Massachusetts Total Maximum Daily Load for the Nutrient Phosphorus* (MassDEP, 2007).

Relevant Water Quality Standards

Water Body Classification: Class B

Applicable State Regulations:

- *314 CMR 4.05 (4)(b) 1. Dissolved Oxygen*. Shall not be less than 5.0 mg/l. Seasonal and daily variations that are necessary to protect existing and designated uses shall be maintained. Where natural background conditions are lower, DO shall not be less than natural background.
- *314 CMR 4.05 (4)(b) 2. Temperature*.
    - a. Shall not exceed 68°F (20°C) based on the mean of the daily maximum temperature over a seven day period in cold water fisheries, unless naturally occurring. Where a reproducing cold water aquatic community exists at a naturally occurring higher temperature, the temperature necessary to protect the community shall not be exceeded and the natural daily and seasonal

temperature fluctuations necessary to protect the community shall be maintained. Temperature shall not exceed 83°F (28.3°C) in warm water fisheries. The rise in temperature due to a discharge shall not exceed 3°F (1.7°0C) in rivers and streams designated as cold water fisheries nor 5°F (2.8°C) in rivers and streams designated as warm water fisheries (based on the minimum expected flow for the month); in lakes and ponds the rise shall not exceed 3°F (1.7°0C) in the epilimnion (based on the monthly average of maximum daily temperature);

  - b. Natural seasonal and daily variations that are necessary to protect existing and designated uses shall be maintained. There shall be no changes from natural background conditions that would impair any use assigned to this Class, including those conditions necessary to protect normal species diversity, successful migration, reproductive functions or growth of aquatic organisms;

- *314 CMR 4.05 (4)(b) 3. pH*. Shall be in the range of 6.5 through 8.5 standard units and not more than 0.2 units outside of the natural background range. There shall be no change from natural background conditions that would impair any use assigned to this Class.
- *314 CMR 4.05 (4)(b) 4. Bacteria*.
  - a. At bathing beaches as defined by the Massachusetts Department of Public Health in 105 CMR 445.010: where E. coli is the chosen indicator, the geometric mean of the five most recent samples taken during the same bathing season shall not exceed 126 colonies per 100 ml and no single sample taken during the bathing season shall exceed 235 colonies per 100 ml; alternatively, where enterococci are the chosen indicator, the geometric mean of the five most recent samples taken during the same bathing season shall not exceed 33 colonies per 100 ml and no single sample taken during the bathing season shall exceed 61 colonies per 100 ml;
  - b. For other waters and, during the non bathing season, for waters at bathing beaches as defined by the Massachusetts Department of Public Health in 105 CMR 445.010: the geometric mean of all E. coli samples taken within the most recent six months shall not exceed 126 colonies per 100 ml typically based on a minimum of five samples and no single sample shall exceed 235 colonies per 100 ml; alternatively, the geometric mean of all enterococci samples taken within the most recent six months shall not exceed 33 colonies per 100 ml typically based on a minimum of five samples and no single sample shall exceed 61 colonies per 100 ml. These criteria may be applied on a seasonal basis at the discretion of the Department;
- *314 CMR 4.05 (4)(b) 5. Solids*. These waters shall be free from floating, suspended and settleable solids in concentrations or combinations that would impair any use assigned to this class, that would cause aesthetically objectionable conditions, or that would impair the benthic biota or degrade the chemical composition of the bottom.
- *314 CMR 4.05 (5)(b) Bottom Pollutants or Alterations*. All surface waters shall be free from pollutants in concentrations or combinations or from alterations that adversely affect the physical or chemical nature of the bottom, interfere with the propagation of fish or shellfish, or adversely affect populations of non-mobile or sessile benthic organisms.
- *314 CMR 4.05 (5)(e) Toxic Pollutants*. All surface waters shall be free from pollutants in concentrations or combinations that are toxic to humans, aquatic life or wildlife. For pollutants not otherwise listed in 314 CMR 4.00, the *National Recommended Water Quality Criteria: 2002, EPA 822R-02-047, November 2002* published by EPA pursuant to Section 304(a) of the Federal Water Pollution Control Act, are the allowable receiving water concentrations for the affected waters, unless the Department either establishes a

site specific criterion or determines that naturally occurring background concentrations are higher. Where the Department determines that naturally occurring background concentrations are higher, those concentrations shall be the allowable receiving water concentrations. The Department shall use the water quality criteria for the protection of aquatic life expressed in terms of the dissolved fraction of metals when EPA's 304(a) recommended criteria provide for use of the dissolved fraction. The EPA recommended criteria based on total recoverable metals shall be converted to dissolved metals using EPA's published conversion factors. Permit limits will be written in terms of total recoverable metals. Translation from dissolved metals criteria to total recoverable metals permit limits will be based on EPA's conversion factors or other methods approved by the Department. The Department may establish site specific criteria for toxic pollutants based on site specific considerations.

Site Description

The North Nashua River (MA81-02) segment originates at the Fitchburg Paper Company Dam #1 in the City of Fitchburg, Massachusetts and flows southeast for 6.9 miles to the Fitchburg East WWTP outfall in the City of Leominster, Massachusetts. The North Nashua River (MA81-02) segment subwatershed, delineated as the portion of the watershed draining directly to the North Nashua River, is approximately 6,362 acres, of which approximately 1,862 acres are impervious surface. MassDOT property in the North Nashua River (MA81-02) segment subwatershed includes portions of Route 2, Route 12, and various bridges (See Figure 1).

Throughout Fitchburg MassDOT owns and maintains numerous bridges along local roadways within the subwatershed of the North Nashua River (MA81-02) segment. These bridges total approximately 1.6 acres of roadway which are either discharged into the municipal stormwater infrastructure systems and conveyed to the North Nashua River or are collected by scuppers and discharged via downspouts directly into the North Nashua River (See Figure 2).

The Route 2 North Main Street (Route 12) interchange is currently under construction as part of the *Bridge Superstructure Replacement Project Route 12 (North Main Street) over Route 2.* The project incorporates the realignment of all on and off ramps to and from Route 2. Both the calculations and the proposed BMP descriptions provided in this document that represent MassDOT's IC area directly contributing to North Nashua River account for the final build out conditions of the ongoing construction project.

North of the Route 2 North Main Street (Route 12) interchange and east of Route 12 is a MassDOT stormwater outfall. Approximately 18.7 acres of Route 2 and Route 12 are collected by a series of numerous catch basins and drainage ditches. The collected stormwater is then conveyed to the MassDOT stormwater outfall where flows are directly discharged to the North Nashua River (See Figure 3)

Assessment under BMP 7U

None of the following impairments for the North Nashua River (MA81-02) have been addressed by a TMDL. Therefore, MassDOT assessed this impairment using the approach described in BMP 7U of MassDOT's *Storm Water Management Plan (Water Quality Impaired Waters Assessment and Mitigation Plan)*, which applies to impairments that have been assigned to a water body prior to completion of a TMDL. As described in MassDOT's *Application of Impervious Cover Method in BMP 7U* (MassDOT, 2011), impervious cover (IC) provides a measure of the potential impact to stormwater on many impairments. For this water body, MassDOT used the IC method to assess the following impairments:

- Ambient Bioassays – Chronic Aquatic Toxicity
- Aquatic Macroinvertebrate Bioassessments

The impairment for Escherichia coli is assessed separately in the section titled, Assessment of Pathogen Impairment.

MassDOT's Application of the Impervious Cover Method

MassDOT's *Application of Impervious Cover Method in BMP 7U* applies many aspects of the United States Environmental Protection Agency (USEPA) Region I's Impervious Cover (IC) Method described in EPA's *Stormwater TMDL Implementation Support Manual* (ENSR, 2006) to MassDOT's program. This method assesses potential stormwater impacts on the impaired water and evaluates the IC reduction necessary to attain the percent imperviousness in the watershed at which stormwater is not likely the cause of the impairments. Consistent with the findings of EPA and others, when a watershed has less than 9% IC, MassDOT concludes that stormwater is not the likely cause of the impairment. Additional information regarding this method is provided under MassDOT's Application of the IC Method document.

Assessment

First, MassDOT calculated the percent IC of the water body's entire contributing watershed (total watershed upstream of the downstream end of an impaired segment) and that of the local watershed contributing to the impaired segment (referred to as the subwatershed in this analysis) to determine whether stormwater has a potential to cause the impairments of the receiving water body. The total watershed and subwatershed to the impaired water body were delineated using the USGS Data Series 451. When USGS Data Series watersheds did not delineate the subwatershed of the water body under review, the GIS shapefiles were modified by delineating to the water body based on USGS topography to add specificity. IC data was available as part of the USGS data layers Data Series 451 and MassGIS's impervious surfaces data layer. In cases where it was determined that stormwater was a potential cause of the impairment, MassDOT calculated the degree to which IC would need to be reduced in the subwatershed to meet the 9% IC target. This reduction was then applied proportionally to the area of MassDOT roadways/properties directly discharging to the water body segment to identify MassDOT's target IC reduction. The 9% IC reduction serves only as a recommended target and is not meant to imply that failing to meet the target would cause an exceedance in water quality standards. As explained in BMP 7U, MassDOT will consider a variety of factors apart from numeric guidelines, including site constraints and the magnitude of any potential exceedances in water quality standards, to determine the precise nature and extent of additional BMPs recommended for particular locations. This approach is consistent with the iterative, adaptive management BMP approach set forth in EPA guidelines.

MassDOT calculated the effective IC reduction afforded by the existing structural BMPs currently incorporated into the stormwater infrastructure of MassDOT's properties. This effective IC reduction was calculated by applying effective impervious cover reduction rates to existing BMPs based on their size, function and contributing watershed. BMP performances were derived from EPA Region 1's *Stormwater Best Management Practices (BMP) Performance Analysis* report (EPA, 2010) and engineering judgment. More information on the approach used to calculate the effective impervious cover reductions is described in BMP 7U. When the reduction in effective impervious cover achieved by the existing BMPs was equal to or greater than the target reduction, no further measures were proposed. When this was not the case, MassDOT considered additional BMPs in order to meet the targeted reduction.

Using this approach, MassDOT derived the following site parameters for the North Nashua River (MA81-02):

Type	Parameter	Quantity	Unit
Subwatershed	Subwatershed Area	6,362	acres
Subwatershed	Impervious Cover (IC) Area	1,862	acres
Subwatershed	Percent Impervious	29.3	%
Subwatershed	IC Area at 9% Goal	573	acres
Subwatershed	Necessary Reduction % in IC	69.3	%
Reductions Applied to MassDOT Direct Watershed	MassDOT's IC Area Directly Contributing to Impaired Segment	20.6	acres
Reductions Applied to MassDOT Direct Watershed	MassDOT's Target Reduction in Effective IC (69.3% of MassDOT Directly Contributing IC)	14.3	acres

The subwatershed to North Nashua River (MA81-02) is greater than 9% impervious cover which indicates that stormwater likely contributes to the impairments assessed under this methodology. In order to reach the 9% target, effective IC within the subwatershed should be reduced by 69.3%. Therefore, MassDOT's target is to reduce effective IC within its own directly contributing watershed by the same percentage, or 14.3 acres.

Existing BMPs

There are no existing BMPs associated with the directly contributing watershed of North Nashua River (MA81-02) that are mitigating potential stormwater quality impacts prior to discharge to the North Nashua River.

Mitigation Plan

Since there are no MassDOT existing BMPs providing mitigation of impervious surface to achieve the target of 14.3 acres, MassDOT considered locations for additional BMPs. In total, four BMPs have been considered, all of which are infiltration basins with sediment forebays.

BMP-1: The grass area between the Route 2 eastbound travel lanes, the Route 2 eastbound off ramp to Route 12, and the Route 12 southbound on ramp to Route 2 eastbound could be modified to accommodate an infiltration basin (See Figure 4). Modifications would include minor adjustments to the existing drainage infrastructure outside of the pavement limits for the construction of a sediment forebay and infiltration basin. Natural Resources and Conservation Services (NRCS) soil data indicates soils in the area are Urban Land and are adjacent to HSG A soils. Further investigation of the soils will be completed to determine the adequacy of the area to infiltrate stormwater. Installing a BMP at this location would reduce the overall effective impervious cover by 0.30 acres.

BMP-2: The grass infield area of the Route 12 southbound on ramp to Route 2 eastbound could be modified to accommodate an infiltration basin (See Figure 4). Modifications would include minor adjustments to the existing drainage infrastructure outside of the pavement limits for the construction of a sediment forebay and infiltration basin. NRCS soil data indicates soils in the area are Urban Land and are adjacent to HSG A soils. Further investigation of the soils will be completed to determine the adequacy of the area to infiltrate stormwater. Installing a BMP at this location would reduce the overall effective impervious cover by 0.50 acres.

BMP-3: The grass infield area of the on ramp from Route 2 westbound to Route 12 northbound could be modified to accommodate an infiltration basin (See Figure 4). Modifications would include minor adjustments to the existing drainage infrastructure outside of the pavement limits for the construction of a sediment forebay and infiltration basin. NRCS soil data indicates soils in the area are Urban Land and are adjacent to HSG A soils. Further investigation of the soils will be completed to determine the adequacy of the area to infiltrate stormwater. Installing a BMP at this location would reduce the overall effective impervious cover by 0.59 acres.

BMP-4: The grass infield area of the Route 12 northbound on ramp to Route 2 westbound could be modified to accommodate an infiltration basin (See Figure 4). Modifications would include minor adjustments to the existing drainage infrastructure outside of the pavement limits for the construction of a sediment forebay and infiltration basin. NRCS soil data indicates soils in the area are Urban Land and are adjacent to HSG A soils. Further investigation of the soils will be completed to determine the adequacy of the area to infiltrate stormwater. Installing a BMP at this location would reduce the overall effective impervious cover by 0.89 acres.

BMP Name	BMP Type	NRCS Hydrologic Soil Group	Storage Volume (inches)	IC Area Treated (acres)	Percent Reduction of Effective IC *	Reduction of Effective IC (acres)
BMP-1	Infiltration Basin	A	1.0	0.31	96%	0.30
BMP-2	Infiltration Basin	A	1.0	0.52	96%	0.50
BMP-3	Infiltration Basin	A	1.0	0.61	96%	0.59
BMP-4	Infiltration Basin	A	1.0	0.93	96%	0.89
Total				**2.37**		**2.28**

*Description of MassDOT's *Application of Impervious Cover Method in BMP 7U (MassDOT Application of IC Method, MassDOT 2011)*.

Assessment of Pathogen Impairment under BMP 7U

MassDOT assessed the pathogen impairment using the approach described in BMP 7U of MassDOT's *Storm Water Management Plan (Water Quality Impaired Waters Assessment and Mitigation Plan)*, which applies to impairments that have been assigned to a water body prior to completion of a TMDL. Pathogen concentrations in stormwater vary widely temporally and spatially; concentrations can vary by an order of magnitude within a given storm event at a single location (MassDEP, 2009b). Therefore, it is difficult to predict pathogen concentrations in stormwater with accuracy. Due to this difficulty, MassDOT generally will not conduct site specific assessments of loading at each location impaired for pathogens. Instead these sites are assessed based on available information on pathogen loading from highways, MassDOT actions, and information available from EPA and DEP. Based on this information MassDOT developed an approach to be consistent with relevant TMDL and permit condition requirements and an iterative adaptive management approach to stormwater management.

In addition, while there is a positive relationship between IC and pathogen loading, the relationship is not as direct as other impairments. According to the Center for Watershed Protection "…Other studies show that concentrations of bacteria are typically higher in urban areas than rural areas (USGS, 1999), but they are not always directly related to IC (CWP, 2003)." Therefore, MassDOT did not rely solely on the IC method to assess pathogen impairments. Instead, MassDOT reviewed its existing programs and their consistency with EPA NPDES MS4 general permit requirements and Pathogen TMDL recommendations.

Pathogens in MassDOT Discharge

A study conducted on MassDOT's Southeast Expressway measured bacterial concentrations in stormwater runoff (Smith, 2002). This study found a geometric mean of 186 fecal coliforms/100 ml. Concentrations of pathogens in stormwater runoff from roadways can vary widely and pathogen concentrations in runoff across the state likely deviate significantly from this stretch of roadway's specific estimate. Event mean concentrations of fecal coliform bacteria in urban stormwater from other sources ranging between 14,000 and 17,000 fecal coliform organisms/100 ml have been reported (MassDEP, 2009b). These data suggest that pathogen loading from highways may be lower than other urban areas.

Consideration of the potential sources of pathogens supports the idea that pathogens are present in lower concentrations in highway runoff since potential pathogen sources are likely to be less prevalent in the highway environment than along other urban roadways:

- Illicit discharges: Due to the typical setback of highways from residential and commercial developments and the stand alone nature of the drainage system, the potential for illicit discharges (e.g. sewer connections, laundry tie-ins) is much lower than in other stormwater systems. This has been confirmed by MassDOT's illicit discharge detection on many miles of urban roadways within a broad range of areas across Massachusetts. After assessment of almost 140 miles, and investigation of more than 2,500 stormwater features, MassDOT's consultant performing the broad scope reviews has found no confirmed illicit discharges.
- Limited Sewer Utilities in Road Right of Ways: Since MassDOT does not provide sewer services, many MassDOT roads do not have sewer utilities within the road's right of way; thereby eliminating the chance of cross-connections or leaking pipes as a source of pathogens into the stormwater system.
- Pet waste: Pets are only present on highways in rare instances. In urban residential areas pets and their associated waste are much more common. MassDOT is aware that pet waste at road side rest stops may represent a potential source of pathogens to stormwater in certain situations and has a pet waste management program underway to address this source where necessary.
- Wildlife: Highways are not generally an attractive place for wildlife. Wildlife generally avoids highways and only occasionally crosses them.

The dearth of pathogen sources on highways and the relatively low concentrations of pathogens measured in the Southeast Expressway study together suggest that pathogen loading from stormwater runoff from highways is lower than other urban sources.

Furthermore, in almost all cases the contribution of pathogens from MassDOT to a specific water body is likely to be very small relative to other sources of pathogens in the watershed. Since MassDOT urban roadways are linear and usually cross watersheds, they represent a small fraction of the receiving water body's watershed. The water quality within these water bodies is dependent on discharge from various sources, including discharges from other stormwater systems and a large number of other factors.

Assessment

Pathogen loadings are highly variable and, as a result, quantitative assessments are challenging and of little value. Therefore, MassDOT reviewed its existing programs and their consistency with EPA NPDES MS4 general permit requirements and Pathogen TMDL recommendations.

TMDLs for pathogen impairments in Massachusetts recognize that pathogens are highly variable and difficult to address and emphasize the need for an iterative adaptive management approach to address pathogens. Examples of relevant language from these TMDLs are included below:

- “given the vast potential number of bacteria sources and the difficulty of identifying and removing them from some sources such as stormwater require an iterative process and will take some time to accomplish. While the stated goal in the TMDL is to meet the water quality standard at the point of discharge it also attempts to be clear that MassDEP’s expectation is that for stormwater an iterative approach is needed…” (MassDEP, 2009a)
- “The NPDES permit does not, however, establish numeric effluent limitations for stormwater discharges. Maximum extent practicable (MEP) is the statutory standard that establishes the level of pollutant reductions that regulated municipalities must achieve. The MEP standard is a narrative effluent limitation that is satisfied through implementation of SWMPs and achievement of measurable goals.” (MassDEP, 2009b)
- “Although the TMDL presents quantified WLAs for stormwater that are set equivalent to the criteria in the Massachusetts Water Quality Standards, the Phase II NPDES permits will not include numeric effluent limitations. Phase II permits are intended to be BMP based permits that will require communities to develop and implement comprehensive stormwater management programs involving the use of BMPs. Massachusetts and EPA believe that BMP based Phase II permits involving comprehensive stormwater management together with specific emphasis on pollutants contributing to existing water quality problems can be consistent with the intent of the quantitative WLAs for stormwater discharges in TMDLs.” (MassDEP, 2002)

This language clearly indicates that an iterative adaptive management approach is the appropriate way to address discharges to pathogen impaired waters. The recommendations in pathogen TMDLs for waters in Massachusetts generally require development and implementation of stormwater management programs, illicit discharge detection and elimination efforts, and in some cases installing BMPs to the maximum extent practicable.

The draft North Coastal Watershed General MS4 permit and the draft Interstate, Merrimack, and South Coastal (IMS) watershed permits contain specific requirements for compliance with pathogen TMDLs (in Appendix G). While these permits are still in draft form, MassDOT believes they represent the best available guidance on what EPA believes is appropriate for addressing stormwater discharges to pathogen-impaired waters. Section 2.2.1(c) of the permit states “For any discharge from its MS4 to impaired waters with an approved TMDL, the permittee shall comply with the specific terms of Part 2.1 of this permit. In addition, where an approved TMDL establishes a WLA that applies to its MS4 discharges, the permittee shall implement the specific BMPs and other permit requirements identified in Appendix G to achieve consistency with the WLA.” Appendix G references a number of programmatic BMPs that are necessary to address pathogen loading. These cover the following general topics:

- Residential educational program
- Illicit connection identification, tracking and removal
- Pet waste management

Mitigation Plan

MassDOT implements a variety of non-structural BMP programs across their system in accordance with their existing Stormwater Management Plan (SWMP) including educational programs, illicit connection review and source control. The specific BMPs that can help reduce potential pathogen loading in the current SWMP include:

- BMP 3C-1: Drainage Connection Policy
- BMP 3C-2: Drainage Tie-In Standard Operating Procedure
- BMP 3D: Illicit Discharge Detection Review
- BMP 5H-1: Post Construction Runoff Enforcement – Illicit Discharge Prohibition
- BMP 5H-2: Post Construction Runoff Enforcement – Drainage Tie-In
- BMP 5H-3: Post Construction Runoff Enforcement – Offsite Pollution to MassHighway Drainage System
- BMP 6A-1: Source Control – 511 Program
- BMP 6A-2: Source Control – Adopt-A-Highway Program
- BMP 6C-1: Maintenance Program

In addition, the structural BMPs that will be considered to reduce the IC will also have the effect of reducing pathogen loads.

MassDOT believes the existing and proposed efforts are consistent with the current and draft MS4 permit's requirements and TMDL recommendations. MassDOT's existing stormwater management plan outlines BMPs that include education and illicit discharge detection and elimination. MassDOT will be implementing a pet waste management program at its rest stops that have discharges to pathogen impaired waters.

Conclusions

The entire subwatershed of MassDOT owned roadways were investigated and approximately 20.6 acres of MassDOT IC contributes stormwater directly to the North Nashua River (MA81-02) segment. There are currently no existing BMPs associated with the directly contributing watershed of the North Nashua River (MA93-44) that are mitigating potential stormwater quality impacts prior to discharge to the North Nashua River. In order to reduce MassDOT's contribution to the effective IC within the North Nashua River (MA81-02) segment subwatershed, MassDOT is proposing the construction of four stormwater BMPs, all of which are at the Route 2 North Main Street (Route 12) interchange. The proposed BMPs provide a reduction of 2.28 acres of effective IC within the North Nashua River (MA81-02) subwatershed. An additional reduction of 12.0 acres of effective IC is required to meet the 9% impervious cover goal.

Impervious Cover Reduction	Quantity	Unit
IC in Directly Contributing Watershed	20.6	acres
Target Reduction in Effective IC	14.3	acres
IC Effectively Reduced by Existing BMPs	0.00	acres
IC Effectively Reduced by Proposed BMPs	2.28	acres
Total IC Effectively Reduced by BMPs	2.28	acres
IC Remaining to Mitigate with Proposed BMPs	12.0	acres

MassDOT has concluded based on review of the draft North Coastal Watershed General MS4 permit, the draft Interstate, Merrimack, and South Coastal watershed permits, and pathogen TMDLs for Massachusetts waters that the BMPs outline in the stormwater management plan and those under consideration for reducing effective IC from MassDOT areas are consistent with its existing permit requirements. MassDOT believes that these measures achieve pathogen reduction (including fecal coliform) to the maximum extent practicable and are consistent with the intent of its existing stormwater permit and the applicable pathogen TMDLs.

As an overall program, MassDOT will continue to identify opportunities to implement additional structural BMPs to reduce effective IC when road work is conducted under MassDOT's programmed projects initiative. Work on programmed projects, which often include broader scale road layout changes, may provide additional opportunities for construction of new treatment BMPs. This is consistent with an iterative adaptive management approach to addressing impairments. MassDOT will include an update in annual reports and biannual submittals to EPA regarding progress made towards meeting target effective IC reductions, plans for construction of additional BMPs, and finalized assessments including reduction achieved by finalized BMP designs. Furthermore, MassDOT will continue to implement non-structural BMPs that reduce the impacts of stormwater.

References

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Impaired Waters Assessment for Nashua River (MA81-05)

Impaired Water Body

Name: Nashua River

Location: Ayer, Bolton, Groton, Harvard, Lancaster, and Shirley, Massachusetts

Water Body ID: MA81-05

Impairments

The Nashua River (MA81-05) is listed under Category 5, “Waters Requiring a TMDL”, on MassDEP’s Final *Massachusetts Year 2012 Integrated List of Waters* (MassDEP, 2013). The causes for the Nashua River impairment are listed as the following:

- Aquatic Macroinvertebrate Bioassessments
- Escherichia coli
- Phosphorus (Total)
- Sediment Bioassays – Acute Toxicity Freshwater

According to the MassDEP’s *Nashua River Watershed 2003 Water Quality Assessment Report* (MassDEP, 2008) the North Nashua River (MA81-02) is impaired for the primary contact recreation use due to Escherichia coli and has alert status for the following designated uses: aquatic life and secondary contact recreation. The Nashua River (MA81-05) is also covered by a Draft Total Maximum Daily Load (TMDL) for Pathogens according to MassDEP’s *Draft Pathogen TMDL for the Nashua River Watershed* (MassDEP, No Date) and a Draft TMDL for the Nutrient Phosphorus according to *MassDEP’s Draft Nashua River, Massachusetts Total Maximum Daily Load for the Nutrient Phosphorus* (MassDEP, 2007).

Relevant Water Quality Standards

Water Body Classification: Class B

Applicable State Regulations:

- *314 CMR 4.05 (4)(b) 1. Dissolved Oxygen*. Shall not be less than 5.0 mg/l. Seasonal and daily variations that are necessary to protect existing and designated uses shall be maintained. Where natural background conditions are lower, DO shall not be less than natural background.
- *314 CMR 4.05 (4)(b) 2. Temperature*.
    - a. Shall not exceed 68°F (20°C) based on the mean of the daily maximum temperature over a seven day period in cold water fisheries, unless naturally occurring. Where a reproducing cold water aquatic community exists at a naturally occurring higher temperature, the temperature necessary to protect the community shall not be exceeded and the natural daily and seasonal temperature fluctuations necessary to protect the community shall be maintained. Temperature shall not exceed 83°F (28.3°C) in warm water fisheries. The rise in

temperature due to a discharge shall not exceed 3°F (1.7°0C) in rivers and streams designated as cold water fisheries nor 5°F (2.8°C) in rivers and streams designated as warm water fisheries (based on the minimum expected flow for the month); in lakes and ponds the rise shall not exceed 3°F (1.7°0C) in the epilimnion (based on the monthly average of maximum daily temperature);

- b. Natural seasonal and daily variations that are necessary to protect existing and designated uses shall be maintained. There shall be no changes from natural background conditions that would impair any use assigned to this Class, including those conditions necessary to protect normal species diversity, successful migration, reproductive functions or growth of aquatic organisms;

- *314 CMR 4.05 (4)(b) 3. pH*. Shall be in the range of 6.5 through 8.5 standard units and not more than 0.2 units outside of the natural background range. There shall be no change from natural background conditions that would impair any use assigned to this Class.
- *314 CMR 4.05 (4)(b) 4. Bacteria.*
    - a. At bathing beaches as defined by the Massachusetts Department of Public Health in 105 CMR 445.010: where E. coli is the chosen indicator, the geometric mean of the five most recent samples taken during the same bathing season shall not exceed 126 colonies per 100 ml and no single sample taken during the bathing season shall exceed 235 colonies per 100 ml; alternatively, where enterococci are the chosen indicator, the geometric mean of the five most recent samples taken during the same bathing season shall not exceed 33 colonies per 100 ml and no single sample taken during the bathing season shall exceed 61 colonies per 100 ml;
    - b. For other waters and, during the non bathing season, for waters at bathing beaches as defined by the Massachusetts Department of Public Health in 105 CMR 445.010: the geometric mean of all E. coli samples taken within the most recent six months shall not exceed 126 colonies per 100 ml typically based on a minimum of five samples and no single sample shall exceed 235 colonies per 100 ml; alternatively, the geometric mean of all enterococci samples taken within the most recent six months shall not exceed 33 colonies per 100 ml typically based on a minimum of five samples and no single sample shall exceed 61 colonies per 100 ml. These criteria may be applied on a seasonal basis at the discretion of the Department;
- *314 CMR 4.05 (4)(b) 5. Solids*. These waters shall be free from floating, suspended and settleable solids in concentrations or combinations that would impair any use assigned to this class, that would cause aesthetically objectionable conditions, or that would impair the benthic biota or degrade the chemical composition of the bottom.
- *314 CMR 4.05 (5)(b) Bottom Pollutants or Alterations*. All surface waters shall be free from pollutants in concentrations or combinations or from alterations that adversely affect the physical or chemical nature of the bottom, interfere with the propagation of fish or shellfish, or adversely affect populations of non-mobile or sessile benthic organisms.
- *314 CMR 4.05 (5)(c) Nutrients*. Unless naturally occurring, all surface waters shall be free from nutrients in concentrations that would cause or contribute to impairment of existing or designated uses and shall not exceed the site specific criteria developed in a TMDL or as otherwise established by the Department pursuant to 314 CMR 4.00. Any existing point source discharge containing nutrients in concentrations that would cause or contribute to cultural eutrophication, including the excessive growth of aquatic plants or algae, in any surface water shall be provided with the most appropriate treatment as determined by the Department, including, where necessary, highest and best practical

treatment (HBPT) for POTWs and BAT for non POTWs, to remove such nutrients to ensure protection of existing and designated uses. Human activities that result in the nonpoint source discharge of nutrients to any surface water may be required to be provided with cost effective and reasonable best management practices for nonpoint source control. All surface waters shall be free from pollutants in concentrations or combinations that settle to form objectionable deposits; float as debris, scum or other matter to form nuisances; produce objectionable odor, color, taste or turbidity; or produce undesirable or nuisance species of aquatic life.

- *314 CMR 4.05 (5)(e) Toxic Pollutants*. All surface waters shall be free from pollutants in concentrations or combinations that are toxic to humans, aquatic life or wildlife. For pollutants not otherwise listed in 314 CMR 4.00, the *National Recommended Water Quality Criteria: 2002, EPA 822R-02-047, November 2002* published by EPA pursuant to Section 304(a) of the Federal Water Pollution Control Act, are the allowable receiving water concentrations for the affected waters, unless the Department either establishes a site specific criterion or determines that naturally occurring background concentrations are higher. Where the Department determines that naturally occurring background concentrations are higher, those concentrations shall be the allowable receiving water concentrations. The Department shall use the water quality criteria for the protection of aquatic life expressed in terms of the dissolved fraction of metals when EPA's 304(a) recommended criteria provide for use of the dissolved fraction. The EPA recommended criteria based on total recoverable metals shall be converted to dissolved metals using EPA's published conversion factors. Permit limits will be written in terms of total recoverable metals. Translation from dissolved metals criteria to total recoverable metals permit limits will be based on EPA's conversion factors or other methods approved by the Department. The Department may establish site specific criteria for toxic pollutants based on site specific considerations.

Site Description

The Nashua River (MA81-05) segment originates at its confluence with North Nashua River in the Town of Lancaster, Massachusetts and flows northeast for 14.2 miles to its confluence with Squannacook River in the Towns of Ayer, Groton, and Shirley, Massachusetts. The Nashua River (MA81-05) segment subwatershed, delineated as the portion of the watershed draining directly to the Nashua River, is approximately 14,477 acres, of which approximately 1,656 acres are impervious surface. MassDOT property in the Nashua River (MA81-05) segment subwatershed includes portions of Route 2, Route 2A, and a Route 117 bridge (See Figure 1).

North of Route 2 and west of the Route 2 westbound on ramp from Jackson Road are numerous MassDOT stormwater outfalls. Approximately 3.09 acres of the Route 2 and the westbound on ramp are collected by various catch basins. The collected stormwater is then conveyed to the MassDOT stormwater outfalls where flows are directly discharged to a bordering wetland system and ultimately the Nashua River (See Figure 2).

North of the Route 2 westbound on ramp from Jackson Road is a MassDOT stormwater outfall. Approximately 0.38 acres of the westbound on ramp is collected by a single catch basin. The collected stormwater is then conveyed to the MassDOT stormwater outfall where flows are directly discharged to the Nashua River (See Figure 2).

In the east and west shoulders of Jackson Road north of the Jackson Road Interchange are numerous MassDOT stormwater outfalls. Approximately 1.03 acres of Jackson Road is collected by various catch basins. The collected stormwater is then conveyed to the MassDOT stormwater outfalls where flows are directly discharged to the Nashua River (See Figure 2).

The Jackson Road bridge over the Nashua River consists of approximately 0.09 acres. Stormwater flows are collected by scuppers and are directly discharged to the Nashua River (See Figure 2).

In the infield area of the Route 2 westbound off ramp to Jackson Road are two MassDOT stormwater outfalls. Approximately 1.86 acres of Route 2 and the westbound off ramp is collected by various catch basins. The collected stormwater is then conveyed to the MassDOT stormwater outfalls where flows are directly discharged to a bordering wetland system and ultimately the Nashua River via a culvert under the westbound on and off ramps (See Figure 2).

In the infield area of the Route 2 westbound on ramp from Jackson Road are two MassDOT stormwater outfalls. Approximately 1.28 acres of Route 2 and Jackson Road is collected by various catch basins. The collected stormwater is then conveyed to the MassDOT stormwater outfalls where flows are directly discharged to a bordering wetland system and ultimately the Nashua River via a culvert under the westbound on ramp (See Figure 2).

Along the northern shoulder of Route 2 westbound between the westbound on and off ramps are five MassDOT stormwater outfalls. Approximately 1.94 acres of Route 2 is collected by numerous catch basins and paved waterways. The collected stormwater is then conveyed to the MassDOT stormwater outfalls where flows are directly discharged to the Nashua River (See Figure 2).

North of the Route 2 westbound off ramp to Jackson Road are five MassDOT stormwater outfalls. Approximately 1.09 acres of Route 2 and the westbound off ramp are collected by five single catch basins. The collected stormwater at each of these catch basin locations is then conveyed to a corresponding MassDOT stormwater outfall where flows are directly discharged to a bordering wetland system and ultimately the Nashus River via a culvert under the westbound off ramp (See Figure 2).

Along the northern and southern shoulders of Route 2 east of the Jackson Road Interchange are numerous MassDOT stormwater outfalls. Approximately 7.64 acres of Route 2 is collected by various catch basins and paved waterways. The collected stormwater is then conveyed to the MassDOT stormwater outfalls where flows are directly discharged to the edge of the Oxbow National Wildlife Refuge wetland system and ultimately the Nashua River (See Figure 2).
Along the southern shoulder of Route 2 eastbound between the Jackson Road overpass and the Oxbow National Wildlife Refuge are three MassDOT stormwater outfalls. Approximately 0.82 acres of Route 2 is collected by numerous catch basins and paved waterways. The collected stormwater is then conveyed to the MassDOT stormwater outfalls where flows are directly discharged to the Nashua River (See Figure 2).

In the infield area of the former Route 2 eastbound off ramp to Jackson Road are three MassDOT stormwater outfalls. Approximately 0.66 acres of Route 2 and Jackson Road is collected by various catch basins and paved waterways. The collected stormwater is then conveyed to the MassDOT stormwater outfalls where flows are directly discharged to a bordering wetland system and ultimately the Nashua River (See Figure 2).

In the infield area of the Route 2 eastbound on ramp from Jackson Road are eight MassDOT stormwater outfalls. Approximately 1.49 acres of Route 2, the eastbound on ramp and Jackson Road is collected by various catch basins and paved waterways. The collected stormwater is then conveyed to the MassDOT stormwater outfalls where flows are directly discharged to a bordering wetland system and ultimately the Nashua River via a culvert under Route 2 (See Figure 2).

Along the northern and southern shoulders of the Route 2 eastbound off ramp to Jackson Road are five MassDOT stormwater outfalls. Approximately 1.14 acres of the eastbound off ramp is collected by five single catch basins. The collected stormwater at each of these catch basins locations is then conveyed to a corresponding MassDOT stormwater outfall where flows are discharged to two water quality swales for treatment prior to being discharged to a bordering wetland system and ultimately the Nashua River (See Figure 2 and the *Existing BMPs* section of this document).

Approximately 0.31 acres of Route 2A west of the Nashua River is collected by a series of paved waterways which directly discharge stormwater flows to the Nashua River (See Figure 3).

Additionally, approximately 1.60 acres of Route 2A east of the Nashua River is collected by a series of paved waterways, catch basins and drainage ditches. The collected stormwater is then conveyed to a sedimentation basin for treatment prior to being discharged to the Nashua River (See Figure 3 and the *Existing BMPs* section of this document).

Assessment under BMP 7U

None of the following impairments for the Nashua River (MA81-05) have been addressed by a TMDL. Therefore, MassDOT assessed this impairment using the approach described in BMP 7U of MassDOT's *Storm Water Management Plan (Water Quality Impaired Waters Assessment and Mitigation Plan)*, which applies to impairments that have been assigned to a water body prior to completion of a TMDL. As described in MassDOT's *Application of Impervious Cover Method in BMP 7U* (MassDOT, 2011), impervious cover (IC) provides a measure of the potential impact to stormwater on many impairments. For this water body, MassDOT used the IC method to assess the following impairments:

- Aquatic Macroinvertebrate Bioassessments
- Phosphorus (Total)
- Sediment Bioassays – Acute Toxicity Freshwater

The impairment for Escherichia coli is assessed separately in the section titled, Assessment of Pathogen Impairment.

MassDOT's Application of the Impervious Cover Method

MassDOT's *Application of Impervious Cover Method in BMP 7U* applies many aspects of the United States Environmental Protection Agency (USEPA) Region I's Impervious Cover (IC) Method described in EPA's *Stormwater TMDL Implementation Support Manual* (ENSR, 2006) to MassDOT's program. This method assesses potential stormwater impacts on the impaired water and evaluates the IC reduction necessary to attain the percent imperviousness in the watershed at which stormwater is not likely the cause of the impairments. Consistent with the findings of EPA and others, when a watershed has less than 9% IC, MassDOT concludes that stormwater is not the likely cause of the impairment. Additional information regarding this method is provided under MassDOT's Application of the IC Method document.

Assessment

First, MassDOT calculated the percent IC of the water body's entire contributing watershed (total watershed upstream of the downstream end of an impaired segment) and that of the local watershed contributing to the impaired segment (referred to as the subwatershed in this analysis) to determine whether stormwater has a potential to cause the impairments of the receiving water body. The total watershed and subwatershed to the impaired water body were delineated using the USGS Data Series 451. When USGS Data Series watersheds did not delineate the subwatershed of the water body under review, the GIS shapefiles were modified by delineating to the water body based on USGS topography to add specificity. IC data was available as part of the USGS data layers Data Series 451 and MassGIS's impervious surfaces data layer. In cases where it was determined that stormwater was a potential cause of the impairment, MassDOT calculated the degree to which IC would need to be reduced in the subwatershed to meet the 9% IC target. This reduction was then applied proportionally to the area of MassDOT roadways/properties directly discharging to the water body segment to identify MassDOT's target IC reduction. The 9% IC reduction serves only as a recommended target and is not meant to imply that failing to meet the target would cause an exceedance in water quality standards. As explained in BMP 7U, MassDOT will consider a variety of factors apart from numeric guidelines, including site constraints and the magnitude of any potential exceedances in water quality standards, to determine the precise nature and extent of additional BMPs recommended for particular locations. This approach is consistent with the iterative, adaptive management BMP approach set forth in EPA guidelines.

MassDOT calculated the effective IC reduction afforded by the existing structural BMPs currently incorporated into the stormwater infrastructure of MassDOT's properties. This effective IC reduction was calculated by applying effective impervious cover reduction rates to existing BMPs based on their size, function and contributing watershed. BMP performances were derived from EPA Region 1's *Stormwater Best Management Practices (BMP) Performance Analysis* report (EPA, 2010) and engineering judgment. More information on the approach used to calculate the effective impervious cover reductions is described in BMP 7U. When the reduction in effective impervious cover achieved by the existing BMPs was equal to or greater than the target reduction, no further measures were proposed. When this was not the case, MassDOT considered additional BMPs in order to meet the targeted reduction.

Using this approach, MassDOT derived the following site parameters for the Nashua River (MA81-05):

Type	Parameter	Quantity	Unit of Measure
Subwatershed	Subwatershed Area	14,477	acres
Subwatershed	Impervious Cover (IC) Area	1,656	acres
Subwatershed	Percent Impervious	11.4	%
Subwatershed	IC Area at 9% Goal	1,303	acres
Subwatershed	Necessary Reduction % in IC	21.1	%
Reductions Applied to MassDOT Direct Watershed	MassDOT's IC Area Directly Contributing to Impaired Segment	24.4	acres
Reductions Applied to MassDOT Direct Watershed	MassDOT's Target Reduction in Effective IC (21.1% of MassDOT Directly Contributing IC)	5.2	acres

The subwatershed to Nashua River (MA81-05) is greater than 9% impervious cover which indicates that stormwater likely contributes to the impairments assessed under this methodology. In order to reach the 9% target, effective IC within the subwatershed should be reduced by 21.1%. Therefore, MassDOT's target is to reduce effective IC within its own directly contributing watershed by the same percentage, or 5.2 acres.

Existing BMPs

There are currently three existing BMPs associated with the direct discharges from MassDOT property tributary to the Nashua River (MA81-05) segment. Effective IC reduction for the existing BMPs was calculated by applying an effective IC reduction rate based on the existing BMP's size, function, contributing watershed and Hydrologic Soil Group (HSG). BMP performances were derived from *EPA Region 1's Stormwater Best Management Practices (BMP) Performance Analysis* report (EPA 2010) and engineering judgment.

Ex-BMP-1: A portion of the Route 2 eastbound off ramp to Jackson Road contributes stormwater runoff from approximately 0.63 acres of impervious surface to an existing water quality swale within the grassed shoulder area south of the off ramp (See Figure 4). The water quality swale is 460 feet in length, has a bottom width of five feet, and stores a depth of one foot behind each check dam. Stormwater runoff is collected by two single catch basins and is discharged to the existing water quality swale though two separate flared end sections with stone protection. The stormwater that is conveyed through the water quality swale flows downstream via two existing culverts where it directly discharges to the Nashua River (MA81-05) segment. Natural Resources and Conservation Service (NRCS) soil data indicates soils in the area are Quonset sandy loam with an assigned HSG of A. Utilizing this rating, the existing BMP at this location reduces overall effective IC by 0.60 acres.

Ex-BMP-2: A portion of the Route 2 eastbound off ramp to Jackson Road contributes stormwater runoff from approximately 0.69 acres of impervious surface to an existing water quality swale within the grassed shoulder area north of the off ramp (See Figure 4). The water quality swale is 400 feet in length, has a bottom width of five feet, and stores a depth of one foot behind each check dam. Stormwater runoff is collected by three single catch basins and is discharged to the existing water quality swale though three separate flared end sections with stone protection. The stormwater that is conveyed through the water quality swale flows downstream via an existing culvert where it directly discharges to the Nashua River (MA81-05) segment. NRCS soil data indicates soils in the area are Agawam fine sandy loam with an assigned HSG of B. Utilizing this rating, the existing BMP at this location reduces overall effective IC by 0.46 acres.

Ex-BMP-3: A portion of the Route 2A (Fitchburg Road) contributes stormwater runoff from approximately 1.60 acres of impervious surface to an existing sedimentation basin within the vegetated shoulder area north of Route 2A and east of the Nashua River (See Figure 5). Of the 1.60 acres, 1.41 acres is MassDOT's property while the remaining 0.19 acres are owned by the Town of Ayer. The sedimentation basin is approximately 75 long, 20 feet wide and has a storage depth of roughly 2.5 feet. Stormwater runoff is collected by a combination of paved waterways, catch basins and drainage ditches and is conveyed to the existing sedimentation basin. The stormwater that is conveyed through the sedimentation basin discharges via a spillway directly into the Nashua River (MA81-05) segment. NRCS soil data indicates soils in the area are Suncook loamy fine sand with an assigned HSG of A. Utilizing this rating, the existing BMP at this location reduces overall effective IC by 1.49 acres.

BMP Name	BMP Type	NRCS Hydrologic Soil Group	Storage Volume (inches)	IC Area Treated (acres)	Percent Reduction of Effective IC *	Reduction of Effective IC (acres)
Ex-BMP-1	Water Quality Swale	A	1.0	0.63	96%	0.60
Ex-BMP-2	Water Quality Swale	B	1.0	0.51	91%	0.46
Ex-BMP-3	Sedimentation Basin	A	0.8	1.60	93%	1.49
Total				**2.74**		**2.55**

*Description of MassDOT's *Application of Impervious Cover Method in BMP 7U (MassDOT Application of IC Method, MassDOT 2011)*.

Mitigation Plan

Since the total reduction of effective IC achieved by the existing MassDOT BMPs is less than the target of 5.2 acres, MassDOT considered locations for additional BMPs. In total, seven BMPs have been considered, five infiltration basins with sediment forebays and two infiltration swales.

<u>BMP-1:</u> The grass infield area of the westbound on and off ramps of Route 2 west of Jackson Road could be modified to accommodate an infiltration basin (See Figures 6 and 8). Modifications would include minor adjustments to the existing drainage infrastructure outside of the pavement limits for the construction of a sediment forebay and infiltration basin. NRCS soil data indicates soil in the area is Limerick silt loam with an assigned HSG of C. Test pit data indicated soils in the area consist of silty sand confirming the HSG. Installing a BMP as this location would reduce overall effective IC by 0.38 acres.

<u>BMP-2:</u> The grass infield area of the of the former eastbound on and off ramps of Route 2 east of Jackson Road and directly south of Route 2 could be modified to accommodate an infiltration basin (See Figures 6 and 8). Modifications would include minor adjustments to the existing drainage infrastructure outside of the pavement limits for the construction of a sediment forebay and infiltration basin. NRCS soil data indicates soil in the area is Limerick silt loam with an assigned HSG of C. Test pit data indicated soils in the area consist of silty sand confirming the HSG. Installing a BMP as this location would reduce overall effective IC by 0.29 acres.

<u>BMP-3:</u> The grass infield area of the of the former eastbound on and off ramps of Route 2 directly east of Jackson Road could be modified to accommodate an infiltration basin (See Figures 6 and 8). Modifications would include minor adjustments to the existing drainage infrastructure outside of the pavement limits for the construction of a sediment forebay and infiltration basin. NRCS soil data indicates soil in the area is Windsor loamy sand with an assigned HSG of A. Test pit data indicated soils in the area consist of silty sand therefore HSG C is used for this location. Installing a BMP as this location would reduce overall effective IC by 0.30 acres.

<u>BMP-4:</u> The grass infield area between the Route 2 eastbound off ramp and Jackson Road could be modified to accommodate an infiltration basin (See Figures 6 and 8). Modifications would include minor adjustments to the existing drainage infrastructure outside of the pavement limits for the construction of a sediment forebay and infiltration basin. NRCS soil data indicates soil in the area is Windsor loamy sand with an assigned HSG of A. Test pit data indicated soils in the area consist of silty sand therefore HSG C is used for this location. Installing a BMP as this location would reduce overall effective IC by 0.16 acres.

BMP-5: The vegetated shoulder south of Route 2A and west of the Nashua River could be modified to accommodate an infiltration swale (See Figures 7 and 9). Modifications would include minor regrading for the construction of a swale and installation of check dams. NRCS soil data indicates soil in the area is Pootatuck fine sandy loam with an assigned HSG of B. Test pit data indicated soils in the area consist of fine sandy loam confirming the HSG. Installing a BMP as this location would reduce overall effective IC by 0.10 acres.

BMP-6: The grassed shoulder north of Route 2A and west of the Nashua River could be modified to accommodate an infiltration swale (See Figures 7 and 9). Modifications would include minor regrading for the construction of a swale and installation of check dams. NRCS soil data indicates soil in the area is Pootatuck fine sandy loam with an assigned HSG of B. Test pit data indicated soils in the area consist of sandy loam confirming the HSG. Installing a BMP as this location would reduce overall effective IC by 0.36 acres.

BMP-7: The grass infield area between the former eastbound off ramp and the eastbound on ramp of Route 2 west of Jackson Road could be modified to accommodate an infiltration basin (See Figure 6). Modifications would include minor adjustments to the existing drainage infrastructure outside of the pavement limits for the construction of a sediment forebay and infiltration basin. NRCS soil data indicates soil in the area is Quonset sandy loam with an assigned HSG of A. Test pit data indicated soils in the area consist of highly compact silty sand with clay fill materials therefore no stormwater BMP is proposed in this location for the treatment of MassDOT's directly contributing IC.

BMP Name	**BMP Type**	**NRCS Hydrologic Soil Group**	**Storage Volume (inches)**	**IC Area Treated (acres)**	**Percent Reduction of Effective IC ***	**Reduction of Effective IC (acres)**
BMP-1	Infiltration Basin	C	1.0	0.46	82%	0.38
BMP-2	Infiltration Basin	C	1.0	0.35	82%	0.29
BMP-3	Infiltration Basin	C	1.0	0.36	82%	0.30
BMP-4	Infiltration Basin	C	1.0	0.20	82%	0.16
BMP-5	Infiltration Swale	B	1.0	0.11	91%	0.10
BMP-6	Infiltration Swale	B	1.0	0.40	91%	0.36
Total				**1.88**		**1.59**

*Description of MassDOT's *Application of Impervious Cover Method in BMP 7U (MassDOT Application of IC Method, MassDOT 2011)*.

Assessment of Pathogen Impairment under BMP 7U

MassDOT assessed the pathogen impairment using the approach described in BMP 7U of MassDOT's *Storm Water Management Plan (Water Quality Impaired Waters Assessment and Mitigation Plan)*, which applies to impairments that have been assigned to a water body prior to completion of a TMDL. Pathogen concentrations in stormwater vary widely temporally and spatially; concentrations can vary by an order of magnitude within a given storm event at a single location (MassDEP, 2009b). Therefore, it is difficult to predict pathogen concentrations in stormwater with accuracy. Due to this difficulty, MassDOT generally will not conduct site specific assessments of loading at each location impaired for pathogens. Instead these sites are assessed based on available information on pathogen loading from highways, MassDOT actions, and information available from EPA and DEP. Based on this information MassDOT developed an approach to be consistent with relevant TMDL and permit condition requirements and an iterative adaptive management approach to stormwater management.

In addition, while there is a positive relationship between IC and pathogen loading, the relationship is not as direct as other impairments. According to the Center for Watershed Protection "…Other studies show that concentrations of bacteria are typically higher in urban areas than rural areas (USGS, 1999), but they are not always directly related to IC (CWP, 2003)." Therefore, MassDOT did not rely solely on the IC method to assess pathogen impairments. Instead, MassDOT reviewed its existing programs and their consistency with EPA NPDES MS4 general permit requirements and Pathogen TMDL recommendations.

Pathogens in MassDOT Discharge

A study conducted on MassDOT's Southeast Expressway measured bacterial concentrations in stormwater runoff (Smith, 2002). This study found a geometric mean of 186 fecal coliforms/100 ml. Concentrations of pathogens in stormwater runoff from roadways can vary widely and pathogen concentrations in runoff across the state likely deviate significantly from this stretch of roadway's specific estimate. Event mean concentrations of fecal coliform bacteria in urban stormwater from other sources ranging between 14,000 and 17,000 fecal coliform organisms/100 ml have been reported (MassDEP, 2009b). These data suggest that pathogen loading from highways may be lower than other urban areas.

Consideration of the potential sources of pathogens supports the idea that pathogens are present in lower concentrations in highway runoff since potential pathogen sources are likely to be less prevalent in the highway environment than along other urban roadways:

- Illicit discharges: Due to the typical setback of highways from residential and commercial developments and the stand alone nature of the drainage system, the potential for illicit discharges (e.g. sewer connections, laundry tie-ins) is much lower than in other stormwater systems. This has been confirmed by MassDOT's illicit discharge detection on many miles of urban roadways within a broad range of areas across Massachusetts. After assessment of almost 140 miles, and investigation of more than 2,500 stormwater features, MassDOT's consultant performing the broad scope reviews has found no confirmed illicit discharges.
- Limited Sewer Utilities in Road Right of Ways: Since MassDOT does not provide sewer services, many MassDOT roads do not have sewer utilities within the road's right of way; thereby eliminating the chance of cross-connections or leaking pipes as a source of pathogens into the stormwater system.
- Pet waste: Pets are only present on highways in rare instances. In urban residential areas pets and their associated waste are much more common. MassDOT is aware that pet waste at road side rest stops may represent a potential source of pathogens to stormwater in certain situations and has a pet waste management program underway to address this source where necessary.
- Wildlife: Highways are not generally an attractive place for wildlife. Wildlife generally avoids highways and only occasionally crosses them.

The dearth of pathogen sources on highways and the relatively low concentrations of pathogens measured in the Southeast Expressway study together suggest that pathogen loading from stormwater runoff from highways is lower than other urban sources.

Furthermore, in almost all cases the contribution of pathogens from MassDOT to a specific water body is likely to be very small relative to other sources of pathogens in the watershed. Since MassDOT urban roadways are linear and usually cross watersheds, they represent a small fraction of the receiving water body's watershed. The water quality within these water bodies is dependent on discharge from various sources, including discharges from other stormwater systems and a large number of other factors.

Assessment

Pathogen loadings are highly variable and, as a result, quantitative assessments are challenging and of little value. Therefore, MassDOT reviewed its existing programs and their consistency with EPA NPDES MS4 general permit requirements and Pathogen TMDL recommendations.

TMDLs for pathogen impairments in Massachusetts recognize that pathogens are highly variable and difficult to address and emphasize the need for an iterative adaptive management approach to address pathogens. Examples of relevant language from these TMDLs are included below:

- "given the vast potential number of bacteria sources and the difficulty of identifying and removing them from some sources such as stormwater require an iterative process and will take some time to accomplish. While the stated goal in the TMDL is to meet the water quality standard at the point of discharge it also attempts to be clear that MassDEP's expectation is that for stormwater an iterative approach is needed…" (MassDEP, 2009a)
- "The NPDES permit does not, however, establish numeric effluent limitations for stormwater discharges. Maximum extent practicable (MEP) is the statutory standard that establishes the level of pollutant reductions that regulated municipalities must achieve. The MEP standard is a narrative effluent limitation that is satisfied through implementation of SWMPs and achievement of measurable goals." (MassDEP, 2009b)
- "Although the TMDL presents quantified WLAs for stormwater that are set equivalent to the criteria in the Massachusetts Water Quality Standards, the Phase II NPDES permits will not include numeric effluent limitations. Phase II permits are intended to be BMP based permits that will require communities to develop and implement comprehensive stormwater management programs involving the use of BMPs. Massachusetts and EPA believe that BMP based Phase II permits involving comprehensive stormwater management together with specific emphasis on pollutants contributing to existing water quality problems can be consistent with the intent of the quantitative WLAs for stormwater discharges in TMDLs." (MassDEP, 2002)

This language clearly indicates that an iterative adaptive management approach is the appropriate way to address discharges to pathogen impaired waters. The recommendations in pathogen TMDLs for waters in Massachusetts generally require development and implementation of stormwater management programs, illicit discharge detection and elimination efforts, and in some cases installing BMPs to the maximum extent practicable.

The draft North Coastal Watershed General MS4 permit and the draft Interstate, Merrimack, and South Coastal (IMS) watershed permits contain specific requirements for compliance with pathogen TMDLs (in Appendix G). While these permits are still in draft form, MassDOT believes they represent the best available guidance on what EPA believes is appropriate for addressing stormwater discharges to pathogen-impaired waters. Section 2.2.1(c) of the permit states "For any discharge from its MS4 to impaired waters with an approved TMDL, the permittee shall comply with the specific terms of Part 2.1 of this permit. In addition, where an approved TMDL establishes a WLA that applies to its MS4 discharges, the permittee shall implement the specific BMPs and other permit requirements identified in Appendix G to achieve consistency with the

WLA." Appendix G references a number of programmatic BMPs that are necessary to address pathogen loading. These cover the following general topics:

- Residential educational program
- Illicit connection identification, tracking and removal
- Pet waste management

Mitigation Plan

MassDOT implements a variety of non-structural BMP programs across their system in accordance with their existing Stormwater Management Plan (SWMP) including educational programs, illicit connection review and source control. The specific BMPs that can help reduce potential pathogen loading in the current SWMP include:

- BMP 3C-1: Drainage Connection Policy
- BMP 3C-2: Drainage Tie-In Standard Operating Procedure
- BMP 3D: Illicit Discharge Detection Review
- BMP 5H-1: Post Construction Runoff Enforcement – Illicit Discharge Prohibition
- BMP 5H-2: Post Construction Runoff Enforcement – Drainage Tie-In
- BMP 5H-3: Post Construction Runoff Enforcement – Offsite Pollution to MassHighway Drainage System
- BMP 6A-1: Source Control – 511 Program
- BMP 6A-2: Source Control – Adopt-A-Highway Program
- BMP 6C-1: Maintenance Program

In addition, the structural BMPs that will be considered to reduce the IC will also have the effect of reducing pathogen loads.

MassDOT believes the existing and proposed efforts are consistent with the current and draft MS4 permit's requirements and TMDL recommendations. MassDOT's existing stormwater management plan outlines BMPs that include education and illicit discharge detection and elimination. MassDOT will be implementing a pet waste management program at its rest stops that have discharges to pathogen impaired waters.

Conclusions

The entire subwatershed of MassDOT owned roadways were investigated and approximately 24.4 acres of MassDOT IC contributes stormwater directly to the Nashua River (MA81-05) segment. There are currently three existing BMPs, two water quality swales and one sedimentation pond that provide a reduction of 2.55 acres of effective IC within the Nashua River (MA81-05) subwatershed. In order to reduce MassDOT's contribution to the effective IC within the Nashua River (MA81-05) segment subwatershed, MassDOT is proposing the construction of six stormwater BMPs, four at the Route 2 Jackson Road Interchange and two along Route 2A. The proposed BMPs provide a reduction of 1.59 acres of effective IC within the Nashua River (MA81-05) subwatershed. An additional reduction of 1.1 acres of effective IC is required to meet the 9% impervious cover goal.

Impervious Cover reduction	Quantity	Unit of Measure
IC in Directly Contributing Watershed	24.4	acres
Target Reduction in Effective IC	5.2	acres
IC Effectively Reduced by Existing BMPs	2.55	acres
IC Effectively Reduced by Proposed BMPs	1.59	acres
Total IC Effectively Reduced by BMPs	4.14	acres
IC Remaining to Mitigate with Proposed BMPs	1.1	acres

MassDOT has concluded based on review of the draft North Coastal Watershed General MS4 permit, the draft Interstate, Merrimack, and South Coastal watershed permits, and pathogen TMDLs for Massachusetts waters that the BMPs outline in the stormwater management plan and those under consideration for reducing effective IC from MassDOT areas are consistent with its existing permit requirements. MassDOT believes that these measures achieve pathogen reduction (including fecal coliform) to the maximum extent practicable and are consistent with the intent of its existing stormwater permit and the applicable pathogen TMDLs.

As an overall program, MassDOT will continue to identify opportunities to implement additional structural BMPs to reduce effective IC when road work is conducted under MassDOT's programmed projects initiative. Work on programmed projects, which often include broader scale road layout changes, may provide additional opportunities for construction of new treatment BMPs. This is consistent with an iterative adaptive management approach to addressing impairments. MassDOT will include an update in annual reports and biannual submittals to EPA regarding progress made towards meeting target effective IC reductions, plans for construction of additional BMPs, and finalized assessments including reduction achieved by finalized BMP designs. Furthermore, MassDOT will continue to implement non-structural BMPs that reduce the impacts of stormwater.

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Impaired Waters Assessment for Grist Mill Pond (MA82055)

Summary

		Stormwater	Non-Stormwater[1]
	Impairments:	Dissolved oxygen saturation, excess algal growth, fecal coliform, phosphorus (total), aquatic plants (macrophytes)	Non-native aquatic plants
Impaired Water[2]	**Category[3]:**	5 (Waters requiring a TMDL)	
	Final TMDLs:	None	
	WQ Assessment:	SuAsCo Watershed 2001 Water Quality Assessment Report [4]	
Location	**Towns:**	Sudbury, Marlborough	
	MassDOT Roads:	State Route 20	
Assessment Method(s)	**7R (TMDL Method)**	☐	
	7U (IC Method)	☒	
BMPs	**Existing:**	None	
	Proposed:	9 Water quality swales and 1 infiltration basin	
			Impervious Cover (IC)
MassDOT	**Directly Contributing Area**		1.9 acres
Contributing Area	**Contributing Area Reduction Target**		0.6 acres
and Targets	**Existing BMPs Reduction**		0.0 acres
	Proposed BMPs Reduction		1.5 acres
	Remaining Treatment to Meet Target		0.0 acres

[1] MassDEP, 2005. SuAsCo Watershed 2001 Water Quality Assessment Report. Available at: http://www.mass.gov/eea/docs/dep/water/resources/71wqar09/82wqar3.pdf

[2] MassDEP, 2013. Massachusetts Year 2012 Integrated List of Waters – Final Listing of the Condition of Massachusetts' Waters Pursuant to Sections 305(b), 314 and 303(d) of the Clean Water Act. Massachusetts. Available at: http://www.mass.gov/eea/docs/dep/water/resources/07v5/12list2.pdf

[3] MassDEP, 2013. Massachusetts Year 2012 Integrated List of Waters – Final Listing of the Condition of Massachusetts' Waters Pursuant to Sections 305(b), 314 and 303(d) of the Clean Water Act. Massachusetts. Available at: http://www.mass.gov/eea/docs/dep/water/resources/07v5/12list2.pdf

[4] MassDEP, 2005. SuAsCo Watershed 2001 Water Quality Assessment Report. Available at: http://www.mass.gov/eea/docs/dep/water/resources/71wqar09/82wqar3.pdf

Site Description

Grist Mill Pond is a 17-acre impoundment located on a stream locally known as Hop Brook. The headwaters of Hop Brook (MA82A-15) are located between the rear yards of a commercial development (Home Depot) and a residential development (Settlers Lane) adjacent to an area historically referred to as Indian Head Hill. Flow from the headwaters travels overland to a 950-foot culvert that conveys the brook northward underneath a commercial parking lot to a wooded area north of Route 20. Hop Brook flows to the northeast and then to the south, passing by the Marlborough Easterly Waste Water Treatment Plant (WWTP) and then passes back under Route 20 to Hager Pond (MA82056). Hop Brook (MA82A-16) exits Hager Pond and flows approximately 900 feet northward (again passing under Route 20) to Grist Mill Pond (MA82055). Figure 1 illustrates the contributing watershed to Grist Mill Pond (MA82056).

The contributing area to Grist Mill Pond occupies approximately 1,760 acres in Marlborough, Sudbury, and Framingham, Massachusetts. Route 20, the only MassDOT-owned roadway in the Grist Mill Pond watershed, bisects the contributing area to Grist Mill Pond from east to west. According to MassGIS landuse data, the contributing area consists of approximately 58% forest, 13% residential, 7% forested wetland, 4% industrial, 4% commercial land uses. Other land uses occupying greater than 1% of the contributing watershed include waste disposal, pasture, open land, cemetery, and urban/public institutional.

The 2001 SuAsCo Water Quality Assessment Report indicates that the waterbody is impaired for the Aquatic Life Designated Use. The identified causes include non-native macrophytes, low dissolved oxygen, and high total phosphorus. The assessment report also indicates that the waterbody is impaired for Primary and Secondary Contact Recreation and Aesthetics due to excess algal growth. The assessment report indicates that discharges from the WWTP are a significant source of nutrients to the Hop Brook system.

"The Marlborough Easterly Wastewater Treatment Plant (WWTP) discharges to Hop Brook upstream of Hager Pond and accounts for a significant amount of flow and nutrient loadings at this water body. Numerous studies have been conducted on the Hop Brook system. In 1984, the USGS determined that approximately 50% of the flow in Hop Brook consists of effluent from the WWTP; in drought conditions, the effluent may account for as much as 90% of the flow."[5]

Figure 2 illustrates the MassDOT property directly draining to Grist Mill Pond. The MassDOT roadway contributing to Grist Mill Pond occupies two lanes (one in each direction). The road is not divided, it does not have curbs. It is crowned at the centerline. Runoff from the eastbound lane flows to the southern side of the road where it flows overland to the cross culverts and to the pond. Runoff from the westbound lane flows to the northern side of the road where it flows overland to the pond. Vegetation including grass and pine needles appear to act as a vegetated curb. Stormwater runoff that is not intercepted at breaks in the vegetated curb travels along the pavement parallel to the road to the low points where it flows off of the pavement to unimproved gravel parking areas (located on both sides of the road). The gravel parking areas are used by the Sudbury Valley Trustees for recreational access to the Pond.

In this area, the paved roadway is approximately 35 feet wide; the right-of-way is approximately 90 feet wide. Some portions of the shoulder (within the right-of-way) are occupied by steep embankments sloping down to meet adjacent grades. Other portions of the shoulder slope gently to meet adjacent grades or to meet existing roadside conveyance swales.

Existing BMPs

MassDOT did not identify any existing BMPs in place to treat the directly discharging roadway runoff before reaching the impaired water segment.

5 MassDEP, 2005. SuAsCo Watershed 2001 Water Quality Assessment Report. Available at: http://www.mass.gov/eea/docs/dep/water/resources/71wqar09/82wqar3.pdf

Assessment

In cases where a TMDL has been approved, MassDOT assessed the waterbody for the impairments covered by the TMDL under the BMP 7R methodology. MassDOT has separately assessed the waterbody for any stormwater-related impairments that are not covered by the TMDL under the BMP 7U methodology. MassDOT assessed Grist Mill Pond (MA82055) using the methodologies described below.

MassDOT has identified a subset of waterbody impairments in the Grist Mill Pond watershed which are not related to stormwater runoff. Specific impairments unrelated to stormwater for the Grist Mill Pond include non-native aquatic species. In accordance with MassDOT's Impaired Waters Assessment for Impaired Waters with Impairments Unrelated to Stormwater in the December 8, 2012 EPA submittal, the non-pollutant impairments are not addressed as part of the Impaired Waters Program.[6]

Assessment 7U for Pathogen Impairment

MassDOT assessed the indicator bacteria (fecal coliform) impairment using the approach described in BMP 7U of MassDOT's Storm Water Management Plan (SWMP).[7] Grist Mill Pond (MA82055) is covered by the Draft Pathogen TMDL for the Concord River Watershed.[8] According to the Draft TMDL, sources of indicator bacteria in the Concord River watershed were found to be many and varied. Most of the bacteria sources in the Concord River watershed are believed to be failing septic systems, combined sewer overflows (CSO), sanitary sewer overflows (SSO), sewer pipes connected to storm drains, certain recreational activities, wildlife including birds along with domestic pets and animals and direct overland stormwater runoff. Additionally, the TMDL states that implementation to achieve the TMDL goals should be an iterative process with selection and implementation of mitigation measures followed by monitoring to determine the extent of water quality improvement realized. Recommended TMDL implementation measures include identification and elimination of prohibited sources such as leaky or improperly connected sanitary sewer flows and best management practices to mitigate storm water runoff volume. MassDOT included a review of the draft report as an informational review as part of this assessment even though, due to their draft status, draft TMDLs are not formally part of the Impaired Waters Retrofit program.

Pathogen concentrations in stormwater vary widely temporally and spatially; concentrations can vary by an order of magnitude within a given storm event at a single location.[9] Therefore, it is difficult to predict pathogen concentrations in stormwater with accuracy. MassDOT's South East Expressway study measured bacterial concentration in stormwater runoff[10] and data indicated that highway's pathogen loading may be lower than urban areas. Considering that the potential sources of pathogens (e.g. illicit discharges, sewer utilities, pet waste and wildlife) are likely to be less prevalent in the highway environment than along urban roads, this finding is not surprising.

MassDOT does not conduct site specific assessments of loading at each location impaired for pathogens. Instead, MassDOT reviewed its existing programs and their consistency with EPA NPDES MS4 general permit requirements and pathogen TMDL requirements. Language in the documents clearly indicate that an iterative adaptive management approach is the appropriate way to address discharges to pathogen impaired waters and recommend implementation of programmatic BMPs such as residential educational programs, illicit connection identification, tracking and removal and pet waste management. MassDOT implements a variety of non-structural BMP programs across their system in accordance with their existing SWMP including educational programs, illicit connection review and source control.

6 MassDOT, December 2012. Impaired Waters Assessment for Impaired Waters with Impairments Unrelated to Stormwater. Available at: http://www.mhd.state.ma.us/downloads/projDev/ImpairedWaters_3/Year3_ImpairedWatersAssessment_1.pdf#page=308

7 MassDOT, 6 April, 2011. Description of MassDOT's Application of Impervious Cover Method in BMP 7U (MassDOT Application of IC Method). http://www.mhd.state.ma.us/downloads/projDev/BMP_7U_ImpairedWaterbodiesAssessment.pdf

8 MassDEP. Draft Pathogen TMDL for the Concord River Watershed. Available at: http://www.mass.gov/eea/docs/dep/water/resources/a-thru-m/concord1.pdf

9 MassDEP. 2009. Final Pathogen TMDL for the Cape Cod Watershed. Available at: http://www.mass.gov/dep/water/resources/capecod1.pdf

10 Smith. (2002). Effectiveness of Three Best Management Practices for Highway Runoff Quality along the Southeast Expressway. USGS Water Resources Investigations Report 02-4059. Boston, Massachusetts.

MassDOT has an ongoing inspection and monitoring program aimed at identifying and addressing illicit discharges to MassDOT's stormwater management system. Any illicit discharges to MassDOT's system could contribute pathogens to impaired waters, however, MassDOT's existing Illicit Discharge Detection and Elimination (IDDE) program is aimed at identifying and addressing these contributions. District maintenance staff note signs of potential illicit discharges, such as dry weather flow and notable odors or sheens. Similarly, Resident Engineers overseeing construction projects also receive instruction regarding the need to note any suspicious connections or flows, and report these for follow-up investigation and action as appropriate. MassDOT will continue to implement this IDDE training, and District staff will continue to report any suspicious flows requiring further investigation. MassDOT investigates any suspicious flows noted, and proceeds to work with owners of confirmed illicit discharges to remove these flows, and thereby minimize pathogen contributions to receiving waters.

MassDOT is in the process of developing a pet waste management program for MassDOT rest stops located within the sub-watershed of a pathogen impaired waterbody. At these prioritized rest stops, MassDOT will be installing signs informing the public of the need to remove pet waste in order to minimize contributions of pathogens to the impaired waterbody and providing pet waste removal bags and disposal cans.

MassDOT believes the existing efforts are consistent with the current and draft MS4 permit's requirements and TMDL recommendations.

BMP 7U for Impervious Cover Related Impairments

MassDOT assessed the stormwater-related impairments not addressed by a TMDL using the approach outlined in the Description of MassDOT's Application of Impervious Cover Method in BMP 7U[11] which was developed using the EPA Region I's Impervious Cover (IC) Method as a basis, described in EPA's Stormwater TMDL Implementation Support Manual.[12] MassDOT used the long-term continuous simulation model (the assessment model)[13] to estimate effective IC. Consistent with the findings of EPA and others, MassDOT concluded that when a watershed had less than 9% IC, stormwater was not the likely cause of the impairment.

MassDOT calculated the following values for the total contributing watershed of the impaired water (Grist Mill Pond) to determine the IC target. The total contributing watershed is shown in Figure 1.

Impaired Segment Watershed

Watershed Area	1,763 acres
Impervious Cover (IC) Area	232 acres
Percent Impervious	13 %
IC Area at 9% Goal	159 acres
Target Effective IC Reduction	32 %

The total watershed is greater than 9% impervious indicating that stormwater is a likely contributor to the impairment. To meet the 9% effective IC target, the effective IC within the watershed will need to be reduced. Therefore, the effective IC of MassDOT's directly contributing area should also be reduced by the

[11] MassDOT, 6 April, 2011. Description of MassDOT's Application of Impervious Cover Method in BMP 7U (MassDOT Application of IC Method). http://www.mhd.state.ma.us/downloads/projDev/BMP_7U_ImpairedWaterbodiesAssessment.pdf

[12] ENSR 2006. Stormwater TMDL Implementation Support Manual for US EPA Region 1. ENSR International & EPA Region 1, Boston, MA. Available at http://www.epa.gov/region1/eco/tmdl/regionalpgrfs.html

[13] MassDOT, June 2012. Long-Term Continuous Simulation for Pollutant Loading and Treatment for MassDOT Impaired Waters Program. Available at: http://www.mhd.state.ma.us/downloads/projDev/ImpairedWaters_2/Attachment7.pdf

same percentage to meet the target. The following table shows how MassDOT calculated the target effective IC for MassDOT's contributing property.

MassDOT Directly Contributing Watershed

Directly Contributing Area	3.4 acres
Directly Contributing IC Area	1.9 acres
Percent Impervious	56 %
Target Effective IC Reduction (32% of DOT Directly Contributing IC)	0.6 acres
Target Effective IC	38 %

This assessment has identified locations for potential stormwater BMPs and estimated the effective IC accounting for their treatment. The Proposed Mitigation Plan section describes the BMPs and their IC reduction performance.

Proposed Mitigation Plan

In this assessment, MassDOT has identified 10 stormwater BMPs that may be implemented on MassDOT property to mitigate the effective IC to address the Grist Mill Pond (MA82055) impairments. These BMPs include 9 water quality swales and one infiltration basin shown with their estimated contributing drainage areas in Figure 3. These locations were chosen based on a cursory review of the drainage systems, topography, property lines, and other site constraints. Water quality swales are proposed on the northern and southern side of Route 20 to promote infiltration in existing drainage ditches. An infiltration basin is proposed at the low point (at the area currently occupied by an unimproved parking area) to promote infiltration adjacent to the pond. Detailed survey, complete utility location information, official property ownership, and soils evaluation information will influence the final selection and design of BMPs. Below is a description of these proposed BMPs.

PR Water Quality Swales (BMPs 1, 2, 3, 4)

Currently, the topography of the area adjacent to the north side of the road embankment consists of undeveloped vegetated cover that gently slopes towards Grist Mill Pond. Stormwater runoff sheets off the roadway toward the edge of the pavement, travels downgradient along the pavement until it meets a break in the raised vegetated curb, and flows overland to Grist Mill Pond.

Water quality swales proposed for the northern side of Route 20 (adjacent to the west-bound lane) would be located along the roadway shoulder and would terminate at the appropriate downgradient points.

Proposed modifications to the stormwater management network for areas on the northern side of Route 20 (adjacent to the west-bound lane) include constructing swales with check dams to promote infiltration, retrofitting the existing roadway shoulder to include breaks in the vegetated curb at regular intervals, and constructing paved waterways to convey intercepted stormwater to the swales.

Underlying soils at the locations of proposed swales 1, 2, and 3 are classified as hydrologic soil group "B," which is generally suitable for infiltration. Underlying soils at the location of proposed swale 4 are classified as hydrologic soil group "C/D" and may not be suitable for infiltration. At swale 4, the underlying soils may be replaced with suitable material, or the swale may be designed to promote settling at the check dams.

Historic layout plans indicate that MassDOT right-of-way is approximately 90 feet wide in this area. The road is approximately 35 to 40 feet wide in this area. There is ample room in the roadway shoulders for placement of the swales. The swales should be constructed in areas with suitable topography to minimize the impacts of construction.

PR Water Quality Swales (BMPs 5, 6, 7, 8, 9)

Currently, the topography of the area adjacent to the south side of the road embankment includes swales and berms that direct runoff to cross culverts that convey stormwater runoff and natural runoff to Grist Mill Pond. Runoff sheets off the roadway toward the edge of the pavement, travels downgradient along the pavement until it meets a break in the raised vegetated edge, and then flows into an existing swale to a cross culvert and eventually to Grist Mill Pond.

Proposed modifications to the stormwater management network for areas on the southern side of Route 20 (adjacent to the east-bound lane) include retrofitting the existing swales to promote infiltration by installing check dams, retrofitting the existing roadway shoulder to include breaks in the vegetated curb at regular intervals, and constructing paved waterways to convey intercepted stormwater to the swales.

NRCS soils maps indicate that the underlying soils at the locations of proposed swales 5, 6, and 7 are classified as hydrologic soil group “B,” which is generally suitable for infiltration. Underlying soils at the location of proposed swales 8 and 9 are rated as hydrologic soil group “C/D” and may not be suitable for infiltration. For swales 8 and 9, the underlying soils may be replaced with suitable material, or the swales may be designed to promote settling at the check dams.

Historic layout plans indicate that MassDOT right-of-way is approximately 90 feet wide in this area. The road is approximately 35 to 40 feet wide in this area.

PR BMP 10

Currently, runoff sheets off the roadway toward the edge of the pavement, travels downgradient along the pavement until it meets a break in the raised vegetated edge, and then flows overland to Grist Mill Pond. The largest consistent break in the raised vegetated curb is located at a place where vehicle parking has worn away the vegetation to result in an unimproved gravel parking area. The parking area is located at the lowest point along the roadway section that drains to Grist Mill Pond.

Proposed modifications to the stormwater management network for this area include construction of an infiltration basin. Underlying soils at the location of the proposed basin are classified as hydrologic soil group “B,” which is generally suitable for infiltration. Overflows from the basin would sheet directly to the pond.

The table below shows the proposed conditions, including BMPs with their MassDOT drainage areas and estimated effective IC reductions. The outputs from the assessment model showing effective IC analysis for each BMP are attached.

Proposed Conditions

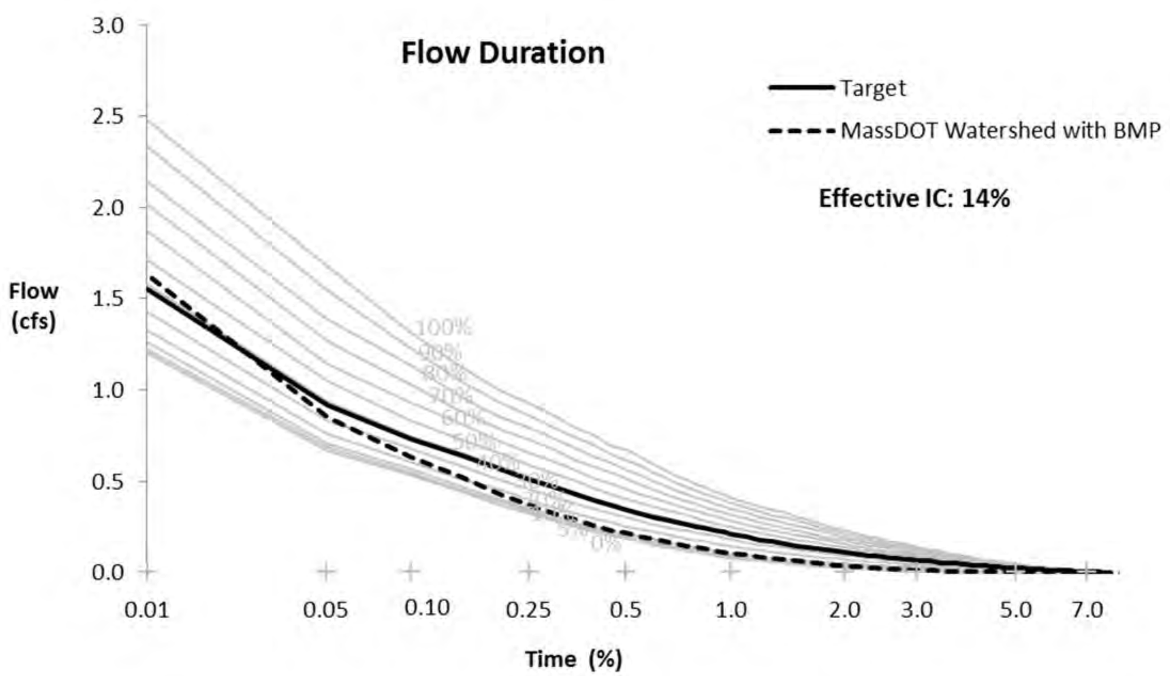
BMP Name	BMP Type	Contributing Effective IC (acres)	Estimated Percent Reduction	Estimated Reduction Effective IC (acres)
PR BMP 1	Water Quality Swale	0.2	120%	0.2
PR BMP 2	Water Quality Swale	0.1	116%	0.1
PR BMP 3	Water Quality Swale	0.1	124%	0.1
PR BMP 4	Water Quality Swale	0.4	63%	0.2
PR BMP 5	Water Quality Swale	0.2	124%	0.2
PR BMP 6	Water Quality Swale	0.1	117%	0.1
PR BMP 7	Water Quality Swale	0.1	124%	0.1
PR BMP 8	Water Quality Swale	0.2	103%	0.2
PR BMP 9	Water Quality Swale	0.4	28%	0.1
PR BMP 10	Infiltration Basin	0.2	80%	0.1
Total*		**1.9**	**78%**	**1.5**
Target				**0.6**

* Total effective IC reduction based on the assessment model results for the total MassDOT directly discharging drainage area to the receiving water (not sum of individual BMP reductions).

Note: The predicted effective IC is determined by comparing the BMP's calculated median annual discharge volume, runoff flow/duration relationship, median annual phosphorus load and median annual total suspended solids load to predicted discharge values for benchmark watersheds with the same size and varying percent IC. In cases where analysis predicts that BMPs would discharges less runoff volume and pollutant mass than those predicted for a 0% IC (pervious, woods in good condition) benchmark watershed, then the predicted effective IC removal would be greater than 100% and reduction of effective IC area will be greater than the BMP contributing IC area

Proposed Median Annual Load Comparison

Simulated IC Watersheds	Runoff (ac-ft)	TP (lb.)	TSS (lb.)
0%IC	2.5	0.2	12
5%IC	2.9	0.3	60
10% IC	3.4	0.4	127
20% IC	4.3	0.9	351
30% IC	5.1	1.5	717
Target 38% IC	**5.8**	**2.3**	**1,111**
40% IC	6.0	2.4	1,210
50% IC	6.8	3.5	1,812
60% IC	7.6	4.6	2,471
70% IC	8.5	5.8	3,137
80% IC	9.3	7.0	3,800
90% IC	10.2	8.1	4,447
100% IC	11.0	9.3	5,105
Existing Conditions	7.81	4.74	2,517
Proposed Conditions	3.1	0.66	198
Reduction %	**60%**	**86%**	**92%**
Effective IC	**7%**	**15%**	**13%**



Effective IC Results

Existing IC	1.9 acres
Proposed Estimated Effective IC	0.4 acres
IC Reduction % under Proposed Conditions	78%
Estimated Effective IC*	12%

*Average of estimated effective IC for annual median runoff volume, phosphorus and TSS loads, and flow duration

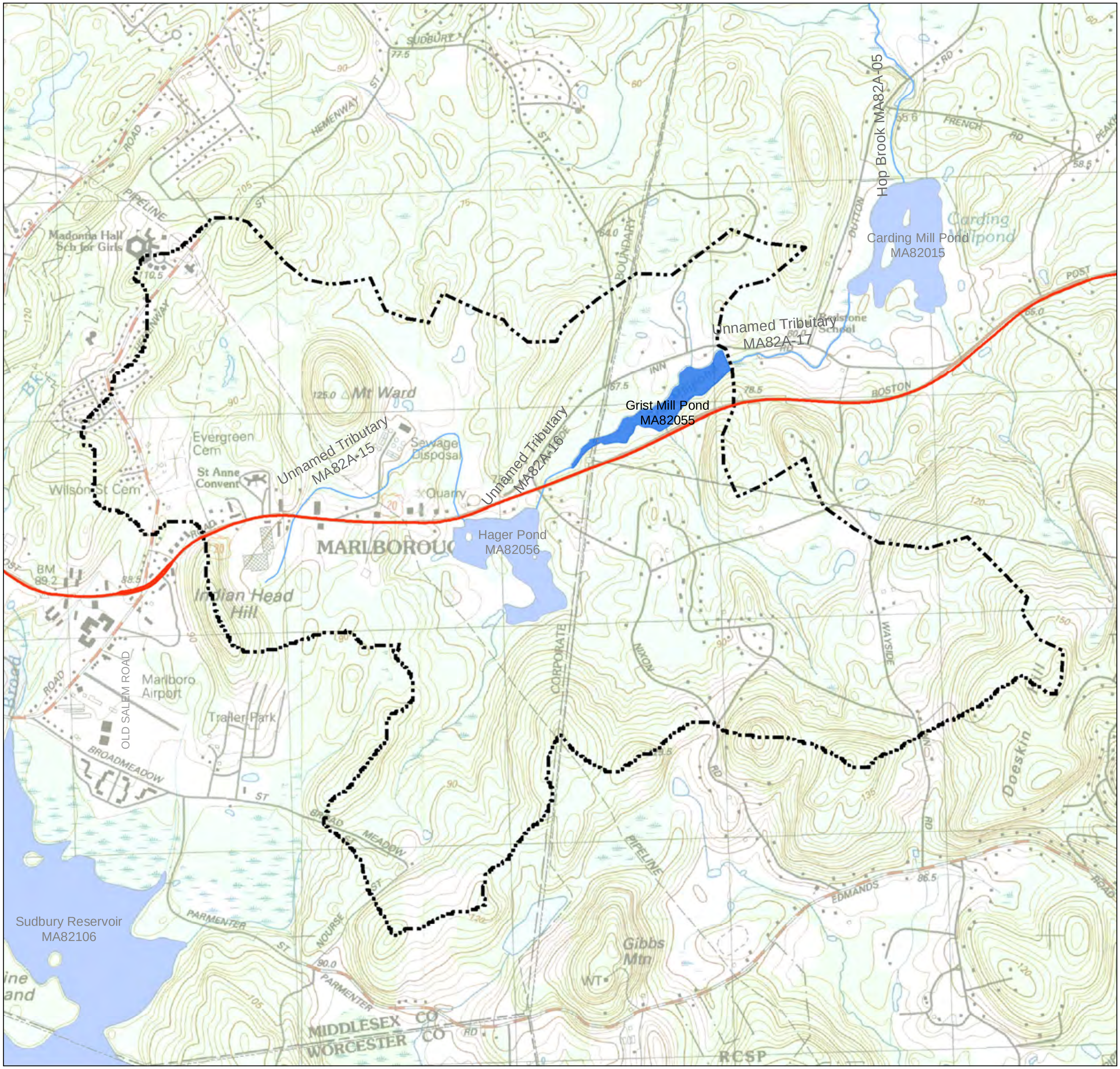
MassDOT estimated the effective IC under proposed conditions by comparing the annual median runoff volume, phosphorus and TSS loads, and flow distribution statistics (flow duration) from the MassDOT drainage area to the receiving water to those results for simulated IC watersheds.

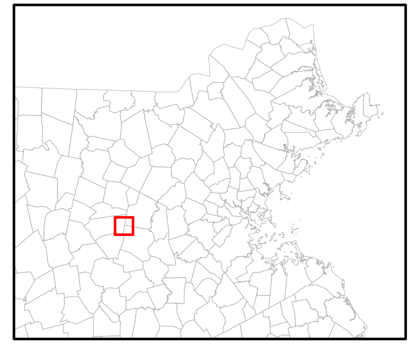
During this assessment phase of the Impaired Waters Program, MassDOT has focused on directly contributing areas and identified BMPs that can be constructed entirely on MassDOT property without resulting in substantial wetland impacts or resulting in an adverse impact on historical or archeological resources. Projects that meet these requirements can utilize the Federal Highway Administration's Alternative Contracting mechanism (SEP-14) created for this program.

The proposed BMPs provide enough treatment to meet the target. Several of the proposed BMPs provide over 100% treatment and have little to no discharge, fully infiltrating contributing run off. While the objective of the Impaired Waters Retrofit Program is to meet the target reduction and not necessarily to construct retrofits to the maximum extent practicable, due to the higher costs and inefficiencies of retrofit projects, it has been MassDOT's experience that during design additional site constraints are identified and often reduce the final number of BMPs and/ or water quality treatment. Therefore, in this assessment we are including BMPs that provide treatment beyond the target and will prioritize the most effective BMPs during the design.

MassDOT will proceed to the design phase to develop construction plans for the proposed BMPs as part of the MassDOT Impaired Waters Program. The project designer will gather additional information in this phase, such as soil data, wetland delineations, and site survey, to further refine the proposed BMPs. Once the design of the proposed BMPs is finalized, MassDOT will provide an update with additional information and summarize the final effective IC reduction based on the as-built condition.

MassDOT will continue to ensure proper non-structural BMPs are being implemented within the watershed of Grist Mill Pond (MA82056), including regular roadway and drainage system maintenance, erosion and sedimentation control, and outreach and education. Further work by MassDOT on programmed projects, which often include broader scale road layout changes, may provide additional opportunities for construction of new treatment BMPs. This is consistent with an iterative adaptive management approach to address impairments. MassDOT will include an update in annual reports to EPA regarding progress made towards meeting target IC reductions, plans for construction of proposed BMPs and finalized assessments including reduction achieved by finalized BMP designs.





MassDOT Roadways in Urban Area
Watershed
Assessed Segment
Impaired Lakes
Impaired Streams
Town Boundaries

N

0 1,000 2,000
Feet
1 inch = 2,000 feet

Figure 1

Grist Mill Pond (MA82055) Watersheds

December 2013

massDOT Massachusetts Department of Transportation Highway Division

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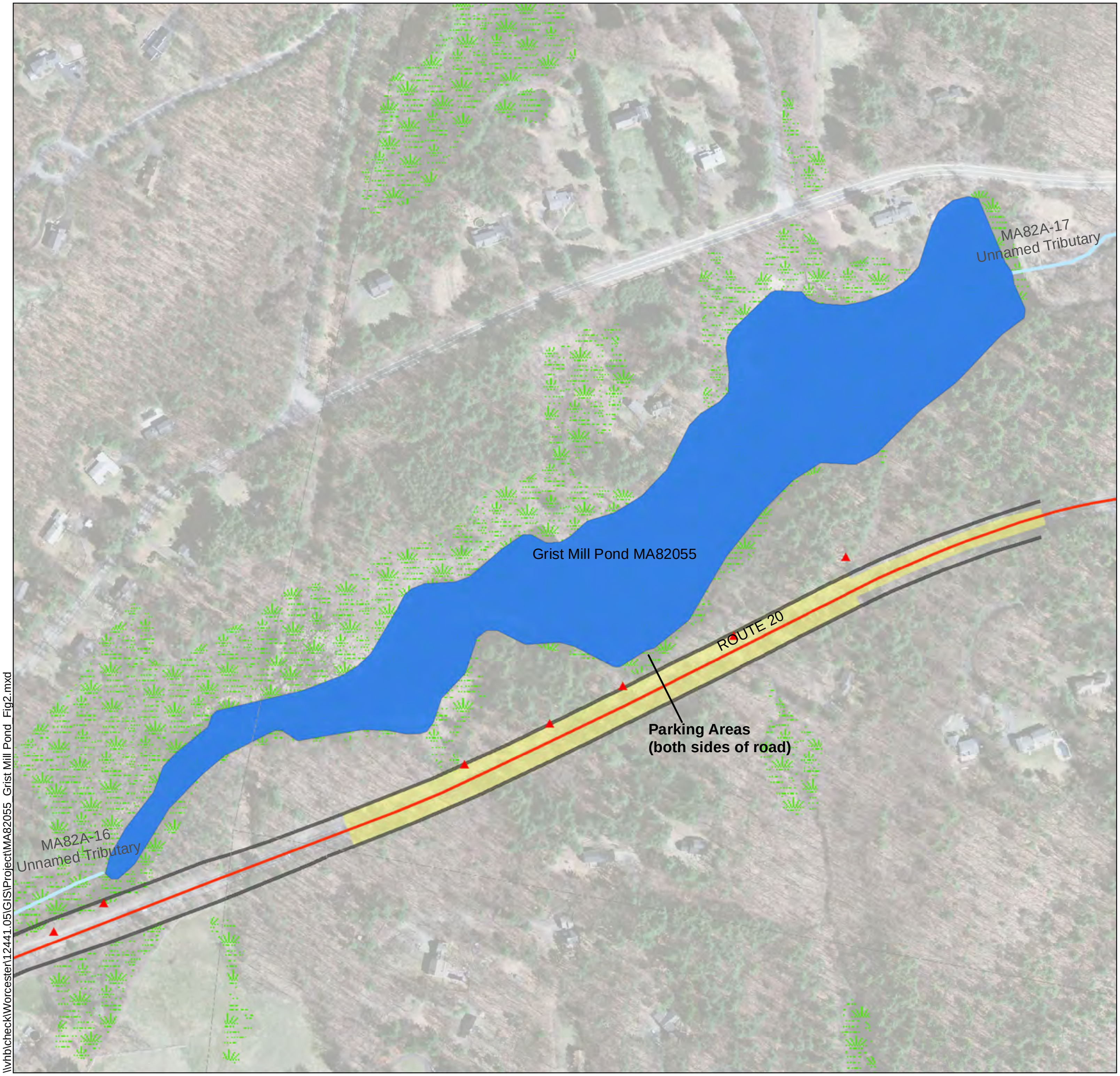

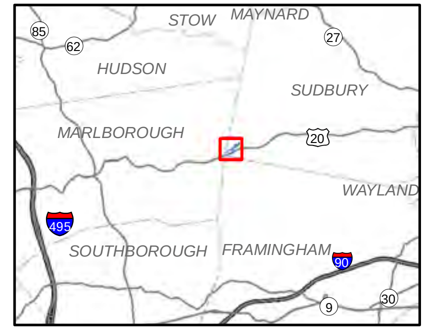

MassDOT Roadways in Urban Area

MassDOT Outfalls

MassDOT Right of Way

MassDOT Directly Discharging Area

Assessed Segment

Impaired Streams

DEP Wetlands

N

0 175 350 Feet

1 inch = 350 feet

Figure 2

Grist Mill Pond (MA82055) Directly Contributing MassDOT Watershed

December 2013

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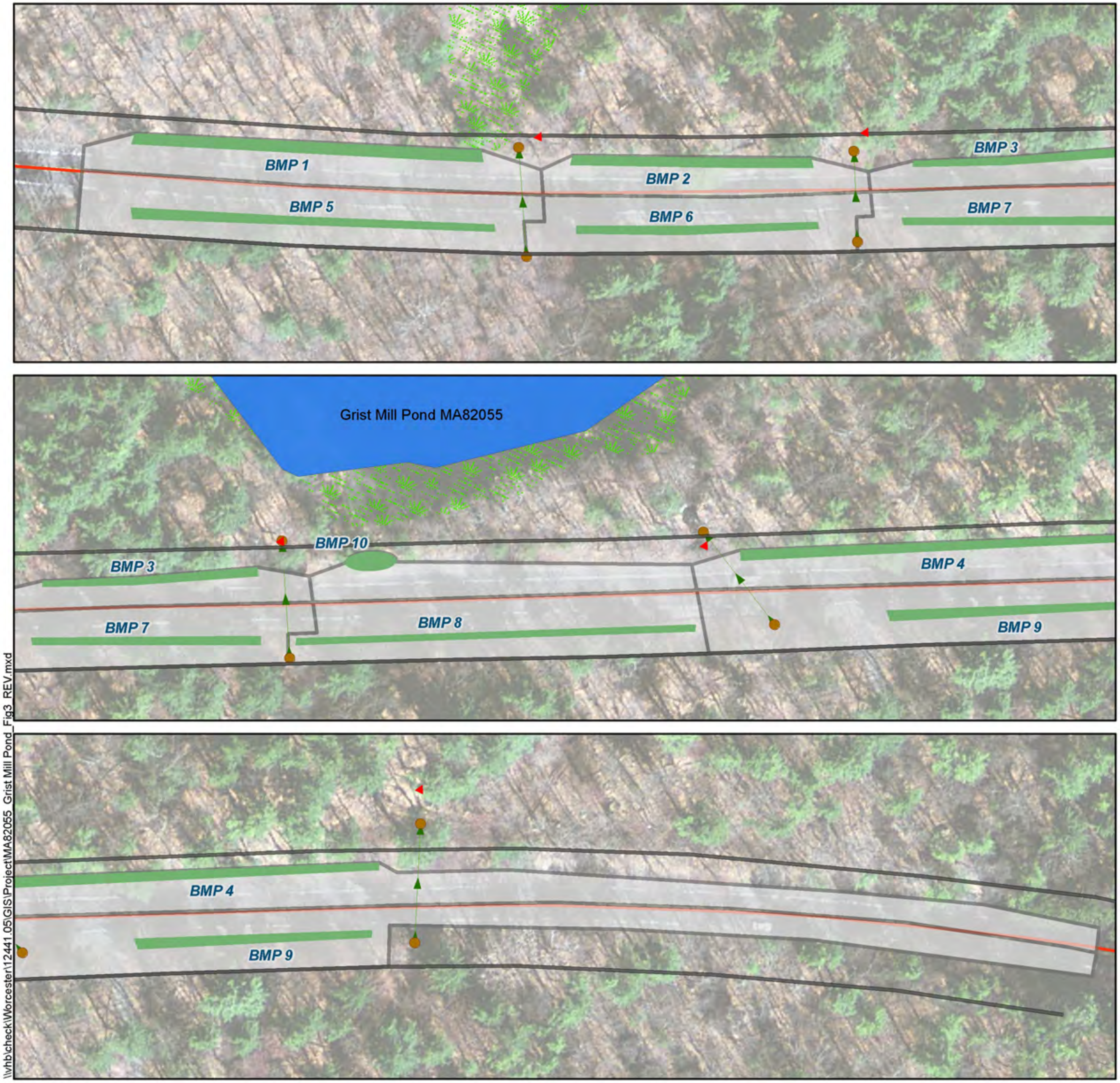

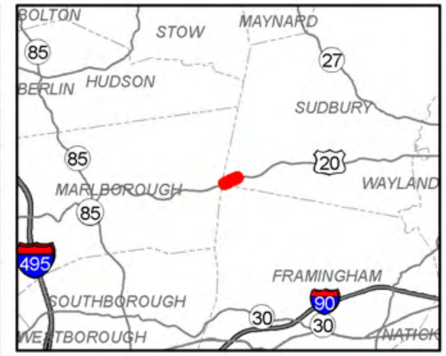

Cross culvert headwalls
Cross Culverts
Proposed BMP
Proposed BMP Watersheds
MassDOT Outfalls
Assessed Segment
Right of Way
DEP Wetlands

N

0 50 100 Feet

1 inch = 100 feet

Figure 3

Grist Mill Pond (MA82055)
Proposed BMPs

December 2013

massDOT
Massachusetts Department of Transportation
Highway Division

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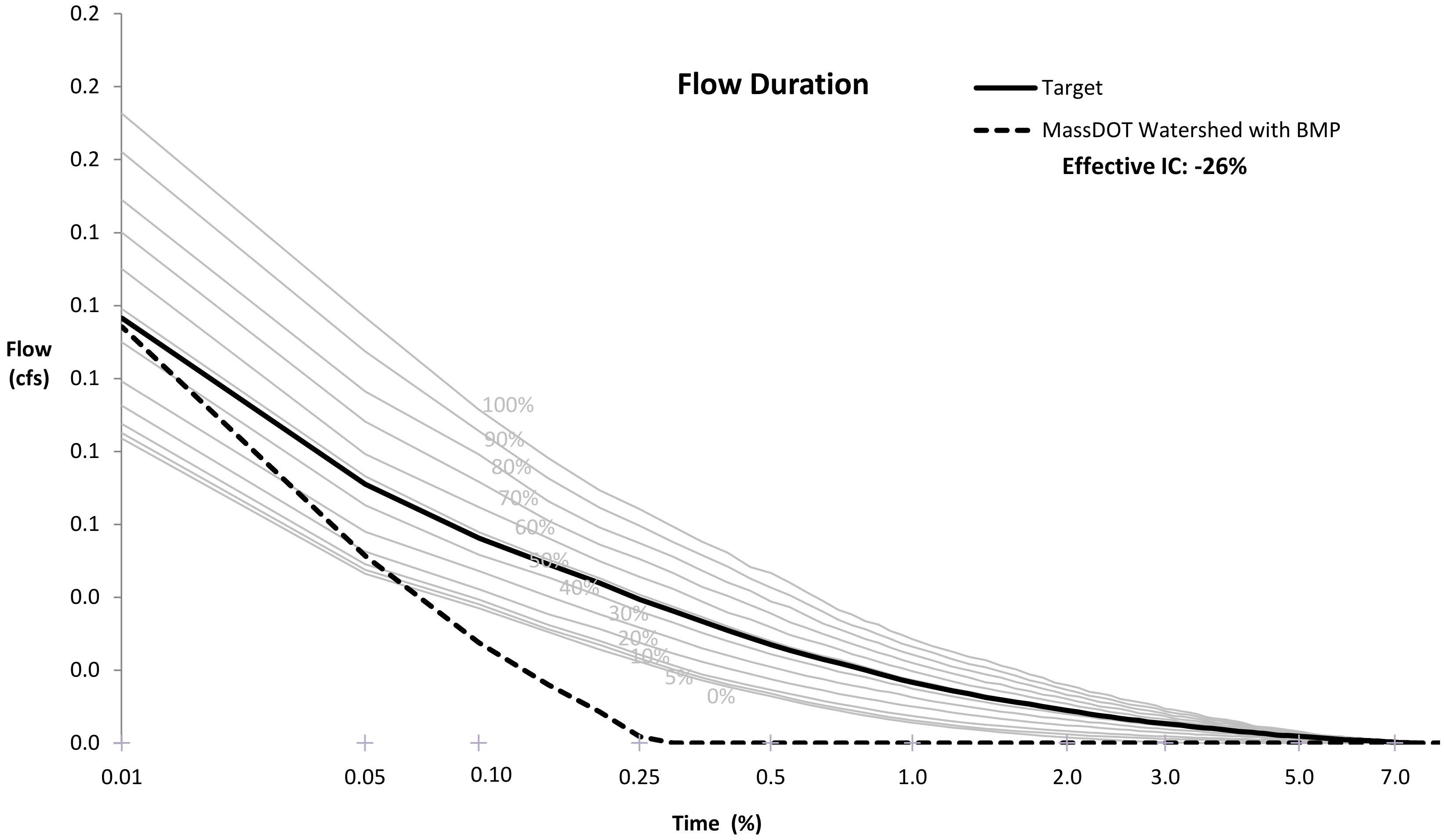
Result Summary
4109.3 BMP 1



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	0.2	0.0	1
5%IC	0.2	0.0	4
10% IC	0.2	0.0	9
20% IC	0.3	0.1	24
30% IC	0.4	0.1	50
40% IC	0.4	0.2	84
50% IC	0.5	0.2	126
60% IC	0.5	0.3	172
70% IC	0.6	0.4	218
80% IC	0.6	0.5	264
90% IC	0.7	0.6	309
100% IC	0.8	0.6	355
Watershed Load	0.62	0.42	224
BMP Output	0.08	0.01	1
Target	0.46	0.22	115
Reduction %	**88%**	**98%**	**100%**
Effective IC	**-16%**	**-4%**	**0%**

Result Summary

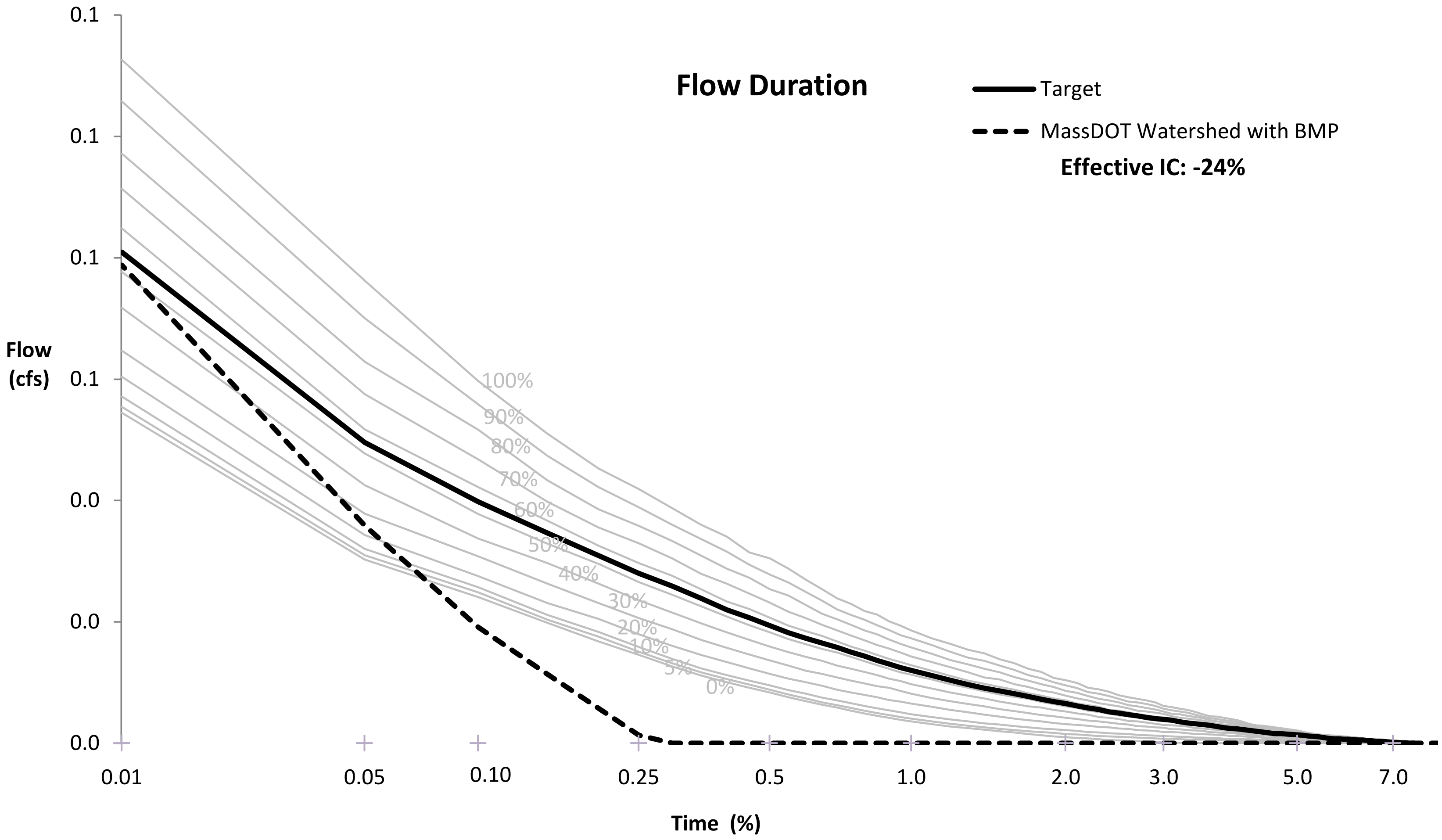
Metric	Area (%)	Area (acres)
Watershed Area		0.2
Watershed IC (no BMP)	70%	0.2
Target IC Reduction	32%	0.5
Effective IC w/BMP	-14%	(0.0)
IC Reduction	120%	0.2

Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	0.2	0.2
Indirect Watershed	-	-
Total	0.2	0.2

