Cost Benefit Resource Toolkit for Phosphorus Control BMPs

Purpose: This Toolkit summarizes cost-benefit data associated with structural stormwater best management practices (BMPs) recently constructed in Massachusetts. For this resource, benefits focus on phosphorus reduction. Cost and phosphorus load reduction data was collected by the Charles River Watershed Association (CRWA) and Brown and Caldwell (BC) as a part of the Phosphorus Control Planning Support project funded MassDEP's FY22 MS4 Municipal Assistance Grant.

Under the MassDEP's Stormwater MS4 Municipal Assistance Grant Program in 2022, CRWA and BC distributed a survey to collect current and regionally specific information for structural BMPs on public property aimed at treating phosphorus. The goal of collecting this data was to provide Charles River and Lake and Pond communities subject to phosphorus control plan (PCP) requirements with more regionally specific information on the costs associated with constructing structural BMPs to treat phosphorus and achieve their PCP goals.

This summary was prepared as a supplemental resource to accompany the PCP Template and Workshop Series presentations available at CRWA's website (https://www.crwa.org/phosphorus-control-planning-support.html). Information included in this Toolkit was presented in "Workshop 3: Public BMPs – Maximizing the Cost-Benefit Equation" on Tuesday, May 10, 2022. The recording of this workshop is included in the link above. For the purposes of this document, "benefit" is defined based on the calculated amount of phosphorus load reduction for a given BMP.

DATA

Cost information was provided by eight communities for 82 BMPs constructed within the Charles River Watershed. A summary of data received is in Table 1.

Table 1. Summary of Data Received - Communities and BMP Types

BMP Types - Individuals	Boston	Brookline	Cambridge	Lexington	Medway	Milford	Newton	Watertown
Biofiltration							X	
Bioswale								X
Detention Basin					X			
Drywell								X
Impervious Area Disconnection via Storage							X	
Infiltration Systems		X		X		X	X	X
Porous Pavement	X		X				X	
Rain Garden					X	X		
Swale							X	
Tree Trench & Tree Box Filters							X	X
Constructed Wetland				X				

In addition to the BMP type, the following criteria were included in the data request:

- Land use type
- Drainage area
- Storm size treated
- Treatment volume
- Phosphorus load credit
- Total engineering cost estimate, date prepared
- Total construction cost, date of construction

- Annual O&M cost

Most of the submissions included land use type, drainage area, phosphorus load credit, total construction cost, and construction date. Therefore, the focus of this data remained on the cost-benefit analysis for the construction costs since insufficient data were provided to assess 20-year life cycle costs. For information regarding estimated BMP maintenance costs in EPA Region 1, refer to the Methodology for developing cost estimates for Opti-Tool (2016).[1]

The ENR Construction Cost Index was used to escalate all construction costs to the same date basis of April 2022 (ENR = 12898.96). The BMPs submitted were constructed between 2014 and 2022. All costs were escalated to a basis of April 2022.

COST ANALYSIS

Based on the data received, there was no single BMP type that presented itself as the most beneficial or cost-effective in reducing phosphorus loading. Rather, the costs and the phosphorus removal characteristics varied significantly across BMP types, installations, locations, and other confounding factors. Figure 1 shows how the unitized cost varies greatly within each type of BMP. These costs are normalized based on the associated pounds of phosphorus removed by each BMP. Tree trench, drywell, detention basin, and grass swale BMPs tended to have lower costs, on the average, than other BMP types in the dataset.

