An Investigation Into Sustainable Water Management System for New SUB

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Abstract

This article overviews a triple bottom line assessment on a sustainable water management (SWM) system for the new Student Union Building (SUB) at UBC. In this triple bottom line assessment, the environmental, economical, and social impacts of such a system are examined. As the concept of sustainability is gaining more popularity around the world and water scarcity being one of the most important issues, it is important to come up with new technological solutions to conserve and avoid overconsumption of this precious resource. UBC is one of the first and leading institutions in North America to promote sustainability, and therefore, a SWM system for the new SUB would provide another opportunity for UBC to be one step closer to win the LEED Platinum+ award. This report provides a general overview of a rainwater harvesting system combined with a greywater recycle system as the main components of the SWM system. It is recommended that a more detailed cost analysis be carried out based on the architectural design and exact price on the construction materials for the building. However, the environmental and social benefits should play the most important factors in the decision making process on the implementation of this system.

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1. INTRODUCTION

A sustainable water management system is one of the most important components concerning water conservation around the world. During the past century, the world population has tripled, but water use has increased six-fold. The UN's Population Division projects that we are adding 240,000 people each day, heading toward a global population of 8.04 billion by the year 2025 resulting in 50% of global population living in 'water stressed' area [12]. It is important to understand that water problems cannot be solved by quick technical solutions. Solutions to water problems require the consideration of cultural, educational, communication and scientific aspects. Given the increasing political recognition of the importance of water in recent years, it is imperative to find methods to have a sustainable freshwater management system to avoid and solve water-related problems and future conflicts [12]. UBC is one of the very first and leading universities in North America to point out the concept of sustainability and begin specific programs for sustainable improvements on the campus. This report investigates the implantation of a sustainable water management system for the new student union building (SUB) at UBC and provides a triple bottom line assessment on this subject. The main components of a sustainable water management system studied in this report are a rain-water harvesting system and a grey-water recycle system. The new SUB will be mostly water independent for irrigation and toilet flushing. It will harvest rainwater and recycle the grey water from sinks, dish washers, and showers. After the water is fully-treated in the building by a tertiary stage processing system, it will be stored in the underground tanks until needed.

1.1 Introduction to rain water collection and reuse system

Rainwater harvesting (RWH) system is a technology used for collecting and storing rainwater from rooftops, the land surface or rock catchments. It is one of the most effective methods for reducing impact of climate change on water supplies as it is a way of supplementing the surface and underground water resources [9]. Rainwater can also be treated further to be potable; however, in this document rainwater is only used for non-potable purposes such as flushing toilets and irrigations.

Components of a Rain Harvesting System [8]:

1. Collection Surface: The roof area draining to the downspouts.
2. Roof Washers: Usually a filter screen to catch the first flush of debris and pollutants from the downspouts before entering the storage cisterns.
3. Delivery System: The pipes that carry the water to the cistern - eaves troughs and downspouts.
4. Cistern/Tank: Storage tank for the water.
5. Filtration System: A chemical or organic filter to clean and treat the water - the extent of filtration depends on its end use
6. Distribution System: The pumps and pipes that deliver the water to the building. Can be the main water source or a parallel plumbing system (keeping drinkable and non-drinkable water separate).

1.2 Introduction to Grey Water Recycling System:

Greywater harvesting is differentiated from other harvested water sources like rainwater or condensate in that is has already been "gently used" usually as water from showers and sinks, but it could also be sourced from the rinse water in a commercial washing machine or dishwasher [10]. It is most often harvested to flush toilets in a building, but the cleaned water can also be used for irrigation and other applications. Toilet waste water is termed "black water" and is not normally considered for harvested water systems. The greywater supply can usually meet 100% of toilet flushing requirements [10]. Harvesting greywater is a relatively new practice in commercial and institutional buildings, and carries many system and regulatory implications not associated with rainwater or condensate harvesting. Unlike other renewable water sources, greywater normally contains biological and chemical contaminants that can quickly turn to "black water", resulting in unpleasant odours, colors and health hazards if not treated correctly [6]. Consequently, a number of leading-edge filtration, sterilization and monitoring steps are required to bring the water to near-potable quality and elimination of any health and aesthetic concerns.

