UBC Social Ecological Economic Development Studies (SEEDS) Student Report

An Investigation into Rain Gardens

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ABSTRACT

Rain gardens are a relatively simple way to dispose of stormwater runoff. 70% of all water pollution is caused by stormwater runoff, which can be effectively managed using a rain garden. A detailed explanation on the construction of a rain garden is included in this report. This includes all considerations that should be taken – area, location, and other design details. A soil-survey must be done before the construction of the rain garden. The type of soil found will partially determine the cost of the project. Soil with high infiltration would cost less to construct on then low infiltration soil. If the soil is completely unsuitable, new soil must be brought in locally, which would increase both the economic and environmental costs. An estimate of the cost is $11-30 per cubic meter of soil. As for maintenance, litter and debris must be cleaned monthly, dead vegetation replaced bi-annually, and re-mulch annually/as needed. Given its benefits, the cost of a rain garden is low compared to other stormwater runoff solutions.

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GLOSSARY

LEED*: Leadership in Energy and Environmental Design. In the United States and in a number of other countries around the world, LEED certification is the recognized standard for measuring building sustainability by gauging improvements in performance of sustainability factors such as energy savings, water efficiency, CO2 emissions reduction, improved indoor environmental quality, and stewardship of resources and sensitivity to their impact.*

SUB: *Student Union Building. Building for student recreation, relaxation, club activities and food services.*

BMP: *Best Management Practices. Best management practices are informal, although generally taken as a procedure, technique or process which can be relied upon to accomplish a task.*

LID: *Low-Impact Development. Planning and Engineering practice to manage the flow of stormwater. LID uses conservation and natural features to conserve and protect water quality.*

Rain Garden: *Planted depression made to absorb, hold, and/or filter the stormwater runoff and rainfall within a certain area. Useful in filtering pollutants and moderating stormwater flow.*

Hydraulic Conductivity: *Property of vascular plants, soil or rock, that describes the ease with which water can move through pore spaces or fractures.*

Loam: *Soil composed of sand, silt and clay. Generally provides better infiltration and drainage than silty clay soils but are more nutrient rich and retain more moisture. However, this is dependent on the loam type as there can be many types of loam such as sandy loam, silty loam, clay loam, sandy clay loam and silty clay loam.*

Triple Bottom Line: *A form of decision making that takes into account social, environmental, and economic impacts (both negative impacts, or costs, and positive impacts, or benefits) when deciding what products to purchase or in design/engineering decisions.*

LIST OF ABBREVIATIONS

LID	Low-Impact Development
BMP	*Best Management Practice*
SUB	*Student Union Building*
LEED	*Leadership in Energy and Environmental Design*
TBL	*Triple Bottom Line*
UBC	*University of British Columbia*

1. INTRODUCTION

Impervious areas now cover most urban cities. Due to the amount of impervious ground, most excess stormwater runoff flows straight into nearby bodies of water. Since many harmful pollutants (such as Fe, Zn, Al, Cu) are carried in stormwater runoff, it is harmful for it to flow into our water systems (2010, Joshi and Balasubramanian). Rain gardens, also called bioretention gardens, are labeled as both low-impact development (LIP) and best management practice (BMP) [1]. They are situated at a lower elevation to allow stormwater runoffs to flow into it, and to allow it to "pond" (See Figure 1 below). A bioretention garden is generally made of a sand and soil mixture, with local shrubs and wild plants, allowing high water flow within it. The bioretention can retain all the pollutants and sediments, while not affecting its infiltration capacity over time [2].