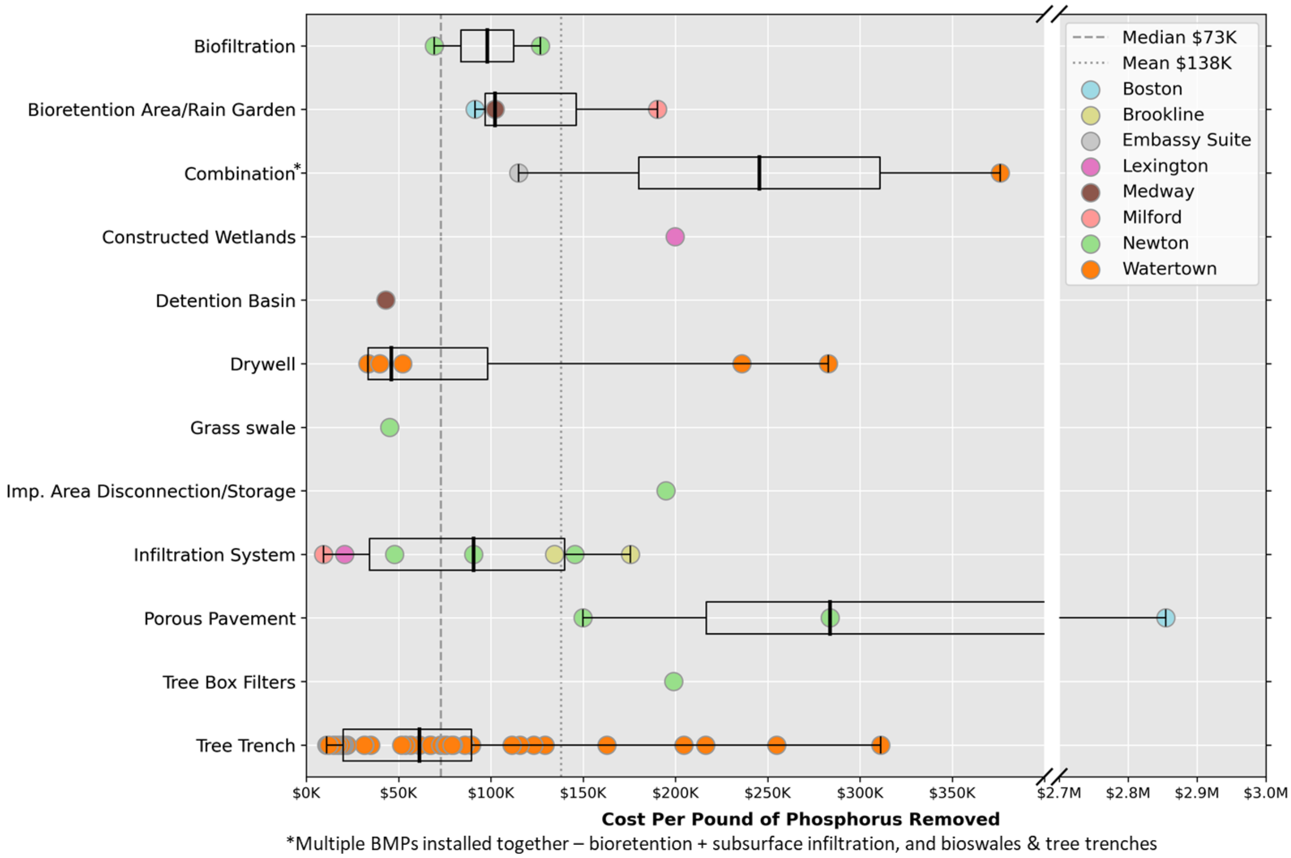

Figure 1. Cost Benefit of Regional BMPs

The mean and median costs per pound of phosphorus removed were $138,000 and $73,000, respectively, for the BMPs received under this project. One outlier, shown in Figure 1 for the porous pavement BMP, skewed this average. Excluding the outlier, the mean cost was around $100,000 per pound of phosphorus removed. This is substantially higher than the estimated costs of approximately $31,700 per pound of phosphorus removed calculated and reported in the Sustainable Stormwater Funding Evaluation for the Upper Charles River Communities of Bellingham, Franklin, and Milford, MA (Horsley Witten Group prepared for USEPA-Region 1, 2011).[2]

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1 EPA Region 1 "Methodology for developing cost estimates for Opti-Tool" (2016) Memorandum: Methodology for developing cost estimates for Opti-Tool (epa.gov)

2 Horsley Witten Group (2011) "Sustainable Stormwater Funding Evaluation for the Upper Charles River Communities of Bellingham, Franklin, and Milford, MA." Prepared for USEPA-Region 1 https://www.epa.gov/system/files/documents/2021-07/20110930-swutilityreport.pdf

Another way of assessing these data is to compare the relative sizes of each of the submitted BMPs. Figure 2 shows the variability in BMP size based on the amount of phosphorus treated for each. Note that all BMPs, including the outlier from Figure 1, are included below. Many of the BMPs remove under a pound of phosphorus; some even under 0.1 lb. Others were designed to remove over 10 pounds of phosphorus.