Components of greywater system [10]:

1. Filtration: Greywater is routed from showers, baths, and sinks through a plumbing system that is separate from toilets and urinals. The first filtration step is designed to remove the larger particulates and a settling tank will separate the heavier and floating material where it can be sent to the sewer system

2. Sterilization/Disinfection: It is necessary to sterilize the water to keep algae, viruses, bacteria and other organic contaminants from forming in the storage tanks. Several technologies available for this purpose are: using sterilizer agents such as Chlorination, Ozone, or Chlorine Dioxide and Ultraviolet sterilizers.

3. Storage: Storage of the treated greywater is determined by the demand and uses for the water, available greywater volume and turnover frequency. storage systems have a connection to a municipal source so that toilet flushing can occur even if there is not an adequate supply source of greywater.

4. Distribution System: Pumps and Pipes

5. Programmable Control System: Controlling the entire process and interfacing with other building automatic alarm systems as well as tracking the amount of water in each tank and the monthly water usage for educational purposes.

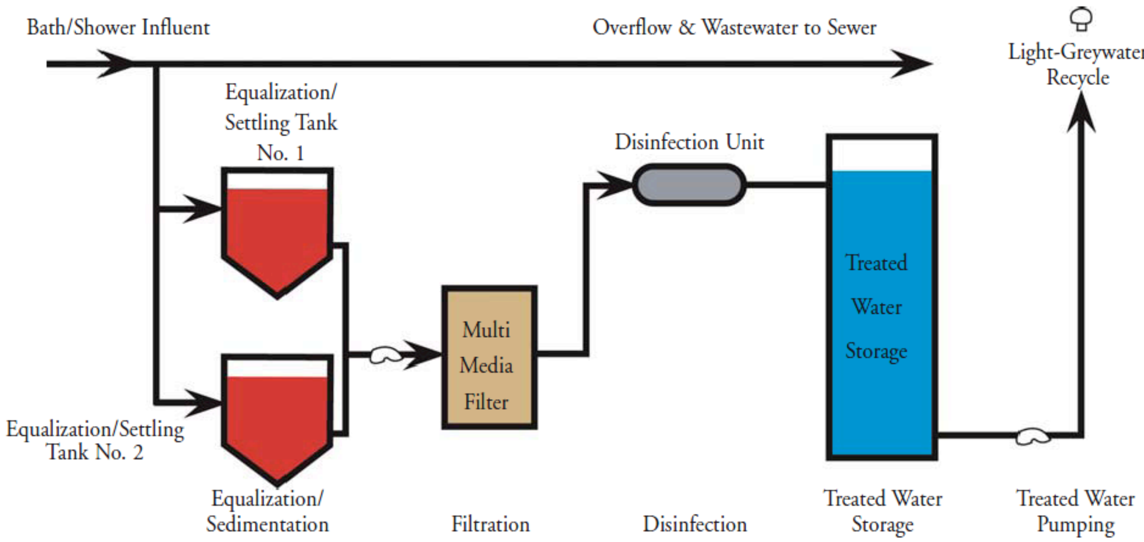

Figure 1. Final Assessment of Conservation Co-op's greywater system [10]

2. ENVIRONMENTAL ASSESMENT

In this section we will look at the environmental side of the possibility of net-zero water consumption in the new SUB. We will look into the viability of large-scale greywater reuse and disposal. Also, we will look at the systems required for storage and reuse. Rainwater, another very viable source of water, will be investigated to determine the environmental risks of storage devices.