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary
4110.3 BMP 2



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	0.1	0.0	1
5%IC	0.1	0.0	3
10% IC	0.2	0.0	6
20% IC	0.2	0.0	16
30% IC	0.2	0.1	33
40% IC	0.3	0.1	55
50% IC	0.3	0.2	82
60% IC	0.3	0.2	112
70% IC	0.4	0.3	142
80% IC	0.4	0.3	173
90% IC	0.5	0.4	202
100% IC	0.5	0.4	232
Watershed Load	0.45	0.33	178
BMP Output	0.05	0.00	1
Target	0.33	0.18	96
Reduction %	**88%**	**99%**	**100%**
Effective IC	**-15%**	**-4%**	**0%**

Result Summary

Metric	Area (%)	Area (acres)
Watershed Area		0.2
Watershed IC (no BMP)	80%	0.1
Target IC Reduction	32%	0.5
Effective IC w/BMP	-13%	(0.0)
IC Reduction	116%	0.1

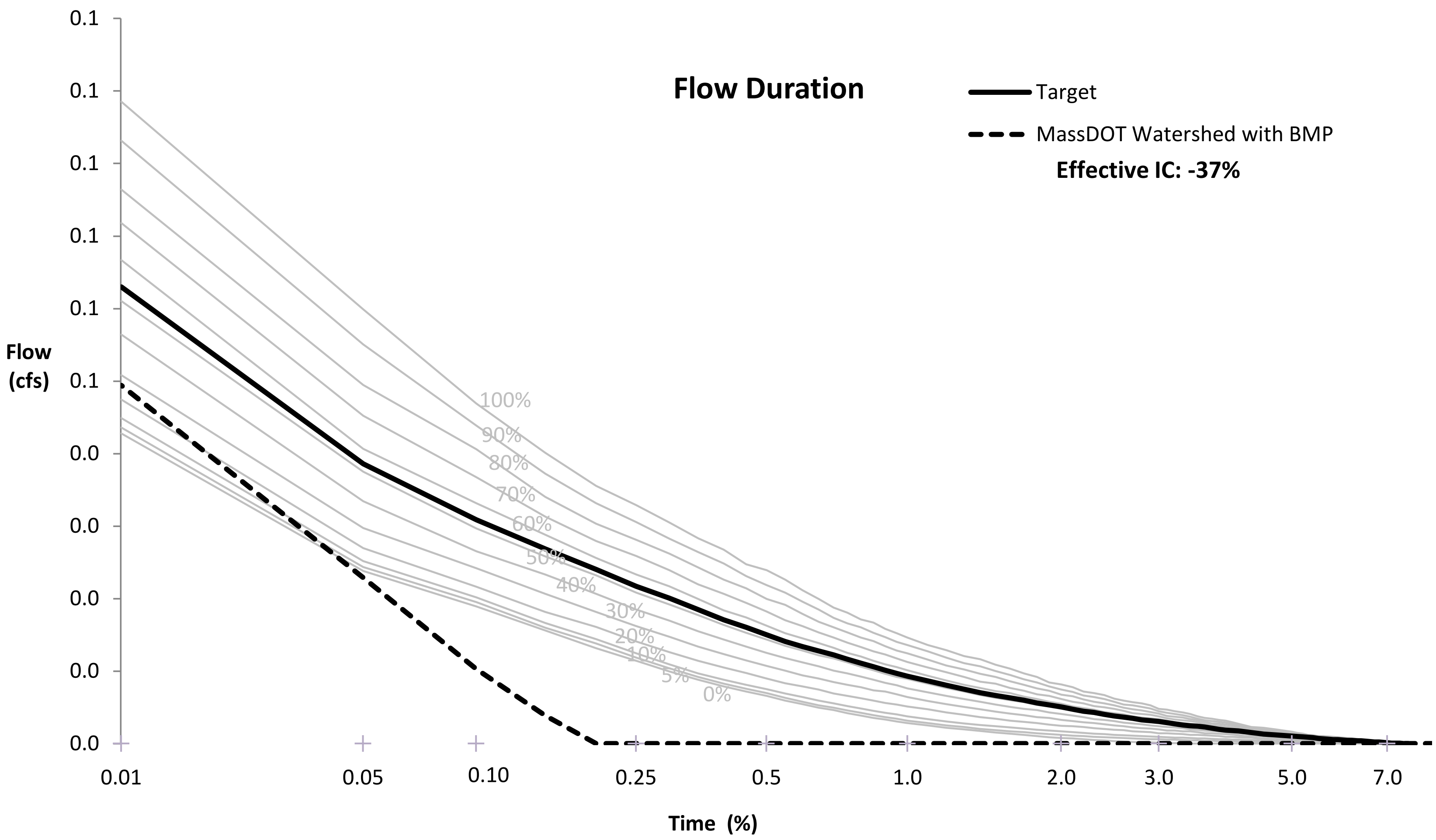
Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	0.1	0.2
Indirect Watershed	-	-
Total	0.1	0.2

* Effective IC calculated as follows:

1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary
4111.3 BMP 3



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	0.1	0.0	0
5%IC	0.1	0.0	2
10% IC	0.1	0.0	5
20% IC	0.2	0.0	13
30% IC	0.2	0.1	26
40% IC	0.2	0.1	43
50% IC	0.2	0.1	65
60% IC	0.3	0.2	88
70% IC	0.3	0.2	112
80% IC	0.3	0.2	136
90% IC	0.4	0.3	159
100% IC	0.4	0.3	182
Watershed Load	0.35	0.25	136
BMP Output	0.03	0.00	0
Target	0.25	0.14	73
Reduction %	**92%**	**99%**	**100%**
Effective IC	**-19%**	**-5%**	**0%**

Result Summary

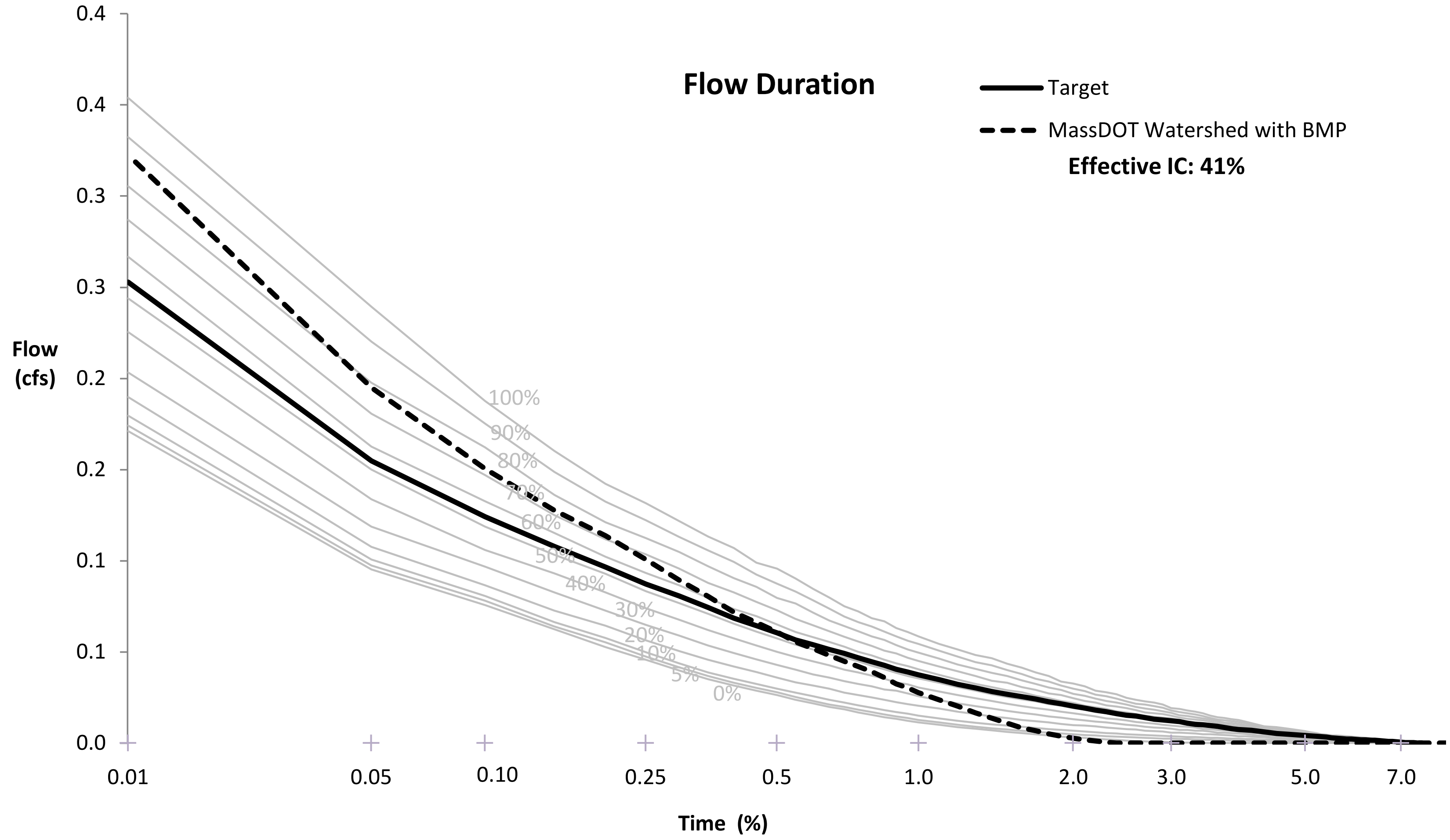
Metric	Area (%)	Area (acres)
Watershed Area		0.1
Watershed IC (no BMP)	79%	0.1
Target IC Reduction	32%	0.5
Effective IC w/BMP	-19%	(0.0)
IC Reduction	124%	0.1

Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	0.1	0.1
Indirect Watershed	-	-
Total	0.1	0.1

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary
4102.3 BMP 4



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	0.4	0.0	2
5%IC	0.4	0.0	9
10% IC	0.5	0.1	18
20% IC	0.6	0.1	50
30% IC	0.7	0.2	102
40% IC	0.9	0.3	173
50% IC	1.0	0.5	259
60% IC	1.1	0.7	353
70% IC	1.2	0.8	447
80% IC	1.3	1.0	542
90% IC	1.4	1.2	634
100% IC	1.6	1.3	728
Watershed Load	1.44	1.03	557
BMP Output	0.67	0.13	38
Target	1.02	0.56	295
Reduction %	**54%**	**87%**	**93%**
Effective IC	**25%**	**21%**	**16%**

Result Summary

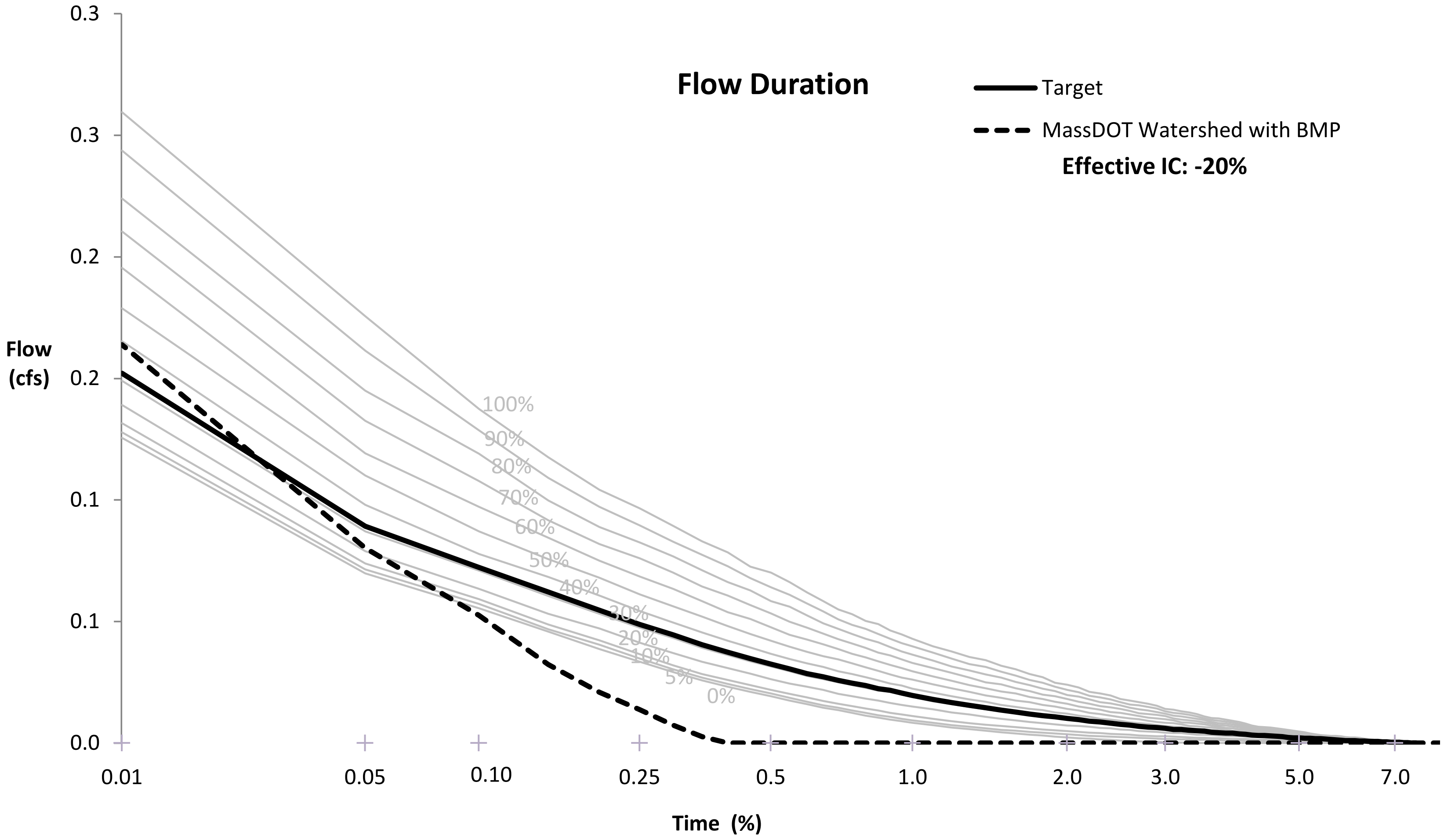
Metric	Area (%)	Area (acres)
Watershed Area		0.5
Watershed IC (no BMP)	79%	0.4
Target IC Reduction	32%	0.5
Effective IC w/BMP	29%	0.1
IC Reduction	63%	0.2

Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	0.4	0.5
Indirect Watershed	-	-
Total	0.4	0.5

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary
4108.3 BMP 5



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	0.3	0.0	1
5%IC	0.3	0.0	6
10% IC	0.4	0.0	13
20% IC	0.4	0.1	37
30% IC	0.5	0.2	75
40% IC	0.6	0.3	127
50% IC	0.7	0.4	190
60% IC	0.8	0.5	259
70% IC	0.9	0.6	328
80% IC	1.0	0.7	398
90% IC	1.1	0.9	465
100% IC	1.2	1.0	534
Watershed Load	0.72	0.36	182
BMP Output	0.13	0.01	2
Target	0.55	0.18	85
Reduction %	**82%**	**97%**	**99%**
Effective IC	**-14%**	**-3%**	**1%**

Result Summary

Metric	Area (%)	Area (acres)
Watershed Area		0.4
Watershed IC (no BMP)	47%	0.2
Target IC Reduction	32%	0.5
Effective IC w/BMP	-11%	(0.0)
IC Reduction	124%	0.2

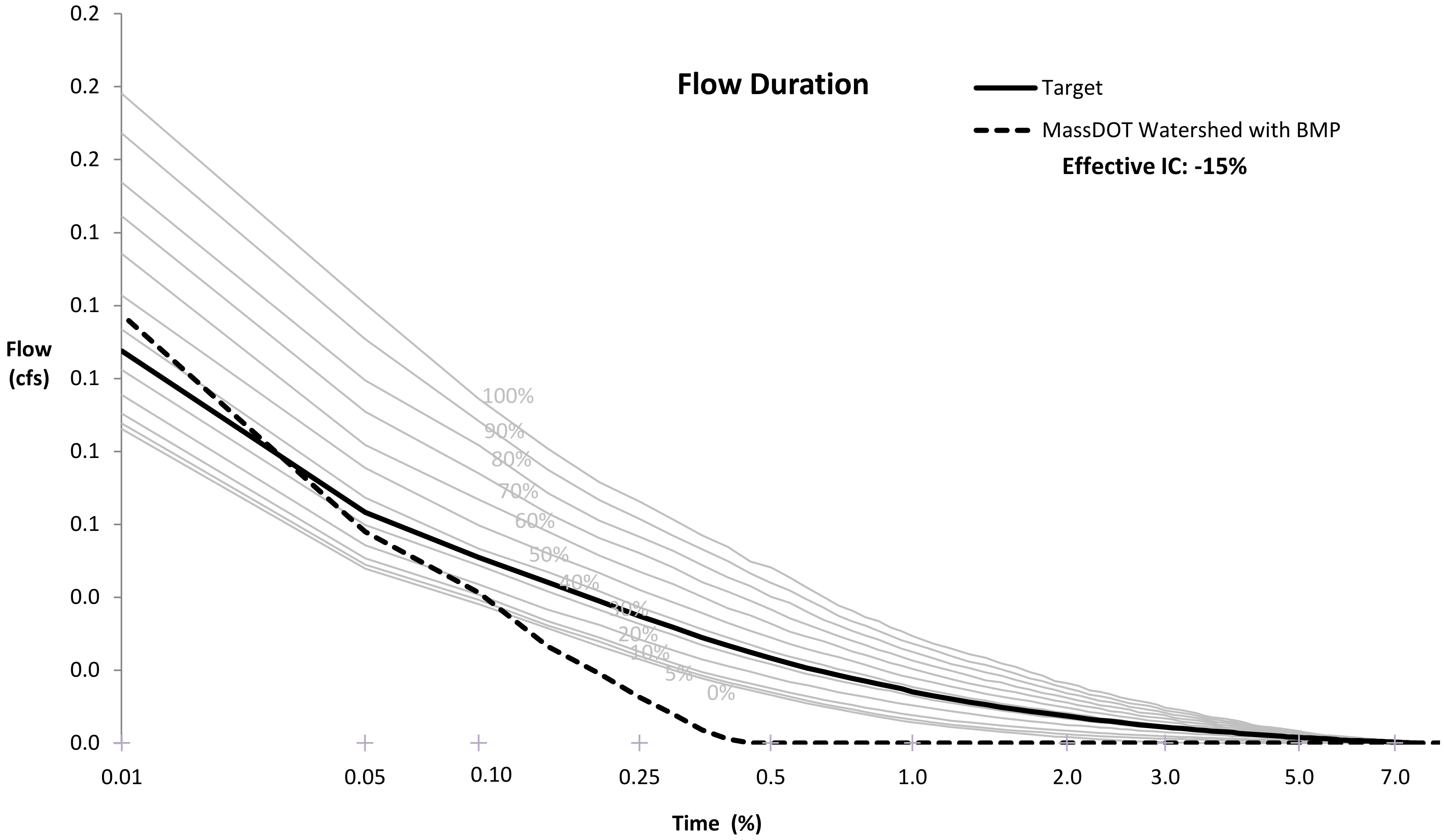
Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	0.2	0.4
Indirect Watershed	-	-
Total	0.2	0.4

* Effective IC calculated as follows:

1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary
4107.3 BMP 6



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	0.2	0.0	1
5%IC	0.2	0.0	4
10% IC	0.2	0.0	9
20% IC	0.3	0.1	25
30% IC	0.4	0.1	51
40% IC	0.4	0.2	87
50% IC	0.5	0.3	130
60% IC	0.5	0.3	177
70% IC	0.6	0.4	225
80% IC	0.7	0.5	273
90% IC	0.7	0.6	319
100% IC	0.8	0.7	366
Watershed Load	0.52	0.28	144
BMP Output	0.10	0.01	2
Target	0.40	0.14	68
Reduction %	**81%**	**96%**	**99%**
Effective IC	**-13%**	**-2%**	**1%**

Result Summary

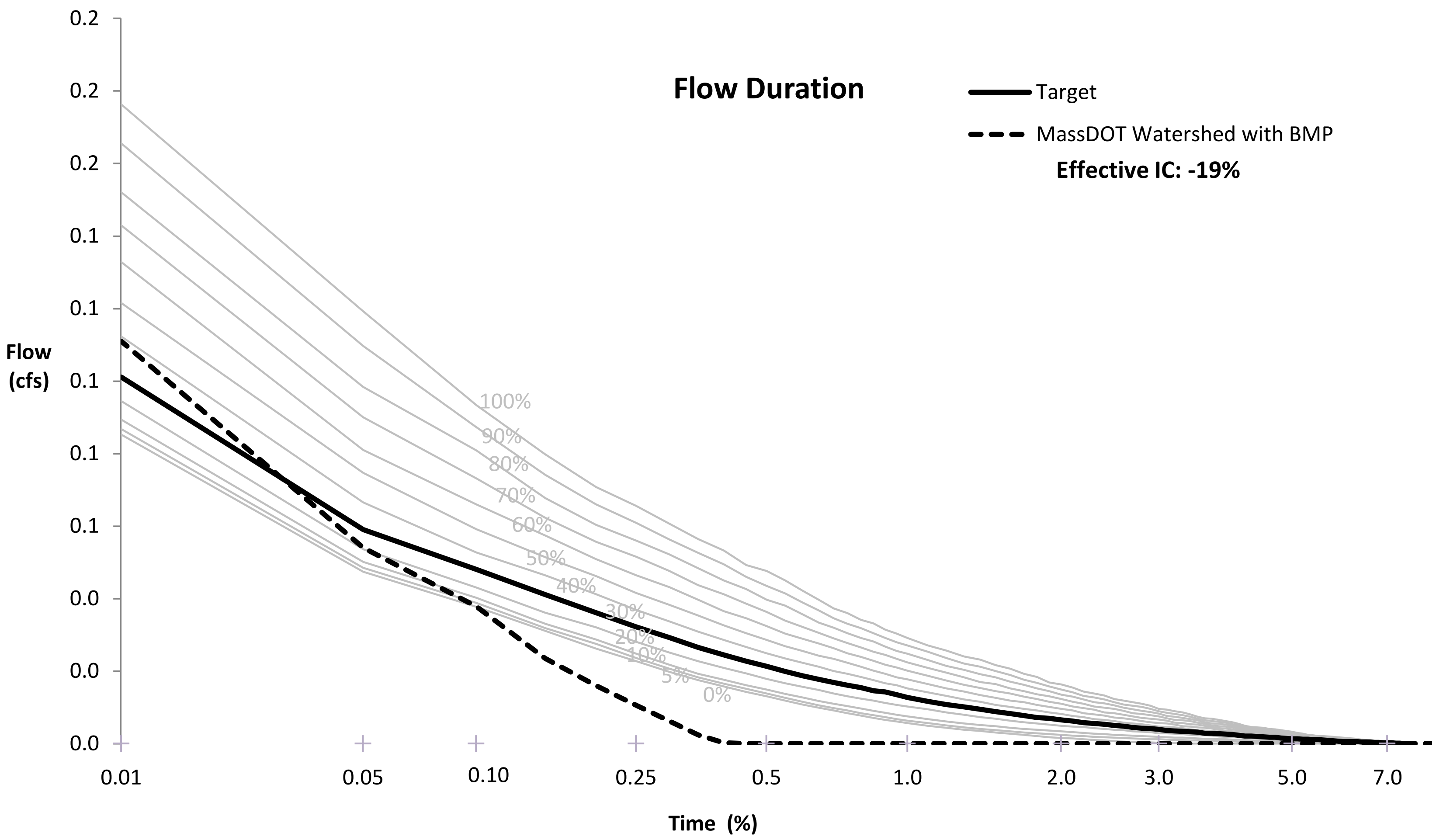
Metric	Area (%)	Area (acres)
Watershed Area		0.2
Watershed IC (no BMP)	51%	0.1
Target IC Reduction	32%	0.5
Effective IC w/BMP	-9%	(0.0)
IC Reduction	117%	0.1

Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	0.1	0.2
Indirect Watershed	-	-
Total	0.1	0.2

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary
4106.3 BMP 7



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	0.2	0.0	1
5%IC	0.2	0.0	4
10% IC	0.2	0.0	9
20% IC	0.3	0.1	25
30% IC	0.4	0.1	51
40% IC	0.4	0.2	86
50% IC	0.5	0.2	129
60% IC	0.5	0.3	176
70% IC	0.6	0.4	223
80% IC	0.7	0.5	270
90% IC	0.7	0.6	316
100% IC	0.8	0.7	363
Watershed Load	0.47	0.22	110
BMP Output	0.09	0.01	1
Target	0.36	0.11	50
Reduction %	**81%**	**96%**	**99%**
Effective IC	**-14%**	**-3%**	**1%**

Result Summary

Metric	Area (%)	Area (acres)
Watershed Area		0.2
Watershed IC (no BMP)	44%	0.1
Target IC Reduction	32%	0.5
Effective IC w/BMP	-11%	(0.0)
IC Reduction	124%	0.1

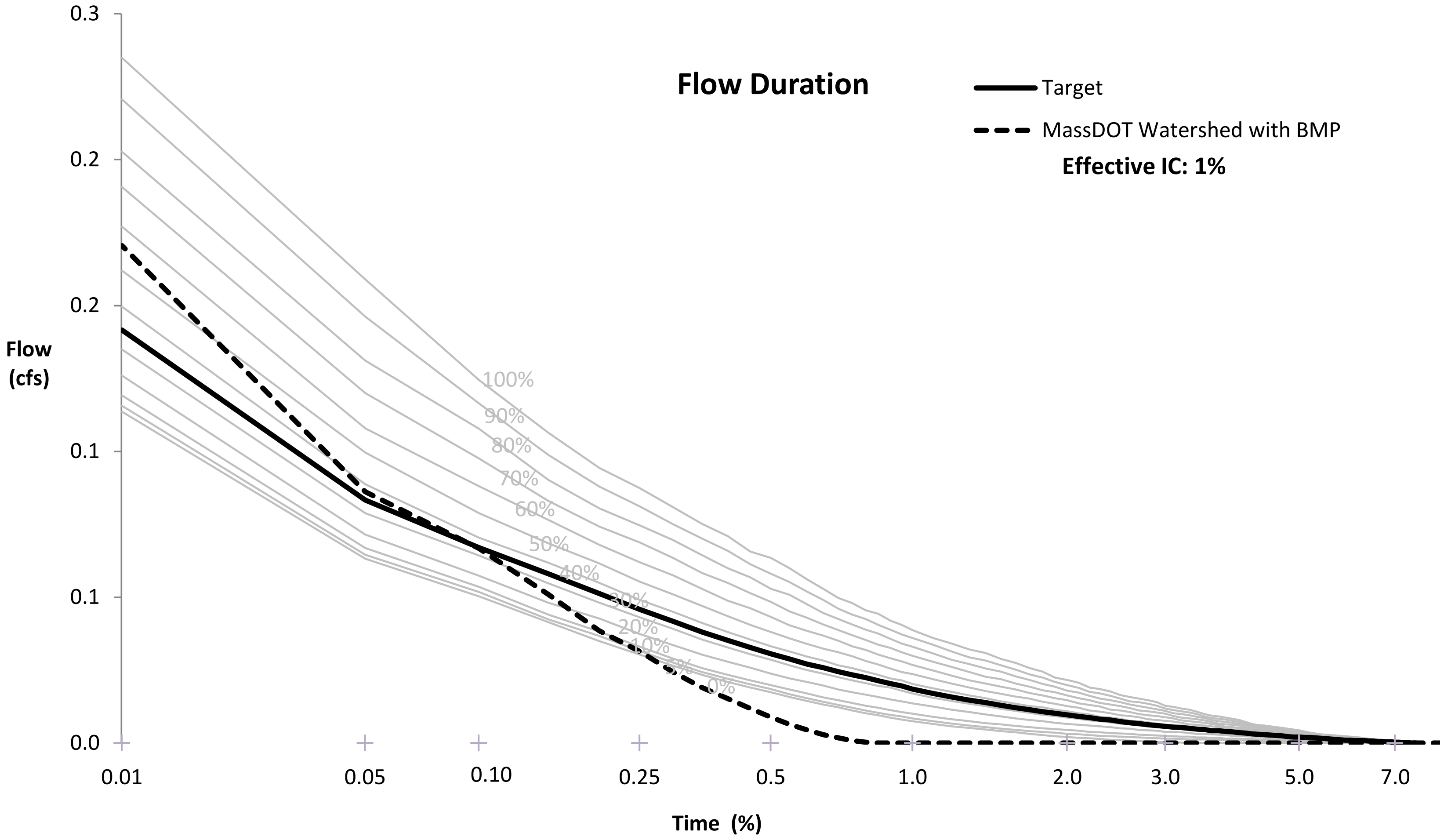
Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	0.1	0.2
Indirect Watershed	-	-
Total	0.1	0.2

* Effective IC calculated as follows:

1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary
4105.3 BMP 8



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	0.2	0.0	1
5%IC	0.3	0.0	6
10% IC	0.3	0.0	12
20% IC	0.4	0.1	33
30% IC	0.5	0.1	68
40% IC	0.6	0.2	115
50% IC	0.6	0.3	172
60% IC	0.7	0.4	234
70% IC	0.8	0.6	297
80% IC	0.9	0.7	360
90% IC	1.0	0.8	421
100% IC	1.0	0.9	483
Watershed Load	0.72	0.37	193
BMP Output	0.17	0.02	4
Target	0.52	0.18	89
Reduction %	**77%**	**95%**	**98%**
Effective IC	**-8%**	**1%**	**3%**

Result Summary

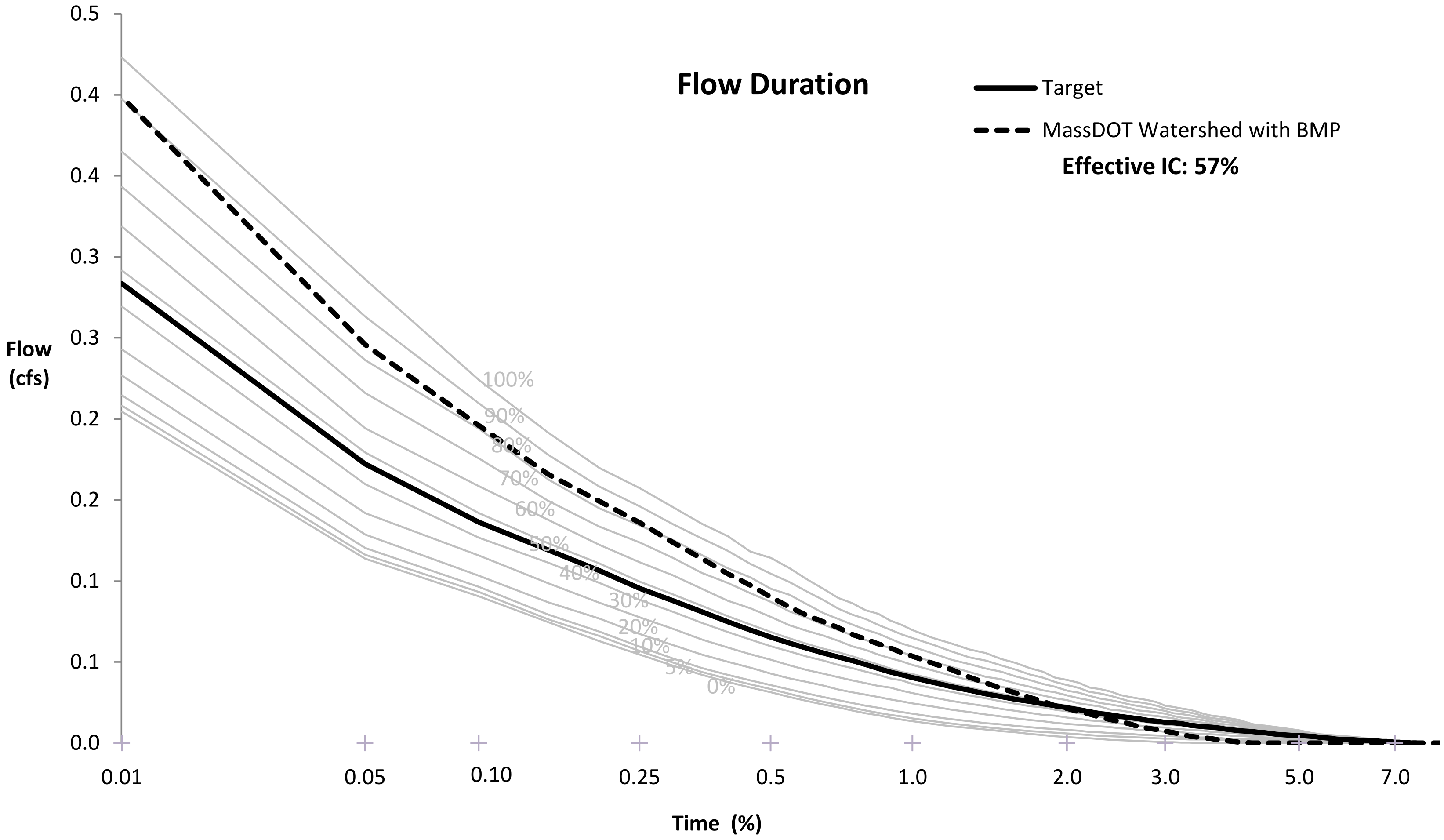
Metric	Area (%)	Area (acres)
Watershed Area		0.3
Watershed IC (no BMP)	51%	0.2
Target IC Reduction	32%	0.5
Effective IC w/BMP	-2%	(0.0)
IC Reduction	103%	0.2

Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	0.2	0.3
Indirect Watershed	-	-
Total	0.2	0.3

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
 a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
 b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary
4104.3 BMP 9



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	0.4	0.0	2
5%IC	0.5	0.0	10
10% IC	0.6	0.1	22
20% IC	0.7	0.1	60
30% IC	0.9	0.3	122
40% IC	1.0	0.4	206
50% IC	1.2	0.6	309
60% IC	1.3	0.8	421
70% IC	1.4	1.0	535
80% IC	1.6	1.2	648
90% IC	1.7	1.4	758
100% IC	1.9	1.6	870
Watershed Load	1.58	1.02	547
BMP Output	1.20	0.38	131
Target	1.11	0.53	272
Reduction %	**24%**	**62%**	**76%**
Effective IC	**53%**	**38%**	**31%**

Result Summary

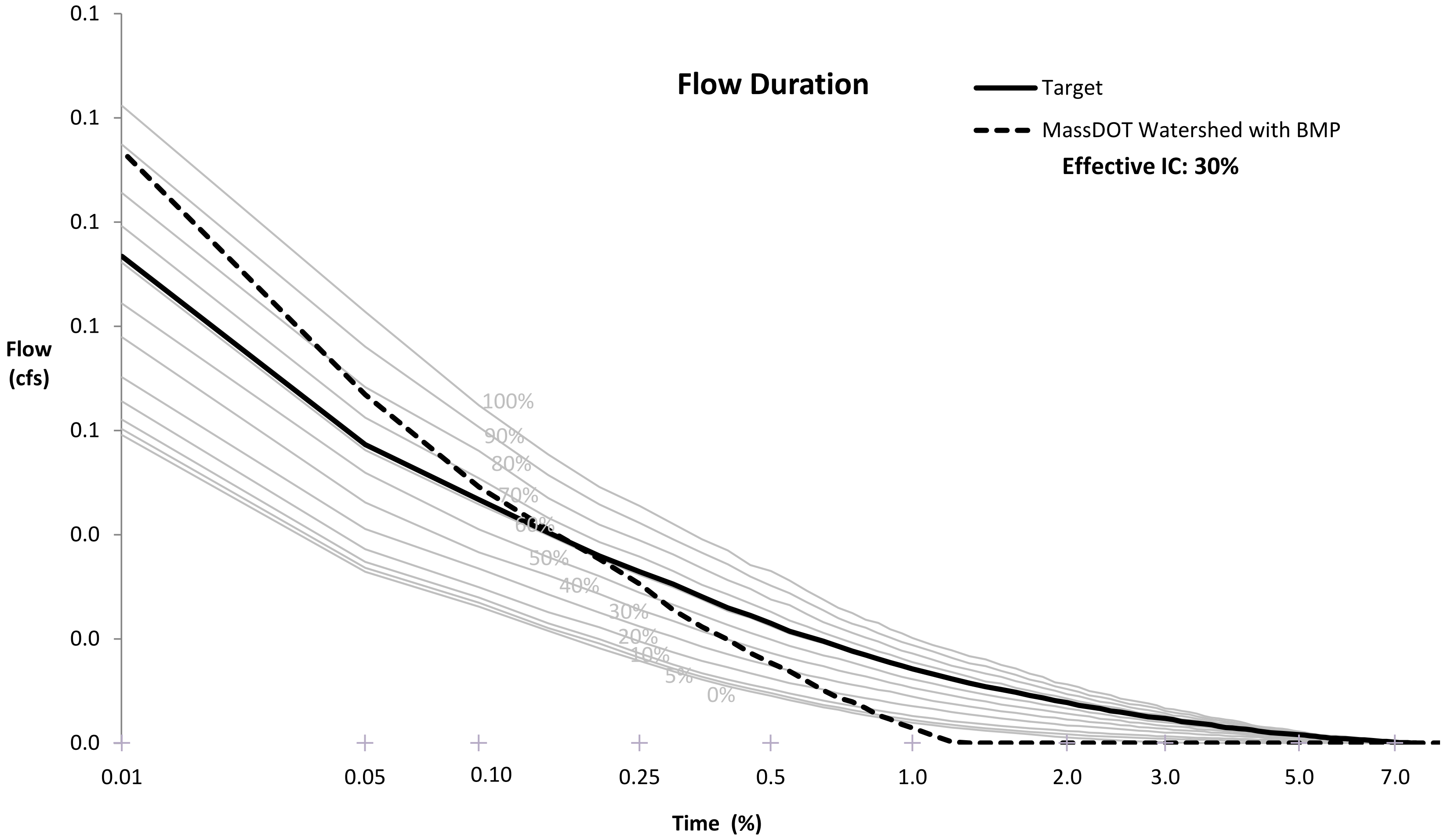
Metric	Area (%)	Area (acres)
Watershed Area		0.6
Watershed IC (no BMP)	68%	0.4
Target IC Reduction	32%	0.5
Effective IC w/BMP	49%	0.3
IC Reduction	28%	0.1

Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	0.4	0.6
Indirect Watershed	-	-
Total	0.4	0.6

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary
4100.3 BMP 10



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	0.1	0.0	1
5%IC	0.1	0.0	3
10% IC	0.2	0.0	6
20% IC	0.2	0.0	17
30% IC	0.3	0.1	35
40% IC	0.3	0.1	60
50% IC	0.3	0.2	89
60% IC	0.4	0.2	122
70% IC	0.4	0.3	155
80% IC	0.5	0.3	187
90% IC	0.5	0.4	219
100% IC	0.5	0.5	252
Watershed Load	0.52	0.42	228
BMP Output	0.17	0.03	7
Target	0.38	0.24	128
Reduction %	**68%**	**93%**	**97%**
Effective IC	**10%**	**14%**	**11%**

Result Summary

Metric	Area (%)	Area (acres)
Watershed Area		0.2
Watershed IC (no BMP)	91%	0.2
Target IC Reduction	32%	0.5
Effective IC w/BMP	18%	0.0
IC Reduction	80%	0.1

Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	0.2	0.2
Indirect Watershed	-	-
Total	0.2	0.2

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Impaired Waters Assessment for Hager Pond (MA82056)

Summary

		Stormwater	Non-Stormwater[2]
Impaired Water[1]	**Impairments:**	DO saturation, excess algal growth, fecal coliform, total phosphorus, turbidity, aquatic plants(macrophytes)	Non-native aquatic plants
	Category:	5 (Waters requiring a TMDL)	
	Final TMDLs:	None	
	WQ Assessment:	SuAsCo Watershed 2001 Water Quality Assessment Report [3]	
Location	**Towns:**	Marlborough	
	MassDOT Roads:	State Route 20	
Assessment Method(s)	**7R (TMDL Method)**	☐	
	7U (IC Method)	☒	
BMPs	**Existing:**	None	
	Proposed:	None	

MassDOT Contributing Area and Targets		Impervious Cover (IC)
	Directly Contributing Area	3.0 acres
	Contributing Area Reduction Target	1.4 acres
	Existing BMPs Reduction	0.0 acres
	Proposed BMPs Reduction	0.0 acres
	Remaining Treatment to Meet Target	1.4 acres

[1] MassDEP, 2013. Massachusetts Year 2012 Integrated List of Waters – Final Listing of the Condition of Massachusetts' Waters Pursuant to Sections 305(b), 314 and 303(d) of the Clean Water Act. Massachusetts. Available at: http://www.mass.gov/eea/docs/dep/water/resources/07v5/12list2.pdf

[2] MassDOT, December 2012. Impaired Waters Assessment for Impaired Waters with Impairments Unrelated to Stormwater. Available at: http://www.mhd.state.ma.us/downloads/projDev/ImpairedWaters_3/Year3_ImpairedWatersAssessment_1.pdf#page=308

[3] MassDEP, 2005. SuAsCo Watershed 2001 Water Quality Assessment Report. Available at: http://www.mass.gov/eea/docs/dep/water/resources/71wqar09/82wqar3.pdf

Site Description

Hager Pond (MA82056) is a 30-acre impoundment on a stream locally referred to as Hop Brook. The contributing area to Hager Pond (MA82056) is approximately 1,090 acres and includes portions of Marlborough and Framingham. Route 20, the only MassDOT-owned roadway in the tributary watershed, bisects the contributing area from east to west. Figure 1 illustrates the location of the Hagar Pond (MA82056) watershed.

The headwaters of Hop Brook (MA82A-15) are located between the rear yards of a commercial development (Home Depot) and a residential development (Settlers Lane) adjacent to an area historically referred to as Indian Hill. Hop Brook (MA82A-15) flows overland for approximately 200 feet, where it enters a ~950-foot long culvert that conveys the brook northward underneath the commercial parking lot to a wooded area north of Route 20. Hop Brook (MA82A-15) flows approximately 4,300 feet to the northeast and then to the south, back under Route 20 to Hager Pond (MA82056). The Marlborough Easterly Waste Water Treatment Plant (WWTP) discharges to the brook approximately 1,800 feet upstream of Hager Pond (MA82056). Hop Brook (MA82A-16) exits Hager Pond and flows approximately 900 feet northward (again passing under Route 20) to Grist Mill Pond (MA82055).

The 2001 SuAsCo Water Quality Assessment Report[4] indicates that the waterbody is impaired for the Aquatic Life Designated Use. The identified causes include non-native macrophytes, low dissolved oxygen and high total phosphorus. The report also indicates that the waterbody is impaired for Primary and Secondary Contact Recreation and Aesthetics due to excess algal growth.

"The Marlborough Easterly Wastewater Treatment Plant (WWTP) discharges to Hop Brook upstream of Hager Pond and accounts for a significant amount of flow and nutrient loadings at this water body. Numerous studies have been conducted on the Hop Brook system. In 1984, the USGS determined that approximately 50% of the flow in Hop Brook consists of effluent from the WWTP; in drought conditions, the effluent may account for as much as 90% of the flow."[5]

Figure 2 illustrates the MassDOT property directly draining to Hager Pond (MA82056).

The eastern portion, Route 20, the MassDOT roadway contributing to this water body, occupies two lanes (one in each direction). Both lanes are graded to direct sheet runoff overland to the south. Runoff from this area is concentrated and directed to Hager Pond overland via a paved waterway. The eastern portion of the paved roadway is approximately 35 feet wide. The right-of way is variable in this area, as shown in Figure 2.

The western portion of the MassDOT roadway contributing to the pond occupies four lanes (two in each direction). Four lanes merge to two at 910 Boston Post Road (Route 20). The road in this section is undivided and crowned at the center. The road slope is steep in the direction of travel. Catch basins, placed at intervals of approximately 150 feet, direct runoff flows to a trunkline which discharges directly to Hager Pond. The western portion of the paved roadway is approximately 60 feet wide. The right-of-way follows the edge of the road at the sidewalk and occasionally encroaches on adjacent properties to include a historical roadway alignment.

Existing BMPs

MassDOT did not identify any existing BMPs in place to treat the directly discharging roadway runoff before reaching the impaired water segment.

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[4] MassDEP, 2005. SuAsCo Watershed 2001 Water Quality Assessment Report. Available at: http://www.mass.gov/eea/docs/dep/water/resources/71wqar09/82wqar3.pdf

[5] *Ibid.*

Assessment

In cases where a TMDL has been approved, MassDOT assessed the waterbody for the impairments covered by the TMDL under the BMP 7R methodology. MassDOT has separately assessed the waterbody for any stormwater-related impairments that are not covered by the TMDL under the BMP 7U methodology. MassDOT assessed Hager Pond (MA82056) using the methodologies described below.

MassDOT has identified a subset of water body impairments in the Hager Pond (MA82056) watershed which are not related to stormwater runoff. Specific impairments unrelated to stormwater for the Hager Pond include non-native aquatic species in accordance to MassDOT's Impaired Waters Assessment for Impaired Waters with Impairments Unrelated to Stormwater in the December 8, 2012 EPA submittal, the non-pollutant impairments are not specifically addressed as part of the Impaired Waters Program.[6]

Assessment 7U for Pathogen Impairment

MassDOT assessed the indicator bacteria (fecal coliform) impairment using the approach described in BMP 7U of MassDOT's Storm Water Management Plan (SWMP).[7] Hager Pond (MA82056) is covered by the Draft Pathogen TMDL for the Concord River Watershed.[8] According to the Draft TMDL, sources of indicator bacteria in the Concord River watershed were found to be many and varied. Most of the bacteria sources in the Concord River watershed are believed to be failing septic systems, combined sewer overflows (CSO), sanitary sewer overflows (SSO), sewer pipes connected to storm drains, certain recreational activities, wildlife including birds along with domestic pets and animals and direct overland stormwater runoff. Additionally, the TMDL states that implementation to achieve the TMDL goals should be an iterative process with selection and implementation of mitigation measures followed by monitoring to determine the extent of water quality improvement realized. Recommended TMDL implementation measures include identification and elimination of prohibited sources such as leaky or improperly connected sanitary sewer flows and best management practices to mitigate storm water runoff volume. MassDOT included a review of the draft report as an informational review as part of this assessment even though, due to their draft status, draft TMDLs are not formally part of the Impaired Waters Retrofit program.

Pathogen concentrations in stormwater vary widely temporally and spatially; concentrations can vary by an order of magnitude within a given storm event at a single location.[9] Therefore, it is difficult to predict pathogen concentrations in stormwater with accuracy. MassDOT's South East Expressway study measured bacterial concentration in stormwater runoff[10] and data indicated that highway's pathogen loading may be lower than urban areas. Considering that the potential sources of pathogens (e.g. illicit discharges, sewer utilities, pet waste and wildlife) are likely to be less prevalent in the highway environment than along urban roads, this finding is not surprising.

MassDOT does not conduct site specific assessments of loading at each location impaired for pathogens. Instead, MassDOT reviewed its existing programs and their consistency with EPA NPDES MS4 general permit requirements and pathogen TMDL requirements. Language in the documents clearly indicate that an iterative adaptive management approach is the appropriate way to address discharges to pathogen impaired waters and recommend implementation of programmatic BMPs such as residential educational programs,

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[6] MassDOT, December 2012. Impaired Waters Assessment for Impaired Waters with Impairments Unrelated to Stormwater. Available at: http://www.mhd.state.ma.us/downloads/projDev/ImpairedWaters_3/Year3_ImpairedWatersAssessment_1.pdf#page=308

[7] MassDOT, 6 April, 2011. Description of MassDOT's Application of Impervious Cover Method in BMP 7U (MassDOT Application of IC Method). http://www.mhd.state.ma.us/downloads/projDev/BMP_7U_ImpairedWaterbodiesAssessment.pdf

[8] MassDEP. Draft Pathogen TMDL for the Concord River Watershed. Available at: http://www.mass.gov/eea/docs/dep/water/resources/a-thru-m/concord1.pdf

[9] MassDEP. 2009. Final Pathogen TMDL for the Cape Cod Watershed. Available at: http://www.mass.gov/dep/water/resources/capecod1.pdf

[10] Smith. (2002). Effectiveness of Three Best Management Practices for Highway Runoff Quality along the Southeast Expressway. USGS Water Resources Investigations Report 02-4059. Boston, Massachusetts.

illicit connection identification, tracking and removal and pet waste management. MassDOT implements a variety of non-structural BMP programs across their system in accordance with their existing SWMP including educational programs, illicit connection review and source control.

MassDOT has an ongoing inspection and monitoring program aimed at identifying and addressing illicit discharges to MassDOT's stormwater management system. Any illicit discharges to MassDOT's system could contribute pathogens to impaired waters, however, MassDOT's existing Illicit Discharge Detection and Elimination (IDDE) program is aimed at identifying and addressing these contributions. District maintenance staff note signs of potential illicit discharges, such as dry weather flow and notable odors or sheens. Similarly, Resident Engineers overseeing construction projects also receive instruction regarding the need to note any suspicious connections or flows, and report these for follow-up investigation and action as appropriate. MassDOT will continue to implement this IDDE training, and District staff will continue to report any suspicious flows requiring further investigation. MassDOT investigates any suspicious flows noted, and proceeds to work with owners of confirmed illicit discharges to remove these flows, and thereby minimize pathogen contributions to receiving waters.

MassDOT is in the process of developing a pet waste management program for MassDOT rest stops located within the sub-watershed of a pathogen impaired waterbody. At these prioritized rest stops, MassDOT will be installing signs informing the public of the need to remove pet waste in order to minimize contributions of pathogens to the impaired waterbody and providing pet waste removal bags and disposal cans.

MassDOT believes the existing efforts are consistent with the current and draft MS4 permit's requirements and TMDL recommendations.

BMP 7U for Impervious Cover Related Impairments

At this time, there are no final TMDLs for Hager Pond. MassDOT assessed the stormwater-related impairments not addressed by a TMDL using the approach outlined in the Description of MassDOT's Application of Impervious Cover Method in BMP 7U[11] which was developed using the EPA Region I's Impervious Cover (IC) Method as a basis, described in EPA's Stormwater TMDL Implementation Support Manual.[12] Consistent with the findings of EPA and others, MassDOT concluded that when a watershed had less than 9% IC, stormwater was not the likely cause of the impairment.

MassDOT calculated the following values for the total contributing watershed of the impaired water (Hager Pond) to determine the IC area and set a target. The total contributing watershed is shown in Figure 1.

Impaired Segment Watershed	
Watershed Area	1,089 acres
Impervious Cover (IC) Area	187 acres
Percent Impervious	17%
IC Area at 9% Goal	98 acres
Target Effective IC Reduction	48%

The total watershed is greater than 9% impervious indicating that stormwater is a likely contributor to the impairment. To meet the 9% effective IC target, the effective IC within the watershed will need to be reduced. Therefore, the effective IC of MassDOT's directly contributing area should also be reduced by the

[11] MassDOT, 6 April, 2011. Description of MassDOT's Application of Impervious Cover Method in BMP 7U (MassDOT Application of IC Method). http://www.mhd.state.ma.us/downloads/projDev/BMP_7U_ImpairedWaterbodiesAssessment.pdf

[12] ENSR 2006. *Stormwater TMDL Implementation Support Manual for US EPA Region 1*. ENSR International & EPA Region 1, Boston, MA. Available at http://www.epa.gov/region1/eco/tmdl/regionalpgrfs.html

same percentage. The following table shows how MassDOT calculated the target effective IC for MassDOT's contributing property.

MassDOT Directly Contributing Watershed

Directly Contributing Area	4.0 acres
Directly Contributing IC Area	3.0 acres
Percent Impervious	74 %
Target Effective IC Reduction (48% Reduction of DOT Directly Contributing IC)	1.4 acres
Target Effective IC	39 %

This assessment was not able to identify practical locations for stormwater management improvements within the current MassDOT right-of-way. The Proposed Mitigation Plan section discusses the site constraints and mitigation plan.

Proposed Mitigation Plan

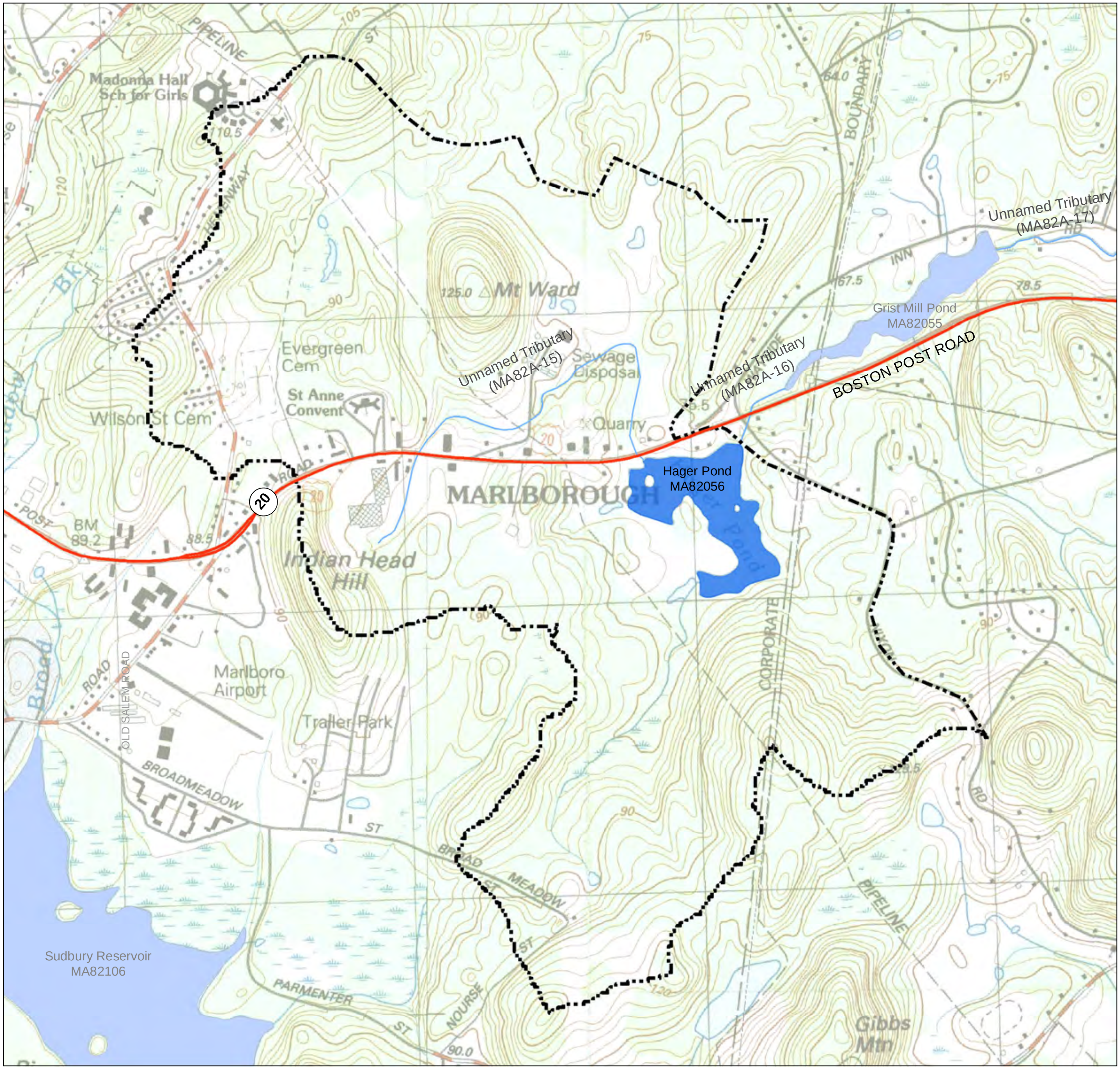
During this assessment phase of the Impaired Waters Program, MassDOT has focused on directly contributing areas and identified BMPs that can be constructed entirely on MassDOT property without resulting in substantial wetland impacts or resulting in an adverse impact on historical or archeological resources. Projects that meet these requirements can utilize the Federal Highway Administration's Alternative Contracting mechanism (SEP-14) created for this program.

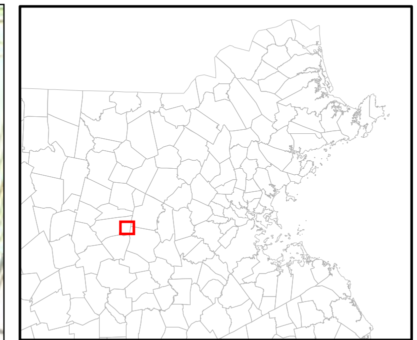
Site limitations for the MassDOT directly discharging area include:

(1) Heavily urbanized areas featuring commercial developments with landscape features adjacent to roadside sidewalks;
(2) Steep grades in the direction of travel;
(3) Limited right-of-way; and
(4) The close proximity of the existing outfalls to the edge of Hager Pond. Both the piped and the overland outfalls are incorporated into a steep embankment within 5 feet of the impoundment.

Based on the review of MassDOT's directly contributing drainage area, no BMPs have been identified that can be implemented under the Impaired Waters Program. No BMPs can be implemented on MassDOT property to address the impairments of the Hager Pond given the site constraints.

MassDOT will continue to ensure proper non-structural BMPs are being implemented within the watershed of Hager Pond (MA82056), including regular roadway and drainage system maintenance, erosion and sedimentation control, and outreach and education. Further work by MassDOT on programmed projects, which often include broader scale road layout changes, may provide additional opportunities for construction of new treatment BMPs. This is consistent with an iterative adaptive management approach to address impairments. MassDOT will include an update in annual reports to EPA regarding progress made towards meeting target IC reductions, plans for construction of proposed BMPs and finalized assessments including reduction achieved by finalized BMP designs.





MassDOT Roadways in Urban Area

Watershed

Assessed Segment

Impaired Lakes

Impaired Streams

N

0 750 1,500

Feet

1 inch = 1,500 feet

Figure 1

Hager Pond (MA82056) Watersheds

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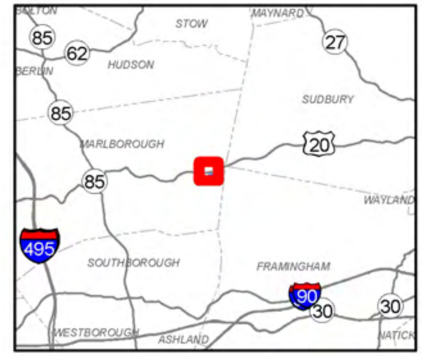

MassDOT Roadways in Urban Area
MassDOT Outfalls
Right of Way
MassDOT Directly Discharging Area
Assessed Segment
Impaired Streams
DEP Wetlands

N

0 150 300 Feet

1 inch = 300 feet

Figure 2

Hager Pond (MA82056) Directly Contributing MassDOT Watershed

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Impaired Waters Assessment for Hop Brook (MA82A-05)

Summary

Impaired Water[1]	**Impairments:**	Dissolved oxygen saturation, excess algal growth, dissolved oxygen, and total phosphorus
	Category:	5 (Waters requiring a TMDL)
	Final TMDLs:	None
	WQ Assessment:	SuAsCo Watershed Year 2001 Water Quality Assessment Report[2]
Location	**Towns:**	Sudbury
	MassDOT Roads:	Route 20
Assessment Method(s)	**7R (TMDL Method)**	☐
	7U (IC Method)	☒
BMPs	**Existing:**	None
	Proposed:	None
MassDOT Contributing Area and Targets		Impervious Cover (IC)
	Directly Contributing Area	0.68 acres
	Contributing Area Reduction Target	0.15 acres
	Existing BMPs Reduction	0 acres
	Proposed BMPs Reduction	0 acres
	Remaining Treatment to Meet Target	0.15 acres

[1] MassDEP, 2013. Massachusetts Year 2012 Integrated List of Waters – Final Listing of the Condition of Massachusetts' Waters Pursuant to Sections 305(b), 314 and 303(d) of the Clean Water Act. Massachusetts. Available at: http://www.mass.gov/eea/docs/dep/water/resources/07v5/12list2.pdf

[2] MassDEP, 2005. SuAsCo Watershed 2001 Water Quality Assessment Report. Available at: http://www.mass.gov/eea/docs/dep/water/resources/71wqar09/82wqar3.pdf

Site Description

Hop Brook is a 6.7 mile long stream in Sudbury, Massachsuetts. From its headwaters at the outflow of Carding Mill Pond (MA82015), Hop Brook flows north and through Stearns Mill Pond (MA82104). Hop Brook then continues east and south before crossing under Route 20 and flowing into the next segment of Hop Brook (MA82A-06). The 15.5 square mile watershed to Hop Brook is shown on Figure 1 and includes portions of Hudson, Marborough, and Framingham. According to the 2001 Water Quality Assessment Report for the SuAsCo Watershed, the source of pollutants to Hop Brook include discharges from municipal separate storm sewer systems (MS4s). Additional suspected sources include a landfill and municipal urbanized high-density areas. The report also states that water quality may be affected by impoundments upstream (i.e. Hager Pond, Grist Mill Pond, and Carding Mill Pond) where dense filamentous green algal mats were present.

Hop Brook flows through the Hopbrook Marsh Conservation Land just north of Carding Mill Pond, and residential areas. East of Stearns Mill Pond, the Sudbury Water District maintains a water treatment facility and drinking water wells which are protected by Zone I and Zone II Wellhead Protection Areas. South of Route 20, the Sudbury Water District maintains additional drinking water wells protected by Zone I and Zone II Wellhead Protection Areas. Cavicchio Greenhouses operates a large wholesale nursery along the banks of Hop Brook, north of its crossing with Route 20.

Approximately 1,000 linear of feet of MassDOT owned Route 20 discharges directly to Hop Brook where Hop Brook crosses Route 20 in Sudbury as shown in Figure 2. Route 20, at the Hop Brook crossing, is an Urban Minor Arterial carrying one lane of traffic in each direction. To the east of Hop Brook, stormwater on Route 20 from the high point at Concord Road to the river crossing is collected in catch basins and piped to an outfall in the eastern river bank. To the west of Hop Brook, stormwater flows from the high point approximately 150 feet west of Maple Avenue to a catch basin at the bridge crossing which discharges into the brook through an outfall in the bridge abutment.

Stormwater from Route 20 further west of the Hop Brook crossing discharges into a wetland system north of Route 20, which eventually outlets to a drainage ditch parallel to Station Road before entering Hop Brook through a culvert just north of Route 20. As the roadway runoff enters a wetland system before entering the brook, it is not considered a direct discharge. Two outfalls east of Concord Road discharge stormwater from Route 20 into wetland systems and are therefore not considered direct dichages. The area west of the Hop Brook crossing of Route 20 is a Zone II Wellhead Protection Area.The area surrounding the Hop Brook crossing of Route 20 has historic significance and includes the South Sudbury Historic Area, the Sudbury First Industrial Area, and the George Pitts Tavern Historic District.

Existing BMPs

MassDOT did not identify any existing BMPs in place to treat the directly discharging roadway runoff before reaching the impaired water segment.

Assessment

In cases where a TMDL has been approved, MassDOT assessed the waterbody for the impairments covered by the TMDL under the BMP 7R methodology. MassDOT has separately assessed the waterbody for any stormwater-related impairments that are not covered by the TMDL under the BMP 7U methodology. MassDOT assessed Hop Brook (MA82A-05) using the methodologies described below.

BMP 7U for Impervious Cover Related Impairments

The Hop Brook impairments are not covered by a TMDL. Therefore, MassDOT assessed the stormwater-related impairments using the approach outlined in the Description of MassDOT's Application of Impervious Cover Method in BMP 7U[3] which was developed using the EPA Region I's Impervious Cover (IC) Method as a basis, described in EPA's Stormwater TMDL Implementation Support Manual.[4] Consistent with the findings of EPA and others, MassDOT concluded that when a watershed had less than 9% IC, stormwater was not the likely cause of the impairment.

MassDOT calculated the following values for the total contributing watershed the impaired water (Hop Brook) to determine the IC target. The total contributing watershed is shown in Figure 1.

Impaired Segment Watershed	
Watershed Area	9,971 acres
Impervious Cover (IC) Area	1,159 acres
Percent Impervious	12 %
IC Area at 9% Goal	897 acres
Target Effective IC Reduction	23 %

The total watersheds is greater than 9% impervious indicating that stormwater is a likely contributor to the impairment. To meet the 9% effective IC target, the effective IC within the watershed will need to be reduced. Therefore, the effective IC of MassDOT's directly contributing area should also be reduced by the same percentage. The following table shows how MassDOT calculated the target effective IC for MassDOT's contributing property.

MassDOT Directly Contributing Watershed	
Directly Contributing Area	0.68 acres
Directly Contributing IC Area	0.68 acres
Percent Impervious	100 %
Target Effective IC Reduction (23% Reduction of DOT Directly Contributing IC)	0.15 acres
Target Effective IC	77 %

Under existing conditions, MassDOT's estimated effective IC exceeds the target as described above. To mitigate the effects of IC, MassDOT will implement stormwater BMPs to the maximum extent practical given site constraints.

This assessment was not able to identify practical locations for stormwater management improvements within the current MassDOT right-of-way. The Proposed Mitigation Plan section discusses the site constraints and mitigation plan.

[3] MassDOT, 6 April, 2011. Description of MassDOT's Application of Impervious Cover Method in BMP 7U (MassDOT Application of IC Method). http://www.mhd.state.ma.us/downloads/projDev/BMP_7U_ImpairedWaterbodiesAssessment.pdf

[4] ENSR 2006. *Stormwater TMDL Implementation Support Manual for US EPA Region 1*. ENSR International & EPA Region 1, Boston, MA. Available at http://www.epa.gov/region1/eco/tmdl/regionalpgrfs.html

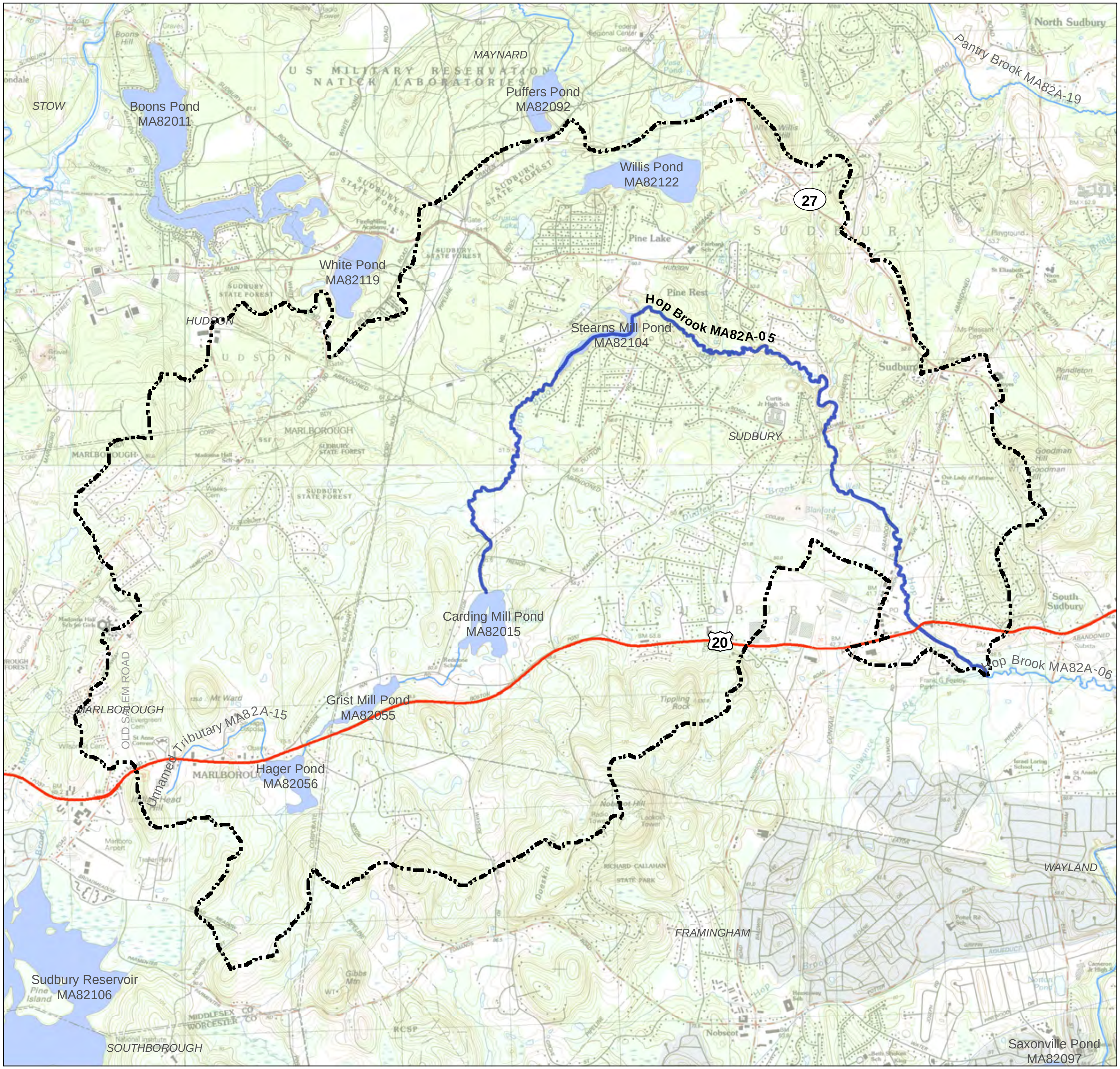
Proposed Mitigation Plan

During this assessment phase of the Impaired Waters Program, MassDOT has focused on directly contributing areas and identified BMPs that can be constructed entirely on MassDOT property without resulting in substantial wetland impacts or resulting in an adverse impact on historical or archeological resources. Projects that meet these requirements can utilize the Federal Highway Administration's Alternative Contracting mechanism (SEP-14) created for this program.

As stormwater flows from high points to the river crossing, the only potential location for BMPs to treat stormwater directly discharging to Hop Brook is at the Hop Brook crossing of Route 20. Site limitations at this location, shown on Figure 3, include: limited right-of-way, zone II wellhead protection areas, local historic districts with potential permitting requirements, and soils with Hydrologic Soil Group (HSG) D according to NRCS soils mapping, indicating poor infiltration potential. In the directly discharging area, the roadway is approximately 40 feet wide and the MassDOT right-of-way is approximately 50 feet wide, which does not allow enough room for consutrion of any type of BMP.

Based on the review of MassDOT's directly contributing drainage area, no BMPs have been identified that can be implemented on MassDOT property to address the impairments of the Hop Brook given the site constraints.

MassDOT will continue to ensure proper non-structural BMPs are being implemented within the watershed of Hop Brook, including regular roadway and drainage system maintenance, erosion and sedimentation control, and outreach and education. Further work by MassDOT on programmed projects, which often include broader scale road layout changes, may provide additional opportunities for construction of new treatment BMPs. This is consistent with an iterative adaptive management approach to address impairments. MassDOT will include an update in annual reports to EPA regarding progress made towards meeting target IC reductions, plans for construction of proposed BMPs and finalized assessments including reduction achieved by finalized BMP designs.



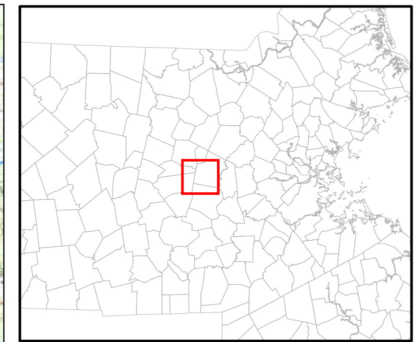


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Figure 1

Hop Brook (MA82A-05) Watershed

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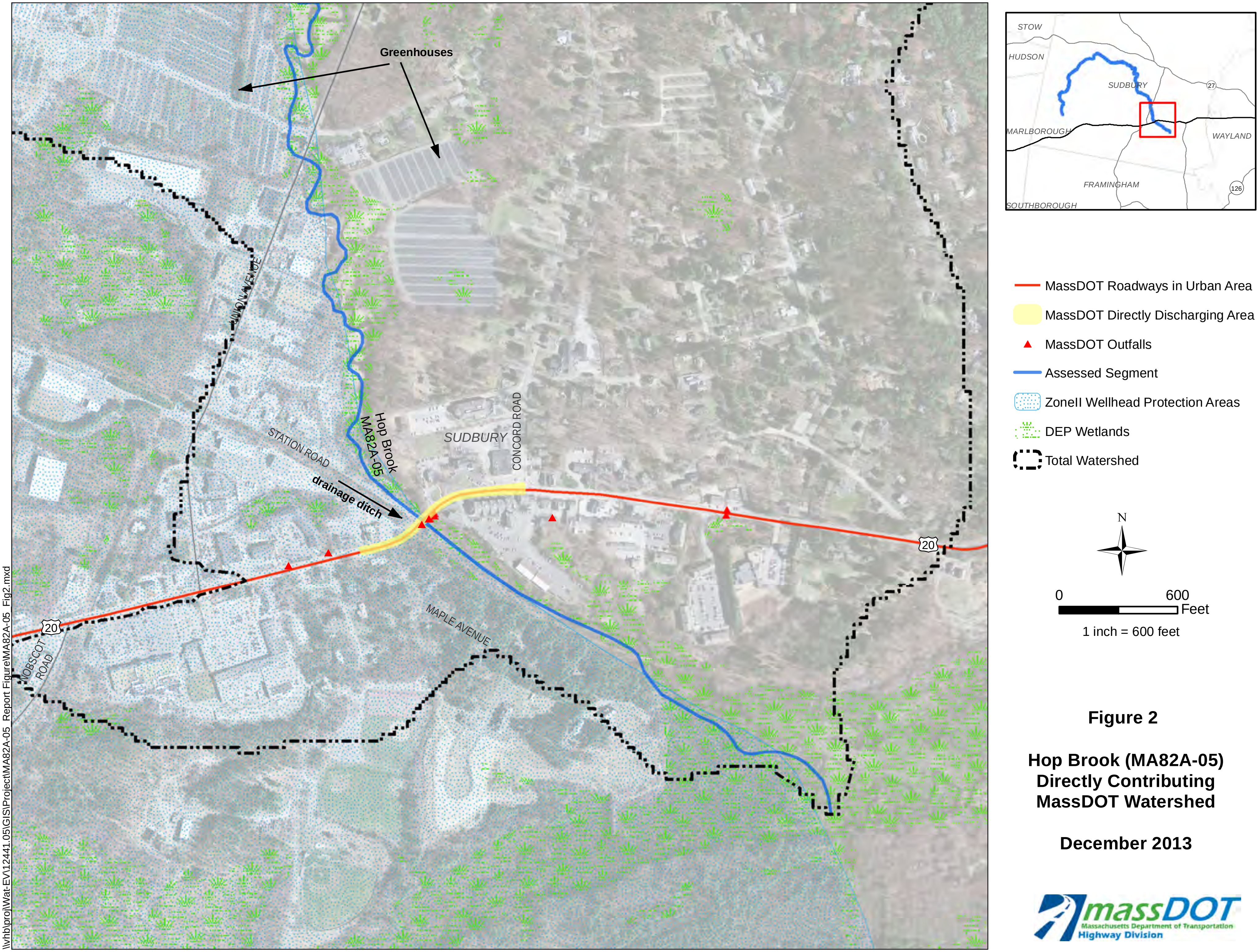

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Figure 2

Hop Brook (MA82A-05) Directly Contributing MassDOT Watershed

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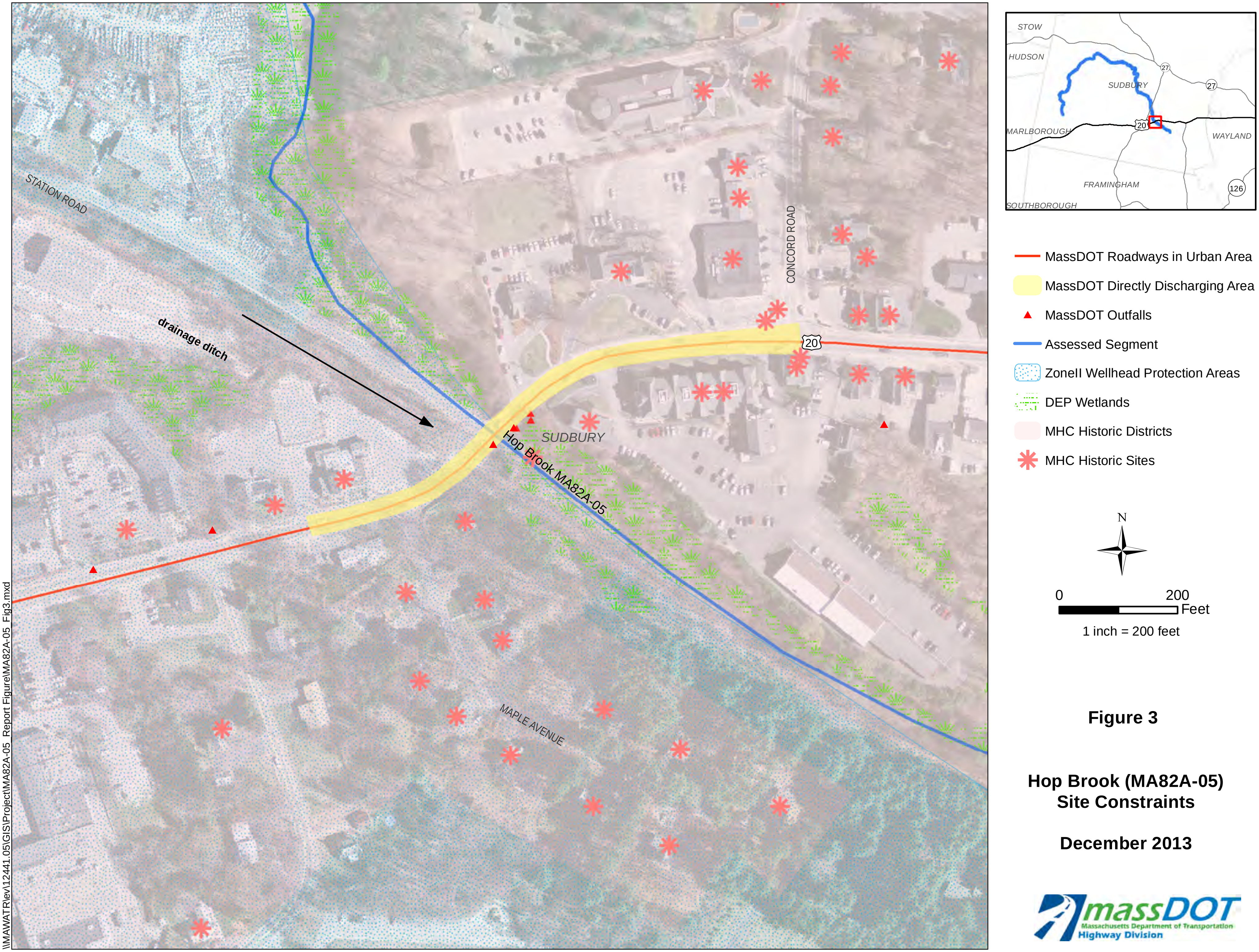

MassDOT Roadways in Urban Area
MassDOT Directly Discharging Area
MassDOT Outfalls
Assessed Segment
ZoneII Wellhead Protection Areas
DEP Wetlands
MHC Historic Districts
MHC Historic Sites

N

0 200 Feet

1 inch = 200 feet

Figure 3

Hop Brook (MA82A-05)
Site Constraints

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Impaired Waters Assessment for Concord River (MA82A-07)

Summary

		Stormwater	Non-Stormwater[2]
Impaired Water[1]	**Impairments:**	Fecal coliform, phosphorus (total)	Non-native aquatic plants; mercury in fish tissue; Eurasian water milfoil, Myriophyllum spicatum
	Category:	5 (Waters requiring a TMDL)	
	Final TMDLs:	None	
	WQ Assessment:	SuAsCo Watershed 2001 Water Quality Assessment Report[3]	
Location	**Towns:**	Billerica, Bedford, Carlisle, Concord	
	MassDOT Roads:	Route 225, Route 4, Route 3, Route 3A	
Assessment Method(s)	**7R (TMDL Method)**	☐	
	7U (IC Method)	☒	
BMPs	**Existing:**	2 Detention Basins	
	Proposed:	1 Infiltration Basin, 18 Water Quality Swales	

		Impervious Cover (IC)
MassDOT Contributing Area and Targets	**Directly Contributing Area**	27.5 acres
	Contributing Area Reduction Target	7.2 acres
	Existing BMPs Reduction	4.6 acres
	Proposed BMPs Reduction	28.6 acres
	Remaining Reduction to Meet Target	0.0 acres

[1] MassDEP, 2013. Massachusetts Year 2012 Integrated List of Waters – Final Listing of the Condition of Massachusetts' Waters Pursuant to Sections 305(b), 314 and 303(d) of the Clean Water Act. Massachusetts. Available at: http://www.mass.gov/eea/docs/dep/water/resources/07v5/12list2.pdf

[2] MassDOT, December 2012. Impaired Waters Assessment for Impaired Waters with Impairments Unrelated to Stormwater. Available at: http://www.mhd.state.ma.us/downloads/projDev/ImpairedWaters_3/Year3_ImpairedWatersAssessment_1.pdf#page=308

[3] MassDEP, 2001. SuAsCo Watershed 2001 Water Quality Assessment Report. Available at: http://www.mass.gov/eea/docs/dep/water/resources/71wqar09/82wqar4.pdf

Site Description

Concord River (MA82A-07) is a 10.4-mile long stream segment in Concord, Bedford, Carlisle, and Billerica, Massachusetts. The stream segment begins at the confluence of Assabet River (MA82B-07) and Sudbury River (MA82A-04) in Concord. It flows northeast for approximately 2.7 miles before reaching the Bedford town border. Concord River continues north for another 3.7 miles, defining the town borders between Concord and Bedford, Carlisle and Bedford, and Carlisle and Billerica. While flowing along the border between Carlisle and Bedford, Concord River passes under the Route 225 bridge, which is adjacent to a section of Route 225 owned by MassDOT. The river then cuts northeast into Billerica for 3.8 miles and passes under MassDOT-owned sections of Route 4, Route 3, and Route 3A. The segment terminates 0.2 miles beyond Route 3A at the Billerica Water Supply intake where the next segment, Concord River (MA82A-08), begins. The total watershed to Concord River is 368 square miles and is shown in Figure 1. It includes the entire watersheds of Assabet River and Sudbury River, which extends to towns as far south as Hopkinton and as far west as Shrewsbury. The subwatershed, which includes portions of Concord, Bedford, Carlisle, and Billerica, is 18.5 square miles and is also shown in Figure 1. South of Billerica, the subwatershed is dominated by forested areas, wetlands, and open space. The watershed within Billerica is more heavily residential with some commercial and industrial areas near Route 3.

According to the 2001 Water Quality Assessment Report for the SuAsCo Watershed, aquatic life within Concord River (MA82A-07) is impaired for non-native aquatic plants, and fish consumption is impaired for mercury. [4] Primary contact, secondary contact, and aesthetics have not yet been assessed. The report includes a recommendation calling for bacteria sampling to aid with assessing primary and secondary contact recommendations and to track the effectiveness of the NPDES Phase II stormwater program. Stormwater is not cited elsewhere in the section for Concord River MA82A-07 except to identify the presence of stormwater outfalls along the river.

Figures 2a, 2b, 2c, and 2d show the portions of MassDOT property that discharge directly to Concord River. The directly discharging roadway includes:

- Route 225 – 0.2 miles (Figure 2a)
- Route 4 – <0.1 miles, bridge over Concord River (Figure 2b)
- Route 3 northbound – 1.2 miles (Figure 2c)
- Route 3 southbound – 1.2 miles (Figure 2c)
- Concord Road – 0.2 miles (Figure 2c)
- Route 3A – 0.4 miles (Figure 2d).

Runoff from the directly discharging section of Route 225 sheet flows laterally off the road to the north and into a wetland that is adjacent and hydrologically connected to Concord River. Great Meadows National Wildlife Refuge surrounds the river to the north and south of Route 225. Runoff from the Route 4 bridge flows along the bridge curbing, off the road, and into gullies sloped toward the river.

The section of Route 3 that discharges to Concord River is a divided highway running north to south with three lanes of travel and two wide shoulders in either direction. The southern boundary of the directly discharging area is the high point in the road profile located just south of the Concord Road exit ramps. The northern boundary is just south of where Route 3 passes over a local access road. An unnamed stream is culverted under Route 3 at this location, capturing runoff from farther north. Route 3 in both directions is crowned between the first and second travel lanes. The grading directs runoff from the second travel lane, third travel lane, and shoulder toward drainage ditches within the

[4] MassDEP, 2001. SuAsCo Watershed 2001 Water Quality Assessment Report. Available at: http://www.mass.gov/eea/docs/dep/water/resources/71wqar09/82wqar4.pdf

median. Runoff from the first travel lane sheet flows into ditches along the shoulder. North of the river crossing, these drainage ditches convey flow to an inlet at the low point in the road profile, ultimately discharging to an outfall in the bridge structure over Concord River. South of the river crossing, a similar drainage layout is utilized. In this area, however, there are two existing detention basins, as discussed in the following section.

The section of Route 3A that discharges directly to Concord River is a two-lane road with businesses bordering the southern side. Low points in the road profile are located on either side of where Route 3A crosses Concord River. Small piped drainage systems discharge directly to Concord River at the outfall locations shown in the figure.

Existing BMPs

There are two existing BMPs within the directly contributing area of Concord River (MA82A-07). EX BMP 01, shown in Figure 2c and Figure 3b, is a detention basin located along the shoulder of Route 3 northbound. EX BMP 01 receives stormwater from all the lanes of Route 3 northbound, including the associated Concord Road ramps, and from the second and third travel lanes of Route 3 southbound. Runoff from impervious cover that drains to the ditch in the median is collected in drop inlets and piped to EX BMP 01. The ditch along the northbound shoulder is graded to discharge at the entrance to EX BMP 01. An outlet control structure is located at the far end of the basin. It features five orifices ranging in size from three inches to six inches and an elevated riser, which can accommodate larger flows. Flows are piped from the outlet control structure to an outfall adjacent to Concord River. A large rip-rap lined channel acts as the emergency spillway, terminating in the same area as the pipe outlet. The Natural Resources Conservation Service (NRCS) soil survey indicates that EX BMP 01 lies within an area of hydrologic soils groups (HSG) C soils. Standing water and wetland vegetation were observed during a site visit, indicating that soil infiltration rates are low. EX BMP 01 appears well maintained. The best opportunities to provide further treatment are in areas upgrade of EX BMP 01, where there is space available for additional BMPs.

EX BMP 02, shown in Figure 2c and Figure 3b, is a detention basin located between the Concord Road ramps along Route 3 southbound. EX BMP 02 receives stormwater from portions of Concord Road, the associated ramps, and the first travel lane of Route 3 southbound. Two outfalls discharge runoff from Concord Road and the ramps, and the remaining runoff from Route 3 enters EX BMP 02 as sheet flow. EX BMP 02 is designed with two cells—a forebay and a basin. A drop inlet at the far end of the basin acts as the primary outlet, and an outlet control structure with an elevated riser provides an overflow. The NRCS soil survey indicates that EX BMP 02 lies within an area of HSG C soils. Standing water and wetland vegetation were observed during a site visit, indicating that soil infiltration rates are low. EX BMP 02 appears well maintained.

Assessment

In cases where a TMDL has been approved, MassDOT assessed the waterbody for the impairments covered by the TMDL under the BMP 7R methodology. MassDOT has separately assessed the waterbody for any stormwater-related impairments that are not covered by the TMDL under the BMP 7U methodology. MassDOT assessed Concord River (MA82A-07) using the methodologies described below.

MassDOT has identified a subset of water body impairments in the Concord River Watershed which are not related to stormwater runoff. Specific impairments unrelated to stormwater for Concord River include non-native aquatic plants, mercury in fish tissue, and Eurasian water milfoil, Myriophyllum spicatum. In accordance with MassDOT's Impaired Waters Assessment for Impaired

Waters with Impairments Unrelated to Stormwater in the December 8, 2012 EPA submittal, the non-pollutant impairments are not specifically addressed as part of the Impaired Waters Program. [5]

Assessment 7U for Pathogen Impairment

MassDOT assessed the indicator bacteria (fecal coliform) impairment using the approach described in BMP 7U of MassDOT's Storm Water Management Plan (SWMP).[6] Concord River (MA82A-07) is covered by the Draft Pathogen TMDL for the Concord River Watershed.[7] According to the Draft TMDL, sources of indicator bacteria in the Concord River watershed were found to be many and varied. Most of the bacteria sources in the Concord River watershed are believed to be failing septic systems, combined sewer overflows (CSO), sanitary sewer overflows (SSO), sewer pipes connected to storm drains, certain recreational activities, wildlife including birds along with domestic pets and animals and direct overland stormwater runoff. Additionally, the TMDL states that implementation to achieve the TMDL goals should be an iterative process with selection and implementation of mitigation measures followed by monitoring to determine the extent of water quality improvement realized. Recommended TMDL implementation measures include identification and elimination of prohibited sources such as leaky or improperly connected sanitary sewer flows and best management practices to mitigate storm water runoff volume. MassDOT included a review of the draft report as an informational review as part of this assessment even though, due to their draft status, draft TMDLs are not formally part of the Impaired Waters Retrofit program.

Pathogen concentrations in stormwater vary widely temporally and spatially; concentrations can vary by an order of magnitude within a given storm event at a single location.[8] Therefore, it is difficult to predict pathogen concentrations in stormwater with accuracy. MassDOT's South East Expressway study measured bacterial concentration in stormwater runoff[9] and data indicated that highway's pathogen loading may be lower than urban areas. Considering that the potential sources of pathogens (e.g. illicit discharges, sewer utilities, pet waste and wildlife) are likely to be less prevalent in the highway environment than along urban roads, this finding is not surprising.

MassDOT does not conduct site specific assessments of loading at each location impaired for pathogens. Instead, MassDOT reviewed its existing programs and their consistency with EPA NPDES MS4 general permit requirements and pathogen TMDL requirements. Language in the documents clearly indicate that an iterative adaptive management approach is the appropriate way to address discharges to pathogen impaired waters and recommend implementation of programmatic BMPs such as residential educational programs, illicit connection identification, tracking and removal and pet waste management. MassDOT implements a variety of non-structural BMP programs across their system in accordance with their existing SWMP including educational programs, illicit connection review and source control.

MassDOT has an ongoing inspection and monitoring program aimed at identifying and addressing illicit discharges to MassDOT's stormwater management system. Any illicit discharges to

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[5] MassDOT, December 2012. Impaired Waters Assessment for Impaired Waters with Impairments Unrelated to Stormwater. Available at: http://www.mhd.state.ma.us/downloads/projDev/ImpairedWaters_3/Year3_ImpairedWatersAssessment_1.pdf#page=308

[6] MassDOT, 6 April, 2011. Description of MassDOT's Application of Impervious Cover Method in BMP 7U (MassDOT Application of IC Method). http://www.mhd.state.ma.us/downloads/projDev/BMP_7U_ImpairedWaterbodiesAssessment.pdf

[7] MassDEP. Draft Pathogen TMDL for the Concord River Watershed. Available at: http://www.mass.gov/eea/docs/dep/water/resources/a-thru-m/concord1.pdf

[8] MassDEP. 2009. Final Pathogen TMDL for the Cape Cod Watershed. Available at: http://www.mass.gov/dep/water/resources/capecod1.pdf

[9] Smith. (2002). Effectiveness of Three Best Management Practices for Highway Runoff Quality along the Southeast Expressway. USGS Water Resources Investigations Report 02-4059. Boston, Massachusetts.

MassDOT's system could contribute pathogens to impaired waters, however, MassDOT's existing Illicit Discharge Detection and Elimination (IDDE) program is aimed at identifying and addressing these contributions. District maintenance staff note signs of potential illicit discharges, such as dry weather flow and notable odors or sheens. Similarly, Resident Engineers overseeing construction projects also receive instruction regarding the need to note any suspicious connections or flows, and report these for follow-up investigation and action as appropriate. MassDOT will continue to implement this IDDE training, and District staff will continue to report any suspicious flows requiring further investigation. MassDOT investigates any suspicious flows noted, and proceeds to work with owners of confirmed illicit discharges to remove these flows, and thereby minimize pathogen contributions to receiving waters.

MassDOT is in the process of developing a pet waste management program for MassDOT rest stops located within the sub-watershed of a pathogen impaired waterbody. At these prioritized rest stops, MassDOT will be installing signs informing the public of the need to remove pet waste in order to minimize contributions of pathogens to the impaired waterbody and providing pet waste removal bags and disposal cans.

MassDOT believes the existing efforts are consistent with the current and draft MS4 permit's requirements and TMDL recommendations.

BMP 7U for Impervious Cover Related Impairments

MassDOT assessed the stormwater-related impairment not addressed by a TMDL using the approach outlined in the Description of MassDOT's Application of Impervious Cover Method in BMP 7U[10] which was developed using the EPA Region I's Impervious Cover (IC) Method as a basis, described in EPA's Stormwater TMDL Implementation Support Manual.[11] MassDOT used the long-term continuous simulation model (the assessment model)[12] to estimate effective IC. Consistent with the findings of EPA and others, MassDOT concluded that when a watershed had less than 9% IC, stormwater was not the likely cause of the impairment.

MassDOT calculated the following values for the total contributing watershed and the subwatershed of the impaired water (Concord River) to determine the IC area and set a target. The total contributing watershed and the subwatershed are shown in Figure 1.

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[10] MassDOT, 6 April, 2011. Description of MassDOT's Application of Impervious Cover Method in BMP 7U (MassDOT Application of IC Method). http://www.mhd.state.ma.us/downloads/projDev/BMP_7U_ImpairedWaterbodiesAssessment.pdf

[11] ENSR 2006. *Stormwater TMDL Implementation Support Manual for US EPA Region 1*. ENSR International & EPA Region 1, Boston, MA. Available at http://www.epa.gov/region1/eco/tmdl/regionalpgrfs.html

[12] MassDOT, June 2012. Long-Term Continuous Simulation for Pollutant Loading and Treatment for MassDOT Impaired Waters Program. Available at: http://www.mhd.state.ma.us/downloads/projDev/ImpairedWaters_2/Attachment7.pdf

Impaired Segment Watershed

	Total Contributing Watershed	Subwatershed
Watershed Area	235,753 acres	11,868 acres
Impervious Cover (IC) Area	30,889 acres	1,444 acres
Percent Impervious	13 %	12 %
IC Area at 9% Goal	21,218 acres	1,068 acres
Target Effective IC Reduction	31 %	26 %

The total and subwatersheds are greater than 9% impervious indicating that stormwater is a likely contributor to the impairment. To meet the 9% effective IC target, the effective IC within the subwatershed will need to be reduced. Therefore, the effective IC of MassDOT's directly contributing area should also be reduced by the same percentage. The following table shows how MassDOT calculated the target effective IC for MassDOT's contributing property.

MassDOT Directly Contributing Watershed

Directly Contributing Area	66.4 acres
Directly Contributing IC Area	27.5 acres
Percent Impervious	41 %
Target Effective IC Reduction (26% Reduction of DOT Directly Contributing IC)	7.2 acres
Target Effective IC	31 %

An existing conditions assessment model was created to estimate the effective IC of the MassDOT contributing drainage areas given treatment provided by existing BMPs. The table below shows the existing BMPs, their MassDOT drainage areas and effective IC reductions. The output from the assessment model showing effective IC analysis for existing BMPs is attached.

Existing Conditions

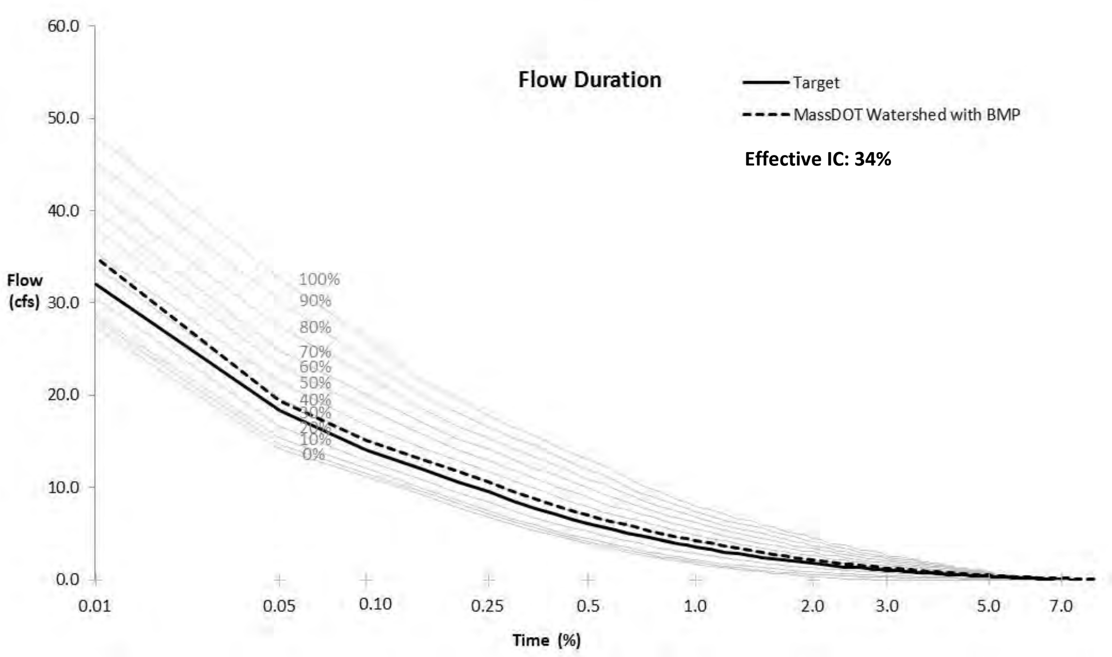
BMP Name	BMP Type	Contributing Effective IC (acres)	Estimated Percent Reduction	Estimated Reduction Effective IC (acres)
EX BMP 01	Extended Detention Basin	7.3	37%	2.7
EX BMP 02	Extended Detention Basin	1.9	98%	1.9
Total*		**27.5**	**17%**	**4.6**

* Total Effective IC reduction based on the assessment model results for the total MassDOT directly discharging drainage area to the receiving water (not sum of individual BMP reductions).

MassDOT estimated the effective IC under existing conditions by comparing the annual median runoff volume, phosphorus and TSS loads, and flow distribution statistics (flow duration) from MassDOT drainage area to the receiving water to those results for simulated IC watersheds. The following table displays the acres of IC the existing BMPs mitigate compared to the target reduction.

Existing Median Annual Load Comparisons

Simulated IC Watersheds		Runoff (ac-ft)	Phos (lb.)	TSS (lb.)
	0% IC	51	4	251
	5% IC	60	13	5,219
	10% IC	68	21	10,239
	20% IC	84	39	20,279
	30% IC	100	57	30,319
Target	**31% IC**	**102**	**59**	**31,323**
	40% IC	117	75	40,359
	50% IC	132	93	50,399
	60% IC	148	111	60,439
	70% IC	164	129	70,479
	80% IC	180	147	80,519
	90% IC	196	165	90,559
	100% IC	213	183	100,643
	Conditions without BMPs	125	64	33,338
	Conditions with Existing BMPs	120	51	24,127
	Reduction %	**4%**	**21%**	**28%**
	Effective IC	**42%**	**27%**	**24%**



Effective IC Results

Existing IC	27.5 acres
Estimated Effective IC with Existing BMPs	22.7 acres
IC Reduction % with Existing BMPs	17%
Estimated Effective IC*	34%

*Average of estimated effective IC for annual median runoff volume, phosphorus and TSS loads, and flow duration.

Under existing conditions, MassDOT's estimated effective IC exceeds the target as described above. To mitigate the effects of IC, MassDOT will implement stormwater BMPs to the maximum extent practical given site constraints.

This assessment has identified locations for potential stormwater BMPs and estimated the effective IC accounting for their treatment. The Proposed Mitigation Plan section describes the BMPs and their IC reduction performance.

Proposed Mitigation Plan

In this assessment, MassDOT has identified 19 stormwater BMPs that may be implemented on MassDOT property to mitigate the effective IC to address the Concord River impairments. These BMPs include one infiltration basin and eighteen water quality swales, shown with their estimated contributing drainage areas in Figures 3a and 3b. These locations were chosen based on a cursory review of the drainage systems, topography, property lines, and other site constraints. The existing drainage layout utilizes drainage ditches as a primary means to convey runoff, and these ditches can be upgraded to water quality swales with the addition of check dams and outlet control. Detailed survey, complete utility location information, official property ownership, and soils evaluation information will influence the final selection and design of BMPs. Below is a description of these proposed BMPs.

PR BMP 01, 03, 05, 06, 08, 11, 16, 19

These BMPs are proposed water quality swales located within the Route 3 median. Route 3 is crowned between the first and second travel lanes, so these BMPs receive lateral sheet flow from the second travel lane, the third travel lane, and the fast-lane shoulder of Route 3 northbound and southbound. The median currently acts as a drainage ditch. Stone check dams are placed downstream of the drop inlets that collect flow from each of these ditches; however, the placement of these check dams does not create detention or infiltration opportunities. Flow from the ditches corresponding to PR BMP 01, 03, 05, and 06 enters the drop inlets and is piped directly to Concord River. Flow from the ditches corresponding to PR BMP 08, 11, 16, and 19 enters the drop inlets and is piped directly to EX BMP 01. The drop inlets can be raised and check dams can be placed upstream to provide outlet control and encourage detention and infiltration.

A MassDOT project (#606353) is underway to add cable guardrail with a paved strip of footing within the median for a stretch of Route 3 beginning in Burlington and extending north through the entire directly discharging area. Observations from a site visit indicate that the new guardrail appears to be installed closer to the northbound lanes; however, its exact position should be confirmed prior to the design of these BMPs. Additional site visit observations identified the presence of a fiber optic cable running along the edge of the median. This cable could present a potential site constraint, and its position should be confirmed.

PR BMP 01 and PR BMP 03 are located in the median north of the Concord River crossing, where soils fall primarily within HSG B, as delineated by the NRCS soil survey. PR BMP 05 is located just north of the Concord River crossing where the soil group changes from B to D. To be conservative, soils for this BMP were modeled as group D. PR BMP 06, 08, 11, 16, and 19 are all located in the median south of the Concord River crossing where soils are anticipated to fall in soil group C.

PR BMP 02, 04, 10

These BMPs are proposed water quality swales located along the shoulders of Route 3 northbound and southbound. Each BMP receives lateral sheet flow from the first travel lane and shoulder of the adjacent roadway. These areas currently act as drainage ditches that convey runoff parallel to Route 3, ultimately terminating in steep drop-offs in the grading that discharge the runoff directly to Concord River. Check dams can be placed upstream of the drop-off to provide outlet control and encourage detention and infiltration.

Drainage plans show subdrains located along the shoulder near where the BMPs are proposed. South of the Concord River crossing, a major drain line runs adjacent to PR BMP 10. The position of these drain lines should be confirmed prior to BMP design. Observations from a site visit identified areas of cut slopes at the more upstream end of PR BMP 10 that have been reinforced with stone, indicating that erosion and/or groundwater intrusion maybe a concern.

PR BMP 02 and PR BMP 04 are located north of the Concord River crossing, where soils fall primarily within HSG B, as delineated by the NRCS soil survey. PR BMP 10 is located south of the Concord River crossing where the HSG is C.

PR BMP 07, 09, 12, 13, 14, 17, 18

These BMPs are proposed water quality swales located along the shoulder of Route 3 northbound and its ramps with Concord Road. Each BMP, with the exception of PR BMP 17, receives lateral sheet flow from one travel lane and the associated shoulder. PR BMP 17 receives piped runoff from an outfall associated with two catch basins on Concord Road. The catch basins capture runoff from the Concord Road bridge over Route 3, beginning at the high point in the middle of the bridge. These proposed BMPs currently act as drainage ditches that convey runoff to a drop inlet or the next BMP in series, ultimately terminating at EX BMP 01. The drop inlets can be raised and check dams can be placed upstream to provide outlet control and encourage detention and infiltration.

With the current grading and drainage layout, the ditch corresponding to PR BMP 18 does not receive runoff from impervious cover. Curb cuts could be added along the ramp to direct flow to the BMP and the catch basin at the junction of the ramp and Route 3 could be piped to the BMP.

Observations from the site visit indicate that the ditches corresponding to PR BMP 07, 09, 12, and 14 currently have wetland vegetation growing within them. PR BMP 07 had some standing water at its downstream end. These areas are likely to be non-jurisdictional, but further investigation should be conducted during the design phase. Observations from a site visit also identified areas of cut slopes along PR BMP 07, 09, and 13 that have been reinforced with stone, indicating that groundwater intrusion maybe a concern.

This group of BMPs is south of the Concord River crossing, where soils fall within HSG C, as delineated by the NRCS soil survey. PR BMP 07, 09, 12, and 14 were modeled with D soils because of the wetland vegetation observed in the field.

PR BMP 15

This BMP is a proposed infiltration basin within the ramp area between Concord Road and the Route 3 southbound off ramp. PR BMP 15 can be designed to receive flow from an existing outfall for a drainage system on Concord Road. The BMP can also be graded to receive sheet flow from a section of the first travel lane and exit lane of Route 3 southbound. Runoff from a small area of the exit ramp is currently collected in two catch basins and piped to Concord River, but these catch basins can be redirected to PR BMP 15. Soils in this area fall within HSG C, as delineated by the NRCS soil survey.

The table below shows the proposed conditions, including BMPs with their MassDOT drainage areas and estimated effective IC reductions. The outputs from the assessment model showing effective IC analysis for each BMP are attached. As currently sized, the 19 BMPs are estimated to completely infiltrate contributing runoff on an annual average bases, providing more than 100% reduction of effective IC for their respective drainage areas.

Proposed Conditions

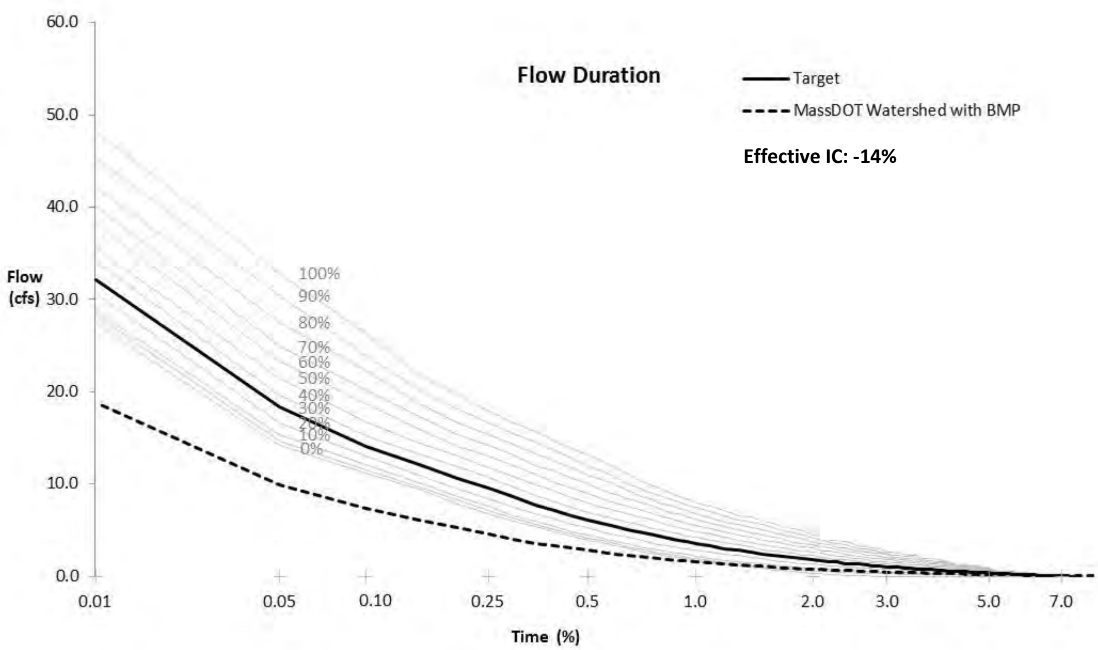
BMP Name	BMP Type	Contributing Effective IC (acres)	Estimated Percent Reduction	Estimated Reduction Effective IC (acres)
EX BMP 01	Extended Detention Basin	7.3	145%	10.5
EX BMP 02	Extended Detention Basin	1.9	98%	1.9
PR BMP 01	Water Quality Swale	2.2	135%	3.0
PR BMP 02	Water Quality Swale	1.1	215%	2.3
PR BMP 03	Water Quality Swale	1.3	132%	1.8
PR BMP 04	Water Quality Swale	1.0	206%	2.1
PR BMP 05	Water Quality Swale	1.1	85%	1.0
PR BMP 06	Water Quality Swale	1.2	128%	1.5
PR BMP 07	Water Quality Swale	2.6	167%	4.3
PR BMP 08	Water Quality Swale	0.7	134%	0.9
PR BMP 09	Water Quality Swale	0.6	162%	1.0
PR BMP 10	Water Quality Swale	1.1	200%	2.2
PR BMP 11	Water Quality Swale	1.8	137%	2.4
PR BMP 12	Water Quality Swale	1.4	178%	2.5
PR BMP 13	Water Quality Swale	0.2	267%	0.6
PR BMP 14	Water Quality Swale	1.2	166%	2.0
PR BMP 15	Infiltration Basin	1.4	150%	2.1
PR BMP 16	Water Quality Swale	0.5	161%	0.9
PR BMP 17	Water Quality Swale	0.4	109%	0.5
PR BMP 18	Water Quality Swale	0.6	206%	1.2
PR BMP 19	Water Quality Swale	1.5	163%	2.4
Total *		**27.5**	**105%**	**28.6**
Target				**7.2**

* Total Effective IC reduction based on the assessment model results for the total MassDOT directly discharging drainage area to the receiving water (not sum of individual BMP reductions).

