Assessment of Water Usage and Conservation Concerns on Carleton Campus, Dalhousie University

ENVS 3502 Campus as a Living Laboratory

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Executive summary

The primary objective of this research project was to determine the amount of water being wasted though dripping faucets, due to mechanical and behavioural error, on the Carleton Campus at Dalhousie University. In addition, general attitudes towards the importance and practices of water conservations at Dalhousie University were investigated within the Dalhousie community. Based on the findings, recommendations on water conservation strategies regarding dripping faucets were made in order to reduce Dalhousie University's over all water consumption. Being an environmental leader within the Halifax community, Dalhousie University is committed to reducing their water consumption and increasing their water use efficiency. By 2020 Dalhousie University is aiming for a twenty-four percent reduction in personal consumption of water and waste produced by all students. In order to achieve our research goals and help Dalhousie University meet its water conservation target, a water audit was conducted to determine how much water was being wasted per year by dripping faucets and what types of aerators were being used within the Dentistry Building and the Tupper Building on the Carleton Campus. Intercept surveys with students attending Dalhousie University were used to determine attitudes toward water conservation, and willingness to contribute to conservation initiatives. In addition, face-to-face interviews with maintenance staff were conducted to uncover potential problems that may have been overlooked.

The results showed that there was minimal water wastage due to public leaking faucets on Carleton Campus. Out of the observed leaking faucets the majority were caused by behavioral leaks compared to mechanical leaks. However, in comparison to the total number of faucets surveyed, the number of behavioral leaks was significantly low. This correlated to the positive findings of the student intercept survey where the majority of students strongly agreed that water conservation was an important issue globally and within Canada. It was recommended to the Office of Sustainability that all faucets should be updated with low flow aerators and automatic taps should be implemented. Finally, a comprehensive water audit should be conducted to further investigate water wastage on Carleton Campus.

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1.0 Introduction

1.1 Background

Water covers around 70% of the world surface, however, it is considered to be a finite resource that should be used carefully and wisely. Only 2.5% of the earth's water is fresh water and out of the fresh water reserve only 1% is available for human consumption (Water News, FAO, 2013). Water is necessary for all life on earth and is one of the planets' most precious, but undervalued, resources. With the growing human population, predicted to reach 9 billion by 2050, it is unlikely that current freshwater reserves will be able to support such a vast population, especially given current per capita use of water (Vital Water Graphics, 2008; Simonovic, 2002). According to the Food and Agricultural Organization of the United Nations (FAO), in the last century global water use has been growing at more than double the rate of population growth (Water News, FAO, 2013). Furthermore, today around one in six people worldwide, 894 million, do not have access to clean fresh drinking water. This number is predicted to increase to 1.8 billion people by 2025 (Water News, FAO, 2013). With these concerning statistics and predictions, water conservation has never been more crucial.

Although Canada contains seven percent of the world's accessible freshwater, more than half of this drains north towards Hudson Bay and the Arctic Ocean, resulting in a great loss of freshwater to marine environments(Water: Frequently Asked Questions, 2012). As a result water conservation and proper management and efficiency techniques are paramount in Canada, as they are globally. According to the Organization for Economic Co-operation and Development, Canada is second in per capita freshwater usage in developed nations. As of 2002, Canadians consumed on average 1,420 m^3 per capita; the only country that consumes more freshwater is the United States, which consumes 1,730 m^3 per capita (Environment: Air, Water and Land, 2005). Although global growth rate is slowing, growth rate continues to increase in developing nations and the demand for freshwater is also increasing (Environment: Air, Water and Land, 2005). The importance of reducing waste and improving efficiency is not a new concept in resource consumption policy, but due to the seemingly infinite supply of freshwater and the exceedingly low costs, this importance seems to be lost on the water industry.

New technologies such as aerators, low-flow toilets and showers technologies, and management strategies to reduce consumption allow for increase in water use efficiency. In order to assess the practicality of investing time and money in new technology, wastage and usage must be quantified and analysed. Water audits are a qualitative and quantitative analysis of water consumption which helps to identify means of reducing, reusing, and recycling water to obtain a balance of water input and water output. They play an important role in business decisions, ranging from residential, commercial, and industrial projects (Sturman et al, 2004). Water wastage and/or over consumption reflects negatively upon businesses, stresses equipment, negatively affects the environment, and results in loss of significant profits.

With universities being one of the largest consumers of fresh water in North America, water conservation becomes a very important aspect in their policy making, not only to save money through

water and energy reduction, but also to reduce their environmental impact and increase their economic savings. Through specific purchasing decisions and shifts in attitudes, many universities across North America have significantly reduced their water usage, saving thousands of dollars in the process (University of Maryland, 2012). An excellent success story of a university implanting water conservation is Stanford University. In 2001 Stanford University developed a water conservation, reuse, and recycling master-plan to identify ways to keep water demand below the current San Francisco Public Utilities Commission (SFPUC) (Stanford University, 2003). From 2001 to 2008 the university completed 50 major water efficiency retrofit projects, overall reducing their average domestic water use from 2.7 million gallons per day in 2000 to 2.3 million gallons per day in 2007, despite campus growth. One of their projects included retrofitting student housing, which has cut their water use by 120 million gallons a year (Stanford University, 2011).

Being located in a coastal city in Atlantic Canada, water efficiency and management is a top priority for Dalhousie University. As outlined in the Sustainability Plan, Dalhousie University is attempting to reduce its impact on the environment and promote resource use sustainability by aiming for a twenty-percent reduction in personal consumption of water and w0aste produced by 2020 for all students (Dalhousie University Sustainability Plan, 2010). In order to assess the amount of waste that is being reduced, there must be a preliminary assessment of current usage and water waste. Water audits can provide the baseline of information that can be used for future comparisons of water waste, as well as providing additional information on flow rate and type of faucets, university attitude towards water use, and a monetary incentive for waste reduction. Reduction of water usage, even when the waste is only through leaking faucets, can result in large savings for the University. Additionally, as an environmental leader in the community, Dalhousie benefits greatly when reducing impacts on marine ecosystems. Water audits help reduce freshwater consumption resulting in reduced runoff into marine ecosystems, reduced number of contaminants in the hydrologic cycle, lower extraction rates from groundwater aquifers, and less stress on municipal water systems (Richardson-Prager et al, 2004).

1.2 Project Objectives

The purpose of this research project was to conduct a water audit to determine and measure the amount of water being wasted through dripping faucets, due to mechanical error, on the Carleton campus at Dalhousie University, specifically addressing the Dentistry and Tupper buildings. The goal of this study was to propose simple recommendations on water conservation strategies to Rochelle Owen, the director of the office of sustainability, and other decision makers, to be implemented on the Carleton campus at Dalhousie University**.** In the long run these recommendations would assist in the decrease of water being wasted through dripping faucets and inefficient aerator types. This would result in the reduction of Dalhousie's overall water consumption and saving the university both energy and money, while helping Dalhousie to become a more sustainable campus. In order to achieve these goals we used a variety of different research tools. These included first an intercept survey with students at Dalhousie to determine their attitude on water conservation and usage patterns. Second, face-to-face interviews with maintenance staff to uncover potential technical problems related to the buildings and general attitudes towards water conservation. Finally a quantitative approach, the water audit, used to

determine how much water was being wasted per year by dripping faucets and what types of aerators were being used throughout the buildings. This report outlines the research methods, results, a discussion of significant findings, and recommendations for future actions and research.

2.0 Research Methods

This study was being performed to gauge water usage inefficiencies with regards to the faucets in public washrooms on Carleton campus. It attempted to gauge through an intercept survey (see appendix) conducted on a sample of the student body how the general Dalhousie University population feels about three aspects of water conservation: 1st the scope of its importance, 2nd who bears the responsibility for water conservation efforts and 3rd would students be willing to contribute financially to the issue. Additionally, in order to ensure the study captures as many relevant details as possible as related to water wastage and conservation on Carleton campus, the help of staff will be enlisted; these interviews will consist of maintenance staff from the Tupper building and the Dentistry building.

2.1 Water and Faucet Audit

Initially a water audit on Carleton campus was performed and the following information was recorded: the number of leaking faucets, location, volume of wasted water, the serial number and the flow rate of aerators; and the model number of the faucets. This was done in order to calculate the total potential volume of water wasted, the possible savings from stopping this wastage; and to help provide data on aerators and faucets for the department of Sustainability at Dalhousie. The water audit data was collected from both the Dentistry and Tupper buildings over the course of a single day in order maintain temporal consistency of the observations and to reduce the potential influence of variables that may change from one day to the next (Bordens and Abbott, 2005). Measuring the actual water loss from all public taps on Carleton Campus was performed using of graduated cylinders demarcated with drip rates that correspond to losses in liter/day and litres/year; due to the number of bathrooms and faucets, data collection was expedited through auditing all public faucets in groups two groups: 1 group audited the Dentistry building and the other group audited the Tupper building.

The procedure consisted of systematically (floor by floor) recording the location of each bathroom and determining via observation if a faucet was leaking. If a faucet was found to be leaking/running, the amount of waste was recorded using a drip gauge, and an attempt was made to shut the faucet; it was noted if the faucet was running due to a mechanical or behavioral problem. Finally, the serial numbers of the aerators and the faucets were recorded. Although not an exhaustive audit, the methodology still conforms to the basic 3 step criteria (Chin, 2006) for a water audit template: step 1 – pre-audit to get agreements, permission to work and background information on the facility, step 2 – collection of data from the site and review operations with water facilities management, step 3 - water system analysis.

3.2 Face-to-Face Interviews with Maintenance

The second part of the study consisted of interviews (see appendix) with maintenance staff that were performed through a non-probalistic and purposive sampling manner. These face to face interviews were undertaken in order to gain a real world perspective about possible issues concerning with the faucets themselves, student behavior around the use of faucets and possible recommendations (Totten et al., 1999). In addition to this capture of "authentic' or real life data there are other advantages to conducting an interview with staff such as: 1) it is thought that staff will feel more comfortable to express their opinion in an anonymous one on one interaction (Totten et al., 1999); 2) increased possibility of uncovering an unheard of or unpopular suggestions or opinions without fear of group/social scorn (Totten et al., 1999); 3) higher rates of participation (around 80-90%) and generally less volunteer bias (Palys and Atkinson, 2008); 4) the interviewer can help the participant to clarify questions and elicit a more of a response especially from short answered responders that might otherwise give an incomplete answer on a self-administered questionnaire or survey (Palys and Atkinson, 2008).

During the interviews researchers respectfully approached maintenance staff members and asked for a few moments of their time; if the researchers were obliged then they explained the purpose of the study and participants were asked to sign a consent form to perform the interview. As well, guidelines were produced for the interviewer that stressed asking questions clearly and carefully, with intent of uncovering issues such as: concerns with the buildings water infrastructure, leaky/running faucets, student/user behavior and possible recommendations (see appendix).

3.3 Intercept Survey with Students

The final aspect of the study entailed performing an intercept survey on students (see appendix) at Dalhousie University (Life Sciences Building, Killiam Library, Dentistry building and the Tupper building. The survey investigated three aspects of water conservation with respect to three main themes of water conservation: the importance of water conservation in respect to scale and possible obligations, the scope of responsibility and personal financial duty. Similar to face-to face interviews, this survey allowed for the capture of large amounts of data very quickly, eliminated group bias, and allowed researchers to clarify questions and achieve better quality responses, particularly from short answer responders that might otherwise have given an incomplete answer on a self-administered questionnaire or survey (Palys and Atkinson, 2008; Totten et al., 1999). However, unlike face-to-face interview this method systematically randomized the participants, making the survey sample more representative of the overall student population (Totten et al., 1999). In addition, systematic sampling was less time consuming and more cost effective than simple random sampling (Bordens and Abbot, 2005).

3.4 Sample Size

In order to start the process of sampling we must determine our sample size; traditionally to determine this we consider a number of factors such as the purpose of the study, the required level of

precision, the level of confidence of risk, response rate and variability (Isreal, 1992); but in this case the data is not going to be analyzed using inferential statistics because the survey design is not quite as sophisticated as Likert-Scale but is more substantial than a Likert-type design (Boone and Boone, 2012); the former loans itself to be analyzed using inferential statistics but the latter is much simpler and more convenient with respect to analysis via descriptive techniques (Boone and Boone, 2012) and the completion date of this study. Additionally it was chosen to err on the side of caution and not over extend our assumptions about the data; therefore confidence intervals were used to obtain our sample size due to it being a more reasonable approach (due to time) in this case than via statistical significance (Hopkins, 2008).

Using the Government of Australia's National Statistic Service sample size calculator it was determined that the sample size by entering: confidence level at 95%, total population size 18400, proportion at 0.5 (conservative estimate of variance because the proportion is unknown) and setting the confidence interval at 0.1 a sample size of 96 participants is obtained. To this 10-20% was added to the estimate the total number of persons that must be enlisted since our participation rate is 80-90% (Palys and Atkinson, 2008); the estimated total number of participants that will have to be approached is ~106 to 116; or the process continues until we satisfy our quota. Each researcher interviewed 25 persons each, interviewing even numbers of males/females at each building. Generally when selecting participants; researchers stood at one particular spot and selected every k^{th} element of the population, with the first element being selected at random (Madow, 1946); for example: A researcher has a population total of 100 individuals and needs 12 subjects; they must pick a number under 100, let us say 5, this will be the start point; then they must pick his/her systematic randomized interval, let us say 8. If these are the choices, then the researcher will choose the 5^{th} individual they encounter, then the 13^{th}, the 21^{st}, 29^{th}, etc. up to the 12^{th} person, number 97; if one possible subject does not want to participate or does not qualify to participate, just count the next 8 people who go by and stop the very next person; continue until each person's quota has been met.

3.5 Data Analysis from Part #1

The following will be calculated using the data collected to analyze:

- Fixing dripping taps to save water = drip gauge will give volume being wasted.
- Fixing dripping taps to reduce costs = (volume saved) * (cost per unit volume of H2O)
- Potential amount of water saved from taps being fitted with new aerators

Total Volume of H2O Saved Using New Aerators

Since the amount of water wasted was recorded using drip gauges in litres/year and this data was noted for each fixture the total amount of water lost over a year was calculated for each building; from this the total monetary loss was calculated according the following equation:

Water lost = Sum of (all water wasted from all taps added together in units of liters/year)
Monetary losses = (Total water lost in liters/year)*(1m3/1000litres)*(Price/m3)

3.6 Data Analysis from Part #2

Due to differences in analyzing Likert type and Likert scales; and this data sharing similarities with both scales as previously mentioned; the analysis with take on a descriptive character that will focus on the following measures: median, mode (measures of central tendency) and frequency (variability) (Boone and Boone, 2012). These measures will be used to describe general trends in the three groupings of the survey with respect to water conservation (its importance, who is responsibility and who is willing to pay). As well different demographics (age, sex, faculty, year of study) could be compared and contrasted with respect to the median, mode and the frequency for the different questions; additionally the data could be analyzed more thoroughly but given the time constraints this option for analysis is still considered to be insightful and valuable; it would however be possible for future students to take this data and use inferential statistics to make some interesting associations and comparisons not able to be made during the present study.

3.7 Limitations and Delimitations

In performing this study, time was of the essence, we limited our sample size of the student intercept surveys and we also limited the number of staff interviews that were performed. In performing student intercept surveys the sample size had to be constrained and the data was analyzed using descriptive statistics and not inferential methods.

In calculating water losses the analysis was primarily limited due to time constraints and a lack of data concerning aerator flow rates simply because they were not inscribed on the taps; an estimation of the number of people that go in and out of the buildings was not known or confirmed and the total water usage for each building was unknown which also hindered the analysis.

3.0 Results

3.1 Water Audit Results

A water Audit was carried out on Friday March 22th 2013 between 2am-5pm at four different locations across the Dalhousie University Campus. A total of 118 faucets were surveyed, with 52 faucets located in the Dentistry building, and 66 faucets in the Tupper Building.

Distribution of surveyed faucets

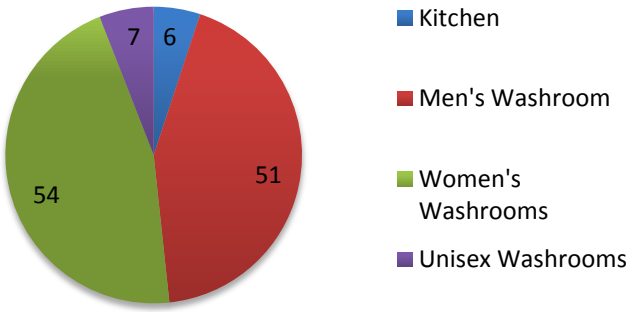

Figure 1. Distribution of publically accessible surveyed faucets in the Dentistry Building and Tupper Building on Dalhousie University Carleton Campus. n = 118

The distribution of surveyed faucets in both the Tupper and Dentistry Building on Carleton Campus, Dalhousie University is equally divided between men's and women's washrooms, with a small number of unisex washrooms and kitchens. In total (n=118), there are 54 women's washrooms, 51 men's washrooms, 7 unisex washrooms (all in the Dentistry Building), and 6 public kitchens. In the Tupper Building (n=66), there are 33 women's washrooms, 31 men's washrooms, and 2 public kitchens. In the Dentistry Building (n=52), there are 21 women's washrooms, 20 men's washrooms, 7unisex washrooms, and 4 public kitchens.

