Understanding Water Consumption in the Life Sciences Center

Submitted by: Jessica Hart, BSc. Biology; Paula Francis, Drummond Frasier,
Heather Reed & Corey Webster; BSc. Environmental Science

Submitted to: Dr. Tarah Wright, Director of Environmental Programmes
Dalhousie University - Halifax, Nova Scotia

ENVS 3502: Environmental Problem Solving – Winter 2007

ABSTRACT

One water meter monitors Dalhousie University's Life Sciences Centre (LSC) water delivery system, highlighting a lack of understanding of water use. A dual approach experimental model (descriptive & exploratory research) was used to increase understanding of perceptions, and volumes, of major water use activities; and to build a foundation to encourage future research. A major water use activity is one that requires water to fulfill its main purpose/function, and seven were highlighted for project inclusion. Questionnaires identified minimal water use in student laboratories, and perceptions that water use can be improved in the LSC. Sampling identified 5.8% of the LSC's total annual water use, and a need for further research to identify how the remaining 94.2% is used. Increasing understanding of water use supports campus sustainability because water costs and water consumption will continue to increase unless action is taken to understand how water is used, and can be conserved.

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1.0 INTRODUCTION

1.1 BACKGROUND

Fresh water is a valuable finite resource necessary for the maintenance of our planet. Globally, available freshwater supplies constitute less than one percent of the Earth's total water inventory (Pidwirny, 2006). Yet the current trend in Canada is one of increasing water consumption, demonstrated by a ninety percent rise in the rate of fresh water withdrawal over the past twenty-four years (Environment Canada, 2006). Similarly, water consumption within the Life Sciences Center (LSC) at Dalhousie University mirrors this national trend in that excessive amounts are used, and efforts to curb or manage water use have been minimal. Adding to this overall lack of transparency and dialogue regarding current water consumption practices only makes determining the amount and destination of water flow within the LSC all the more difficult to identify. To address this concern, we have endeavoured to understand water consumption and water use within the LSC and – through a micro-case study – determine the requirements and perceptions of water use within the biology and earth sciences student teaching laboratories.

Generally speaking, water conservation policies are not foreign to the zeitgeist of campus sustainability, evidenced by countless campus initiatives with demonstrated results in cost savings and consumption reduction. The University of Manitoba, for example - the largest consumer of water in the city of Winnipeg – has implemented conservation measures that have effectively cut campus water consumption in half. Massive infrastructure changes need not be the required panacea. In fact, simple retrofitting of campus toilets and faucets to the low flush and aerated alternatives, have contributed to savings of over 545 million gallons of water (University of Manitoba, Office of Sustainability, 2005). Similarly, the University of British Columbia - having since implemented the largest energy and water retrofit project of all Canadian universities - has been able to reduce annual water consumption by over 30% with annual savings of $22.5 million (University of British Columbia, Sustainability Office, 2006).

Closer to home, the University of New Brunswick recently implemented energy improvement projects that have reduced both water consumption and cost. The replacement of previous water cooling equipment with more efficient water recycling systems has reduced water use by 44,500 m^3 annually, with a cost avoidance of $45,160 (Natural Resources Canada, Office of Energy Efficiency, 2005).

South of the border, universities have also been leaders in water conservation initiatives. The Massachusetts Institute of Technology (MIT) has had water conservation schemes in place since the early 1990's that have been met with great success. For example, between 1997 and 2005, the university was able to reduce campus water use by 60%. Again, such a monumental figure did not require an about face in daily university operations. In fact, it was relatively simple but effective measures – like the installation of low flush toilets and faucet aerators within all academic buildings – that allowed MIT to incur savings of 11,802,922 gallons of water per year (MIT, 2007).

This is all to say that water efficiency measures generate savings – in both resource use and monetary cost – and are not outside the realm of possibility. While the concern of high costs and low returns is certainly justified, it does not, however, obscure the fact that water efficiency measures can produce tangible results. Reductions in water use – read: reductions in cost – will benefit Dalhousie insofar as monies previously earmarked for water or energy bills can potentially be freed up and made available for other campus priorities.