It is important to consider these options because in an average household, greywater can be between 50% and 80% of the total wastewater, the rest being blackwater. In the case of the new SUB, most wastewater will likely be from food production. This will create a large constituent of greywater potentially viable for reuse. Vancouver's climate allows the possibility of rainwater to be a viable source of possibly clean drinking water, or for other uses. The rainwater may be stored and cleaned for use in several applications.

Table 1: Average Monthly Vancouver Rainfall

Month	Rainfall: mm / inches
January	**131.6 / 5.18**

February	**115.6 / 4.55**
March	**105.4 / 4.15**
April	**74.9 / 2.95**
May	**61.7 / 2.43**
June	**45.7 / 1.8**
July	**36.1 / 1.42**
August	**38.1 / 1.5**
September	**64.4 / 2.54**
October	**115.3 / 4.54**
November	**167.2 / 6.58**
December	**161.2 / 6.35**

Source: https//www.bcpassport.com/vancouver-vital-information/vancouver-climate-tempurature.aspx

The water used in North America ends mostly as wastewater. The use of water is at an alarming rate. Canada ranks second only to the United State for water consumption in the Developed world.

2.1 Greywater

Due to the nature of the water's first use, greywater contains a variety of chemical, microbiological organisms, and physical particles[1]. The diversity and concentrations of theses contaminants is determinate of the main source of greywater, primarily kitchen, laundry, and bathroom. A large portion of the current Student Union Building is food production; this would produce a lot of greywater containing many food particles, grease, and oil products. Inevitably a filtration system would be required to prevent clogging. Effective reuse options for greywater are use as a flushing agent in a toilet and irrigation. As the new SUB will have lots student and pedestrian traffic it will be a high use zone for washrooms and therefore will need water for this purpose.

Reuse of greywater for irrigation has a primary environmental concern. All the contaminants pose risk to any environment in which the water is disposed. Greywater has the potential to raise soil pH[2] which limits the plant growth and invasive to any ecosystem. The soaps and detergents from sinks and showers can be harmful and if not biodegradable are particularly damaging. It would then be necessary to use biodegradable cleaning substances and other chemicals that would regularly enter the water system.

2.2 Rainwater Systems

Common rainwater systems consist of a catchment area (rooftop) and a storage tank. These tanks, or cisterns, are usually made from plastics, steel, or concrete depending on size. The tanks can be placed underground or on the surface. Environmental concerns with tanks are the materials that they consist of.

Plastic tanks are made of Polyethylene[3]. This is non-degradable and once the tank is no longer functional (cracked or broken) it will not be have to be discarded. Steel tanks are made of Galvanized steel (steel coated in zinc). Once these tanks are unsuitable for water storage they can be reformed and recycled. Concrete tanks can be effective, however concrete is known for its CO_2 emissions during production.

The Optimal tank would seem to be steel, however due to corrosion the estimated life of a steel tank is five years. This frequent need for replacement would drive up costs since the SUB is a large roof area and would need to collect thousands of litres of water.

2.3 Environmental Recommendations

Our first priority for the environment is to minimize the consumption of water. The largest use of water without any possible reuse is blackwater (toilet water). The simplest way to eliminate blackwater is the use of composting toilets; with zero water input they would be ideal to minimize water use. Composting toilets have an average saving of up to 1000 litres of water per day. Also composting toilets do not require the use of extra systems to reuse greywater as a flushing agent. On the down side this may be unattainable as the compostable toilets do not deal well with very high traffic.

Another recommendation is extensive use of rainwater capturing systems. With a large roof area, the ability to retain gross amounts of rainwater allow for possibly no reliance on city water. A green roof would be optimal. With the ability to store up to 75% of stormwater[4] it would also decrease the need for storage tanks.

