UBC Social, Ecological Economic Development Studies (SEEDS) Student Reports

An Investigation into Net Zero Water Usage and Water Reduction for the Proposed Student Union Building

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APSC 262

April 2010

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"Water is a limited natural resource and a public good fundamental for life and health. The human right to water is indispensable for leading a life in human dignity. It is a prerequisite for the realization of other human rights." (United Nations 2002)

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Submitted: April 6, 2010

Abstract

A new Student Union Building will be constructed at UBC in 2012, and the AMS hopes that it will be a leader in sustainability by reducing its energy and water consumption. We have researched the water requirements of the building and have provided suggestions for how the building can aim towards consuming Net Zero Water. The water requirements were calculated by scaling up the water consumption of the current SUB, using the ratio of expected occupancy between the new and old buildings. An outline was included to perform this estimation with the statistics of the current building. The water requirements were divided into two categories; potable water and water for flushing washroom facilities. To supply potable water, we recommend the collection of rainwater from the roof of the new building, and processing the water using microfilters and a sterilization system. To supply the water for flushing in washroom facilities, it was suggested to reuse grey water from the kitchens and showers, which eliminates the requirement of freshwater to flush toilets because of the high grey water production. It was found that the potable water requirements are much higher than the water that can be collected from rainwater; however the suggestions provided will greatly reduce water consumption.

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I – INTRODUTION

The AMS SUB Renewal project, led by Jensen Metchie, is working on developing a design for a new Student Union Building at UBC which will be an example of sustainability. To achieve this goal, one objective to aim for is the net zero water consumption for this building. This will be a major challenge as the new building will have much higher expected occupancy and more facilities than the current Student Union Building, which already has high water requirements. This report aims to provide suggestions for how to accomplish this objective, using a triple bottom line assessment to ensure that these suggestions will be feasible economically, socially, and environmentally.

This report will begin with calculations of the estimated water requirements of the new SUB, which will be done by scaling up the current building's water usage in conjunction with using water standards for large buildings. The design of the new building will be investigated to determine the number of water requiring facilities will be present. This will be followed by a discussion of rainwater collection, focusing on the collection and processing of rainwater to be potable. To use net zero water, rainwater must be the main source of freshwater for this building, therefore calculations will be done to determine how much water can theoretically be provided by this method. The next topic will be methods of reducing water consumption, such as by using water saving facilities in washrooms and kitchens. Because of the large number of washroom facilities and expanded cafeteria, reducing the water requirements of these facilities will greatly lower the consumption of the whole building. The second suggestion to be discussed will be the reuse of grey water. Much of the water requirements of the building can be met by grey water reuse and there should also be many sources of grey water in the building. This section will discuss the collection of grey water, list facilities that can make use of grey water, and calculations will be done to determine the water that can be saved. These analyses will be tied back to the water requirement calculations and a conclusion will be drawn on whether net zero water consumption can be met by using these methods. If the objective will not be met by using only these suggestions, we will make further suggestions that we believe to be worth investigating.

II - WATER REQUIREMENTS AND STATISTICS

To determine the approximate water requirements of the new SUB, the water usage of the current building will be scaled up by comparing the differences in building sizes and expected occupancy. In addition, building codes and standards will be referenced to ensure that the estimates are accurate for recently built buildings. The new building will have five floors, with a total area of 255000 to 280000 sq-ft. This is approximately 3/2 times the area of the current building, which is about 160000 sq-ft. The footprint of the building will be between 51000 to

56000 sq-ft, which will be important in determining the theoretical rainwater collected. From the Schematic Design Program for the new SUB, 5205 sq-ft of the building will be allocated for washrooms, which is approximately twice the area that was allocated for washrooms in the current building.

From this information, it was estimated that the building will have ten washrooms, which will each be larger than the facilities in the current building. To determine the washroom water usage, the statistics for the current SUB can be used as a guideline However, because it was not possible to obtain these statistics, an outline of the necessary calculations is given as follows: Since the washroom area will be doubled in the new building, the usage will also approximately be doubled; However, because our suggestions involve the use of low flow toilets (discussed in section III), it will be useful to find the total number of toilet flushes per day occur on average. To calculate this, it can be assumed that 60% of water in male washroom and 75% in female washrooms is used to flush toilets. Using the volume per flush of the current washrooms, the number of flushes per day can be found. The total calculation is shown below:

$$V'_{washrooms\ (m\,/f)} = 2V_{washrooms\ (m/f)}$$

$$V_{flushes,washroom\ (m)} = 0.6V'_{washrooms\ (m)}$$

$$V_{flushes,washroom\ (f)} = 0.75V'_{washrooms\ (f)}$$

$$N_{flushes,m} = \frac{V_{flushes,washrooms(m)}}{V_{per\ flush}}$$

$$N_{flushes,f} = \frac{V_{flushes,washrooms(f)}}{V_{per\ flush}}$$

These numbers can then be applied to the volume per flush of more efficient toilets to find the water required for the new SUB (Efficient flush toilets can use around 4.2L per flush).

