2021

Bantam Lake
Watershed Based Plan

EPA Contract Number: BPA-68HE0118A0001-003

Prepared for:

United States Environmental Protection Agency Region 1 – New England
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Contents

Appendices

List of Tables

List of Figures

Executive Summary

The Connecticut Department of Energy and Environmental Protection (CTDEEP) has developed a Statewide Lake Nutrient Total Maximum Load (TMDL) core document to address nutrient-impaired lakes in Connecticut. In support of the core document, lake-specific appendices and watershed-based plan addendums (WBPAs) to implement the TMDL are being developed. Bantam Lake was prioritized for development of a TMDL Appendix and WBPA due to occurrences of Harmful Algal Blooms (HABs).

The primary goal of this WBPA for Bantam Lake is to provide a plan for implementing actions that will result in measurable improvements in water quality and aquatic habitat. As shown below, the Bantam Lake TMDL specifies water quality targets for two nutrient pollutants: total phosphorus and total nitrogen. However, phosphorus is typically the limiting nutrient for plant and algae growth in freshwater systems such as Bantam Lake, and this WBPA is focused primarily on the phosphorus reduction target.

	Total Phosphorus		**Total Nitrogen**	
	Existing Conditions	TMDL Load Reduction Target	Existing Conditions	TMDL Load Reduction Target
In-Lake Concentration (µg/L)	24.7	20.0	528.6	400.0
Total Loading (kg/yr)	1,614.3	1,211.1	26,806.0	20,325.7

Key findings and recommendations from this WBPA include the following:

- **Pollutant Load Reduction Optimization Analysis:** An optimization analysis was performed to identify the least-cost mix of ten nonpoint source (NPS) best management practices (BMPs) that could be implemented in the Bantam Lake watershed to achieve the phosphorus load reduction target allocated by CTDEEP for non-regulated stormwater sources in the watershed (48.6 kg/year). Four optimization scenarios were performed, the results of which are summarized in Section 2 of this WBPA and presented in detail in Appendix A. The least-cost scenario (Scenario 4) estimated a cost of $3.7 million to achieve the target phosphorus reduction of 48.6 kg/year.
- **Watershed Field Investigation/Structural BMP Concepts:** A watershed field investigation was performed to evaluate high priority sites for potential structural BMPs as determined based on a desktop analysis, field reconnaissance, and consensus with project stakeholders. The BMP concept designs presented in Section 3.1 were based on site-specific factors (e.g., proximity to lake or a tributary, available space, drainage patterns, site constraints, etc.). The 20 sites presented in Section 3.1 could be constructed for an estimated cost of $732,800 (middle of cost range) and would reduce the annual phosphorus load to Bantam Lake by an estimated 13.65 kg/year, which is 28.1% of the target for non-regulated stormwater.
- **Non-structural BMPs:** Section 3.2 of this WBPA discusses non-structural BMPs that could be implemented in the watershed to help achieve the TMDL pollutant load reduction targets. Non-structural BMPs do not involve construction of site-specific infrastructure and generally focus on reducing pollutant loads through public information and education, land conservation, regulatory tools, and institutional practices. Pollutant load reductions from non-structural BMPs are more difficult to estimate than those from structural BMPs, but can play a significant role in reducing NPS pollution in the Bantam Lake watershed.
- This WBPA includes a summary of potential funding sources (Section 3.3) for the recommended BMPs, an implementation schedule with interim milestones (Section 4), and criteria for evaluating progress in implementing the WBPA and achieving water quality targets for Bantam Lake (Section 5).

Introduction

The Connecticut Department of Energy and Environmental Protection (CTDEEP) received funding from the United States Environmental Protection Agency (EPA) to develop a statewide Lake Nutrient Total Maximum Load (TMDL) core document to address nutrient impairments throughout Connecticut. In addition to the core document, which provides general information about lake nutrient impairments and lists the nutrient-impaired lakes in Connecticut, lake-specific appendices and watershed-based plan addendums (WBPAs) to implement the TMDL are being developed as available resources allow. CTDEEP has prioritized Bantam Lake for development of a nutrient TMDL Appendix and associated WBPA due to repeated occurrences of Harmful Algal Blooms (HABs).

The primary goal of this WBPA for the Bantam Lake watershed is to provide a plan for implementing actions that will result in measurable improvements in water quality and aquatic habitat. To achieve this goal, this WBPA was developed to supplement the statewide Lake Nutrient TMDL core document and the Bantam Lake watershed-specific TMDL Appendix to meet the **nine elements specified in the EPA's guidance for watershed-based plans.** The nine elements are summarized below:

The Nine Required Elements of a Watershed-Based Plan

a. **Identify the causes and pollutant sources** (or groups of similar sources) that will need to be controlled to achieve the pollutant load reductions specified in the WBPA for the water body, as discussed in element (b) below.

b. **Estimate the pollutant load reductions** expected for the management measures described under element c) below (recognizing the natural variability and difficulty in precisely predicting the performance of management measures over time).

c. **Describe the nonpoint source (NPS) pollutant management measures** that will need to be implemented to achieve the pollutant load reductions estimated under element (b) above (as well as to achieve other watershed goals identified in the WBPA), and identify the critical areas in which those measures will be needed to implement the plan.

d. **Estimate the technical and financial assistance needed**, associated costs, and/or the sources and authorities that will be relied upon, to implement the plan. This includes identification of technical skills that may be needed to implement the WBPA (e.g., civil engineering, wetland regulatory support, legal services, etc.) and potential funding sources such as relevant federal, state, and private grants.

e. An **information/education component** that will be used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the NPS management measures that will be implemented.

f. A **schedule for implementing the NPS management measures** identified in the WBPA that is reasonably expeditious.

g. Describe **interim, measurable milestones** for determining whether NPS management measures or other control actions are being implemented.

h. A **set of criteria** to determine if loading reductions are being achieved over time and substantial progress is being made towards attaining water quality standards and TMDL pollutant reduction targets and, if not, the criteria for determining whether the WBPA or TMDL needs to be revised.

i. A **monitoring component** to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under element (h) above.

The location of each of the nine required elements within in the Bantam Lake WBPA, the TMDL Core Document, and the TMDL Appendix is listed in Table 1.

Table 1: Location of the Required Nine Elements of a Watershed Plan

EPA Watershed-Based Plan Elements		WBPA Section	TMDL Core Document Section	TMDL Appendix Section
Element A	Identify causes and sources of pollution that need to be controlled.	1	3	4
Element B	Determine pollutant load reductions needed to meet water quality goals.	1	2, 4	6
Element C	Develop management measures to achieve water quality goals.	2 and 3	6	7
Element D	Technical and financial assistance needed.	3	5.2.4 and 7	6 and 7
Element E	Public information and education	3	5.2.5	5
Element F	Implementation schedule	4	5.2.6	--
Element G	Interim measurable milestones	4	5.2.7	--
Element H	Criteria to measure progress	5	5.2.8	--
Element I	Monitoring	5	5.2.9	8

1. Bantam Lake Watershed and Water Quality Targets

1.1 BANTAM LAKE WATERSHED

Bantam Lake (CT6705-00-3-L3_01) is the largest naturally formed freshwater lake in Connecticut. This 946-acre lake has a 20,962-acre watershed (Figure 1) located in the towns of Goshen (41%), Litchfield (39%), Morris (15%), and Torrington (5%).

For a detailed description of Bantam Lake and its watershed, refer to the CT Statewide Lake Nutrient TMDL, Appendix 1: Bantam Lake Watershed.

1.2 WATER QUALITY TARGETS

Bantam Lake is classified as an Inland Surface Water Class AA surface water. Class AA surface waters have designated uses of existing or potential drinking water supply, fish and wildlife habitat, agricultural and industrial supply, and recreational use (CTDEEP, 2020). Bantam Lake is listed in CTDEEP's 2020 Integrated Water Quality Report (IWQR) as impaired for recreation (CTDEEP, 2020). Impairment causes were noted as chlorophyll-*a*, excess algal growth, and nutrient/eutrophication biological indicators

The Bantam Lake TMDL specifies in-lake water quality targets for two nutrient pollutants: total phosphorus (TP) and total nitrogen (TN):

- The current estimated in-lake TP concentration[1] is 24.7 µg/l and the TMDL target is 20.0 µg/l.
- The current estimated in-lake TN concentration[1] is 528.6 µg/l and the TMDL target is 400.0 µg/l.

The pollutant load reductions required to meet these targets are shown in Table 2. For the purposes of the WBPA, the term "pollutant load" refers hereafter to the pollutant loads of TP and TN. However, phosphorus is typically the limiting nutrient for plant and algae growth in freshwater systems such as Bantam Lake. As such, subsequent sections of this WBPA are focused primarily on the TP reduction target specified in the TMDL.

For a detailed description of Bantam Lake water quality targets and pollutant load reduction targets, refer to the CT Statewide Lake Nutrient TMDL, Appendix 1: Bantam Lake Watershed (Section 6).

1. Estimate from Bantam Lake Nutrient TMDL Model – Modeling Report. Comprehensive Environmental, February 2020.

Table 2: TMDL Water Quality Targets for Bantam Lake

		Current Load (kg/yr)		TMDL Load Reduction Targets[1] (kg/yr)		TMDL % Reduction	
Load Categories	**Description**	TP	TN	TP	TN	TP	TN
Total Waste Load Allocation (WLA)	Load from the Woodridge Lake Sewer District Discharge	265.9	989.5	22.5	335.7	91.5%	66.1%
Total Load Allocation to Lake	Includes Nonpoint Sources: Non-regulated Stormwater[2], Internal Load[3], and Septic Systems[3]	733.5	7,458.6	513.2	615.6	30.0%	91.7%
Total Background	Includes Nonpoint Sources: Forested Load, Atmospheric Load[3], and Waterfowl[3]	614.9	18,358	614.9	18,358.1	0.0%	0.0%
Margin of Safety	5% of Total Load to Lake for TMDL	NA	NA	60.6	1,016.3	-	-
Total Load to Lake	**All Sources**	**1,614.3**	**26,806**	**1,211.2**	**20,325.7**	**25.0%**	**24.2%**

Inputs from Various Sources	**Description**	**TP** (kg/yr)	**TN** (kg/yr)
WLA from NPDES-regulated Stormwater[2]	Load from stormwater regulated under NPDES Phase II MS4 permit. *None of the watershed is regulated as an MS4 area.*	0.0	0.0
WLA from NPDES Regulated Wastewater Discharges	Woodridge Lake Sewer District Discharge	265.9	989.5
Nonregulated Stormwater	The watershed load associated with non-regulated stormwater minus background loads and permitted loads	163.8	7,070.4
Septic Systems[3]	Load estimated from on-site wastewater treatment systems located within approximately 300 feet from Bantam Lake	9.7	388.2
Internal Phosphorus Load[3]	Estimated seasonal internal phosphorus load released from bottom sediments	560.0	--
Background Watershed Loads	Estimated watershed load under fully forested watershed conditions[3]	547.7	14,293.3
Waterfowl[3]	Load estimated from waterfowl (geese, ducks)	25.2	119.7
Atmospheric Load[3]	Estimated pollutant load from atmospheric deposition directly to Bantam Lake	42.0	3,945.0

Notes:

1. TMDL Load Reduction Targets are the annual pollutant load targets established by the TMDL for the total load to the lake and for specific load source categories. For Bantam Lake, achieving an annual TP load of 1,211.2 kg/yr would require reducing the current TP load (1,614.3 kg/yr) by 403.1 kg/yr (25%).
2. Non-regulated stormwater is stormwater not regulated under the NPDES Phase II MS4 permit. No part of the watershed is regulated as an MS4 area.
3. Estimate from Bantam Lake Nutrient TMDL Model – Modeling Report. Comprehensive Environmental, February 2020.

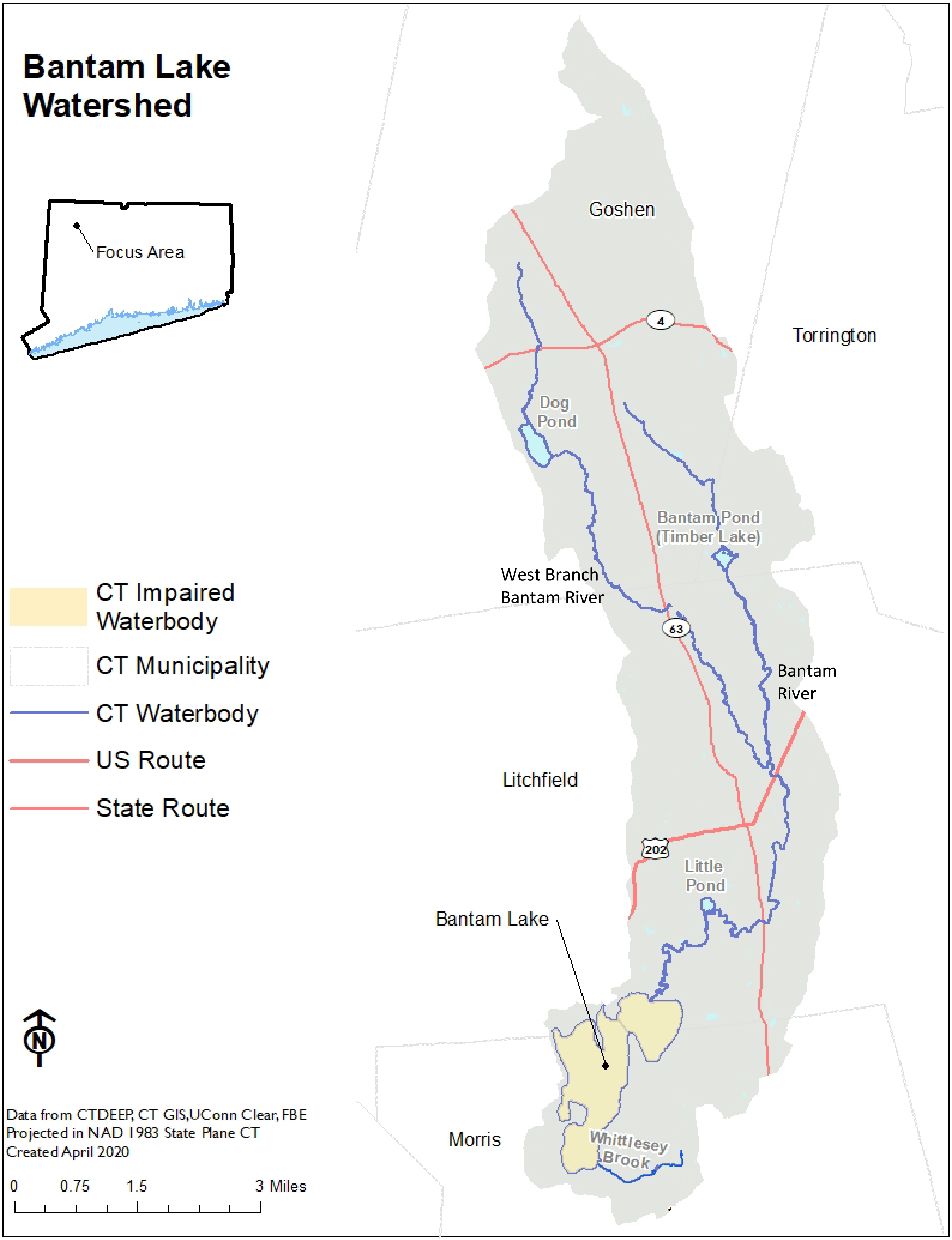

Figure 1. Bantam Lake Base Map

Note: CTDEEP completed calculations and minor revisions in the TMDL Appendix after CEI conducted the following analysis.The revisions are unlikely to significantly affect any outcome.

2. Pollutant Load Reduction Optimization Analysis

2.1 INTRODUCTION

A desktop-based optimization analysis was performed to evaluate and identify the best mixture of nonpoint source (NPS) best management practices (BMPs) that could be implemented throughout the Bantam Lake watershed to achieve pollutant load reduction targets for nutrients at the most reasonable cost.

The planning level analysis module of version 2 of EPA's Opti-Tool was used for analysis and optimization of structural BMPs. Opti-Tool does not currently support evaluation of a variety of other non-structural BMP types, such as public education efforts, land conservation, institutional practices (e.g., street sweeping and catch basin cleaning), buffer zone improvements (i.e., tree/shrub plantings), and agricultural BMPs such as livestock exclusion fencing. For this reason, pollutant load reductions and implementation costs for several BMPs not currently supported by Opti-Tool were estimated from other reputable sources.

Wetland along the Little Pond Boardwalk Trail, White Memorial Foundation (Litchfield, CT)

A summary of this analysis is provided below and the full analysis is provided in greater detail in Appendix A.

2.2 POLLUTANT LOAD REDUCTION TARGETS

The Connecticut Statewide Lake Nutrient Total Maximum Daily Load (TMDL) establishes pollutant load reduction targets for Bantam Lake. For the purposes of the optimization analysis, CTDEEP determined that pollutant reductions should be applied to estimated nonpoint source watershed loads minus background loads and permitted loads (i.e., "non-regulated loads") as summarized by Table 3. Phosphorus is typically the limiting nutrient for plant and algae growth in freshwater systems such as Bantam Lake. As such, subsequent sections of this analysis focus on phosphorus as the primary pollutant of concern. Although the optimization analysis was focused on phosphorus load reduction, the analysis was also conducted for nitrogen.

Table 3. Pollutant Load Reduction Targets Used in Optimization Analysis

Description	Total Phosphorus (TP)	Total Nitrogen (TN)
Predicted Loading (kg /yr)[1]	163.8	7,070.4
Reduction Targets (%)	29.7%	91.7%
Reduction Targets	**48.6 kg/yr** (107 lb/yr)	**6,483.6 kg/yr** (14,294 lb/yr)

Table 3 Notes:

1. Predicted loading in Table 3 refers to the TP and TN watershed load allocations for non-regulated stormwater, as calculated in the *CT Statewide Lake Nutrient TMDL, Appendix 1: Bantam Lake Watershed*.
2. The optimization analysis was based on applying the % reduction targets (for the total load allocation to the lake) in an equal manner across all sources that contribute NPS TP and TN loads.
3. Reduction targets are presented in kilograms and pounds per year. As the Opti-Tool analysis was performed using pounds per year, the remainder of Section 2 and Appendix A reports in pounds per year only.

2.3 BMPs for Optimization Analysis

The optimization analysis was initiated by developing a categorized list of ten BMPs that could be implemented throughout the watershed to reduce nutrient loads to Bantam Lake (Table 4). These BMPs fall into three categories: Structural BMPs, Institutional BMPs, and Agricultural BMPs.

Table 4. List of BMPs for Optimization Analysis

<table>
<tr><th>BMP Category</th><th>BMP Name</th><th>Description</th></tr>
<tr><td rowspan="6">Structural</td><td>Bioretention Area (High Infiltration)</td><td rowspan="6">These structural BMPs are commonly deployed throughout watersheds to provide runoff attenuation and nutrient removal. These structural BMPs can be evaluated using EPA's Opti Tool.

"High Infiltration" BMPs are most suitable in Type A or B Soils. "Poor Infiltration BMPs" are most suitable in Type C or D Soils.</td></tr>
<tr><td>Infiltration Basin (High Infiltration)</td></tr>
<tr><td>Sand Filter (High Infiltration)</td></tr>
<tr><td>Bioretention with ISR[1] (Poor Infiltration)</td></tr>
<tr><td>Gravel Wetland (Poor Infiltration)</td></tr>
<tr><td>Wet Pond (Poor Infiltration)</td></tr>
<tr><td rowspan="2">Institutional (aka non-structural)</td><td>Street Sweeping</td><td rowspan="2">These practices are commonly deployed by municipalities for pollutant removal as required by the NPDES Small MS4 Permit.</td></tr>
<tr><td>Catch Basin Cleaning</td></tr>
<tr><td rowspan="2">Agricultural / Other</td><td>Riparian Buffer Improvement</td><td>This commonly used and well-studied BMP involves improving upland areas adjacent to wetlands and surface waters through vegetation establishment (e.g., forest, grass).</td></tr>
<tr><td>Livestock Exclusion Fencing</td><td>Installation of fencing in pasture areas to keep livestock from having direct access to waterways and streambanks.</td></tr>
<tr><td colspan="3">[1] Bioretention with Internal Storage Reservoir (ISR). The ISR is comprised of gravel and has an underlying impermeable membrane.</td></tr>
</table>

2.4 BMP SCENARIO ANALYSES

An analysis was performed to determine the best potential mix of BMPs at the lowest possible cost to meet the TP load reduction target (for watershed BMPs) of 107 pounds per year. Four scenarios were evaluated as follows:

Scenario 1: Maximum Potential BMP Implementation

This scenario was used to identify an upper bound on potential watershed-wide BMP implementation to enable comparisons to subsequent iterations. Results from this scenario are summarized in Table 13a of Appendix A. This scenario estimates a possible TP load reduction of 888.2 lb/yr at a cost of $58.3M. Non-structural BMPs (i.e., institutional, riparian buffers, agricultural BMPs) are estimated to be significantly more cost-effective than structural BMPs based on cost per pound of TP load reduction.

Scenario 2: Realistic BMP Implementation

The purpose of this scenario was to establish a more realistic implementation extent for each BMP type. Results from this scenario are summarized in Table 13b of Appendix A. This scenario estimates a TP load reduction of 112.5 lb/yr at a cost of $5.9M. This scenario exceeds the 107 lb/yr TP load reduction target by 5.5 lb/yr. The combined non-structural BMPs achieve a TP load reduction of 29.8 lb/yr vs. 82.7 lb/yr for the structural BMPs. The non-structural BMPs are more cost effective than structural BMPs and therefore were unchanged in subsequent scenarios.

Scenario 3: Realistic BMP Implementation with Structural BMP Adjustments

The purpose of this scenario was to perform adjustments to the initially established BMP implementation percentages to reduce cost. Results from this Scenario are summarized in Table 13c of Appendix A. This scenario estimates a TP load reduction of 113.1 lb/yr at a cost of $5.1M. This scenario exceeds the 107 lb/yr TP load reduction target by 6.1 lb/yr and is $0.80M less expensive than Scenario 2.

Scenario 4: Realistic BMP Implementation with Structural BMP Adjustments and Optimization

The purpose of this scenario was to perform an optimization analysis to finalize the “best” mixture of BMPs to achieve the most cost effective pollutant load reductions. Opti-Tool performs optimization calculations by identifying the most cost effective treated runoff depth and subsequent BMP storage capacity that meets the target load reduction. Structural BMPs for Scenarios 1, 2, and 3 were all initially sized based on a treated runoff depth of 1 inch. The optimization analysis runs thousands of simulations to determine which runoff depth(s) result in the most load reductions at the lowest cost.

Results from this scenario are summarized in Table 13d of Appendix A, which shows that an overall TP load reduction of 107 lb/yr is achieved at a cost of $3.7M. This scenario meets the 107 lb/yr TP load reduction target and is $1.4M less expensive than Scenario 3. The cost per pound of TP reduced for Scenario 4 is significantly lower than Scenarios 1-3.

2.5 DISCUSSION

The scenario results summarized in Section 2.4 were sequentially improved by each scenario, as depicted by **Figure 2**. Based on these findings, Scenario 4 provides the “best” mixture of BMPs to meet pollutant load reductions at the lowest cost.

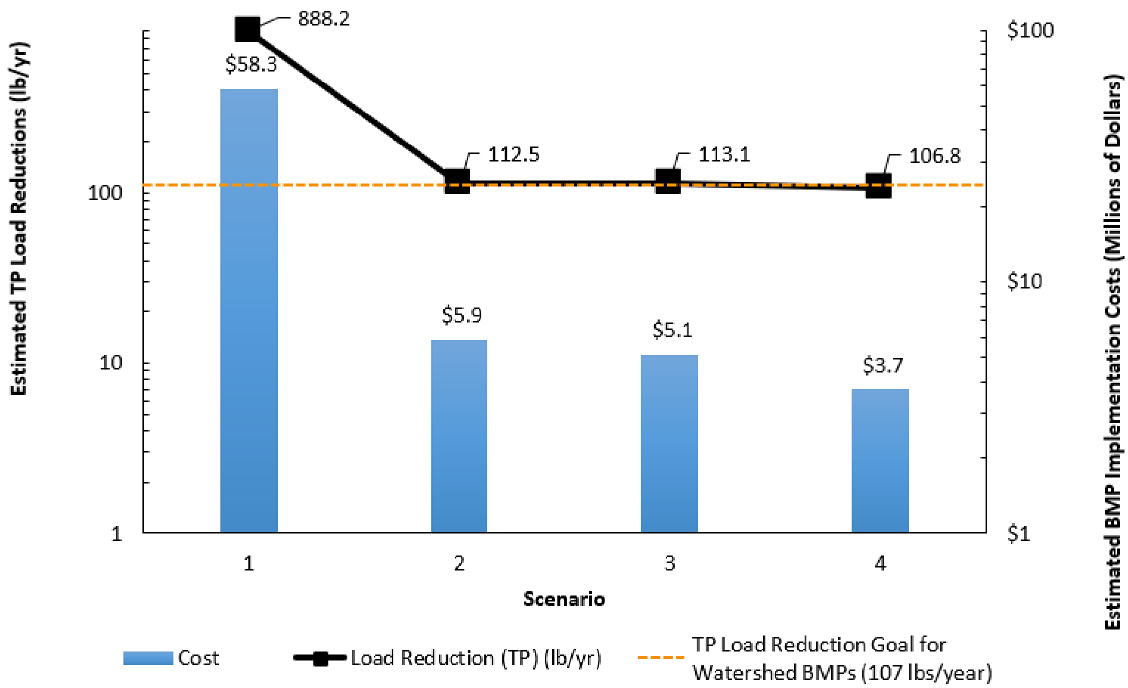

Figure 2. Summary of Results by Scenario

It is important to note that Scenario 4 maximizes pollutant load reductions while reducing costs. However, BMPs provide other useful functions, including peak flow attenuation. The effective treatment depth of most Scenario 4 BMPs are less than those presented by other scenarios and will therefore result in less peak flow attenuation.

It is recommended that future implementation efforts seek to strike a balance between Scenario 3 and Scenario 4. For example, if a prospective BMP site is constrained for space, design to the optimized treatment depth presented by Scenario 4. If a prospective BMP site has adequate space, consider designing the BMP to capture and treat at least 1 inch of runoff as presented by Scenario 3. By striking this balance, it is likely that overall implementation costs to meet pollutant load reduction targets will end up between Scenario 3 ($5.1M) and Scenario 4 ($3.7M).

Based on this analysis, the following implementation sequence is recommended to achieve the TP load reduction target in the Bantam Lake watershed.

1. Evaluate and implement site-specific structural BMP recommendations presented in **Section 3.1.**

2. In parallel, implement non-structural BMPs discussed in **Section 3.2** as feasible. Non-structural BMPs are estimated to be more cost effective than structural BMPs. Riparian buffer enhancements could be particularly effective on a cost per pound of TP removed basis. Refer to Figure 2 of Appendix A for potential non-structural BMP implementation locations, including locations of specific buffer enhancement locations.

3. Perform widespread implementation of structural BMPs to attain the remaining TP load reduction needed to achieve the Bantam Lake water quality target.

    - Use Figure 1 of Appendix A as a site-specific guide to screen for suitable BMP implementation areas based on soil type (i.e., suitable vs. not suitable for infiltration).

    - Perform initial BMP implementation as close to nearshore areas as feasible before upland areas.

    - Design for treatment of 1 inch of runoff where feasible (Scenario 3), but capitalize on space-constrained sites to provide more cost-effective treatment (Scenario 4).

3. Watershed Management

To address nutrient pollution in the Bantam Lake watershed, sources of pollution and management measures to address these sources are discussed in the following sections:

Section	Description
Pollutant Load Reduction Optimization Analysis (Section 2; Appendix A)	A Pollutant Load Reduction Optimization Analysis was conducted to determine watershed-wide potential BMP locations and the best mix of BMP types to **achieve the Bantam Lake pollutant load reduction target at the lowest cost**. This planning-level analysis was based on (1) use of the EPA's Opti-Tool for a suite of structural BMPs with EPA-approved performance curves, and (2) evaluation of a limited number of non-structural BMPs with supporting cost and performance data from reputable sources as discussed in Appendix A.
Field Investigation for Structural BMPs (Section 3.1)	The potential structural BMP sites presented in Section 3.1 are based on a (1) desktop analysis (review of maps, GIS data, soil types, etc.), (2) a volunteer field reconnaissance effort led by the White Memorial Foundation which looked at over 200 sites, and (3) a field assessment conducted by CEI which **evaluated high priority sites** as determined by and based on the desktop analysis and volunteer reconnaissance, and consensus with project stakeholders. The BMP concept designs presented in Section 3.1 were based on CEI's assessment of a variety of site-specific factors (e.g., proximity to the lake or a tributary, available space, drainage patterns, site constraints/constructability, etc.). The BMP options presented as concepts were not limited to the list of BMP types used in the Optimization Analysis, as some sites were well suited for approaches that included measures that are not able to be evaluated with Opti-Tool (e.g., bank stabilization, level spreaders, etc.).
Non-structural BMPs (Section 3.2)	Section 3.2 describes approaches for implementing non-structural BMPs. Unlike structural BMPs, non-structural BMPs do not involve construction of site-specific infrastructure and generally focus on reducing pollutant loads through public information and education, land conservation, regulatory tools, and institutional practices and programs.

The CT Statewide Lake Nutrient TMDL Core Document (Section 6) and associated Appendix (Section 7) provide general information on BMPs.

3.1 STRUCTURAL BEST MANAGEMENT PRACTICES

Morris Boat Launch in Morris, CT

Structural BMPs are infrastructure designed to slow runoff, allowing for treatment of pollutants found in stormwater. Structural BMPs include a range of practices such as rain gardens, infiltration trenches, permeable pavement, green roofs, vegetated filter strips, swales.

To identify locations for the implementation of BMPs throughout the Bantam Lake watershed, a field investigation and Pollutant Load Reduction Optimization Analysis (Section 2) were conducted.

3.1.1 Watershed Field Investigation

Preliminary Investigation

CEI conducted a preliminary desktop evaluation of potential pollutant sources to Bantam Lake prior to an on-the-ground field investigation. This evaluation included:

1. The review of existing maps or the creation of maps listed below.
    - Land use
    - Soils
    - Impervious cover
    - Sewer / septic systems
    - Vegetated buffer zones
    - High intensity land uses
2. The review of existing water quality and watershed-specific reports, such as studies conducted by or on behalf of municipal, state, and federal agencies, studies by local lake and watershed organizations, etc.
3. Meetings and other communication (e.g., phone calls, email) with local stakeholders to identify known or potential problem areas for field assessment, such as:
    - Areas of suspected septic system failure;
    - Areas prone to flooding and any associated areas of erosion;
    - Developed areas either lacking adequate stormwater management measures or with good potential for retrofits (e.g., infiltration techniques in areas with well-draining soils) to improve stormwater pollutant attenuation;
    - Agricultural activities within or close to poorly drained or somewhat poorly drained soils;
    - Evaluation of agricultural manure management practices;
    - Evaluation of manure management practices on horse farms and other facilities with livestock;
    - Location, maintenance and containment of garbage disposal receptacles and facilities (including municipal and commercial facilities, and transfer stations);

- Municipal, commercial, residential practices for maintaining playing fields, lawns, golf courses and related;
- Municipal and commercial housekeeping practices such as street sweeping, leaf disposal, etc.
- Public areas near watercourses that are popular for dog walking where proper disposal of pet waste may be a concern;
- Grassy areas adjacent to waterbodies (e.g., concerns related to use of lawn fertilizers, limited shoreline buffers, waterfowl activity, etc.); and
- Eroding streambank and riparian areas.

In addition to the desktop investigation by CEI, a local field investigation was organized by the White Memorial Foundation to assist CEI in identifying potential pollutant sources for a full in-field investigation. This local field investigation relied on the use of EpiCollect 5, a user-friendly data-gathering platform, and utilized the services of local watershed stakeholders from land trusts, the White Memorial Foundation, and the Bantam Lake Protective Association (BLPA), amongst others. CEI conducted a virtual training webinar to provide background information on how to determine potential pollutant sites and how to document their findings. Training materials are documented in Appendix B.

These stakeholders gathered information on over 200 potential pollutant source sites using the EpiCollect 5 app. The information collected included a site description and location, potential pollutant sources at the site, and photographs of the site. Once collected, the sites were categorized by the White Memorial Foundation into the following categories:

- Agriculture/Manure Management (4 sites);
- Culverts/Infrastructure (80 sites).
- Parking lots (13 sites);
- Road shoulder erosion (35 sites);
- Shoreline/stream bank erosion (40 sites);
- Shoreline with no or little vegetative buffer (1 site);
- Surface erosion (28 sites);
- Uncovered soil stockpiles (10 sites);
- Unmaintained land (1 site);
- Wildlife droppings (2 sites);
- Disrupted land (1 site);
- Failing septic system (1 site).

The sites identified through this investigation can be seen here and are identified in Appendix B:

https://www.google.com/maps/d/u/0/edit?mid=11s7QTgN99mgTZqFq9pXQx-BHbaN9toaG&ll=41.77642157268843%2C-73.21732955&z=11

Field Investigation

Based on preliminary information collected during the desktop analysis, the White Memorial Foundation field investigation, and other information provided by local stakeholders, CEI identified approximately twenty high priority sites for further field assessment. The prioritization of these sites was confirmed based on discussion with the White Memorial Foundation prior to field activities.

CEI's watershed field investigation was conducted on June 30, 2020, with the goal of identifying locations where structural BMPs could be constructed to reduce pollutant loads within the Bantam Lake watershed. CEI staff visited each of the 20 high priority sites and also visited many of the other sites identified by the White Memorial Foundation's field investigations. Potential structural BMPs identified for the 20 high-priority locations were based on the following factors:

- Proximity to Bantam Lake, its tributaries and wetlands;
- Existing “available” space (i.e., land without buildings or other structures);
- Parking lot configuration/traffic flow (i.e., how much parking is currently provided? are there paved medians? would improvement impact or alter traffic patterns?);
- Entrances to the site and buildings (i.e., highly visible areas);
- Below-ground infrastructure/utilities as well as groundwater elevations;
- Site drainage patterns and proximity to existing inlets to enable overflow drainage;
- Potential for disconnecting and routing roof drains/headers or other catchment areas to structures;
- Locations with existing infrastructure in poor condition where strategic improvements can be made to serve dual benefits (e.g., replace crumbling walkway or asphalt with permeable pavement); and
- Constructability concerns (proximity to foundations, overhead utilities, wetland resource areas and other permitting constraints, etc.).

The potential structural BMP locations described in this section are not intended to be an all-inclusive listing of potential structural retrofit improvements possible within the watershed.

Note: For Bantam Lake, the TP reduction target for non-regulated stormwater is 48.6 kg/year (107 lbs/year). If all of the structural BMPs presented in Section 3.1.2 (and listed in Table 7) are constructed, this would reduce TP by 13.65 kg/yr (30.1 lbs/yr), which is 28.1% of the TMDL target for non-regulated stormwater. *Please note that Section 3.1.2 reports estimated TP load reductions for specific sites in pounds per year only.*

3.1.2 Structural BMP Recommendations

Potential structural BMP implementation locations were identified during the field investigations (Figure 3) and are described in this section.

The field investigation form used in the field investigation can be found in Appendix B-3. Refer to **Table 7** for a summary of estimated costs, estimated pollutant load reductions, and recommended priority for each proposed BMP.

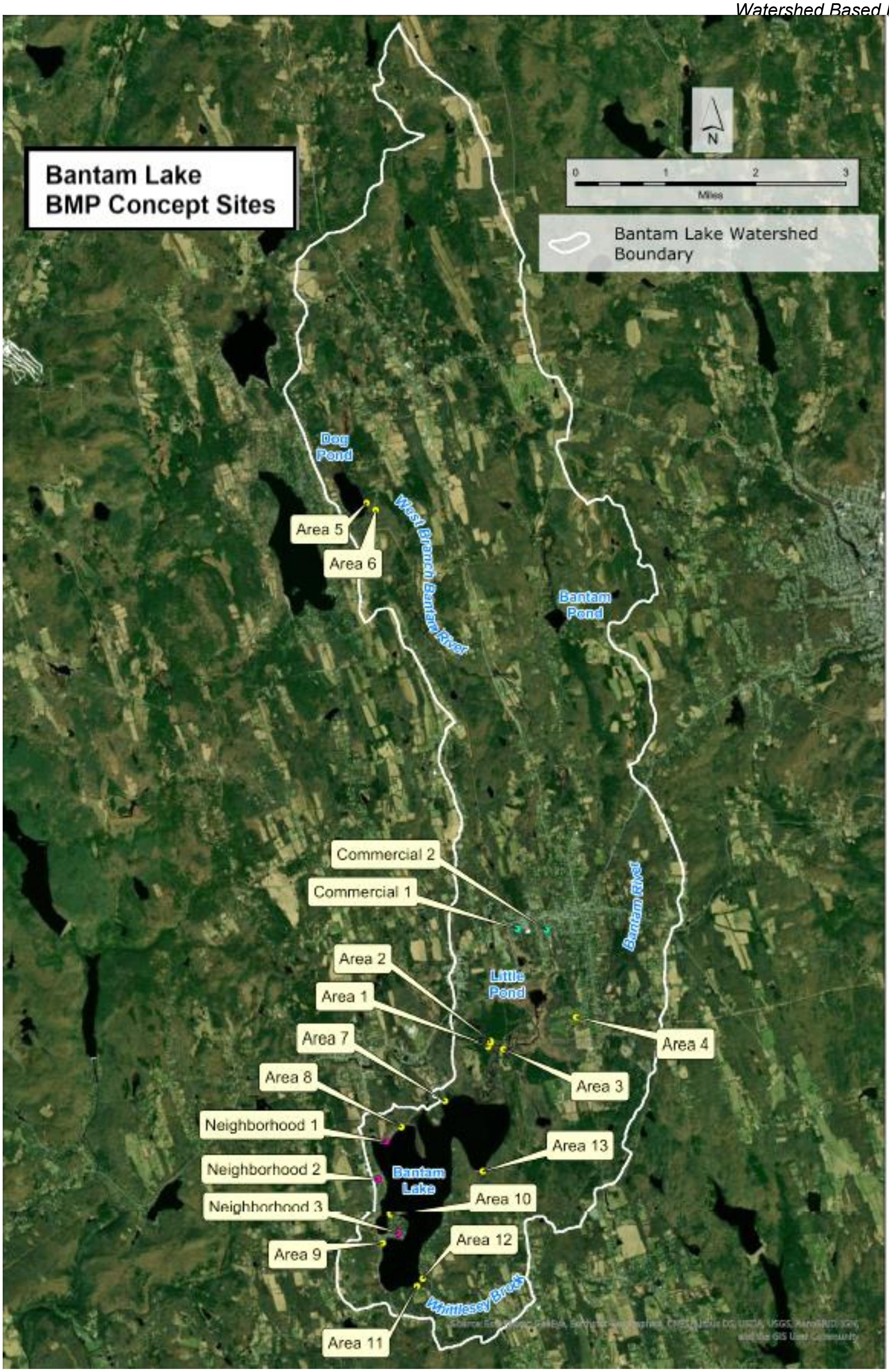

Figure 3. Potential Structural BMP, Neighborhood, and Commerical Area Locations in the Bantam Lake Watershed

Methodology

Potential sizing, costs, and pollutant load reductions were calculated for each recommended structural BMP by using the Massachusetts Department of Environmental Protection's (MassDEP) Watershed Based Plans Tool (WBPT)[2]. Required inputs include: BMP Type, design storm size, drainage area, and land use. Outputs include: anticipated BMP footprint based on a typical cross section; estimated construction cost; and estimated pollutant load reduction for Total Phosphorus (TP), Total Nitrogen (TN), and Total Suspended Solids (TSS). Outputs from the MassDEP WBPT have been previously reviewed and approved by EPA Region 1.

The WBPT has been configured for a subset of common structural BMPs. Output parameters for BMPs not currently included in the WBPT were calculated as feasible based on published information and professional judgement as described below. Specific methods for this analysis were as follows:

- **Delineate Drainage Area and Determine Land Use Information**: Where applicable, the drainage area to proposed BMP features was delineated using one-foot contours from the University of Connecticut Environmental Conditions Online (CT ECO) geodatabase[3], aerial imagery, and best professional judgement based on field observations (e.g., observed drainage patterns, roadway grading, etc.). The land use / cover type within each delineated drainage area was estimated using classifications from the National Land Cover Database (NLCD)4 using GIS tools. For example, the area of "Forest" vs. "Pervious Medium Intensity Residential" vs. "Impervious Residential" was tabulated within the delineated drainage boundary.
- **Performance Sizing:** A general design objective is to size each BMP to treat and potentially infiltrate the water quality volume (WQV) to the maximum extent practicable. The WQV is the minimum amount of stormwater runoff from a rainfall event that should be captured and treated to remove the majority of stormwater pollutants on an average annual basis. The WQV is defined in the Connecticut Stormwater Quality Manual[5] as the volume of runoff generated by the first one-inch of rainfall. However, each proposed BMP should be designed to get the most treatment that is practical given the size and constraints of each site. Applicable BMPs (e.g., bioretention cells) were sized using the MassDEP WBPT based on a one-inch design storm.
- **Estimate Costs:** Construction costs for structural BMPs were first estimated using output from the MassDEP WBPT, then adjusted based on best professional judgement based on site size"" and complexity (i.e., inflated upwards for conservatism). BMPs not supported by the MassDEP WBPT were estimated using inflation-adjusted unit pricing from past projects as summarized in Appendix C. Once construction costs were calculated, engineering and design costs were calculated to be 30% of the estimated construction cost. Engineering and design costs represent approximate costs for engineering design and analysis, survey, design drawing preparation, and permitting. The 30% estimate may vary on a site-specific basis. An overall capital cost for each structural BMP was then estimated by summing estimated construction and engineering costs. A contingency factor of ±20% was applied to provide a cost estimate range. Cost estimates do not include engineering services related to bidding and construction quality assurance.
- **Calculate Potential Pollutant Load Reductions:** Pollutant loading estimates associated with applicable structural BMPs were calculated based on the MassDEP WBPT. Structural BMPs not

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2 MassDEP WBPT, Element C BMP Selector Tool: http://prj.geosyntec.com/MassDEPWBP/Home.
3 CT ECO: http://cteco.uconn.edu/map_services.htm
4 NLCD: https://www.mrlc.gov/data
5 2004 Connecticut Stormwater Quality Manual, Connecticut Department of Environmental Protection.

supported by the MassDEP WBPT (e.g., bank stabilization) where calculated based on the EPA Region 5 Spreadsheet Model for Estimating Load Reductions[6].

- **Perform scoring and prioritization**: BMP recommendations were scored and prioritized based on factors described by **Table 5**. BMP scoring ranges from Low (30) to High (100). BMPs were prioritized based on scoring. The top third were ranked as "High" priority, the middle third were ranked as "Medium" priority, and the bottom third were ranked as "Low" **priority**.

Table 5. BMP Scoring Criteria

Factor	Criteria			Score		
	Low	Medium	High	Low	Medium	High
TP Removal	< 0. 6 lb/yr	0.6 to 1.5 lb/yr	> 1.5 lb/yr	10	15	25
Capital Cost	> $60k	$20k - $60k	< $20k	10	15	25
Waterbody Proximity	Not Near Waterbody	Within 100-ft of Waterbody	Within 100' of Bantam Lake	5	10	20
Implementation Complexity	High	Moderate	Low	5	10	20
Public Visibility / Outreach	Low Visibility	Moderate Visibility	High Visibility	0	5	10
			Possible Point Range:	**30**	**55**	**100**

Notes:

1. TP is the limiting nutrient in Bantam Lake for which a TMDL is being developed. Total Phosphorus was therefore used to score pollutant removal from evaluated BMPs.