Percentage of surveyed faucets with aerators

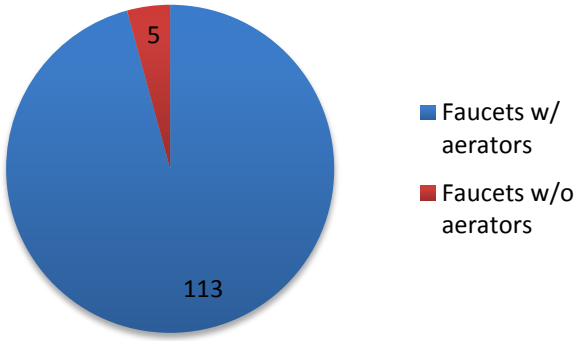

Figure 2. Faucets with and without aerators for all public faucets surveyed in the Dentistry Building and Tupper Building on Dalhousie Carleton Campus. 96% of all the faucets surveyed had aerators present. n = 118.

Out of 118 total faucets surveyed on Carleton Campus, only 5 did not have aerators present (96% had aerators present). In the Tupper Building, 65 out of 66 surveyed faucets had aerators present (98%); the Kitchen faucet on the main floor was missing a faucet. In the Dentistry Building, 48 out of 52

surveyed faucets had aerators present (92%); a second floor kitchen and two men's washrooms and one women's washroom also had no aerators present.

Flow rate and aerator type

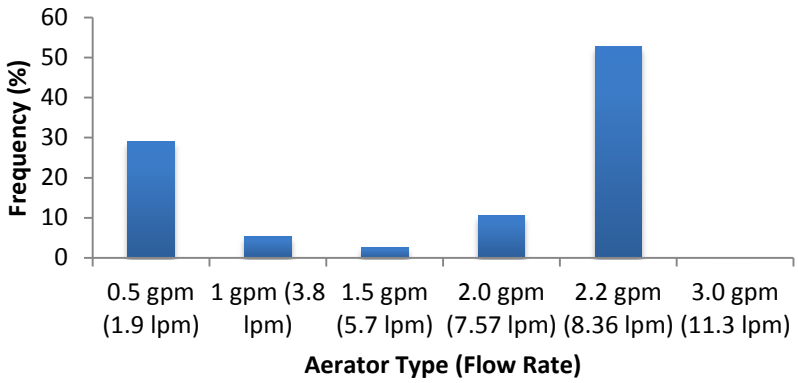

Figure 3. Aerator type for readable aerators in the Dentistry Building and Tupper Building on Dalhousie University Carleton Campus. 75 of the public faucets that were surveyed were unreadable or contained no flow rate. n=38.

The total number of surveyed faucets for both buildings on the Carleton Campus was 118, of which 113 had aerators present. Many aerators had unreadable or not present flow rate and aerator type information (75 of 113 were unreadable). The total number of surveyed faucets with readable aerators was 38. 53% of surveyed faucets had aerators with 2.2 gpm flow rate, 29% had aerators with 0.5 gpm flow rate, while there were no faucets recorded as having 3.0 gpm flow rate aerators. In the Tupper Building (n=14 readable aerators) the majority of readable aerators (43%) are low-flow 0.5 gpm aerators; with only 21% being 2.2 gpm flow rate. In the Dentistry Building (n=24 readable aerators) the majority of readable aerators (71%) are 2.2 gpm aerators; with only 21% being low-flow 0.5 gpm flow rate. There are no recorded faucets with 1 gpm or 1.5 gpm flow rate aerators.

Table 1. Total number of faucets, aerators, and aerator type in the Tupper Building and Dentistry Building on Dalhousie University Carleton Campus. Data was collected on March 22, 2013.

Building	Total # faucets	Faucets w/ aerators	0.5 gpm	1.0 gpm	1.5 gpm	2.0 gpm	2.2 gpm	3.0 gpm	unreadable
Tupper	66	65	6	2	1	2	3	0	51
Dentistry	52	48	5	0	0	2	17	0	24
Both	118	113	11	2	1	4	20	0	75

Table 1 summarizes the number of aerators present in each building and in total, as well as the frequency of aerator type and flow rate (gpm) recorded for all readable aerators for each building and in total. Number of unreadable aerators is also provided.

The cause of leaking faucets

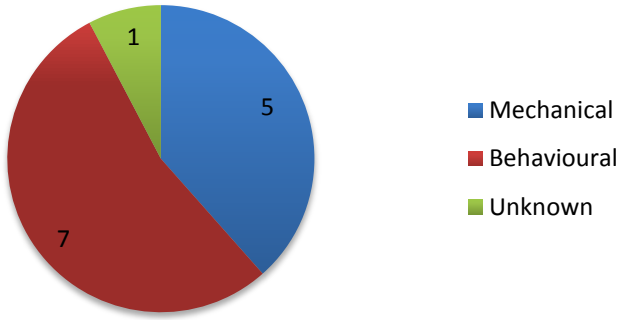

Figure 4. Causes of leaking faucets in both the Tupper Building and Dentistry Building on Dalhousie University Carleton Campus. Note, only 2 leaking faucets were recorded in the Dentistry Building, both of which were mechanical. n = 13

There were 13 total dripping faucets observed in the Tupper Building and Dentistry Building on March 22, 2013. There were two drips observed in the Dentistry Building, both of which were mechanical. In the Tupper Building, there were 11 observed dripping faucets. 7 of these drips were behavioral (64%), 3 were mechanical (27%), and 1 was unknown. The unknown dripping faucet is a kitchen faucet located in the basement of the Tupper Building – despite being publically accessible, researchers were asked to leave the area and were not able to determine the mechanism of the drip; however, the amount of water wasted (lpy) was recorded (1000 lpy).

Potential savings from water wastage

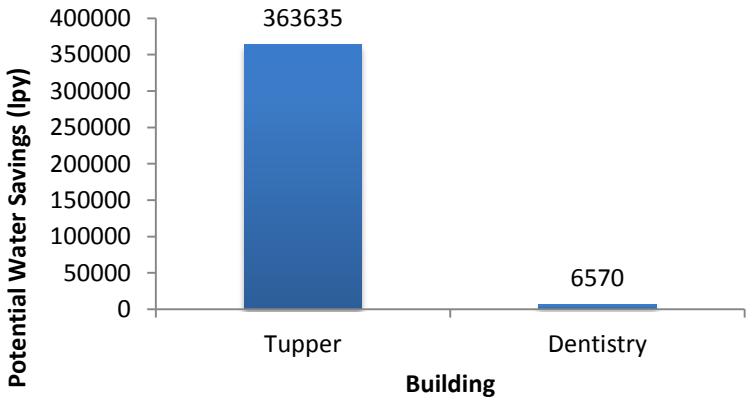

Figure 5. Potential water savings (lpy) from leaking faucets (mechanical, behavioural, and unknown) for the Tupper Building and Dentistry Building on Dalhousie University Carleton Campus, March 22, 2013.

For both the Tupper and Dentistry Buildings, there was a total of 370,205 lpy wasted water from dipping faucets. Using a cost of $0.509/meter^3 (HRM, 2013) this amounts to a potential savings of $188.43 per year. The majority of the wasted water was from the Tupper Building (98%), with 363,635 lpy wasted – this amounts to a potential savings of $185.09 per year. However, 59% of all the wasted water was from one washroom faucet left on in a men's washroom in the Tupper Building. The Dentistry Building only had two mechanical drips, amounting to 6,570 lpy, or $3.34 per year in potential savings.

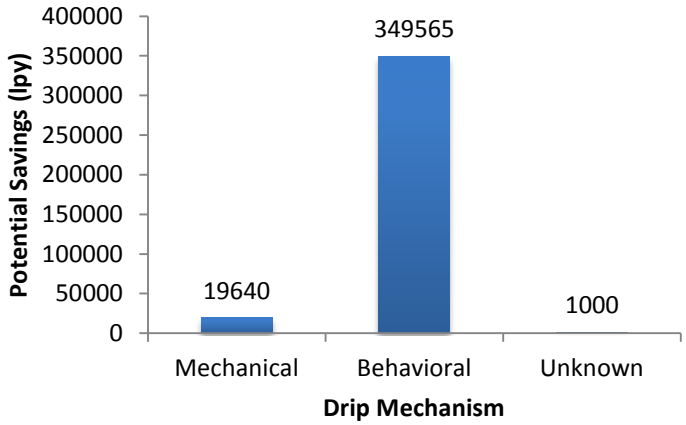

Figure 6. Potential water savings (lpy) from leaking faucets broken down by mechanism (mechanical, behavioural, or unknown) for the Tupper Building and Dentistry Building on Dalhousie University Carleton Campus.

The majority of the wasted water was from behavioral drips, with 349,565 lpy wasted (94%); this translate to $177.93 per year using a cost of $0.509/meter^3. Mechanical drips wasted 19,640 lpy (5%) or $10.00 per year, while 1% (1000 lpy, $0.51 /yr) of the waste was caused from an unknown dripping mechanism (the researchers were unable to determine the cause of the drip due to restrictions to the area).

There were only 2 dripping faucets in the Dentistry Building, both of which were mechanical. This amounts to 6,570 lpy of water wasted, or $3.34 per year potential savings. In the Tupper Building, 11 drips were observed. Behavioral drips in the Tupper account for the majority of all water wasted (94%); 349,565 lpy were wasted, a savings of $177.93 per year. Mechanical drips in the Tupper Building account for 13,070 lpy, or a savings of $6.65 per year. 1000 lpy of wasted water is from an unknown dripping mechanism in the basement kitchen in the Tupper Building, this amounts to $0.51 per year. All potential water savings are based on a cost of $0.509/meter^3 (HRM, 2013).

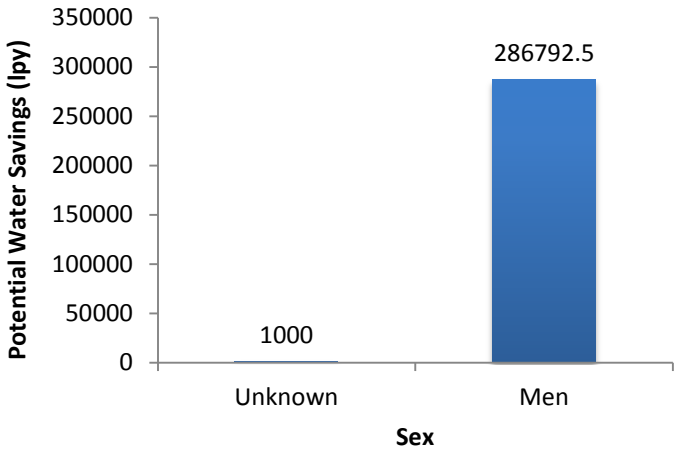

Figure 7. Potential water savings (lpy) from leaking faucets caused by a behavioural mechanism for men and women in the Tupper Building on Dalhousie University Carleton Campus.

Where data was available, behavioral drips were analyzed based on sex. No behavioural drips were recorded in the Dentistry Building. In the Tupper Building, 7 drips resulting from behavioural mechanism were observed for a total of 349,565 lpy. Of this, 286,792.5 lpy (82%) were associated with male behavior and only 62, 772.5 lpy (18%) for female behaviour. However, one faucet was left on near full flow rate in a men's washroom (219792.5 lpy), and accounts for 63% of all the water wasted through behavioral means.

Table 2. Potential savings ($/yr and lpy) from leaking faucets in the Tupper Building and Dentistry Building on Dalhousie University Carleton Campus, March 22, 2013. Data was collected on March 22, 2013.

Building	Total		Mechanical		Behavioural		Unknown	
	lpy	$/yr	lpy	$/yr	lpy	$/yr	lpy	$/yr
Tupper	363,635	$185.09	13,070	$6.65	349,565	$177.93	1000	$0.51
Dentistry	6,570	$3.34	6,570	$3.34	----	----	----	----
Both	370,205	$188.43	19,640	$10.00	349,565	$177.93	1000	$0.51

Table 2 summarizes the water wasted from the Tupper Building and Dentistry Building, as well as total amount wasted. It provides a breakdown of wasted water by building and by mechanism (mechanical, behavioral, unknown). The table also summarizes the potential savings from wasted water based on a cost of $0.509/meter^3.

3.2 Student Intercept Survey Results

Student Intercept Surveys were carried out on Friday March 29th 2013 between 12am-6pm at four different locations across the Dalhousie University Campus. The sampling locations were at the

entrance of the Killam Library and the Life Sciences Center (Studley Campus), the Dentistry building and the Tupper medical building (Carleton Campus).

Demographics

A total of 100 Dalhousie University students participated in the survey (n=100), with a distribution of 46 male and 54 female participants. The average age of all participants was found to be ~21 years, with the majority of students being in their third year of study (see Appendix X)

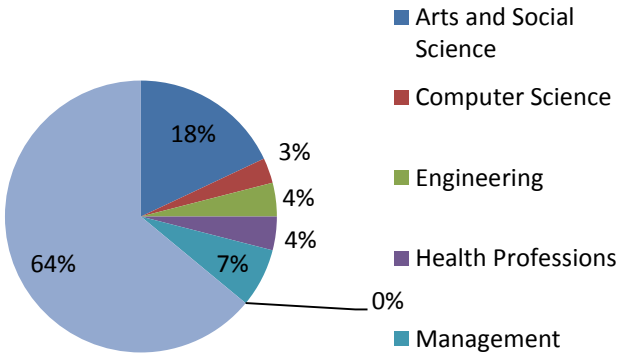

Figure 8: Student Intercept Survey participants breakdown by faculty with total of 100 participants (n=100). Faculties considered were: Arts and Social Science, Computer Science, Engineering, Health Professions, Management, Medicine and Dentistry, and Science.

The majority of students who participated in the survey belonged to the faculty of science (64/100), followed by Arts and Social Science (18/100) and Management (7/100). The remaining (11/100) was split among Engineering, Health professions and Computer Science. No participants from Medicine or Dentistry were recorded (see Figure 8).

Response to survey questions

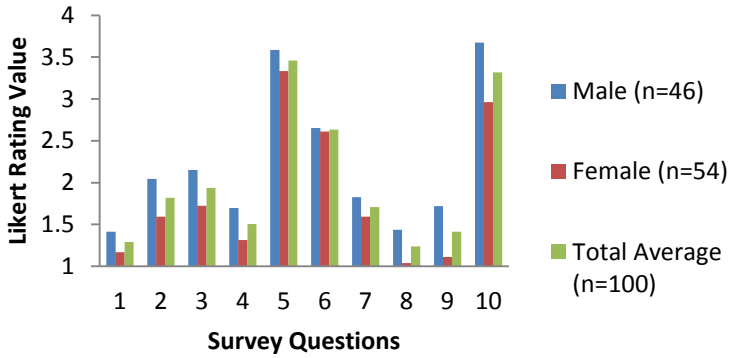

Figure 9: Bar graph displaying averaged student survey responses of males (n=46), females (n=54), and total average responses (n=100), for survey questions one to ten. Likert rating scale ranging from 1 (strongly agree) 2 (agree) 3 (neutral) 4 (disagree) 5 (strongly disagree).

As we can see in figure 9, students showed (on average) a strong degree of agreement with most survey questions, except questions 5 and 10. Females tended to rate questions more strongly compared to males (who rated questions more neutral). For List of Survey questions, see Appendix X.

Scope of Water Conservation Issue

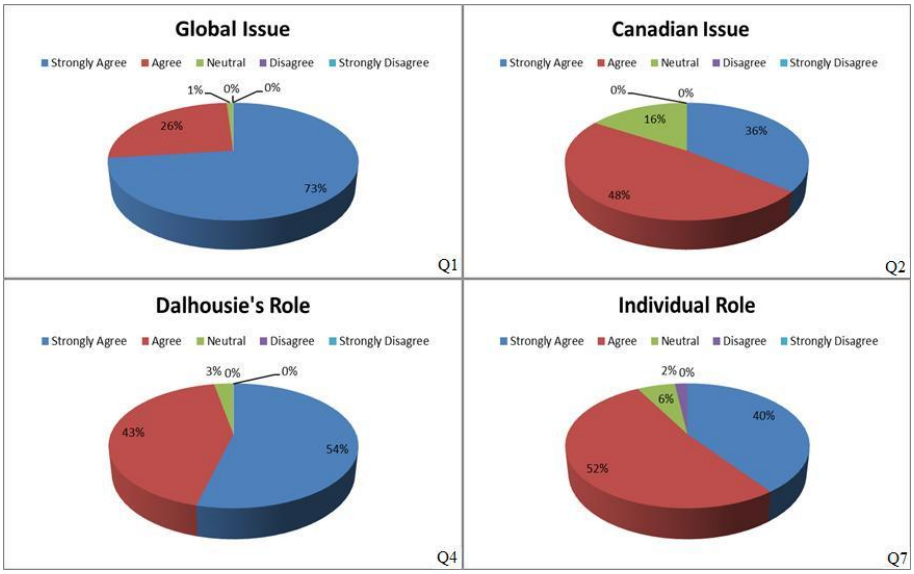

Figure 9: Student answers to survey questions one, two, four and 7, regarding the scope of water conservation issues. Scope broken down into four categories: Global (Q1), Canada (Q2), Dalhousie University (Q4), and Individual role (Q7). n=100 for each question.