$$V_{new,tot} = V_{per\ flush,new}\left[N_{flushes,m} + N_{flushes,f}\right] =$$

15% of the current water usage in male washrooms can be assumed to be used by urinals, which can be mitigated by low-flow urinals or waterless urinals if possible, discussed in section III of the report. The last 25% in male and female washrooms will be assumed to be used by sinks. This will also be important in section III as the amount can be reduced by using more efficient faucets, and the majority of that water can still be reused as grey water.

III - WATER USAGE REDUCTION AND COLLECTION

When considering the prospect of net-zero water, one must consider how much water could potentially be collected.

WATER COLLECTION STORAGE AND POTABILITY

One important consideration for a concept of net zero water are the sources of human consumable, or potable water. Water will be consumed by venders in the cafeteria, and for drinking fountains among other uses. To achieve a net zero system either grey water must be completely recycled, or another source harvested. This is a matter to be considered thoroughly as poor water quality presents non trivial health concerns.

With 1240mm of rainfall annually we determine that each year. It is noteworthy that the period of lowest rainwater availability would be during the summer semester, when the load on the system is smallest.

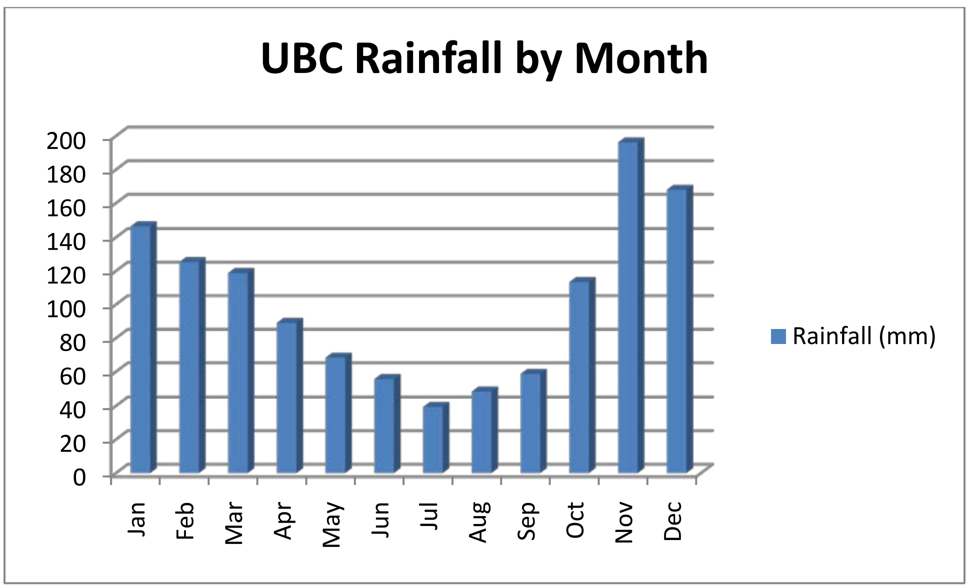

Figure 1 (Evironment Canada, 2010)

With a roof space of 4,700 - 5,200 m^2 an estimated 5,874 - 6,444 m^3 of water could be collected annually. With consideration given to water usage reduction this is the most plausible route to net zero water.

Though the details of the new sub architecture are not yet known, such a system would consist of relatively standard components that water would pass through. Such a system is outlined below (Pushard,2010).

Debris filter:

Large debris such as plan mater, rocks or garbage should be removed using a macro-filter. This component could be as simple as a grate that prevents these large objects from reaching the water storage tank.

Storage tank:

For practical reasons, water will be stored at time of large rainfall and held in reserve when there is no rain. As the estimated water use of the sub shows that demand will always exceed supply, a large storage capacity may not be necessary; however some intermediate system to handle a large rainfall would be desirable. Such tanks are often specifically designed to limit the amount of sediment that is drawn to subsequent stages.

