ERS 250 – Greening the Campus and Community

Rainwater Collection from the ES2 Building

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1.0 Introduction

1.1 Environmental Studies 2 Building: Opportunities and Challenges

The Faculty of Environmental Studies at the University of Waterloo is the oldest of its kind in Canada (Kay 2004). While a number of universities in Ontario and accross the country have recently built 'green,' sustainable buildings, the University of Waterloo, at present, has none.

With the recent move of the Department of Architecture to the City of Cambridge, the Environmental Studies 2 (ES2) building presents a prime and unique opportunity for the University of Waterloo to develop its first green building. With several indoor and outdoor components to consider, a venture in greening the existing ES2 building would carry a number of challenges to reach a desirable, feasible and acceptable state for sustainability.

WATgreen is an initiative at the University of Waterloo and its mandate, along with the ERS 250 class, is to transform the university into "a showcase of sustainability…a process referred to as 'Greening the Campus' " (Cook 2004). At present, the ERS 250 class is currently researching and integrating greening building initiatives and components to allow the ES2 building be a "true ecosystem in harmony with its environment" (Cook 2004). These components and initiatives include green roofs, solar energy use, rainwater collection, outdoor landscaping, lighting, waste management, heating/cooling systems, biofiltration, building maintenance and work environment.

1.2 Rainwater Collection from the ES2 Building

Water conservation is an important aspect of sustainable living. One method to reduce water consumption and reliance on traditional sources is to utilise rainwater. Each year, south-western Ontario receives an average of 95 cm of precipitation (Environment Canada 2004). This rainwater often simply returns to the hydrologic cycle, unused, either as evaporation, groundwater recharge, or run-off into rivers and streams. Depending on the quality of the rainwater (which can be contaminated by bird droppings or pollutants in the air such as SO_2, various NO_x compounds, etc.), the water can be collected, stored and used in a number of different ways to ease pressure on current sources.

Although rainwater is rarely accepted as potable and the treatment required to make it so would be unfeasible, it can be useful for other applications such as watering plants, flushing toilets, and even washing clothes (Gould and Nissen-Petersen 1999).

Figure 1 displays the water dynamics of the University of Waterloo's (UW) Environmental Studies 2 (ES2) Building.

