Chapter 5: Economic Analysis of Stormwater Management Alternatives

In order to help the Spring Lake Watershed stakeholders with the selection – and ultimately the implementation – of best management practices (BMPs), the Rein in the Runoff project team conducted an economic analysis of the different BMP alternatives listed for the Spring Lake Watershed. BMP costs generally included direct costs, such as those for construction and maintenance, and potential opportunity costs associated with alternative uses for the land where the BMP is applied (for example, a grow zone might be installed in place of cropland). Benefits of BMPs included lower stormwater flows into storm drains, decreases in external phosphorus loading to Spring Lake, decreases in sedimentation in waterways and storm drains, improved water quality, and in some cases a decreased need for city-provided domestic water and septic sewer services.

This economic analysis utilized the benefit transfer approach, which assigns economic costs and benefits at a targeted "policy site" (i.e., the Spring Lake Watershed), by using primary data and information collected by different researchers at other "study sites" (Groothuis 2005). Wherever possible, the project team estimated the construction and maintenance costs of BMPs using specific examples from the literature – instead of calculating cost estimates – so that policy-makers had data and information regarding actual usage of different BMPs. Alternatively, the team utilized online tools such as worksheets designed by the Minnesota Pollution Control Agency (2008) and the Water Environment Federation (2009) that can be used for estimating costs; however the team found that these tools were most appropriate for estimating costs for specifically-identified projects. All costs were converted to the cost of infiltrating runoff from one acre of impervious surface area so that the values for all BMPs were comparable. For those BMPs that could not completely infiltrate all of the runoff from a storm event, additional costs associated with traditional stormwater management features – such as curbs and gutters, stormwater vaults, and storm sewers – were included in the costs.

This chapter includes a technical description of the economic analyses completed by the Rein in the Runoff project team, as well as summary tables and information to assist Spring Lake Watershed stakeholders with decision-making.

DIRECT COSTS

Average direct costs were calculated by taking the total direct costs of BMP construction and implementation for bioretention/rain gardens, vegetated swales, pervious pavement, and constructed wetlands, and dividing these numbers by the total number of acres of impervious surfaces being treated. Those numbers were then converted to

2008 U.S. dollars using the Bureau of Labor Statistics consumer price index (http://www.bls.gov/cpi) and averaged together to give the average cost for these different BMPs. Finally, a study in Portland (OR) provided an estimation of $14.75 per square foot for green roofs (MacMullan et al. 2008). This number was converted to acres and used as the applicable direct cost (Table 5-1).

Table 5-1. Direct Initial Costs to Treat 1 Acre of Impervious Surface Area.

BMP	Burnsville, MN[1]	Durham, NH[2]	Fredericksburg, VA[3]	Rouge River Watershed, MI[4]	Portland, OR[5]	Case Study Average
Bioretention/ Rain Gardens	$24,000	$18,000	$14,473	$25,400		$21,500
Vegetated/Bio-Swales		$12,000		$18,150		$16,620
Green Roofs					$686,070	$686,070
Pervious Pavement		$371,100				$371,100
Constructed Wetlands		$22,500				$22,500
Stormwater Retrofits	Highly variable – depends on retrofit.					

1 (Minnesota Pollution Control Agency 2008).

2 (University of New Hampshire 2008).

3 (U.S. Environmental Protection Agency 2007).

4 (Alliance of Rouge Communities 2009).

5 (MacMullan et al. 2008).

For many of the alternative BMPs recommended for use in the Spring Lake Watershed, there were also additional maintenance costs. These included cleaning, planting, and periodic inspections. However, since the municipalities in the Spring Lake Watershed that actively participated in this project already had some type of street sweeping or roadside maintenance program in place, the project team assumed that this was in fact

Table 5-2. Additional Yearly Maintenance Costs per 1 Acre of Impervious Surface Area.

