UBC Social Ecological Economic Development Studies (SEEDS) Student Report

Water Management through Rain Gardens:

A Social, Environmental and Economic Analysis

Emma Amiralaei

Ahmed Attieh

Robert Baumann

Kome Eto

Othusitse Ndeke

University of British Columbia

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WATER MANAGEMENT THROUGH RAIN GARDENS

A social, environmental and economic analysis

Emma Amiralaei, Ahmed Attieh, Robert Baumann, Kome Eto, Othusitse Ndeke

Instructor: Dr. Akram Alfantazi

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Abstract

An investigation has been carried out in this report regarding rain gardens. Rain gardens offer a unique and sustainable solution when dealing with large amounts of runoff water. A depth analysis has been carried out in this report regarding the effectiveness of rain gardens to deal with this problem. Due to high amounts of rain in Vancouver, the University of British Columbia (UBC) has chosen to build a rain garden next to the newly built alumni building (being the lowest point on campus).

The rain garden is twenty meters cubed in area (4m x 5m) and can hold vast amounts of water at any given time. The bowl shaped rain garden must be built at the lowest point on campus in order to effectively collect the runoff. Soil selection is an important parameter since the soil used effects the water absorption ability of the rain garden. The optimal composition of soil to be used in order to maximize water absorption are as follows; 25-35% Sand, 50% or more compost and 15-25% native soil. Another important parameter to consider is plant selection. During this analysis specific requirements such as grass/flower ratio, height and sunlight availability have been conducted and a list of plants with the right properties has been included in this report. The final analysis conducted in this report is the economical aspect of building a rain garden. The rain garden will cost a total three thousand dollars (including plants, soil and design). In prospective this is a minimal amount to pay in order to integrate a working sustainable solution to UBC's water runoff problem.

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1.0 Introduction

A rain garden is a planted depression that allows runoff water to be collected and re-used in a sustainable manner. Rain gardens cannot only hold vast amounts of water, they are aesthetically pleasing, can decontaminate water and reduce pollution in the surrounding area. Rain gardens are a relatively inexpensive solution to runoff water and are easy to maintain.

In this report a detailed investigation regarding on all parameters of the rain garden design are analyzed. These parameters include soil selection, plant selection, dimensions (size and slope) and cost. The following parameters have to be optimized specifically to Vancouver weather as well as the designed location. This will allow for a rain garden that is highly adaptable to the changing runoff conditions present while maintaining a high standard of efficiency.

2.0 Design Parameters

The design of a rain garden depends on many aspects such as site selection, size and slope the garden, plant and soil selection, and the amount of rain fall collected. Upon choosing the appropriate parameters, maximum amount of infiltration can then be achieved. Also, by following the design parameters, minimum maintenance of the garden and pest control is obtained. Once a successful rain garden is built on UBC campus, then the overall water quality in the area can be improved and groundwater can be recharged. This section of the report entails technical information regarding the design parameters for rain gardens in Vancouver and specifically on UBC campus.

2.1 Site selection

The first step in designing a rain garden is to choose an appropriate site selection. In this section some of the general requirements for site selection are discussed followed by the analysis of the actual site of the rain garden on UBC campus. The first requirement is that the rain garden should be at least ten feet away from any building foundation so that the moisture does not seep into the foundation. Also, the rain garden should be at least 25 feet away from septic systems. It is important to avoid locating the rain garden where the water already ponds or is usually moist and it is also important to avoid large tree roots. In the figures below, the adequate location of the rain garden with respect to a drainage system is illustrated:

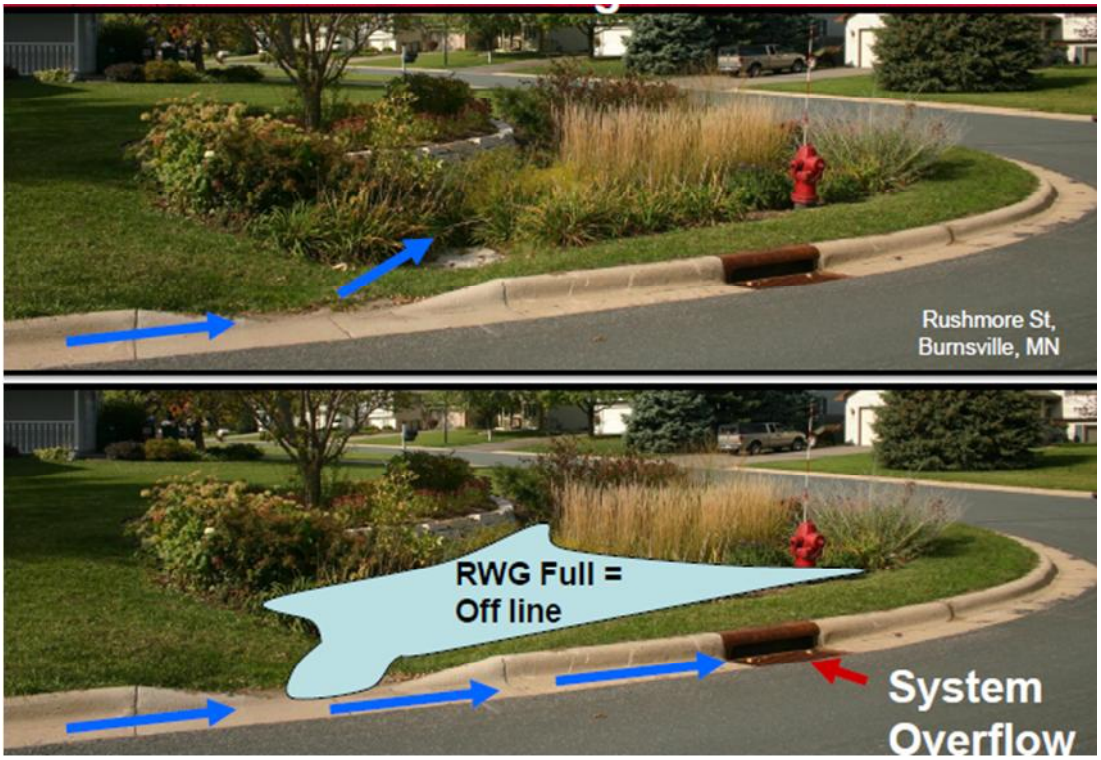

Figure 1: Position of Rain Garden with respect to Drain System in case of Overflow

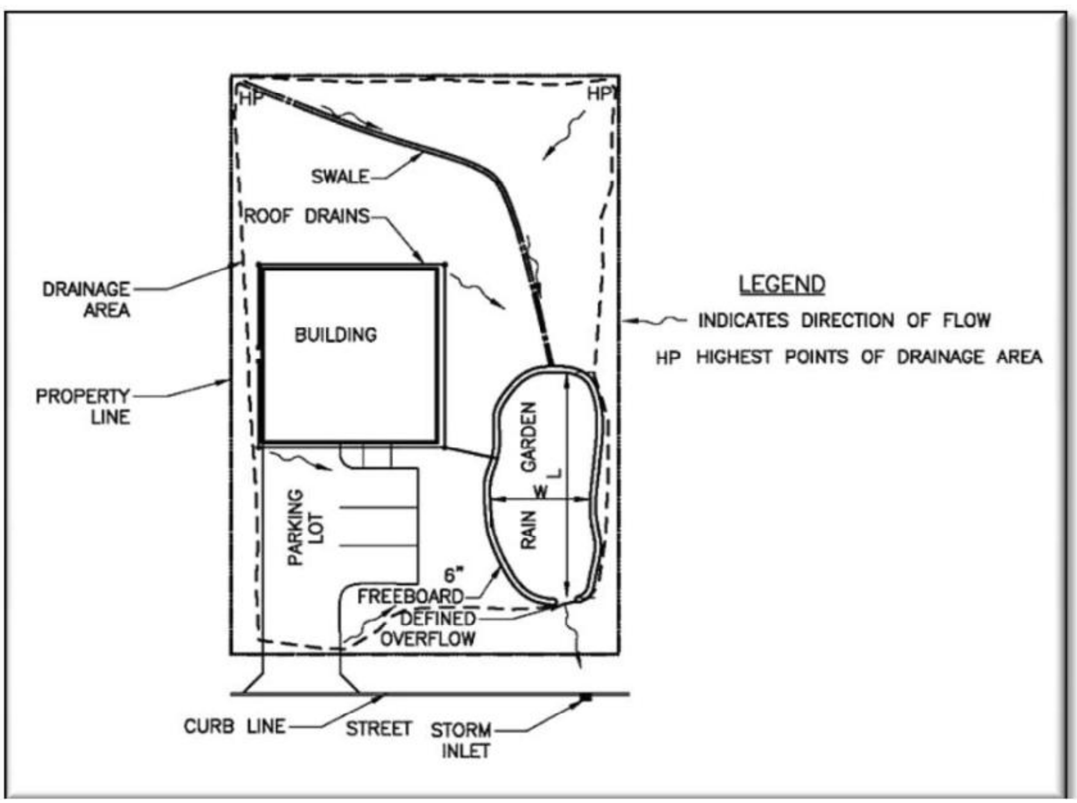

Figure 2: Position of Rain Garden with respect to Building Foundation and Drainage Area