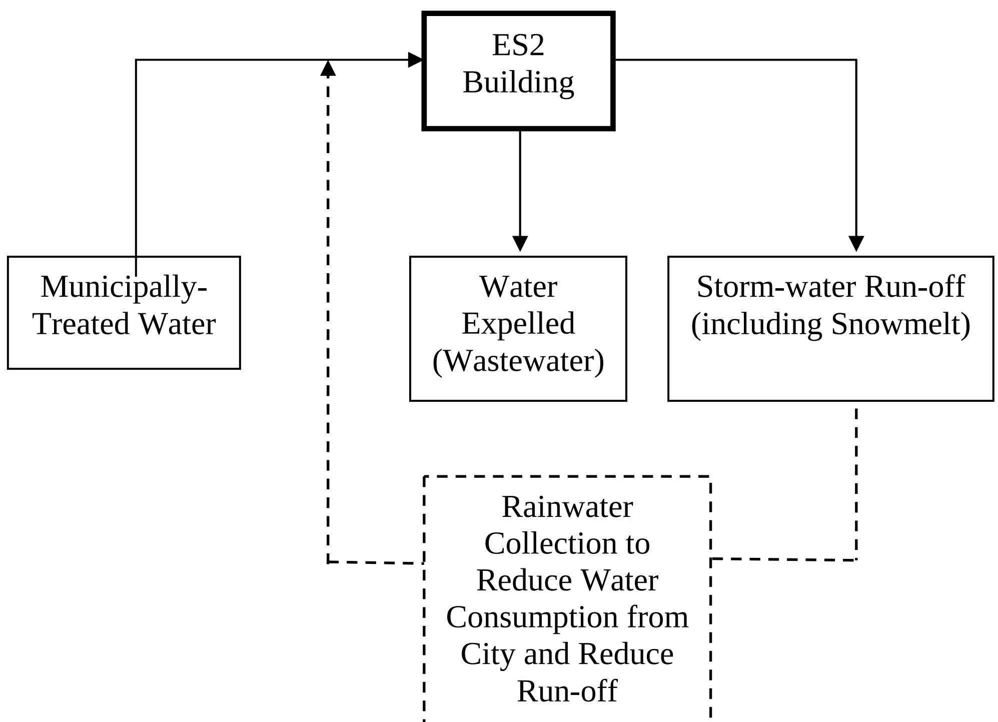


Figure 1. Water Dynamics of the Environmental Studies 2 (ES2) Building

The ES2 building consumes municipally-treated water, expels wastewater, and contributes to storm-water run-off during a precipitation event. With the goals of reducing water consumption in the building and reducing the amount of storm-water run-off, the focus of this project is the collection, storage and usage of rainwater. Since the majority of landscaping on campus (and around ES2) has been designed by UW's Department of Plant Operations to not require watering, using the stored rainwater for toilet flushes would make the most sense in order to reach the proposed goals (Galloway 2004).

2.0 Purpose

There are two goals for the collection of rainwater from the Environmental Studies 2 building:

1) To reduce the amount of municipally-treated water consumed by the ES2 building.

Benefits:

- Conserves water
- Reduces water-intake costs for the University of Waterloo

2) To minimise storm-water run-off from the ES2 building during a precipitation event.

Benefits:

- Reduces contaminated surface run-off to adjacent Laurel Creek
- Minimises the contribution of the building’s run-off to minor flash-flooding events

Rainwater collection directly from a roof can be an important element to greening the ES2 Building and contributes to the overall purpose of a green building. A ‘green’ or ‘sustainable’ building is one that uses energy, water, and other natural resources efficiently and provides a safe and productive indoor and outdoor environment (Environmental Stewardship Committee 2002).

Water management is an integral component to green, sustainable building design. Communities require adequate potable water during drought, yet also require protection from flooding during storm events (Environmental Stewardship Committee 2002). The possibility of collecting rainwater for use in toilet flushing can ease ES2’s pressure on the Regional Municipality of Waterloo’s groundwater and surface water (i.e. the Grand River) resources. In 1995, students as part of UW’s ERS 285 Class proposed and designed a storm-water system to be implemented at the new Environmental Science and Engineering Building (now known as the Centre for Environmental Information Technology). This system would store rainwater for toilet flushing (Durley et al. 1995). According to Professor James Robinson, this system was not implemented due to high costs. In addition to conservation, reducing ES2's water consumption can help lower the University of Waterloo's cost for water intake.

Storm-water run-off can contribute to sudden floods and carry gasoline, nitrates, phosphates and other pollutants. In a study carried out by UW's ERS 285 Class students in 1994, rainwater collected from storm drains around the Mathematics and Computer (MC) Building was found to be severely contaminated with chlorides, oil, sediment, lawn and tree debris, litter and bird faeces (Allin et al. 1994). The collection of rainwater from ES2 would minimise its contribution to the increased, polluted surface run-off typical of the built environment.

In terms of water conservation, there have been both university and community-wide efforts to protect the Waterloo Region's water resource. Since 1990, UW's Department of Plant Operations has installed devices to minimise the flush on toilets and the water pressure on showers (Cook 2003). Water used to cool buildings has been reduced as a result of overnight pre-cooling, and the recycling of water in chillers (Cook 2003). These innovations have led to significant reductions in the University's water consumption (Cook 2003). The Regional Municipality of Waterloo is currently implementing their Toilet Replacement Program and Rain Barrel Distribution Program (Region of Waterloo 2004). Both the university and wider-community are committed toward water conservation.

Rainwater collection will contribute to greening the ES2 Building and therefore contributes to the WATgreen vision of transforming the University of Waterloo into a showcase of sustainability.

3.0 Objectives

The following are the objectives to determine the feasibility of establishing a rainwater collection system in the ES2 building:

1) Characterising the rainwater quality and quantity in the Waterloo Region and off of the ES2 building.
2) Identifying rainwater collection methods.
3) Identifying potential rainwater uses and the selection of the most practical use.
4) Designing and implementing a rainwater collection system for the ES2 building for the selected use.
5) Calculating costs and possible savings or benefits for proposed system.
6) Identifying alternatives if the proposed use or system is unfeasible due to costs or lack of integration with other greening initiatives for the ES2 building.