2. TP removal criteria categories were established by determining the TP removal range for the lower third, middle third, and upper third of all evaluated BMPs.

3. For cost factors, lower cost = higher priority.

4. Priority is higher for BMPs with closer proximity to Bantam Lake and its tributaries, as greater distance generally allows for more opportunities for natural pollutant attenuation.

5. Other watersheds may require the use of different pollutants such as TSS or TN to score BMP pollutant removal. Pollutant removal criteria categories for TSS and TN could be established according to the same method described above for TP (lower third, middle third, and upper third removal ranges for each pollutant for all BMPs evaluated). Based on this method, the following criteria could be used if TSS or TN were "pollutants of interest" in Bantam Lake:

TSS Removal: Low: < 0.07 ton/yr; Medium: 0.07 ton/yr to 0.7 ton/yr; High: > 0.7 ton/yr
TN Removal: Low: < 2 lb/yr; Medium: 2 lb/yr to 5 lb/yr; High: > 5 lb/yr

6. Implementation complexity is a qualitative factor based on the following criteria: property ownership, site access, potential for underground utility conflicts, potential for tree removal, potential for traffic impacts, and residential fresh water wetland permitting. Scored based on professional judgement.

Supporting calculations and data are provided in Appendix C, including: drainage area delineations, soil type, pollutant load reduction notes, and detailed cost estimate breakdown. Cost estimates and sizing are for planning purposes only and must be re-evaluated during more detailed design. Recommended components to evaluate during detailed design include, but aren't limited to: 1) site survey to verify grades, 2) soil infiltration testing, and 3) depth to groundwater evaluation.

[6] EPA Region 5 Load Reduction Model: https://www.epa.gov/nps/region-5-model-estimating-pollutant-load-reductions

BMP Site Descriptions

A detailed description of each BMP recommendation is provided on the following pages and includes:

- A site summary and description of proposed structural BMP(s);
- Estimated capital costs;
- Estimated pollutant removals; and
- Recommended priority for BMP implementation (low, medium or high).

Location coordinates (in decimal degrees) for each BMP site are as listed below:

Table 6. BMP Site Location Coordinates

BMP Site	Lat	Long
Area 1	41.725594	-73.209059
Area 10	41.698398	-73.229886
Area 11	41.686901	-73.224054
Area 12	41.688081	-73.222841
Area 13	41.705577	-73.210084
Area 2	41.726286	-73.208529
Area 3	41.725255	-73.205829
Area 4		
LCC 1	41.730998	-73.193986
LCC 2	41.730350	-73.193163
LCC 3	41.730288	-73.192632
LCC 4	41.729507	-73.191739
LCC 5	41.729068	-73.191886
LCC 6	41.727864	-73.192999
LCC 7	41.727850	-73.191540
LCC 8	41.728458	-73.191302
Area 5	41.812878	-73.235821
Area 6	41.811740	-73.233868
Area 7	41.716846	-73.218286
Area 8	41.712624	-73.227594
Area 9	41.693768	-73.231446
Commercial 1	41.744330	-73.202916
Commercial 2	41.744174	-73.196695
Neighborhood 1	41.710290	-73.230868
Neighborhood 2	41.704249	-73.232599
Neighborhood 3	41.695400	-73.228137

The CT Statewide Lake Nutrient TMDL Core Document (Section 6) and associated Appendix (Section 7) provide general information on BMP types.

AREA 1: White Mountain Foundation Road Flooding and Watershed-wide Culverts

Location:	Whitehall Road trail network	**Source Type**:	Culvert
Owner:	White Memorial Foundation	**Priority**:	Low

Site Description

A 24” culvert directs water beneath Whitehall Road from a wetland to the Bantam River. This portion of the road floods multiple times per year. The upstream wetland was previously used by CTDEEP as a fishery breeding area and is no longer in use. Whitehall Road is used for access to recreation on White Memorial Foundation trails. This culvert is one of approximately 70 culverts identified through the White Memorial Foundation field survey located throughout the watershed.

Photo 1-1: Section of Whitehall Road that floods multiple times per year.

Photo 1-2: Downstream side of culvert discharges to Bantam River.

Photo 1-3: Top of upstream side of culvert draining wetland.

Proposed Area 1 Improvements

1. The above culvert is a 24” inch culvert that drains an approximate 147.2-acre watershed, including Duck Pond. It is likely that this culvert would require upsizing and replacement. Depending on overall priority, replace culvert to meet stream crossing sizing standards for passage of peak flows and wildlife passage (1.2 times bankfull width).

Note: *There are likely numerous culverts in the watershed that require upsizing and replacement. To ensure that funds are spent with the appropriate prioritization, a* ***watershed-wide culvert assessment*** *is recommended to identify potential culvert issues that contribute to nutrient loading via transport of sediment and attached phosphorus. The assessment should also include consideration of overall structure condition, aquatic organism passage compatibility, geomorphic compatibility, and hydraulic vulnerability (flooding). Inspect all culverts, identify potential issues (e.g., undersized, scour, bank erosion, etc.), and develop prioritized replacement / maintenance plan.*

See **Appendix D** for conceptual design details for culvert replacement.

Estimated Costs: $60,000 - $90,000 (*for watershed-wide culvert assessment*)

Estimated Pollutant Load Reduction:

- Total Suspended Solids: N/A ton/yr
- Total Phosphorus: N/A lb/yr
- Total Nitrogen: N/A lb/yr

Anticipated Permits: Municipal Inland Wetland Permit; 401 Water Quality Certification (*for implementation of priority sites*)

AREA 2: White Memorial Foundation Canoe/Kayak Launch

Location: Whitehall Road trail network	**Source Type**: Shoreline Erosion
Owner: White Memorial Foundation	**Priority**: Medium

Site Description

An unofficial canoe and kayak boat launch on Whitehall Road has led to severe bank erosion on the Bantam River. Whitehall Road is used for access to the White Memorial Foundation trails. The shoreline has eroded severely into the river and the banks on either side of the site are beginning to be undercut.

Photo 2-1: Canoe/kayak launch to the Bantam River.

Photo 2-2: Severe erosion at site.

Photo 2-3: Sandy soils eroding into Bantam River.

Proposed Area 2 Improvements

1. Regrade the canoe/kayak launch and install safe access point such as large steps with handrail (Photo 2-3). Approximate extent of proposed improvement area is 20' wide by 25' long.
2. Armor the soil with a combination of stone stabilization and vegetation to prevent additional erosion into the river (Photo 2-2 and 2-3). Where appropriate, native rock/stone and vegetation should be used.
3. Re-vegetate the sides of the ramp; stabilize area with biodegradable erosion control blanket.
4. Stabilize undercut areas at base of slope.

See **Appendix D** for conceptual design details for bank stabilization.

Estimated Costs: $26,000 - $39,000

Estimated Nutrient Load Reduction:

- Total Suspended Solids: 4.7 ton/yr
- Total Phosphorus: 4.0 lb/yr
- Total Nitrogen: 4.8 lb/yr

Anticipated Permits: Municipal Inland Wetland Permit; 401 Water Quality Certification

AREA 3: Boat Launch to Bantam River Parking Area

Location:	West side of bridge on Mattatuck Trail	**Source Type**:	Boat Launch
Owner:	Town of Litchfield	**Priority**:	High

Site Description

A town-owned boat launch for canoes and kayaks with an adjacent gravel parking lot is located on the Bantam River directly downstream of the bridge on Mattatuck Trail. The bridge and boat launch were replaced in 2017 by the Town of Litchfield. The new gravel boat launch is beginning to show wear, exposing the larger base layer rock on the east side of the launch. The parking area above the launch is relatively flat and bordered by forest and trails within the White Memorial Foundation trail network. Runoff from the parking area flows down the boat launch and enters the river or flows to the adjacent forest.

Photo 3-1: Erosion of gravel on east side of boat launch

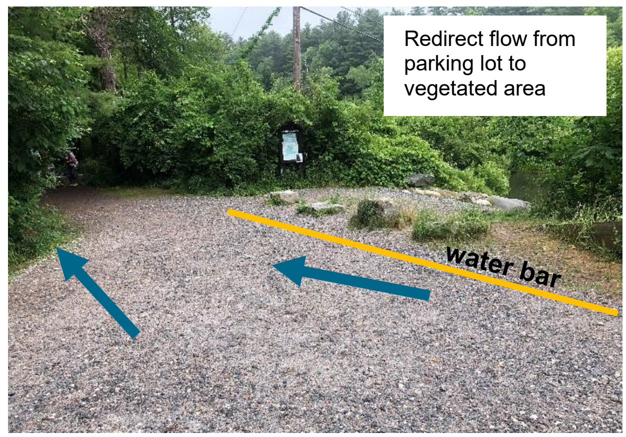

Photo 3-2: Stormwater flows from gravel parking lot towards the boat launch or to the vegetated area near the trailhead.

Proposed Area 3 Improvements

1. Stabilize the eroded side of the boat launch with additional stone (approximately 6’ wide by 35’ long) (Photo 3-1).
2. Redirect flow from the parking area to the vegetated area to the west of the site. Install earthen berm or water bar (approximately 20’ in length) to direct all flow from parking area to vegetated area near trailhead (Photo 3-2). Install stone energy dissipation pad at outlet.

See **Appendix D** for conceptual design details for water bar diversions.

Estimated Costs: $11,440 - $17,160

Estimated Nutrient Load Reduction:

- Total Suspended Solids: 0.8 ton/yr
- Total Phosphorus: 0.8 lb/yr
- Total Nitrogen: 1.5 lb/yr

Anticipated Permits: Municipal Inland Wetland Permit

AREA 4: Litchfield Country Club (multiple sites)

Location:	256 Old South Road, Litchfield	**Source Type**:	Golf course
Owner:	White Memorial Foundation	**Priority**:	Varies (See **Table 1**)

Site Description

The Litchfield Country Club (LCC) property is owned by the White Memorial Foundation and leased to the country club. A nine-hole golf course is located on the property much of which is in the 200-foot buffer of the Bantam River that flows towards Little Pond. Eight locations for potential improvements were identified along the banks of the Bantam River (LCC 1 - LCC 8, see folowing pages). In many locations, the golf course is mowed to the edge of the river with little vegetation intact. Geese congregations and geese droppings were observed on the property. Stockpiled materials were observed adjacent to the Bantam River.

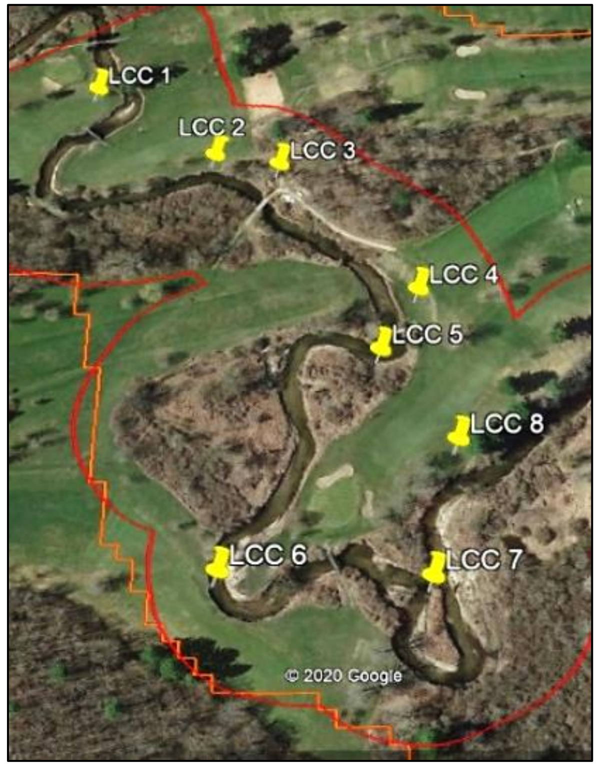

Photo 4-1: LCC potential improvement sites (LCC1 – LCC8). The 200-foot buffer from Bantam River is shown in red.

Summary of Proposed Area 4 Improvements

1. Enhance buffers with non-invasive and preferably native plantings where feasible.
2. Stabilize eroding banks using biostabilization techniques (e.g., plantings within biodegradable erosion control blanket; coir logs with live staking, etc.) and a combination of stone stabilization and vegetation as needed. Where possible, native stone and vegetation should be used.
3. Move stockpiles from the shoreline and cover.

Many of the proposed LCC sites have the potential to remove relatively high amounts of TSS, TP, and TN through bank stabilization of buffer enhancements. The two highest ranked LCC sites were LCC-4 (expand “no mow” buffer”) and LCC-5 (stabilize 100 ft long eroding bank). See the following pages for descriptions of sites LCC-1 through LCC-8. See Table 7 for individual site estimates relative to costs and pollutant load reduction. See **Appendix D** for conceptual design details for planting buffer enhancements and streambank stabilization.

Note: *In addition to the sites-specific improvements proposed for the LCC, an evaluation of LCC fertilizer use practices is recommended to determine if there are opportunities to reduce fertilizer nutrient loads, particularly in areas nearest to the Bantam River.*

Estimated Costs: $64,480 - $96,720

Estimated Pollutant Load Reduction:

- Total Suspended Solids: 11 ton/yr
- Total Phosphorus: 15.3 lb/yr
- Total Nitrogen: 33.9 lb/yr

Anticipated Permits: Municipal Inland Wetland Permit

LCC 1 – Eroding Shoreline and Inadequate Buffer

The fairway is mowed very close to the shoreline. A small area of concentrated erosion along the bank can be seen in Photo 4-2. This area is approximately 20’ wide by 8’ deep. Recommend stabilizing the bank with bio-stabilization techniques (e.g., biodegradable erosion control blanket, live stakes, coconut coir logs) and expanding the width of a “no-mow” buffer area as feasible.

Photo 4-2: Shoreline erosion and lack of vegetated buffer at LCC1.

Photo 4-3: Upstream side of bridge at LCC1.

LCC 2 – Inadequate Buffer and Geese

The fairway is mowed very close to the shoreline. Geese were also seen in in this area. As this area is not located directly on the fairway, it may be possible to enhance the buffer in this area. This section of shoreline is approximately 100’ in length. Expand width of “no-mow” buffer as feasible. Install double width row of plantings to accelerate process.

Photo 4-4: Limited vegetated buffer at LCC2.

Photo 4-5: Geese congregating near LCC2.

LCC 3 – Exposed Soil Stockpiles

Stockpiles of exposed soil are stored in a maintenance area adjacent to Bantam River. Some are covered with a tarp while others are not. The stockpile in Photo 4-6 is located directly adjacent to the river and is not covered. Sediment from these stockpiles can runoff into the river during rain events. Recommend moving the stockpiles to the adjacent side of the access road and ensuring all piles are covered or surrounded with perimeter controls such as coir waddles.

Photo 4-6: Exposed soil stockpile at LCC3.

Photo 4-7: Soil stockpile partially covered with a tarp.

LCC 4 –Inadequate Buffer

The fairway is mowed very close to the shoreline and has a steep slope in this area. The bank is beginning to be undercut in some areas, but the extent was unclear. Recommend expanding the width of a "no-mow" buffer area to the extent practicable. This section is approximately 100' in length.

Photo 4-8: Steep slope at LLC4.

Photo 4-9: Banks are beginning to be undercut in some areas.

LCC 5 – Eroding Bank

The shoreline along the bank is eroding as shown by Photo 4-10. Areas of erosional material are concentrating at specific locations along the bank as shown in Photo 4-11. Recommend stabilizing the bank with stone and bio-stabilization techniques. This section of shoreline is approximately 100' in length.

Photo 4-10: Eroding banks at LLC5.

Photo 4-11: Debris accumulating along banks.

LCC 6 – Eroding Bank and Inadequate Buffer

The shoreline along the bank is eroding as shown in Photos 4-12 through 4-14. There is an inadequate buffer along most of this area. Recommend (1) stabilizing the bank with armoring stone and bio-stabilization techniques and (2) increasing the unmowed vegetated buffer width where feasible. This section of the shoreline is approximately 200' in length.

Photo 4-12: Eroding bank along Bantam River at LCC6.

Photo 4-13: Eroding bank at LCC6 with inadequate buffer.

Photo 4-14: Bank beginning to undercut at LCC6.

LCC 7 – Oxbow Formation

An oxbow has formed along this section of the Bantam River. The oxbow is now completely cut off from the rest of the river and has stagnant water in its bed. Recommend allowing the oxbow to proceed naturally as the river begins to form its new course. When left to natural processes, over time, the "cut off" section of river can filter and process excess nutrients and increase flood storage capacity of the river.

Photo 4-15: Debris and sediment in river from LCC-7 oxbow.

Photo 4-16: Cut-off section of oxbow at LCC7.

LCC 8 – Eroding Bank and Inadequate Buffer

The shoreline along the bank is eroding as can be seen in Photos 4-17 through 4-18. There is an inadequate buffer along most of this area. Recommend (1) stabilizing the bank with stone and bio-stabilization techniques and (2) increasing the unmowed vegetated buffer width where feasible. This section of the shoreline is approximately 50' in length and 6' deep.

Photo 4-17, 4-18, and 4-19: Eroding bank with inadequate buffer along Bantam River at LCC8.

AREA 5: State Boat Launch at Dog Pond

Location:	Town Hill Road, Goshen	**Source Type**:	Boat Launch
Owner:	State of Connecticut	**Priority**:	Medium

Site Description

A state-owned gravel boat launch for with an adjacent gravel parking lot is located on the Dog Pond on the West Branch of the Bantam River in Goshen. Runoff from the parking area either flows down the boat launch or directly into the Pond from the parking area. Although the area surrounding the boat launch and parking lot is vegetated, there is only a grassed buffer strip along the shoreline. Runoff from the road leading to the boat launch flows towards the surrounding vegetated areas. There is a small culvert under the gravel road at the entrance to the boat launch that drains to the surrounding vegetated areas.

Photo 5-1: State Boat Launch on Dog Pond

Photo 5-2: Culvert under gravel road at parking lot entrance.

Photo 5-3: Gravel parking lot at boat launch.

Photo 5-4: Boat launch to Dog Pond.

<u>Proposed Area 5 Improvements</u>

1. Enhance buffer along bottom edge of parking area with a double row of woody plantings (approximately 80' long by 5' wide) (Photo 5-3).

Notes:

1. Pollutant load reduction estimates are not available for this site – there is currently insufficient published data from reputable sources for narrow width vegetated buffers. Given the small upstream drainage area (0.1 acres), it is likely that load reductions would be ranked as "Low" for this site (see Table 5).

2. The upgradient road and parking area is comprised of dirt/gravel and the existing grading will make is challenging to install an effective BMP at this location. An alternative configuration to maximize capture of total phosphorus and other stormwater pollutants would be to: 1) pave the access roadway and parking lots and install new articulated concrete boat ramp. 2) Design grades to direct runoff to the northern edge of parking lot. 3) Install bioretention cell with stabilized overflow / level spreader to discharge to Dog Pond. The BMP would drain an upstream area of approximately 0.30 acres and could capture approximately 0.16 kg (0.35 lbs) of Total Phosphorus per year.

See **Appendix D** for conceptual design details for planting buffer enhancements.

Estimated Costs: $5,200 - $7,800

Estimated Pollutant Load Reduction:

- Total Suspended Solids: N/A ton/yr
- Total Phosphorus: N/A lb/yr
- Total Nitrogen: N/A lb/yr

Anticipated Permits: N/A

AREA 6: Town Hill Road

Location:	Beach Street to Thorncrest Farm	**Source Type**:	Steep Gravel Road
Owner:	Town of Goshen	**Priority**:	Low

Site Description

A town-owned gravel road crosses a small unnamed stream near the intersection of Town Hill Road and Beach Street. The unnamed stream merges with the West Branch of the Bantam River. The road above the stream is relatively steep and shows signs of road shoulder erosion on the west side of the road from Thorncrest Farm to the Beach Street intersection. Thorncrest Farm is an active dairy farm. The road occasionally floods and must be regraded multiple times per year. The Goshen DPW has installed roadside swales on portions of the road.

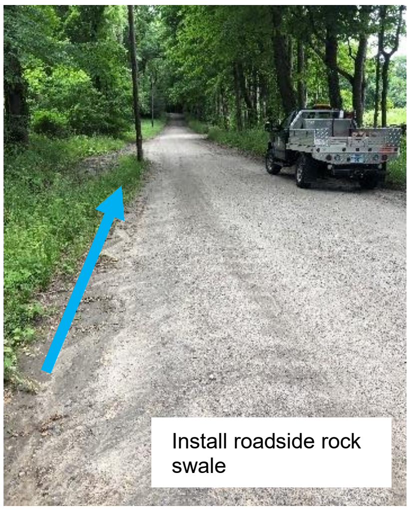

Photo 6-1: Roadside erosion from Town Hill Road.

Photo 6-2: Roadside swale installed by Goshen DPW.

Photo 6-3: Small stream at base of Town Hill Road.

Proposed Area 6 Improvements

1. Maintain and potentially enlarge existing rock swales and install new rock swales along east side of road adjacent to existing agricultural field (appx. 1,000 linear feet). Direct runoff into rock swale via regularly spaced water bars (approx. 100 ft spacing).
2. Install regularly spaced stone check dams within swales (appx. 100 ft spacing) (Photo 6-1). Install water bars at appx. 100' spacing along remaining forested 2,000' of road to unnamed stream with depressed riprap aprons with level spreader at each discharge point to capture and infiltrate runoff and reduce erosion potential.

See Photo 6-4 for an overview of proposed improvements and **Appendix D** for conceptual design details for roadside rock swales, check dams, and water bar diversions.

Estimated Costs: $74,880 - $112,320

Estimated Pollutant Load Reduction:

- Total Suspended Solids: 5.3 ton/yr
- Total Phosphorus: 4.5 lb/yr
- Total Nitrogen: 8.9 lb/yr

Anticipated Permits: Municipal Inland Wetland Permit

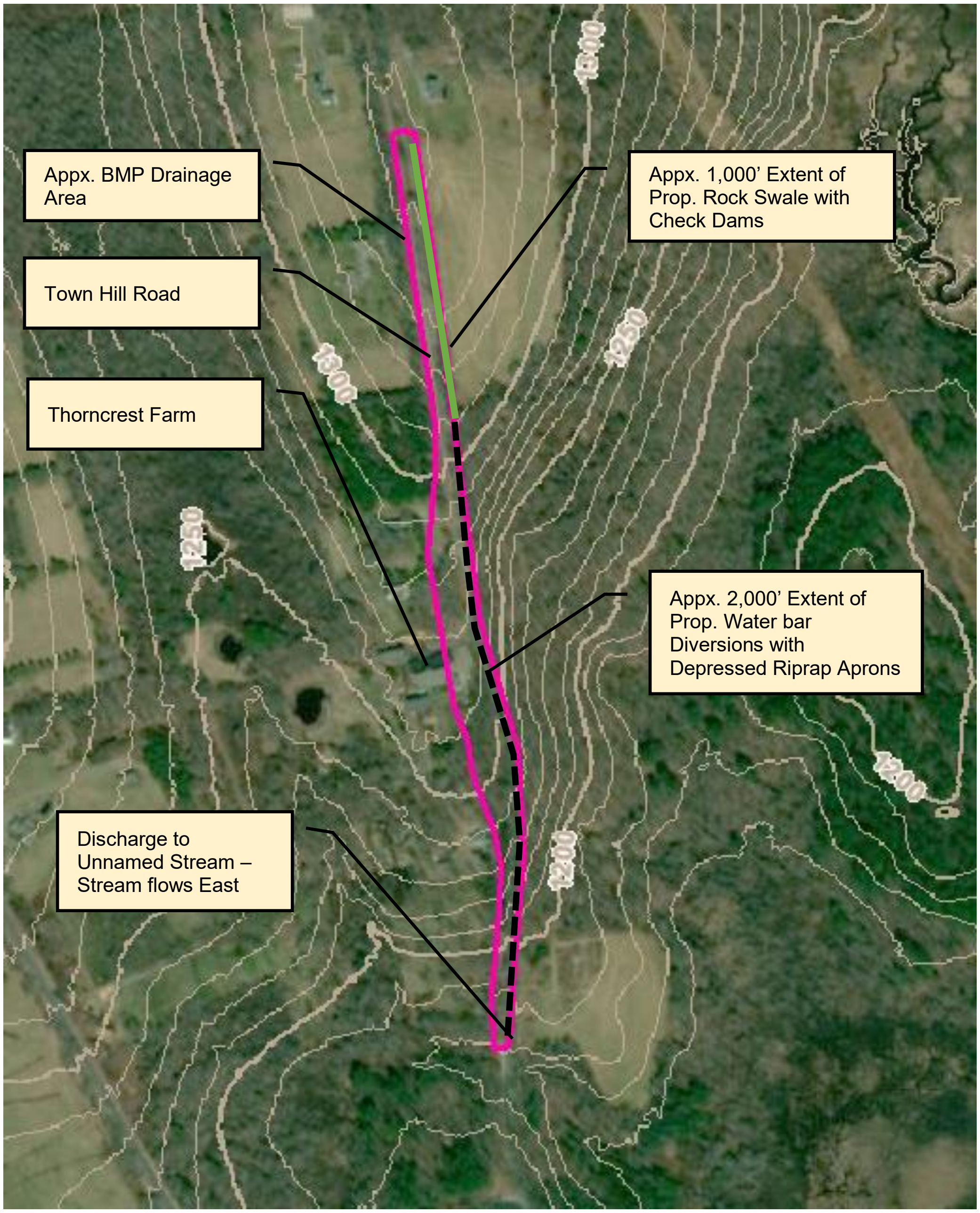

Photo 6-4: Proposed improvements along Town Hill Road.

AREA 7: Litchfield Boat Launch and Town Beach

Location:	1 North Shore Road, Litchfield	**Source Type**:	Boat Launch/Town Beach
Owner:	Town of Litchfield	**Priority**:	Medium

<u>Site Description</u>

The Town of Litchfield Boat Launch and Town Beach is located on North Shore Road in Litchfield. The site has a gravel parking area that drains to a wetland area to the west of the launch. The access roadway to the boat launch is paved and the boat launch was recently replaced with articulated concrete blocks. A sandy town beach is located to the west of the boat launch and is separated from the boat launch by a concrete retaining wall supporting a grass strip and a small grassy area. The Litchfield Rowing Club building is located on the property. Runoff from the road leading to the boat launch and from the sandy beach drain to Bantam Lake.

Photo 7-1: Road leading down to boat launch.

Photo 7-2: Recently replaced boat launch.

Photo 7-3: Sandy beach adjacent to the boat launch.

Photo 7-4: Grass strip and concrete blocks along the road to the boat launch.

Photo 7-5: Vegetated area adjacent to the sandy beach and road to the boat launch.

Proposed Area 7 Improvements

1. Redirect surface runoff from gravel access roadway to the grassy area behind beach (if needed) (Photo 7-5).

2. Install appx. 45' x 20' bioretention cell with curb inlet, underdrain and stabilized riprap spillway to capture runoff from the dirt/gravel road. Install cape cod berms as needed to direct flow into inlet.

See Photo 7-6 for an overview of proposed improvements and **Appendix D** for conceptual design details for a bioretention cell.

Note: The entire length of the appx. 800' long dirt/gravel access road receives runoff from an adjacent hillside to the west. An alternative configuration to maximize capture of phosphorus and other stormwater pollutants would be to: 1) pave the access roadway and adjacent parking lots, 2) install a roadside rock swale or gravel infiltration trench to collect runoff from the adjacent hillside and paved roadway, 3) install a bioretention cell downstream of the swale with a stabilized overflow / level spreader to the adjacent wetland.

Estimated Costs:	$35,360 - $53,040
Estimated Pollutant Load Reduction:	
• Total Suspended Solids:	0.09 ton/yr
• Total Phosphorus:	0.6 lb/yr
• Total Nitrogen:	4.3 lb/yr
Anticipated Permits:	Municipal Inland Wetland Permit

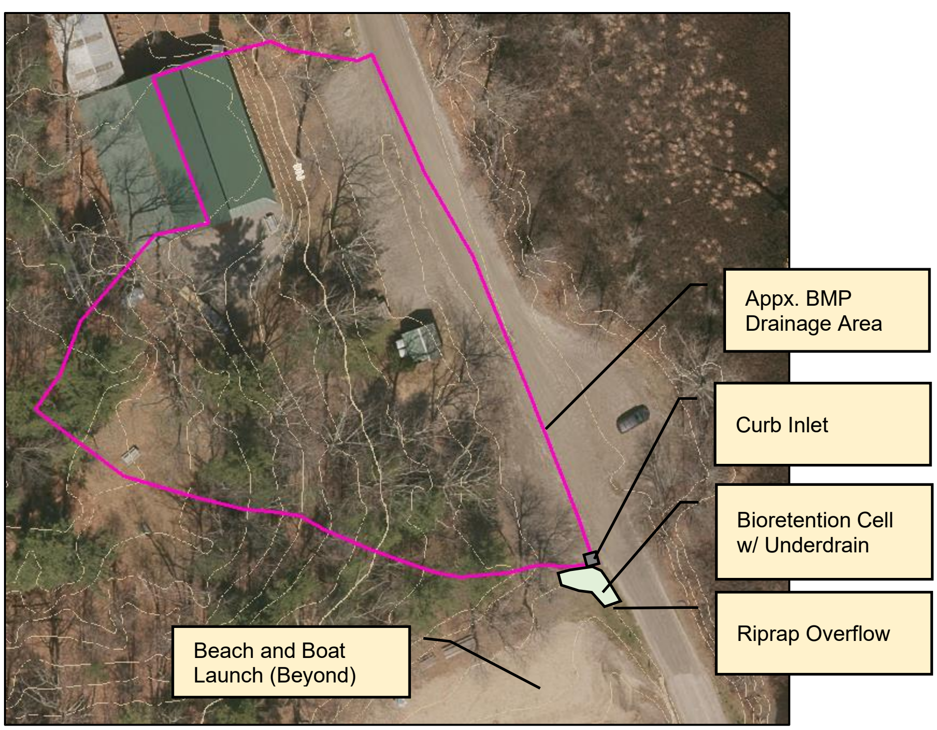

Photo 7-6: Proposed Improvements at Litchfield Town Beach and Boat Launch.

AREA 8: White Memorial Foundation Boat Launch and Campground Store Parking Lot

Location:	North Shore Road, Litchfield	**Source Type**:	Boat Launch/Parking Lot
Owner:	White Memorial Foundation	**Priority**:	Medium

Site Description

The White Memorial Foundation Boat Launch and parking lot for the campground are located on North Shore Road just west of Point Folly. The campground parking lot is unpaved and drains to catch basins on North Shore Road (Photo 8-2) which discharge across the street directly into Bantam Lake. There is a grass island separating part of the parking lot from North Shore Road. There is a steeply sloped area behind the parking lot with a potential drainage area of approximately 15-acres and an elevation gain of almost 200 feet. Runoff from North Shore Road and/or the steep forested area is causing erosion around the top of the outfall across from the Campground Store. The boat launch is located across the street from the store and is a paved ramp that slopes directly into Bantam Lake. The pavement is broken and cracked. There is a grassy area located to the east of the boat launch.

Proposed Area 8 Improvements

Additional investigations would be required to determine the cause of erosion at the outfall pipe and to propose sustainable remedies. Potential causes may include undersized drainage network on North Shore Road, upstream hillside, or other. The following improvements are recommended in lieu of more detailed study:

1. Stabilize area upgradient of the outfall with stone (approximately 10’ long by 3’ wide) (Photo 8-3)

2. Install an approximately 40’ by 20’ bioretention cell within grassed area at front of Campground Store parking lot. Connect to the downstream catch basin on North Shore Road via overflow riser and underdrain. Direct runoff into the biorientation cell from the parking lot and North Shore Road through a combination of water bars, cape cod berms, and curb inlets (See Photo 8-7).

Depending on the extent of potential flooding from upgradient areas, additional measures may include: 1) upsizing drainage network along North Shore Road and installing hydrodynamic separators to capture sediment and other particulates; 2) installing underground infiltration chamber under Camp Store parking lot and repaving; or 3) replace the lower portion of the boat ramp with an articulated concrete block ramp with a trench drain and re-direct runoff to a hydrodynamic separator.

See Photo 8-7 for an overview of proposed improvements and Appendix D for conceptual design details for a bioretention cell and bank stabilization.

Estimated Costs: $41,600 - $62,400

Estimated Pollutant Load Reduction:

- Total Suspended Solids: 0.09 ton/yr
- Total Phosphorus: 1.1 lb/yr
- Total Nitrogen: 4.8 lb/yr

Anticipated Permits: Municipal Inland Wetland Permit

Photo 8-1: White Memorial Foundation Campground Store.

Photo 8-2: Campground store parking lot with catch basin.

Photo 8-3: Erosion around top of outfall on North Shore Road.

Photo 8-4: White Memorial Boat Launch.

Photo 8-5: White Memorial Boat Launch with vegetated area to the east.

Photo 8-6: White Memorial Boat Launch on North Shore Road.

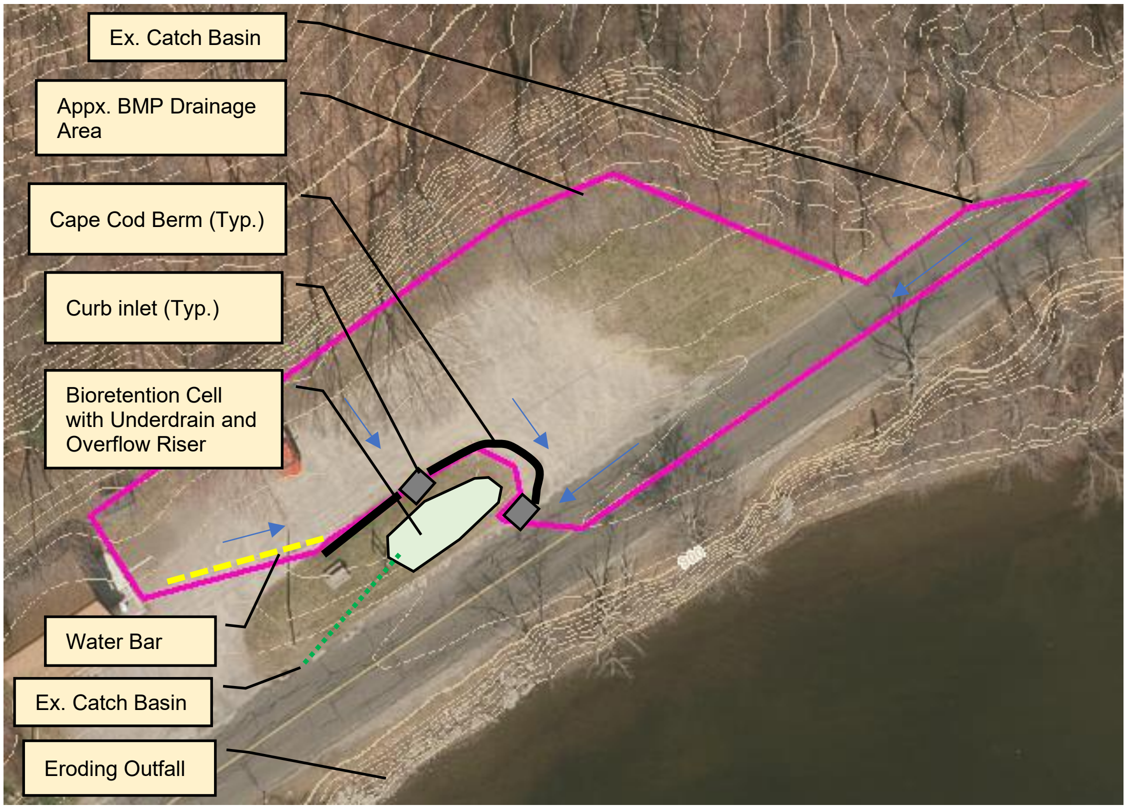

Photo 8-7: Proposed BMP Configuration.

AREA 9: State Boat Launch

Location:	48 Palmer Road, Morris	**Source Type**:	Boat Launch/Parking Lot
Owner:	State of Connecticut	**Priority**:	Low

Site Description

The State Boat Launch and parking lot are located on Route 209 at the intersection with Palmer Road. The parking lot is relatively flat and unpaved and drains as surface runoff down the boat launch into Bantam Lake. There is a narrow grass island in the center of the parking lot separating the parking spaces and grassy areas around the edges of the parking lot including to the east and west sides of the boat launch ramp. The ramp is paved down to the water with obvious cracks in the pavement. Bollards block a section of the paved ramp.

Proposed Area 9 Improvements

1. Install appx. 60’ by 30’ bioretention cell in existing grassed area to east of boat ramp with curb inlet to capture sediment / debris from upgradient gravel parking lot. Install riprap overflow to discharge to Bantam Lake.
2. Reduce paved area to the west of existing boat ramp bollards and replace with vegetation (approximately 17’ wide by 30’ long) (Photo 9-5).
3. Replace paved boat ramp with articulated block ramp (appx. 30’ wide by 30’ long).
4. Install trench drain at the top of boat launch ramp (approximately 46 ‘ wide) and direct flow to east of ramp to bioretention cell.
5. Install asphalt cape cod berms around edge of existing gravel parking lot pavement to direct runoff to boat ramp trench drain and bioretention cell.

See Photo 9-1 for an overview of proposed improvements and **Appendix D** for conceptual design details for a bioretention cell.

Note: One alternative to this approach is to pave the entire parking area and install subsurface drainage structures to direct all runoff to a centralized BMP(s). This approach would be more costly, but would potentially capture and treat phosphorus from the entire parking area and portions of Palmer Road.

Estimated Costs:	$78,000 - $117,000
Estimated Pollutant Load Reduction:	
• Total Suspended Solids:	0.2 ton/yr
• Total Phosphorus:	1.4 lb/yr
• Total Nitrogen:	8.4 lb/yr
Anticipated Permits:	Municipal Inland Wetland Permit; 401 Water Quality Certification

Photo 9-1: State Boat Launch and parking area at Route 209 and Palmer Road. Proposed BMP Configuration.

Photo 9-2: State Boat Launch parking area.

Photo 9-3: State Boat Launch.

Photo 9-4: State Boat Launch parking area.

Photo 9-5, 9-6, 9-7: State Boat Launch

AREA 10: Deer Island Boat Launch

Location: 1 Pioneer Lane, Morris	**Source Type**: Boat Launch
Owner: Private	**Priority**: Low

Site Description

The Deer Island Boat Launch is located at the end of Pioneer Lane and provides access to Bantam Lake for residents of Deer Island. The paved road down to the launch is very steep with residential properties on each side of the road. The boat launch is an unpaved gravel area at the base of Pioneer Lane. Visible surface erosion is occurring at the launch directly adjacent to Bantam Lake. There is limited space on either side of the boat launch, however, a metal bollard blocks the western edge of the boat launch from cars.

Photo 10-1: Pioneer Lane down to the Deer Island Boat Launch.

Photo 10-2 and 10-3: Erosion at boat launch to Bantam Lake.

Proposed Area 10 Improvements

1. Install two (2) Tree Box Filters along either side of the side of road, upstream of the boat ramp (Photo 10-1).
2. Replace gravel boat ramp with an articulated concrete block ramp (20' long and 12' wide).
3. Install trench drain at the top of boat launch ramp to capture bypass / overflow from upstream Tree Box Filters. Direct discharge from trench train to a concrete level spreader which discharges to a riprap energy dissipation pad.

See Photo 10-4 for an overview of proposed improvements and **Appendix D** for conceptual design details for tree box filters.

Estimated Costs: $52,000 - $78,000

Estimated Pollutant Load Reduction:

- Total Suspended Solids: 0.1 ton/yr
- Total Phosphorus: 0.4 lb/yr
- Total Nitrogen: 3.0 lb/yr

Anticipated Permits: Municipal Inland Wetland Permit; 401 Water Quality Certification

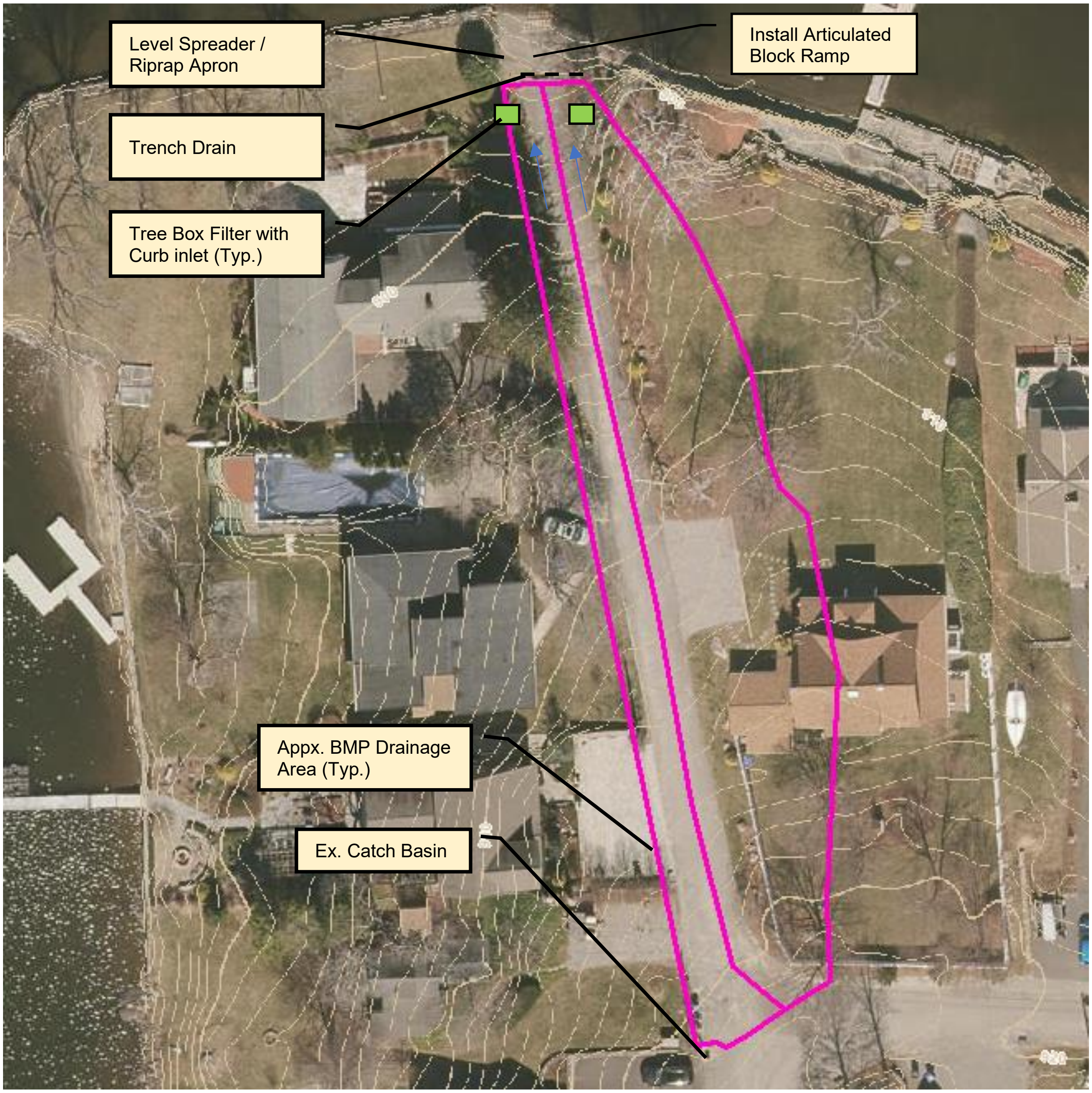

Photo 10-4: Proposed improvements along Deer Island Boat Launch.