BMP	Burnsville, MN[1]	Durham, NH[2]	Rouge River Watershed, MI[3]	Portland, OR[4]	Case Study Average
Bioretention/Rain Gardens	$0 - $1,000	$0			$250
Vegetated/Bio-Swales		$0	$60		$32
Green Roofs				$600	$600
Pervious Pavement		$0			$0
Constructed Wetlands		$0	$60		$32
Stormwater Retrofits	Highly variable – depends on retrofit.				

1 (Minnesota Pollution Control Agency 2008).

2 (University of New Hampshire 2008).

3 (Alliance of Rouge Communities 2009).

4 (MacMullan et al. 2008).

true throughout the watershed. Since some watershed municipalities might budget less for such maintenance than others, this had the potential to bias these cost estimates downward. Estimates of the additional maintenance costs are provided in Table 5.2, but these were not used in the final capital cost comparisons. As a result, while these costs for street sweeping and roadside maintenance would not be greatly affected by implementation of BMPs, their omission in this analysis does create an underestimation of the true cost of these BMPs.

OPPORTUNITY COSTS AND BENEFITS

There are many costs and benefits beyond installation and maintenance of BMPs that must be taken into account. Opportunity costs are those costs related to a foregone alternative. For example, using a vegetated swale for stormwater management means that some other stormwater management technique (e.g., curb and gutter or storm sewers) did not have to be used. As the Spring Lake Watershed is primarily developed, some type of stormwater management system will need to be in place – whether it be a more traditional design or Low Impact Development (LID). From an economic standpoint, the only difference will be the cost of the different types of systems. The costs associated with traditional stormwater management systems were estimated using two case studies: Central Park Commercial Redesigns and Bellingham (WA) Parking Lots (U.S. Environmental Protection Agency 2007). These case studies were chosen because they were well-documented and had stormwater management needs similar to those in the West Michigan (i.e., in the Spring Lake Watershed). These case studies gave costs associated with traditional stormwater management systems, which the project team adjusted by dividing the value by the number of impervious acres being treated in each case. This gave an estimated range of values for stormwater management practices, from which the team took the average and converted to 2008 U.S. dollars (Table 5-3).

Another way to calculate the opportunity cost would be to compare not only the capital costs, but also the difference in the value of land area required by a particular BMP design. The project tam calculated the opportunity cost of land by using parking space data, because many of the BMP alternatives for the Spring Lake Watershed would be implemented near parking lots (or roadways), and most have a direct impact on the available parking area overall. An average sized parking space is 9x18 feet, but 270 square feet (9x30 feet) is needed to include the average space required to back out (Parkinglotplanet.com). If it costs $2,000 to install a standard parking space (University of New Hampshire 2008), the project team assumed that the market is in equilibrium and the value of the land is also $2,000 for the same 270 square feet. However, in some cases, BMPs would be incorporated into an already-existing land use, in which case the cost of the land would be zero. In particular, green roofs and pervious pavement needed no additional land, and other BMPs could be built into existing rights-of-way that currently have little value (e.g., vegetated swales and rain gardens). Accordingly, the opportunity cost for this lost land use and cover resulting from application of BMPs would be between $0 and $2,000 per 270 square feet, depending on the BMP implemented and its particular location.

Table 5-3. Opportunity Costs to Treat 1 Acre of Impervious Surface Area.

BMP	Durham, NH[1] (land area)	Durham, NH[1] (standard asphalt)	Fredericksburg, VA & Bellingham, WA[2] (standard stormwater)	Portland, OR[3] (cost of actual roof)	Future Re-Installation Costs	Case Study Average
Bioretention/ Rain Gardens	$0 - $24,000		$13,010 - $55,2000		$6,350	$17,100
Vegetated/Bio-Swales	$0 - $20,000		$13,010 - $55,200		$4,910	$20,500
Green Roofs			$0 - $27,600	$435,600	$0	$442,765
Pervious Pavement		$322,700	$6,505 - $27,600		$0	$340,400
Constructed Wetlands	$0 - $19,000		$13,010 – $55,200		$0	$25,900
Stormwater Retrofits	Highly variable – depends on retrofit.					