The results regarding the scope of water conservation display, that 99% of respondents agree that water conservation is an important global issue (agree+strongly agree), 84% agree that it is an important Canadian Issue (agree+strongly agree), 97% agree that Dalhousie University can play a major role in water conservation (agree+strongly agree), and 92% agree that they, as individuals, can play a role in water conservation. None of the respondents rated questions lower than “neutral”, except 2% believed that they (as individuals) cannot play a role in water conservation.

Individual Perception

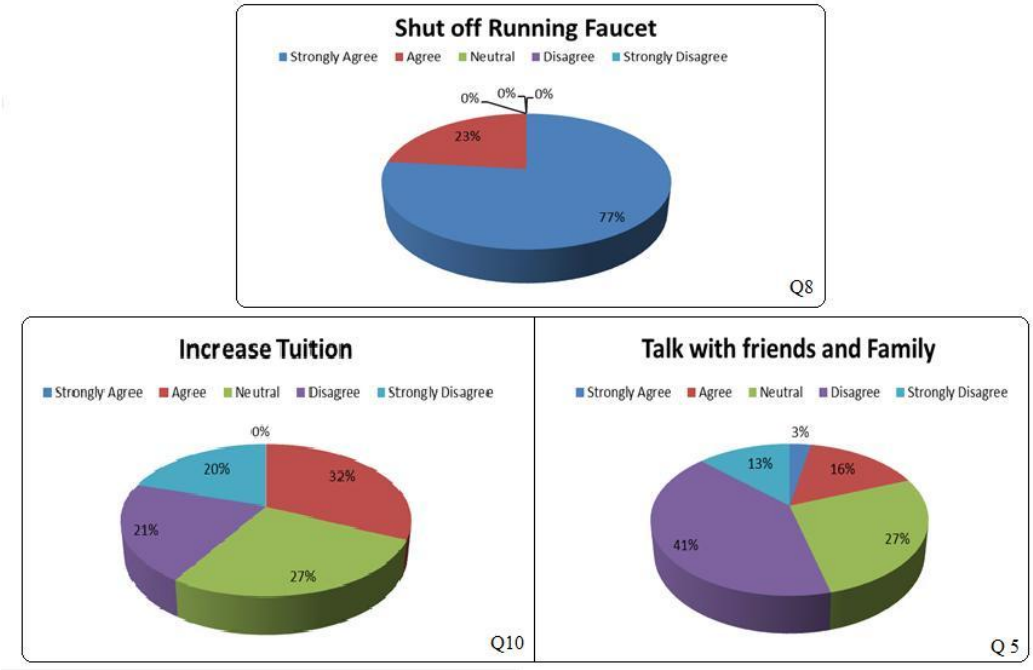

Figure 10: Student answers to survey questions five, eight, and ten, regarding their individual perception on water conservation. Looking at following factors: Whether a running faucet should be turned off (Q8), whether an increase in tuition would be acceptable to improve water conservation (Q10), and whether students talk about water conservation issues (Q5). n=100 for each question.

As figure 10 displays, all respondents declared that running faucets should be turned off (77% of them emphasized this strongly) (Q8). The question (Q10) whether or not students would support an increase in tuition to improve water conservation efforts on campus, resulted in the majority of responses to either neutral-agree-strongly agree, with 68%. No respondent replied with strongly agree. The question, whether students talk to their peers or family about water conservation (Q5), displayed that the majority of respondents do not talk to their friends about water conservation (54% disagree-strongly disagree) compared to only 19% talking about water conservation.

3.3 Interviews with Maintenance Staff

Interviews with maintenance staff were conducted on Monday April 1st 2013. A total of 2 individuals agreed to participate in our study, with 1 participant from the Dentistry building, and 1 participant from the Tupper Building.

Results from the Dentistry Building

The interviews conducted with the Dentistry maintenance staff expressed, that dripping of faucets is mainly due to mechanical flaws (rather than behavioral), due to age of infrastructure/equipment. It was stated, that faucets in non-public areas (cubicles in clinical areas of dentistry building) might be a major source of water wasted, due to constantly running faucets.

Results from the Tupper Building

The interviews conducted with the Tupper building maintenance staff expressed, that leaking faucets occur mainly in the custodian closets, due to age and mechanical problems. These seemed to be a major concern and requested to be upgraded. Additionally, most water is believed to be wasted in the labs (non-public areas), due to purposely leaving them running. Mechanical problems due to age of equipment and building were also a major concern.

4.0 Discussion

The purpose of conducting this study was to provide a preliminary baseline of water usage efficiencies/inefficiencies with regards to the public access faucets on the Carleton campus of Dalhousie University. As well as to determine how the general Dalhousie University population feels about water conservation.

After analyzing the results of the water audit conducted on the Carleton campus the significant findings were as follows; it was found that the vast majority (96%) of faucets were outfitted with an aerator to conserve water; however, only 38% of them had a readable flow rate. The incidence of leaking faucets was low, with the rate of occurrence being 13 out of 118 surveyed faucets (11%). Behavioral causes of leakage were slightly more frequent than mechanical causes (53% and 38%, respectively). It was determined that a total of 370,205 lpy of water is wasted from these leaks; this translates to a financial loss of $188.43 per year. Behavioral leaks were more significant than mechanical, with behavioral leaks making up 94% of all water wasted. It must be noted however that 59% of all water wasted was the result of a single behavioral leak, a faucet was left on at near full flow rate in a men's washroom in the Tupper Building.

The intercept survey portion of the study revealed that for questions 1, 2, 3, 4, 7, 8, and 9 the respondents (both males and females),on average, selected agree or strongly agree as their response. This indicates that the students sampled, representing the Dalhousie University student population, believe that water conservation is an important global issue as well as an important Canadian issue. Also that they would support strict government water conservation laws and feel that Universities should play a role in water conservation. Respondents also believe that they can play a role in water conservation, that a running/dripping faucet should be turned off, and that others should feel an obligation to shut off a running/dripping faucet on campus. Question 6 resulted in a response between agree and neutral (leaning slightly towards the neutral response) on average. This indicates that respondents had a more neutral attitude towards the proposal of a tax increase for funding water conservation efforts or research.

Questions 5 and 10 resulted in a response between neutral and disagree (leaning towards neutrality) on average. This indicates that the respondents were unlikely to discuss water conservation issues with friends and family and would be unsupportive of an increase in tuition for upgrades to water conservation efforts at Dalhousie University. For all questions the average male response had a higher Likert rating value (more negative) than the average female response.

The overwhelmingly positive responses to the intercept survey questions would indicate that the respondents are aware of the issue of water conservation and that their attitude towards acceptable behavior regarding the proper usage of faucets on campus (shutting off upon completion of use) would suggest minimal occurrence of behavioral leaks. This is supported by the water audit portion of the study as 7 of 118 faucets (just under 6%) were observed to have behavioral leaks.

The face to face maintenance staff interview portion of the study revealed that, in the maintenance staff members opinions, the loss of water from publically accessible faucets is insignificant in comparison to publically inaccessible faucets. Also a general concern about leaks due to the age of the building/faucets was voiced. A negative opinion was recorded regarding the implementation of automatic faucets with concern about sensor issues as well as increased labour due to the requirement of both a plumber and electrician if repair/service is required.

In comparison to similar audits conducted in the University setting, the results of this study indicate a considerably smaller loss of water. However it must be noted that this study has only taken two buildings and only publically accessible faucets into consideration, not the campus as a whole. A comprehensive water audit at a University in Cambridge Massachusetts, followed by campus wide retrofitting of water fixtures, resulted in annual savings of 120 million litres of water and $282, 000. (University: Water Savings Case Study, 2004). A comprehensive professional water audit of Dalhousie would be required to determine total potential annual savings.

5.0 Conclusion

Water conservation is important economically, socially and environmentally. As large institution consuming a significant amount of water, Dalhousie University has the responsibility to advance sustainable water conservation initiatives on campus. This study directly contributes to Dalhousie's goal to reduce their water consumption by auditing public leaking faucets on Carleton Campus and determining how much water was wasted and how Dalhousie's student body felt toward water conservation. The major finding of this study was that there was minimal loss of water due to public leaking faucets. Out of the observed leaking faucets the majority were caused by behavioral leaks in comparison to mechanical leaks. However, in comparison to the total number of faucets surveyed, the number of behavioral leaks is significantly low. This correlated to the positive findings of the student intercept survey where the majority of students strongly agreed that water conservation was an important issue both globally and in Canada. The most intriguing finding was that water loss from publically accessible faucets was insignificant compared to water loss form inaccessible faucets on Carleton camps as voiced by maintenance staff. Furthermore, it was found that the majority of faucets had sometime of aerator, however many of their serial numbers and flow rates where unreadable and the aerator themselves were generally out of date. This resulted in the inability to calculate total water usage on Carleton Campus.

The first recommended for the Office of Sustainability at Dalhousie University is to update all public faucets in the Dentistry building and the Tupper building with new low flow aerators. Low flow aerators reduce the flow of water from the faucet without reducing the pressure thus saving both water

and energy. Just by installing a low flow aerator on one faucet approximately 13000 gallons of water and 100 dollars a year can be saved (Macfaucets, 2008). With an institution the size of Dalhousie University, installing a low flow aerator on every faucet can have tremendous energy, money and water savings. The second recommendation is to in install automatic faucets within public bathrooms on Carleton Campus. This will save 70% of water that is flushed down the drain when using non-automatic faucets. However, it is recommended that the automatic faucets should not have sensors (Macfaucets, 2008). This will prevent increased energy cost and increased need for electrical staff as voiced by the Dalhousie maintenance staff.

The final recommendation is to conduct a comprehensive water audit on Carleton Campus that not only includes publicly accessible faucets but also private faucets and the potential influence of the age of the building on water wastage. As mentioned above maintenance staff explained that the majority of water wastage on Carleton Campus was happing behind closed doors, in private areas of the buildings. They also mentioned that the age of the buildings had a major influence on water wastage due to its out dated infrastructure and technology. Unfortunately due to time and consent limitations these important factors were not included in this study. Furthermore, inferential statistics were not conduced within this study due to time limitations. However, this is strongly recommended in coming studies to strengthen the reliability and validity of the study and to determine any significant trends in demographics.

6.0 Acknowledgments

The researchers would like to extend special thanks to Jennifer Organ, Tarah Wright, and Rochelle Owen for their continued assistance and guidance throughout the length of the project. We would also like to acknowledge the students who participated in the intercept survey – without them, any quantitative data would have been insignificant. Finally, we would like to thank the maintenance staff of Carleton Campus for their cooperation in the face-to-face interviews and for allowing us to survey the public faucets; in particular, we would like to thank Greg McNutt, the Building Services Manager for his enthusiasm and insight into water use and wastage on campus.

7.0 References

Boone, D. A., & Boone, H. N. (2012). Analyzing Likert Data. *Journal of Extension*, 50(2).

Chin, Raymond. (2006, May). GVRD Regional Utility Planning: Standardized ICI Water Audit Process Final Report, Stantec.

Creswell, J. W. (2008). *Research design: Qualitative, quantitative, and mixed methods approaches*. (3rd ed.). SAGE. Retrieved February 14, 2013, from http://books.google.ca/books?hl=en&lr=&id=bttwENORfhgC&oi=fnd&pg=PR1&dq=research project design&ots=CaHulQ0-Y8&sig=jEUA5p7Arv4CJl3wB9JyL5DFMp0.

Dalhousie University. (2013). *Halifax Campuses: A vibrant, collaborative community*. Retrieved February 20, 2013, from http://www.dal.ca/about/halifax-campuses.html

Dalhousie University Sustainability Plan. (2010, June). *Dalhousie University Office of Sustainability* . Retrieved February 13, 2013, from www.dal.ca/content/dam/dalhousie/pdf/sustainability/Dalhousie_University_Sustainability_Plan_June_2010%20(389%20KB).pdf

Environment: Air, Water and Land. (2005). *Organisation for Economic Co-operation and Development*. Retrieved February 14, 2013, from www.oecd.org/publications/factbook/34416097.pdf

Environment Canada. (2012). *Wise Water Use*. Retrieved February 20, 2013, from http://www.ec.gc.ca/eau-water/default.asp?lang=En&n=F25C70EC-1

European Commission. (2012, September 6). *How to prepare a communication plan?*. Retrieved February 20, 2013, from http://ec.europa.eu/ipg/go_live/promotion/communication_plan/index_en.htm

Facts and Trends: Water (2002). *World Business Council for Sustainable Development*. UN Water. Martin, R. (director). Retrieved February 18, 2013, from www.unwater.org/downloads/Water_facts_and_trends.pdf

HRM. (2013). Water, Wastewater/Stormwater Rates & Fees. Retrieved March 12, 2013 from http://www.halifax.ca/hrwc/RatesAndFees.html.

Kubba, S. (2010). Chapter 8 - water efficiency and sanitary waste. LEED practices, certification, and accreditation handbook (pp. 271-291). Boston: Butterworth-Heinemann. doi: 10.1016/B978-1-85617-691-0.00008-4

Lockie, S., Lawrence, G., Dale, A., & Taylor, B. (2002). 'Capacity for Change': Testing a Model for the Inclusion of Social Indicators in Australia's National Land and Water Resources Audit. *Journal Of Environmental Planning & Management*, 45(6), 813-826. doi:10.1080/0964056022000024352

MacDonald, Jill, Courtney Morrison, Cara Pembroke, Victoria Reed, Sonya Tancock. (2011, April 13). Cooler Than Tap Water: A Study of Water Coolers and Tap Water on Dalhousie University Campus. ENVS/SUST 3502, Final Report.

Macfaucets, A. (2008). Automatic faucets. Retrieved April 12 2012 from http://www.macfaucets.com/education.htm Automatic

Mayhall, R. (2008, May 26). *How to develop a communications plan*. Retrieved February 20, 2013, from http://www.hieran.com/comet/howto.html

Oki, T., & Kanae, S. (2006). Global Hydrological Cycles and World Water Resources. *Science*, *313*, 1068- 1072.

T., Payls., & C., Atchison. (2008). *Research Designs* (4th ed.). Toronto: Nelson.

Abeyasekera, S. Quantitative Analysis Approaches To Qualitative Data: Why, When And How. (2003).. University of Reading. Retrieved February 20, 2013, from http://www.reading.ac.uk/ssc/n/resources/Docs/Quantitative_analysis_approaches_to_qualitative_data.pdf

Reichardt, K. (2011). Forget taxes… it's water we need to audit. Sustainable Facility, 36(2), 24-27.

Richardson-Prager, L., Sturby, D., Shaffer, C., & McMaster, E. (2004, April 13). Dalplex Water Audit. *Dalhousie Department of Environmental Science*. Retrieved February 13, 2013, from environmental.science.dal.ca/Files/Environmental%20Programs/DalplexWaterAudit_-_final_copy1.pdf

Romero-Lankao, P., Borbor-Cordova, M., Abrutsky, R., Günther, G., Behrentz, E., & Dawidowsky, L. (2013). ADAPTE: A tale of diverse teams coming together to do issue-driven interdisciplinary research. *Environmental Science & Policy*, 2629-39. doi:10.1016/j.envsci.2011.12.003

Stanford University. (2011). *Water*. Retrieved February 21, 2013, from http://sustainablestanford.stanford.edu/water

Stanford University. (2003). *Water Conservation, Reuse and Recycling Master Plan Final*. Retrieved February 21, 2013, from http://lbre.stanford.edu/sem/sites/all/lbre-shared/files/docs_public/FINALStanfordConservation_Recommended_Plan10_16_033%5b1%5d.pdf

Simonovic, S. P. (2002). World water dynamics: global modeling of water resources. Journal of Environmental Management, 66(3), 249-267.

Sturman, J., Ho, G.E., and Mathew, K. (2004). Water Auditing and Water Conservation. Cornwall: IWA Publishing.