Micro Filter:

Water should be passed through a micro filter to remove matter such as dirt and smaller debris that were not remove by the debris filter

Sterilization System:

Even though the water may be practically potable, this cannot be assured until further measures are taken. Foreign matter such as dirt, bacteria and bird feces will inevitably be found in some amount in the water supply. This stage is less daunting than it may appear as a number of closed system solutions are available (see below), however, it would be necessary for any water that is to be consumed by humans.

Possible Water Sterilization Methods:

- Ultra Violet
- Micro Filtration
- Chlorination
- Reverse Osmosis
- Oxidation

Design and Maintenance Considerations

Due to the complexity of such a system, any such plans would require to be signed off by a professional engineer. For this reason it is recommended that a firm specializing in such work be consulted, and we have listed a number of local consultants in the appendix of this report.

Triple Bottom Line Assessment

While there is a clearly an ecological and social benefit to using the rain water that can be collected from the roof space of the sub (and possibly perhaps other parts of the facility – pending design), decisions must be made on to what extent the resource would be used.

Environmental

If an environmentally friendly treatment option is chosen, this system would reduce the buildings dependency on the city water system, and would reduce the use of chlorinated water.

Many different sterilization options are available, many of which are more environmentally friendly than chlorination (Mone, 2010).

Social

As water over use and scarcity is a growing concern, and new architecture will be in place for many decades, it is socially responsible to incorporate any such system, or at the very least design in such a way that a future upgrade would be possible.

Economic

Water is currently very inexpensive compared to the cost of processing, installing and maintaining many conservation systems, however, as mentioned above this cannot be guaranteed to continue as the city and demand of water continues to grow. Consideration should be given to the long term cost savings rainwater harvesting systems can provide.

WASHROOMS, FACILITIES AND USAGE EFFICIENCY

It was assumed that most of the water usage would be from the washrooms. With thousands of students walking through the SUB each day and an extrapolation of thirty to forty percent of those people using the washrooms in the current SUB, it is reason to state that a large amount of water is wasted through the sinks and toilets. Below is the triple bottom line analysis of some of the solutions to reducing the water consumption.

Urinals

The new SUB is being built to accommodate the increasing student body at UBC. There is currently 2742 square feet of washroom space in the SUB. There will be approximately 5205 square feet of washroom space installed in the new SUB (SUB Renewal Project). With the7 washrooms presently installed in the old SUB, it would be reasonable to assess that the number of washrooms would approximately be doubled. The figure below calculates a rough estimate of how much water would be used in the new SUB per month.

	Flushes/day	# of users/day	Amount of water flushed (Litres)	Number of urinals	Waste water/month (Litres)
Current urinals	32	150	3	40	115200
Non-flush urinals	N/A	150	N/A	40	0

Table 1: Waste Water per Month

Based on these assumptions, we recommend that non-flush toilets be installed in the new sub. With the installation of non-flush Urinals, there would already be a huge saving in the amount of water used in the SUB. The Macleod Building at UBC has already installed the f-1000 non-flush unit on their first floor manufactured by Falcon Waterfree Technologies. Below is a figure of the f-1000 series.

Figure 2: F-1000 non-flush series by Falcon waterfree technologies

But there is always more to think about than just the amount of water saved. The costs of installing these new urinals must be considered.

Social

The major issue with non-flush urinals is the concern of lingering odour of urine. To reduce the smell of urine, the urinals use an eco-trap system. Urine passes though the drain where it flows through a floating layer of BlueSeal. BlueSeal is a Liquid that is less dense than urine forming a barrier that prevents the sewer vapour from entering the rest of the atmosphere(A Waterless Advantage). The figure below shows how the Eco-trap system works.

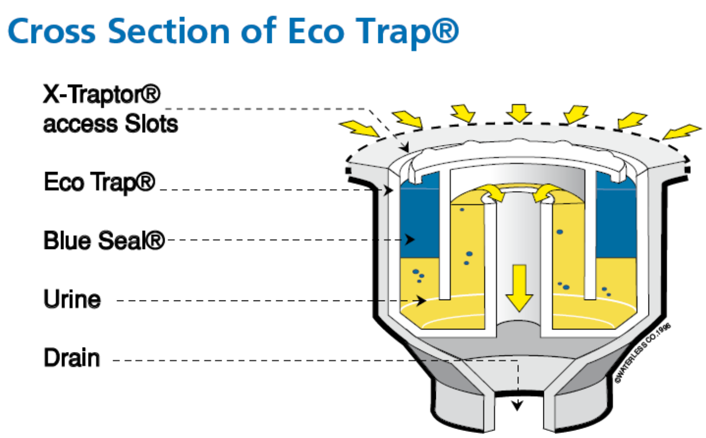

Figure 3: non-flush Eco-Trap system

http://www.lwgemmell.com.au/products08/Waterless%20Urinal/Waterless%20Brochure.pdf

The washrooms in Macleod where the non-flush urinal is installed also has the windows always open, allowing for efficient air circulation. When the new SUB is built, it is important to have high-quality air circulation to eliminate the smell of urine in the washrooms.