It has been decided that the location of the rain garden to be placed in is near the new Alumni building which will be near the new SUB building. Similar to the previous discussions, the location of the UBC rain garden will be located adequately away from any if the infrastructures. It is also of important to note that the new location will be the lowest point on campus to ensure that maximum collection of rain/storm water can be collected.

2.2 Size and Slope

Rain garden depth and slope are important parameters and in general, the rain garden should be flat in the center and sloped around the inside edges. The so called bowl-shape of the garden will provide water collection above the rooting zone ("Sustainable landscape systems”)[4]. The maximum depth of the water pond should be 10 inches, with a rooting zone no shallower than 24 inches if a nearby drain is installed. In general, the depth of a rain garden depends on the slope of the site. The size of the garden on campus has been finalized to be (4mX5m). The diagram below is an illustration of how the rain garden depth and slope calculations can be obtained for the UBC campus:

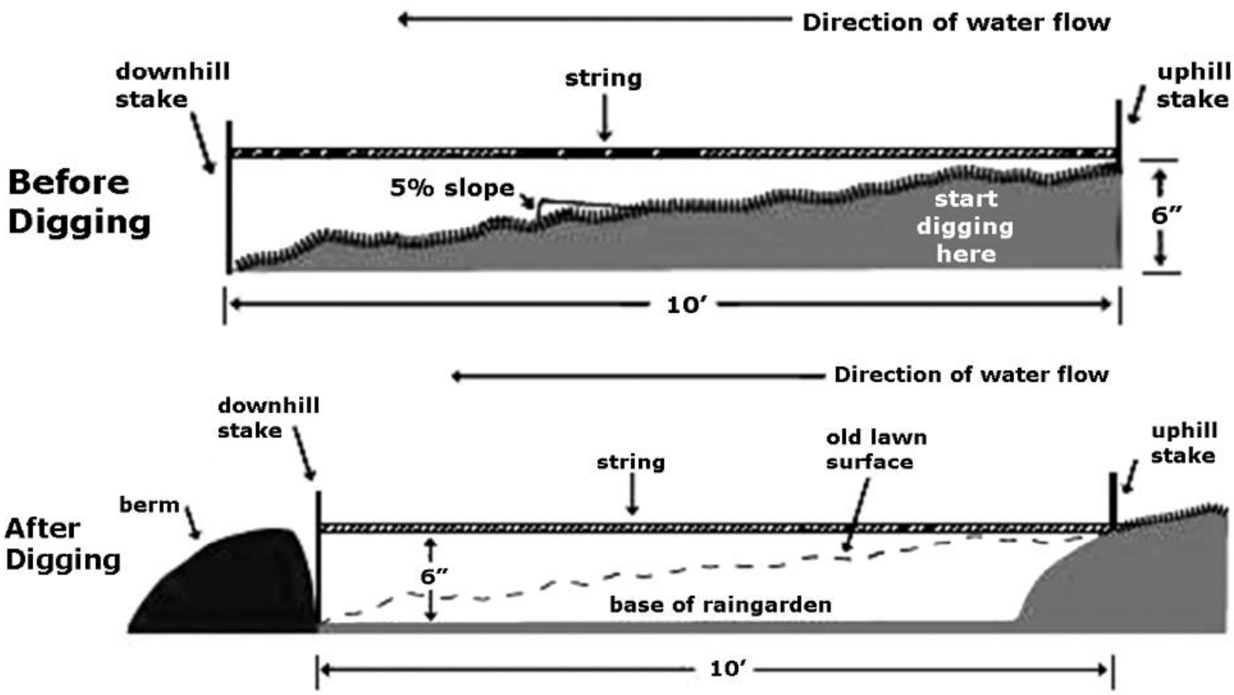

Figure 3: Example of Rain Garden Depth

Plant and soil selection are extremely important for designing a rain garden because in most cases regional guidelines are used instead of general guidelines. Aesthetically pleasing plants are usually considered, however, on a more important level, the tolerance of water intake and exposure of the plants to sunlight is to be considered. The best choice for plants is to select Vancouver native plants because they have already evolved to regional climatic trends.