Note: The predicted effective IC is determined by comparing the BMP's calculated median annual discharge volume, runoff flow/duration relationship, median annual phosphorus load and median annual total suspended solids load to predicted discharge values for benchmark watersheds with the same size and varying percent IC. In cases where analysis predicts that BMPs would discharges less runoff volume and pollutant mass than those predicted for a 0% IC (pervious, woods in good condition) benchmark watershed, then the predicted effective IC removal would be greater than 100% and reduction of effective IC area will be greater than the BMP contributing IC area.

Proposed Median Annual Load Comparisons

Simulated IC Watersheds		Runoff (ac-ft)	Phos (lb.)	TSS (lb.)
	0% IC	52	4	252
	5% IC	60	13	5,238
	10% IC	68	21	10,277
	20% IC	84	39	20,354
	30% IC	101	57	30,431
Target	**31% IC**	**103**	**59**	**31,439**
	40% IC	117	75	40,509
	50% IC	133	93	50,586
	60% IC	149	111	60,663
	70% IC	165	130	70,741
	80% IC	181	148	80,818
	90% IC	197	166	90,895
	100% IC	214	184	101,017
	Existing Conditions	120	51	24,127
	Proposed Conditions	49	21	10,432
	Reduction %	**59%**	**71%**	**72%**
	Effective IC	**-2%**	**10%**	**10%**



Effective IC Results

Existing IC	27.5 acres
Proposed Estimated Effective IC	-1.3 acres
IC Reduction % under Proposed Conditions	105%
Estimated Effective IC*	-2%

*Average of estimated effective IC for annual median runoff volume, phosphorus and TSS loads, and flow duration

MassDOT estimated the effective IC under proposed conditions by comparing the annual median runoff volume, phosphorus and TSS loads, and flow distribution statistics (flow duration) from MassDOT drainage area to the receiving water to those results for simulated IC watersheds.

The proposed BMPs provide more than enough treatment to meet the target. Almost all of the proposed BMPs provide over 100% IC treatment and have little to no discharge, fully infiltrating contributing runoff. While the objective of the Impaired Waters Retrofit Program is to meet the target reduction and not necessarily to construct retrofits to the maximum extent practicable, due to the higher costs and inefficiencies of retrofit projects, it has been MassDOT's experience that during design additional site constraints are identified and often reduce the final number of BMPs and/or water quality treatment. Therefore, in this assessment we are including BMPs that provide treatment beyond the target and will prioritize the most effective BMPs during the design.

MassDOT will proceed to the design phase and develop construction plans for the proposed BMPs as part of the MassDOT Impaired Waters Program. The project designer will gather additional information in this phase, such as soil data, wetland delineations, and site survey, to further refine the proposed BMPs. Once the design of the proposed BMPs is finalized, MassDOT will provide an update with additional information and summarize the final effective IC reduction based on the as-built condition.

MassDOT will continue to ensure proper non-structural BMPs are being implemented within the watershed of Concord River, including regular roadway and drainage system maintenance, erosion and sedimentation control, and outreach and education. Further work by MassDOT on programmed projects, which often include broader scale road layout changes, may provide additional opportunities for construction of new treatment BMPs. This is consistent with an iterative adaptive management approach to address impairments. MassDOT will include an update in annual reports to EPA regarding progress made towards meeting target IC reductions, plans for construction of proposed BMPs and finalized assessments including reduction achieved by finalized BMP designs.

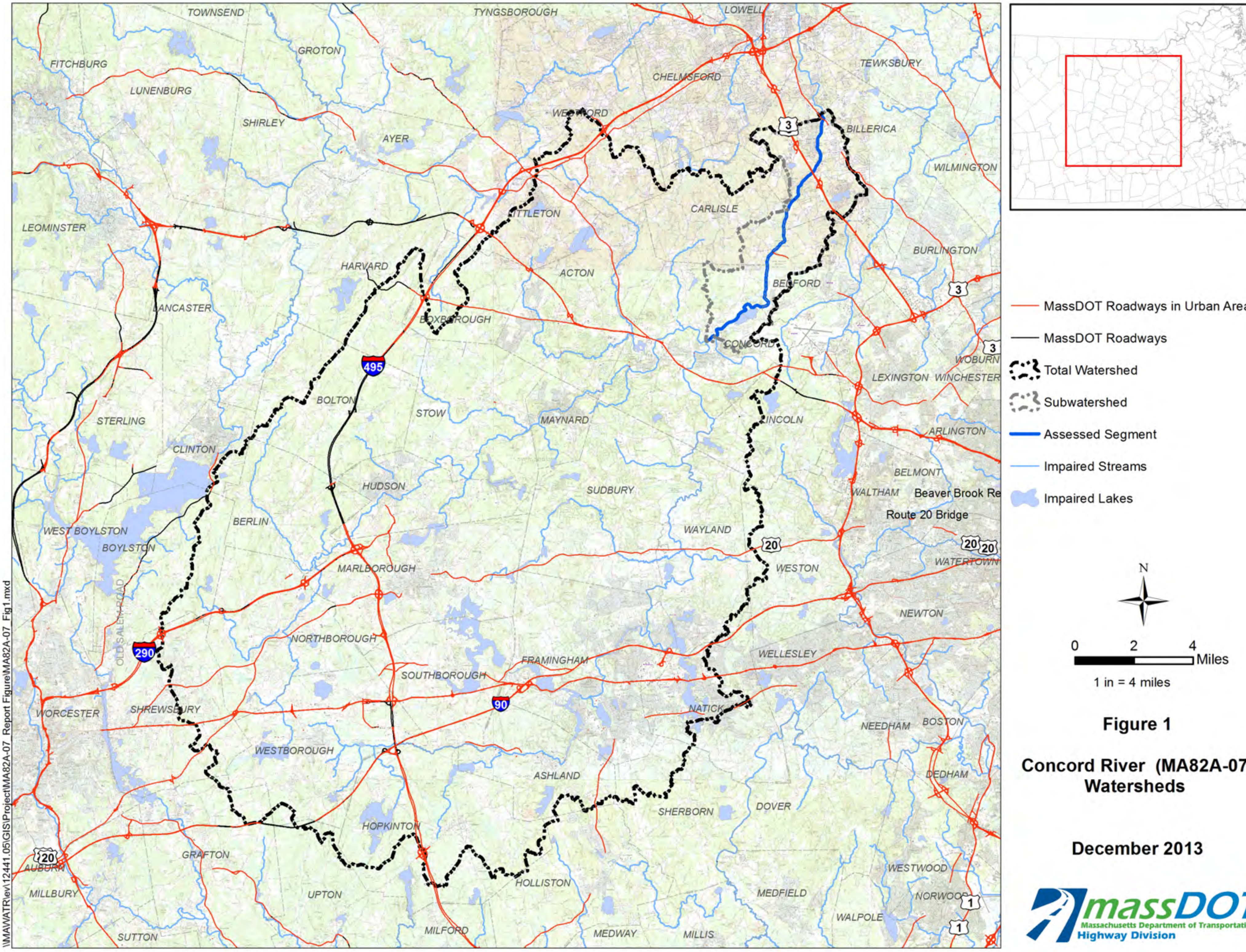
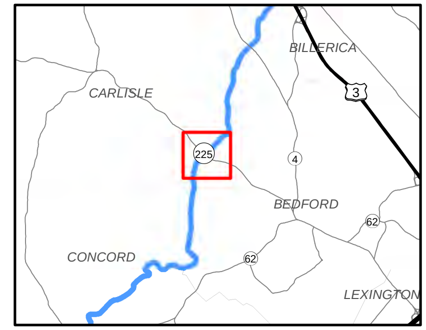


Figure 1

Concord River (MA82A-07) Watersheds

December 2013



MassDOT Directly Discharging Area

MassDOT Roadways in Urban Area

Assessed Segment

DEP Wetlands

Great Meadows Wildlife Refuge

N

0 250 500 Feet

1 inch = 500 feet

Figure 2a

Concord River (MA82A-07) Directly Contributing MassDOT Watershed

December 2013

massDOT Massachusetts Department of Transportation Highway Division

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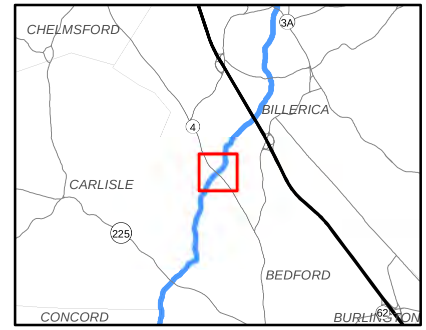

MassDOT Directly Discharging Area
MassDOT Roadways in Urban Area
Assessed Segment
DEP Wetlands

N

0 200 400 Feet

1 inch = 400 feet

Figure 2b

Concord River (MA82A-07) Directly Contributing MassDOT Watershed

December 2013

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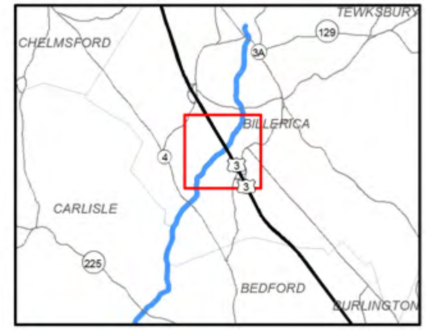

- MassDOT Outfalls
- MassDOT Directly Discharging Area
- Existing BMPs
- MassDOT Roadways in Urban Area
- Assessed Segment
- Impaired Streams
- Impaired Lakes
- DEP Wetlands

N

0 400 800 Feet

1 inch = 800 feet

Figure 2c

Concord River (MA82A-07) Directly Contributing MassDOT Watershed

December 2013

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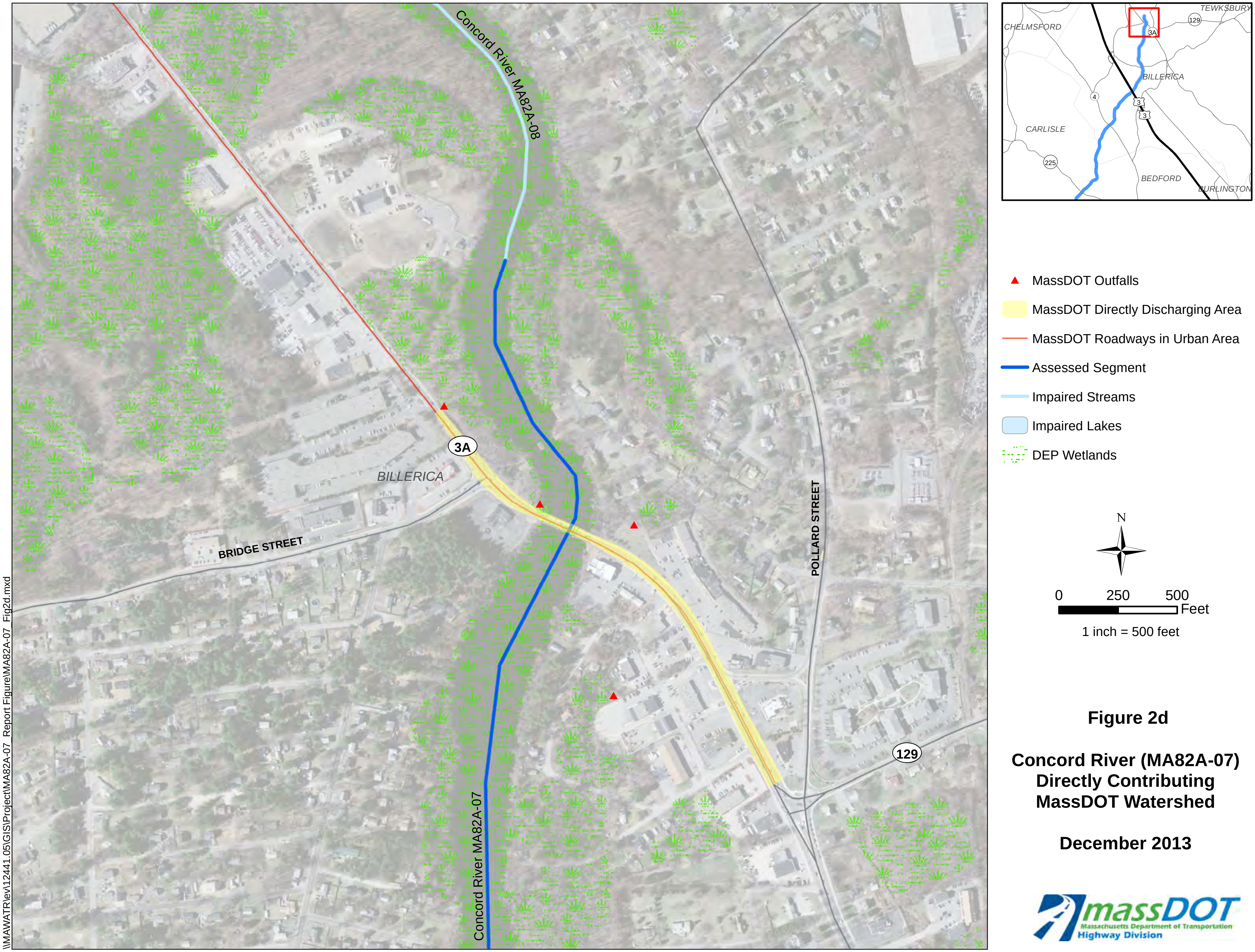

Figure 2d

Concord River (MA82A-07)
Directly Contributing
MassDOT Watershed

December 2013

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Figure 3a

Concord River (MA82A-07) Proposed BMPs

December 2013

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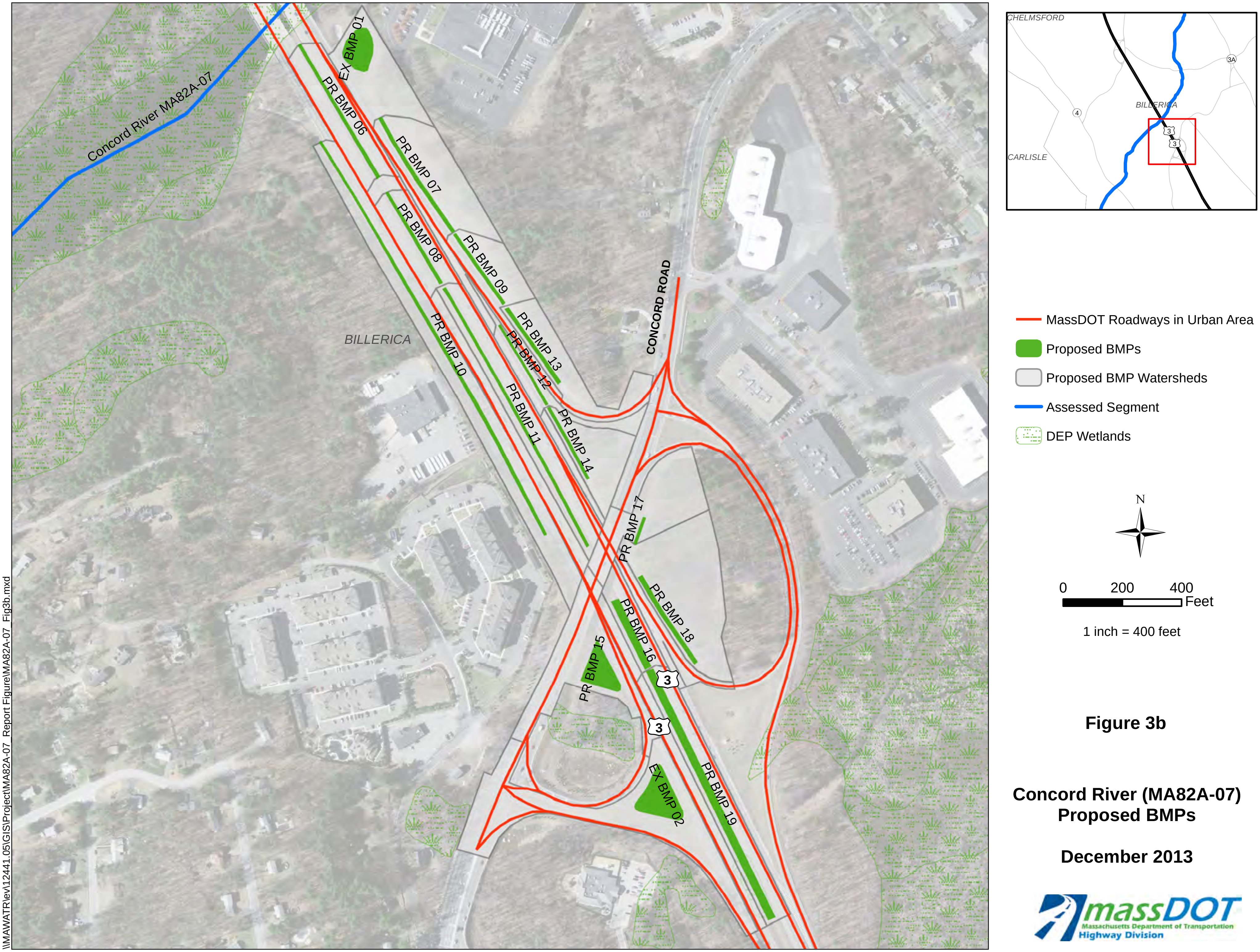

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Figure 3b

Concord River (MA82A-07)
Proposed BMPs

December 2013

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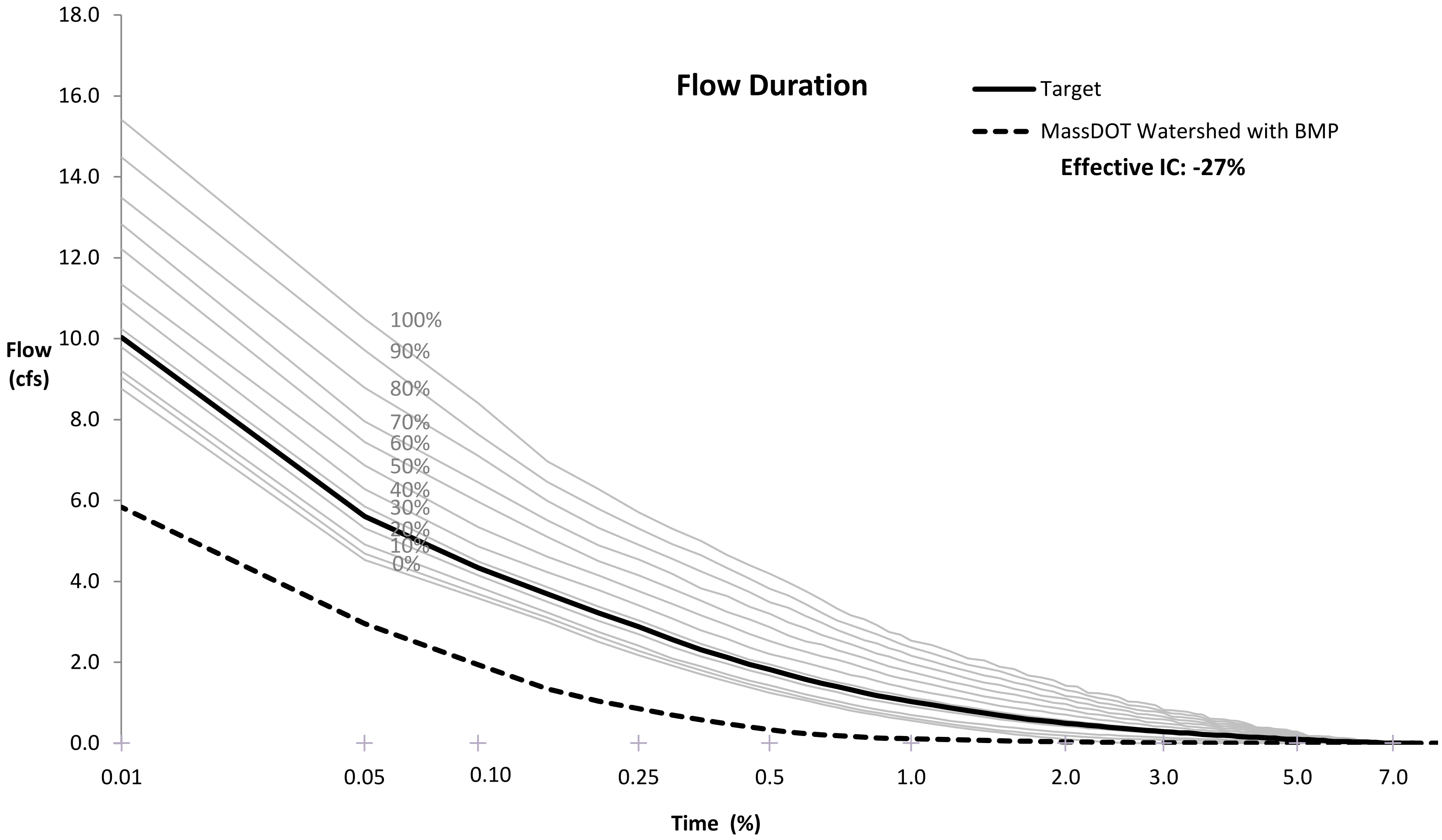
Result Summary
5.3 EX BMP 01



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	16	1	80
5%IC	19	4	1,673
10% IC	22	7	3,283
20% IC	27	13	6,502
30% IC	32	18	9,721
40% IC	37	24	12,940
50% IC	42	30	16,159
60% IC	48	36	19,378
70% IC	53	41	22,597
80% IC	58	47	25,817
90% IC	63	53	29,036
100% IC	68	59	32,269
Watershed Load	34.16	19.15	10,097
BMP Output	6.68	0.54	64
Target	29.79	15.64	8,253
Reduction %	**80%**	**97%**	**99%**
Effective IC	**-19%**	**-1%**	**0%**

Result Summary

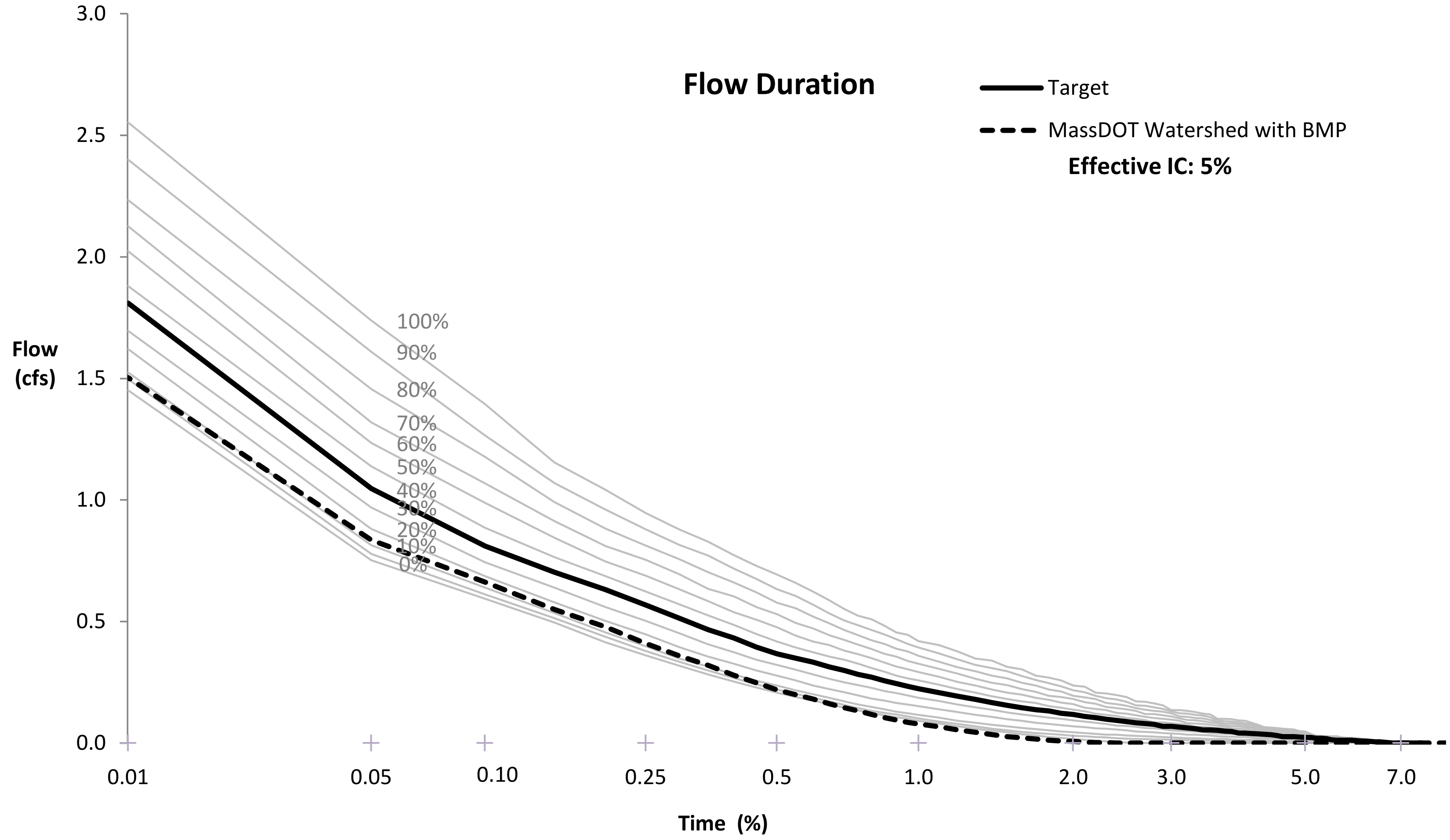
Metric	Area (%)	Area (acres)
Watershed Area		21.2
Watershed IC (no BMP)	34%	7.3
Target IC Reduction	26.0%	1.9
Effective IC w/BMP	-15%	(3.2)
IC Reduction	145%	10.5

Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	0.3	1.6
Indirect Watershed	7.0	19.6
Total	7.3	21.2

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary
1.3 EX BMP 02



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	3	0	13
5%IC	3	1	277
10% IC	4	1	544
20% IC	4	2	1,078
30% IC	5	3	1,611
40% IC	6	4	2,145
50% IC	7	5	2,679
60% IC	8	6	3,212
70% IC	9	7	3,746
80% IC	10	8	4,280
90% IC	10	9	4,813
100% IC	11	10	5,349
Watershed Load	7.32	4.92	2,648
BMP Output	2.55	0.26	43
Target	6.24	4.04	2,173
Reduction %	**65%**	**95%**	**98%**
Effective IC	**-2%**	**1%**	**1%**

Result Summary

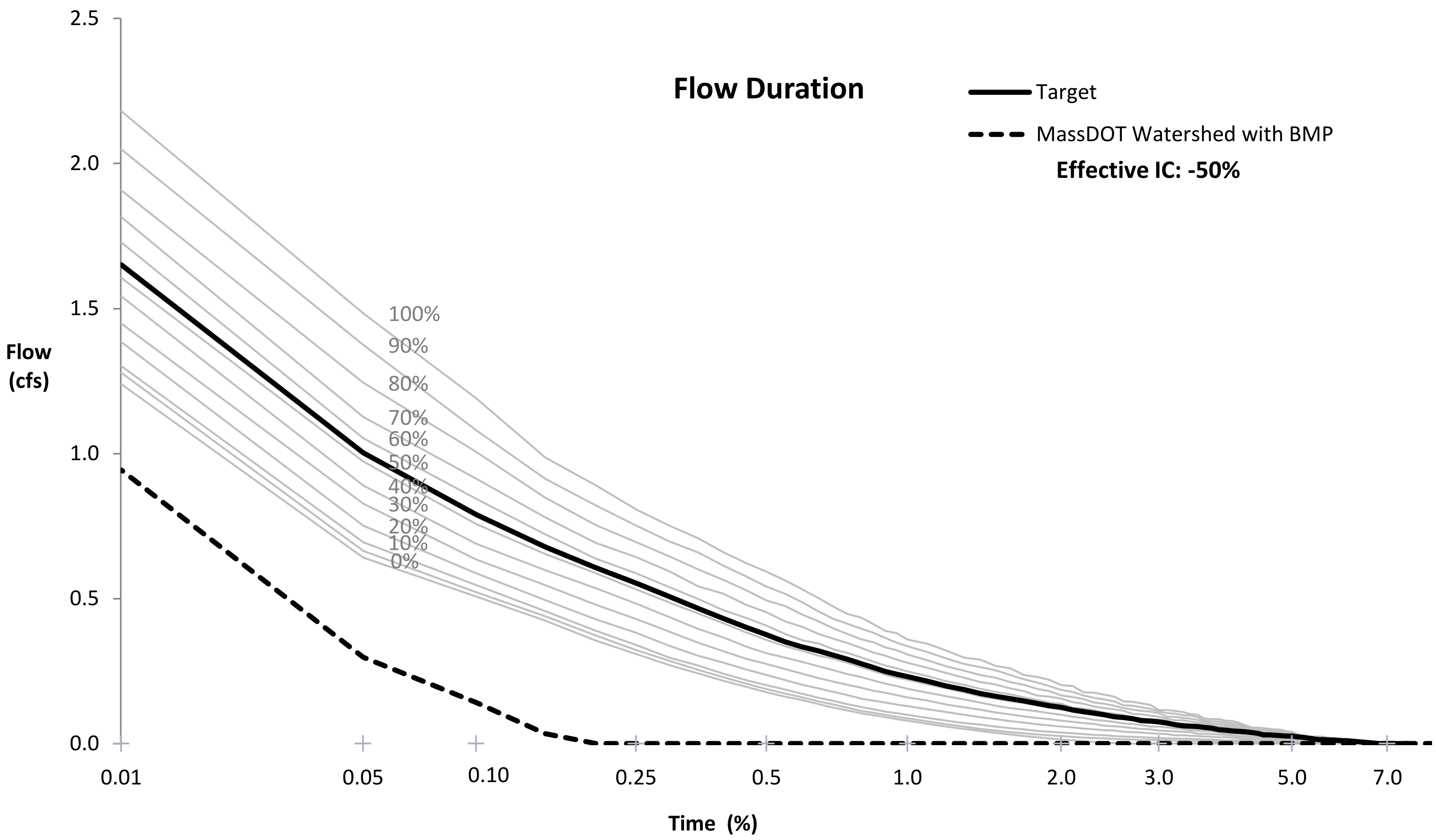
Metric	Area (%)	Area (acres)
Watershed Area		3.5
Watershed IC (no BMP)	55%	1.9
Target IC Reduction	26.0%	0.5
Effective IC w/BMP	1%	0.0
IC Reduction	98%	1.9

Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	1.9	3.5
Indirect Watershed	-	-
Total	1.9	3.5

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary
18.3 PR BMP 01



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	2	0	11
5%IC	3	1	237
10% IC	3	1	465
20% IC	4	2	920
30% IC	5	3	1,376
40% IC	5	3	1,832
50% IC	6	4	2,288
60% IC	7	5	2,743
70% IC	7	6	3,199
80% IC	8	7	3,655
90% IC	9	7	4,111
100% IC	10	8	4,568
Watershed Load	7.52	5.52	3,000
BMP Output	0.39	0.03	2
Target	6.28	4.53	2,456
Reduction %	**95%**	**99%**	**100%**
Effective IC	**-26%**	**-2%**	**0%**

Result Summary

Metric	Area (%)	Area (acres)
Watershed Area		3.0
Watershed IC (no BMP)	73%	2.2
Target IC Reduction	26.0%	0.6
Effective IC w/BMP	-26%	(0.8)
IC Reduction	135%	3.0

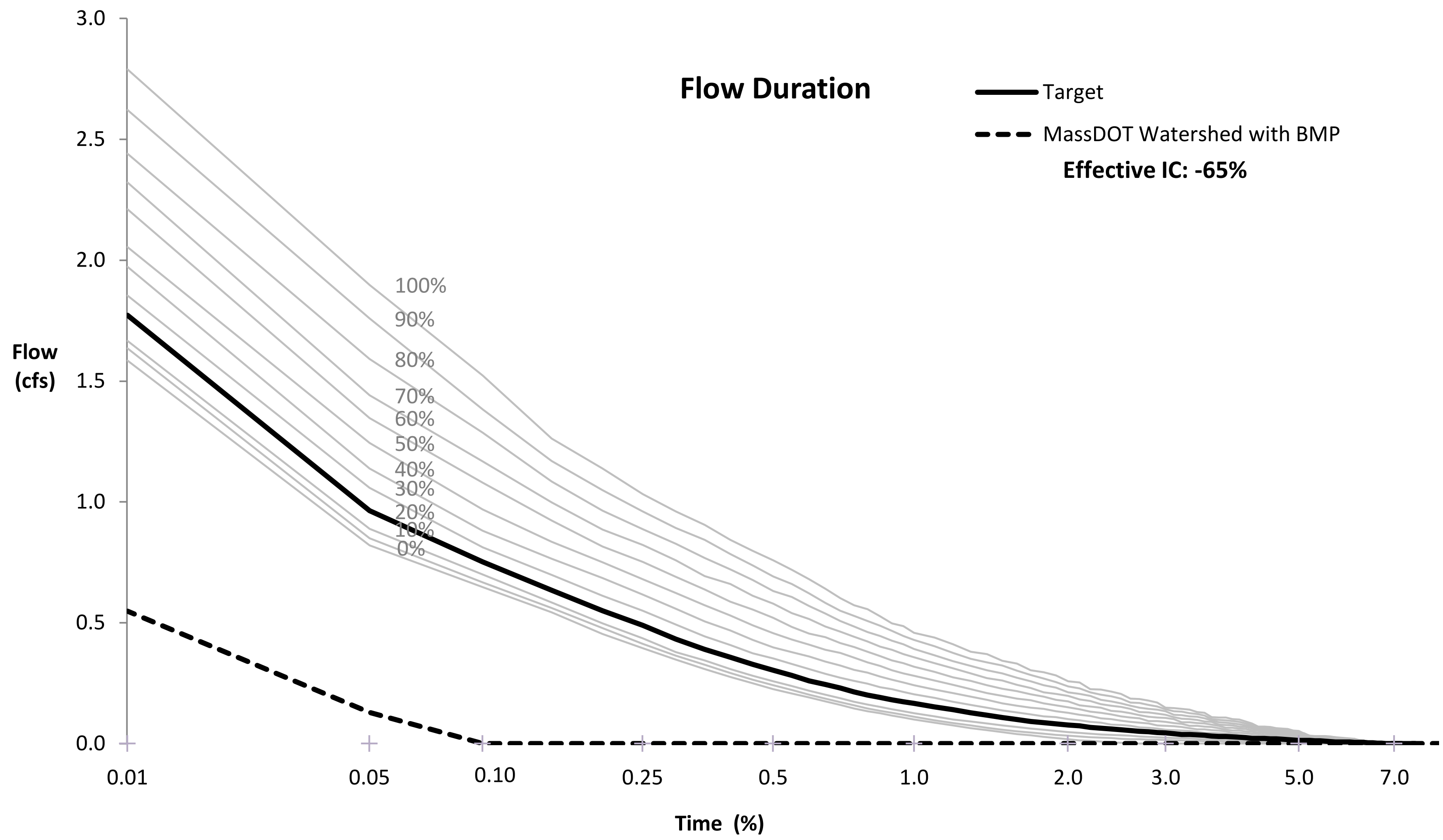
Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	2.2	3.0
Indirect Watershed	-	-
Total	2.2	3.0

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary

20.3 PR BMP 02



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	3	0	15
5%IC	3	1	303
10% IC	4	1	594
20% IC	5	2	1,177
30% IC	6	3	1,760
40% IC	7	4	2,343
50% IC	8	5	2,926
60% IC	9	6	3,509
70% IC	10	7	4,092
80% IC	10	9	4,675
90% IC	11	10	5,258
100% IC	12	11	5,843
Watershed Load	4.88	2.76	1,457
BMP Output	0.16	0.01	0
Target	4.90	2.29	1,191
Reduction %	**97%**	**100%**	**100%**
Effective IC	**-30%**	**-2%**	**0%**

Result Summary

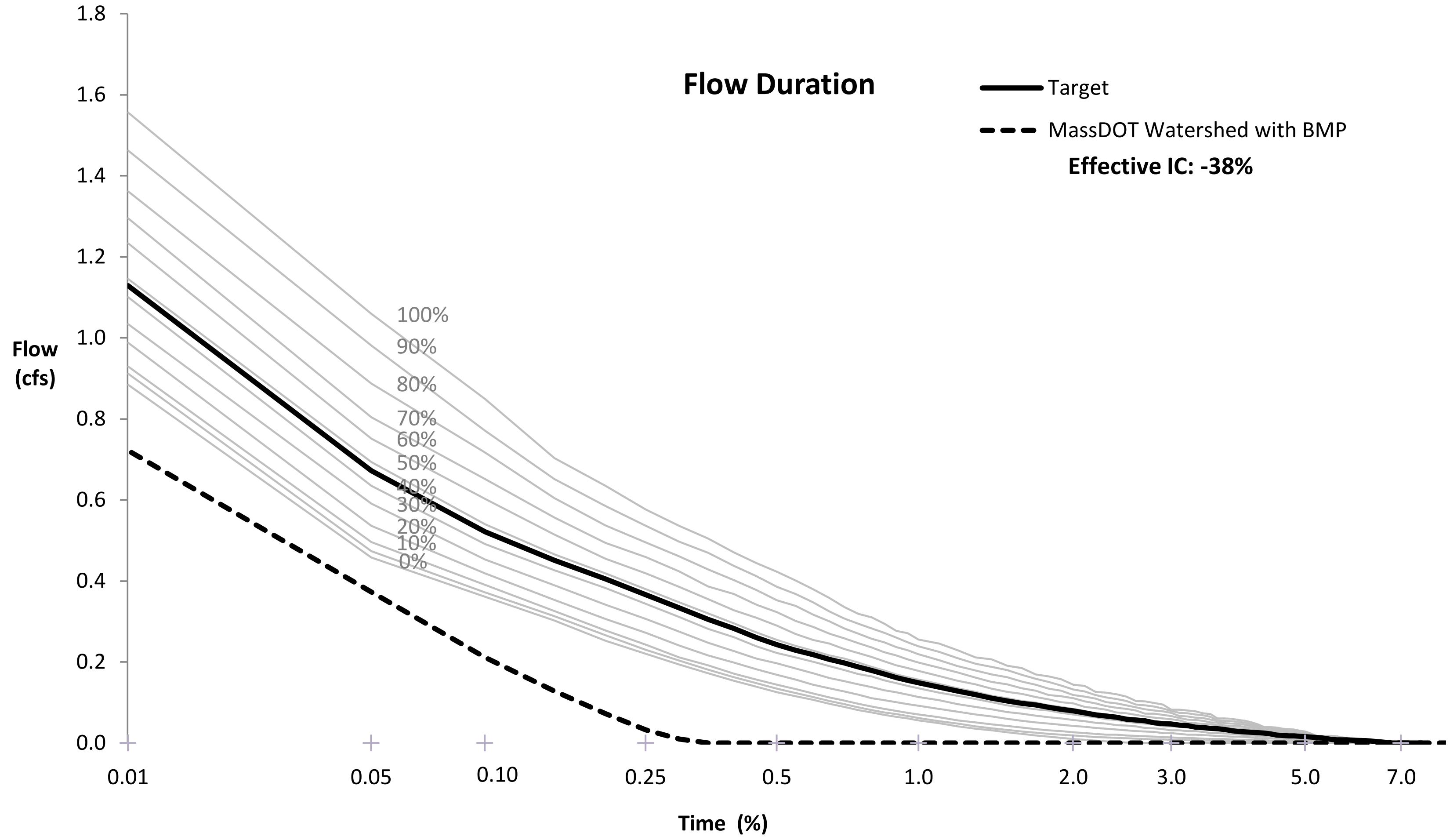
Metric	Area (%)	Area (acres)
Watershed Area		3.8
Watershed IC (no BMP)	27%	1.1
Target IC Reduction	26.0%	0.3
Effective IC w/BMP	-32%	(1.2)
IC Reduction	215%	2.3

Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	1.1	3.8
Indirect Watershed	-	-
Total	1.1	3.8

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary
22.3 PR BMP 03



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	2	0	8
5%IC	2	0	169
10% IC	2	1	332
20% IC	3	1	657
30% IC	3	2	982
40% IC	4	2	1,307
50% IC	4	3	1,632
60% IC	5	4	1,957
70% IC	5	4	2,283
80% IC	6	5	2,608
90% IC	6	5	2,933
100% IC	7	6	3,260
Watershed Load	4.73	3.40	1,844
BMP Output	0.48	0.03	3
Target	4.10	2.79	1,510
Reduction %	**90%**	**99%**	**100%**
Effective IC	**-23%**	**-2%**	**0%**

Result Summary

Metric	Area (%)	Area (acres)
Watershed Area		2.1
Watershed IC (no BMP)	63%	1.3
Target IC Reduction	26.0%	0.3
Effective IC w/BMP	-20%	(0.4)
IC Reduction	132%	1.8

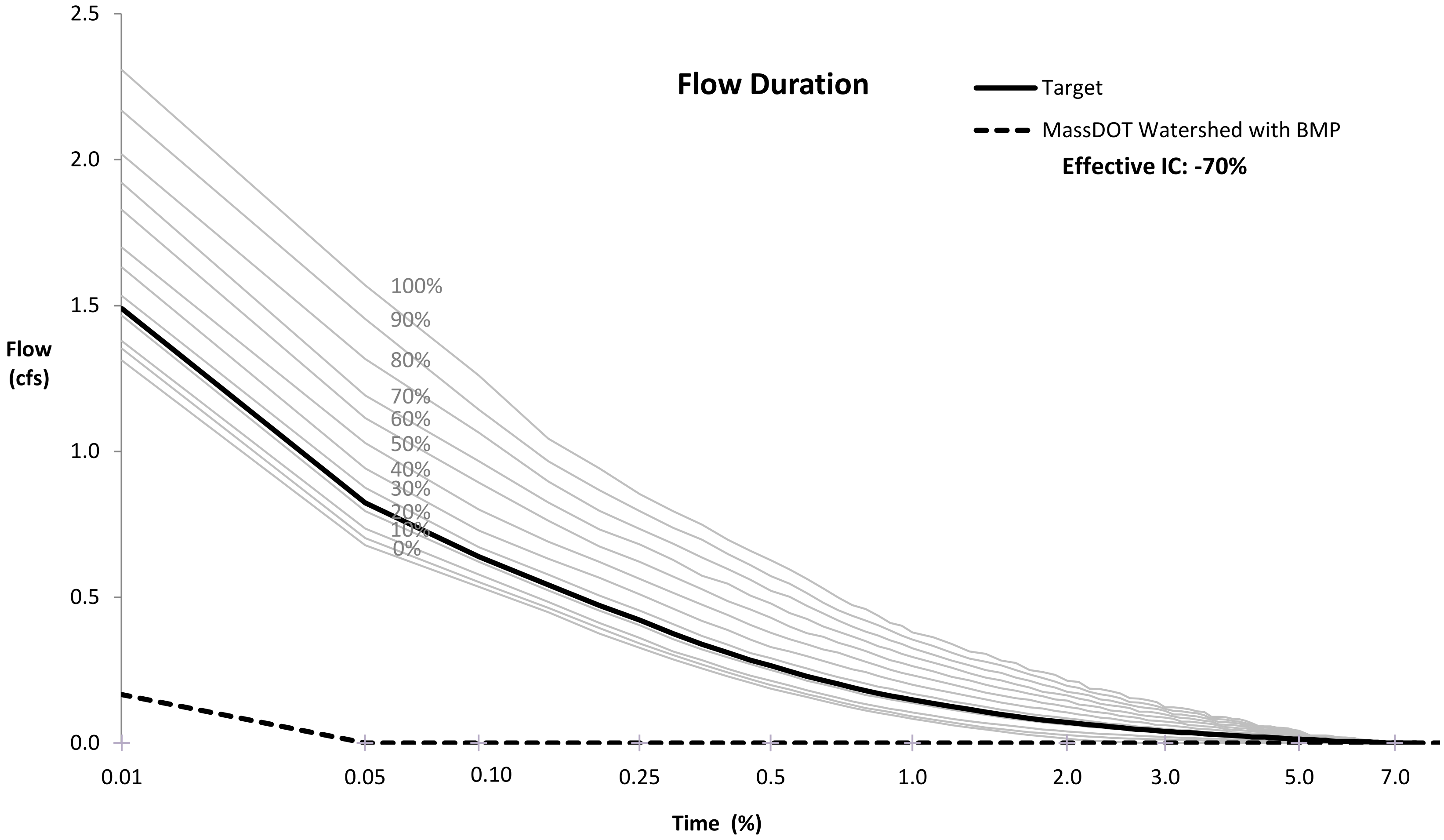
Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	1.3	2.1
Indirect Watershed	-	-
Total	1.3	2.1

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary

24.3 PR BMP 04



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	2	0	12
5%IC	3	1	251
10% IC	3	1	492
20% IC	4	2	974
30% IC	5	3	1,456
40% IC	6	4	1,938
50% IC	6	4	2,420
60% IC	7	5	2,902
70% IC	8	6	3,384
80% IC	9	7	3,866
90% IC	9	8	4,348
100% IC	10	9	4,832
Watershed Load	4.36	2.63	1,403
BMP Output	-	-	-
Target	4.32	2.18	1,147
Reduction %	**100%**	**100%**	**100%**
Effective IC	**-32%**	**-2%**	**0%**

Result Summary

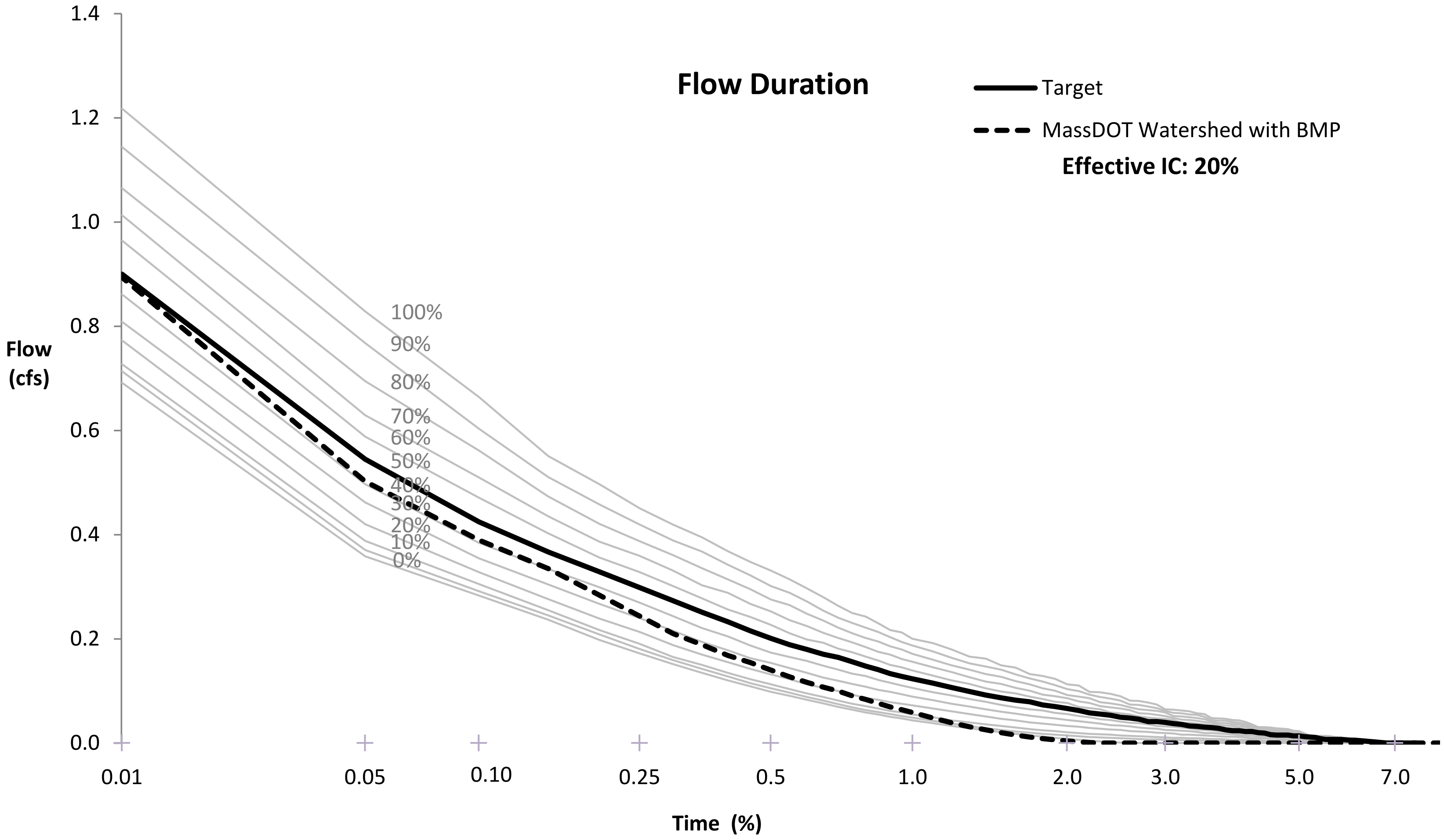
Metric	Area (%)	Area (acres)
Watershed Area		3.2
Watershed IC (no BMP)	32%	1.0
Target IC Reduction	26.0%	0.3
Effective IC w/BMP	-34%	(1.1)
IC Reduction	206%	2.1

Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	1.0	3.2
Indirect Watershed	-	-
Total	1.0	3.2

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary
26.3 PR BMP 05



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	1	0	6
5%IC	2	0	132
10% IC	2	1	260
20% IC	2	1	514
30% IC	3	1	768
40% IC	3	2	1,023
50% IC	3	2	1,277
60% IC	4	3	1,532
70% IC	4	3	1,786
80% IC	5	4	2,041
90% IC	5	4	2,295
100% IC	5	5	2,551
Watershed Load	4.08	2.91	1,576
BMP Output	1.64	0.21	45
Target	3.38	2.38	1,289
Reduction %	**60%**	**93%**	**97%**
Effective IC	**8%**	**3%**	**2%**

Result Summary

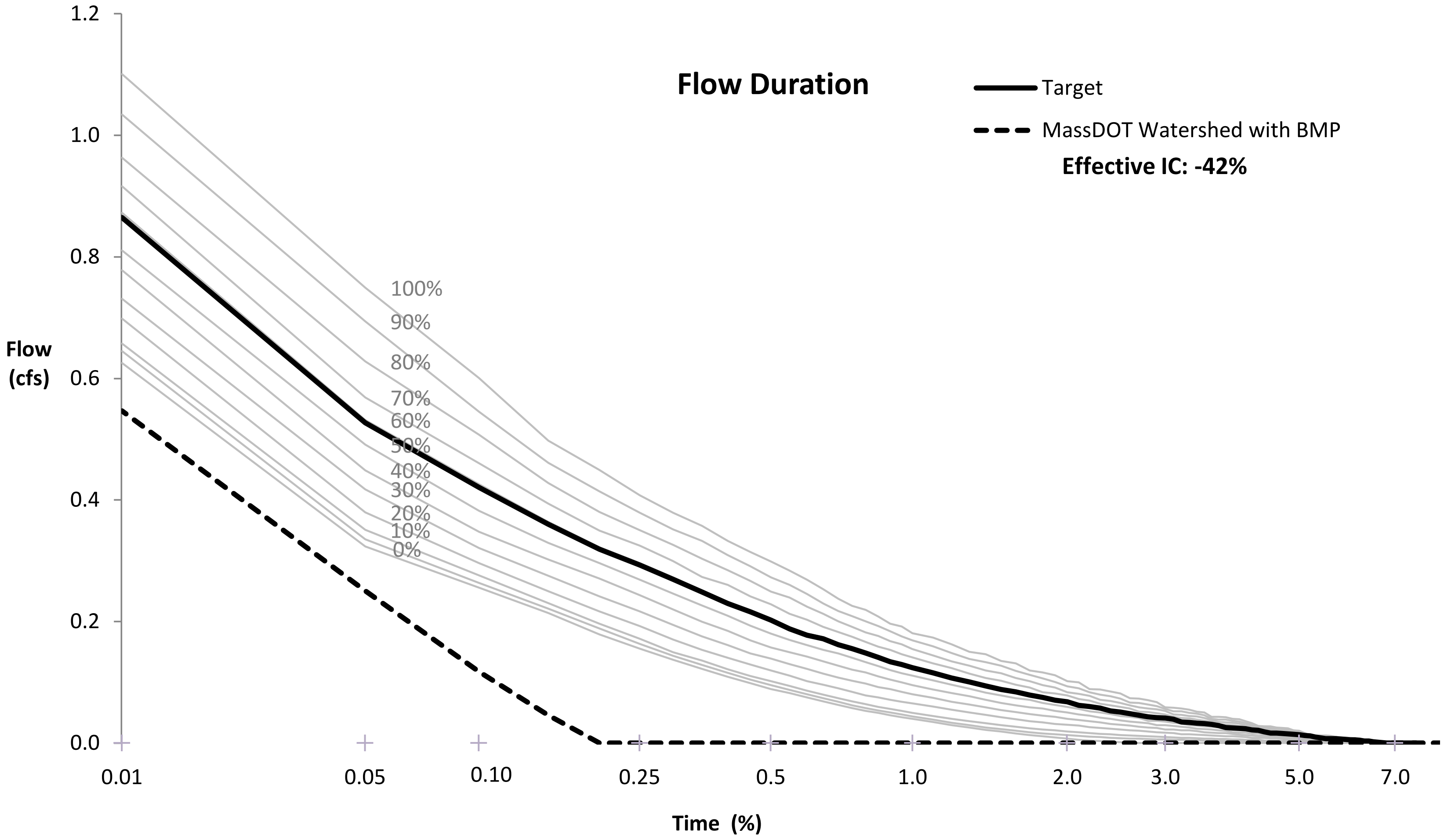
Metric	Area (%)	Area (acres)
Watershed Area		1.7
Watershed IC (no BMP)	68%	1.1
Target IC Reduction	26.0%	0.3
Effective IC w/BMP	10%	0.2
IC Reduction	85%	1.0

Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	1.1	1.7
Indirect Watershed	-	-
Total	1.1	1.7

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary
28.3 PR BMP 06



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	1	0	6
5%IC	1	0	120
10% IC	2	0	235
20% IC	2	1	465
30% IC	2	1	695
40% IC	3	2	925
50% IC	3	2	1,155
60% IC	3	3	1,385
70% IC	4	3	1,615
80% IC	4	3	1,845
90% IC	5	4	2,075
100% IC	5	4	2,306
Watershed Load	4.14	3.05	1,658
BMP Output	0.30	0.02	2
Target	3.35	2.50	1,358
Reduction %	**93%**	**99%**	**100%**
Effective IC	**-24%**	**-2%**	**0%**

Result Summary

Metric	Area (%)	Area (acres)
Watershed Area		1.5
Watershed IC (no BMP)	79%	1.2
Target IC Reduction	26.0%	0.3
Effective IC w/BMP	-22%	(0.3)
IC Reduction	128%	1.5

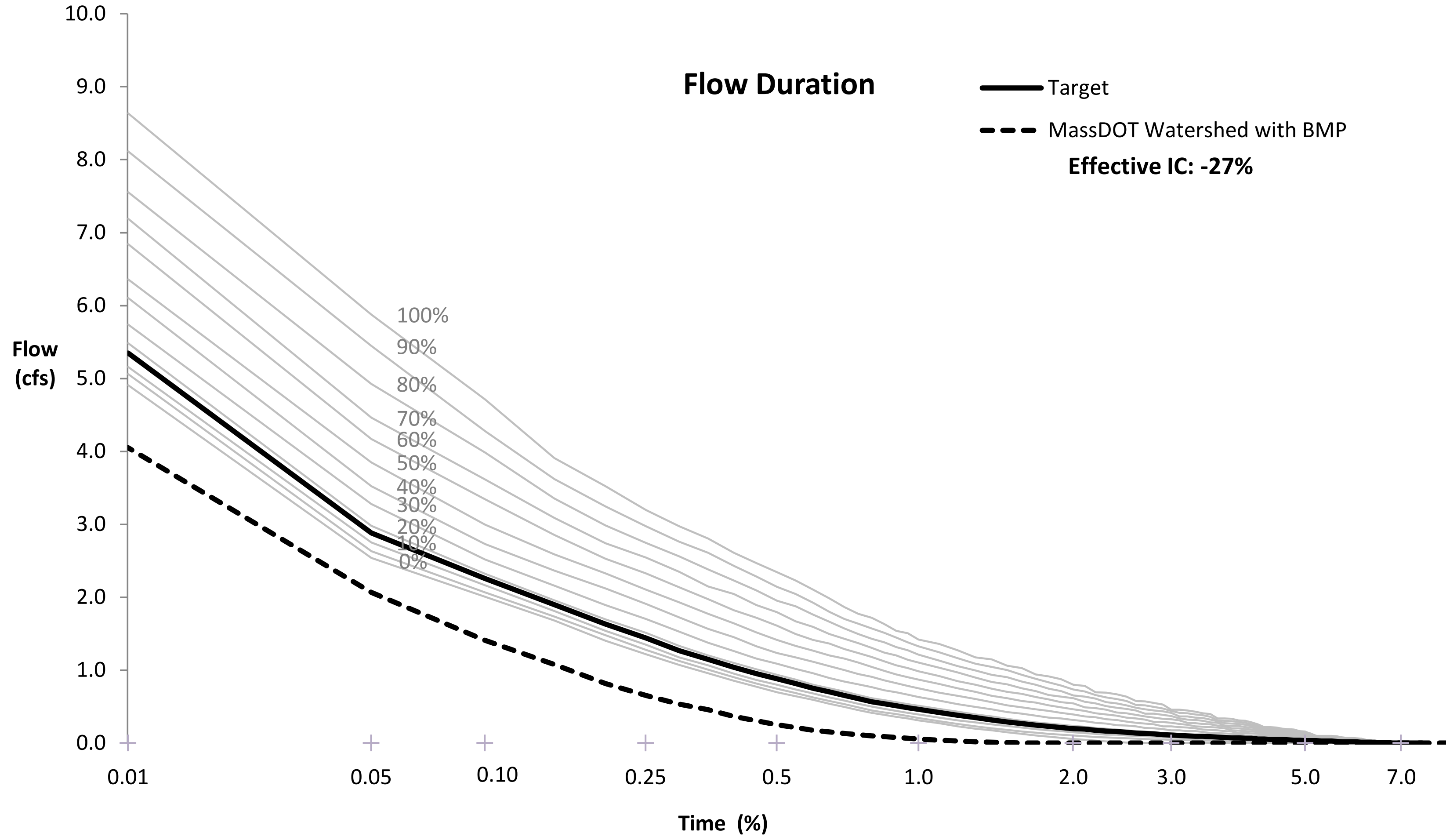
Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	1.2	1.5
Indirect Watershed	-	-
Total	1.2	1.5

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary

30.3 PR BMP 07



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	9	1	45
5%IC	11	2	938
10% IC	12	4	1,840
20% IC	15	7	3,645
30% IC	18	10	5,449
40% IC	21	13	7,254
50% IC	24	17	9,058
60% IC	27	20	10,862
70% IC	29	23	12,667
80% IC	32	26	14,471
90% IC	35	30	16,276
100% IC	38	33	18,088
Watershed Load	15.26	6.94	3,552
BMP Output	4.45	0.36	42
Target	13.90	5.69	2,902
Reduction %	**71%**	**95%**	**99%**
Effective IC	**-16%**	**-1%**	**0%**

Result Summary

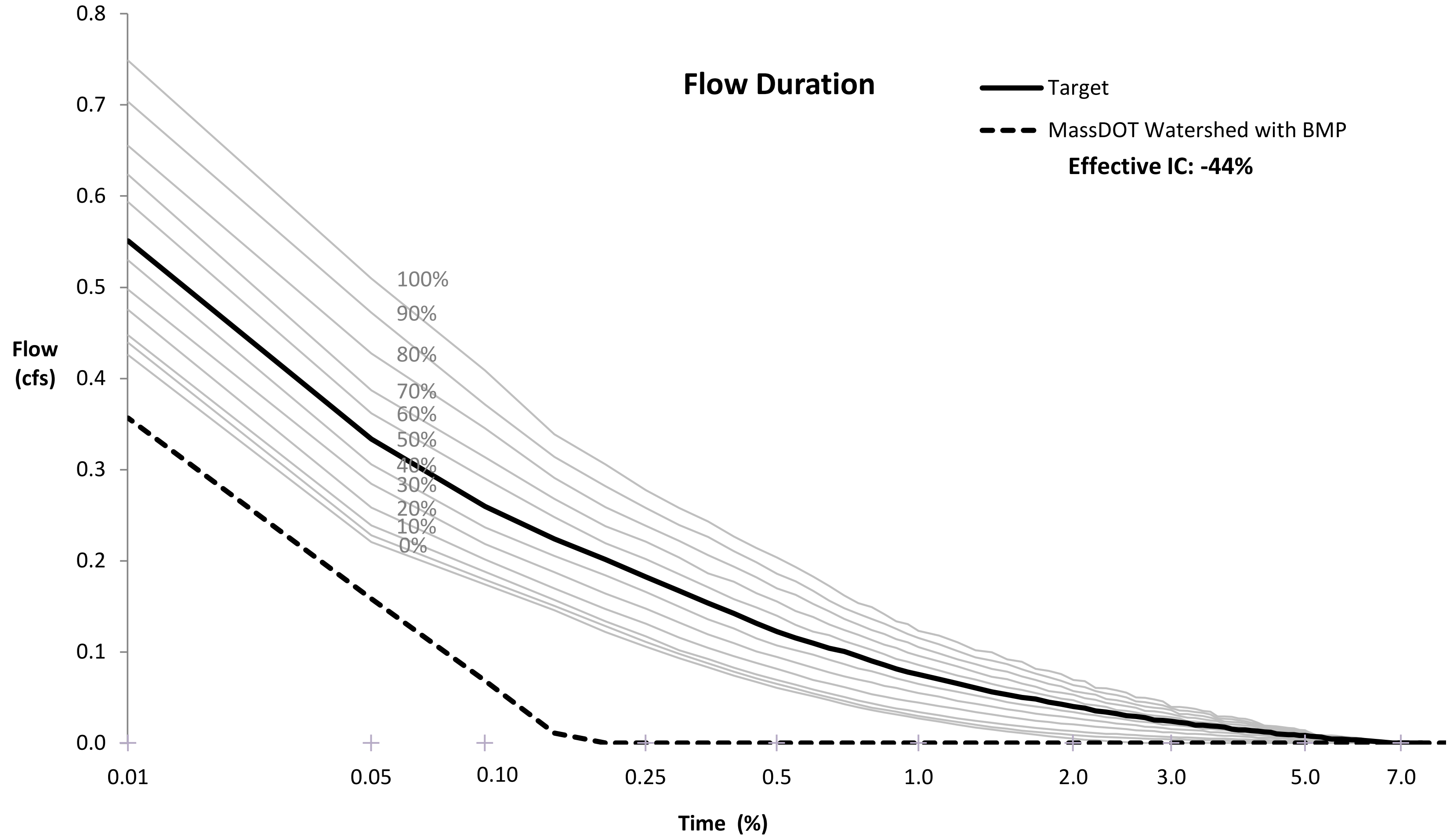
Metric	Area (%)	Area (acres)
Watershed Area		11.9
Watershed IC (no BMP)	21%	2.6
Target IC Reduction	26.0%	0.7
Effective IC w/BMP	-14%	(1.7)
IC Reduction	167%	4.3

Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	0.5	2.2
Indirect Watershed	2.1	9.7
Total	2.6	11.9

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary
32.3 PR BMP 08



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	1	0	4
5%IC	1	0	81
10% IC	1	0	160
20% IC	1	1	316
30% IC	2	1	473
40% IC	2	1	629
50% IC	2	1	786
60% IC	2	2	942
70% IC	3	2	1,099
80% IC	3	2	1,255
90% IC	3	3	1,411
100% IC	3	3	1,569
Watershed Load	2.51	1.77	957
BMP Output	0.18	0.01	1
Target	2.06	1.44	783
Reduction %	**93%**	**99%**	**100%**
Effective IC	**-24%**	**-2%**	**0%**

Result Summary

Metric	Area (%)	Area (acres)
Watershed Area		1.0
Watershed IC (no BMP)	67%	0.7
Target IC Reduction	26.0%	0.2
Effective IC w/BMP	-23%	(0.2)
IC Reduction	134%	0.9

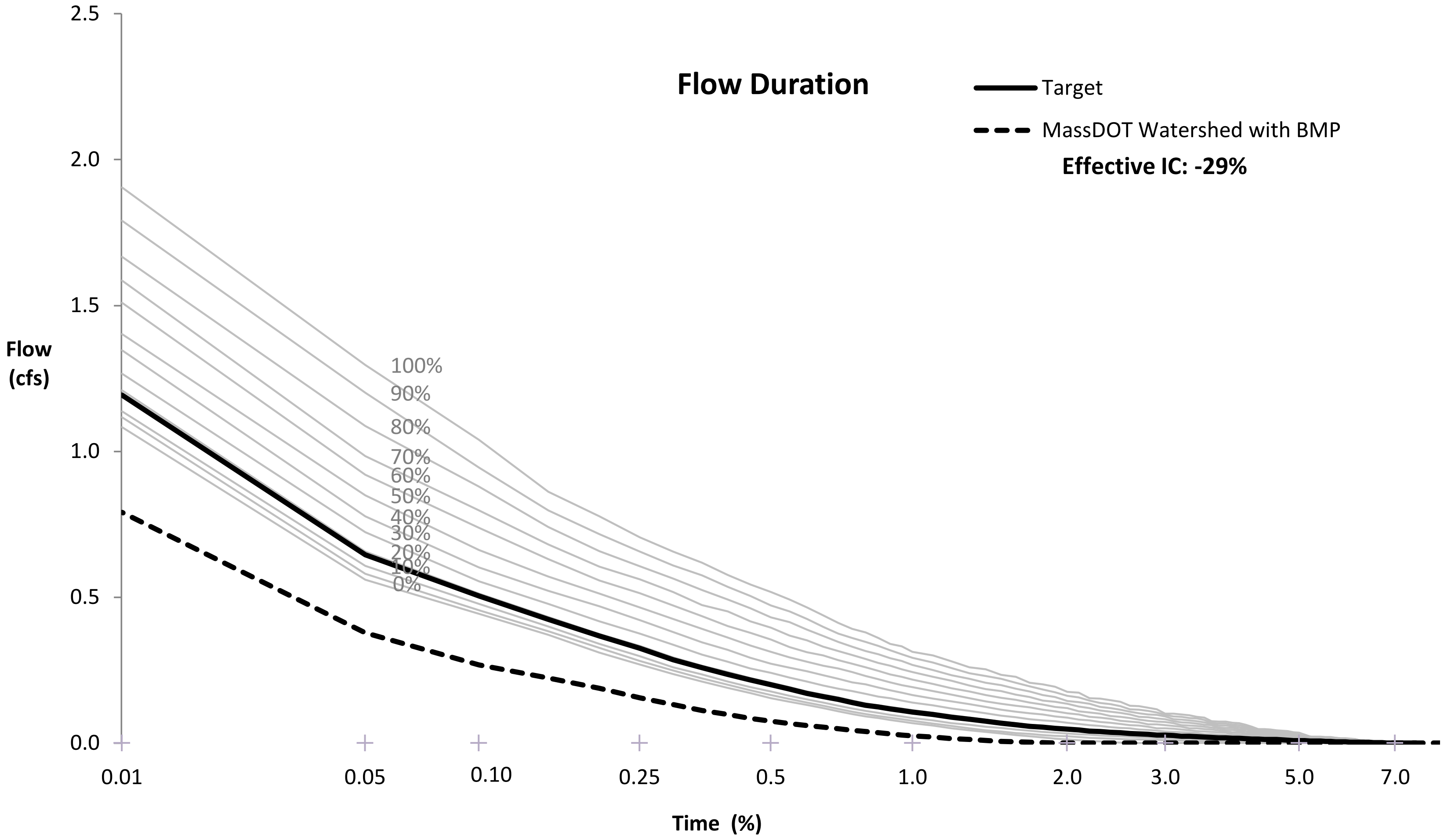
Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	0.7	1.0
Indirect Watershed	-	-
Total	0.7	1.0

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary

34.3 PR BMP 09



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	2	0	10
5%IC	2	0	207
10% IC	3	1	406
20% IC	3	2	804
30% IC	4	2	1,202
40% IC	5	3	1,600
50% IC	5	4	1,999
60% IC	6	4	2,397
70% IC	7	5	2,795
80% IC	7	6	3,193
90% IC	8	7	3,591
100% IC	8	7	3,991
Watershed Load	3.58	1.69	872
BMP Output	1.05	0.10	17
Target	3.18	1.38	711
Reduction %	**71%**	**94%**	**98%**
Effective IC	**-15%**	**-1%**	**0%**

Result Summary

Metric	Area (%)	Area (acres)
Watershed Area		2.6
Watershed IC (no BMP)	24%	0.6
Target IC Reduction	26.0%	0.2
Effective IC w/BMP	-15%	(0.4)
IC Reduction	162%	1.0

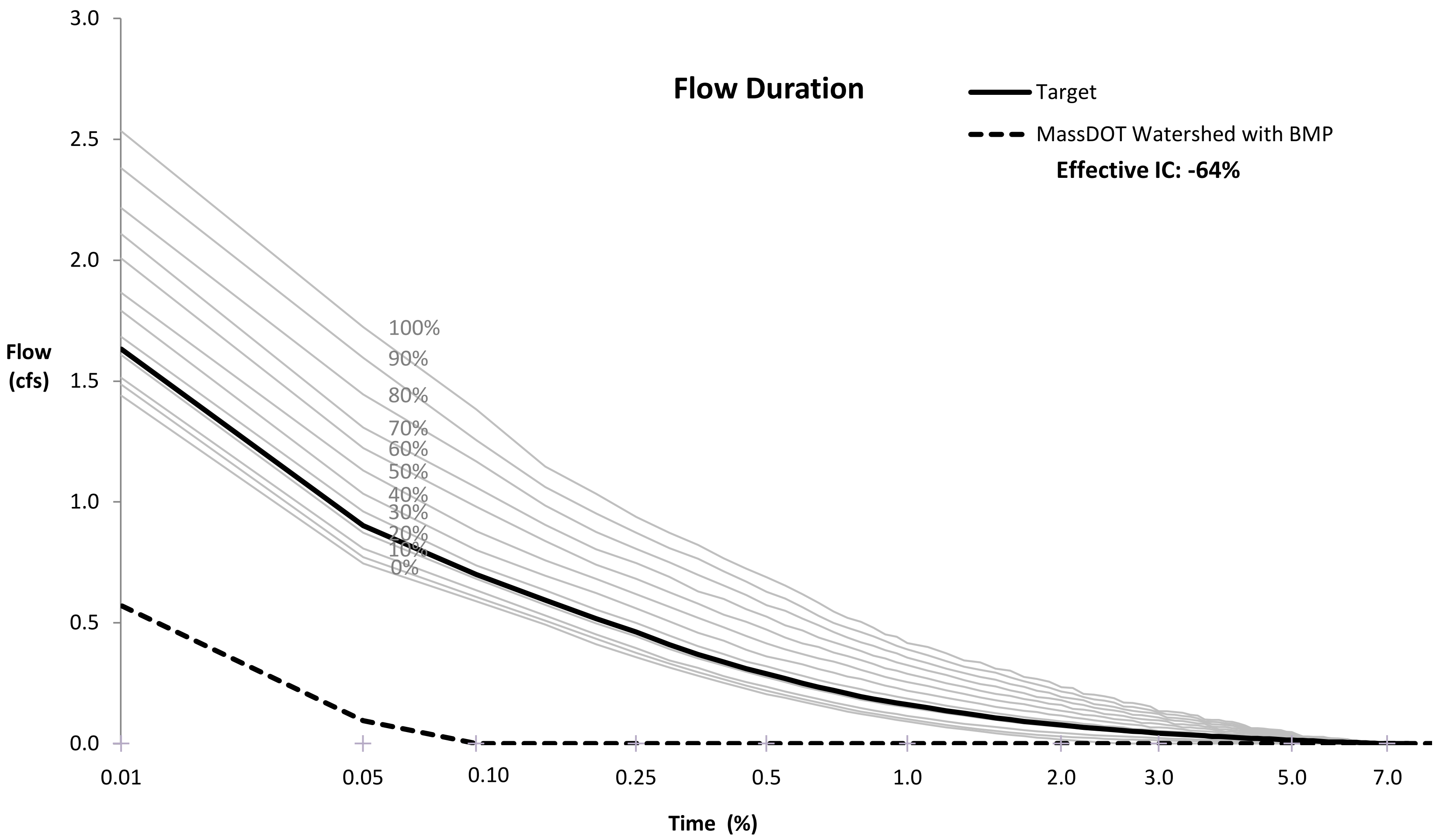
Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	0.4	1.2
Indirect Watershed	0.2	1.4
Total	0.6	2.6

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary

36.3 PR BMP 10



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	3	0	13
5%IC	3	1	275
10% IC	4	1	540
20% IC	4	2	1,069
30% IC	5	3	1,598
40% IC	6	4	2,128
50% IC	7	5	2,657
60% IC	8	6	3,186
70% IC	9	7	3,715
80% IC	9	8	4,245
90% IC	10	9	4,774
100% IC	11	10	5,306
Watershed Load	5.39	2.89	1,518
BMP Output	0.14	0.01	0
Target	4.71	2.36	1,239
Reduction %	**97%**	**100%**	**100%**
Effective IC	**-30%**	**-2%**	**0%**

Result Summary

Metric	Area (%)	Area (acres)
Watershed Area		3.5
Watershed IC (no BMP)	31%	1.1
Target IC Reduction	26.0%	0.3
Effective IC w/BMP	-31%	(1.1)
IC Reduction	200%	2.2

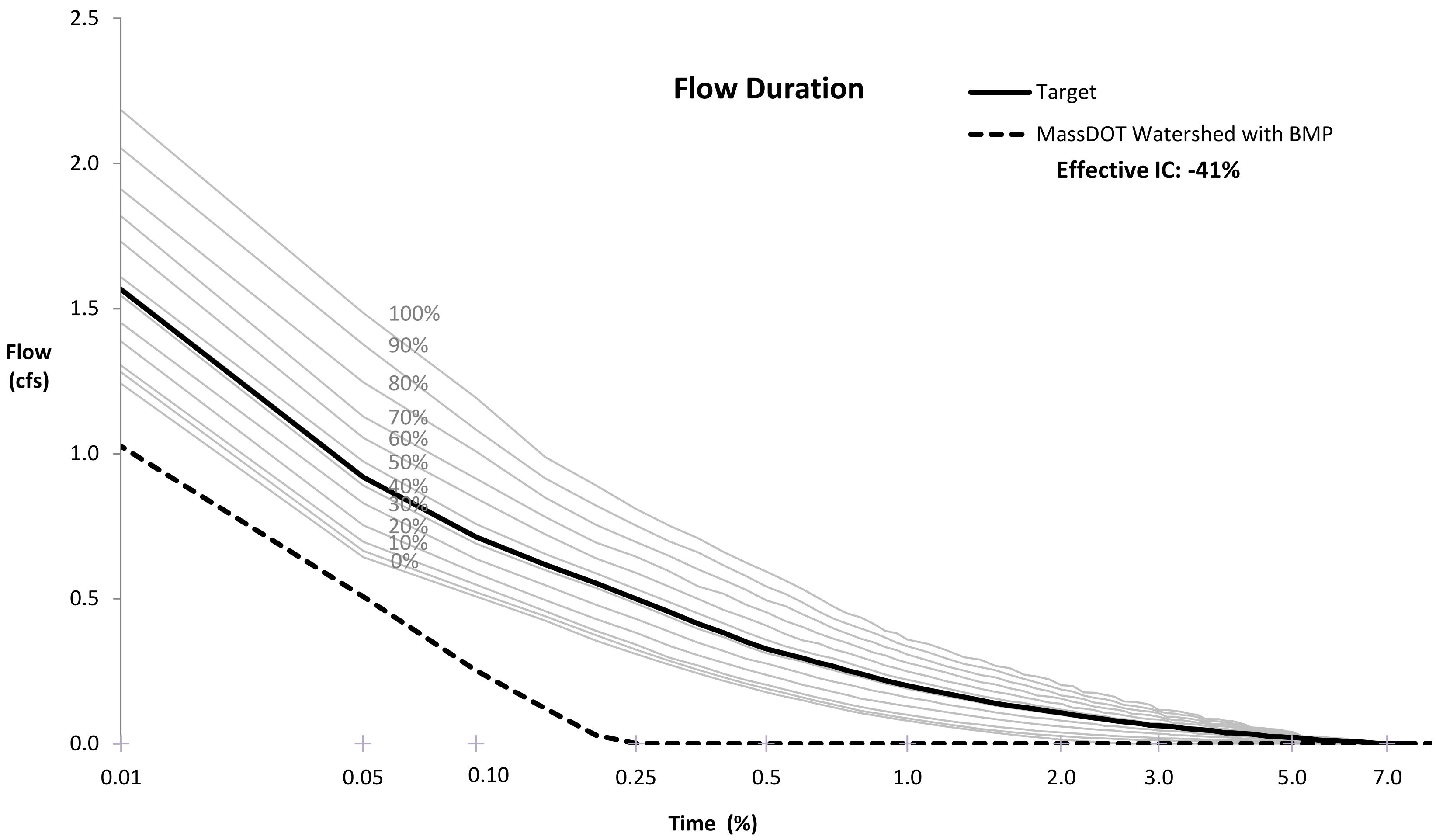
Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	1.1	3.5
Indirect Watershed	-	-
Total	1.1	3.5

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary

38.3 PR BMP 11



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	2	0	11
5%IC	3	1	237
10% IC	3	1	465
20% IC	4	2	921
30% IC	5	3	1,378
40% IC	5	3	1,834
50% IC	6	4	2,290
60% IC	7	5	2,746
70% IC	7	6	3,202
80% IC	8	7	3,658
90% IC	9	7	4,115
100% IC	10	8	4,573
Watershed Load	6.67	4.50	2,424
BMP Output	0.60	0.04	3
Target	5.54	3.68	1,985
Reduction %	**91%**	**99%**	**100%**
Effective IC	**-23%**	**-2%**	**0%**

Result Summary

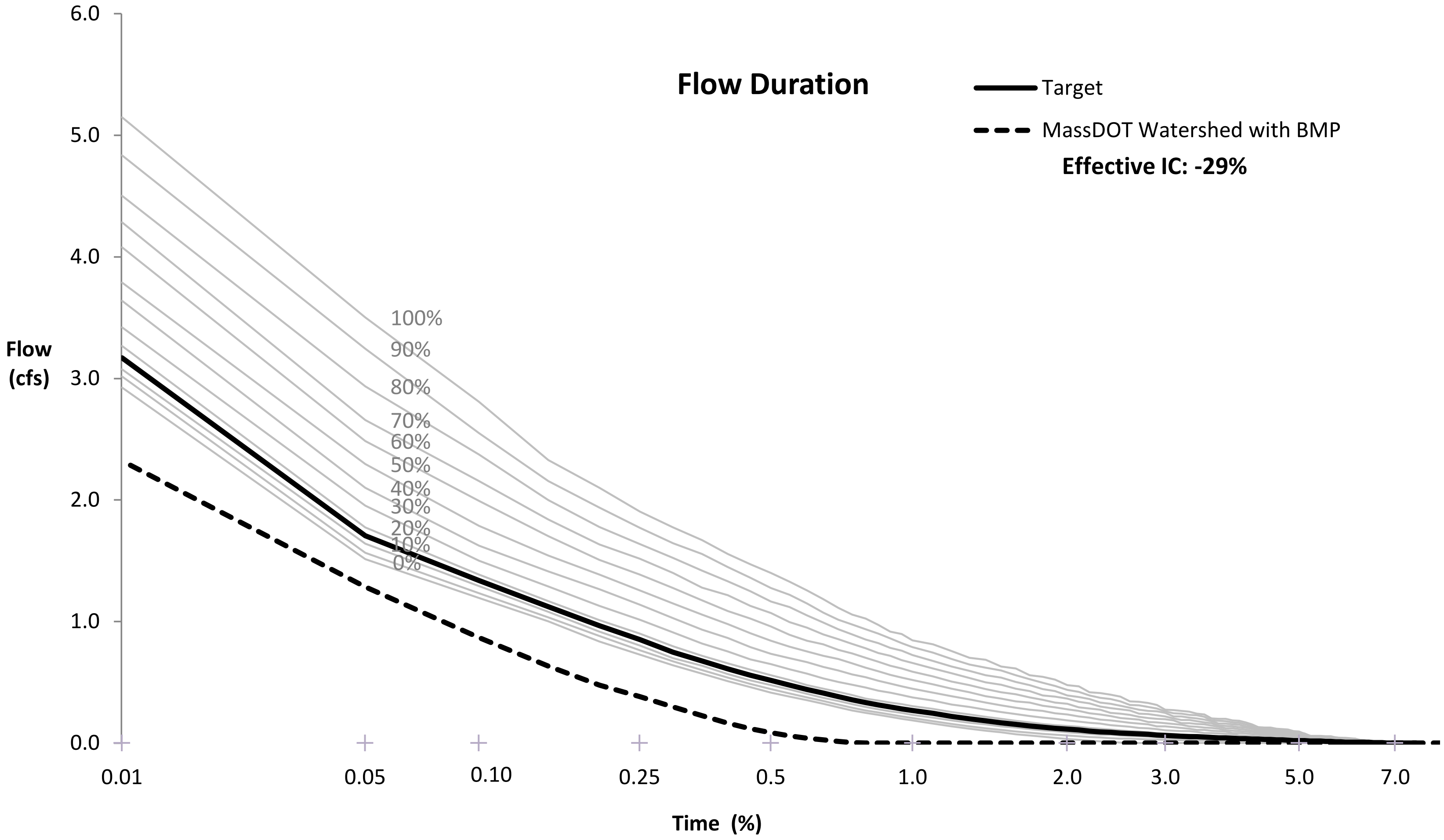
Metric	Area (%)	Area (acres)
Watershed Area		3.0
Watershed IC (no BMP)	59%	1.8
Target IC Reduction	26.0%	0.5
Effective IC w/BMP	-22%	(0.7)
IC Reduction	137%	2.4

Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	1.8	3.0
Indirect Watershed	-	-
Total	1.8	3.0

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary
40.3 PR BMP 12



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	6	0	27
5%IC	6	1	559
10% IC	7	2	1,097
20% IC	9	4	2,173
30% IC	11	6	3,248
40% IC	12	8	4,324
50% IC	14	10	5,399
60% IC	16	12	6,475
70% IC	18	14	7,551
80% IC	19	16	8,626
90% IC	21	18	9,702
100% IC	23	20	10,782
Watershed Load	8.78	3.90	1,989
BMP Output	2.37	0.17	15
Target	8.11	3.21	1,624
Reduction %	**73%**	**96%**	**99%**
Effective IC	**-18%**	**-1%**	**0%**

Result Summary

Metric	Area (%)	Area (acres)
Watershed Area		7.1
Watershed IC (no BMP)	20%	1.4
Target IC Reduction	26.0%	0.4
Effective IC w/BMP	-16%	(1.1)
IC Reduction	178%	2.5

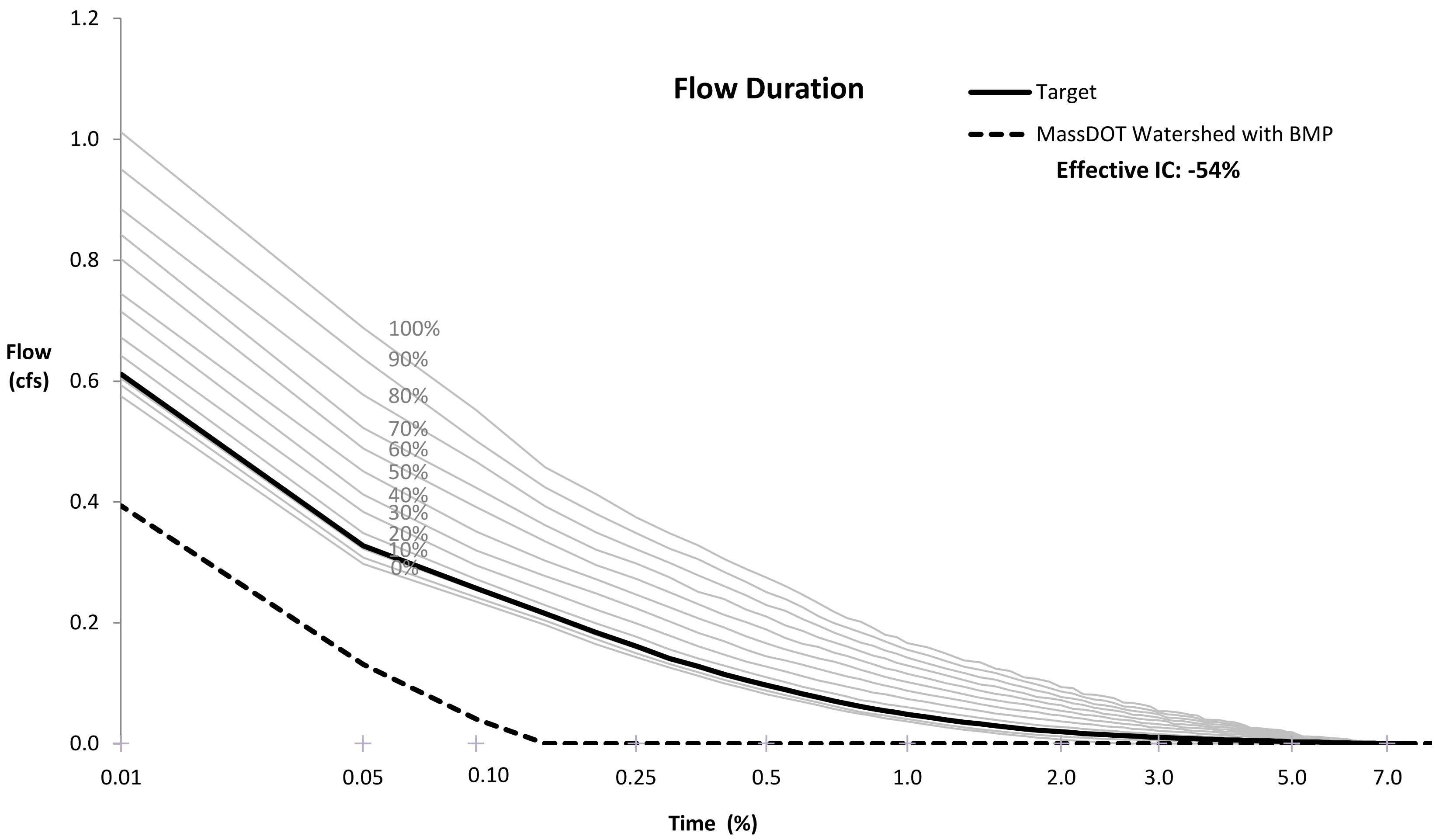
Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	0.2	0.7
Indirect Watershed	1.2	6.4
Total	1.4	7.1

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary

42.3 PR BMP 13



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	1	0	5
5%IC	1	0	110
10% IC	1	0	215
20% IC	2	1	427
30% IC	2	1	638
40% IC	2	2	849
50% IC	3	2	1,061
60% IC	3	2	1,272
70% IC	3	3	1,483
80% IC	4	3	1,695
90% IC	4	3	1,906
100% IC	4	4	2,118
Watershed Load	1.63	0.63	314
BMP Output	0.15	0.01	0
Target	1.49	0.52	256
Reduction %	**91%**	**99%**	**100%**
Effective IC	**-27%**	**-2%**	**0%**

Result Summary

Metric	Area (%)	Area (acres)
Watershed Area		1.4
Watershed IC (no BMP)	16%	0.2
Target IC Reduction	26.0%	0.1
Effective IC w/BMP	-27%	(0.4)
IC Reduction	267%	0.6

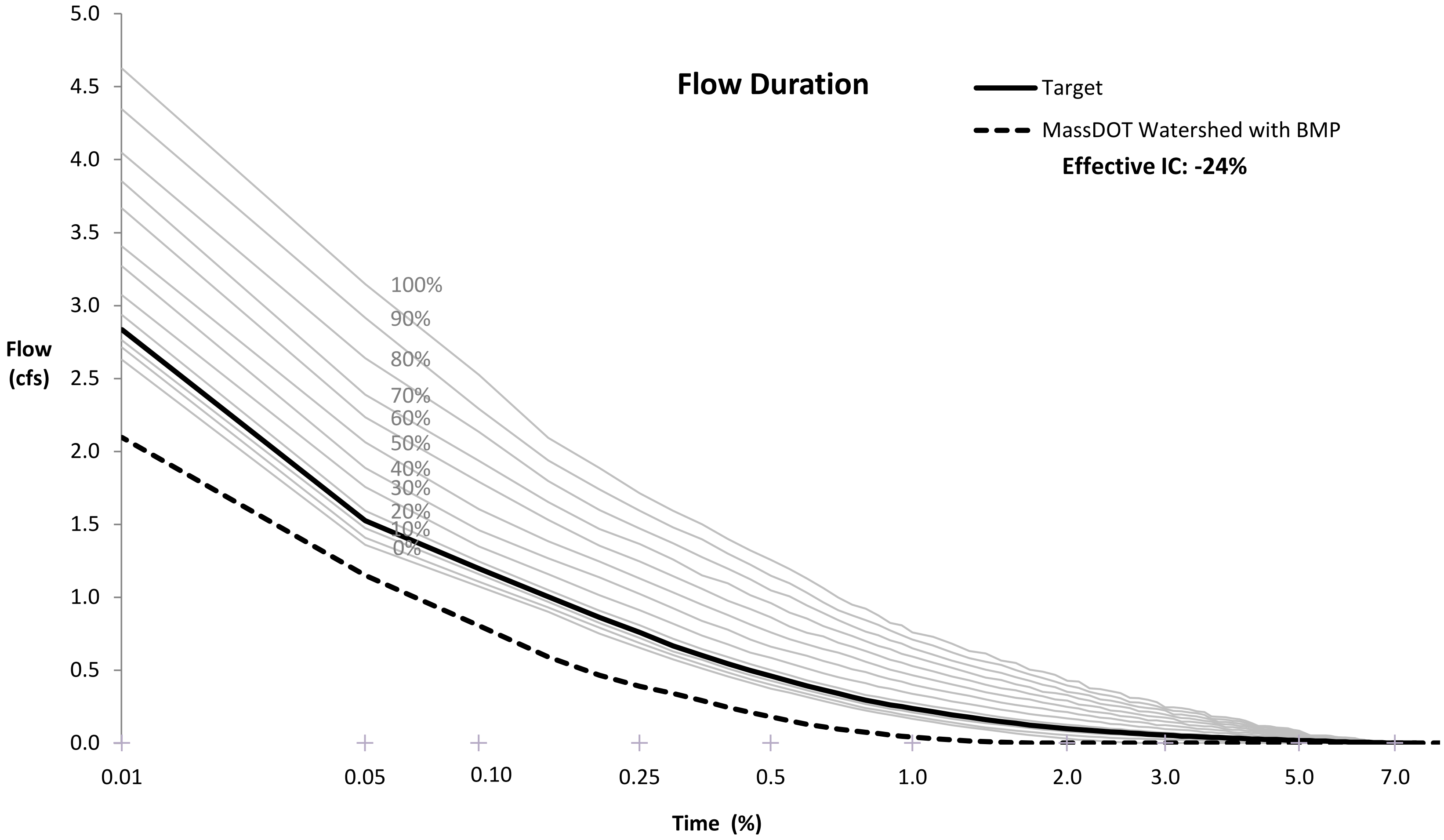
Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	0.2	1.4
Indirect Watershed	-	-
Total	0.2	1.4

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary

44.3 PR BMP 14



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	5	0	24
5%IC	6	1	502
10% IC	7	2	985
20% IC	8	4	1,952
30% IC	10	5	2,918
40% IC	11	7	3,884
50% IC	13	9	4,851
60% IC	14	11	5,817
70% IC	16	12	6,783
80% IC	17	14	7,749
90% IC	19	16	8,716
100% IC	20	18	9,686
Watershed Load	7.73	3.37	1,710
BMP Output	2.75	0.22	27
Target	7.19	2.77	1,397
Reduction %	**64%**	**94%**	**98%**
Effective IC	**-14%**	**-1%**	**0%**

Result Summary

Metric	Area (%)	Area (acres)
Watershed Area		6.4
Watershed IC (no BMP)	19%	1.2
Target IC Reduction	26.0%	0.3
Effective IC w/BMP	-13%	(0.8)
IC Reduction	166%	2.0

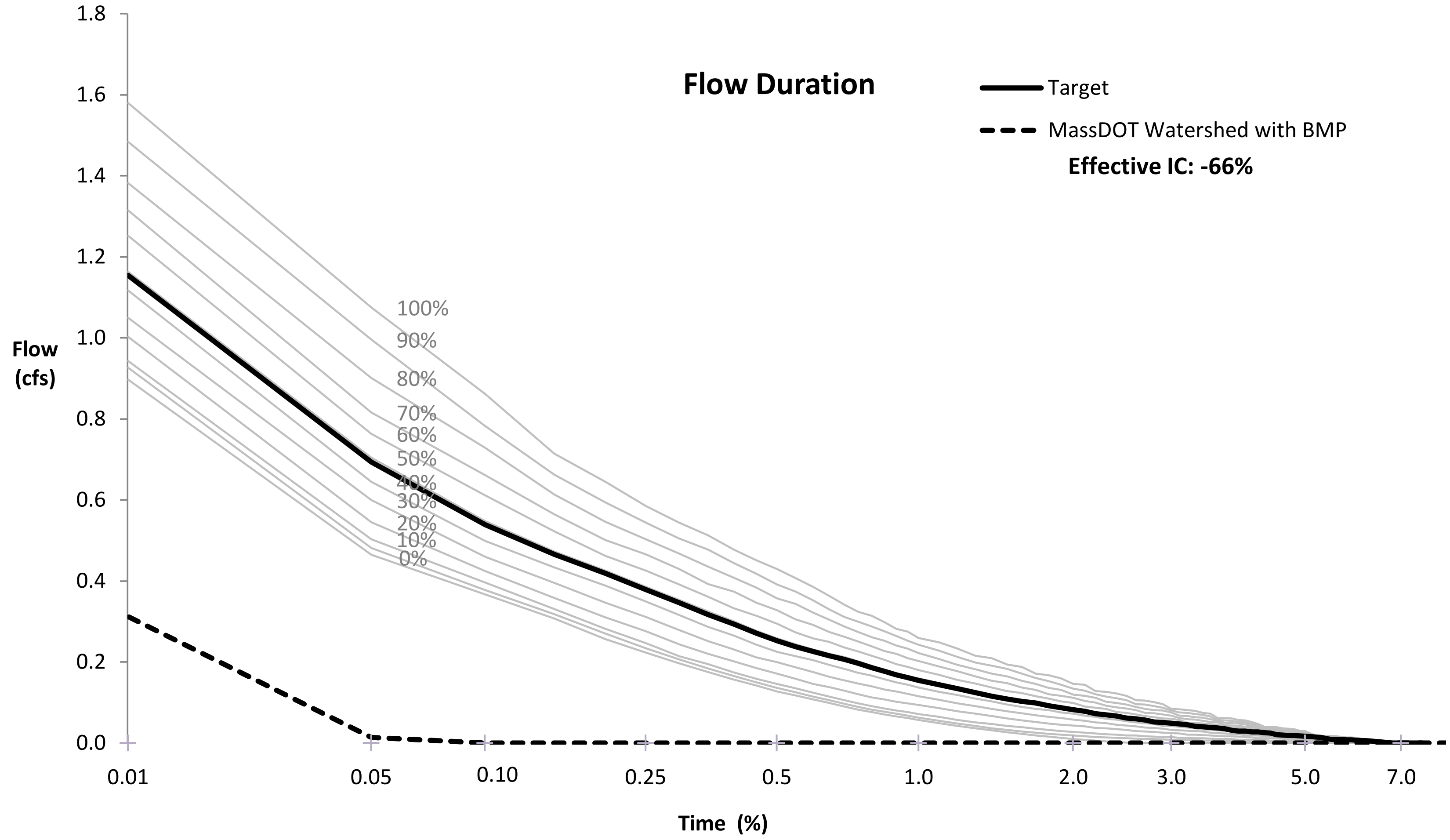
Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	0.2	1.3
Indirect Watershed	1.0	5.1
Total	1.2	6.4

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary

46.3 PR BMP 15



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	2	0	8
5%IC	2	0	172
10% IC	2	1	337
20% IC	3	1	667
30% IC	3	2	997
40% IC	4	2	1,327
50% IC	4	3	1,657
60% IC	5	4	1,987
70% IC	5	4	2,317
80% IC	6	5	2,647
90% IC	6	5	2,978
100% IC	7	6	3,309
Watershed Load	5.18	3.61	1,951
BMP Output	0.06	0.00	0
Target	4.26	2.95	1,598
Reduction %	**99%**	**100%**	**100%**
Effective IC	**-30%**	**-2%**	**0%**

Result Summary

Metric	Area (%)	Area (acres)
Watershed Area		2.2
Watershed IC (no BMP)	65%	1.4
Target IC Reduction	26.0%	0.4
Effective IC w/BMP	-32%	(0.7)
IC Reduction	150%	2.1

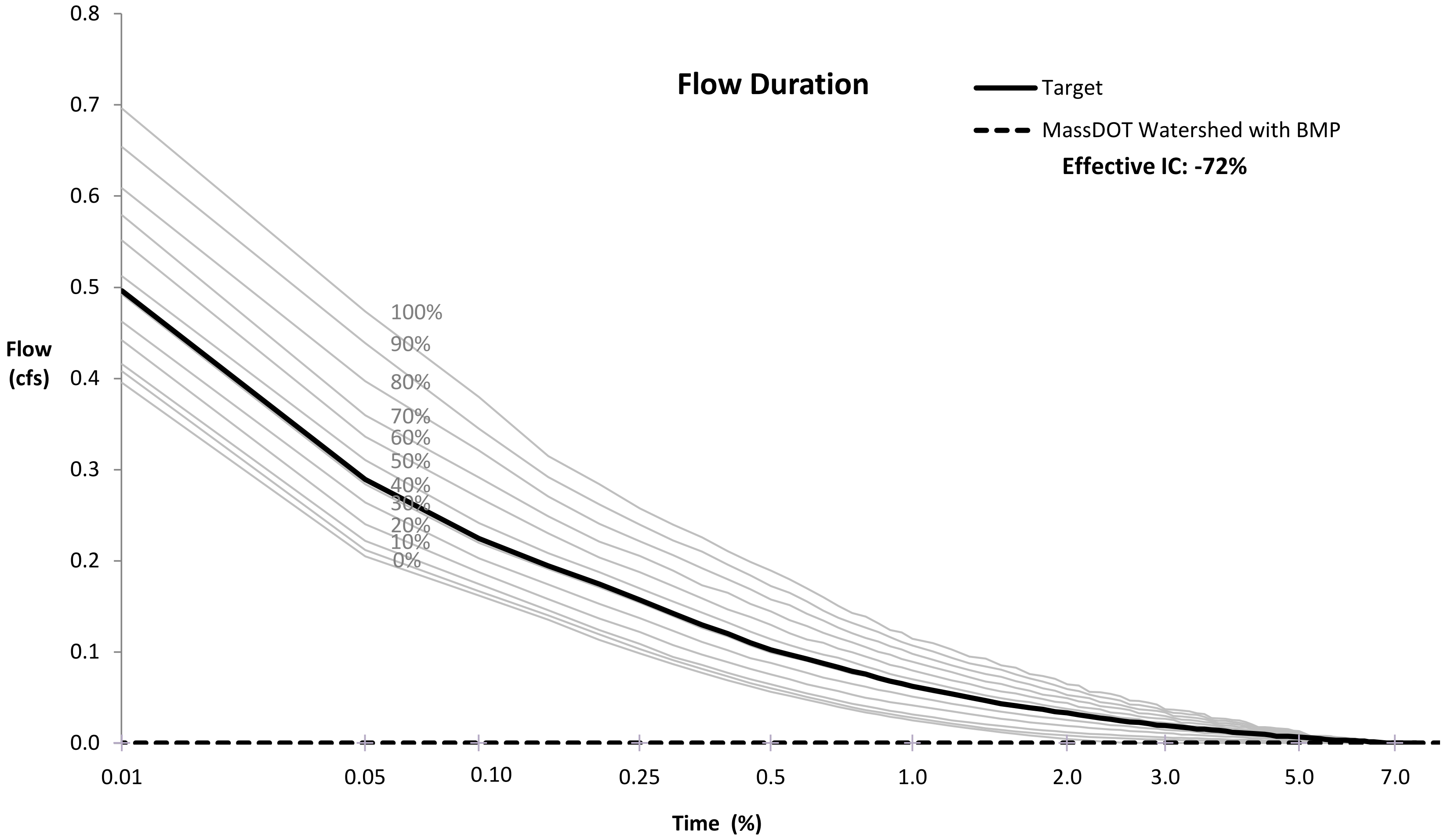
Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	1.4	2.2
Indirect Watershed	-	-
Total	1.4	2.2

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary

48.3 PR BMP 16



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	1	0	4
5%IC	1	0	76
10% IC	1	0	148
20% IC	1	1	294
30% IC	1	1	439
40% IC	2	1	585
50% IC	2	1	730
60% IC	2	2	875
70% IC	2	2	1,021
80% IC	3	2	1,166
90% IC	3	2	1,312
100% IC	3	3	1,458
Watershed Load	2.08	1.40	752
BMP Output	-	-	-
Target	1.74	1.14	614
Reduction %	**100%**	**100%**	**100%**
Effective IC	**-32%**	**-2%**	**0%**

Result Summary

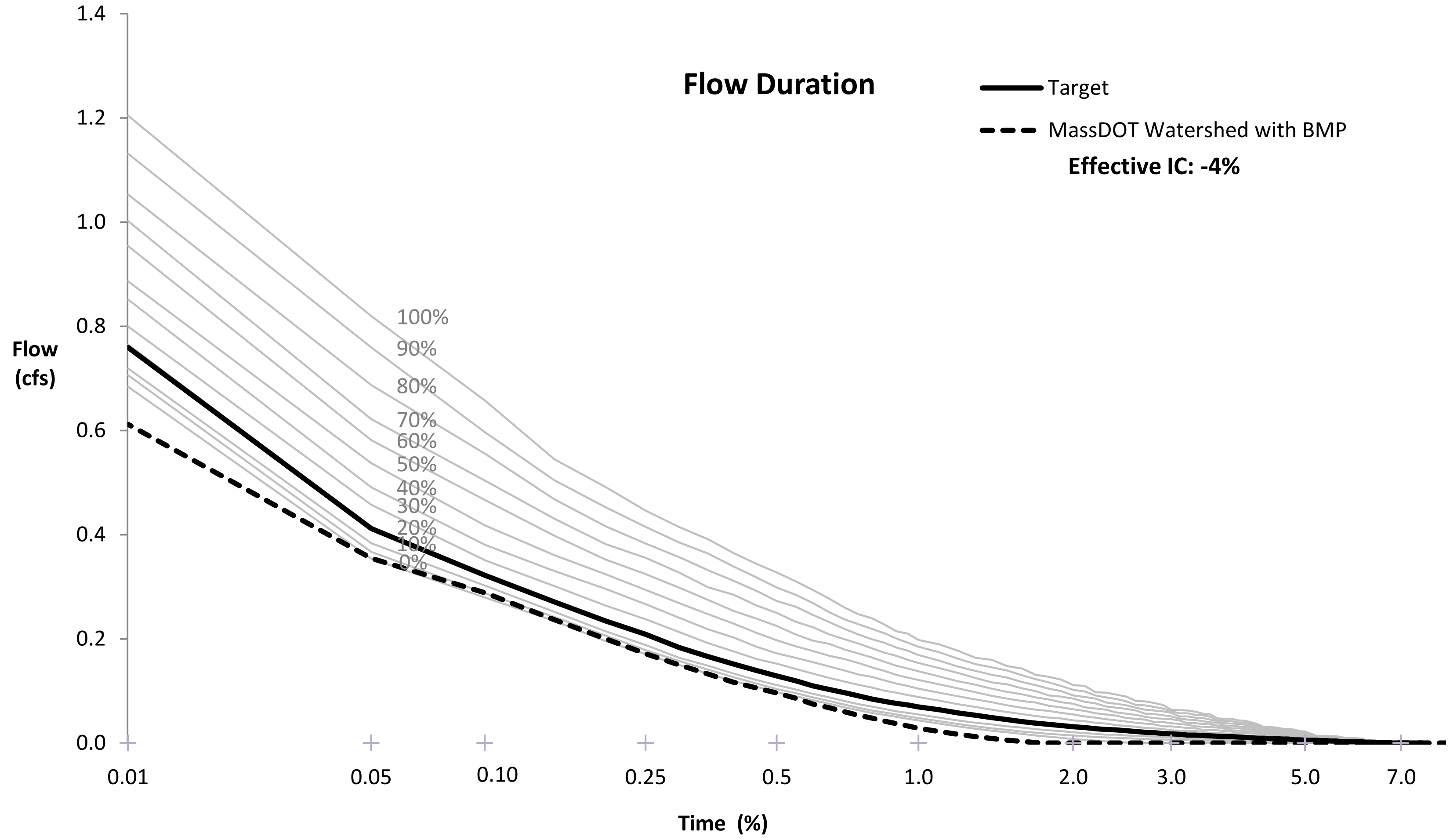
Metric	Area (%)	Area (acres)
Watershed Area		1.0
Watershed IC (no BMP)	57%	0.5
Target IC Reduction	26.0%	0.1
Effective IC w/BMP	-34%	(0.3)
IC Reduction	161%	0.9

Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	0.5	1.0
Indirect Watershed	-	-
Total	0.5	1.0

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary
50.3 PR BMP 17



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	1	0	6
5%IC	1	0	131
10% IC	2	1	257
20% IC	2	1	508
30% IC	3	1	760
40% IC	3	2	1,011
50% IC	3	2	1,263
60% IC	4	3	1,515
70% IC	4	3	1,766
80% IC	5	4	2,018
90% IC	5	4	2,269
100% IC	5	5	2,522
Watershed Load	2.25	1.13	590
BMP Output	1.14	0.12	23
Target	2.06	0.93	482
Reduction %	**49%**	**90%**	**96%**
Effective IC	**-4%**	**1%**	**1%**

Result Summary

Metric	Area (%)	Area (acres)
Watershed Area		1.7
Watershed IC (no BMP)	26%	0.4
Target IC Reduction	26.0%	0.1
Effective IC w/BMP	-2%	(0.0)
IC Reduction	109%	0.5

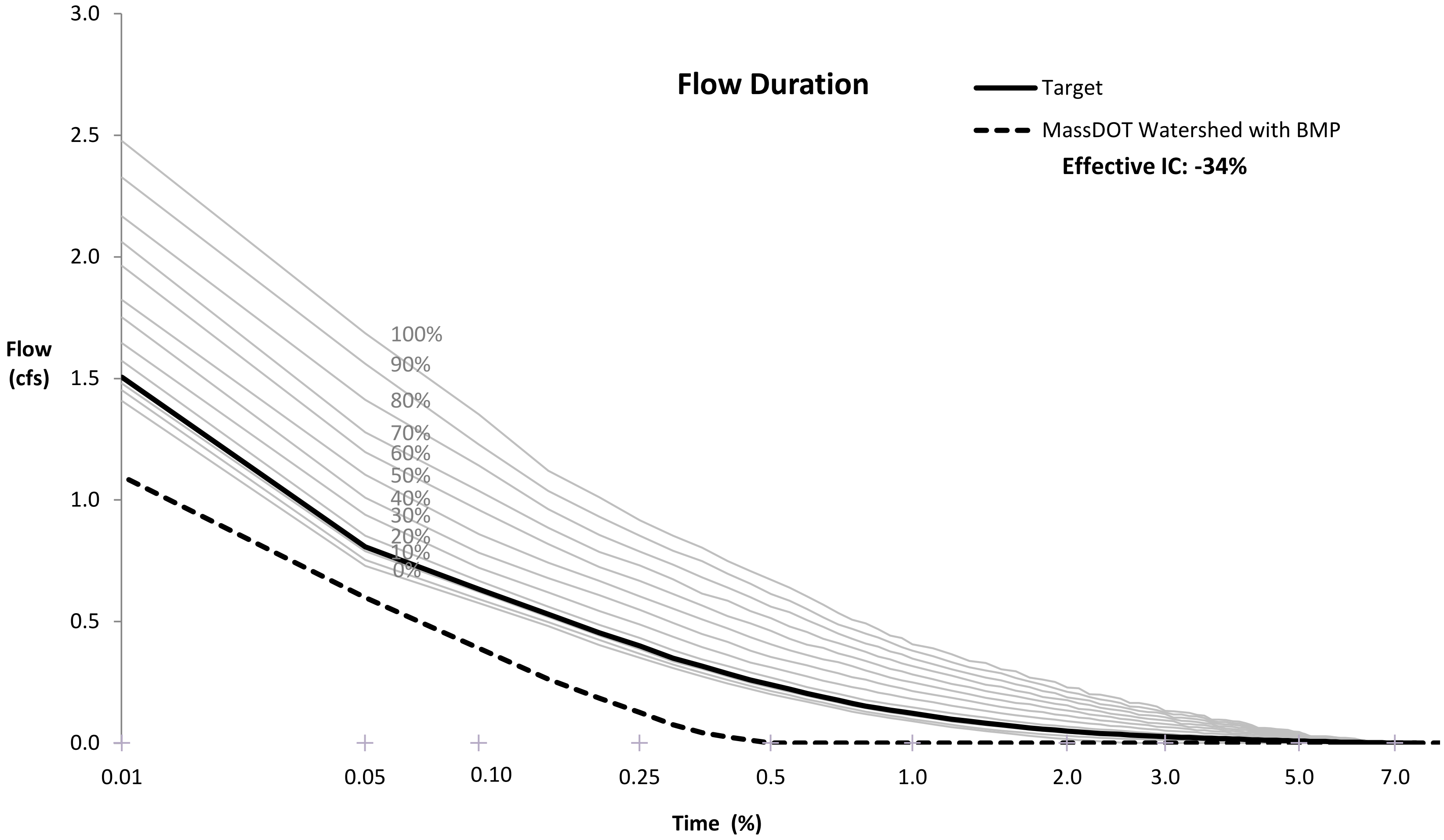
Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	0.4	1.7
Indirect Watershed	-	-
Total	0.4	1.7

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary

52.3 PR BMP 18



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	3	0	13
5%IC	3	1	269
10% IC	3	1	528
20% IC	4	2	1,045
30% IC	5	3	1,563
40% IC	6	4	2,080
50% IC	7	5	2,597
60% IC	8	6	3,115
70% IC	8	7	3,632
80% IC	9	8	4,150
90% IC	10	9	4,667
100% IC	11	9	5,187
Watershed Load	3.96	1.63	819
BMP Output	0.95	0.06	2
Target	3.72	1.34	669
Reduction %	**76%**	**96%**	**100%**
Effective IC	**-20%**	**-1%**	**0%**

Result Summary

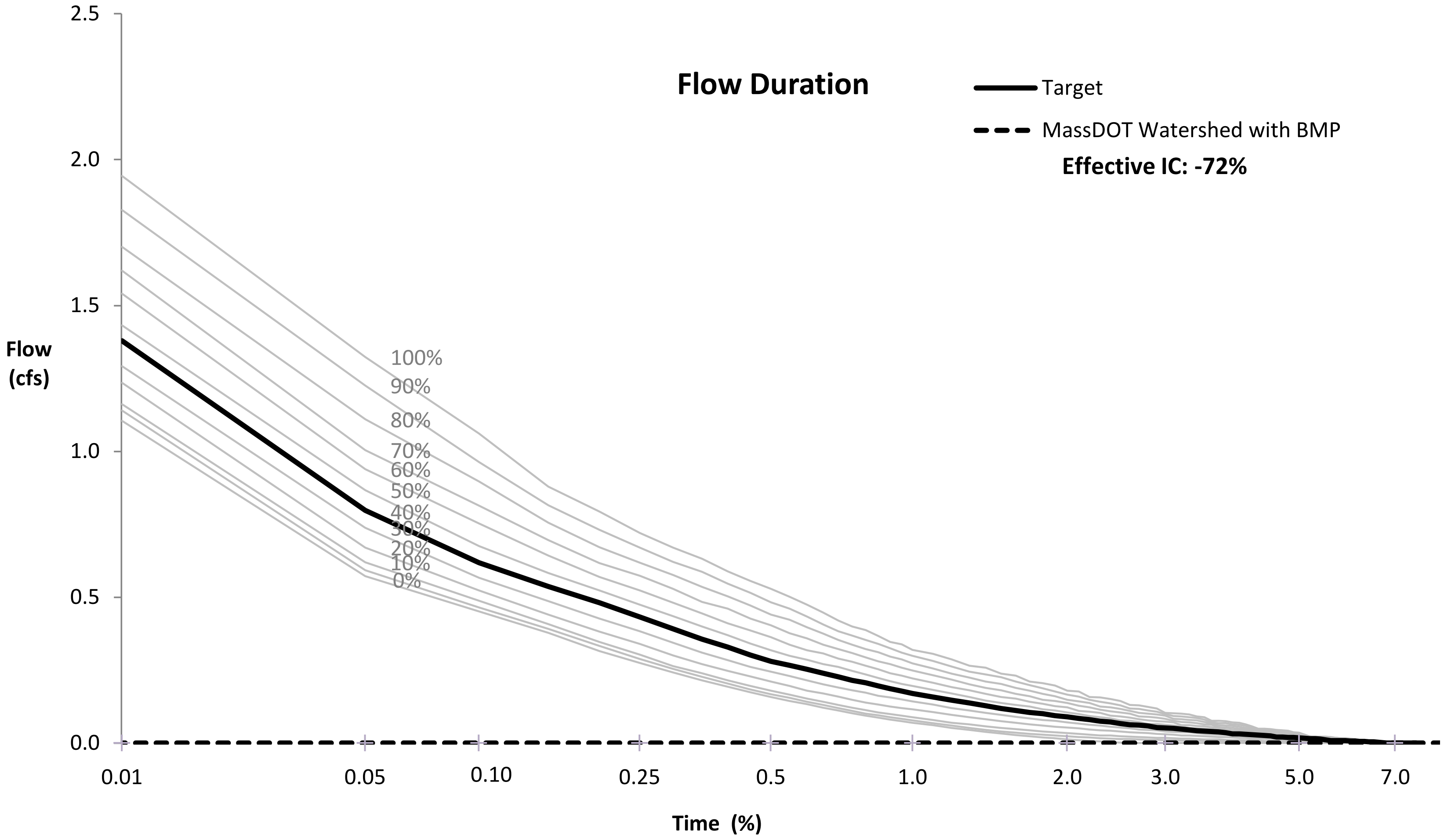
Metric	Area (%)	Area (acres)
Watershed Area		3.4
Watershed IC (no BMP)	17%	0.6
Target IC Reduction	26.0%	0.2
Effective IC w/BMP	-18%	(0.6)
IC Reduction	206%	1.2

Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	0.6	3.4
Indirect Watershed	-	-
Total	0.6	3.4

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary
54.3 PR BMP 19



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	2	0	10
5%IC	2	1	211
10% IC	3	1	414
20% IC	3	2	821
30% IC	4	2	1,227
40% IC	5	3	1,634
50% IC	5	4	2,040
60% IC	6	4	2,447
70% IC	7	5	2,853
80% IC	7	6	3,259
90% IC	8	7	3,666
100% IC	9	7	4,074
Watershed Load	5.72	3.78	2,034
BMP Output	-	-	-
Target	4.76	3.08	1,660
Reduction %	**100%**	**100%**	**100%**
Effective IC	**-32%**	**-2%**	**0%**

Result Summary

Metric	Area (%)	Area (acres)
Watershed Area		2.7
Watershed IC (no BMP)	55%	1.5
Target IC Reduction	26.0%	0.4
Effective IC w/BMP	-34%	(0.9)
IC Reduction	163%	2.4

Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	1.5	2.7
Indirect Watershed	-	-
Total	1.5	2.7

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Impaired Waters Assessment for Unnamed Tributary (MA82A-15)

Summary

		Stormwater	Non-Stormwater[2]
Impaired Water[1]	**Impairments:**	Excess algal growth, dissolved oxygen, total phosphorus, total suspended solids	Non-native aquatic plants
	Category:	5 (Waters requiring a TMDL)	
	Final TMDLs:	None	
	WQ Assessment:	SuAsCo Watershed 2001 Water Quality Assessment Report [3]	
Location	**Towns:**	Marlborough	
	MassDOT Roads:	State Route 20	
Assessment Method(s)	**7R (TMDL Method)**	☐	
	7U (IC Method)	☒	
BMPs	**Existing:**	None	
	Proposed:	None	
MassDOT Contributing Area and Targets			Impervious Cover (IC)
	Directly Contributing Area		3.4 acres
	Contributing Area Reduction Target		2.0 acres
	Existing BMPs Reduction		0.0 acres
	Proposed BMPs Reduction		0.0 acres
	Remaining Treatment to Meet Target		2.0 acres

[1] MassDEP, 2013. Massachusetts Year 2012 Integrated List of Waters – Final Listing of the Condition of Massachusetts' Waters Pursuant to Sections 305(b), 314 and 303(d) of the Clean Water Act. Massachusetts. Available at: http://www.mass.gov/eea/docs/dep/water/resources/07v5/12list2.pdf

[2] MassDOT, December 2012. Impaired Waters Assessment for Impaired Waters with Impairments Unrelated to Stormwater. Available at: http://www.mhd.state.ma.us/downloads/projDev/ImpairedWaters_3/Year3_ImpairedWatersAssessment_1.pdf#page=308

[3] MassDEP, 2005. SuAsCo Watershed 2001 Water Quality Assessment Report. Available at: http://www.mass.gov/eea/docs/dep/water/resources/71wqar09/82wqar3.pdf

Site Description

MA82A-15 is an unnamed tributary to Hager Pond. It is referred to locally as “Hop Brook.” The contributing area to Unnamed Tributary (MA82A-15) occupies approximately 623 acres in Marlborough. Route 20, the only MassDOT-owned roadway in the tributary watershed, bisects the contributing area from east to west. Figure 1 illustrates the contributing area to Unnamed Tributary (MA82A-15).