AREA 11: Morris Town Beach

Location:	East Shore Drive, Morris	**Source Type**:	Town Beach/Parking Lot
Owner:	Town of Morris	**Priority**:	Low

Site Description

The Morris Town Beach is located off East Shore Road on the southeastern shore of Bantam Lake. Whittlesey Brook flows into Bantam Lake just northeast of the beach. A large gravel parking lot (250' long by 150' wide) is located on the property and has a catch basin that drains the western portion of the parking lot and other upstream areas. Drainage from the catch basin discharges to a vegetated area near the beach. The remainder of the parking lot flows towards the beach as surface runoff. A small, sandy beach is located along the shoreline and has volleyball court. The rest of the property is vegetated with grassy areas. A recreation area is also located on the property and has a horseshoe area, baseball and soccer fields.

Proposed Improvements

1. Install appx. 60' x 30' bioretention cell with curb inlet, underdrain and stabilized riprap overflow to capture runoff from existing gravel parking lot. Direct runoff to bioretention cell via cape cod berms and/or swales.
2. Install protective wooden fence in front of bioretention cell (appx. 50' long)

See Photo 11-6 for an overview of proposed improvements and **Appendix D** for conceptual design details for a bioretention cell.

Note: One alternative is to expand this approach is to install an additional infiltration BMP at the outlet of the existing catch basin to capture runoff from the area upgradient of the parking area. The additional BMP would likely capture a similar amount of total phosphorus as the proposed BMP for a similar cost.

Estimated Costs: $66,560 - $99,840

Estimated Pollutant Load Reduction:

- Total Suspended Solids: 0.2 ton/yr
- Total Phosphorus: 1.3 lb/yr
- Total Nitrogen: 9.5 lb/yr

Anticipated Permits: Municipal Inland Wetland Permit

Photo 11-1: Morris Town Beach and recreation area on East Shore Road. Whittlesey Brook flows into Bantam Lake just northeast of the beach site.

Photo 11-2: Morris Town Beach; gravel parking area.

Photo 11-3: Sandy beach at Morris Town Beach.

Photo 11-4: Morris Town Beach recreation area. Catch basin for parking lot is shown.

Photo 11-5: Grassy area off of parking lot and volleyball court.

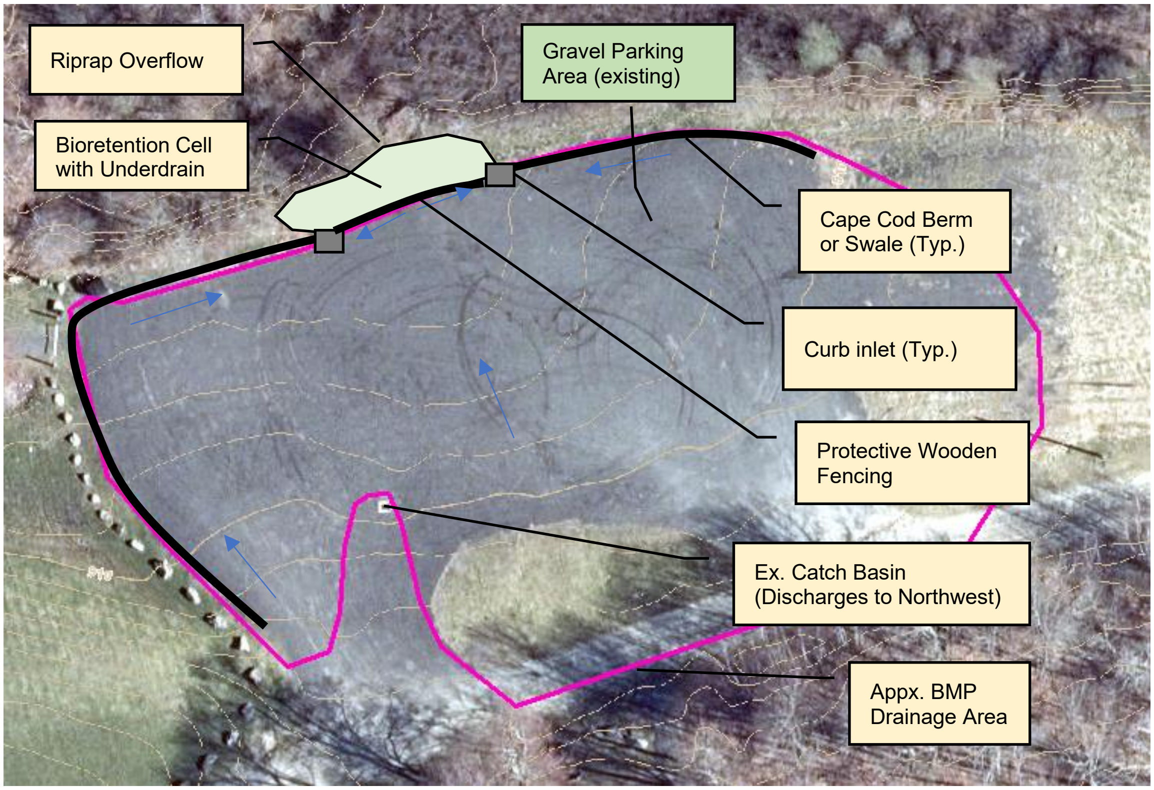

Photo 11-6: Proposed BMP configuration for gravel-surfaced parking area.

AREA 12: Morris Boat Launch

Location:	East Shore Road, Morris	**Source Type**:	Boat Launch
Owner:	Town of Morris	**PRIORITY**:	Low

Site Description

The Morris Boat Launch is located off of East Shore Road and provides access to Bantam Lake for residents of Morris. The gravel road to the boat launch is relatively flat and is approximately 600 feet in length. The road is surrounded by wetlands and a small stream to the north. The first 300 feet of road drains to the surrounding wetland areas. Surface runoff from the remaining length of the road flows down the boat launch and discharges to Bantam Lake. The area near the boat launch is paved and has a small paved parking area. The boat launch is 8 feet long by 20 feet wide and is made of concrete articulated blocks.

Photo 12-1: Gravel road to Morris Boat Launch

Photos 12-2 and 12-3: Morris Boat Launch to Bantam Lake and small parking area.

Proposed Improvements

1. Install appx. 15' x 20' bioretention cell on either side of parking lot with curb inlet and riprap overflow (two total).
2. Install treebox filter with curb inlet adjacent to boat launch.
3. Install cape cod berms to re-direct runoff to each proposed feature.

See Photo 12-4 for an overview of proposed improvements and **Appendix D** for conceptual design details for a bioretention cell and tree box filters.

Estimated Costs: $44,720 - $67,080

Estimated Pollutant Load Reduction:

- Total Suspended Solids: 0.1 ton/yr
- Total Phosphorus: 0.5 lb/yr
- Total Nitrogen: 3.8 lb/yr

Anticipated Permits: Municipal Inland Wetland Permit

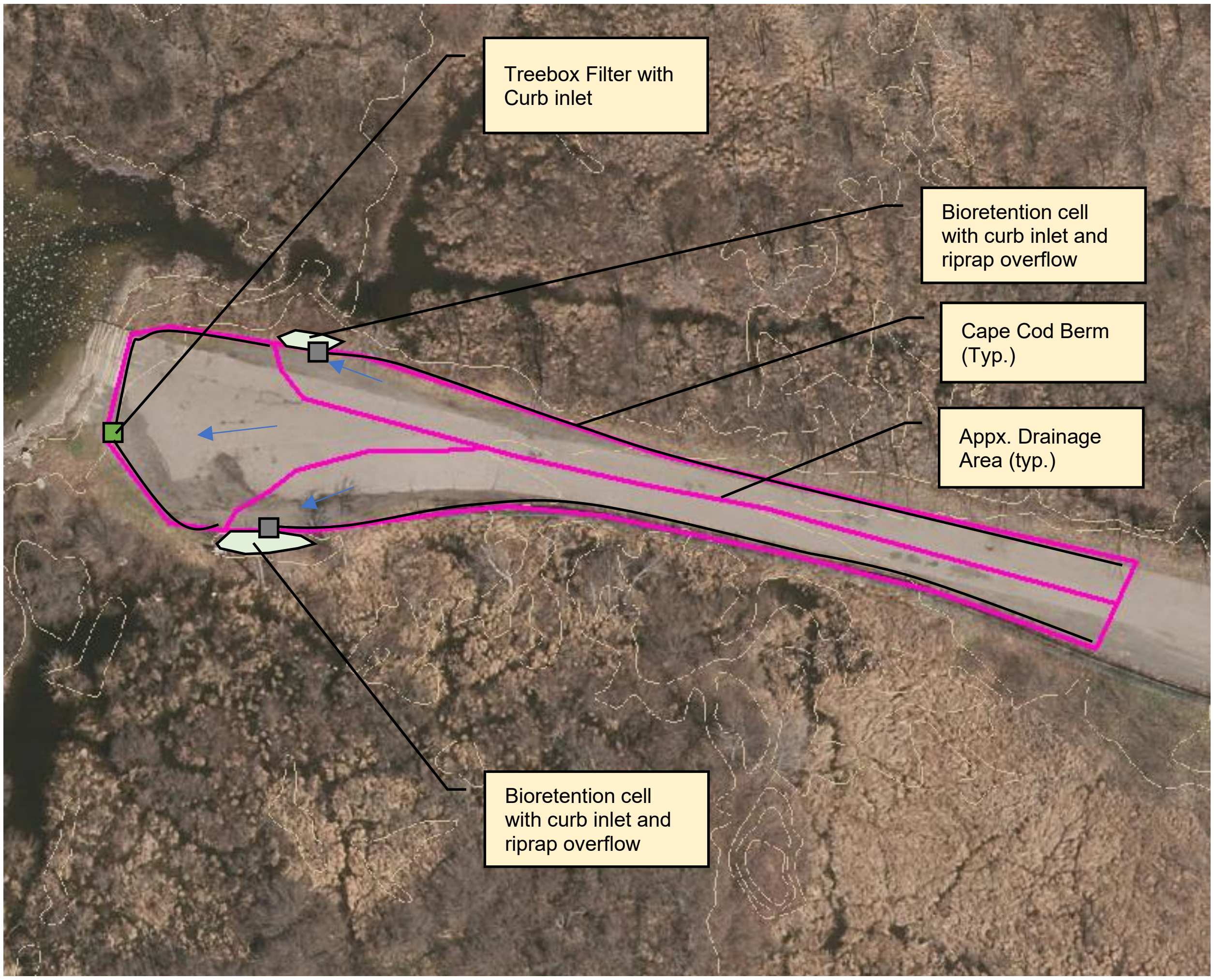

Photo 12-4: Proposed improvements along Morris Boat Launch.

AREA 13: Sandy Beach

Location:	East Shore Drive, Morris	**Source Type**:	Town Beach
Owner:	Towns of Morris and Litchfield	**PRIORITY**:	Low

Site Description

Sandy Beach is located off of East Shore Road on the eastern shore of Bantam Lake. A small stream flows into Bantam Lake at the center of the beach under an access road through multiple pipes. A large grassy parking lot (200' long by 130' wide) is located on the property and surface runoff from the parking lot and paved entrance road flows to the vegetated areas to the south and east. Once at the site, the access road is unpaved. A sandy beach is located along the shoreline. A large erosion gully at the outlet of the pipes has formed and drains directly to Bantam Lake.

Proposed Improvement

1. Install appx. six (6) runoff diversion water bars at approximate 100-ft intervals along entire length of access road. Install depressed riprap aprons with level spreader at each discharge point to capture and infiltrate runoff and reduce erosion potential (Photo 13-4).

Note that the existing erosion gully at the outlet of the pipes drains a large upstream area of approximately 102 acres. More detailed study and hydrologic and hydraulic modeling would be required to determine potential solutions to minimize runoff and pipe discharge. Potential solutions may include installation of large scale upgradient constructed wetlands, pipe upsizing, and stabilization techniques.

See Photo 13-5 for an overview of proposed improvements and **Appendix D** for conceptual design details for water bar diversions.

Estimated Costs: $26,000 - $39,000

Estimated Pollutant Load Reduction:

- Total Suspended Solids: 0.1 ton/yr
- Total Phosphorus: 0.3 lb/yr
- Total Nitrogen: 2.1 lb/yr

Anticipated Permits: Municipal Inland Wetland Permit

Photo 13-1: Access road to Sandy Beach.

Photo 13-2: Sandy Beach with perched outlet pipes discharging to the lake via an eroded gully.

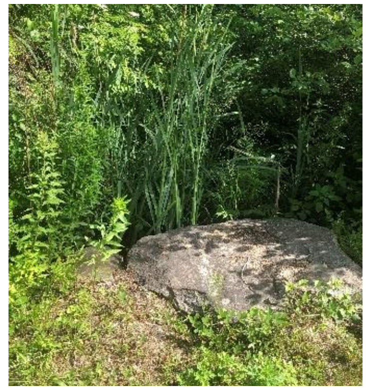

Photo 13-3: Upstream inlet of stream to Sandy Beach.

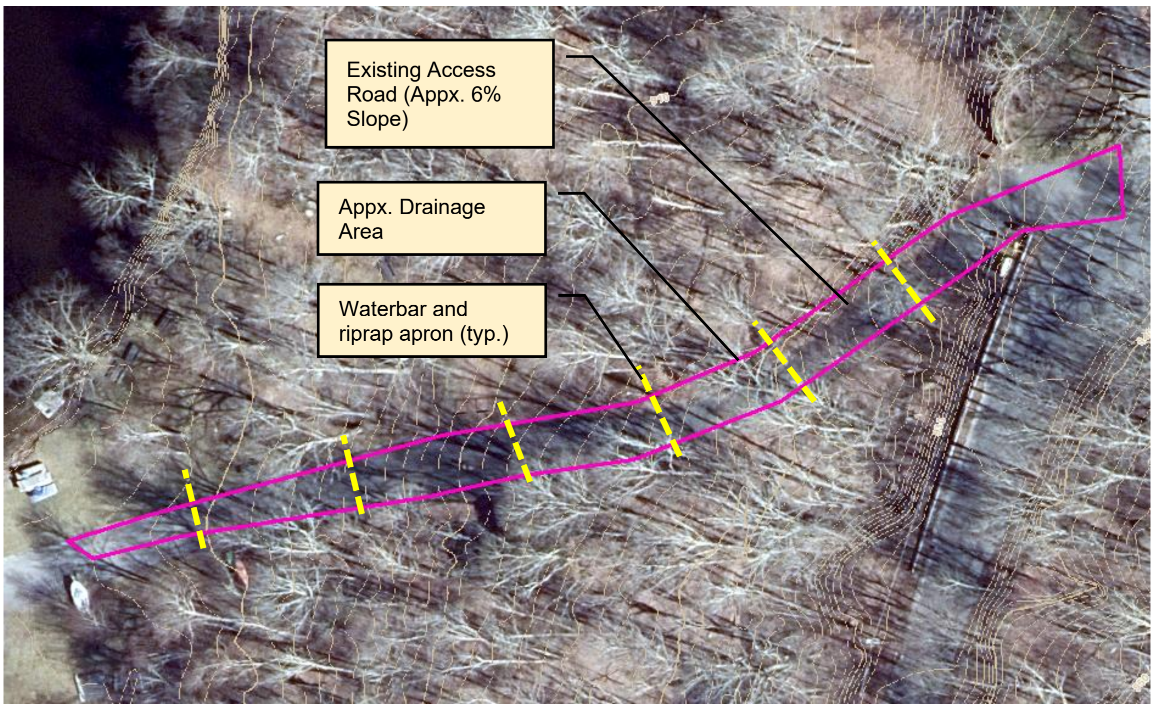

Photo 13-4: Proposed Improvements at Sandy Beach

Neighborhood Sites

Some areas of the watershed were identified as neighborhoods with increased potential for stormwater runoff and subsequent impacts to the water quality of Bantam Lake. These neighborhoods were identified by their proximity to the lake and density of housing and include portions of North Shore Road, the neighborhood off of Route 209 to include Brunetto Grove, and Deer Island (Figure 4). All of these neighborhoods rely on septic systems. A description of these neighborhoods and potential neighborhood programs that could be implemented in these areas are described in Neighborhood sections below.

<u>Proposed Improvements</u>

1. **Provide educational materials to** homeowners about stormwater runoff, lawn/landscaping fertilizer management, and septic system maintenance, with a focus on potential impacts to water quality.
2. **Develop a neighborhood rain garden program** to infiltrate stormwater and reduce direct surface runoff discharged to the lake.
3. Encourage homeowners to **enhance buffers along the lake shore.**

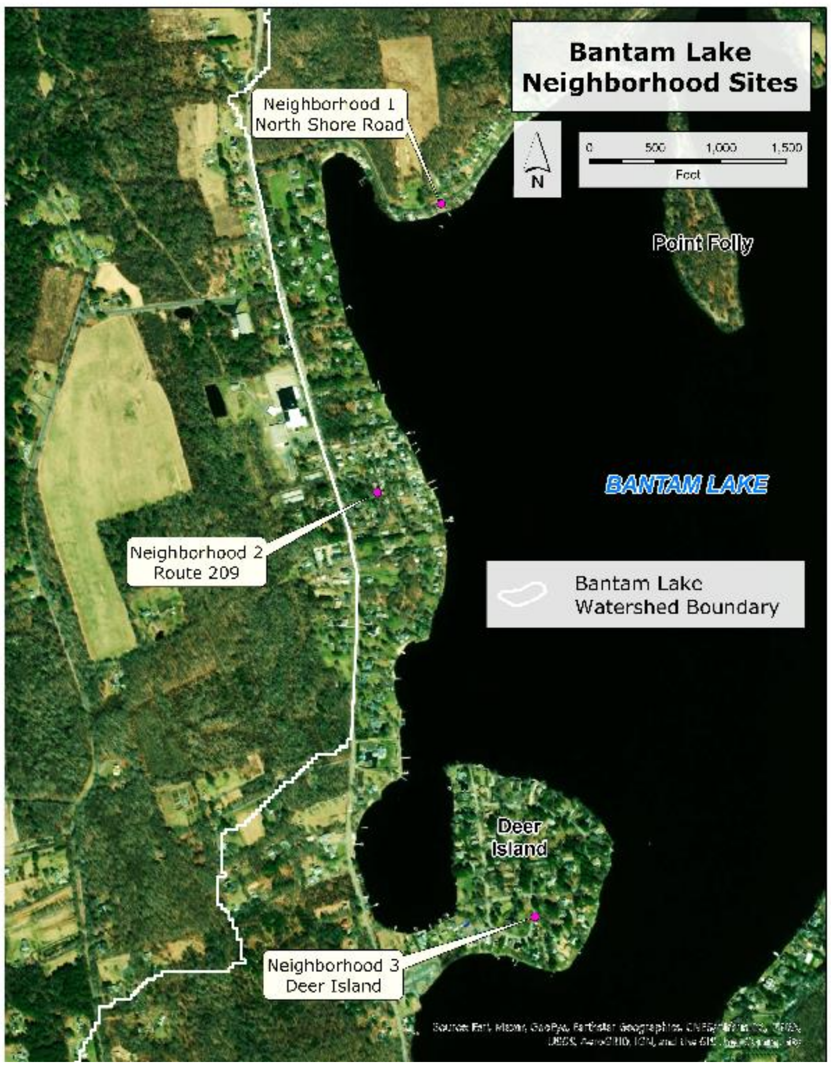

Figure 4. Location of Bantam Lake Neighborhood Sites

NEIGHBORHOOD 1: North Shore Road	
Location: North Shore Road, Litchfield	**Source Type**: Paved town road
Owner: Town of Litchfield	**PRIORITY**: LOW

Site Description

North Shore Road from the White Memorial Boat Launch to Keeler Cove (Photo N1-3) is a residential street with multiple homes located on both the northside of the road and along the northern shore of Bantam Lake. This paved road is sloped away from the lake. However, catch basins on the northside of the road are located approximately 200 feet apart and discharge directly to the lake.

Photos N1, N1-2, and N1-3: North Shore Road along Bantam Lake.

NEIGHBORHOOD 2: Route 209	
Location: Off of Route 209, Morris	**Source Type**: Paved/unpaved town roads
Owner: Town of Morris	**PRIORITY**: LOW

Site Description

The neighborhood off of Route 209 just south of the i2 Systems building on the western shore of Bantam Lake is densely populated with roads that are sloped towards the lake. Many of these roads are in poor condition with obvious shoulder and road erosion. This neighborhood includes Oak Drive, Willow Road, Brunetto Grove, and Heron Pointe Road.

Photo N2-1: Neighborhood off of Route 209

NEIGHBORHOOD 3: Deer Island

Location: Deer Island, Morris	**Source Type**: Lake access
Owner: Private	**PRIORITY**: LOW

Site Description

Deer Island is a neighborhood located on a peninsula in the western portion of Bantam Lake. Many of the access points to the lake, called “Passways,” are open to residents of Deer Island and are grassy or gravel areas that slope steeply towards the lake. The roads in the neighborhood are paved with catch basins collecting stormwater runoff and discharging them to outfalls along the shoreline.



Photos N3-1, N3-2, and N3-3: Deer Island “Passways”

Commercial Sites

Surface runoff from commercial properties in Litchfield along Route 202 between Constitution Way and Russel Street (Figure 5) flow south through vegetated wetlands to Little Pond. During the kickoff meeting, representatives from CTDEEP Fisheries noted that Little Pond has shown increased levels of conductivity in recent years and that stormwater runoff from the commercial areas on Route 202 may be contributing to this increase.   From its outlet, Little Pond discharges to the south to Bantam Lake via the Bantam River. A description of these commercial areas and potential programs that could be implemented to address stormwater runoff from these areas is provided below.

Figure 5. Bantam Lake Commercial Sites

<u>Proposed Improvements</u>

1. Provide educational materials to business owners and developers about stormwater runoff and its potential impacts to water quality, including de-icing alternatives to reduce the use of salt.
2. Install infiltration BMPs in parking lots to encourage flow to infiltrate into the ground before being discharged from the property. Determine if there are any town-owned parcels adjacent to these properties to treat stormwater.

Commercial Area 1: Route 202 between Constitution Way and South Lake Street

Location: Route 202, Litchfield	**Source Type**: Parking lots
Owner: Private	**PRIORITY**: LOW

Site Description

Ocean State Job Lot, the Stop-n-Shop Plaza, and other commercial properties along Route 202 have large parking lots that discharge to the south towards Little Pond.

Photo C1-1: Back parking lot of Ocean State Job Lot

Photo C1-2: Stop-n-Shop Plaza, adjacent to parking lot

Commercial Area 2: Russel Street

Location: Russel Street, Litchfield	**Source Type**: Paved roads
Owner: Town of Litchfield	**PRIORITY**: LOW

Site Description

Russel Street runs parallel to Tannery Brook, a tributary to Little Pond. The street has both commercial and residential properties and the Litchfield Department of Public Works yard is located at the end of the street.


Photo C2-1: Russel Street off of Route 202.


Photo C2-2: Tannery Brook


Photo C2-3: End of Russel Street at the entrance to the DPW yard.

Table 7. Structural BMP Scoring and Prioritization Summary

Site No.	Site ID	Location	Existing Issues	Proposed Improvements	Est. Load Reduction			Capital Cost Range		Ranking Factors / Scoring						PRIORITY
					TSS (ton/yr)	TP (lb/yr)	TN (lb/yr)	Low	High	TP Removal	Capital Cost	Water Proximity	Complexity to Implement	Visibility/ Outreach	Score	
1	Area 1	White Mountain Cons. Ctr. & Culverts	Culverts throughout the watershed lead to flooding, scour, and bank erosion.	Perform watershed-wide culvert assessment to identify potential culvert issues that contribute to nutrient loading and flooding.	-	-	-	$60,000	$90,000	L	L	M	H	L	50	L
2	Area 2	Whitehall Road Trail Network	Severe bank erosion caused by unoffical canoe and kayak boat launch.	Regrade; then stabilize, armor, and vegetate appx. 20' x 15' steep slope. Provide improved public access (i.e., steps).	4.70	4.0	8.00	$26,000	$39,000	H	M	M	M	H	70	M
3	Area 3	Bantam River Boat Launch (Mattatuck Trail)	Eroding gravel boat launch.	Stabilize gravel boat launch with add'l stone. Redirect flow from upstream parking area to vegetated area to west of the site via water bar / earthen berm with riprap outlet.	0.80	0.8	1.50	$11,440	$17,160	M	H	M	H	H	80	H
4	Area 4, LCC 1	Litchfield Country Club	Erosion of Bantam River Bank; inadequate vegetated buffer	Stabilize appx. 20' by 8' eroded bank with bio-stabilizaton techniques. Expand width of "no-mow" buffer as feasible.	0.60	0.6	1.20	$5,200	$7,800	M	H	M	H	L	70	M
5	Area 4, LCC 2	Litchfield Country Club	Inadequate vegetated buffer; Geese congregation.	Expand buffer width along appx. 100' length of streambank as feasible to reduce amount of geese droppings that enter Bantam River.	-	2.0	9.50	$10,400	$15,600	H	H	M	H	L	80	H
6	Area 4, LCC 3	Litchfield Country Club	Exposed topsoil stockpiles directly adjacent to Bantam River.	Cover stockpile and surround with perimeter controls when not in use. Relocate stockpiles to adjacent side of access road.	0.51	0.5	1.00	$0	$0	L	H	M	H	L	65	M
7	Area 4, LCC 4	Litchfield Country Club	Inadequate vegetated buffer and steep upstream slopes for appx. 100' long section.	Expand "no-mow" buffer width along appx. 100' length of streambank as feasible to reduce fertilizer loading from upstream fairway.	-	2.3	2.30	$0	$0	H	H	M	H	L	80	H
8	Area 4, LCC 5	Litchfield Country Club	Erosion of appx. 100' section of Bantam River Bank	Stabilize eroding bank (appx. 100' by 5') using combination of bio-stabilization and armoring techniques.	1.90	1.9	3.80	$8,320	$12,480	H	H	M	H	L	80	H
9	Area 4, LCC 6	Litchfield Country Club	Erosion of appx. 200' section of Bantam River Bank.	Stabilize eroding bank (appx. 200' by 6') using combination of bio-stabilization and armoring techniques. Expand "no mow" buffer as feasible.	4.60	4.6	9.20	$28,080	$42,120	H	M	M	M	L	60	L
10	Area 4, LCC 7	Litchfield Country Club	Oxbow formation	Allow oxbow formation to proceed naturally.	-	-	-	$0	$0	L	H	M	H	L	65	M
11	Area 4, LCC 8	Litchfield Country Club	Erosion of appx. 50' section of Bantam River Bank.	Stabilize eroding bank (appx. 50' by 6') using combination of bio-stabilization and armoring) techniques. Expand "no mow" buffer as feasible.	3.40	3.4	6.90	$12,480	$18,720	H	H	M	M	L	70	M
12	Area 5	Dog Pond Boat Launch	Untreated runoff from gravel parking lot to Dog Pond.	Enhance buffer along bottom edge of parking area with double row of plantings (appx. 80' x 5').	-	-	-	$5,200	$7,800	L	H	M	H	L	65	M
13	Area 6	Town Hill Road (Goshen)	Steep 3,500 linear foot gravel road with shoulder erosion that discharges into an unnamed stream.	Install rock swales with check dams along east side of road for appx. 1,000'. Install waterbar diversions that discharge to depressed riprap aprons along remaining forested 2,000' of road to unnamed stream.	5.30	4.5	8.90	$74,880	$112,320	H	L	M	L	L	50	L
14	Area 7	Litchfield Boat Launch	Discharge of untreated runoff from road into Bantam Lake.	Install approx. 45' x 20' bioretention cell with curb inlet, underdrain and stabilized riprap spillway to capture runoff from the dirt/gravel road.	0.09	0.6	4.30	$35,360	$53,040	M	M	H	L	H	65	M
15	Area 8	White Memorial Foundation Campground Store	Downstream outfall erosion, untreated runoff to Bantam Lake.	Stabilize gully erosion at outfall with stone (appx. 10' x 3' area). Install appx. 40' x 20' bioretention cell within grassed area at front of Campground Store parking lot. Connect to existing catchbasin via overflow riser and underdrain.	0.09	1.1	4.80	$41,600	$62,400	M	M	H	L	H	65	M
16	Area 9	State Boat Launch (Morris)	Discharge of untreated runoff from gravel/dirt parking lot into Bantam Lake.	Replace existing boat launch with articulated concrete blocks with trench drain on top. Install appx. 60' x 30' bioretention cell with deep sump curb inlet inlets, underdrain, and stabilized riprap overflow.	0.17	1.4	8.40	$78,000	$117,000	M	L	H	L	H	60	L
17	Area 10	Deer Island Boat Launch (Morris)	Gully erosion at gravel boat launch from steep upgradient paved road.	Install two (2) Tree Box Filters on either side of road. Install 20' x 12' articulated concrete block boat ramp with trench drain that discharges to level spreader / riprap apron.	0.06	0.4	3.00	$52,000	$78,000	L	L	H	L	M	50	L
18	Area 11	Morris Town Beach	Untreated runoff from gravel parking area to wetland upgradient of Bantam Lake.	Install appx. 60' x 30' bioretention cell with curb inlet, underdrain and stabilized riprap overflow to capture runoff from existing gravel parking lot. Direct runoff to bioretention cell via cape cod berms and/or swales.	0.20	1.3	9.50	$66,560	$99,840	M	L	H	L	H	60	L
19	Area 12	Morris Boat Launch	Discharge of untreated runoff from gravel/dirt road into Bantam Lake.	Install two (2) bioretention cells on either side of road with curb inlets and riprap overflow, one (1) tree box filter adjacent to boat launch, and cape cod berms to direct runoff to proposed features.	0.08	0.5	3.78	$44,720	$67,080	L	M	H	M	M	60	L
20	Area 13	Sandy Beach (Morris)	Discharge of untreated runoff to Bantam Lake from access road & gully erosion from two pipes that discharge to beach.	Install runoff diversion water bars at appx. 100-ft intervals along access road with depressed riprap aprons / level spreader at each discharge point.	0.06	0.3	2.08	$26,000	$39,000	L	M	H	M	L	55	L
				Totals	**22.6**	**30.1**	**88.2**	**$586,240**	**$879,379**							

Notes:
1. See Table 5 for an explanation of scoring criteria.
2. See Appendix B for supporting calculations.
3. Capital costs include construction cost estimate and engineering design estimate. Engineering design assumed to be 30% of construction costs.
4. If all BMPs in Table 7 are constructed, this would reduce TP by 13.65 kg/yr (30.1 lbs/yr), which is 28.1% of the TMDL target for non-regulated stormwater.

BMP Priority Ranking Factors*

L = Low	M = Medium	H = High

** For cost factors, lower cost = higher priority*

Permitting Considerations for Structural BMPs

The sections below summarize the types of environmental permits and authorizations that are most commonly required for the types of structural BMPs described in Section 2. Other permits may be required for some projects, depending on the type and location of the project.

Overview of Wetland and Watercourse Permitting in Connecticut

In Connecticut, regulation of inland wetlands and watercourses occurs primarily at the municipal level. The Connecticut Inland Wetlands and Watercourses Act (IWWA) established in 1972 defines inland wetlands solely by soil type (poorly drained, very poorly drained, and alluvial/floodplain) and watercourses as very broad categories of inland waterways including lakes, rivers, marshes, swamps, and bogs. In 1989, the Inland Wetlands and Watercourses Act (IWWA) was amended to declare it a public policy of the state to require municipal regulation of such activities. As a result, every municipality has established an inland wetlands agency to implement and enforce the law. The CTDEEP Inland Wetlands Management Section provides training, regulatory, and technical assistance to Connecticut's municipal inland wetlands agencies in the administration of the Connecticut Inland Wetlands and Watercourses Act (section 22a-36 through 45 of the Connecticut General Statutes). Depending on the town, a planning and zoning commission, conservation commission, or other entity may act as the inland wetlands agency responsible for implementing and enforcing Connecticut's IWWA.

If any work is to be conducted in or near inland wetland and watercourses, a description of the proposed project must be submitted for review and approval to the municipal inland wetlands' agency. If work is to be conducted on state land, a permit is required from the CTDEEP. If the work falls into the category of a "regulated activity," a permit is required. Regulated activities are broadly defined by that state to mean, "any operation or use of a wetland or watercourse involving removal or deposition of material, or any obstruction, construction, alteration or pollution, of such wetlands or watercourses." Some activities are considered "nonregulated" and do not require a permit. These activities may involve certain agricultural, residential, water company, maintenance, conservation, and recreational uses of inland wetlands and watercourses.

Municipal Inland Wetland Regulations

The Bantam Lake watershed lies in four municipalities: Goshen, Morris, Litchfield, and Torrington. Each municipality has its own Inland Wetlands and Watercourses Regulations that should be consulted prior to performing any activity within wetlands and/or watercourses or within the regulated area.

- **Town of Litchfield:** Inland Wetlands and Watercourses Regulations originally adopted in 1973; last revised in 2007.

  Regulated activity:

  - Any operation or use of a wetland or watercourse involving removal or deposition of material, or any obstruction, construction, alteration or pollution of, such wetlands or watercourses;
  - Any earth-moving, filling, construction, or clear-cutting of trees or installation of septic systems within one hundred (100) feet, measured horizontally from the boundary of the wetlands or one hundred fifty (150) feet, measured horizontally from the ordinary high water mark of watercourses or within 200 feet of watercourses as defined by a pond or lake with a surface area greater than 5 acres.

  - Since the environmental impact of proposed activity may, in some instances, come from outside the physical boundaries of a wetland or watercourse, the intent of these regulations is to regulate these adjacent areas and thereby implement the statutory authority necessary to effectuate the legislative purpose set forth in the Connecticut General Statutes 22a-36 and regulation means the construction of or alteration of ponds, means any construction to alter or create a wetland, but shall not include the activities specified in Section 4 of these regulations. The agency may rule that any other activity located within such upland area or any other non-wetland or non-watercourse area is likely to impact or affect wetlands or watercourses and is a regulated activity."

- **City of Torrington:** Inland Wetlands and Watercourses Regulations adopted in 1978; last revised in 2007.

  Regulated activity: Operation or use of a wetland or watercourse involving removal or deposition of material, or any obstruction, construction, alteration or pollution, of such wetlands or watercourses, and any earth-moving, filling, construction or clear-cutting of trees within 75 feet of wetlands or 100 feet of watercourses.

- **Town of Goshen:** Inland Wetlands and Watercourses Regulations adopted in 1974; last revised in 2009.

  Regulated activity: Any wetlands or watercourses and land within one hundred (100) feet of wetland and within two hundred (200) feet of a watercourse.

- **Town of Morris:** Inland Wetlands and Watercourses Regulations adopted in 1979; last revised in 2007.

  Regulated activity: Any wetlands or watercourses and land within one hundred (100) feet of wetland and within two hundred (200) feet of a watercourse.

Other Relevant Regulations

401 Water Quality Certification

The federal Clean Water Act requires a 401 Water Quality Certification for certain activities in wetlands and waters. This law gives states the authority to review projects that must obtain federal licenses or permits and that result in a discharge to state waters. The purpose of state 401 review is to ensure that a project will comply with state water quality standards and other appropriate requirements of state law.

In Connecticut, the 401 Water Quality Certification program is administered by the CT DEEP Bureau of Water Protection and Land Reuse - Land and Water Resources Division. If the proposed activity may result in any discharge, including the discharge of dredged and fill material and stormwater during construction, incidental discharge of sediments from dredging or excavating, and any excavation, flooding, draining, and clearing and grading in or affecting the navigable waters, a 401 Water Quality Certificate from CTDEEP must be obtained.

Any activity that results in a discharge of dredged material, dredging, or dredged material disposal greater than 100 cubic yards to waters subject requires a 401 Water Quality Certification for Dredging Activities. If no federal permit is needed for an activity, then a 401 certification is not required from CTDEEP.

3.2 NON-STRUCTURAL BEST MANAGEMENT PRACTICES

Unlike structural BMPs, non-structural BMPs do not involve construction of site-specific infrastructure and generally focus on reducing pollutant loads through the following:

1. **Public Information and Education:** Changing behavior and land use patterns through efforts to inform, educate, and engage the public on issues related to protection of water quality and aquatic habitat.

2. **Land Conservation:** Reducing pollutants at the source through natural systems, such as land conservation and protection of sensitive land areas through purchase, easements, etc. In additional to municipal planning documents (e.g., master plans, conservation plans, open space and recreation plans) regional resources for more information about protected open space in the watershed and potential priority areas for future land conservation efforts can be found at:

    - Litchfield Hills Greenprint Collaborative
    - Housatonic Valley Association – Connecting Forest Corridors

3. **Regulatory Tools:** Changing behavior and land use patterns through regulation (e.g., state laws, municipal ordinances)

4. **Institutional Practices and Programs:** Reducing pollutant loads through improved institutional practices such as enhanced street sweeping, catch basin cleaning, leaf litter pickup programs, etc.

The pollutant load reductions associated with non-structural measures are generally more difficult to estimate than those for structural BMPs, but can play a significant role in reducing NPS pollution in many watersheds. As discussed in Section 2 and Appendix A, non-structural BMPs can in some cases be more cost-effective than structural BMPs with regard to cost per unit of pollutant reduction. Many water quality problems result from the collective impact of individual actions and the solutions are often voluntary practices. Non-structural practices that are community driven (such as public education and engagement efforts which involve private land owners) can promote adoption of management practices and behavior changes (e.g., landscaping practices and reduction in fertilizer use) that help achieve water quality targets.

Strategies for reducing pollutant loads in the Bantam Lake Watershed through non-structural BMPs are discussed in **the CT Statewide Lake Nutrient TMDL Appendix 1: Bantam Lake Watershed (Section 7) and examples of non-structural BMPs are provided in the TMDL Core Document.** Non-structural BMPs recommended for the Bantam Lake watershed are summarized in Table 8.

Table 8. Non-Structural BMP Prioritization Summary

Non-structural BMP Category	BMP Description	Relevant Authorities	How BMP Achieves Pollutant Load Reductions or Other WBP Goals	Pollutant Load Reduction Potential	Anticipated Costs	Feasibility	PRIORITY
Public Information and Education	Develop a Watershed Management Team to coordinate WBPA implementation efforts.	Municipalities, health departments, BLPA, watershed homeowners, watershed stakeholders, CTDEEP	Reduces nutrient loading by improving coordination with agencies that are critical to plan implementation. Improves schedule coordination, BMP prioritization, and implementation logistics.	M	H	H	**High**
	Coordinate with NRCS to develop Comprehensive Nutrient Management Plans for farming activities on agricultural lands.	NRCS, BLPA, agricultural landowners, CTDEEP	Reduces nutrient loading by educating agricultural land owners on the potential water quality effects of their practices.	M	H	H	**High**
	Evaluate local education and outreach programs regarding waterfowl, pet waste, septic systems, fertilizer/pesticide use, and ensuring adequate vegetative buffers and bank protection.	CTDEEP, BLPA, watershed homeowners, consultant	Reduces nutrient loading by educating homeowners and promoting best practices.	L	H	H	**Medium**
	Conduct *Low Impact Development (LID) Techniques for Homeowners* workshop	CTDEEP, BLPA, watershed homeowners, consultant	Prevents increases in pollutant loading associated with land development.	L	H	H	**Medium**
Land Conservation	Coordinate with conservation groups to prioritize land conservation goals/target parcels.	Town planning staff and other local land conservation orgs.	Prevents increases in pollutant loading associated with land development.	H	H	H	**High**
Regulatory Tools	Establish town regulations to enable/promote installation of alternative wastewater treatment systems based on proximity to a waterbody (i.e., 200 meters) for new development, redevelopment and replacement of failed systems.	Municipal Boards of Health and Boards of Selectmen	Reduces nutrient loading from wastewater sources.	**H**	**H**	M	**High**
	Develop landscaping fertilizer ordinances	Municipal Planning Boards and Boards of Selectmen	Reduces nutrient loading from landscaping fertilizer applications.	H	L-M	M	**Medium**
	Develop septic system pumping ordinances requiring homeowners to pump their septic systems every 3-5 years.	Municipal Boards of Health and Boards of Selectmen	Reduces nutrient loading from wastewater sources.	M	L-M	M	**Medium**
Institutional Practices	Increase frequency of catch basin cleaning (2 additional cleanings per year)	Town DPW/Highway Depts., CTDOT	Reduces nutrient load as calculated according to CT Small MS4 General Permit formulas for each practice.	M	L	M	**Medium**
	Develop Enhanced Street/Pavement Cleaning Programs	Town DPW/Highway Depts., CTDOT		M	L-M	M	**Medium**
	Develop Enhanced Organic Waste and Leaf Litter Collection Programs	Town DPW/Highway Depts., CTDOT		M	L-M	M	**Medium**

BMP Priority Ranking Factors*

L = Low	M = Medium	H = High

** For cost factors, lower cost = higher priority*

3.3 Potential Funding Sources

Funding assistance for nutrient pollutant mitigation and other watershed management projects is available from various governmental and private sources. Table 9 provides a summary description of key funding programs, as excerpted from the Connecticut Statewide Lake Nutrient TMDL.

For more information about these funding sources, please see the program links provided or Section 7.1 of the Connecticut Statewide Lake Nutrient TMDL.