Economical

The cost of ordering and installing the urinals are approximately the same. The biggest savings comes from the amount of water that will be saved. In Canada the cost of water is approximately 40 to 80 cents per 1000 litres. Using the numbers from table 1, the savings amount to about $1.15 per month from the urinals alone.

There is also the savings from the amount of labour work needed because the urinals would have to be cleaned less often. With the eco-trap system the BlueSeal liquid is good for up to 1500 uses. Other than daily maintenance and cleaning, the costs of labour would be much smaller.

Ecological

If the water consumption is looked from a larger scale prospective, the more water this building requires means the more water the city has to produce. In turn more rivers would need to be dammed off to collect the water needed which floods the local environment and surroundings. As well as all the water sent anywhere is treated before distribution. The energy used to treat the water produces a greater carbon footprint in the world. With these non-flush urinals, this whole process can be prevented.

Toilets

The biggest problem with toilets is there is no way to eliminate water from the equation. Therefore the main goal when researching new sustainable toilets was to find one that uses or reduces the amount of water per flush. Below is a table outlining the estimated water per month used by the existing toilets if installed in the new SUB.

	# of users/ day	Amount of water/flush (Litres)	Waste water/month (Litres)
Current toilets	150	6	27000
Dual flush Toilets	150	3-6	13500-27000

Many different types of toilets were looked into, including low flush and low flow toilets, but all seemed inefficient or not suited for use compared to dual flush toilets. Dual flush toilets offered both the opportunity to save up to 50% of the waste water as well as ensuring enough water pressure was in place to flush down solid waste down the drains.

Social

Before installing these new toilets, the group was most concerned whether these dual flush toilets had enough power/pressure to flush solid waste down the drains as well as the already existing toilets. The Canadian Mortgage and Housing Corporation conducted a test using 56 Coroma dual-flush and 14 single-flush ultralow flush toilets (Dual flush toilet testing). In their conclusion they stated “Despite some complaints about bowl streaking, all survey respondents indicated they liked the dual flush toilets"(Dual flush toilet testing) . With these results we are able to move on to the cost savings.

Economical

The Cost savings on buying the new dual flush toilets were pretty much the same as a regular single flush toilet ranging from around $390 to $465. According to the Canadian Mortgage and Housing Corporation, the "dual flush toilets have a payback period of 8.5 years"(Dual flush toilet testing). Because the new SUB is planned to last for more than 10 years there is plenty of time to pay of the toilets.

Ecological

We were unable to find any disadvantage of the dual flush toilets in an Ecological sense. Although there was still waste water being produced, there was no alternative other than trying to reduce the amount of water wasted.

Showers and Sinks

When considering the possibility of water consumption neutral building one must be concerned by the new showers and sinks being installed in the new SUB due to the lack of clean water being collected from rain. One solution that came to mind was to modify the sustainability methods used on the CIRC building being constructed at UBC. The only way to collect enough clean water, is to draw it from somewhere else; specifically the old SUB. To maintain a net-zero water building, the new SUB would supply the old SUB with the excess collected grey water, and perhaps rainwater, which could once again be used in the toilets and urinals in the washrooms for the best ecological outcome.

Garden and Landscaping

It is understood that an estimated half of the new SUB's roof space will be used for the purposes of a garden. We also understand that there will very likely be landscaping that is also done on the grounds. To minimize the water consumption of these features, we recommend that consideration be given to the types of plants chosen, primarily that they be drought resistant for the summer months, and in the case of a rooftop garden, that water not absorbed be collected and recycled as greywater.

Social Considerations

It should be noted that while we recommend numerous technical solutions, the problem of water usage is by nature largely social. For this reason we recommend that a zero water waste program be maintained within the new sub, and that all parties, students, facilities management and venders within the cafeteria be involved reducing wasteful water usage.