University of Maryland. (2012). *Water Conservation*. Retrieved February 20, 2013, from http://www.sustainability.umd.edu/content/campus/water.php

University: Water Savings Case Study. (2004). *Energy Vortex*. Retrieved February 22, 2013, from http://www.energyvortex.com/pages/headlinedetails.cfm?id=1089

Vectren Corporations. (2010). *Install low-flow faucet aerators and save $100 a year*. Retrieved February 17, 2013, from http://www.vectrenlivesmart.com/content/install-low-flow-faucet-aerators-and-save-100-a-year-060109.html

Vital Water Graphics. (2008). *United Nations Environment Programme (UNEP)*. Retrieved February 15, 2013, from http://www.unep.org/dewa/vitalwater/index.html

Water: Frequently Asked Questions. (2012, February 16). *Environment Canada*. Retrieved February 13, 2013, from https://www.ec.gc.ca/eau-water/default.asp?lang=En&n=1C100657-1#ws46B1DCC

Water News: water scarcity. (2013). *FAO: Food and Agriculture Organization of the United Nations*. Retrieved February 15, 2013, from http://www.fao.org/nr/water/issues/scarcity.htm

8.0 Appendices

8.1 Results Data

Water Drip Audit Sheet

Building Name: Dentistry
Date: March 22, 2013
Auditors Christoph Voegole, Allison Welk, Elliott Quider

Key- Code Faucet with B for bathroom, W for women, and M for men, K for kitchen, floor number (ex. BW1-1 would be womens bathroom on first floor first tap). If there is more than one BW1 provide more details in notes. Enter data in cells - 1 is yes, 0 is no except for actual amount from gauge in LPY; mechanical means there is a problem with the faucet (can't turn it off); behavioural is that it wasn't turned off

	Aerators												
Faucet	0.5 gpm (1.9 lpm)	1 gpm (3.8 lpm)	1.5 gpm (5.7 lpm)	2.2 gpm (8.36 lpm)	3.0 gpm (11.3 lpm)	aerator	Drip	mechanical	behavioura	LPY (rain gauge)	Notes	Aerator Serial #	Faucet Brand
BM1-1	0	0	0	0	0	1	0	0	0	0	Entrance	Unreadable/absent	Crane
BM1-2	0	0	0	0	0	1	0	0	0	0	Entrance	Unreadable/absent	Waltec
BM1-3	0	0	0	0	0	1	0	0	0	0	Entrance	Unreadable/absent	Crane
BW1-1	0	0	0	0	0	1	0	0	0	0	Entrance	Unreadable/absent	Crane
BW1-2	0	0	0	0	0	1	0	0	0	0	Entrance	Unreadable/absent	Crane
BW1-3	0	0	0	1	0	1	0	0	0	0	Entrance	A112181M	Delta
BU0-1	0	0	0	0	0	1	0	0	0	0	McLean Centre	Unreadable/absent	Crane
BU0-2	0	0	0	0	0	1	0	0	0	0	McLean Centre	Unreadable/absent	Crane
BU1-1	0	0	0	0	0	1	0	0	0	0	Near Clinic Entrance	Unreadable/absent	Crane
BU1-2	0	0	0	1	0	1	0	0	0	0	Near Clinic Entrance	A112181M	Crane
BM1-4	0	0	0	1	0	1	0	0	0	0	Near Stairs	Unreadable/absent	Waltec
BM1-5	0	0	0	1	0	1	0	0	0	0	Near Stairs	Unreadable/absent	Waltec
BM1-6	0	0	0	1	0	1	0	0	0	0	Near Stairs	Unreadable/absent	Waltec
BM1-7	0	0	0	0	0	1	0	0	0	0	2 gpm	Unreadable/absent	Waltec
BM0-2	0	0	0	0	0	1	0	0	0	0	2 gpm	A112181M	Crane
BM0-4	0	0	0	0	0	1	0	0	0	0	Basement	A112181M	Crane
BM0-3	0	0	0	0	0	1	0	0	0	0	Near Basement Stairs	Unreadable/absent	Crane
BM0-1	0	0	0	1	0	1	0	0	0	0	Dr. Mclean Centre	A112181M	Crane
BW0-1	0	0	0	1	0	1	0	0	0	0	Near Stairs	A112181M	Delta
BW0-2	0	0	0	0	0	1	0	0	0	0	Near Stairs	Unreadable/absent	Crane
BW0-3	0	0	0	0	0	1	0	0	0	0	Near Stairs	Unreadable/absent	Crane
BM2-1	0	0	0	0	0	1	0	0	0	0	Microbiology floor	Conserverator	Crane
BM2-2	0	0	0	0	0	0	0	0	0	0	Microbiology floor	No Aerator	Crane
BW2-1	0	0	0	0	0	1	0	0	0	0	Microbiology floor	Unreadable/absent	unreadable/absent
BW2-2	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**0**	**3285**	**Microbiology floor**	**No Aerator**	**Crane**
K2-1	0	0	0	0	0	0	0	0	0	0	Microbiology floor	No Aerator	unreadable/absent
BM3-1	0	0	0	0	0	0	0	0	0	0	Research lab floor	No Aerator	Crane
BM3-2	0	0	0	1	0	1	0	0	0	0	Research lab floor	A112181M	Delta
BW3-1	0	0	0	1	0	1	0	0	0	0	Research lab floor	A112181M	Delta
BW3-2	0	0	0	0	0	1	0	0	0	0	Research lab floor	Unreadable/absent	Crane
BM4-1	0	0	0	0	0	1	0	0	0	0	Top Floor	Unreadable/absent	Crane
BM4-2	0	0	0	0	0	1	0	0	0	0	Top Floor	Unreadable/absent	Crane
BM4-3	0	0	0	1	0	1	0	0	0	0	Top Floor	Masco	Delta
BW4-1	0	0	0	1	0	1	0	0	0	0	Top Floor	A112181M	Delta
BW4-2	0	0	0	1	0	1	0	0	0	0	Top Floor	A112181M	Crane
BW4-3	0	0	0	1	0	1	0	0	0	0	Top Floor	A112181M	Crane
K4-1	0	0	0	0	0	1	0	0	0	0	Top Floor	Unreadable/absent	Delta

Water Drip Audit Sheet

Building Name: Tupper Buil
Date: March 22, 2013
Auditors Paul Singh and Anthony Mallinson

Key- Code Faucet with B for bathroom, W for women, and M for men, K for kitchen, floor number (ex. BW1-1 would be womens bathroom on first floor first tap). If there is more than one BW1 provide more details in notes. Enter data in cells - 1 is yes, 0 is no except for actual amount from gauge in LPY; mechanical means there is a problem with the faucet (can't turn it off); behavioural is that it wasn't turned off

	Aerators													
Faucet	0.5 gpm (1.9 lpm)	1 gpm (3.8 lpm)	1.5 gpm (5.7 lpm)	2.2 gpm (8.36 lpm)	3.0 gpm (11.3 lpm)	aerator	Drip	mechanical	behavioural	LPY (rain gauge)	Notes		Aerator Serial Number	Faucet Brand Name and Model
BW15-1	0	0	0	0	0	1	0	0	0	0	0		0	Teck A112.18.1M
BW15-2	0	0	0	0	0	1	0	0	0	0	0		0	Teck A112.18.1M
BW14-1	0	0	0	0	0	1	0	0	0	0	0		0	Teck A112.18.1M
BW14-2	0	0	0	0	0	1	0	0	0	0	0		0	Teck A112.18.1M
BW13-1	0	0	0	0	0	1	0	0	0	0	0		0	Teck A112.18.1M
BW13-2	0	0	0	0	0	1	0	0	0	0	0		0	Teck A112.18.1M
BW12-1	0	0	0	0	0	1	**1**	**1**	**0**	**3285**	0		0	Teck A112.18.1M
BW12-2	0	0	0	0	0	1	0	0	0	0	0		0	Teck A112.18.1M
BW11-1	0	0	0	0	0	1	0	0	0	0	0		0	Teck A112.18.1M
BW11-2	0	0	0	0	0	1	0	0	0	0	0		0	Teck A112.18.1M
BW10-1	0	0	0	0	0	1	**1**	**0**	**1**	**50837.5**	0		0	Teck A112.18.1M
BW10-2	0	0	0	0	0	1	0	0	0	0	0		0	Teck A112.18.1M
BW9-1	0	0	0	0	0	1	**1**	**1**	**0**	**3285**	0		0	Teck A112.18.1M
BW9-2	0	0	0	0	0	1	0	0	0	0	0		0	Teck A112.18.1M
BW8-1	0	0	0	0	0	1	0	0	0	0	0		0	Teck A112.18.1M
BW8-2	0	0	0	0	0	1	0	0	0	0	0		0	Teck A112.18.1M
BW7-1	0	0	0	0	0	1	0	0	0	0	0		0	Teck A112.18.1M
BW7-2	0	0	0	0	0	1	**1**	**0**	**1**	**1650**	0		0	Teck A112.18.1M
BW6-1	0	0	0	0	0	1	0	0	0	0	0		0	Teck A112.18.1M
BW6-2	0	0	0	0	0	1	0	0	0	0	0		0	Teck A112.18.1M
BW5-1	0	0	0	0	0	1	0	0	0	0	0		Consarvation	Teck 12 Cambridge
BW5-2	0	0	0	0	0	1	0	0	0	0	0		Consarvation	Teck 12 Cambridge
BW4-1	0	0	0	0	0	1	0	0	0	0	0		Consarvation	Teck A112.18.1M
BW4-2	0	0	0	0	0	1	**1**	**0**	**1**	**7000**			Consarvation	Teck A112.18.1M
BW3-1	0	0	0	0	0	1	0	0	0	0	0		Consarvation	Teck A112.18.1M
BW3-2	0	0	0	0	0	1	**1**	**0**	**1**	**3285**	0		Consarvation	Teck A112.18.1M
BW2-1	0	0	0	0	0	0	0	0	0	0	0		0	No access to second floor facilities
BW2-2	0	0	0	0	0	0	0	0	0	0	0		0	No access to second floor facilities
BW1-1	**1**	0	0	0	0	**1**	0	0	0	0	0		MOSCO	Delta Automatic Faucets
BW1-2	**1**	0	0	0	0	**1**	0	0	0	0	0		MOSCO	Delta Automatic Faucets
BW1-3	**1**	0	0	0	0	**1**	0	0	0	0	0		MOSCO	Delta Automatic Faucets
BW1-4	**1**	0	0	0	0	**1**	0	0	0	0	0		MOSCO	Delta Automatic Faucets
BW1-5	**1**	0	0	0	0	**1**	0	0	0	0	0		MOSCO	Delta Automatic Faucets
BW0-1	0	0	0	0	0	1	0	0	0	0	2 gpm		0	Waltec A112.18.1M
BW0-2	0	0	0	0	0	1	0	0	0	0	2 gpm		0	Waltec A112.18.1M
BM15-1	0	0	0	0	0	1	0	0	0	0	0		0	ridge BRAS Teck A112.18.1M
BM15-2	0	0	0	0	0	1	0	0	0	0	0		0	ge BRAS CAS Teck 12 A112.18.1
BM14-1	0	0	0	0	0	1	0	0	0	0	0		0	ridge BRAS Teck A112.18.1M
BM14-2	0	0	0	0	0	1	0	0	0	0	0		0	ridge BRAS Teck A112.18.1M
BM13-1	0	0	0	0	0	1	0	0	0	0	0		0	ridge BRAS Teck A112.18.1M
BM13-2	0	0	0	0	0	1	0	0	0	0	0		0	ridge BRAS Teck A112.18.1M
BM12-1	0	0	0	0	0	1	0	0	0	0	0		0	ridge BRAS Teck A112.18.1M
BM12-2	0	0	0	0	0	1	0	0	0	0	0		0	ridge BRAS Teck A112.18.1M
BM11-1	0	0	0	0	0	1	0	0	0	0	0		0	ridge BRAS Teck A112.18.1M
BM11-2	0	0	0	0	0	1	0	0	0	0	0		0	ridge BRAS Teck A112.18.1M
BM10-1	0	0	0	0	0	1	**1**	**0**	**1**	**219792.5**	0		0	ridge BRAS Teck A112.18.1M
BM10-2	0	0	0	0	0	1	0	0	0	0	0		0	ridge BRAS Teck A112.18.1M
BM9-1	0	0	0	0	0	1	0	0	0	0	0		0	ridge BRAS Teck A112.18.1M
BM9-2	0	0	0	0	0	1	0	0	0	0	0		0	ridge BRAS Teck A112.18.1M
BM8-1	0	0	0	0	0	1	0	0	0	0	0		0	ridge BRAS Teck A112.18.1M
BM8-2	0	0	0	0	0	1	0	0	0	0	0		0	ridge BRAS Teck A112.18.1M
BM7-1	0	0	0	0	0	1	0	0	0	0	0		0	ridge BRAS Teck A112.18.1M
BM7-2	0	0	0	0	0	1	0	0	0	0	0		0	ridge BRAS Teck A112.18.1M
BM6-1	0	0	0	0	0	1	**1**	0	**1**	**20000**	0		0	ridge BRAS Teck A112.18.1M
BM6-2	0	0	0	0	0	1	0	0	0	0	0		0	ridge BRAS Teck A112.18.1M
BM5-1	0	0	0	**1**	0	1	0	0	0	0	0		Consarvation	WALTEC A112.18.1M
BM5-2	0	0	0	**1**	0	1	0	0	0	0	0		Consarvation	WALTEC A112.18.1M
BM4-1	0	0	0	0	0	1	0	0	0	0	0		Consarvation	ridge BRAS Teck A112.18.1M
BM4-2	0	0	0	0	0	1	0	0	0	0			Consarvation	ridge BRAS Teck A112.18.1M
BM3-1	0	0	0	0	0	1	0	0	0	0	0		Consarvation	ridge BRAS Teck A112.18.1M
BM3-2	0	0	0	0	0	1	0	0	0	0	0		Consarvation	ridge BRAS Teck A112.18.1M
BM2-1	0	0	0	0	0	0	0	0	0	0	0		0	No access to second floor facilities
BM2-2	0	0	0	0	0	0	0	0	0	0	0		0	No access to second floor facilities
BM1-1	0	1	0	0	0	1	0	0	0	0	0		MOSCO	Delta Automatic Faucet w/ MASCO aerator A112.18.1M
BM1-2	**1**	0	0	0	0	1	0	0	0	0	0		MOSCO	Delta Automatic Faucet w/ MASCO aerator A112.18.1M
BM1-3	0	**1**	0	0	0	1	0	0	0	0	0		MOSCO	Delta Automatic Faucet w/ MASCO aerator A112.18.1M
BM0-1	0	0	0	1	0	1	**1**	0	**1**	**47000**	0		0	cet w/ MASCO aerator A112.18
BM0-2	0	0	**1**	0	0	1	**1**	**1**	0	**6500**	0		0	cet w/ MASCO aerator A112.18
K1-1	0	0	0	0	0	0	0	0	0	0	**sed (but no aerator)**		**no aerator**	**elta faucet w/ no aerator**
K0-1	0	0	0	0	0	1	**1**	**unknown**	**unknown**	**1000**	**e sink being in an unrestricte**		0	unknown

Rating Scale	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree									
Value	1	2	3	4	5									
Male Participant #:	Program	Year of Study	Location	Age	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
1	Journalism	3	Halifax	21	1	1	3	1	4	2	2	2	2	4
2	Management	3	Ontario	22	2	2	3	2	4	5	3	2	3	4
3	Engineering	1	Lebanon	19	1	2	4	2	4	4	2	2	2	4
4	Marine-Bio	3	Sasketchewan	21	1	1	1	2	3	2	1	1	1	3
5	Math	4	Halifax	25	2	3	2	1	4	3	1	1	1	5
6	Science	1	New Foundland	23	2	3	2	2	4	3	2	2	2	3
7	Physics	2	Halifax	21	1	3	2	2	4	4	1	1	2	4
8	Art	2	Halifax	20	2	3	4	1	5	4	2	2	3	4
9	Management	3	Ottawa	22	1	2	3	1	4	3	2	1	2	5
10	Law	2	Halifax	21	1	2	2	1	4	3	1	1	2	4
11	Computer Science	2	Iran	23	2	3	3	2	4	4	2	2	3	4
12	Environmental Science	3	Ottawa	26	1	1	1	1	4	1	1	1	1	2
13	Biology	2	British Columbia	20	1	2	1	1	1	2	1	1	2	2
14	Biology	4	Caribbean	24	1	2	2	1	3	3	4	1	1	5
15	Biochemistry	3	Ontario	20	2	3	2	2	4	2	2	2	2	4
16	Neuroscience	4	Ontario	22	1	2	2	1	3	3	2	2	2	4
17	Kinesiology	3	Ontario	21	1	2	1	3	3	2	1		3	2
18	Contemporary Studies/Classics	4	Ontario	24	1	2	1	3	4	2	1	1	1	2
19	IDS/Sustainability	3	Ontario	21	1	1	1	1	3	2	1	2	2	3
20	Commerce	3	Ontario	21	1	2	2	2	3	1	3	2	2	3
21	Pyschology	2	Niagra Falls, Ontario	22	1	3	3	2	5	4	2	1	1	3
22	Chemistry	3	Nova Scotia	20	2	2	2	2	3	4	2	1	1	4
23	Biochemistry	3	Nova Scotia	21	1	3	4	1	3	4	1	1	1	5
24	English	2	Ontario	20	1	2	1	1	3	2	2	1	1	3
25	Biochemistry	2	New Brunswick	20	1	2	2	1	4	3	2	1	1	3
26	Marine Biology	2	Ontario	20	1	2	1	1	2	1	1	1	1	2
27	Bio	2	ON	21	2	2	2	2	4	2	2	2	1	4
28	Chem	3	NS	22	1	2	2	2	3	2	1	1	1	3
29	Comp Sci	4	ON	23	1	3	4	2	4	4	2	2	3	5
30	B.A.	2	NS	20	2	2	2	2	4	2	2	1	1	3
31	Math	4	NS	24	2	2	3	2	3	3	2	1	1	2
32	Science	1	NL	19	1	2	2	1	4	2	1	1	1	2
33	Econ	2	NS	20	1	1	2	2	4	2	2	1	1	3
34	Management	3	ON	21	2	2	2	2	4	2	2	2	2	5
35	Bio	3	BC	22	1	2	2	2	4	2	2	2	1	4
36	Science	2	ON	19	1	1	2	1	2	2	1	1	1	3
37	English	3	NS	21	1	2	4	2	5	4	2	2	2	5
38	Math	4	ON	23	2	2	3	2	5	2	2	2	2	4
39	Commerce	3	Toronto	21	2	3	2	2	4	3	2	2	5	5
40	Economics	4	NS	22	1	1	2	1	3	2	1	1	1	3
41	Art	1	Barrie	18	2	2	2	3	2	2	1	2	1	5
42	Art	1	Vancover	18	2	2	2	2	2	2	2	2	2	5
43	Engineer	1	Brazil	21	2	1	1	2	3	2	3	1	2	5
44	Science	1	ON	18	2	2	1	2	3	2	2	2	3	5
45	Computer Science	2	Halifax	23	3	3	2	2	5	5	4	1	1	5
46	Community Design	1	Halifax	19	1	1	2	2	5	2	3	2	2	2
Mean (male):		2,52173913		21,19565217	1,413043478	2,043478	2,15217391	1,695652	3,586957	2,652174	1,826087	1,434783	1,717391	3,673913
Total Mean:		2,69605475		20,98671498	1,289855072	1,818035	1,93719807	1,505233	3,460145	2,631643	1,70934	1,23591	1,414251	3,318438
					Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Mode:					1	2	2	1	4	2	2	1	1	2