4.0 Methods

4.1 Rainwater Quality and Quantity in the Waterloo Region and off of the ES2 Building

The amount of rainfall was obtained from Environment Canada's online climate database. Although there are no studies on the rainwater quality of the Waterloo region, Gould and Nissen-Petersen (1999) and Forster (1999) discuss rainwater quality on a general basis. In addition, assumptions, based on common sense, were made to determine rainwater quality, such as contamination from bird faeces, leaves and other plant debris, and airborne pollutants.

4.2 Identifying Rainwater Collection Methods

Rainwater Catchment Systems for Domestic Supply by Gould and Nissen-Petersen (1999) was the main source in identifying rainwater collection methods. By comparing rooftop catchments and ground catchments, it was decided that rooftop catchments would be a more desirable, feasible and acceptable way of implementing the rainwater collection system for ES2.

4.3 Identifying Potential Rainwater Uses and Selecting the Best Use

Based on rainwater quality information from Gould and Nissen-Petersen (1999) and Forster (1999), as well as information from the Department of Plant Operations, the potential uses of harvested rainwater were determined.

4.4 Designing the Rainwater System for Toilet Use

During the process of rainwater collection research, one of the first required tasks was to understand the existing water system of ES2. The piping and drainage system of the ES2 building was identified through blueprints from the Department of Plant Operations. This information was needed to design the piping that would lead to the toilets after the implementation of the rainwater system. Professor James Robinson provided different options with regard to the placement of equipment and the required materials for the system.

Based on the data collected from Environment Canada's online climate database and the website of the UK Rainwater Harvesting Association, calculations for the tank size were made.

4.5 Estimating Water Use at Regular Building Occupancy

Flush demand data at University of Waterloo is non-existent at this time (Durley et al. 1995). Since architecture students moved out of ES2 in 2004 before this project began, surveys with regard to flush demand could not be conducted. As a result, flush demand had to be based on estimations in place of surveys. The number of toilets and urinals were recorded, and it was assumed that the flow of people remained constant throughout the year. (This is not the case, yet concrete data is lacking in this area.) Assumptions for flush volumes were also made.

4.6 Calculating Costs and Savings

Calculations were made based on equipment prices that were found from international suppliers. There are no local rain water equipment suppliers in the Waterloo Region. Savings were calculated using the price of water from UW's 2003-2004 water bill and the total harvestable rainwater.

5.0 Results

5. 1 Rainwater Quality

Rainwater is generally acidic (University of Waterloo, 2004a). The quality of rainfall is difficult to specify, as it varies from locations and the surfaces where rainwater is collected. No study of rainwater collected from a roof surface has been carried out on campus. One could still estimate the rainwater quality by examining the environment around ES2.

The University of Waterloo campus is located in the suburban of the region of Waterloo, and therefore does not experience heavy air pollution from major industrial activities. On a smaller scale, however, ES2 is located next to the Ring Road. It is vulnerable to traffic fumes and dust which may contain heavy metals such as lead (Re-earthing the City). It may also be affected by the emission of the chimney at the Central Services Building. Depending on the direction of the wind, emitted particles can be carried and deposited on the roof top of ES2. Rainwater collected off from the roof might also contain organic material such as leaf litters and geese droplets. The water would require extensive and expensive treatment in order to make the water potable. It is more feasible to use the harvested rain water for flushing toilets or for landscaping (watering plants).

With regard to the quality of roof runoff, Forster (1999, 137) found that such water could be contaminated by the dissolution of the roof's metal components in addition to air pollutants, particularly due to the fact that rainwater is acidic. Gould and Nissen-Peterson (1999, 144) note that despite excessive atmospheric pollution, levels of contamination of rainfall are low until the water makes contact with the catchment surface and system materials.

5.2 Rainwater Quantity

The following are a series of calculations to determine water quantity and the size of tank that would be required to hold such water.