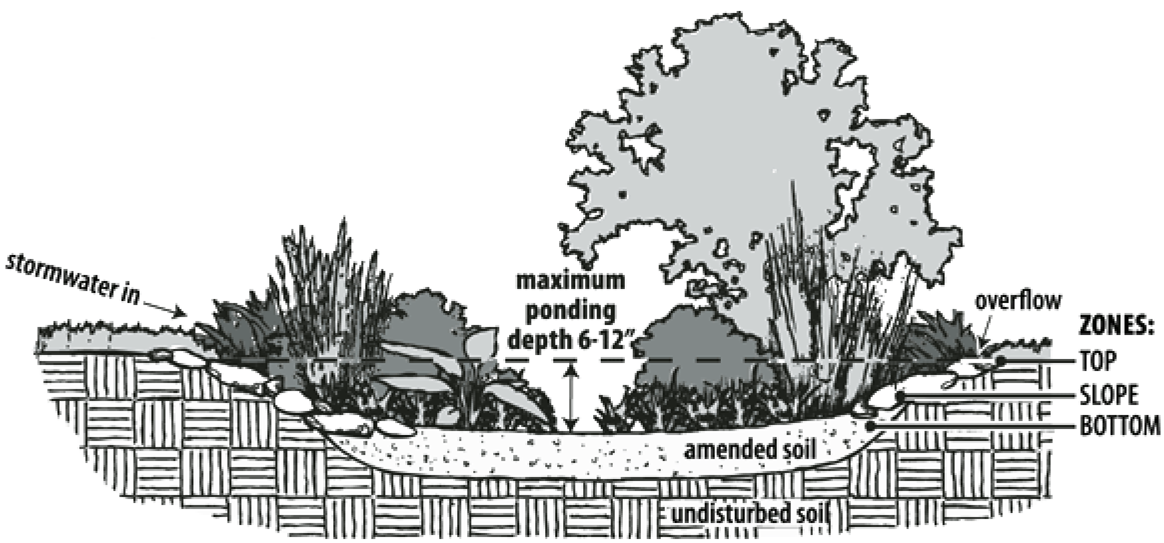

Figure 1. *Example of a Rain Garden - http://www.stewardshippartners.org/graphics/rain_diagram_1.gif*

In order for the new Student Union Building (SUB) to reach Leadership in Energy and Environmental Design (LEED) Platinum status, they must take stormwater management into account. As noted from Canada Green Building Council [3] as of December 2010, out of 189 LEED projects in Canada, only 13 are platinum level. Within these 13, 10 of them treat stormwater runoff. Stormwater treatment accounts for 2 points out of 14 points in the category “Sustainable Sites”, and 70 points in total [3].

Rain gardens are widely used in Canadian cities today. A specific example is the City of Calgary. They first implemented rain gardens in 1979, and by 1988, the had created enough to withstand a 1 in 100 year rainfall [4].

The reason rain gardens are used is because they have been proven to improve water quality, remove pollutants, require low maintenance, be sustainable, and have a low cost [4]. This shows that there are positive economical, social, and environmental costs – covering the triple bottom line. Residential areas contain approximately 20% impervious ground, whereas commercial areas contain up to 85% impervious ground [5]. This proves to be a large problem in Metro Vancouver due to the rapidly growing population.

The rain garden at the new SUB has a few key aspects that must be assessed. The rain garden must be constructed based on its local climate and soil. We have included different ways to handle each case. This report will also include our suggestion on steps to take to create the rain garden. The soil composition depends on what soil is in the area. The amount of sunlight and precipitation must also be taken into consideration. Since rain gardens are meant to handle stormwater runoff, the soil must be very permeable. Vegetation such as plants and shrubs will help increase the permeability of the soil. A mulch top layer must be in place to filter out pollutants. Heavier woods work better, as they do not float away with heavy rain. This layer will require replacement as needed.

2. RAIN GARDEN CONSTRUCTION

The recommendations for rain garden construction laid out in this report are based on the Stormwater Source Control Design Guidelines 2005 published by the Greater Vancouver Sewerage & Drainage District, the Recharge Garden/Rain Garden/Bioretention Garden BMP's in the Pennsylvania Stormwater Management Manual and In-Situ Bioretention Design Concept by Michael Clar. During rain garden construction, the Greater Vancouver Stormwater Source Control Guidelines should be used alongside these recommendations.

This report outlines a method of rain garden construction using an In-Situ approach where appropriate. In-Situ design requires that you use the local site soil as a basis for the growing/filtering media, hereby referred to as the rain garden media. This approach is cheaper and more sustainable as soil does not need to be brought to the garden site.

2.1. General Construction

The following are recommendations about the general design aspects of the rain garden. More detailed design decisions can only be made once more information about the water flow into the garden, the native soil type in the rain garden site, and the type of plants that will be used has been determined.

Area and Depth

Current practice states that the area of the rain garden should be no less that 10-20% of the total upstream impervious area [6]. If the infiltration rate of the local soil is low, the garden should be a larger percentage of the upstream area. The volume is determined by the flow into the rain garden and the infiltration rate of the soil. It is recommended that the actual sizing be calculated by a design professional for a 2-year storm event, using continuous flow modelling [6].