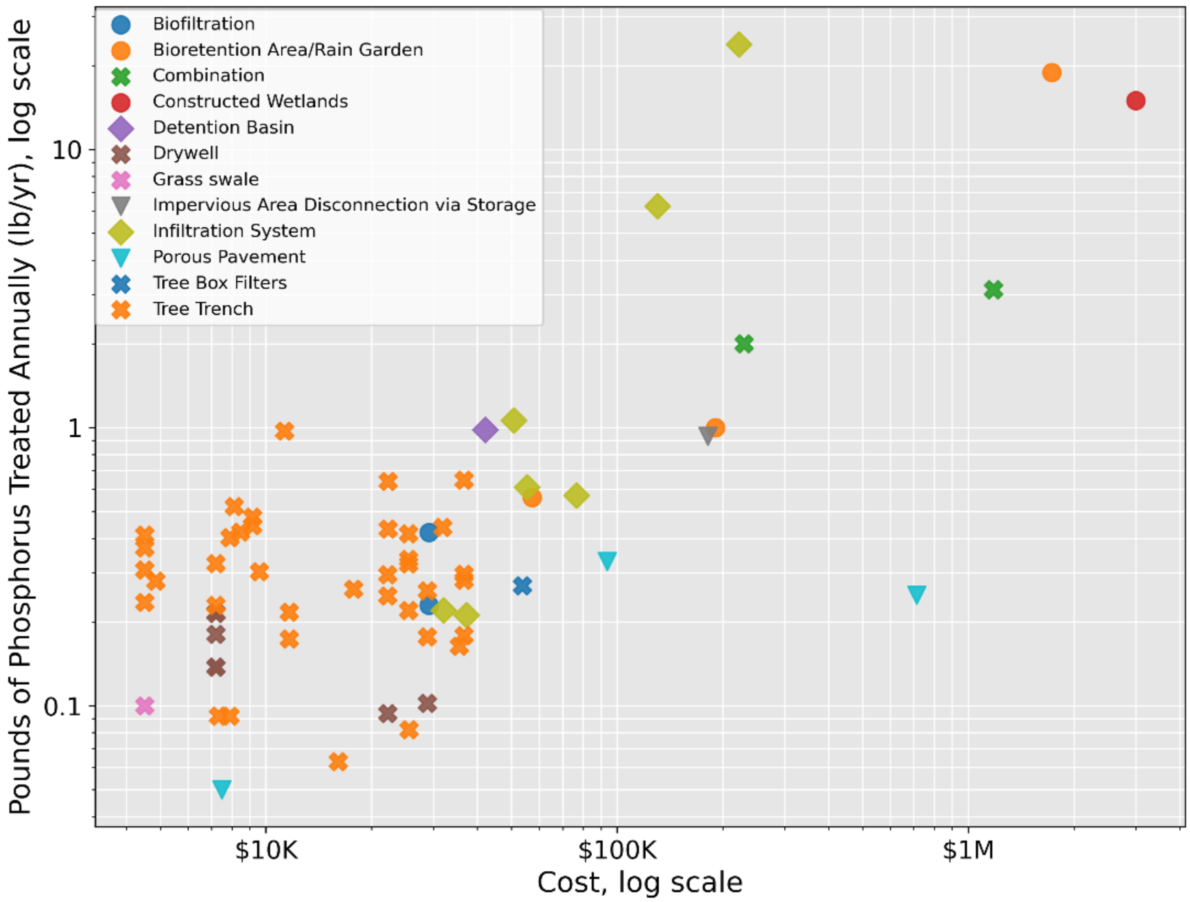


Figure 2. Logarithmic Plot of BMP Costs and Phosphorus Removal

There was relative consistency in Figure 2 as well with the types of BMPs and associated costs and treatment benefits. Some of these key takeaways include:

- While tree trenches and tree box filters were generally lower cost solutions, they also were designed to treat smaller loads.
- The types of BMPs best suited to larger scale benefits include biofiltration, constructed wetlands, and infiltration systems. Infiltration systems were the most cost-effective of these three based on the data received.
- Some BMP types show variability in possible treatment sizes – infiltration systems demonstrated the largest variability in phosphorus removal.

COMMUNITY IMPLICATIONS

As a part of collecting this regionally specific BMP cost information, the team used the trends described above to estimate the financial impacts of PCP implementation on the communities in the Charles River. While it is understood that each community will develop their own unique implementation plan, leveraging non-structural and structural BMPs in ways that best reflect the site suitability, other goals, and financial constraints of their municipality, this data enabled us to develop some highly generalized PCP cost implications.

The approximate average structural BMP implementation cost was about $100,000 per pound of phosphorus removed, based on the data provided. This value does not include operation and maintenance costs. Using this estimate, and an assumption that some of the credits will be achieved via non-structural BMPs, full implementation of the PCP could potentially cost the combined Charles River Watershed communities up to $4 billion dollars. This assumption is calculated in 2022 USD and assumes that the costs would be incurred over the next 1-2 decades, in a timeline that aligns with Phosphorus Control Plan requirements. Figure 3 illustrates how these costs are distributed, and the assumptions that were incorporated in this estimate.

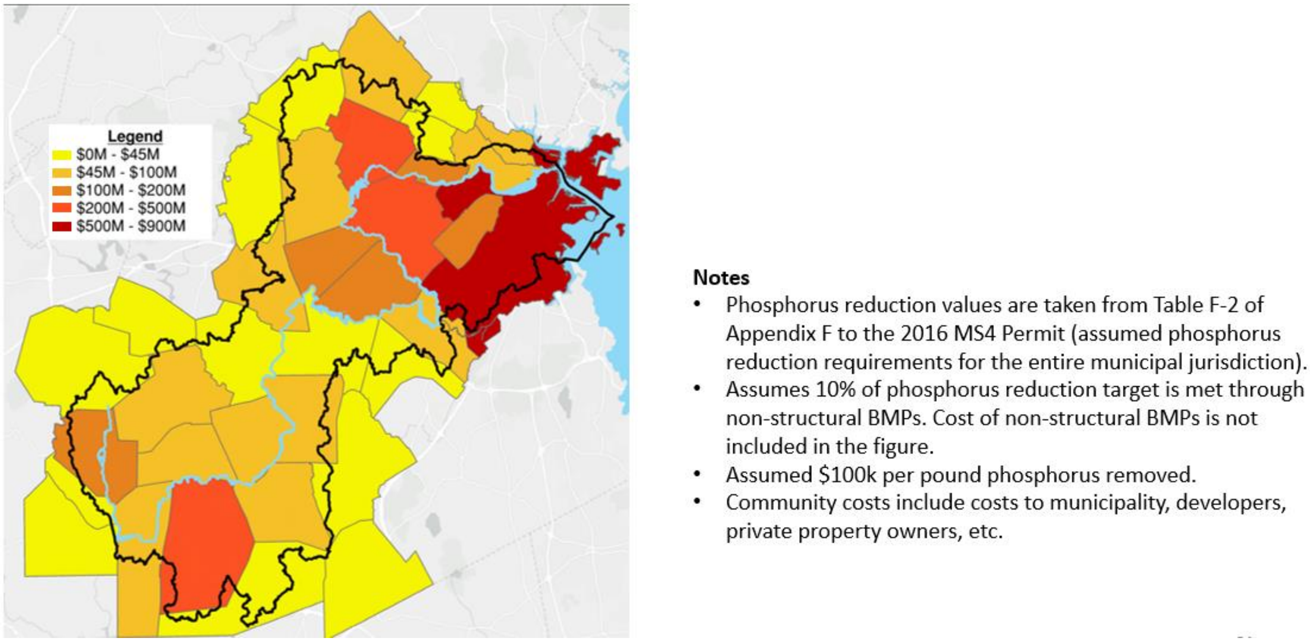
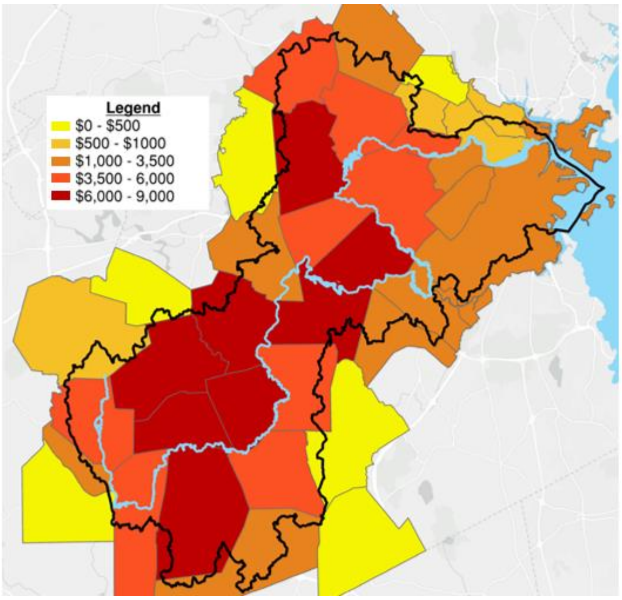