The headwaters of Unnamed Tributary (MA82A-15) are located between the rear yards of a commercial development (Home Depot) and a residential development (Settlers Lane). The headwaters consist of a small storage area (0.2 acres) that is often dry. Major contributors to the storage area include a large stormwater basin attributed to a nearby commercial development and a stormwater outfall. Unnamed Tributary (MA82A-15) flows overland for approximately 200 feet, where it enters a 950-foot long culvert that conveys the brook northward underneath the commercial parking lot to a wooded area north of Route 20. Unnamed Tributary (MA82A-15) flows approximately 4,300 feet to the northeast and then to the south, back under Route 20 to Hager Pond (MA82056). The Marlborough Easterly Waste Water Treatment Plant discharges to the brook approximately 1,800 feet upstream of Hager Pond (MA82056).

The 2001 SuAsCo Water Quality Assessment Report indicates that the waterbody is impaired for the aquatic life designated use. The identified causes include total phosphorus, and total suspended solids. The identified sources include: municipal point source discharges from MS4s, landfill, and municipal urbanized high density areas. Other uses were not assessed.

“The Marlborough Easterly Wastewater Treatment Plant (WWTP) discharges to Hop Brook upstream of Hager Pond and accounts for a significant amount of flow and nutrient loadings at this water body. Numerous studies have been conducted on the Hop Brook system. In 1984, the USGS determined that approximately 50% of the flow in Hop Brook consists of effluent from the WWTP; in drought conditions, the effluent may account for as much as 90% of the flow.”[4]

Figure 2 illustrates the portion of Route 20, the MassDOT property directly draining to Unnamed Tributary (MA82A-15). .

The contributing area to the westernmost outfall (Outfall 1) begins approximately 400 feet west of the western end of DiCenzio Boulevard and ends approximately 600 feet east of DiCenzio Boulevard. In this area, stormwater runoff from four lanes (two travel lanes in each direction constructed as undivided highway with a crown at the centerline) is collected by a two separate curb/catchbasin systems that discharge into other stormwater management systems outside the MassDOT right-of-way (see Outfalls 1A and 1B). One segment (1A) captures approximately 400 linear feet of roadway, and, most likely, joins the municipal stormwater system underneath DiCenzio Boulevard. The other segment (1B) captures approximately 700 feet of roadway, and, most likely, joins into the commercial stormwater system underneath the parking lot.

The location of the second outfall (Outfall 2) is unconfirmed, but it is likely located within the culvert structure that brings MA82A-15 northward underneath Route 20. The contributing area to the second outfall begins approximately 600 feet east of DiCenzio Boulevard. From this point to approximately 450 feet east, stormwater runoff from 4 lanes (two travel lanes in each direction constructed as undivided highway with a crown at the centerline) is collected by a curb/catchbasin system that discharges into the cross culvert that conveys MA82A-15 northward underneath Route 20.

The third outfall (Outfall 3) is located on the south side of Route 20 and discharges to a low lying area between the eastern end of DiCenzio Boulevard and the landfill. Stormwater that reaches this area passes overland and likely infiltrates to groundwater; the headwaters of MA82A-15 are approximately 2,500 feet

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[4] MassDEP, 2005. SuAsCo Watershed 2001 Water Quality Assessment Report. Available at: http://www.mass.gov/eea/docs/dep/water/resources/71wqar09/82wqar3.pdf

away. This outfall does not discharge directly to MA82A-15. The contributing area to the third outfall begins approximately 1,000 feet west of the eastern end of DiCenzio Boulevard. Stormwater runoff from 4 lanes (two travel lanes in each direction constructed as undivided highway with a crown at the centerline) is collected by a curb/catchbasin system that discharges to the low lying area to the south of Route 20.

The right-of-way along this length of Route 20 is irregular and limited. The roadside is flanked with sidewalks and landscape areas belonging to the adjacent commercial properties.

Existing BMPs

MassDOT did not identify any existing BMPs in place to treat the directly discharging roadway runoff before reaching the impaired water segment.

Assessment

In cases where a TMDL has been approved, MassDOT assessed the waterbody for the impairments covered by the TMDL under the BMP 7R methodology. MassDOT has separately assessed the waterbody for any stormwater-related impairments that are not covered by the TMDL under the BMP 7U methodology. MassDOT assessed Unnamed Tributary (MA82A-15) using the methodologies described below.

MassDOT has identified a subset of water body impairments in the Unnamed Tributary (MA82A-15) watershed which are not related to stormwater runoff. Specific impairments unrelated to stormwater for the Unnamed Tributary include non-native aquatic species in accordance with MassDOT's Impaired Waters Assessment for Impaired Waters with Impairments Unrelated to Stormwater in the December 8, 2012 EPA submittal, the non-pollutant impairments are not specifically addressed as part of the Impaired Waters Program.[5]

BMP 7U for Impervious Cover Related Impairments

MassDOT assessed the stormwater-related impairments not addressed by a TMDL using the approach outlined in the Description of MassDOT's Application of Impervious Cover Method in BMP 7U[6] which was developed using the EPA Region I's Impervious Cover (IC) Method as a basis, described in EPA's Stormwater TMDL Implementation Support Manual.[7] Consistent with the findings of EPA and others, MassDOT concluded that when a watershed had less than 9% IC, stormwater was not the likely cause of the impairment.

MassDOT calculated the following values for the total contributing watershed of the impaired water (Unnamed Tributary) to determine the IC target. The total contributing watershed is shown in Figure 1.

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[5] MassDOT, December 2012. Impaired Waters Assessment for Impaired Waters with Impairments Unrelated to Stormwater. Available at: http://www.mhd.state.ma.us/downloads/projDev/ImpairedWaters_3/Year3_ImpairedWatersAssessment_1.pdf#page=308

[6] MassDOT, 6 April, 2011. Description of MassDOT's Application of Impervious Cover Method in BMP 7U (MassDOT Application of IC Method). http://www.mhd.state.ma.us/downloads/projDev/BMP_7U_ImpairedWaterbodiesAssessment.pdf

[7] ENSR 2006. *Stormwater TMDL Implementation Support Manual for US EPA Region 1*. ENSR International & EPA Region 1, Boston, MA. Available at http://www.epa.gov/region1/eco/tmdl/regionalpgrfs.html

Impaired Segment Watershed	
Watershed Area	623 acres
Impervious Cover (IC) Area	138 acres
Percent Impervious	22%
IC Area at 9% Goal	56 acres
Target Effective IC Reduction	59%

The total watershed is greater than 9% impervious indicating that stormwater is a likely contributor to the impairment. To meet the 9% effective IC target, the effective IC within the watershed will need to be reduced. Therefore, the effective IC of MassDOT's directly contributing area should also be reduced by the same percentage to meet the target. The following table shows how MassDOT calculated the target effective IC for MassDOT's contributing property.

MassDOT Directly Contributing Watershed	
Directly Contributing Area	4.4 acres
Directly Contributing IC Area	3.4 acres
Percent Impervious	78 %
Target Effective IC Reduction (59% Reduction of DOT Directly Contributing IC)	2.0 acres
Target Effective IC	32 %

This assessment was not able to identify practical locations for stormwater management improvements within the current MassDOT right-of-way. The Proposed Mitigation Plan section discusses the site constraints and mitigation plan.

Proposed Mitigation Plan

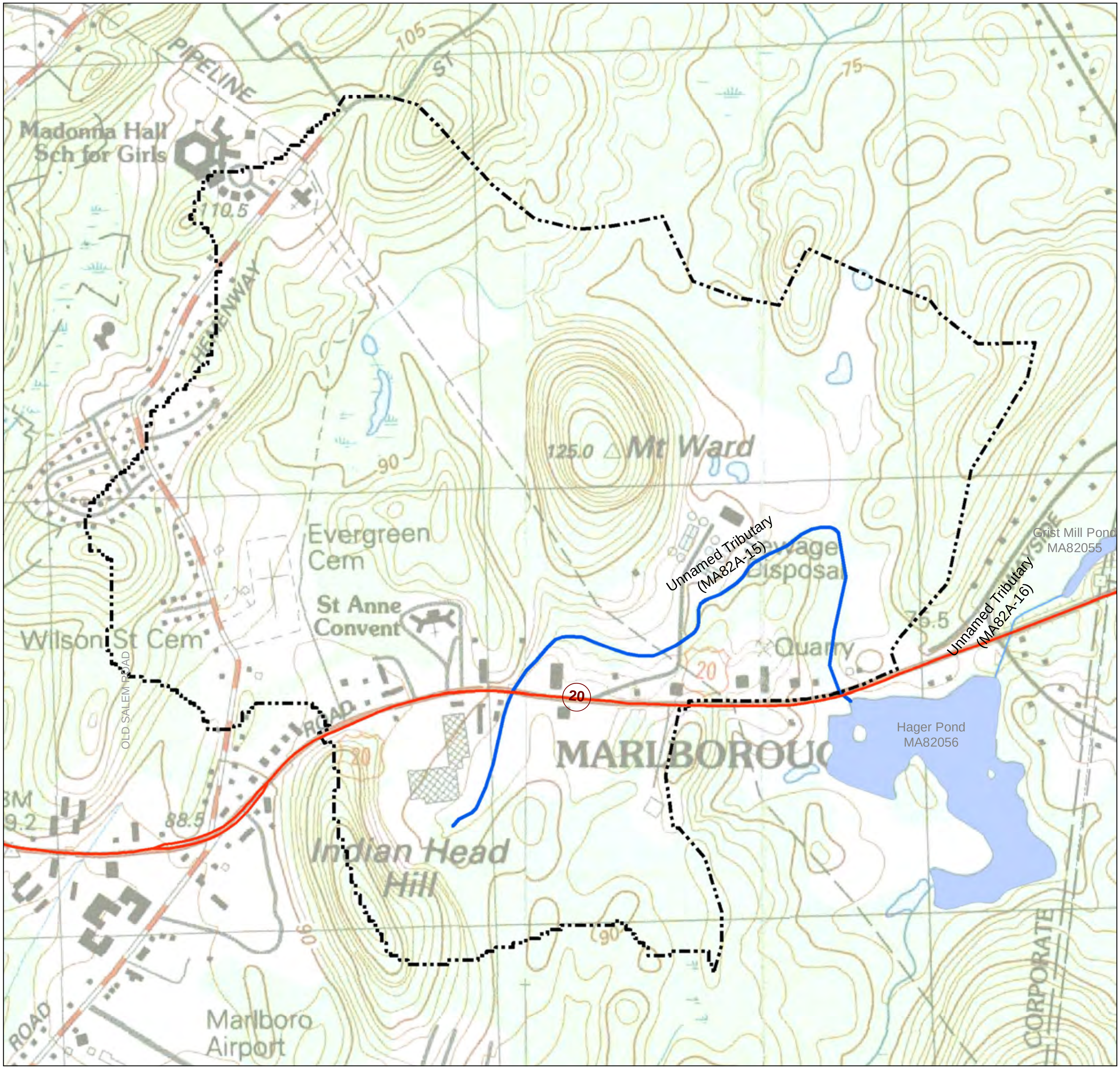
During this assessment phase of the Impaired Waters Program, MassDOT has focused on directly contributing areas and identified BMPs that can be constructed entirely on MassDOT property without resulting in substantial wetland impacts or resulting in an adverse impact on historical or archeological resources. Projects that meet these requirements can utilize the Federal Highway Administration's Alternative Contracting mechanism (SEP-14) created for this program.

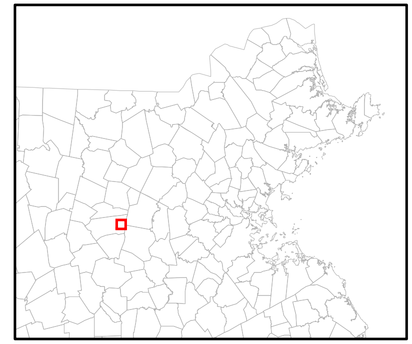
Site limitations for the MassDOT directly discharging area:

(1) Heavily urbanized areas with limited right-of-way;
(2) Right-of-way areas occupied by landscaping, sidewalks, and curb cut entrances to high-traffic commercial properties; and
(3) Outfalls discharging to municipal MS4s with no MassDOT property in the vicinity of the final discharge point and no opportunities to install BMPs in MassDOT right of way for treatment of runoff prior to discharge to the MS4.

Based on the review of MassDOT's directly contributing drainage area, no BMPs have been identified that can be implemented under the Impaired Waters Program. No BMPs can be implemented on MassDOT property to address the impairments of the Unnamed Tributary given the site constraints.

MassDOT will continue to ensure proper non-structural BMPs are being implemented within the watershed of Unnamed Tributary (MA82A-15), including regular roadway and drainage system maintenance, erosion and sedimentation control, and outreach and education. Further work by MassDOT on programmed projects, which often include broader scale road layout changes, may provide additional opportunities for construction of new treatment BMPs. This is consistent with an iterative adaptive management approach to address impairments. MassDOT will include an update in annual reports to EPA regarding progress made towards meeting target IC reductions, plans for construction of proposed BMPs and finalized assessments including reduction achieved by finalized BMP designs.





- MassDOT Roadways in Urban Area
- Watershed
- Assessed Segment
- Impaired Lakes

N

0 500 1,000

Feet

1 inch = 1,000 feet

Figure 1

Unnamed Tributary (MA82A-15) Watersheds

December 2013

massDOT Massachusetts Department of Transportation Highway Division

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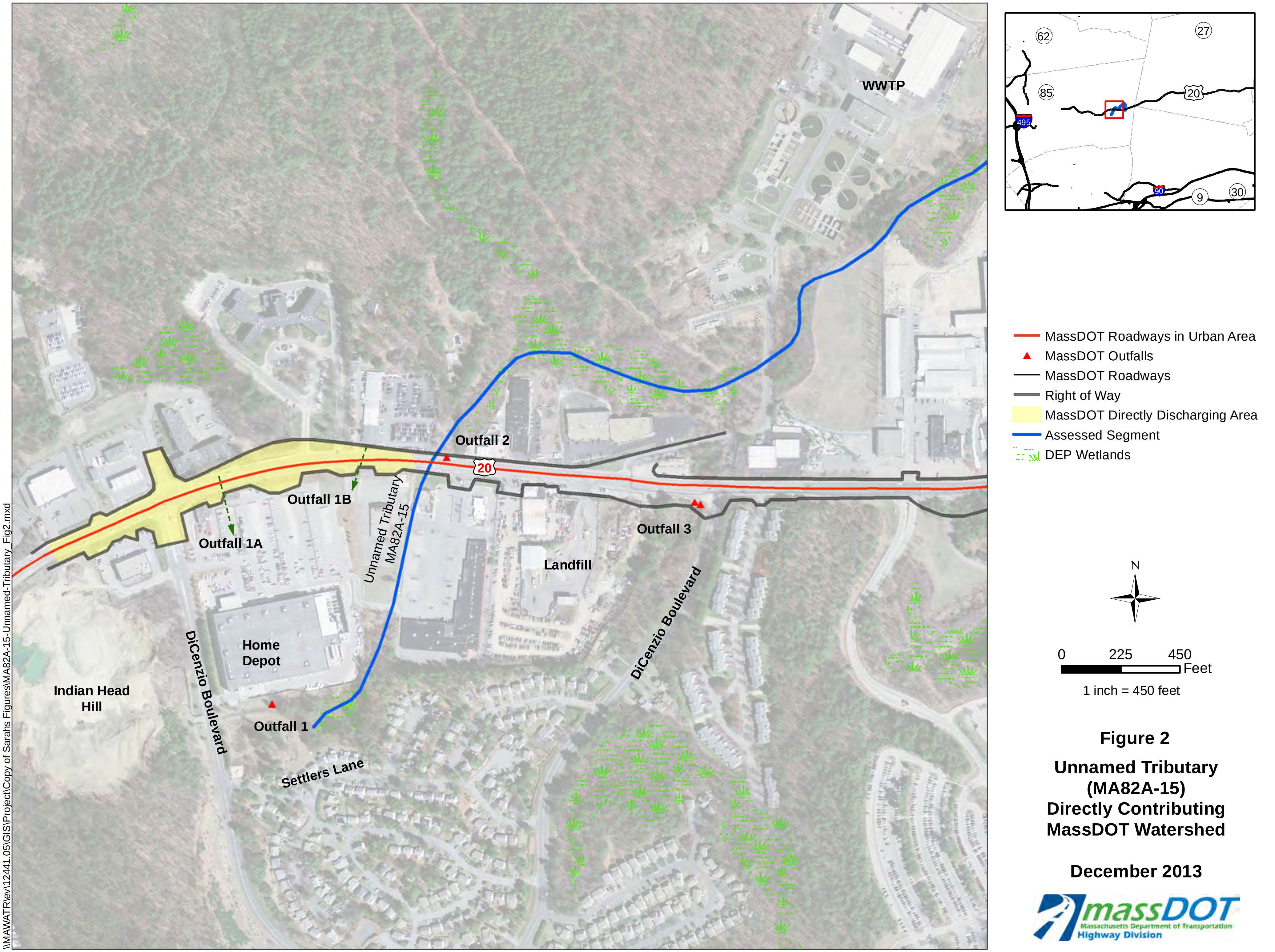

Figure 2

Unnamed Tributary (MA82A-15) Directly Contributing MassDOT Watershed

December 2013

Impaired Waters Assessment for Unnamed Tributary (MA82A-16)

Summary

Impaired Water[1]	**Impairments:**	Dissolved oxygen saturation, excess algal growth, phosphorus (total), total suspended solids, pH
	Category:	5 (Waters requiring a TMDL)
	Final TMDLs:	None
	WQ Assessment:	SuAsCo Watershed 2001 Water Quality Assessment Report[2]
Location	**Towns:**	Marlborough
	MassDOT Roads:	State Route 20
Assessment Method(s)	**7R (TMDL Method)**	☐
	7U (IC Method)	☒
BMPs	**Existing:**	None
	Proposed:	1 water quality swale
MassDOT Contributing Area and Targets		Impervious Cover (IC)
	Directly Contributing Area	2.0 acres
	Contributing Area Reduction Target	0.9 acres
	Existing BMPs Reduction	0.0 acres
	Proposed BMPs Reduction	0.1 acres
	Remaining Treatment to Meet Target	0.8 acres

[1] MassDEP, 2013. Massachusetts Year 2012 Integrated List of Waters – Final Listing of the Condition of Massachusetts' Waters Pursuant to Sections 305(b), 314 and 303(d) of the Clean Water Act. Massachusetts. Available at: http://www.mass.gov/eea/docs/dep/water/resources/07v5/12list2.pdf

[2] MassDEP, 2005. SuAsCo Watershed 2001 Water Quality Assessment Report. Available at: http://www.mass.gov/eea/docs/dep/water/resources/71wqar09/82wqar3.pdf

Site Description

Unnamed Tributary (MA82A-16), commonly referred to as “Hop Brook,” is located in Marlborough, Massachusetts. It connects Hager Pond (MA82056) to Grist Mill Pond (MA82055). The contributing area to Unnamed Tributary (MA82A-16) occupies approximately 1,130 acres in Marlborough, Framingham, and Sudbury. Route 20, the only MassDOT-owned roadway in the tributary watershed, bisects the contributing area from east to west.

The 2001SuAsCo Water Quality Assessment Report indicates that Unnamed Tributary is impaired for the Aquatic Life Designated Use. The identified causes include Total Phosphorus, Dissolved Oxygen Saturation, and pH.

“The Marlborough Easterly Wastewater Treatment Plant (WWTP) discharges to Hop Brook upstream of Hager Pond and accounts for a significant amount of flow and nutrient loadings at this water body. Numerous studies have been conducted on the Hop Brook system. In 1984, the USGS determined that approximately 50% of the flow in Hop Brook consists of effluent from the WWTP; in drought conditions, the effluent may account for as much as 90% of the flow.”[3]

Figure 2 illustrates the MassDOT property directly draining to Unnamed Tributary (MA82A-16). The MassDOT roadway contributing to this water body, Route 20, occupies two lanes (one in each direction). The road is not divided, it does not have curbs.

Starting at the limit west of the intersection with Hager Road, both lanes are graded to direct runoff southward to the east-bound lane. West of the Hager Road ramp turnoff, runoff sheets overland from MassDOT roadway to a City of Marlborough roadway where it is collected in Marlborough MS4 catch basins and discharged directly to Unnamed Tributary (MA82A-16).

Runoff originating east of the Hager Road turnoff sheets overland from MassDOT roadway to a Marlborough MS4 catch basin located on Hager Road. The stormwater infrastructure discharges directly to Unnamed Tributary (MA82A-16).

The roadway to the east of the intersection with Hager Road is crowned at the centerline. Runoff from the eastbound lane drains to the southern side of the road where it flows overland to the cross culverts and to Unnamed Tributary (MA82A-16). Runoff from the westbound lane drains to the northern side of the road where it flows overland to Unnamed Tributary (MA82A-16). Vegetation including grass and pine needles appear to act as a vegetated curb. Stormwater runoff travels along the pavement, parallel to the road, to breaks in the vegetated curb. Along this portion of Route 20, the breaks in the vegetated curb are located at the low points of the roadway. Runoff that drains to the north side of the road flows off of the pavement to Unnamed Tributary. Runoff that flows to the south side of the road flows off of the pavement to a cross culvert that discharges to the Unnamed Tributary.

In this area, the paved roadway is approximately 35 feet wide. The right-of-way is approximately 90 feet wide. Some portions of the shoulder (within the right-of-way) are occupied by steep embankments sloping down to meet adjacent grades. Other portions of the shoulder slope gently to meet adjacent grades or to meet existing roadside conveyance swales.

Existing BMPs

MassDOT did not identify any existing BMPs in place to treat roadway runoff before reaching the impaired water segment.

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[3] MassDEP, 2005. SuAsCo Watershed 2001 Water Quality Assessment Report. Available at: http://www.mass.gov/eea/docs/dep/water/resources/71wqar09/82wqar3.pdf

Assessment

In cases where a TMDL has been approved, MassDOT assessed the waterbody for the impairments covered by the TMDL under the BMP 7R methodology. MassDOT has separately assessed the waterbody for any stormwater-related impairments that are not covered by the TMDL under the BMP 7U methodology. MassDOT assessed Unnamed Tributary (MA82A-16) using the methodologies described below.

Assessment 7U for Pathogen Impairment

MassDOT assessed the indicator bacteria (fecal coliform) impairment using the approach described in BMP 7U of MassDOT's Storm Water Management Plan (SWMP).[4] Unnamed Tributary (MA82A-16) is covered by the Draft Pathogen TMDL for the Concord River Watershed.[5] According to the Draft TMDL, sources of indicator bacteria in the Concord River watershed were found to be many and varied. Most of the bacteria sources in the Concord River watershed are believed to be failing septic systems, combined sewer overflows (CSO), sanitary sewer overflows (SSO), sewer pipes connected to storm drains, certain recreational activities, wildlife including birds along with domestic pets and animals and direct overland stormwater runoff. Additionally, the TMDL states that implementation to achieve the TMDL goals should be an iterative process with selection and implementation of mitigation measures followed by monitoring to determine the extent of water quality improvement realized. Recommended TMDL implementation measures include identification and elimination of prohibited sources such as leaky or improperly connected sanitary sewer flows and best management practices to mitigate storm water runoff volume. MassDOT included a review of the draft report as an informational review as part of this assessment even though, due to their draft status, draft TMDLs are not formally part of the Impaired Waters Retrofit program.

Pathogen concentrations in stormwater vary widely temporally and spatially; concentrations can vary by an order of magnitude within a given storm event at a single location.[6] Therefore, it is difficult to predict pathogen concentrations in stormwater with accuracy. MassDOT's South East Expressway study measured bacterial concentration in stormwater runoff[7] and data indicated that highway's pathogen loading may be lower than urban areas. Considering that the potential sources of pathogens (e.g. illicit discharges, sewer utilities, pet waste and wildlife) are likely to be less prevalent in the highway environment than along urban roads, this finding is not surprising.

MassDOT does not conduct site specific assessments of loading at each location impaired for pathogens. Instead, MassDOT reviewed its existing programs and their consistency with EPA NPDES MS4 general permit requirements and pathogen TMDL requirements. Language in the documents clearly indicate that an iterative adaptive management approach is the appropriate way to address discharges to pathogen impaired waters and recommend implementation of programmatic BMPs such as residential educational programs, illicit connection identification, tracking and removal and pet waste management. MassDOT implements a variety of non-structural BMP programs across their system in accordance with their existing SWMP including educational programs, illicit connection review and source control.

MassDOT has an ongoing inspection and monitoring program aimed at identifying and addressing illicit discharges to MassDOT's stormwater management system. Any illicit discharges to MassDOT's system could contribute pathogens to impaired waters, however, MassDOT's existing Illicit Discharge Detection and Elimination (IDDE) program is aimed at identifying and addressing these contributions. District maintenance

[4] MassDOT, 6 April, 2011. Description of MassDOT's Application of Impervious Cover Method in BMP 7U (MassDOT Application of IC Method). http://www.mhd.state.ma.us/downloads/projDev/BMP_7U_ImpairedWaterbodiesAssessment.pdf

[5] MassDEP. Draft Pathogen TMDL for the Concord River Watershed. Available at: http://www.mass.gov/eea/docs/dep/water/resources/a-thru-m/concord1.pdf

[6] MassDEP. 2009. Final Pathogen TMDL for the Cape Cod Watershed. Available at: http://www.mass.gov/dep/water/resources/capecod1.pdf

[7] Smith. (2002). Effectiveness of Three Best Management Practices for Highway Runoff Quality along the Southeast Expressway. USGS Water Resources Investigations Report 02-4059. Boston, Massachusetts.

staff note signs of potential illicit discharges, such as dry weather flow and notable odors or sheens. Similarly, Resident Engineers overseeing construction projects also receive instruction regarding the need to note any suspicious connections or flows, and report these for follow-up investigation and action as appropriate. MassDOT will continue to implement this IDDE training, and District staff will continue to report any suspicious flows requiring further investigation. MassDOT investigates any suspicious flows noted, and proceeds to work with owners of confirmed illicit discharges to remove these flows, and thereby minimize pathogen contributions to receiving waters.

MassDOT is in the process of developing a pet waste management program for MassDOT rest stops located within the sub-watershed of a pathogen impaired waterbody. At these prioritized rest stops, MassDOT will be installing signs informing the public of the need to remove pet waste in order to minimize contributions of pathogens to the impaired waterbody and providing pet waste removal bags and disposal cans.

MassDOT believes the existing efforts are consistent with the current and draft MS4 permit's requirements and TMDL recommendations.

BMP 7U for Impervious Cover Related Impairments

MassDOT assessed the stormwater-related impairments not addressed by a TMDL using the approach outlined in the Description of MassDOT's Application of Impervious Cover Method in BMP 7U[8] which was developed using the EPA Region I's Impervious Cover (IC) Method as a basis, described in EPA's Stormwater TMDL Implementation Support Manual. [9] MassDOT used the long-term continuous simulation model (the assessment model)[10] to estimate effective IC. Consistent with the findings of EPA and others, MassDOT concluded that when a watershed had less than 9% IC, stormwater was not the likely cause of the impairment.

MassDOT calculated the following values for the total contributing watershed and the subwatershed of the impaired water (Unnamed Tributary) to determine the IC target. The total contributing watershed is shown in Figure 1.

Impaired Segment Watershed	
Watershed Area	1,130 acres
Impervious Cover (IC) Area	192 acres
Percent Impervious	17 %
IC Area at 9% Goal	102 acres
Target Effective IC Reduction	47 %

The total watershed is greater than 9% impervious indicating that stormwater is a likely contributor to the impairment. To meet the 9% effective IC target, the effective IC within the watershed will need to be reduced. Therefore, the effective IC of MassDOT's directly contributing area should also be reduced by the same percentage to meet the target. The following table shows how MassDOT calculated the target effective IC for MassDOT's contributing property.

[8] MassDOT, 6 April, 2011. Description of MassDOT's Application of Impervious Cover Method in BMP 7U (MassDOT Application of IC Method). http://www.mhd.state.ma.us/downloads/projDev/BMP_7U_ImpairedWaterbodiesAssessment.pdf

[9] ENSR 2006. *Stormwater TMDL Implementation Support Manual for US EPA Region 1*. ENSR International & EPA Region 1, Boston, MA. Available at http://www.epa.gov/region1/eco/tmdl/regionalpgrfs.html

[10] MassDOT, June 2012. Long-Term Continuous Simulation for Pollutant Loading and Treatment for MassDOT Impaired Waters Program. Available at: http://www.mhd.state.ma.us/downloads/projDev/ImpairedWaters_2/Attachment7.pdf

MassDOT Directly Contributing Watershed	
Directly Contributing Area	3.7 acres
Directly Contributing IC Area	2.0 acres
Percent Impervious	55 %
Target Effective IC Reduction (47% of DOT Directly Contributing IC)	0.9 acres
Target Effective IC	29 %

This assessment has identified locations for potential stormwater BMPs and estimated the effective IC accounting for their treatment. The Proposed Mitigation Plan section describes the BMPs and their IC reduction performance.

Proposed Mitigation Plan

In this assessment, MassDOT has identified one (1) stormwater BMP, a water quality swale, which may be implemented on MassDOT property to mitigate the effective IC to address the Unnamed Tributary (MA82A-16) impairments. The BMP is shown with its estimated contributing drainage area in Figure 3. The location of the BMP was chosen based on a cursory review of the drainage systems, topography, property lines, and other site constraints. The water quality swale is proposed on the northern side of Route 20 to promote infiltration in the roadway shoulder. Detailed survey, complete utility location information, official property ownership, and soils evaluation information will influence the final selection and design of the BMP. A description of the BMP follows below.

PR BMP 1 Water Quality Swale

The water quality swale proposed for this impaired waterbody would be located adjacent to the west-bound lane starting at the Framingham town line and extending approximately 220 feet downgradient alongside the roadway shoulder. Proposed modifications to the stormwater management infrastructure in this area include constructing the swale with check dams, retrofitting the existing roadway shoulder to include breaks in the vegetated curb at regular intervals and including paved waterways to convey intercepted stormwater to the swale.

Underlying soils at the locations of the proposed swale, according to NRCS soils mapping, are rated as hydrologic soil group “B,” which is generally suitable for infiltration.

Historic layout plans indicate that MassDOT right-of-way is approximately 90 feet wide in this area. The road is approximately 35 to 40 feet wide in this area.

The table below shows the proposed conditions, including BMPs with their MassDOT drainage areas and estimated effective IC reductions. The outputs from the assessment model showing effective IC analysis for each BMP are attached.

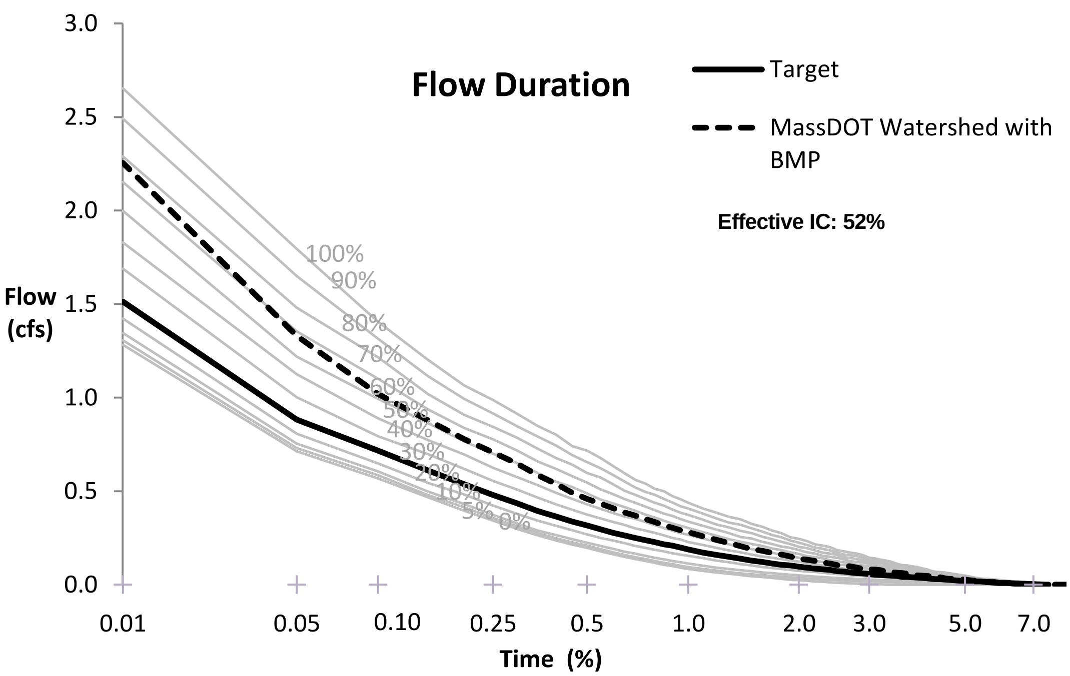
Proposed Conditions

BMP Name	BMP Type	Contributing Effective IC (acres)	Estimated Percent Reduction	Estimated Reduction Effective IC (acres)
BMP 1	Water Quality Swale	0.3	92%	0.2
Total*		**2.0**	**4%**	**0.1**
Target				**0.9**

* Total effective IC reduction based on the assessment model results for the total MassDOT directly discharging drainage area to the receiving water (not sum of individual BMP reductions).

Proposed Median Annual Load Comparisons

Simulated IC Watersheds	Runoff (ac-ft)	TP (lb.)	TSS (lb.)
0% IC	2.7	0.2	13
5% IC	3.2	0.3	64
10% IC	3.6	0.5	136
20% IC	4.5	0.9	376
Target 29% IC	**5.4**	**1.6**	**727**
30% IC	5.5	1.7	766
40% IC	6.4	2.6	1,294
50% IC	7.3	3.7	1,938
60% IC	8.2	5.0	2,643
70% IC	9.1	6.2	3,355
80% IC	10.0	7.5	4,064
90% IC	10.9	8.7	4,756
100% IC	11.8	9.9	5,459
Existing Conditions	8.29	4.61	2,416
Proposed Conditions	7.57	3.94	2,047
Reduction %	9%	15%	15%
Effective IC	53%	52%	52%



Effective IC Results

Existing IC	2.0 acres
Proposed Estimated Effective IC	1.9 acres
IC Reduction % under Proposed Conditions	4 %
Estimated Effective IC*	52 %

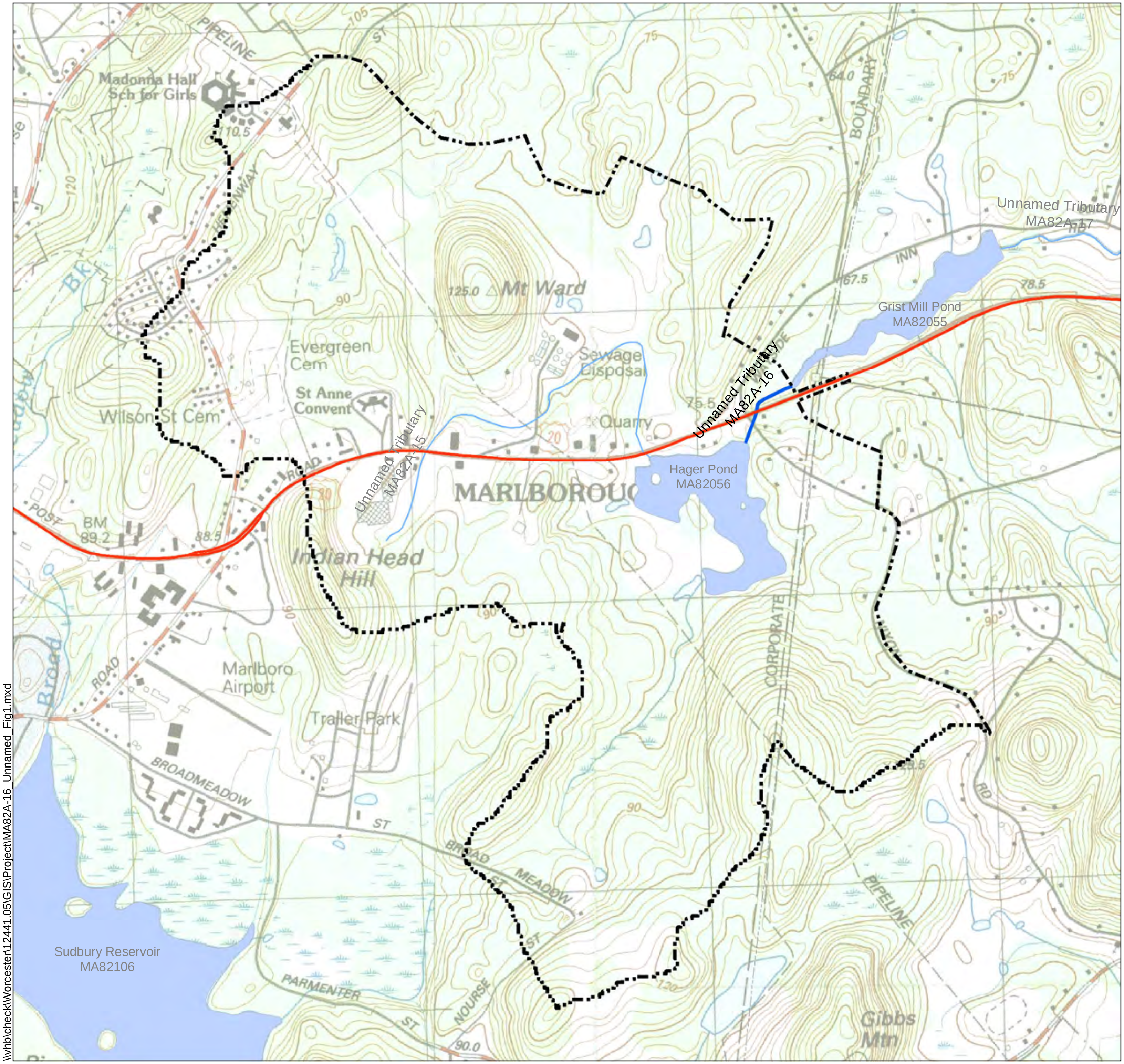
*Average of estimated effective IC for annual median runoff volume, phosphorus and TSS loads, and flow duration

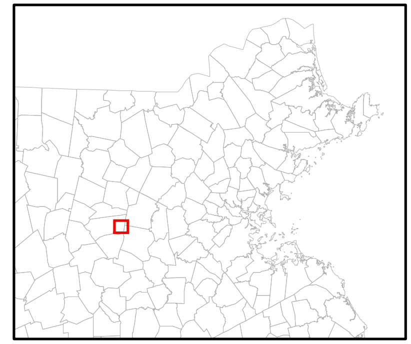
MassDOT estimated the effective IC under proposed conditions by comparing the annual median runoff volume, phosphorus and TSS loads, and flow distribution statistics (flow duration) from MassDOT drainage area to the receiving water to those results for simulated IC watersheds.

The proposed BMPs do not provide enough treatment to meet the target due to the site constraints of the area. The proposed linear water quality swale will be sufficient to provide water quality treatment for the impervious cover contributing to the swale itself. Wetlands adjacent to both sides of the roadway prevent the construction of additional swales to provide treatment of the remaining directly discharging area. In places where MassDOT stormwater runoff is intercepted by the Marlborough MS4, there is no space to construct BMPs without disturbing the existing travel lanes.

MassDOT will proceed to the design phase to develop construction plans for the proposed BMP as part of the MassDOT Impaired Waters Program. The project designer will gather additional information in this phase, such as soil data, wetland delineations, and site survey, to further refine the proposed BMPs. Once the design of the proposed BMPs is finalized, MassDOT will provide an update with additional information and summarize the final effective IC reduction based on the as-built condition.

MassDOT will continue to ensure proper non-structural BMPs are being implemented within the watershed of Unnamed Tributary (MA82A-16), including regular roadway and drainage system maintenance, erosion and sedimentation control, and outreach and education. Further work by MassDOT on programmed projects, which often include broader scale road layout changes, may provide additional opportunities for construction of new treatment BMPs. This is consistent with an iterative adaptive management approach to address impairments. MassDOT will include an update in annual reports to EPA regarding progress made towards meeting target IC reductions, plans for construction of proposed BMPs and finalized assessments including reduction achieved by finalized BMP designs.





MassDOT Roadways in Urban Area
Watershed
Assessed Segment
Impaired Lakes
Impaired Streams

N

0 750 1,500
Feet
1 inch = 1,500 feet

Figure 1

Unnamed Tributary (MA82A-16) Watersheds

December 2013

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Highway Division

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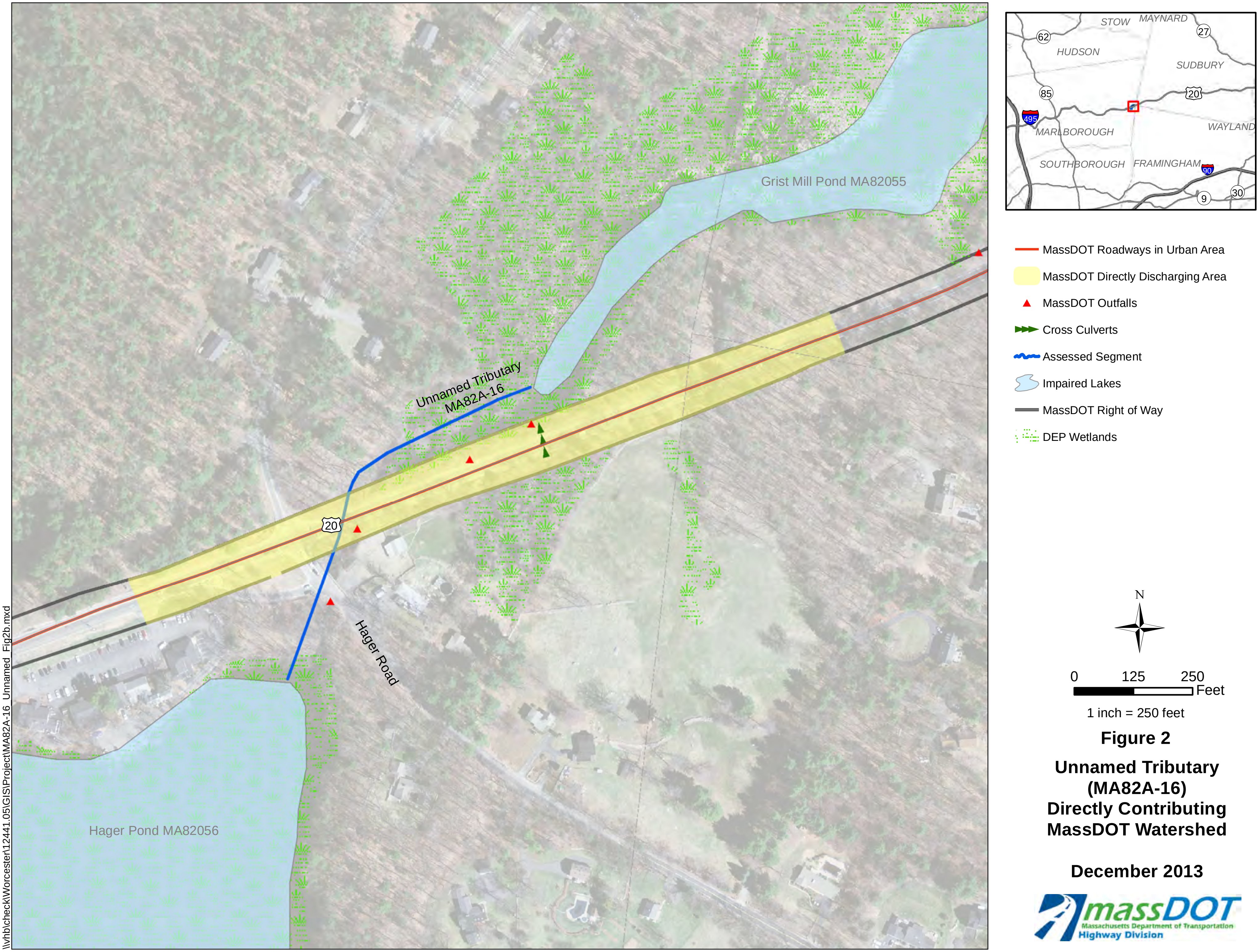

Figure 2

Unnamed Tributary (MA82A-16) Directly Contributing MassDOT Watershed

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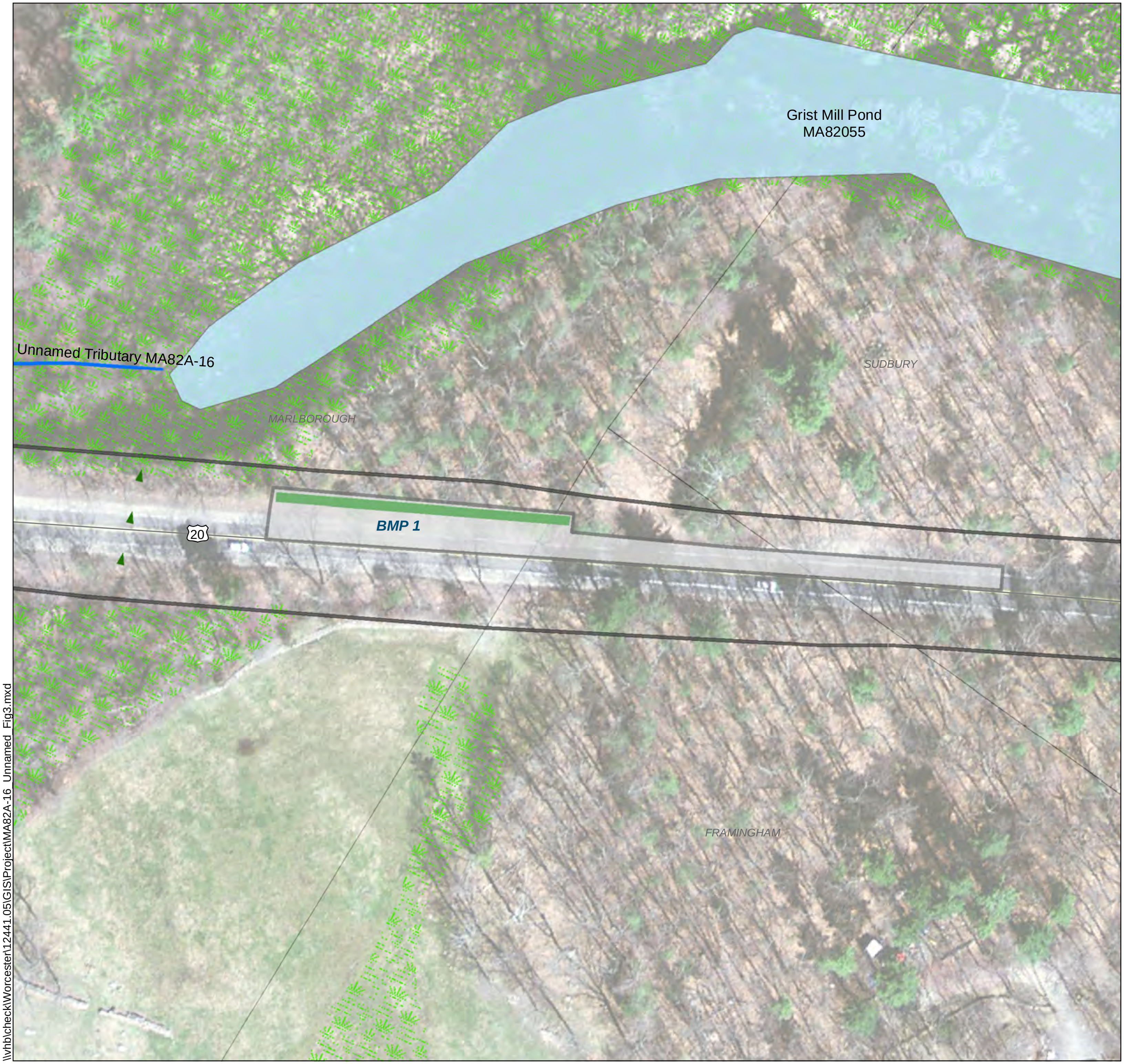

Cross Culverts
Proposed BMPs
Proposed BMP Watersheds
MassDOT Right of Way
Assessed Segment
Impaired Lakes
Town Boundaries
DEP Wetlands

N

0 50 100 Feet

1 inch = 100 feet

Figure 3

Unnamed Tributary (MA82A-16) Proposed BMPs

December 2013

massDOT Massachusetts Department of Transportation Highway Division

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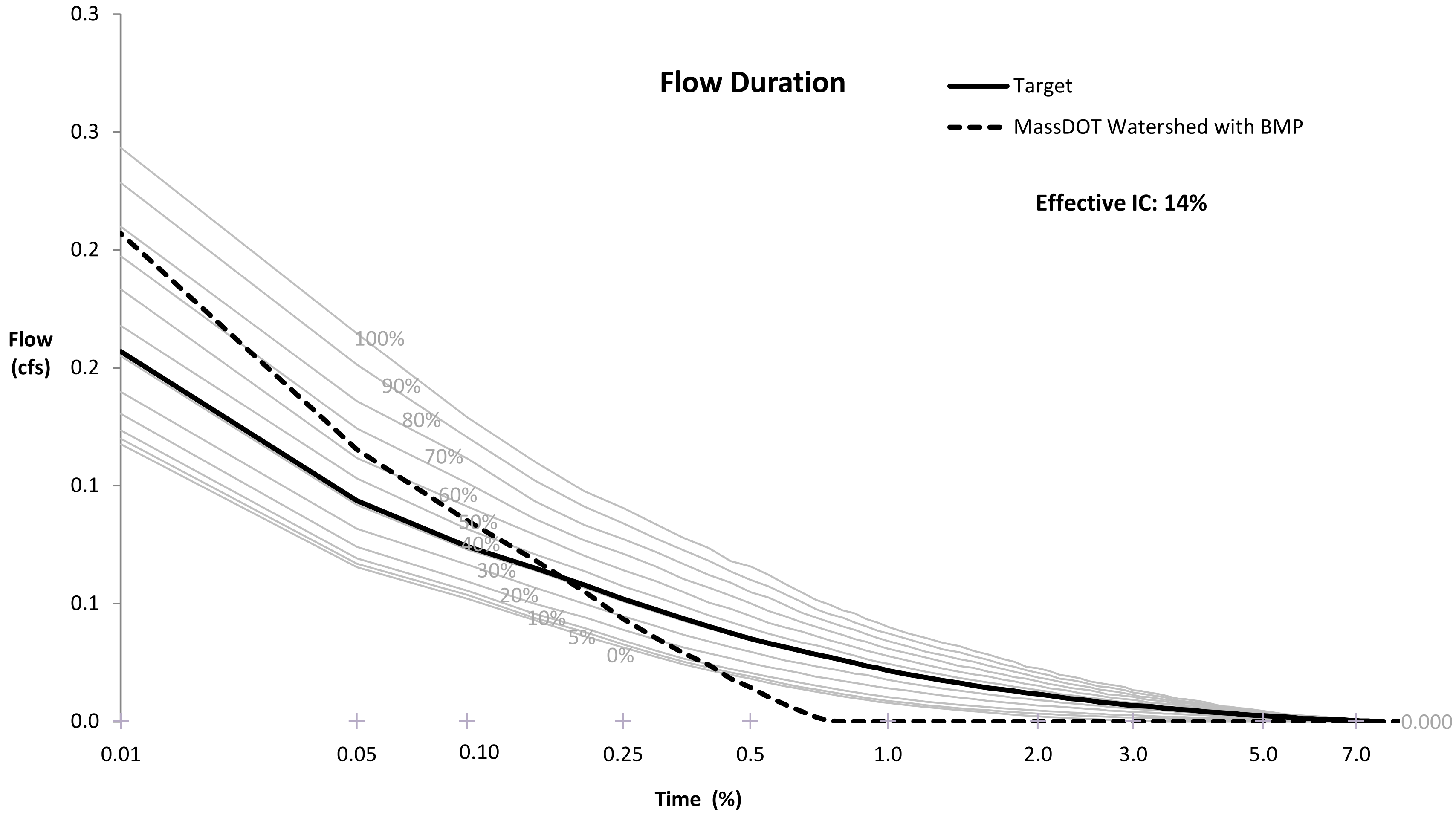
Result Summary
3100.3 BMP 1



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	0.2	0.0	1
5%IC	0.3	0.0	6
10% IC	0.3	0.0	12
20% IC	0.4	0.1	34
30% IC	0.5	0.2	70
40% IC	0.6	0.2	119
50% IC	0.7	0.3	178
60% IC	0.7	0.5	242
70% IC	0.8	0.6	308
80% IC	0.9	0.7	373
90% IC	1.0	0.8	436
100% IC	1.1	0.9	501
Watershed Load	0.96	0.69	376
BMP Output	0.23	0.03	7
Target	0.60	0.25	128
Reduction %	**76%**	**96%**	**98%**
Effective IC	**-2%**	**6%**	**6%**

Result Summary

Metric	Area (%)	Area (acres)
Watershed Area		0.3
Watershed IC (no BMP)	78%	0.3
Target IC Reduction	47%	0.1
Effective IC w/BMP	6%	0.0
IC Reduction	92%	0.2

Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	0.3	0.3
Indirect Watershed	-	-
Total	0.3	0.3

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Impaired Waters Assessment for Assabet River (MA82B-04)

Summary

Impaired Water[1]	**Impairments:**	Aquatic macroinvertebrate bioassessments, excess algal growth, fecal coliform, phosphorus, taste and odor
	Category:	5 (Waters requiring a TMDL)
	Final TMDLs:	Assabet River Total Maximum Daily Load for Total Phosphorus[2]
	WQ Assessment:	SuAsCo 2001 Water Quality Assessment Report[3]
Location	**Towns:**	Hudson, Marlborough, Berlin
	MassDOT Roads:	I-495, I-290, Route 85 Washington St. Bridge
Assessment Method(s)	**7R (TMDL Method)**	☒
	7U (IC Method)	☒
BMPs	**Existing:**	2 Wet Ponds and 2 Vegetated Filter Strips
	Proposed:	7 Water Quality Swales and 1 Infiltration Basin
MassDOT Contributing Area and Targets		Impervious Cover (IC)
	Directly Contributing Area	18.0 acres
	Contributing Area Reduction Target	10.2 acres
	Existing BMPs Reduction	3.4 acres
	Proposed BMPs Reduction	16.8 acres
	Remaining Treatment to Meet Target	0.0 acres

[1] MassDEP, 2013. Massachusetts Year 2012 Integrated List of Waters – Final Listing of the Condition of Massachusetts' Waters Pursuant to Sections 305(b), 314 and 303(d) of the Clean Water Act. Massachusetts. Available at: http://www.mass.gov/eea/docs/dep/water/resources/07v5/12list2.pdf

[2] MassDEP. 2004. Assabet River Total Maximum Daily Load for Total Phosphorus. Available at: http://www.mass.gov/eea/docs/dep/water/resources/a-thru-m/anuttmdl.pdf

[3] MassDEP, 2001. SuAsCo Watershed 2001Water Quality Assessment Report. Available at: http://www.mass.gov/eea/docs/dep/water/resources/71wqar09/82wqar2.pdf

Site Description

Segment MA82B-04 of the Assabet River runs north for 8.0 miles, shown in Figure 1, starting at the Marlborough West Wastewater Treatment Plant discharge in Marlborough to the Hudson Wastewater Treatment Plant in Hudson. This section of the Assabet River starts south of I-290, then crosses under I-290 and I-495 where it then flows through downtown Hudson and under two Main Street bridges. The subwatershed to the Assabet River is comprised of commercial areas surrounded by medium density residential land with the majority of the subwatershed consisting of forested land and open space. According to MassDEP's Water Quality Assessment Report[4] the suspected causes of the impairments are listed as discharge from municipal separate storm sewer systems (MS4s), internal nutrient recycling, highway/road/bridge run off, and municipal urbanized high density areas.

Figure 2a shows the major contributing MassDOT roads to this segment of the Assabet River, I-495 and I-290, which cross over the Assabet River. Figure 2a shows the MassDOT directly discharging area. I-290 contributes stormwater runoff from three lanes and two shoulders from both I-290 East and West. This section of I-290 does not have any curbs and only a few catch basins located in the shoulders. Stormwater primarily sheet flows into existing drainage ditches within the shoulder and medians that drain to the Assabet River. The roadway is crowned between the outer and middle lanes. The directly discharging area east of the Assabet River crossing on I-290 was determined through field verification as the point where stormwater is not conveyed directly to the Assabet River and instead infiltrates. Located just west of the Assabet River crossing on I-290 East, Muddy Pond receives the majority of stormwater from I-290 East, defining areas west of Muddy River as indirectly discharging to the Assabet River. Stormwater runoff from sections of I-290 West to the west of the Assabet River are also considered indirectly discharging despite their proximity to the Assabet River due to the topography of the right of way area and an existing wetland. Stormwater runoff from this portion of I-290 sheet flows to the shoulders or median where it overland flows into wooded areas; there is no defined channel that conveys the stormwater to the Assabet River. There is also a small wetland west of the Assabet River that captures the majority of stormwater from I-290 West before flowing into the Assabet River.

Stormwater runoff from portions of I-495 and the I-495/I-290 interchange are also considered directly discharging. Figure 3b shows the specific roadway sections of discharging area that are comprised of three lanes and two shoulders from I-495 South and North and two ramps from the interchange contribute stormwater runoff to the Assabet River. Stormwater runoff from the ramp that connects I-495 South to I-290 West as well a section of I-495 South and its adjacent pervious median area, is collected in catch basins and drop inlets and is piped to a culvert under Donald Lynch Boulevard where a paved water way conveys the stormwater into the Assabet River . Stormwater runoff from sections of the ramp that connect I-290 West to I-495 South and a section of I-495 South is captured in catch basins and outlets to a small depression within the triangular vegetated island. Overflow from this depression is captured by a drop inlet which is connected to the same pipe that culverts under Donald Lynch Boulevard. The section of I-495 North and South between River Road and Donald Lynch Boulevard is considered directly discharging due the road's proximity to the river. This section of roadway is not curbed, therefore stormwater primarily sheet flows into the medians, however there are some catch basins in the shoulders which outlet directly into the shoulders of I-495 North and South. The area north of River Rd is not considered directly discharging due to the lack of a direct conveyance from this area to the river. The portions of the area south I-290 and the remaining portion of the I-290/I-495 interchange are not directly discharging because stormwater from this area is piped into an existing BMP adjacent to Donald Lynch Boulevard and I-495 North, this BMP outlets into a wetland system east of Wheeler Hill Boulevard.

[4] MassDEP, 2001. SuAsCo Watershed 2001 Water Quality Assessment Report. Available at: http://www.mass.gov/eea/docs/dep/water/resources/71wqar09/82wqar1.pdf

Figure 2c and 2d show the two MassDOT owned bridges in the Assabet subwatershed that directly discharge to the Assabet River. The bridges are located on Main Street in Hudson. The stormwater runoff from the bridges either collect stormwater in catch basins which directly discharge to the Assabet River or stormwater sheet flows into the river where the curbing stops at the end of the bridges.

The environmental constraints of the project area that limit the potential for retrofit BMPs are predominately wetland resource areas.

Existing BMPs

There are four existing BMPs located within the directly contributing area of the Assabet River Segment MA82B-04. EX BMP 1 and EX BMP2 are depressions in the medians that only receive stormwater and have developed into wetlands over time. Figure 3a shows EX BMP 1, located in the median of I-290 that receives stormwater from outer lanes and shoulders of I-290 East and West. In general, drop inlets line the median of I-290 and pipe stormwater to a mainline located in the pervious shoulders of I-290 West and East. The drop inlet that captures the overflow from EX BMP 1 is piped to the mainline located along I-290 West. Since EX BMP 1 is likely a jurisdictional wetland, the overflow is also jurisdictional, therefore the mainline must remain intact to maintain the flow to the Assabet River. There is no potential to route additional stormwater to the BMP. EX BMP 2 shown in Figure 3b, receives stormwater from I-495/1-290 interchange area and discharges into a drop inlet which connects to the existing drainage system of I-495 South. Currently, stormwater runoff from an impervious section of I-495 South consisting of three lanes and two shoulders as well as a section of the ramp from I-290 West to I-495 South is captured in catch basins and piped to EX BMP 2. There is the potential to direct more stormwater to the wetland which would help increase the treatment of the watershed area; however it would need to be pretreated before entering an existing resource area. Overflow from EX BMP 2 is captured in a drop inlet which is connected to the pipe that is culverted under Donald Lynch Boulevard, where stormwater is then conveyed to the river via a paved water way. Since EX BMP 2 is a likely a jurisdictional wetland, the area downstream would also be jurisdictional, therefore the paved waterway cannot be altered.

EX BMP 3 and 4, shown in Figure 3b, are two vegetated filter strips within the medians north and south of the Assabet River between River Road and Donald Lynch Boulevard. Stormwater from the outer lane and shoulder sheet flow into the vegetated median, where stormwater is treated. Due to the crest in the road and the existing draining patterns, there is no potential to divert more stormwater to this area and due to the high vegetation in the area construction of a BMP is not beneficial.

Assessment

MassDOT has separately assessed the waterbody for any stormwater-related impairments that are not covered by the TMDL under the BMP 7U methodology. In cases where a TMDL has been approved, MassDOT assessed the waterbody for the impairments covered by the TMDL under the BMP 7R methodology. MassDOT assessed Assabet River (MA82B-04) using the methodologies described below.

BMP 7R for Phosphorus TMDL (CN 201.0)

The *Assabet River Total Maximum Daily Load for Total Phosphorus (CN 201.0)*[5] addresses the total phosphorus for this water body. However, the TMDL does not specifically address stormwater

[5] MassDEP. 2004. Assabet River Total Maximum Daily Load for Total Phosphorus. Available at: http://www.mass.gov/eea/docs/dep/water/resources/a-thru-m/anuttmdl.pdf

contributions to the river and does not provide a waste load allocation (WLA) for stormwater discharges. Therefore, MassDOT assessed the contribution of phosphorus from MassDOT properties to this waterbody using the approach described in BMP 7U[6] of MassDOT's Storm Water Management Plan (Water Quality Impaired Waters Assessment and Mitigation Plan), which applies to impairments that have not been addressed by a TMDL.

Assessment 7U for Pathogen Impairment

MassDOT assessed the indicator bacteria (fecal coliform) impairment using the approach described in BMP 7U of MassDOT's Storm Water Management Plan (SWMP).[7] Assabet River (MA82B-04) is covered by the Draft Pathogen TMDL for the Concord River Watershed.[8] According to the Draft TMDL, sources of indicator bacteria in the Concord River watershed were found to be many and varied. Most of the bacteria sources in the Concord River watershed are believed to be failing septic systems, combined sewer overflows (CSO), sanitary sewer overflows (SSO), sewer pipes connected to storm drains, certain recreational activities, wildlife including birds along with domestic pets and animals and direct overland stormwater runoff. Additionally, the TMDL states that implementation to achieve the TMDL goals should be an iterative process with selection and implementation of mitigation measures followed by monitoring to determine the extent of water quality improvement realized. Recommended TMDL implementation measures include identification and elimination of prohibited sources such as leaky or improperly connected sanitary sewer flows and best management practices to mitigate storm water runoff volume. MassDOT included a review of the draft report as an informational review as part of this assessment even though, due to their draft status, draft TMDLs are not formally part of the Impaired Waters Retrofit program.

Pathogen concentrations in stormwater vary widely temporally and spatially; concentrations can vary by an order of magnitude within a given storm event at a single location.[9] Therefore, it is difficult to predict pathogen concentrations in stormwater with accuracy. MassDOT's South East Expressway study measured bacterial concentration in stormwater runoff[10] and data indicated that highway's pathogen loading may be lower than urban areas. Considering that the potential sources of pathogens (e.g. illicit discharges, sewer utilities, pet waste and wildlife) are likely to be less prevalent in the highway environment than along urban roads, this finding is not surprising.

MassDOT does not conduct site specific assessments of loading at each location impaired for pathogens. Instead, MassDOT reviewed its existing programs and their consistency with EPA NPDES MS4 general permit requirements and pathogen TMDL requirements. Language in the documents clearly indicate that an iterative adaptive management approach is the appropriate way to address discharges to pathogen impaired waters and recommend implementation of programmatic BMPs such as residential educational programs, illicit connection identification, tracking and removal and pet waste management. MassDOT implements a variety of non-structural BMP programs across their system in accordance with their existing SWMP including educational programs, illicit connection review and source control.

MassDOT has an ongoing inspection and monitoring program aimed at identifying and addressing illicit discharges to MassDOT's stormwater management system. Any illicit discharges to

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[6] MassDOT, 6 April, 2011. Description of MassDOT's Application of Impervious Cover Method in BMP 7U (MassDOT Application of IC Method). http://www.mhd.state.ma.us/downloads/projDev/BMP_7U_ImpairedWaterbodiesAssessment.pdf

[7] MassDOT, 6 April, 2011. Description of MassDOT's Application of Impervious Cover Method in BMP 7U (MassDOT Application of IC Method). http://www.mhd.state.ma.us/downloads/projDev/BMP_7U_ImpairedWaterbodiesAssessment.pdf

[8] MassDEP. Draft Pathogen TMDL for the Concord River Watershed. Available at: http://www.mass.gov/eea/docs/dep/water/resources/a-thru-m/concord1.pdf

[9] MassDEP. 2009. Final Pathogen TMDL for the Cape Cod Watershed. Available at: http://www.mass.gov/dep/water/resources/capecod1.pdf

[10] Smith. (2002). Effectiveness of Three Best Management Practices for Highway Runoff Quality along the Southeast Expressway. USGS Water Resources Investigations Report 02-4059. Boston, Massachusetts.

MassDOT's system could contribute pathogens to impaired waters, however, MassDOT's existing Illicit Discharge Detection and Elimination (IDDE) program is aimed at identifying and addressing these contributions. District maintenance staff note signs of potential illicit discharges, such as dry weather flow and notable odors or sheens. Similarly, Resident Engineers overseeing construction projects also receive instruction regarding the need to note any suspicious connections or flows, and report these for follow-up investigation and action as appropriate. MassDOT will continue to implement this IDDE training, and District staff will continue to report any suspicious flows requiring further investigation. MassDOT investigates any suspicious flows noted, and proceeds to work with owners of confirmed illicit discharges to remove these flows, and thereby minimize pathogen contributions to receiving waters.

MassDOT is in the process of developing a pet waste management program for MassDOT rest stops located within the sub-watershed of a pathogen impaired waterbody. At these prioritized rest stops, MassDOT will be installing signs informing the public of the need to remove pet waste in order to minimize contributions of pathogens to the impaired waterbody and providing pet waste removal bags and disposal cans.

MassDOT believes the existing efforts are consistent with the current and draft MS4 permit's requirements and TMDL recommendations.

BMP 7U for Impervious Cover Related Impairments

The Assabet River phosphorus TMDL does not address non-point sources of phosphorus or additional impairments including aquatic macroinvertebrate bioassessments, and fishes bioassessments. Therefore, MassDOT assessed the stormwater-related impairments not addressed by a TMDL using the approach outlined in the Description of MassDOT's Application of Impervious Cover Method in BMP 7U which was developed using the EPA Region I's Impervious Cover (IC) Method as a basis, described in EPA's Stormwater TMDL Implementation Support Manual.[11] MassDOT used the long-term continuous simulation model (the assessment model)[12] to estimate effective IC. Consistent with the findings of EPA and others, MassDOT concluded that when a watershed had less than 9% IC, stormwater was not the likely cause of the impairment.

MassDOT calculated the following values for the total contributing watershed and the subwatershed of the impaired water (Assabet River) to determine the IC target. The total contributing watershed and the subwatershed are shown in Figure 1.

Impaired Segment Watershed

	Total Contributing Watershed	Subwatershed
Watershed Area	47,346 acres	7,517acres
Impervious Cover (IC) Area	6,288 acres	1,581acres
Percent Impervious	13 %	21 %
IC Area at 9% Goal	4,261 acres	676 acres
Target Effective IC Reduction	32 %	57 %

[11] ENSR 2006. *Stormwater TMDL Implementation Support Manual for US EPA Region 1*. ENSR International & EPA Region 1, Boston, MA. Available at http://www.epa.gov/region1/eco/tmdl/regionalpgrfs.html

[12] MassDOT, June 2012. Long-Term Continuous Simulation for Pollutant Loading and Treatment for MassDOT Impaired Waters Program. Available at: http://www.mhd.state.ma.us/downloads/projDev/ImpairedWaters_2/Attachment7.pdf

The total and subwatersheds are greater than 9% impervious indicating that stormwater is a likely contributor to the impairment. To meet the 9% effective IC target, the effective IC within the subwatershed will need to be reduced. Therefore, the effective IC of MassDOT's directly contributing area should also be reduced by the same percentage. The following table shows how MassDOT calculated the target effective IC for MassDOT's contributing property.

MassDOT Directly Contributing Watershed

Directly Contributing Area	50.0 acres
Directly Contributing IC Area	18.0 acres
Percent Impervious	36%
Target Effective IC Reduction (57% Reduction of DOT Directly Contributing IC)	10.2 acres
Target Effective IC	15 %

An existing conditions assessment model was created to estimate the effective IC of the MassDOT contributing drainage areas given treatment provided by existing BMPs. The existing wet depressions were modeled as wet ponds. The table below shows the existing BMPs, their MassDOT drainage areas and effective IC reductions. The output from the assessment model showing effective IC analysis for existing BMPs is attached.

Existing BMPs

BMP Name	BMP Type	Contributing Effective IC (acres)	Estimated Percent Reduction	Estimated Reduction Effective IC (acres)
EX BMP 1	Wet Pond	0.6	65%	0.4
Ex BMP 2	Wet Pond	0.7	45%	0.3
EX BMP 3	Vegetated Filter Strip	0.5	71%	0.4
EX BMP 4	Vegetated Filter Strip	0.9	71%	0.7
Total		**17.9**	**19%**	**3.4**

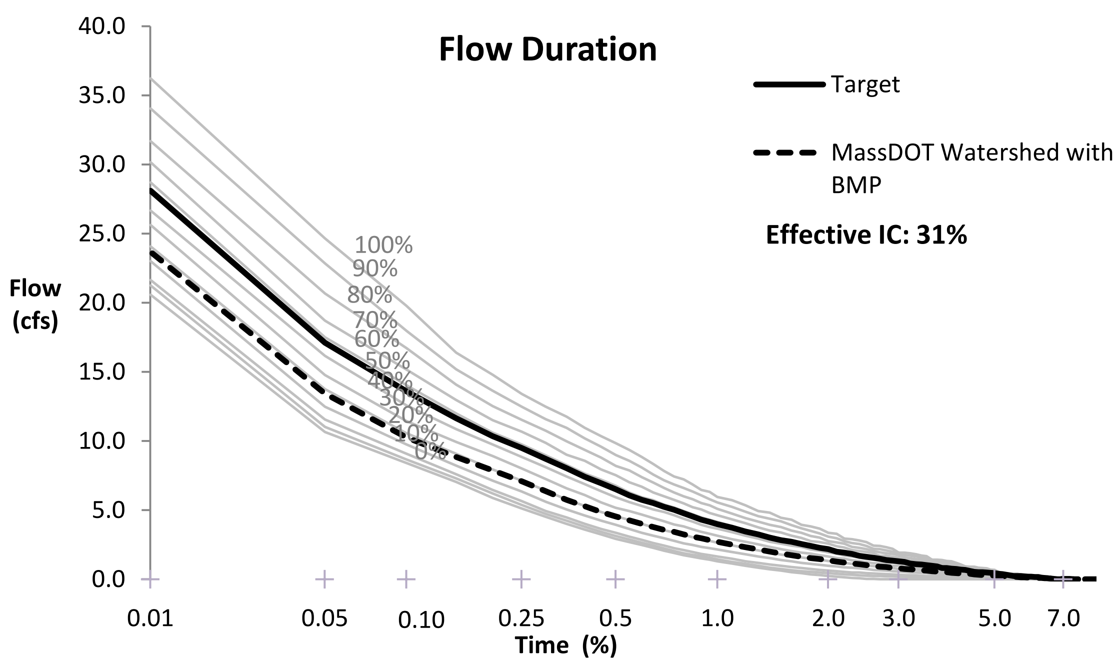
* Total Effective IC reduction based on the assessment model results for the total MassDOT directly discharging drainage area to the receiving water (not sum of individual BMP reductions).

Note: The predicted effective IC is determined by comparing the BMP's calculated median annual discharge volume, runoff flow/duration relationship, median annual phosphorus load and median annual total suspended solids load to predicted discharge values for benchmark watersheds with the same size and varying percent IC. In cases where analysis predicts that BMPs would discharges less runoff volume and pollutant mass than those predicted for a 0% IC (pervious, woods in good condition) benchmark watershed, then the predicted effective IC removal would be greater than 100% and reduction of effective IC area will be greater than the BMP contributing IC area.

MassDOT estimated the effective IC under existing conditions by comparing the annual median runoff volume, phosphorus and TSS loads, and flow distribution statistics (flow duration) from MassDOT drainage area to the receiving water to those results for simulated IC watersheds. The following table displays the acres of IC the existing BMPs mitigate compared to the target reduction.

Existing Median Annual Load Comparisons

	Simulated IC Watersheds	Runoff (ac-ft)	TP (lb.)	TSS (lb.)
	0% IC	38.8	2.8	189
	5% IC	44.9	9.5	3,935
	10% IC	51.1	16.0	7,721
Target	**15% IC**	**57.2**	**22.7**	**11,506**
	20% IC	63.4	29.4	15,292
	30% IC	75.7	43.0	22,863
	40% IC	87.9	56.6	30,434
	50% IC	99.9	70.2	38,005
	60% IC	111.8	83.7	45,576
	70% IC	123.7	97.3	53,147
	80% IC	135.7	110.9	60,718
	90% IC	148.2	124.5	68,289
	100% IC	160.6	138.1	75,894
	Conditions without BMPs	81.21	44.72	23,414
	Conditions with Existing BMPs	75.75	37.45	19,452
	Reduction %	**7%**	**16%**	**17%**
	Effective IC	**30%**	**26%**	**25%**



Effective IC Results

Existing IC	17.9 acres
Estimated Effective IC with Existing BMPs	14.5 acres
IC Reduction % with Existing BMPs	19%
Estimated Effective IC*	29%

*Average of estimated effective IC for annual median runoff volume, phosphorus and TSS loads, and flow duration.

Under existing conditions, MassDOT's estimated effective IC exceeds the target as described above. To mitigate the effects of IC, MassDOT will implement stormwater BMPs to the maximum extent practical given site constraints.

This assessment has identified locations for potential stormwater BMPs and estimated the effective IC accounting for their treatment. The Proposed Mitigation Plan section describes the BMPs and their IC reduction performance.

Proposed Mitigation Plan

In this assessment, MassDOT identified eight stormwater BMPs that may be implemented on MassDOT property to mitigate the effective IC thereby addressing the Assabet River impairments. These BMPs include seven water quality swales and one infiltration basin, shown with their estimated contributing drainage areas in Figures 3a and 3b. These locations were chosen based on a cursory review of the drainage systems, topography, property lines, and other site constraints. The water quality swales are proposed as modifications of existing drainage ditches which already receive stormwater via sheet flow. More stormwater can be diverted to the existing drainage ditches by daylighting catch basin outlets and storage within the ditches can be increased by installing check dams and raising drop inlets to promote infiltration. The infiltration basin is proposed to pretreat stormwater that can then be diverted to EX BMP 2. The limited MassDOT owned area at the bridge crossings does not provide enough allowable area to construct BMPs. Detailed survey, complete utility location information, official property ownership, and soils evaluation information will influence the final selection and design of BMPs. Below is a description of these proposed BMPs.

PR BMP 1, 4, 6

PR BMP 1, 4 and 6, shown in Figure 3a, are proposed to be water quality swales located in the median of I-290 to the east and west of the Assabet River. Currently, stormwater from the outer lane and shoulder primarily sheet flows into the median due to the lack of curbing. There are few catch basins that are located in the inner shoulder that pipe the stormwater into the drainage system of the outer shoulders of I-290. Stormwater that enters the median is captured by drop inlets which line the median. The drop inlets pipe the stormwater to drainage systems in the shoulders. The median's size and existing drainage features allow it to be a potential location for swales. By installing check dams and raising the existing drop inlets, storage could be increased to help promote infiltration. Infiltration could be constrained due to the HSG C soils, according to NRCS Soil Mapping, in the proposed locations.

PR BMP 2, 3, 5

PR BMP 2, 3 and 5, shown in Figure 3a, are proposed water quality swales located in the shoulders of I-290 East and West. Currently, in all potential swale locations, runoff from two lanes and one shoulder of I-290 sheet flows into the existing drainage ditches located in the shoulders on the adjacent portion of I-290. Drop inlets located in existing drainage ditches are connected to a mainline that runs under the shoulder and outfalls to the Assabet River. There are also several connections from the drop inlets in the median and catch basins in the outer and inner shoulders to the mainline. The existing drainage ditches can be enhanced into swales by installing check dams to increase storage and to help promote infiltration. More stormwater can be diverted to the existing drainage ditches by discharging the outlets from the median drop inlets and catch basins. The proposed area has HSG C Soils, according to the NRCS Soil mapping, potentially limiting amount of infiltration provided by the swale. Proposed BMP 5 has a small wetland located upstream, it is unclear whether or not the wetland flows into the existing drainage ditch, making the area downstream of the wetland potentially jurisdictional, which would eliminate the location as a potential location for a BMP. Further investigation in the design stage will be required to determine the feasibility of this BMP.

PR BMP 7

PR BMP 7 is a proposed water quality swale. Figure 3b shows the proposed area for the BMP, located within the pervious infield of the I-290 West off ramp at the I-290/I-495 interchange. The current drainage system consist of catch basins that outlet water directly into an existing drainage ditch, the proposed location for PR BMP 7. At the downstream end of the drainage ditch, a drop inlet captures stormwater and is connected to the existing drainage system which outlets to EX BMP 2. This BMP would provide pretreatment of stormwater before it enters EX BMP 2. The proposed area has HSG C soils, according to NRCS Soil Mapping, potentially limiting the infiltration potential.

PR BMP 8

PR BMP 8 is a proposed infiltration basin. Figure 3b shows that it is located in the same vegetated island where EX BMP 2 is located. The purpose of PR BMP 8 would be to pre-treat the additional stormwater that could be diverted to EX BMP 2. PR BMP 8 could receive stormwater from the ramp that connects I-495 South to I-290 West by diverting catch basins located in the shoulders of the ramp to the proposed BMP area. Stormwater from a section of I-495, which includes three lanes and two shoulders, and its adjacent pervious median, could also be diverted to PR BMP 8 by intercepting additional drainage. PR BMP 8 could also receive stormwater from PR BMP 7. Overflow from the basin could discharge to EX BMP 2.

The table below shows the proposed conditions, including BMPs with their MassDOT drainage areas and estimated effective IC reductions. The outputs from the assessment model showing effective IC analysis for each BMP are attached.

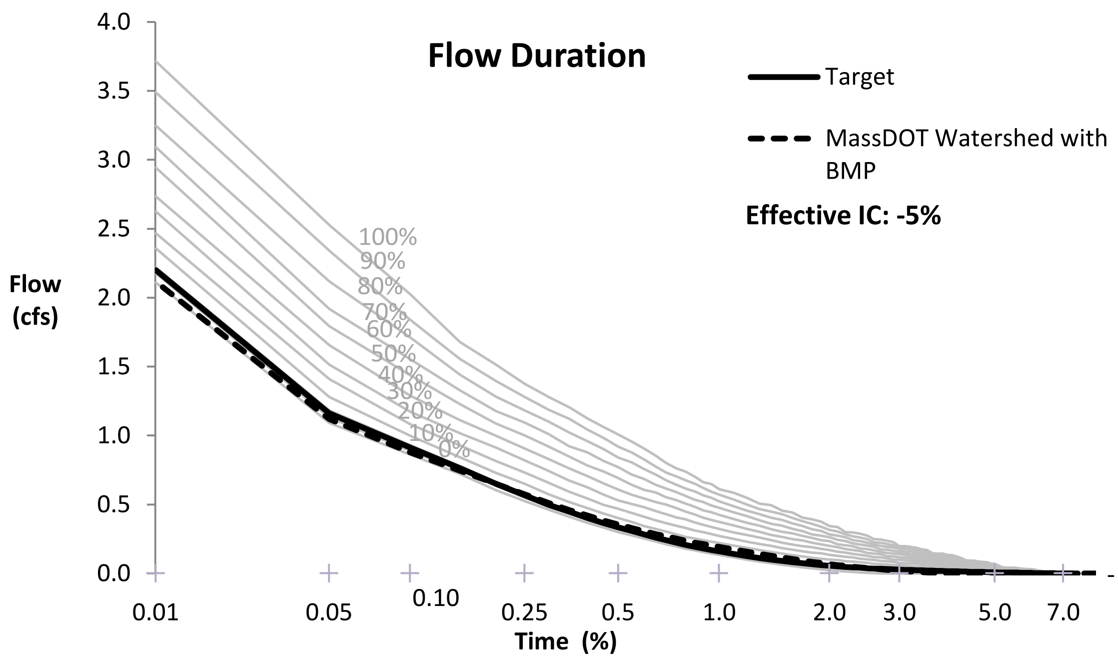
Proposed Conditions

BMP Name	BMP Type	Contributing Effective IC (acres)	Estimated Percent Reduction	Estimated Reduction Effective IC (acres)
EX BMP 1	Wet Pond	0.6	65%	0.4
EX BMP 2	Wet Pond	1.6	112%	1.8
EX BMP 3	Vegetated Filter Strip	0.5	71%	0.4
EX BMP 4	Vegetated Filter Strip	0.9	71%	0.7
PR BMP 1	Water Quality Swale	1.0	206%	2.0
PR BMP 2	Water Quality Swale	1.9	168%	3.3
PR BMP 3	Water Quality Swale	1.7	158%	2.7
PR BMP 4	Water Quality Swale	0.8	195%	1.6
PR BMP 5	Water Quality Swale	1.7	143%	2.5
PR BMP 6	Water Quality Swale	0.4	230%	0.9
PR BMP 7	Water Quality Swale	0.4	179%	0.7
PR BMP 8	Infiltration Basin	0.8	181%	1.5
Total*		**17.9**	**94%**	**16.8**
Target				**10.2**

* Total effective IC reduction based on the assessment model results for the total MassDOT directly discharging drainage area to the receiving water (not sum of individual BMP reductions).
Note: The predicted effective IC is determined by comparing the BMP's calculated median annual discharge volume, runoff flow/duration relationship, median annual phosphorus load and median annual total suspended solids load to predicted discharge values for benchmark watersheds with the same size and varying percent IC. In cases where analysis predicts that BMPs would discharges less runoff volume and pollutant mass than those predicted for a 0% IC (pervious, woods in good condition) benchmark watershed, then the predicted effective IC removal would be greater than 100% and reduction of effective IC area will be greater than the BMP contributing IC area

Proposed Median Annual Load Comparisons

Simulated IC Watersheds	Runoff (ac-ft)	TP (lb.)	TSS (lb.)
0% IC	38.8	2.8	189
5% IC	44.9	9.5	3,935
10% IC	51.1	16.0	7,721
Target 15% IC	**57.2**	**22.7**	**11,506**
20% IC	63.4	29.4	15,292
30% IC	75.7	43.0	22,863
40% IC	87.9	56.6	30,434
50% IC	99.9	70.2	38,005
60% IC	111.8	83.7	45,576
70% IC	123.7	97.3	53,147
80% IC	135.7	110.9	60,718
90% IC	148.2	124.5	68,289
100% IC	160.6	138.1	75,894
Existing Conditions	75.75	37.45	19,452
Proposed Conditions	42.36	13.82	6,483
Reduction %	**44%**	**63%**	**67%**
Effective IC	**3%**	**8%**	**8%**



Effective IC Results

Existing IC	18 acres
Proposed Estimated Effective IC	1.0 acres
IC Reduction % under Proposed Conditions	94%
Estimated Effective IC*	2%

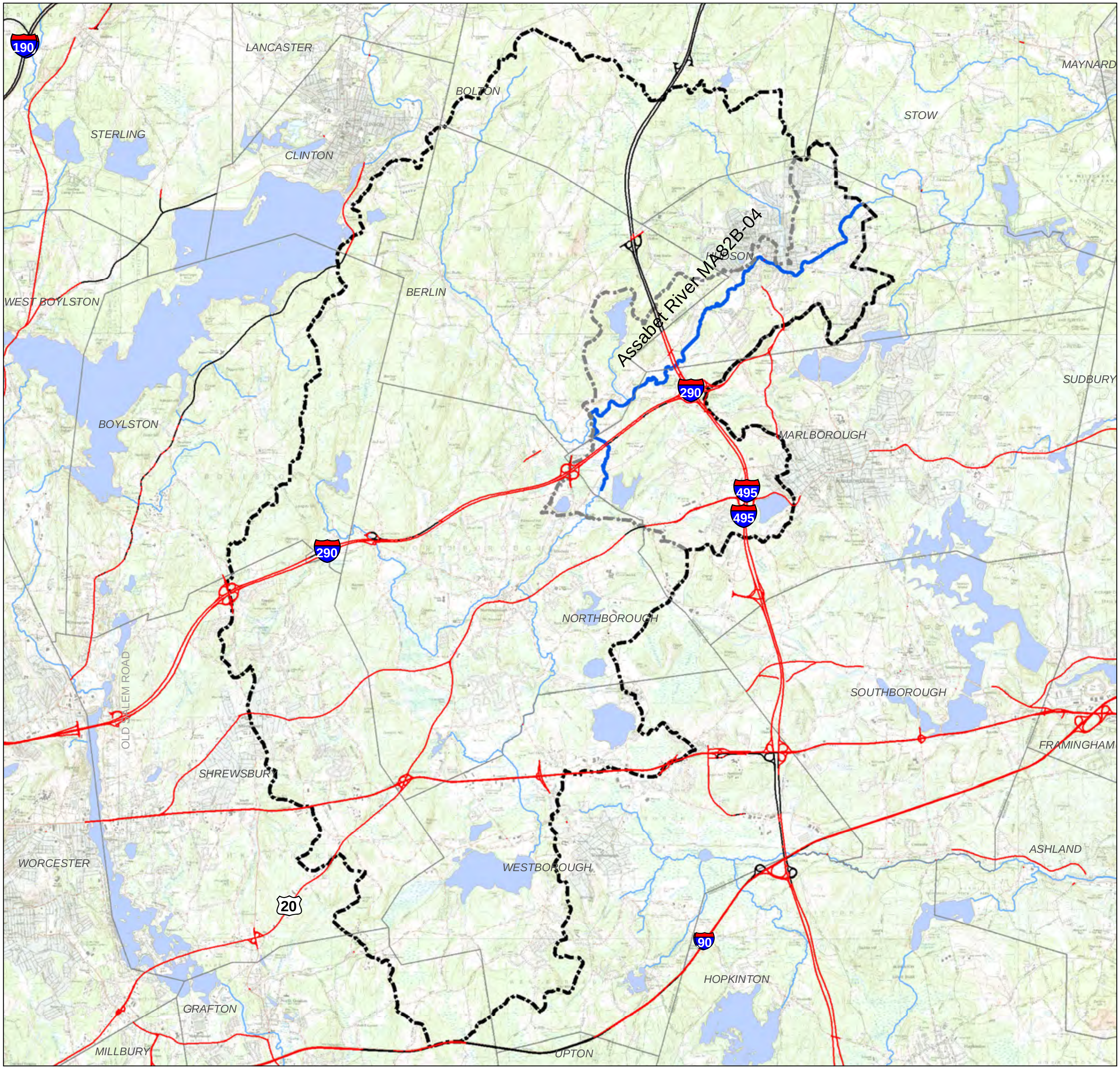
*Average of estimated effective IC for annual median runoff volume, phosphorus and TSS loads, and flow duration

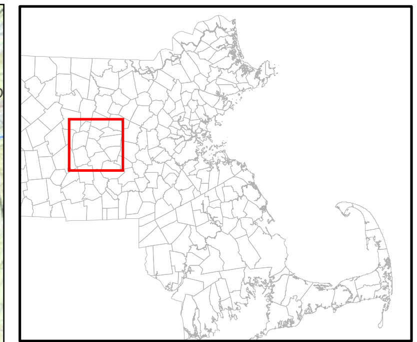
MassDOT estimated the effective IC under proposed conditions by comparing the annual median runoff volume, phosphorus and TSS loads, and flow distribution statistics (flow duration) from MassDOT drainage area to the receiving water to those results for simulated IC watersheds.

The proposed BMPs provide enough treatment to meet the target. All the proposed BMPs provide over 100% treatment and have little to no discharge, fully infiltrating contributing run off. While the objective of the Impaired Waters Retrofit Program is to meet the target reduction and not necessarily to construct retrofits to the maximum extent practicable, due to the higher costs and inefficiencies of retrofit projects, it has been MassDOT's experience that during design additional site constraints are identified and often reduce the final number of BMPs and/ or water quality treatment. Therefore, in this assessment we are including BMPs that provide treatment beyond the target and will prioritize the most effective BMPs during the design.

MassDOT will proceed to the design phase to develop construction plans for the proposed BMPs as part of the MassDOT Impaired Waters Program. The project designer will gather additional information in this phase, such as soil data, wetlands, and site survey, to further refine the proposed BMPs. Once the design of the proposed BMPs is finalized, MassDOT will provide an update with additional information and summarize the effective IC reduction based on the as-built condition.

MassDOT will continue to ensure proper non-structural BMPs are being implemented within the watershed of Assabet River, including regular roadway and drainage system maintenance, erosion and sedimentation control, and outreach and education. Further work by MassDOT on programmed projects, which often include broader scale road layout changes, may provide additional opportunities for construction of new treatment BMPs. This is consistent with an iterative adaptive management approach to address impairments. MassDOT will include an update in annual reports to EPA regarding progress made towards meeting target IC reductions, plans for construction of proposed BMPs and finalized assessments including reduction achieved by finalized BMP designs.