Location

The rain garden should be positioned at least 30m from wells and at least 3m down-slope of building foundations equipped with footing drains. Geo-technical advice should be acquired if it must be placed closer than 3m to building foundations. Crossing of utility lines through or under the garden is not recommended. If utility lines are placed close, trench dams should be used to avoid water following the trenches [6].

Erosion and Sediment Prevention

Erosion and sediment flow into the rain garden should be prevented to conserve the infiltration rate of the media. To prevent inflow erosion and to catch sediment from entering, an inflow swale can be used. The swale should be shaped so that the inflow becomes a distributed sheet flow and should be 50-300cm long [6]. Also recommended is a sediment clean-out basin to catch sediment before it enters the rain garden.

Bottom Design

The bottom of the rain garden should have a flat cross-section with a longitudinal slope of up to 2% or be a natural bowl shape. It should be a minimum of 60cm wide (300cm desirable) and have a 5-7.5cm covering of mulch [6].

Side Slope Design

The side slopes of the rain garden should have a slope no steeper than 2 horizontal:1 vertical with a ratio of 4:1 preferred for maintenance. Like the bottom, the sides should also be covered with 5-7.5cm of mulch [6].

Ponding

During a rain event, the ponding level in the rain garden should not exceed 15cm [6]. For ponding over 15cm, a non-erodible spillway should be constructed to carry the overflow to a storm sewer. Water should not pond for more than 48 hours after rain to avoid the creation of mosquito habitat.

Drain-Rock Reservoir

The bottom of the drain-rock reservoir should be level [6]. The reservoir should also have geotextile fabric on all sides, enclosing it completely.

2.2. In-Site Design Approach

The main concern of the rain garden media is that it has a high infiltration rate and that it is a suitable growing medium for the desired plants. Frequently, situation exist where the existing local soil doesn't need to be replaced, but can be augmented to make it more suitable for use as a media [7]. By using existing soil, costs can be lowered and the rain garden can be constructed in a more sustainable way.

For ideal local soil, modification is performed by adding well aged organic material such as composted leaf mulch, double shredded mulch or pine fines to the native soil that will be used as the media. If the local soil is very sandy, the soil should be over-excavated by 15cm and good topsoil should be added as well as the well aged organic material [7].

If the local soil in the rain garden area has a moderate or poor infiltration rate, the In-Situ approach is not recommended. The native soil should be excavated and replaced by with good soil media [7]. A drain-rock reservoir and under-drain should also be used.

2.3. Local Soil Dependent Design Recommendations

Before construction, a soil-survey or on-site test of the local soil at the rain garden's location should be performed to determine the soil type and infiltration rate. The following recommendations correspond to the determined Hydrologic Group of the soil and should be done along with the recommendation given in the General Construction section.

Hydrologic Soil Group A – Sand/Loamy Sand

Excavate the soil a minimum of 60cm (a minimum of 135cm is recommended when trees will be planted in the rain garden) and mix into it, 10cm of good topsoil and 7.5cm of well aged organic material. Replace the modified soil in the excavation site without compacting it.

Hydrologic Soil Group B – Sandy Loam/Loam

Excavate a pit for the rain garden to the required volume to hold rainfall for a 2-year storm event [6]. While sizing, assume that the drain-rock and growing media is 40% porous [7], the 15cm ponding area is free volume and that the infiltration rate is 6mm/hour. Construct a drain-rock reservoir and size it so that the depth of the growing media is a minimum of 45cm deep (a minimum of 120cm is recommended when trees are to be planted). Mix 10cm of well aged organic material into the soil that will be used as the growing media and replace it in the excavated pit without compacting it.

Hydrologic Soil Group C – Silt Loam/Sandy Clay Loam

Excavate a pit for the rain garden to the required volume to hold rainfall for a 2-year storm event [6]. While sizing, assume that the drain-rock and growing media is 40% porous [7], the 15cm ponding area is free volume and that the infiltration rate is 6mm/hour. Construct a drain-rock reservoir and size it so that the depth of the growing media is a minimum of 45cm deep (a minimum of 120cm is recommended when trees are to be planted). Use a perforated pipe as an under-drain leading to a storm-sewer and place it in the top part of the drain-rock reservoir. Fill in the rest of the rain garden pit with good soil media.

Hydrologic Soil Group D – Clay Loam-Clay

This type of soil should be treated exactly like that of Hydrologic Soil Group C except that the under-drain should be placed a minimum of 30cm from the top of the drain-rock reservoir [6].