The main concern is the effect of greywater irrigation on surrounding flora and soil. With a proper filtering system and monitored use of biodegradable cleaning products the irrigation area will safe. A detailed analysis of a purification system to eliminate all the harmful and non-degradable chemicals from the water might be effective to guarantee the cleanliness of the water. Therefore a primary filtration and pre-treatment system is needed. This would allow the greywater to be used for irrigation and other non-potable uses. Also, with the green roof greywater can be pumped up and the roof can act as a natural filter. The Figure below shows the concept of a simple greywater treatment system.

Unfortunately, green roofs have other concerns, which would limit their use, and so do composting toilets. Extensive green roofs are extremely heavy; therefore require extra structural support incurring much higher costs. They also require constant maintenance, gardening and trimming for example, a cost that will always be needed. Composting toilets are limited in that they require a shaft directly beneath them. Unlike that of a conventional toilet where plumbing can be hidden behind walls, these shafts would restrict placement. Also, the toilets ability to compost waste is limited and depending on anticipated usage may not be able to supports the demands in high traffic areas.

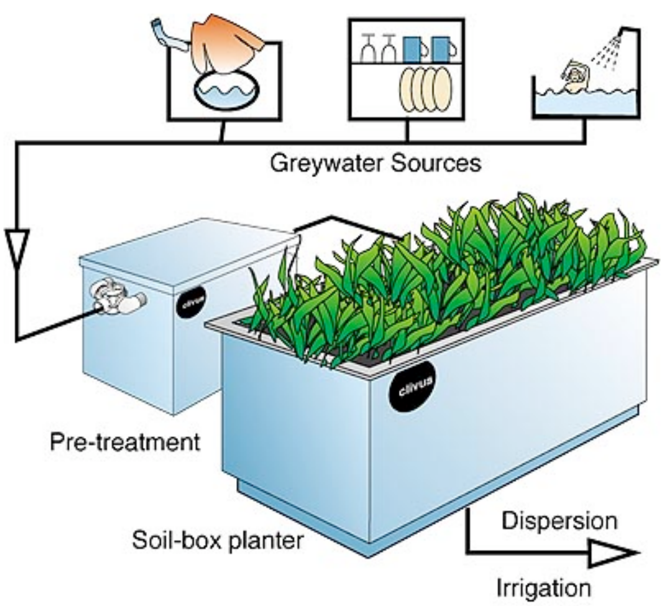

Figure 2: Simple Greywater Filtration Diagram

Source: Clivus Mutrum Website

3. ECONOMIC ANALYSIS

In most countries the cost of water has steadily increased over the past decade. In fact, a 2007 report on world water consumption revealed that between 2002 and 2007 Canadian water rates increased 58% [12]. One economical benefit of having a SWMS is the savings on the amount of water that would be necessarily to be purchased from the municipal water system otherwise. Considering the new SUB having an approximate 50,000 square feet of available roof surface area that can be used as rainwater catchment area, and also with average precipitation of 1000 mm annually in Vancouver, it is estimated that on average about 10,000 litre of water per day can be provided from the RWH system (Assuming a 80% efficiency for RWH system) [11]. Furthermore, the grey water recycling system also contributes to the water savings as it recycles the water from sinks, dish washers, and showers. On other hand, as an economical disadvantage, implantation of such systems are comparably very expensive because they are very comprehensive and need full professional design and consultation, as well as the operation and maintenance costs. Never the less, it is speculated that in long run, the savings in water usage would cover the costs.

RWH systems are site specific and hence it is difficult to give a generalised cost. The major components of a rainwater harvesting system are catchment area, piping connections, pumps, and storage facilities. The cost for these components could be brought down considerably by judiciously fixing up the slopes of roofs and location of rainwater outlets[8]. Water from RWH system will be supplementing the municipal water supplies by providing with an alternative supply of safe, reliable water. The most important factors to keep in mind for designing such a system are the quality and the volume of the rain water. RWH systems must therefore be designed to both ensure rainwater quality and maximize the volume of water that is collected. The performance of RWH systems can be affected by factors such as the amount of rainfall and size of the catchment surface (roof) and also to losses from the roof or the pre-treatment devices. The cost for designing such a system is so far considered as one of the most compelling obstacles to the widespread usage of RWH systems [9].