MassDOT Roadways

MassDOT Roadways in Urban Area

Impaired Lakes

Impaired Streams

Assessed Segment

Total Watershed

Sub Watershed

N

0 5,000 10,000 Feet

1 inch = 10,000 feet

Figure 1

Assabet River (MA82B-04) Watersheds

December 2013

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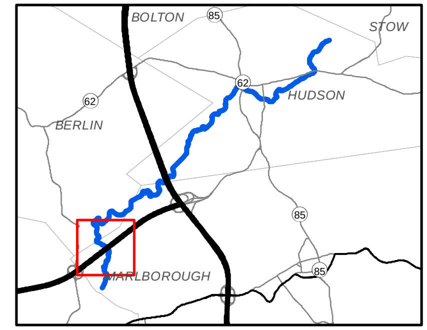

MassDOT Outfalls
MassDOT Roadways in Urban Area
MassDOT Roadways
Assessed Segment
Impaired Streams
Impaired Lakes
MassDOT Directly Discharging Area
DEP Wetlands

N

0 300 600 Feet
1 inch = 600 feet

Figure 2a

Assabet River (MA82B-04) Directly Contributing MassDOT Watershed

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Highway Division

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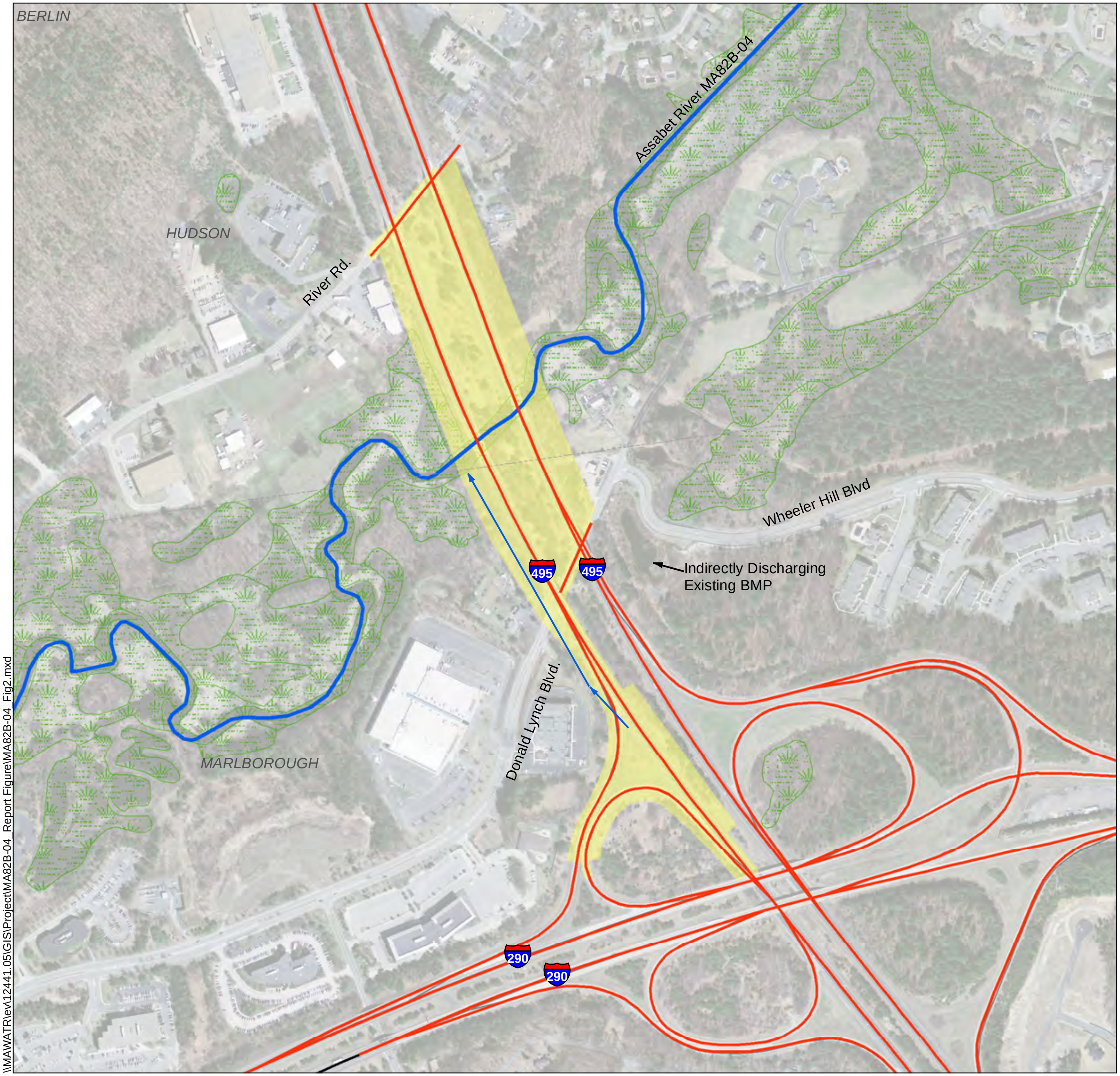

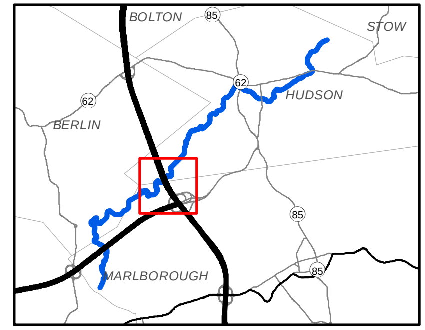

- MassDOT Outfalls
- MassDOT Roadways in Urban Area
- MassDOT Roadways
- Assessed Segment
- Impaired Streams
- Impaired Lakes
- MassDOT Directly Discharging Area
- DEP Wetlands

N

0 300 600 Feet

1 inch = 600 feet

Figure 2b

Assabet River (MA82B-04)
Directly Contributing
MassDOT Watershed

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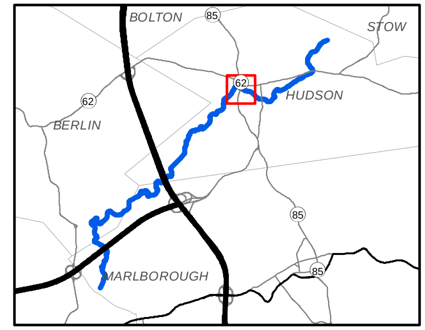

- MassDOT Outfalls
- MassDOT Roadways in Urban Area
- MassDOT Roadways
- Assessed Segment
- Impaired Streams
- Impaired Lakes
- MassDOT Directly Discharging Area
- DEP Wetlands

N

0 150 300 Feet

1 inch = 300 feet

Figure 2c

Assabet River (MA82B-04)
Directly Contributing
MassDOT Watershed

December 2013

massDOT
Massachusetts Department of Transportation
Highway Division

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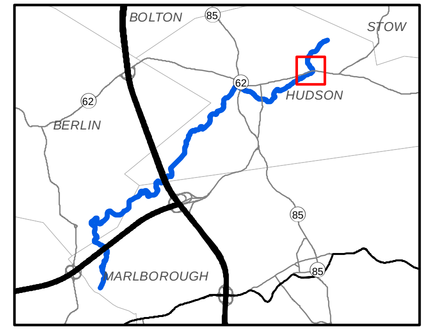

▲ MassDOT Outfalls

MassDOT Roadways in Urban Area

MassDOT Roadways

Assessed Segment

Impaired Streams

Impaired Lakes

MassDOT Directly Discharging Area

DEP Wetlands

N

0 150 300 Feet

1 inch = 300 feet

Figure 2d

Assabet River (MA82B-04) Directly Contributing MassDOT Watershed

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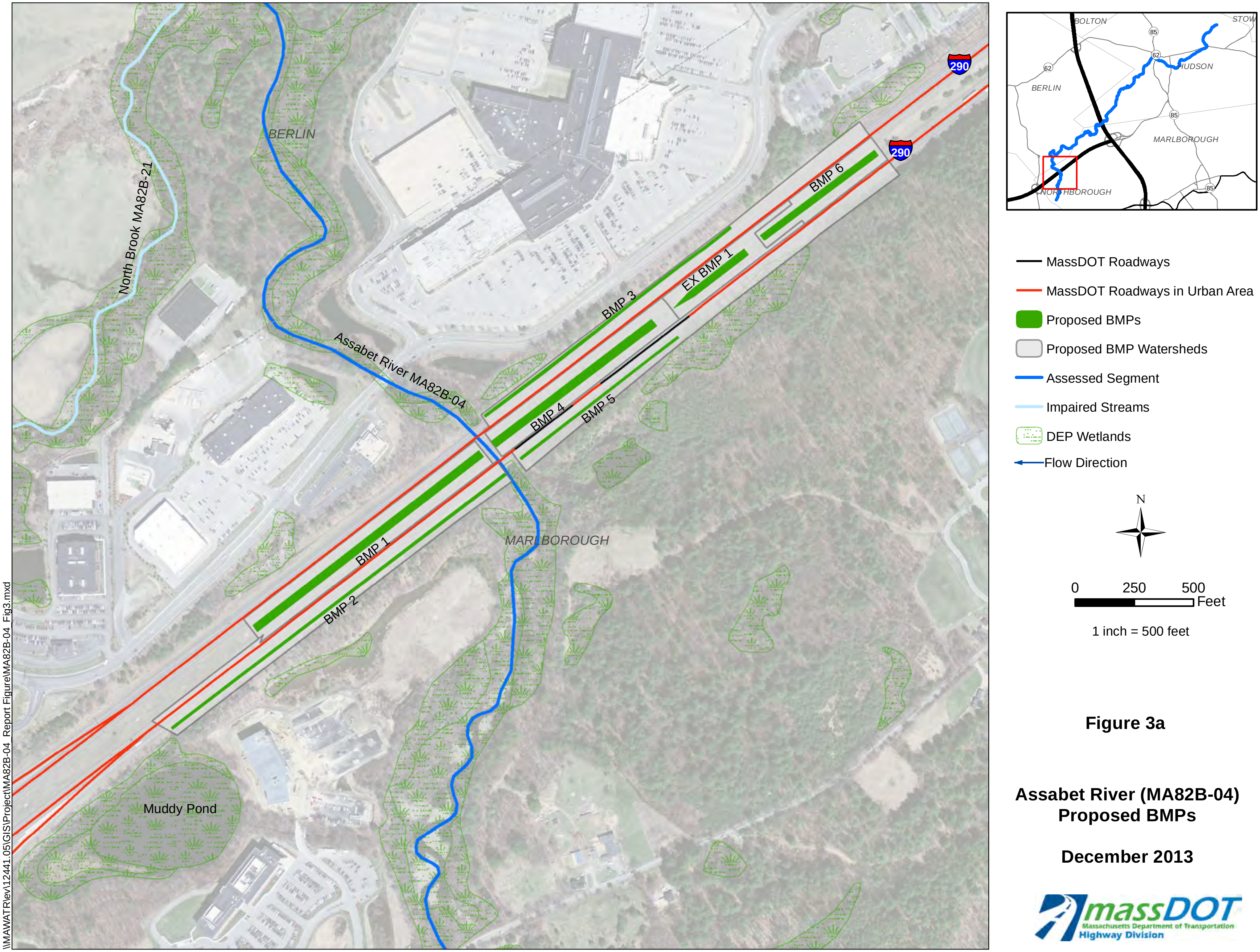
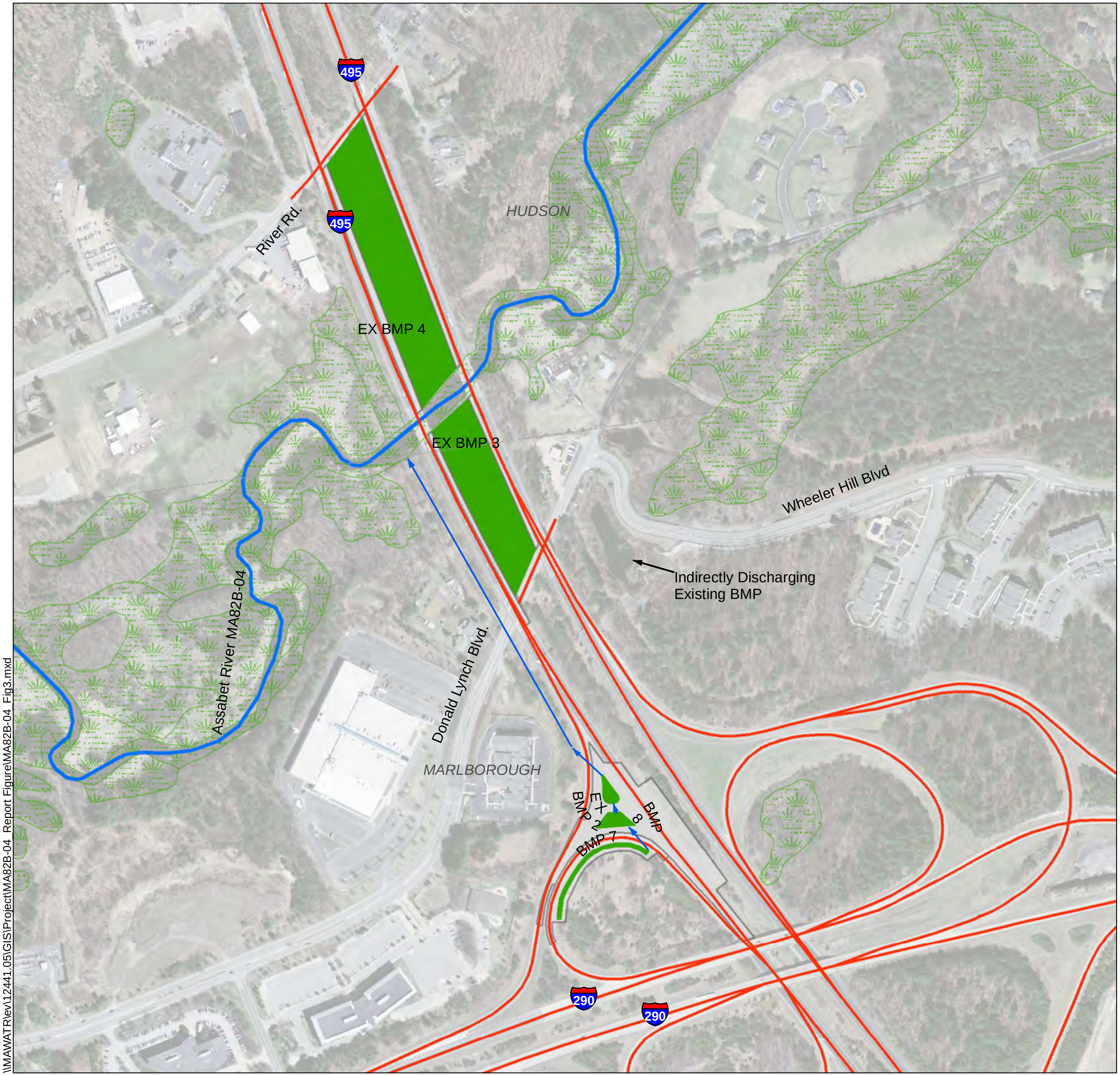


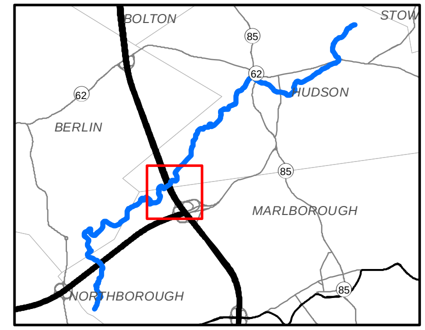
Figure 3a

Assabet River (MA82B-04)
Proposed BMPs

December 2013

massDOT
Massachusetts Department of Transportation
Highway Division





MassDOT Roadways
MassDOT Roadways in Urban Area
Proposed BMPs
Proposed BMP Watersheds
Assessed Segment
Impaired Streams
DEP Wetlands
Flow Direction

N

0 250 500 Feet

1 inch = 500 feet

Figure 3b

Assabet River (MA82B-04) Proposed BMPs

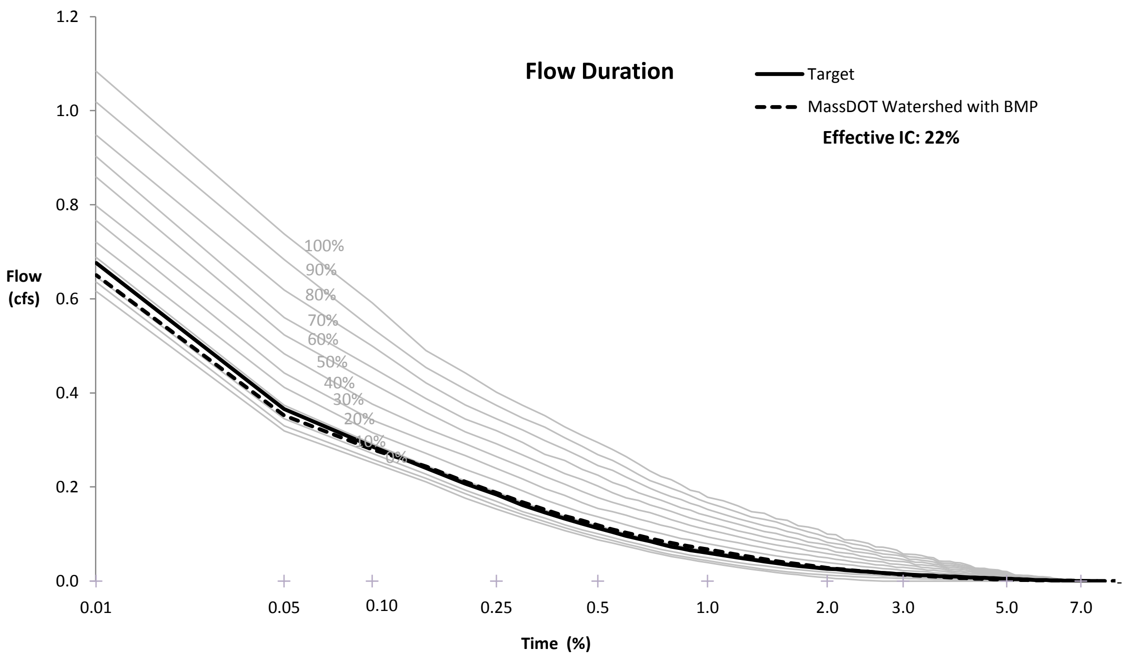
December 2013

massDOT
Massachusetts Department of Transportation
Highway Division

\\MAWATR\ev\12441.05\GIS\Project\MA82B-04_Report Figure\MA82B-04_Fig3.mxd

Result Summary

9.7 EX BMP 1



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	1.2	0.1	6
5%IC	1.3	0.3	118
10% IC	1.5	0.5	231
20% IC	1.9	0.9	458
30% IC	2.3	1.3	684
40% IC	2.6	1.7	911
50% IC	3.0	2.1	1,137
60% IC	3.3	2.5	1,364
70% IC	3.7	2.9	1,590
80% IC	4.1	3.3	1,817
90% IC	4.4	3.7	2,043
100% IC	4.8	4.1	2,271
Watershed Load	2.47	1.68	905
BMP Output	1.79	0.20	24
Target	1.79	0.76	393
Reduction %	**28%**	**88%**	**97%**
Effective IC	**17%**	**3%**	**1%**

Result Summary

Metric	Area (%)	Area (acres)
Watershed Area		1.5
Watershed IC (no BMP)	40%	0.6
Target IC Reduction	57%	0.3
Effective IC w/BMP	14%	0.21
IC Reduction	65%	0.4

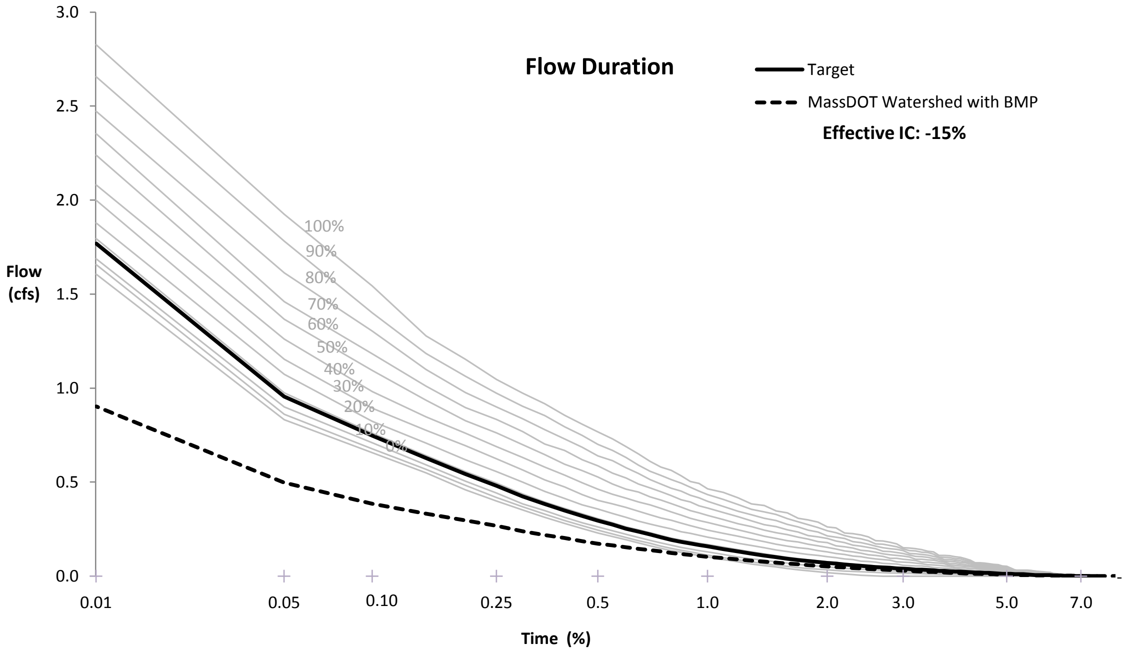
Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	0.6	1.5
Indirect Watershed	-	-
Total	0.6	1.5

* Effective IC calculated as follows:

1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary
8.7 EX BMP 2



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	3.0	0.2	15
5%IC	3.5	0.7	307
10% IC	4.0	1.2	602
20% IC	4.9	2.3	1,193
30% IC	5.9	3.4	1,784
40% IC	6.9	4.4	2,375
50% IC	7.8	5.5	2,965
60% IC	8.7	6.5	3,556
70% IC	9.7	7.6	4,147
80% IC	10.6	8.7	4,737
90% IC	11.6	9.7	5,328
100% IC	12.5	10.8	5,921
Watershed Load	6.52	4.48	2,409
BMP Output	2.83	0.43	102
Target	4.71	2.03	1,046
Reduction %	**57%**	**90%**	**96%**
Effective IC	**-2%**	**2%**	**1%**

Result Summary

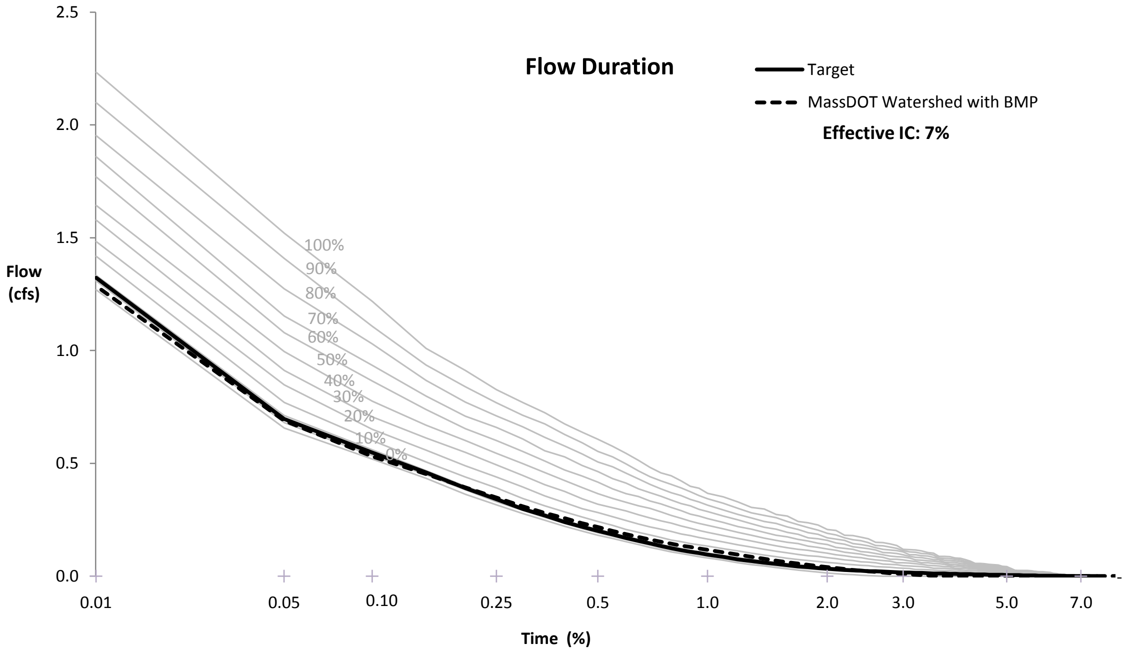
Metric	Area (%)	Area (acres)
Watershed Area		3.9
Watershed IC (no BMP)	41%	1.6
Target IC Reduction	57%	0.9
Effective IC w/BMP	-5%	-0.19
IC Reduction	112%	1.8

Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	0.7	1.9
Indirect Watershed	0.8	2.0
Total	1.6	3.9

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary
22.5 EX BMP 3



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	2.4	0.2	12
5%IC	2.8	0.6	243
10% IC	3.1	1.0	476
20% IC	3.9	1.8	943
30% IC	4.7	2.6	1,409
40% IC	5.4	3.5	1,876
50% IC	6.2	4.3	2,342
60% IC	6.9	5.2	2,809
70% IC	7.6	6.0	3,276
80% IC	8.4	6.8	3,742
90% IC	9.1	7.7	4,209
100% IC	9.9	8.5	4,678
Watershed Load	4.69	1.83	904
BMP Output	2.93	0.31	70
Target	2.97	0.80	368
Reduction %	**38%**	**83%**	**92%**
Effective IC	**7%**	**2%**	**1%**

Result Summary

Metric	Area (%)	Area (acres)
Watershed Area		3.1
Watershed IC (no BMP)	18%	0.5
Target IC Reduction	57%	0.3
Effective IC w/BMP	5%	0.16
IC Reduction	71%	0.4

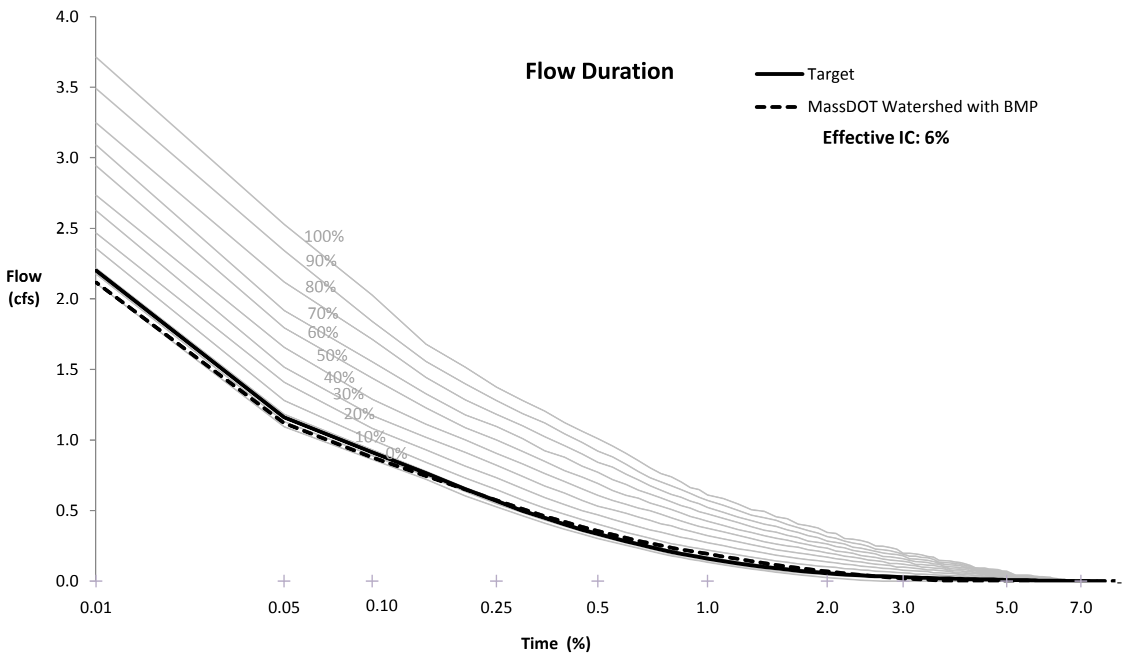
Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	0.5	3.1
Indirect Watershed	-	-
Total	0.5	3.1

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary

18.5 EX BMP 4



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	4.0	0.3	19
5%IC	4.6	1.0	403
10% IC	5.2	1.6	791
20% IC	6.5	3.0	1,567
30% IC	7.8	4.4	2,343
40% IC	9.0	5.8	3,119
50% IC	10.2	7.2	3,895
60% IC	11.5	8.6	4,671
70% IC	12.7	10.0	5,446
80% IC	13.9	11.4	6,222
90% IC	15.2	12.8	6,998
100% IC	16.5	14.2	7,778
Watershed Load	7.97	3.12	1,543
BMP Output	4.95	0.52	118
Target	4.97	1.36	629
Reduction %	**38%**	**83%**	**92%**
Effective IC	**8%**	**2%**	**1%**

Result Summary

Metric	Area (%)	Area (acres)
Watershed Area		5.1
Watershed IC (no BMP)	18%	0.9
Target IC Reduction	57%	0.5
Effective IC w/BMP	5%	0.27
IC Reduction	71%	0.7

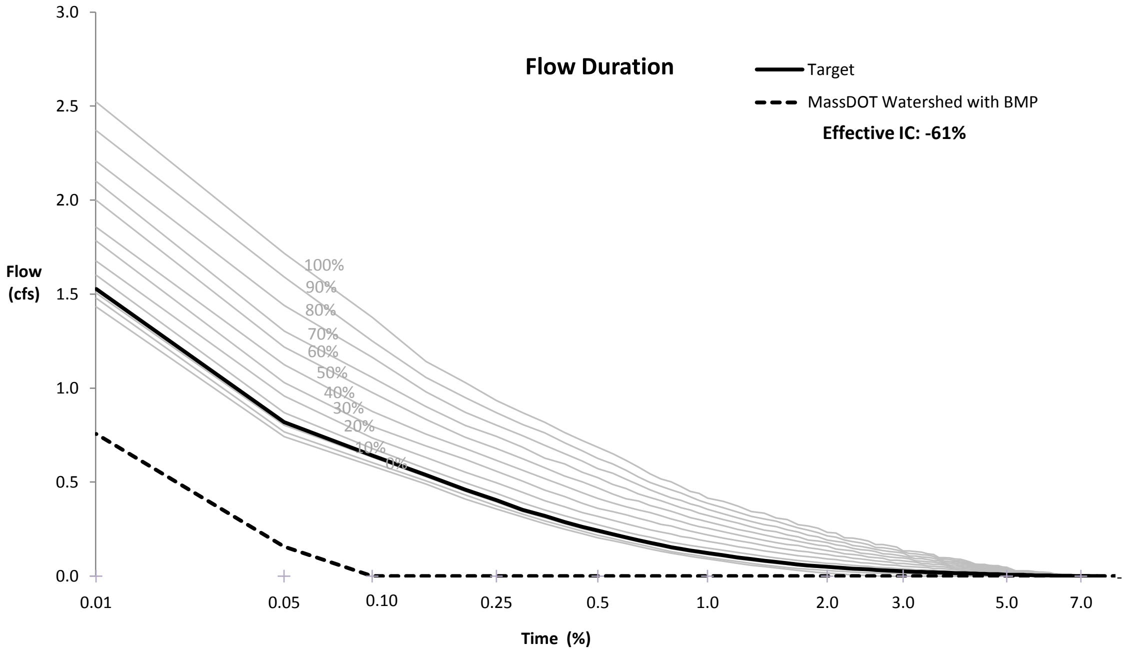
Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	0.9	5.1
Indirect Watershed	-	-
Total	0.9	5.1

* Effective IC calculated as follows:

1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary
1.7 BMP 1



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	2.7	0.2	13
5%IC	3.1	0.7	274
10% IC	3.6	1.1	538
20% IC	4.4	2.0	1,065
30% IC	5.3	3.0	1,592
40% IC	6.1	3.9	2,119
50% IC	7.0	4.9	2,646
60% IC	7.8	5.8	3,173
70% IC	8.6	6.8	3,700
80% IC	9.4	7.7	4,227
90% IC	10.3	8.7	4,754
100% IC	11.2	9.6	5,284
Watershed Load	4.71	2.85	1,512
BMP Output	0.19	0.01	0
Target	3.75	1.33	657
Reduction %	**96%**	**100%**	**100%**
Effective IC	**-29%**	**-2%**	**0%**

Result Summary

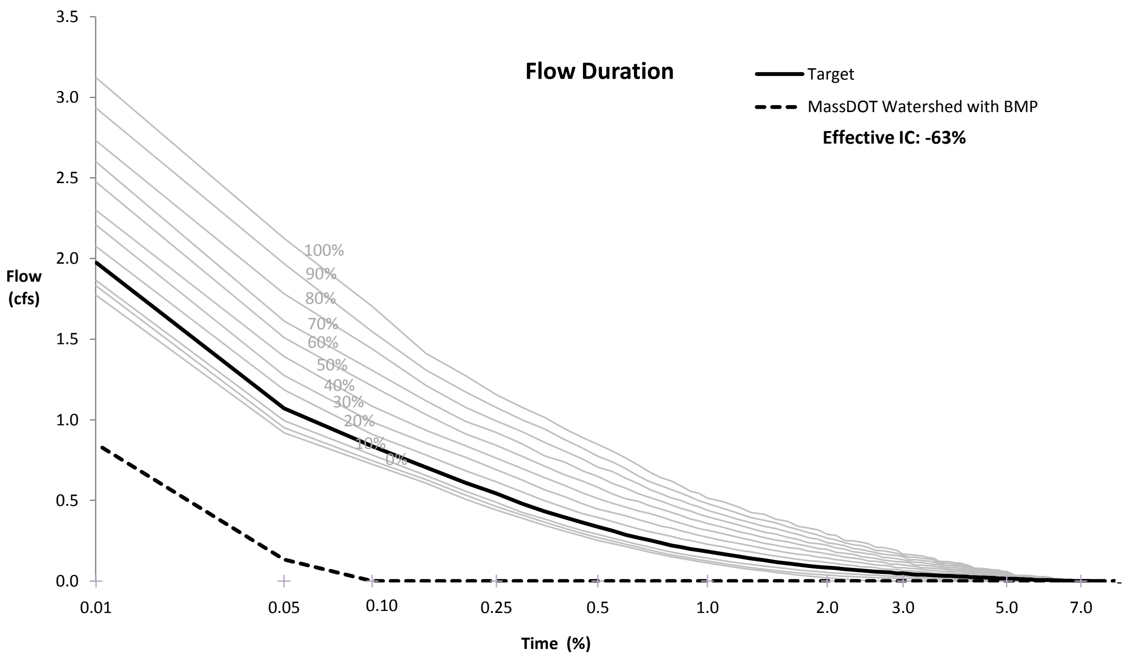
Metric	Area (%)	Area (acres)
Watershed Area		3.5
Watershed IC (no BMP)	29%	1.0
Target IC Reduction	57%	0.6
Effective IC w/BMP	-30%	-1.05
IC Reduction	206%	2.0

Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	1.0	3.5
Indirect Watershed	-	-
Total	1.0	3.5

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary
2.7 BMP 2



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	3.3	0.2	16
5%IC	3.9	0.8	339
10% IC	4.4	1.4	665
20% IC	5.5	2.5	1,318
30% IC	6.5	3.7	1,970
40% IC	7.6	4.9	2,622
50% IC	8.6	6.0	3,275
60% IC	9.6	7.2	3,927
70% IC	10.7	8.4	4,579
80% IC	11.7	9.6	5,232
90% IC	12.8	10.7	5,884
100% IC	13.8	11.9	6,539
Watershed Load	7.69	5.47	2,953
BMP Output	0.19	0.01	0
Target	5.40	2.47	1,281
Reduction %	**97%**	**100%**	**100%**
Effective IC	**-30%**	**-2%**	**0%**

Result Summary

Metric	Area (%)	Area (acres)
Watershed Area		4.3
Watershed IC (no BMP)	45%	1.9
Target IC Reduction	57%	1.1
Effective IC w/BMP	-31%	-1.33
IC Reduction	168%	3.3

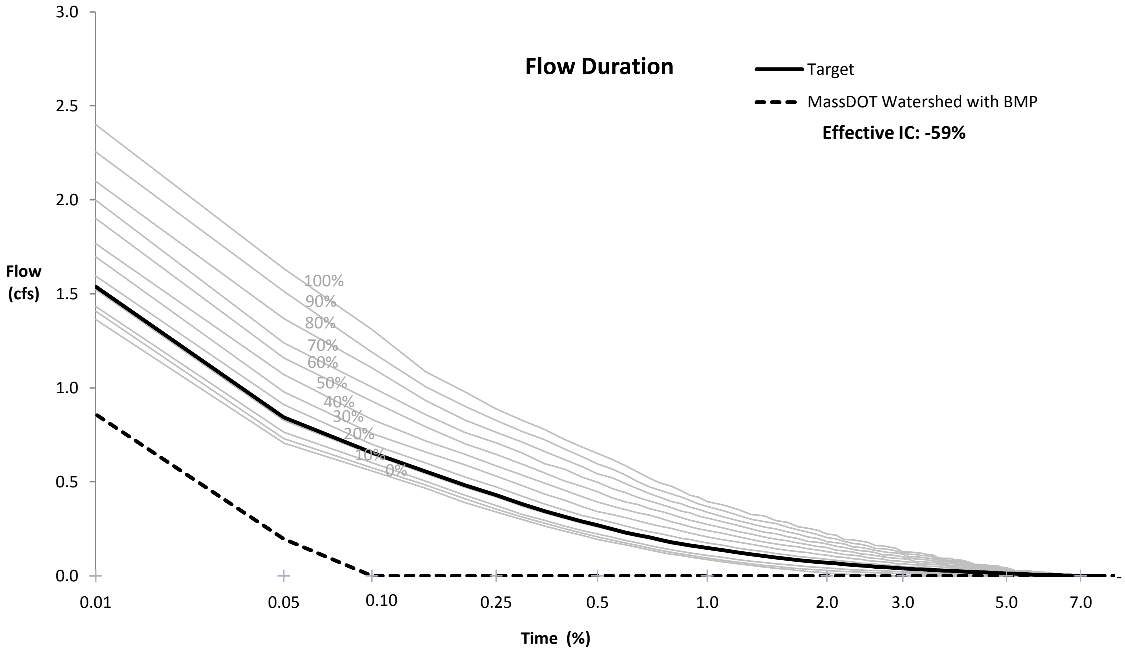
Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	1.9	4.3
Indirect Watershed	-	-
Total	1.9	4.3

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary

3.7 BMP 3



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	2.6	0.2	13
5%IC	3.0	0.6	261
10% IC	3.4	1.1	511
20% IC	4.2	1.9	1,013
30% IC	5.0	2.8	1,514
40% IC	5.8	3.7	2,015
50% IC	6.6	4.6	2,517
60% IC	7.4	5.5	3,018
70% IC	8.2	6.4	3,519
80% IC	9.0	7.3	4,021
90% IC	9.8	8.2	4,522
100% IC	10.6	9.1	5,026
Watershed Load	6.42	4.71	2,552
BMP Output	0.21	0.01	0
Target	4.36	2.12	1,111
Reduction %	**97%**	**100%**	**100%**
Effective IC	**-29%**	**-2%**	**0%**

Result Summary

Metric	Area (%)	Area (acres)
Watershed Area		3.3
Watershed IC (no BMP)	51%	1.7
Target IC Reduction	57%	1.0
Effective IC w/BMP	-29%	-0.97
IC Reduction	158%	2.7

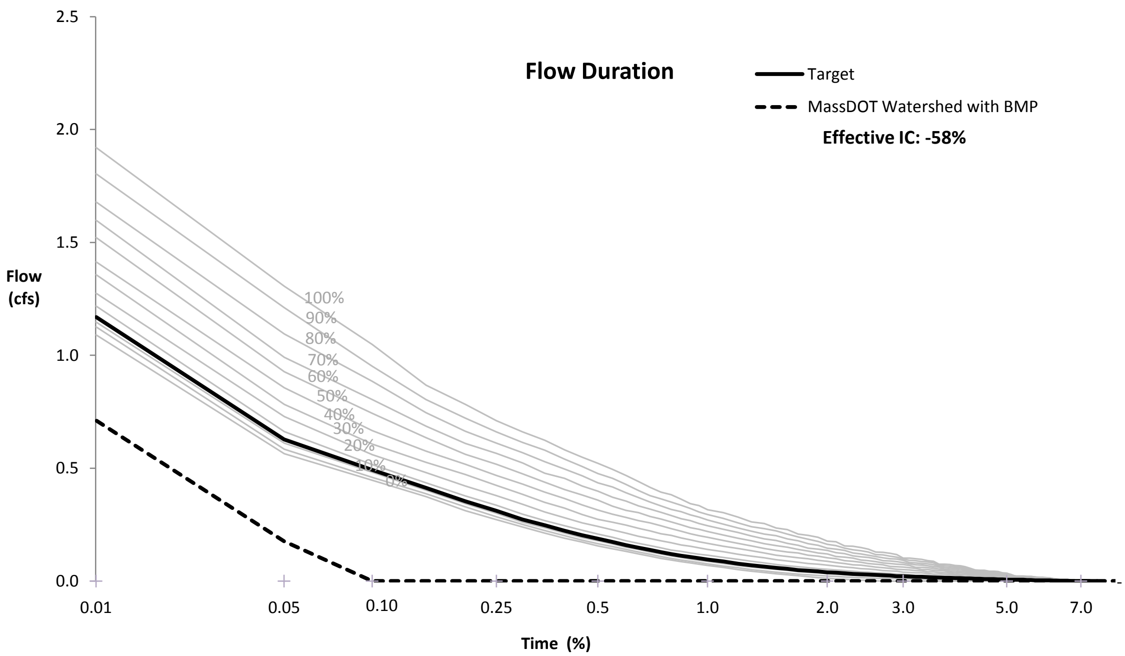
Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	1.7	3.3
Indirect Watershed	-	-
Total	1.7	3.3

* Effective IC calculated as follows:

1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary
4.7 BMP 4



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	2.1	0.1	10
5%IC	2.4	0.5	209
10% IC	2.7	0.8	409
20% IC	3.4	1.6	810
30% IC	4.0	2.3	1,211
40% IC	4.7	3.0	1,613
50% IC	5.3	3.7	2,014
60% IC	5.9	4.4	2,415
70% IC	6.6	5.2	2,816
80% IC	7.2	5.9	3,217
90% IC	7.9	6.6	3,619
100% IC	8.5	7.3	4,022
Watershed Load	3.73	2.32	1,234
BMP Output	0.18	0.01	0
Target	2.91	1.07	536
Reduction %	**95%**	**100%**	**100%**
Effective IC	**-29%**	**-2%**	**0%**

Result Summary

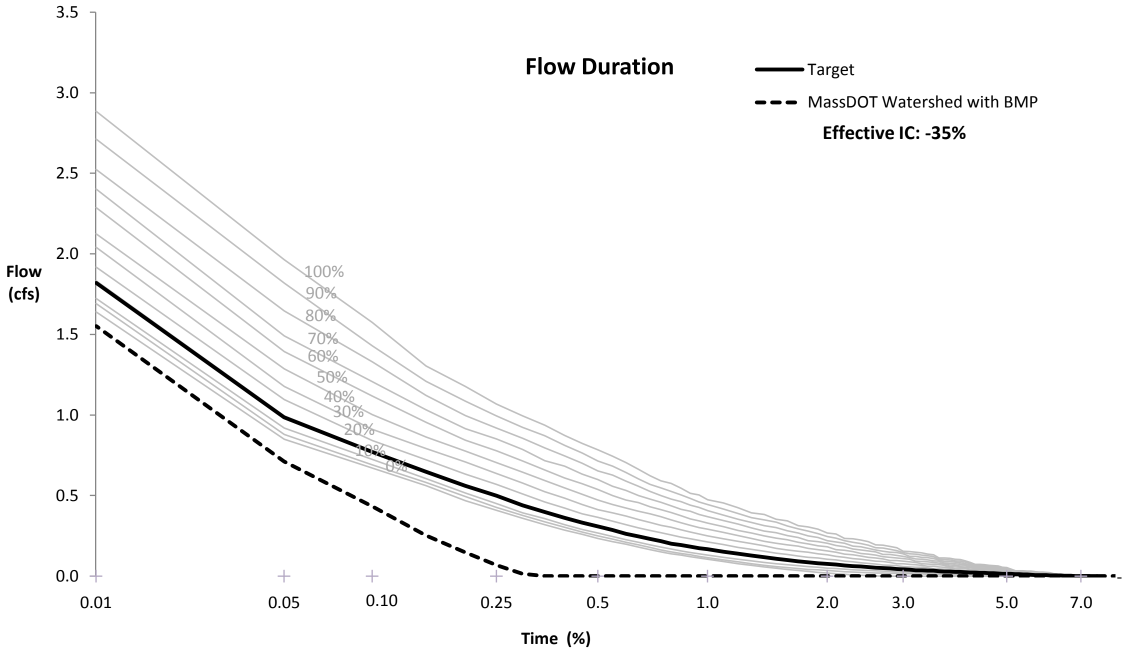
Metric	Area (%)	Area (acres)
Watershed Area		2.6
Watershed IC (no BMP)	31%	0.8
Target IC Reduction	57%	0.5
Effective IC w/BMP	-29%	-0.77
IC Reduction	195%	1.6

Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	0.8	2.6
Indirect Watershed	-	-
Total	0.8	2.6

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary
5.7 BMP 5



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	3.1	0.2	15
5%IC	3.6	0.8	313
10% IC	4.1	1.3	615
20% IC	5.0	2.3	1,218
30% IC	6.0	3.4	1,821
40% IC	7.0	4.5	2,424
50% IC	8.0	5.6	3,027
60% IC	8.9	6.7	3,630
70% IC	9.9	7.8	4,233
80% IC	10.8	8.8	4,836
90% IC	11.8	9.9	5,439
100% IC	12.8	11.0	6,044
Watershed Load	7.00	4.90	2,642
BMP Output	0.97	0.07	6
Target	4.94	2.22	1,150
Reduction %	**86%**	**99%**	**100%**
Effective IC	**-22%**	**-1%**	**0%**

Result Summary

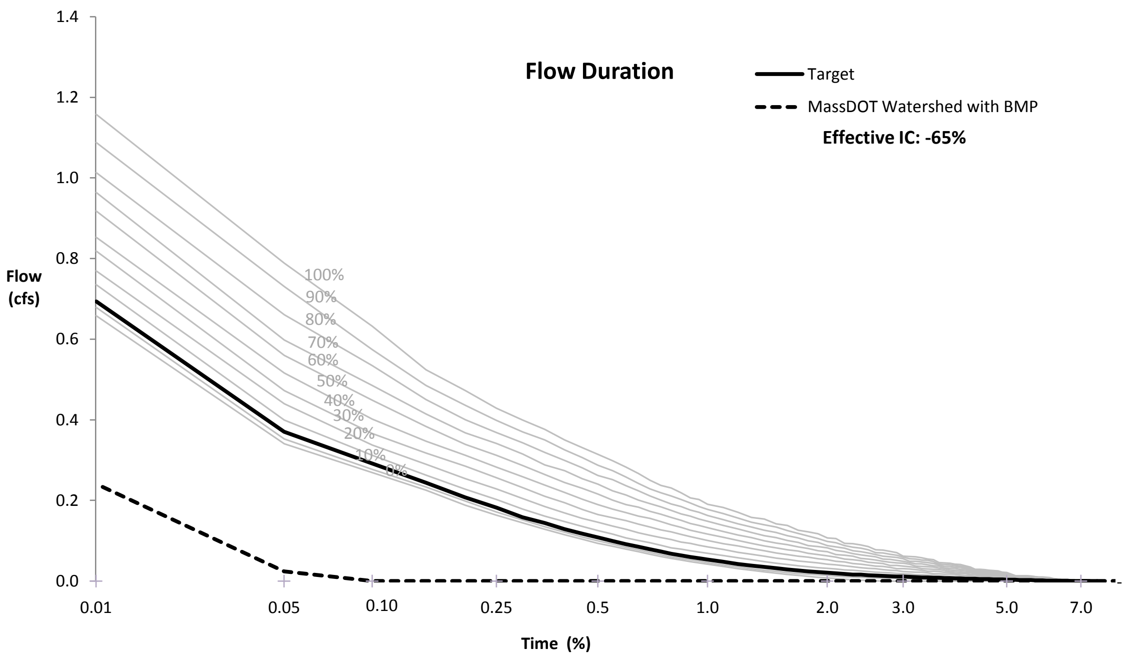
Metric	Area (%)	Area (acres)
Watershed Area		4.0
Watershed IC (no BMP)	44%	1.7
Target IC Reduction	57%	1.0
Effective IC w/BMP	-19%	-0.75
IC Reduction	143%	2.5

Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	1.7	4.0
Indirect Watershed	-	-
Total	1.7	4.0

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary
6.7 BMP 6



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	1.2	0.1	6
5%IC	1.4	0.3	126
10% IC	1.6	0.5	247
20% IC	2.0	0.9	489
30% IC	2.4	1.4	731
40% IC	2.8	1.8	973
50% IC	3.2	2.2	1,215
60% IC	3.6	2.7	1,457
70% IC	4.0	3.1	1,699
80% IC	4.3	3.5	1,941
90% IC	4.7	4.0	2,183
100% IC	5.1	4.4	2,426
Watershed Load	2.00	1.13	597
BMP Output	0.05	0.00	0
Target	1.65	0.53	260
Reduction %	**97%**	**100%**	**100%**
Effective IC	**-30%**	**-2%**	**0%**

Result Summary

Metric	Area (%)	Area (acres)
Watershed Area		1.6
Watershed IC (no BMP)	24%	0.4
Target IC Reduction	57%	0.2
Effective IC w/BMP	-32%	-0.51
IC Reduction	230%	0.9

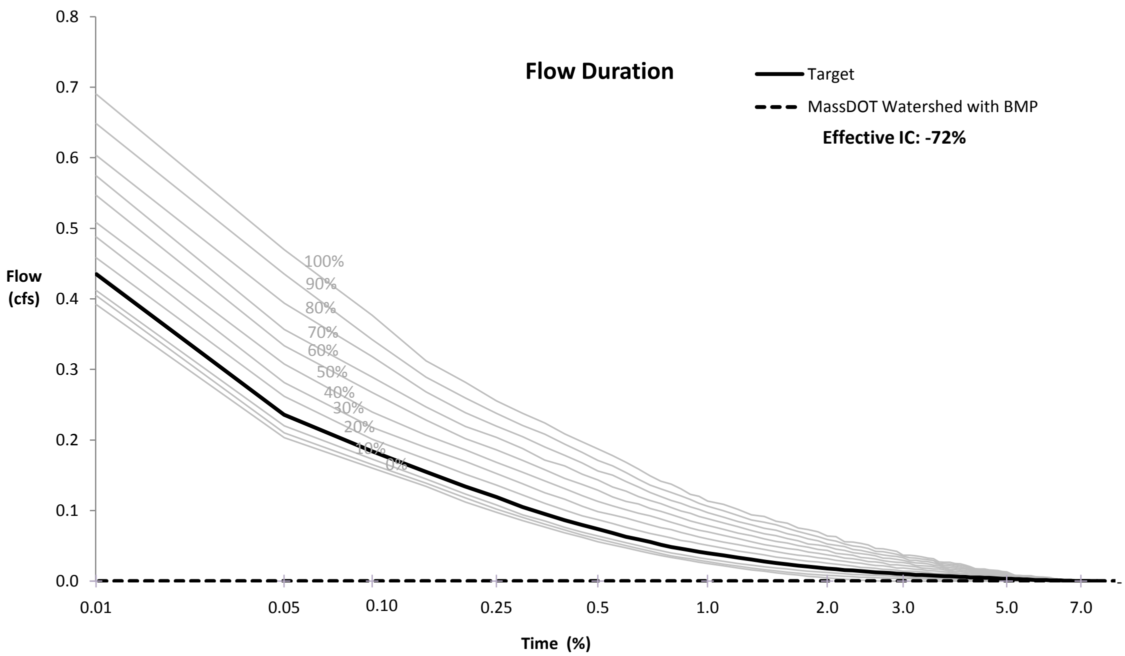
Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	0.4	1.6
Indirect Watershed	-	-
Total	0.4	1.6

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary

7.7 BMP 7



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	0.7	0.1	4
5%IC	0.9	0.2	75
10% IC	1.0	0.3	147
20% IC	1.2	0.6	291
30% IC	1.4	0.8	435
40% IC	1.7	1.1	580
50% IC	1.9	1.3	724
60% IC	2.1	1.6	868
70% IC	2.4	1.9	1,012
80% IC	2.6	2.1	1,156
90% IC	2.8	2.4	1,301
100% IC	3.1	2.6	1,445
Watershed Load	1.67	1.17	631
BMP Output	-	-	-
Target	1.18	0.53	274
Reduction %	**100%**	**100%**	**100%**
Effective IC	**-32%**	**-2%**	**0%**

Result Summary

Metric	Area (%)	Area (acres)
Watershed Area		1.0
Watershed IC (no BMP)	44%	0.4
Target IC Reduction	57%	0.2
Effective IC w/BMP	-34%	-0.33
IC Reduction	179%	0.7

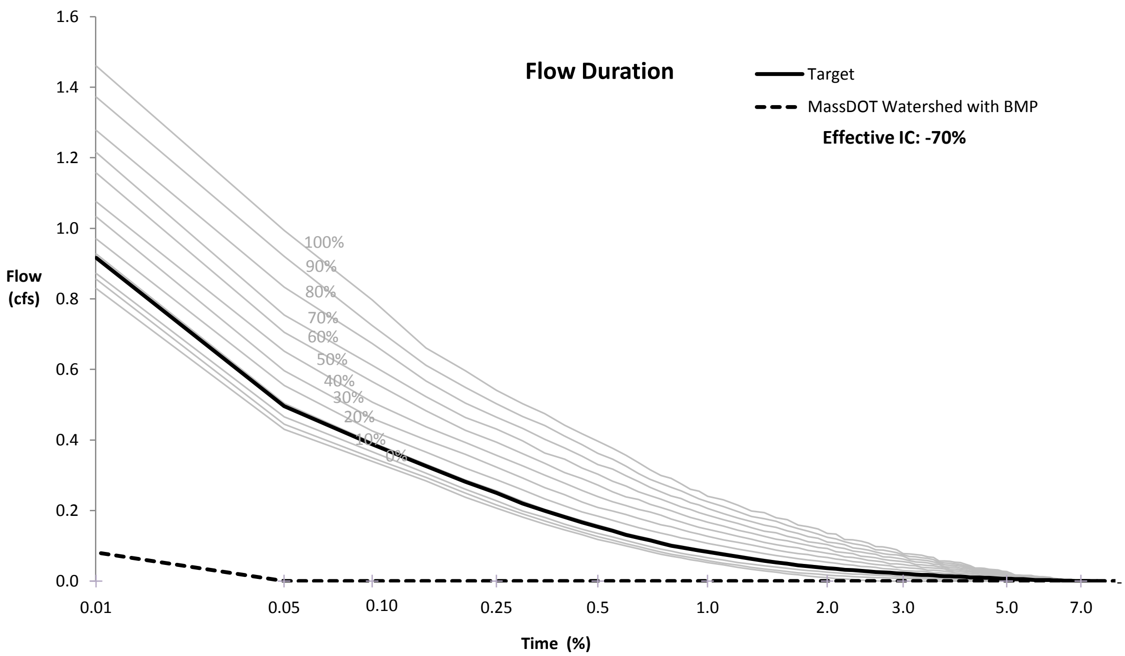
Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	0.4	1.0
Indirect Watershed	-	-
Total	0.4	1.0

* Effective IC calculated as follows:

1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary
10.7 BMP 8



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	1.6	0.1	8
5%IC	1.8	0.4	159
10% IC	2.1	0.6	311
20% IC	2.6	1.2	616
30% IC	3.1	1.7	922
40% IC	3.5	2.3	1,227
50% IC	4.0	2.8	1,532
60% IC	4.5	3.4	1,837
70% IC	5.0	3.9	2,142
80% IC	5.5	4.5	2,447
90% IC	6.0	5.0	2,753
100% IC	6.5	5.6	3,059
Watershed Load	3.44	2.38	1,282
BMP Output	0.00	0.00	0
Target	2.46	1.08	557
Reduction %	**100%**	**100%**	**100%**
Effective IC	**-31%**	**-2%**	**0%**

Result Summary

Metric	Area (%)	Area (acres)
Watershed Area		2.0
Watershed IC (no BMP)	42%	0.8
Target IC Reduction	57%	0.5
Effective IC w/BMP	-34%	-0.68
IC Reduction	181%	1.5

Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	0.4	1.1
Indirect Watershed	0.4	1.0
Total	0.8	2.0

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Impaired Waters Assessment for Assabet River (MA82B-07)

Summary

Impaired Water[1]	**Impairments:**	Fecal coliform, total phosphorus
	Category:	5 (Waters requiring a TMDL)
	Final TMDLs:	Assabet River Total Maximum Daily Load for Total Phosphorus[2]
	WQ Assessment:	SuAsCo 2001 Water Quality Assessment[3]
Location	**Towns:**	Concord and Acton, MA
	MassDOT Roads:	Route 2, Route 2A, Elm Street
Assessment Method(s)	**7R (TMDL Method)**	☒
	7U (IC Method)	☒
BMPs	**Existing:**	None
	Proposed:	3 Water Quality Swales and 2 Infiltration Basins
MassDOT Contributing Area and Targets		Impervious Cover (IC)
	Directly Contributing Area	8.8 acres
	Contributing Area Reduction Target	4.0 acres
	Existing BMPs Reduction	0.0 acres
	Proposed BMPs Reduction	5.4 acres
	Remaining Treatment to Meet Target	0.0 acres

[1] MassDEP, 2013. Massachusetts Year 2012 Integrated List of Waters – Final Listing of the Condition of Massachusetts' Waters Pursuant to Sections 305(b), 314 and 303(d) of the Clean Water Act. Massachusetts. Available at: http://www.mass.gov/eea/docs/dep/water/resources/07v5/12list2.pdf

[2] MassDEP. 2004. Assabet River Total Maximum Daily Load for Total Phosphorus. Available at: http://www.mass.gov/eea/docs/dep/water/resources/a-thru-m/anuttmdl.pdf

[3] MassDEP, 2001. SuAsCo Watershed 2001Water Quality Assessment Report. Available at: http://www.mass.gov/eea/docs/dep/water/resources/71wqar09/82wqar2.pdf

Site Description

The Assabet River, segment MA82B-07, is located in Concord and Acton, MA. The Assabet River, flows for 6.4 miles from the Powdermill Dam in Acton to its confluence with the Sudbury River in Concord. Figure 1 shows the overall watershed to river and the more detailed subwatershed to the segment under review. The land use areas of the 5,668 acre Assabet River subwatershed consist of 17% imperviousness, which reflects commercial land use areas surrounded by medium density residential land use areas. The remaining land use is forest and open space. Segment MA82B-07 is impaired for fecal coliform and total phosphorus, and MassDEP's Water Quality Assessment Report[4] for this receiving water identified the suspected sources as discharges from municipal separate storm sewer systems.

Figure 2a shows areas owned by MassDOT that directly discharge stormwater to the Assabet River. The roadways consist of Route 2/2A and a portion of Elm Street. This section of Route 2/2A roadway is a divided highway with a thin impervious median and a guardrail, comprised of two lanes and one outside shoulder East and West. The directly discharging sections of MassDOT roadways includes a portion of Elm Street where it merges with Route 2/2A. The drainage system on Route 2/2A East and West, east of the river crossing, consists of catch basins in the roadway shoulders and drop inlets within the pervious shoulder right of way area which capture stormwater and pipe it to a trunkline adjacent to Route 2/2A East. The trunkline is piped under the pervious shoulder of Route 2/2A East towards the Assabet River. The trunkline is daylighted just before Baker Avenue Extension and then culverted under Baker Avenue Extension where it flows through a drainage ditch, surrounded by wetlands, to the Assabet River. Stormwater at the Elm Street and Route 2/2A merge is captured in catchbasins and outlets into the drainage ditch, just west of Baker Avenue Extension. Stormwater west of the Assabet River crossing is collected in catch basins in the shoulders of Route 2/2A east and west which outfall directly at the edge of the Assabet River. The directly discharging area is bounded by a high point on Route 2, just north of the MBTA Railway and a high point east of the Concord rotary. Stormwater from the Concord rotary discharges to Warners Pond and stormwater past the MBTA Railway discharges to the Sudbury River.

Figure 2b and 2c show four MassDOT owned bridges that also directly discharge stormwater to the Assabet River. The four bridges are on Route 62 in Concord and Acton. All the bridges have granite curbing along the edges of the roadway, however stormwater either sheet flows into the river where the curb ends or is collected by a catch basin which outlets into the Assabet River. The Old Stow Road bridge crossing that MassDOT owns, shown on Figure 2b, is a bridge over an MBTA railway. Stormwater runoff sheet flows into the shoulders at the two ends of the bridge. The land cover at the ends of the bridge is wooded and there is no direct conveyance system for stormwater from this bridge to reach the Assabet River.

Existing BMPs

MassDOT did not identify any existing BMPs in place to treat the directly draining roadway runoff before reaching the impaired water segment.

Assessment

In cases where a TMDL has been approved, MassDOT assessed the waterbody for the impairments covered by the TMDL under the BMP 7R methodology. MassDOT has separately assessed the waterbody for any stormwater-related impairments that are not covered by the TMDL

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[4] MassDEP, 2001. SuAsCo Watershed 2001 Water Quality Assessment Report. Available at: http://www.mass.gov/eea/docs/dep/water/resources/71wqar09/82wqar2.pdf

under the BMP 7U methodology. MassDOT assessed Assabet River (MA82B-07) using the methodologies described below.

BMP 7R for Phosphorus TMDL (CN 201.0)

The *Assabet River Total Maximum Daily Load (TMDL) for Phosphorus(CN 201.0)*[5] addresses the total phosphorus for this water body. However, the TMDL does not specifically address stormwater contributions to the river and does not provide a waste load allocation (WLA) for stormwater discharges. Therefore, MassDOT assessed the contribution of phosphorus from MassDOT properties to this waterbody using the approach described in BMP 7U[6] of MassDOT's Storm Water Management Plan (Water Quality Impaired Waters Assessment and Mitigation Plan), which applies to impairments that have not been addressed by a TMDL.

Assessment 7U for Pathogen Impairment

MassDOT assessed the indicator bacteria (fecal coliform) impairment using the approach described in BMP 7U of MassDOT's Storm Water Management Plan (SWMP).[7] Assabet River (MA82B-07) is covered by the Draft Pathogen TMDL for the Concord River Watershed.[8] According to the Draft TMDL, sources of indicator bacteria in the Concord River watershed were found to be many and varied. Most of the bacteria sources in the Concord River watershed are believed to be failing septic systems, combined sewer overflows (CSO), sanitary sewer overflows (SSO), sewer pipes connected to storm drains, certain recreational activities, wildlife including birds along with domestic pets and animals and direct overland stormwater runoff. Additionally, the TMDL states that implementation to achieve the TMDL goals should be an iterative process with selection and implementation of mitigation measures followed by monitoring to determine the extent of water quality improvement realized. Recommended TMDL implementation measures include identification and elimination of prohibited sources such as leaky or improperly connected sanitary sewer flows and best management practices to mitigate storm water runoff volume. MassDOT included a review of the draft report as an informational review as part of this assessment even though, due to their draft status, draft TMDLs are not formally part of the Impaired Waters Retrofit program.

Pathogen concentrations in stormwater vary widely temporally and spatially; concentrations can vary by an order of magnitude within a given storm event at a single location.[9] Therefore, it is difficult to predict pathogen concentrations in stormwater with accuracy. MassDOT's South East Expressway study measured bacterial concentration in stormwater runoff[10] and data indicated that highway's pathogen loading may be lower than urban areas. Considering that the potential sources of pathogens (e.g. illicit discharges, sewer utilities, pet waste and wildlife) are likely to be less prevalent in the highway environment than along urban roads, this finding is not surprising.

MassDOT does not conduct site specific assessments of loading at each location impaired for pathogens. Instead, MassDOT reviewed its existing programs and their consistency with EPA NPDES MS4 general permit requirements and pathogen TMDL requirements. Language in the

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[5] MassDEP. 2004. Assabet River Total Maximum Daily Load for Total Phosphorus. Available at: http://www.mass.gov/eea/docs/dep/water/resources/a-thru-m/anuttmdl.pdf

[6] Massachusetts Department of Transportation (MassDOT), July 22, 2010. BMP 7R: TMDL Watershed Review. Available at: http://www.mhd.state.ma.us/downloads/projDev/BMP_7R_TMDL_WatershedReview.pdf

[7] MassDOT, 6 April, 2011. Description of MassDOT's Application of Impervious Cover Method in BMP 7U (MassDOT Application of IC Method). http://www.mhd.state.ma.us/downloads/projDev/BMP_7U_ImpairedWaterbodiesAssessment.pdf

[8] MassDEP. Draft Pathogen TMDL for the Concord River Watershed. Available at: http://www.mass.gov/eea/docs/dep/water/resources/a-thru-m/concord1.pdf

[9] MassDEP. 2009. Final Pathogen TMDL for the Cape Cod Watershed. Available at: http://www.mass.gov/dep/water/resources/capecod1.pdf

[10] Smith. (2002). Effectiveness of Three Best Management Practices for Highway Runoff Quality along the Southeast Expressway. USGS Water Resources Investigations Report 02-4059. Boston, Massachusetts.

documents clearly indicate that an iterative adaptive management approach is the appropriate way to address discharges to pathogen impaired waters and recommend implementation of programmatic BMPs such as residential educational programs, illicit connection identification, tracking and removal and pet waste management. MassDOT implements a variety of non-structural BMP programs across their system in accordance with their existing SWMP including educational programs, illicit connection review and source control.

MassDOT has an ongoing inspection and monitoring program aimed at identifying and addressing illicit discharges to MassDOT's stormwater management system. Any illicit discharges to MassDOT's system could contribute pathogens to impaired waters, however, MassDOT's existing Illicit Discharge Detection and Elimination (IDDE) program is aimed at identifying and addressing these contributions. District maintenance staff note signs of potential illicit discharges, such as dry weather flow and notable odors or sheens. Similarly, Resident Engineers overseeing construction projects also receive instruction regarding the need to note any suspicious connections or flows, and report these for follow-up investigation and action as appropriate. MassDOT will continue to implement this IDDE training, and District staff will continue to report any suspicious flows requiring further investigation. MassDOT investigates any suspicious flows noted, and proceeds to work with owners of confirmed illicit discharges to remove these flows, and thereby minimize pathogen contributions to receiving waters.

MassDOT is in the process of developing a pet waste management program for MassDOT rest stops located within the sub-watershed of a pathogen impaired waterbody. At these prioritized rest stops, MassDOT will be installing signs informing the public of the need to remove pet waste in order to minimize contributions of pathogens to the impaired waterbody and providing pet waste removal bags and disposal cans.

MassDOT believes the existing efforts are consistent with the current and draft MS4 permit's requirements and TMDL recommendations.

BMP 7U for Impervious Cover Related Impairments

The Assabet River Phosphorus TMDL does not address non-point sources discharges to the Assabet River. Therefore, MassDOT assessed the stormwater-related impairments using the approach outlined in the Description of MassDOT's Application of Impervious Cover Method in BMP 7U[11] which was developed using the EPA Region I's Impervious Cover (IC) Method as a basis, described in EPA's Stormwater TMDL Implementation Support Manual. [12] MassDOT used the long-term continuous simulation model (the assessment model)[13] to estimate effective IC. Consistent with the findings of EPA and others, MassDOT concluded that when a watershed had less than 9% IC, stormwater was not the likely cause of the impairment.

MassDOT calculated the following values for the total contributing watershed and the subwatershed of the impaired water (Assabet River) to determine the IC target. The total contributing watershed and the subwatershed are shown in Figure 1.

[11] MassDOT, 6 April, 2011. Description of MassDOT's Application of Impervious Cover Method in BMP 7U (MassDOT Application of IC Method). http://www.mhd.state.ma.us/downloads/projDev/BMP_7U_ImpairedWaterbodiesAssessment.pdf

[12] ENSR 2006. *Stormwater TMDL Implementation Support Manual for US EPA Region 1*. ENSR International & EPA Region 1, Boston, MA. Available at http://www.epa.gov/region1/eco/tmdl/regionalpgrfs.html

[13] MassDOT, June 2012. Long-Term Continuous Simulation for Pollutant Loading and Treatment for MassDOT Impaired Waters Program. Available at: http://www.mhd.state.ma.us/downloads/projDev/ImpairedWaters_2/Attachment7.pdf

Impaired Segment Watershed	Total Contributing Watershed	Subwatershed
Watershed Area	113,806 acres	5,668 acres
Impervious Cover (IC) Area	13,149 acres	946 acres
Percent Impervious	12 %	17 %
IC Area at 9% Goal	10,243 acres	510 acres
Target Effective IC Reduction	22 %	46 %

The total and subwatersheds are greater than 9% impervious indicating that stormwater is a likely contributor to the impairment. To meet the 9% effective IC target, the effective IC within the subwatershed will need to be reduced. Therefore, the effective IC of MassDOT's directly contributing area should also be reduced by the same percentage to meet the target. The following table shows how MassDOT calculated the target effective IC for MassDOT's contributing property.

MassDOT Directly Contributing Watershed	
Directly Contributing Area	14.5 acres
Directly Contributing IC Area	8.8 acres
Percent Impervious	61%
Target Effective IC Reduction (46% Reduction of DOT Directly Contributing IC)	4.0 acres
Target Effective IC	33 %

This assessment has identified locations for potential stormwater BMPs and estimated the effective IC accounting for their treatment. The Proposed Mitigation Plan section describes the BMPs and their IC reduction performance.

Proposed Mitigation Plan

In this assessment, MassDOT has identified five stormwater BMPs that may be implemented on MassDOT property to mitigate the effective IC to address the Assabet River impairments. These BMPs include two infiltraion basins and threewater quality swales, shown with their estimated contributing drainage areas in Figure 3. These locations were chosen based on a cursory review of the drainage systems, topography, property lines, and other site constraints. The three proposed swales will be located in existing drainage ditches and the two proposed basins will be located within pervious intersection islands. Encroaching wetland boundaries into MassDOT's right of way limit the ability to proposed additional BMPs. Detailed survey, complete utility location information, official property ownership, and soils evaluation information will influence the final selection and design of BMPs. Below is a description of these proposed BMPs which are shown in Figure 3.

PR BMP 1

The area proposed for BMP 1 is an existing drainage ditch located in the pervious shoulder of Route 2/2A East. Currently, stormwater from two lanes and one shoulder of Route 2/2A East is either caught in catch basins in the shoulder of the roadway or, because of the lack of curbs, sheet flows into the drainage ditch which is lined with drop inlets. Stormwater captured in drop inlets located within the drainage ditch connect to a trunkline. The trunkline surfaces into a stone lined drainage ditch east of Baker Avenue Extension and is then culverted into a drainage ditch that runs along the edge of a wetland until it outlets into the Assabet River. The proposed water quality swale could consist of daylighting the outlets into the trunkline and installing check dams upstream of the drop inlets to create storage within the swale. The addition of check dams would promote infiltration before the stormwater discharges to the Assabet River. The width of the BMP is constrained by the limited MassDOT right of way; commercial businesses are located south of the swale. The potential volume of stormwater infiltrated could be limited by the HSG C soils in the area, according to the NRCS soil mapping.

PR BMP 2 & 3

PR BMP 2 and 3 are proposed water quality swales that could be located in an existing drainage ditch in the pervious shoulder of Route 2/2A West. Currently, stormwater from two lanes and one shoulders of Route 2/2A West is either caught in catch basins in the shoulder of the roadway or, because of the lack of curbs, sheet flows into the drainage ditch which is lined with drop inlets. Stormwater is then piped from the drop inlets or catch basins under the roadway and is discharged into a trunkline which runs under the pervious shoulder of Route 2/2A West. The proposed water quality swales could consist of daylighting the catch basin into the swale and installing check dams upstream of the drop inlets. The installation of the check dams would create storage within the swale to promote infiltration before the stormwater is discharge to the other side of the road into proposed BMP 1. The potential volume of stormwater infiltrated by the BMPs is constrained due to the limitations in width set by the mature vegetation on the edge of MassDOT's right of way and the existing soil types which consist of HSG A and C soil types, according to the NRCS soil mapping.

PR BMP 4-5

PR BMP 4 and 5 are infiltration basins that are proposed within the vegetated islands between Elm Street and Route 2/2A. Currently, catch basins that collect stormwater from Elm Street and Route 2/2A West connect to a drop inlet located within the pervious island. The outlets of these catch basins could be daylighted into an infiltration basin located in the pervious islands before discharging into the drainage ditch in the pervious right of way area along Route 2/2A East. Drop inlets are located within the pervious island which will capture overflow stormwater from the basins and discharge to the drainage ditch. The pervious area could be regraded and the drop inlet could be raised to increase the storage and promote infiltration. The amount of stormwater that could be treated by the BMP is limited due to the slope of the roadway, which sends the stormwater away from the BMP. The existing soil type consists of HSG C soils, therefore potentially limiting the amount of infiltration provided by the BMP, according to the NRCS soil mapping data.

The table below shows the proposed conditions, including BMPs with their MassDOT drainage areas and estimated effective IC reductions. The outputs from the assessment model showing effective IC analysis for each BMP are attached.

Proposed Conditions

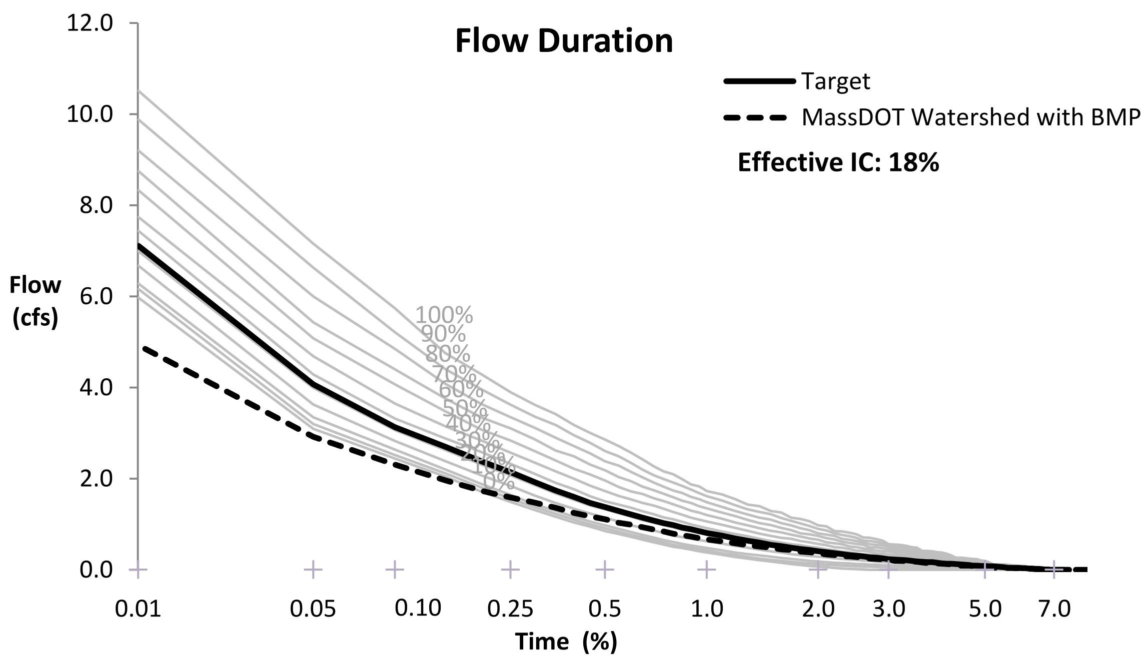
BMP Name	BMP Type	Contributing Effective IC (acres)	Estimated Percent Reduction	Estimated Reduction Effective IC (acres)
PR BMP 1	Water Quality Swale	2.7	163%	4.4
PR BMP 2	Water Quality Swale	0.6	170%	1.0
PR BMP 3	Water Quality Swale	0.3	181%	0.6
PR BMP 4	Infiltration Basin	0.8	106%	0.8
PR BMP 5	Infiltration Basin	0.8	209%	0.6
Total*		**8.8**	**62%**	**5.4**
Target				**4.0**

* Total effective IC reduction based on the assessment model results for the total MassDOT directly discharging drainage area to the receiving water (not sum of individual BMP reductions).

Note: The predicted effective IC is determined by comparing the BMP's calculated median annual discharge volume, runoff flow/duration relationship, median annual phosphorus load and median annual total suspended solids load to predicted discharge values for benchmark watersheds with the same size and varying percent IC. In cases where analysis predicts that BMPs would discharges less runoff volume and pollutant mass than those predicted for a 0% IC (pervious, woods in good condition) benchmark watershed, then the predicted effective IC removal would be greater than 100% and reduction of effective IC area will be greater than the BMP contributing IC area.

Proposed Median Annual Load Comparisons

Simulated IC Watersheds	Runoff (ac-ft)	TP (lb.)	TSS (lb.)
0% IC	11.3	0.8	55
5% IC	13.0	2.8	1,142
10% IC	14.8	4.6	2,241
20% IC	18.4	8.5	4,438
30% IC	22.0	12.5	6,635
Target 33% IC	**23.0**	**13.7**	**7,294**
40% IC	25.5	16.4	8,832
50% IC	29.0	20.4	11,029
60% IC	32.4	24.3	13,226
70% IC	35.9	28.2	15,423
80% IC	39.4	32.2	17,620
90% IC	43.0	36.1	19,818
100% IC	46.6	40.1	22,024
Existing Conditions	30.9	23.3	12,666
Proposed Conditions	18.2	13.0	7,046
Reduction %	**41%**	**44%**	**44%**
Effective IC	**19%**	**31%**	**32%**



Effective IC Results

Existing IC	8.8 acres
Proposed Estimated Effective IC	3.4 acres
IC Reduction % under Proposed Conditions	62%
Estimated Effective IC*	23%

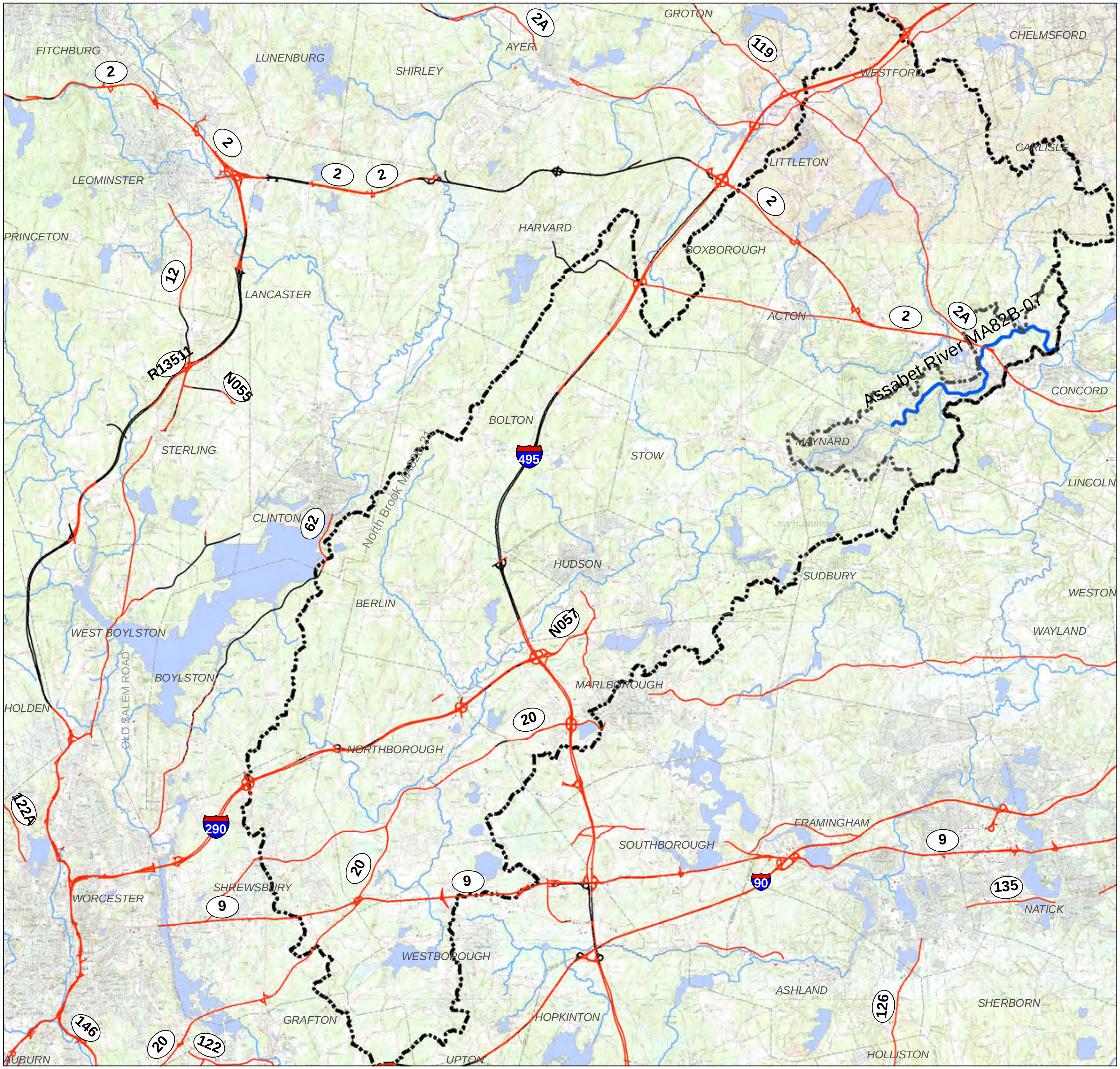
*Average of estimated effective IC for annual median runoff volume, phosphorus and TSS loads, and flow duration

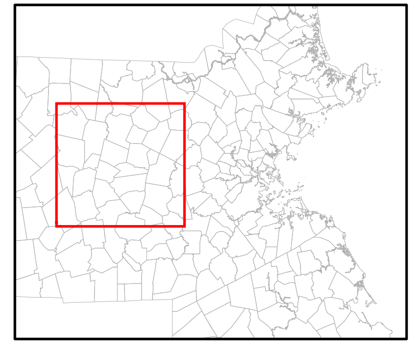
MassDOT estimated the effective IC under proposed conditions by comparing the annual median runoff volume, phosphorus and TSS loads, and flow distribution statistics (flow duration) from MassDOT drainage area to the receiving water to those results for simulated IC watersheds.

The proposed BMPs provide enough treatment to meet the target. All the proposed BMPs provide over 100% treatment and have little to no discharge, fully infiltrating contributing run off. While the objective of the Impaired Waters Retrofit Program is to meet the target reduction and not necessarily to construct retrofits to the maximum extent practicable, due to the higher costs and inefficiencies of retrofit projects, it has been MassDOT's experience that during design additional site constraints are identified and often reduce the final number of BMPs and/ or water quality treatment. Therefore, in this assessment we are including BMPs that provide treatment beyond the target and will prioritize the most effective BMPs during the design. The BMP locations are limited to areas within MassDOT's right of way and outside of resource areas. There are no BMPs proposed at the MassDOT owned bridge crossings due to the limited MassDOT owned area. The impervious cover area closest to the Assabet River crossing was unable to be treated due to wetland resource areas within the MassDOT's right of way, leaving limited adequate area remaining for proposed BMPs.

MassDOT will proceed to the design phase to develop construction plans for the proposed BMPs as part of the MassDOT Impaired Waters Program. The project designer will gather additional information in this phase, such as soil data, wetland delineations, and site survey, to further refine the proposed BMPs. Once the design of the proposed BMPs is finalized, MassDOT will provide an update with additional information and summarize effective IC reduction based on the as-built condition.

MassDOT will continue to ensure proper non-structural BMPs are being implemented within the watershed of Assabet River, including regular roadway and drainage system maintenance, erosion and sedimentation control, and outreach and education. Further work by MassDOT on programmed projects, which often include broader scale road layout changes, may provide additional opportunities for construction of new treatment BMPs. This is consistent with an iterative adaptive management approach to address impairments. MassDOT will include an update in annual reports to EPA regarding progress made towards meeting target IC reductions, plans for construction of proposed BMPs and finalized assessments including reduction achieved by finalized BMP designs.





MassDOT Roadways in Urban Area

MassDOT Roadways

Sub Watershed

Total Watershed

Assessed Segment

Impaired Lakes

Impaired Streams

N

0 8,000 16,000 Feet

1 inch = 16,000 feet

Figure 1

Assabet River (MA82B-07) Total Watershed

December 2013

massDOT Massachusetts Department of Transportation Highway Division

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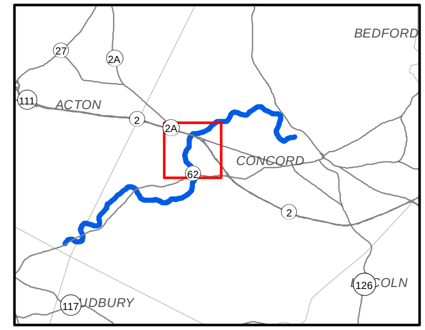

- MassDOT Roadways in Urban Area
- MassDOT Roadways
- Assessed Segment
- Impaired Streams
- Impaired Lakes
- MassDOT Directly Discharging Area
- Flow Direction

N

0 300 600 Feet

1 inch = 600 feet

Figure 2a

Assabet River (MA82B-07) Directly Contributing MassDOT Watershed

December 2013

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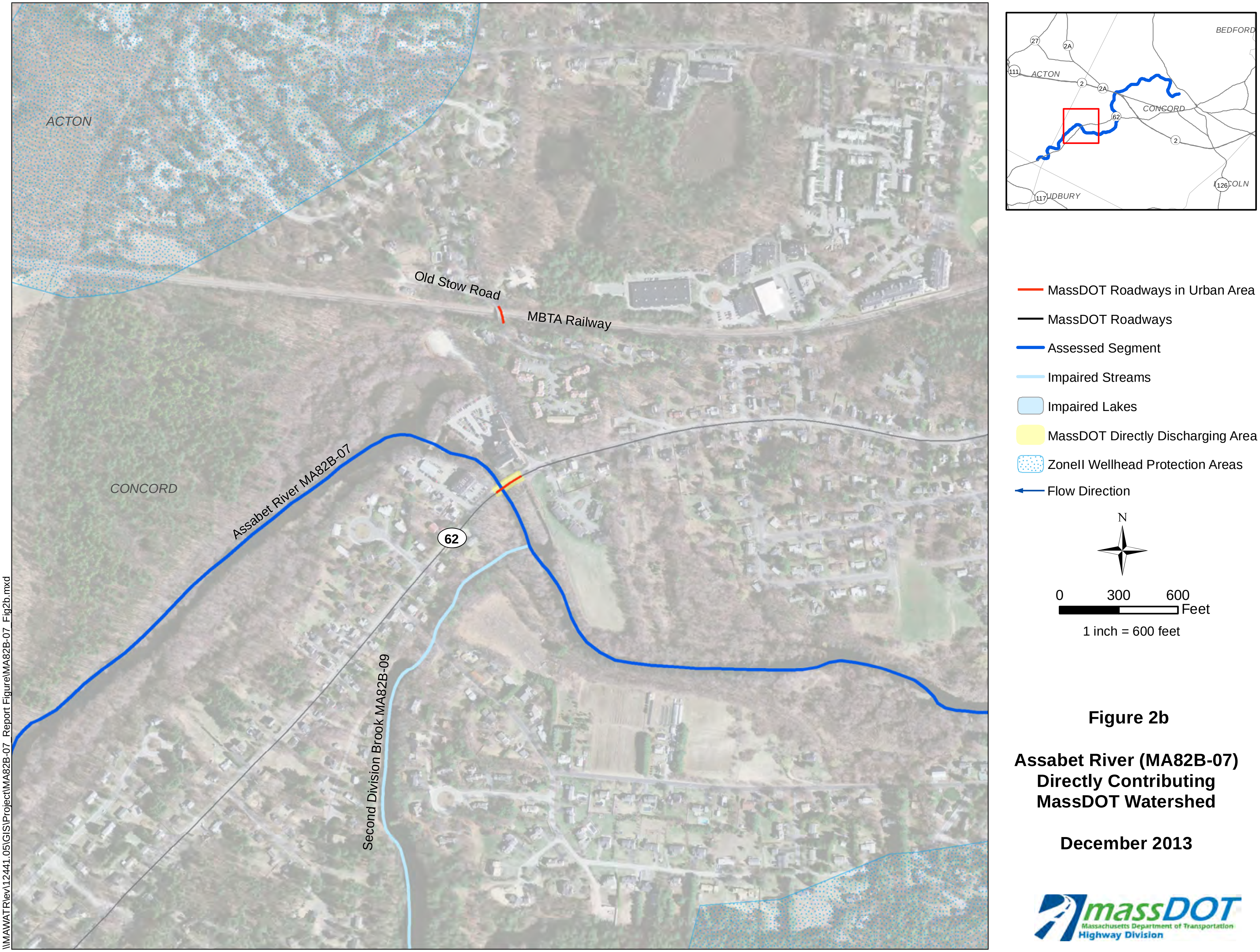

Figure 2b

Assabet River (MA82B-07) Directly Contributing MassDOT Watershed

December 2013

massDOT
Massachusetts Department of Transportation
Highway Division

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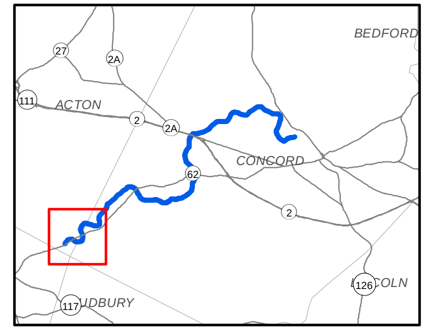

MassDOT Roadways in Urban Area

MassDOT Roadways

Assessed Segment

Impaired Streams

Impaired Lakes

MassDOT Directly Discharging Area

ZoneII Wellhead Protection Areas

Flow Direction

N

0 300 600 Feet

1 inch = 600 feet

Figure 2c

Assabet River (MA82B-07) Directly Contributing MassDOT Watershed

December 2013

massDOT Massachusetts Department of Transportation Highway Division

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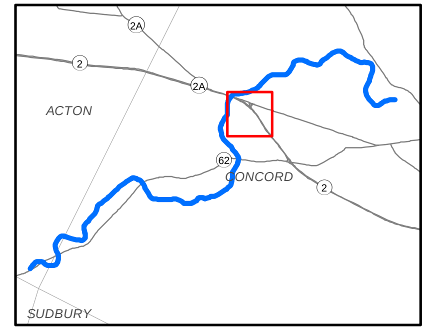

MassDOT Roadways in Urban Area

Assessed Segment

Proposed BMP Watersheds

DEP Wetlands

Flow Direction

N

0 150 300 Feet

1 inch = 300 feet

Figure 3

Assabet River (MA82B-07)
Proposed BMPs

December 2013

massDOT Massachusetts Department of Transportation Highway Division

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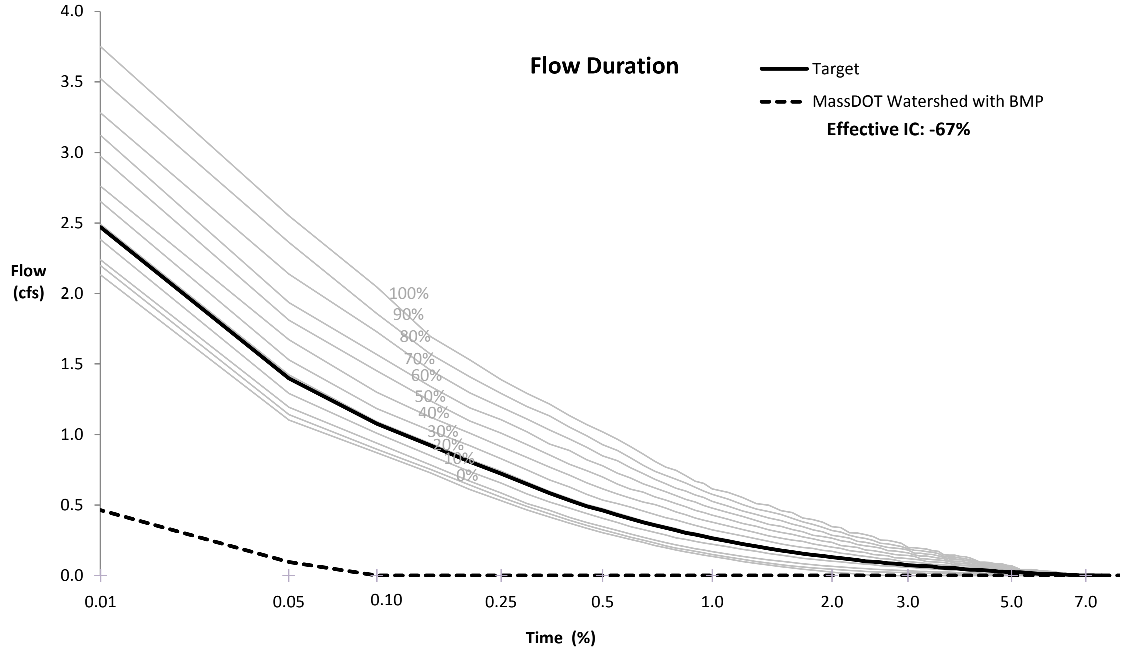
Result Summary

1.7 BMP 1



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	4.0	0.3	20
5%IC	4.6	1.0	407
10% IC	5.3	1.7	799
20% IC	6.6	3.0	1,582
30% IC	7.8	4.4	2,365
40% IC	9.1	5.9	3,149
50% IC	10.3	7.3	3,932
60% IC	11.6	8.7	4,715
70% IC	12.8	10.1	5,499
80% IC	14.0	11.5	6,282
90% IC	15.3	12.9	7,065
100% IC	16.6	14.3	7,852
Watershed Load	9.69	7.51	4,090
BMP Output	0.12	0.01	0
Target	7.60	4.19	2,223
Reduction %	**99%**	**100%**	**100%**
Effective IC	**-31%**	**-2%**	**0%**

Result Summary

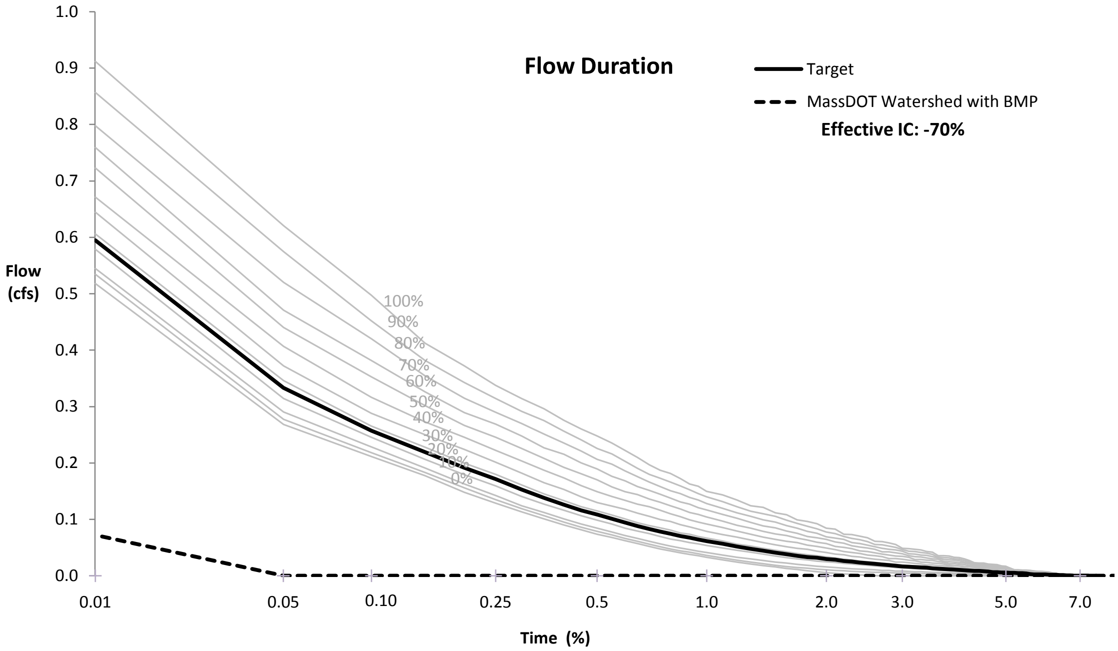
Metric	Area (%)	Area (acres)
Watershed Area		5.2
Watershed IC (no BMP)	52%	2.7
Target IC Reduction	46%	1.2
Effective IC w/BMP	-33%	-1.7
IC Reduction	163%	4.4

Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	1.8	3.2
Indirect Watershed	0.9	2.0
Total	2.7	5.2

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary
2.7 BMP 2



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	1.0	0.1	5
5%IC	1.1	0.2	99
10% IC	1.3	0.4	194
20% IC	1.6	0.7	385
30% IC	1.9	1.1	575
40% IC	2.2	1.4	766
50% IC	2.5	1.8	956
60% IC	2.8	2.1	1,147
70% IC	3.1	2.4	1,337
80% IC	3.4	2.8	1,528
90% IC	3.7	3.1	1,719
100% IC	4.0	3.5	1,910
Watershed Load	2.12	1.68	914
BMP Output	-	-	-
Target	1.78	0.94	498
Reduction %	**100%**	**100%**	**100%**
Effective IC	**-32%**	**-2%**	**0%**

Result Summary

Metric	Area (%)	Area (acres)
Watershed Area		1.3
Watershed IC (no BMP)	48%	0.6
Target IC Reduction	46%	0.3
Effective IC w/BMP	-34%	-0.4
IC Reduction	170%	1.0

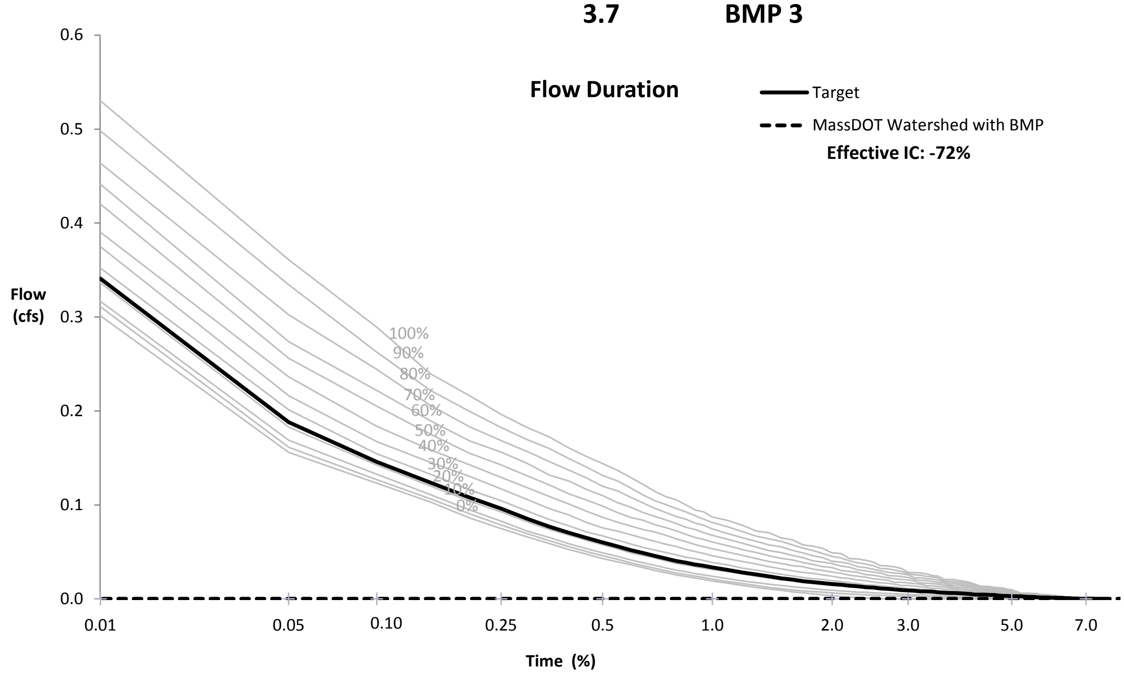
Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	0.6	1.3
Indirect Watershed	-	-
Total	0.6	1.3

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary

3.7 BMP 3



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	0.6	0.0	3
5%IC	0.7	0.1	58
10% IC	0.7	0.2	113
20% IC	0.9	0.4	224
30% IC	1.1	0.6	334
40% IC	1.3	0.8	445
50% IC	1.5	1.0	556
60% IC	1.6	1.2	667
70% IC	1.8	1.4	777
80% IC	2.0	1.6	888
90% IC	2.2	1.8	999
100% IC	2.3	2.0	1,110
Watershed Load	1.25	0.87	470
BMP Output	-	-	-
Target	0.98	0.49	255
Reduction %	**100%**	**100%**	**100%**
Effective IC	**-32%**	**-2%**	**0%**

Result Summary

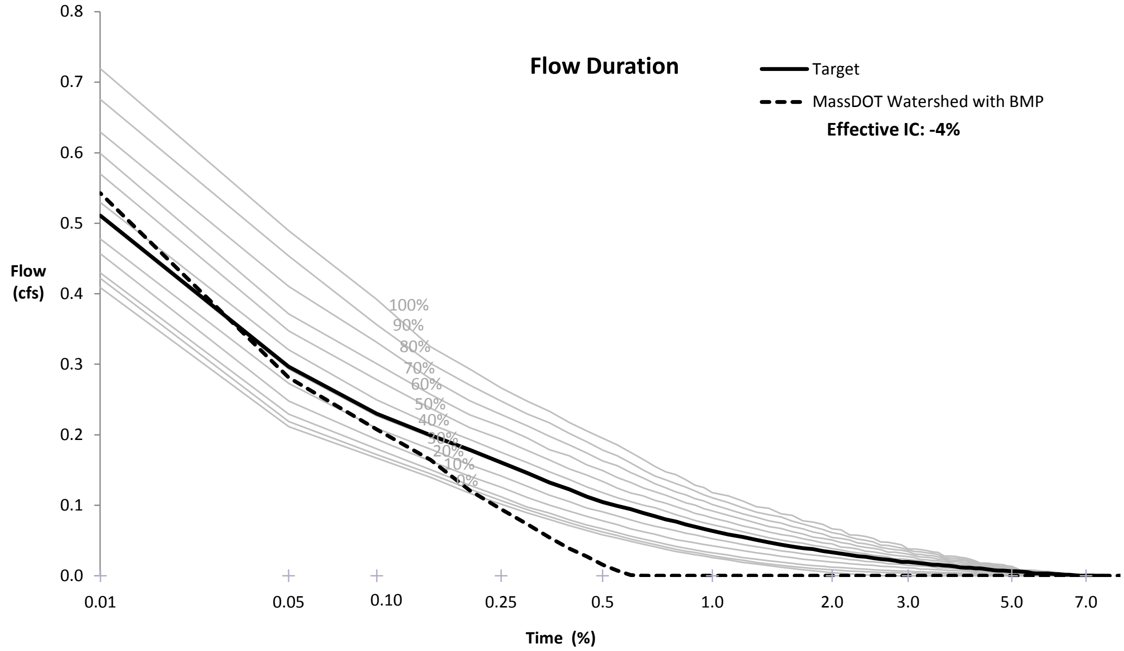
Metric	Area (%)	Area (acres)
Watershed Area		0.7
Watershed IC (no BMP)	42%	0.3
Target IC Reduction	46%	0.1
Effective IC w/BMP	-34%	-0.3
IC Reduction	181%	0.6

Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	0.3	0.7
Indirect Watershed	-	-
Total	0.3	0.7

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary
4.7 BMP 4



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	0.8	0.1	4
5%IC	0.9	0.2	78
10% IC	1.0	0.3	153
20% IC	1.3	0.6	303
30% IC	1.5	0.9	454
40% IC	1.7	1.1	604
50% IC	2.0	1.4	754
60% IC	2.2	1.7	904
70% IC	2.5	1.9	1,055
80% IC	2.7	2.2	1,205
90% IC	2.9	2.5	1,355
100% IC	3.2	2.7	1,506
Watershed Load	2.57	2.10	1,147
BMP Output	0.53	0.06	13
Target	1.77	1.15	622
Reduction %	**79%**	**97%**	**99%**
Effective IC	**-10%**	**0%**	**1%**

Result Summary

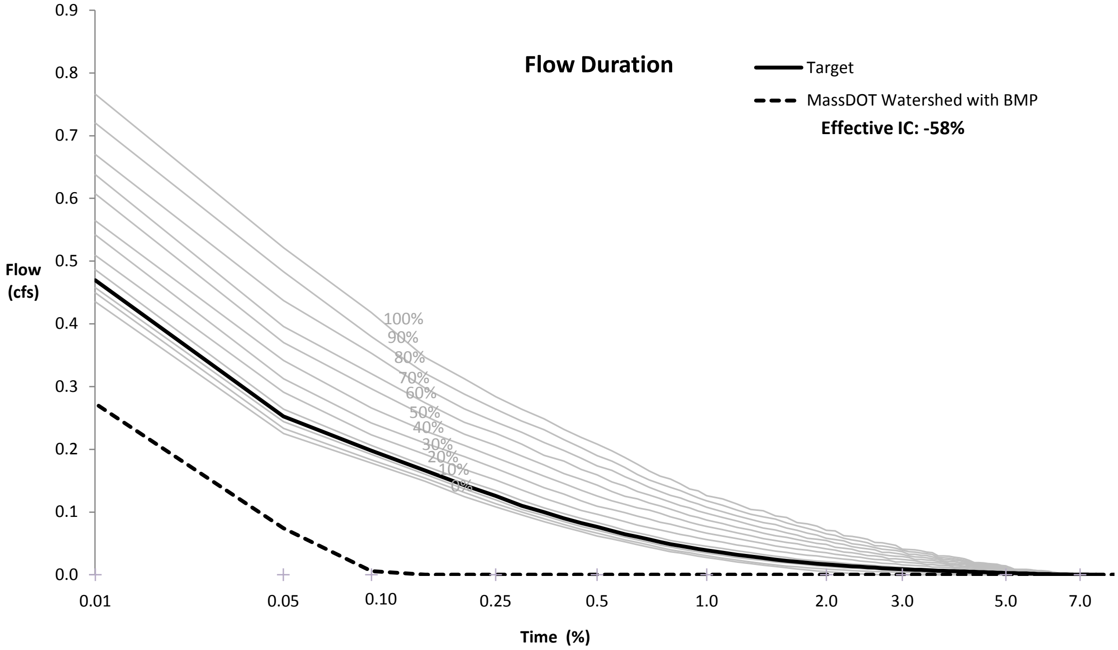
Metric	Area (%)	Area (acres)
Watershed Area		1.0
Watershed IC (no BMP)	76%	0.8
Target IC Reduction	46%	0.3
Effective IC w/BMP	-4%	0.0
IC Reduction	106%	0.8

Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	0.8	1.0
Indirect Watershed	-	-
Total	0.8	1.0

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary
5.7 BMP 5



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	0.8	0.1	4
5%IC	1.0	0.2	83
10% IC	1.1	0.3	163
20% IC	1.3	0.6	323
30% IC	1.6	0.9	483
40% IC	1.9	1.2	644
50% IC	2.1	1.5	804
60% IC	2.4	1.8	964
70% IC	2.6	2.1	1,124
80% IC	2.9	2.3	1,284
90% IC	3.1	2.6	1,444
100% IC	3.4	2.9	1,605
Watershed Load	1.30	0.80	424
BMP Output	0.09	0.01	0
Target	1.19	0.46	230
Reduction %	**93%**	**99%**	**100%**
Effective IC	**-28%**	**-2%**	**0%**

Result Summary

Metric	Area (%)	Area (acres)
Watershed Area		1.1
Watershed IC (no BMP)	26%	0.3
Target IC Reduction	46%	0.1
Effective IC w/BMP	-29%	-0.3
IC Reduction	209%	0.6

Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	0.3	1.1
Indirect Watershed	-	-
Total	0.3	1.1

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Impaired Waters Assessment for Nashoba Brook (MA82B-14)

Summary

Impaired Water[1]		Stormwater	Non-Stormwater[2]
	Impairments:	Fishes bioassessments	Low flow alterations
	Category	5 (Waters requiring a TMDL)	
	Final TMDLs:	None	
	WQ Assessment:	SuAsCo 2001 Water Quality Assessment Report[3]	
Location	**Towns:**	Westford, Acton, Concord	
	MassDOT Roads:	Great Road/Route 2A, Littleton Road, I-495, Route 2	
Assessment Method(s)	**7R (TMDL Method)**	☐	
	7U (IC Method)	☒	
BMPs	**Existing:**	None	
	Proposed:	6 Water Quality Swales	
MassDOT Contributing Area and Targets			Impervious Cover (IC)
	Directly Contributing Area		30.6 acres
	Contributing Area Reduction Target		8.5 acres
	Existing BMPs Reduction		0.0 acres
	Proposed BMPs Reduction		10.8 acres
	Remaining Treatment to Meet Target		0.0 acres

[1] MassDEP, 2013. Massachusetts Year 2012 Integrated List of Waters – Final Listing of the Condition of Massachusetts' Waters Pursuant to Sections 305(b), 314 and 303(d) of the Clean Water Act. Massachusetts. Available at: http://www.mass.gov/eea/docs/dep/water/resources/07v5/12list2.pdf

[2] MassDOT, December 2012. Impaired Waters Assessment for Impaired Waters with Impairments Unrelated to Stormwater. Available at: http://www.mhd.state.ma.us/downloads/projDev/ImpairedWaters_3/Year3_ImpairedWatersAssessment_1.pdf#page=308

[3] MassDEP, 2001. SuAsCo Watershed 2001 Water Quality Assessment Report. Available at: http://www.mass.gov/eea/docs/dep/water/resources/71wqar09/82wqar2.pdf

Site Description

Nashoba Brook, segment MA82B-14 runs 9.4 miles from just south of Route 110 in Westford through Ice House Pond, to its confluence with Fort Pond Brook (MA82B-13) in Concord as shown in Figure 1. The watershed of Nashoba Brook is comprised of commercial land used areas surrounded by medium density residential area, the remaining area is forested with some open space. According to MassDEP's Water Quality Assessment Report,[4] causes of impairment are nutrient loading from malfunction on-site wastewater systems, stormwater and non-point source pollutions from upstream waters.

Several MassDOT roads, I-495, Route 110, Powers Road, Route 2A and Route 2, directly discharge into Nashoba Brook. Figure 2a, 2b and 2c show the varying types of roadways, I-495 discharges two lanes and two shoulders from I-495 North and South, Route 110 discharges one lane and one shoulder in each direction, Powers Road discharges one lane in each direction, Route 2A discharges one lane and one shoulder in each direction and Route 2 discharges two lanes and one shoulder in each direction. The drainage system varies in each location, stormwater from I-495, Route 2 and Route 2A predominately uses drainage infrastructure for means of conveyance, where Route 110 and Powers Road rely on overland sheet flow to convey stormwater to Nashoba Brook.

Stormwater runoff from I-495 in Littleton is collected in drainage features and piped to outfalls at the banks of a large wetland system, shown in Figure 2a, that surrounds Nashoba Brook. The wetland is channelized throughout and is culverted under Route 110 and Interstate 495, this allows for stormwater to easily be conveyed to Nashoba Brook. The stormwater from the roadway surrounding the culvert under I-495 eventually enters a mainline in each of the pervious shoulders adjacent to the culvert. The mainlines outfall into the large wetland system at each corner of the culvert under I-495. The directly discharging area from Interstate 495 is sectionalized based on how where in the wetland the stormwater is discharged. Only the outfalls that enter the wetland northeast, southeast and southwest of the culvert are considered directly discharging, because the stormwater is discharged either into a defined channel or a paved water way that conveys the water to the channels in the wetland. The outfall that discharges to the northwest of the culvert does outfall to a natural channel however it must flow 1,500 feet through the wetland before reaching the culvert, therefore MassDOT determined that this outfall is not directly discharging.