3. SOIL AND VEGETATION

Soil is one of the many important factors that must be taken into account before the construction of a rain garden. All soil have a factor of Hydraulic Conductivity (represented here as *K*) which represents the ease in which water can move through the soil's pore spacing and affects the infiltration rate of water through the soil [9]. The native soil is normally composed of either sand, clay, or a combination of both. There is also another type of soil known as Loam. This soil is a possible mixture of sand, silt and clay. Sand generally provides better infiltration and drainage than silty clay soils but are less nutrient rich. As shown in the table below, Sand provides a considerably greater infiltration rate than any of the other choices.

USDA Soil Class	Saturated hydraulic conductivity (mm/hr)
Sand	210
Loamy sand	61*
Sandy loam	26*
Loam	13
Silt loam	6.8
Sandy clay loam	4.3
Clay loam	2.3
Silty clay loam	1.5
Sandy clay	1.2
Silty clay	0.9
Clay	0.6

*Target soil texture for growing medium Level 2 "Groomed" and Level 3 "Moderate" landscape areas in B.C. Landscape Standard, which represent a good balance between infiltration performance and water retention capabilities.

Table 1 *Saturated Hydraulic Conductivity [9]*

The minimum suggested infiltration rate is 13mm/hr [9]. With this requirement in mind, it would be suggested that the use of Loam type soil be more heavily sand based to ensure a higher infiltration rate and reduce the possibility of water overflow which could damage soil and garden plant life.

There is also the issue of mulch that should be noticed. Soil that is left in the rain will have the top 2mm of soil compacted due to raindrop impacts [9]. This compaction will reduced the infiltration rate of our soil. By providing 50-70mm of mulch on top of our soil, we will be able to protect our soil from this compaction [9]. In addition, this mulch will protect our soil from erosion during heavy periods of rain and it is also important in pollution removal and soil moisture maintenance. As was mentioned by Balster and Selbig, it is preferable that the mulch be of dense materials such as hardwood chips or shredded wood as lighter materials will tend to float and erode away easier [10].

Finally, there is the issue of vegetation that should be taken into account. Most rain gardens can support a range of surface plantings including trees, shrubs, sedges, rushes and grass. This plant life can be used as rainfall arrestors which can not only reduce the rain's velocity and infiltration rates but increase the soil's hydraulic conductivity. This is because root production increases the macro-porosity of the soil. For soils with low hydraulic conductivity plant life could increase their hydraulic conductivity by over 10 times [9]. In addition to increased hydraulic conductivity, the physical leaves of grasses or similar plants are also important in removing sediments and pollutants from storm runoff. As such, with all these benefits from adding vegetation to the rain garden, it is suggested that a variety of plant life from trees to shrubs and grasses be added to the rain garden's surface. Plants that are suitable for UBC's environment are listed by environmental conditions, availability, and size spacing in the Stormwater Source Control Design Guidelines 2005 as shown below [9]. These plants can be taken into account along with the list of plants already considered by the New Sub Project design report.

Candidate Plant List — Stormwater Source Control Design Guidelines 2005

Latin Name / Botanical name	Common Name	Type	Light Condition	Typical Size / Spacing	Application	Availability
MOIST SITES						
TREES						
Acer rubra	Red Maple	Broadleaf Deciduous Tree	Full Sun /Part Shade	25m	Wet/Moist	A
Acer saccharinum	Silver Maple	Broadleaf Deciduous Tree	Full Sun	35m	Moist	A
Cercis canadensis	Redbud	Broadleaf Deciduous Tree	Full Sun /Part Shade	8m	Moist	A
Gleditsia triacanthos	Honeylocust	Broadleaf Deciduous Tree	Full Sun	30m	Moist	A
Liriodendron tulipifera	Tulip Tree	Broadleaf Deciduous Tree	Full Sun	35m	Moist	A
Malus fusca	Pacific Crabapple	Broadleaf Deciduous Tree	Full Sun	13m	Moist	B
Nyssa sylvatica	Black Gum	Broadleaf Deciduous Tree	Full Sun /Part Shade	20m	Wet/Moist	A
Picea sitchensis	Sitka Spruce	Coniferous Evergreen	Full Sun /Part Shade	70m	Moist	B

Figure 2 *Plant Life Guide [10]*

4. TRIPLE BOTTOM LINE ASSESSMENT

The phrase Triple Bottom Line (TBL) was originally coined by John Elkington. TBL accounting incorporates the assessment of the social, economic and environmental performance of a project. By assessing these three criteria together, the goal of sustainability can be met.