Area of Roof

$$14000\,ft^2 \cdot \frac{0.3048m}{ft} \cdot \frac{0.3048m}{ft}$$

$$= 1300.6m^2$$

Total Theoretical Possible Rain Harvest Volume
(assuming 95cm rain/year, Environment Canada 2004)

$$1300.6m^2 \cdot \frac{95cm}{year} \cdot \frac{1m}{100cm}$$

$$= \frac{1235.6m^3}{year}$$

$$\frac{1235.6m^3}{year} \cdot \frac{1000L}{m^3}$$

$$= \frac{1234600L}{year}$$

Actual Harvest Volume

85% efficiency (underground filter/tank system)
0.5 (roof runoff coefficient for a flat roof)
(Rain harvesting Systems Ltd. 2004)

Rainwater yield *(litres per year)* ***= roof area*** *(m2)* ***x annual rainfall*** *(mm)* ***x run-off coefficient x filter efficiency***
(Rain harvesting Systems Ltd. 2004)

$$95cm \cdot \frac{10mm}{1cm}$$

$$= 950mm$$

$$0.85 \cdot 0.5 \cdot 1300.6m^3 \cdot \frac{950mm}{year}$$

$$= \frac{524875L}{year}$$

$$= \frac{524.8m^3}{year}$$

Tank Size
Tank should be able to hold 5% of annual harvest
(Rain harvesting Systems Ltd. 2004)

$$= 0.05 \cdot 524875L$$

$$= 26243.75L$$

The tank should be at least $26m^3$ ($30m^3$ is the next biggest size tank available) (Tim the Tank Man 2004).

5.3 Water Demand & Consumption: University of Waterloo and the ES2 Building

The university's total water bill for 2003/2004 fiscal year was $796,000 (Zalagenas 2004). At a cost of $\$1.60/m^3$, 532,000 m^3 of water was used.

- **Landscaping**

Since the university is conscientious about planting native species that do not require additional water besides rainfall, the only landscapes that are watered are areas of new sod or seed, few small gardens of annual plants, and the football, soccer and rugby fields at the Columbia Ice Fields (Galloway 2004). This watering only happens in the spring and summer. It is estimated that approximately 11.35 m^3 of water on an annual basis for the sod/seeds and gardens (Galloway 2004). Total water usage for the fields has been approximated to 380 m^3/year.

- **Human Needs - Daily Toilet Consumption Calculations for the ES2 Building**

Inventory of ES2:
- 8 toilets
- 3 urinals

Assume toilets each use 15L/flush and urinals each use 4L/flush, based on best estimation.

Daytime hours (between 8am and 8pm)*, assume toilets and urinals are flushed 4 times/hour on average.*

Toilets

$$\frac{4times}{hour} \cdot 12hours \cdot 8toilets$$
$$= 384\,flushes$$
$$384\,flushes \cdot \frac{15L}{flush}$$
$$= 5760L$$

Urinals

$$\frac{4times}{hour} \cdot 12hours \cdot 3urinals$$
$$= 144\ flushes$$

$$144\ flushes \cdot \frac{4L}{flush}$$
$$= 576L$$

Night-time hours (8pm and 8am)*, assume toilets and urinals are flushed 0.25 times/hour on average.*

Toilets

$$\frac{0.25times}{hour} \cdot 12hours \cdot 8toilets$$
$$= 24\ flushes$$

$$24\ flushes \cdot \frac{15L}{flush}$$
$$= 360L$$

Urinals

$$\frac{0.25times}{hour} \cdot 12hours \cdot 3urinals$$
$$= 9\ flushes$$

$$9\ flushes \cdot \frac{4L}{flush}$$
$$= 36L$$

Total Daily Consumption *(assumes that weekdays and weekends are equal)*

$$5760L + 576L + 360L + 36L$$
$$= 6732L$$

Total Annual Consumption *(assumes equal usage throughout the year)*

$$\frac{6732L}{day} \cdot \frac{365days}{year}$$
$$= \frac{2457180L}{year}$$
$$= \frac{2457.18m^3}{year}$$

5.4 Implementing a Rainwater Collection System for Toilet Use in the ES2 Building

Figure 2. displays the existing underground toilet pipe network of the ES2 building, as well as the *proposed* pipes and storage tank for the rainwater collection system. The rectangular form is the outline of the ES2 building. The 'incoming water source' refers to municipally-treated water. The 'outgoing water source' refers to waste-water, which will eventually lead to the nearby sewage treatment plant.