Arts and Social Science	Computer Science	Engineering	Health Professions	Management	Medicine & Dentistry	Science
18	3	4	4	7	0	64

Female Participant #:	Program	Year of Study	Location	Age	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
1	Art	4	Ontario	22	1	1	3	1	4	3	1	1	1	5
2	Marine-Bio	3	Yukon	20	2	2	2	2	4	3	2	1	1	2
3	Engineering	4	Ontario	21	1	1	2	1	3	4	1	1	1	4
4	Science	1	Calgary	18	1	2	2	1	3	2	2	1	1	2
5	Kinesiology	1	Halifax	21	1	1	1	1	3	2	1	1	1	2
6	Science	4	Ottawa	23	1	1	2	2	5	2	2	1	1	3
7	Environmental Science	3	Halifax	26	1	2	2	1	2	3	1	1	1	4
8	Biology	3	Ottawa	22	2	3	3	2	4	4	2	2	3	5
9	Environmental Science	3	Ontario	20	1	2	4	1	1	4	1	1	1	5
10	Oceanography	5	Montreal	23	2	2	2	1	4	3	1	1	1	2
11	Geology	1	Ontario	19	1	2	2	1	4	4	1	1	1	4
12	Engineering	3	Ontario	22	1	3	3	1	4	4	2	1	1	5
13	Biology	2	Halifax	20	1	1	2	1	3	2	1	1	1	2
14	Neuroscience	3	Ontario	21	2	3	2	2	3	3	2	1	1	2
15	Neuroscience	3	Ontario	21	2	2	2	2	4	3	2	1	1	3
16	IDS	4	British Columbia	22	1	2	2	1	1	3	2	2	2	5
17	History	3	Ontario	21	2	2	1	1	3	2	2	1	3	2
18	Journalism	2	New Brunswick	20	1	1	1	2	4	4	1	1	1	4
19	Pyschology	3	Ontario	21	1	2	2	2	4	3	2	1	1	4
20	Biology	4	New Brunswick	22	1	2	3	2	4	3	2	1	1	4
21	Earth Science	3	Ontario	20	1	2	2	2	4	2	2	1	2	2
22	Neuroscience	2	Nova Scotia	19	1	2	2	1	2	3	2	1	1	3
23	IDS	3	Ontario	22	1	1	1	1	3	2	2	1	1	3
24	Neuroscience	3	British Columbia	21	2	2	2	1	3	2	2	1	1	2
25	Marine Bio	1	ON	18	1	1	1	1	2	3	1	1	1	2
26	Kinesiology	3	ON	20	2	2	2	2	5	2	2	1	1	2
27	Bio	3	NS	20	1	1	1	1	2	3	1	1	1	2
28	Science	4	QC	22	1	1	1	1	2	2	1	1	1	2
29	Management	2	BC	20	1	2	1	1	2	1	1	1	1	2
30	Bio	1	AB	18	1	1	2	2	3	4	2	1	1	2
31	Marine Bio	1	ON	18	1	1	1	1	4	1	1	1	1	2
32	B.A.	3	NS	23	1	2	1	1	2	3	1	1	1	3
33	Geology	4	ON	22	1	1	1	1	2	2	2	1	1	2
34	Bio	4	NS	23	2	2	3	2	2	4	2	1	1	3
35	Science	2	QC	21	1	1	2	2	4	2	2	1	1	3
36	Environmental Science	3	ON	21	1	2	2	1	4	3	2	1	1	3
37	Sustainability	2	NS	20	1	1	1	1	3	2	1	1	1	2
38	Marine-Bio	4	BC	23	1	1	1	2	4	2	2	1	1	3
39	Marine-Bio	3	SK	20	1	1	1	1	3	1	1	1	1	2
40	Environmental Science	3	Ottawa	21	1	1	2	1	4	2	1	1	1	4
41	Sust	4	Calgary	23	1	1	1	1	2	1	1	1	1	3
42	Biology/Sust	3	Halifax	20	1	3	3	1	4	5	1	1	1	2
43	Environmental Science	4	NS	21	1	1	1	2	2	3	2	1	1	2
44	BA	2	NS	30	1	1	1	1	5	2	2	1	1	4
45	Master in Enviromental Science	1	Montreal	24	1	1	1	1	5	2	2	1	1	2
46	French	4	NS	21	1	2	1	1	4	1	1	1	1	5
47	Sicence	1	ON		1	2	2	2	5	2	3	1	1	3
48	Biology	4	Halifax	21	1	3	1	1	4	3	1	1	1	5
49	Sicence	4	ON	21	1	1	2	2	5	3	3	1	1	3
50	Environmental Science	2	Montreal	20	1	1	2	1	2	3	1	1	1	3
51	Kinesology	3	Ottawa	22	1	1	2	1	3	2	2	1	1	3
52	Marine-Bio	3	ON	21	1	1	1	1	4	2	2	1	1	2
53	Management	4	Vancover	20	1	2	1	1	5	3	2	1	1	3
54	English	3	AB	21	1	1	1	1	3	2	1	1	1	2
Mean (female):		2,87037037		20,77778	1,166667	1,592593	1,722222	1,314815	3,333333	2,611111	1,592593	1,037037	1,111111	2,962963

Survey	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	

Participant											
1	1	1	3	1	4	2	2	2	2	4	
2	2	2	3	2	4	5	3	2	3	4	
3	1	2	4	2	4	4	2	2	2	4	
4	1	1	1	2	3	2	1	1	1	3	
5	2	3	2	1	4	3	1	1	1	5	
6	2	3	2	2	4	3	2	2	2	3	
7	1	3	2	2	4	4	1	1	2	4	
8	2	3	4	1	5	4	2	2	3	4	
9	1	2	3	1	4	3	2	1	2	5	
10	1	2	2	1	4	3	1	1	2	4	
11	2	3	3	2	4	4	2	2	3	4	
12	1	1	1	1	4	1	1	1	1	2	
13	1	2	1	1	1	2	1	1	2	2	
14	1	2	2	1	3	3	4	1	1	5	
15	2	3	2	2	4	2	2	2	2	4	
16	1	2	2	1	3	3	2	2	2	4	
17	1	2	1	3	3	2	1		3	2	
18	1	2	1	3	4	2	1	1	1	2	
19	1	1	1	1	3	2	1	2	2	3	
20	1	2	2	2	3	1	3	2	2	3	
21	1	3	3	2	5	4	2	1	1	3	
22	2	2	2	2	3	4	2	1	1	4	
23	1	3	4	1	3	4	1	1	1	5	
24	1	2	1	1	3	2	2	1	1	3	
25	1	2	2	1	4	3	2	1	1	3	
26	1	2	1	1	2	1	1	1	1	2	
27	2	2	2	2	4	2	2	2	1	4	
28	1	2	2	2	3	2	1	1	1	3	
29	1	3	4	2	4	4	2	2	3	5	
30	2	2	2	2	4	2	2	1	1	3	
31	2	2	3	2	3	3	2	1	1	2	
32	1	2	2	1	4	2	1	1	1	2	
33	1	1	2	2	4	2	2	1	1	3	
34	2	2	2	2	4	2	2	2	2	5	
35	1	2	2	2	4	2	2	2	1	4	
36	1	1	2	1	2	2	1	1	1	3	
37	1	2	4	2	5	4	2	2	2	5	
38	2	2	3	2	5	2	2	2	2	4	
39	2	3	2	2	4	3	2	2	5	5	
40	1	1	2	1	3	2	1	1	1	3	

41	2	2	2	3	2	2	1	2	1	5	
42	2	2	2	2	2	2	2	2	2	5	
43	2	1	1	2	3	2	3	1	2	5	
44	2	2	1	2	3	2	2	2	3	5	
45	3	3	2	2	5	5	4	1	1	5	
46	1	1	2	2	5	2	3	2	2	2	
47	1	1	3	1	4	3	1	1	1	5	
48	2	2	2	2	4	3	2	1	1	2	
49	1	1	2	1	3	4	1	1	1	4	
50	1	2	2	1	3	2	2	1	1	2	
51	1	1	1	1	3	2	1	1	1	2	
52	1	1	2	2	5	2	2	1	1	3	
53	1	2	2	1	2	3	1	1	1	4	
54	2	3	3	2	4	4	2	2	3	5	
55	1	2	4	1	1	4	1	1	1	5	
56	2	2	2	1	4	3	1	1	1	2	
57	1	2	2	1	4	4	1	1	1	4	
58	1	3	3	1	4	4	2	1	1	5	
59	1	1	2	1	3	2	1	1	1	2	
60	2	3	2	2	3	3	2	1	1	2	
61	2	2	2	2	4	3	2	1	1	3	
62	1	2	2	1	1	3	2	2	2	5	
63	2	2	1	1	3	2	2	1	3	2	
64	1	1	1	2	4	4	1	1	1	4	
65	1	2	2	2	4	3	2	1	1	4	
66	1	2	3	2	4	3	2	1	1	4	
67	1	2	2	2	4	2	2	1	2	2	
68	1	2	2	1	2	3	2	1	1	3	
69	1	1	1	1	3	2	2	1	1	3	
70	2	2	2	1	3	2	2	1	1	2	
71	1	1	1	1	2	3	1	1	1	2	
72	2	2	2	2	5	2	2	1	1	2	
73	1	1	1	1	2	3	1	1	1	2	
74	1	1	1	1	2	2	1	1	1	2	
75	1	2	1	1	2	1	1	1	1	2	
76	1	1	2	2	3	4	2	1	1	2	
77	1	1	1	1	4	1	1	1	1	2	
78	1	2	1	1	2	3	1	1	1	3	
79	1	1	1	1	2	2	2	1	1	2	
80	2	2	3	2	2	4	2	1	1	3	
81	1	1	2	2	4	2	2	1	1	3	

82	1	2	2	1	4	3	2	1	1	3	
83	1	1	1	1	3	2	1	1	1	2	
84	1	1	1	2	4	2	2	1	1	3	
85	1	1	1	1	3	1	1	1	1	2	
86	1	1	2	1	4	2	1	1	1	4	
87	1	1	1	1	2	1	1	1	1	3	
88	1	3	3	1	4	5	1	1	1	2	
89	1	1	1	2	2	3	2	1	1	2	
90	1	1	1	1	5	2	2	1	1	4	
91	1	1	1	1	5	2	2	1	1	2	
92	1	2	1	1	4	1	1	1	1	5	
93	1	2	2	2	5	2	3	1	1	3	
94	1	3	1	1	4	3	1	1	1	5	
95	1	1	2	2	5	3	3	1	1	3	
96	1	1	2	1	2	3	1	1	1	3	
97	1	1	2	1	3	2	2	1	1	3	
98	1	1	1	1	4	2	2	1	1	2	
99	1	2	1	1	5	3	2	1	1	3	
100	1	1	1	1	3	2	1	1	1	2	
Mean:	1,28	1,8	1,92	1,49	3,45	2,63	1,7	1,22	1,39	3,29	
Mode:	1	2	2	1	4	2	2	1	1	2	
Frequency (mode):	73	48	48	54	41	44	52	76	72	32	
Strongly Agree	73	36	33	54	3	8	40	76	72	0	**Frequency (1):**
Agree	26	48	48	43	16	44	52	23	19	32	**Frequency (2):**
Neutral	1	16	13	3	27	28	6	0	8	27	**Frequency (3):**
Disagree	0	0	6	0	41	17	2	0	0	21	**Frequency (4):**
Strongly Disagree	0	0	0	0	13	3	0	0	1	20	**Frequency (5):**

Detailed Table of Maintenance Staff Interviews

Question	Responses from Tupper	Responses from Dentistry

	Building Staff	Building Staff
Do you know approx. how many people use the bathrooms?*	No, but you could assume that the capacity of the building uses the bathroom at least once in a day.	No, but you could assume that the capacity of the building uses the bathroom at least once in a day.
Do people ever leave the faucets running?	Yes, in the custodian closets; we have asked the administration to upgrade them because they are very old and leak a lot.	No, faucets leak once in a while but this is due to the age of the infrastructure. Toilets leak often
Have you ever seen a leaky faucet?	Yes, water in constantly running in the red labs; there are 105 labs that run each week, and 5 gallons of water is used for each lab; sometimes this number doubles.	Very rarely
Are there any mechanical problems with any of the faucets?	Yes, the infrastructure is worn out as the building was built in 1967.	Yes, the building requires constant upgrades; to replace a single item throughout the building is expensive
Can you recommend anything that you think would help to reduce the amount of water used on Carleton campus?	Yes, need to service requests from custodians.	Yes, reuse water through the construction of cisterns as has been done in the Mona Cambell building. Use water more efficiently throughout the building.
Have you ever seen the automatic faucets? If yes, do you think they should be installed across Carleton campus? If yes or no, why or why not?	Yes, they do not provide enough water and there are sensor issues	Yes, they do not use as much water but they have many more issue than standard taps as they require an electrical and a plumbing connection. If an issue does occur it takes more labor and time as a plumber and electrician is required sometimes to perform the repair and upgrade to these faucets.

Are there any consistent or unusual problems with students and the bathrooms such as: leaving on faucets, using excessive water, or maybe abusing the washroom in any other way?, if so how often does it occur?	Yes, one issue is the ergonomics of the bathroom; the sinks and the paper towel dispenser are too far away from each other and this causes a lot of water mess on the counters and the floor; and this causes more water wastage. Self-flushing toilets waste a lot of water. Carleton campus students are very good, no issues.	No, but the faucets in non-public areas waste a lot of water; cubicles in the clinical area in the dentistry building are constantly running as they do not shut off.

*Greg McNutt; the Tupper buildings services manager explained that several years ago (approximately 10), a foot traffic assessment was performed on the Tupper building; the analysis showed that more 8000 people go in and out of the building in a single day.

8.2 Recruitment Script for Student Intercept Survey

Hello,

My name _____ and I am an undergraduate student at Dalhousie University in the environmental science program. Under the direction of Dr. Tarah Wright my classmates and I are investigating several issues with respect to Dalhousie campus as a living laboratory of examples of current issues relating to sustainability and the environment.

I am studying the issue of water wastage on Carleton campus and my research aims to evaluate how students feel about water conservation, roughly gauge the amount of water wasted and hopefully uncover any potential savings.

I feel your input is really valuable and necessary for the success of this project. I was wondering if you would like to participate in a quick survey and help to contribute to our study.

(IF YES, start with the qualifying questions, if they qualify then begin the survey; IF they don't qualify be courteous and explain to them that they don't qualify because of…. and find the next participant)

(IF NO, be courteous and thank them for their time)

8.3 Consent Form for Face to Face Interviews with Maintenance Staff

Carleton Water Audit Consent Form

Introduction

My name is (student researcher) (Allison Welk, Anthony Mallinson, Elliott Quidder, Christoph Voegele, Paul Singh) and I am a student here at Dalhousie University. I'm currently enrolled in ENVS 3502 "The Campus as a Living Laboratory" instructed by Dr. Tarah Wright (Tarah.wright@dal.ca). An element of this class requires us to complete a research project that focuses on increased sustainability or environmental awareness on campus.

Purpose

For our research project we will be conducting a water audit to determine the amount of water being wasted through dripping faucets, due to mechanical error, on the Carleton campus specifically looking at the Dentistry and Tupper buildings.

Study Procedures

I would like to ask you some questions about any potential technical problems related to the buildings and their facilities as well as water conservation on Carleton Campus. I expect to need approximately 10 to 25 minutes of your time. If you agree to participate, the information you give me will be used anonymously in our final report which will be published and put on the environmental science website.

Confidentiality

All documents from the interview will be identified by code number and stored electronically – paper-copies will be kept until the completion of the project (April 12th, 2013) in a secure location. Any details which might identify you will not be shared within the report, with the class, or to any other individuals. You should feel free not to provide any information you do not wish to share with me or to end the interview at any time. If you wish to end the interview early, any information you have provided up to that point will be included in the study data unless you ask specifically not to include it.

Consent

Your participation in this study is entirely voluntary and you may refuse to participate or withdraw from the study at any time. Do you have any questions about the purpose of the study or the process? Is there anything else you would like me to clarify? If you have any concerns about your treatment or rights as a research participant, you can contact Dr. Tarah Wright at Tarah.wright@dal.ca.