Table 9. List of Key Potential Funding Sources

Funding Source	Description /Link
Water Quality Grants	
Section 319 Nonpoint Source Management Grants	Section 319 Grants are available to assist in the implementation of projects to promote restoration of water quality by reducing and managing nonpoint pollution. *Eligible applicants:* Municipalities, other governmental agencies and non-profit organizations, schools, and universities http://www.ct.gov/dep/cwp/view.asp?a=2719&q=325588&depNav_GID=1654
CT DEEP Clean Water Fund (CWF)	The CWF provides funding and loans for projects aimed at water pollution control, sewage treatment plant construction and upgrades, nutrient removal projects, NPS pollution control, river restoration and drinking water treatment plant upgrades. *Eligible applicants:* Municipalities; drinking water projects and private water systems are eligible for reimbursement through the Drinking Water division of the DPH. https://www.ct.gov/deep/cwp/view.asp?a=2719&q=325576&deepNav_GID=1654
USDA Natural Resources Conservation Service (NRCS) Wildlife Habitat Incentive Program (WHIP)	WHIP offers technical assistance and up to 75% cost-share assistance for development and improvement of fish and wildlife habitat on private land. *Eligible applicants*: private landowners https://www.nrcs.usda.gov/wps/portal/nrcs/detail/ct/technical/ecoscience/invasive/?cid=nrcs142p2_011104
CT DEEP Recreation and Natural Heritage Trust Program	This program acquires land to expand the State's system of parks, forests, wildlife, and natural open spaces, with a focus on land representing the ecological and cultural diversity of CT, including rivers, mountains, rare natural communities, scenic qualities, historic significance, connections to other protected land, and access to water. *Eligible applicants*: landowners willing to sell their land now or for a future sale or donation of the property http://www.ct.gov/dep/cwp/view.asp?a=2706&q=323840&depNav_GID=1642
CT DEEP Open Space and Watershed Land Acquisition Grant Program	This program offers funding to towns or organizations for purchase of land for recreation, forestry, fishing, and conservation of wildlife and natural resources. *Eligible applicants:* municipalities, non-profit land conservation orgs., water companies http://www.ct.gov/dep/cwp/view.asp?a=2687&q=322338&depNav_GID=1511
STEAP - Small Town Economic Assistance Program (CGS Section 4-66g)	STEAP provides grants for environmental protection, economic development, community conservation, and quality-of-life capital projects for localities that are ineligible to receive Urban Action (CGS Section 4-66c) bonds. *Eligible applicants:* certain smaller municipalities https://portal.ct.gov/OPM/Bud-Other-Projects/STEAP/STEAP_Home

Infrastructure Grants	
National Recreational Trails Program	The Recreational Trails Program supports construction of new trails, maintenance and restoration of existing trails, disability access to trails, purchase of trail construction equipment, and purchase of land for trails. Trail maintenance can prevent erosion and sedimentation, a major source of nutrient pollution to lakes and tributary streams. *Eligible applicants*: non-profit organizations, municipalities, State departments https://www.ct.gov/deep/cwp/view.asp?a=2707&q=513740&deepNav_GID=1650
NFWF Long Island Sound Futures Fund	The Long Island Sound Futures Fund (LISFF) supports projects that restore and protect the health and living resources of Long Island Sound and its coastal watersheds. Projects focus on habitat restoration, water quality improvement, watershed management plan development and public awareness of water resource issues. LISFF considers funding for upland water quality improvement projects that reduce nutrients to LIS. Funding is provided by EPA, U.S. Fish and Wildlife Service, and the National Fish and Wildlife Foundation (NFWF) http://longislandsoundstudy.net/about/grants/lis-futures-fund/
Drinking Water State Revolving Loan Fund	This loan program provides funds to repair or improve privately-owned drinking water systems. Connecticut's DPH approves loans to obtain permits, design, plan, construct, repair, or improve eligible water systems to comply with federal and State standards. *Eligible applicants*: Privately-owned community water systems and privately-owned non-profit, non-community public water systems. https://portal.ct.gov/DPH/Drinking-Water/DWS/Drinking-Water-State-Revolving-Fund-Program
Connecticut DPH Source Water Assessment and Protection Unit (SWP)	The SWP offers a range of programs and support to protect surface and ground water drinking water supply sources. *Eligible applicants:* Community and non-profit public water systems (PWSs) https://portal.ct.gov/DPH/Drinking-Water/DWS/Source-Water-Assessment-and-Protection
Connecticut Community Development Program Block Grants (aka Small Cities Program)	This program provides grants for assistance projects for low- and moderate-income communities with populations under 50,000. Projects include improvements to water, sewer, and roads serving economic development and housing. *Eligible applicants*: Any CT municipality or incorporated village chartered to function as a general-purpose unit of local government. https://portal.ct.gov/DOH/DOH/Programs/Small-Cities-Program
USDA Rural Utilities Service Water and Environmental Programs (WEP)	The WEP program supports community development projects in communities with populations under 10,000. Eligible projects include public water supply improvements, sanitary sewer, solid waste disposal, new systems, renovations, expansions, purchase of an existing system, or "buy-in" fees to existing systems. *Eligible applicants*: Any public body (town, village, special purpose district) or a non-profit association serving a community with a population of less than 10,000 people. Applicants must also show that they are unable to afford commercial credit. https://www.rd.usda.gov/programs-services/all-programs/water-environmental-programs
Agricultural Grants	
Connecticut Conservation Stewardship Program (USDA-NRCS)	The USDA-NRCS in CT provides funds for landowners with agricultural and forest land to address natural resource conservation and management activities on their properties. *Eligible applicants:* private landowners of agricultural and non-industrial private forest land

Farms, Forest and Open Space Property Tax Benefits	Under Connecticut Public Act 490, all farm, forest, and open space land can apply for a use value assessment that may lower property taxes for the landowner. *Eligible applicants:* landowners with farm, forest, or open space land must apply at their local tax assessor's office. Landowners with designated forest land must have an area totaling 25 acres or more in parcels no smaller than 10 acres. https://www.ct.gov/deep/cwp/view.asp?a=2697&q=322788&deepNav_GID=1631
Department of Agriculture NRCS Environmental Quality Incentives Program (EQIP)	EQIP is a voluntary conservation grant program designed to promote and stimulate innovative approaches to environmental enhancement and protection, while improving agricultural production. Farmers and forestland managers may receive financial and technical help to install or implement structural and management conservation practices on eligible agricultural and forest land. EQIP provides funding to promote ground and surface water conservation activities to improve irrigation systems; to convert to the production of less water intensive agricultural commodities; to improve water storage through measures such as water banking and groundwater recharge; or to institute other measures that improve groundwater and surface water conservation. EQIP payment rates may cover up to 75% of the costs of installing certain conservation practices. *Eligible applicants:* Any person engaged in livestock, agricultural production, aquaculture, or forestry on eligible land. https://www.nrcs.usda.gov/wps/portal/nrcs/detail/ct/programs/financial/eqip/?cid=nrcs142p2_011038
Additional Resources	
U.S. Environmental Protection Agency (EPA)	The EPA recognizes that committed watershed organizations and State and local governments need adequate resources to achieve the goals of the CWA and improve our nation's water quality. To this end, the EPA has created the following website to provide tools, databases, and information about sources of funding to practitioners and funders that serve to protect watersheds: https://www.epa.gov/aboutepa/about-office-water#wetlands
U.S. Department of Agriculture (USDA)	The USDA offers several potential sources of funding for the protection, restoration and stewardship of our water resources, including the USFS Landscape Scale Restoration Grants, the Watershed and Flood Prevention Operations Program, and the Water Resources Program. https://www.fs.usda.gov/naspf/working-with-us/grants/landscape-scale-restoration-grants https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/landscape/wfpo/ https://www.fsa.usda.gov/programs-and-services/environmental-cultural-resource/water-resources/index

4. Next Steps: Schedule and Milestones

Table 10 presents an implementation schedule and milestones for this Watershed Based Plan based on a five-year planning and implementation period from July 2021 through June 2026.

Deer Island Boat Launch

The schedule and milestones are organized according to the following categories:

- Structural Stormwater BMPs
- Non-structural BMPs
  - Public Information and Education
  - Land Conservation
  - Regulatory Tools
  - Institutional Practices
- Monitoring
- Adaptive Management

Table 10. Schedule and Interim Milestones

BMP CATEGORY	TASKS (lead organizations)	Year 1	Year 2	Year 3	Year 4	Year 5	
		2021	2022	2023	2024	2025	2026
Structural Stormwater BMPs	Select priority sites for structural stormwater BMPs described in Section 3.1 (BLPA, CTDEEP)						
	Prepare application for CTDEEP Section 319 NPS Grant applications for final design/construction of priority BMP sites (BLPA, CTDEEP)						
	Prepare priority BMP sites final designs and permitting (pending grant funding) (BLPA, CTDEEP)						
	Construct priority BMP Sites (BLPA, contractor)						
	Prepare grant application for design and construction of additional BMP sites (BLPA, CTDEEP)						
	Obtain grant funding for additional BMP sites/construct BMPs (BLPA, CTDEEP)						
Non-structural BMPs: Public Information and Education	Develop Watershed Management Team (ongoing with WBPA project partners)						
	Coordinate with USDA-NRCS to develop Comprehensive Nutrient Management Plans (USDA-NRCS)						
	Evaluate Local Education and Outreach Programs (BLPA., White Memorial Foundation)						
	Conduct *LID for Homeowners* workshop (BLPA, CEI, Inc.)						
Non-structural BMPs: Land Conservation	Coordinate with conservation groups to prioritize land conservation goals/target parcels (HVA, Litchfield Hills Greenprint Collaborative, local land trusts)						
Non-structural BMPs: Regulatory Tools	Establish town regulations to enable/promote installation of alternative wastewater treatment systems based on proximity to a waterbody (i.e., 200 meters) for new development, redevelopment and replacement of failed systems. (Town Planning Boards)						
	Develop landscaping fertilizer ordinances (Town Planning Boards)						
	Develop septic system pumping ordinances requiring homeowners to pump their septic systems every 3-5 years. (Town Boards of Health)						

Table 10. Schedule and Interim Milestones *(continued)*

BMP CATEGORY	TASKS (lead organizations)	Year 1		Year 2		Year 3		Year 4		Year 5	
		2021	2022		2023		2024		2025		2026
Non-structural BMPs: Institutional Practices	Increase frequency of catch basin cleaning (Town DPWs, Highway Depts.)										
	Develop and Implement Enhanced Street/Pavement Cleaning Programs (Town DPWs, Highway Depts.)										
	Develop and Implement Enhanced Organic Waste and Leaf Litter Collection Programs (Town DPWs, Highway Depts.)										
Monitoring	Conduct annual watershed-scale monitoring (BLPA, White Memorial Foundation)										
Adaptive Management	Review progress towards meeting WRMP water quality targets and project-specific goals and update as needed (CTDEEP and local project partners)										

Note Regarding Schedule and Interim Milestones:

For Bantam Lake, the TP reduction target for non-regulated stormwater is 48.6 kg/year (107 lbs/year). If all of the structural BMPs listed in Table 7 are constructed, this would reduce TP by 13.7 kg/yr (30.1 lbs/yr), which is 28% of the target for non-regulated stormwater. This WBPA sets an interim, measurable milestone of constructing 50% of the Table 7 BMPs to achieve 50% of the associated TP reductions (approximately 6.8 kg/year or 15 lbs/year) by the end of 2026. If this goal has not been met, interim targets should be re-assessed as discussed in Section 5.3 (Adaptive Management).

5. Evaluation Criteria and Monitoring

5.1 EVALUATION CRITERIA

Evaluation criteria for the Bantam Lake Watershed include the categories presented below.

- **Water Quality Targets:** ***For a detailed description of the Water Quality Targets for Bantam Lake, refer to the CT Statewide Lake Nutrient TMDL Appendix 1: Bantam Lake Watershed (Section 4.0).*** These targets are summarized in Table 2 of this plan.
- **TMDL Performance Criteria:** ***For a detailed description of TMDL Performance Criteria for Bantam Lake, refer to the CT Statewide Lake Nutrient TMDL Appendix 1: Bantam Lake Watershed (Section 6).***
- **Project-Specific Criteria**: Project-specific performance indicators may be used as criteria for activities recommended in this WBPA. These project-specific indicators are generally intended to quantify an activity and, whenever possible, explain how that activity achieves load reductions for targeted pollutants or other co-benefits (e.g., improved aquatic habitat, reduced flooding, etc.). In cases where it is not possible to quantify a pollutant load reduction, the project-specific indicator states the target pollutant(s) expected to be reduced as a result of the activity. For instance, project-specific indicators for the Bantam Lake WBPA may include:
  - Number of structural BMPs implemented;
  - Annual nutrient load reduced from BMP implementation;
  - Meetings of the Watershed Management Team to coordinate implementation efforts;
  - Number of watershed residents who attended workshops focused on reducing nutrient loading (e.g., *LID Techniques for Homeowners* workshop);
  - Acres of land acquired or preserved through conservation efforts;
  - Number of septic systems pumped annually; and
  - Miles of streets swept annually.

5.2 MONITORING

Continued watershed-scale water quality monitoring is recommended to address Element I requirements and help document the extent that implementation efforts are succeeding.

> *For a detailed description of Monitoring Recommendations for Bantam Lake, refer to the CT Statewide Lake Nutrient TMDL Appendix 1: Bantam Lake Watershed (Section 8.2).*

Morris Town Beach

5.3 ADAPTIVE MANAGEMENT

If, after five years of WBPA management measure implementation, the direct measurements and indirect indicators do not show progress towards meeting the water quality targets established in this WBPA, management measures and water quality targets should be revisited and modified accordingly. If progress towards meeting water quality targets is not being met despite efforts to implement the watershed-based structural and non-structural management measures described in this WBPA, adaptive management efforts should include evaluation of options to reduce pollutant loads from on-site septic systems and the lake's seasonal internal load. As presented in Table 2, septic systems are estimated to contribute a very small fraction of the overall phosphorus loading to Bantam Lake (9.7 kg/yr, which is 0.6% of the total estimated TP load to the lake). Internal loading is estimated to contribute a much larger fraction of the lake's phosphorus load (560 kg/yr, 34.7 % of the lake's total estimated TP load). Control of this internal load (e.g., through phosphorus inactivation measures such as application of alum or modified zeolite) may be an important component of an integrated phosphorus management approach once watershed phosphorus sources have been reduced.

APPENDIX A:

Pollutant Load Reduction Optimization Analysis for the Bantam Lake Watershed

Appendix A:
Pollutant Load Reduction Optimization Analysis
for the Bantam Lake Watershed

1. INTRODUCTION

A desktop-based optimization analysis was performed to evaluate and identify the best mixture of nonpoint source (NPS) best management practices (BMPs) that could be implemented throughout the Bantam Lake watershed to achieve pollutant load reduction targets for nutrients at the most reasonable cost.

Wetland along the Little Pond Boardwalk Trail, White Memorial Foundation (Litchfield, CT)

2. POLLUTANT LOAD REDUCTION TARGETS

The Connecticut Statewide Lake Nutrient Total Maximum Daily Load (TMDL) establishes pollutant load reduction targets for Bantam Lake. For the purposes of this optimization analysis, CTDEEP determined that nutrient reductions should be applied to estimated nonpoint source watershed loads (i.e., "non-regulated loads") minus background loads and permitted loads as summarized by Table 1. Phosphorus is typically the limiting nutrient for plant and algae growth in freshwater systems such as Bantam Lake. As such, subsequent sections of this analysis focus on phosphorus as the primary pollutant of concern. Although the optimization analysis was focused on phosphorus load reduction, the reduction analysis was also conducted for nitrogen. For purposes of this document, the term "pollutant load" refers hereafter to the nutrient loads of phosphorus and nitrogen.

Table 1. Pollutant Load Reduction Targets Used in Optimization Analysis

Description	Total Phosphorus (TP)	Total Nitrogen (TN)
Predicted Loading (lb /yr)[1]	361	15,888
Reduction Target (%)	29.7%	91.7%
Reduction Target (lb/yr)	**107**	**14,924**

Notes:

1. Predicted loading for this optimization analysis refers to the TP and TN watershed load allocations for non-regulated stormwater, as calculated in the *CT Statewide Lake Nutrient TMDL, Appendix 1: Bantam Lake Watershed*.
2. The optimization analysis was based on applying the % reduction targets in an equal manner across all sources that contribute NPS TP and TN loads.

3. BMP IDENTIFICATION

The analysis was initiated by developing a categorized list of ten BMPs that could be implemented throughout the watershed to reduce pollutant loads to Bantam Lake (Table 2). These BMPs fall into three categories: Structural BMPs, Institutional BMPs, and Agricultural BMPs.

Table 2. List of BMPs for Optimization Analysis

BMP Category	BMP Name	Description
Structural	Bioretention Area *(High Infiltration)*	These structural BMPs are commonly deployed throughout watersheds to provide runoff attenuation and pollutant removal. These structural BMPs can be evaluated using EPA's Opti Tool. "High Infiltration" BMPs are most suitable in Type A or B Soils. "Poor Infiltration BMPs" are most suitable in Type C or D Soils.
	Infiltration Basin *(High Infiltration)*	
	Sand Filter *(High Infiltration)*	
	Bioretention with ISR[1] *(Poor Infiltration)*	
	Gravel Wetland *(Poor Infiltration)*	
	Wet Pond *(Poor Infiltration)*	
Institutional *(aka non-structural)*	Street Sweeping	These practices are commonly deployed by municipalities for pollutant removal as required by the NPDES Small MS4 Permit.
	Catch Basin Cleaning	
Agricultural / Other	Riparian Buffer Improvement	This commonly used and well-studied BMP involves improving upland areas adjacent to wetlands and surface waters through vegetation establishment (e.g., forest, grass).
	Livestock Exclusion Fencing	This BMP involves constructing fencing in pasture areas to keep livestock from having direct access to waterways and streambanks.
[1] Bioretention with Internal Storage Reservoir (ISR). The ISR is comprised of gravel and has an underlying impermeable membrane.		

4. INITIAL BMP EVALUATION

Once BMPs were identified, an initial evaluation was performed to understand the potential maximum implementation extent, pollutant load reductions, and estimated costs associated with their widespread implementation.

Important: The **potential maximum implementation extent** is not realistically achievable given site constraints (e.g., how much impervious area can actually be treated or how wide vegetated buffers can extend before being constrained by a road or other site feature). The purpose of identifying a potential maximum implementation extent is to put an **upper bound** on potential watershed-wide implementation to enable comparison amongst realistic implementation scenarios.

The initial BMP evaluation included the following steps for each BMP category:

- **Step 1**: Identify potential maximum implementation extent of selected BMPs;
- **Step 2**: Calculate potential maximum load reductions from BMP implementation and
- **Step 3**: Calculate potential costs from maximum BMP implementation.

Structural BMPs

The planning level analysis module of version 2 of EPA's Opti-Tool was used for analysis and optimization of structural BMPs.[1] Opti-Tool is a spreadsheet-based optimization tool designed to assist in preparation of technically sound and cost-effective watershed management plans to achieve needed pollutant and volume reductions more affordably from developed landscapes throughout the New England Region. Opti-Tool does not currently support evaluation other BMP types (e.g., non-structural BMPs, including non-structural agricultural practices). For this reason, pollutant load reductions and potential implementation costs for non-structural BMPs were estimated from other reputable sources as described in the sections below.

- **Step 1 (Potential Implementation Extent)**: Opti-Tool performs structural BMP analysis based on treated impervious area. The analysis was initiated by using the 2016 National Land Cover Dataset (NLCD) to tabulate the amount of impervious area for each major land use type. NRCS Soils data was then paired with impervious land use types to identify potential structural BMP implementation locations. Soils with a Hydrologic Soil Group (HSG) classification of A or B are expected to be suitable for infiltrating practices such as bioretention, infiltration basins, and sand filters. Soils with a HSG of C or D are not typically suitable for infiltration BMPs, but are expected to be suitable for excavated or lined management measures such as gravel wetlands, dry ponds, or wet ponds.[2] Based on this analysis, approximately 285 impervious acres in the watershed are suitable for treatment by infiltrating practices, while approximately 467 impervious acres in the watershed are suitable for treatment by excavated or lined practices (Table 3).
  The next step of the analysis was to assign a potential "BMP opportunity area" to each structural BMP. The potential BMP opportunity area of each structural BMP was calculated using methods that are consistent with EPA's *Buzzards Bay Opti-Tool Pilot Report*[3], which defines BMP opportunity area as "*the BMP footprints needed to capture up to 1 inch of runoff from the impervious drainage areas*". BMPs were first separated into two categories: 1) suitable for infiltration (HSG A/B); 2) not suitable for infiltration (HSG C/D). As a starting point, a potential implementation percentage was then assigned to each BMP as summarized by Table 4. These implementation percentages were later refined during the optimization process as discussed in Section 6.

  The total impervious area for each land use classification was then proportionally distributed to the implementation percentage of each available structural BMP. For example, there are 53 impervious acres of impervious low-density residential area underlain by HSG A/B B soils within the watershed. The impervious area that could be potentially treated with infiltration basins is therefore 26.5 acres (50% of 53 acres).

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[1] EPA Region 1 Opti-Tool: https://www.epa.gov/tmdl/opti-tool-epa-region-1s-stormwater-management-optimization-tool.

[2] HSG Note: Soils are sometimes assigned a dual HSG. The first letter applies to the drained condition and the second to the undrained condition. For this analysis, soils with dual HSGs were grouped based on their undrained condition. For example, an A/D soil was classified as poorly drained and not suitable for infiltration.

[3] Buzzards Bay Opti-Tool Pilot Report: https://www3.epa.gov/region1/npdes/stormwater/ma/opti-tool-case-study-demo-buzzards-bay-watershed.pdf.

Table 3. Potential Watershed-Wide Structural BMP Treatment Area by Land Use and Soil Type

Opti-Tool Land Use Classification	Potential Watershed-Wide BMP Treatment Area	
	Impervious Area: A / B Soils (ac)	Impervious Area: C / D Soils (ac)
Agriculture	31	58
Forest	80	158
High Density Residential	14	5
Low Density Residential	53	94
Medium Density Residential	48	27
Open Land	60	125
Totals:	**285**	**467**

Notes:

1. EPA's Opti-Tool uses a different land use classification scheme that the 2016 NLCD; therefore, a lookup table was created to enable conversation between the 2016 NLCD and Opti-Tool land use classifications.

2. High Density Residential includes Commercial and Industrial Areas are included in the High-Density Residential land use classification – the 2016 NLCD does not have a separate category for commercial and industrial. These land use types all have similar pollutant export rates.

3. Impervious area data obtained from CT ECO.

3. Open water was excluded from analysis.

Table 4. Potential BMP Implementation Percentage by Hydrologic Soil Group

BMP Category	BMP Name	Percentage
Suitable for Infiltration *(HSG A or B)*	Bioretention Area	25%
	Infiltration Basin	50%
	Sand Filter	25%
	Total	**100%**
Not Suitable for Infiltration *(HSG C or D)*	Bioretention with ISR	25%
	Gravel Wetland	50%
	Wet Pond	25%
	Total	**100%**

- **Step 2 (Potential Load Reductions)**: Potential pollutant load reductions were then calculated using Opti-Tool's "Planning Level Analysis" Module. Opti-Tool default watershed-specific total phosphorus and total nitrogen export rates were used for each land use classification[4.] Structural BMPs were initially evaluated to capture a runoff depth of 1-inch. This is a commonly used design parameter which typically results in treatment of most annual precipitation events. Opti-Tool calculates potential pollutant load reductions through use of BMP-specific performance curves. For example, a bioretention cell with a treated runoff depth of 1 inch would be expected to remove 53% of TP, while a bioretention cell with a treated runoff depth of 0.6 inches would be expected to remove 44% of TP.
- **Step 3 (Potential Implementation Costs)**: Potential implementation costs were calculated using Opti-Tool's "Planning Level Analysis" Module.5 Opti-Tool calculates implementation costs based on unit cost estimates per cubic feet of required storage capacity to meet pollutant load reduction targets. For example, an infiltration basin is assigned a cost of $6.24 per cubic foot of required storage capacity.

See Figure 1 for the potential impervious treatment extent of structural BMPs delineated by soil type. Note that Figure 1 depicts soils that underly potential impervious BMP treatment areas to be consistent with how the Opti-Tool structural BMP analysis is performed based on treated impervious area. Hydrologic Soils Group (HSG) A and B soils are most suitable for infiltrating BMPs. HSG C and D soils are most suitable for non-infiltrating BMPs. Refer to **Section 6** of this Appendix for a summary of preliminary results from the structural BMP analysis (see Scenario 1).

[4] Lake Loading Response Model (LLRM) specific export coefficients from the *2020 Bantam Lake TMDL Modeling Effort* were not used for this analysis. LLRM coefficients rely on land uses comprised of both pervious and impervious areas. Opti-Tool calculations are only based on pollutant loading from impervious areas.

[5] Planning level costs from Opti-Tool are based on 2016 dollars.

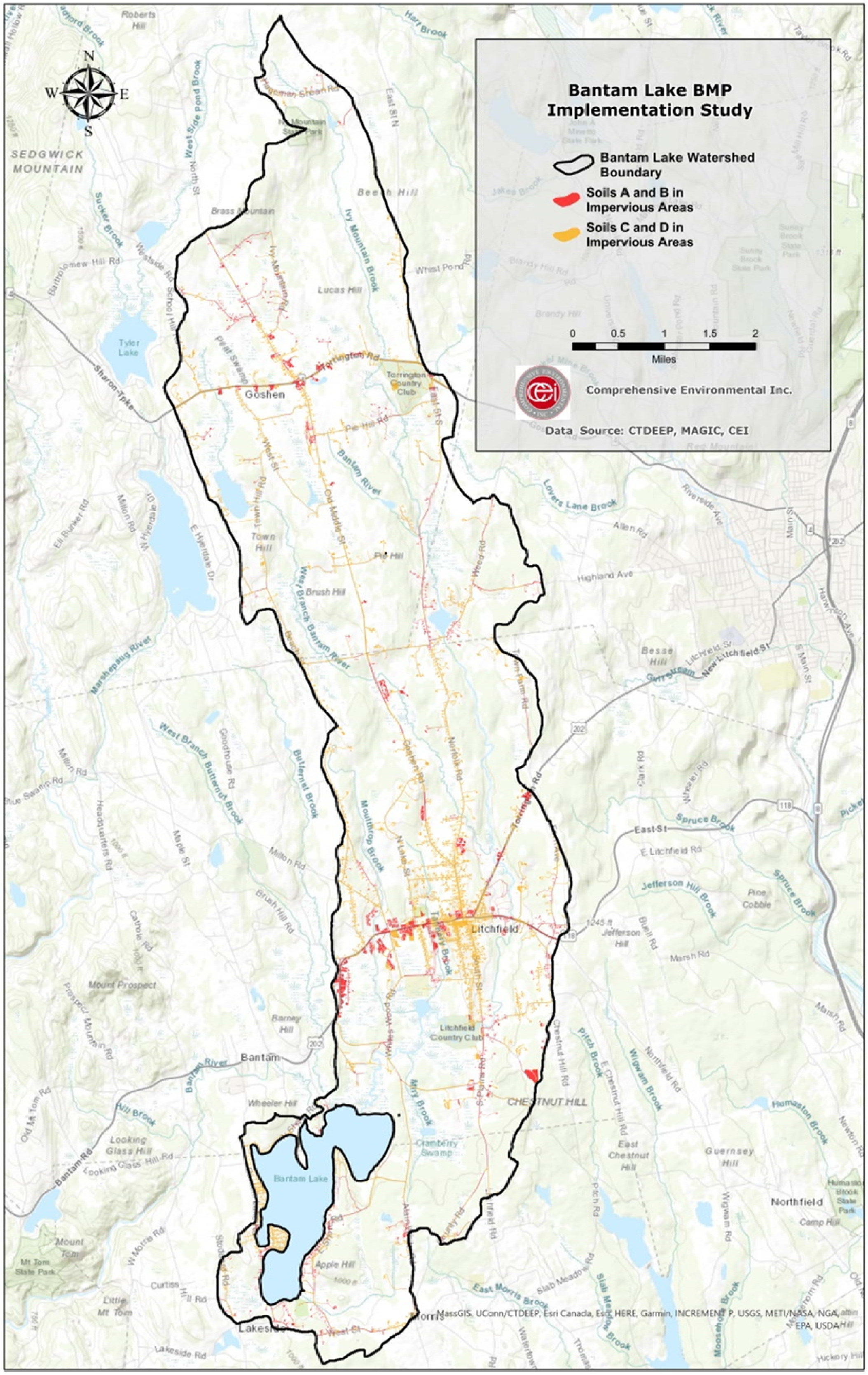


Figure 1. Potential Impervious Treatment Extent for Structural BMPs based on Soil Type

(Figure 1 depicts soils that underlie potential impervious BMP treatment areas to be consistent with how the Opti-Tool structural BMP analysis is performed based on treated impervious area. A/B soils are most suitable for infiltrating BMPs, C/D soils are most suitable for non-infiltrating BMPs.)

Institutional BMPs

- **Step 1 (Potential Implementation Extent)**:
  - o Street Sweeping: The potential maximum implementation extent of street sweeping was delineated based on the extent of impervious roadways within the watershed. The 2012 CTDEEP Impervious Data Layer indicates that there are 267 acres of impervious roads in the watershed, excluding parking lots and driveways.
  - o Catch Basin Cleaning: Based on review of data from municipalities with similar land use and population density, it was assumed that there are approximately 1,000 catch basins within the Bantam River watershed.
- **Step 2 (Potential Load Reductions)**: The potential pollutant loading from contributing impervious areas that can be swept or have catch basins that can be cleaned was calculated based on Pollutant Load Export Rates (PLERs) obtained from *EPA Region 1's 2016 Small MS4 Permit*. The PLER for medium density residential is 2.0 lb/ac/yr for TP and 14.1 lb/ac/yr for TN.[6, 7]
  - o Street Sweeping: Potential load reductions were calculated based on Appendix F to the *EPA Region 1's Small MS4 Permit* (*Equation 2-1, Equation 2-2, Table 2-4*). It was assumed that mechanical street sweeping would be performed on a monthly basis for nine months out of the year.
  - o Catch Basin Cleaning: Potential load reductions were calculated based on Appendix F to the *EPA Region 1's Small MS4 Permit* (*Equation 2-3, Equation 2-4, Table 2-5*). It was assumed that each catch basin would be cleaned twice per year.
- **Step 3 (Potential Implementation Costs)**:
  - o Street Sweeping: Street sweeping costs can vary widely. For conservatism, it was assumed that street sweeping would be performed by a private contractor on a monthly basis at a cost of approximately $500/road mile swept.
  - o Catch Basin Cleaning: Catch basin costs can wary widely. For conservatism, it was assumed that catch basin cleaning was performed by a private contractor twice per year at aproximately $100 per catch basin.

A summary of initial street sweeping and catch basin cleaning calculations and results is provided by Table 5 and Table 6. See Figure 2 for the potential implementation extent of street sweeping (based on impervious roads). Summarized results with comparisons to other evaluated BMPs are provided by **Section 6** of this Appendix (see Scenario 1).

[6] Medium Density Residential (MDR) was selected for calculation of PLERs as the most representative developed land use classification in the watershed that has the potential to be swept.

[7] EPA Region 1 Small MS4 Permit: https://www3.epa.gov/region1/npdes/stormwater/ma/2016fpd/appendix-f-attach-2-2016-ma-sms4-gp-mod.pdf.

Table 5. Maximum Potential Street Sweeping Implementation Extent, Load Reductions, and Annual Costs

Calculation Type	Calculation Description	Result
Potential Implementation Extent	Area of Impervious Roads in Watershed (ac)	267.0
	Percent Routinely Swept (%)	**100%**
	Area of Roads Routinely Swept (ac)	**267.0**
Potential Pollutant Loading	TP PLER from Residential Land Use (lb/ac/yr)	2.0
	TN PLER from Residential Land Use (lb/ac/yr)	14.1
	Estimated TP from Residential Land Use (lb/yr)	**523.3**
	Estimated TN from Residential Land Use (lb/yr)	**3,764.7**
Potential Pollutant Removal	Pollutant Reduction Factor	2%
	Potential TP Load Reduction (lb/yr)	**11.8**
	Potential TN Load Reduction (lb/yr)	**84.7**
Potential Cost	Road Miles Swept per year (mi) *(i.e., all roads swept 9x/yr)*	**662.2**
	Cost per road mile ($ / mi)	**$500.0**
	Assumed Cost per Year	**$331,000**

Notes:
1. Calculation from Appendix F to EPA's Small MS4 Permit (Equations 2-1, 2-2, and Table 2-4)
2. Pollutant Reduction Factor Assumptions: Street sweeping 9 months/year, mechanical street sweeper (Table 2-4).
3. Assume sweeping performed by private contractor. "Road miles swept" calculated from known impervious area based on typical width of 30 feet.

Table 6. Maximum Potential Catch Basin Cleaning Extent, Load Reductions, and Annual Costs

Calculation Type	Calculation Description	Result
Potential Implementation Extent	Number of Catch Basins to Clean / yr (estimated)	**1,000**
	Impervious Area to each Catch Basin (ac)	0.25
	Total Contributing Impervious Area (ac)	**250.0**
Potential Pollutant Loading	TP PLER from Residential Land Use (lb/ac/yr)	2.0
	TN PLER from Residential Land Use (lb/ac/yr)	14.1
	Estimated TP from Residential Land Use (lb/yr)	**490.0**
	Estimated TN from Residential Land Use (lb/yr)	**3,525.0**
Potential Pollutant Removal	TP Reduction Factor	2%
	TN Reduction Factor	6%
	Potential TP Load Reduction (lb/yr)	**9.8**
	Potential TN Load Reduction (lb/yr)	**70.5**
Potential Cost	Cost per Catch Basin / yr (*i.e., cost to clean 2x/yr)*	$100
	Assumed Cost per Year	**$100,000**

Notes:
1. Calculation from Appendix F to EPA's Small MS4 Permit (Equations 2-3, 2-4, and Table 2-5)
2. Pollutant Reduction Factor Assumptions: each catch basin cleaned twice per year.
3. Assume cleaning performed by private contractor.

Agricultural / Other BMPs

Riparian Buffer Improvement

- **Step 1 (Potential Implementation Extent)**: The potential maximum implementation extent of riparian buffer improvements within the watershed was estimated by performing a desktop analysis of 2019 orthophotos from Connecticut Environmental Conditions Online (CTECO) to identify stream riparian areas with a natural vegetated buffer (e.g., forest or other vegetation unaltered by land uses such as agriculture, golf courses, etc.) less than 100 feet wide. Based on the *Credit for Going Green Project*, the "optimal" riparian buffer width is approximately 100 feet. [8]

  Based on this review, 15 areas throughout the watershed were identified (Figure 2). An estimated contributing upland distance of 400 feet was assigned to each buffer based on *Table 2* from the *Credit for Going Green Proj*ect – a contributing upland area of 400 feet represents a typical land use with less than 36% impervious cover density.

- **Step 2 (Potential Load Reductions)**: The potential maximum pollutant loading from the contributing upland area was then estimated from *Table 2* of the *Credit for Going Green Project.* Based on a typical land use of less than 36% impervious cover density, the potential pollutant load export rate for this land use type is approximately 0.55 lb/acre/yr for TP and 3.8 lb/acre/yr for TN.

  The potential maximum pollutant load reduction for implementation of riparian buffers was then estimated based on performance curves from the *Credit for Going Green Project*. The performance curves depict potential pollutant removal efficiency as a function of buffer width (i.e. 20 to 100 feet), soil type (HSG A, B, C, D), and buffer type (grassed or forested). The "optimal" buffer width of 100 feet was used for this initial estimate. Pollutant removal efficiecies were estimated based on an assumed Type C HSG for all riparian buffer locations for conservatism.

- **Step 3 (Potential Implementation Costs)**: Potential implementation costs were estimated on a per acre basis based on comparable studies. Buffer implemention costs depend on a wide variety of factors such as planting type, spacing, and site preparation. Based on review of comparable studies, potential implementation costs can range from approximately $500 per acre to $2,500 per acre (in 2021 US Dollars). An implementation cost of $2,500 per acre was estimated.

A summary of initial riparian buffer calculations and results is provided by Table 7. Summarized results with comparisons to other evaluated BMPs are provided by **Section 6** of this Appendix (see Scenario 1).

[8] 2019 Credit for Going Green Project (UNH Stormwater Center / Great Bay National Estuarine Research Reserve): https://www.unh.edu/unhsc/https%3A//www.unh.edu/unhsc/news/credit-going-green.

Table 7. Maximum Potential Riparian Buffer Improvement Extent, Load Reductions, and Annual Costs

Buffer ID	Potential Implementation Extent				Potential Pollutant Loading				Potential Pollutant Removal						Potential Implementation Cost	
	Appx. Length (ft)	Number of Sides	Contributing Upland Distance (ft)	Contributing Upland Area (ac)	TP PLER (lb/ac/yr)	TN PLER (lb/ac/yr)	TP Export (lb/yr)	TN Export (lb/yr)	Buffer Width (ft)	Buffer Area (ac)	TP Removal Eff. (%)	TN Removal Eff. (%)	TP Removed with Buffer (lb/yr)	TN Removed with Buffer (lb/yr)	Buffer Planting ($ / ac)	Total Buffer Planting Cost ($)
1	1,905	2	400	35.0	0.55	3.8	19.24	132.95	100	8.75	19%	48%	3.66	63.81	$ 2,500.00	$ 22,000
2	404	2	400	7.4	0.55	3.8	4.08	28.19	100	1.85	19%	48%	0.78	13.53	$ 2,500.00	$ 5,000
3	1,519	1	400	13.9	0.55	3.8	7.67	53.00	100	3.49	19%	48%	1.46	25.44	$ 2,500.00	$ 9,000
4	898	1	400	8.2	0.55	3.8	4.54	31.34	100	2.06	19%	48%	0.86	15.04	$ 2,500.00	$ 5,000
5	403	1	400	3.7	0.55	3.8	2.04	14.06	100	0.93	19%	48%	0.39	6.75	$ 2,500.00	$ 2,000
6	816	1	400	7.5	0.55	3.8	4.12	28.47	100	1.87	19%	48%	0.78	13.67	$ 2,500.00	$ 5,000
7	2,000	2	400	36.7	0.55	3.8	20.20	139.58	100	9.18	19%	48%	3.84	67.00	$ 2,500.00	$ 23,000
8	5,000	2	400	91.8	0.55	3.8	50.51	348.94	100	22.96	19%	48%	9.60	167.49	$ 2,500.00	$ 57,000
9	1,735	1	400	15.9	0.55	3.8	8.76	60.54	100	3.98	19%	48%	1.66	29.06	$ 2,500.00	$ 10,000
10	636	1	400	5.8	0.55	3.8	3.21	22.19	100	1.46	19%	48%	0.61	10.65	$ 2,500.00	$ 4,000
11	397	1	400	3.6	0.55	3.8	2.01	13.85	100	0.91	19%	48%	0.38	6.65	$ 2,500.00	$ 2,000
12	1,684	2	400	30.9	0.55	3.8	17.01	117.52	100	7.73	19%	48%	3.23	56.41	$ 2,500.00	$ 19,000
13	660	2	400	12.1	0.55	3.8	6.67	46.06	100	3.03	19%	48%	1.27	22.11	$ 2,500.00	$ 8,000
14	2,754	2	400	50.6	0.55	3.8	27.82	192.20	100	12.64	19%	48%	5.29	92.26	$ 2,500.00	$ 32,000
15	1,105	2	400	20.3	0.55	3.8	11.16	77.12	100	5.07	19%	48%	2.12	37.02	$ 2,500.00	$ 13,000
Totals:	**21,916**	**-**	**-**	**343.7**	**-**	**-**	**189.03**	**1,306.03**	**-**	**85.92**	**-**	**-**	**35.92**	**626.89**	**-**	**$ 216,000**

Notes:

1. PLERs and removal efficiencies estimated based on the *Credit for Going Green Project*.
2. Total buffer planting cost rounded to the nearest thousand dollars.

Livestock Exclusion Fencing

- **Step 1 (Potential Implementation Extent)**: The potential maximum implementation extent of livestock fencing (i.e. exclusion of livestock from waterways and streambanks by installing fence) within the watershed was identified based on available agricultural land use data. According to the 2016 NLCD, there are approximately 2,110 acres of pasture and hay area within the watershed. Most of this area is comprised of hay; however, it was assumed that 10 percent includes pasture area (i.e., dairy farm, horse stables) based on review of aerial imagery. Most pasture areas in the watershed do not provide direct access to waterways and steambanks. It was therefore assumed that just 5 percent of pasture area in the watershed could benefit from exclusion fencing. Based on these assumptions, approximately 10.5 acres of pasture in the watershed could benefit from exclusion fencing.

- **Step 2 (Potential Load Reductions)**: The potential maximum pollutant loading from pasture areas without livestock fencing was estimated based on values obtained from Bantam Lake's Lake Loading Response Model (LLRM) completed in February 2020, based on the "Agricultural Grazing" land use category. The PLER for agricultural grazing is approximately 0.40 lb/acre/yr for TP and 4.9 lb/acre/yr for TN.

  The potential maximum pollutant load reduction for implementation of livestock exclusion fencing was obtained by applying a a pollutant removal efficiency of 55% from the Lake Champlain BMP Scenario Tool Report.[9]

- **Step 3 (Potential Implementation Costs)**: Potential implementation costs were obtained by estimating the linear footage of fencing to be constructed over the 10.6 acre area. The required fencing was assumed to be 850 linear feet per acre (this number represents the perimeter of a square acre for conservatism). Fencing types and costs can vary widely. It was estimated that fencing would cost appx. $3.50 per linear foot for a woven wire fence with wood posts.[10]

A summary of initial agricultural exclusion fencing calculations and results is provided in Table 8. See Figure 2 for the potential implementation extent of agricultural exclusion fencing (based on parcels). Summarized results with comparisons to other evaluated BMPs are provided in **Section 6** of this Appendix.

[9] US EPA Region 1 Lake Champlain BMP Scenario Tool Report: https://www.epa.gov/sites/production/files/2015-09/documents/lake-champlain-bmp-scenario-tool-report.pdf.

[10] Estimated Costs for Livestock Fencing. Iowa State University Extension and Outreach. https://www.extension.iastate.edu/agdm/livestock/html/b1-75.html. (*Note: Estimated costs are $2.28 per linear foot by converting 2011 costs estimate to 2021 dollars based on U.S. Bureau of Labor Statistics Consumer Price Index Inflation Calculator*. This estimate was further inflated for conservatism to $3.50 given the small potential implementation extent.)

Table 8. Maximum Potential Agricultural Pasture Area Improvement Extent, Load Reductions, and Capital Costs

Calculation Type	Calculation Description	Result
Potential Implementation Extent	Total Pasture/Hay Area (ac)	2,110.3
	Assumed Pasture Percent (%)	10%
	Estimated Pasture Area (ac)	211.0
	Assumed Pasture Percent without Fencing (%)	5%
	Estimated Pasture Area without Fencing (ac)	**10.6**
Potential Pollutant Loading	TP PLER from Pasture Area with Livestock (lb/ac/yr)	0.4
	TN PLER from Pasture Area with Livestock (lb/ac/yr)	4.9
	Estimate TP from Pasture Area (lb/yr)	**3.8**
	Estimate TN from Pasture Area (lb/yr)	**51.7**
Potential Pollutant Removal	Removal Efficiency of Exclusion Fencing (%)	55%
	Potential TP Load Reduction (lb/yr)	**2.1**
	Potential TN Load Reduction (lb/yr)	**28.4**
Potential Cost	Estimated length of fencing needed (ft)	8,863.3
	Estimated cost per linear ft ($/ft)	$3.50
	Total Cost	**$31,000**

Notes:

1. PLERs from *2020 Bantam Lake TMDL Modeling Effort.*
2. Removal efficiency for exclusion fencing from Lake Champlain BMP Scenario Report.