1 (University of New Hampshire 2008).

2 (U.S. Environmental Protection Agency 2007).

3 (MacMullan et al. 2008).

The opportunity costs calculated from these two different methods were averaged together to determine the cost for each Rein in the Runoff BMP. These values were added to the costs that were unique to specific BMPs. For BMPs such as green roofs and pervious pavement, the project team adjusted the possible replacement costs with the costs for standard sewer and alternative surfacing materials. The team assumed that BMP installation would require only half the sewer infrastructure for pervious pavement, and between zero and one-half of the sewer infrastructure for green roofs, which is consistent with studies summarized in MacMullan et al. (2008). The respective averages for the reduced sewer infrastructure were added to the estimated costs for these BMP substitutes. For pervious pavement, the substitute was the cost of a standard asphalt parking lot (University of New Hampshire 2008); for green roofs the substitute was a standard commercial roof estimated at $10 per square foot (MacMullan et al. 2008). For bioretention/rain gardens and vegetative swales, which have shorter life spans than standard sewer treatments (Conservation Research Institute 2005), the project team took the present value of replacement (r = .05) in 25 years and included that as a cost in the calculation (see Table 5-3).

Many direct benefits of BMPs were not used in these calculations because the numbers did not include enough detail to transfer to the Spring Lake Watershed. In each case, the project team chose to use the most conservative assumptions, so that net benefits would be generally biased downward. The team assumed that the sewer systems within the watershed were not at capacity, so there was no benefit from reducing the need to expand the current systems. The project team also assumed that these BMPs would not affect the overall maintenance costs associated with the current sewer systems. However, the use of BMPs will lower peak flows and remove suspended solids, which will lead to lower maintenance costs for the current sewer system. It was assumed that the BMPs will not affect energy costs, although, increased green space and green roofs have been shown to decrease energy use, particularly during the summer cooling season (Banting et al. 2005). This can be a substantial benefit for green roofs when compared to a traditional tar roof; however, when compared to other energy-saving roofing systems, this benefit shrinks considerably. Finally, pervious pavement has been shown to decrease the need for road salt in the winter in colder climates by 50% – 75% (University of New Hampshire 2008). By not including these benefits, the Rein in the Runoff project team derived a conservative estimate of the economic benefits of BMPs.

COST EFFECTIVENESS AND POLLUTION REDUCTION

Construction costs were added to the sum of the opportunity costs and benefits to generate the total cost of treating one acre of impervious surface area. However, some of the BMPs were better than others at reducing certain pollutants, and in some cases the BMP's effectiveness at reducing pollutant loads was highly variable (Table 5-4). To adjust for these factors, the project team divided the total cost by the average percent reduction in pollutants for each BMP. This effectively meant that if one BMP reduces pollutant loading by 100% and another BMP reduces it by only 50%, twice as many of the less effective BMPs would need to be implemented to achieve the same level of pollutant reduction.

Table 5-4. Average Percent Reductions in Pollutant Loads for Different BMPs.

BMP	**Percent Reductions in P Loads**			**Percent Reductions in TSS Loads**		**Percent Reductions in N Loads**	
	MPCA[1]	UNHSC[2]	**Average**	UNHSC	**Average**	UNHSC	**Average**
Bioretention/ Rain Gardens	50-100%	5-83%	**60%**	90-99%	**95%**	23-44%	**34%**
Vegetated Bio-Swales	0-100%	9-65%	**44%**	30-90%	**60%**	0-80%	**40%**
Pervious Pavement		38-71%	**54.5%**	82-99%	**91%**	N/A[3]	**N/A[3]**
Constructed Wetlands		40-55%	**48%**	80-99%	**90%**	75-81%	**78%**
Stormwater Retrofits	Depends on retrofit						

1 Minnesota Pollution Control Agency (2008).
2 University of New Hampshire (2008).
3 Data not available.

COST-BENEFIT ANALYSIS

One issue that came up repeatedly throughout the Rein in the Runoff Integrated Assessment (IA) project was the costs associated with BMP implementation and long-term maintenance. Stakeholders are reluctant to implement BMPs that are expensive at the outset or over the long run (or potentially both). However, there is some willingness among local officials in the Spring Lake Watershed to consider BMPs that have higher implementation costs if the long-term maintenance or replacement costs are lower than those associated with traditional stormwater management systems.