More specifically, plant selection is dependent on the following aspects:

- **Sunlight availability:** The amount of sunlight an area receives determines the types of plants that will survive those light conditions so that they will bloom and set seed. The area that will be occupied by rain garden on campus is considered a "shaded" area, where plants receive less than 3 hours of direct sun per day.
- **Height:** When selecting species, each plant's ultimate height and spread at maturity must be considered. Plant height should be in proportion with the size of planting.
- **Grass/flower ratio:** The proportion of species for a reasonable mix of grass/sedge and for species that mimic the natural structure and character of a native prairie rain garden can be anywhere between 30% and 60% grass.

Based on the criteria listed above, the following is a list of plants suggested for the UBC rain garden [5]:

- Carex rostrata
- Carex stipata
- Cornus Stolonifera
- Juncus effusus
- Salix purpurea
- Sagittaria latifolia
- Typha latifolia

A general rule for plant selection is also to avoid plant species that require full shade, are susceptible to winterkill or are prone to wind damage.

As previously discussed, soil mixture selection is important because surface water moves into soil where it can further be absorbed and routed to shallow groundwater. Therefore, the soil texture dictates in large part the ability of soil to filter water. The rain garden should be composed of the following typical soil mixture:

- 25-35% sand
- 50% or more compost
- 15-25% native soil

3.0 Economic Analysis

The economic impact is another important factor to consider when evaluating the feasibility of a project. Capital costs, operation costs, maintenance costs and benefits and damage prevention have to be considered. The implementation of a rain garden near and around UBC's new SUB will not only have an economic impact on the building or the campus, but also Vancouver as a city of which the University is an integral part.

3.1 Capital Cost

The one-time cost of installing the rain garden is vital to determining if having a rain garden near UBC's new SUB is economically feasible. The general features of a bioretention system include an approximately 1m depth of sand/soil/organic media for treating the storm water run-off, a surface mulch layer and various forms of vegetation [6].

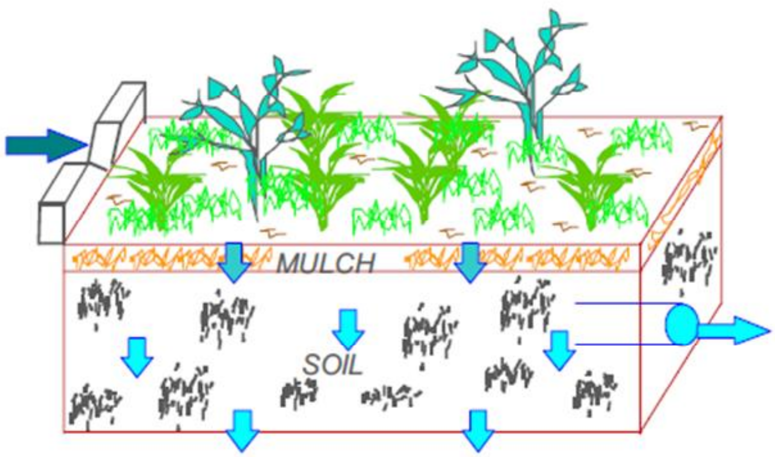

Figure 4: Typical Rain Garden (Bioretention Technology: Overview of Current Practice and Future Needs, 2009)

In addition to the labour cost of excavating the site where the rain garden is going to be built, these materials will be the main start-up costs.

The area around the SUB that is to be used as a rain garden is $20m^2$ (4m x 5m).This means that the volume of this bioretention system will be $20m^3$. According to Best Management Practices Guide for Stormwater [7], the budget for construction of this type of system should be according to the following formula

$$Budget = 28.9 \times (35.31 \cdot V)^{0.7}$$

Where, V is the volume of the rain garden. Thus, the construction costs will total **$2851.99**.

Due to the various types of rain gardens that may be implemented in the new SUB project, the types and prices of the materials needed to build the rain garden will cover a large range. The only specifications provided are those of the vegetation selection for the rain garden.

Table 1: Vegetation required for Rain Garden.