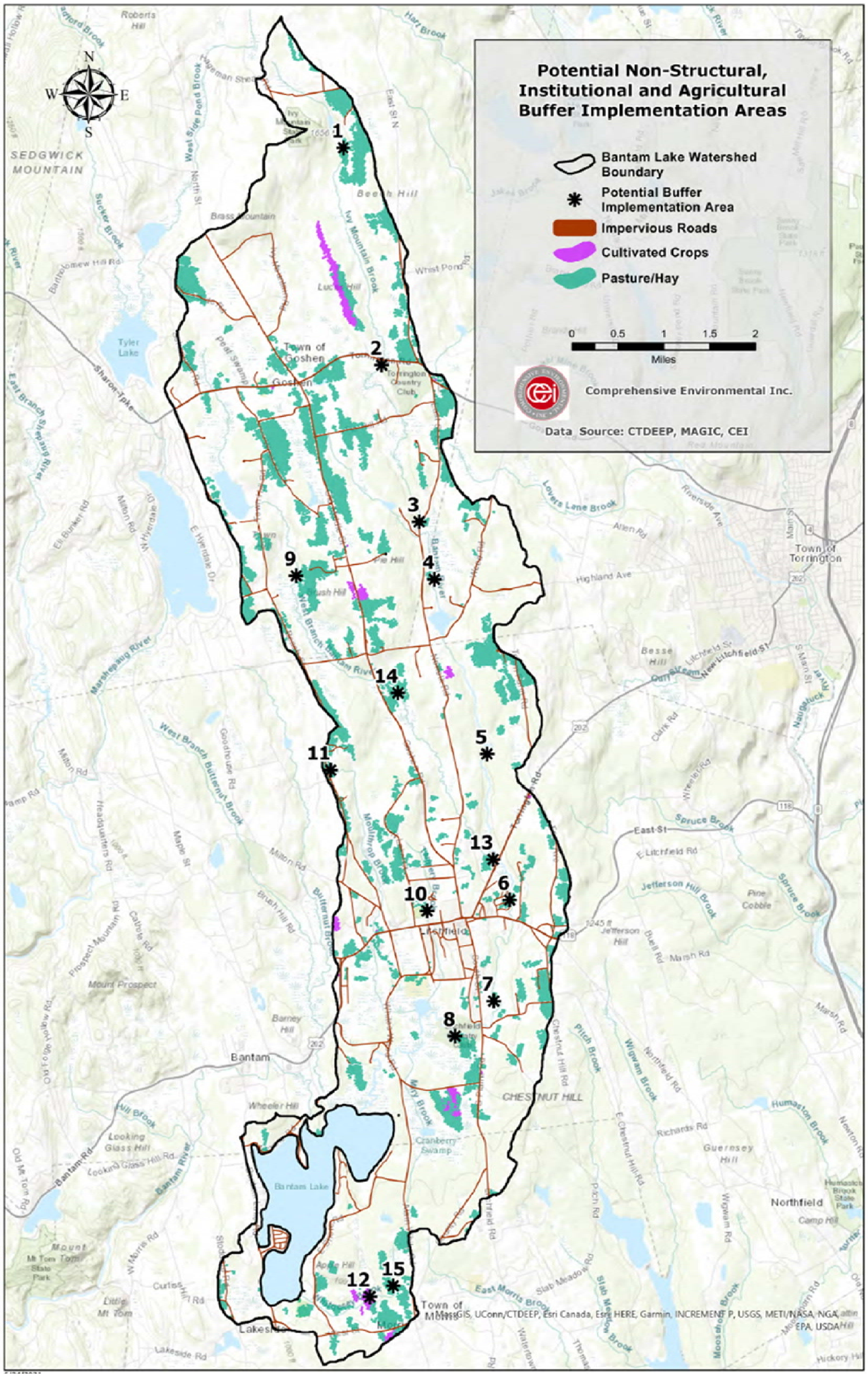


Figure 2. Potential Implementation Extent for Institutional, Riparian Buffer, and Agricultural BMPs

(Impervious roads include potential street sweeping extent; ***numbered asterisks (*)*** *include potential riparian buffer improvement areas; pasture/hay include potential agriculture areas.)*

5. REFINED BMP EVALUATION

Once initial BMP evaluations were complete, an analysis was performed to establish a more realistic implementation extent for each BMP type. The following adjustments were made:

- **Structural BMPs:** It is unlikely that all impervious area in the watershed can be treated by structural BMPs. A more realistic implementation exent that comprises 10% of impervious area in the watershed was used for further analysis as summarized by Table 9.
- **Street Sweeping:** It is unlikely that all impervious roadways in the watershed can be swept on a monthly basis for nine months of the year. It was assumed that approximately 5% of high priority impervious roadways could reasonably be swept on a monthly basis for nine months of the year (Table 10).
- **Catch Basins:** It is unlikely that all of the approximately 1000 catch basins in the watershed can be cleaned twice per year. It was assumed that approximately 250 high priority catch basins in the watershed could be cleaned twice per year (Table 11).
- **Riparian Buffers**: The maximum potential buffer implementation extent was set to the "optimal" 100 feet as determined by the *Credit for Going Green Project*. Based on review of the 15 potential riparian buffer implementation areas, a buffer width of 100 feet will not be feasible in every instance. A more conservative typical implementation width of 30 feet was used to estimate potential pollutant load reductions and implementation cost (Table 12).
- **Agricultural Livestock Fencing:** No changes were made. The "maximum" and "realistic" implementation extents are the same (Table 8).

Table 9. Comparison of Potential Structural BMP Treatment Area by Land Use and Soil Type

Opti-Tool Land Use Classification	Potential Watershed-Wide BMP Treatment Area *(Scenario 1)*		Potential Realistic BMP Treatment Area ***(10% of Total)*** *(Scenarios 2, 3, 4)*	
	Imp. Area: A / B Soils (ac)	Imp. Area: C / D Soils (ac)	Imp. Area: A / B Soils (ac)	Imp. Area: C / D Soils (ac)
Agriculture	31	58	3	6
Forest	80	158	8	16
High Density Residential	14	5	1	1
Low Density Residential	53	94	5	9
Medium Density Residential	48	27	5	3
Open Land	60	125	6	13
Totals	**285**	**467**	**29**	**47**

Notes:

1. EPA's Opti-Tool uses a different land use classification scheme that the 2016 NLCD; therefore, a lookup table was created to enable conversation between the 2016 NLCD and Opti-Tool land use classifications.
2. Commercial and Industrial Areas are included in the High Density Residential land use classification – the 2016 NLCD does not have a separate category for commercial and industrial. These land use types all have similar pollutant export rates.
3. Open water was excluded from analysis.

Table 10. Realistic Potential Street Sweeping Implementation Extent, Load Reductions, and Annual Costs

Calculation Type	Calculation Description	Result
Potential Implementation Extent	Area of Impervious Roads in Watershed (ac)	267.0
	Percent Routinely Swept (%)	**5%**
	Area of Roads Routinely Swept (ac)	**13.4**
Potential Pollutant Loading	TP PLER from Residential Land Use (lb/ac/yr)	2.0
	TN PLER from Residential Land Use (lb/ac/yr)	14.1
	Estimated TP from Residential Land Use (lb/yr)	**26.2**
	Estimated TN from Residential Land Use (lb/yr)	**188.2**
Potential Pollutant Removal	Pollutant Reduction Factor	2%
	Potential TP Load Reduction (lb/yr)	**0.6**
	Potential TN Load Reduction (lb/yr)	**4.2**
Potential Cost	Road Miles Swept per year (mi) *(i.e., all roads swept 9x/yr)*	**33.1**
	Cost per road mile ($ / mi)	**$500.0**
	Assumed Cost per Year	**$17,000**

Notes:

1. Calculation from Appendix F to EPA's Small MS4 Permit (Equations 2-1, 2-2, and Table 2-4)
2. Pollutant Reduction Factor Assumptions: Street sweeping 9 months per year, mechanical street sweeper (Table 2-4).
3. Assume sweeping performed by private contractor. "Road miles swept" calculated from known impervious area based on typical width of 30 feet.

Table 11. Realistic Potential Catch Basin Cleaning Extent, Load Reductions, and Annual Costs

Calculation Type	Calculation Description	Result
Potential Implementation Extent	Number of High Priority Catch Basins to Clean / yr	**250**
	Impervious Area to each High Priority Catch Basin (ac)	0.25
	Total Contributing Impervious Area (ac)	**62.5**
Potential Pollutant Loading	TP PLER from Residential Land Use (lb/ac/yr)	2.0
	TN PLER from Residential Land Use (lb/ac/yr)	14.1
	Estimate TP from Residential Land Use (lb/yr)	**122.5**
	Estimate TN from Residential Land Use (lb/yr)	**881.3**
Potential Pollutant Removal	TP Reduction Factor	2%
	TN Reduction Factor	6%
	Potential TP Load Reduction (lb/yr)	**2.5**
	Potential TN Load Reduction (lb/yr)	**17.6**
Potential Cost	Cost per Catch Basin / yr (*i.e., cost to clean 2x/yr)*	$100
	Assumed Cost per Year	**$25,000**

Notes:

1. Calculation from Appendix F to EPA's Small MS4 Permit (Equations 2-3, 2-4, and Table 2-5)
2. Pollutant Reduction Factor Assumptions: each catch basin cleaned twice per year.
3. Assume cleaning performed by private contractor.

Table 12. Realistic Potential Riparian Buffer Improvement Extent, Load Reductions, and Annual Costs

Buffer ID	Potential Implementation Extent				Potential Pollutant Loading				Potential Pollutant Removal						Potential Implementation Cost	
	Appx. Length (ft)	Number of Sides	Contributing Upland Distance (ft)	Contributing Upland Area (ac)	TP PLER (lb/ac/yr)	TN PLER (lb/ac/yr)	TP Export (lb/yr)	TN Export (lb/yr)	Buffer Width (ft)	Buffer Area (ac)	TP Removal Eff. (%)	TN Removal Eff. (%)	TP Removed with Buffer (lb/yr)	TN Removed with Buffer (lb/yr)	Buffer Planting ($ / ac)	Total Buffer Planting Cost ($)
1	1,905	2	400	35.0	0.55	3.8	19.24	132.95	30	2.62	12%	12%	2.31	15.95	$ 2,500.00	$ 7,000
2	404	2	400	7.4	0.55	3.8	4.08	28.19	30	0.56	12%	12%	0.49	3.38	$ 2,500.00	$ 1,000
3	1,519	1	400	13.9	0.55	3.8	7.67	53.00	30	1.05	12%	12%	0.92	6.36	$ 2,500.00	$ 3,000
4	898	1	400	8.2	0.55	3.8	4.54	31.34	30	0.62	12%	12%	0.54	3.76	$ 2,500.00	$ 2,000
5	403	1	400	3.7	0.55	3.8	2.04	14.06	30	0.28	12%	12%	0.24	1.69	$ 2,500.00	$ 1,000
6	816	1	400	7.5	0.55	3.8	4.12	28.47	30	0.56	12%	12%	0.49	3.42	$ 2,500.00	$ 1,000
7	2,000	2	400	36.7	0.55	3.8	20.20	139.58	30	2.75	12%	12%	2.42	16.75	$ 2,500.00	$ 7,000
8	5,000	2	400	91.8	0.55	3.8	50.51	348.94	30	6.89	12%	12%	6.06	41.87	$ 2,500.00	$ 17,000
9	1,735	1	400	15.9	0.55	3.8	8.76	60.54	30	1.19	12%	12%	1.05	7.27	$ 2,500.00	$ 3,000
10	636	1	400	5.8	0.55	3.8	3.21	22.19	30	0.44	12%	12%	0.39	2.66	$ 2,500.00	$ 1,000
11	397	1	400	3.6	0.55	3.8	2.01	13.85	30	0.27	12%	12%	0.24	1.66	$ 2,500.00	$ 1,000
12	1,684	2	400	30.9	0.55	3.8	17.01	117.52	30	2.32	12%	12%	2.04	14.10	$ 2,500.00	$ 6,000
13	660	2	400	12.1	0.55	3.8	6.67	46.06	30	0.91	12%	12%	0.80	5.53	$ 2,500.00	$ 2,000
14	2,754	2	400	50.6	0.55	3.8	27.82	192.20	30	3.79	12%	12%	3.34	23.06	$ 2,500.00	$ 9,000
15	1,105	2	400	20.3	0.55	3.8	11.16	77.12	30	1.52	12%	12%	1.34	9.25	$ 2,500.00	$ 4,000
Totals:	**21,916**	**-**	**-**	**343.7**	**-**	**-**	**189.03**	**1,306.03**	**-**	**25.78**	**-**	**-**	**22.68**	**156.72**	**-**	**$ 65,000**

Notes:
1. PLERs and removal efficiencies estimated based on the *Credit for Going Green Project*.

6. BMP SCENARIO ANALYSIS RESULTS

Once initial and refined BMP evaluations were complete, an analysis was performed to determine the best potential mix of BMPs at the lowest possible cost to meet the total phosphorus load reduction goal (for watershed BMPs) of 107 pounds per year. Four scenarios were evaluated as follows:

- **Scenario 1:** Evaluated the maximum potential BMP implementation extent.
- **Scenario 2:** Identified a realistic BMP implementation extent.
- **Scenario 3:** Performed adjustments to structural BMPs.
- **Scenario 4:** Performed final structural BMP optimization.

Results from each scenario are discussed in more detail by the below sections.

Scenario 1: Maximum Potential BMP Implementation

The purpose of this scenario was to identify an upper bound on potential watershed-wide BMP implementation to enable comparisons to subsequent iterations. Results from this scenario were tabulated based on findings from the “initial” BMP evaluation in Section 4. As indicated by Table 13a, the maximum BMP implementation extent results in a possible TP load reduction of 888.2 lb/yr at a cost of $58.3M. Non-structural BMPs (i.e., institutional, riparian buffers, agriculture) are estimated to be significantly more cost-effective than structural BMPs based on cost per pound of TP load reduction.

Scenario 2: Realistic BMP Implementation

The purpose of this scenario was to establish a more realistic implementation extent for each BMP type. Results from this scenario were tabulated based on findings from the “refined” BMP evaluation presented by Section 5. As indicated by the Table 13b, a TP load reduction of 112.5 lb/yr is achieved at an estimated cost of $5.9M. This scenario exceeds the 107 lb/yr TP load reduction goal by 5.5 lb/yr. The combined non-structural BMPs achieve a load reduction of 29.8 lb/yr vs. 82.7 lb/yr for the structural BMPs. The non-structural BMPs are more cost effective than structural BMPs and therefore remain unchanged in subsequent scenarios.

Scenario 3: Realistic BMP Implementation with Structural BMP Adjustments

The purpose of this scenario was to perform adjustments to the initially established BMP implementation percentages summarized in **Table 4** to reduce cost. The following adjustments were made:

- **Infiltration BMPs (suitable for HSG A/B Soils)**: As indicated by Table 13b, infiltration basins are more cost effective than bioretention areas and sand filters on a cost per pound removed basis. Based on this result, the impervious treatment extent of infiltration BMPs were adjusted as follows:
  - Infiltration basins: **increased** from 50% to 70%
  - Bioretention areas: **decreased** from 25% to 15%
  - Sand filters: **decreased** from 25% to 15%

- **Non-Infiltration BMPs (suitable for HSG C/D Soils)**: As indicated by Table 13b, bioretention areas with ISR are more expensive on a cost per pound basis than wet ponds and gravel wetlands. Wet ponds are the most cost effective of the evaluated non-infiltration BMPs. Based on this result, the impervious impervious treatment extent of non-infiltration BMPs were adjusted as follows:

- Wet ponds: **increased** from 25% to 45%
- Gravel wetlands: **decreased** from 50% to 40%
- Bioretention areas with ISR: **decreased** from 25% to 15%

Refer to Table 14 for a comparison of BMP implementation percentages used for this Scenario vs. previous Scenarios. Results from this Scenario are summarized in Table 13c. As indicated by Table 13c, an overall TP load reduction of 113.1 lb/yr is achieved at a cost of $5.1M. This scenario exceeds the 107 lb/yr TP load reduction goal by 6.1 lb/yr and is $0.80M less expensive than Scenario 2.

Scenario 4: Realistic BMP Implementation with Structural BMP Adjustments and Optimization

The purpose of this scenario was to perform an optimization analysis to finalize the "best" mixture of BMPs to achieve the most cost effective load reductions. Opti-Tool performs optimization calculations by identifying the most cost effective treated runoff depth and subsequent BMP storage capacity that meets the target load reduction. Structural BMPs for Scenarios 1, 2, and 3 were all initially sized based on a treated runoff depth of 1 inch. The optimization analysis runs thousands of simulations to determine which runoff depth(s) result in the most load reductions at the lowest cost.

Results from this updated scenario are summarized in Table 13d, which shows that an overall TP load reduction of 107 lb/yr is achieved at a cost of $3.7M. This scenario meets the 107 lb/yr TP load reduction goal and is $1.4M less expensive than Scenario 3. The cost per pound of TP reduced for Scenario 4 is significantly lower than Scenarios 1-3. For example, bioretention areas went from a cost of $129,812 per pound removed (with a treatment depth of 1 inch) for Scenario 3 to a cost of $74,183 per pound removed (with a treatment depth of 0.4 inch) for Scenario 4.

Table 13a. Scenario 1 Results

(Maximum Possible Implementation Extent, No Optimization)

BMP Category	BMP Name	Treated Area (ac)	TP Load Reduction (lb/yr)	TN Load Reduction (lb/yr)	Cost ($)	Cost per Pound P Reduced ($ / lb)
Structural	Bioretention Area *(HSG A/B)*	71.3	61.7	284.0	$ 8,005,079	**$ 129,700**
	Sand Filter *(HSG A/B)*	71.3	88.5	284.0	$ 9,289,206	**$ 29,204**
	Bioretention w/ ISR *(HSG C/D)*	116.7	137.9	1,057.4	$ 13,229,308	**$ 104,951**
	Gravel Wetland *(HSG C/D)*	233.5	221.4	1,748.2	$ 14,881,912	**$ 95,934**
	Wet Pond *(HSG C/D)*	116.7	96.2	451.2	$ 5,762,927	**$ 67,226**
	Infiltration Basin *(HSG A/B)*	142.6	221.3	1,757.1	$ 6,462,056	**$ 59,924**
Institutional *(aka Non-structural)*	Street Sweeping	267.0	11.8	84.7	$ 331,000	**$ 28,051**
	Catch Basin Cleaning	250.0	9.8	70.5	$ 100,000	**$ 10,204**
Agricultural / Other	Riparian Buffer Improvement	343.7	35.9	626.9	$ 216,000	**$ 6,017**
	Livestock Exclusion Fencing	10.6	3.8	51.7	$ 31,000	**$ 8,158**
	Totals:	**1,623.5**	**888.2**	**6,415.6**	**$ 58,308,488**	**$ 65,645**

Note:

1. Treated runoff depth is 1" for all structural BMPs.
2. Street Sweeping and Catch Basin Cleaning results are annual.
3. TP reduction goal is 107 lb/yr.
4. Color scale for "Cost per pound of P Reduced" ranges from lowest (green) to highest (red).

Table 13b. Scenario 2 Results

(Realistic Implementation Extent, No Optimization)

BMP Category	BMP Name	Treated Area (ac)	TP Load Reduction (lb/yr)	TN Load Reduction (lb/yr)	Cost ($)	Cost per Pound P Reduced ($ / lb)
Structural	Bioretention Area *(HSG A/B)*	7.1	6.2	28.4	$ 800,508	**$ 129,742**
	Sand Filter *(HSG A/B)*	7.1	8.9	28.4	$ 928,921	**$ 29,200**
	Bioretention w/ ISR *(HSG C/D)*	11.7	13.8	105.7	$ 1,322,931	**$ 104,963**
	Gravel Wetland *(HSG C/D)*	23.4	22.1	174.8	$ 1,488,191	**$ 95,934**
	Wet Pond *(HSG C/D)*	11.7	9.6	45.1	$ 576,293	**$ 67,217**
	Infiltration Basin *(HSG A/B)*	14.3	22.1	175.7	$ 646,206	**$ 59,906**
Institutional *(aka Non-structural)*	Street Sweeping	13.4	0.8	5.6	$ 17,000	**$ 21,250**
	Catch Basin Cleaning	62.5	2.5	17.6	$ 25,000	**$ 10,000**
Agricultural / Other	Riparian Buffer Improvement	343.7	22.7	156.7	$ 65,000	**$ 2,863**
	Livestock Exclusion Fencing	10.6	3.8	51.7	$ 31,000	**$ 8,158**
	Totals:	**505.4**	**112.5**	**789.8**	**$ 5,901,050**	**$ 52,454**

Note:

1. Treated runoff depth is 1" for all structural BMPs.
2. Street Sweeping and Catch Basin Cleaning results are annual.
3. TP reduction goal is 107 lb/yr.
4. Color scale for “Cost per pound of P Reduced” ranges from lowest (green) to highest (red).

Table 13c. Scenario 3 Results

(Realistic Implementation Extent, Adjust Structural BMP Implementation %, No Optimization)

BMP Category	BMP Name	Treated Area (ac)	TP Load Reduction (lb/yr)	TN Load Reduction (lb/yr)	Cost ($)	Cost per Pound P Reduced ($ / lb)
Structural	**Bioretention Area** *(HSG A/B)*	4.3	3.7	17.0	$ 480,305	**$ 129,812**
	Sand Filter *(HSG A/B)*	4.3	5.3	17.0	$ 557,352	**$ 29,202**
	Bioretention w/ ISR *(HSG C/D)*	7.0	8.3	63.4	$ 793,758	**$ 104,963**
	Gravel Wetland *(HSG C/D)*	18.7	17.7	139.9	$ 1,190,553	**$ 95,980**
	Wet Pond *(HSG C/D)*	21.0	17.3	81.2	$ 1,037,327	**$ 67,225**
	Infiltration Basin *(HSG A/B)*	20.0	31.0	246.0	$ 904,688	**$ 59,926**
Institutional *(aka Non-structural)*	Street Sweeping	13.4	0.8	5.6	$ 17,000	**$ 21,250**
	Catch Basin Cleaning	62.5	2.5	17.6	$ 25,000	**$ 10,000**
Agricultural / Other	Riparian Buffer Improvement	343.7	22.7	156.7	$ 65,000	**$ 2,863**
	Livestock Exclusion Fencing	10.6	3.8	51.7	$ 31,000	**$ 8,158**
	Totals:	**505.4**	**113.1**	**796.2**	**$ 5,101,983**	**$ 45,118**

Note:
1. Treated runoff depth is 1" for all structural BMPs.
2. Street Sweeping and Catch Basin Cleaning results are annual.
3. TP reduction goal is 107 lb/yr.
4. Color scale for “Cost per pound of P Reduced” ranges from lowest (green) to highest (red).

Table 13d. Scenario 4 Results

(Realistic Implementation Extent, Adjust Structural BMP Implementation %, No Optimization)

BMP Category	BMP Name	Treated Area (ac)	TP Load Reduction (lb/yr)	TN Load Reduction (lb/yr)	Cost ($)	Cost per Pound P Reduced ($ / lb)	Treated Runoff Depth (in)
Structural	**Bioretention Area** *(HSG A/B)*	4.3	2.6	12.3	$ 192,133	**$ 74,183**	0.4
	Bioretention w/ ISR *(HSG C/D)*	7.0	7.0	55.8	$ 476,259	**$ 24,127**	0.6
	Sand Filter *(HSG A/B)*	4.3	3.7	12.3	$ 223,318	**$ 60,194**	0.4
	Wet Pond *(HSG C/D)*	21.0	17.3	81.2	$ 1,037,324	**$ 68,330**	1.0
	Gravel Wetland *(HSG C/D)*	18.7	16.5	135.4	$ 939,921	**$ 57,103**	0.8
	Infiltration Basin *(HSG A/B)*	20.0	30.0	243.5	$ 723,818	**$ 59,926**	0.8
Institutional *(aka Non-structural)*	Street Sweeping	13.4	0.8	5.6	$ 17,000	**$ 21,250**	-
	Catch Basin Cleaning	62.5	2.5	17.6	$ 25,000	**$ 10,000**	-
Agricultural / Other	Riparian Buffer Improvement	343.7	22.7	156.7	$ 65,000	**$ 2,863**	-
	Livestock Exclusion Fencing	10.6	3.8	51.7	$ 31,000	**$ 8,158**	-
	Totals:	**505.4**	**106.8**	**772.0**	**$ 3,730,773**	**$ 34,919**	**-**

Note:

1. Street Sweeping and Catch Basin Cleaning results are annual.
2. TP reduction goal is 107 lb/yr.
3. Color scale for “Cost per pound of P Reduced” ranges from lowest (green) to highest (red).

Table 14. Comparison of Potential BMP Implementation Percentage by Hydrologic Soil Group

BMP Category	BMP Name	Initial Percentage *(Scenario 1 & 2)*	Updated Percentage *(Scenario 3 & 4)*
Suitable for Infiltration *(HSG A or B)*	Bioretention Area	25%	15%
	Infiltration Basin	50%	70%
	Sand Filter	25%	15%
	Total	**100%**	**100%**
Not Suitable for Infiltration *(HSG C or D)*	Bioretention with ISR	25%	15%
	Gravel Wetland	50%	40%
	Wet Pond	25%	45%
	Total	**100%**	**100%**

7. DISCUSSION

The findings presented in Section 6 depict several BMP implementation scenarios, including maximum potential implementation, realistic implementation, and optimized realistic implementation. Results were sequentially improved by each scenario as depicted by **Figure 3**. Based on these findings, Scenario 4 provides the "best" mixture of BMPs to meet pollutant load reductions at the lowest cost.

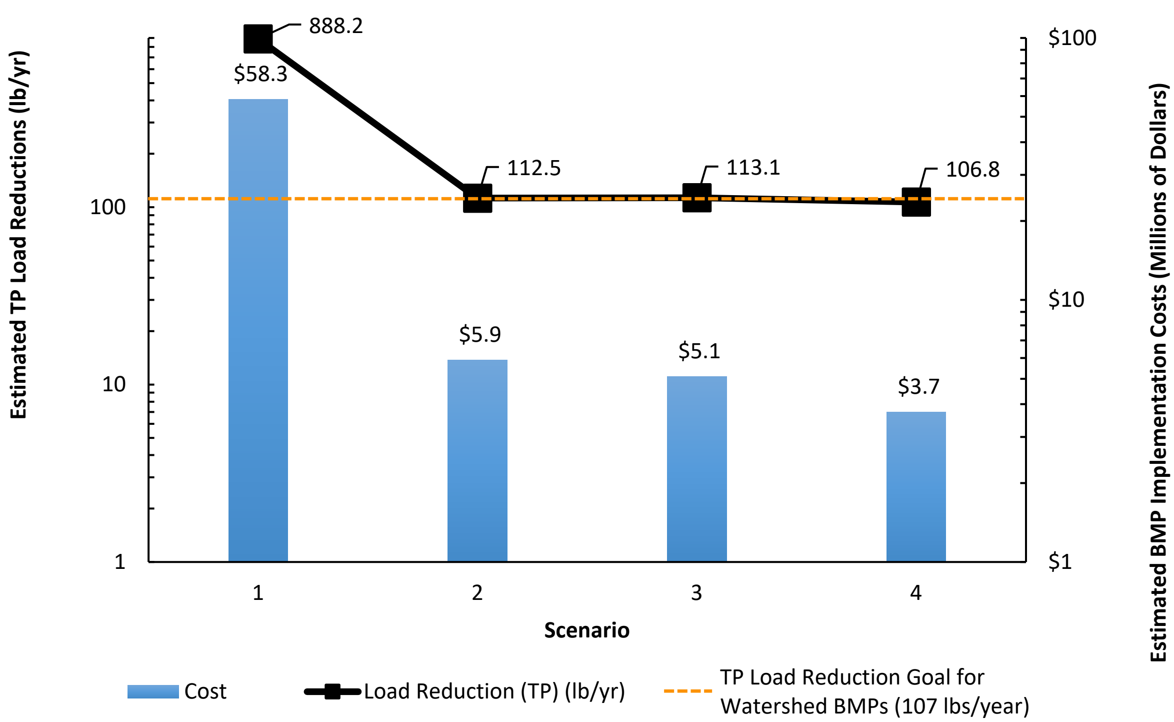


Figure 3. Summary of Results by Scenario

It is important to note that Scenario 4 maximizes pollutant load reductions while reducing costs. However, BMPs provide other useful functions, including peak flow attenuation. The effective treatment depth of most Scenario 4 BMPs are less than those presented by other scenarios and will therefore result in less peak flow attenuation.

It is recommended that future implementation efforts seek to strike a balance between Scenario 3 and Scenario 4. For example, if a prospective BMP site is constrained for space, design to the optimized treatment depth presented by Scenario 4. If a prospective BMP site has adequate space, consider designing the BMP to capture and treat at least 1 inch of runoff as presented by Scenario 3. By striking this balance, it is likely that overall implementation costs to meet TP load reduction targets will end up between Scenario 3 ($5.1M) and Scenario 4 ($3.7M).

Based on this analysis, the following implementation sequence is recommended to achieve TP load reduction targets in the Bantam Lake Watershed.

1. Evaluate and implement site-specific structural BMP recommendations presented in **Section 3.1** of the Bantam Lake WBPA.
2. In parallel, implement non-structural BMPs discussed in **Section 3.2** of the Bantam Lake WBPA as feasible.
3. Riparian buffer enhancements could be particularly effective on a cost per pound of TP removed basis and therefore more cost effective than other BMPs. Refer to Figure 2 for potential non-structural BMP implementation locations, including locations of specific buffer enhancement locations.
4. Perform widespread implementation of structural BMPs to attain the remaining TP load reduction needed to achieve the Bantam Lake water quality targets.
    - Use Figure 1 as a site-specific guide to screen for suitable BMP implementation areas based on soil type (i.e., suitable vs. not suitable for infiltration).
    - Perform initial BMP implementation as close to nearshore areas as feasible before upland areas.
    - Design for treatment of 1 inch of runoff where feasible (Scenario 3), but capitalize on space-constrained sites to provide more cost-effective treatment (Scenario 4).

APPENDIX B:

White Memorial Foundation Preliminary Investigation

B-1: Field Investigation Training Slides

B-2: White Memorial Foundation BMP Sites

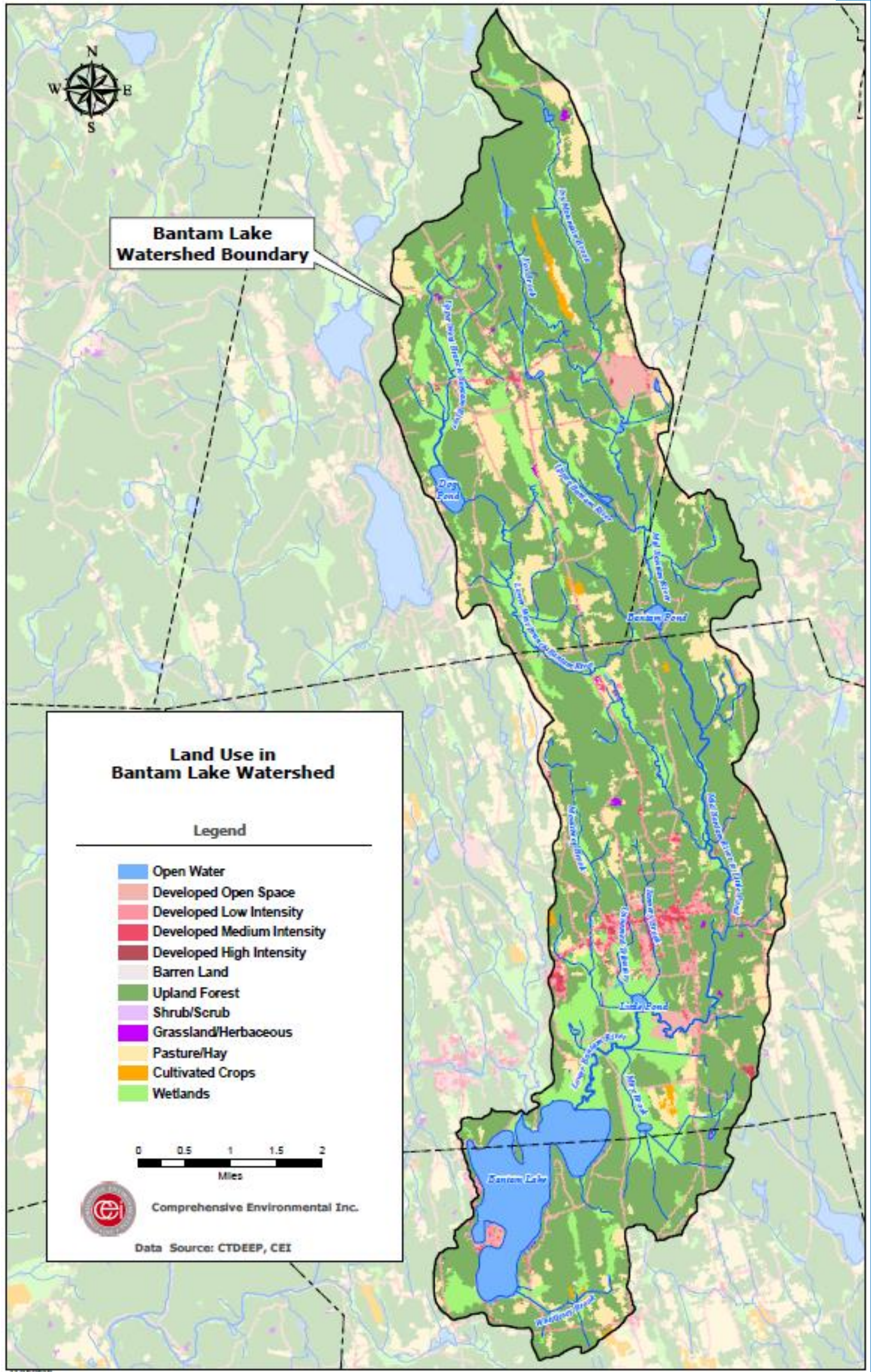
B-3: Field Survey Form

B-1: Field Investigation Training Slides

Project Task:

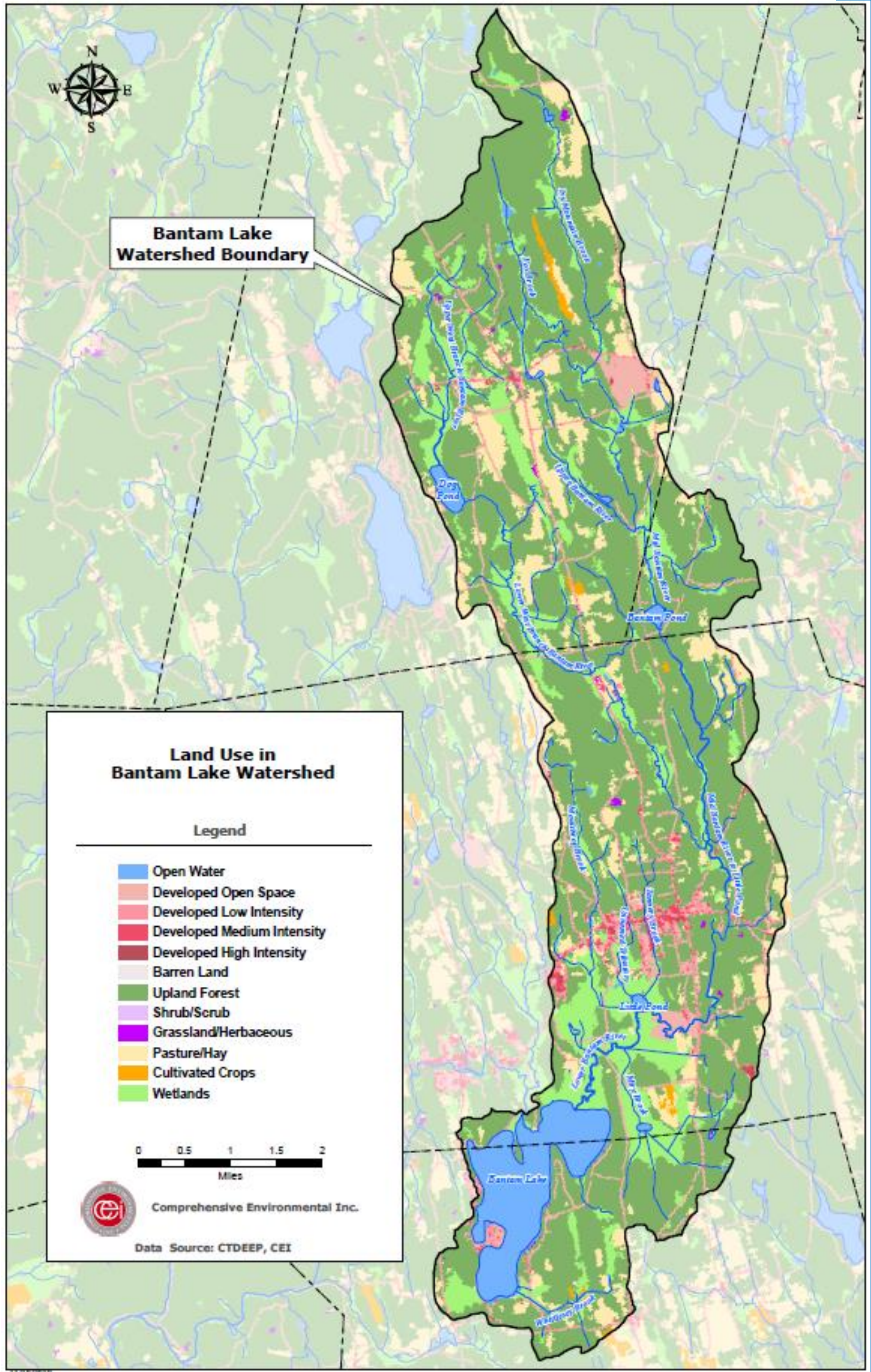
Bantam Lake Watershed Assessment

- **Guided by public input and desktop analysis**
- **Field assessment of watershed, pollution sources, and BMP sites**



Potential Sources of Phosphorus

Problem Type
Erosion
Culverts/Infrastructure
Parking Lots
Shoreline
Agriculture
Animals
Septic Systems



Potential Sources of Phosphorus

Problem Type
EROSION - Surface Erosion - Road Shoulder Erosion - Ditch - Shoreline / Stream Bank - Bare/uncovered soil/sand/salt stockpile

Potential Sources of Phosphorus

Problem Type

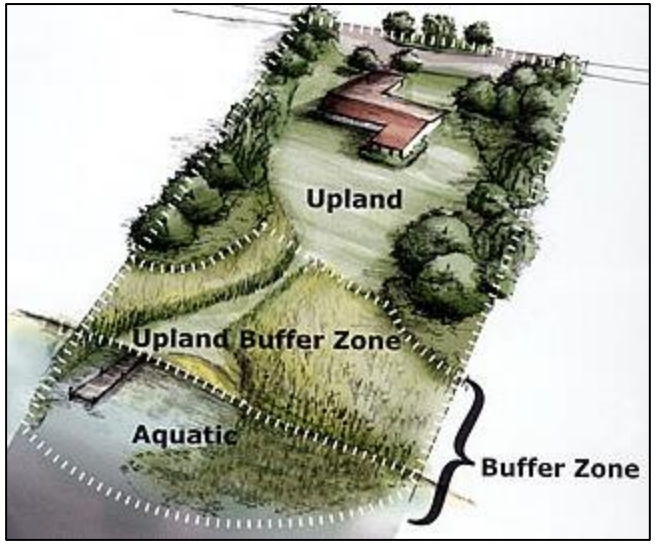
Culverts/Infrastructure

Potential Sources of Phosphorus

Problem Type
Parking Lots

Potential Sources of Phosphorus

Problem Type
Shoreline



Potential Sources of Phosphorus

Problem Type
Agriculture
Potentially Failing Septic Systems
Animals


Bantam Lake Watershed Assessment – Field Survey Forms

Bantam Lake Watershed Assessment Field Survey Form

Site # ____ Date:______________ Field Crew:____

Weather Conditions: _______________________ Rain in last 48 hours?_________________

Location (*house #, road name, intersection*) ____

GPS Coordinates: ____Photos Taken? ______

Land Use/Activity: *circle one*

State Road	*Residential*	*Trail/Path*
Municipal Road	*Commercial*	*Agriculture*
Private Road	*Municipal/Public*	*Construction Site*
Driveway	*Boat Access*	*Other:* _______________

Description of Problems: *circle ALL that apply*

Problem Type	Description (circle)	Notes/Description of Problem	Approximate Size (length x width)
Surface Erosion	*Slight* *Moderate* *Severe*		
Road Shoulder Erosion	*Slight* *Moderate* *Severe*		
Soil	*Bare* *Uncovered Pile* *Winter Sand*		
Culvert	*Unstable Inlet/Outlet* *Clogged* *Crushed/Broken* *Undersized*		
Ditch	*Slight Erosion* *Moderate Erosion* *Severe Erosion* *Bank Failure* *Undersized*		
Parking Lot	*Drains Directly to Waterbody* *Evidence of Concentrated Flow*		
Shoreline	*Undercut* *Lack of Shoreline Vegetation* *Erosion* *Unstable Access*		
Agriculture	*Livestock Access to Waterbody* *Tilled Eroding Fields* *Manure Washing Off-Site* *Inadequate Buffer*		
Other			

Recommended BMP(s): *circle ALL that apply*

Add Vegetation	*Armor with Stone*	*Install Catch Basin*
Establish Buffer	*Divert Runoff*	*Armor Inlet/Outlet (Culvert)*
Enhance Buffer	*Rain Garden*	*Replace Culvert*
Mulch	*Detention Basin*	*Enlarge Culvert*
Add New Surface Material	*Infiltration Trench*	*Install Plunge Pool (Culvert)*
Grade	*Water Retention Swales*	*Other:* _______________

Description of Recommendation(s):

Potential Site Constraints: *circle ALL that apply*

Limited Space	*Permitting Issues*	*May Interfere with Snow Plowing*
Utilities	*Steep Slope*	*Other:* _______________
Private Property	*Difficult Access*	
Crosses Property Lines		

Drawing of Recommended BMP(s):

Field Survey Write-up Example

Site 7: Grassed Island at Intersection of Post Road and Fern Road (across from 31 Post Road), North Hampton, NH

Site Summary:

Stormwater runoff from impervious road surfaces at the intersection of Fern Road and Post Road drain via overland flow to a grassed island (Photo 7-1). A storm drain culvert leaves the island (Photo 7-2) and discharges into an unnamed tributary to the Winnicut River.

Soils in the vicinity of the site are characterized as Hoosic gravelly fine sandy loam, which is a well-drained HSG A soil. (https://websoilsurvey.nrcs.usda.gov).

Proposed Improvements:

Retrofit existing grassed island with a 600 sq. ft. bioretention cell to capture and treat road runoff prior to discharging into an existing culvert inlet at this grassed island.