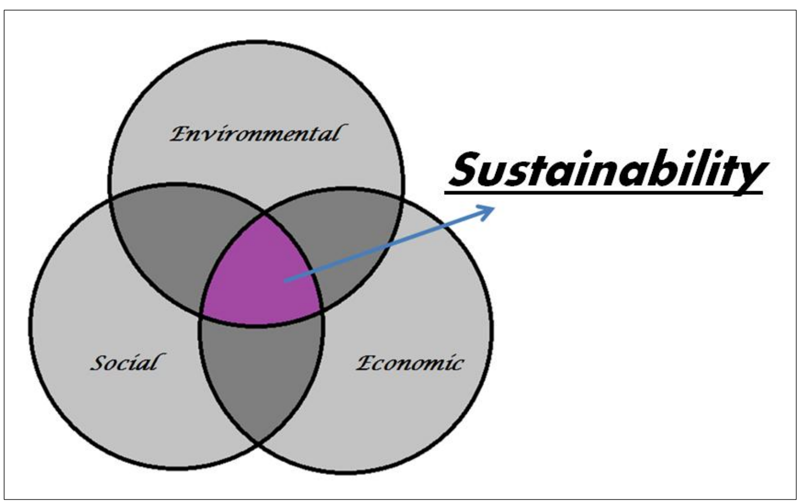

Figure 3 *Triple Bottom Line*

In this section, a Triple Bottom Line assessment is performed on the plan to build a rain garden near the new SUB building on the UBC campus.

4.1. Social

One important factor when creating a rain garden is considering the impacts it could have from a social perspective.

4.1.1. Students and Staff

In an educated setting where students and staff are often stressed, it is recommended to increase the amount of green space on campus. Environmental psychologists have proven that the interaction with nature, ranging from wilderness to grass, can enhance health and well-being of individuals by reducing stress and mental fatigue [11], and lowering rates of anxiety and depression. The relation between the lack of green spaces and people suffering from depression and anxiety disorders is significant [12]. While the level of stress is reduced, a research [13] conducted by Ulrich states that unstressed university students have better learning performance, more positive emotions and are relaxed more. Isen [14] also found out that grades are significantly higher on functioning tests and creativity tests when individuals are in a positive emotional state.

4.1.2. School and Communities

Rain gardens are landscaping features that help manage storm water run-off while providing beautiful wildlife habitat for butterflies and birds. According to the Leadership in Energy and Environmental Design (LEED) Certification rating system, proper management of stormwater from impervious areas can help the new SUB project acheive LEED Platinum [15]. Moreover, by taking part in sustainable public projects, the university can help raise awareness and promote sustainability and environmental programs to other schools and communities.

4.2. Environmental

The positive effects of a rain garden far outweigh any negative effects it may have. First, we will evaluate the environmental issues that might be brought up from rain gardens, then we will discuss how beneficial rain gardens are to the natural ecosystem.

4.2.1. Pollutant in Stormwater

The use of rain gardens is a natural on-site treatment method that is completely sustainable and provides solutions to water pollution and stormwater runoff. Runoff carries sediment, chemicals, and other pollutants to lakes and the oceans. Stormwater runoff creates problems in the water cycle and is one of the main causes of water pollution in urban area. According to US Environmental Protection Agency (USEPA), it is estimated that 'pollutants carried by rainwater runoff account for 70% of all water pollution'. The major pollutants that are commonly found in urban runoff are solids, oxygen-demanding substances, nitrogen, phosphorus, pathogens, petroleum hydrocarbons, metals, and synthetic organics [16].

4.2.2. Problems of Stormwater

Stormwater runoff has raised awareness for the problem of impaired water quality and quantity, and also the rate of water that flow into rivers, lakes and streams. The Water Quality Inventory report of 1996 demonstrated that among the bodies of water surveyed, that the water impairment from urban runoff occurs on 47 percent of the ocean shoreline, 22 percent of the lakes and 14 percent of the rivers [17]. Figure 4 shows the level of impaired waters in rivers and streams.