Water supply benefits can be defined in terms of amount of rainwater replacing municipal supply, which can be translated into dollars based on the cost of water. Another cost associated with this system is the cost for a regular professional maintenance and inspection to ensure that the system is providing clean water. Cleaning the roof, eaves troughs, filters and monitoring water quality are examples of the ongoing requirements for this system. Other detailed compartments of a sustainable water system for the new SUB included low-flow toilets, taps and faucets, and efficient dishwashers.

4. SOCIAL ASSESSMENT

This section will talk about the social affects of using rainwater catchment systems, a green roof, and reusing greywater.

4.1 Rainwater/Storm Water Runoff

There are many factors that affect water to make is hazardous. In rainwater, the pollutants in the air can be absorbed by the clouds and trapped in the precipitation that falls. More significantly, it is animal feces and bacteria/protozoan growth on catchment areas that are washed over by the rainwater with cause the most significant health risks.

Rainwater use is affective because with filtration and purification it can have potable uses. However, with rainwater storage health risks increase. When the water is stored without treatment the bacteria and other harmful microorganisms can incubate and grow. Canada's guidelines for Drinking water quality are clear in the amount and spices of bacteria and protozoa allowed for safe consumption of water.

Many studies around the world have found many problems with the storage of rainwater and continually found many forms of bacteria. As seen below in table 2 there is a zero tolerance for any kind of microbiological substance in drinking water which means there is a requirement for proper filtration and purification if rainwater is to be considered a replacement for the SUB. Some organisms are very difficult to test for and an investigation and some experimentation into the quality of Vancouver's rainwater would provide needed information on the filtration and purification needs for a system in the SUB.

Also once the water is treated and is safe to drink, the type of storage tank can affect the taste. Steel storage tanks tend to leave the water with a metallic taste[5], concrete tanks give off a bitter taste.

Table 2: Microbiological Allowances in Canadian Drinking Water

Parameter	Guideline (mg/L)	Previous guideline (mg/L)	CHE approval
Microbiological parameters[a]			
Bacteriological		0 coliforms/100 mL	
E.coli	0 per 100 mL		2006
Total coliforms	0 per 100 mL		2006
Heterotrophic plate count	No numerical guideline required		2006
Emerging pathogens	No numerical guideline required		2006
Protozoa	No numerical guideline required	None	2004
Enteric viruses	No numerical guideline required	None	2004
Turbidity	0.3/1.0/0.1 NTU[b]	1.0 NTU	2004

Source[7]: Health Canada Guidelines For Canadian Drinking Water Quality

Although rainwater may require further analysis and investigation for accurate use as drinking water, it is certainly viable for use as a non-potable water source. The environmental affects of rainwater are negligible as, it is a natural source of water, however issues arise once it have been used and becomes greywater or blackwater, which will be discussed in the following section.

4.2 Greywater

Greywater is wastewater that comes form sink drains, laundry/washing machines, showers/bath drains, and other sinks. This water has the potential for reuse. Unfortunately the contaminants in greywater, obtained from its original use, eliminate it as a potable source. Greywater cases social issues in that if stored it produces foul odours. These odours would leach out when used as the flushing agent in a toilet and offend users.

5. CONCLUSION

What can be concluded from this report is that having a SWM system for the new SUB is a fully advantageous choice. The only disadvantage would be the extra cost for the system to be implemented and even that would be mostly covered by the savings on the water consumption. The only uncertainty associated is the amount of extra costs for the required material such as piping, storage tanks, and the rain catchment which need to be determined based on detailed price on each part. In order to further the sustainability of the new SUB even more costs would have to be induced. The cost for a green roof would be huge and this would not be feasible for this project. Socially this project can help educate and inspire the students and visitors to do their part for the environment and sustainability of our planet in terms of water conservation.

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