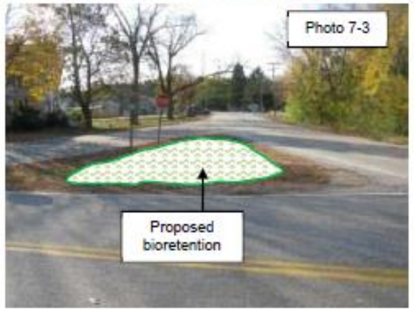
Estimated Costs:

- Capital Costs (Engineering Design and Construction): $18,900 - $27,400
- Annual O/M: $1,050/yr
- 20-year Life Cycle Cost: $44,150

Estimated Nutrient Load Reduction:

- Phosphorus: 0.5 – 0.6 lb P/yr
- Nitrogen: 4.0 – 4.5 lb N/yr
- Cost per lb. of P and N Reduction per Year: $4,100 (P); $600 (N)

Priority: **Medium**



BMP Recommendations Table Example

Site #	Location	BMP Description	Relevant Authorities	Capital Costs[1] (Engineering Design and Construction)	20 -Year Life Cycle Cost[2]	Annual Nutrient Load Reduction (lbs. of P and N)[3]	$ per Pound of P and N Load Reduction per Year[4]	Public Visibility/ Outreach[5]	Feasibility to Construct[6]	SITE PRIORITY
1	Winnicutt Road near Arnold Palmer Dr., north side (Stratham)	Catch basin maintenance; Install outlet protection, vegetated swale, and bioretention.	NHDOT; property owner	$21,300 - $30,800	$49,050	P: 0.5 lb/yr N: 3.2 lb/yr	$5,500 (P) $800 (N)	L	M	Medium
2	Winnicutt Road near Arnold Palmer Dr, south side (Stratham)	Daylight culvert pipe and stabilize outlet; Install bioretention cell with a stabilized outlet.	NHDOT; property owner	$11,900 - $17,100	$27,500	P: 0.3 lb/yr N: 2.1 lb/yr	$4,600 (P) $700 (N)	L	M	Medium
3	682 Post Road at Norton Brook crossing (Greenland)	Divert low flows from road into bioretention swale via level spreader/vegetated filter strip. Install catch basins on both sides of road; discharge to bioretention in grassed island.	Greenland Highway Department; property owner	$50,500 – 73,000	$116,750	P: 0.5 lb/yr N: 3.4 lb/yr	$13,000 (P) $1,800 (N)	L	M	Low
4	Greenland Central School (Greenland)	Raingarden demonstration project with educational kiosk	Greenland School Department; Greenland DPW	$3,900 - $5,700	$8,800	P: 0.2 lb/yr N: 1.4 lb/yr	$2,200 (P) $400 (N)	H	H	High
5	Stratham Memorial School, 39 Gifford Farm Rd. (Stratham)	Retrofit existing depression/swale with a meandering flow path, vegetation and engineered soil media to treat stormwater runoff and provide infiltration; Install educational kiosk.	Stratham School Department; Stratham Highway Department	$26,100 - $37,700	$59,900	P: 0.3 lb/yr N: 2.1 lb/yr	$12,200 (P) $1,400 (N)	H	H	Low
6	NHDOT Facility, 174 South Road (North Hampton)	Install an infiltration bed or infiltrating swale in grassed island on NHDOT property; Install diversions to increase BMP's stormwater capture.	NHDOT	$51,200 – 74,000	$118,600	P: 1.4 lb/yr N: 10 lb/yr	$4,400 (P) $600 (N)	L	H	Medium
7	Intersection of Post Road and Fern Road (North Hampton)	Retrofit grassed island with a bioretention cell to capture and treat road runoff prior to discharging into an existing culvert inlet.	North Hampton DPW	$18,900 - $27,400	$44,150	P: 0.6 lb/yr N: 4.3 lb/yr	$4,100 (P) $600 (N)	L	M	Medium
8	72 Meadow Fox Road (North Hampton)	Install infiltration basin to reduce erosion and provide water quality treatment.	North Hampton DPW; property owner	$121,400 - $175,200	$269,300	P: 6.1 lb/yr N: 42 lb/yr	$2,300 (P) $400 (N)	L	H	High
9-10	10 and 12 Sylvan Road (North Hampton)	Install two rain gardens on properties located at 10 and 12 Sylvan Road to provide treatment to property and road runoff prior to discharging into the storm drain network	Property owners	$1,600 - $2,300	$3,950	P: 0.1 lb/yr N: 0.7 lb/yr	$2,000 (P) $300 (N)	M	H	High
11	8 Winterberry Lane (Stratham)	Retrofit dry detention basin with micropool to enhance pollutant removal and prevent sediment resuspension.	Property owner (Winterberry Lane subdivision); Stratham Highway Dept. (potential)	$21,300 - $30,800	$49,050	P: 0.2 lb/yr N: 1.5 lb/yr	$12,300 (P) $1,700 (N)	L	M	Low
12	11 and 12 Strawberry Lane (Stratham)	Retrofit grassed swales into treatment swales designed to hold water for a longer period and provide higher pollutant removal efficiencies.	Stratham Highway Dept.; property owners	$20,300 - $29,200	$46,750	P: 0.3 lb/yr N: 2.2 lb/yr	$9,500 (P) $1,100 (N)	M	H	Medium
13	Domain Drive at Timberland Entrance (Stratham)	Reconstruct asphalt swale into a treatment swale with forebay, to provide treatment prior to discharge to existing the flood storage basin.	Timberland Inc. (property owner)	$3,000 - $4,300	$6,650	P: 0.04 lb/yr N: 0.3 lb/yr	$9,500 (P) $1,000 (N)	L	H	Medium
14	Cul-de-sac at the end of Marin Way (Stratham)	Retrofit grassed area with bioretention cell which uses the culvert as an overflow structure.	Property owner (corporate park area)	$37,900 - $54,800	$87,350	P: 1.1 lb/yr N: 8.5 lb/yr	$3,900 (P) $600 (N)	L	H	High
15	8 Marin Way (Stratham)	Install bioretention cell in grassed area; Use existing catch basin as an overflow structure.	Property owner (corporate park area)	$44,300 - $63,900	$102,100	P: 1.3 lb/yr N: 9.9 lb/yr	$3,900 (P) $600 (N)	M	H	High
16	Adjacent to Timberland Parking Lot off Marin Way (Stratham)	Retrofit existing swales as treatment swales with pre-treatment forebays, to provide treatment prior to discharge to flood storage basin.	Timberland Inc. (property owner)	$20,300 - $29,200	$46,750	P: 0.3 lb/yr N: 2.2 lb/yr	$9,500 (P) $1,100 (N)	H	H	Medium
17	Timberland Parking Lot off Marin Way (Stratham)	Retrofit asphalt apron of catch basin into a bioretention cell, using catch basin for overflow.		$12,700 - $18,200	$29,450	P: 0.4 lb/yr N: 2.8 lb/yr	$3,900 (P) $600 (N)	L	H	Medium
18	588 Portsmouth Avenue (Greenland)	Retrofit the grassed area with a gravel wetland to provide enhanced water quality treatment prior to discharging to the Winnicut River.	Property owner; Greenland DPW	$252,700 - $365,000	$400,850	P: 9.4 lb/yr N: 93 lb/yr	$2,200 (P) $300 (N)	H	M	High

Bantam Lake Watershed Assessment – Sites to Date

Location	Specific Location	Potential Source	Notes
Stormwater/Erosion			
Litchfield Country Club	256 Old South Road, Litchfield	Erosion along banks; fertilizer practices	Land owed by White Memorial; Contact Duncan McGallen
Palmer Road between Route 209 and Deer Island		Frequent flooding up onto lawn and over road	
Culvert on Route 209; quarter mile before junction with Route 109 connecting wetlands and South Bay		Frequent flooding of road	
Stone and dirt piles on Russel Street		Sediment	
Dirt road stream crossing on Town Hill Road off of Beach Street in Goshen		Sediment	
DOT culvert that drains down from Route 63 located at 339 South Street in Litchfield			Culvert crosses sewer line
Forman School	12 Norfolk Road, Litchfield		Property abuts the Bantam River
Area north of Little Pond behind Ocean State Job Lot (South of Route 202)	331 West Street, Litchfield	Unknown	High levels of conductivity found in this area
Brandywine Assisted Living on Constitution Way	19 Constitution Way, Litchfield	Stormwater runoff	No catch basins
Agriculture			
Arethusa Farm on Route 63 in Litchfield	556 S Plains Road, Litchfield	Large dairy farm	Uses Eager Earth to recycle their manure
Small farm on North Lake Street in Litchfield (north of 202 towards Little Pond)		Small farm with crops and cattle	
Horse and hobby farms throughout watershed		manure, fertilizer	
Septic/Sewer			
White Memorial property on north shore of lake; other lake front properties		Septic systems	
Sewer Line that runs north to south along River starting at Route 118 south toward and through the golf course		Sewage	In some places, gets within 75-100 feet of the river.
Old Litchfield Sewer Beds on Whiteswood Road and Bissell		Sewer Beds	
Miscellaneous			
I-2 Systems on Route 209		Industrial practices (LED lights)	

Brainstorming for Watershed Assessment

Contact for watershed assessment information:

Emily DiFranco
edifranco@ceiengineers.com
603-343-6311

B-2: White Memorial Foundation BMP Sites

Site Number	Latitude	Longitude	Comments	Property Ownership	Nutrient Loading Type
JG25	41.738242	-73.2012	Cemetery with excavation and regular mowing	Other	Disrupted Land
JG3	41.73901	-73.206189	Pit toilet edge of playing fields	Town Owned	Failing Septic System
JF5	41.693676	-73.231356	State boat launch parking lot next to lake	State Road	Parking Lot
JF14	41.725247	-73.205777	Boat launch on Bantam River with parking area run off into river	Town Owned	Parking Lot
JF23	41.688179	-73.223075	Morris boat launchParking lot next to lake	Town Owned	Parking Lot
JF3	41.716926	-73.21822	Parking lot erosion at Litchfield Town Beach and boat launch	Town Owned	Parking Lot
JG6	41.728907	-73.185951	Gravel parking lot of playing field with no drainage, low area	Other	Parking Lot
BAS1	41.706545	-73.234649	Parking lots at i2 systems factory on Rt 209 Given gradient they may not drain into our watershed but into the Bantam River downstream of it	Private	Parking Lot
Db7	41.757382	-73.182923	Back of funeral home parking lot	Private	Parking Lot
JF35	41.681926	-73.215792	Erosion run off from parking lot	Private	Parking Lot
JG12	41.747366	-73.179624	Parking lot runoff directly into Bantam River at Litchfield Locker. Clogged catch basin	Private	Parking Lot
JG13	41.752071	-73.177867	Large parking lot above river at Lourdes Shrine no catch basins	Private	Parking Lot
JG21	41.737826	-73.216692	Parking lot Litchfield Inn , no catch basins	Private	Parking Lot
JG24	41.745217	-73.207874	Parking lot of vehicle and supplies storage an restaurant with no catch basins into Moulthrop Brook drainage	Private	Parking Lot
JF27	41.747584	-73.198345	Litchfield community field parking lot erosion due to run off	Town Owned	Parking Lot
CT3	41.696408	-73.230011	Drainage	Private	Road Shoulder Erosion
BAS10	41.693375	-73.240287	Small farm with horses	Private	Agriculture Manure
Bas9	41.693229	-73.240228	Small farm with horse(s)	Private	Agriculture Manure
Gsn42	41.848861	-73.229494	Horse farm with pond but no observable inlet or outlet. Culvert does not extend to pond.	Private	Agriculture Manure
JM 02	41.783616	-73.20281	Little buffer from manure and shore of West Bantam	Private	Agriculture Manure
JF6	41.694684	-73.230946	Palmer Rd. Intermittent road flooding	Driveway	Culverts/Infrastructure
Gsn5	41.826646	-73.203696	Culvert clear and stream moving but roadside erosion.	Land Trust	Culverts/Infrastructure
JB 123-2	41.709126	-73.182284	The culvert eroded and there is a human influence from the trails. There is surrounding vegetation, mainly leaves.	Land Trust	Culverts/Infrastructure
JB 123-3	41.711408	-73.183305	No culvert sighted but there are two streams that connect in the pond. The boardwalk may have an influence.	Land Trust	Culverts/Infrastructure
JB 123-4	41.713381	-73.182279	This has the potential for too much water. The culvert is the right size for the amount of water present. There can be an agricultural and human influence of the surrounding pond! There is plenty of vegetation	Land Trust	Culverts/Infrastructure
JB 123-5	41.709999	-73.188989	No erosion and the culver opening is clear. This is underneath a trail with surrounding vegetation.	Land Trust	Culverts/Infrastructure
JB 123-6	41.708324	-73.190162	Erosion by the right side of the culvert. There is too much water and mud that does not allow much water flow through. There is vegetation surrounding and a lot of mud/sediment. There is a human influence and a	Land Trust	Culverts/Infrastructure
JB124-2	41.741339	-73.178588	There is erosion from the left side of the culvert and there is a mass amount of leaves and sediment.	Land Trust	Culverts/Infrastructure
JB124-3	41.741127	-73.179108	There is extra sediment and deterioration of the land and culvert.	Land Trust	Culverts/Infrastructure
JF13	41.723906	-73.200219	Undersized culvert	Land Trust	Culverts/Infrastructure

Site Number	Latitude	Longitude	Comments	Property Ownership	Nutrient Loading Type
JF17	41.725502	-73.20904	Restricted culvert, occasional gravel road flooding	Land Trust	Culverts/Infrastructure
JF21	41.709332	-73.205503	Restricted culvert	Land Trust	Culverts/Infrastructure
JF71	41.740133	-73.182249	Woods road erosion into stream	Land Trust	Culverts/Infrastructure
JLB123-1	41.708159	-73.183176	There is no erosion sited. There are lots of rocks, leaves, and vegetation nearby. There is a hiking, road, and human influence.	Land Trust	Culverts/Infrastructure
BAS 4	41.711213	-73.233857	Culvert under North Shore Rd between swamp and lake. See BAS3 for roadside description.	Other	Culverts/Infrastructure
CT1	41.695678	-73.230332	Culvert drainage	Private	Culverts/Infrastructure
CT2	41.695966	-73.226961	Culvert damage	Private	Culverts/Infrastructure
Db14	41.741147	-73.182537	Erosion along trail	Private	Culverts/Infrastructure
JF70	41.742577	-73.208426	Tapping Reece parking lot drains into Moulthrup Brook	Private	Culverts/Infrastructure
JG19	41.737881	-73.216361	Apparent large water catch area for Litchfield Inn. Overflow pipe sticking up in middle unknown outlet	Private	Culverts/Infrastructure
JG23	41.744721	-73.208273	Culverts from parking area and highway into Moulthrop Brook near True Value	Private	Culverts/Infrastructure
JG34	41.750031	-73.183356	Collapsed culvert. East Litchfield cemetery with drainage	Private	Culverts/Infrastructure
BAS13	41.681455	-73.218177	Culvert under Rt 109 with tributary to Wittelsy Brook	State Road	Culverts/Infrastructure
BAS14	41.681982	-73.2098	Culvert under Rt 109 with tributary to Wittlesy Brook	State Road	Culverts/Infrastructure
Db 16	41.746014	-73.197126	Culvert running under rye 202 and outflow facings south toward public works dept	State Road	Culverts/Infrastructure
Db14	41.747434	-73.179271	118 bridge	State Road	Culverts/Infrastructure
Db8	41.756411	-73.182898	Bridge construction across route 202	State Road	Culverts/Infrastructure
Gsn54	41.831186	-73.23631	Guard fence recently replaced. Lots of riprap around posts and road edge. One area appears to be eroding down to marsh.	State Road	Culverts/Infrastructure
Gsn57	41.830878	-73.240997	75 foot ditch from end of lawn feeding into culvert. Some erosion from roadside.	State Road	Culverts/Infrastructure
JF8	41.687341	-73.23214	Restricted culvert	State Road	Culverts/Infrastructure
JF9	41.697214	-73.233286	Catch basin clean out on SR 209	State Road	Culverts/Infrastructure
JG11	41.685874	-73.229573	Drainage pipe into Lake at Camp Columbia boathouse	State Road	Culverts/Infrastructure
BAS3	41.711614	-73.233913	This is a swamp on the north side of North Shore Rd just east of BAS2. There is a large culvert (photo 2) that links the swamp to the lake across the road (photo 3)"	Town Owned	Culverts/Infrastructure
Db18	41.73742	-73.194491	Culvert under Gallows Lane downstream from public works	Town Owned	Culverts/Infrastructure
Db19	41.741111	-73.195991	Storm drain to wetland along brook	Town Owned	Culverts/Infrastructure
Gsn59	41.829791	-73.241963	Uncovered piles of soil and gravel behind firehouse. No apparent sand pile. Wetland area behind this lot.	Town Owned	Culverts/Infrastructure
JF15	41.720713	-73.190513	Restricted culvert	Town Owned	Culverts/Infrastructure
JF16	41.720421	-73.194406	Restricted culvert, grave road crossing stream	Town Owned	Culverts/Infrastructure
JF22	41.701655	-73.209239	Culvert with erosion	Town Owned	Culverts/Infrastructure
JF24	41.686892	-73.223794	Morris town beach culverts and erosion into lake	Town Owned	Culverts/Infrastructure

Site Number	Latitude	Longitude	Comments	Property Ownership	Nutrient Loading Type
JF29	41.750717	-73.197425	Restricted culvert	Town Owned	Culverts/Infrastructure
JF31	41.800248	-73.231864	Town hill rd gravel road crossing stream	Town Owned	Culverts/Infrastructure
JF56	41.748858	-73.207151	Road run off at old beidge	Town Owned	Culverts/Infrastructure
JG3	41.740568	-73.203724	Blocked roadside culvert Between swamps	Town Owned	Culverts/Infrastructure
BAS2	41.711512	-73.234031	Storm drain at bottom of short but steep hill on south side of North Shore Rd. Very close to Bantam Lake. Pipe inside drain points directly toward lake"	Town Road	Culverts/Infrastructure
Gsn11	41.827964	-73.200615	Plastic outlet south side broken but water is flowing. Ditch on north side of road shows erosion and flows in toward culvert.	Town Road	Culverts/Infrastructure
Gsn13	41.817332	-73.195547	Very little water. West side road sloped off to culvert. Again east side fields for hay and ditch flows into culvert.	Town Road	Culverts/Infrastructure
Gsn14	41.814175	-73.196805	Appears to be runoff from road to stream bed on both sides. Very high culvert has water dropping over rocks before reaching stream bef	Town Road	Culverts/Infrastructure
Gsn15	41.812305	-73.197484	Culvert is open dry. Westside road shoulder eroding into stream.	Town Road	Culverts/Infrastructure
GSN17	41.804269	-73.198758	Small ditch directing runoff to stream bed. Culvert is open.	Town Road	Culverts/Infrastructure
Gsn19	41.791795	-73.194329	Southside of culvert shows bank erosion. Soil gouged out on right side of culvert.	Town Road	Culverts/Infrastructure
Gsn20	41.801097	-73.188042	Ditch is dry but slopes toward culvert.	Town Road	Culverts/Infrastructure
Gsn21	41.801617	-73.187957	Ditch is dry and culvert appears partially blocked. Neighbor stated there is never water here.	Town Road	Culverts/Infrastructure
Gsn22	41.803855	-73.186763	Ditch on West side drains to culvert. Steep bank on east side shows runoff to stream.	Town Road	Culverts/Infrastructure
Gsn25	41.844598	-73.243125	Significant erosion roadside toward culvert. Culvert troughs rusted away	Town Road	Culverts/Infrastructure
Gsn35	41.840032	-73.230396	Culvert clogged with debris but no observable outlet on opposite roadside. Some erosion of road surface and slope ito culvert ditch.	Town Road	Culverts/Infrastructure
Gsn36	41.840696	-73.229591	Culvert open but no water in stream. Slope on south side could have runoff from road.	Town Road	Culverts/Infrastructure
Gsn37	41.842323	-73.229465	Very steep dropoff from south side road to culvert but no sign of erosion. Culvert open but no water flowing.	Town Road	Culverts/Infrastructure
Gsn38	41.843605	-73.228682	Culvert open on south side. No observable opening on north side.	Town Road	Culverts/Infrastructure
Gsn39	41.844668	-73.228347	Culverts open. No evidence of significant erosion.	Town Road	Culverts/Infrastructure
Gsn40	41.846926	-73.228512	Strong smell of septic waste here. Culverts open. Steep bank from road to culvert on east side.	Town Road	Culverts/Infrastructure
Gsn41	41.84776	-73.228874	Runoff from lawn into west side culvert with obvious ditch.	Town Road	Culverts/Infrastructure
Gsn43	41.850021	-73.230151	Some road runoff on east side. Significant erosion around culvert on West side.	Town Road	Culverts/Infrastructure
Gsn46	41.84478	-73.236505	Low point of Holmes at stop sign to 63. Both culverts open. Drainage from wooded areas.	Town Road	Culverts/Infrastructure
Gsn6	41.877483	-73.224541	Erosion roadside at top of culvert. Ditch erosion opposite . Culvert open and water moving through.	Town Road	Culverts/Infrastructure
JF12	41.740658	-73.215604	New culvert replaces 2019	Town Road	Culverts/Infrastructure
JF12	41.740188	-73.215663	Restricted culvert next to agricultural field	Town Road	Culverts/Infrastructure
JF18	41.727334	-73.211221	Restricted culvert, road flooding	Town Road	Culverts/Infrastructure
JF19	41.727425	-73.210413	Restricted culvert, road flooding	Town Road	Culverts/Infrastructure
JF2	41.720963	-73.201543	Undersized culvert	Town Road	Culverts/Infrastructure

Site Number	Latitude	Longitude	Comments	Property Ownership	Nutrient Loading Type
JF24	41.686215	-73.220961	Box culvert	Town Road	Culverts/Infrastructure
JF33	41.808666	-73.233576	Town hill road widening project	Town Road	Culverts/Infrastructure
JF4	41.705709	-73.204246	Old catch basin	Town Road	Culverts/Infrastructure
JF9	41.71264	-73.22775	White Memorial campground store parking lot Ron off into catch basin then into lake North shore rd run off into lake"	Town Road	Culverts/Infrastructure
JG16	41.744484	-73.196754	Shoulder erosion and clogged culvert near Town garage	Town Road	Culverts/Infrastructure
JG17	41.763352	-73.20633	Shoulder erosion clogged culvert North Lake Street dirt road	Town Road	Culverts/Infrastructure
JG32	41.746551	-73.172299	Roadside erosion, blocked culvert, East Litchfield Rd near Collins Rd	Town Road	Culverts/Infrastructure
JM 01	41.787262	-73.222955	New Brooks Road culvert with minimal sedimentation	Town Road	Culverts/Infrastructure
JG27	41.73567	-73.202421	Low trail crossing possible overflow erosion along community trail	Trail/Path	Culverts/Infrastructure
CT5	41.695784	-73.229354	Culvert. Drainage.	Private	Culverts/Infrastructure-Surface Erosion
Gsn44	41.853148	-73.238261	Road runoff into ditch flows to culvert on north side of road. south side culvert flows into pond. Sounds of rooster and other fowl from area behind pond but no visible shelter	Private	Road Shoulder Erosion
JF57	41.773685	-73.219173	Litchfield Horticultural Center East side of Beach St.	Private	Road Shoulder Erosion
JF61	41.801807	-73.219339	Woodbridge Lake Sewer treatment Facility	Private	Road Shoulder Erosion
JF61	41.833385	-73.197628	Action Wildlife Trust	Private	Road Shoulder Erosion
JM 03	41.757292	-73.182642	Drive way run potential from Funeral home and veterinary offices	Private	Road Shoulder Erosion
Gsn33	41.836042	-73.215477	Roadside erosion (route 4) and culvert flow into Fox Brook stream.	State Road	Road Shoulder Erosion
Gsn52	41.831106	-73.237332	Route 4 runoff into marsh in 2 places by design. The areas are macadamed.	State Road	Road Shoulder Erosion
Gsn53	41.831071	-73.23523	Disturbed roadside area sloping toward marsh edge.	State Road	Road Shoulder Erosion
Gsn55	41.831212	-73.237264	Route 4 runoff into marsh by design.	State Road	Road Shoulder Erosion
Gsn56	41.831066	-73.239376	Route 4 runoff into ditch running to west branch bantam river.	State Road	Road Shoulder Erosion
Gsn58	41.830359	-73.244136	Route 4 runoff by design ito forested area. Additional washout from road alongside macadamed area.	State Road	Road Shoulder Erosion
JF59	41.812682	-73.235921	State boat launch at Dog Pond, parking lot next to lake	State Road	Road Shoulder Erosion
JF67	41.785044	-73.208772	Road run off into river	State Road	Road Shoulder Erosion
JG14	41.747341	-73.178873	Direct runoff from State Highway 118 into Bantam River	State Road	Road Shoulder Erosion
BAS8	41.743179	-73.195973	Various material piles at Litchfield DPW near brook (Tanners?) and across the street from wetlands	Town Owned	Road Shoulder Erosion
Db11	41.730013	-73.184754	Camp Dutton rd along river	Town Owned	Road Shoulder Erosion
Db17	41.745	-73.196862	Brook along road to public works	Town Owned	Road Shoulder Erosion
JF30	41.750569	-73.197184	Sheldon Ave roadside erosion and run off into stream	Town Owned	Road Shoulder Erosion
JF31	41.750552	-73.199178	Sheldon Ave run off and erosion	Town Owned	Road Shoulder Erosion
Db2	41.791793	-73.194308	Weed rd erosion	Town Road	Road Shoulder Erosion

Site Number	Latitude	Longitude	Comments	Property Ownership	Nutrient Loading Type
Gsn18	41.803891	-73.198776	Ditch erosion on West side. Road runoff on east side.	Town Road	Road Shoulder Erosion
Gsn23	41.803253	-73.187434	Road and bank eroding on West side of culvert. Less erosion on east side.	Town Road	Road Shoulder Erosion
Gsn24	41.805774	-73.186496	Bank with steep slope from road edge. Road edge erosion.	Town Road	Road Shoulder Erosion
Gsn45	41.851364	-73.24169	Roadside erosion down Holmes and flowing north along 63 into ditch.	Town Road	Road Shoulder Erosion
JF58	41.812197	-73.23391	Gravel road over stream	Town Road	Road Shoulder Erosion
JF60	41.811477	-73.221834	Gravel road crossing stream, road erosion run off into stream	Town Road	Road Shoulder Erosion
JF62	41.802828	-73.216635	Road run off	Town Road	Road Shoulder Erosion
JF63	41.803863	-73.209322	Gravel Road crossing stream	Town Road	Road Shoulder Erosion
JF64	41.788023	-73.218716	Occasional road flooding	Town Road	Road Shoulder Erosion
JF65	41.78989	-73.204084	Road run off into stream	Town Road	Road Shoulder Erosion
JF66	41.789173	-73.210807	Road run off into stream	Town Road	Road Shoulder Erosion
JG28	41.720918	-73.201394	Roadside erosion Webster Rd	Town Road	Road Shoulder Erosion
JG29	41.719235	-73.182957	Roadside erosion Pitch Rd	Town Road	Road Shoulder Erosion
JG30	41.720617	-73.18521	Roadside erosion, Pitch Rd	Town Road	Road Shoulder Erosion
JF1	41.726584	-73.208146	River bank erosion accelerated by foot traffic when canoes and kayaks are launched from this location	Land Trust	Shoreline/Stream Bank Erosion
JF10	41.712404	-73.227963	White Memorial boat launch run off into lake	Land Trust	Shoreline/Stream Bank Erosion
JF20	41.710034	-73.205936	Shoreline vegetation disturbance	Land Trust	Shoreline/Stream Bank Erosion
JF25	41.686738	-73.225635	Sediments entering lake	Land Trust	Shoreline/Stream Bank Erosion
JF36	41.685104	-73.214399	Stream bank erosion	Land Trust	Shoreline/Stream Bank Erosion
JF46	41.730612	-73.194068	Riverbank erosion	Land Trust	Shoreline/Stream Bank Erosion
JF49	41.727786	-73.192972	Riverbank erosion	Land Trust	Shoreline/Stream Bank Erosion
JF52	41.728471	-73.191406	Riverbank erosion	Land Trust	Shoreline/Stream Bank Erosion
JF7	41.693818	-73.23206	Run off from SR 209 into state boat launch and into lake	State Road	Shoreline/Stream Bank Erosion
JF12	41.735968	-73.195267	Sewer line above stream	Town Owned	Shoreline/Stream Bank Erosion
Gsn1	41.83342	-73.209716	Riverbank erosion at trail bridge bank supports. Also dog poop on trail near bridge.	Land Trust	Shoreline/Stream Bank Erosion
Gsn2	41.831006	-73.207351	Bank erosion where stream bends.	Land Trust	Shoreline/Stream Bank Erosion
Gsn31	41.83416	-73.213926	River bank erosion.	Land Trust	Shoreline/Stream Bank Erosion
Gsn32	41.83894	-73.215136	Stream bank erosion. Fox Brook.	Land Trust	Shoreline/Stream Bank Erosion
Gsn4	41.829341	-73.206153	Riverbank erosion downhill.	Land Trust	Shoreline/Stream Bank Erosion
JB 123-7	41.708589	-73.195341	The right side is open and free flowing but the left side is sour rounded by vegetation and sediment. The water flow is minimal on the left side because of the mud. There is a human influence through biking	Land Trust	Shoreline/Stream Bank Erosion

Site Number	Latitude	Longitude	Comments	Property Ownership	Nutrient Loading Type
JF19	41.709384	-73.206635	Sediments entering the lake	Land Trust	Shoreline/Stream Bank Erosion
JF34	41.726006	-73.208657	Erosion on Bantam River	Land Trust	Shoreline/Stream Bank Erosion
JF44	41.731158	-73.194894	Riverbank erosion	Land Trust	Shoreline/Stream Bank Erosion
JF47	41.729674	-73.191926	Riverbank erosion	Land Trust	Shoreline/Stream Bank Erosion
JF48	41.72925	-73.191678	Riverbank erosion	Land Trust	Shoreline/Stream Bank Erosion
JF50	41.727926	-73.192153	Riverbank erosion	Land Trust	Shoreline/Stream Bank Erosion
JF51	41.727631	-73.191794	River oxbow	Land Trust	Shoreline/Stream Bank Erosion
JF55	41.732523	-73.195551	Riverbank erosion	Land Trust	Shoreline/Stream Bank Erosion
JF73	41.742923	-73.180767	River bank erosion	Land Trust	Shoreline/Stream Bank Erosion
Gsn27	41.814153	-73.201615	Bank erosion. West Bank of Ivy Mtn. Brook.	Other	Shoreline/Stream Bank Erosion
Gsn28	41.813382	-73.201372	Bank erosion, west side Ivy Mtn. Brook.	Other	Shoreline/Stream Bank Erosion
Gsn30	41.810529	-73.199611	Bank erosion west side Ivy Mtn. Brook	Other	Shoreline/Stream Bank Erosion
Db10	41.730691	-73.185792	Cleared land to river edge	Private	Shoreline/Stream Bank Erosion
Db3	41.782818	-73.189146	80. + yards vegetation is cleared 8 ft wide much erosion clearing runs along river and into river	Private	Shoreline/Stream Bank Erosion
Db5	41.774945	-73.185729	Erosion on West Bank of river	Private	Shoreline/Stream Bank Erosion
Db6	41.757306	-73.18454	Forman school athletics fields to edge of river erosion	Private	Shoreline/Stream Bank Erosion
Db9	41.729398	-73.187596	Large grass playing fields edge river	Private	Shoreline/Stream Bank Erosion
Gsn47	41.830765	-73.239137	Stream bank erosion. School bus parking lot about 75 feet away. Paved lot	Private	Shoreline/Stream Bank Erosion
Gsn48	41.830256	-73.239562	Some minor erosion of river bank.	Private	Shoreline/Stream Bank Erosion
Gsn26	41.816626	-73.202572	Bank erosion.	Town Owned	Shoreline/Stream Bank Erosion
Gsn29	41.811056	-73.199478	Bank erosion east side Ivy Mtn. brook	Town Owned	Shoreline/Stream Bank Erosion
Gsn16	41.807959	-73.199533	Road shoulder erosion both ends. Pile of soil on West River bank.	Town Road	Shoreline/Stream Bank Erosion
JG4	41.737917	-73.20224	Released beaver dam material next to water including dirt	Town Road	Shoreline/Stream Bank Erosion
JF37	41.686302	-73.211287	Stream bank erosion from run off agricultural field	Private	Shoreline/Stream Bank Erosion/Surface Erosion
JF54	41.730351	-73.193145	Narrow vegetated buffer along riverbank	Land Trust	Shorelines with no or little vegetative buffer
JF68	41.697342	-73.230251	Storm water run off into lake	Private	Surface Erosion
JB 124-1	41.742563	-73.174479	The area is clear, but has surrounding vegetation. There is a human influence due to the trail and surrounding homes.	Land Trust	Surface Erosion
JF40	41.686686	-73.212306	Agricultural run off	Land Trust	Surface Erosion
JF41	41.686868	-73.212783	Agricultural run off	Land Trust	Surface Erosion
JG5	41.728829	-73.185885	Playing fields, flood regularly White Memorial soccer fields"	Land Trust	Surface Erosion

Site Number	Latitude	Longitude	Comments	Property Ownership	Nutrient Loading Type
BAS6	41.709873	-73.234047	Lakeside garden work	Private	Surface Erosion
CT4	41.696781	-73.230156	Drainage	Private	Surface Erosion
Db14	41.747386	-73.197882	Pond between Community Field and plaza on 202	Private	Surface Erosion
Db15	41.747195	-73.197328	Stream behind parking in back of 202 plaza	Private	Surface Erosion
Db4	41.787546	-73.190259	Cleared path through streams and along river	Private	Surface Erosion
Gsn51	41.833908	-73.220374	Comerford animal farm with fields extending to marsh area in back but unable to take photo.	Private	Surface Erosion
JF11	41.740104	-73.215851	Agricultural pasture field	Private	Surface Erosion
JF32	41.803277	-73.232259	Thorncrest Farm - agricultural run off dairy cows	Private	Surface Erosion
JF38	41.686901	-73.21029	Tractor access road stream crossing	Private	Surface Erosion
JF38	41.686483	-73.211057	Tractor access road stream crossing	Private	Surface Erosion
JF39	41.686825	-73.211117	Tractor access path stream crossing	Private	Surface Erosion
JF42	41.682416	-73.209915	Agricultural run off	Private	Surface Erosion
JG10	41.743053	-73.172178	Agriculture, vineyard	Private	Surface Erosion
JG31	41.722817	-73.17665	Auto salvage yard Little Pitch Rd	Private	Surface Erosion
JG33	41.749366	-73.182723	Cemetery with drainage , regular mowing, excavation	Private	Surface Erosion
JF28	41.74764	-73.197342	Litchfield Community fields run off erosion	Town Owned	Surface Erosion
JF29	41.749014	-73.197717	Litchfield community field batting cages run off erosion	Town Owned	Surface Erosion
JF74	41.734508	-73.206159	Beaver impoundment on sewer ROW	Town Owned	Surface Erosion
JG1	41.741936	-73.206707	Maintained playing fields, possible fertilizer and herbicide	Town Owned	Surface Erosion
JG2	41.739232	-73.204826	Maintained playing fields, possible fertilizer and herbicides	Town Owned	Surface Erosion
JG7	41.725117	-73.1783	Former landfill dump, present recycling location	Town Owned	Surface Erosion
Gsn12	41.818735	-73.195335	Next to large fields which appear to be for hay not cattle. Ditch appears to flow into culvert on east side. West side is dry.	Town Road	Surface Erosion
JG26	41.735965	-73.20179	Erosion around trail edge between swamp drainage, Greenway trail behind cemetery	Trail/Path	Surface Erosion
Gsn3	41.829977	-73.206368	Erosion of the hillside carrying sand pile, uncovered, from Torrington Country Club.	Land Trust	Uncovered Stockpiles
Gsn49	41.830155	-73.205358	Upslope from site 3. Significant water erosion and used sand pile from golf course collapse causing sand to wash downslope to stream on Goshen Land Trust property. Occurred 2 years ago. Situation remediated in coordination with Goshen Land Trust. GLT monitors for further erosion."	Land Trust	Uncovered Stockpiles
JF53	41.730203	-73.192639	Uncovered piles of soil and other materials near river could be a run off issue	Land Trust	Uncovered Stockpiles
BAS12	41.683097	-73.237706	Construction site	Private	Uncovered Stockpiles
Bas5	41.709929	-73.234037	Sand box at edge of Lake in Breezy Knoll	Private	Uncovered Stockpiles
JF69	41.698429	-73.229985	Storm water run off into lake	Private	Uncovered Stockpiles
JG9	41.727547	-73.181181	Heavy construction business Little Pitch Road. Open dirt piles and Dirt screening operation"	Private	Uncovered Stockpiles

Site Number	Latitude	Longitude	Comments	Property Ownership	Nutrient Loading Type
JG20	41.737871	-73.216631	State highway garage. Sand,salt storage, truck washing	State Road	Uncovered Stockpiles
BAS7	41.741257	-73.196068	Litchfield DPW sand and other pile near wetland and stream	Town Owned	Uncovered Stockpiles
Gsn50	41.832556	-73.222278	Sand and soil piles uncovered at Goshen Town garage. Pond on edge of property.	Town Owned	Uncovered Stockpiles
JF43	41.729033	-73.19991	Lichfield's old sewer beds	Land Trust	Unmaintained Land
JF45	41.730792	-73.193999	High concentration of Canada Goose droppings	Land Trust	Wildlife Droppings
Gsn34	41.831807	-73.195499	Pond on Action Wildlife connected to pond on other side of Route 4. Geese and livestock have access to both bodies of water.	Private	Wildlife Droppings

B-3: Field Survey Form

Bantam Lake Watershed Assessment Field Survey Form

Site # ____ Date:_______________ Field Crew:____

Weather Conditions: _________________________ Rain in last 48 hours?__________________________

Location (*house #, road name, intersection)* ____

GPS Coordinates: ____Photos Taken? ______

Land Use/Activity: *circle one*

State Road	*Residential*	*Trail/Path*
Municipal Road	*Commercial*	*Agriculture*
Private Road	*Municipal/Public*	*Construction Site*
Driveway	*Boat Access*	*Other:* ________________

Description of Problems: *circle ALL that apply*

Problem Type	Description (circle)	Notes/Description of Problem	Approximate Size (length x width)
Surface Erosion	*Slight* *Moderate* *Severe*		
Road Shoulder Erosion	*Slight* *Moderate* *Severe*		
Soil	*Bare* *Uncovered Pile* *Winter Sand*		
Culvert	*Unstable Inlet/Outlet* *Clogged* *Crushed/Broken* *Undersized*		
Ditch	*Slight Erosion* *Moderate Erosion* *Severe Erosion* *Bank Failure* *Undersized*		
Parking Lot	*Drains Directly to Waterbody* *Evidence of Concentrated Flow*		
Shoreline	*Undercut* *Lack of Shoreline Vegetation* *Erosion* *Unstable Access*		
Agriculture	*Livestock Access to Waterbody* *Tilled Eroding Fields* *Manure Washing Off-Site* *Inadequate Buffer*		
Other			

Recommended BMP(s): *circle ALL that apply*

Add Vegetation	*Armor with Stone*	*Install Catch Basin*
Establish Buffer	*Divert Runoff*	*Armor Inlet/Outlet (Culvert)*
Enhance Buffer	*Rain Garden*	*Replace Culvert*
Mulch	*Detention Basin*	*Enlarge Culvert*
Add New Surface Material	*Infiltration Trench*	*Install Plunge Pool (Culvert)*
Grade	*Water Retention Swales*	*Other:* __________________

Description of Recommendation(s):

Potential Site Constraints: *circle ALL that apply*

Limited Space	*Permitting Issues*	*May Interfere with Snow Plowing*
Utilities	*Steep Slope*	*Other:* __________________
Private Property	*Difficult Access*	
Crosses Property Lines		

Drawing of Recommended BMP(s):

APPENDIX C:

BMP Documentation

C-1: Structural Stormwater BMP Cost and Pollutant Reduction Estimates

C-2: Supporting Reference BMP Unit Pricing from Past Projects

C-3: Supporting Output from MassDEP WBP BMP Selector Tool

C-4: Supporting Load Reduction Output from EPA Region 5 Tool

C-1: Structural Stormwater BMP Cost and Pollutant Reduction Estimates

Area 1: White Mountain Foundation Road Flooding & Watershed-wide Culverts

Misc. Supporting Values, Pollutant Load Reduction Calculations, and BMP Sizing

Variable	Value
Drainage Area (ac)	147.2
Land Use	N/A
Typical Soil Type	N/A
Issue(s)	Culverts throughout the watershed lead to flooding, scour, and bank erosion.
Proposed Improvements	Perform watershed-wide culvert assessment to identify potential culvert issues that contribute to nutrient loading and flooding.
TSS Load Reduction (Tons/yr)	-
TP Load Reduction (lb/yr)	-
TN Load Reduction (lb/yr)	-

Table Notes:

1. Upstream Drainage Area of example culvert deineated from USGS StreamStats.

Construction Cost Estimate

Description	Unit of Measure	Quantity	Unit Price	Total
N/A				
			Total:	**$0.00**
			Rounded Total:	

Table Notes:

1. Order-of-magnitude unit pricing for culvert replacements can be found on CEI Cost Reference Table from past projects (Appendix A.2)

Area 2: Whitehall Road Trail Network, unofficial canoe and kayak launch.

Misc. Supporting Values, Pollutant Load Reduction Calculations, and BMP Sizing

Variable	Value
Drainage Area (ac)	N/A
Land Use	N/A
Typical Soil Type	Loamy Sand, Type A
Issue(s)	Severe bank erosion caused by unoffical canoe and kayak boat launch.
Proposed Improvements	Regrade; then stabilize, armor, and vegetate appx. 20' x 15' steep slope. Provide improved public access (i.e., steps).
TSS Load Reduction (Tons/yr)	4.7
TP Load Reduction (lb/yr)	4
TN Load Reduction (lb/yr)	8

Table Notes:

1. Upstream Drainage Area and Land Use is Not Applicable. Issue is localized from human use.

2. Load Reduction Source is EPA Region 5 Calculator (Appendix A.4)

Construction Cost Estimate

Description	Unit of Measure	Quantity	Unit Price	Total
Mobilization / Demobilization	LS	1	$5,000.00	$5,000.00
Regrade, then stabilize steep slope	SF	300	$10.00	$3,000.00
Install improved public access steps	LS	1	$7,500.00	$7,500.00
Vegetate sides of access point	SF	300	$10.00	$3,000.00
Stabilize streambank	SF	100	$10.00	$1,000.00
Misc. Items	LS	1	$5,000.00	$5,000.00
			Total:	**$24,500.00**
			Rounded Total:	**$25,000.00**

Table Notes:

1. Unit pricing based on CEI Cost Reference Table from past projects (Appendix A.2). Rounded up given small overall project footprint for conservatism.

Area 3: Boat Launch to Bantam River, West Side of Bridge on Mattatuck Trail

Misc. Supporting Values, Pollutant Load Reduction Calculations, and BMP Sizing

Variable	Value
Drainage Area (ac)	0.07
Land Use	N/A
Typical Soil Type	Silt Loam, Type B/D
Issue(s)	Eroding gravel boat launch.
Proposed Improvements	Stabilize gravel boat launch with add'l stone. Redirect flow from upstream parking area to vegetated area to west of the site via water bar / earthen berm with riprap outlet.
TSS Load Reduction (Tons/yr)	0.8
TP Load Reduction (lb/yr)	0.8
TN Load Reduction (lb/yr)	1.5

Table Notes:

1. Potential BMP upstream drainage area delineated from 1-ft contours and aerial imagery.

2. Load Reduction Source is EPA Region 5 Calculator. See Attached sheet for calculation.

Construction Cost Estimate

Description	Unit of Measure	Quantity	Unit Price	Total
Mobilization / Demobilization	LS	1	$5,000.00	$5,000.00
Stabilize gravel boat ramp	SF	225	$10.00	$2,250.00
Water Bar / Earthen Berm	LF	50	$50.00	$2,500.00
Misc.	LS	1	$1,000.00	$1,000.00
			Total:	**$10,750.00**
			Rounded Total:	**$11,000.00**

Table Notes:

1. Unit pricing based on CEI Cost Reference Table from past projects. Rounded up given small overall project footprint for conservatism.

Area 4: Litchfield Country Club (Site 1 of 8)

Misc. Supporting Values, Pollutant Load Reduction Calculations, and BMP Sizing

Variable	Value
Drainage Area (ac)	N/A
Land Use	N/A
Typical Soil Type	Silt Loam, Type B/D
Issue(s)	Erosion of Bantam River Bank, Inadequate vegetated buffer
Proposed Improvements	Stabilize appx. 20' by 8' eroded bank with bio-stabilizaton techniques. Expand width of "no-mow" buffer as feasible.
TSS Load Reduction (Tons/yr)	0.6
TP Load Reduction (lb/yr)	0.6
TN Load Reduction (lb/yr)	1.2

Table Notes:

1. Upstream Drainage Area and Land Use is Not Applicable. Issue is localized from human use.

2. Load Reduction Source is EPA Region 5 Calculator (Appendix A.4)

Construction Cost Estimate

Description	Unit of Measure	Quantity	Unit Price	Total
Mobilization / Demobilization	LS	1	$0.00	$0.00
Erosion Repair	SF	200	$2.00	$400.00
Naturalized Bank Stabilization	SF	200	$15.00	$3,000.00
Misc.	LS	1	$1,000.00	$1,000.00
			Total:	**$4,400.00**
			Rounded Total:	**$5,000.00**

Table Notes:

1. Unit pricing based on CEI Cost Reference Table from past projects (Appendix A.2). Rounded up given small overall project footprint for conservatism.

2. Assume Litchfield Country Club personnel will perform stabilization. Therefore, Contractor mobilization and demobilization is not applicable.

Area 4: Litchfield Country Club (Site 2 of 8)

Misc. Supporting Values, Pollutant Load Reduction Calculations, and BMP Sizing

Variable	Value
Drainage Area (ac)	N/A
Land Use	N/A
Typical Soil Type	N/A
Issue(s)	Inadequate vegetated buffer; Geese congregation.
Proposed Improvements	Expand buffer width along appx. 100' length of streambank as feasible to reduce amount of geese droppings that enter Bantam River.
TSS Load Reduction (Tons/yr)	-
TP Load Reduction (lb/yr)	1.98
TN Load Reduction (lb/yr)	9.5

Table Notes:

1. Upstream Drainage Area and Land Use is Not Applicable. Issue is localized and there is no erosion to repair.

2. Assume 30 geese generally use this area per year and each export 0.44 lb/yr of TP per Lake Load Response Model defaults (existing load = 13.2 lb/yr of TP). Assume enhanced buffer reduces existing load by 15%.