The directly discharging area of Route 110 and Powers Road, presented on Figure 2a, contributes stormwater from two lanes and two shoulders from both roadways. Stormwater sheet flows into the pervious shoulders of the roadway and travel through small drainage ditches in the shoulder to Nashoba Brook.

The directly discharging area from Route 2A correlates to where Nashoba Brook runs parallel to Route 2A. Throughout Route 2A there are several small stormwater infrastructure systems that collect stormwater in catchbasins and pipe it to an outfall at the edge of Nashoba Brook or into small drainage ditches that flow to Nashoba Brook.

Figure 2c displays the directly discharging area from Route 2 which is constrained due to the neighboring water bodies Warners Pond (MA82110) and Fort Pond Brook (MA82B-13). Most stormwater runoff from west of the Nashoba Brook drains to Fort Pond Brook and most stormwater east of the Nashoba Brook drains to Warners Pond.

The environmental resources in the project area are outside of the locations that are proposed to install BMPs. However, there are some environmental resources within MassDOT's directly

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[4] MassDEP, 2001. *SuAsCo Watershed 2001 Water Quality Assessment Report*. Available at: http://www.mass.gov/eea/docs/dep/water/resources/71wqar09/82wqar1.pdf

contributing watershed to the Nashoba Brook, Zone II Wellhead Protection areas and MHC Historic Districts surround portions of Route 2A.

Existing BMPs

MassDOT did not identify any existing BMPs in place that treat directly discharging roadway runoff before reaching the impaired water segment.

Assessment

In cases where a TMDL has been approved, MassDOT assessed the waterbody for the impairments covered by the TMDL under the BMP 7R methodology. MassDOT has separately assessed the waterbody for any stormwater-related impairments that are not covered by the TMDL under the BMP 7U methodology. MassDOT assessed Nashoba Brook (MA82B-14) using the methodologies described below.

MassDOT has identified a subset of water body impairments in the Nashoba Brook Watershed which are not related to stormwater runoff. Specific impairments unrelated to stormwater for the Nashoba Brook include low flow alterations. In accordance to MassDOT's Impaired Waters Assessment for Impaired Waters with Impairments Unrelated to Stormwater in the December 8, 2012 EPA submittal, the non-pollutant impairments are not addressed as part of the Impaired Waters Program.[5]

BMP 7U for Impervious Cover Related Impairments

MassDOT assessed the stormwater-related impairments not addressed by a TMDL using the approach outlined in the Description of MassDOT's Application of Impervious Cover Method in BMP 7U[6] which was developed using the EPA Region I's Impervious Cover (IC) Method as a basis, described in EPA's Stormwater TMDL Implementation Support Manual.[7] MassDOT used the long-term continuous simulation model (the assessment model)[8] to estimate effective IC. Consistent with the findings of EPA and others, MassDOT concluded that when a watershed had less than 9% IC, stormwater was not the likely cause of the impairment.

MassDOT calculated the following values for the total contributing watershed and the subwatershed of the impaired water (Nashoba Brook) to determine the IC target. The total contributing watershed and the subwatershed are shown in Figure 1.

[5] MassDOT, December 2012. Impaired Waters Assessment for Impaired Waters with Impairments Unrelated to Stormwater. Available at: http://www.mhd.state.ma.us/downloads/projDev/ImpairedWaters_3/Year3_ImpairedWatersAssessment_1.pdf#page=308

[6] MassDOT, 6 April, 2011. Description of MassDOT's Application of Impervious Cover Method in BMP 7U (MassDOT Application of IC Method). http://www.mhd.state.ma.us/downloads/projDev/BMP_7U_ImpairedWaterbodiesAssessment.pdf

[7] ENSR 2006. *Stormwater TMDL Implementation Support Manual for US EPA Region 1*. ENSR International & EPA Region 1, Boston, MA. Available at http://www.epa.gov/region1/eco/tmdl/regionalpgrfs.html

[8] MassDOT, June 2012. Long-Term Continuous Simulation for Pollutant Loading and Treatment for MassDOT Impaired Waters Program. Available at: http://www.mhd.state.ma.us/downloads/projDev/ImpairedWaters_2/Attachment7.pdf

Impaired Segment Watershed

	Total Contributing Watershed	Subwatershed
Watershed Area	13,509 acres	8,742 acres
Impervious Cover (IC) Area	1,601 acres	1,087 acres
Percent Impervious	12 %	12%
IC Area at 9% Goal	1,216 acres	787 acres
Target Effective IC Reduction	24%	28 %

The total and subwatersheds are greater than 9% impervious indicating that stormwater is a likely contributor to the impairment. To meet the 9% effective IC target, the effective IC within the subwatershed will need to be reduced. Therefore, the effective IC of MassDOT's directly contributing area should also be reduced by the same percentage to meet the target. The following table shows how MassDOT calculated the target effective IC for MassDOT's contributing property.

MassDOT Directly Contributing Watershed

Directly Contributing Area	48.5 acres
Directly Contributing IC Area	30.6 acres
Percent Impervious	63 %
Target Effective IC Reduction (28 % Reduction of DOT Directly Contributing IC)	8.5 acres
Target Effective IC	46 %

This assessment has identified locations for potential stormwater BMPs and estimated the effective IC accounting for their treatment. The Proposed Mitigation Plan section describes the BMPs and their IC reduction performance.

Proposed Mitigation Plan

In this assessment, MassDOT has identified six stormwater BMPs that may be implemented on MassDOT property to mitigate the effective IC to address the Nashoba Brook impairments. These BMPs include six water quality swales, shown with their estimated contributing drainage areas in Figures 3a and 3b. These locations were chosen based on a cursory review of the drainage systems, topography, property lines, and other site constraints. The proposed swales are located within existing drainage ditches or pervious ROW area in the shoulders of the contributing roadways. Detailed survey, complete utility location information, official property ownership, and soils evaluation information will influence the final selection and design of BMPs. Below is a description of these proposed BMPs.

PR BMP 1&3

PR BMP 1 and 3 are proposed water quality swales, displayed on Figure 3a, that could be located within the median of Route 2 on either side of the Nashoba Brook crossing at Route 2. Currently, stormwater predominately sheet flows from the inner most lane and shoulder due to the crest in the road into the median where one drop inlet in the median adjacent to the brook captures the stormwater and discharges it to Nashoba Brook. At the proposed location for

PR BMP 3 there is a mainline located in median which collects stormwater from catch basins, located in the outer shoulders of Route 2 East and West. The mainline connects to the drop inlet in the median. This portion of Route 2 does not have any curbs that help direct stormwater to the catch basin and it is visible from site visits that most of the stormwater sheet flows to either the median or the shoulder. Therefore, for this assessment we have assumed the inner lanes as draining to the median. The proposed swale could treat stormwater from the catch basins by daylighting the outlets, and any stormwater that sheet flows from Route 2. Check dams could be added to the swale and the existing drop inlets could be raised to help increase storage and the potential for infiltration. The amount of treatment area provided by the swale is constrained by the limited width of the median. The soils in the potential locations of the swales are HSG A soils and HSG D soils, according to NRCS soils mapping which could impact the amount of infiltration that occurs.

PR BMP 2

PR BMP 2 is a proposed water quality swale located in the pervious shoulder adjacent to Route 2 East, located to the east of Nashoba Brook which can be seen on Figure 3a. Currently, stormwater from the outer lane and shoulder sheet flow into this pervious shoulder and is carried through an existing drainage ditch to the brook. The drainage ditch could be enhanced by installing check dams to increase storage to help promote infiltration. The basin is proposed within HSG A soils, according to NRCS soils mapping, but infiltration provided by the swale could be constrained due to a section of HSG D soils within the proposed area.

PR BMP 4-6

PR BMP 4, 5 and 6 are proposed water quality, shown in Figure 3b, swales located within existing drainage ditches in the shoulders of I-495 North and South. Currently, stormwater predominately sheet flows into the existing drainage ditches within the shoulders and medians. However some stormwater is captured either in catch basins within the shoulders or in drop inlets located within the pervious shoulders and medians. A mainline that runs under each of the areas proposed for BMPs 4, 5, and 6 which the catch basins and drop inlets discharge to. The swales are located in the pervious area above the mainline, the mainline will not interfere with the infiltration of the swale because they are likely deep underground. The amount of stormwater that could be treated by the proposed swales could be increased by discharging the outlets of the catch basins and median drop inlets into the swale. The amount of storage in the swale could be increased by installing check dams and raising the drop inlets, to promote infiltration. The length of PR BMP 4 is limited due to potential wetland conflict located at the outfall of the mainline and at the start of the paved waterway that carries the stormwater to the DEP identified wetland, regulating work that can be done in that area. The potential infiltration provided by the swales is limited due to the predominantly HSG C soils in the area.

The table below shows the proposed conditions, including BMPs with their MassDOT drainage areas and estimated effective IC reductions. The outputs from the assessment model showing effective IC analysis for each BMP are attached. As currently sized, the swales either completely infiltration or nearly infiltrate contributing runoff on an annual average basis, providing more than 100% reduction of effective IC.

Proposed Conditions

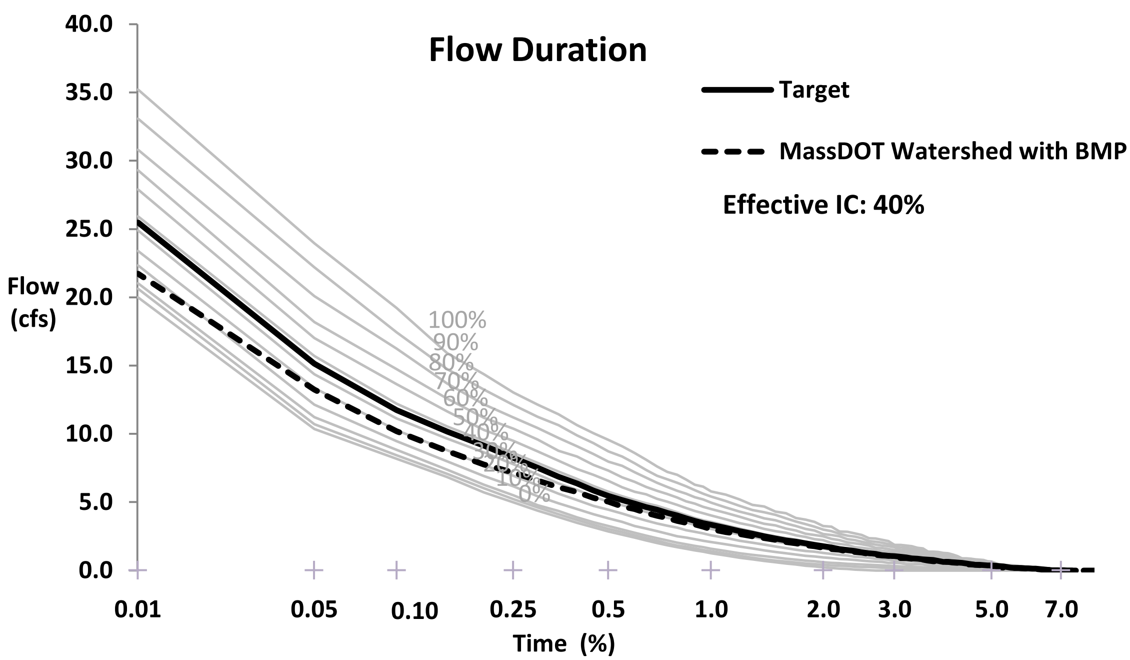
BMP Name	BMP Type	Contributing Effective IC (acres)	Estimated Percent Reduction	Estimated Reduction Effective IC (acres)
PR BMP 01	Water Quality Swale	0.4	161%	0.6
PR BMP 02	Water Quality Swale	0.3	168%	0.5
PR BMP 03	Water Quality Swale	0.2	131%	0.3
PR BMP 04	Water Quality Swale	3.3	170%	5.5
PR BMP 05	Water Quality Swale	1.6	162%	2.7
PR BMP 06	Water Quality Swale	1.4	113%	1.6
Total*		**30.6**	**35%**	**10.8**
Target				**8.5**

* Total effective IC reduction based on the assessment model results for the total MassDOT directly discharging drainage area to the receiving water (not sum of individual BMP reductions).

Note: The predicted effective IC is determined by comparing the BMP's calculated median annual discharge volume, runoff flow/duration relationship, median annual phosphorus load and median annual total suspended solids load to predicted discharge values for benchmark watersheds with the same size and varying percent IC. In cases where analysis predicts that BMPs would discharges less runoff volume and pollutant mass than those predicted for a 0% IC (pervious, woods in good condition) benchmark watershed, then the predicted effective IC removal would be greater than 100% and reduction of effective IC area will be greater than the BMP contributing IC area.

Proposed Median Annual Load Comparisons

Simulated IC Watersheds	Runoff (ac-ft)	TP (lb.)	TSS (lb.)
0% IC	37.7	2.7	184
5% IC	43.7	9.2	3,824
10% IC	49.6	15.6	7,503
20% IC	61.6	28.6	14,860
30% IC	73.5	41.7	22,217
40% IC	85.4	55.0	29,574
Target 46% IC	**92.4**	**62.9**	**33,988**
50% IC	97.0	68.2	36,931
60% IC	108.6	81.4	44,288
70% IC	120.2	94.6	51,644
80% IC	131.9	107.8	59,001
90% IC	144.0	121.0	66,358
100% IC	156.1	134.2	73,748
Existing Conditions	108.70	80.40	43,594
Proposed Conditions	83.00	60.52	32,886
Reduction %	**24%**	**25%**	**25%**
Effective IC	**38%**	**44%**	**45%**



Effective IC Results

Existing IC	30.6 acres
Proposed Estimated Effective IC	19.8 acres
IC Reduction % under Proposed Conditions	35%
Estimated Effective IC*	41%

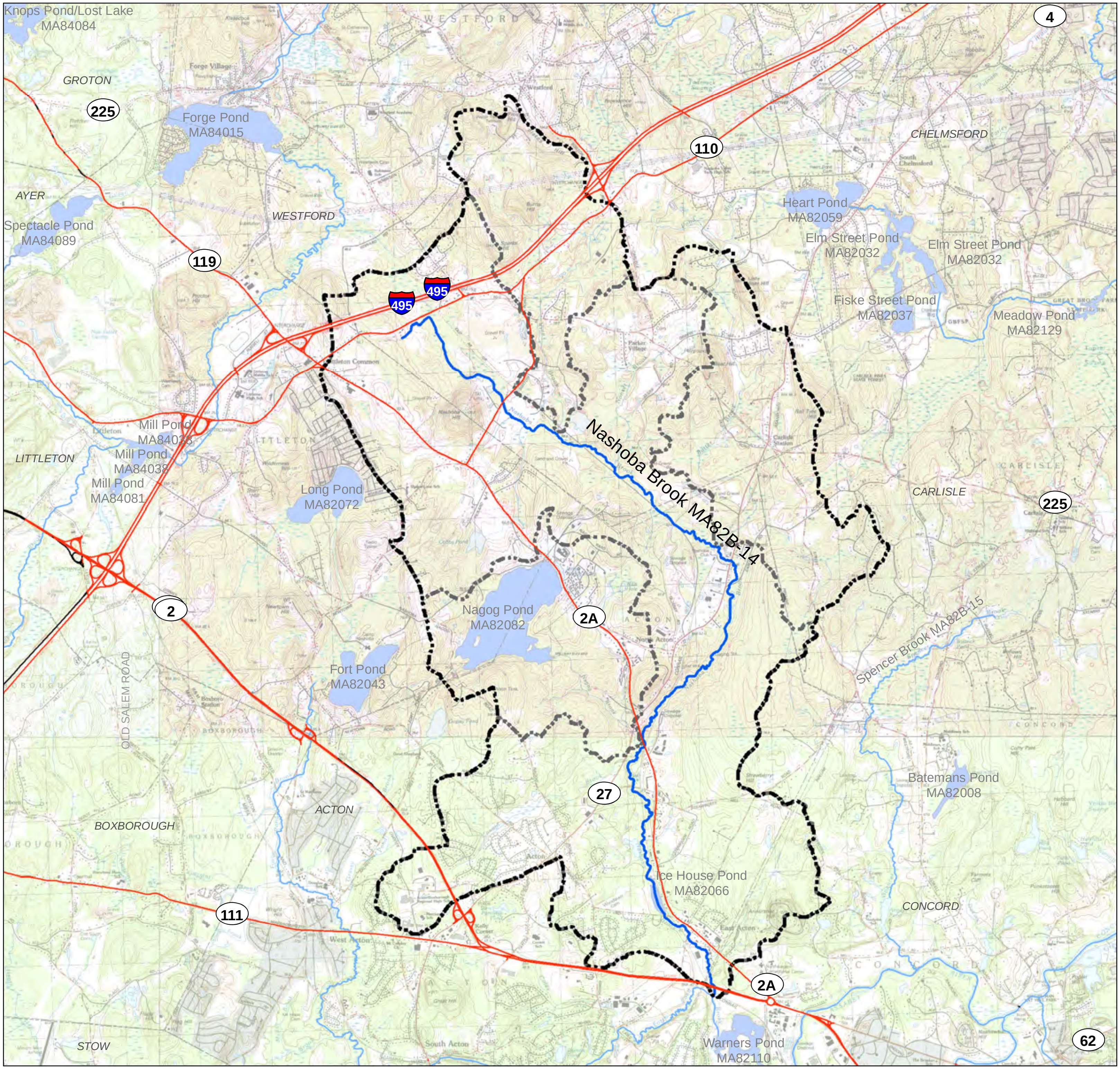
*Average of estimated effective IC for annual median runoff volume, phosphorus and TSS loads, and flow duration

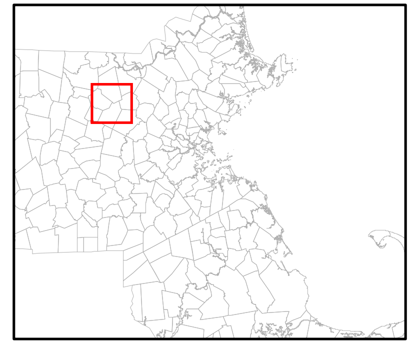
MassDOT estimated the effective IC under proposed conditions by comparing the annual median runoff volume, phosphorus and TSS loads, and flow distribution statistics (flow duration) from MassDOT drainage area to the receiving water to those results for simulated IC watersheds.

The proposed BMPs provide enough treatment to meet the target. All the proposed BMPs provide over 100% treatment and have little to no discharge, fully infiltrating contributing run off. While the objective of the Impaired Waters Retrofit Program is to meet the target reduction and not necessarily to construct retrofits to the maximum extent practicable, due to the higher costs and inefficiencies of retrofit projects, it has been MassDOT's experience that during design additional site constraints are identified and often reduce the final number of BMPs and/ or water quality treatment. Therefore, in this assessment we are including BMPs that provide treatment beyond the target and will prioritize the most effective BMPs during the design.

MassDOT will proceed to the design phase and develop construction plans for the proposed BMPs as part of the MassDOT Impaired Waters Program. The project designer will gather additional information in this phase, such as soil data, site survey, and wetland delineations to further refine the proposed BMPs. Once the design of the proposed BMPs is finalized, MassDOT will provide an update with additional information and summarize the effective IC reduction based on the as-built condition.

MassDOT will continue to ensure proper non-structural BMPs are being implemented within the watershed of Nashoba Brook, including regular roadway and drainage system maintenance, erosion and sedimentation control, and outreach and education. Further work by MassDOT on programmed projects, which often include broader scale road layout changes, may provide additional opportunities for construction of new treatment BMPs. This is consistent with an iterative adaptive management approach to address impairments. MassDOT will include an update in annual reports to EPA regarding progress made towards meeting target IC reductions, plans for construction of proposed BMPs and finalized assessments including reduction achieved by finalized BMP designs.





MassDOT Roadways in Urban Area

MassDOT Roadways

Assessed Segment

Subwatershed

Total Watershed

Impaired Streams

Impaired Lakes

N

0 3,000 6,000
Feet

1 inch = 6,000 feet

Figure 1

Nashoba Brook (MA82B-14) Watersheds

December 2013

massDOT
Massachusetts Department of Transportation
Highway Division

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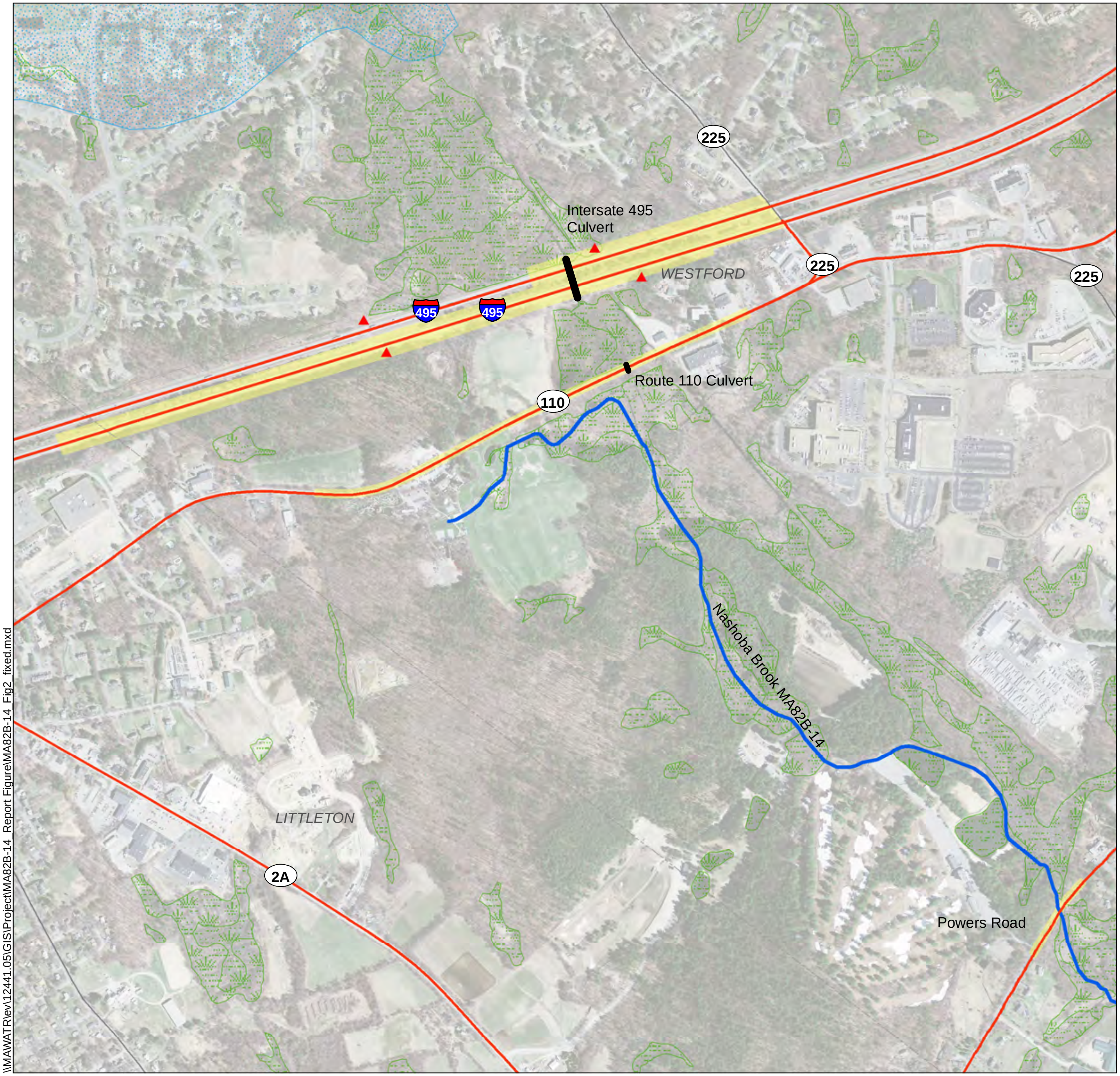

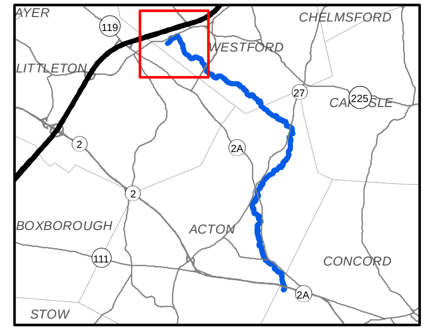

MassDOT Directly Contributing Area
MassDOT Outfalls
MassDOT Roadways in Urban Area
Assessed Segment
Impaired Streams
Impaired Lakes
DEP Wetlands
Zone II Wellhead Protection Areas

N

0 500 1,000 Feet

1 inch = 1,000 feet

Figure 2a

Nashoba Brook (MA82B-14)
Directly Contributing
MassDOT Watershed

December 2013

massDOT Massachusetts Department of Transportation Highway Division

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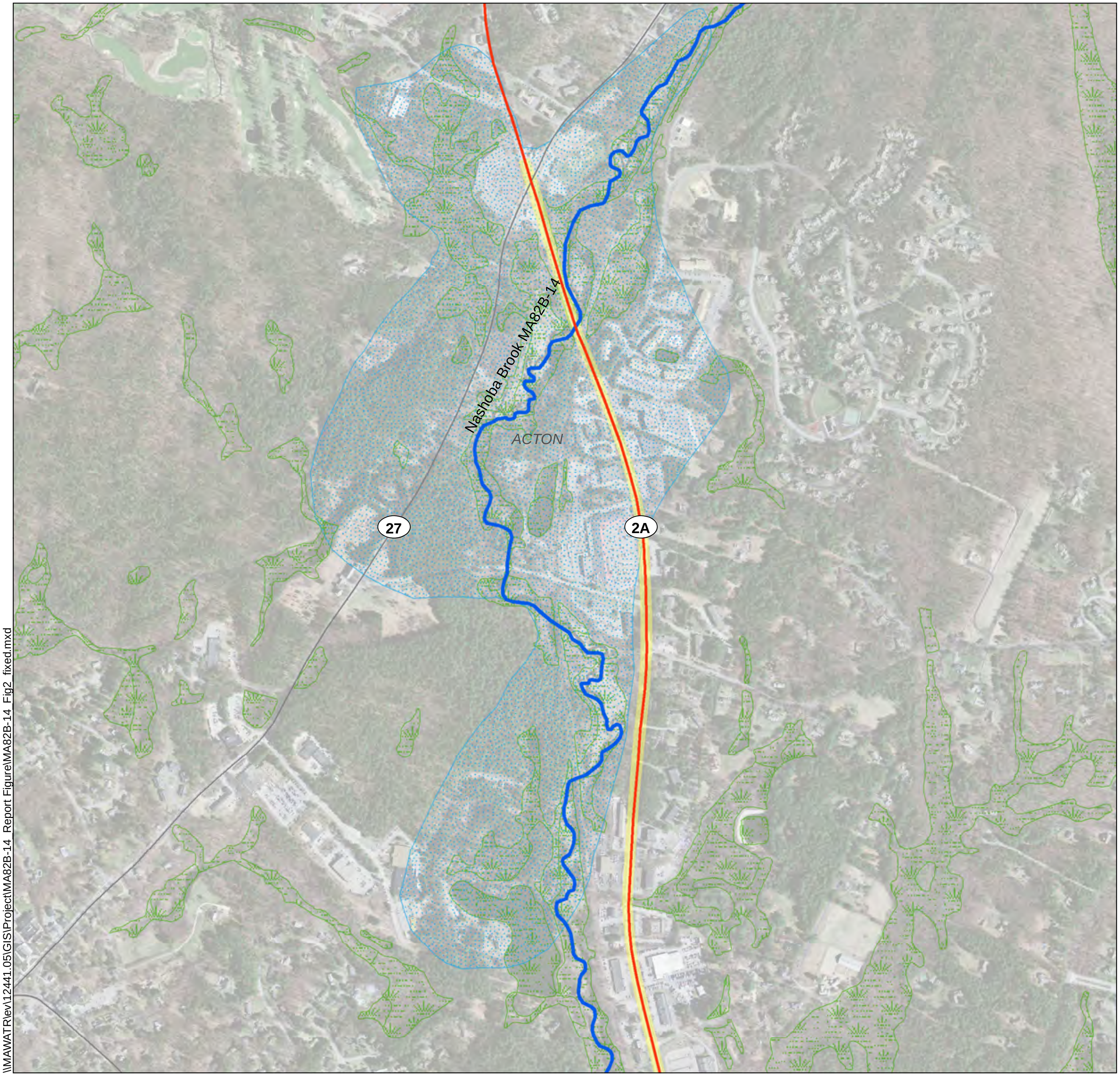

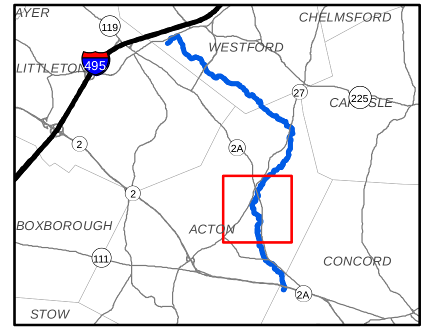

MassDOT Directly Contributing Area
MassDOT Outfalls
MassDOT Roadways in Urban Area
Assessed Segment
Impaired Streams
Impaired Lakes
DEP Wetlands
Zone II Wellhead Protection Areas

N

0 500 1,000 Feet

1 inch = 1,000 feet

Figure 2b

Nashoba Brook (MA82B-14) Directly Contributing MassDOT Watershed

December 2013

massDOT Massachusetts Department of Transportation Highway Division

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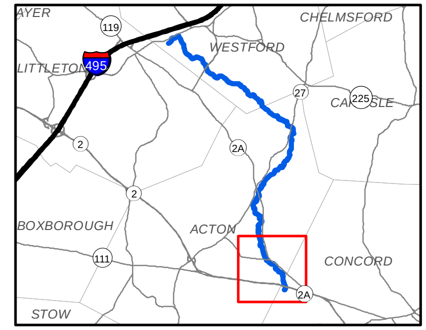

MassDOT Directly Contributing Area
MassDOT Outfalls
MassDOT Roadways in Urban Area
Assessed Segment
Impaired Streams
Impaired Lakes
DEP Wetlands
Zone II Wellhead Protection Areas

N

0 500 1,000 Feet

1 inch = 1,000 feet

Figure 2c

Nashoba Brook (MA82B-14)
Directly Contributing
MassDOT Watershed

December 2013

massDOT
Massachusetts Department of Transportation
Highway Division

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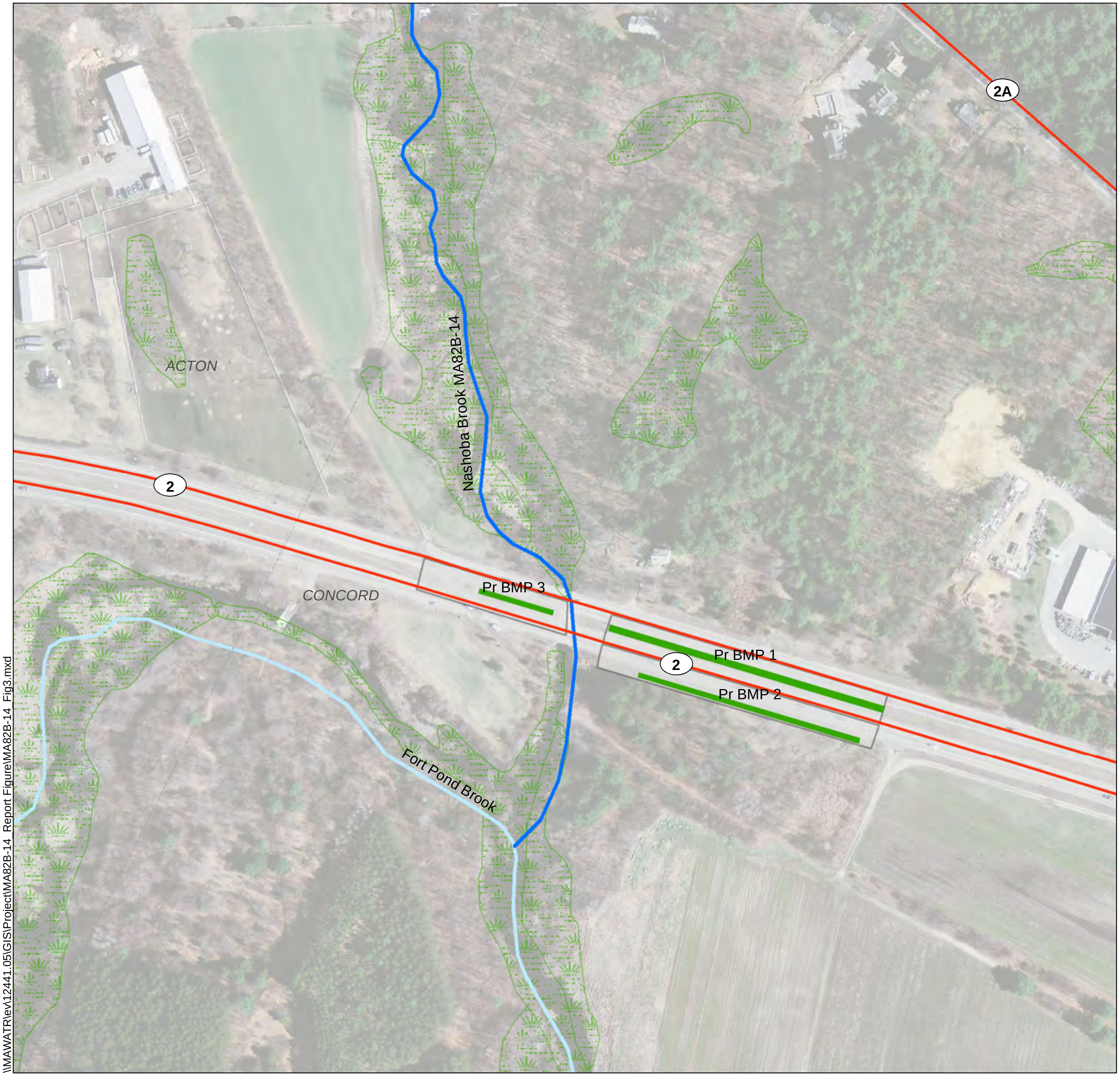
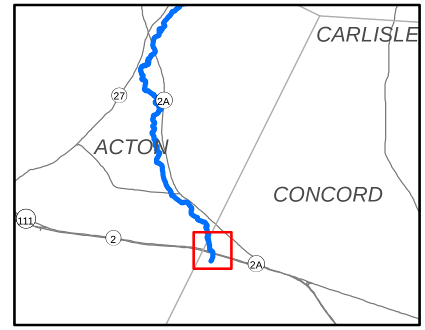




MassDOT Outfalls

MassDOT Roadways in Urban Area

Proposed BMPs

Proposed BMP Watersheds

Assessed Segment

DEP Wetlands

N

0 125 250 Feet

1 inch = 250 feet

Figure 3a

Nashoba Brook (MA82B-14)
Proposed BMPs

December 2013

massDOT Massachusetts Department of Transportation Highway Division

\\MAWATR\ev\12441.05\GIS\Project\MA82B-14_Report Figure\MA82B-14_Fig3.mxd

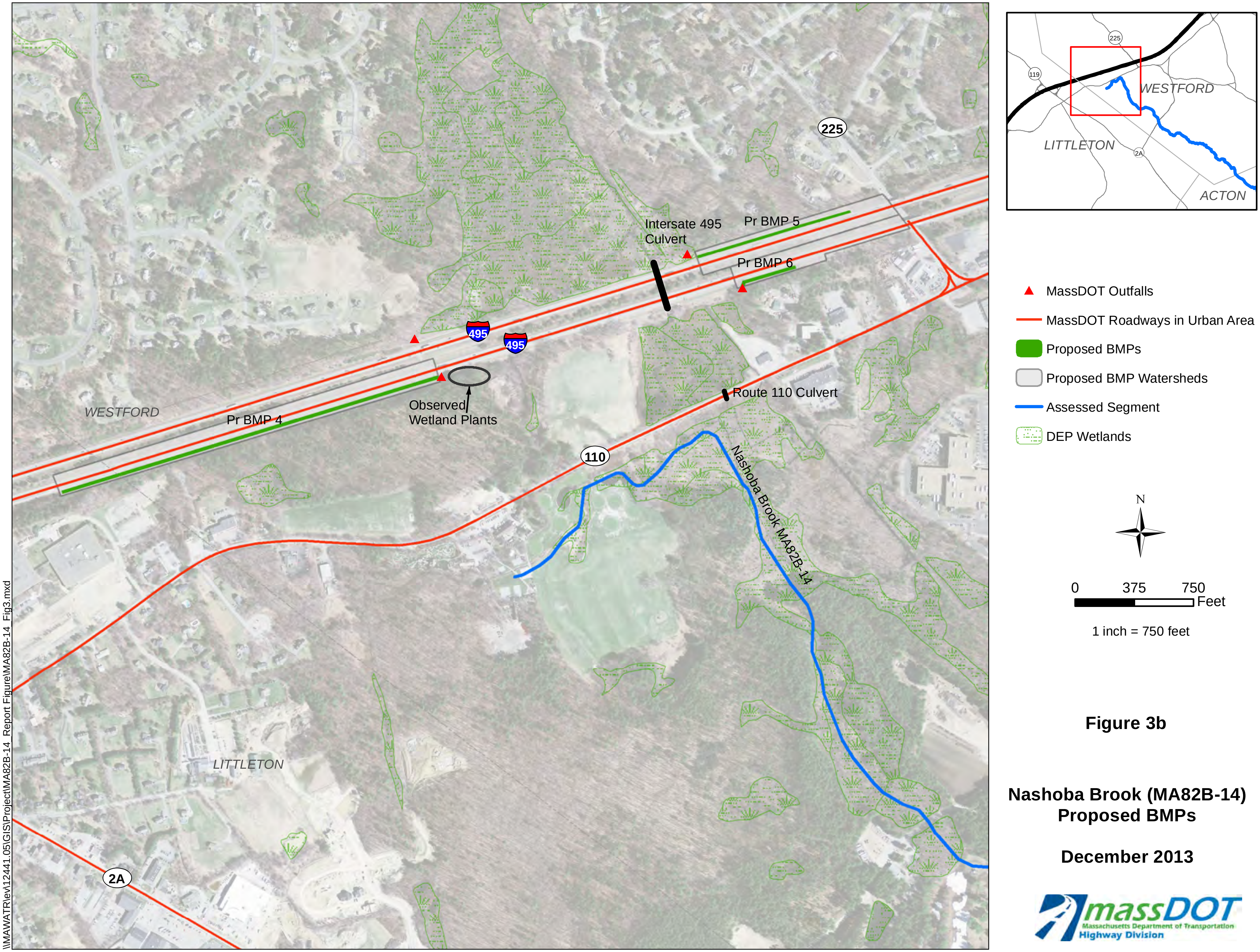
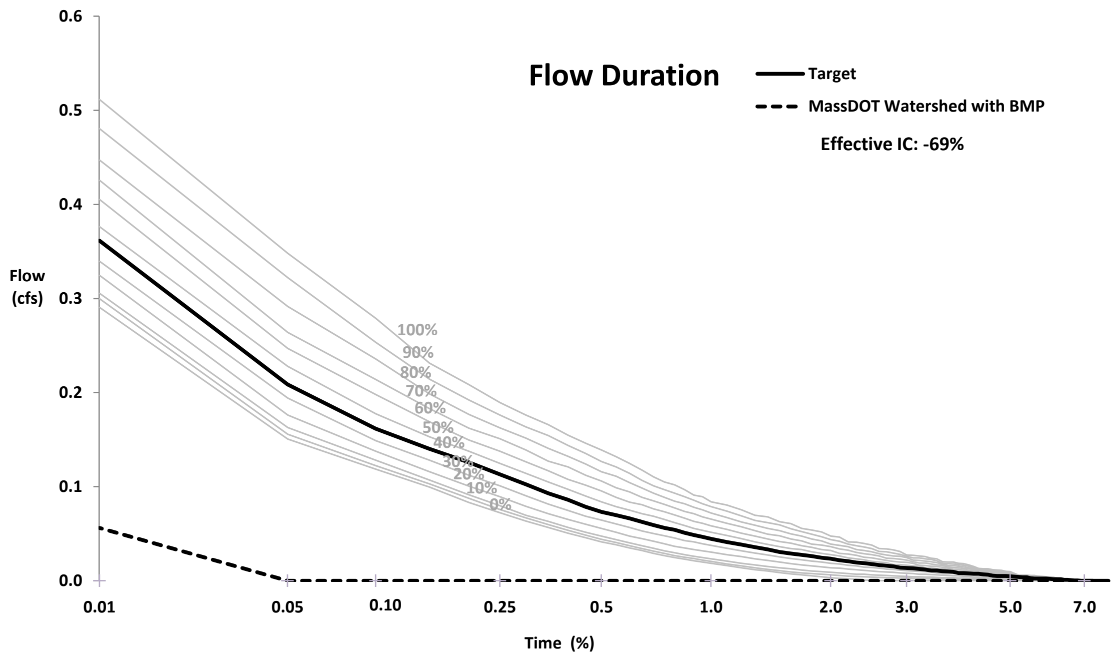


Figure 3b

Nashoba Brook (MA82B-14)
Proposed BMPs

December 2013

Result Summary
1.7 Pr BMP 1



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	0.5	0.0	3
5%IC	0.6	0.1	56
10% IC	0.7	0.2	109
20% IC	0.9	0.4	216
30% IC	1.1	0.6	323
40% IC	1.2	0.8	429
50% IC	1.4	1.0	536
60% IC	1.6	1.2	643
70% IC	1.7	1.4	750
80% IC	1.9	1.6	857
90% IC	2.1	1.8	964
100% IC	2.3	1.9	1,071
Watershed Load	1.39	1.09	593
BMP Output	-	-	-
Target	1.24	0.80	430
Reduction %	**100%**	**100%**	**100%**
Effective IC	**-32%**	**-2%**	**0%**

Result Summary

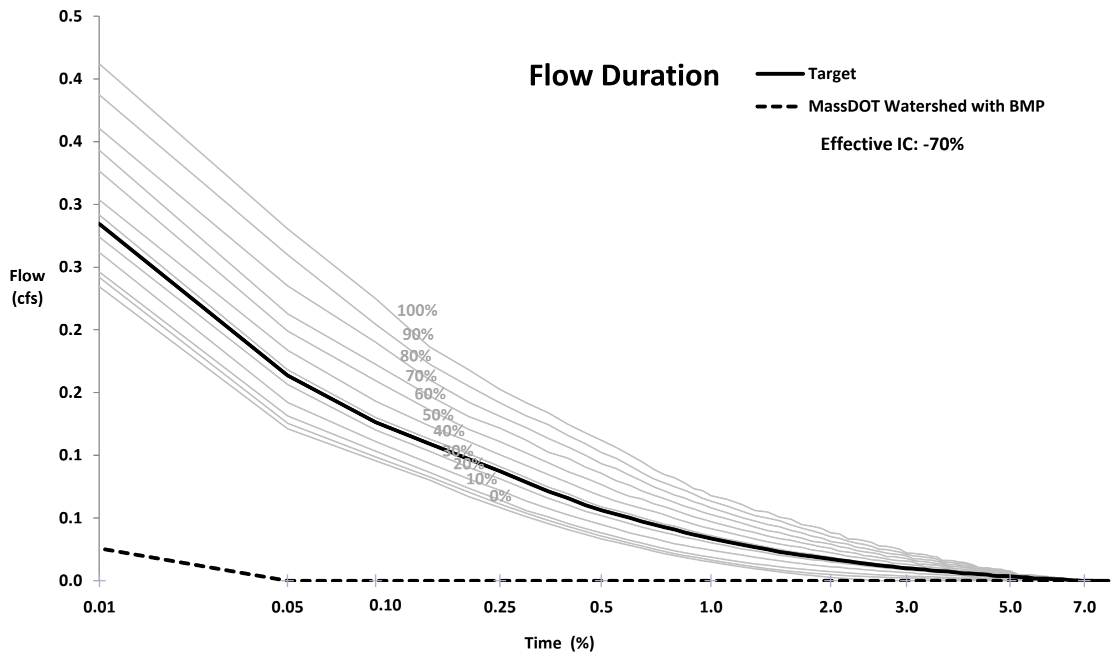
Metric	Area (%)	Area (acres)
Watershed Area		0.7
Watershed IC (no BMP)	55%	0.4
Target IC Reduction	28%	0.1
Effective IC w/BMP	-34%	-0.236227
IC Reduction	161%	0.6

Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	0.4	0.7
Indirect Watershed	-	-
Total	0.4	0.7

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary
2.7 Pr BMP 2



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	0.4	0.0	2
5%IC	0.5	0.1	45
10% IC	0.6	0.2	88
20% IC	0.7	0.3	174
30% IC	0.9	0.5	260
40% IC	1.0	0.6	346
50% IC	1.1	0.8	432
60% IC	1.3	1.0	518
70% IC	1.4	1.1	604
80% IC	1.5	1.3	690
90% IC	1.7	1.4	777
100% IC	1.8	1.6	863
Watershed Load	1.04	0.79	430
BMP Output	-	-	-
Target	0.95	0.58	313
Reduction %	**100%**	**100%**	**100%**
Effective IC	**-32%**	**-2%**	**0%**

Result Summary

Metric	Area (%)	Area (acres)
Watershed Area		0.6
Watershed IC (no BMP)	50%	0.3
Target IC Reduction	28%	0.1
Effective IC w/BMP	-34%	-0.192629
IC Reduction	168%	0.5

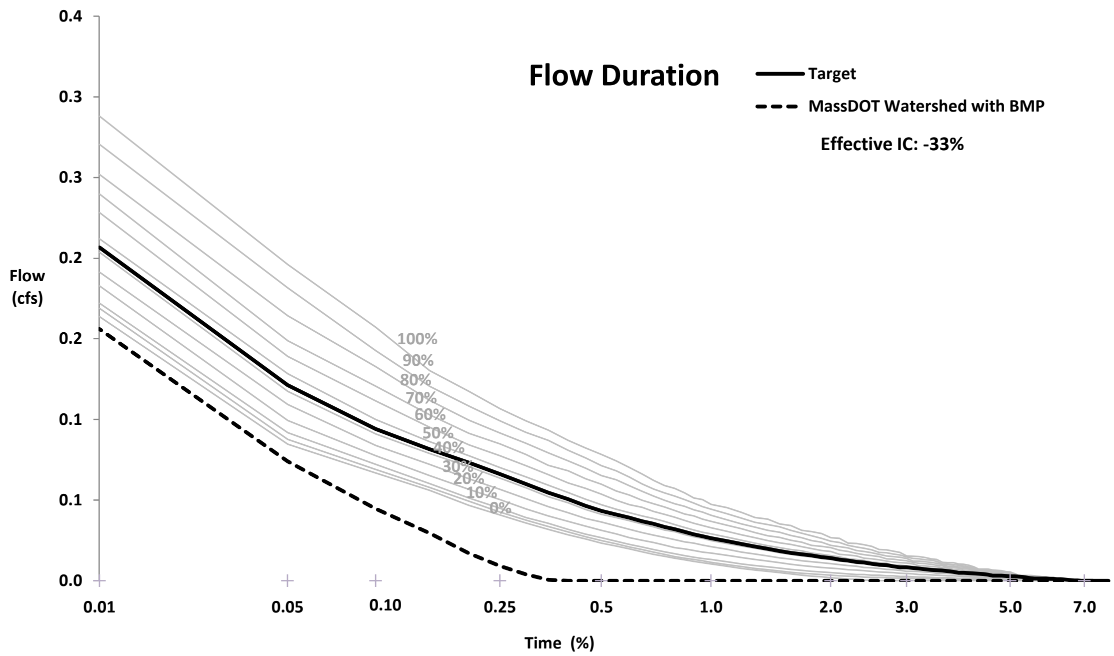
Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	0.3	0.6
Indirect Watershed	-	-
Total	0.3	0.6

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary

3.7 Pr BMP 3



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	0.3	0.0	2
5%IC	0.4	0.1	31
10% IC	0.4	0.1	61
20% IC	0.5	0.2	122
30% IC	0.6	0.3	182
40% IC	0.7	0.4	242
50% IC	0.8	0.6	302
60% IC	0.9	0.7	362
70% IC	1.0	0.8	422
80% IC	1.1	0.9	483
90% IC	1.2	1.0	543
100% IC	1.3	1.1	603
Watershed Load	0.84	0.67	363
BMP Output	0.09	0.01	1
Target	0.73	0.49	263
Reduction %	**89%**	**99%**	**100%**
Effective IC	**-22%**	**-1%**	**0%**

Result Summary

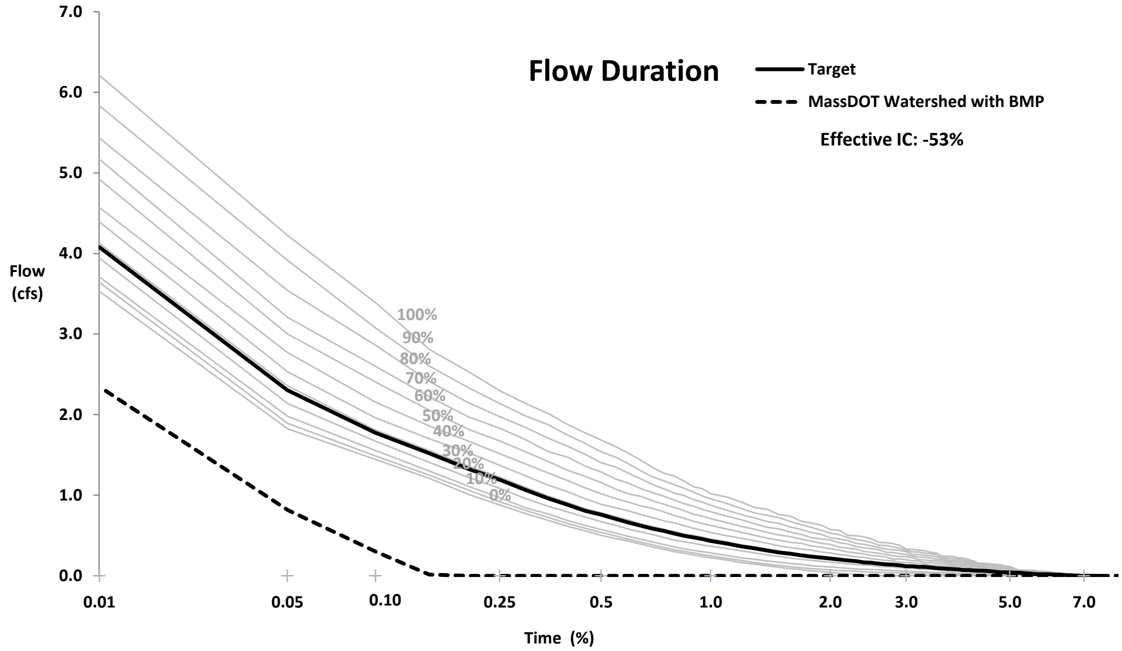
Metric	Area (%)	Area (acres)
Watershed Area		0.4
Watershed IC (no BMP)	60%	0.2
Target IC Reduction	28%	0.1
Effective IC w/BMP	-18%	-0.072902
IC Reduction	131%	0.3

Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	0.2	0.4
Indirect Watershed	-	-
Total	0.2	0.4

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary
4.7 Pr BMP 4



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	6.6	0.5	32
5%IC	7.7	1.6	674
10% IC	8.8	2.7	1,323
20% IC	10.9	5.0	2,620
30% IC	13.0	7.4	3,917
40% IC	15.1	9.7	5,214
50% IC	17.1	12.0	6,511
60% IC	19.2	14.3	7,808
70% IC	21.2	16.7	9,106
80% IC	23.3	19.0	10,403
90% IC	25.4	21.3	11,700
100% IC	27.5	23.7	13,003
Watershed Load	13.75	9.22	4,951
BMP Output	0.96	0.06	2
Target	12.46	6.80	3,606
Reduction %	**93%**	**99%**	**100%**
Effective IC	**-27%**	**-2%**	**0%**

Result Summary

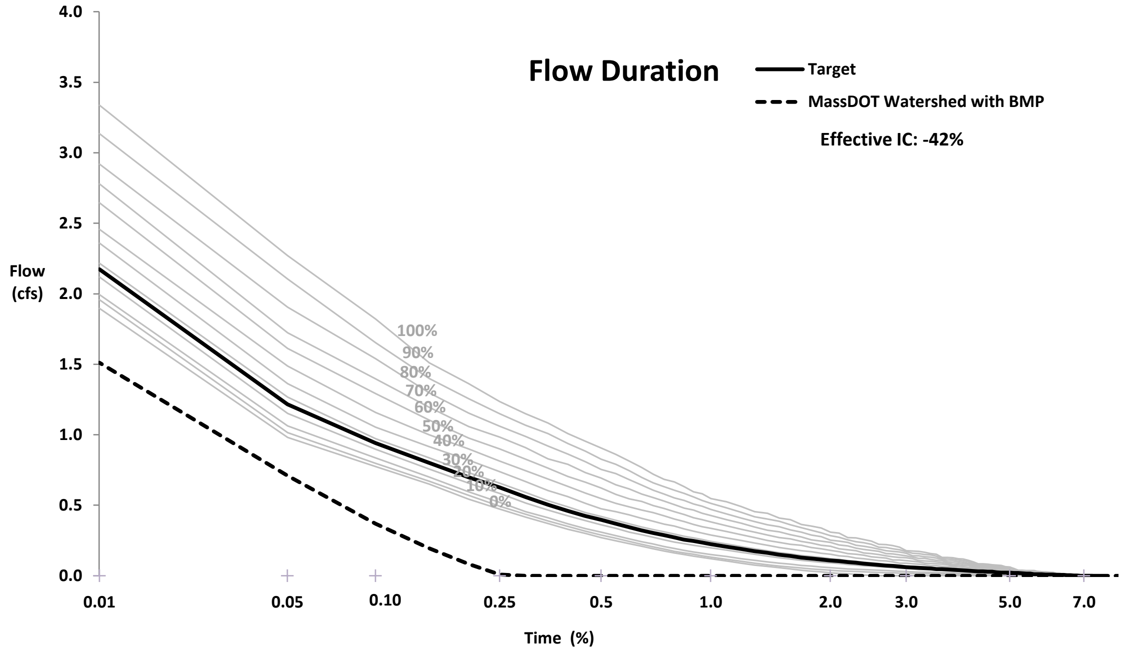
Metric	Area (%)	Area (acres)
Watershed Area		8.6
Watershed IC (no BMP)	38%	3.3
Target IC Reduction	28%	0.9
Effective IC w/BMP	-27%	-2.288867
IC Reduction	170%	5.5

Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	3.3	8.6
Indirect Watershed	-	-
Total	3.3	8.6

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary
5.7 Pr BMP 5



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	3.6	0.3	17
5%IC	4.1	0.9	362
10% IC	4.7	1.5	711
20% IC	5.8	2.7	1,408
30% IC	7.0	4.0	2,106
40% IC	8.1	5.2	2,803
50% IC	9.2	6.5	3,500
60% IC	10.3	7.7	4,197
70% IC	11.4	9.0	4,895
80% IC	12.5	10.2	5,592
90% IC	13.6	11.5	6,289
100% IC	14.8	12.7	6,990
Watershed Load	7.09	4.62	2,475
BMP Output	0.86	0.06	3
Target	6.49	3.42	1,808
Reduction %	**88%**	**99%**	**100%**
Effective IC	**-24%**	**-2%**	**0%**

Result Summary

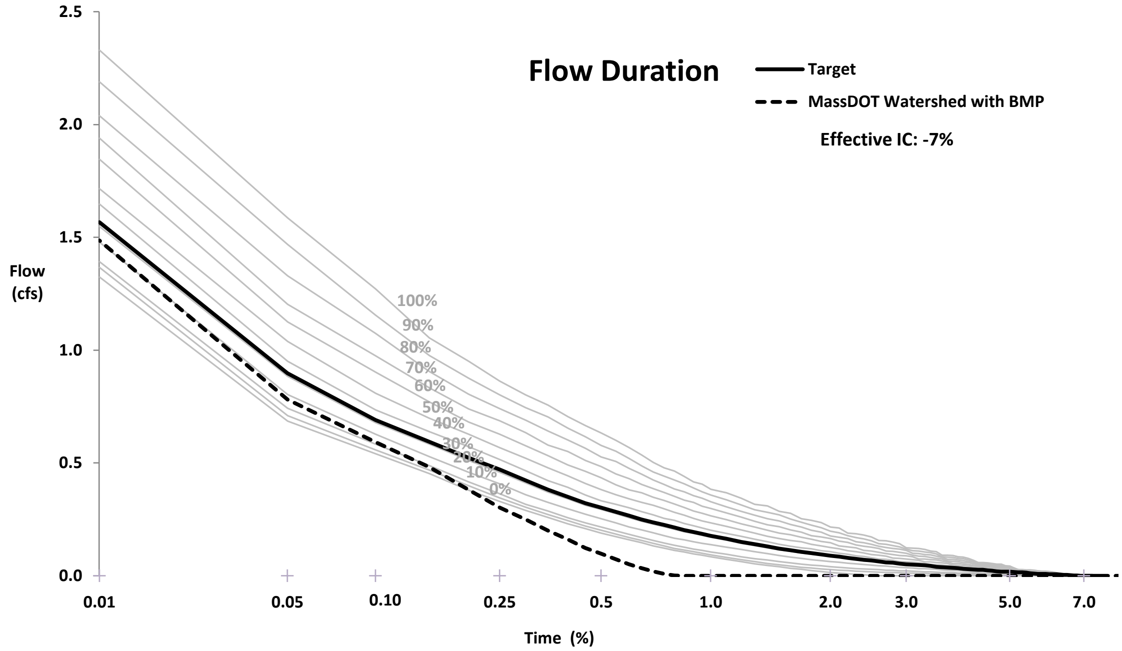
Metric	Area (%)	Area (acres)
Watershed Area		4.6
Watershed IC (no BMP)	36%	1.6
Target IC Reduction	28%	0.5
Effective IC w/BMP	-22%	-1.018043
IC Reduction	162%	2.7

Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	1.6	4.6
Indirect Watershed	-	-
Total	1.6	4.6

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary
6.7 Pr BMP 6



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	2.5	0.2	12
5%IC	2.9	0.6	253
10% IC	3.3	1.0	496
20% IC	4.1	1.9	983
30% IC	4.9	2.8	1,470
40% IC	5.7	3.6	1,957
50% IC	6.4	4.5	2,444
60% IC	7.2	5.4	2,931
70% IC	8.0	6.3	3,417
80% IC	8.7	7.1	3,904
90% IC	9.5	8.0	4,391
100% IC	10.3	8.9	4,880
Watershed Load	5.66	3.98	2,149
BMP Output	1.67	0.17	34
Target	5.02	2.94	1,567
Reduction %	**71%**	**96%**	**98%**
Effective IC	**-10%**	**0%**	**0%**

Result Summary

Metric	Area (%)	Area (acres)
Watershed Area		3.2
Watershed IC (no BMP)	44%	1.4
Target IC Reduction	28%	0.4
Effective IC w/BMP	-6%	-0.183761
IC Reduction	113%	1.6

Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	1.4	3.2
Indirect Watershed	-	-
Total	1.4	3.2

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Impaired Waters Assessment for Shawsheen River (MA83-01)

Summary

		Stormwater	Non-Stormwater[2]
Impaired Water[1]	**Impairments:**	Fecal coliform, dissolved oxygen, sedimentation/siltation	Physical substrate habitat alterations
	Category:	5 (Waters requiring a TMDL)	
	Final TMDLs:	Bacteria TMDL for the Shawsheen River Basin[3]	
	WQ Assessment:	Shawsheen River Watershed 2000 Water Quality Assessment Report[4]	
Location	**Towns:**	Bedford	
	MassDOT Roads:	Route 4 (The Great Road)	
Assessment Method(s)	**7R (TMDL Method)**	☐	
	7U (IC Method)	☒	
BMPs	**Existing:**	None	
	Proposed:	None	

		Impervious Cover (IC)
MassDOT Contributing Area and Targets	**Directly Contributing Area**	2.3 acres
	Contributing Area Reduction Target	1.5 acres
	Existing BMPs Reduction	0 acres
	Proposed BMPs Reduction	0 acres
	Remaining Reduction to Meet Target	1.5 acres

[1] MassDEP, 2013. Massachusetts Year 2012 Integrated List of Waters – Final Listing of the Condition of Massachusetts' Waters Pursuant to Sections 305(b), 314 and 303(d) of the Clean Water Act. Massachusetts. Available at: http://www.mass.gov/eea/docs/dep/water/resources/07v5/12list2.pdf

[2] MassDOT, December 2012. Impaired Waters Assessment for Impaired Waters with Impairments Unrelated to Stormwater. Available at: http://www.mhd.state.ma.us/downloads/projDev/ImpairedWaters_3/Year3_ImpairedWatersAssessment_1.pdf#page=308

[3] MassDEP. 2002. Bacteria TMDL for the Shawsheen River Basin. Available at: http://www.mass.gov/eea/docs/dep/water/resources/n-thru-y/shawshee.pdf

[4] MassDEP, 2000. Shawsheen River Watershed 2000 Water Quality Assessment Report. Available at: http://www.mass.gov/eea/docs/dep/water/resources/71wqar09/83wqar.pdf

Site Description

Shawsheen River (MA83-01) is a 1.7-mile long stream segment in Bedford, Massachusetts. The stream begins at Summer Street in Bedford where the segment that forms the headwaters, Shawsheen River (MA83-08), ends. Shawsheen River flows north and passes under Route 4, or The Great Road, before joining with Elm Brook (MA83-05). Shawsheen River continues north and ends at its confluence with Spring Brook (MA83-14) where the next segment of Shawsheen River (MA83-17) begins. The total watershed to this Shawsheen River segment is 13.8 square miles and is shown in Figure 1. It includes portions of Bedford, Lexington, Lincoln, and Concord. The subwatershed, which includes portions of the same towns, is 7.8 square miles and is also shown in Figure 1. The southwest portion of the subwatershed is dominated by the Hanscom Air Force Base, which includes the airport and associated residential area. The base occupies approximately one quarter of the entire subwatershed. The rest of the subwatershed is predominantly residential with large forested areas interspersed throughout. A strip of commercial and residential space runs in parallel to I-95 through the center of the subwatershed.

According to the 2000 Water Quality Assessment Report for the Shawsheen River Watershed, the Shawsheen River Watershed Storm Drain Assessment Project conducted in 2002 involved collection of water samples analyzed for fecal coliform and E. coli bacteria from six storm drains within the vicinity of Shawsheen River. The storm drains are confirmed sources of bacteria. Elevated fecal coliform levels led the Primary Contact Recreational Use to be classified as impaired and the Secondary Contact Recreational Use to be classified as support.

Approximately 2,000 linear feet of MassDOT-owned Route 4 discharge directly to Shawsheen River, as shown in Figure 2. At the river crossing, Route 4 is a two-lane road. The subwatershed boundary for Shawsheen River cuts through The Great Road Shopping Center, which is located just to the west of Shawsheen River and demarcates the end of the directly discharging area. To the east of Shawsheen River, the directly discharging portion of Route 4 ends at the next high point in the road profile.

The MassDOT right of way along Route 4 extends only to the boundary of the road, which is tightly lined by homes and business on either side of the directly discharging area. Shawsheen Cemetery, a protected open space and historical area, is adjacent to the intersection of Route 4 and Shawsheen Road. The Smith Bell Farm Carriage House is located on the southern side of the same intersection and is also of historical significance. A former Gulf station, currently a Jiffy Lube, is located adjacent to Shawsheen River and is classified as a MassDEP Oil Hazardous Material AUL site. North of the intersection of Route 4 and Shawsheen Road, the Bedford Department of Public Works maintains drinking water wells which are protected by Zone II Wellhead Protection Areas.

Existing BMPs

MassDOT did not identify any existing BMPs in place to treat directly discharging roadway runoff before reaching the impaired water segment.

Assessment

In cases where a TMDL has been approved, MassDOT assessed the waterbody for the impairments covered by the TMDL under the BMP 7R methodology. MassDOT has separately assessed the waterbody for any stormwater-related impairments that are not covered by the TMDL under the BMP 7U methodology. MassDOT assessed Shawsheen River (MA83-01) using the methodologies described as follows.

MassDOT has identified a water body impairment in the Shawsheen River Watershed which is not related to stormwater runoff. The specific impairment unrelated to stormwater for the Shawsheen River is physical substrate habitat alterations. In accordance with MassDOT's Impaired Waters Assessment for Impaired Waters with Impairments Unrelated to Stormwater in the December 8, 2012 EPA submittal, non-pollutant impairments are not addressed as part of the Impaired Waters Program.[5]

BMP 7R for Pathogen TMDL (CN 122.0)

MassDOT assessed the pathogen impairment using the approach described in BMP 7R of MassDOT's Storm Water Management Plan (SWMP).[6] The Total Maximum Daily Load (TMDL) of Bacteria for Shawsheen River Basin (CN 122.0) covers the Shawsheen River.[7] The TMDL states that sources of indicator bacteria include illicit sewer connections, sewer line leaks, septic systems, and urban stormwater runoff.

Pathogen concentrations in stormwater vary widely temporally and spatially; concentrations can vary by an order of magnitude within a given storm event at a single location.[8] Therefore, it is difficult to predict pathogen concentrations in stormwater with accuracy. MassDOT's South East Expressway study measured bacterial concentration in stormwater runoff[9] and data indicated that highway's pathogen loading may be lower than urban areas. Considering that the potential sources of pathogens (e.g. illicit discharges, sewer utilities, pet waste and wildlife) are likely to be less prevalent in the highway environment than along urban roads, this finding is not surprising.

MassDOT does not conduct site specific assessments of loading at each location impaired for pathogens. Instead, MassDOT reviewed its existing programs and their consistency with EPA NPDES MS4 general permit requirements and pathogen TMDL requirements. The TMDL states that sources of indicator bacteria in the Shawsheen River Watershed were found to be many and varied. On page 1, the TMDL states that "urban stormwater runoff is much more difficult to control, so additional monitoring is recommended to pinpoint urban stormwater runoff sources before implementing controls. There are a lot of good housekeeping type practices (e.g., proper pet waste removal, street sweeping, reduction in runoff volumes through diversions of impervious areas to impervious areas, etc.) that should not be delayed until more data are collected." MassDOT implements a variety of non-structural BMP programs across their system in accordance with their existing SWMP including educational programs, illicit connection review and source control.

MassDOT has an ongoing inspection and monitoring program aimed at identifying and addressing illicit discharges to MassDOT's stormwater management system. Any illicit discharges to MassDOT's system could contribute pathogens to impaired waters, however, MassDOT's existing Illicit Discharge Detection and Elimination (IDDE) program is aimed at identifying and addressing these contributions. District maintenance staff note signs of potential illicit discharges, such as dry weather flow and notable odors or sheens. Similarly, Resident Engineers overseeing construction projects also receive instruction regarding the need to note any suspicious connections or flows, and report these for follow-up investigation and action as appropriate. MassDOT will continue to

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5 MassDOT, December 2012. Impaired Waters Assessment for Impaired Waters with Impairments Unrelated to Stormwater. Available at: http://www.mhd.state.ma.us/downloads/projDev/ImpairedWaters_3/Year3_ImpairedWatersAssessment_1.pdf#page=308

6 Massachusetts Department of Transportation (MassDOT), July 22, 2010. BMP 7R: TMDL Watershed Review. Available at: http://www.mhd.state.ma.us/downloads/projDev/BMP_7R_TMDL_WatershedReview.pdf

7 Mass DEP 2002. *Bacteria TMDL for the Shawsheen River (CN 122.0).* Available at: http://www.mass.gov/eea/docs/dep/water/resources/n-thru-y/shawshee.pdf

8 MassDEP. 2009. Final Pathogen TMDL for the Cape Cod Watershed. Available at: http://www.mass.gov/dep/water/resources/capecod1.pdf

9 Smith. (2002). Effectiveness of Three Best Management Practices for Highway Runoff Quality along the Southeast Expressway. USGS Water Resources Investigations Report 02-4059. Boston, Massachusetts.

implement this IDDE training, and District staff will continue to report any suspicious flows requiring further investigation. MassDOT investigates any suspicious flows noted, and proceeds to work with owners of confirmed illicit discharges to remove these flows, and thereby minimize pathogen contributions to receiving waters.

MassDOT believes the existing efforts are consistent with the TMDL recommendations.

BMP 7U for Impervious Cover Related Impairments

The Shawsheen River pathogen TMDL does not address all of the Shawsheen River's impairments including dissolved oxygen and sedimentation/siltation. Therefore, MassDOT assessed the stormwater-related impairments not addressed by a TMDL using the approach outlined in the Description of MassDOT's Application of Impervious Cover Method in BMP 7U[10] which was developed using the EPA Region I's Impervious Cover (IC) Method as a basis, described in EPA's Stormwater TMDL Implementation Support Manual.[11] Consistent with the findings of EPA and others, MassDOT concluded that when a watershed had less than 9% IC, stormwater was not the likely cause of the impairment.

MassDOT calculated the following values for the total contributing watershed and the subwatershed of the impaired water (Shawsheen River) to determine the IC target. The total contributing watershed and the subwatershed are shown in Figure 1.

Impaired Segment Watershed

	Total Contributing Watershed	Subwatershed
Watershed Area	8,831 acres	4,966 acres
Impervious Cover (IC) Area	1,926 acres	1,309 acres
Percent Impervious	22 %	26 %
IC Area at 9% Goal	795 acres	447 acres
Target Effective IC Reduction	59 %	66 %

The total and subwatersheds are greater than 9% impervious, indicating that stormwater is a likely contributor to the impairment. To meet the 9% effective IC target, the effective IC within the subwatershed will need to be reduced. Therefore, the effective IC of MassDOT's directly contributing area should also be reduced by the same percentage. The following table shows how MassDOT calculated the target effective IC for MassDOT's contributing property.

[10] MassDOT, 6 April, 2011. Description of MassDOT's Application of Impervious Cover Method in BMP 7U (MassDOT Application of IC Method). http://www.mhd.state.ma.us/downloads/projDev/BMP_7U_ImpairedWaterbodiesAssessment.pdf

[11] ENSR 2006. *Stormwater TMDL Implementation Support Manual for US EPA Region 1*. ENSR International & EPA Region 1, Boston, MA. Available at http://www.epa.gov/region1/eco/tmdl/regionalpgrfs.html

MassDOT Directly Contributing Watershed	
Directly Contributing Area	2.3 acres
Directly Contributing IC Area	2.3 acres
Percent Impervious	100 %
Target Effective IC Reduction (66% Reduction of DOT Directly Contributing IC)	1.5 acres
Target Effective IC	34 %

Under existing conditions, MassDOT's estimated effective IC exceeds the target as described above. To mitigate the effects of IC, MassDOT will implement stormwater BMPs to the maximum extent practical given site constraints.

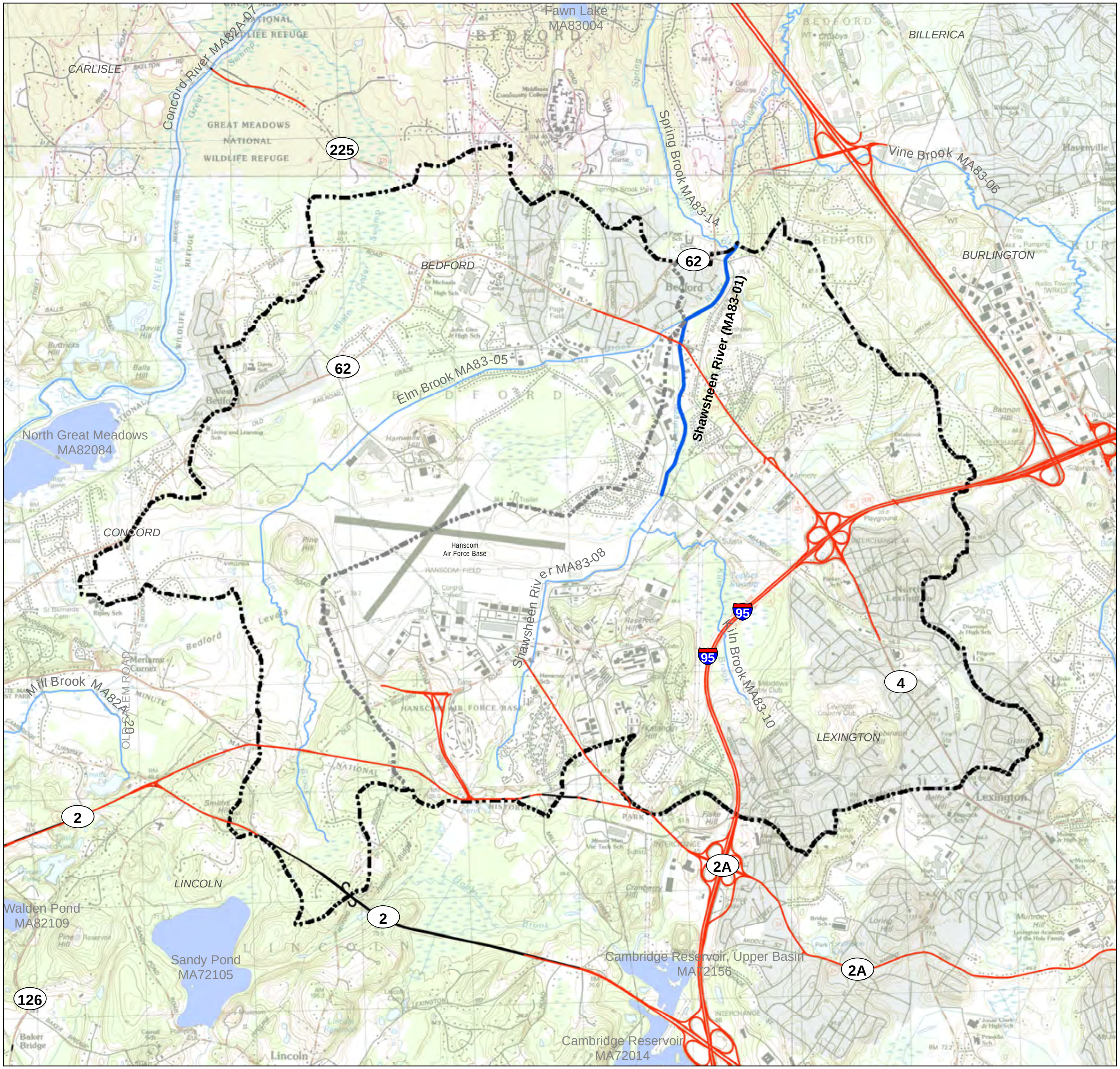
This assessment was not able to identify practical locations for stormwater management improvements within the current MassDOT right-of-way. The Proposed Mitigation Plan section discusses the site constraints and mitigation plan.

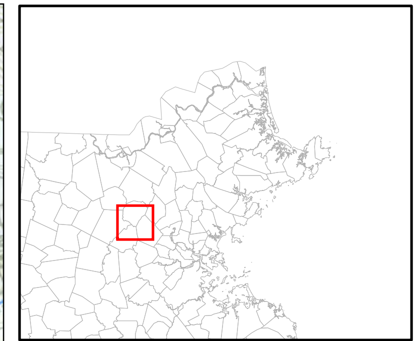
Proposed Mitigation Plan

During this assessment phase of the Impaired Waters Program, MassDOT has focused on directly contributing areas and identified BMPs that can be constructed entirely on MassDOT property without resulting in substantial wetland impacts or resulting in an adverse impact on historical or archeological resources. Projects that meet these requirements can utilize the Federal Highway Administration's Alternative Contracting mechanism (SEP-14) created for this program.

The directly discharging areas between the high points and the river crossing have little to no potential for BMPs due to the limited right-of-way, which does not include any green space. Based on the review of MassDOT's directly contributing drainage area, no BMPs have been identified that can be implemented under the Impaired Waters Program on MassDOT property to address the impairments of the Shawsheen River given the site constraints.

MassDOT will continue to ensure proper non-structural BMPs are being implemented within the watershed of Shawsheen River, including regular roadway and drainage system maintenance, erosion and sedimentation control, and outreach and education. Further work by MassDOT on programmed projects, which often include broader scale road layout changes, may provide additional opportunities for construction of new treatment BMPs. This is consistent with an iterative adaptive management approach to address impairments. MassDOT will include an update in annual reports to EPA regarding progress made towards meeting target IC reductions, plans for construction of proposed BMPs and finalized assessments including reduction achieved by finalized BMP designs.





MassDOT Roadways in Urban Area

Total Watershed

Subwatershed

Assessed Segment

Impaired Streams

Impaired Lakes

N

0 2,000 4,000 Feet

1 inch = 4,000 feet

Figure 1

Shawsheen River (MA83-01) Watersheds

December 2013

massDOT Massachusetts Department of Transportation Highway Division

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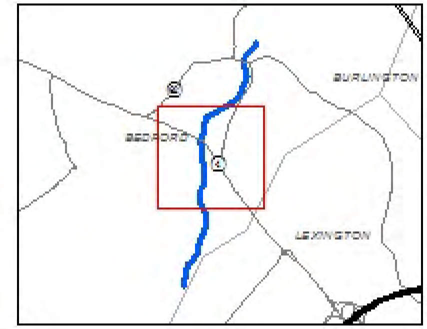

Figure 2

**Shawsheen River (MA 83-01)
Directly Contributing
MassDOT Watershed**

December 2013

massDOT
Massachusetts Department of Transportation
Highway Division

Impaired Waters Assessment for Shawsheen River (MA83-17)

Summary

Impaired Water[1]	**Impairments:**	Fecal coliform, dissolved oxygen
	Category:	5 (Waters requiring a TMDL)
	Final TMDLs:	Bacteria TMDL for the Shawsheen River Basin[2]
	WQ Assessment:	Shawsheen River Watershed 2000 Water Quality Assessment Report[3]
Location	**Towns:**	Bedford, Billerica
	MassDOT Roads:	Route 3, Route 3A (Boston Road)
Assessment Method(s)	**7R (TMDL Method)**	☒
	7U (IC Method)	☒
BMPs	**Existing:**	1 Detention Basin
	Proposed:	1 Infiltration Basin, 1 Extended Detention Basin, 13 Water Quality Swales

		Impervious Cover (IC)
MassDOT Contributing Area and Targets	**Directly Contributing Area**	23.1 acres
	Contributing Area Reduction Target	12.5 acres
	Existing BMPs Reduction	7.0 acres
	Proposed BMPs Reduction	23.1 acres
	Remaining Reduction to Meet Target	0.0 acres

[1] MassDEP, 2013. Massachusetts Year 2012 Integrated List of Waters – Final Listing of the Condition of Massachusetts' Waters Pursuant to Sections 305(b), 314 and 303(d) of the Clean Water Act. Massachusetts. Available at: http://www.mass.gov/eea/docs/dep/water/resources/07v5/12list2.pdf

[2] MassDEP. 2002. Bacteria TMDL for the Shawsheen River Basin. Available at: http://www.mass.gov/eea/docs/dep/water/resources/n-thru-y/shawshee.pdf

[3] MassDEP, 2000. Shawsheen River Watershed 2000 Water Quality Assessment Report. Available at: http://www.mass.gov/eea/docs/dep/water/resources/71wqar09/83wqar.pdf

Site Description

Shawsheen River (MA83-17) is a 5.7-mile long stream segment in Bedford and Billerica, Massachusetts. The stream segment begins at the confluence of Spring Brook (MA83-14) and the upstream segment of Shawsheen River (MA83-01) in Bedford. It flows northeast and under Route 3 for approximately two miles before crossing into Billerica. The stream passes under Route 3A (Boston Road) in Billerica and terminates at the Burlington Water Department's surface water intake in Billerica, where the next segment, Shawsheen River (MA83-18), begins. The total watershed to Shawsheen River is 35.7 square miles and is shown in Figure 1. It includes portions of Billerica, Burlington, Woburn, Bedford, Lexington, Lincoln, and Concord. The subwatershed, which includes portions of Billerica, Burlington, Bedford, and Lexington, is 12.3 square miles and is also shown in Figure 1. The subwatershed is primarily residential with some forested areas and pockets of industrial and commercial space. Most of the development is to the northeast of Route 3. Industrial and commercial areas are clustered near the town line between Bedford and Billerica, and higher density residential areas are further north near the more downstream end of Shawsheen River.

According to the 2000 Water Quality Assessment Report for the Shawsheen River Watershed, the Shawsheen River Watershed Storm Drain Assessment Project conducted in 2001 involved collection of fecal coliform and E. coli bacteria from six storm drains within the vicinity of Shawsheen River. [4] The storm drains are confirmed sources of bacteria. Elevated fecal coliform levels led the Primary Contact Recreational Use to be classified as impaired and the Secondary Contact Recreational Use to be classified as support. The report includes a recommendation calling for water quality monitoring to better evaluate the status of the Aquatic Life Use, with particular attention to diurnal dissolved oxygen concentrations.

Figures 2a and 2b show the portions of MassDOT property that discharge directly to Shawsheen River. The directly discharging roadway includes approximately 1.2 miles of Route 3, which is shown in Figure 2a, and approximately 0.8 miles of Route 3A (Boston Road), which is shown in Figure 2b. The section of Route 3 that discharges to Shawsheen River is a divided highway running north to south with three lanes of travel and two wide shoulders in either direction. Route 3 crosses over Shawsheen River just downstream of its confluence with Vine Brook (MA83-06). The boundary of the Shawsheen River subwatershed doubles as the southern boundary of MassDOT's directly discharging area to Shawsheen River. Vine Brook flows adjacent to Route 3, receiving sections of Route 3 drainage as dictated by road grading. Route 3 in both directions is crowned between the first and second travel lanes. The grading directs runoff from the second travel lane, third travel lane, and shoulder toward drainage ditches within the median. North of the river crossing, these drainage ditches convey flow to an inlet at the low point in the road profile, ultimately discharging to an outfall northeast of Route 3 and adjacent to Shawsheen River. South of the river crossing, a similar drainage layout is utilized. In this area, however, there is an existing detention basin, as discussed in the following section. In the vicinity of the Route 62 (Burlington Road) ramps south of the Shawsheen River crossing, runoff from the first travel lane and shoulder sheet flows to drainage ditches, which are ultimately directed to the existing BMP along the northbound shoulder. North of the Shawsheen River crossing, bermed curbing along the first travel lanes convey runoff to catch basins, which are piped to the outfalls in the shoulders indicated on Figure 2a.

The section of Route 3A that discharges directly to Shawsheen River is a two-lane road bordered by a mixture of homes and businesses on both sides. The low point in the road profile is located about 100 feet east of where Route 3A crosses Shawsheen River. Shawsheen River receives directly discharging runoff from the section of Route 3A bounded by the nearest high points in the

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[4] MassDEP, 2000. Shawsheen River Watershed 2000 Water Quality Assessment Report. Available at: http://www.mass.gov/eea/docs/dep/water/resources/71wqar09/83wqar.pdf

road profile to the east and west. The drainage system directs stormwater down trunk lines which discharge into Shawsheen River at the outfalls shown in Figure 2b.

Existing BMPs

There is one existing BMP within the directly contributing area of Shawsheen River (MA83-17). EX BMP 01, shown in Figure 2a and Figure 3b, is a detention basin located along the shoulder of Route 3 northbound. EX BMP 01 receives stormwater from the entire directly discharging area south and upgrade of the BMP. Runoff from impervious cover that drains to ditches along the shoulders and median is collected in drop inlets and piped to EX BMP 01, where it enters the BMP via one of two outfalls. EX BMP 01 is designed with two cells for water containment—a forebay and a basin. An outlet control structure is located at the far end of the basin. It features four orifices ranging in size from three inches to six inches and an elevated riser, which can accommodate larger flows. Flows are piped from the outlet control structure to a wetland area that is hydrologically connected to Shawsheen River. A large rip-rap lined channel acts as the emergency spillway, terminating in the same area of wetland as the discharge piped from the primary outlet control structure.

The Natural Resources Conservation Service (NRCS) soil survey indicates that EX BMP 01 lies within areas of hydrologic soils groups (HSG) B and C soils. However, standing water and wetland vegetation were observed during a site visit, indicating that soil infiltration rates are low. The ground surface around EX BMP 01 is bermed to maximize the storage volume in the basin. EX BMP 01 appears well maintained.

Assessment

In cases where a TMDL has been approved, MassDOT assessed the waterbody for the impairments covered by the TMDL under the BMP 7R methodology. MassDOT has separately assessed the waterbody for any stormwater-related impairments that are not covered by the TMDL under the BMP 7U methodology. MassDOT assessed Shawsheen River (MA83-17) using the methodologies described below.

BMP 7R for Pathogen TMDL (CN 122.0)

MassDOT assessed the pathogen impairment using the approach described in BMP 7R of MassDOT's Storm Water Management Plan (SWMP).[5] The Total Maximum Daily Load (TMDL) of Bacteria for Shawsheen River Basin (CN 122.0) covers the Shawsheen River.[6] The TMDL states that sources of indicator bacteria include illicit sewer connections, sewer line leaks, septic systems, and urban stormwater runoff.

Pathogen concentrations in stormwater vary widely temporally and spatially; concentrations can vary by an order of magnitude within a given storm event at a single location.[7] Therefore, it is difficult to predict pathogen concentrations in stormwater with accuracy. MassDOT's South East Expressway study measured bacterial concentration in stormwater runoff[8] and data indicated that highway's pathogen loading may be lower than urban areas. Considering that the potential sources

[5] Massachusetts Department of Transportation (MassDOT), July 22, 2010. BMP 7R: TMDL Watershed Review. Available at: http://www.mhd.state.ma.us/downloads/projDev/BMP_7R_TMDL_WatershedReview.pdf

[6] Mass DEP 2002. *Bacteria TMDL for the Shawsheen River (CN 122.0).* Available at: http://www.mass.gov/eea/docs/dep/water/resources/n-thru-y/shawshee.pdf

[7] MassDEP. 2009. Final Pathogen TMDL for the Cape Cod Watershed. Available at: http://www.mass.gov/dep/water/resources/capecod1.pdf

[8] Smith. (2002). Effectiveness of Three Best Management Practices for Highway Runoff Quality along the Southeast Expressway. USGS Water Resources Investigations Report 02-4059. Boston, Massachusetts.

of pathogens (e.g. illicit discharges, sewer utilities, pet waste and wildlife) are likely to be less prevalent in the highway environment than along urban roads, this finding is not surprising.

MassDOT does not conduct site specific assessments of loading at each location impaired for pathogens. Instead, MassDOT reviewed its existing programs and their consistency with EPA NPDES MS4 general permit requirements and pathogen TMDL requirements. The TMDL states that sources of indicator bacteria in the Shawsheen River Watershed were found to be many and varied. On page 1, the TMDL states that “urban stormwater runoff is much more difficult to control, so additional monitoring is recommended to pinpoint urban stormwater runoff sources before implementing controls. There are a lot of good housekeeping type practices (e.g., proper pet waste removal, street sweeping, reduction in runoff volumes through diversions of impervious areas to impervious areas, etc.) that should not be delayed until more data are collected.” MassDOT implements a variety of non-structural BMP programs across their system in accordance with their existing SWMP including educational programs, illicit connection review and source control.

MassDOT has an ongoing inspection and monitoring program aimed at identifying and addressing illicit discharges to MassDOT’s stormwater management system. Any illicit discharges to MassDOT’s system could contribute pathogens to impaired waters, however, MassDOT’s existing Illicit Discharge Detection and Elimination (IDDE) program is aimed at identifying and addressing these contributions. District maintenance staff note signs of potential illicit discharges, such as dry weather flow and notable odors or sheens. Similarly, Resident Engineers overseeing construction projects also receive instruction regarding the need to note any suspicious connections or flows, and report these for follow-up investigation and action as appropriate. MassDOT will continue to implement this IDDE training, and District staff will continue to report any suspicious flows requiring further investigation. MassDOT investigates any suspicious flows noted, and proceeds to work with owners of confirmed illicit discharges to remove these flows, and thereby minimize pathogen contributions to receiving waters.

MassDOT is in the process of developing a pet waste management program for MassDOT rest stops located within the sub-watershed of a pathogen impaired waterbody. At these prioritized rest stops, MassDOT will be installing signs informing the public of the need to remove pet waste in order to minimize contributions of pathogens to the impaired waterbody and providing pet waste removal bags and disposal cans.

MassDOT believes the existing efforts are consistent with the TMDL recommendations.

BMP 7U for Impervious Cover Related Impairments

The Shawsheen River pathogen TMDL does not address the Shawsheen River’s remaining impairment for dissolved oxygen. Therefore, MassDOT assessed this stormwater-related impairment not addressed by a TMDL using the approach outlined in the Description of MassDOT’s Application of Impervious Cover Method in BMP 7U[9] which was developed using the EPA Region I’s Impervious Cover (IC) Method as a basis, described in EPA’s Stormwater TMDL Implementation Support Manual. [10] MassDOT used the long-term continuous simulation model (the assessment model)[11] to estimate effective IC. Consistent with the findings of EPA and others, MassDOT

[9] MassDOT, 6 April, 2011. Description of MassDOT’s Application of Impervious Cover Method in BMP 7U (MassDOT Application of IC Method). http://www.mhd.state.ma.us/downloads/projDev/BMP_7U_ImpairedWaterbodiesAssessment.pdf

[10] ENSR 2006. *Stormwater TMDL Implementation Support Manual for US EPA Region 1*. ENSR International & EPA Region 1, Boston, MA. Available at http://www.epa.gov/region1/eco/tmdl/regionalpgrfs.html

[11] MassDOT, June 2012. Long-Term Continuous Simulation for Pollutant Loading and Treatment for MassDOT Impaired Waters Program. Available at: http://www.mhd.state.ma.us/downloads/projDev/ImpairedWaters_2/Attachment7.pdf

concluded that when a watershed had less than 9% IC, stormwater was not the likely cause of the impairment.

MassDOT then calculated the following values for the total contributing watershed and the subwatershed of the impaired water (Shawsheen River) to determine the IC target. The total contributing watershed and the subwatershed are shown in Figure 1.

Impaired Segment Watershed

	Total Contributing Watershed	Subwatershed
Watershed Area	22,819 acres	7,864 acres
Impervious Cover (IC) Area	5,052 acres	1,524 acres
Percent Impervious	22 %	19 %
IC Area at 9% Goal	2,054 acres	708 acres
Target Effective IC Reduction	59 %	54 %

The total and subwatersheds are greater than 9% impervious, indicating that stormwater is a likely contributor to the impairment. To meet the 9% effective IC target, the effective IC within the subwatershed will need to be reduced. Therefore, the effective IC of MassDOT's directly contributing area should also be reduced by the same percentage. The following table shows how MassDOT calculated the target effective IC for MassDOT's contributing property.

MassDOT Directly Contributing Watershed

Directly Contributing Area	53.0 acres
Directly Contributing IC Area	23.1 acres
Percent Impervious	44 %
Target Effective IC Reduction (54% Reduction of DOT Directly Contributing IC)	12.5 acres
Target Effective IC	20 %

An existing conditions assessment model was created to estimate the effective IC of the MassDOT contributing drainage areas given treatment provided by existing BMPs. The table below shows the existing BMPs, their MassDOT drainage areas and effective IC reductions. The output from the assessment model showing effective IC analysis for existing BMPs is attached.

Existing Conditions

BMP Name	BMP Type	Contributing Effective IC (acres)	Estimated Percent Reduction	Estimated Reduction Effective IC (acres)
EX BMP 01	Extended Detention Basin	6.4	74%	4.8
Total*		**23.1**	**30%**	**7.0**

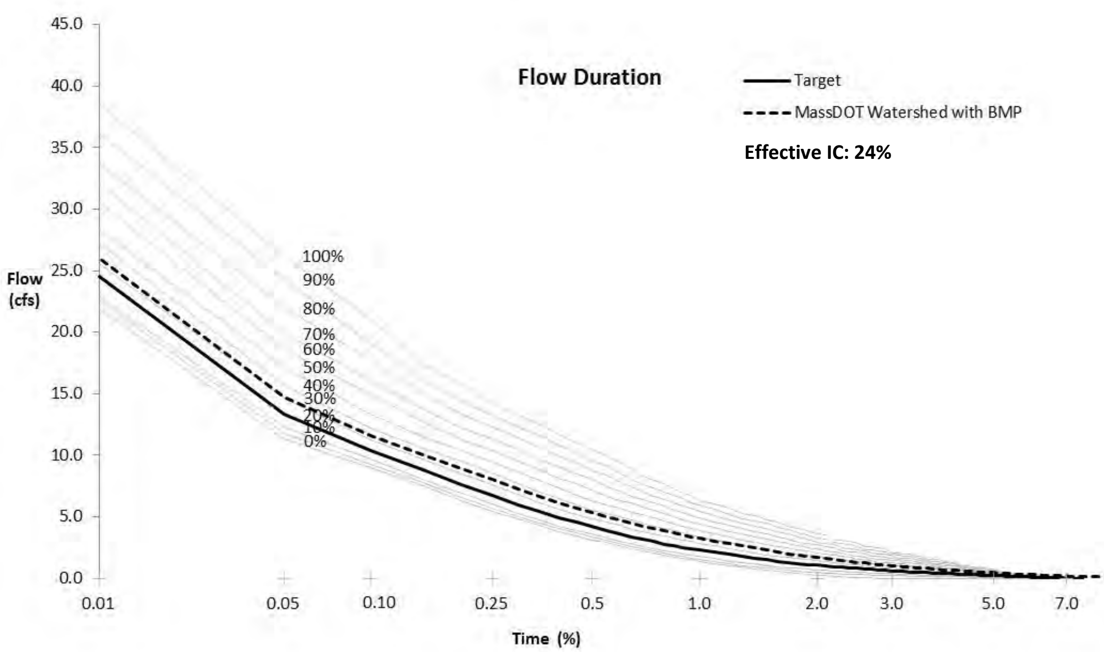
* Total Effective IC reduction based on the assessment model results for the total MassDOT directly discharging drainage area to the receiving water (not sum of individual BMP reductions).

MassDOT estimated the effective IC under existing conditions by comparing the annual median runoff volume, phosphorus and TSS loads, and flow distribution statistics (flow duration) from

MassDOT drainage area to the receiving water to those results for simulated IC watersheds. The following table displays the acres of IC the existing BMPs mitigate compared to the target reduction.

Existing Median Annual Load Comparisons

Simulated IC Watersheds		Runoff (ac-ft)	Phos (lb.)	TSS (lb.)
	0% IC	41	3	201
	5% IC	48	10	4,183
	10% IC	54	17	8,207
Target	**20% IC**	**67**	**31**	**16,256**
	30% IC	80	46	24,304
	40% IC	93	60	32,352
	50% IC	106	75	40,400
	60% IC	119	89	48,448
	70% IC	132	103	56,496
	80% IC	144	118	64,544
	90% IC	158	132	72,592
	100% IC	171	147	80,676
	Conditions without BMPs	101	54	27,801
	Conditions with Existing BMPs	96	39	19,503
	Reduction %	**5%**	**26%**	**30%**
	Effective IC	**42%**	**26%**	**24%**



Effective IC Results

Existing IC	23.1 acres
Estimated Effective IC with Existing BMPs	16.4 acres
IC Reduction % with Existing BMPs	30%
Estimated Effective IC*	31%

*Average of estimated effective IC for annual median runoff volume, phosphorus and TSS loads, and flow duration.

Under existing conditions, MassDOT's estimated effective IC exceeds the target as described above. To mitigate the effects of IC, MassDOT will implement stormwater BMPs to the maximum extent practical given site constraints.

This assessment has identified locations for potential stormwater BMPs and estimated the effective IC accounting for their treatment. The Proposed Mitigation Plan section describes the BMPs and their IC reduction performance.

Proposed Mitigation Plan

In this assessment, MassDOT has identified 15 stormwater BMPs that may be implemented on MassDOT property to mitigate the effective IC to address the Shawsheen River impairments. These BMPs include 1 infiltration basin, 1 extended detention basin, and 13 water quality swales, shown with their estimated contributing drainage areas in Figures 3a, 3b, and 3c. These locations were chosen based on a cursory review of the drainage systems, topography, property lines, and other site constraints. The existing drainage layout utilizes drainage ditches as a primary means to convey runoff, and these ditches can be upgraded to water quality swales with the addition of check dams and outlet control. Detailed survey, complete utility location information, official property ownership, and soils evaluation information will influence the final selection and design of BMPs. Below is a description of these proposed BMPs.

PR BMP 01, 03, 04, 05, 06, 07, 08, 10, 13

These BMPs are proposed water quality swales located within the Route 3 median. Route 3 is crowned between the first and second travel lanes, so these BMPs receive lateral sheet flow from the second travel lane, the third travel lane, and the fast-lane shoulder of Route 3 northbound and southbound. The median currently acts as a drainage ditch. Stone check dams are placed downstream of the drop inlets that collect flow from each of these ditches; however, the placement of these check dams does not create detention or infiltration opportunities. Flow from the ditches corresponding to PR BMP 01, 03, 04, 05, 06, 07, and 08 enters the drop inlets and is piped directly to Shawsheen River. Flow from the ditches corresponding to PR BMP 10 and PR BMP 13 enters the drop inlets and is piped directly to EX BMP 01. The drop inlets can be raised and check dams can be placed upstream to provide outlet control and encourage detention and infiltration.

A MassDOT project (#606353) is underway to add cable guardrail with a paved strip of footing within the median for a stretch of Route 3 beginning in Burlington and extending north through the entire directly discharging area. Observations from a site visit indicate that the new guardrail appears to be installed closer to the northbound lanes; however, its exact position should be confirmed during the design phase to identify potential impacts on the proposed swales.

PR BMP 01, 03, 04, and 06 are located in the median north of the Shawsheen River crossing, where soils fall primarily within hydrologic soil group (HSG) D, as delineated by the NRCS soil survey. Soils with HSG D have limited potential for infiltration, so additional evaluation should be conducted during the design phase to determine if alternative BMPs would be more appropriate. PR BMP 05 is located within an isolated area of HSG A soils north of the Shawsheen River crossing. PR BMP 07, 08, 10, and 13 are all located in the median south of the Shawsheen River crossing where soils fall within HSG C, as delineated by the NRCS soil survey.

PR BMP 02, 09, 11, 14

These BMPs are proposed water quality swales located along the shoulder of Route 3 northbound and its ramps with Route 62. Each BMP receives lateral sheet flow from one travel lane and the associated shoulder. These proposed BMPs currently act as drainage ditches that convey runoff to a drop inlet, which is piped directly to Shawsheen River or to EX BMP 01. Flow from PR BMP 02 is currently piped to an outlet within a wetland area adjacent to Shawsheen River. Flow from PR BMP 09 and PR BMP 11 is piped to EX BMP 01. Flow from PR BMP 14 is piped to the beginning of PR BMP 11 prior to making its way to EX BMP 01. The drop inlets can be raised and check dams can be placed upstream to provide outlet control and encourage detention and infiltration.

With the current grading and drainage layout, the ditch corresponding to PR BMP 02 does not receive runoff from impervious cover. The curbing along PR BMP 02 could be removed, allowing runoff to sheet flow laterally into the swale in the same manner as the other proposed water quality swales.

Observations from a site visit identified areas of cut slopes along PR BMP 02 that have been reinforced with stone, indicating that erosion and/or groundwater intrusion maybe a concern. Observations from the site visit also indicate that the ditch corresponding to PR BMP 11 currently has wetland vegetation growing within it. This wetland area is likely to be non-jurisdictional, but further investigation should be conducted.

PR BMP 02 is located north of the Shawsheen River crossing, where soils fall primarily within HSG D, as delineated by the NRCS soil survey. Soils with HSG D have limited potential for infiltration, so additional evaluation should be conducted during the design phase to determine if alternative BMPs would be more appropriate. PR BMP 09, 11, and 14 are all located in the median south of the Shawsheen River crossing where soils fall within HSG C, as delineated by the NRCS soil survey.

PR BMP 12

This BMP is a proposed infiltration basin within the ramp area between the Route 3 southbound on and off ramps with Route 62. PR BMP 12 can be designed to receive sheet flow from a section of the first travel lane and on ramp for Route 3 southbound. Soils in this area fall within HSG C, as delineated by the NRCS soil survey.

PR BMP 15

This BMP is located along Route 3A in Billerica. It has been designed as part of MassDOT project 601426, which is at the 100% design stage. PR BMP 15 is located on a proposed permanent drainage easement between Jade Pacific Restaurant and Shawsheen River. The applicable utility and grading plan from the project identifies the BMP as a proposed water quality basin with a stone check dam providing outlet control. PR BMP 15 is located on soils with hydrologic soil groups B and D, but due to its close proximity to Shawsheen River, it was modeled in this assessment as an extended detention basin with group D soils. Although we have included this BMP as a proposed BMP for this assessment, it is assumed that this BMP will be constructed under Project 601426 and will not need to be carried further under the Retrofit Program.

The table below shows the proposed conditions, including BMPs with their MassDOT drainage areas and estimated effective IC reductions. The outputs from the assessment model showing effective IC analysis for each BMP are attached. As currently sized, the 15 BMPs are estimated to completely infiltrate contributing runoff on an annual average bases, providing 100% reduction of effective IC for their respective drainage areas.

Proposed Conditions

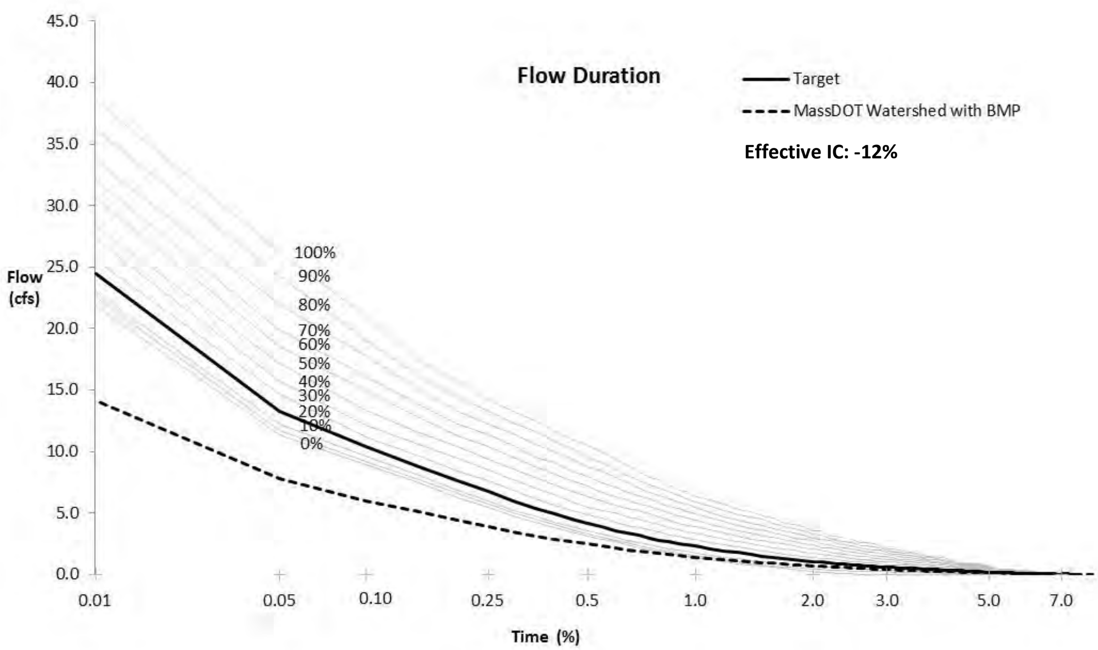
BMP Name	BMP Type	Contributing Effective IC (acres)	Estimated Percent Reduction	Estimated Reduction Effective IC (acres)
EX BMP 01	Extended Detention Basin	6.4	158%	10.1
PR BMP 01	Water Quality Swale	1.8	131%	2.4
PR BMP 02	Water Quality Swale	0.6	157%	0.9
PR BMP 03	Water Quality Swale	1.0	114%	1.2
PR BMP 04	Water Quality Swale	1.0	111%	1.1
PR BMP 05	Water Quality Swale	0.6	147%	0.9
PR BMP 06	Water Quality Swale	0.6	71%	0.5
PR BMP 07	Water Quality Swale	1.1	128%	1.4
PR BMP 08	Water Quality Swale	1.4	149%	2.1
PR BMP 09	Water Quality Swale	0.4	177%	0.8
PR BMP 10	Water Quality Swale	1.0	158%	1.5
PR BMP 11	Water Quality Swale	1.2	177%	2.1
PR BMP 12	Infiltration Basin	0.8	178%	1.4
PR BMP 13	Water Quality Swale	2.5	130%	3.2
PR BMP 14	Water Quality Swale	0.5	154%	0.8
PR BMP 15	Extended Detention Basin	2.7	39%	1.1
Total *		**23.1**	**100%**	**23.1**
Target				**12.5**

* Total Effective IC reduction based on the assessment model results for the total MassDOT directly discharging drainage area to the receiving water (not sum of individual BMP reductions).

Note: The predicted effective IC is determined by comparing the BMP's calculated median annual discharge volume, runoff flow/duration relationship, median annual phosphorus load and median annual total suspended solids load to predicted discharge values for benchmark watersheds with the same size and varying percent IC. In cases where analysis predicts that BMPs would discharges less runoff volume and pollutant mass than those predicted for a 0% IC (pervious, woods in good condition) benchmark watershed, then the predicted effective IC removal would be greater than 100% and reduction of effective IC area will be greater than the BMP contributing IC area.

Proposed Median Annual Load Comparisons

Simulated IC Watersheds		Runoff (ac-ft)	Phos (lb.)	TSS (lb.)
	0% IC	41	3	201
	5% IC	48	10	4,183
	10% IC	54	17	8,207
Target	**20% IC**	**67**	**31**	**16,255**
	30% IC	80	46	24,303
	40% IC	93	60	32,351
	50% IC	106	75	40,398
	60% IC	119	89	48,446
	70% IC	132	103	56,494
	80% IC	144	118	64,542
	90% IC	158	132	72,590
	100% IC	171	147	80,673
	Existing Conditions	96	39	19,503
	Proposed Conditions	41	19	9,666
	Reduction %	**55%**	**70%**	**72%**
	Effective IC	**0%**	**12%**	**12%**



Effective IC Results

Existing IC	23.1 acres
Proposed Estimated Effective IC	0.0 acres
IC Reduction % under Proposed Conditions	100%
Estimated Effective IC*	0%

*Average of estimated effective IC for annual median runoff volume, phosphorus and TSS loads, and flow duration.

MassDOT estimated the effective IC under proposed conditions by comparing the annual median runoff volume, phosphorus and TSS loads, and flow distribution statistics (flow duration) from MassDOT drainage area to the receiving water to those results for simulated IC watersheds.

The proposed BMPs provide enough treatment to meet the target. All but two of the proposed BMPs provide over 100% IC treatment and have little to no discharge, fully infiltrating contributing runoff. While the objective of the Impaired Waters Retrofit Program is to meet the target reduction and not necessarily to construct retrofits to the maximum extent practicable, due to the higher costs and inefficiencies of retrofit projects, it has been MassDOT's experience that during design additional site constraints are identified and often reduce the final number of BMPs and/or water quality treatment. Therefore, in this assessment we are including BMPs that provide treatment beyond the target and will prioritize the most effective BMPs during the design.

MassDOT will proceed to the design phase to develop construction plans for the proposed BMPs as part of the MassDOT Impaired Waters Program. The project designer will gather additional information in this phase, such as soil data, wetland delineations, and site survey, to further refine the proposed BMPs. Once the design of the proposed BMPs is finalized, MassDOT will provide an update with additional information and summarize the effective IC reduction based on the as-built condition.