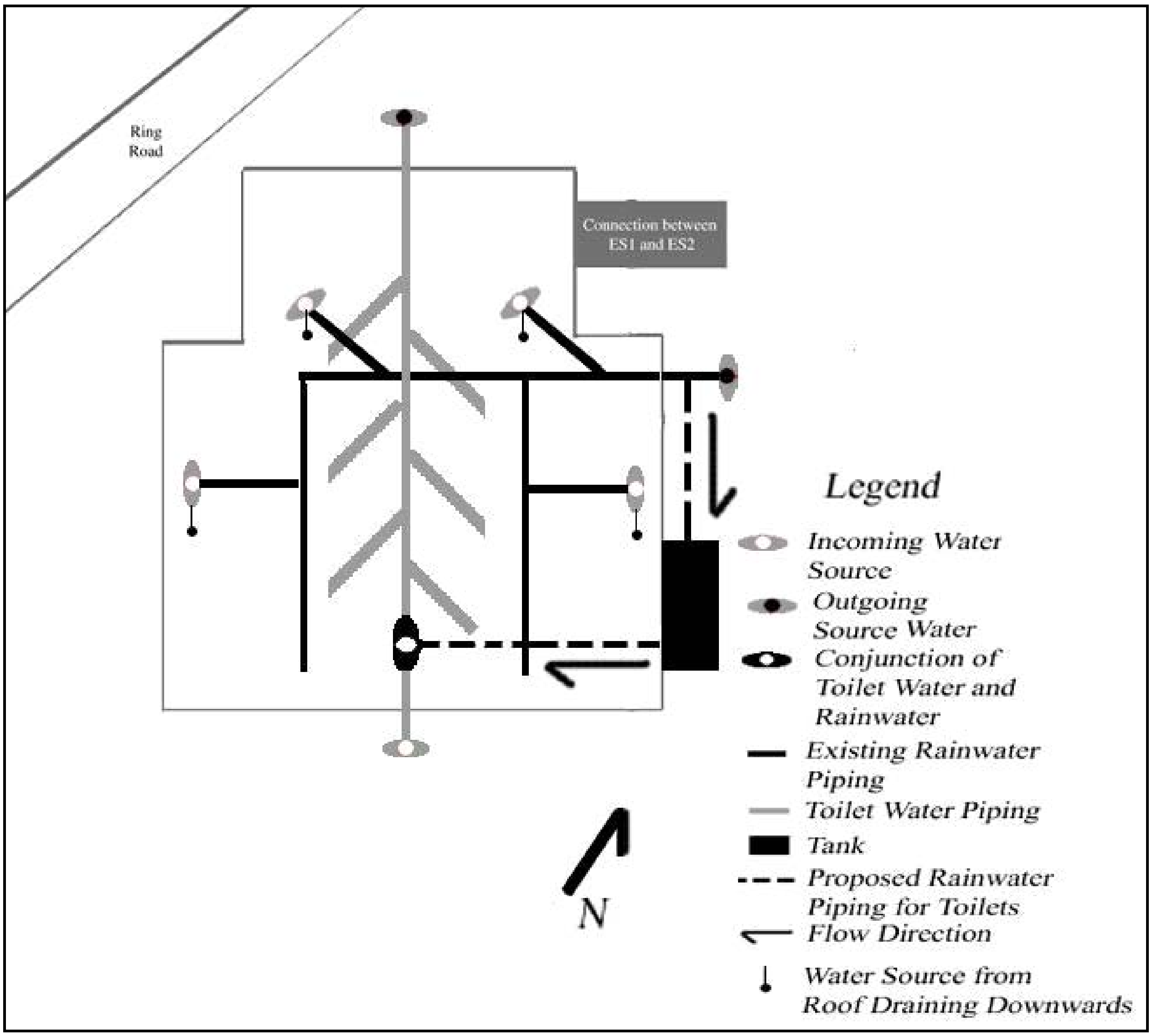
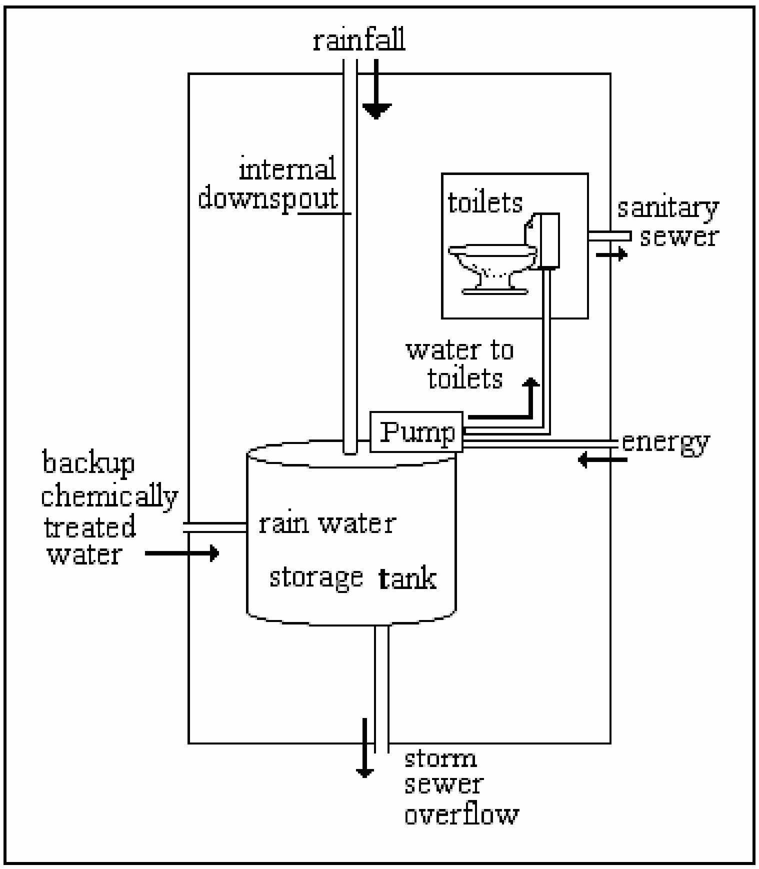