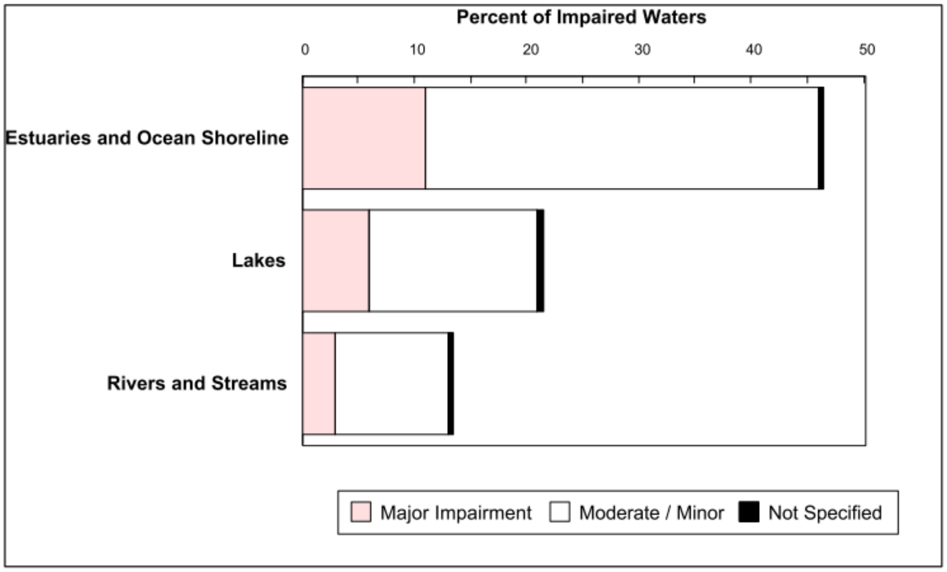

Figure 4 *level of impaired waters in rivers and streams. [18]*

The increase in the rate of water flow into rivers plays an important role in stormwater runoff. Studies conducted by the EPA show that the amount of runoff increases as development in the surroundings increase [19]. Paved areas are a significant threat to the environment because of the large amount of impervious coverage they form. This will cause stormwater to drain into streams since it cannot infiltrate through the ground. Figure 5 depicts the relationship between runoff coefficient and the amount of impervious coverage, and Table 2, shows the impacts that may be caused by increasing impervious surface areas.

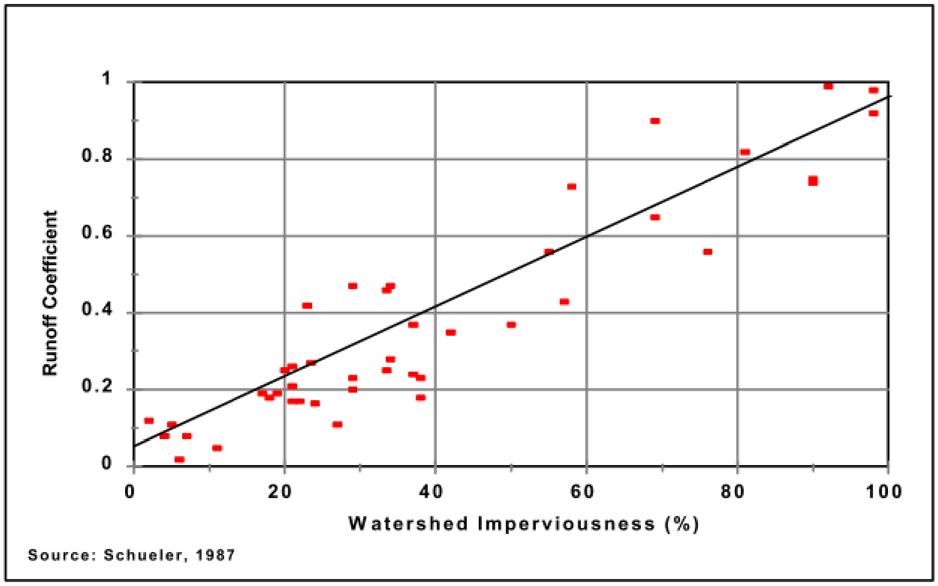

Figure 5 *Watershed Imperviousness v.s. Runoff Coefficient [28]*

Increased Imperviousness Leads to:	Resulting Impacts				
	Flooding	Habitat loss	Erosion	Channel Widening	Stream bed Alteration
Increased Volume	✔	✔	✔	✔	✔
Increased Peak Flow	✔	✔	✔	✔	✔
Increased Peak Duration	✔	✔	✔	✔	✔
Increased Stream Temp.		✔			
Decreased Base Flow		✔			
Changes in Sediment Loading	✔	✔	✔	✔	✔

Table 2 *Issues of Increasing Imperviousness [9]*

4.2.3. Impacts to Wildlife Habitat

The impact to the natural ecosystem, including animal habitat and plants caused by stormwater runoff is sometimes underestimated. The stormwater quality affects the pollutant concentration of downstream water supplies and further affects the in-stream aquatic habitat. Table 3 explains the effects of degraded water quality on animal habitat ranging from alteration of species distribution, increasing level of contamination, decreasing spawning areas to reducing dissolved oxygen levels.