MassDOT will continue to ensure proper non-structural BMPs are being implemented within the watershed of Shawsheen River, including regular roadway and drainage system maintenance, erosion and sedimentation control, and outreach and education. Further work by MassDOT on programmed projects, which often include broader scale road layout changes, may provide additional opportunities for construction of new treatment BMPs. This is consistent with an iterative adaptive management approach to address impairments. MassDOT will include an update in annual reports to EPA regarding progress made towards meeting target IC reductions, plans for construction of proposed BMPs and finalized assessments including reduction achieved by finalized BMP designs.

- MassDOT Roadways in Urban Area
- Total Watershed
- Subwatershed
- Assessed Segment
- Impaired Streams
- Impaired Lakes

0 3,500 7,000 Feet

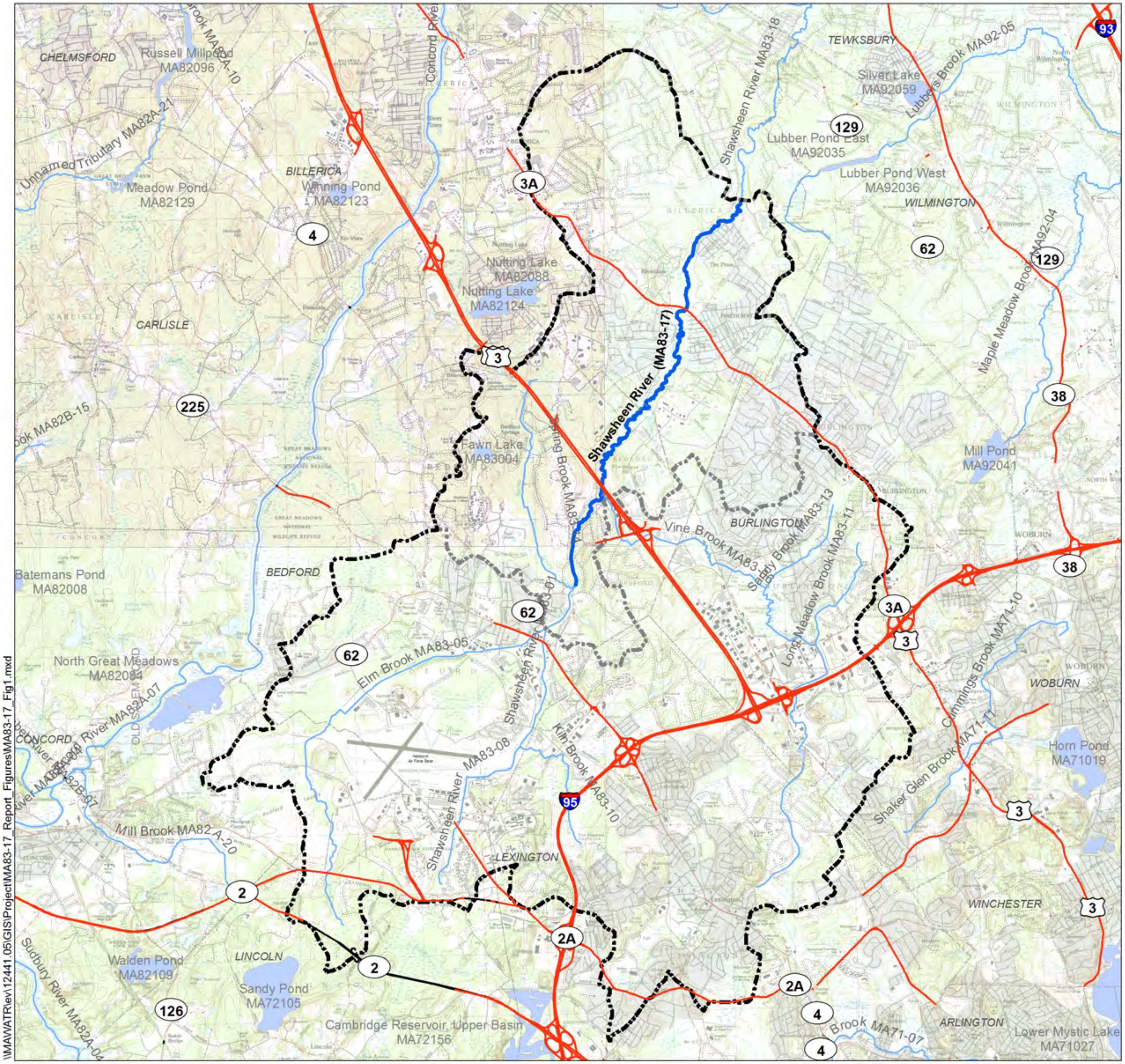
1 inch = 7,000 feet

Figure 1

Shawsheen River (MA83-17) Watersheds

December 2013

massDOT Massachusetts Department of Transportation Highway Division



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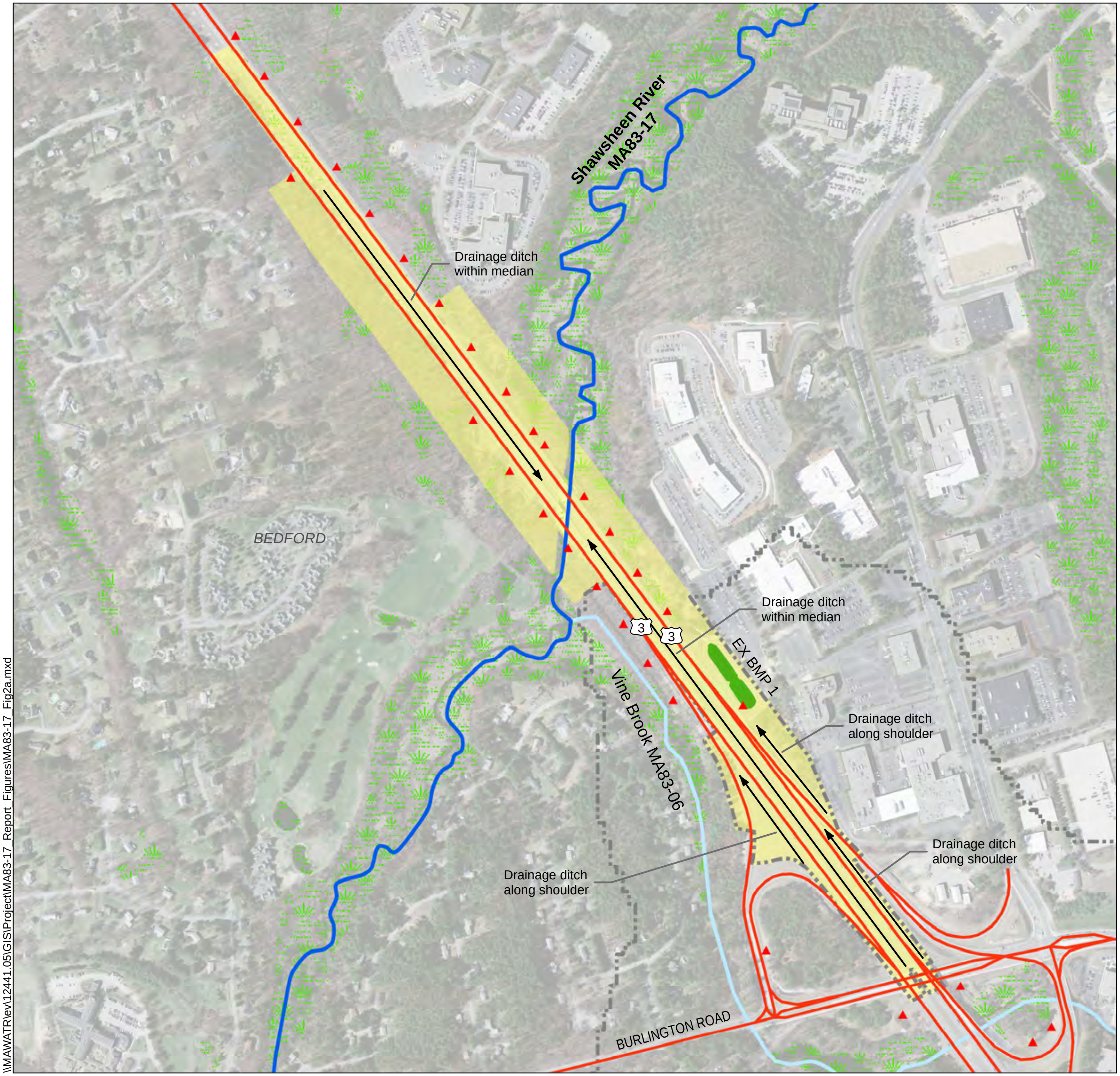
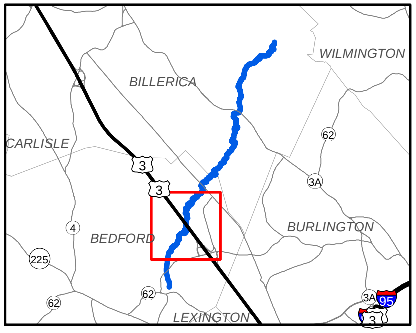




MassDOT Outfalls
MassDOT Directly Discharging Area
Existing BMPs
MassDOT Roadways in Urban Area
Subwatershed
Assessed Segment
Impaired Streams
DEP Wetlands

N

0 350 700 Feet

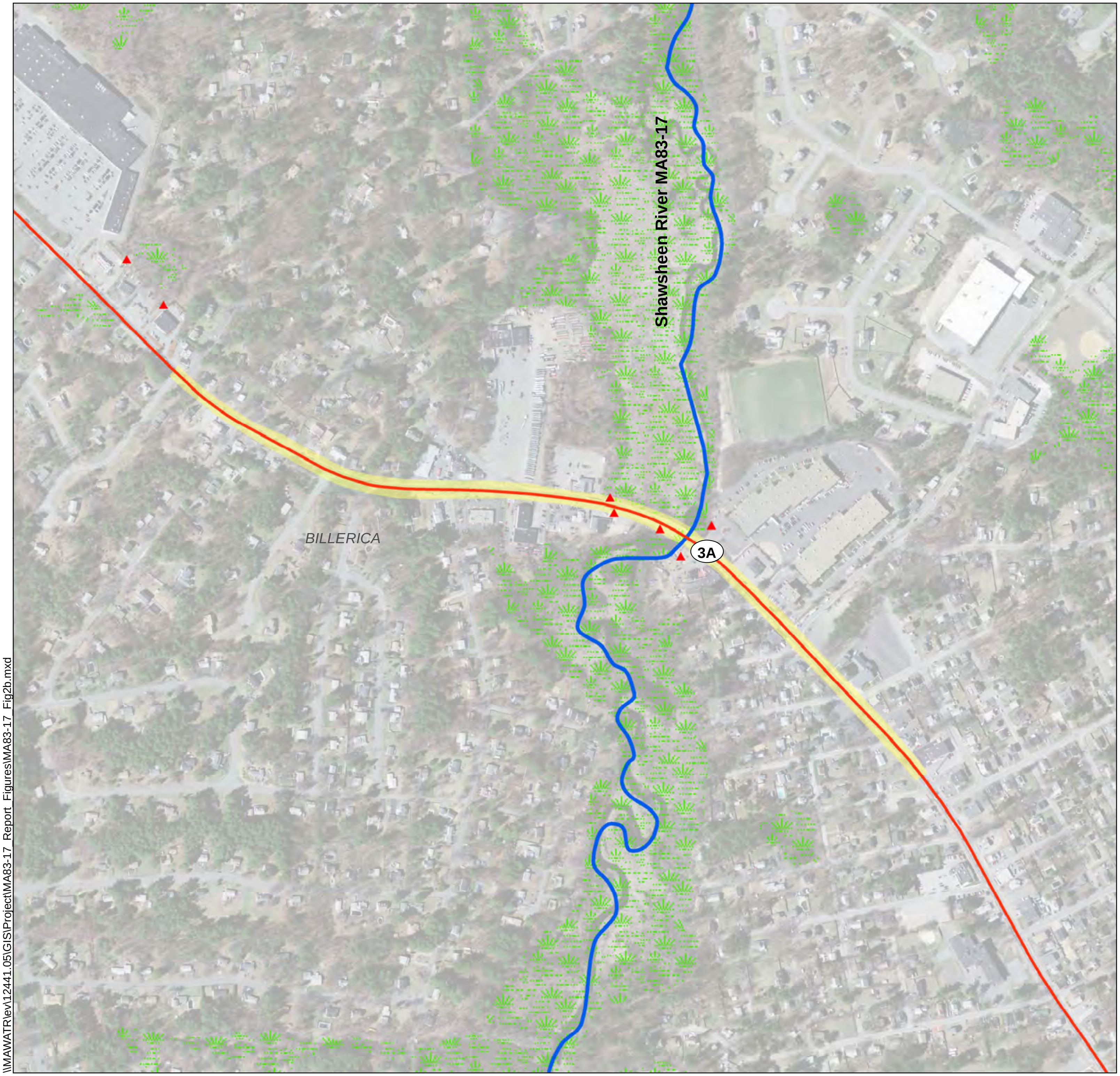
1 inch = 700 feet

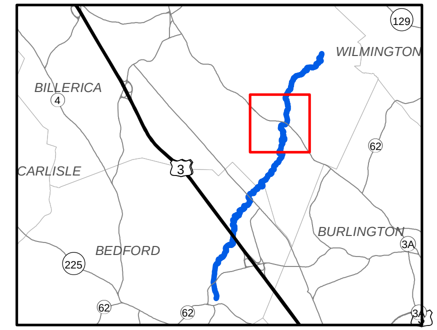
Figure 2a

Shawsheen River (MA83-17) Directly Contributing MassDOT Watershed

December 2013

massDOT Massachusetts Department of Transportation Highway Division





MassDOT Outfalls
MassDOT Directly Discharging Area
MassDOT Roadways in Urban Area
Assessed Segment
Impaired Streams
DEP Wetlands

N

0 300 600 Feet
1 inch = 600 feet

Figure 2b

Shawsheen River (MA83-17) Directly Contributing MassDOT Watershed

December 2013

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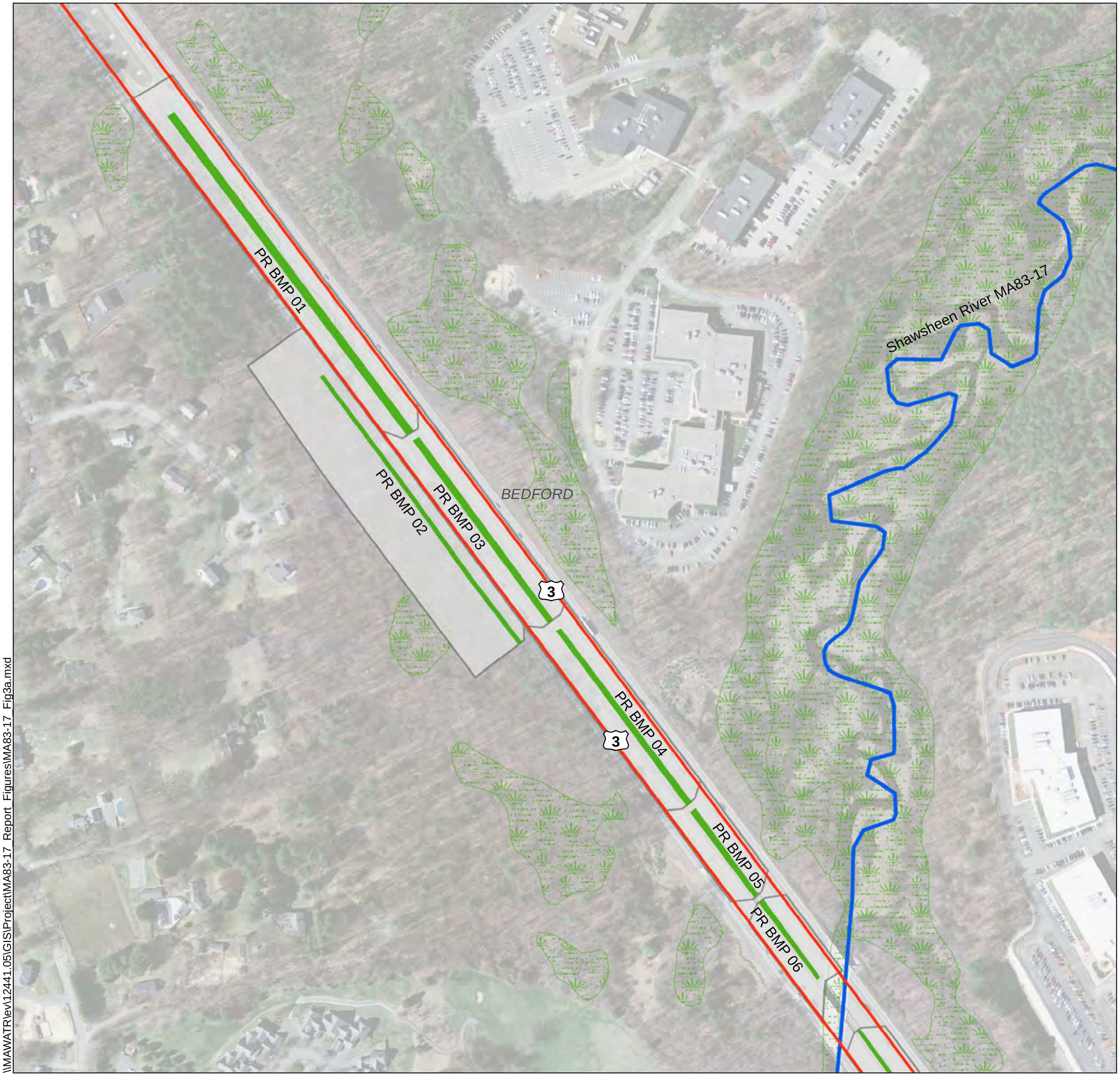

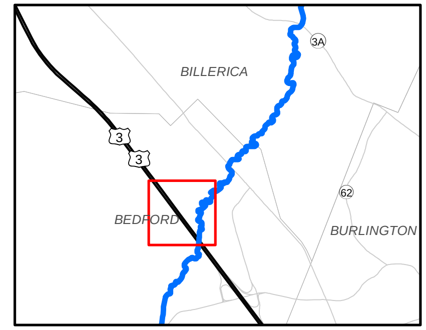

MassDOT Roadways in Urban Area

Proposed BMPs

Proposed BMP Watersheds

Assessed Segment

DEP Wetlands

N

0 175 350 Feet

1 inch = 350 feet

Figure 3a

Shawsheen River (MA83-17) Proposed BMPs

December 2013

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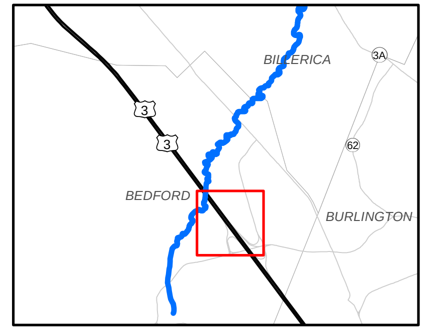

MassDOT Roadways in Urban Area
Proposed BMPs
Proposed BMP Watersheds
Assessed Segment
DEP Wetlands

N

0 175 350 Feet

1 inch = 350 feet

Figure 3b

Shawsheen River (MA83-17) Proposed BMPs

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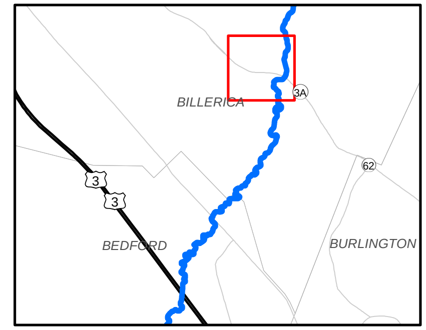

MassDOT Roadways in Urban Area
Proposed BMPs
Proposed BMP Watersheds
Assessed Segment
DEP Wetlands

N

0 175 350 Feet

1 inch = 350 feet

Figure 3c

Shawsheen River (MA83-17) Proposed BMPs

December 2013

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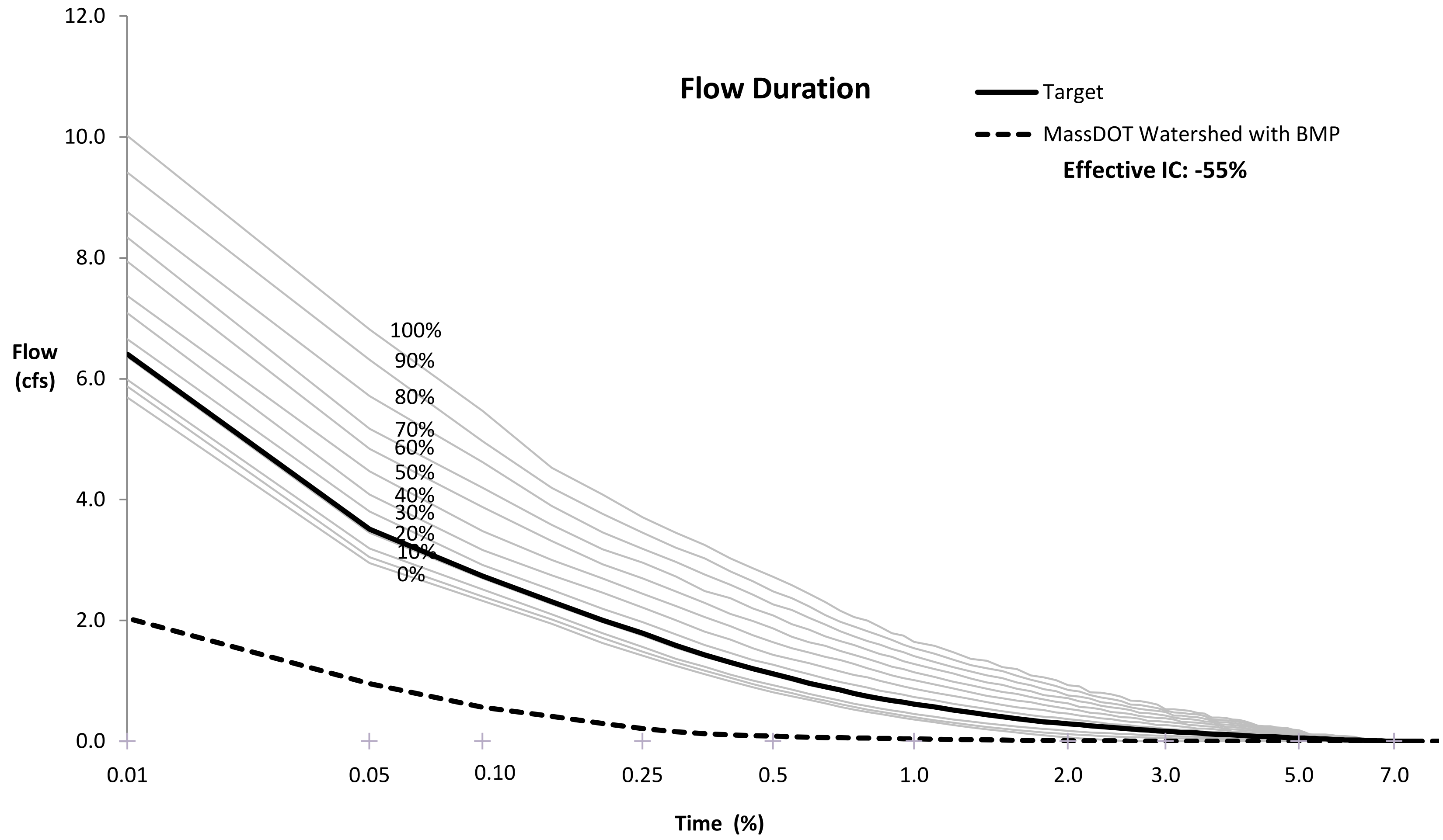
Result Summary
1.3 EX BMP 01



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	11	1	52
5%IC	12	3	1,088
10% IC	14	4	2,134
20% IC	18	8	4,227
30% IC	21	12	6,320
40% IC	24	16	8,413
50% IC	28	19	10,506
60% IC	31	23	12,599
70% IC	34	27	14,691
80% IC	38	31	16,784
90% IC	41	34	18,877
100% IC	44	38	20,979
Watershed Load	25.51	18.03	9,732
BMP Output	1.94	0.13	4
Target	18.08	8.74	4,569
Reduction %	**92%**	**99%**	**100%**
Effective IC	**-26%**	**-2%**	**0%**

Result Summary

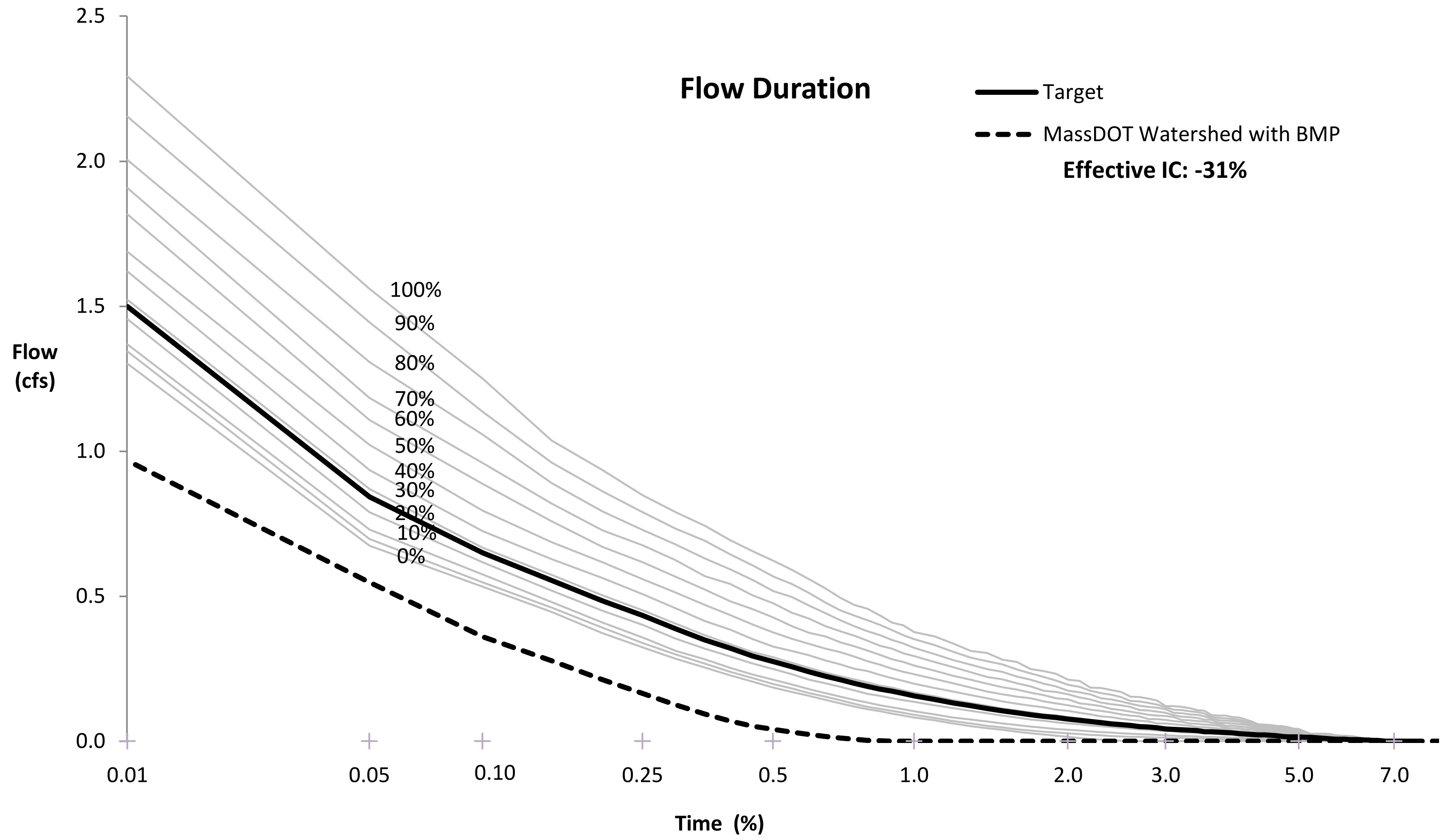
Metric	Area (%)	Area (acres)
Watershed Area		13.8
Watershed IC (no BMP)	47%	6.4
Target IC Reduction	53.6%	3.4
Effective IC w/BMP	-27%	(3.7)
IC Reduction	158%	10.1

Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	0.6	2.7
Indirect Watershed	5.9	11.1
Total	6.4	13.8

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary
6.3 PR BMP 01



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	2	0	12
5%IC	3	1	249
10% IC	3	1	488
20% IC	4	2	967
30% IC	5	3	1,446
40% IC	6	4	1,925
50% IC	6	4	2,404
60% IC	7	5	2,883
70% IC	8	6	3,362
80% IC	9	7	3,841
90% IC	9	8	4,319
100% IC	10	9	4,800
Watershed Load	6.96	5.07	2,745
BMP Output	0.79	0.07	10
Target	4.52	2.43	1,283
Reduction %	**89%**	**99%**	**100%**
Effective IC	**-21%**	**-1%**	**0%**

Result Summary

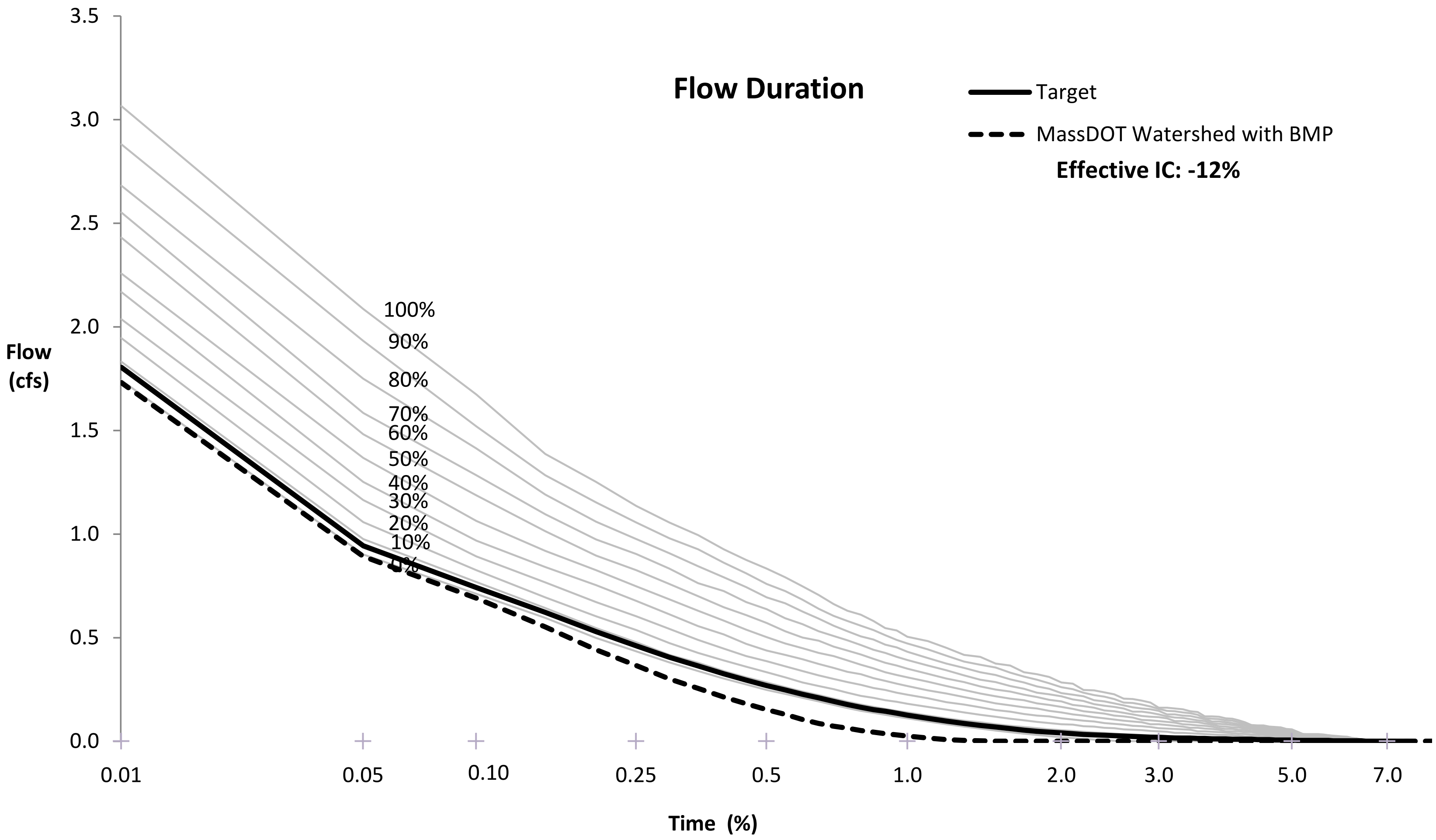
Metric	Area (%)	Area (acres)
Watershed Area		3.2
Watershed IC (no BMP)	57%	1.8
Target IC Reduction	53.6%	1.0
Effective IC w/BMP	-17%	(0.6)
IC Reduction	131%	2.4

Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	1.8	3.2
Indirect Watershed	-	-
Total	1.8	3.2

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary
8.3 PR BMP 02



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	3	0	16
5%IC	4	1	333
10% IC	4	1	654
20% IC	5	2	1,295
30% IC	6	4	1,935
40% IC	7	5	2,576
50% IC	8	6	3,217
60% IC	9	7	3,858
70% IC	10	8	4,499
80% IC	11	9	5,140
90% IC	13	11	5,781
100% IC	14	12	6,425
Watershed Load	5.01	1.79	874
BMP Output	2.12	0.16	15
Target	3.93	0.94	411
Reduction %	**58%**	**91%**	**98%**
Effective IC	**-11%**	**-1%**	**0%**

Result Summary

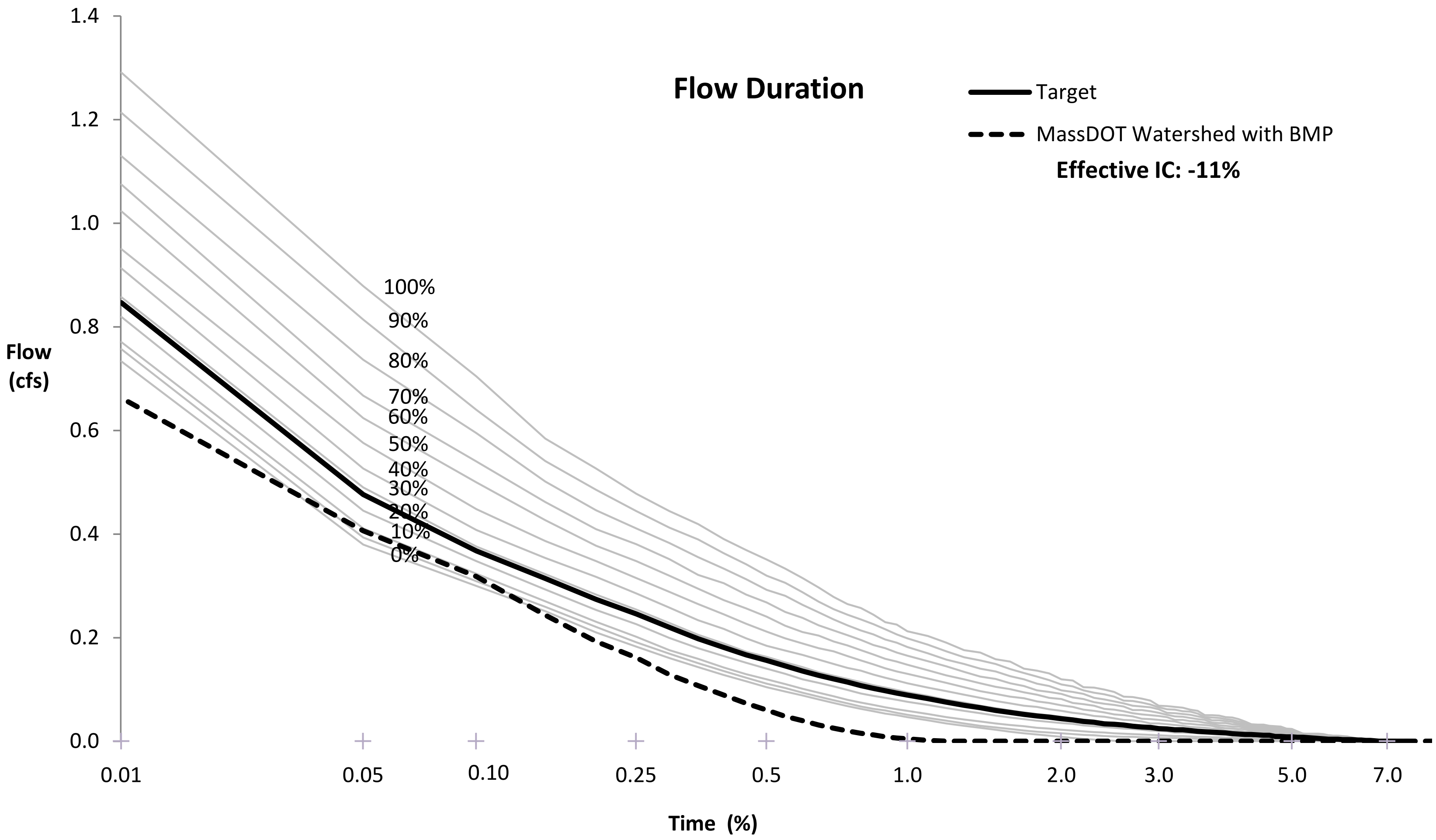
Metric	Area (%)	Area (acres)
Watershed Area		4.2
Watershed IC (no BMP)	13%	0.6
Target IC Reduction	53.6%	0.3
Effective IC w/BMP	-8%	(0.3)
IC Reduction	157%	0.9

Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	0.6	4.2
Indirect Watershed	-	-
Total	0.6	4.2

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary
10.3 PR BMP 03



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	1	0	7
5%IC	2	0	140
10% IC	2	1	275
20% IC	2	1	545
30% IC	3	2	815
40% IC	3	2	1,085
50% IC	4	3	1,355
60% IC	4	3	1,625
70% IC	4	3	1,894
80% IC	5	4	2,164
90% IC	5	4	2,434
100% IC	6	5	2,705
Watershed Load	4.05	2.90	1,569
BMP Output	0.83	0.08	13
Target	2.57	1.39	734
Reduction %	**79%**	**97%**	**99%**
Effective IC	**-13%**	**0%**	**0%**

Result Summary

Metric	Area (%)	Area (acres)
Watershed Area		1.8
Watershed IC (no BMP)	58%	1.0
Target IC Reduction	53.6%	0.6
Effective IC w/BMP	-8%	(0.1)
IC Reduction	114%	1.2

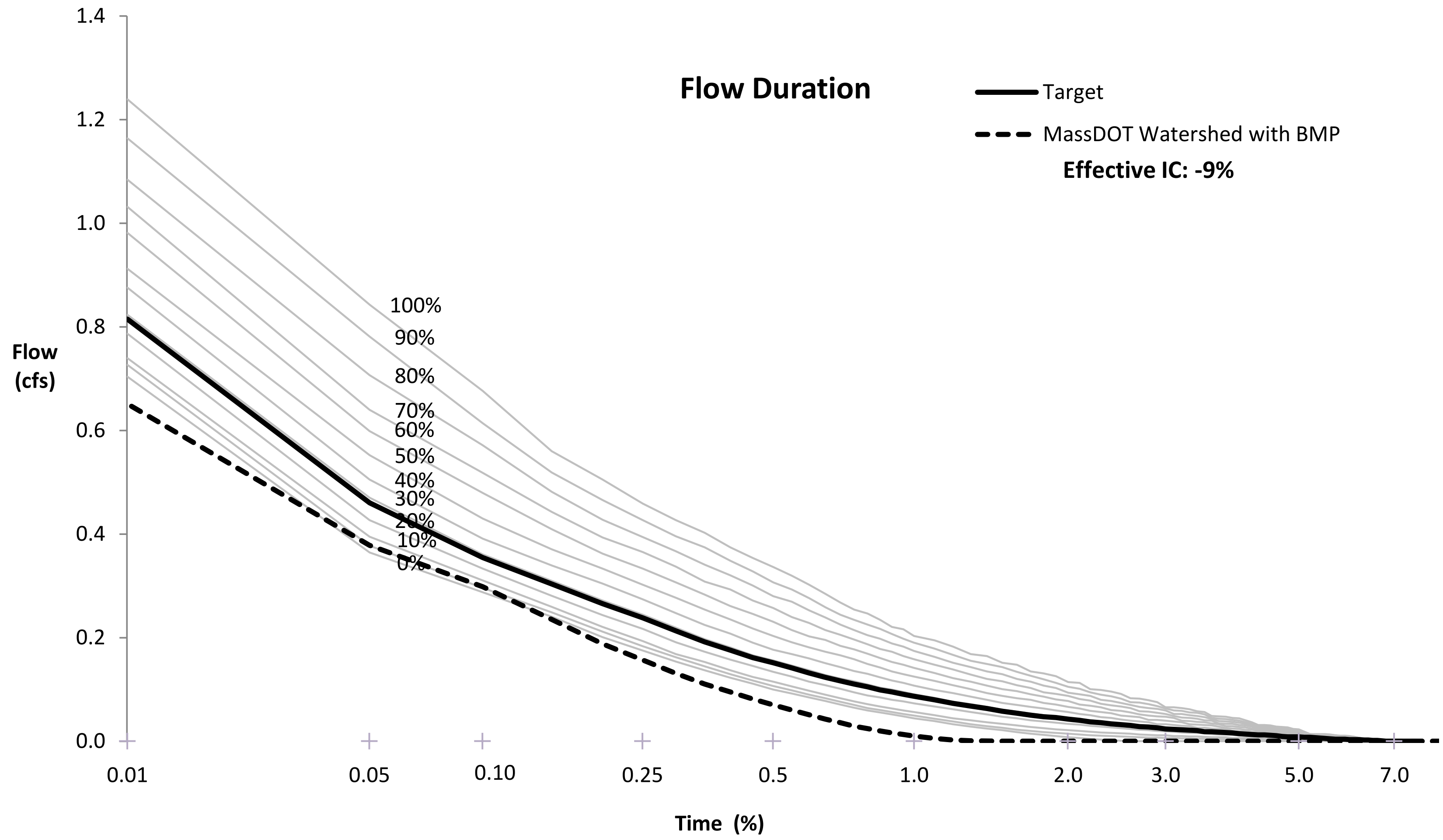
Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	1.0	1.8
Indirect Watershed	-	-
Total	1.0	1.8

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary

12.3 PR BMP 04



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	1	0	6
5%IC	2	0	135
10% IC	2	1	264
20% IC	2	1	523
30% IC	3	1	782
40% IC	3	2	1,041
50% IC	3	2	1,300
60% IC	4	3	1,559
70% IC	4	3	1,818
80% IC	5	4	2,077
90% IC	5	4	2,336
100% IC	5	5	2,596
Watershed Load	3.63	2.84	1,547
BMP Output	0.85	0.09	16
Target	2.49	1.37	724
Reduction %	**77%**	**97%**	**99%**
Effective IC	**-11%**	**0%**	**0%**

Result Summary

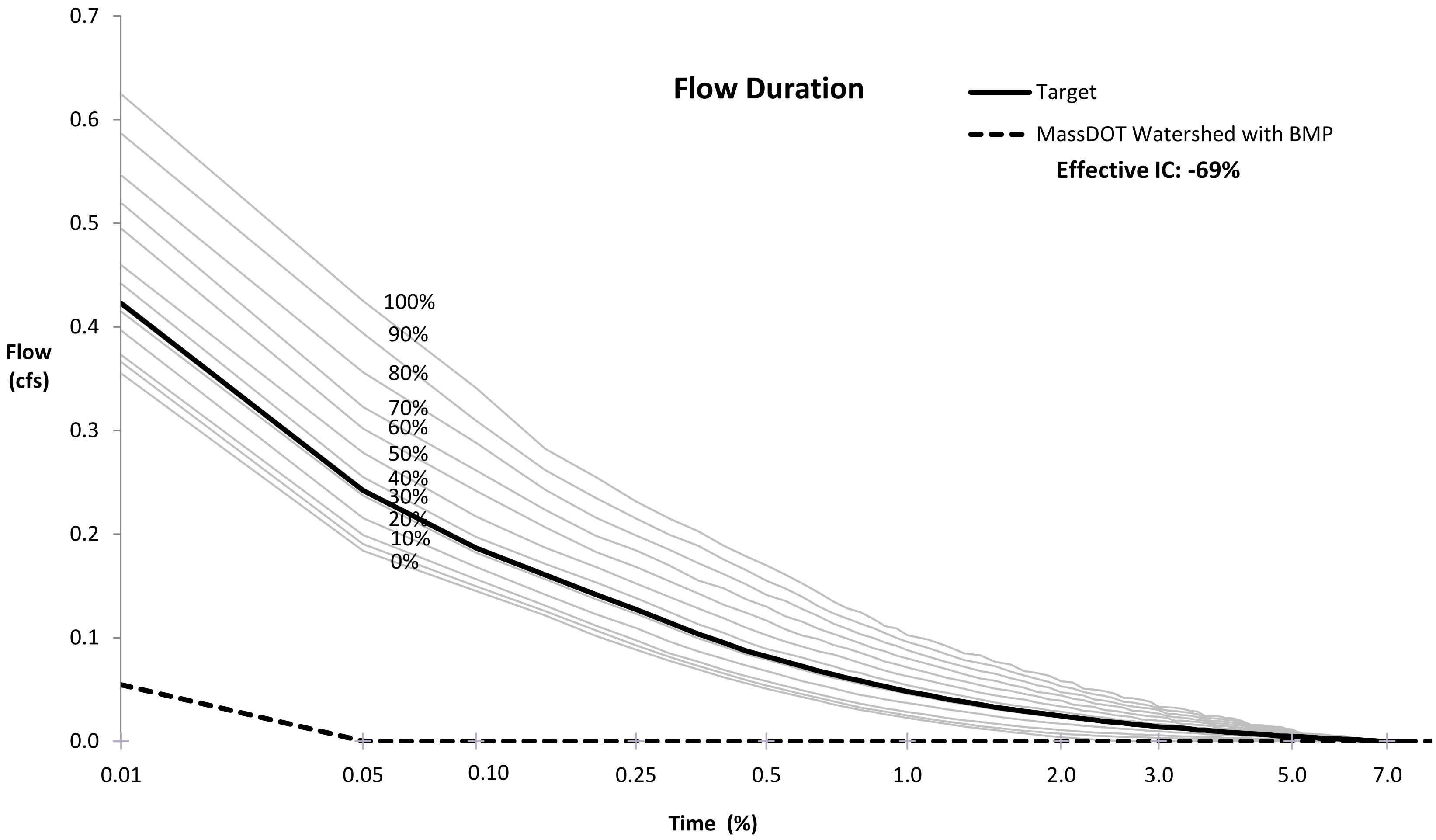
Metric	Area (%)	Area (acres)
Watershed Area		1.7
Watershed IC (no BMP)	60%	1.0
Target IC Reduction	53.6%	0.5
Effective IC w/BMP	-7%	(0.1)
IC Reduction	111%	1.1

Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	1.0	1.7
Indirect Watershed	-	-
Total	1.0	1.7

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary
14.3 PR BMP 05



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	1	0	3
5%IC	1	0	68
10% IC	1	0	133
20% IC	1	1	264
30% IC	1	1	394
40% IC	2	1	525
50% IC	2	1	655
60% IC	2	1	786
70% IC	2	2	916
80% IC	2	2	1,047
90% IC	3	2	1,177
100% IC	3	2	1,308
Watershed Load	2.01	1.68	920
BMP Output	0.01	0.00	0
Target	1.36	0.81	431
Reduction %	**100%**	**100%**	**100%**
Effective IC	**-31%**	**-2%**	**0%**

Result Summary

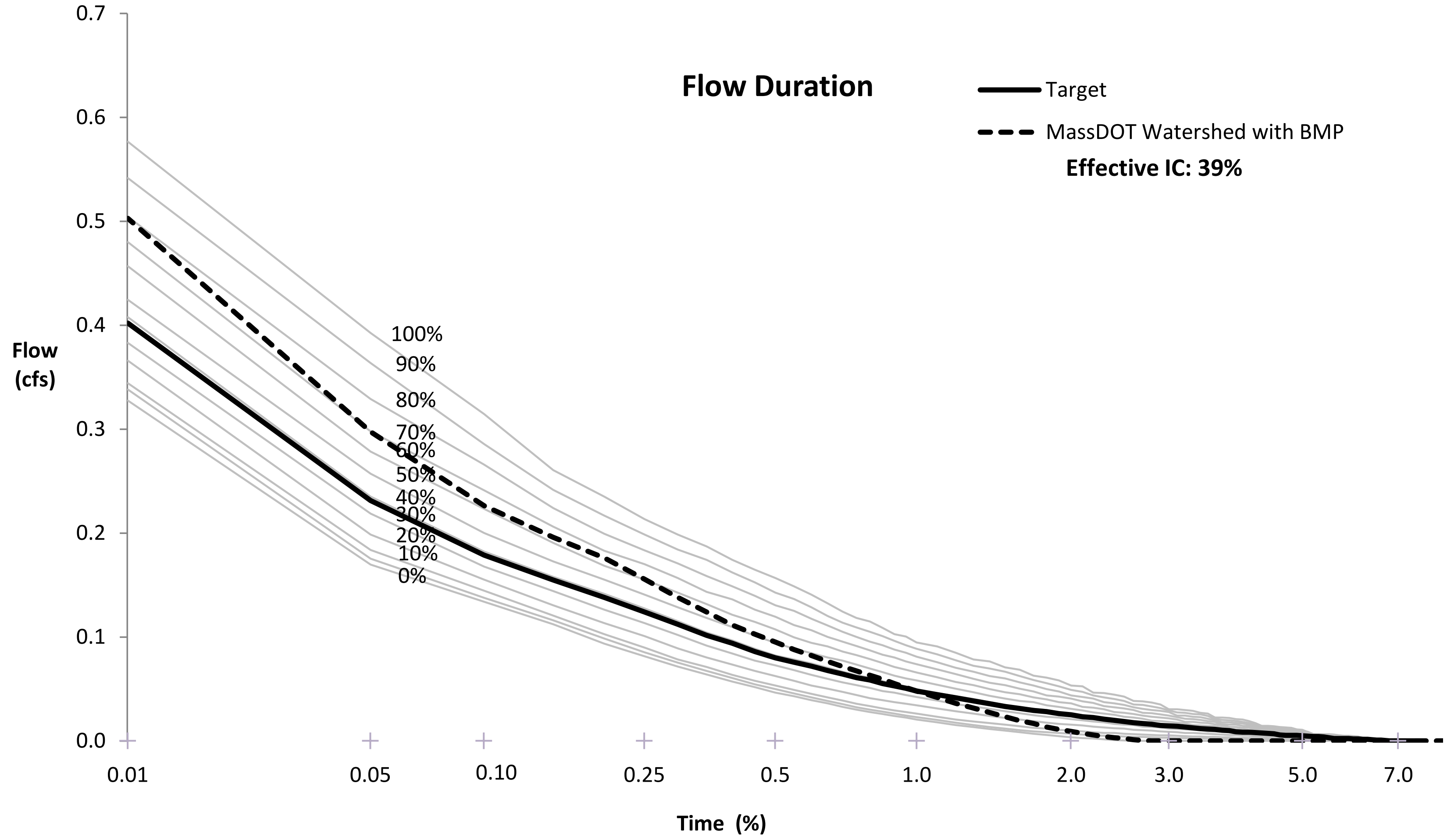
Metric	Area (%)	Area (acres)
Watershed Area		0.9
Watershed IC (no BMP)	71%	0.6
Target IC Reduction	53.6%	0.3
Effective IC w/BMP	-34%	(0.3)
IC Reduction	147%	0.9

Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	0.6	0.9
Indirect Watershed	-	-
Total	0.6	0.9

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary
16.3 PR BMP 06



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	1	0	3
5%IC	1	0	63
10% IC	1	0	123
20% IC	1	0	243
30% IC	1	1	364
40% IC	1	1	484
50% IC	2	1	605
60% IC	2	1	725
70% IC	2	2	846
80% IC	2	2	967
90% IC	2	2	1,087
100% IC	3	2	1,208
Watershed Load	2.21	1.78	973
BMP Output	1.14	0.18	45
Target	1.35	0.85	456
Reduction %	**49%**	**90%**	**95%**
Effective IC	**27%**	**7%**	**4%**

Result Summary

Metric	Area (%)	Area (acres)
Watershed Area		0.8
Watershed IC (no BMP)	81%	0.6
Target IC Reduction	53.6%	0.3
Effective IC w/BMP	24%	0.2
IC Reduction	71%	0.5

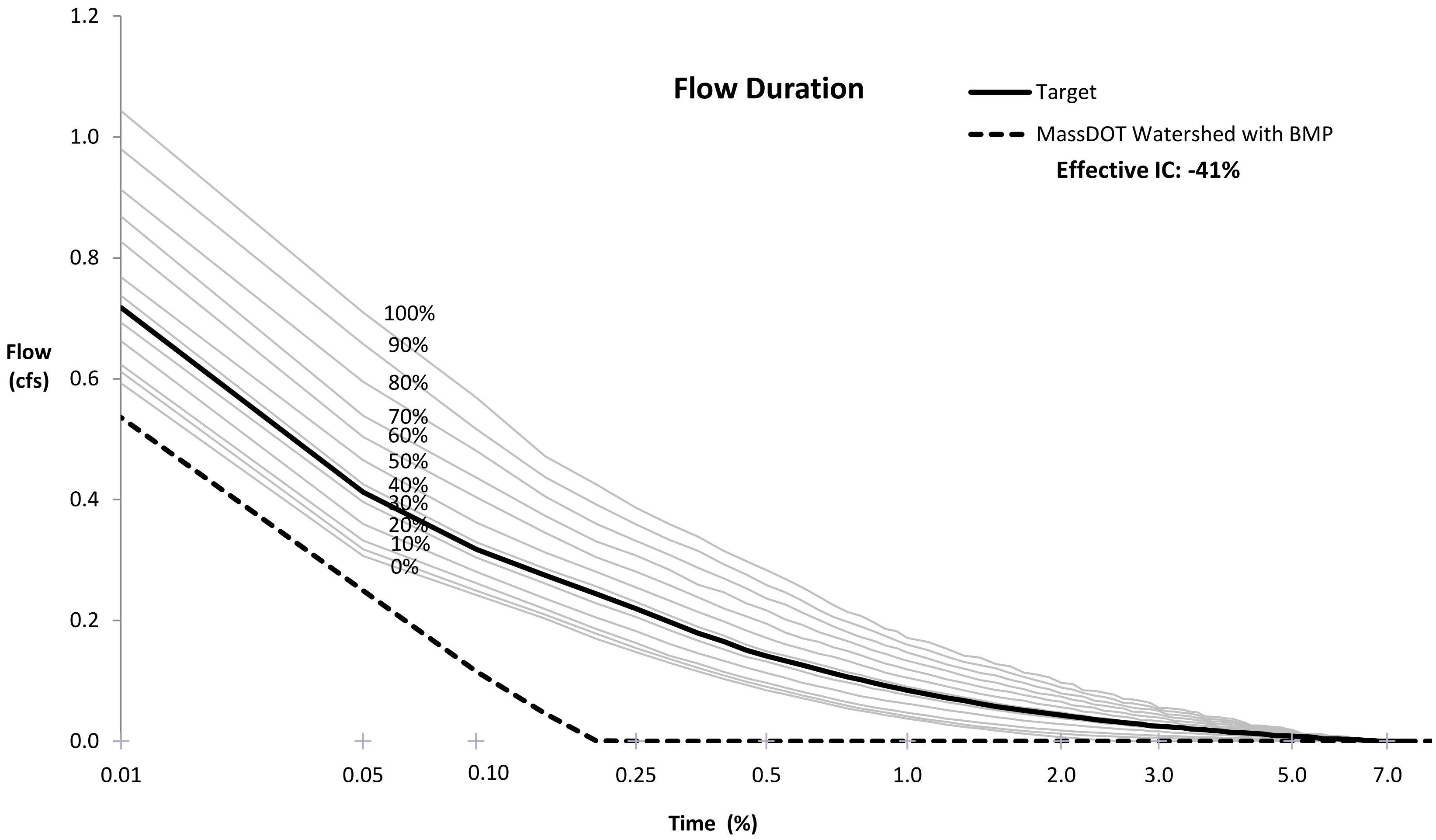
Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	0.6	0.8
Indirect Watershed	-	-
Total	0.6	0.8

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary

18.3 PR BMP 07



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	1	0	5
5%IC	1	0	113
10% IC	1	0	222
20% IC	2	1	440
30% IC	2	1	658
40% IC	3	2	876
50% IC	3	2	1,094
60% IC	3	2	1,312
70% IC	4	3	1,530
80% IC	4	3	1,748
90% IC	4	4	1,965
100% IC	5	4	2,184
Watershed Load	3.79	3.04	1,661
BMP Output	0.28	0.02	2
Target	2.37	1.45	778
Reduction %	**93%**	**99%**	**100%**
Effective IC	**-24%**	**-2%**	**0%**

Result Summary

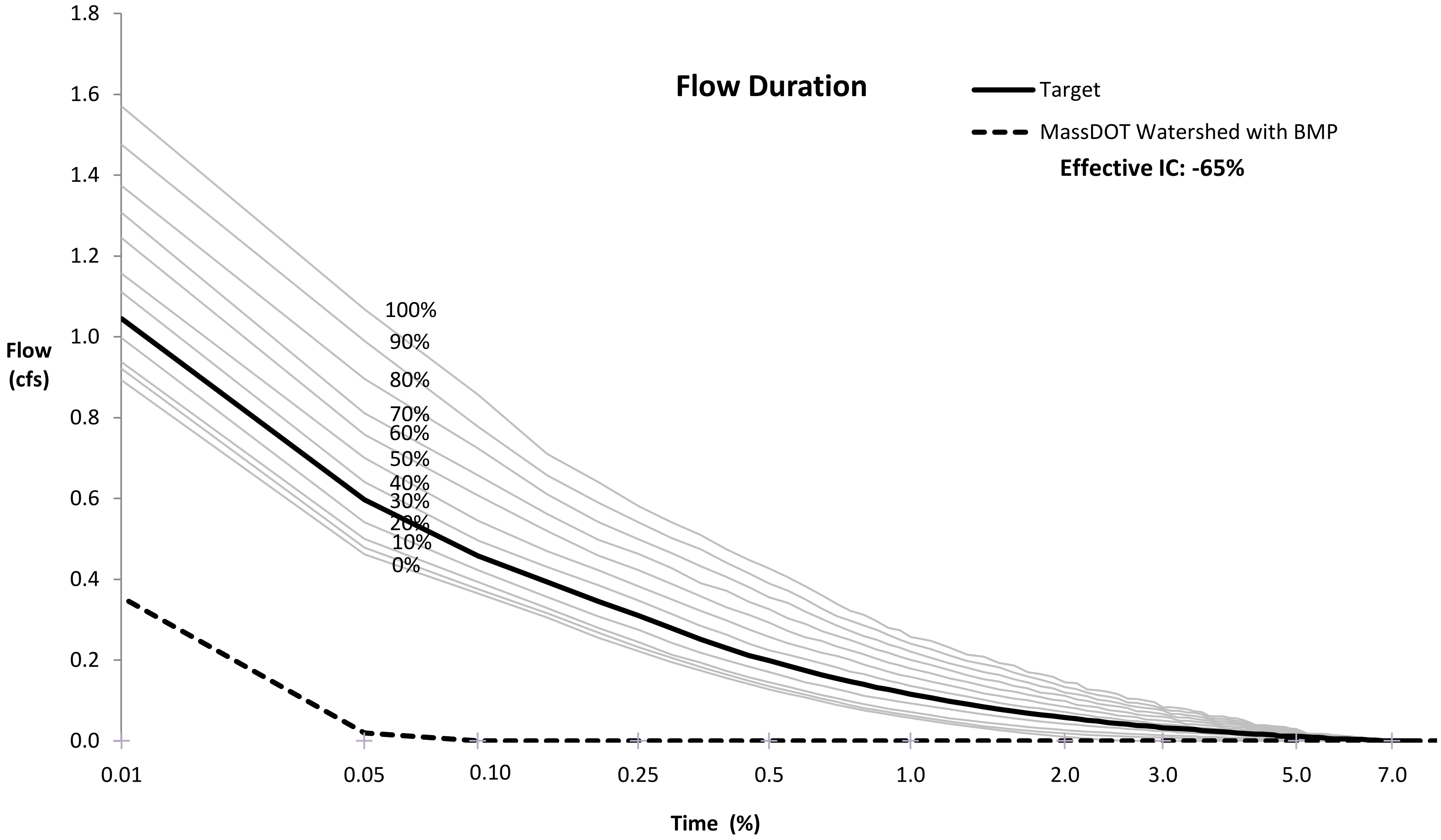
Metric	Area (%)	Area (acres)
Watershed Area		1.4
Watershed IC (no BMP)	77%	1.1
Target IC Reduction	53.6%	0.6
Effective IC w/BMP	-22%	(0.3)
IC Reduction	128%	1.4

Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	1.1	1.4
Indirect Watershed	-	-
Total	1.1	1.4

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary
20.3 PR BMP 08



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	2	0	8
5%IC	2	0	171
10% IC	2	1	335
20% IC	3	1	663
30% IC	3	2	991
40% IC	4	2	1,319
50% IC	4	3	1,647
60% IC	5	4	1,975
70% IC	5	4	2,304
80% IC	6	5	2,632
90% IC	6	5	2,960
100% IC	7	6	3,289
Watershed Load	5.11	3.92	2,136
BMP Output	0.06	0.00	0
Target	3.29	1.88	1,000
Reduction %	**99%**	**100%**	**100%**
Effective IC	**-30%**	**-2%**	**0%**

Result Summary

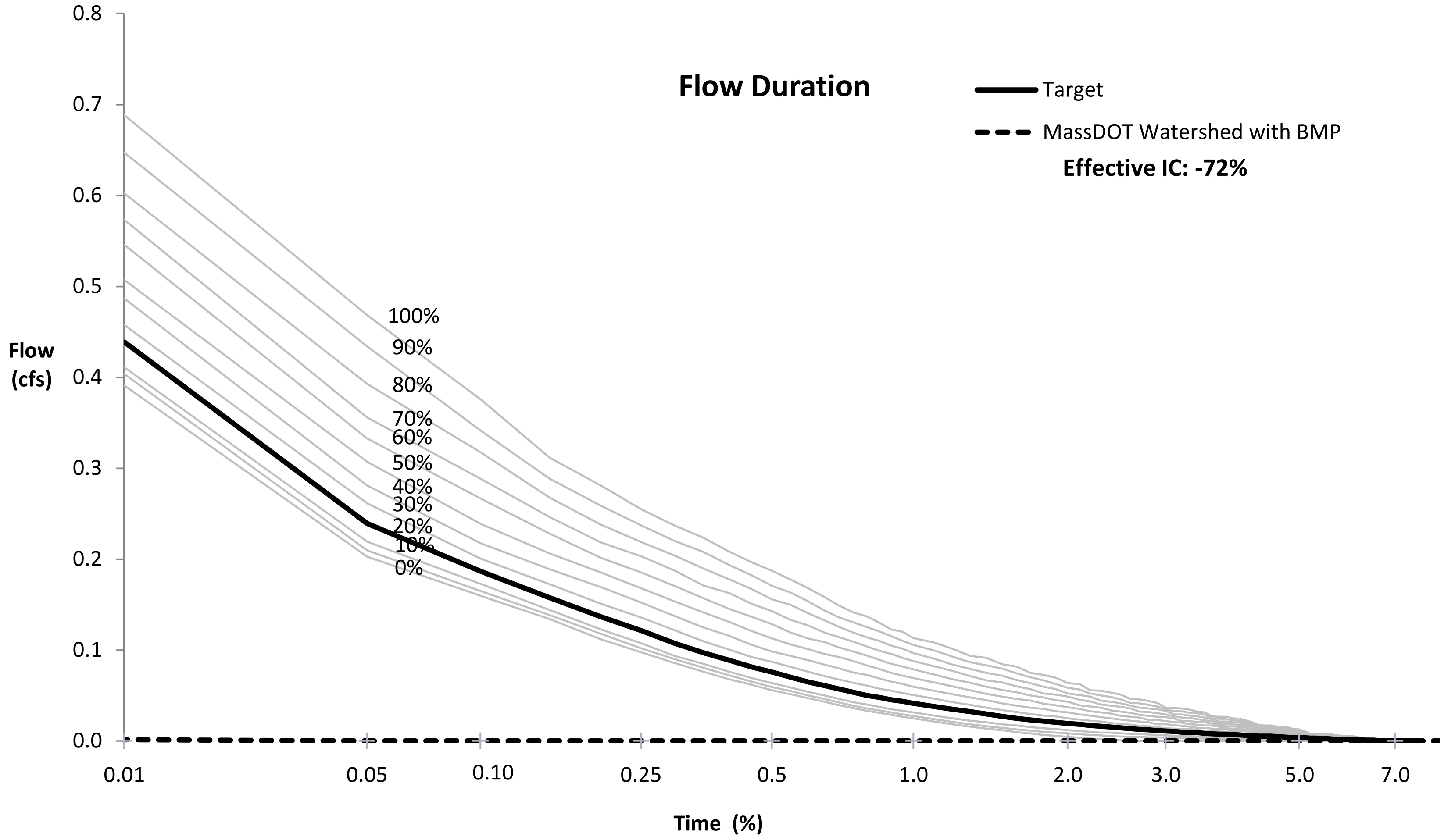
Metric	Area (%)	Area (acres)
Watershed Area		2.2
Watershed IC (no BMP)	65%	1.4
Target IC Reduction	53.6%	0.8
Effective IC w/BMP	-32%	(0.7)
IC Reduction	149%	2.1

Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	1.4	2.2
Indirect Watershed	-	-
Total	1.4	2.2

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary
22.3 PR BMP 09



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	1	0	4
5%IC	1	0	75
10% IC	1	0	147
20% IC	1	1	291
30% IC	1	1	434
40% IC	2	1	578
50% IC	2	1	722
60% IC	2	2	866
70% IC	2	2	1,010
80% IC	3	2	1,154
90% IC	3	2	1,298
100% IC	3	3	1,442
Watershed Load	1.67	1.19	645
BMP Output	-	-	-
Target	1.22	0.58	302
Reduction %	**100%**	**100%**	**100%**
Effective IC	**-32%**	**-2%**	**0%**

Result Summary

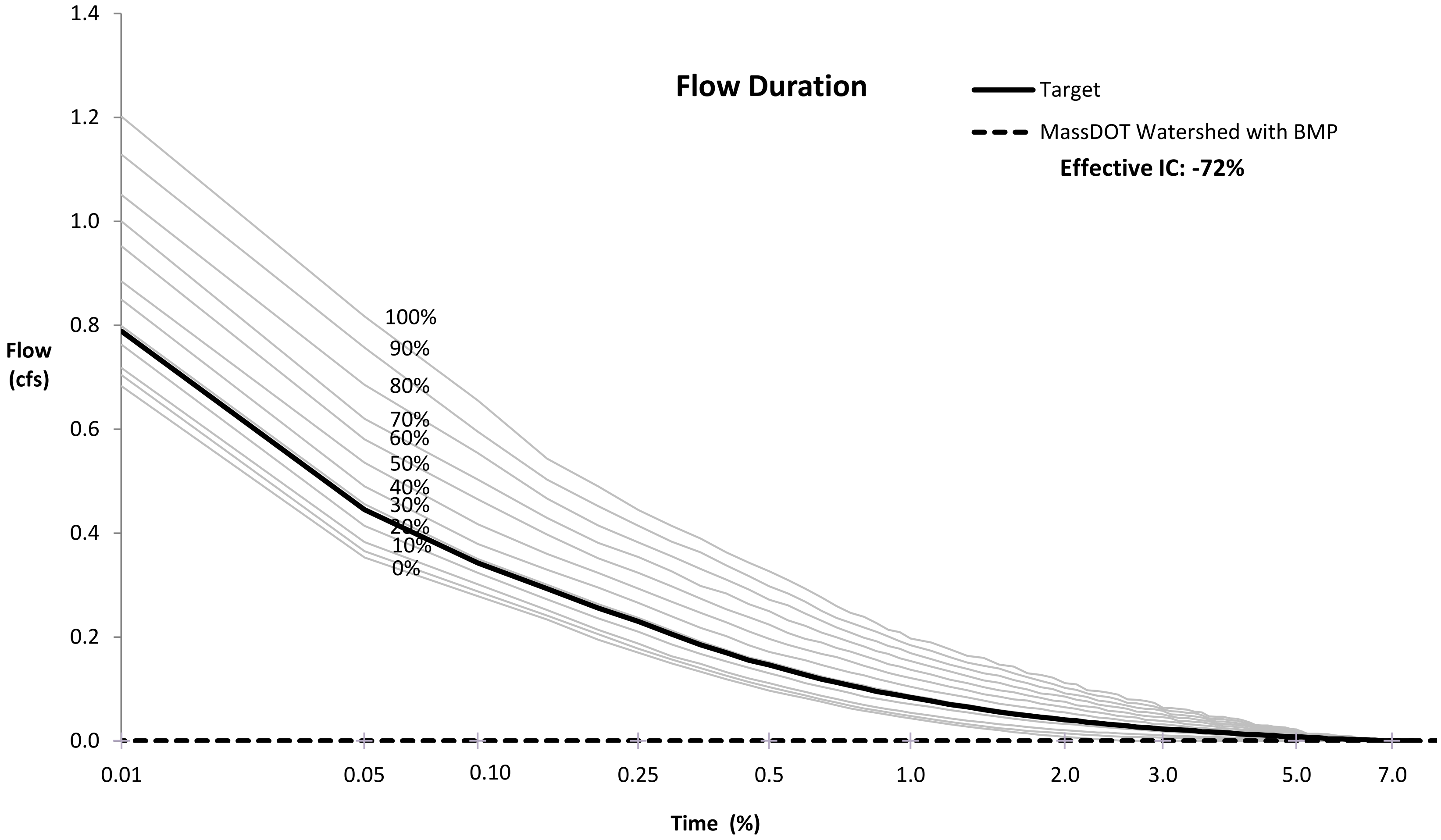
Metric	Area (%)	Area (acres)
Watershed Area		0.9
Watershed IC (no BMP)	45%	0.4
Target IC Reduction	53.6%	0.2
Effective IC w/BMP	-34%	(0.3)
IC Reduction	177%	0.8

Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	0.4	0.9
Indirect Watershed	-	-
Total	0.4	0.9

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary
24.3 PR BMP 10



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	1	0	6
5%IC	1	0	130
10% IC	2	1	256
20% IC	2	1	507
30% IC	3	1	758
40% IC	3	2	1,009
50% IC	3	2	1,260
60% IC	4	3	1,511
70% IC	4	3	1,762
80% IC	5	4	2,013
90% IC	5	4	2,264
100% IC	5	5	2,516
Watershed Load	3.66	2.73	1,481
BMP Output	-	-	-
Target	2.40	1.31	692
Reduction %	**100%**	**100%**	**100%**
Effective IC	**-32%**	**-2%**	**0%**

Result Summary

Metric	Area (%)	Area (acres)
Watershed Area		1.7
Watershed IC (no BMP)	59%	1.0
Target IC Reduction	53.6%	0.5
Effective IC w/BMP	-34%	(0.6)
IC Reduction	158%	1.5

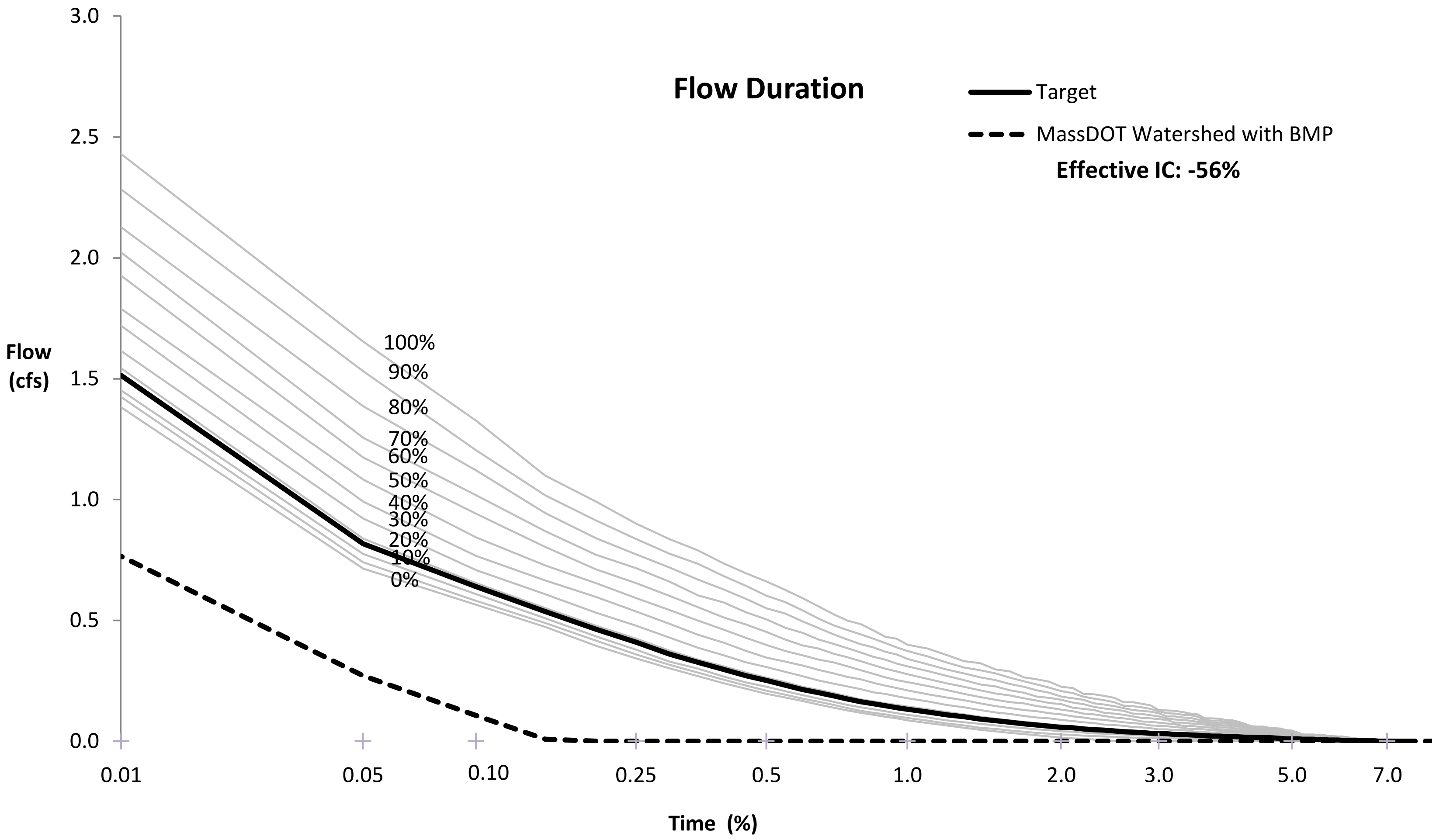
Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	1.0	1.7
Indirect Watershed	-	-
Total	1.0	1.7

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary

26.3 PR BMP 11



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	3	0	13
5%IC	3	1	264
10% IC	3	1	518
20% IC	4	2	1,026
30% IC	5	3	1,533
40% IC	6	4	2,041
50% IC	7	5	2,549
60% IC	7	6	3,056
70% IC	8	7	3,564
80% IC	9	7	4,072
90% IC	10	8	4,580
100% IC	11	9	5,090
Watershed Load	5.18	3.43	1,840
BMP Output	0.31	0.02	1
Target	3.99	1.68	862
Reduction %	**94%**	**99%**	**100%**
Effective IC	**-28%**	**-2%**	**0%**

Result Summary

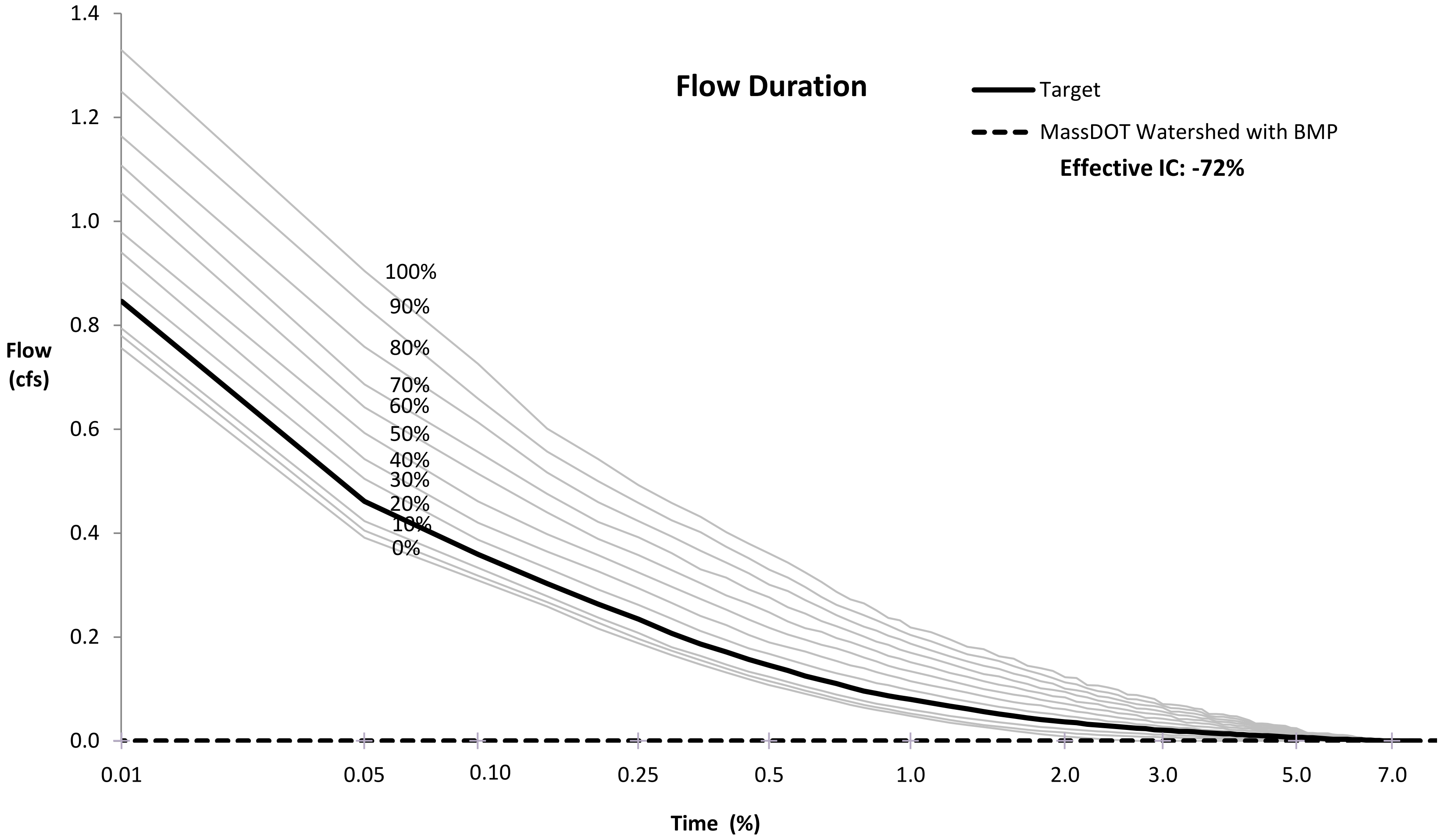
Metric	Area (%)	Area (acres)
Watershed Area		3.3
Watershed IC (no BMP)	36%	1.2
Target IC Reduction	53.6%	0.6
Effective IC w/BMP	-28%	(0.9)
IC Reduction	177%	2.1

Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	0.7	2.6
Indirect Watershed	0.5	0.8
Total	1.2	3.3

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary
28.3 PR BMP 12



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	1	0	7
5%IC	2	0	144
10% IC	2	1	283
20% IC	2	1	561
30% IC	3	2	839
40% IC	3	2	1,117
50% IC	4	3	1,395
60% IC	4	3	1,672
70% IC	5	4	1,950
80% IC	5	4	2,228
90% IC	5	5	2,506
100% IC	6	5	2,785
Watershed Load	3.37	2.26	1,211
BMP Output	-	-	-
Target	2.35	1.11	578
Reduction %	**100%**	**100%**	**100%**
Effective IC	**-32%**	**-2%**	**0%**

Result Summary

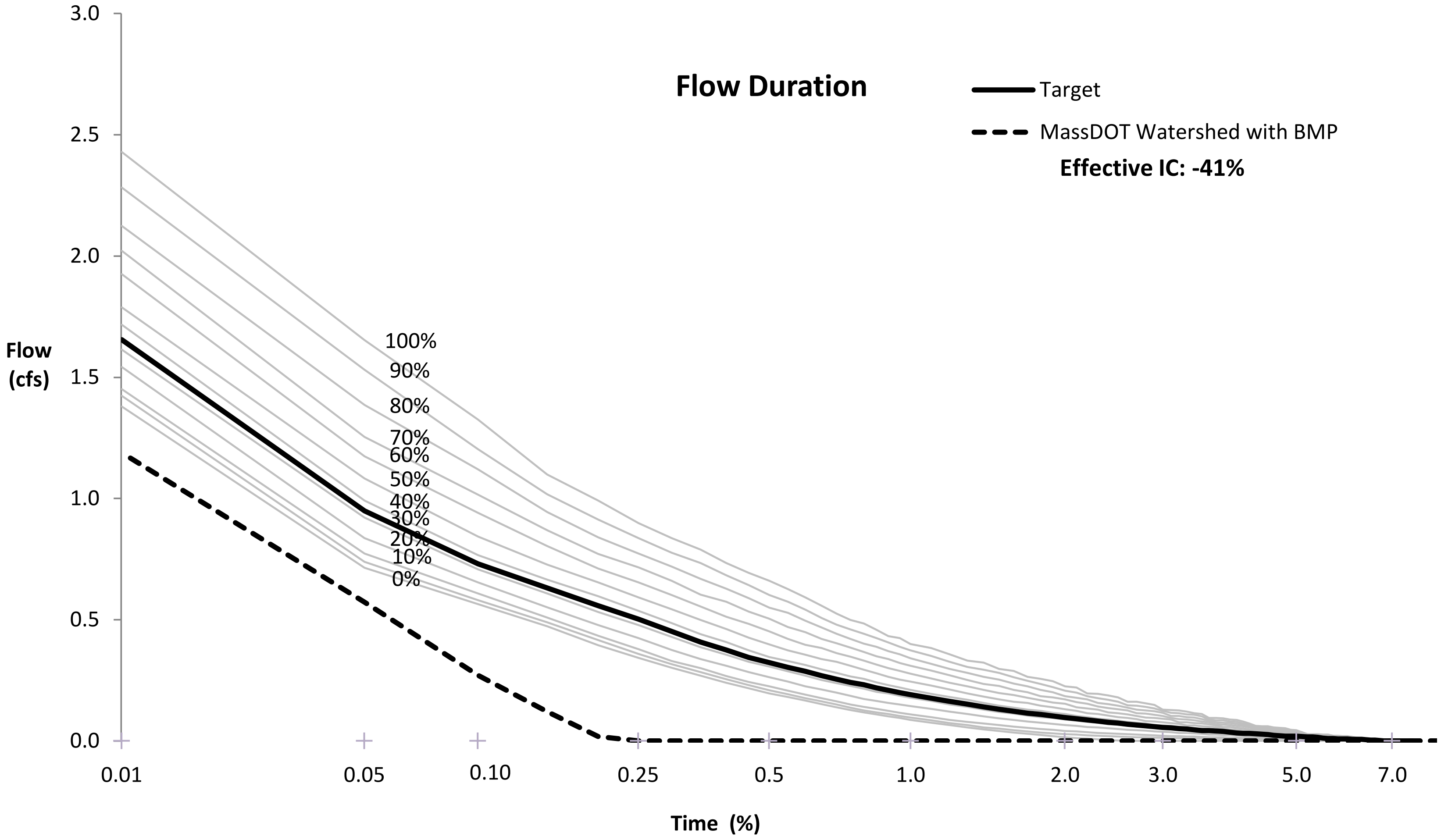
Metric	Area (%)	Area (acres)
Watershed Area		1.8
Watershed IC (no BMP)	44%	0.8
Target IC Reduction	53.6%	0.4
Effective IC w/BMP	-34%	(0.6)
IC Reduction	178%	1.4

Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	0.8	1.8
Indirect Watershed	-	-
Total	0.8	1.8

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary
30.3 PR BMP 13



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	3	0	13
5%IC	3	1	264
10% IC	3	1	518
20% IC	4	2	1,025
30% IC	5	3	1,533
40% IC	6	4	2,041
50% IC	7	5	2,548
60% IC	7	6	3,056
70% IC	8	7	3,564
80% IC	9	7	4,071
90% IC	10	8	4,579
100% IC	11	9	5,089
Watershed Load	8.55	6.79	3,705
BMP Output	0.66	0.05	3
Target	5.40	3.24	1,735
Reduction %	**92%**	**99%**	**100%**
Effective IC	**-24%**	**-2%**	**0%**

Result Summary

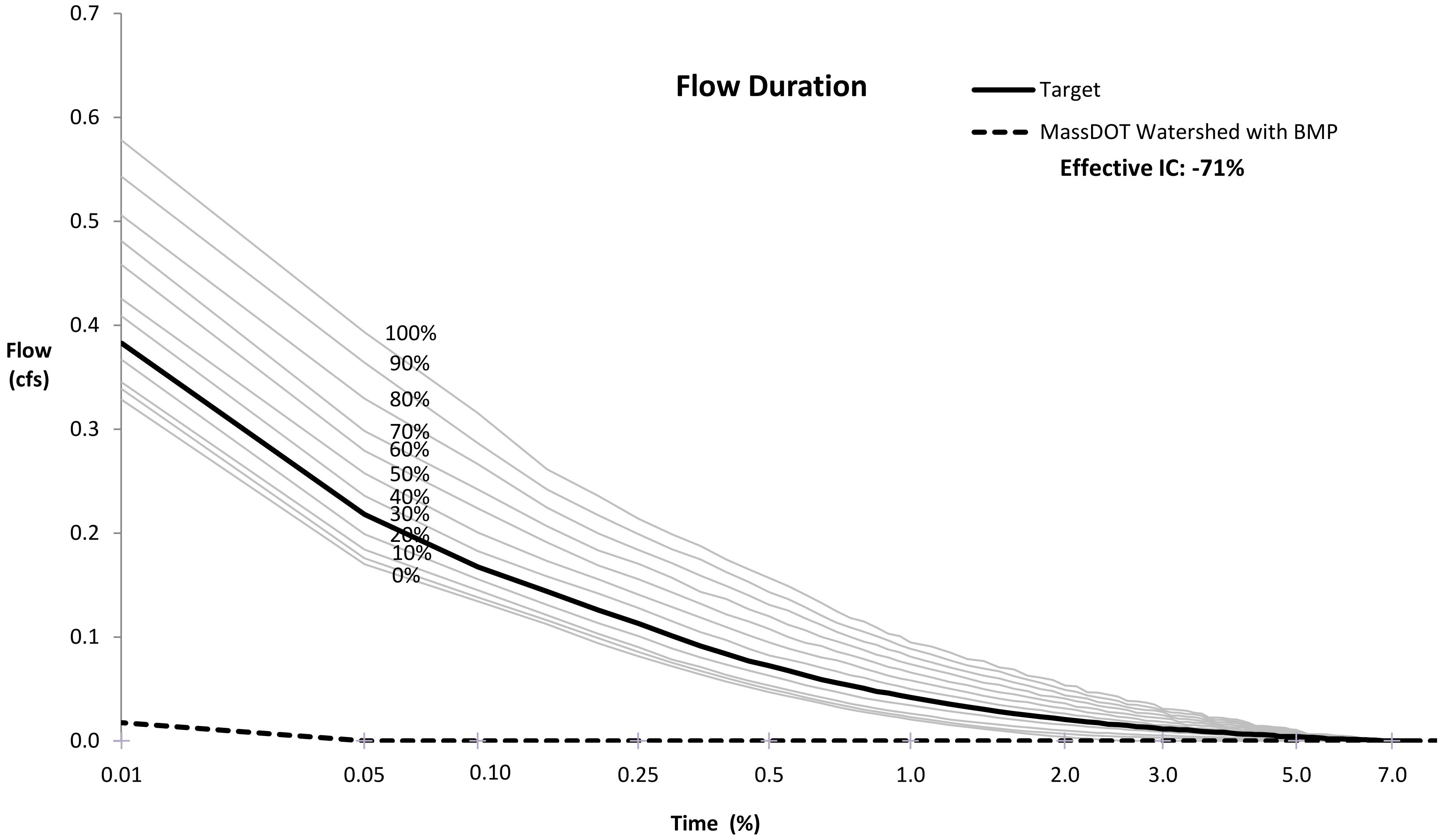
Metric	Area (%)	Area (acres)
Watershed Area		3.3
Watershed IC (no BMP)	73%	2.5
Target IC Reduction	53.6%	1.3
Effective IC w/BMP	-22%	(0.7)
IC Reduction	130%	3.2

Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	2.5	3.3
Indirect Watershed	-	-
Total	2.5	3.3

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary
32.3 PR BMP 14



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	1	0	3
5%IC	1	0	63
10% IC	1	0	123
20% IC	1	0	244
30% IC	1	1	365
40% IC	1	1	485
50% IC	2	1	606
60% IC	2	1	727
70% IC	2	2	848
80% IC	2	2	968
90% IC	2	2	1,089
100% IC	3	2	1,211
Watershed Load	1.85	1.41	765
BMP Output	0.00	0.00	0
Target	1.20	0.67	357
Reduction %	**100%**	**100%**	**100%**
Effective IC	**-32%**	**-2%**	**0%**

Result Summary

Metric	Area (%)	Area (acres)
Watershed Area		0.8
Watershed IC (no BMP)	63%	0.5
Target IC Reduction	53.6%	0.3
Effective IC w/BMP	-34%	(0.3)
IC Reduction	154%	0.8

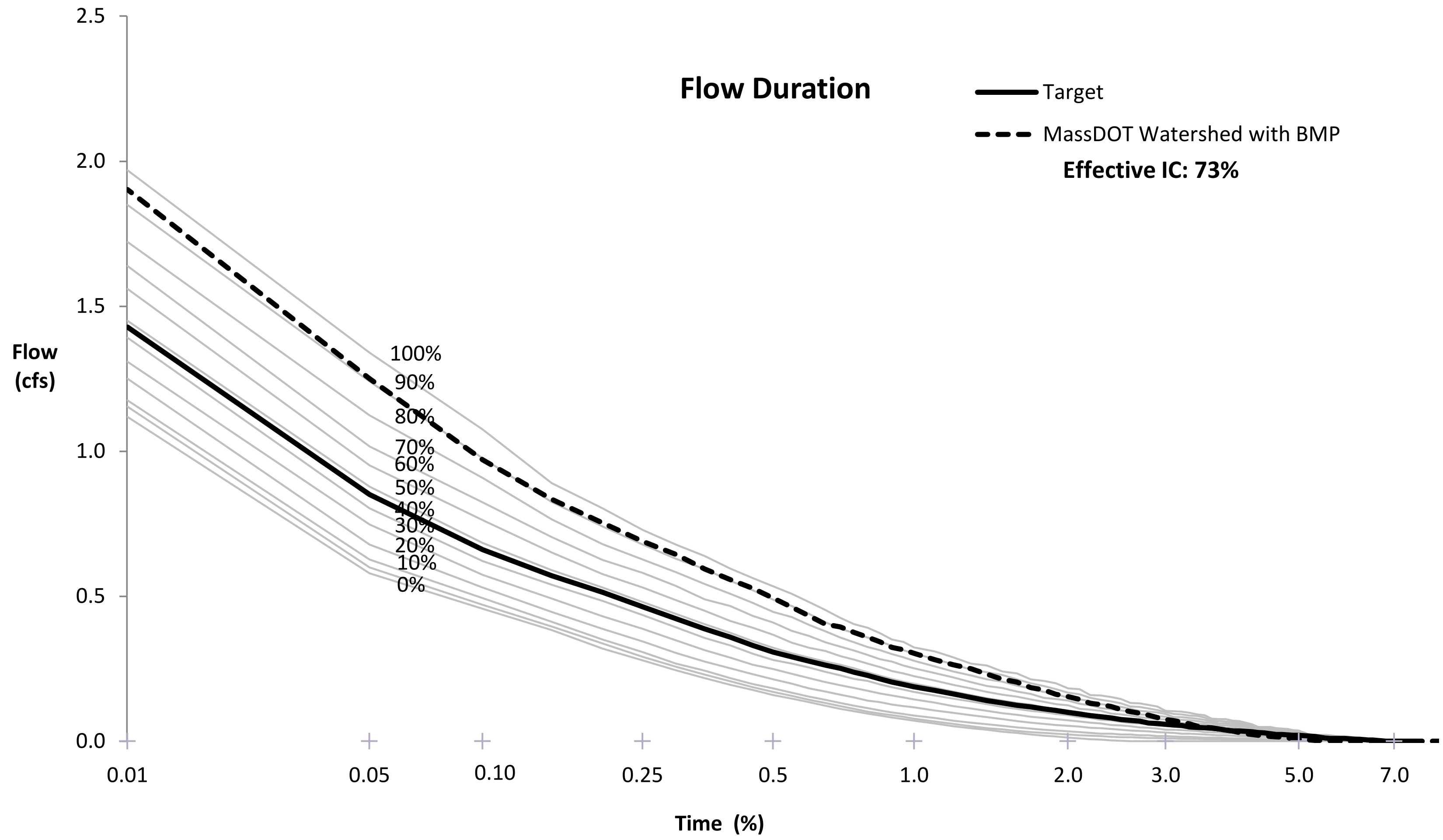
Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	0.5	0.8
Indirect Watershed	-	-
Total	0.5	0.8

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Result Summary

34.3 PR BMP 15



Median Annual Load Comparison Table

Condition	Runoff (ac-ft)	Phos. (lb.)	TSS (lb.)
0%IC	2	0	10
5%IC	2	1	214
10% IC	3	1	420
20% IC	3	2	831
30% IC	4	2	1,242
40% IC	5	3	1,654
50% IC	5	4	2,065
60% IC	6	5	2,477
70% IC	7	5	2,888
80% IC	7	6	3,299
90% IC	8	7	3,711
100% IC	9	8	4,124
Watershed Load	8.72	7.48	4,111
BMP Output	7.32	2.41	817
Target	5.19	3.55	1,917
Reduction %	**16%**	**68%**	**80%**
Effective IC	**79%**	**31%**	**20%**

Result Summary

Metric	Area (%)	Area (acres)
Watershed Area		2.7
Watershed IC (no BMP)	100%	2.7
Target IC Reduction	53.6%	1.5
Effective IC w/BMP	61%	1.7
IC Reduction	39%	1.1

Watershed Data

Metric	IC (acres)	Total (acres)
Direct Wateshed	2.7	2.7
Indirect Watershed	-	-
Total	2.7	2.7

* Effective IC calculated as follows:
1. Interpolate effective IC separately for each metric via interpolation of reference tables/curves
   a. For TSS, P and Flow volume, calculate effective percentage% by using linear interpolation of percentage to closest load/volume values
   b. For flow duration, calculate average of individually interpolated values taken at equal probability intervals (based on normal distribution)
2. Determine the maximum IC indictor for the flow metrics (TSS load and TP load)
3. Take the average of the three IC indicators (runoff volume, maximum of TSS and TP load, flow duration) as the representative effective IC for the watershed

Impaired Waters Assessment for Spectacle Pond (MA84089) – Final Report

Impaired Waterbody

Name: Spectacle Pond

Location: Littleton and Ayer, MA

Water Body ID: MA84089

Impairments

Spectacle Pond (MA84089) is listed under Category 5, "Waters Requiring a TMDL", on MassDEP's *Final Massachusetts Year 2012 Integrated List of Waters* (MassDEP, 2013). Spectacle Pond is impaired for the following:

- Dissolved oxygen
- non-native aquatic plants

According to MassDEP's *Merrimack River Watershed 2004-2009 Water Quality Assessment Report* (MassDEP, 2010), three non-native aquatic plant species (Cabomba caroliniana, Potamogeton crispus, and Myriophyllum heterophyllum) were identified in Spectacle Pond. Additionally, the Littleton Water Department is authorized (MAG6400002 issued March 2002) to discharge an average monthly flow of 0.02 MGD (0.03 MGD maximum daily) from Spectacle Pond Water Production Facility near Route 119 to Spectacle Pond.

Relevant Water Quality Standards

Water Body Classification: Class B, WWF

Applicable State Regulations:

- 314 CMR 4.05 (4)(b) 1 Dissolved Oxygen. Shall not be less than 5.0 mg/l. Seasonal and daily variations that are necessary to protect existing and designated uses shall be maintained. Where natural background conditions are lower, DO shall not be less than natural background.
- 314 CMR 4.05 (5)(a) Aesthetics. All surface waters shall be free from pollutants in concentrations or combinations that settle to form objectionable deposits; float as debris, scum or other matter to form nuisances; produce objectionable odor, color, taste or turbidity; or produce undesirable or nuisance species of aquatic life.

Site Description

Spectacle Pond (MA84089) is a water body almost entirely in Littleton, Massachusetts, with a small portion in Ayer (**Figure 1**). The pond is approximately 79 acres and has one primary inlet, Bennett's Brook, one secondary unnamed inlet, and one primary outlet, Gilson Brook.

The closest MassDOT roadway is Route 119 which passes over Gilson Brook in the immediate vicinity of Spectacle Pond's outlet (**Figure 2**). This is the only MassDOT-owned property with potential direct stormwater discharge to Spectacle Pond. Drainage from Route 119 in this area flows to a low point located southeast of the railroad bridge near the boat launch located approximately at station 265 of the Route 119 (Littleton Road) State Highway Layout (SHLO).

A portion of Route 119 at the Gilson Brook culvert which controls the water level in Spectacle Pond was rebuilt by MassDOT recently after heavy rains washed out the existing culvert and roadway. The westbound approach to the bridge enters into a curve which is superelevated and is not crowned at the centerline of the roadway. Rainfall that falls on the majority of the pavement in this area runs off to the east curb line and enters into rip rapped drainage swales that contribute directly to Gilson Brook, which is not an impaired waterway. Runoff that falls on the western shoulder of Route 119 and a portion of the eastbound travel lanes is considered to directly contribute to Spectacle Pond via observed drainage channels along the edge of the boat launch (**Figure 3**).

Assessment under BMP 7U

None of the impairments for Spectacle Pond have been addressed by a TMDL. MassDOT assessed the impairments using the approach described in BMP 7U of MassDOT's Storm Water Management Plan (*Water Quality Impaired Waters Assessment and Mitigation Plan*), which applies to impairments that have been assigned to a water body prior to completion of a TMDL. As described in MassDOT's Application of Impervious Cover Method in BMP 7U (MassDOT, 2011), impervious cover (IC) provides a measure of the potential impact of storm water on many impairments. For this water body, MassDOT used the IC method to assess the following impairments:

- Dissolved oxygen

Similarly, the non-native plants impairment is not addressed in this assessment as these impairments are considered non-pollutants and unrelated to stormwater according to the *Final Massachusetts Year 2012 Integrated List of Waters*. Therefore, MassDOT has determined that further assessment of this impairment for the water bodies is not required under BMP 7U.

MassDOT's Application of the Impervious Cover Method

MassDOT's Application of Impervious Cover Method in BMP 7U applies many aspects of USEPA Region I's Impervious Cover Method described in EPA's *Stormwater TMDL Implementation Support Manual* (ENSR, 2006) to MassDOT's program. This method assesses potential stormwater impacts on the impaired water and evaluates the IC reduction necessary to attain the percent imperviousness in the watershed at which stormwater is not likely the cause of the impairments. Consistent with findings of EPA and others, when a watershed has less than 9% IC, MassDOT concludes that stormwater is not the likely cause of the impairment. Additional information regarding this method is provided in MassDOT's Application of IC Method document.

Assessment

First, MassDOT calculated the percent IC of the water body's entire contributing watershed (total watershed upstream of the downstream end of an impaired segment) and that of the local watershed contributing to the impaired segment (referred to as the subwatershed in this analysis) to determine whether stormwater has a potential to cause the impairments of the receiving water body. The total watershed and subwatershed to the impaired water body were delineated using the USGS Data Series 451. When USGS Data Series watersheds did not delineate the subwatershed of the water body under review, the GIS shapefiles were modified by delineating to the water body based on USGS topography to add specificity. IC data was available as part of the USGS data layers Data Series 451 and MassGIS's impervious surfaces data layer.

In cases where it was determined that stormwater was a potential cause of the impairment, MassDOT calculated the degree to which IC would need to be reduced in the subwatershed to meet the 9% IC target. This reduction was then applied proportionally to the area of MassDOT roadways/properties directly discharging to the water body segment to identify MassDOT's target IC reduction. The 9% IC reduction serves only as a recommended target and is not meant to imply that failing to meet the target would cause an exceedance in water quality standards. As explained in BMP 7U, MassDOT will consider a variety of factors apart from numeric guidelines, including site constraints and the magnitude of any potential exceedances in water quality standards, to determine the precise nature and extent of additional BMPs recommended for particular locations. This approach is consistent with the iterative, adaptive management BMP approach set forth in EPA guidelines.

MassDOT calculated the effective IC reduction afforded by the existing structural BMPs currently incorporated into the stormwater infrastructure of MassDOT's properties. This effective IC reduction was calculated by applying effective IC reduction rates to existing BMPs based on their size, function and contributing watershed. BMP performances were derived from EPA Region 1's *Stormwater Best Management Practices (BMP) Performance Analysis* report (EPA, 2010) and engineering judgment. More information on the approach used to calculate the effective IC reductions is described in BMP 7U. When the reduction in effective IC achieved by the existing BMPs was equal to or greater than the target reduction, no further measures were proposed. When this was not the case, MassDOT considered additional BMPs in order to meet the targeted reduction.

Using this approach, MassDOT derived the following site parameters for Spectacle Pond (MA84089):

Table 1. Site Parameters for Spectacle Pond (MA84089)

Type	Parameter	Quantity	Unit of Measure
Total and Subwatershed	Subwatershed Area	4,443	acres
Total and Subwatershed	Impervious Cover (IC) Area	618	acres
Total and Subwatershed	Percent Impervious	13.9	%
Total and Subwatershed	IC Area at 9% Goal	400	acres
Total and Subwatershed	Target Reduction% in IC	35.3	%
Reductions Applied	MassDOT's IC Area Directly Contributing to Impaired Segment	0.23	acres
Reductions Applied	MassDOT's Target Reduction in Effective IC (35.2% of DOT Directly Contributing IC)	0.08	acres

The subwatershed is greater than 9% impervious cover, indicating that stormwater likely contributes to the impairments assessed under this methodology. In order to reach the 9% target, effective IC within the subwatershed should be reduced by 35.2%. Therefore, MassDOT's target is to reduce effective IC within its own directly contributing watershed by the same percentage, or 0.08 acres.

Existing BMPs

Based on the site visit, there are no existing BMPs in the Spectacle Pond (MA84089) directly contributing watershed that are mitigating potential stormwater quality impacts prior to discharge to Spectacle Pond (MA84089).

Mitigation Plan

Because the total mitigation of impervious surface achieved by MassDOT's existing BMPs is less than the target reduction of 0.08 acres, MassDOT will consider the implementation of additional BMPs.

Conclusions

MassDOT used the IC Method to assess Spectacle Pond for the impairments identified in MassDEP's final Massachusetts Year 2012 Integrated List of Waters. Results indicate that MassDOT should reduce its effective IC within its directly contributing subwatershed by 0.08 acres to achieve the targeted reduction in effective IC. MassDOT evaluated its property within the directly contributing watershed to Spectacle Pond (MA84089) to identify existing BMPs and found that there were no existing BMPs to contribute to the target reduction in effective IC. During assessment it was noted that there are no feasible locations in the vicinity of the directly contributing watershed for installation of stormwater BMPs.

MassDOT will continue to identify opportunities to implement additional structural BMPs to address pollutant loading when road work is conducted under MassDOT's programmed projects initiative. Work on programmed projects, which often include broader scale road layout changes, may provide additional opportunities for construction of new treatment BMPs. This is consistent with an iterative adaptive management approach to addressing impairments. MassDOT will include an update in annual reports and biannual submittals to EPA regarding progress made towards meeting target IC reductions, plans for construction of additional BMPs, and finalized assessments including reductions achieved by finalized BMP designs. Furthermore, MassDOT will continue to implement non-structural BMPs that reduce the impacts of stormwater.