1.2 RESEARCH PROBLEM

Thus, our research problem - understanding water consumption and water use within the LSC - is addressed through two separate but complimentary approaches. This method is both necessary and appropriate given the water metering practices currently employed within the LSC. Previous investigations have revealed that only a single meter exists to monitor water flow throughout the entire building – therefore making it difficult to determine with precision how water is consumed and used throughout the building (personal communication, January 29, 2007). It is for this reason we chose to adopt a dual approach experimental model that incorporates both exploratory and descriptive research to address the identified problem (Palys, 2003:72).

Together these approaches establish the reliability and validity upon which our project is built, and allow for further exploration and research into water use within the LSC. Accordingly, we chose to employ an information gathering paradigm under the understanding that future Dalhousie students may follow up with an increasingly action focused paradigm. Most importantly, we hope this project will shape future policies by generating recommendations for future modifications to the water delivery system. By pointing out inefficiencies in current management of water resources within the LSC, we hope to influence the implementation of efficiency measures where appropriate, and provide guidance for the possible/ proposed $50 million renovation to the LSC.

We have attempted to address this deficit in water management and conservation by first outlining the principle water consuming activities within the LSC and quantifying the respective proximate volumes of water consumed by each. Combined, this information provides a greater understanding of the water consumption trends within the LSC. In addition to this exploratory approach to understanding water consumption in the LSC, we accomplished a more descriptive analysis of water usage within the laboratories of the LSC by means of conducting a micro case study.

1.3 Importance and Rationale

By gaining an understanding of the ways in which water is *used* throughout the LSC, one can potentially address the ways in which water can be *conserved* throughout the LSC. Conservation of water not only has profound implications for the university; moreover, proper management of environmental resources on campus can effect resounding change throughout entire communities. On the one hand, implementing conservation efforts can save the university money and limit the use of a finite resource. On the other, by showing an interest in how water is managed, Dalhousie is leading by example. As an institute of higher learning, what happens on campus can often set the precedent for emulation throughout surrounding communities. Therefore, this project contributes to greater campus and community sustainability by bringing to light the inefficiencies of water use, and what can be done to mitigate – if not resolve – these problems. Because increasing the sustainability of a university is commensurable with increasing its overall integrity, our project is important insofar that it not only recognizes water inefficiencies, but also because it generates overall awareness regarding how water is managed in the LSC.

Similarly, the rationale for undertaking this project stemmed from concerns that higher water efficiency standards were not being met within the LSC. If attitudes towards water usage can be addressed, and if certain policies regarding water consumption can be recognized, then the avenues for possible remediation increase. With a comprehensive understanding of water use within the LSC, we have generated knowledge that can be used to provide recommendations for a sustainable future.

1.4 RESEARCH OBJECTIVES

Rather than dwelling on previous inaction and infrastructure inefficiencies, we believe Dalhousie has instead been presented with a golden opportunity to effect change and be on the vanguard of the 'greening of the campus' movement. That is, through information gathered within the body of this report, Dalhousie has the potential to present itself as a national leader all the while reducing water consumption and increasing monetary savings.

Another driver in undertaking this research project is the ability to make recommendations for future modifications to the water delivery system. We anticipate that by providing reliable and valid information regarding the current management of water resources within the LSC, we can influence the implementation of efficiency measures where appropriate, and provide guidance for the possible/ proposed $50 million renovation to the LSC.

Additionally, a major objective of this research project was the development of a solid framework upon which further research can be sustained in the future. This was viewed as essential because there is currently so little understanding of how water *is* used in the LSC. As such, we believe that the approach chosen, and the experimental model developed will help to achieve this objective.

2.1 RESEARCH DESIGN

Preliminary investigation revealed that only one water meter oversees the whole of the LSC's water delivery system (personal communication, January 29, 2007). Thus, understanding the LSC's water use required the development of a dual approach experimental model (Figure 1). Both descriptive and exploratory research was conducted in order to assess perceptions of water use within a specific major water use activity, and to estimate volumes of water used by major water use activities respectively (Palys, 2003:72).