Figure 3. Estimated Potential PCP Implementation Costs for Structural BMPs in the Charles River Watershed

Of course, not all credits will be achieved through structural BMPs, and not all structural BMPs are likely to be implemented on public property. While the values presented in Figure 3 assume that 10% of each municipality's reduction requirement is met through non-structural BMPs, what is not included here is any assumption of what the distribution will be between public and private BMPs, and what the associated administrative costs are for tracking BMPs on private property. These values are intended as an order of magnitude approximation to illustrate the potential costs of the PCP.

Similarly, most of the BMP data received focused exclusively on capital, construction, and/or engineering costs. Therefore, operation and maintenance costs are excluded from this analysis. Staff time, equipment, and recording and reporting time will add to the overall cost to maintain the long-term benefits associated with the PCP and further work may incorporate these data for a holistic estimation of phosphorus control plan implementation costs.

Since not all BMPs are likely to be implemented on public property, this begs the question of how communities will distribute BMPs, and their associated costs, across public and private property. If the costs displayed above in Figure 3 were borne entirely by the populations of each municipality, these costs can be converted to a cost per-capita. While the costs will *not* be paid for directly by the population, the trends in Figure 4 illustrate how the cost burdens may evolve when population is considered.



Notes

- Estimated phosphorus reduction costs were divided by 2020 Census population data.
- Assumes 10% of phosphorus reduction target is met through non-structural BMPs. Cost of non-structural BMPs is not included in the figure.
- Assumed $100k per pound of phosphorus removed.
- This purpose of this figure is to provide some context of the anticipated phosphorus removal costs relative to population. It is for illustrative purposes only. It is not indicative of costs that will be incurred directly by residents. Costs will be paid by the municipal government, developers, private property owners, etc.

Figure 4. Estimated Potential PCP Implementation Costs for Structural BMPs in the Charles River, Normalized by Population

Figure 4 shows that some of the communities with the highest overall cost (e.g., Boston) have lower unit costs when normalized by population. Conversely, many of the communities in the Upper Charles have relatively lower overall costs, but due to the smaller populations, the population-normalized costs are much higher.

Understanding these trends, and potential cost burdens, are both important steps for consideration as communities build their PCPs. Some communities may be better positioned to offset BMP implementation to private property than others based on the amount of development taking place on private property anticipated over the coming years. The last consideration reviewed here is the geographic land availability for structural BMPs. Most communities are covered by largely private land, with the municipality directly responsible only for a subset of properties in the community. This will play a critical role in determining the sizes of public and private BMP programs for each community.