Figure 2. Existing and Proposed Underground Piping Network of the ES2 Building
(Department of Plant Operations 2004)

It was found that the rainwater drainage piping system from the roof was separate from the water leaving the toilets and urinals. Using the proposed rainwater system, water collected from the rooftop will lead to the storage tank, which will then lead to the toilet system. The most appropriate location for installing the storage tank is underground on the East side of ES2 beside the Psychology, Anthropology, Sociology Building (PAS) parking lot. The tank, once underground, will not disturb proposed future 'green' gardens. Figure 3. displays a theoretical model of the proposed rainwater collection system for toilet usage.



<u>Figure 3.</u> Rainwater Collection Design (Durley 1995, Appendix A)

5.5 Costs and Savings

Since the university has regular building maintenance for ES2 (which includes the cleaning of the drains on the roof), there would not be additional maintenance costs after the implementation of the project. However, once the rainwater system is implemented, regular monitoring of the rain water flow will be needed to assess the efficiency of the system.

The following is a series of calculations to determine the costs and possible savings.

- **Price for Water**

Costs (Galloway 2004)

$$\frac{\$1.60}{m^3}$$

$$= \frac{\$0.82}{m3} \text{supply} + \frac{\$0.78}{m^3} \text{sewage}$$

- **Current Toilet Water Usage Costs**

Total Annual Costs for Toilet Water Consumption in ES2

$$\frac{2289.7m^3}{year} \cdot \frac{\$1.60}{m^3}$$

$$\frac{\$3663.52}{year}$$

- **Implementation Costs**

(Costs Accounted for tank, screens for drain covers, and pump only.)

30,000L Tank (Tim the Tank Man 2004)

- Diameter - 4100mm (13' 6")
- Inlet Height - 2400mm (7' 11")
- Total Height - 3000mm (9' 10")
- Supplied with 500mm Inlet Strainer, 40mm Brass Outlet and 90mm Overflow

$$\$3150 Australian \cdot \frac{\$1 CAD}{\$1.08 Australian}$$

$$= \$2916 CAD$$

Screens for Drain (6 required, one for each drain) (Tim the Tank Man 2004)

$$6 \cdot \$16.50 Australian \cdot \frac{\$1 CAD}{\$1.08 Australian}$$

$$= \$93 CAD$$

Pump (Spectra Pure Inc. 2000)

$$\$550 US \cdot \frac{\$1 CAD}{\$0.85 US}$$

$$= \$647 CAD$$

Pipe

15m of copper piping (Plumbing World 2004)

(Cost for other types of piping unavailable due to fluctuations in market price and ‘membership’ requirements to obtain estimates.)

Plumbing World is more expensive than most piping suppliers because their pipes are all hand cut. They also only deal in 4ft increments. The calculated cost for 15m is $1323. To account for this discrepancy, the estimate used in total cost calculations is $1000.