3. Assume 30 geese generally use this area per year and each export 2.1 lb/yr of TN per Lake Load Response Model defaults (existing load = 63 lb/yr of TP). Assume enhanced buffer reduces existing load by 15%.

Construction Cost Estimate

Description	Unit of Measure	Quantity	Unit Price	Total
Mobilization / Demobilization	LS	1	$0.00	$0.00
Install Vegetated Buffer	SF	1000	$8.50	$8,500.00
Misc.	LS	1	$1,000.00	$1,000.00
			Total:	**$9,500.00**
			Rounded Total:	**$10,000.00**

Table Notes:

1. Unit pricing based on CEI Cost Reference Table from past projects (Appendix A.2). Rounded up given small overall project footprint for conservatism.

2. Assume Litchfield Country Club personnel will perform stabilization. Therefore, Contractor mobilization and demobilization is not applicable.

Area 4: Litchfield Country Club (Site 3 of 8)

Misc. Supporting Values, Pollutant Load Reduction Calculations, and BMP Sizing

Variable	Value
Drainage Area (ac)	N/A
Land Use	N/A
Typical Soil Type	N/A
Issue(s)	Exposed topsoil stockpiles directly adjacent to Bantam River.
Proposed Improvements	Cover stockpile and surround with perimeter controls when not in use. Relocate stockpiles to adjacent side of access road.
TSS Load Reduction (Tons/yr)	0.51
TP Load Reduction (lb/yr)	0.51
TN Load Reduction (lb/yr)	1

Table Notes:

1. Upstream Drainage Area and Land Use is Not Applicable. Issue is localized and there is no erosion to repair.

2. Load Reduction Source is EPA Region 5 Calculator (Appendix A.4)

Construction Cost Estimate

Description	Unit of Measure	Quantity	Unit Price	Total
Re-locate stockpiles	LS	1	$0.00	$0.00
			Total:	**$0.00**
			Rounded Total:	

Table Notes:

1. Assume Litchfield Country Club personnel will perform stockpile re-location at no cost.

Area 4: Litchfield Country Club (Site 4 of 8)

Misc. Supporting Values, Pollutant Load Reduction Calculations, and BMP Sizing

Variable	Value
Drainage Area (ac)	1
Land Use	N/A
Typical Soil Type	N/A
Issue(s)	Inadequate vegetated buffer and steep upstream slopes for appx. 100' long section.
Proposed Improvements	Expand "no-mow" buffer width along appx. 100' length of streambank as feasible to reduce fertilizer loading from upstream fairway.
TSS Load Reduction (Tons/yr)	-
TP Load Reduction (lb/yr)	2.3
TN Load Reduction (lb/yr)	2.3

Table Notes:

1. Potential BMP upstream drainage area delineated from 1-ft contours and aerial imagery.

2.Fertilizer load reduction: Assume application of 10%-10%-10% (N-P-K) formula fertilizer at 3.5 lbs per 1000 square feet twice per growing season for an overall application of 30.4 lb TP/TN . Assume 10% of existing TP/TN load washes into the Bantam River (3 lb/yr). Assume enhanced buffer will reduce the existing load by 75% for an overall reduction of 2.3 lb TP/TN per yr.

Construction Cost Estimate

Description	Unit of Measure	Quantity	Unit Price	Total
Expand No-Low Buffer	LS	1	$0.00	$0.00
			Total:	**$0.00**
			Rounded Total:	

Table Notes:

1. Assume Litchfield Country Club personnel to adjust mowing extent at no cost.

Area 4: Litchfield Country Club (Site 5 of 8)

Misc. Supporting Values, Pollutant Load Reduction Calculations, and BMP Sizing

Variable	Value
Drainage Area (ac)	N/A
Land Use	N/A
Typical Soil Type	Silt Loam, Type B/D
Issue(s)	Erosion of appx. 100' section of Bantam River Bank
Proposed Improvements	Stabilize eroding bank (appx. 100' by 5') using combination of bio-stabilization and armoring techniques.
TSS Load Reduction (Tons/yr)	1.9
TP Load Reduction (lb/yr)	1.9
TN Load Reduction (lb/yr)	3.8

Table Notes:

1. Upstream Drainage Area and Land Use is Not Applicable. Issue is localized from human use.

2. Load Reduction Source is EPA Region 5 Calculator (Appendix A.4)

Construction Cost Estimate

Description	Unit of Measure	Quantity	Unit Price	Total
Mobilization / Demobilization	LS	1	$0.00	$0.00
Erosion Repair	SF	375	$2.00	$750.00
Bank Stabilization	SF	375	$15.00	$5,625.00
Misc.	LS	1	$1,000.00	$1,000.00
			Total:	**$7,375.00**
			Rounded Total:	**$8,000.00**

Table Notes:

1. Unit pricing based on CEI Cost Reference Table from past projects (Appendix A.2). Rounded up given small overall project footprint for conservatism.

2. Erosion was not present along entire 100' foot section. Assume stabilization will be required for appx. 75'.

3. Assume Litchfield Country Club personnel will perform stabilization. Therefore, Contractor mobilization and demobilization is not applicable.

Area 4: Litchfield Country Club (Site 6 of 8)

Misc. Supporting Values, Pollutant Load Reduction Calculations, and BMP Sizing

Variable	Value
Drainage Area (ac)	N/A
Land Use	N/A
Typical Soil Type	Silt Loam, Type B/D
Issue(s)	Erosion of appx. 200' section of Bantam River Bank.
Proposed Improvements	Stabilize eroding bank (appx. 200' by 6') using combination of bio-stabilization and armoring techniques. Expand "no mow" buffer as feasible.
TSS Load Reduction (Tons/yr)	4.6
TP Load Reduction (lb/yr)	4.6
TN Load Reduction (lb/yr)	9.2

Table Notes:

1. *Upstream Drainage Area and Land Use is Not Applicable. Issue is localized from human use.*
2. *Load Reduction Source is EPA Region 5 Calculator. See Attached sheet for calculation.*

Construction Cost Estimate

Description	Unit of Measure	Quantity	Unit Price	Total
Mobilization / Demobilization	LS	1	$5,000.00	$5,000.00
Erosion Repair	SF	1200	$2.00	$2,400.00
Bank Stabilization	SF	1200	$15.00	$18,000.00
Misc.	LS	1	$1,000.00	$1,000.00
			Total:	**$26,400.00**
			Rounded Total:	**$27,000.00**

Table Notes:

1. *Unit pricing based on CEI Cost Reference Table from past projects. Rounded up given small overall project footprint for conservatism.*
2. Given severity of erosion, assume speciality Contractor will be required.

Area 4: Litchfield Country Club (Site 7 of 8)

Misc. Supporting Values, Pollutant Load Reduction Calculations, and BMP Sizing

Variable	Value
Drainage Area (ac)	N/A
Land Use	N/A
Typical Soil Type	N/A
Issue(s)	Oxbow Formation
Proposed Improvements	Allow oxbow formation to proceed naturally.
TSS Load Reduction (Tons/yr)	-
TP Load Reduction (lb/yr)	-
TN Load Reduction (lb/yr)	-

Table Notes:

1. *None.*

Construction Cost Estimate

Description	Unit of Measure	Quantity	Unit Price	Total
N/A - No Recommended Action				$0.00
			Total:	**$0.00**
			Rounded Total:	**$0.00**

Table Notes:

1. *None*

Area 4: Litchfield Country Club (Site 8 of 8)

Misc. Supporting Values, Pollutant Load Reduction Calculations, and BMP Sizing

Variable	Value
Drainage Area (ac)	N/A
Land Use	N/A
Typical Soil Type	Silt Loam, Type B/D
Issue(s)	Erosion of appx. 50' section of Bantam River Bank.
Proposed Improvements	Stabilize eroding bank (appx. 50' by 6') using combination of bio-stabilization and armoring) techniques. Expand "no mow" buffer as feasible.
TSS Load Reduction (Tons/yr)	3.4
TP Load Reduction (lb/yr)	3.4
TN Load Reduction (lb/yr)	6.9

Table Notes:

1. Potential BMP upstream drainage area delineated from 1-ft contours and aerial imagery.

2. Load Reduction Source is EPA Region 5 Calculator (Appendix A.4)

Construction Cost Estimate

Description	Unit of Measure	Quantity	Unit Price	Total
Mobilization / Demobilization	LS	1	$5,000.00	$5,000.00
Erosion Repair	SF	300	$2.00	$600.00
Bank Stabilization	SF	300	$15.00	$4,500.00
Misc.	LS	1	$1,000.00	$1,000.00
			Total:	**$11,100.00**
			Rounded Total:	**$12,000.00**

Table Notes:

1. Unit pricing based on CEI Cost Reference Table from past projects (Appendix A.2). Rounded up given small overall project footprint for conservatism.

2. Given severity of erosion, assume speciality Contractor will be required.

Area 5: State Boat Launch at Dog Pond, Town Hill Road, Goshen

Misc. Supporting Values, Pollutant Load Reduction Calculations, and BMP Sizing

Variable	Value
Drainage Area (ac)	0.1
Land Use	Low density residential (100% Impervious)
Typical Soil Type	N/A
Issue(s)	Untreated runoff from gravel parking lot to Dog Pond.
Proposed Improvements	Enhance buffer along bottom edge of parking area with double row of plantings (appx. 80' x 5').
TSS Load Reduction (Tons/yr)	-
TP Load Reduction (lb/yr)	-
TN Load Reduction (lb/yr)	-

Table Notes:

1. Potential BMP upstream drainage area delineated from 1-ft contours and aerial imagery.

2. Insufficient data to calculate potential load reductions.

Construction Cost Estimate

Description	Unit of Measure	Quantity	Unit Price	Total
Double row of plantings / Vegetated Buffer	SF	500	$10.00	$5,000.00
			Total:	**$5,000.00**
			Rounded Total:	**$5,000.00**

Table Notes:

1. Unit pricing based on CEI Cost Reference Table from past projects (Appendix A.2). Rounded up given small overall project footprint for conservatism.

Area 6: Town Hill Road, Beach Street to Thorncrest Farm

Misc. Supporting Values, Pollutant Load Reduction Calculations, and BMP Sizing

Variable	Value
Drainage Area (ac)	4.6
Land Use	Imperv. Low Density Residential (50%); Perv. Forest (50%)
Typical Soil Type	Fine Sandy Loam, Well Drained
Issue(s)	Steep 3,500 linear foot gravel road with shoulder erosion that discharges into an unnamed stream.
Proposed Improvements	Install rock swales with check dams along east side of road for appx. 1,000'. Install waterbar diversions that discharge to depressed riprap aprons along remaining forested 2,000' of road to unnamed stream.
TSS Load Reduction (Tons/yr)	5.3
TP Load Reduction (lb/yr)	4.5
TN Load Reduction (lb/yr)	8.9

Table Notes:

1. Potential BMP upstream drainage area delineated from 1-ft contours and aerial imagery.

2. Load Reduction Source is EPA Region 5 Calculator (Appendix A.4). See Attached sheet for calculation. Assume erosion is present along appx. 20% of the 3,500 linear foot alignment at a width of 2 feet and a shallow depth of 3 inches.

Construction Cost Estimate

Description	Unit of Measure	Quantity	Unit Price	Total
Mobilization / Demobilization	LS	1	$5,000.00	$5,000.00
Erosion Repair	SF	1400	$2.50	$3,500.00
Install roadside rock swales with check dams	SF	3000	$6.00	$18,000.00
Install Water Bar and Riprap Apron	EA	20	$2,000.00	$40,000.00
Misc.	LS	1	$5,000.00	$5,000.00
			Total:	**$71,500.00**
			Rounded Total:	**$72,000.00**

Table Notes:

1. Assume erosion is present along appx. 20% of the 3,500 linear foot alignment at a width of 2 feet.

2. Assume swales will have width of appx. 3 feet pending detailed design.

Area 7: Litchfield Boat Launch and Town Beach, 1 North Shore Road

Misc. Supporting Values, Pollutant Load Reduction Calculations, and BMP Sizing

Variable	Value
Drainage Area (ac)	0.9
Land Use	Developed Open Space (100% Impervious Road)
Typical Soil Type	Loamy Sand, Excessively Drained
Issue(s)	Discharge of untreated runoff from road into Bantam Lake.
Proposed Improvements	Install appx. 45' x 20' bioretention cell with curb inlet, underdrain and stabilized riprap spillway to capture runoff from the dirt/gravel road.
TSS Load Reduction (Tons/yr)	0.09
TP Load Reduction (lb/yr)	0.57
TN Load Reduction (lb/yr)	4.3

Table Notes:

1. Potential BMP upstream drainage area delineated from 1-ft contours and aerial imagery.

2. Load Reduction is from BMP Selector Tool from Element C of MA WBP-Planning Tool (Appendix A.3). Sizing is for treatment of a 1" rainfall event.

Construction Cost Estimate

Description	Unit of Measure	Quantity	Unit Price	Total
Mobilization / Demobilization	LS	1	$5,000.00	$5,000.00
Bioretention Cell with Plantings	SF	900	$25.00	$22,500.00
curb inlet Forebay	LS	1	$4,500.00	$4,500.00
Other Misc. Items	LS	1	$2,000.00	$2,000.00
			Total:	**$34,000.00**
			Rounded Total:	**$34,000.00**

Table Notes:

1. Bioretention Cell Pricing from BMP Selector Tool from Element C of MA WBP-Planning Tool (Appendix A.3). Unit pricing slightly inflated for conservatism.

Area 8: White Memorial Foundation Boat Launch and Campground Store Parking Lot, North Shore Road, Litchfield

Misc. Supporting Values, Pollutant Load Reduction Calculations, and BMP Sizing

Variable	Value
Drainage Area (ac)	0.33
Land Use	Medium Density Residential (100% Imp.)
Typical Soil Type	Fine Sandy Loam, Well Drained, Type C
Issue(s)	Downstream outfall erosion, untreated runoff to Bantam
Proposed Improvements	Stabilize gully erosion at outfall with stone (appx. 10' x 3' area). Install appx. 40' x 20' bioretention cell within grassed area at front of Campground Store parking lot. Connect to existing catchbasin via overflow riser and underdrain.
TSS Load Reduction (Tons/yr)	0.09
TP Load Reduction (lb/yr)	1.06
TN Load Reduction (lb/yr)	4.8

Table Notes:

1. Potential BMP upstream drainage area delineated from 1-ft contours and aerial imagery.

2. Gully Erosion Load Reduction Source is EPA Region 5 Calculator (Appendix A.4).

2. Load Reduction is from BMP Selector Tool from Element C of MA WBP-Planning Tool (Appendix A.3). Sizing is for treatment of a 1" rainfall event.

Construction Cost Estimate

Description	Unit of Measure	Quantity	Unit Price	Total
Mobilization / Demobilization	LS	1	$5,000.00	$5,000.00
Bioretention Cell with Plantings	SF	800	$25.00	$20,000.00
curb inlet Forebay	LS	2	$4,500.00	$9,000.00
Erosion Repair	SF	50	$2.00	$100.00
Bank Stabilization	SF	50	$15.00	$750.00
Other Misc. Items	LS	1	$5,000.00	$5,000.00
			Total:	**$39,850.00**
			Rounded Total:	**$40,000.00**

Table Notes:

1. Bioretention Cell Pricing from BMP Selector Tool from Element C of MA WBP-Planning Tool (Appendix A.3). Unit pricing slightly inflated for conservatism.

2. Unit pricing based on CEI Cost Reference Table from past projects. Rounded up given small overall project footprint for conservatism (Appendix A.2).

Area 9: State Boat Launch, 48 Palmer Road, Morris

Misc. Supporting Values, Pollutant Load Reduction Calculations, and BMP Sizing

Variable	Value
Drainage Area (ac)	0.8
Land Use	Gravel Parking Area (100% Impervious)
Typical Soil Type	Urban Land Complex, well drained
Issue(s)	Discharge of untreated runoff from gravel/dirt parking lot into Bantam Lake.
Proposed Improvements	Replace existing boat launch with articulated concrete blocks with trench drain on top. Install appx. 60' x 30' bioretention cell with deep sump curb inlet inlets, underdrain, and stabilized riprap overflow.
TSS Load Reduction (Tons/yr)	0.173
TP Load Reduction (lb/yr)	1.4
TN Load Reduction (lb/yr)	8.4

Table Notes:

1. Potential BMP upstream drainage area delineated from 1-ft contours and aerial imagery.

2. Load Reduction is from BMP Selector Tool from Element C of MA WBP-Planning Tool (Appendix A.3). Sizing is for treatment of a 1" rainfall event.

Construction Cost Estimate

Description	Unit of Measure	Quantity	Unit Price	Total
Mobilization / Demobilization	LS	1	$5,000.00	$5,000.00
Bioretention Cell with Plantings	SF	1500	$25.00	$37,500.00
curb inlet Forebay	LS	2	$4,500.00	$9,000.00
Boat ramp demo / misc. items	LS	1	$10,000.00	$10,000.00
Install articulated concrete blocks	SF	900	$15.00	$13,500.00
			Total:	**$75,000.00**
			Rounded Total:	**$75,000.00**

Table Notes:

1. Bioretention Cell Pricing from BMP Selector Tool from Element C of MA WBP-Planning Tool (Appendix A.3). Unit pricing slightly inflated for conservatism.

2. Boat Ramp Cost based on Best Professional Judgement and past project cost data.

Area 10: Deer Island Boat Launch, 1 Pioneer Lane, Morris

Misc. Supporting Values, Pollutant Load Reduction Calculations, and BMP Sizing

Variable	Value
Drainage Area (ac)	0.37
Land Use	Medium Density Residential (Appx. 75% Impervious)
Typical Soil Type	Fine Sandy Loam, Type C
Issue(s)	Gully erosion at gravel boat launch from steep upgradient paved road.
Proposed Improvements	Install two (2) Tree Box Filters on either side of road. Install 20' x 12' articulated concrete block boat ramp with trench drain that discharges to level spreader / riprap apron.
TSS Load Reduction (Tons/yr)	0.061
TP Load Reduction (lb/yr)	0.41
TN Load Reduction (lb/yr)	3

Table Notes:

1. Potential BMP upstream drainage area delineated from 1-ft contours and aerial imagery.

2. Sizing is from rule of thumb sizing from the Pioneer Valley Planning Commission Fact Sheet on Tree Box Filters accessed at http://www.pvpc.org/sites/default/files/files/PVPC-Tree%20Box%20Filters.pdf. A tree box filter can treat approximately one-quarter to a half-acre of drainage area depending on site specific conditions.

3. Load Reduction is from BMP Selector Tool from Element C of MA WBP-Planning Tool (Appendix A.3). Sizing is for treatment of a 1" rainfall event.

Construction Cost Estimate

Description	Unit of Measure	Quantity	Unit Price	Total
Mobilization / Demobilization	LS	1	$5,000.00	$5,000.00
Tree Box Filter	EA	2	$15,000.00	$30,000.00
Boat ramp demo / misc. items	LS	1	$10,000.00	$10,000.00
Install articulated concrete blocks	SF	300	$15.00	$4,500.00
			Total:	**$49,500.00**
			Rounded Total:	**$50,000.00**

Table Notes:

1. Tree Box Filter Cost Estimate is from past project data and rule of thumb sizing from the Pioneer Valley Planning Commission Fact Sheet on Tree Box Filters accessed at http://www.pvpc.org/sites/default/files/files/PVPC-Tree%20Box%20Filters.pdf.

2. Boat Ramp Cost based on past project cost data.

Area 11: Morris Town Beach, East Shore Drive, Morris

Misc. Supporting Values, Pollutant Load Reduction Calculations, and BMP Sizing

Variable	Value
Drainage Area (ac)	1
Land Use	Medium Density Residential (Appx. 90% Impervious)
Typical Soil Type	Fine Sandy Loam, Moderately Well Drained
Issue(s)	Untreated runoff from gravel parking area to wetland upgradient of Bantam Lake.
Proposed Improvements	Install appx. 60' x 30' bioretention cell with curb inlet, underdrain and stabilized riprap overflow to capture runoff from existing gravel parking lot. Direct runoff to bioretention cell via cape cod berms and/or swales.
TSS Load Reduction (Tons/yr)	0.2
TP Load Reduction (lb/yr)	1.3
TN Load Reduction (lb/yr)	9.5

Table Notes:

1. Potential BMP upstream drainage area delineated from 1-ft contours and aerial imagery.

2. Load Reduction is from BMP Selector Tool from Element C of MA WBP-Planning Tool (Appendix A.3). Sizing is for treatment of a 1" rainfall event.

Construction Cost Estimate

Description	Unit of Measure	Quantity	Unit Price	Total
Mobilization / Demobilization	LS	1	$5,000.00	$5,000.00
Bioretention Cell with Plantings	SF	1800	$20.00	$36,000.00
Cape Cod Berm and/or Swales	LF	500	$15.00	$7,500.00
Other Misc. Items (curb inlets, Fencing, Etc.)	LS	1	$15,000.00	$15,000.00
			Total:	**$63,500.00**
			Rounded Total:	**$64,000.00**

Table Notes:

1. Bioretention Cell Pricing from BMP Selector Tool from Element C of MA WBP-Planning Tool (Appendix A.3). Unit pricing slightly inflated for conservatism.

2. Other unit pricing based on CEI Cost Reference Table from past projects with rounding for conservatism (Appendix A.2).

Area 12: Morris Boat Launch, East Shore Road

Misc. Supporting Values, Pollutant Load Reduction Calculations, and BMP Sizing

Variable	Value
Drainage Area (ac)	0.36
Land Use	Gravel Road, Medium Density Res. (100% Impervious)
Typical Soil Type	Loam, poorly drained
Issue(s)	Discharge of untreated runoff from gravel/dirt road into Bantam Lake.
Proposed Improvements	Install two (2) bioretention cells on either side of road with curb inlets and riprap overflow, one (1) tree box filter adjacent to boat launch, and cape cod berms to direct runoff to proposed features.
TSS Load Reduction (Tons/yr)	0.078
TP Load Reduction (lb/yr)	0.53
TN Load Reduction (lb/yr)	3.78

Table Notes:

1. Potential BMP upstream drainage areas delineated from 1-ft contours and aerial imagery.

2. Sizing is from rule of thumb sizing from the Pioneer Valley Planning Commission Fact Sheet on Tree Box Filters accessed at http://www.pvpc.org/sites/default/files/files/PVPC-Tree%20Box%20Filters.pdf. A tree box filter can treat approximately one-quarter to a half-acre of drainage area depending on site specific conditions.

3. Load Reduction is from BMP Selector Tool from Element C of MA WBP-Planning Tool (Appendix A.3). Sizing is for treatment of a 1" rainfall event.

Construction Cost Estimate

Description	Unit of Measure	Quantity	Unit Price	Total
Mobilization / Demobilization	LS	1	$5,000.00	$5,000.00
Bioretention Cell with Plantings	SF	600	$20.00	$12,000.00
Bioretention Cell curb inlets	LS	2	$4,500.00	$9,000.00
Tree box filter with curb inlet	LS	1	$15,000.00	$15,000.00
Other Misc. Items (asphalt, shrub plantings, etc.)	LS	1	$2,000.00	$2,000.00
			Total:	**$43,000.00**
			Rounded Total:	**$43,000.00**

Table Notes:

1. Bioretention Cell Pricing from BMP Selector Tool from Element C of MA WBP-Planning Tool (Appendix A.3). Unit pricing slightly inflated for conservatism.

2. Tree Box Filter Cost Estimate is from past project data and rule of thumb sizing from the Pioneer Valley Planning Commission Fact Sheet on Tree Box Filters accessed at http://www.pvpc.org/sites/default/files/files/PVPC-Tree%20Box%20Filters.pdf.

Area 13: Sandy Beach, East Shore Drive, Morris

Misc. Supporting Values, Pollutant Load Reduction Calculations, and BMP Sizing

Variable	Value
Drainage Area (ac)	0.23
Land Use	Developed Open Space (100% Impervious)
Typical Soil Type	Fine Sandy Loam, Well Drained
Issue(s)	Discharge of untreated runoff to Bantam Lake from access road & gully erosion from two pipes that discharge to beach.
Proposed Improvements	Install runoff diversion water bars at appx. 100-ft intervals along access road with depressed riprap aprons / level spreader at each discharge point.
TSS Load Reduction (Tons/yr)	0.06
TP Load Reduction (lb/yr)	0.28
TN Load Reduction (lb/yr)	2.08

Table Notes:

1. Potential BMP upstream drainage area delineated from 1-ft contours and aerial imagery.

2. Waterbar spacing determined from MassDEP Clean Water Toolkit Fact Sheet for Water Bars. The existing access road is approximately 630' long with an elevation drop of approximately 38' resulting in a slope of 6%. A diversion spacing of approximately 100' is recommended for slopes from 5-10%.

3. Load Reduction is from BMP Selector Tool Guidance from Element C of MA WBP-Planning Tool. Expected pollutant load export from impervious open space is 0.325 tons/yr for TSS, 1.52 lb/acre/yr for TP, and 11.33 lb/acre/yr for TN. Assume 80% capture efficiency of water bars accross the 0.23 acre drainage area.

Construction Cost Estimate

Description	Unit of Measure	Quantity	Unit Price	Total
Mobilization / Demobilization	LS	1	$5,000.00	$5,000.00
Install Water Bar and Riprap Apron	EA	6	$2,500.00	$15,000.00
Misc. / Materials	LS	1	$5,000.00	$5,000.00
			Total:	**$25,000.00**
			Rounded Total:	**$25,000.00**

Table Notes:

1. Water bar installation assumes installation of one (1) water bar per day for a crew of three (3) people at $300/hour. Heavy equipment costs assumed to be covered by mob/demob.

C-2: Supporting Reference BMP Unit Pricing from Past Projects

BMP Unit Pricing from Past Projects

	Install	Material	Total	Unit
Extended Detention Pond	$2.50	$1.30	$3.80	per CF
Infiltration Pond	$2.50	$3.10	$5.60	per CF
Stilling Basin	$2.50	$1.90	$4.40	per CF
Gravel Wetland	$3.70	$6.10	$9.80	per CF
Wetpond/Constructed Wetlands	$3.10	$3.70	$6.80	per CF
Large Biorentention	$3.10	$4.30	$7.40	per CF
Small Rain Garden	$6.10	$18.20	$24.30	per CF
Small Infiltration Trench	$2.50	$9.70	$12.20	per CF
Sediment Forebay BMP	$1.90	$1.30	$3.20	per CF
Dredge	$1.90	$0.00	$1.90	per CF
Roadside Swales & BMPs	$1.90	$3.70	$5.60	per SF
Maintenance Level Spreader	$6.10	$18.20	$24.30	per SF
Riprap Spillway	$6.10	$12.10	$18.20	per SF
Riprap Infiltration BMP	$3.70	$9.70	$13.40	per SF
Filter Media BMP	$12.10	$24.20	$36.30	per SF
Streambank Stabilization	$3.70	$5.50	$9.20	per SF
Naturalized Bank Stabilization	$4.90	$7.30	$12.20	per SF
Steep Slope Stabilization	$2.50	$3.70	$6.20	per SF
Erosion Repair	$0.70	$1.30	$2.00	per SF
Vegetated Buffer	$2.50	$4.90	$7.40	per SF
Geogrid	$9.70	$12.10	$21.80	per SF
Pavers	$12.10	$18.20	$30.30	per SF
Curb & Backing	$6.10	$12.10	$18.20	per SF
Erosion Mulch	$2.50	$4.90	$7.40	per SF
Small Diameter Culvert	$600.00	$300.00	$900.00	per LF
Large Diameter Culvert	$800.00	$400.00	$1,200.00	per LF
Small Box Culvert Replacement	$1,200.00	$600.00	$1,800.00	per LF
Large Box Culvert Replacement	$3,000.00	$1,200.00	$4,200.00	per LF

Notes:

1. BMP Unit Pricing is based on past project data and is for informational purposes only. Individual sites may vary widely.
2. Unit pricing has been adjusted for inflation.

C-3: Supporting Output from MassDEP WBP BMP Selector Tool

Supplemental Calculations from MA WBP-Tool BMP Selector Tool

Area 7: Litchfield Boat launch

BMP TYPE (edit)
BIORETENTION AND RAIN GARDENS

BMP SIZE (design storm depth; inches): 1.00
DRAINAGE AREA (acres): 0.90

BMP LOCATION
Area 7: Litchfield Boat Launch

LAND USE/COVER TYPE (in drainage area)	% OF DRAINAGE AREA
FOREST, Pervious	60
MEDIUM DENSITY RESIDENTIAL, Impervious	40

+ land use/cover

ESTIMATED POLLUTANT LOAD REDUCTIONS (lbs/yr)			ESTIMATED FOOTPRINT (sf)	ESTIMATED COST ($)
TN: 4.24841	TP: 0.57470	TSS: 172.18248	907.5	29,693

Area 8: White Memorial Campground Store

BMP TYPE (edit)
BIORETENTION AND RAIN GARDENS

BMP SIZE (design storm depth; inches): 1.00
DRAINAGE AREA (acres): 0.32

BMP LOCATION
Area 8: White Memorial Foundation Camp Store

LAND USE/COVER TYPE (in drainage area)	% OF DRAINAGE AREA
LOW DENSITY RESIDENTIAL, Impervious	100

+ land use/cover

ESTIMATED POLLUTANT LOAD REDUCTIONS (lbs/yr)			ESTIMATED FOOTPRINT (sf)	ESTIMATED COST ($)
TN: 3.36150	TP: 0.36260	TSS: 139.06027	613.1	10,557

Area 9: State Boat Launch

BMP TYPE (edit)
BIORETENTION AND RAIN GARDENS

BMP SIZE (design storm depth; inches): 1.00
DRAINAGE AREA (acres): 0.80

BMP LOCATION
Area 9: State Boat Launch

LAND USE/COVER TYPE (in drainage area)	% OF DRAINAGE AREA
HIGH DENSITY RESIDENTIAL, Impervious	100

+ land use/cover

ESTIMATED POLLUTANT LOAD REDUCTIONS (lbs/yr)			ESTIMATED FOOTPRINT (sf)	ESTIMATED COST ($)
TN: 8.40374	TP: 1.38642	TSS: 347.65068	1,532.7	26,394

Area 10: Deer Island Boat Launch

BMP TYPE (edit)		**LAND USE/COVER TYPE** (in drainage area)	**% OF DRAINAGE AREA**
BIORETENTION AND RAIN GARDENS		MEDIUM DENSITY RESIDENTIAL, Impervious	75
BMP SIZE (design storm depth; inches)	**DRAINAGE AREA** (acres)	MEDIUM DENSITY RESIDENTIAL, Pervious	25
1.00	0.37	+ land use/cover	
BMP LOCATION			
Area 10: Deer Island Boat Launch			

ESTIMATED POLLUTANT LOAD REDUCTIONS (lbs/yr)			ESTIMATED FOOTPRINT (sf)	ESTIMATED COST ($)
TN: 2.99500	TP: 0.41494	TSS: 123.28748	569.3	12,207

Note:
1. Load reduction calculatoin is for tree box filter which has similar removal efficiency to bioretention cells. Cost estimate not used.

Area 11: Morris Town Beach

BMP TYPE (edit)		**LAND USE/COVER TYPE** (in drainage area)	**% OF DRAINAGE AREA**
BIORETENTION AND RAIN GARDENS		MEDIUM DENSITY RESIDENTIAL, Impervious	90
BMP SIZE (design storm depth; inches)	**DRAINAGE AREA** (acres)	MEDIUM DENSITY RESIDENTIAL, Pervious	10
1.00	1.00	+ land use/cover	
BMP LOCATION			
Area 11: Morris Town Beach			

ESTIMATED POLLUTANT LOAD REDUCTIONS (lbs/yr)			ESTIMATED FOOTPRINT (sf)	ESTIMATED COST ($)
TN: 9.54064	TP: 1.32843	TSS: 394.02176	1,764.6	32,992

Area 12: Morris Boat Launch

Structural BMPs

BMP TYPE (edit)		**LAND USE/COVER TYPE** (in drainage area)	**% OF DRAINAGE AREA**
BIORETENTION AND RAIN GARDENS		MEDIUM DENSITY RESIDENTIAL, Impervious	100
BMP SIZE (design storm depth; inches)	**DRAINAGE AREA** (acres)	+ land use/cover	
1.00	0.36		
BMP LOCATION			
Area 12: Morris Boat Launch			

ESTIMATED POLLUTANT LOAD REDUCTIONS (lbs/yr)			ESTIMATED FOOTPRINT (sf)	ESTIMATED COST ($)
TN: 3.78168	TP: 0.52791	TSS: 156.44280	689.7	11,877

Note:
1. Load reduction calculation is for tree box filter and two bioretention cell which habve similar removal efficiency.

C-4: Supporting Load Reduction Output from EPA Region 5 Tool

Area 2
EPA Region 5 Pollutant Load Calculation Sheet

Bank Stabilization

If estimating for just one bank, put "0" in areas for Bank #2.

Please select a soil textural class:

- Sands, loamy sands
- Sandy loam
- Fine sandy loam
- Loams, sandy clay loams, sandy clay
- Silt loam
- Silty clay loam, silty clay
- Clay loam
- Clay
- Organic

(Sandy Loam)

Please fill in the gray areas below:

Parameter		Bank #1	Bank #2	**Example**	
Length (ft)		25	0	**500**	
Height (ft)		20	0	**15**	
Lateral Recession Rate (ft/yr)*		0.2	0	**0.5**	
Soil Weight (tons/ft^3)		0.0525	0.0525	**0.04**	
Soil P Conc (lb/lb soil)**	DEFAULT	0.0005	0.0005	**0.0005**	**
Soil N Conc (lb/lb soil)**	DEFAULT	0.001	0.001	**0.001**	**

** If not using the default values, users must provide input (in red) for Total P and Total N soil concentrations
*Lateral Recession Rate (LRR) is the rate at which bank deterioration has taken place and is measured in feet per year. This rate may not be easily determined by direct measurement. Therefore best professional judgement may be required to estimate the LRR. Please refer to the narrative descriptions in Table 1.

Estimated Load Reductions

	BMP Efficiency* Bank #1	**BMP Efficiency* Bank #2**	**Bank #1**	**Bank #2**	**Example**
Sediment Load Reduction (ton/year)	0.90		4.7	0.0	**135**
Phosphorus Load Reduction (lb/year)			0.0	0.0	**135**
Nitrogen Load Reduction (lb/yr)			0.0	0.0	**270**

* BMP efficiency values should be between 0 and 1, and 1 means 100% pollutant removal efficiency.

Table 1

LRR (ft/yr)	**Category**	**Description**
0.01 - 0.05	Slight	Some bare bank but active erosion not readily apparent. Some rills but no vegetative overhang. No
0.06 - 0.2	Moderate	Bank is predominantly bare with some rills and vegetative overhang.
0.3 - 0.5	Severe	Bank is bare with rills and severe vegetative overhang. Many exposed tree roots and some fallen trees and slumps or slips. Some changes in cultural features such as fence corners missing and realignment of roads or trails. Channel cross-section becomes more U-shaped as opposed to V-shaped.
0.5+	Very Severe	Bank is bare with gullies and severe vegetative overhang. Many fallen trees, drains and culverts eroding out and changes in cultural features as above. Massive slips or washouts common. Channel cross-section is U-shaped and streamcourse or gully may be meandering.

Source: Steffen, L.J. 1982. Channel Erosion (personal communication), as printed in "Pollutants Controlled Calculation and Documentation for Section 319 Watersheds Training Manual," June 1999 Revision; Michigan Department of Environmental Quality - Surface Water Quality Division - Nonpoint Source Unit. EQP 5841 (6/99).

Area 3
EPA Region 5 Pollutant Load Calculation Sheet

Gully Stabilization

These may include:

- Grade Stabilization Structure
- Grassed Waterway
- Critical Area Planting in areas with gullies
- Water and Sediment Control Basins

Please select a soil textural class:

- ○ Sands, loamy sands
- ○ Sandy loam
- ○ Fine sandy loam
- ○ Loams, sandy clay loams, sandy clay
- ● Silt loam
- ○ Silty clay loam, silty clay
- ○ Clay loam
- ○ Clay
- ○ Organic

(Silt Loam)

Please fill in the gray areas below:

Parameter		Gully	Example	
Top Width (ft)		6	**15**	
Bottom Width (ft)		6	**4**	
Depth (ft)		0.3	**5**	
Length (ft)		35	**20**	
Number of Years		3	**5**	
Soil Weight (tons/ft^3)		0.0425	**0.05**	
Soil P Conc (lb/lb soil)*	DEFAULT	0.0005	**0.0005**	*
Soil N Conc (lb/lb soil)*	DEFAULT	0.001	**0.001**	*

* If not using the default values, users must provide input (in red) for Total P and Total N soil concentrations

(Boat Launch replaced 2017, calculation performed in 2020)

Estimated Load Reductions

	BMP Efficiency*	Gully	Example
Sediment Load Reduction (ton/year)	0.90	0.8	**9**
Phosphorus Load Reduction (lb/year)		0.8	**7**
Nitrogen Load Reduction (lb/yr)		1.6	**15**

* BMP efficiency values should be between 0 and 1, and 1 means 100% pollutant removal efficiency.

Area 4.1
EPA Region 5 Pollutant Load Calculation Sheet

Bank Stabilization

If estimating for just one bank, put "0" in areas for Bank #2.

Please select a soil textural class:

- Sands, loamy sands
- Sandy loam
- Fine sandy loam
- Loams, sandy clay loams, sandy clay
- Silt loam
- Silty clay loam, silty clay
- Clay loam
- Clay
- Organic

(Silt Loam)

Please fill in the gray areas below:

Parameter		Bank #1	Bank #2	Example	
Length (ft)		20	0	**500**	
Height (ft)		8	0	**15**	
Lateral Recession Rate (ft/yr)*		0.1	0	**0.5**	
Soil Weight (tons/ft^3)		0.0425	0.0425	**0.04**	
Soil P Conc (lb/lb soil)**	DEFAULT	0.0005	0.0005	**0.0005**	**
Soil N Conc (lb/lb soil)**	DEFAULT	0.001	0.001	**0.001**	**

** If not using the default values, users must provide input (in red) for Total P and Total N soil concentrations
*Lateral Recession Rate (LRR) is the rate at which bank deterioration has taken place and is measured in feet per year. This rate may not be easily determined by direct measurement. Therefore best professional judgement may be required to estimate the LRR. Please refer to the narrative descriptions in Table 1.

Estimated Load Reductions

	BMP Efficiency* Bank #1	BMP Efficiency* Bank #2	Bank #1	Bank #2	Example
Sediment Load Reduction (ton/year)	0.90		0.6	0.0	**135**
Phosphorus Load Reduction (lb/year)			0.0	0.0	**135**
Nitrogen Load Reduction (lb/yr)			0.0	0.0	**270**

* BMP efficiency values should be between 0 and 1, and 1 means 100% pollutant removal efficiency.

Table 1

LRR (ft/yr)	Category	Description
0.01 - 0.05	Slight	Some bare bank but active erosion not readily apparent. Some rills but no vegetative overhang.
0.06 - 0.2	Moderate	Bank is predominantly bare with some rills and vegetative overhang.
0.3 - 0.5	Severe	Bank is bare with rills and severe vegetative overhang. Many exposed tree roots and some fallen trees and slumps or slips. Some changes in cultural features such as fence corners missing and realignment of roads or trails. Channel cross-section becomes more U-shaped as opposed to V-shaped.
0.5+	Very Severe	Bank is bare with gullies and severe vegetative overhang. Many fallen trees, drains and culverts eroding out and changes in cultural features as above. Massive slips or washouts common. Channel cross-section is U-shaped and streamcourse or gully may be meandering.

Source: Steffen, L.J. 1982. Channel Erosion (personal communication), as printed in "Pollutants Controlled Calculation and Documentation for Section 319 Watersheds Training Manual," June 1999 Revision; Michigan Department of Environmental Quality - Surface Water Quality Division - Nonpoint Source Unit. EQP 5841 (6/99).

Area 4.3
EPA Region 5 Pollutant Load Calculation Sheet

Bank Stabilization

If estimating for just one bank, put "0" in areas for Bank #2.

Please select a soil textural class:

- ○ Sands, loamy sands
- ○ Sandy loam
- ○ Fine sandy loam
- ○ Loams, sandy clay loams, sandy clay
- ● Silt loam
- ○ Silty clay loam, silty clay
- ○ Clay loam
- ○ Clay
- ○ Organic

(Silt Loam)

Please fill in the gray areas below:

Parameter	Bank #1	Bank #2	**Example**	
Length (ft)	11	0	**500**	
Height (ft)	11	0	**15**	
Lateral Recession Rate (ft/yr)*	0.1	0	**0.5**	
Soil Weight (tons/ft^3)	0.0425	0.0425	**0.04**	
Soil P Conc (lb/lb soil)** DEFAULT	0.0005	0.0005	**0.0005**	**
Soil N Conc (lb/lb soil)** DEFAULT	0.001	0.001	**0.001**	**

(Calculation is for soil stockpiles -- adjusted model for assumed TSS reduction of 0.5 year to enable compuation of corresponding TP and TN reductions)

** If not using the default values, users must provide input (in red) for Total P and Total N soil concentrations
*Lateral Recession Rate (LRR) is the rate at which bank deterioration has taken place and is measured in feet per year. This rate may not be easily determined by direct measurement. Therefore best professional judgement may be required to estimate the LRR. Please refer to the narrative descriptions in Table 1.

Estimated Load Reductions

	BMP Efficiency* Bank #1	**BMP Efficiency* Bank #2**	**Bank #1**	**Bank #2**	**Example**
Sediment Load Reduction (ton/year)	1.00		0.51	0.0	**150**
Phosphorus Load Reduction (lb/year)			0.51	0.0	**150**
Nitrogen Load Reduction (lb/yr)			1.03	0.0	**300**

* BMP efficiency values should be between 0 and 1, and 1 means 100% pollutant removal efficiency.

Table 1

LRR (ft/yr)	**Category**	**Description**
0.01 - 0.05	Slight	Some bare bank but active erosion not readily apparent. Some rills but no vegetative overhang.
0.06 - 0.2	Moderate	Bank is predominantly bare with some rills and vegetative overhang.
0.3 - 0.5	Severe	Bank is bare with rills and severe vegetative overhang. Many exposed tree roots and some fallen trees and slumps or slips. Some changes in cultural features such as fence corners missing and realignment of roads or trails. Channel cross-section becomes more U-shaped as opposed to V-shaped.
0.5+	Very Severe	Bank is bare with gullies and severe vegetative overhang. Many fallen trees, drains and culverts eroding out and changes in cultural features as above. Massive slips or washouts common. Channel cross-section is U-shaped and streamcourse or gully may be meandering.

Source: Steffen, L.J. 1982. Channel Erosion (personal communication), as printed in "Pollutants Controlled Calculation and Documentation for Section 319 Watersheds Training Manual," June 1999 Revision; Michigan Department of Environmental Quality - Surface Water Quality Division - Nonpoint Source Unit. EQP 5841 (6/99).

Area 4.5
EPA Region 5 Pollutant Load Calculation Sheet

Bank Stabilization

If estimating for just one bank, put "0" in areas for Bank #2.