Figure 5 shows one example community in the Charles River Watershed. The “TMDL” and “Allowable Load” bar and line represent the maximum phosphorus load at the end of PCP implementation. For this community – and likely most others in the watershed – it will be impossible to reach the required PCP load reduction on public property alone. These numbers are calculated using the same method that EPA used to calculate the baseline loads for each community, and then the corresponding land use types for each of the loads were used to symbolize where those loads are found.

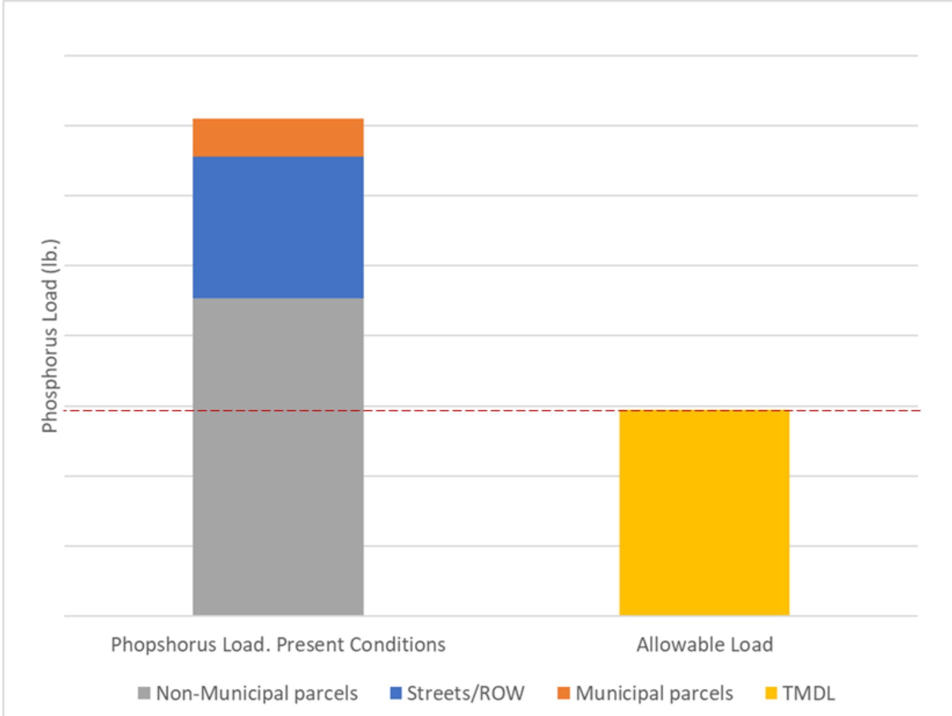


Figure 5. Geographic Distribution of Phosphorus Loads in Example Charles River Community

CONCLUSIONS AND NEXT STEPS

The goal of this task was to compile localized BMP cost data specific to the Charles River Watershed and Massachusetts communities under obligations to implement phosphorus reducing BMPs. The information received represents a subset of these target areas, and it provides a localized update to other national resources on structural BMP implementation costs. We learned that there was a large amount of variability in cost effectiveness of phosphorus load reducing BMPs constructed within the Charles River watershed in recent years. On the average, the cost to reduce phosphorus loading by one pound was about $100,000. At this rate, Charles River and Lakes and Pond communities subject to phosphorus control plan requirements will be making billions of dollars in investments over the upcoming decades to meet MS4 Permit requirements. Planning to cost-effectively meet these requirements, maintain the infrastructure, and document the effectiveness of BMPs is critical.

Since many communities are in the earlier stages of BMP implementation and optimization for phosphorus removal, questions remain about how these unit costs will evolve over the PCP planning horizon. Will communities find more cost-effective methods for reducing phosphorus? Will unit costs increase as the most readily available phosphorus is removed and the remaining required removals become more difficult? These questions can only be answered with further studies collected as PCP implementation continues.