Subtotal:

$$\$2916 + \$93 + \$647 + \$1000$$
$$= \$4656$$

Plus costs for:

Installation of all equipment, one way valves to prevent contamination of drinking water, automatic float control (mechanism to sense insufficient rainwater quantity, and trigger the inflow of municipally treated water to the toilet piping), delivery of materials, concrete for reinforcement under the tank, etc.

Labour beyond installation is not required because all work falls into outside common maintenance routine, caretaker routine (i.e. cleaning the drains) that would be done anyway. The same applies to monitoring of the water system.

- ## Pay-off Time and Future Savings

Total Annual Savings (if all the rainwater is used to supplement toilet flushing)

$$\frac{524.8m^3}{year} \cdot \frac{\$0.82}{m^3} \text{supply}$$
$$= \frac{\$433.29}{year}$$

(This does not include electrical costs for operation of the pump.)

Pay-off Time

Pay-off time = cost / (savings/year)

$$payofftime = (\geq \$4656) \div \frac{\$433.29}{year}$$

$$= \geq 10.7\,years$$

The actual payoff time will be greater than 10.7 years due to additional costs not factored into calculation

6.0 Analysis

6.1 Possible Uses

This project focuses on using the rainwater toilet flushing but other uses for harvested rainwater are possible. Landscape watering would be the most obvious option, given the quality of the rainwater and necessary treatment were it to be used for other things, such as drinking.

6.2. Feasibility

With a payoff time that is greater than 10.7 years, harvesting rainwater from the roof of ES2 to supplement water used for toilet flushing is not a very feasible idea as the life of the equipment is unknown and might be not much more than the payoff time. Annual savings are not great because the 78 cents per m^3 of water that gets flushed still needs to be paid for.

The addition to the university's electrical bill for the operation of the pump also needs to be factored in and subtracted from annual savings.

Due to a lack of available local suppliers, much of the proposed equipment comes from international sources. Although all costs have been converted to Canadian currency, shipping of certain purchases may not be possible.

Using the rainwater for landscaping would be another option. Although the amount of rainwater that could theoretically be collected each year is greater than the estimated need for the gardens of annuals and the sports fields at Columbia Ice Fields, the transportation costs of the water would make it unfeasible.

6.3 Scenarios

Harvesting rainwater from rooftop runoff from ES2 is an initiative that might possibly conflict with several other greening the campus projects. Considerations have been made for each case.

- **Solar panels**

The presence of solar panels on the roof might interfere with the quality and the quantity of rainwater collected. Further studies need to be done regarding the positioning of the panels and the materials they are made of to determine whether the proposed rainwater collection system could function in harmony with the solar panels.

- **Green roof**

Presumably, if there were to be a green roof on ES2, it would soak up most or all of the rainwater that might otherwise be collected as runoff. In this case, we propose a ground catchment as an alternative to the roof to harvest rainwater. A possible location is between ES2 and the Psychology Anthropology and Sociology (PAS) building parking lot. Further studies need to be done.

7.0 Conclusion and Recommendations

The ultimate goal of the “Greening the Campus” project series is to transform University of Waterloo into a more sustainable campus. On a smaller scale, the main focus of this term is the renovation of the proposed space for ERS faculty in the ES2 building. The water system group attempted to develop a rainwater collection system that would reduce the consumption of municipally-treated water of the building and eliminate excess storm-water run-off into Laurel Creek during a precipitation event. After researching the existing water systems, accepted rainwater collection practices, etc, plans for ES2 began to take shape. Based on the assumption of water quality, the collected rainwater would be most appropriate for toilet flushing as it requires minimal treatment. Different rainwater collection systems were studied in order to design the most appropriate system to incorporate into the existing water system of ES2. Theoretical harvested rainwater was also calculated in order to figure out suitable sizes and quantity of required equipment. Cost and savings of the system were calculated based on the estimation of water consumption, implementation costs, and pay-back calculations. The design of the system also considers the incorporation of other working groups. Its flexibility allows it to compromise with the green roof and solar panel groups.

As determined in Section 6.0, the proposed rainwater collection system for toilet flushing is not as feasible as one might hope. The major obstacle of the system is the implementation and running costs. Due to expensive equipment, long-term electricity required to run the system and low annual savings, the pay-off time is very long (10+ years). As a result, this project may face heavy objection by the administration of the faculty and/or the university.