Your signature indicates that you consent to participate in this study.

_____

Subject Signature Date

8.4 Face to face interview questions

1) Do you know approximately how many people use the bathrooms here each day?
2) Have you ever seen a leaky faucet? If yes, then how often and where?
3) Do people ever leave the faucets running?
4) Are there any mechanical problems (major or minor) with any of the faucets in public areas (explain what we mean by public) in the Tupper/Dentistry buildings?
5) Can you recommend anything that you think would help to reduce the amount of water used on Carleton campus (Tupper/Dentistry buildings)?
6) Have you ever seen the automatic faucets? If yes, do you think they should be installed on the Carleton campus? if yes or no, why or why not?
7) Are there any consistent or unusual problems with students and the bathrooms such as leaving the faucets on, using excessive water, spilling excessive water or abusing the washrooms in any other way?, if so how often does it occur?.

8.5 Intercept Survey Questions for Dalhousie Students:

Qualifying Question

1st - Are you a Dalhousie student?

- If yes conduct interview, if no find next participant.
- Ask if they would like to participate in our survey.
- If yes conduct interview, if no find next participant.

Additional Questions after Participant has Agreed to the Survey

2nd - What program are you in?

3rd - What year of study are you in?

4th – Where are you from?

Note – the last question asks the participants age and should be posed after the primary questions are posed

Primary Questions

1) Do you feel that water conservation is an important global issue?

Strongly Agree **Agree** **Neutral** **Disagree** **Strongly Disagree**

2) Do you think water conservation is an important issue in Canada?

Strongly Agree **Agree** **Neutral** **Disagree** **Strongly Disagree**

3) Do you feel it is important enough that the government make strict laws to support water conservation?

Strongly Agree **Agree** **Neutral** **Disagree** **Strongly Disagree**

4) Do you feel that Universities should play a role in water conservation?

Strongly Agree **Agree** **Neutral** **Disagree** **Strongly Disagree**

5) Do you feel that your circle of friends and family talk about water conservation issues?

Strongly Agree **Agree** **Neutral** **Disagree** **Strongly Disagree**

6) Do you feel that the issue of water conservation is important enough to raise taxes to increase the funding for water conservation efforts or research?

Strongly Agree **Agree** **Neutral** **Disagree** **Strongly Disagree**

7) Do you think you can play a role in water conservation?

Strongly Agree **Agree** **Neutral** **Disagree** **Strongly Disagree**

8) Do you think a running/dripping faucet should be shut off?

Strongly Agree **Agree** **Neutral** **Disagree** **Strongly Disagree**

9) Do you think others should feel an obligation to shut off running or dripping faucets on campus?

Strongly Agree **Agree** **Neutral** **Disagree** **Strongly Disagree**

10) Do you feel that a very small increase in tuition would be warranted to support upgrades to water conservation efforts at Dalhousie University?

Strongly Agree **Agree** **Neutral** **Disagree** **Strongly Disagree**

5th – May I ask how old are you?

*****Record whether the participant is male or female.

8.6 Ethics Form

ENVIRONMENTAL SCIENCE PROGRAM

FACULTY OF SCIENCE

DALHOUSIE UNIVERSITY

(Version 2010)

APPLICATION FOR ETHICS REVIEW OF RESEARCH INVOLVING HUMAN PARTICIPANTS

UNDERGRADUATE THESES AND IN NON-THESIS COURSE PROJECTS

GENERAL INFORMATION

1. Title of Project: Carleton campus water audit

2. Faculty Supervisor(s) Shannon Sterling **Department** Shannon Sterling **e-mail:** shannon.sterling@dal.ca **ph:** 902-494-7741

3. Student Investigator(s) Elliott Quider, Allison Welk, Christoph Voegele, Anthony Mallinson, Paul Singh **Department** Environmental Science **e-mail:** elliott.quider@gmail.com, al839928@dal.ca, ch914460@dal.ca, an503801@dal.ca **ph:** 905-577-3833

4. Level of Project: Non-thesis Course Project [X] Undergraduate [X] Graduate [ ]

Specify course and number: 3502 ENVS/SUST Campus as a Living Lab

5. a. Indicate the anticipated commencement date for this project: March 20th 2013

b. Indicate the anticipated completion date for this project: April 12th 2013

SUMMARY OF PROPOSED RESEARCH

1. Purpose and Rationale for Proposed Research: *Briefly describe the purpose (objectives) and rationale of the proposed project and include any hypothesis(s)/research questions to be investigated*

Purpose - to determine if water wastage is occurring on Carleton campus.

- to determine any potential losses/savings associated with water conservation

- to assess the attitudes of students with respect to water conservation.

Rationale - This study is being conducted to assist Dalhousie University in water conservation efforts on Carleton campus as well as to assess student and staff attitudes towards water conservation.

Hypothesis - We expect that we will encounter a certain amount of water wastage on Carleton campus and that the student body will show a strong awareness of issues surrounding water conservation; in addition we expect varying opinions within different demographics with respect to issues of scope, social responsibility, and contributing monetarily to water conservation.

2. Methodology/Procedures

a. ***Which of the following procedures will be used? Provide a copy of all materials to be used in this study***.

[ ] Survey(s) or questionnaire(s) (mail-back)

[x] Survey(s) or questionnaire(s) (in person)

[ ] Computer-administered task(s) or survey(s)]

[x] Interview(s) (in person)

[ ] Interview(s) (by telephone)

[ ] Focus group(s)

[ ] Audio taping

[ ] Videotaping

[ ] Analysis of secondary data (no involvement with human participants)

[ ] Unobtrusive observations

[ ] Other, specify _____

b. ***Provide a brief, sequential description of the procedures to be used in this study***. ***For studies involving multiple procedures or sessions, the use of a flow chart is recommended.***

Initially we will gather quantitative data comprised of faucet model, aerator type and water wasted due to dripping faucets within the Tupper and Dentistry buildings on Dalhousie's Carleton campus. This will be followed up with qualitative data collected through intercept surveys with students who frequent Carleton campus, and face-to-face interviews with the maintenance staff of Carleton campus. The surveys and interviews will provide supplementary data used to assess the feasibility of implementing

water conservation policies at Dalhousie. We hope to be able to identify sources of waste and provide potential solutions that help to reduce water costs and increase efficiency of use.

3. Participants Involved in the Study: ***Indicate who will be recruited as potential participants in this study****.*

Dalhousie Participants:

[x] Undergraduate students

[x] Graduate students

[x] Faculty and/or staff

Non-Dal Participants:

[ ] Adolescents

[ ] Adults

[ ] Seniors

[ ] Vulnerable population* (e.g. Nursing Homes, Correctional Facilities)

** Applicant will be required to submit ethics application to appropriate Dalhousie Research Ethics Board*

b*. **Describe the potential participants in this study including group affiliation, gender, age range and any other special characteristics. If only one gender is to be recruited, provide a justification for this****.*

Target groups of the intercept survey are university students, with age limits ranging from approximately 18 years old to possibly 60-70 years old (there is no age-limit for being a student and all opinions are relevant for the project). The target group of the face-to-face interviews will be Dalhousie maintenance staff, and as a result, we expect the age of participants to fall between 25-65 years of age.

c. ***How many participants are expected to be involved in this study?***

100 students, at least 5 maintenance staff (1 interview per researcher)

4. Recruitment Process and Study Location

a. ***From what source(s) will the potential participants be recruited?***

[ ] Dalhousie University undergraduate and/or graduate classes

[X] Other Dalhousie sources (specify) __ staff may be recruited through the sustainability office or recruited by students on campus_____

[ ] Local School Boards*

[ ] Halifax Community

[ ] Agencies

[ ] Businesses, Industries, Professions

[ ] Health care settings*

[X] Other, specify (e.g. mailing lists) ____students will be chosen randomly on Carleton campus for the intercept survey___ ** Applicant may also require ethics approval from relevant authority, e.g. school board, hospital administration, etc.*

b. *Identify who will recruit potential participants and describe the recruitment process.* *Provide a copy of any materials to be used for recruitment (e.g. posters(s), flyers, advertisement(s), letter(s), telephone and other verbal scripts in the appendices section.*

Potential participants will be identified by all group members, as all researchers will be carrying out interviews with maintenance staff and performing intercept surveys on students on the Carleton Campus. Non-probabilistic purposive sampling will be used for selecting the maintenance staff for face-to-face interviews. The researcher must respectfully approach the staff member and briefly ask if they have a few moments and explain what we are doing (using recruitment script/consent form provided); it is imperative that the participant is given and signs the consent form; otherwise the interview cannot be conducted. The interviewer must ask the questions clearly and carefully with the intent to focus uncovering issues such as: concerns with the buildings water infrastructure, leaky/running faucets, student/user behavior and possible recommendations.

Participants for the student intercept survey are to be chosen via a non-probabilistic, but

systematic method. Using the Government of Australia's National Statistic Service sample size calculator we determined out sample size by entering: confidence level at 95%, total population size 18400, proportion at 0.5 (conservative estimate of variance because the proportion is unknown) and setting the confidence interval at 0.1 we obtain a sample size of 96 participants. To this we must add 10-20% to estimate the total number of persons that must be enlisted since our participation rate is 80-90%; the estimated total number of participants that will have to be approached is ~106 to 116; or the process continues until we satisfy our quota. In any case each researcher should interview ~20-24 persons each; preferably interviewing even numbers of males/females at each building.

Generally when selecting participants; researchers should stand at one particular spot and select every *k*th element of the population, with the first element being selected at random; for example:

> A researcher has a population total of 100 individuals and needs 12 subjects; they must pick a number under 100, let us say 5, this will be the start point; then they must pick his/her systematic randomized interval, let us say 8. If these are the choices, then the researcher will choose the 5th individual they encounter, then the 13th, the 21st, 29th, etc. up to the 12th person, number 97; if one possible subject does not want to participate or does not qualify to participate, just count the next 8 people who go by and stop the very next person; continue until each person's quota has been met.

5. Compensation of Participants*:* Will participants receive compensation (financial or otherwise) for participation?

Yes [X] No [ ] If **Yes**, provide details:

It is possible that the use of Halloween sized Toblerone chocolate bars may be used as incentive to be granted an interview.

6. Feedback to Participants

Briefly describe the plans for provision of feedback and attach a copy of the feedback letter to be used.

Wherever possible, written feedback should be provided to study participants including a statement of appreciation, details about the purpose and predictions of the study, contact information for the researchers, and the ethics review and clearance statement. Note: When available, a copy of an executive summary of the study outcomes also should be provided to participants.

We will provide the participants the web link to where to study is being stored online. This will likely be link to a read-only Google document, and the link has yet to be established.

POTENTIAL BENEFITS FROM THE STUDY

1. Identify and describe any known or anticipated direct benefits to the participants from their involvement in the project.

Contributing to body of research that will potentially help alleviate global freshwater crisis, and to increase efficiency of water use in Halifax and at Dalhousie. Research has the potential for economic savings for Dalhousie University.

2. Identify and describe any known or anticipated benefits to society from this study.

Anticipate potential reduction of water use and increase in efficiency for Carleton Campus - benefits for environment and societal well-being. Additionally, the study will lead to increased awareness of global water issues and the freshwater situation, as well as, awareness of freshwater consumption and personal usage patterns at Dalhousie University.

POTENTIAL RISKS TO PARTICIPANTS FROM THE STUDY

1. **For each procedure used in this study, provide a description of any known or anticipated risks/stressors to the participants. Consider physiological, psychological, emotional, social, economic, legal, etc. risks/stressors and burdens.**

   [ ] No known or anticipated risks Explain why no risks are anticipated:

   [X] Minimal risk * Description of risks: Possible allergic reaction to chocolates we distribute as incentive (minor risk).

   [ ] Greater than minimal risk** Description of risks:

***** *This is the level of risk associated with everyday life. ** This level of risk will require ethics review by appropriate Dalhousie Research Ethics Board*

2. Describe the procedures or safeguards in place to protect the physical and psychological health of the participants in light of the risks/stresses identified in Question 1.

If we choose to use incentives when or if participants are not willing to participate in our study we will inform participants of the potential for allergic reactions or other health risks. If there is any uncertainty in their response, the mini Toblerone bar will not be offered as an incentive.

INFORMED CONSENT PROCESS

Refer to: http://pre.ethics.gc.ca/english/policystatement/section2.cfm**;**

1. What process will be used to inform the potential participants about the study details and to obtain their consent for participation?

[X] Information letter with written consent form; provide a copy

[X] Information letter with verbal consent; provide a copy

[X] Information/cover letter; provide a copy

[ ] Other (specify)

Note: For the interviews with maintenance staff we will provide copies of written consent forms, for the student intercept survey verbal consent from an information letter will suffice. The reason why verbal consent will suffice is, that we are not collecting any personal or sensitive information, and all answers will be anonymous.

2. If written consent cannot be obtained from the potential participants, provide a justification.

If written consent cannot be obtained for the potential participant, a new participant will be selected randomly using the same processes as outlined above.

ANONYMITY OF PARTICIPANTS AND CONFIDENTIALITY OF DATA

1. Explain the procedures to be used to ensure anonymity of participants and confidentiality of data both during the research and in the release of the findings.

No personal information will be collected during the survey, as such, there are no issues associated with anonymity of participants. All data will be stored security and disposed of following the end of the project in a discreet manner (documents will be shredded, electronic files will be erased).

2. Describe the procedures for securing written records, questionnaires, video/audio tapes and electronic data, etc.

Data will be recorded on paper copy, and then transferred to a secure hard-drive at one of the researchers homes (in the form of spreadsheets in Excel format). Back-up copies will exist of all information during the course of the project.

3. Indicate how long the data will be securely stored as well as the storage location over the duration of the study. Also indicate the method to be used for final disposition of the data.

[1 month - X] Paper Records

[ ] Confidential shredding after 1 month_____

[X] Data will be retained until completion of specific course.

[n/a] Audio/Video Recordings

[n/a] Erasing of audio/video tapes after _____

[1 month] Electronic

[X] Erasing of electronic data after completion of the course

[X] Data will be retained until completion of specific course.

[ ]
Other _____

(Provide details on type, retention period and final disposition, if applicable)

Specify storage location: _Stored in secure location at one of the five researchers residences on hard-drive. _____

Appendices: ATTACHMENTS Please **check** below all appendices that are attached as part of your application package:

[X] **Recruitment Materials**: A copy of any poster(s), flyer(s), advertisement(s), letter(s), telephone or other verbal script(s) used to recruit/gain access to participants.

[X] **Information Letter and Consent Form(s)**. Used in studies involving interaction with participants (e.g. interviews, testing, etc.)

[ ] **Information/Cover Letter(s)**. Used in studies involving surveys or questionnaires.

[X] **Materials**: A copy of all survey(s), questionnaire(s), interview questions, interview themes/sample questions for open-ended interviews, focus group questions, or any standardized tests used to collect data.

Copy of Recruitment Script:

Hello,

My name _____ and I am an undergraduate student at Dalhousie University in the environmental science program. Under the direction of Dr. Tarah Wright my classmates and I are investigating several issues with respect to Dalhousie campus as a living laboratory of examples of current issues relating to sustainability and the environment.

I am studying the issue of water wastage on Carleton campus and my research aims to evaluate how students feel about water conservation, roughly gauge the amount of water wasted and hopefully uncover any potential savings.

I feel your input is really valuable and necessary for the success of this project. I was wondering if you would like to participate in a quick survey and help to contribute to our study.

(IF YES, start with the qualifying questions, if they qualify then begin the survey; IF they don't qualify be courteous and explain to them that they don't qualify because of…. and find the next participant)

(IF NO, be courteous and thank them for their time)

Copy of Consent Form for Face-to-Face Interview with Maintenance Staff:

Carleton Water Audit Consent Form

Introduction

My name is (student researcher) (Allison Welk, Anthony Mallinson, Elliott Quidder, Christoph Voegele, Paul Singh) and I am a student here at Dalhousie University. I'm currently enrolled in ENVS 3502 "The Campus as a Living Laboratory" instructed by Dr. Tarah Wright (Tarah.wright@dal.ca). An element of this class requires us to complete a research project that focuses on increased sustainability or environmental awareness on campus.

Purpose

For our research project we will be conducting a water audit to determine the amount of water being wasted through dripping faucets, due to mechanical error, on the Carleton campus specifically looking at the Dentistry and Tupper buildings.

Study Procedures

I would like to ask you some questions about any potential technical problems related to the buildings and their facilities as well as water conservation on Carleton Campus. I expect to need approximately 10 to 25 minutes of your time. If you agree to participate, the information you give me will be used anonymously in our final report which will be published and put on the environmental science website.

Confidentiality

All documents from the interview will be identified by code number and stored electronically – paper-copies will be kept until the completion of the project (April 12th, 2013) in a secure location. Any details which might identify you will not be shared within the report, with the class, or to any other individuals. You should feel free not to provide any information you do not wish to share with me or to end the

interview at any time. If you wish to end the interview early, any information you have provided up to that point will be included in the study data unless you ask specifically not to include it.

Consent

Your participation in this study is entirely voluntary and you may refuse to participate or withdraw from the study at any time. Do you have any questions about the purpose of the study or the process? Is there anything else you would like me to clarify? If you have any concerns about your treatment or rights as a research participant, you can contact Dr. Tarah Wright at Tarah.wright@dal.ca.