Please select a soil textural class:

- Sands, loamy sands
- Sandy loam
- Fine sandy loam
- Loams, sandy clay loams, sandy clay
- Silt loam
- Silty clay loam, silty clay
- Clay loam
- Clay
- Organic

(Silt Loam)

Please fill in the gray areas below:

Parameter		Bank #1	Bank #2	**Example**	
Length (ft)		100	0	**500**	
Height (ft)		5	0	**15**	
Lateral Recession Rate (ft/yr)*		0.1	0	**0.5**	
Soil Weight (tons/ft^3)		0.0425	0.0425	**0.04**	
Soil P Conc (lb/lb soil)**	DEFAULT	0.0005	0.0005	**0.0005**	**
Soil N Conc (lb/lb soil)**	DEFAULT	0.001	0.001	**0.001**	**

** If not using the default values, users must provide input (in red) for Total P and Total N soil concentrations
*Lateral Recession Rate (LRR) is the rate at which bank deterioration has taken place and is measured in feet per year. This rate may not be easily determined by direct measurement. Therefore best professional judgement may be required to estimate the LRR. Please refer to the narrative descriptions in Table 1.

Estimated Load Reductions

	BMP Efficiency* Bank #1	**BMP Efficiency* Bank #2**	**Bank #1**	**Bank #2**	**Example**
Sediment Load Reduction (ton/year)	0.90		1.9	0.0	**135**
Phosphorus Load Reduction (lb/year)			0.0	0.0	**135**
Nitrogen Load Reduction (lb/yr)			0.0	0.0	**270**

* BMP efficiency values should be between 0 and 1, and 1 means 100% pollutant removal efficiency.

Table 1

LRR (ft/yr)	**Category**	**Description**
0.01 - 0.05	Slight	Some bare bank but active erosion not readily apparent. Some rills but no vegetative overhang.
0.06 - 0.2	Moderate	Bank is predominantly bare with some rills and vegetative overhang.
0.3 - 0.5	Severe	Bank is bare with rills and severe vegetative overhang. Many exposed tree roots and some fallen trees and slumps or slips. Some changes in cultural features such as fence corners missing and realignment of roads or trails. Channel cross-section becomes more U-shaped as opposed to V-shaped.
0.5+	Very Severe	Bank is bare with gullies and severe vegetative overhang. Many fallen trees, drains and culverts eroding out and changes in cultural features as above. Massive slips or washouts common. Channel cross-section is U-shaped and streamcourse or gully may be meandering.

Source: Steffen, L.J. 1982. Channel Erosion (personal communication), as printed in "Pollutants Controlled Calculation and Documentation for Section 319 Watersheds Training Manual," June 1999 Revision; Michigan Department of Environmental Quality - Surface Water Quality Division - Nonpoint Source Unit. EQP 5841 (6/99).

Area 4.6
EPA Region 5 Pollutant Load Calculation Sheet

Bank Stabilization

If estimating for just one bank, put "0" in areas for Bank #2.

Please select a soil textural class:

- Sands, loamy sands
- Sandy loam
- Fine sandy loam
- Loams, sandy clay loams, sandy clay
- Silt loam
- Silty clay loam, silty clay
- Clay loam
- Clay
- Organic

(Silt Loam)

Please fill in the gray areas below:

Parameter		Bank #1	Bank #2	**Example**	
Length (ft)		200	0	**500**	
Height (ft)		6	0	**15**	
Lateral Recession Rate (ft/yr)*		0.1	0	**0.5**	
Soil Weight (tons/ft^3)		0.0425	0.0425	**0.04**	
Soil P Conc (lb/lb soil)**	DEFAULT	0.0005	0.0005	**0.0005**	**
Soil N Conc (lb/lb soil)**	DEFAULT	0.001	0.001	**0.001**	**

** If not using the default values, users must provide input (in red) for Total P and Total N soil concentrations
*Lateral Recession Rate (LRR) is the rate at which bank deterioration has taken place and is measured in feet per year. This rate may not be easily determined by direct measurement. Therefore best professional judgement may be required to estimate the LRR. Please refer to the narrative descriptions in Table 1.

Estimated Load Reductions

	BMP Efficiency* Bank #1	**BMP Efficiency* Bank #2**	**Bank #1**	**Bank #2**	**Example**
Sediment Load Reduction (ton/year)	0.90		4.6	0.0	**135**
Phosphorus Load Reduction (lb/year)			0.0	0.0	**135**
Nitrogen Load Reduction (lb/yr)			0.0	0.0	**270**

* BMP efficiency values should be between 0 and 1, and 1 means 100% pollutant removal efficiency.

Table 1

LRR (ft/yr)	**Category**	**Description**
0.01 - 0.05	Slight	Some bare bank but active erosion not readily apparent. Some rills but no vegetative overhang.
0.06 - 0.2	Moderate	Bank is predominantly bare with some rills and vegetative overhang.
0.3 - 0.5	Severe	Bank is bare with rills and severe vegetative overhang. Many exposed tree roots and some fallen trees and slumps or slips. Some changes in cultural features such as fence corners missing and realignment of roads or trails. Channel cross-section becomes more U-shaped as opposed to V-shaped.
0.5+	Very Severe	Bank is bare with gullies and severe vegetative overhang. Many fallen trees, drains and culverts eroding out and changes in cultural features as above. Massive slips or washouts common. Channel cross-section is U-shaped and streamcourse or gully may be meandering.

Source: Steffen, L.J. 1982. Channel Erosion (personal communication), as printed in "Pollutants Controlled Calculation and Documentation for Section 319 Watersheds Training Manual," June 1999 Revision; Michigan Department of Environmental Quality - Surface Water Quality Division - Nonpoint Source Unit. EQP 5841 (6/99).

Area 4.8
EPA Region 5 Pollutant Load Calculation Sheet

Bank Stabilization

If estimating for just one bank, put "0" in areas for Bank #2.

Please select a soil textural class:

- ○ Sands, loamy sands
- ○ Sandy loam
- ○ Fine sandy loam
- ○ Loams, sandy clay loams, sandy clay
- ○ Silt loam
- ○ Silty clay loam, silty clay
- ○ Clay loam
- ○ Clay
- ○ Organic

(Silt Loam)

Please fill in the gray areas below:

Parameter	Bank #1	Bank #2	**Example**
Length (ft)	50	0	**500**
Height (ft)	6	0	**15**
Lateral Recession Rate (ft/yr)*	0.3	0	**0.5**
Soil Weight (tons/ft^3)	0.0425	0.0425	**0.04**
Soil P Conc (lb/lb soil)** DEFAULT	0.0005	0.0005	**0.0005** **
Soil N Conc (lb/lb soil)** DEFAULT	0.001	0.001	**0.001** **

(severe recession - can see visible evidence of "chunk" taken out of bank from aerial photos)

** If not using the default values, users must provide input (in red) for Total P and Total N soil concentrations
*Lateral Recession Rate (LRR) is the rate at which bank deterioration has taken place and is measured in feet per year. This rate may not be easily determined by direct measurement. Therefore best professional judgement may be required to estimate the LRR. Please refer to the narrative descriptions in Table 1.

Estimated Load Reductions

	BMP Efficiency* Bank #1	**BMP Efficiency* Bank #2**	**Bank #1**	**Bank #2**	**Example**
Sediment Load Reduction (ton/year)	0.90		3.4	0.0	**135**
Phosphorus Load Reduction (lb/year)			0.0	0.0	**135**
Nitrogen Load Reduction (lb/yr)			0.0	0.0	**270**

* BMP efficiency values should be between 0 and 1, and 1 means 100% pollutant removal efficiency.

Table 1

LRR (ft/yr)	**Category**	**Description**
0.01 - 0.05	Slight	Some bare bank but active erosion not readily apparent. Some rills but no vegetative overhang.
0.06 - 0.2	Moderate	Bank is predominantly bare with some rills and vegetative overhang.
0.3 - 0.5	Severe	Bank is bare with rills and severe vegetative overhang. Many exposed tree roots and some fallen trees and slumps or slips. Some changes in cultural features such as fence corners missing and realignment of roads or trails. Channel cross-section becomes more U-shaped as opposed to V-shaped.
0.5+	Very Severe	Bank is bare with gullies and severe vegetative overhang. Many fallen trees, drains and culverts eroding out and changes in cultural features as above. Massive slips or washouts common. Channel cross-section is U-shaped and streamcourse or gully may be meandering.

Source: Steffen, L.J. 1982. Channel Erosion (personal communication), as printed in "Pollutants Controlled Calculation and Documentation for Section 319 Watersheds Training Manual," June 1999 Revision; Michigan Department of Environmental Quality - Surface Water Quality Division - Nonpoint Source Unit. EQP 5841 (6/99).

Area 6
EPA Region 5 Pollutant Load Calculation Sheet

Gully Stabilization

These may include:

Grade Stabilization Structure
Grassed Waterway
Critical Area Planting in areas with gullies
Water and Sediment Control Basins

Please select a soil textural class:

- Sands, loamy sands
- Sandy loam
- Fine sandy loam
- Loams, sandy clay loams, sandy clay
- Silt loam
- Silty clay loam, silty clay
- Clay loam
- Clay
- Organic

(Fine Sandy Loam)

Please fill in the gray areas below:

Parameter		**Gully**	**Example**
Top Width (ft)		2	**15**
Bottom Width (ft)		2	**4**
Depth (ft)		0.25	**5**
Length (ft)		1050	**20**
Number of Years		3	**5**
Soil Weight (tons/ft^3)		0.05	**0.05**
Soil P Conc (lb/lb soil)*	DEFAULT	0.0005	**0.0005**
Soil N Conc (lb/lb soil)*	DEFAULT	0.001	**0.001**

Assume erosion is present along appx. 20% of the 3,500 linear foot alignment at a width of 2 feet and a shallow depth of 3"

* If not using the default values, users must provide input (in red) for Total P and Total N soil concentrations

Estimated Load Reductions

	BMP Efficiency*	**Gully**	**Example**
Sediment Load Reduction (ton/year)	0.60	5.3	**6**
Phosphorus Load Reduction (lb/year)		0.0	**5**
Nitrogen Load Reduction (lb/yr)		0.0	**10**

* BMP efficiency values should be between 0 and 1, and 1 means 100% pollutant removal efficiency.

Area 8
EPA Region 5 Pollutant Load Calculation Sheet

Gully Stabilization

These may include:

Grade Stabilization Structure
Grassed Waterway
Critical Area Planting in areas with gullies
Water and Sediment Control Basins

Please select a soil textural class:

- Sands, loamy sands
- Sandy loam
- Fine sandy loam
- Loams, sandy clay loams, sandy clay
- Silt loam
- Silty clay loam, silty clay
- Clay loam
- Clay
- Organic

(Sandy Loam)

Please fill in the gray areas below:

Parameter	Gully	Example	
Top Width (ft)	3	**15**	
Bottom Width (ft)	3	**4**	
Depth (ft)	2	**5**	
Length (ft)	10	**20**	
Number of Years	3	**5**	
Soil Weight (tons/ft^3)	0.0525	**0.05**	
Soil P Conc (lb/lb soil)* DEFAULT	0.0005	**0.0005**	*
Soil N Conc (lb/lb soil)* DEFAULT	0.001	**0.001**	*

* If not using the default values, users must provide input (in red) for Total P and Total N soil concentrations

Estimated Load Reductions

	BMP Efficiency*	Gully	Example
Sediment Load Reduction (ton/year)	0.80	0.8	**8**
Phosphorus Load Reduction (lb/year)		0.0	**6**
Nitrogen Load Reduction (lb/yr)		0.0	**13**

* BMP efficiency values should be between 0 and 1, and 1 means 100% pollutant removal efficiency.

APPENDIX D:

Conceptual BMP Designs

BANTAM LAKE WATERSHED BASED PLAN

CONCEPTUAL STRUCTURAL BMP DETAILS

AUGUST 2020

Note: BMP Details contained herein are intended to show general Structural BMP types that are proposed as part of this watershed based plan . Details are not site-specific and are for informational purposes only.

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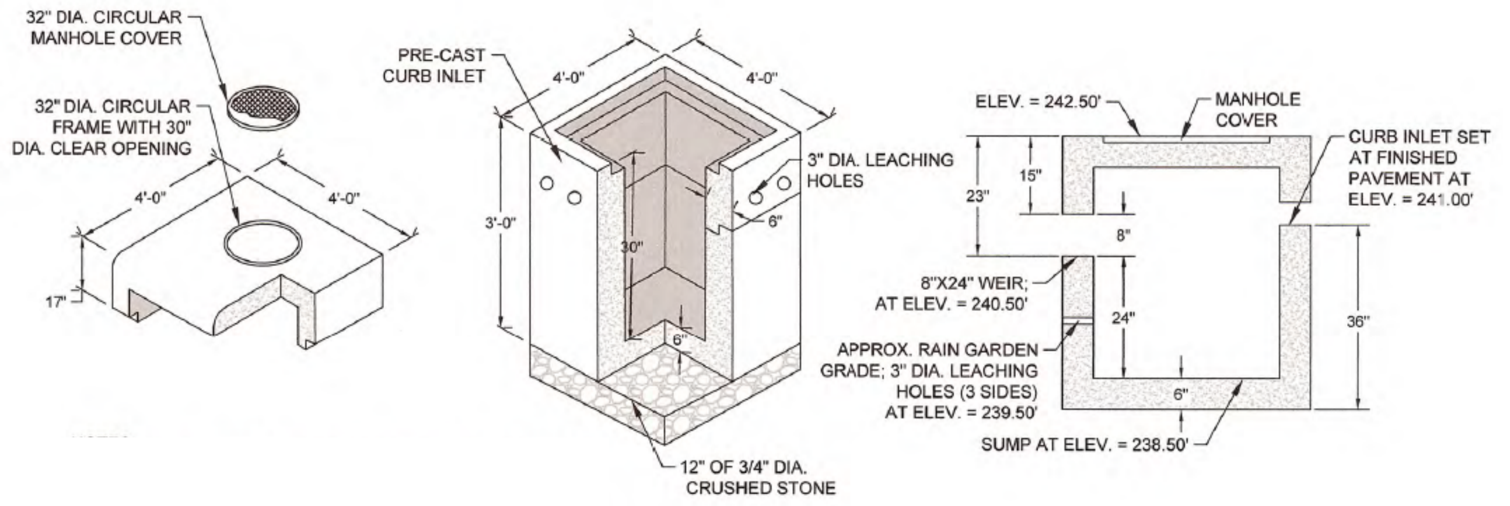
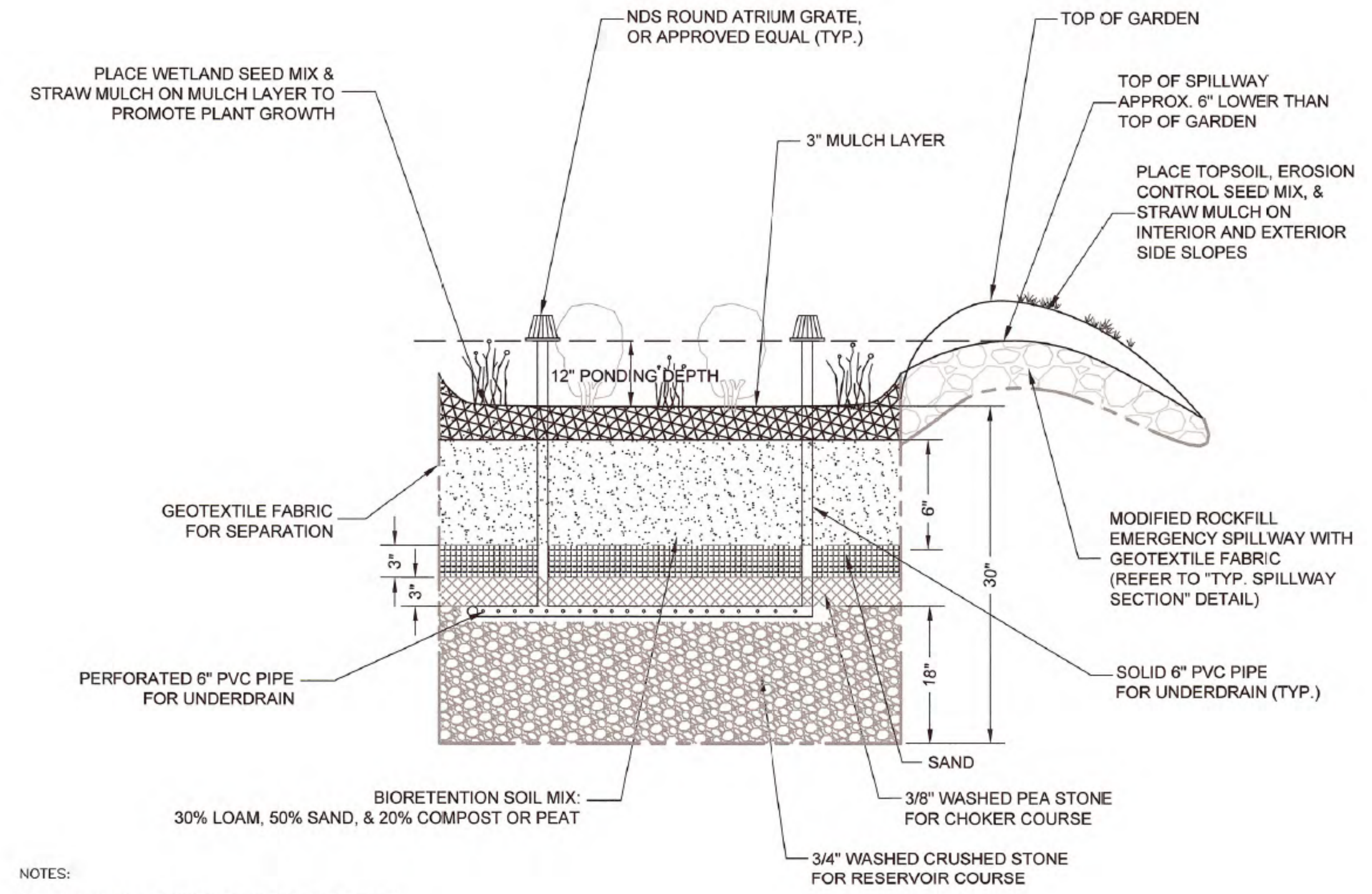


Typical Pre-Cast Concrete Curb Inlet Detail



Bioretention Cell Section with Underdrain and Riprap Overflow

GENERAL NOTES

1. BMP Detail Source is from past CEI Project.

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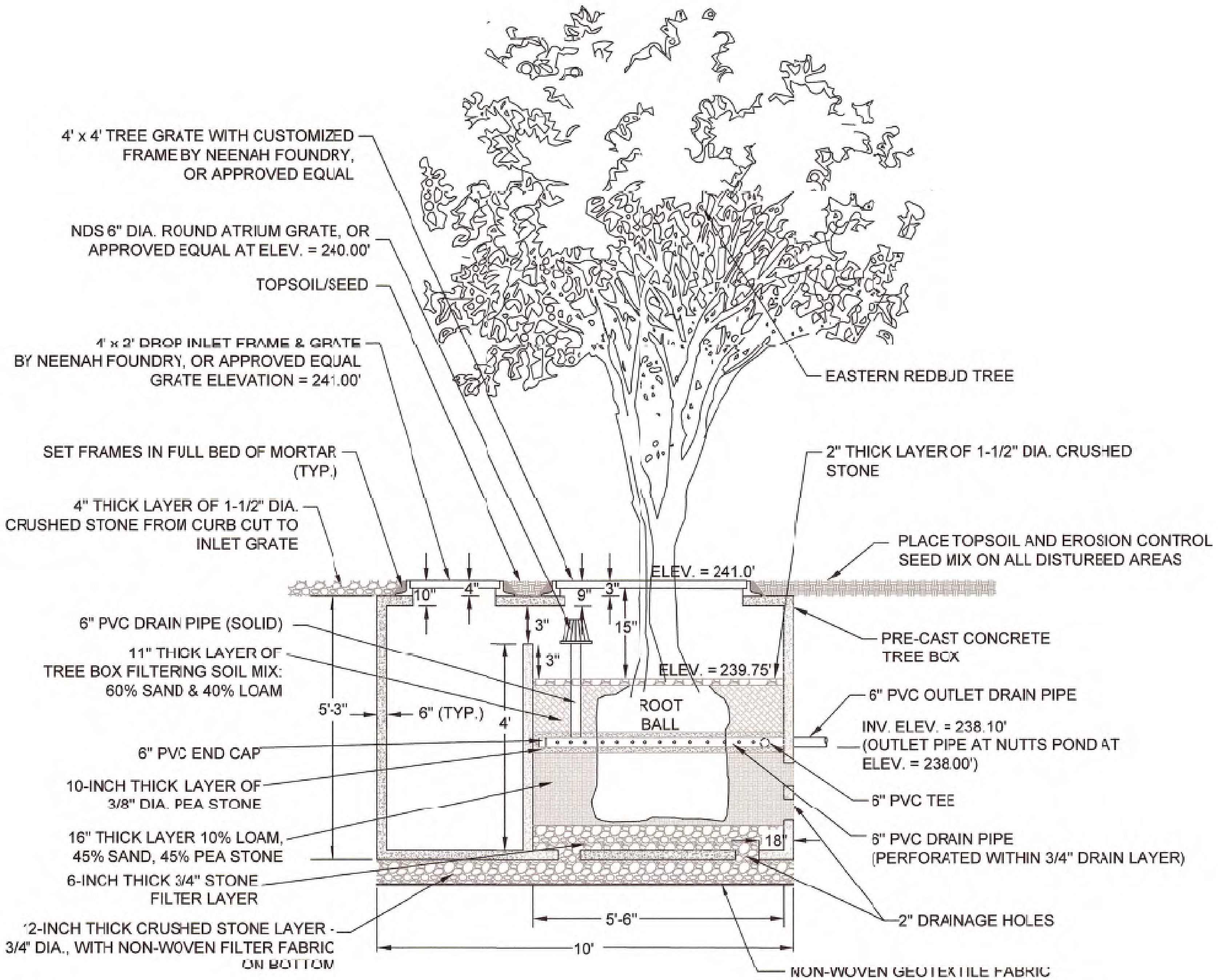

NOTES:

1. SET FRAMES IN FULL BED OF MORTAR.
2. TREE FRAME AND GRATE MAY BE CUSTOMIZED.

Typical Tree Box Filter Detail

GENERAL NOTES

1. BMP Detail Source is from past CEI Project.

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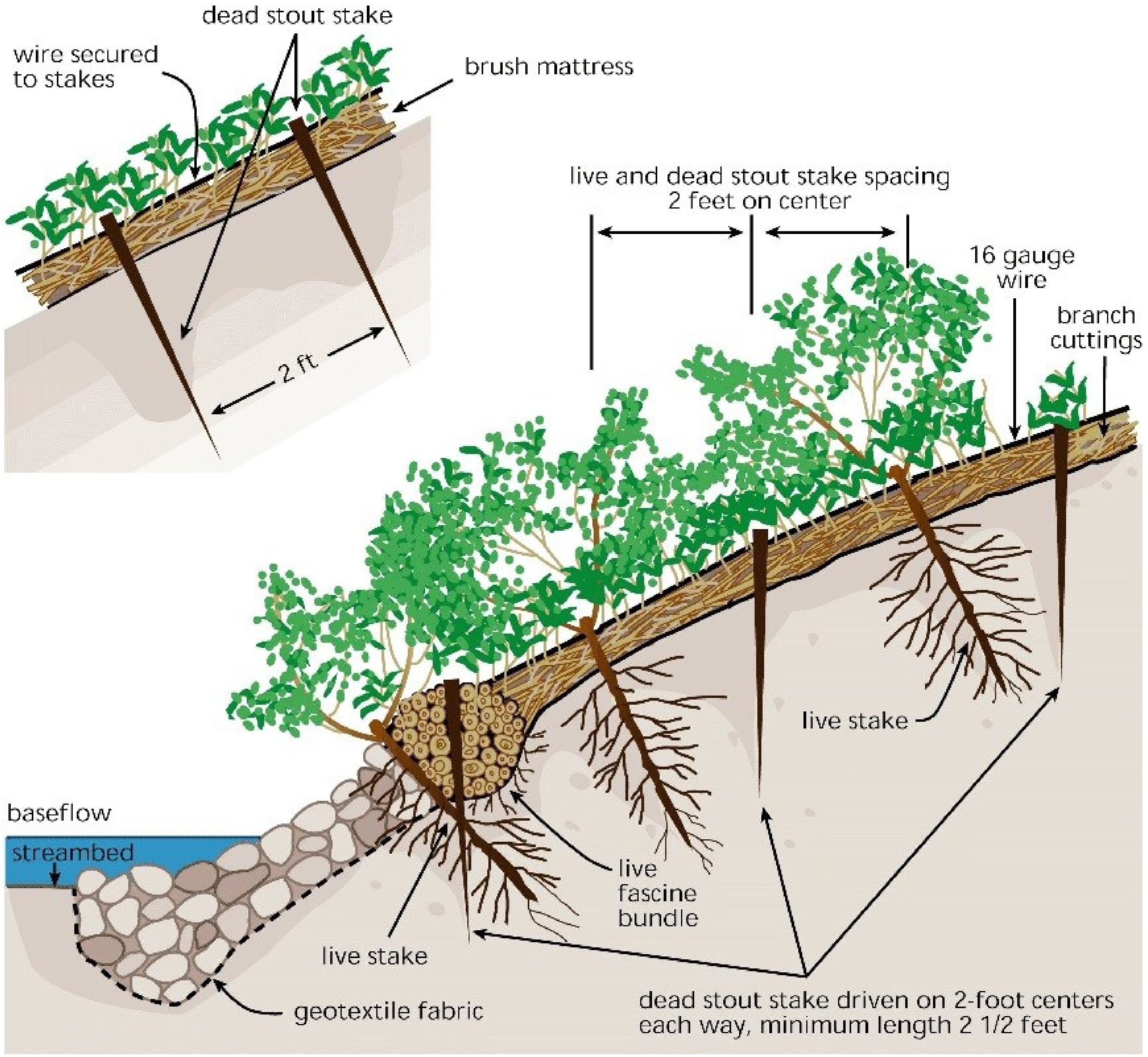

Vegetated Bank Stabilization with Toe Protection

GENERAL NOTES

1. MassDEP NPS Manual.

No.	Revision/Issue	Date

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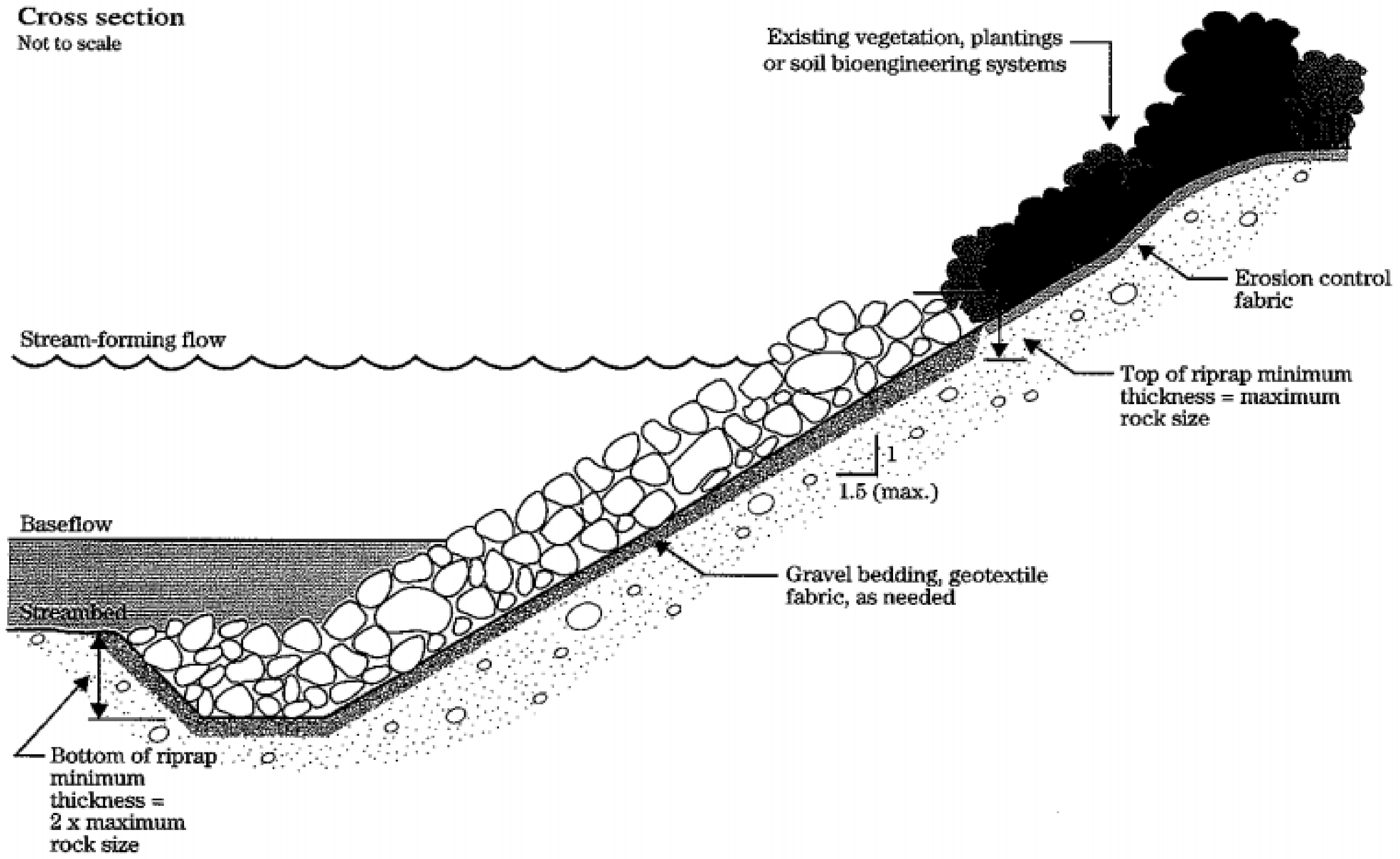

Classic Armored Riprap Revetment for Bank Stabilization

GENERAL NOTES

1. NRCS Engineering Field Handbook.

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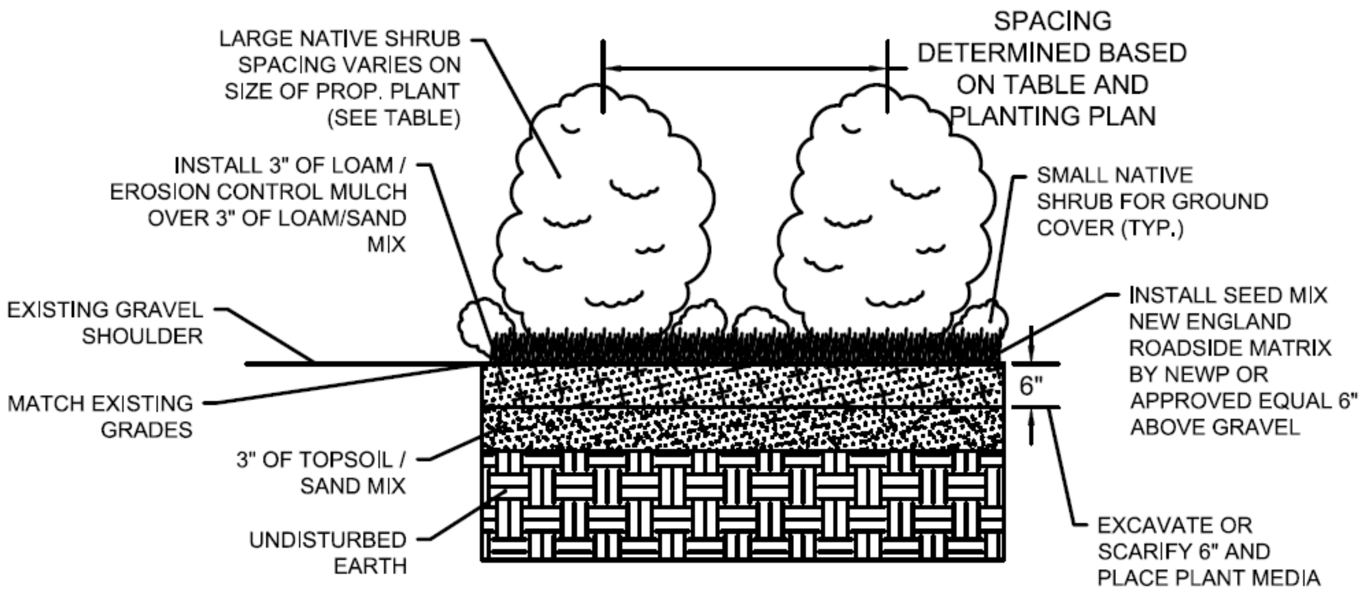
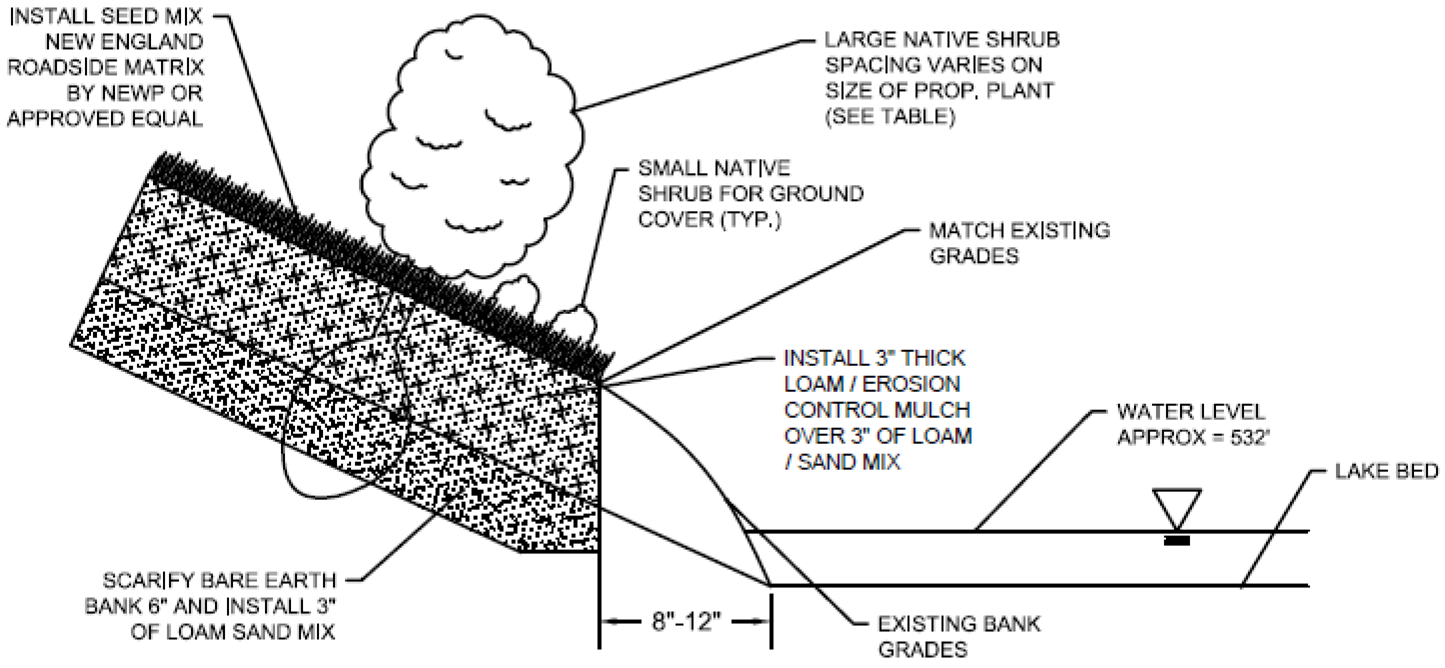


Vegetative Buffer (Flat Surface)



Vegetative Buffer (Sloped Surface)

GENERAL NOTES

1. BMP Detail Source is from past CEI Project.

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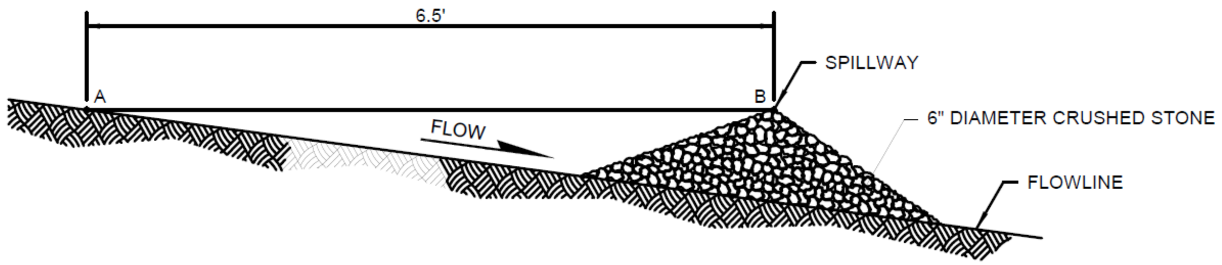
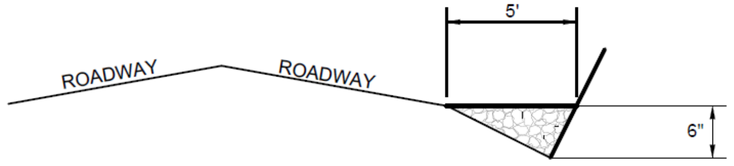


PROFILE VIEW

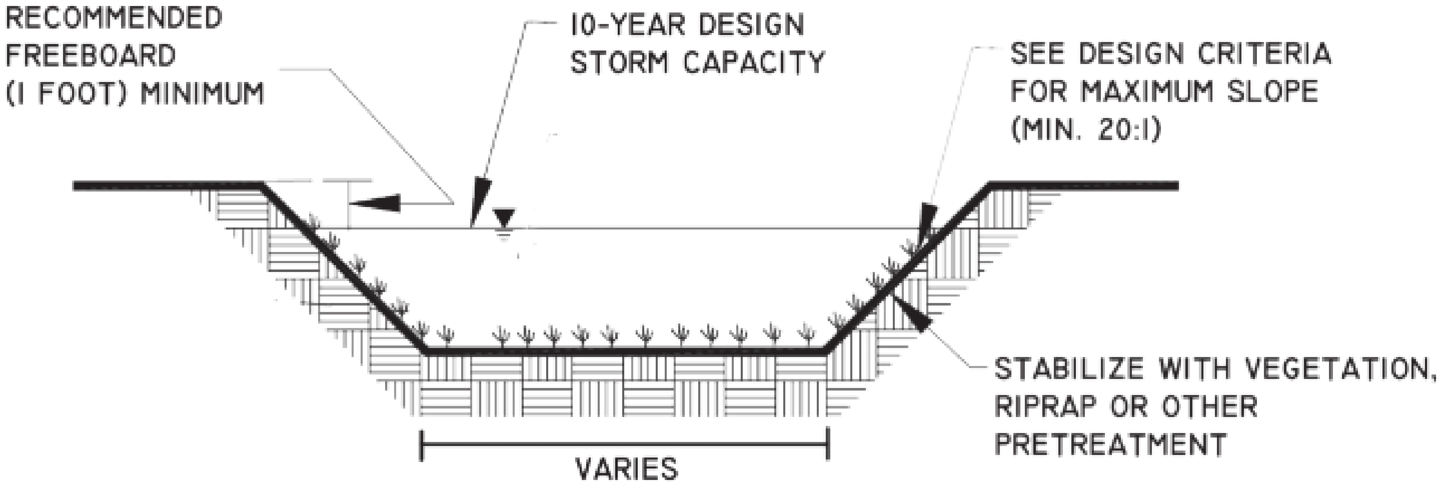
ROCK CHECK DAMS SHALL BE PLACED OUTSIDE OF THE CLEAR ZONE, OR BEHIND TRAFFIC BARRIER.

EXISTING CROSS–SECTION



PROPOSED CROSS–SECTION

Roadside Check Dam



Roadside Conveyance Swale

GENERAL NOTES

1. Check Dam Detail Source is from past CEI Project.

2. Swale Detail Source is NHDES Stormwater Manual.

No.	Revision/Issue	Date

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Example Water bar with Discharge to Depressed Rock Outlet Protection

Example Slope Stabilization with Coir Blanket and Vegetation

GENERAL NOTES

1. Source is University of Wisconsin Lakes Extension.

No.	Revision/Issue	Date

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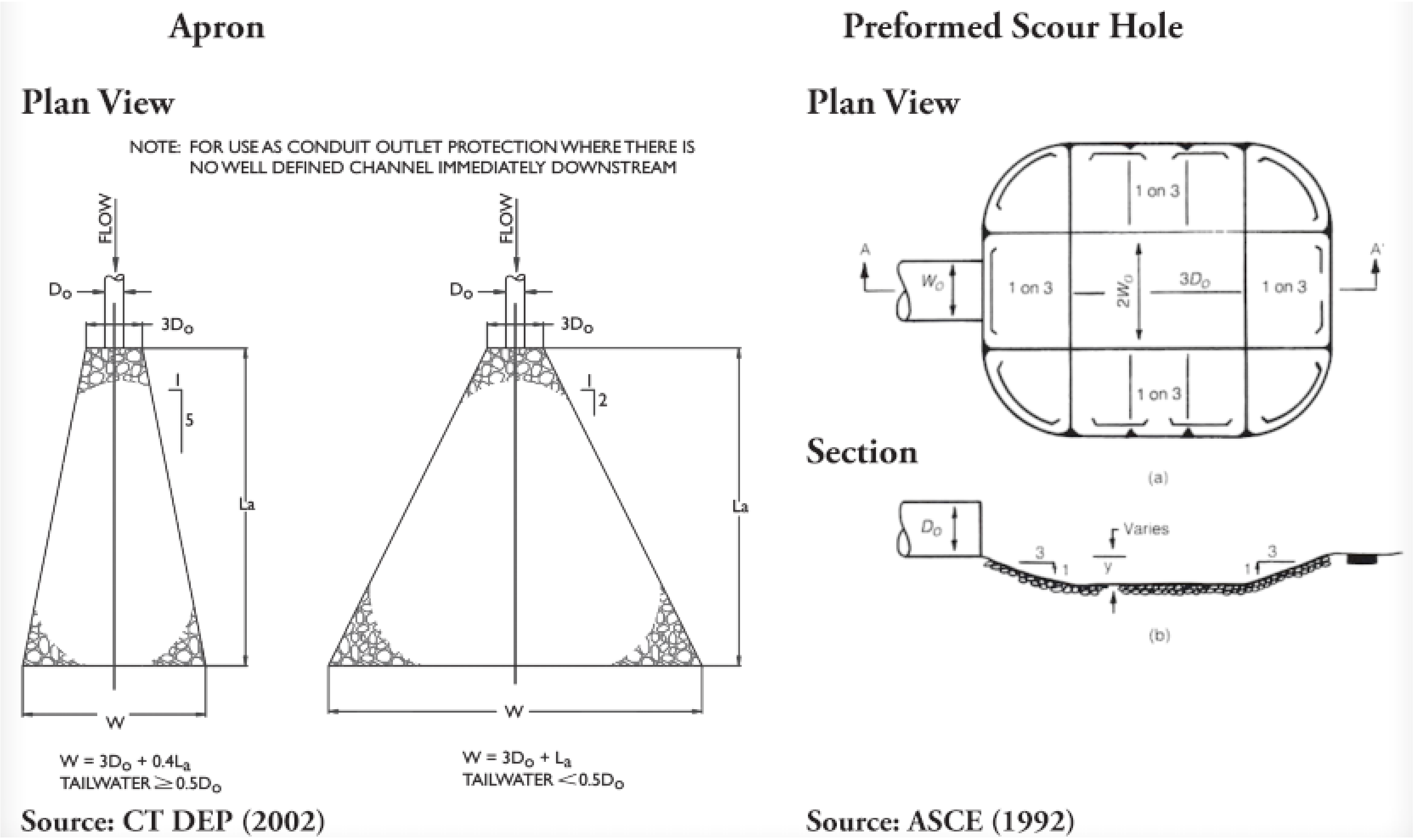

Typical Riprap Apron Outlet Protection

GENERAL NOTES

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Example Culvert Replacement

GENERAL NOTES

1. Source is CEI Project Photo.

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