A rainwater collection system for a storm-water management pond is recommended in the case of an objection of rainwater collection for toilet flushing. The possible location for this pond is the area between ES2 building the PAS parking lot. (This location will not conflict with proposed future garden plans. Rather, it compliments the plans as a wetland/marsh garden.) In this scenario, rainwater collection is still desirable; The ES2 building will still be able to become a "greener" building in terms of reducing polluted surface run-off to Laurel Creek and contributing its surface run-off to minor flash-flooding events. Further study is required to determine the feasibility of the recommended storm water pond for not only the ES2 building, but for other buildings on the University of Waterloo campus. This study should include but not limit itself to: the technical skill required, the viability of the location, the benefits, safety issues, the opinion of UW students and faculty stuff, and implementation costs.

8.0 References

Allin, Kevin, Michelle Lee, Heather Rand and Piotr Tokarski. (1994) Impact Analysis of the Math and Computer Building Storm Sewer on Laurel Creek Watershed Dynamics. Waterloo: University of Waterloo, WATgreen Report #60.

Cook, Patti. (2004) "WATgreen: Greening the Campus." <http://www.adm.uwaterloo.ca/inf-owast/watgreen/> Accessed November 27, 2004.

Cook, Patti. (2003) "WATgreen: Water." <http://www.adm.uwaterloo.ca/infowast/watgreen/pr-ojects/water_conservation.html> Accessed November 2, 2004.

Department of Plant Operations. (2004) Environmental Studies Building 2 Map. Waterloo: University of Waterloo.

Durley, Jenny, Jason King, Sharon Nowlan and Natalie Wood. (1995) Storm-water Usage System for the New ESE Building. Waterloo: University of Waterloo, WATgreen Report #69.

Environment Canada. (2004) "Canadian Climate Normals, 1971-2000: Waterloo Wellington A." <http://www.climate.weatheroffice.ec.gc.ca/climate_normals/results_e.html?Pro-vince=ALL&StationName=Waterloo%20Wellington&SearchType=BeginsWith&LocateBy=Province&Proximity=25&ProximityFrom=City&StationNumber=&IDType=MSC&CityName=&ParkName=&LatitudeDegrees=&LatitudeMinutes=&LongitudeDegrees=&LongitudeMinutes=&NormalsClass=A&SelNormals=&StnId=4832&&autofwd=1&pageid=2&lang=ENG> Accessed November 2, 2004.

Environmental Stewardship Committee. (2002) The Guidelines for Sustainable Buildings. Stanford: Stanford University.

Foster, J. (1999) "Variability of Roof Runoff Quality". Water Science and Technology 39 (5):137-144

Galloway, Tom. (2004) Email Correspondence, November 23. Waterloo: University of Waterloo, Department of Plant Operations.

Gould, J. and E. Nissen-Petersen. (1999) Rainwater Catchment Systems for Domestic Supply. Guildford: Intermediate Technology Publications.

Kay, Paul. (2004) ERS 250 Class Lecture, November 23. Waterloo: University of Waterloo.

Plumbing World. (2004) "Rigid Copper Pipe" <http://www.plumbingworld.com-/copperpipe.html> Accessed November 28, 2004.

Rain harvesting Systems Inc. (2004) "Design Calculations." <http://www.rainharvesting.co.u-k/design/calculations.htm> Accessed November 28, 2004.

Re-earthing the City (2004) “Rainwater in Cities” <http://www.users.on.net/~arachne/rainwater.-html> Accessed November 27, 2004.

Region of Waterloo. (2004) “Water Services Welcome.” <http://www.region.waterloo.on.ca/w-eb/Region.nsf/c56e308f49bfeb7885256abc0071ec9a/37A888F08FD43A5C85256E43007-5588B-?OpenDocument> Accessed November 28, 2004.

Spectra Pure Inc. (2000) “Drinking Water Systems” <http://www.spectrapure.com/newprices.htm> Accessed November 28, 2004.

University of Waterloo. (2004a)“Natural Water.” <http://www.science.uwaterloo.ca/~cchieh/c-act/applychem/waternatural.html> Accessed November 3, 2004.

Tim the Tank Man. (2004) “Water Tanks.” <http://www.timthetankman.com.au/watertanks.htm> Accessed November 28, 2004.

Zalagenas, Rick. (2004) Email Correspondence, November 24. Waterloo: University of Waterloo, Department of Plant Operations.