GREY WATER COLLECTION

In order to achieve Net Zero Water, all wasteful water produced by the building and its occupants must be reused and recycled. Wastewater can be separated into two categories: grey water and black water. Since black water filtration systems are expensive and unsuitable for single buildings, this section will mainly focus on the recycling of grey water. Grey Water is defined as wastewater that is not from a toilet. The sources are therefore mainly from kitchen sinks, dishwashers, bathroom sinks, tubs and showers. Since the SUB contains numerous kitchens and bathrooms, it has large grey water production and recycling this can have a dramatic impact on over all water conservation. Grey water collection will be the main source of water for most of the equipment that does not require clean water. This includes the washrooms and parts of the garden that are not being used for consumption. There are many sources for grey water such as the showers that will be installed in the new SUB as well as any water used by the kitchen while cleaning the dishes.

Our group devised two main ways to use the recycled grey water. From our research around 30% -40% of the wasteful water is used to flush toilets. This means that generally, we are flushing clean, un-used water straight down the drain while all of this can be done with the recycled grey water. Our group proposes the installation of the Grey Water recycling system that can store the wasteful water from kitchens and showers and use them to flush later on. One disadvantage about grey water is that because it contains small amounts of nutrition and food particles, its condition can rapidly deteriorate into black water. Since the washrooms for the SUB are constantly under use this will not be a problem, as most of the grey water will be consumed immediate before deterioration.

From the specifications of the new SUB, 50% of the roof will be comprised of a garden. We can extend the benefit of grey water recycling by using the leftover grey water to irrigate the roof top garden. This will be especially beneficial during summer when rainwater is scarce, and irrigation using fresh water is wasteful. In addition to irrigating the plants, grey water can fertilize plants better than just fresh water and can restore nourishment back into the soil.

Grey water recycling is beneficial in everyway, it enables the efficient use of water, reduce the pressure on the water suppliers and have a positive social impact. We recommend BRAC system because its Canadian made which will support our domestic economy.

Types of systems

Three different types of systems were looked into to best recycle used water. All had its advantages and disadvantages. Each system is discussed further below.

Direct Reuse System

Directly reusing the water would be the most cost effective system compared to the others. The only concern is where the water is coming from. Because there is no treatment before the water is being reused, one would be concerned on where this water is being used. If the grey water is being used water the gardens, the possibility of cross contamination is huge.

Short Retention System

With this system, only the surface of the water would be used to allow particles to settle to the bottom of the tank. This system is reliable, inexpensive and inexpensive to maintain. The only disadvantage of this system is the lack of water collection compared to the other two systems. As well the concern of the direct reuse system appears where this water would be used.

Chemical Cleaning System

Finally, chemically cleaning the water for reuse would provide both a way for the grey water to be used as a source of clean water as well as grey water use. This gives the SUB more options in how to use they grey water. The Disadvantage is that this system is more expensive, and chemically cleaning the water brings the concern on whether this water should be used for consumption and cleaning.

In Conclusion, the best solution would be to use chemical cleaning due to the fact that it gives the SUB multiple uses for the water. Although the cost of reusing the water would be higher, it is the safest solution, without cross contaminating the clean water source.

The product that will best accomplish the job is the CGW-19800 grey water recycling system developed by BRAC SYSTEMS. The liquid capacity of the CGW-19800 is 17400 Liters, which could recycle enough greywater per day to fully service the toilet flush volume requirements in a building with occupancy of 480 people. Depending on the final occupancy of the new SUB, we can increase the number of systems installed. The CGW-19800 is comprised of three 6600 main holding tanks connected in series and is specifically used in applications when a higher flow volume of greywater is required. The high output 15hp pump manufactured by BRAC Systems is capable of delivering 50,000 Liters /hour (13,192 GPH) at 71psi. This high output is perfect for delivering greywater at above minimum working pressures when used in taller buildings or for multiple flush valve applications such as public washrooms in SUB.

III – CONCLUSION AND RECOMMENDATIONS

There are a great number of potential ways though which the water consumption of the sub could be greatly reduced. While we cannot predict whether net zero water is indeed feasible without the proper statistics available to determine the load on a water system in the new sub, the reduction of water waste through systems such as efficient toilets and urinals is highly recommended. As discussed above, the main source of clean water will be through rain water collection. As well, clean water will be substituted for greywater with the old SUB to maintain a net zero exchange. We also recommend the consideration of recycling and collection techniques, as outlined, pending design and specification of the new sub.

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Appendix A - Resources and Consultants

- A comprehensive list of companies in BC that deal in water conservation services and products
  - http://www.harvesth2o.com/vendors.shtml#bc_ca
- Rainwater Connection – Design , implementation and maintenance of residential and commercial rainwater systems.
  - http://www.rainwaterconnection.com/services/service.htm
- Tiger Purification Systems Inc - Engineering services, purification systems and consulting.
  - http://www.watertiger.net/about/history.htm