The project team transferred cost and benefit data from various published resources to calculate BMP costs and benefits for the Spring Lake Watershed stakeholders (Minnesota Pollution Control Agency 2008; University of New Hampshire 2008; U.S. Environmental Protection Agency 2007; Alliance of Rouge Communities 2009; MacMullan et al. 2008). However, the cost and benefit information for each BMP was generally limited to only a few case studies (generally, less than five). In addition, the use of these particular sources has generally resulted in upper bound estimates for the costs presented here for several reasons: (1) these reports do not focus on residential applications of these BMPs (where the main stakeholder cost would be time), but instead focus on contractor and municipal worker costs; (2) academic papers focus on novel uses of technologies that have not yet gained cost advantages associated with repetition of processes; and (3) the design and maintenance specifications for the BMPs in many of these studies were targeted solely at scientific study, as opposed to cost-saving applications, thereby increasing initial construction costs. As a result, the BMP costs calculated for the Rein in the Runoff project were biased upward. Finally, the actual cost of any given BMP varied greatly with existing vegetation and soil conditions at the site. Actual implementation costs for a particular BMP at a particular site could be well-above or well-below these benchmark costs (Table 5-5).

Table 5-5. Estimated BMP Costs per 1 Acre of Impervious Surface Area

BMP	Direct Initial Costs	Total Opportunity Costs	Annual Maintenance Costs
Bioretention/Rain Gardens	$21,500	$17,100	$250
Vegetated/Bio-Swale	$16,620	$20,500	$32
Green Roofs	$686,070	$442,765	$600
Pervious Pavement	$371,100	$340,400	$0
Constructed Wetlands	$22,500	$25,900	$32
Stormwater Retrofits	Highly variable. Depends on retrofit.		

The benefits associated with these same BMPs were calculated based on their ability to reduce average pollutant loads for Total Phosphorus (TP), Total Nitrogen (TN), and Total Suspended Solids (TSS) (Table 5-6) using the results reported in University of New Hampshire (2008). Total installation costs were added to opportunity and indirect costs to arrive at a total BMP cost number. A positive value for total cost was equivalent to a net cost, and a negative total cost value was actually a net benefit. For example, for vegetative swales the installation cost of alternative stormwater management BMPs was high enough that the vegetative swale BMP is actually cheaper than traditional stormwater management techniques, leading to a negative total cost.

Table 5-6. Cost Effectiveness Associated with Pollutant Load Reductions Per Treated Acre.

BMP	Total Installation Cost	Total Opportunity Cost[1]	25 Year Maintenance Costs[2]	Total Cost	Net Costs Associated with Pollutant Load Reductions[3]		
					TP	TN	TSS
Bioretention/ Rain Gardens	$21,500	($17,100)	$3,773	$8,173	$13,622	$24,038	$8,603
Vegetated/ Bio-Swales	$16,620	($20,500)	$483	($3,396)	($7,718)	($8,490)	($5,660)
Green Roofs	$686,070	($442,765)	$9,056	$252,361	$315,451	$315,451	$315,451
Pervious Pavement	$371,100	($340,400)	$0[4]	$30,700	$56,330	Not Calculated	$33,736
Constructed Wetlands	$22,500	($25,900)	$483	($2,917)	($6,077)	($3,740)	($3,241)

1 These represent added costs associated with traditional stormwater management practices and/or replacement costs.

2 Maintenance costs were the net present value of annual maintenance costs from Table 5-5 over 25 years, given a 5% discount rate.