RAIN GARDENS		
450-600mm growing medium depth		
Latin Name	**Common Name**	
Carex rostrata	Beaked Sedge	#1 pot
Carex stipata	Sawbeak Sedge #1 pot	#1 pot
Cornus stolonifera	Red-stemmed dogwood #3 pot	#3 pot
Juncus effusus	Common Rush	#1 pot
Salix purpurea 'Nana"	Dwarf Purple Willow	#3 pot
Saggitaria latifolia	Arrowhead	#1 pot
Typha latifolia 'Miniature'	Miniature Cattail	#1 pot

If 300 seeds of each of these plants are purchased, the total cost of vegetation will amount to **$65**[8]. Summation of the cost of construction and cost of vegetation produces a total of **$2917**. This capital cost of approximately $3000 is quite a low cost compared to the long term benefits of building a rain garden near the lowest point on the University of British Columbia campus.

3.2 Maintenance Costs

The benefit of having a rain garden to filter the storm water run-off is that it requires little maintenance. Most of the maintenance for a bioretention system like the one that is to be implemented near UBC's new SUB is aesthetic in nature i.e. removing trash, pruning, mowing, adding mulch, etc [9]. The main problem that requires maintenance of the rain garden is that of sediment build up. As a rule of thumb, usually it is necessary to remove this build up after 25% of the volume the garden caught is sediment [10]. In Vancouver this is expected to happen quite frequently because it has an average of 1219mm of rainfall per year [11] and assuming that volume lost to sedimentation is usually 1% per year, it is recommended to check for sediment build up once every season.

Furthermore, the expected life of outlet structures is calculated to be around 25 years for corrugated metal and 50-75 years for structural steel. This numbers can be easily corroborated with any material analysis. With this in mind since the SUB is expected to last at least 50 years, there is no necessity to rebuild the foundation of the rain garden in the long run.

Other maintenance activities include removing debris and sediments that affect the flow properties of the overflow pipes. This maintenance task would also include unclogging the outlet structures whenever they are obstructed. The overall cost of maintaining the rain garden would equal to that of the wage of a designated person to be responsible for the regular supervision since all this tasks can be done by a single person.

On a more detailed basis, laboratory research suggests that sediments and heavy metals collect in the top 5-10cm of the rain garden; the exact degree of maintenance require to remove this kind of debris depends on the exact catchment method and if the rain garden was pre-treated [12].

On this basis, it is clear that a rain garden is very low maintenance.

3.3 Water treatment

The treatment of water as you can see in the following picture is virtually $0. There is no need to implement any filtration system unless otherwise specified.

	Conventional		'Green'
Pollutant	Oil-Grit Seperator	Stormceptor	Bioretention
Sediment	**5-40%**	**53%**	**86%**
Oil	**5-20%**	**43%**	**67-98%**
Zinc	**3-15%**	**39%**	**99%**
Phosphorus	**<5%**	**32%**	**81%**
Cost	**$3,000**	**$25,000**	**$0-5,000***

Source: An economic rationale for ISM. Integrated stormwater management.

Figure 5: Comparison of conventional street water separator method and bioretention "green" method.

This graph clearly shows that the bioretention method is not only more cost effective, but also it is almost two times more efficient when it comes to sediment, oil, zinc, and phosphorus retention.

3.4 Benefits and Damage prevention

Some of the economic benefits will be discussed in the following section. The city of Vancouver is a world leader in promoting more sustainable applications to buildings and new developments; however, the city does not currently have a tangible economic incentive to promote the implementation of rain gardens [13]. Aside from that the issue is discussed in the Vancouver 2020 action plan to become the greenest city in the world.

Rain gardens could potentially save thousands of dollars and prevent irreversible damages to the environment. One of them, and probably the most important one, is the issue of erosion in the west side of the Campus. This phenomenon is already happening and the only way to prevent it is to lower the load of runoff water taken by the streets and low points like this one.

Another major problem is that runoff water that is overloaded takes with it all sort of chemicals and toxic components that end up in the beaches and coastal waters. This problem is the main factor of beach closures as well as beach decontamination.

Furthermore, the water quality of the main water streams (English bay, Burrard inlet, Strait of Georgia) gets highly contaminated. This contamination changes the composition of the water and therefore damages the aquatic habitat. Eventually this problem is translated to decline of salmon fishery which can become a big economic problem.