Your signature indicates that you consent to participate in this study.

_____

Subject Signature Date

Copy of Face-to-Face Interview Questions for Maintenance Staff

1) Do you know approximately how many people use the bathrooms here each day?
2) Have you ever seen a leaky faucet? If yes, then how often and where?
3) Do people ever leave the faucets running?
4) Are there any mechanical problems (major or minor) with any of the faucets in public areas (explain what we mean by public) in the Tupper/Dentistry buildings?
5) Can you recommend anything that you think would help to reduce the amount of water used on Carleton campus (Tupper/Dentistry buildings)?
6) Have you ever seen the automatic faucets? If yes, do you think they should be installed on the Carleton campus? if yes or no, why or why not?
7) Are there any consistent or unusual problems with students and the bathrooms such as leaving the faucets on, using excessive water, spilling excessive water or abusing the washrooms in any other way?, if so how often does it occur?.

Copy of intercept survey for Dalhousie students:

Five Qualifying Question

1st - Are you a Dalhousie student?

- If yes conduct interview, if no find next participant.
- Ask if they would like to participate in our survey.
- If yes conduct interview, if no find next participant.

Additional Questions after Participant has Agreed to the Survey

2nd - What program are you in?

3rd - What year of study are you in?

4th – Where are you from?

Note – the last question asks the participants age and should be posed after the primary questions are posed

Primary Questions

1) Do you feel that water conservation is an important global issue?

Strongly Agree **Agree** **Neutral** **Disagree** **Strongly Disagree**

2) Do you think water conservation is an important issue in Canada?

Strongly Agree **Agree** **Neutral** **Disagree** **Strongly Disagree**

3) Do you feel it is important enough that the government make strict laws to support water conservation?

Strongly Agree **Agree** **Neutral** **Disagree** **Strongly Disagree**

4) Do you feel that Universities should play a role in water conservation?

Strongly Agree **Agree** **Neutral** **Disagree** **Strongly Disagree**

5) Do you feel that your circle of friends and family talk about water conservation issues?

Strongly Agree **Agree** **Neutral** **Disagree** **Strongly Disagree**

6) Do you feel that the issue of water conservation is important enough to raise taxes to increase the funding for water conservation efforts or research?

Strongly Agree **Agree** **Neutral** **Disagree** **Strongly Disagree**

7) Do you think you can play a role in water conservation?

Strongly Agree **Agree** **Neutral** **Disagree** **Strongly Disagree**

8) Do you think a running/dripping faucet should be shut off?

Strongly Agree **Agree** **Neutral** **Disagree** **Strongly Disagree**

9) Do you think others should feel an obligation to shut off running or dripping faucets on campus?

Strongly Agree **Agree** **Neutral** **Disagree** **Strongly Disagree**

10) Do you feel that a very small increase in tuition would be warranted to support upgrades to water conservation efforts at Dalhousie University?

Strongly Agree **Agree** **Neutral** **Disagree** **Strongly Disagree**

5th – May I ask how old are you?

*****Record whether the participant is male or female.

SIGNATURES OF RESEARCHERS _____ _____

Signature of Student Investigator(s) Date _____

Signature of Student Investigator(s) Date _____

Signature of Student Investigator(s) Date _____

Signature of Student Investigator(s) Date _____

Signature of Student Investigator(s) Date _____

Signature of Student Investigator(s) Date _____ _____

Signature of Student Investigator(s) Date

FOR ENVIRONMENTAL SCIENCE PROGRAM USE ONLY: Ethics proposal been checked for eligibility according to the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans

_____

Signature Date

_____

Signature Date

8.7 Preliminary Proposal

Preliminary Proposal - Carleton Campus Water Audit Winter 2013

Group Members: Paul Singh, Christoph Voegele, Anthony Mallinson, Elliott Quider, Allison Welk

Mentor: Jennifer Organ, MES Candidate 2012

Submission Date: February 22, 2013

1. PROJECT DEFINITION

Water covers around 70% of the world surface, however, it is considered to be a finite resource that should be used carefully and wisely. Only 2.5% of the earth's water is fresh water and out of the fresh water reserve only 1% of it is available for human consumption (Water News, FAO, 2013). Water is necessary for all life on earth and is one of the planets' most precious, but undervalued, resources. With the growing human population increasing water demand and increasing rates of water pollution diminishing water quality, viable drinking water is decreasing at an alarming rate (Simonovic, 2002). Today, around one in six people worldwide, 894 million, do not have access to clean fresh drinking water. This number is predicted to increase to 1 800 million people by 2025. Furthermore, by 2025 two-thirds of the world population will live in countries or regions under severe water stressed conditions (Water News, FAO, 2013). With these concerning statistics and predictions, water conservation has never been more crucial.

Water conservation includes a variety of policies, strategies and activates to manage freshwater as a sustainable resource, to protect aquatic environments and to meet current and future human demand

(Sturman et al, 2004). However, water conservation does not only have environmental and future benefits, it has current economic benefits. Presently, in Canada water costs approximately $0.31 per cubic metre (SHOULD BE 0.509), which is very little compared to other countries such as Germany, which pays $2.16 per cubic metre (Environment Canada, 2012). Nevertheless, by implanting water conservation policies, strategies, and activities in a large institution that uses a significant amount of water, such as a university, one can save thousands of dollars a year on energy and water. For example, by installing a low-flow aerator to one faucet, which reduces the flow of water from the faucet without reducing the pressure thus saving both water and energy, approximately 13,000 gallons of water and 100 dollars can be saved. The potential for savings through implementation of simple water conservation strategies is tremendous for large institutions, industrial, and commercial properties.

With universities being one of the largest consumers of fresh water in North America, water conservation becomes a very important aspect in their policy making, not only to save money through water and energy reduction, but also to reduce their environmental impact and increase their economic savings. Through specific purchasing decisions and shifts in attitudes, many universities across North America have significantly reduced their water usage, saving thousands of dollars in the process (University of Maryland, 2012). An excellent success story of a university implanting water conservation is Stanford University. In 2001 Stanford University developed a water conservation, reuse, and recycling master-plan to identify ways to keep water demand below the current San Francisco Public Utilities Commission (SFPUC) (Stanford University, 2003). From 2001 to 2008 the university completed 50 major water efficiency retrofit projects, overall reducing their average domestic water use from 2.7 million gallons per day in 2000 to 2.3 million gallons per day in 2007, despite campus growth. One of their projects included retrofitting student housing, which has cut their water use by 120 million gallons a year (Stanford University, 2011).

The purpose of this research project is to conduct a water audit to determine and measure the amount of water being wasted through dripping faucets, due to mechanical error, on the Carleton campus at Dalhousie University. A water audit is a qualitative and quantitative analysis of water consumption that helps identify means of reducing, reusing, and recycling water to obtain a balance of water input and water output (Sturman et al, 2004). Within in our water audit we will be recording the number of dripping faucets and measuring how much water is wasted per year. We will also be marking down what type of aerator each faucet contains. This will allow us to compare different types of aerators, conclude which one has the lowest flow rate, and determine what the potential water and energy saving for the university by making the switch to the most efficient aerator. Finally, we will be interviewing students and maintenance staff to further investigate water conservation views and recommendations on Carleton campus.

For this specific research project we will be narrowing our scope down to the Carleton campus at Dalhousie University located in Halifax, Nova Scotia, Canada. The Carleton campus is located on the corner of Robbie Street and University Avenue in the south end of Halifax. The campus is in close proximity to both the IWK Health centre and the Queen Elizabeth II hospital, which provides clinical practice for the campuses' health science students. The faculties located on the Carleton campus are

medicine, dentistry and health profession (Dalhousie University, 2013). The campus has two main buildings that the study will focus on; the Dentistry building and the Tupper building. Within these two buildings, we will be looking only at publically accessible faucets, which include public bathrooms and kitchen faucets, as well as interviewing and surveying maintenance staff and students that are directly involved. To obtain the information to answer the research question, we will be using a variety of different research tools. These will include; intercept surveys with students on the Carleton Campus to determine their attitude on water conservation and usage patterns. Face-to-face interviews will be conducted with maintenance staff to uncover potential technical problems related to the buildings, in addition to general attitudes towards water conservation. Finally, our quantitative approach, the water audit, will be conducted to determine how much water is being wasted per year by dripping faucets and what types of aerators are being used through the buildings.

This project will propose simple recommendations on water conservation strategies to Rochelle Owen, the director of the office of sustainability, and other decision makers, to be implemented on the Carleton campus at Dalhousie University. The long run goal of this research project will be to decrease the amount of water being wasted through dripping faucets and inefficient aerator types to reduce Dalhousie's overall water consumptions and save the university energy and money, while helping Dalhousie become a more sustainable campus.

2. BACKGROUND AND RATIONALE

The rationale for a water audit is very simple – water audits help reveal sources of waste and provide opportunities to increase efficiency and sustainability. According to a UN projection, the population will reach at least 9 billion people by 2050, an increase of 2 billion people in 30 years. It is unlikely that current available global freshwater will be able to support such a vast population, especially given current per capita use of water (Vital Water Graphics, 2008). Further, freshwater reserves are already stressed due to overexploitation and inefficient use. Currently, there are more than two billion people living in regions experiencing high levels of water stress (Oki, T., *et al*, 2006). A UN report on global water consumption found that "in 60% of European cities with more than 100,000 people, groundwater is being used at a faster rate than it can be replenished" (Facts and Trends: Water, 2002). Additionally, numerous cities around the world, including Mexico City, Bangkok, Manila, Beijing, Madras, and Shanghai, have experienced drops in groundwater aquifers from of up to 50m (Facts and Trends: Water, 2002). Even more worrisome, according to the Food and Agricultural Organization of the United Nations (FAO), in the last century global water use has been growing at more than double the rate of population growth (Water News, FAO, 2013). At the current rate of exploitation and water usage, freshwater will not be an available resource in the future, for humanity or natural systems.

Water security and sustainability will continue to become increasingly important as the human population continues to grow. However, there are numerous other factors that increase the stress on

freshwater systems; increasing global levels of affluence, expansion of industrial and business activity, urbanization and land-use change, as well as climate change (Facts and Trends: Water, 2002). These factors drastically increase global water consumption and are worsening the problem of water scarcity in undeveloped regions of the world. Increasing affluence inevitably means more water consumption as per capita use increases; business expansion and urbanization increase supply and sanitation demands of water supply, as well as extensive investment in water service infrastructure; additionally, anthropogenically induced climate change results in severe alterations to the hydrological cycle, and changes in local precipitation patterns, rates of evaporation, and rates of runoff in cities (Facts and Trends: Water, 2002).

Although Canada contains seven percent of the world's accessible freshwater, more than half of this drains north towards Hudson Bay and the Arctic Ocean, resulting in the remaining supply becoming heavily stressed (Water: Frequently Asked Questions, 2012). As a result water conservation and proper management and efficiency techniques are paramount in Canada, as they are globally. According to the Organization for Economic Co-operation and Development, Canada is second in per capita freshwater usage in developed nations. As of 2002, Canadians consumed on average 1,420 m^3 per capita; the only country that consumes more freshwater is the United States, which consumes 1,730 m^3 per capita (Environment: Air, Water and Land, 2005). Although global growth rate is slowing, growth rate continues to increase in developing nations and the demand for freshwater is also increasing (Environment: Air, Water and Land, 2005). The importance of reducing waste and improving efficiency is not a new concept in resource consumption policy, but due to the seemingly infinite supply of freshwater and the exceedingly low costs, this importance seems to be lost on the water industry. New and old technologies exist which allow increases in water use efficiency – including, aerators, which restrict flow rate on faucets, flow-reduction technologies for toilets and showers, and management strategies to reduce consumption. In order to assess the practicality of investing time and money in new technology, wastage and usage must be quantified and analysed. Water audits therefore play increasingly important roles in business decisions – ranging from residential, commercial, and industrial projects. Water wastage or over consumption reflects negatively on the business or resident, stresses equipment, and negatively affects the environment, contributing to climate change, and results in loss of significant profits.

Being a coastal city in Atlantic Canada, water management and efficient use is always a top priority in Halifax. Accordingly, as outlined in the Sustainability Plan, Dalhousie University is attempting to reduce its impact on the environment and promote resource use sustainability (Dalhousie University Sustainability Plan, 2010). Dalhousie is aiming for a twenty-percent reduction in personal consumption of water and waste produced by 2020 for all students (Dalhousie University Sustainability Plan, 2010). In order to assess the amount of waste that is being reduced, there must be a preliminary assessment of current usage and water waste. Our audit will provide the baseline of information that can be used for future comparisons of water waste, as well as providing additional information on flow rate and type of faucets, university attitude towards water use, and a monetary incentive for waste reduction. Reduction of water usage – even when the waste is only through leaking faucets – can result in large savings for the University. An audit conducted on a ten-thousand student university in Cambridge, Massachusetts, resulted in annual savings of $282, 000 and 120 million litres annually. At this rate it would only take 1.8

years to payback the cost of the audit (University: Water Savings Case Study, 2004). The UN examines four ways that humans directly contribute to freshwater stresses. It stresses that inefficient use of freshwater resources, specifically; "leakage in water delivery systems" and "excessive consumption by individuals" significantly impacts water reserves. (Facts and Trends: Water, 2002) Additionally, as an environmental leader in the community, Dalhousie benefits greatly when reducing impacts on marine ecosystems. Water audits help reduce freshwater consumption and reduce the impact of anthropogenic freshwater use on Earth's natural systems. Less freshwater consumption results in reduced runoff into marine ecosystems, reduced number of contaminants in the hydrologic cycle, lower extraction rates from groundwater aquifers, and less stress on municipal water systems (Richardson-Prager, L. *et al,* 2004).

JUSTIFICATION

The goals of this study are two fold:

First, to quantify in terms of volume and monetary losses the water lost due to leaking faucets and to define the potential savings from using new aerators. Normally calculating the losses from leaking faucets is fairly straight forward; and would entail finding the volume wasted over the day and multiplying this quantity by the price per unit of water; but no data exists or is not accessible on the exact water usage of public faucets on Carleton campus (Tupper building and Dentistry building) . Therefore the methods used only provide an estimation of the water waste and the potential savings.

The estimate breaks down hand washing in to four steps as the CDC (Centers for Disease Control) does as: wetting, soaping rubbing and rinsing. This assumes that the time a faucet would be running while an individual washes their hands to be between 30-60 on the basis that the CDC recommends that soaping alone should take 20 seconds. We then conservatively assume 30 seconds as a minimum time and 60 seconds as a maximum time that the average individual would require for the faucet to be left on during hand washing.

The second goal is accomplished through a two part interviewing process, 1st it is hoped that information can be gained about the maintenance issues: technical, logistical or behavioral from staff. It is felt that this group would have intimate knowledge of the facilities, problems from the past and potentially may know of future issues. The second interviewing segment explores some of the feelings, behaviors and attitudes that students of differing demographics have with respect to water conservation (Lockie et al., 2002). This is accomplished using 10 questions that focus on 3 criteria: how the participant feels about the scope of the issue, the role of individuals and institutions, and is the participant willing to contribute monetarily. It is thought that the use of both quantitative/qualitative design methods as well as the interdisciplinary nature of our group will provide a more complete or holistic understanding (Romero

et al., 2013) of water usage and water conservation attitudes on Carleton campus.

3. RESEARCH METHODS

This study is being performed to gauge water usage efficiencies/inefficiencies with regards to the faucets in public washrooms on Carleton campus. It will also attempt to gauge through an intercept survey (see appendix) conducted on a sample of the student body how the general Dalhousie University population feels about three aspects of water conservation: 1st the scope of its importance, 2nd who bears the responsibility for water conservation efforts and 3rd would students be willing to contribute financially to the issue. These criteria will be further examined through the responses of different demographics that compose the sample on the basis of the participants' place of origin, sex, faculty and age/year of study. Additionally, in order to ensure the study captures as many relevant details as possible as related to water wastage and conservation on Carleton campus, the help of staff will be enlisted; these interviews will consist of maintenance staff from the Tupper building and the Dentistry building.

Part 1

Water and Faucet Audit:

Initially we will be performing a water audit on Carleton campus and the following information will be recorded: the number of leaking faucets, their exact location, the volume of wasted water, and the serial number and flow rate of the aerators. This is done in order to calculate the potential total volume of water wasted over time and the possible savings from fixing the leaking faucets/installing low flow aerators (Kubba, 2010).

The data should be collected from both the Dentistry and Tupper buildings over the course of a single day in order maintain temporal consistency of the observations and to reduce the potential influence of variables that may change from one day to the next (Bordens and Abbott, 2005). Measuring water loss from all public water taps on Carleton Campus will be performed through the use of graduated cylinders that are demarcated with drip rates that correspond to losses in liter/day and litres/year; due to the number of bathrooms and faucets, data collection will be expedited through auditing all public faucets in groups two groups: 1 group will audit the Dentistry building and the other will audit the Tupper building.

Using maps of each floor as provided by Dalhousie Sustainability Office (see appendix) the location of each bathroom should be marked off and the following procedure should be followed: 1st record the location of the faucet, 2nd record the aerator type (serial and flow rate) of each faucet, 3rd if a faucet is

found to be leaking an attempt should be made to turn it off; should the faucet not completely close and still exhibit dripping the graduated cylinder should be used to measure this dripping phenomenon. The occurrence of whether the faucet has been found to be left running, or if it's a mechanical problem, should be; recorded as well.