3 These costs were adjusted based upon the BMPs' ability to reduce pollutant loads (Table 5-4).

4 Zero maintenance costs for pervious pavement are based on the assumption that current pervious pavement technologies were used and that high efficiency street sweeping is already in place.

In addition, these total costs (benefits) were also adjusted to take into account the effectiveness of each BMP at remediating particular pollutants. This was done by adjusting the total cost to the equivalent of eliminating all of the pollution from stormwater runoff from a 1 acre site. If a particular BMP is only 50% effective at reducing this pollution, then the installation for that BMP would need to be constructed to capture the stormwater flow from 2 acres. To illustrate this, notice that after the adjustment for TN, the total cost of rain gardens almost tripled, whereas the total cost of green roofs increased by only about 20%. This is because green roofs are generally much more efficient at reducing TN.

After all the adjustments were made, both vegetated/bio-swales and constructed wetlands were found to be cost effective BMPs to implement, even without the benefits of reduced pollutant loads to local waterbodies – an important consideration identified by the Spring Lake Watershed stakeholders. Bioretention/rain garden BMPs have lower costs and smaller footprints then swales or wetlands, making them better-suited economically to areas where land is available but not abundant. Although they cost on average $8,200 more to implement than the alternative practices used to calculate the opportunity costs contained in Table 5-3, there are some limited effects of pollution control to local waterways.

In general, green roofs and pervious pavement are extremely expensive to implement – with direct costs increasing by 10% to nearly 30% compared to traditional stormwater management practices. To make these BMPs worthwhile at the local level, the economic cost savings associated with the reduced pollution (i.e., water quality improvement) would have to make up the difference in cost. Alternatively, the cost of land would have to be prohibitive, thereby dramatically increasing the implementation costs of the other, less expensive BMPs, to make green roofs or pervious pavement competitive ways to reduce pollution. It should be noted here that there may be other reasons to install green roofs or pervious pavement (e.g., education, energy cost savings, etc. as discussed earlier) which offset their high implementation costs; our analysis was based strictly on stormwater-related pollutant reduction.

Three BMPs suggested for potential implementation in the Spring Lake Watershed have more variation in their net benefits, and also manage stormwater differently, than the suite of BMPs already discussed:

- Grow zones generally consist of native plants. These BMPs slow the flow of water toward the storm drain or waterbody, thereby reducing the overall pollutant loads. The degree to which a grow zone is effective at reducing these loads depends on the slope, soil type, and the type of plants. However, installation and maintenance costs for this BMP are relatively inexpensive at approximately $200 - $800 per acre, and $4 - $200 per acre, respectively (Alliance of Rouge Communities 2009).

- Rain barrels collect rainwater from downspouts. The water can then be slowly drained to facilitate infiltration (thereby decreasing peak flows and reducing pollutant loads to Spring Lake), or is used for irrigation. In West Michigan, the cost range for a

50-60 gallon rain barrel is $25 - $200. In addition to the stormwater control benefits, this BMP also reduces the household consumption (and monthly cost) of water for irrigating lawns and gardens.

- Tree plantings along roadways can also reduce the amount of water entering the stormwater system. An acre of tree canopy over impervious surface areas reduces stormwater discharge by 6,700 cubic feet during a 2.37 inch storm event (Denning and Sanborn 2008), which can reduce the need for additional stormwater infrastructure. However, the current sewer systems in the Spring Lake Watershed were assumed not to be at capacity and many of the residential areas are older neighborhoods with lots of mature trees, so these benefits of additional tree cover at this time would be minimal, particularly without some type of assurance that this BMP would be maintained for the life of the roadway or parking lot. Additional benefits associated with tree plantings include limited increases in property values, pollution reduction, cooler runoff temperatures, and energy saving benefits during the cooling season.