Water Quality Parameter	Habitat Effect
Bacteria	Contamination
Heavy Metals	Alteration of species distribution
Toxic Organics	Alteration of species distribution
Nutrients	Eutrophication, algal blooms
Sediment	Decreased spawning areas
Biochemical Oxygen Demand	Reduced dissolved oxygen levels
Temperature	Reduced dissolved oxygen levels
pH	Alteration of species distribution

Table 3 *Water Quality Parameters Affecting Habitat [22]*

The recreational uses of urban streams and biological integrity are also limited due to pollutants and poor animal habitat caused by stormwater runoff [21]. The relationship between stormwater discharges and biological integrity is shown in Figure 6.

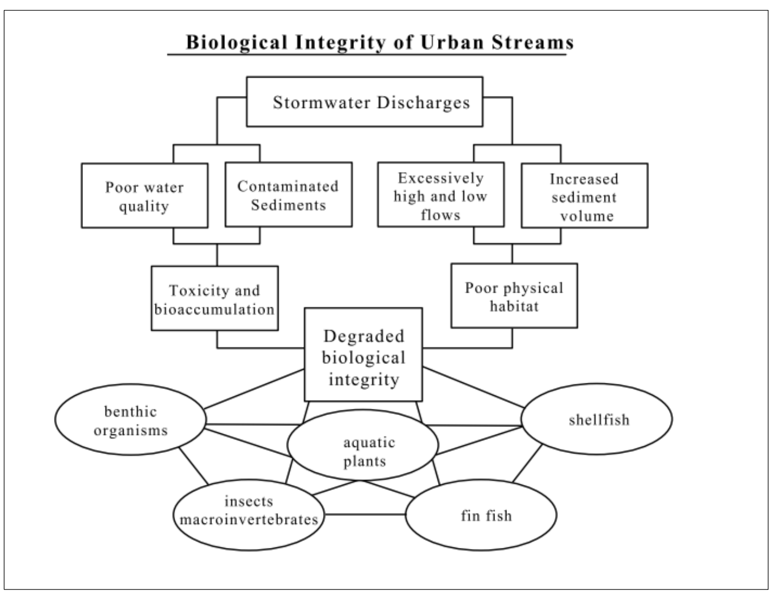

Figure 6 *Watershed Imperviousness v.s. Runoff Coefficient [21]*

4.2.4. Solutions to Stormwater Pollution

Schueler [20] has stated that "no single factor is responsible for the progressive degradation of urban stream ecosystems. Rather, it is probably the cumulative impacts of many individual factors such as sedimentation, scouring, increased flooding, lower summer flows, higher water temperatures, and pollution." It is required to improve and minimize the impacts of each individual factor, and further, to contribute to the improvement of stormwater pollution. For the construction of the new Student Union Building on the UBC campus, it is feasible to contribute to cleaner water and better stormwater management by building a rain garden outside of the new SUB.

Rain gardens, also known as bioretention systems, are suggested to be a Best Management Practices (BMP) when trying to infiltrate stormwater naturally and control outfall contaminated stormwater. Nevertheless, rain gardens also improve water quality via filtration [23]. Rain gardens collect stormwater runoff from impervious surfaces that would otherwise carry polluted water directly to streams. According to the studies done by Bell (1998) on the pollutant removal effectiveness of bioretention sites, rain gardens are very effective at pollutant removal, removing up to 95-97% of metals, 75% of phosphorus, 69% of total Kjeldahl nitrogen, 79% of ammonia, 21% of nitrate, and 56% of nitrogen [24]. Moreover, in comparison with normal gardens, rain gardens can absorb 30% more water into the ground [25].