Although not an exhaustive audit the methodology still conforms to the basic 3 step criteria (Chin, 2006) for a water audit template: step 1 – pre-audit to get agreements, permission to work and background information on the facility, step 2 – collection of data from the site and review operations with water facilities management, step 3 - water system analysis.

PART 2a

Face-to-Face Interviews with Maintenance:

A) The second part of the study consists of interviews (see appendix) with maintenance staff conducted through a non-probalistic and purposive sampling manner. Each of the researchers (in this case 5) must get at least 1 staff person from maintenance to participate with the caveat of not interviewing a person another researcher has had contact with; preferably with 3 interviews coming from the Tupper building (larger) and 2 from the Dentistry building (smaller). These face to face interviews are undertaken in order to gain real world perspective (Totten et al., 1999) about possible issues concerning with the faucets themselves, student behavior around the use of faucets and possible recommendations. In addition to this capture of "authentic' or real life data there are other advantages to conducting an interview with staff such as: 1) it is thought that staff will feel more comfortable to express their opinion in an anonymous one on one interaction (Totten et al., 1999); 2) increased possibility of uncovering an unheard of or unpopular suggestions or opinions without fear of group/social scorn (Totten et al., 1999); 3) higher rates of participation (around 80-90%) and generally less volunteer bias (Palys and Atkinson, 2008); 4) the interviewer can help the participant to clarify questions and elicit a more of a response especially from short answered responders that might otherwise give an incomplete answer on a self-administered questionnaire or survey (Palys and Atkinson, 2008).

The researcher must respectfully approach the staff member and briefly ask if they have a few moments and explain what we are doing (see appendix); it is imperative that the participant is given and signs the consent form; otherwise the interview cannot be conducted. The interviewer must ask the questions clearly and carefully with the intent to focus uncovering issues such as: concerns with the buildings water infrastructure, leaky/running faucets, student/user behavior and possible recommendations (see appendix).

PART 2b Intercept Survey with Students:

The last part of the study entails performing an intercept survey with students (see appendix) on Carleton Campus. The survey investigates three aspects of water conservation with respect to three main themes with regards to water conservation. The first issue is the importance of water conservation with respect to its scale and our possible obligations (questions 1, 2, 5, 8, and 9), the second is the scope of responsibility (questions 3, 4, 7) and 3rd personal financial duty with regards to conservation (questions 6, 10).

Similar to the interviews with maintenance this survey allows for 1) the capture of large amounts of data very quickly (Totten et al., 1999); 2) it eliminates group bias (Totten et al., 1999); 3) allows the researcher to clarify questions and get better quality responses especially from short answered responders that might otherwise give an incomplete answer on a self-administered questionnaire or survey (Palys and Atkinson, 2008); but 4) unlike our interview this method systematically randomizes who our participant will be, making the survey sample more representative of the overall student population (Totten et al., 1999). In addition a systematic sampling is less time consuming and more cost effective than simple random sampling (Bordens and Abbot, 2005).

In order to start the process of sampling we must determine our sample size; traditionally to determine this we consider a number of factors such as the purpose of the study, the required level of precision, the level of confidence of risk, response rate and variability (Isreal, 1992);

but in this case the data is not going to be analyzed using inferential statistics because the survey design is not quite as sophisticated as Likert-Scale but is more substantial than a Likert-type design (Boone and Boone, 2012); the former loans itself to be analyzed using inferential statistics but the latter is much simpler and more convenient with respect to analysis via descriptive techniques (Boone and Boone, 2012) and the completion date of this study. Additionally it was chosen to err on the side of caution and not over extend our assumptions about the data; therefore we will have to use confidence intervals to obtain our sample size because this is more reasonable approach (due to time) in this case than via statistical significance (Hopkins, 2008).

Using the Government of Australia's National Statistic Service sample size calculator we determined out sample size by entering: confidence level at 95%, total population size 18400, proportion at 0.5 (conservative estimate of variance because the proportion is unknown) and setting the confidence interval at 0.1 we obtain a sample size of 96 participants. To this we must add 10-20% to estimate the total number of persons that must be enlisted since our participation rate is 80-90% (Palys and Atkinson, 2008); the estimated total number of participants that will have to be approached is ~106 to 116; or the process continues until we satisfy our quota. In any case each researcher should interview ~20-24 persons each; preferably interviewing even numbers of males/females at each building.

Generally when selecting participants; researchers should stand at one particular spot and select every *k*th element of the population, with the first element being selected at random (Madow, 1946); for example:

> A researcher has a population total of 100 individuals and needs 12 subjects; they must pick a number under 100, let us say 5, this will be the start point; then they must pick his/her systematic randomized interval, let us say 8. If these are the choices, then the researcher will choose the 5th individual they encounter, then the 13th, the 21st, 29th, etc. up to the 12th person, number 97; if one possible subject does not want to participate or does not qualify to participate, just count the next 8 people who go by and stop the very next person; continue until each person's quota has been met.

Summary of the Methods

1st- Find an appropriate place on Carleton campus (Dentistry or Tupper)

2nd - Be sure to follow the pre-survey instructions.

3rd – Make sure you qualify the participant

4th – Ask the additional questions

5th – Administer the survey

6th – Continue until you reach 24 surveys

DATA ANALYSIS

Data from Part #1

The following will be calculated using the data collected to analyze:

- Fixing dripping taps to save water = drip gauge will give volume being wasted.
- Fixing dripping taps to reduce costs = (volume saved) * (cost per unit volume of H_2O)
- Potential amount of water saved from taps being fitted with new aerators

Total Volume of H2O Saved Using New Aerators

Estimations were sought on average using a setting similar to Carleton campus but these estimates along with calculations were primarily focused on household water usage and savings, water saved nationally, electricity and natural gas saved per household and nationally and the potential savings (USEPA, 2007).

Using these as examples it has therefore been suggested to calculate potential savings that we must presume two things 1st in washing ones hands, there are four stages, wetting, soaping, rubbing and rinsing. If the CDC guidelines state a person should not take less than 20 seconds for the rubbing stage a few rough estimates can be made (wetting does not take more than 10 seconds, soaping does not take more than 5 seconds of water use, rinsing does not take more than 20 seconds); giving us a total of 55 seconds, round up to give 60 seconds, use 30 seconds as low estimate and 60 seconds as high estimate; 2nd assume that the entire capacity each building (the number of persons allowed in the building according to fire code at any one time) uses the bathroom at least once in a day then:

High Estimate

= (Old Flow Rate – New Flow Rate)*(Occupancy of the building)*(60 seconds)

= Total estimated volume

Low Estimate

= (Old Flow Rate – New Flow Rate)*(Occupancy of the building)*(30 seconds)

= Total estimated volume

The "old flow" rate is the present total rate of all facets with the "new flow" rate being the rate after new aerators have been fitted. This estimation is on the low side of the calculation considering that the Tupper and Dentistry buildings fill/empty to capacity several times a day and also host many transient persons who may also use the facilities.

DATA ANALYSIS

Data from part #2

Due to differences in analyzing Likert type and Likert scales; and this data sharing similarities with both scales as previously mentioned; the analysis with take on a descriptive character that will focus on the following measures: median, mode (measures of central tendency) and frequency (variability) (Boone and Boone, 2012). These measures will be used to describe general trends in the three groupings of the survey

with respect to water conservation (its importance, who is responsibility and who is willing to pay). As well different demographics (age, sex, faculty, year of study) will be compared and contrasted with respect to the median, mode and the frequency for the different questions. The data could have been analyzed more thoroughly but given the time constraints this option for analysis is still considered to be insightful and valuable; it would however be possible for future students to take this data and use inferential statistics to make some interesting associations and comparisons not able to be made during the present study.

4. TENTATIVE SCHEDULE AND BUDGET

Potential Schedule: The following table displays the tentative schedule/ timeframe within which we plan to conduct all necessary steps to complete the project.

Week (date)	Major task	Responsibility
Reading Week (February 25th – March 3rd)	- in depth review of compiled literature to this point - additional research (other case studies) - review comments on "Lab 3" research tool (if marked), change if necessary	- individually (communicate findings among group)
Week 9 (March 4th – 10th)	- determine distribution of sampling areas among group members (who samples what building/floor) - data collection (water sampling) at Carleton Campus on March 6th - group meeting to gather all collected data	- Group
Week 10 (March 11th – 17th)	- review of collected data (also by TA) - review comments on preliminary proposal - finalizing research tool (face-to-face interview)	- Group
Week 11 (March 18th – 24th)	- conducting student interviews on March 20th around noon - conducting interviews with maintenance on March 21st (time to be determined) - compiling collected surveys and analysis (may be time intensive)	- every group member conducts the interviews individually - data analysis evenly distributed

		among group (i.e. two questions per person)
Week 12 (March 25th – 31st)	- beginning write-up of finalized report (findings/results/discussion) - determining format of group presentation - creating power point presentation	- distribution of sections to be determined
Week 13 (April 1st – 7th)	- finalizing power point presentation - **submit** presentation by April 1st	- Group
Week of April 12th 2013	- minor improvements/ formatting to finalized report - **submit** report April 12th - peer evaluations - group celebration beer	- Group - Evaluations to be done individually

Note: Tentative schedule; changes or adjustments may be done during the project process.

Potential Budget:

The budget for the Carleton campus water audit is very limited. Tools for collecting data (measuring drip rate of leaking faucets) have been supplied by ENVS3502 and Dr. Tarah Wright. Additionally, there is very little other software or equipment required. Statistical analysis and data management is basic and inexpensive to perform. There will be minor costs associated with printing costs of interview and questionnaire sheets; these costs will be limited as well and we will not be applying for any additional funding. There may be further costs associated with providing an incentive (mini Toblerone bars) with respect to questionnaires for students (depending on initial attitude and response rates). Note, if a water audit is to be completed outside of a university setting, the majority of the cost will be associated with cost of labour and time, as well as additional equipment required to measure usage and efficiency of water systems.

5. DELIVERABLES AND COMMUNICATION PLAN

Project Deliverables

Quantitative

- Identification of faucet model and aerator types (serial and flow rate) within the Tupper and Dentistry buildings on Dalhousie's Carleton campus
- Projections of water use for current, and suggested replacement, aerators
- Identification of dripping faucets, their location and cause of dripping
    - human error

    - mechanical failure
- Calculation of water loss through dripping faucets
    - Daily
    - yearly

Qualitative

- Collection of qualitative data through face to face Interview
    - maintenance staff on Carleton Campus
    - students on Carleton Campus

Cumulative

- Provide water conservation suggestions based on data gathered
    - mechanical
    - human behavior

(Creswell, 2008)

Communications plan

Objectives: The collection of qualitative data about faucets and water conservation through face-to-face interview with the students and maintenance staff of Dalhousie's Carleton campus.

Target Audience: The students and maintenance staff of Dalhousie's Carleton campus.

Tools: The qualitative tool utilized will be individual face-to-face interviews with predetermined questions, which are outlined in detail within the methods section above.

Evaluation: The measurement of effort will be carried out through careful analysis of the responses to the individual interviews. The responses will be reviewed to find any notable trends or useful information regarding the faucets on Carleton campus or water conservation, if they occur therein.

(European Commission, 2012) (Mayhall, 2008)

6. REFERENCES

Boone, D. A., & Boone, H. N. (2012). Analyzing Likert Data. *Journal of Extension*, 50(2).

Chin, Raymond. (2006, May). GVRD Regional Utility Planning: Standardized ICI Water Audit Process Final Report, Stantec.

Creswell, J. W. (2008). *Research design: Qualitative, quantitative, and mixed methods approaches*. (3rd ed.). SAGE. Retrieved February 14, 2013, from http://books.google.ca/books?hl=en&lr=&id=bttwENORfhgC&oi=fnd&pg=PR1&dq=research project design&ots=CaHulQ0-Y8&sig=jEUA5p7Arv4CJl3wB9JyL5DFMp0.

Dalhousie University. (2013). *Halifax Campuses: A vibrant, collaborative community*. Retrieved February 20, 2013, from http://www.dal.ca/about/halifax-campuses.html

Dalhousie University Sustainability Plan. (2010, June). *Dalhousie University Office of Sustainability* . Retrieved February 13, 2013, from www.dal.ca/content/dam/dalhousie/pdf/ sustainability/Dalhousie_University_Sustainability_Plan_June_2010%20(389%20KB).pdf

Environment: Air, Water and Land. (2005). *Organisation for Economic Co-operation and Development*. Retrieved February 14, 2013, from www.oecd.org/publications/factbook /34416097.pdf

Environment Canada. (2012). *Wise Water Use*. Retrieved February 20, 2013, from http://www.ec.gc.ca/eau-water/default.asp?lang=En&n=F25C70EC-1

European Commission. (2012, September 6). *How to prepare a communication plan?*. Retrieved February 20, 2013, from http://ec.europa.eu/ipg/go_live/promotion/communication

_plan/index_en.htm

Facts and Trends: Water (2002). *World Business Council for Sustainable Development*. UN Water. Martin, R. (director). Retrieved February 18, 2013, from www.unwater.org/downloads/

Water_facts_and_trends.pdf

Kubba, S. (2010). Chapter 8 - water efficiency and sanitary waste. LEED practices, certification, and accreditation handbook (pp. 271-291). Boston: Butterworth-Heinemann. doi: 10.1016/B978-1-85617-691-0.00008-4

Lockie, S., Lawrence, G., Dale, A., & Taylor, B. (2002). 'Capacity for Change': Testing a Model for the Inclusion of Social Indicators in Australia's National Land and Water Resources Audit. *Journal Of Environmental Planning & Management*, 45(6), 813-826. doi:10.1080/0964056022000024352

MacDonald, Jill, Courtney Morrison, Cara Pembroke, Victoria Reed, Sonya Tancock. (2011, April 13). Cooler Than Tap Water: A Study of Water Coolers and Tap Water on Dalhousie University Campus. ENVS/SUST 3502, Final Report.

Mayhall, R. (2008, May 26). *How to develop a communications plan*. Retrieved February 20, 2013, from http://www.hieran.com/comet/howto.html

Oki, T., & Kanae, S. (2006). Global Hydrological Cycles and World Water Resources. *Science, 313*, 1068- 1072.

T., Payls., & C., Atchison. (2008). *Research Designs* (4th ed.). Toronto: Nelson.

Abeyasekera, S. Quantitative Analysis Approaches To Qualitative Data: Why, When And How. (2003).. University of Reading. Retrieved February 20, 2013, from http://www.reading.

ac.uk/ssc/n/resources/Docs/Quantitative_analysis_approaches_to_qualitative_data.pdf

Reichardt, K. (2011). Forget taxes… it's water we need to audit. Sustainable Facility, 36(2), 24-27.

Richardson-Prager, L., Sturby, D., Shaffer, C., & McMaster, E. (2004, April 13). Dalplex Water Audit. *Dalhousie Department of Environmental Science*. Retrieved February 13, 2013, from environmental.science.dal.ca/Files/Environmental%20Programs/DalplexWaterAudit_-_final_copy1.pdf

Romero-Lankao, P., Borbor-Cordova, M., Abrutsky, R., Günther, G., Behrentz, E., & Dawidowsky, L. (2013). ADAPTE: A tale of diverse teams coming together to do issue-driven interdisciplinary research. *Environmental Science & Policy*, 2629-39. doi:10.1016/j.envsci.2011.12.003

Stanford University. (2011). *Water*. Retrieved February 21, 2013, from http://sustainablestanford.stanford.edu/water

Stanford University. (2003). *Water Conservation, Reuse and Recycling Master Plan Final*. Retrieved February 21, 2013, from http://lbre.stanford.edu/sem/sites/all/lbre-shared/files/docs_public/FINALStanfordConservation_Recommended_Plan10_16_033%5b1%5d.pdf

Simonovic, S. P. (2002). World water dynamics: global modeling of water resources. Journal of Environmental Management, 66(3), 249-267.

Sturman, J., Ho, G.E., and Mathew, K. (2004). Water Auditing and Water Conservation. Cornwall: IWA Publishing.

University of Maryland. (2012). *Water Conservation*. Retrieved February 20, 2013, from http://www.sustainability.umd.edu/content/campus/water.php

University: Water Savings Case Study. (2004). *Energy Vortex*. Retrieved February 22, 2013, from http://www.energyvortex.com/pages/headlinedetails.cfm?id=1089

Vectren Corporations. (2010). *Install low-flow faucet aerators and save $100 a year*. Retrieved February 17, 2013, from http://www.vectrenlivesmart.com/content/install-low-flow-faucet-aerators-and-save-100-a-year-060109.html

Vital Water Graphics. (2008). *United Nations Environment Programme (UNEP)*. Retrieved February 15, 2013, from http://www.unep.org/dewa/vitalwater/index.html

Water: Frequently Asked Questions. (2012, February 16). *Environment Canada*. Retrieved February 13, 2013, from https://www.ec.gc.ca/eau-water/default.asp?lang=En&n

=1C100657-1#ws46B1DCC

Water News: water scarcity. (2013). *FAO: Food and Agriculture Organization of the United Nations*. Retrieved February 15, 2013, from http://www.fao.org/nr/water/issues/scarcity.htm