Money can also be saved by taking advantage that the water filtered by the rain garden is relatively clean and it can be used for other application without having to clean the dirty water with chemicals. Another direct consequence is that if load of runoff water is reduced the city and the community itself save a lot of money for not having to install wider pipes to prevent overloading of the drainage system.

As stated before, if 10% of the water in the SUB area is collected by the rain garden one LEED point is achieved towards the Platinum certification goal. With the certification more people would be interested in visiting the SUB which will become a green building icon in Vancouver. The concurrence of people would eventually create economic benefit because they would obviously spend money while being in the SUB.

3.5 Economic Recommendation

From this points discussed it is very clear that start up cost are not high relative to the benefits that can be obtained from the rain garden. As an example, a quantitative data of the cost of a big erosion displacement in the west end of the campus is very hard to predict but it can be estimated to be extremely high. By implementing this method of runoff water management this problem can be greatly diminished. Besides the start up capital cost, the maintenance and water treatment cost are virtually zero. It would be as stated before that of the wage of personnel in charge of supervising the garden periodically.

4.0 Environmental Analysis

The environmental impacts will be discussed in this section. Although most of the impact is expected to be positive it is important to underline these aspects to have a better understanding of these benefits.

4.1 Benefits/Impact

Rain gardens achieve more environmental benefits due to their significant structures. However, these gardens would provide the building inhabitants, the UBC environment, and the wider community with many benefits. Rain gardens would beautify the environment, improve air quality, decrease amount of storm water runoff, reduce pollutants in the environment, prevent soil erosion, improve air quality and increase thermal resistance.

The rain garden would have stunning flowers, shrubs, and trees; these will beautify the environment hence making UBC environment more attractive and eye catching. Flowers have beautiful colors, and they come in different shapes and size; therefore, these flowers will give the environment its shape, color and pattern. In the other hand, shrubs, flowers and trees will provide the environment with fresh air (oxygen): making the environment a good place to live. Fresh air and good smell from flowers will attract birds, insects and butterflies, hence diversifying the ecosystem.

Moreover, rain gardens also reduce pollutants and decrease erosion; gardens reduce rain runoff by delaying peak flow. Gardens also contain plants that have extensive roots, these roots will catch some pollutants and temporarily hold rain water and it will slowly infiltrate it to the UBC water sewage system. Moreover, rain gardens may also be aimed to promote slow sand filtration system where sand filters small particles, pathogenic organisms, and in addition prevents turbidity; they make passing water through a bed of media [14]. Erosion is also minimized by reduction of the rain water runoff rate and the plants will also use some of these captured runoff rain water.

5.0 Social Analysis

Rooftop Garden will benefit the public by promoting community self-dependence, encouraging sustainability, increasing quantity of local food source and improving air. Trapping of dust and pollutants from the atmosphere by plant leaves would improve air quality, in which the community would benefit from.

The new sub project is aiming for an L.E.E.D. Platinum certification and having a rain garden for rain water management will add one point to reach the goal. If this goal is reached the SUB will become an iconic building in UBC. It will be a place of research and an example to the Canadian society of how a green building can be implemented with the help of the community surrounding the building. Furthermore, people in UBC will tend to visit the building frequently since there would be awareness that the SUB is less harmful to the environment than other buildings.

The rain garden will also become a place of relaxation and appreciation of the local flora. Currently one of the most frequently used spaces in UBC is the 'knoll' which is just a piece of elevated grass, but the fact that it is a green spot in the middle of concrete structures makes it appealing to the people and therefore attractive. This exact same reaction the people would get with the rain garden.

Lastly, the biggest social aspect that would be achieved is that it would contribute to the good cause proposed by some governors of the City council which is to make Vancouver the greenest city in the world by 2020.

6.0 Conclusion and Recommendations

This investigation has shown that for an effective rain garden to be built it must be placed at the lowest point on campus. The bowl shaped rain garden along with the soil and plant selections provided can offer an effective and sustainable solution to the runoff water. The rain garden also offers many social benefits such as promoting community self-dependence, encouraging sustainability, reducing pollution; all of which tie in to UBC global sustainable vision. The rain garden is also relatively inexpensive and low maintenance adding to the vast benefits the rain garden offers. It s recommended that the rain garden is kept maintained to a daily basis by removing any debris or materials that can obstruct the soil from absorbing water. Another important recommendation is that an added water management system is inserted into the rain garden in order to prevent the rain garden from overflowing (essentially damaging) runoff water during periods of heavy rain.

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