4.2.5. Benefits of Rain Garden

The chosen plants for the rain garden at new SUB should be local native plants that do not require fertilization, watering and pesticide.By using the rain garden to re-establish native plants in the landscape, not only does the rain garden become a good habitat for birds, butterflies, and insects, but it also becomes an aesthetically pleasing environment. Moreover, with pollutants being filtered out by rain gardens, the water quality and quantity flow in to rivers, lakes and ocean will be improved. The effectiveness of pollutant removal can also improve the habitat of fish and aquatic organisms. Finally, from the environmental aspect, rain gardens act like the first line of defense in protecting our environment from water pollution.

4.3. Economic

Based on the research, rain gardens are a sustainable green infrastructure hat is simple, effective, easy to implement, and cost efficient. This section evaluates the financial cost, including the initial cost, construction cost and maintenance fees.

4.3.1. Initial Cost

Little information is available on the costs of bioretention because it is a relatively new practice. Brown and Schueler [20] found consistent construction costs of approximately $5.30 per cubic foot of water quality volume for the construction cost. The water quality volume includes the pooling area above the surface of the bioretention structure.

Rain Garden Soil Cost	
Total # Rain Gardens [8]	2
(Approximate) Area of a Rain Garden [8]	(pi)(5)^2 = 78.5m^2
Rain Garden Depth [8]	450-600mm
Total Volume	70.6 - 94.2 m^3
Soil cost per cubic yard (Estimate)	$15 - $40 [7]
Soil cost per cubic meter	[$15 * (0.7646)] to [$40 * (0.7646)] = $11.47 - $30.58
Soil cost of Rain Gardens	$53.98 - $94.21

Table 4 *Rain Garden Soil Cost*

Much of a rain garden's cost is entirely dependent upon the rain garden's infiltration requirements and its current soil status. If the soil is investigated and found to be sufficiently hydraulically conductive then less work is required than if the soil was found to be of a heavy clay composition. If the soil was found to be unsuitable, then the current soil would have to either be removed or mixed with a more suitable composition of sand and silt. This would increase labor costs and require soil to be transported in. Fortunately, the soil can be local and transportation costs would be minimal. In addition, the vegetation that is to be planted for the rain garden can be local as well and would require less costs than foreign vegetation. There are additional costs as well if drain rock reservoir and overflow basin options are chosen as well. Overall, the cost of the Rain Garden is highly variable with much of the cost dependent on the current soil at the Rain Garden sites, the vegetation type chosen(trees, shrubs, grasses), amount of vegetation added and if the reservoir and overflow basin are added in. Transportation costs should be minimal due to the local option of vegetation and soil.

4.3.2. Maintenance

In order to make sure the bioretention area maintains its functionality of treating stormwater runoff, proper landscaping maintenance is required in the first three years after installation. Less maintenance is required over time. Research has shown that with correct choices of local native plants, less regular maintenance activities will be required for rain gardens. Table 5 presents the recommended maintenance tasks for rain gardens.

Activity	Schedule
Re-mulch void areas Treat diseases trees and shrubs Mow turf areas	As needed
Water plants daily for 2 weeks	At project completion
Inspect soil and repair eroded areas Remove litter and debris	Monthly
Remove and replace dead and diseased vegetation	Twice a year
Add mulch Replace tree stakes and wires	Once a year

Table 5 *common maintenance for rain gardens [26]*

4.3.3. Stormwater Management Reduction

A proper functional rain garden can be an effective solution to drainage problems on land. Building a rain garden outside of the new SUB not only provides social and environmental benefits, but also provides long term economical benefits. With the improvement in drainage issues, the budget for stormwater management at UBC can be reduced.

5. CONCLUSION

Based on the findings, rain gardens are recommended as an exceptional way to manage the runoff around the new SUB. Rain gardens are considered low-impact developments and best management practice. The cost of this project will vary depending on the type of soil found on site. The cost per cubic meter of soil will range from $11-30. The soil must be permeable to allow high hydraulic flow, so if the soil on site has high infiltration rates, the cost will be lowered. In the case where the soil has a poor infiltration rate, all the soil will need to be replaced, which could nearly triple the minimum price. In any case a rain garden is still cost effective given its environmental benefits. Maintenance costs are generally higher the first three years, lowering to the cost of maintaining a regular garden over time. The rain garden may also potentially help lower the costs of drainage in the event of a large storm event.

This project will contribute to the goal of the new SUB to achieve LEED Platinum certification. Stormwater management accounts for 2 out of 70 points in the rating system. If the goal is achieved, this will be the first LEED Platinum student union building in the world. It will be a leading example to greener and more sustainable buildings in the future.

6. REFERENCES

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