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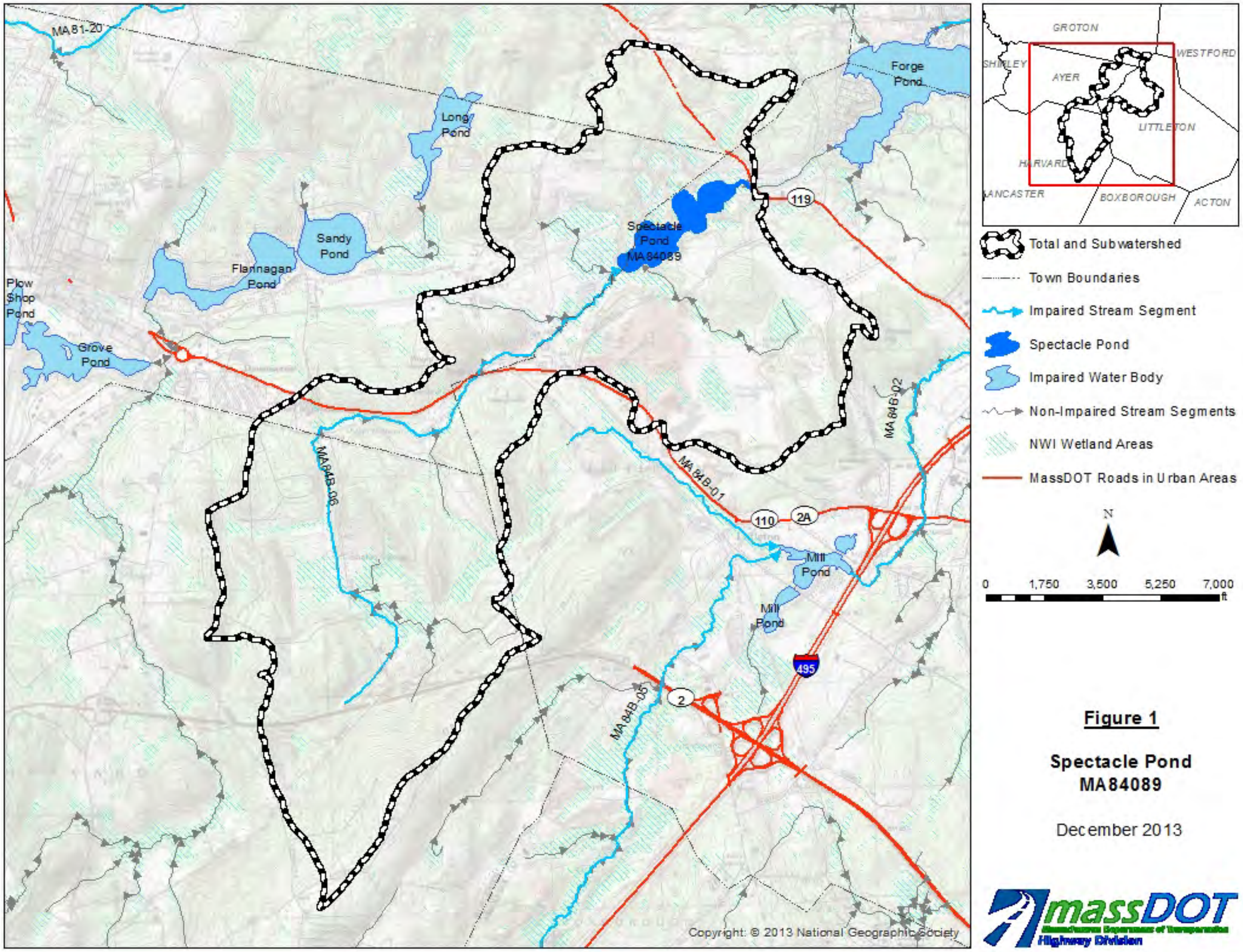

Figure 1

Spectacle Pond MA84089

December 2013

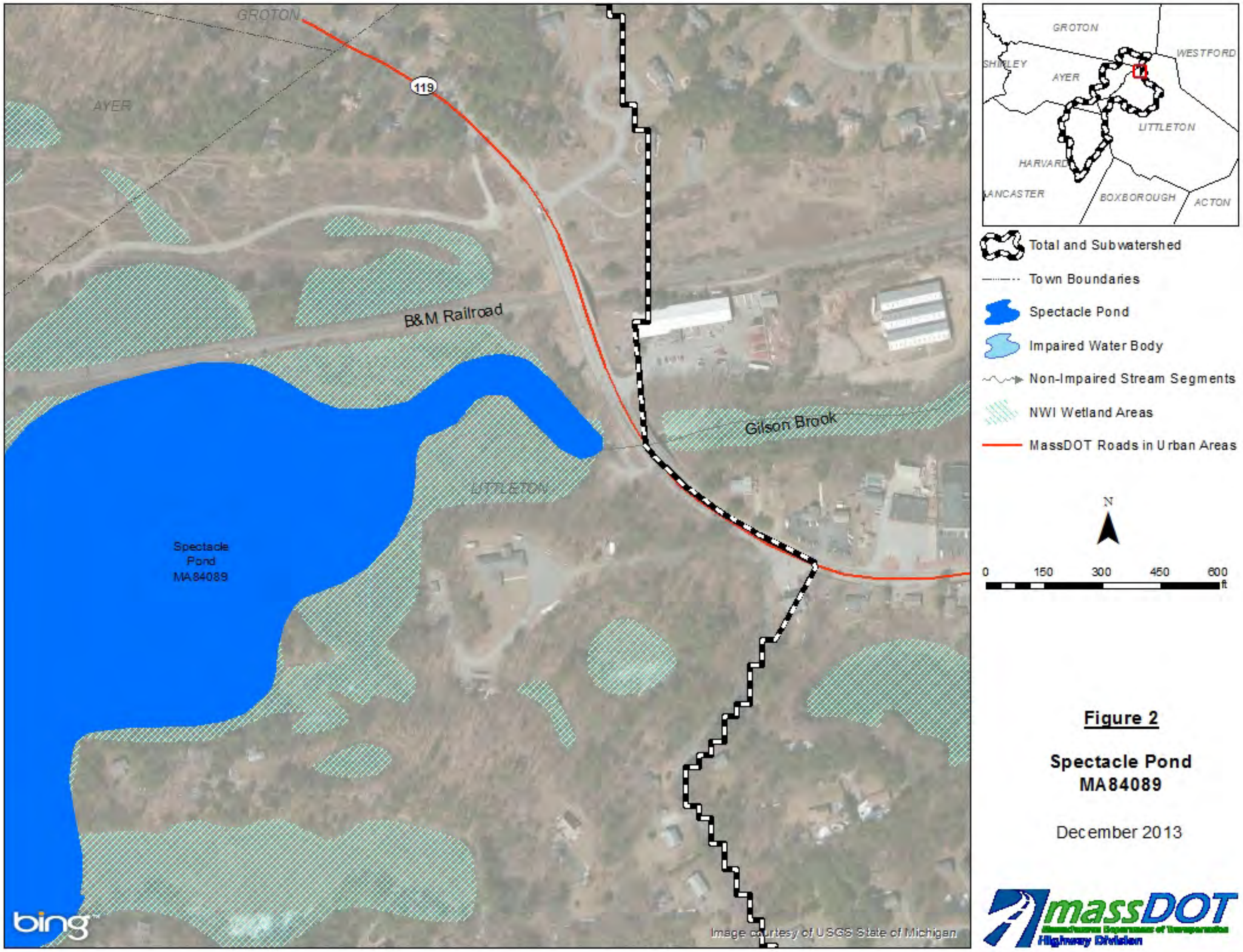

Figure 2

Spectacle Pond MA84089

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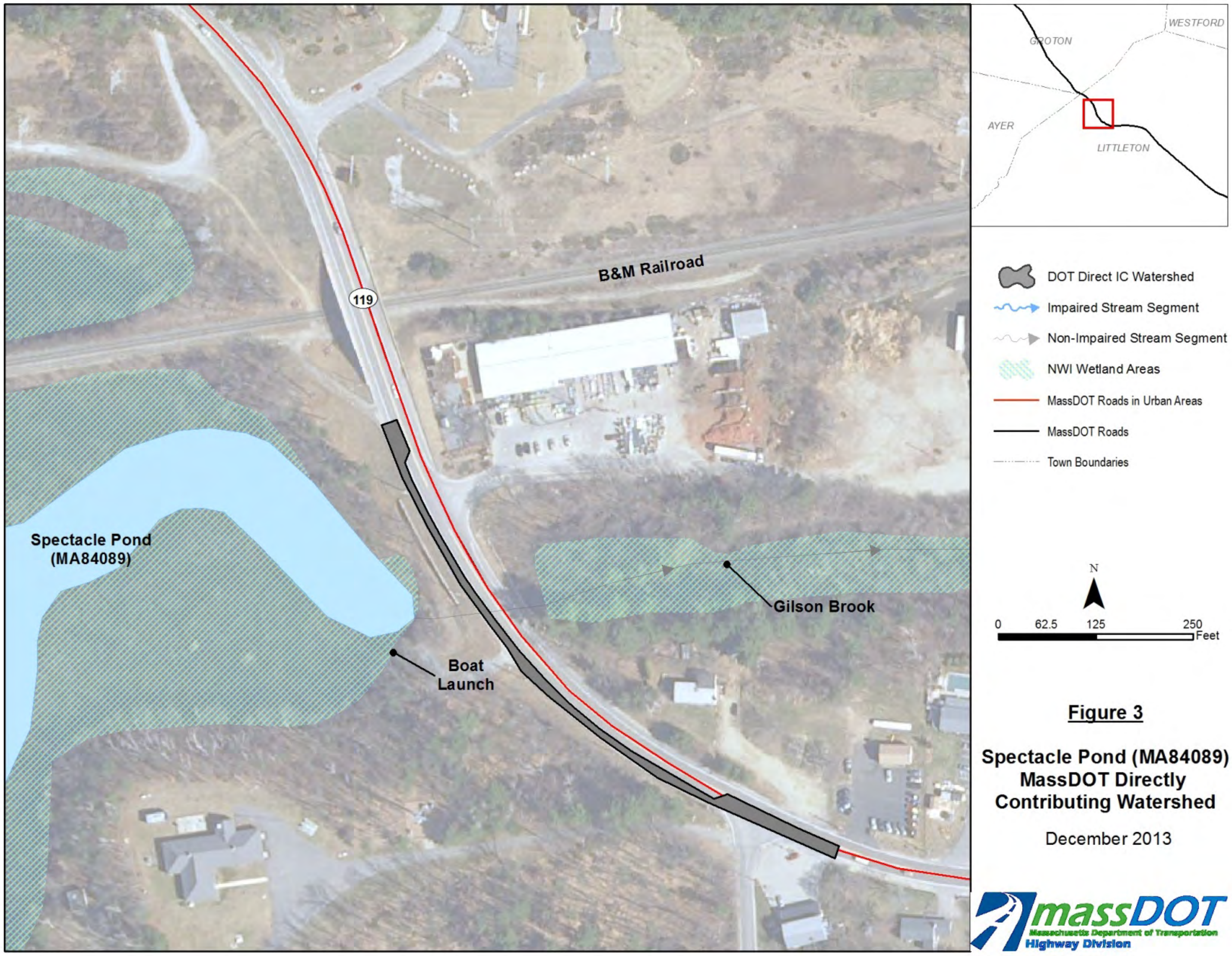
B&M Railroad
119
Spectacle Pond
(MA84089)
Gilson Brook
Boat
Launch
WESTFORD
GROTON
AYER
LITTLETON
DOT Direct IC Watershed
Impaired Stream Segment
Non-Impaired Stream Segment
NWI Wetland Areas
MassDOT Roads in Urban Areas
MassDOT Roads
Town Boundaries
N
0 62.5 125 250
Feet
Figure 3
Spectacle Pond (MA84089)
MassDOT Directly
Contributing Watershed
December 2013
massDOT
Massachusetts Department of Transportation
Highway Division

12/08/2013

Impaired Waters Assessment for Deep Brook (MA84A-21) – Final Report

Impaired Water Body

Name: Deep Brook

Location: Chelmsforid and Tyngsborough, MA

Water Body ID: MA84A-21

Impairments

Deep Brook (MA84A-21) is listed under Category 5, "Waters Requiring a TMDL", on MassDEP's final *Massachusetts Year 2012 Integrated List of Waters* (MassDEP, 2013). Deep Brook is impaired for the following:

- Habitat Assessment (Streams)
- Aquatic Microinvertibrate bioassessments
- Escherichia coli
- Fishes bioassessment
- Sedimentation/Siltation

According to MassDEP's *Merrimack River Watershed 2004 Water Quality Assessment Report* (MassDEP, 2010a), a 2.9 mile reach of the Deep Brook, which flows from the Headwaters east of the Everett turnpike, Tyngsboro to confluence with Merrimack River Chelmsford, is impaired because of unspecified urban stormwater, highways, roads, bridges, and new construction. Deep Brook is included in the draft TMDL for the Merrimack River Watershed (MassDEP, 2010b).

Relevant Water Quality Standards

Water Body Classification: Class B

Applicable State Regulations:

- *314 CMR 4.05 (5)(a) Aesthetics*. All surface waters shall be free from pollutants in concentrations or combinations that settle to form objectionable deposits; float as debris, scum or other matter to form nuisances; produce objectionable odor, color, taste or turbidity; or produce undesirable or nuisance species of aquatic life.

- *314 CMR 4.05 (3)(b)5 Solids*. These waters shall be free from floating, suspended and settleable solids in concentrations or combinations that would impair any use assigned to this class, that would cause aesthetically objectionable conditions, or that would impair the benthic biota or degrade the chemical composition of the bottom.

- *314 CMR 4.05 (3)(b) 2 Temperature*.

    - a. Shall not exceed 68°F (20°C) based on the mean of the daily maximum temperature over a seven day period in cold water fisheries, unless naturally occurring. Where a reproducing cold water aquatic community exists at a naturally occurring higher temperature, the temperature necessary to protect the community shall not be exceeded and the natural daily and seasonal temperature fluctuations necessary to protect the community shall be maintained. Temperature shall not exceed 83°F (28.3°C) in warm water fisheries. The rise in temperature due to a discharge shall not exceed 3°F (1.7°0C) in rivers and streams designated as cold water fisheries nor 5°F (2.8°C) in rivers and streams designated as warm water fisheries (based on the minimum expected flow for the month); in lakes and ponds the rise shall not exceed 3°F (1.7°0C) in the epilimnion (based on the monthly average of maximum daily temperature);

    - b. natural seasonal and daily variations that are necessary to protect existing and designated uses shall be maintained. There shall be no changes from natural background conditions that would impair any use assigned to this Class, including those conditions necessary to protect normal species diversity, successful migration, reproductive functions or growth of aquatic organisms;

- *314 CMR 4.05 (5)(e) Toxic Pollutants*. All surface waters shall be free from pollutants in concentrations or combinations that are toxic to humans, aquatic life or wildlife. For pollutants not otherwise listed in 314 CMR 4.00, the National Recommended Water Quality Criteria: 2002, EPA 822R-02-047, November 2002 published by EPA pursuant to Section 304(a) of the Federal Water Pollution Control Act, are the allowable receiving water concentrations for the affected waters, unless the Department either establishes a site specific criterion or determines that naturally occurring background concentrations are higher. Where the Department determines that naturally occurring background concentrations are higher, those concentrations shall be the allowable receiving water concentrations. The Department shall use the water quality criteria for the protection of aquatic life expressed in terms of the dissolved fraction of metals when EPA's 304(a) recommended criteria provide for use of the dissolved fraction. The EPA recommended criteria based on total recoverable metals shall be converted to dissolved metals using EPA's published conversion factors. Permit limits will be written in terms of total recoverable metals. Translation from dissolved metals criteria to total recoverable metals permit limits will be based on EPA's conversion factors or other methods approved by the Department. The Department may establish site specific criteria for toxic pollutants based on site specific considerations.

- *314 CMR 4.05 (3)(b)1 Dissolved Oxygen.* Shall not be less than 6.0 mg/l in cold water fisheries and not less than 5.0 mg/l in warm water fisheries. Where natural background conditions are lower, DO shall not be less than natural background conditions. Natural seasonal and daily variations that are necessary to protect existing and designated uses shall be maintained.

- *314 CMR 4.05 (5)(b) Bottom Pollutants or Alterations*. All surface waters shall be free from pollutants in concentrations or combinations or from alterations that adversely affect the physical or chemical nature of the bottom, interfere with the propagation of fish or shellfish, or adversely affect populations of non-mobile or sessile benthic organisms.

- *314 CMR 4.05 (3)(b)3 pH.* Shall be in the range of 6.5 through 8.3 standard units but not more than 0.5 units outside of the natural background range. There shall be no change from natural background conditions that would impair any use assigned to this Class.

- *314 CMR 4.05 (3)(b)4 Bacteria.*
  - a. At bathing beaches as defined by the Massachusetts Department of Public Health in 105 CMR 445.010: where E. coli is the chosen indicator, the geometric mean of the five most recent samples taken during the same bathing season shall not exceed 126 colonies per 100 ml and no single sample taken during the bathing season shall exceed 235 colonies per 100 ml; alternatively, where enterococci are the chosen indicator, the geometric mean of the five most recent samples taken during the same bathing season shall not exceed 33 colonies per 100 ml and no single sample taken during the bathing season shall exceed 61 colonies per 100 ml;

  - b. for other waters and, during the non-bathing season, for waters at bathing beaches as defined by the Massachusetts Department of Public Health in 105 CMR 445.010: the geometric mean of all E. coli samples taken within the most recent six months shall not exceed 126 colonies per 100 ml typically based on a minimum of five samples and no single sample shall exceed 235 colonies per 100 ml; alternatively, the geometric mean of all enterococci samples taken within the most recent six months shall not exceed 33 colonies per 100 ml typically based on a minimum of five samples and no single sample shall exceed 61 colonies per 100 ml. These criteria may be applied on a seasonal basis at the discretion of the Department;

Site Description

Deep Brook (MA84A-21) is formed near the headwaters east of the Everett Turnpike in Tyngsboro and flows into the Merrimack River in Chelmsford. It flows for approximately 2.9 miles before entering into the Merrimack River.

MassDOT's property directly contributing stormwater runoff to Deep Brook is comprised of portions of Route 3, and Route 3A (Tyngsboro Road), and a bridge crossing Route 3 (Dunstable Road). The total watershed is shown in Figure 1 which is same as the subwatershed.

The stretch of Route 3 that passes through the subwatershed is curbed resulting in much of the stormwater being conveyed through catch basins. The directly contributing portion of Route 3 starts at the exit 34 off ramp of Route 3N and ends about 0.75 miles southbound (Figure 2). The widening of US Route 3 in the early 2000's, required the incorporation of stormwater BMPs to the maximum extent practicable. The stormwater in this section of highway is primarily treated with infiltration swales in the median of the highway (Figure 3a). A small portion of the southbound roadway is collected in catch basins and discharges to an upland on the west side of the highway and is not considered as contributing to Deep Brook.

Route 3A (Tyngsboro Road) is curbed at certain portions of the street. Stormwater is directly discharged to Deep Brook for a stretch of 0.7 miles, starting at Vinyl Street and ending near Pailet Drive. The brook itself passes under Tyngsboro Road, at a low point on the street. There is an existing outfall that discharges flows from Route 3A to a small wetland less than 500 feet from Deep Brook. This area is included in directly contributing to Deep Brook.

Assessment under BMP 7U

None of the impairments for Deep Brook have been addressed by a TMDL. MassDOT assessed the impairments using the approach described in BMP 7U of MassDOT's Storm Water Management Plan (*Water Quality Impaired Waters Assessment and Mitigation Plan*), which applies to impairments that have been assigned to a water body prior to completion of a TMDL. As described in MassDOT's Application of Impervious Cover Method in BMP 7U (MassDOT, 2011), impervious cover (IC) provides a measure of the potential impact of storm water on many impairments. For this water body, MassDOT used the IC method to assess the following impairments:

- Habitat Assessment (Streams)
- Aquatic Microinvertibrate bioassessments
- Sedimentation/Siltation
- Fishes bioassessment

The following sections describe the methodology used by MassDOT to assess the impairment potentially linked to stormwater that have not been addressed by a TMDL.

MassDOT's Application of the Impervious Cover Method

MassDOT's Application of Impervious Cover Method in BMP 7U applies many aspects of USEPA Region I's Impervious Cover Method described in EPA's *Stormwater TMDL Implementation Support Manual* (ENSR, 2006) to MassDOT's program. This method assesses potential stormwater impacts on the impaired water and evaluates the IC reduction necessary to attain the percent imperviousness in the watershed at which stormwater is not likely the cause of the impairments. Consistent with findings of EPA and others, when a watershed has less than 9% IC, MassDOT concludes that stormwater is not the likely cause of the impairment. Additional information regarding this method is provided in MassDOT's Application of IC Method document.

Assessment

First, MassDOT calculated the percent IC of the water body's entire contributing watershed (total watershed upstream of the downstream end of an impaired segment) and that of the local watershed contributing to the impaired segment (referred to as the subwatershed in this analysis) to determine whether stormwater has a potential to cause the impairments of the receiving water body. The total watershed and subwatershed to the impaired water body were delineated using the USGS Data Series 451. When USGS Data Series watersheds did not delineate the subwatershed of the water body under review, the GIS shapefiles were modified by delineating to the water body based on USGS topography to add specificity. IC data was available as part of the USGS data layers Data Series 451 and MassGIS's impervious surfaces data layer.

In cases where it was determined that stormwater was a potential cause of the impairment, MassDOT calculated the degree to which IC would need to be reduced in the subwatershed to meet the 9% IC target. This reduction was then applied proportionally to the area of MassDOT roadways/properties directly discharging to the water body segment to identify MassDOT's target IC reduction. The 9% IC reduction serves only as a recommended target and is not meant to imply that failing to meet the target would cause an exceedance in water quality standards. As explained in BMP 7U, MassDOT will consider a variety of factors apart from numeric guidelines, including site constraints and the magnitude of any potential exceedances in water quality standards, to determine the precise nature and extent of additional BMPs recommended for particular locations.

This approach is consistent with the iterative, adaptive management BMP approach set forth in EPA guidelines.

MassDOT calculated the effective IC reduction afforded by the existing structural BMPs currently incorporated into the stormwater infrastructure of MassDOT’s properties. This effective IC reduction was calculated by applying effective IC reduction rates to existing BMPs based on their size, function and contributing watershed. BMP performances were derived from EPA Region 1’s *Stormwater Best Management Practices (BMP) Performance Analysis* report (EPA, 2010) and engineering judgment. More information on the approach used to calculate the effective IC reductions is described in BMP 7U. When the reduction in effective IC achieved by the existing BMPs was equal to or greater than the target reduction, no further measures were proposed. When this was not the case, MassDOT considered additional BMPs in order to meet the targeted reduction.

Using this approach, MassDOT derived the following site parameters for Deep Brook (MA82A-21):

Table 1. Site Parameters for Deep Brook (MA84A-21)

Type	Parameter	Quantity	Unit of Measure
Total and Subwatershed	Watershed Area	1,713	acres
Total and Subwatershed	Impervious Cover (IC) Area	343	acres
Total and Subwatershed	Percent Impervious	20*	%
Total and Subwatershed	IC Area at 9% Goal	154	acres
Total and Subwatershed	Target Reduction% in IC	55.1	%
Reductions Applied	MassDOT's IC Area Directly Contributing to Impaired Segment	14.3	acres
Reductions Applied	MassDOT's Target Reduction in Effective IC (55.1% of DOT Directly Contributing IC)	7.9	acres

*Rounding accounts for differences in calculations.

The subwatershed is greater than 9% impervious cover, indicating that stormwater likely contributes to the impairments assessed under this methodology. In order to reach the 9% target, effective IC within the subwatershed should be reduced by 55.1%. Therefore, MassDOT's target is to reduce effective IC within its own directly contributing watershed by the same percentage, or 7.9 acres.

Existing BMPs

MassDOT has one existing BMP in the Deep Brooksubwatershed that treats stormwater runoff. prior to discharge to Deep Brook. Figure 3 shows the BMP location. In our analysis, existing BMPs receive credit for removing the effect of IC depending on their type, size relative to the IC that they process, and the local soil conditions. Table 2 presents a summary of the existing BMP.

Ex-BMP-1: Infiltration swales are present along the median of Route 3, which is part of the directly contributing watershed to Deep Brook. The existing infiltration swales intercept and infiltrate stormwater that would otherwise flow directly into Deep Brook, and fully meet the design criteria to be considered infiltration swales, as the Route 3 design was designed to meet the Massachusetts Stormwater Regulations to the maximum extent practicable (FY 2004). This area was characterized to have an effective IC removal efficiency of 97%, providing a reduction of 11.48 acres of IC.

Table 1. Summary of Existing BMPs

BMP Name	BMP Type	Soil Type	Depth of Runoff Treated (inches)	IC Area Treated (acres)	Reduction of Effective IC* (%)	Reduction of Effective IC (acres)
Ex-BMP-1	Infiltration Swale	B - Loam 0.52 in/hr	4.8	11.83	97	11.48

*Description of MassDOT's Application of Impervious Cover Method in BMP 7U (MassDOT, 2011)

Mitigation Plan

Because the total mitigation of impervious surface achieved by MassDOT's existing BMPs is greater than the target reduction of 8.3 acres, MassDOT will not consider the implementation of additional BMPs.

Assessment of Pathogen Impairment under BMP 7U

MassDOT assessed the pathogen impairment using the approach described in BMP 7U of MassDOT's Storm Water Management Plan (*Water Quality Impaired Waters Assessment and Mitigation Plan*), which applies to impairments that have been assigned to a water body prior to completion of a TMDL. Pathogen concentrations in stormwater vary widely temporally and spatially; concentrations can vary by an order of magnitude within a given storm event at a single location (MassDEP, 2009b). Therefore, it is difficult to predict pathogen concentrations in stormwater with accuracy. Due to this difficulty, MassDOT generally will not conduct site specific assessments of loading at each location impaired for pathogens. Instead these sites are assessed based on available information on pathogen loading from highways, MassDOT actions, and information available from EPA and DEP. Based on this information MassDOT developed an approach to be consistent with relevant TMDL and permit condition requirements and an iterative adaptive management approach to stormwater management.

In addition, while there is a positive relationship between IC and pathogen loading, the relationship is not as direct as other impairments. According to the Center for Watershed Protection "…Other studies show that concentrations of bacteria are typically higher in urban areas than rural areas (USGS, 1999), but they are not always directly related to IC (CWP, 2003)." Therefore, DOT did not rely solely on the IC method to assess pathogen impairments. Instead, MassDOT reviewed its existing programs and their consistency with EPA NPDES MS4 general permit requirements and Pathogen TMDL recommendations.

Pathogens in MassDOT Discharge

A study conducted on MassDOT's South East Expressway measured bacterial concentrations in stormwater runoff (Smith, 2002). This study found a geometric mean of 186 fecal coliforms/100 ml. Concentrations of pathogens in stormwater runoff from roadways can vary widely and pathogen concentrations in runoff across the state likely deviate significantly from this stretch of roadway's specific estimate. Event mean concentrations of fecal coliform bacteria in urban stormwater from other sources ranging between 14,000 and 17,000 fecal coliform organisms/100 mL have been reported (MassDEP, 2009b). These data suggest that pathogen loading from highways may be lower than other urban areas.

Consideration of the potential sources of pathogens supports the idea that pathogens are present in lower concentrations in highway runoff since potential pathogen sources are likely to be less prevalent in the highway environment than along other urban roadways:

- Illicit discharges: Due to the typical setback of highways from residential and commercial developments and the stand alone nature of the drainage system, the potential for illicit discharges (e.g. sewer connections, laundry tie-ins) is much lower than in other stormwater systems. This has been confirmed by MassDOT's illicit discharge detection on many miles of urban roadways within a broad range of areas across Massachusetts. After assessment of almost 140 miles, and investigation of more than 2,500 stormwater features, MassDOT's consultant performing the broad scope reviews has found no confirmed illicit discharges.
- Limited Sewer Utilities in Road Right of Ways: Since DOT does not provide sewer services, many MassDOT roads do not have sewer utilities within the road's right of way; thereby eliminating the chance of cross-connections or leaking pipes as a source of pathogens into the stormwater system.
- Pet waste: Pets are only present on highways in rare instances. In urban residential areas pets and their associated waste are much more common. MassDOT is aware that pet waste at road side rest stops may represent a potential source of pathogens to stormwater in certain situations, and has a pet waste management program underway to address this source where necessary.
- Wildlife: Highways are not generally an attractive place for wildlife. Wildlife generally avoids highways and only occasionally crosses them.

The dearth of pathogen sources on highways and the relatively low concentrations of pathogens measured in the South East Expressway study together suggest that pathogen loading from stormwater runoff from highways is lower than other urban sources.

Furthermore, in almost all cases the contribution of pathogens from MassDOT to a specific water body is likely to be very small relative to other sources of pathogens in the watershed. Since MassDOT urban roadways are linear and usually cross watersheds, they represent a small fraction of the receiving water body's watershed. The water quality within these water bodies is dependent on discharge from various sources, including discharges from other stormwater systems and a large number of other factors.

Assessment

Pathogen loadings are highly variable and, as a result, quantitative assessments are challenging and of little value. Therefore, MassDOT reviewed its existing programs and their consistency with EPA NPDES MS4 general permit requirements and Pathogen TMDL recommendations.

TMDLs for pathogen impairments in Massachusetts recognize that pathogens are highly variable and difficult to address and emphasize the need for an iterative adaptive management approach to address pathogens. Examples of relevant language from these TMDLs are included below:

- "given the vast potential number of bacteria sources and the difficulty of identifying and removing them from some sources such as stormwater require an iterative process and will take some time to accomplish. While the stated goal in the TMDL is to meet the water quality standard at the point of discharge it also attempts to be clear that MassDEP's expectation is that for stormwater an iterative approach is needed…" (MassDEP, 2009a)

- "The NPDES permit does not, however, establish numeric effluent limitations for stormwater discharges. Maximum extent practicable (MEP) is the statutory standard that establishes the level of pollutant reductions that regulated municipalities must achieve. The MEP standard is a narrative effluent limitation that is satisfied through implementation of SWMPs and achievement of measurable goals."(MassDEP, 2009b)
- "Although the TMDL presents quantified WLAs for stormwater that are set equivalent to the criteria in the Massachusetts Water Quality Standards, the Phase II NPDES permits will not include numeric effluent limitations. Phase II permits are intended to be BMP based permits that will require communities to develop and implement comprehensive stormwater management programs involving the use of BMPs. Massachusetts and EPA believe that BMP based Phase II permits involving comprehensive stormwater management together with specific emphasis on pollutants contributing to existing water quality problems can be consistent with the intent of the quantitative WLAs for stormwater discharges in TMDLs." (MassDEP, 2002).

This language clearly indicates that an iterative adaptive management approach is the appropriate way to address discharges to pathogen impaired waters. The recommendations in pathogen TMDLs for waters in Massachusetts generally require development and implementation of stormwater management programs, illicit discharge detection and elimination efforts, and in some cases installing BMPs to the maximum extent practicable.

The draft North Coastal Watershed General MS4 permit and the draft Interstate, Merrimack, and South Coastal (IMS) watershed permits contain specific requirements for compliance with pathogen TMDLs (in Appendix G). While these permits are still in draft form, MassDOT believes they represent the best available guidance on what EPA believes is appropriate for addressing stormwater discharges to pathogen-impaired waters. Section 2.2.1(c) of the permit states "For any discharge from its MS4 to impaired waters with an approved TMDL, the permittee shall comply with the specific terms of Part 2.1 of this permit. In addition, where an approved TMDL establishes a WLA that applies to its MS4 discharges, the permittee shall implement the specific BMPs and other permit requirements identified in Appendix G to achieve consistency with the WLA." Appendix G references a number of programmatic BMPs that are necessary to address pathogen loading. These cover the following general topics:

- Residential educational program
- Illicit connection identification, tracking and removal
- Pet waste management

Mitigation Plan

MassDOT implements a variety of non-structural BMP programs across their system in accordance with their existing Stormwater Management Plan (SWMP) including educational programs, illicit connection review and source control. The specific BMPs that can help reduce potential pathogen loading in the current SWMP include:

- BMP 3C-1: Drainage Connection Policy
- BMP 3C-2: Drainage Tie-In Standard Operating Procedure
- BMP 3D: Illicit Discharge Detection Review
- BMP 5H-1: Post Construction Runoff Enforcement – Illicit Discharge Prohibition

- BMP 5H-2: Post Construction Runoff Enforcement – Drainage Tie-In
- BMP 5H-3: Post Construction Runoff Enforcement – Offsite Pollution to MassHighway Drainage System
- BMP 6A-1: Source Control – 511 Program
- BMP 6A-2: Source Control – Adopt-A-Highway Program
- BMP 6C-1: Maintenance Program

In addition, the structural BMPs that will be considered to reduce the IC will also have the effect of reducing pathogen loads.

MassDOT believes the existing and proposed efforts are consistent with the current and draft MS4 permit's requirements and TMDL recommendations. MassDOT's existing stormwater management plan outlines BMPs that include education and illicit discharge detection and elimination. MassDOT will be implementing a pet waste management program at its rest stops that have discharges to pathogen impaired waters. In addition, MassDOT has requested coverage under an individual stormwater permit for the next permit term. This permit may contain additional programmatic BMPs to address pathogens.

Conclusions

MassDOT used the IC Method to assess Deep Brook for the impairments identified in MassDEP's final Massachusetts Year 2012 Integrated List of Waters. Results indicate that MassDOT should reduce its effective IC within its directly contributing subwatershed by 8.3 acres to achieve the targeted reduction in effective IC. MassDOT evaluated its property within the directly contributing watershed to Deep Brook (MA84A-21), to identify existing BMPs and found that existing BMPs treat 11.48 acres and provide 165% of the target reduction in effective IC. This information is summarized in Table 2 below.

Table 3. Effective IC Reductions under Existing & Proposed Conditions

Type of reduction	Quantity	Unit of Measure
IC in Directly Contributing Watershed	14.3	acres
Target Reduction in Effective IC	7.9	acres
IC Effectively Reduced by Existing BMPs	11.5	acres
IC Remaining to Mitigate with Proposed BMPs	0	acres

As a result, no additional BMP's are required because of the greater than 100% of the target reduction in effective IC is already met.

MassDOT has concluded based on review of the draft North Coastal Watershed General MS4 permit, the draft Interstate, Merrimack, and South Coastal watershed permits, and pathogen TMDLs for Massachusetts waters, that the BMPs outlined in the stormwater management plan and those under consideration for reducing effective IC from MassDOT areas are consistent with its existing permit requirements. MassDOT believes that these measures achieve pathogen reductions (including fecal coliform) to the maximum extent practicable and are consistent with the intent of its existing stormwater permit and the applicable Pathogen TMDLs. As stated previously, pathogen loadings are highly variable and although there is potential for stormwater runoff from DOT roadways to be a contributing source it is unlikely to be warrant action relative to other sources of pathogens in the watershed.

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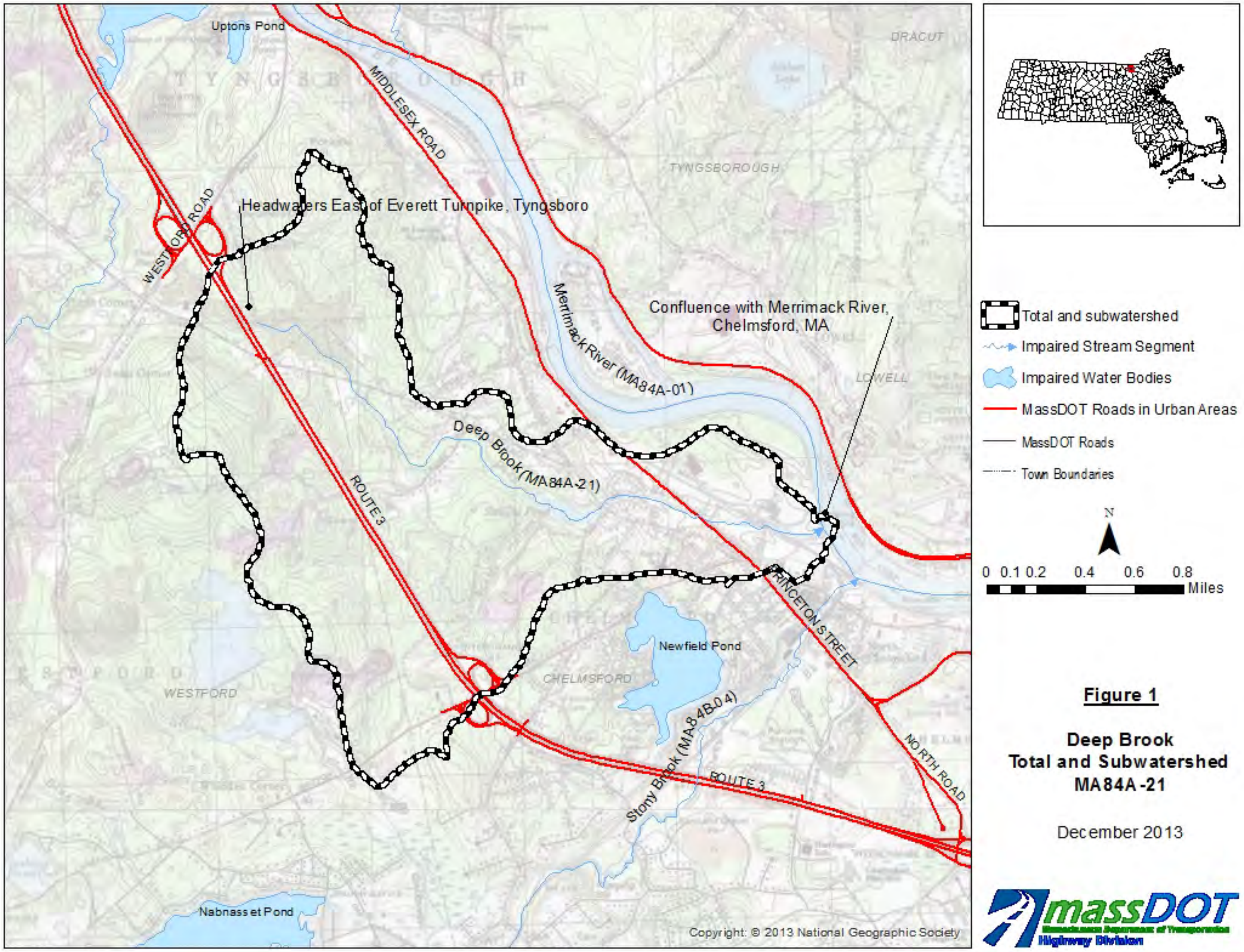

Figure 1

Deep Brook
Total and Subwatershed
MA84A-21

December 2013

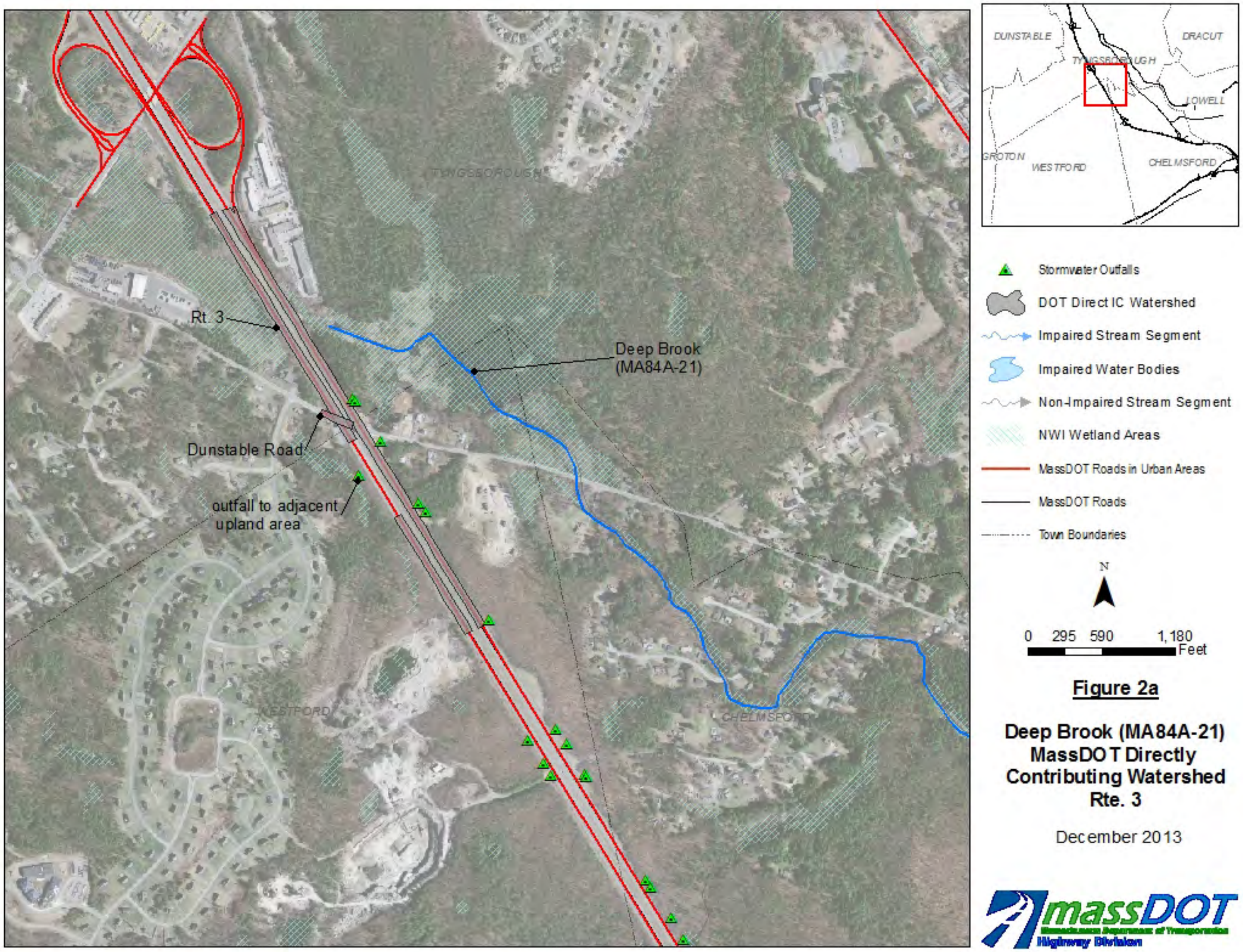

Figure 2a

Deep Brook (MA84A-21)
MassDOT Directly Contributing Watershed
Rte. 3

December 2013

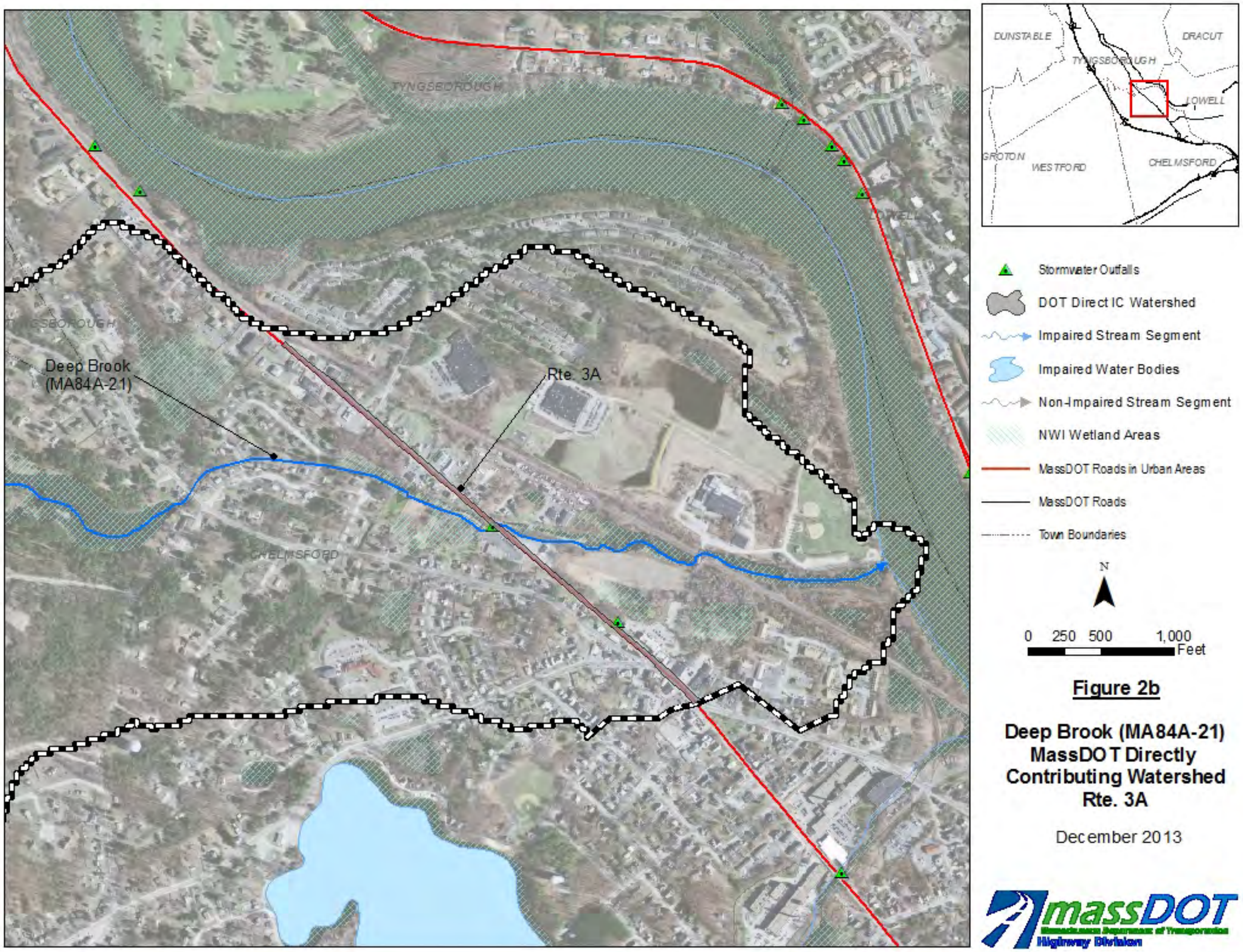

Figure 2b

Deep Brook (MA84A-21) MassDOT Directly Contributing Watershed Rte. 3A

December 2013

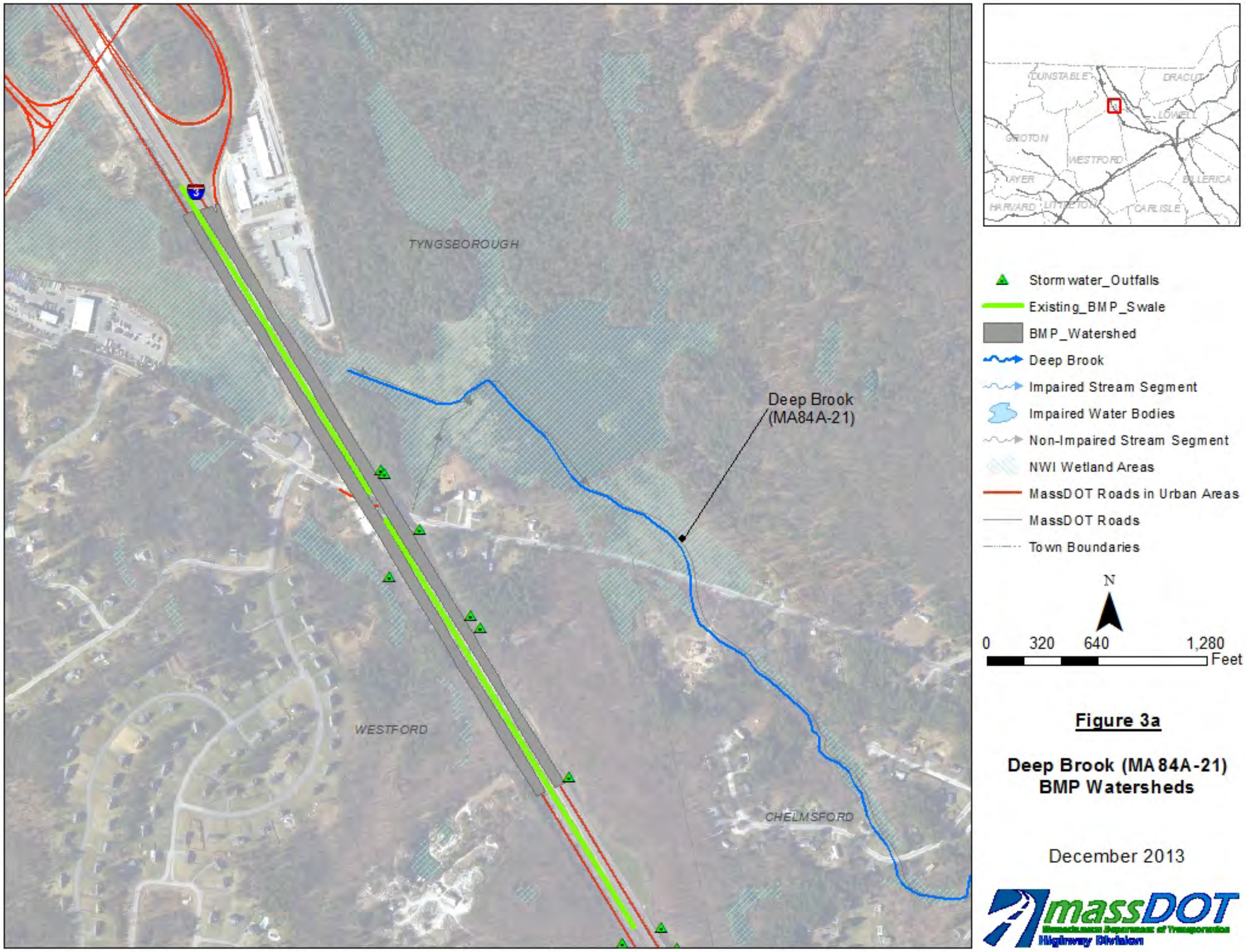

Figure 3a

Deep Brook (MA84A-21) BMP Watersheds

December 2013

Impaired Waters Assessment for Stony Brook (MA84B-04) – Final Report

Impaired Water body

Name: Stony Brook

Location: Westford and Chelmsford, MA

Water Body ID: MA84B-04

Impairments

Stony Brook (MA84B-04) is listed under Category 5, "Waters Requiring a TMDL", on MassDEP's final *Massachusetts Year 2012 Integrated List of Waters* (MassDEP, 2013). Stony Brook is impaired for the following:

- aquatic macroinvertebrate bioassessments
- Escherichia coliform

According to MassDEP's *Merrimack River Watershed 2004 Water Quality Assessment Report* (MassDEP, 2010a), the primary contact recreational use is impaired within segment MA84B-04 of the Merrimack River due to *Escherichia coli* from unknown sources.

According to MassDEP's Draft Pathogen TMDL for the Merrimack River Watershed (MassDEP, 2010b), Fletcher Granite Quarry in Westford discharges overflow to this brook and two communities (Littleton and Westford) have NPDES Phase II stormwater permits.

Relevant Water Quality Standards

Water Body Classification: Class B/WWF

Applicable State Regulations:

- 314 CMR 4.05 (3)(b) 4 Bacteria.
  - a. At bathing beaches as defined by the Massachusetts Department of Public Health in 105 CMR 445.010: where E. coli is the chosen indicator, the geometric mean of the five most recent samples taken during the same bathing season shall not exceed 126 colonies per 100 ml and no single sample taken during the bathing season shall exceed 235 colonies per 100 ml; alternatively, where enterococci are the chosen indicator, the geometric mean of the five most recent samples taken during the same bathing season shall not exceed 33 colonies per 100 ml and no single sample taken during the bathing season shall exceed 61 colonies per 100 ml;

  - b. For other waters and, during the non bathing season, for waters at bathing beaches as defined by the Massachusetts Department of Public Health in 105 CMR 445.010: the geometric mean of all E. coli samples taken within the most recent six months shall not exceed 126 colonies per 100 ml typically based on a minimum of five samples and no single sample shall exceed 235 colonies per 100 ml; alternatively, the geometric mean of all enterococci samples taken within the most recent six months shall not exceed 33 colonies per 100 ml typically based on a minimum of five samples and no single sample shall exceed 61 colonies per 100 ml. These criteria may be applied on a seasonal basis at the discretion of the Department;

- *314 CMR 4.05 (5)(b) Bottom Pollutants or Alterations*. All surface waters shall be free from pollutants in concentrations or combinations or from alterations that adversely affect the physical or chemical nature of the bottom, interfere with the propagation of fish or shellfish, or adversely affect populations of non-mobile or sessile benthic organisms.

- *314 CMR 4.05 (3)(b) Solids.* These waters shall be free from floating, suspended and settleable solids in concentrations or combinations that would impair any use assigned to this class, that would cause aesthetically objectionable conditions, or that would impair the benthic biota or degrade the chemical composition of the bottom.

- *314 CMR 4.05 (5)(e)Toxic Pollutants*. All surface waters shall be free from pollutants in concentrations or combinations that are toxic to humans, aquatic life or wildlife. For pollutants not otherwise listed in 314 CMR 4.00, the National Recommended Water Quality Criteria: 2002, EPA 822R-02-047, November 2002 published by EPA pursuant to Section 304(a) of the Federal Water Pollution Control Act, are the allowable receiving water concentrations for the affected waters, unless the Department either establishes a site specific criterion or determines that naturally occurring background concentrations are higher. Where the Department determines that naturally occurring background concentrations are higher, those concentrations shall be the allowable receiving water concentrations. The Department shall use the water quality criteria for the protection of aquatic life expressed in terms of the dissolved fraction of metals when EPA's 304(a) recommended criteria provide for use of the dissolved fraction. The EPA recommended criteria based on total recoverable metals shall be converted to dissolved metals using EPA's published conversion factors. Permit limits will be written in terms of total recoverable metals. Translation from dissolved metals criteria to total recoverable metals permit limits will be based on EPA's conversion factors or other methods approved by the Department. The Department may establish site specific criteria for toxic pollutants based on site specific considerations.

- *314 CMR 4.05 (3)(b) 1Dissolved Oxygen.*a. Shall not be less than 6.0 mg/l in cold water fisheries and not less than 5.0 mg/l in warm water fisheries. Where natural background conditions are lower, DO shall not be less than natural background conditions. Natural seasonal and daily variations that are necessary to protect existing and designated uses shall be maintained.

- *314 CMR 4.05 (3)(b) 2 Temperature.*

  - a. Shall not exceed 68°F (20°C) based on the mean of the daily maximum temperature over a seven day period in cold water fisheries, unless naturally occurring. Where a reproducing cold water aquatic community exists at a naturally occurring higher temperature, the temperature necessary to protect the community shall not be exceeded and the natural daily and seasonal temperature fluctuations necessary to protect the community shall be maintained. Temperature shall not exceed 83°F (28.3°C) in warm water fisheries. The rise in temperature due to a discharge shall not exceed 3°F (1.7°0C) in rivers and streams designated as cold water fisheries nor 5°F (2.8°C) in rivers and streams designated as warm water fisheries (based on the minimum expected flow for the month); in lakes and ponds the rise shall not exceed 3°F (1.7°0C) in the epilimnion (based on the monthly average of maximum daily temperature);

– b. natural seasonal and daily variations that are necessary to protect existing and designated uses shall be maintained. There shall be no changes from natural background conditions that would impair any use assigned to this Class, including those conditions necessary to protect normal species diversity, successful migration, reproductive functions or growth of aquatic organisms;

- *314 CMR 4.05 (3)(b) 3 pH.* Shall be in the range of 6.5 through 8.3 standard units but not more than 0.5 units outside of the natural background range. There shall be no change from natural background conditions that would impair any use assigned to this Class.

Site Description

Segment MA84B-04 of Stony Brook begins in the vicinity of the intersection of Brookside Road and Lowell Road in Westford and flows northeast through Chelmsford where it discharges into the Merrimack River.

The watershed to Segment 84B-04 of Stony Brook is highly rural along the majority of its 3.4 mile route which runs adjacent to the Boston and Maine railroad tracks through Westford and Chelmsford. Refer to Figure 1 for the total watershed to Segment MA84B-04 Stony Brook.

MassDOT's property directly contributing stormwater runoff to Segment MA84B-04 is comprised of portions of the following roadways:

- Route 3A (Princeton Street)
- US Route 3

Refer to Figure 2 for the location of these roadways within the subwatershed to Segment MA84B-04 of Stony Brook. As shown in Figure 3, drainage from Route 3 northbound and southbound in the vicinity of where the roadway crosses Stony Brook discharges to segment MA84B-04, with the exception of a portion of the roadway on both sides where the outer lanes directly discharge to MA84046 Newfield Pond. The drainage from Route 3 outer lanes in both directions discharges by sheetflow to the brook, while the inner lanes sheetflow toward the median where there are existing infiltration swales. The widening of US Route 3 in the early 2000's, required the incorporation of stormwater BMPs to the maximum extent practicable.

Figure 3 also shows the drainage from the railroad bridge crossing on Route 3A, the only portion of the drainage which directly contributes to the Stony Brook, via sheetflow to a catch basin network which discharges through an existing outfall to Stony Brook.

Assessment under BMP 7U

Of the impairments listed for Segment MA84B-04 of Stony Brook, one is potentially linked to stormwater runoff and has not been addressed by a TMDL. Therefore, MassDOT assessed these impairments using the approach described in BMP 7U of MassDOT's Stormwater Management Plan (*Water Quality Impaired Waters Assessment and Mitigation Plan*), which applies to impairments that have been assigned to a water body prior to completion of a TMDL. As described in MassDOT's Application of Impervious Cover Method in BMP 7U (MassDOT, 2011), impervious cover (IC) provides a measure of the potential impact of stormwater on many impairments. For this water body, MassDOT used the IC method to assess the following impairments:

- aquatic macroinvertebrate bioassessments

The following sections describe the methodology used by MassDOT to assess the impairment potentially linked to stormwater that have not been addressed by a TMDL.

The impairment for Escherichia Coli is assessed separately in the section titled Assessment of Pathogen Impairment.

MassDOT's Application of the Impervious Cover Method

MassDOT's Application of Impervious Cover Method in BMP 7U applies many aspects of USEPA Region I's Impervious Cover Method described in EPA's *Stormwater TMDL Implementation Support Manual* (ENSR, 2006) to MassDOT's program. This method assesses potential stormwater impacts on the impaired water and evaluates the IC reduction necessary to attain the percent imperviousness in the watershed at which stormwater is not likely the cause of the impairments. Consistent with findings of EPA and others, when a watershed has less than 9% IC, MassDOT concludes that stormwater is not the likely cause of the impairment. Additional information regarding this method is provided in MassDOT's Application of IC Method document.

Assessment

First, MassDOT calculated the percent IC of the water body's entire contributing watershed (total watershed upstream of the downstream end of an impaired segment) and that of the local watershed contributing to the impaired segment (referred to as the subwatershed in this analysis) to determine whether stormwater has a potential to cause the impairments of the receiving water body. The total watershed and subwatershed to the impaired water body were delineated using the USGS Data Series 451. When USGS Data Series watersheds did not delineate the subwatershed of the water body under review, the GIS shapefiles were modified by delineating to the water body based on USGS topography to add specificity. IC data was available as part of the USGS data layers Data Series 451 and MassGIS's impervious surfaces data layer.

In cases where it was determined that stormwater was a potential cause of the impairment, MassDOT calculated the degree to which IC would need to be reduced in the subwatershed to meet the 9% IC target. This reduction was then applied proportionally to the area of MassDOT roadways/properties directly discharging to the water body segment to identify MassDOT's target IC reduction. The 9% IC reduction serves only as a recommended target and is not meant to imply that failing to meet the target would cause an exceedance in water quality standards. As explained in BMP 7U, MassDOT will consider a variety of factors apart from numeric guidelines, including site constraints and the magnitude of any potential exceedances in water quality standards, to determine the precise nature and extent of additional BMPs recommended for particular locations. This approach is consistent with the iterative, adaptive management BMP approach set forth in EPA guidelines.

MassDOT calculated the effective IC reduction afforded by the existing structural BMPs currently incorporated into the stormwater infrastructure of MassDOT's properties. This effective IC reduction was calculated by applying effective IC reduction rates to existing BMPs based on their size, function and contributing watershed. BMP performances were derived from EPA Region 1's *Stormwater Best Management Practices (BMP) Performance Analysis* report (EPA, 2010) and engineering judgment. More information on the approach used to calculate the effective IC reductions is described in BMP 7U. When the reduction in effective IC achieved by the existing BMPs was equal to or greater than the target reduction, no further measures were proposed. When this was not the case, MassDOT considered additional BMPs in order to meet the targeted reduction.

Using this approach, MassDOT derived the following site parameters for Segment MA84B-04 of Stony Brook:

Table 1. Site Parameters for Stony Brook (MA-84B-04)

Type	Parameter	Quantity	Unit of Measure
Total Watershed	Watershed Area	29,007	acres
Total Watershed	Impervious Cover (IC) Area	3,439	acres
Total Watershed	Percent Impervious	11.9	%
Subwatershed	Subwatershed Area	4,767	acres
Subwatershed	Impervious Cover (IC) Area	735	acres
Subwatershed	Percent Impervious	15.4*	%
Subwatershed	IC Area at 9% Goal	429	acres
Subwatershed	Target Reduction% in IC	41.6	%
Reductions Applied	MassDOT's IC Area Directly Contributing to Impaired Segment	13.4	acres
Reductions Applied	MassDOT's Target Reduction in Effective IC (41.6% of DOT Directly Contributing IC)	5.6	acres

*Rounding accounts for differences in calculations.

The subwatershed is greater than 9% impervious cover, indicating that stormwater likely contributes to the impairments assessed under this methodology. In order to reach the 9% target, effective IC within the subwatershed should be reduced by 41.6%. Therefore, MassDOT's target is to reduce effective IC within its own directly contributing watershed by the same percentage, or 5.6 acres.

Existing BMPs

MassDOT has existing infiltration swales along the median of Route 3 which is directly contributing watershed to Stony Brook. The existing infiltration swales intercept and infiltrate stormwater that would otherwise flow directly into Stony Brook, and fully meet the design criteria to be considered infiltration swales, as the Route 3 design was designed to meet the MassStormwater Regulations to the maximum extent practicable, as designed and built in the early 2000's. The existing infiltration swale is designed in the median, where stormwater flows either via sheetflow or conveyed via a closed drainage system to the swale and then into an outlet control structure that discharges to Stony Brook.

The existing infiltration swales are shown on Figure 3B and were constructed the length of the drainage area contributing to the Stony Brook segment. Construction plans for the US Route 3 widening project were reviewed and this data was included in the GIS database. These areas were included in the IC method calculations as reduction credits. For these reasons, IC effective reduction credits have been assigned to these infiltration swales.

Assessment of Pathogen Impairment under BMP 7U

MassDOT assessed the pathogen impairment using the approach described in BMP 7U of MassDOT's Stormwater Management Plan (*Water Quality Impaired Waters Assessment and Mitigation Plan*), which applies to impairments that have been assigned to a water body prior to completion of a TMDL. Pathogen concentrations in stormwater vary widely temporally and spatially; concentrations can vary by an order of magnitude within a given storm event at a single location (MassDEP, 2009b). Therefore, it is difficult to predict pathogen concentrations in stormwater with accuracy. Due to this difficulty, MassDOT generally will not conduct site specific assessments of loading at each location impaired for pathogens. Instead these sites are assessed based on available information on pathogen loading from highways, MassDOT actions, and information available from EPA and DEP. Based on this information MassDOT developed an approach to be consistent with relevant TMDL and permit condition requirements and an iterative adaptive management approach to stormwater management.

In addition, while there is a positive relationship between IC and pathogen loading, the relationship is not as direct as other impairments. According to the Center for Watershed Protection "…Other studies show that concentrations of bacteria are typically higher in urban areas than rural areas (USGS, 1999), but they are not always directly related to IC (CWP, 2003)." Therefore, DOT did not rely solely on the IC method to assess pathogen impairments. Instead, MassDOT reviewed its existing programs and their consistency with EPA NPDES MS4 general permit requirements and Pathogen TMDL recommendations.

Pathogens in MassDOT Discharge

A study conducted on MassDOT's South East Expressway measured bacterial concentrations in stormwater runoff (Smith, 2002). This study found a geometric mean of 186 fecal coliforms/100 ml. Concentrations of pathogens in stormwater runoff from roadways can vary widely and pathogen concentrations in runoff across the state likely deviate significantly from this stretch of roadway's specific estimate. Event mean concentrations of fecal coliform bacteria in urban stormwater from other sources ranging between 14,000 and 17,000 fecal coliform organisms/100 mL have been reported (MassDEP, 2009b). These data suggest that pathogen loading from highways may be lower than other urban areas.

Consideration of the potential sources of pathogens supports the idea that pathogens are present in lower concentrations in highway runoff since potential pathogen sources are likely to be less prevalent in the highway environment than along other urban roadways:

- <u>Illicit discharges:</u> Due to the typical setback of highways from residential and commercial developments and the stand alone nature of the drainage system, the potential for illicit discharges (e.g. sewer connections, laundry tie-ins) is much lower than in other stormwater systems. This has been confirmed by MassDOT's illicit discharge detection on many miles of urban roadways within a broad range of areas across Massachusetts. After assessment of almost 140 miles, and investigation of more than 2,500 stormwater features, MassDOT's consultant performing the broad scope reviews has found no confirmed illicit discharges.

- Limited Sewer Utilities in Road Right of Ways: Since DOT does not provide sewer services, many MassDOT roads do not have sewer utilities within the road's right of way; thereby eliminating the chance of cross-connections or leaking pipes as a source of pathogens into the stormwater system.
- Pet waste: Pets are only present on highways in rare instances. In urban residential areas pets and their associated waste are much more common. MassDOT is aware that pet waste at road side rest stops may represent a potential source of pathogens to stormwater in certain situations and has a pet waste management program underway to address this source where necessary.
- Wildlife: Highways are not generally an attractive place for wildlife. Wildlife generally avoids highways and only occasionally crosses them.

The dearth of pathogen sources on highways and the relatively low concentrations of pathogens measured in the South East Expressway study together suggest that pathogen loading from stormwater runoff from highways is lower than other urban sources.

Furthermore, in almost all cases the contribution of pathogens from MassDOT to a specific water body is likely to be very small relative to other sources of pathogens in the watershed. Since MassDOT urban roadways are linear and usually cross watersheds, they represent a small fraction of the receiving water body's watershed. The water quality within these water bodies is dependent on discharge from various sources, including discharges from other stormwater systems and a large number of other factors.

Assessment

Pathogen loadings are highly variable and, as a result, quantitative assessments are challenging and of little value. Therefore, MassDOT reviewed its existing programs and their consistency with EPA NPDES MS4 general permit requirements and Pathogen TMDL recommendations.

TMDLs for pathogen impairments in Massachusetts recognize that pathogens are highly variable and difficult to address and emphasize the need for an iterative adaptive management approach to address pathogens. Examples of relevant language from these TMDLs are included below:

- "given the vast potential number of bacteria sources and the difficulty of identifying and removing them from some sources such as stormwater require an iterative process and will take some time to accomplish. While the stated goal in the TMDL is to meet the water quality standard at the point of discharge it also attempts to be clear that MassDEP's expectation is that for stormwater an iterative approach is needed…" (MassDEP, 2009a)
- "The NPDES permit does not, however, establish numeric effluent limitations for stormwater discharges. Maximum extent practicable (MEP) is the statutory standard that establishes the level of pollutant reductions that regulated municipalities must achieve. The MEP standard is a narrative effluent limitation that is satisfied through implementation of SWMPs and achievement of measurable goals."(MassDEP, 2009b)
- "Although the TMDL presents quantified WLAs for stormwater that are set equivalent to the criteria in the Massachusetts Water Quality Standards, the Phase II NPDES permits will not include numeric effluent limitations. Phase II permits are intended to be BMP based permits that will require communities to develop and implement comprehensive stormwater management programs involving the use of BMPs. Massachusetts and EPA believe that BMP based Phase II permits involving comprehensive stormwater management together

with specific emphasis on pollutants contributing to existing water quality problems can be consistent with the intent of the quantitative WLAs for stormwater discharges in TMDLs." (MassDEP, 2002).

This language clearly indicates that an iterative adaptive management approach is the appropriate way to address discharges to pathogen impaired waters. The recommendations in pathogen TMDLs for waters in Massachusetts generally require development and implementation of stormwater management programs, illicit discharge detection and elimination efforts, and in some cases installing BMPs to the maximum extent practicable

The draft North Coastal Watershed General MS4 permit and the draft Interstate, Merrimack, and South Coastal (IMS) watershed permits contain specific requirements for compliance with pathogen TMDLs (in Appendix G). While these permits are still in draft form, MassDOT believes they represent the best available guidance on what EPA believes is appropriate for addressing stormwater discharges to pathogen-impaired waters. Section 2.2.1(c) of the permit states "For any discharge from its MS4 to impaired waters with an approved TMDL, the permittee shall comply with the specific terms of Part 2.1 of this permit. In addition, where an approved TMDL establishes a WLA that applies to its MS4 discharges, the permittee shall implement the specific BMPs and other permit requirements identified in Appendix G to achieve consistency with the WLA." Appendix G references a number of programmatic BMPs that are necessary to address pathogen loading. These cover the following general topics:

- Residential educational program
- Illicit connection identification, tracking and removal
- Pet waste management

Mitigation Plan

MassDOT implements a variety of non-structural BMP programs across their system in accordance with their existing Stormwater Management Plan (SWMP) including educational programs, illicit connection review and source control. The specific BMPs that can help reduce potential pathogen loading in the current SWMP include:

- BMP 3C-1: Drainage Connection Policy
- BMP 3C-2: Drainage Tie-In Standard Operating Procedure
- BMP 3D: Illicit Discharge Detection Review
- BMP 5H-1: Post Construction Runoff Enforcement – Illicit Discharge Prohibition
- BMP 5H-2: Post Construction Runoff Enforcement – Drainage Tie-In
- BMP 5H-3: Post Construction Runoff Enforcement – Offsite Pollution to MassHighway Drainage System
- BMP 6A-1: Source Control – 511 Program
- BMP 6A-2: Source Control – Adopt-A-Highway Program
- BMP 6C-1: Maintenance Program

MassDOT believes the existing and proposed efforts are consistent with the current and draft MS4 permit's requirements and TMDL recommendations. MassDOT's existing stormwater management plan outlines BMPs that include education and illicit discharge detection and elimination. MassDOT will be implementing a pet waste management program at its rest stops that have discharges to pathogen impaired waters.

MassDOT anticipates the issuance of an individual stormwater permit from U.S. EPA which will outline details of a required Illicit Detection.

Conclusions

MassDOT used the IC Method to assess Segment 84B-04 of Stony Brook for the impairments identified in MassDEP's final *Massachusetts Year 2012 Integrated List of Waters* that are potentially linked to stormwater runoff and for which no TMDL exists. Results indicate that MassDOT should reduce its effective IC within its directly contributing watershed by 5.7 acres to achieve the targeted reduction in effective IC. MassDOT evaluated its property within the directly contributing watershed to Stony Brook to identify existing BMPs and found that existing BMPs provide over 100% of the target reduction in effective IC. This information is summarized in Table 2 below.

Table 2. Effective IC Reductions under Existing & Proposed Conditions

Type of Reduction	Quantity	Unit of Measure
IC in Directly Contributing Watershed	13.8	acres
Target Reduction in Effective IC	5.7	acres
IC Effectively Reduced by Existing BMPs	8.4	acres
IC Remaining to Mitigate with Proposed BMPs	0.0	acres

MassDOT has concluded based on review of the draft North Coastal Watershed General MS4 permit, the draft Interstate, Merrimack, and South Coastal watershed permits, and pathogen TMDLs for Massachusetts waters, that the BMPs outlined in the stormwater management plan and those under consideration for reducing effective IC from MassDOT areas are consistent with its existing permit requirements. MassDOT believes that these measures achieve pathogen reductions (including fecal coliform) to the maximum extent practicable and are consistent with the intent of its existing stormwater permit and the applicable Pathogen TMDLs. As stated previously, pathogen loadings are highly variable and although there is potential for stormwater runoff from DOT roadways to be a contributing source it is unlikely to be warrant action relative to other sources of pathogens in the watershed.

MassDOT will continue to identify opportunities to implement additional structural BMPs to address pollutant loading when road work is conducted under MassDOT's programmed projects initiative. Work on programmed projects, which often include broader scale road layout changes, may provide additional opportunities for construction of new treatment BMPs. This is consistent with an iterative adaptive management approach to addressing impairments. MassDOT will include an update in annual reports and biannual submittals to EPA regarding progress made towards meeting target IC reductions, plans for construction of additional BMPs, and finalized assessments including reductions achieved by finalized BMP designs. Furthermore, MassDOT will continue to implement non-structural BMPs that reduce the impacts of stormwater.

References

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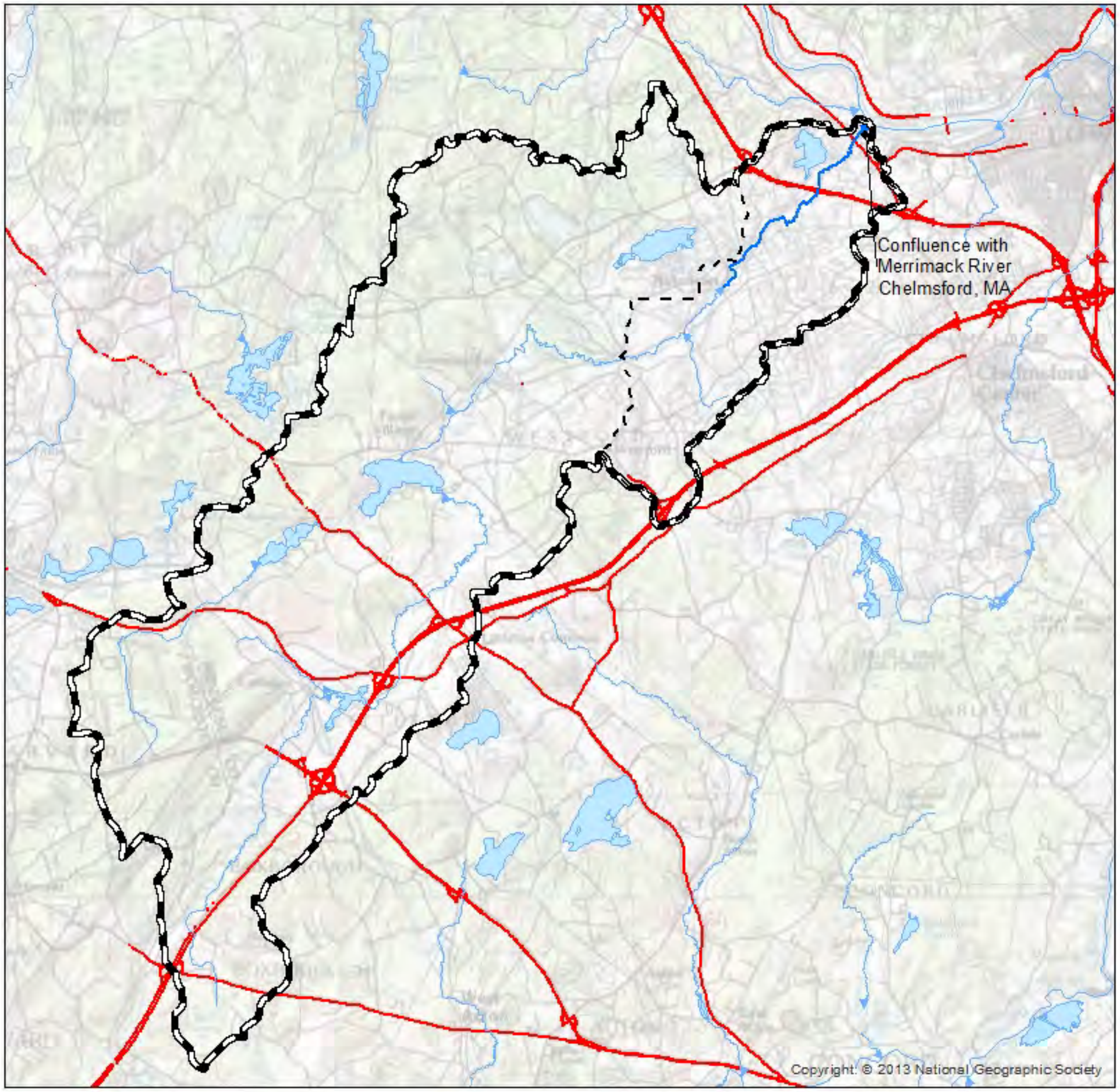

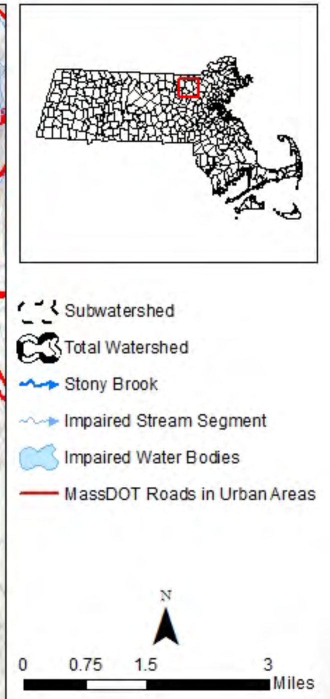

Figure 1

Stony Brook
Total Watershed
MA84B-04

December 2013

massDOT
Massachusetts Department of Transportation
Highway Division

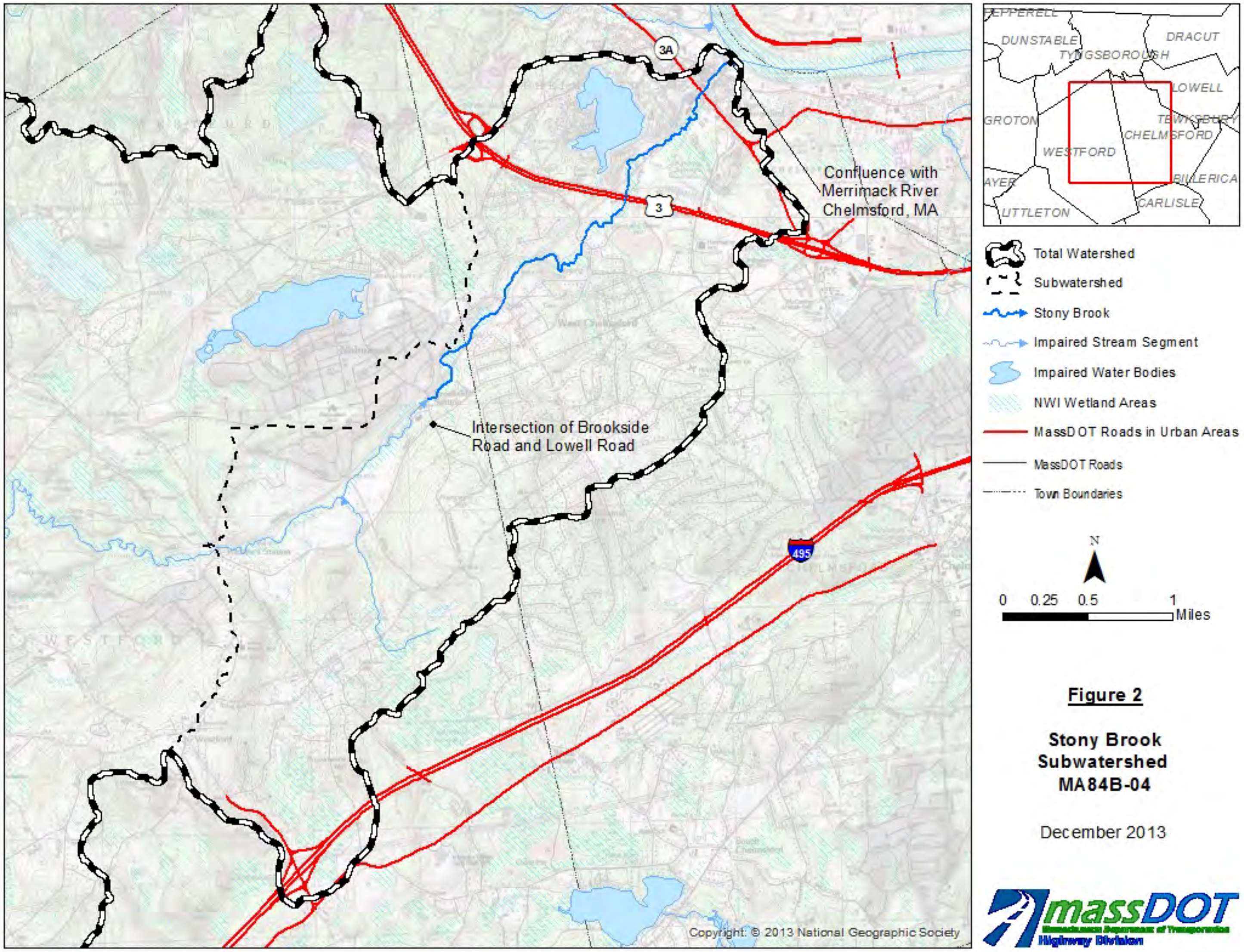

Figure 2

Stony Brook Subwatershed MA84B-04

December 2013

12/08/2013

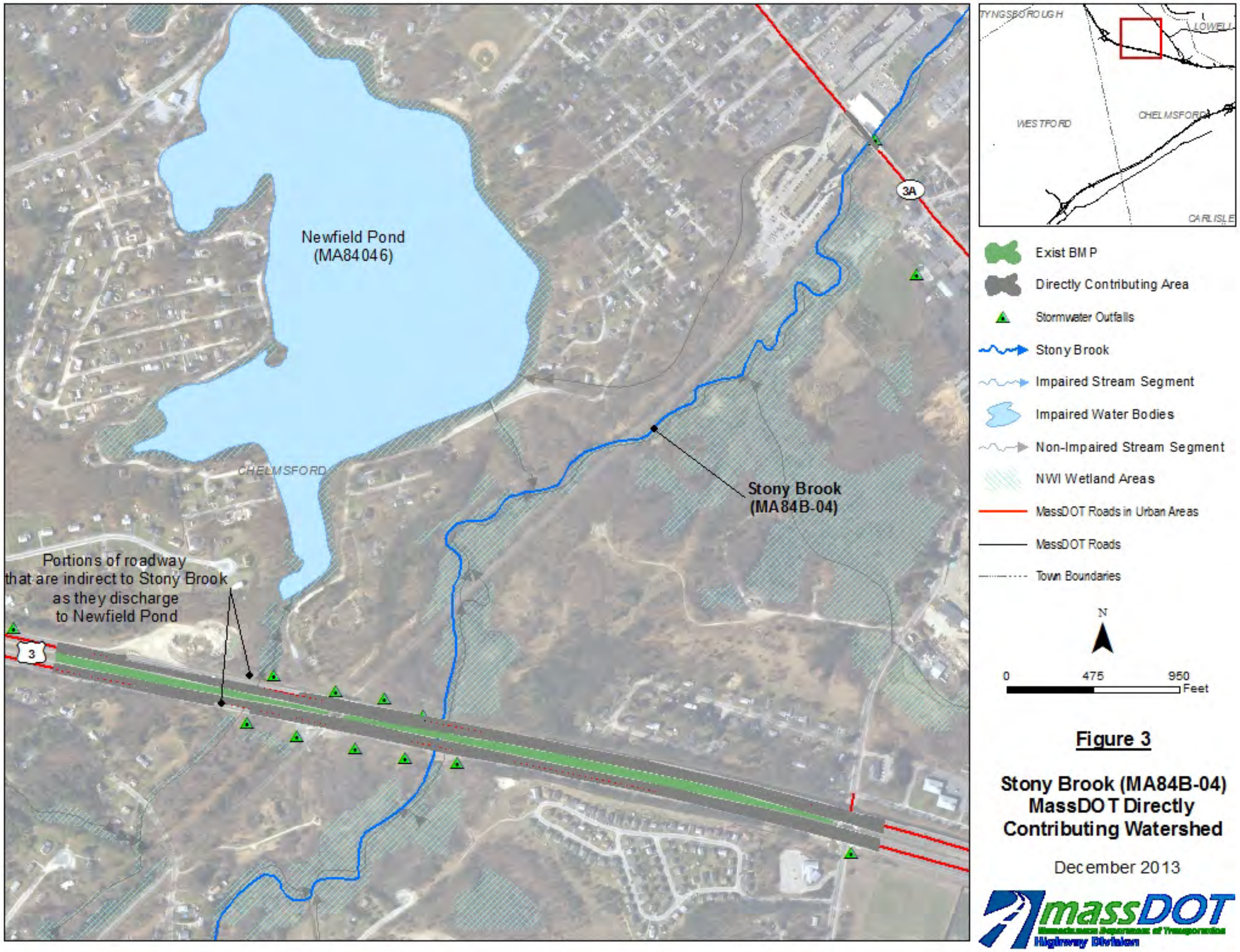

Figure 3

Stony Brook (MA84B-04) MassDOT Directly Contributing Watershed

December 2013

Impaired Waters Assessment for Saugus River (MA93-44)

Impaired Water Body

Name: Saugus River

Location: Lynn, Revere, and Saugus, Massachusetts

Water Body ID: MA93-44

Impairments

The Saugus River (MA93-44) is listed under Category 5, “Waters Requiring a TMDL”, on MassDEP’s Final *Massachusetts Year 2012 Integrated List of Waters* (MassDEP, 2013). The causes for the Saugus River impairment are listed as the following:

- (Other flow regime alterations*)
- Fecal Coliform
- Oil and Grease
- Temperature, water

According to the MassDEP’s *North Shore Coastal Watersheds 2002 Water Quality Assessment Report* (MassDEP, 2007) the Saugus River (MA93-44) is impaired for the shellfish harvesting use due to elevated fecal coliform bacteria and has alert status for the following designated uses: aesthetics, fish, other aquatic life and wildlife habitat, primary contact recreation and secondary contact recreation. The Saugus River (MA93-44) is also covered by a Total Maximum Daily Load (TMDL) for Pathogens according to MassDEP’s *Final Pathogen TMDL for the North Coastal Watershed* (MassDEP, 2012).

Relevant Water Quality Standards

Water Body Classification: Class SB

Applicable State Regulations:

- *314 CMR 4.05 (4)(b) 2. Temperature*.
    - a. Shall not exceed 85ºF (29.4ºC) nor a maximum daily mean of 80ºF (26.7ºC), and the rise in temperature due to a discharge shall not exceed 1.5ºF (0.8ºC) during the summer months (July through September) nor 4ºF (2.2ºC) during the winter months (October through June);
    - b. There shall be no changes from natural background that would impair any uses assigned to this class including those conditions necessary to protect normal species diversity, successful migration, reproductive functions or growth of aquatic organisms;
- *314 CMR 4.05 (4)(b) 4. Bacteria*.

- a. Waters designated for shellfishing shall not exceed a fecal coliform median or geometric mean MPN of 88 organisms per 100 ml, nor shall more than 10% of the samples exceed an MPN of 260 per 100 ml or other values of equivalent protection based on sampling and analytical methods used by the Massachusetts Division of Marine Fisheries and approved by the National Shellfish Sanitation Program in the latest revision of the *Guide For The Control of Molluscan Shellfish* (more stringent regulations may apply, see 314 CMR 4.06 (1)(d)(5));
- b. At bathing beaches as defined by the Massachusetts Department of Public Health in 105 CMR 445.010, no single enterococci sample taken during the bathing season shall exceed 104 colonies per 100 ml and the geometric mean of the five most recent samples taken within the same bathing season shall not exceed 35 enterococci colonies per 100 ml. In non-bathing beach waters and bathing beach waters during the non bathing season, no single enterococci sample shall exceed 104 colonies per 100 ml and the geometric mean of all of the samples taken during the most recent six months typically based on a minimum of five samples shall not exceed 35 enterococci colonies per 100 ml. These criteria may be applied on a seasonal basis at the discretion of the Department;

- *314 CMR 4.05 (4)(b) 7. Oil and Grease*. These waters shall be free from oil, grease and petrochemicals that produce a visible film on the surface of the water, impart an oily taste to the water or an oily or other undesirable taste to the edible portions of aquatic life, coat the banks or bottom of the water course, or are deleterious or become toxic to aquatic life.
- *314 CMR 4.05 (5)(a) Aesthetics*. All surface waters shall be free from pollutants in concentrations or combinations that settle to form objectionable deposits; float as debris, scum or other matter to form nuisances; produce objectionable odor, color, taste or turbidity; or produce undesirable or nuisance species of aquatic life.
- *314 CMR 4.05 (5)(b) Bottom Pollutants or Alterations*. All surface waters shall be free from pollutants in concentrations or combinations or from alterations that adversely affect the physical or chemical nature of the bottom, interfere with the propagation of fish or shellfish, or adversely affect populations of non-mobile or sessile benthic organisms.

Site Description

The Saugus River (MA93-44) segment originates at Lincoln Avenue/Boston Street in the Town of Saugus and City of Lynn, Massachusetts and flows southeast for approximately 2.3 miles and covers 0.363 square miles before it reaches its mouth at Lynn Harbor in the Cities of Lynn and Revere, Massachusetts. The Saugus River (MA93-44) segment subwatershed, delineated as the portion of the watershed draining directly to the Saugus River, is approximately 9,151 acres, of which approximately 3,373 acres are impervious surface. MassDOT property in the Saugus River (MA93-44) segment subwatershed includes portions of Route 1A and Route 107 (See Figure 1).

West of Route 107 (Western Avenue) on the northern bank of the Saugus River is a MassDOT stormwater outfall. Approximately 3.44 acres of MassDOT's Route 107 is collected by a series of catch basins and stormwater flows are conveyed to the MassDOT stormwater outfall where flows are directly discharged into the Saugus River (See Figure 2).

East of Route 107 (Salem Turnpike) on the southern bank of the Saugus River is a MassDOT stormwater outfall. Approximately 1.03 acres of MassDOT's Route 107 is collected by a series of catch basins and stormwater flows are conveyed to the MassDOT stormwater outfall where flows are directly discharged into the Saugus River (See Figure 2).

Approximately 6.37 acres of MassDOT's Route 107 (Salem Turnpike) is collected by numerous catch basins and stormwater flows are conveyed to several MassDOT stormwater outfalls located on the northbound and southbound shoulders of Route 107. These stormwater flows are discharged to salt marsh and tidal flats directly connected to the Saugus River and are considered directly discharging (See Figure 2).

West of Route 1A (North Shore Avenue) on the southern bank of the Saugus River is a MassDOT stormwater outfall. 3.27 acres of MassDOT's Route 1A and its Revere Beach interchange is collected by a series of catch basins and stormwater flows are conveyed to the MassDOT stormwater outfall where flows are directly discharged into the Saugus River (See Figure 3).

East of Route 1A (North Shore Avenue) on the southern banks of the Saugus River is a City of Revere stormwater outfall. Approximately 0.05 acres of MassDOT's Route 1A Revere Beach interchange is collected by a series of catch basins and stormwater flows are conveyed to the City of Revere stormwater outfall where flows are directly discharged into the Saugus River (See Figure 3).

Assessment under BMP 7U

None of the following impairments for the Saugus River (MA93-44) have been addressed by a TMDL. Therefore, MassDOT assessed this impairment using the approach described in BMP 7U of MassDOT's *Storm Water Management Plan (Water Quality Impaired Waters Assessment and Mitigation Plan)*, which applies to impairments that have been assigned to a water body prior to completion of a TMDL. As described in MassDOT's *Application of Impervious Cover Method in BMP 7U* (MassDOT, 2011), impervious cover (IC) provides a measure of the potential impact to stormwater on many impairments. For this water body, MassDOT used the IC method to assess the following impairments:

- Oil and Grease
- Temperature, water

According to the Final *Massachusetts Year 2012 Integrated List of Waters*, other flow regime alterations are considered non-pollutants and unrelated to stormwater. Therefore, MassDOT has determined that further assessment of this impairment for the water bodies is not required under BMP 7U.

The impairment for fecal coliform is assessed separately in the section titled, Assessment of Pathogen Impairment.

MassDOT's Application of the Impervious Cover Method

MassDOT's *Application of Impervious Cover Method in BMP 7U* applies many aspects of the United States Environmental Protection Agency (USEPA) Region I's Impervious Cover (IC) Method described in EPA's *Stormwater TMDL Implementation Support Manual* (ENSR, 2006) to MassDOT's program. This method assesses potential stormwater impacts on the impaired water and evaluates the IC reduction necessary to attain the percent imperviousness in the watershed at which stormwater is not likely the cause of the impairments. Consistent with the findings of EPA and others, when a watershed has less than 9% IC, MassDOT concludes that stormwater is not the likely cause of the impairment. Additional information regarding this method is provided under MassDOT's Application of the IC Method document.

Assessment

First, MassDOT calculated the percent IC of the water body's entire contributing watershed (total watershed upstream of the downstream end of an impaired segment) and that of the local watershed contributing to the impaired segment (referred to as the subwatershed in this analysis) to determine whether stormwater has a potential to cause the impairments of the receiving water body. The total watershed and subwatershed to the impaired water body were delineated using the USGS Data Series 451. When USGS Data Series watersheds did not delineate the subwatershed of the water body under review, the GIS shapefiles were modified by delineating to the water body based on USGS topography to add specificity. IC data was available as part of the USGS data layers Data Series 451 and MassGIS's impervious surfaces data layer. In cases where it was determined that stormwater was a potential cause of the impairment, MassDOT calculated the degree to which IC would need to be reduced in the subwatershed to meet the 9% IC target. This reduction was then applied proportionally to the area of MassDOT roadways/properties directly discharging to the water body segment to identify MassDOT's target IC reduction. The 9% IC reduction serves only as a recommended target and is not meant to imply that failing to meet the target would cause an exceedance in water quality standards. As explained in BMP 7U, MassDOT will consider a variety of factors apart from numeric guidelines, including site constraints and the magnitude of any potential exceedances in water quality standards, to determine the precise nature and extent of additional BMPs recommended for particular locations. This approach is consistent with the iterative, adaptive management BMP approach set forth in EPA guidelines.

MassDOT calculated the effective IC reduction afforded by the existing structural BMPs currently incorporated into the stormwater infrastructure of MassDOT's properties. This effective IC reduction was calculated by applying effective impervious cover reduction rates to existing BMPs based on their size, function and contributing watershed. BMP performances were derived from EPA Region 1's *Stormwater Best Management Practices (BMP) Performance Analysis* report (EPA, 2010) and engineering judgment. More information on the approach used to calculate the effective impervious cover reductions is described in BMP 7U. When the reduction in effective impervious cover achieved by the existing BMPs was equal to or greater than the target reduction, no further measures were proposed. When this was not the case, MassDOT considered additional BMPs in order to meet the targeted reduction.

Using this approach, MassDOT derived the following site parameters for the Saugus River (MA93-44):

Type	Parameter	Quantity	Unit
Subwatershed	Subwatershed Area	9,151	acres
Subwatershed	Impervious Cover (IC) Area	3,373	acres
Subwatershed	Percent Impervious	36.9	%
Subwatershed	IC Area at 9% Goal	824	acres
Subwatershed	Necessary Reduction % in IC	75.6	%
Reductions Applied	MassDOT's IC Area Directly Contributing to Impaired Segment	14.2	acres
Reductions Applied	MassDOT's Target Reduction in Effective IC (75.6% of MassDOT Directly Contributing IC)	10.7	acres

The subwatershed to Saugus River (MA93-44) is greater than 9% impervious cover which indicates that stormwater likely contributes to the impairments assessed under this methodology. In order to reach the 9% target, effective IC within the subwatershed should be reduced by

75.6%. Therefore, MassDOT's target is to reduce effective IC within its own directly contributing watershed by the same percentage, or 10.7 acres.

Existing BMPs

There are currently no existing BMPs associated with the direct discharges from MassDOT property tributary to the Saugus River (MA93-44) segment.

Mitigation Plan

Since there are no MassDOT existing BMPs providing mitigation of impervious surface to achieve the target of 10.7 acres, MassDOT considered locations for additional BMPs. In total, three BMPs have been considered, all of which are infiltration basins with sediment forebays.

<u>BMP-1:</u> The grass infield area of the turnaround ramp in the eastern shoulder of Route 107 could be modified to accommodate an infiltration basin (See Figure 4). Modifications would include minor adjustments to the existing drainage infrastructure outside of the pavement limits for the construction of a sediment forebay and infiltration basin. Natural Resources and Conservation Service (NRCS) soil data indicates soil in the area is Ipswich and Westbrook mucky peats and further investigation is required to determine the adequacy of the area for the placement of a stormwater BMP.

<u>BMP-2:</u> The grass infield area of the southbound on ramp to Route 1A at the Revere Beach interchange could be modified to accommodate an infiltration basin (See Figure 5). Modifications would include minor adjustments to the existing drainage infrastructure outside of the pavement limits for the construction of a sediment forebay and infiltration basin. NRCS soil data indicates soil in the area is Udorthents, wet substratum and further investigation is required to determine the adequacy of the area for the placement of a stormwater BMP.

<u>BMP-3:</u> The grass infield area of the southbound on and off ramps of Route 1A at the Revere Beach interchange could be modified to accommodate an infiltration basin (See Figure 5). Modifications would include minor adjustments to the existing drainage infrastructure outside of the pavement limits for the construction of a sediment forebay and infiltration basin. NRCS soil data indicates soil in the area is Udorthents, wet substratum and further investigation is required to determine the adequacy of the area for the placement of a stormwater BMP.

Further investigation of the three potential BMP locations was completed and test pit data indicated poor soil conditions including the presence of clay and organics as well as highly compact urban fill material. In locations where the soil conditions were more favorable there was a high groundwater table present therefore no stormwater BMPs are proposed for the treatment of MassDOT's directly contributing IC in the Saugus River (MA93-44) subwatershed.

Assessment of Pathogen Impairment under BMP 7R

MassDOT assessed the pathogen impairment using the approach described in BMP 7R of MassDOT's *Storm Water Management Plan (TMDL Watershed Review)*, which applies to impairments that have been assigned to a water body covered by a final TMDL. Pathogen concentrations in stormwater vary widely temporally and spatially; concentrations can vary by an order of magnitude within a given storm event at a single location (MassDEP, 2009b). Therefore, it is difficult to predict pathogen concentrations in stormwater with accuracy. Due to this difficulty, MassDOT generally will not conduct site specific assessments of loading at each location impaired for pathogens. Instead these sites are assessed based on available information on pathogen loading from highways, MassDOT actions, and information available from EPA and DEP. Based on this information MassDOT developed an approach to be consistent with relevant TMDL and permit condition requirements and an iterative adaptive management approach to stormwater management.

In addition, while there is a positive relationship between IC and pathogen loading, the relationship is not as direct as other impairments. According to the Center for Watershed Protection "…Other studies show that concentrations of bacteria are typically higher in urban areas than rural areas (USGS, 1999), but they are not always directly related to IC (CWP, 2003)." Therefore, MassDOT did not rely solely on the IC method to assess pathogen impairments. Instead, MassDOT reviewed its existing programs and their consistency with EPA NPDES MS4 general permit requirements and Pathogen TMDL recommendations.

Pathogens in MassDOT Discharge

A study conducted on MassDOT's Southeast Expressway measured bacterial concentrations in stormwater runoff (Smith, 2002). This study found a geometric mean of 186 fecal coliforms/100 ml. Concentrations of pathogens in stormwater runoff from roadways can vary widely and pathogen concentrations in runoff across the state likely deviate significantly from this stretch of roadway's specific estimate. Event mean concentrations of fecal coliform bacteria in urban stormwater from other sources ranging between 14,000 and 17,000 fecal coliform organisms/100 ml have been reported (MassDEP, 2009b). These data suggest that pathogen loading from highways may be lower than other urban areas.

Consideration of the potential sources of pathogens supports the idea that pathogens are present in lower concentrations in highway runoff since potential pathogen sources are likely to be less prevalent in the highway environment than along other urban roadways:

- <u>Illicit discharges:</u> Due to the typical setback of highways from residential and commercial developments and the stand alone nature of the drainage system, the potential for illicit discharges (e.g. sewer connections, laundry tie-ins) is much lower than in other stormwater systems. This has been confirmed by MassDOT's illicit discharge detection on many miles of urban roadways within a broad range of areas across Massachusetts. After assessment of almost 140 miles, and investigation of more than 2,500 stormwater features, MassDOT's consultant performing the broad scope reviews has found no confirmed illicit discharges.
- <u>Limited Sewer Utilities in Road Right of Ways:</u> Since MassDOT does not provide sewer services, many MassDOT roads do not have sewer utilities within the road's right of way; thereby eliminating the chance of cross-connections or leaking pipes as a source of pathogens into the stormwater system.
- <u>Pet waste:</u> Pets are only present on highways in rare instances. In urban residential areas pets and their associated waste are much more common. MassDOT is aware that pet waste at road side rest stops may represent a potential source of pathogens to stormwater in certain situations and has a pet waste management program underway to address this source where necessary.
- <u>Wildlife:</u> Highways are not generally an attractive place for wildlife. Wildlife generally avoids highways and only occasionally crosses them.

The dearth of pathogen sources on highways and the relatively low concentrations of pathogens measured in the Southeast Expressway study together suggest that pathogen loading from stormwater runoff from highways is lower than other urban sources.

Furthermore, in almost all cases the contribution of pathogens from MassDOT to a specific water body is likely to be very small relative to other sources of pathogens in the watershed. Since MassDOT urban roadways are linear and usually cross watersheds, they represent a small fraction of the receiving water body's watershed. The water quality within these water bodies is dependent on discharge from various sources, including discharges from other stormwater systems and a large number of other factors.

Assessment

Pathogen loadings are highly variable and, as a result, quantitative assessments are challenging and of little value. Therefore, MassDOT reviewed its existing programs and their consistency with EPA NPDES MS4 general permit requirements and Pathogen TMDL recommendations.

TMDLs for pathogen impairments in Massachusetts recognize that pathogens are highly variable and difficult to address and emphasize the need for an iterative adaptive management approach to address pathogens. Relevant language from the *Final Pathogen TMDL for the North Coastal Watershed* is included below:

- TMDL implementation to achieve these goals should be an iterative process by first prioritizing areas based on available data while considering their impact to down gradient resources. This information should then be used to identify and remove specific sources including the removal of illicit connections (if applicable) contributing to wet and dry weather violations. Once illicit connections are removed then priority should be given to identifying and implementing best management practices (BMPs) to mitigate stormwater runoff."
- "MassDEP realizes that an iterative approach to achieving compliance with this pathogen TMDL is warranted, given the vast potential number of bacteria sources, and the difficulty of identifying and removing some sources (e.g., stormwater). While the stated goal in the TMDL is to meet the water quality standard at the point of discharge it also attempts to be clear that MassDEP's expectation is that adaptive management is needed for implementation of stormwater control measures that includes prioritization of outfalls and the application of BMPs."
- "Setting and achieving TMDLs must be an iterative process, with realistic goals over a reasonable timeframe and adjusted as warranted based on ongoing monitoring. The concentrations set out in the TMDL represent reductions that will require substantial time and financial commitment to be attained. A comprehensive control strategy is needed to address the numerous and diverse sources of pathogens in the North Coastal watershed."
- "The NPDES permit does not, however, establish numeric effluent limitations for stormwater discharges. Maximum extent practicable (MEP) is the statutory standard that establishes the level of pollutant reductions that regulated municipalities must achieve. The MEP standard is a narrative effluent limitation that is satisfied through implementation of SWMPs and achievement of measurable goals."

This language clearly indicates that an iterative adaptive management approach is the appropriate way to address discharges to pathogen impaired waters. The recommendations in the *Final Pathogen TMDL for the North Coastal Watershed* requires development and implementation of stormwater management programs, illicit discharge detection and elimination efforts, repair of failing infrastructure, control of impacts associated with Combined Sewer Overflows (CSOs), and in some cases installing BMPs to the maximum extent practicable.

The draft North Coastal Watershed General MS4 permit and the draft Interstate, Merrimack, and South Coastal (IMS) watershed permits contain specific requirements for compliance with pathogen TMDLs (in Appendix G). While these permits are still in draft form, MassDOT believes they represent the best available guidance on what EPA believes is appropriate for addressing stormwater discharges to pathogen-impaired waters. Section 2.2.1(c) of the permit states "For any discharge from its MS4 to impaired waters with an approved TMDL, the permittee shall comply with the specific terms of Part 2.1 of this permit. In addition, where an approved TMDL establishes a WLA that applies to its MS4 discharges, the permittee shall implement the specific BMPs and other permit requirements identified in Appendix G to achieve consistency with the WLA." Appendix G references a number of programmatic BMPs that are necessary to address pathogen loading. These cover the following general topics:

- Residential educational program
- Illicit connection identification, tracking and removal
- Pet waste management

Language relevant to specific pathogen TMDL recommendations from the *Final Pathogen TMDL for the North Coastal Watershed* is included below:

- Illicit sewer connections, failing infrastructure and CSOs

  "Elimination of illicit sewer connections, repairing failing infrastructure and controlling impacts associated with CSOs are of extreme importance. Several municipalities have already implemented programs, have programs in place, or are planning programs to eliminate sewage discharge from CSOs and/or illicit septic system connection to stormwater drains."

  "Elimination of illicit sewer connections and repairing failing infrastructure are of extreme importance. EPA's Phase II rule specifies an MS4 community must develop, implement, and enforce a stormwater management program that is designed to reduce the discharge of pollutants to the maximum extent practicable, protect water quality, and satisfy the applicable water quality requirements of the Clean Water Act." "Communities that are not covered under the Phase II rule are encouraged to implement a program for detecting and eliminating sewage discharges to storm sewer systems including illicit sewer connections. Implementation of the Phase II rule, whether voluntarily or mandated will help communities achieve bacteria TMDLs."

- Pet and wildlife waste management

  "Address pet waste as a water quality issue. People are generally unaware of the connection between pet waste and water quality" "Reduce public geese feeding, especially along lakes where both geese and people congregate. Goose waste is a major source of bacterial runoff."

- Public educational program

  "Educate communities to consider permit and development strategies that address stormwater runoff – implementing BMPs that reduce runoff, beneficial stormwater recharge, buffer zones, and Low Impact Development (LID) in general."

  "Encourage communities and watershed groups to take advantage of the U.S. Department of Agriculture's Natural Resources Conservation Service interest in working with communities to identify sources of stormwater contamination, and evaluate remedial options."

  "Recreational waters receive pathogen inputs from swimmers and boats. To reduce swimmers' contribution to pathogen impairment, shower facilities can be made available, and bathers should be encouraged to shower prior to swimming. In addition, parents should check and change young children's diapers when they are dirty."

- Failing on-site septic systems

  "Septic system bacteria contributions to the North Coastal watershed may be reduced in the future through septic system maintenance and/or replacement. Additionally, the implementation of Title 5, which requires inspection of private sewage disposal systems before property ownership may be transferred, building expansions, or changes in use of properties, will aid in the discovery of poorly operating or failing systems. Because systems which fail must be repaired or upgraded, it is expected that the bacteria load from septic systems will be significantly reduced in the future."

Unlike other TMDLs that establish pollutant load allocations based on mass per time, many bacteria and pathogen TMDLs in Massachusetts establish bacterial TMDLs that are concentration based and equivalent to the MassDEP water quality standard for the receiving water body. This requirement therefore requires that at the point of discharge to the receiving water, all sources include bacteria concentrations that are equal or less than the MassDEP water quality standard for the receiving water body.

Mitigation Plan

MassDOT implements a variety of non-structural BMP programs across their system in accordance with their existing Stormwater Management Plan (SWMP) including educational programs, illicit connection review and source control. The specific BMPs that can help reduce potential pathogen loading in the current SWMP include:

- BMP 3C-1: Drainage Connection Policy
- BMP 3C-2: Drainage Tie-In Standard Operating Procedure
- BMP 3D: Illicit Discharge Detection Review
- BMP 5H-1: Post Construction Runoff Enforcement – Illicit Discharge Prohibition
- BMP 5H-2: Post Construction Runoff Enforcement – Drainage Tie-In
- BMP 5H-3: Post Construction Runoff Enforcement – Offsite Pollution to MassHighway Drainage System
- BMP 6A-1: Source Control – 511 Program
- BMP 6A-2: Source Control – Adopt-A-Highway Program
- BMP 6C-1: Maintenance Program

In addition, the structural BMPs that will be considered to reduce the IC will also have the effect of reducing pathogen loads.

MassDOT believes the existing and proposed efforts are consistent with the current and draft MS4 permit's requirements and TMDL recommendations. MassDOT's existing stormwater management plan outlines BMPs that include education and illicit discharge detection and elimination, and has a pet waste management program underway to address this source where necessary.

Conclusions

The entire subwatershed of MassDOT owned roadways were investigated and approximately 14.2 acres of MassDOT IC contributes stormwater directly to the Saugus River (MA93-44) segment. There are currently no existing BMPs associated with the directly contributing watershed of the Saugus River (MA93-44) segment that are mitigating potential stormwater quality impacts prior to discharge to the Saugus River. In order to reduce MassDOT's contribution to the effective IC within the Saugus River (MA93-44) segment subwatershed, MassDOT reviewed their property and sited three potential locations for stormwater BMPs. Upon further evaluation of the three potential BMP locations test pit data indicated poor soil conditions including the presence of clay and organics as well as highly compact urban fill material. In locations where the soil conditions were more favorable there was a high groundwater table present. In conclusion, MassDOT determined that due to the limitations of the existing soil characteristics and groundwater elevation the placement of BMPs for the treatment of their directly contributing IC is not feasible.

Impervious Cover Reduction	**Quantity**	**Unit**
IC in Directly Contributing Watershed	14.2	acres
Target Reduction in Effective IC	10.7	acres
IC Effectively Reduced by Existing BMPs	0.0	acres
IC Effectively Reduced by Proposed BMPs	0.0	acres
Total IC Effectively Reduced by BMPs	0.0	acres
IC Remaining to Mitigate with Proposed BMPs	10.7	acres

As an overall program, MassDOT will continue to identify opportunities to implement additional structural BMPs to reduce effective IC when road work is conducted under MassDOT's programmed projects initiative. Work on programmed projects, which often include broader scale road layout changes, may provide additional opportunities for construction of new treatment BMPs. This is consistent with an iterative adaptive management approach to addressing impairments. MassDOT will include an update in annual reports and biannual submittals to EPA regarding progress made towards meeting target effective IC reductions, plans for construction of additional BMPs, and finalized assessments including reduction achieved by finalized BMP designs. Furthermore, MassDOT will continue to implement non-structural BMPs that reduce the impacts of stormwater.

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