The descriptive approach involved distributing questionnaires to Biology and Earth Science faculty who lead student teaching laboratories. The exploratory approach involved measuring both stationary and flowing water volumes of the identified major water use activities occurring in the LSC. Major water use activities were identified and defined as any activity that required the use of water in order to fulfill its main purpose and/or function. Seven activities were identified for preliminary inclusion in the project as is depicted in Figure1.

Again, this dual approach is reasoned to be necessary because understanding water use is not simply a matter of identifying technical problems with the water delivery system; but also about recognizing and identifying the social forces behind those technical problems. We also believe that that as a result of this approach, much of the reliability and validity of our project stems from the model itself.

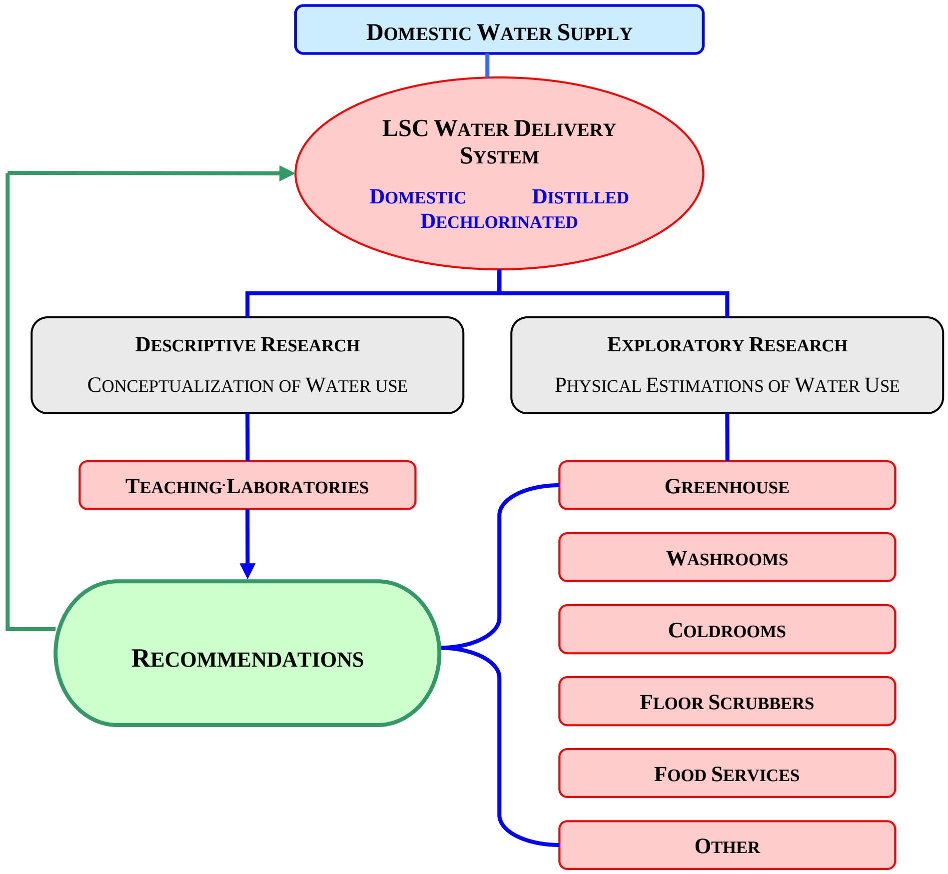

Figure 1: A graphical representation of the dual approach experimental model used to generate understanding of water use within Dalhousie University's Life Sciences Center (LSC) water delivery system. Source: Heather Reed, 2007

2.2 RESEARCH PROCEDURES

The descriptive approach attempted to accurately portray water requirements and perceptions of water use within one of the identified water use activities occurring in the LSC (Palys, 2003:74). To this end, questionnaires were used in an attempt to gain insight into, and accurately portray the perceptions and requirements of faculty who develop and lead student teaching laboratories (Palys, 2003:74). This probabilistic sampling technique of simple random sampling was used within our chosen population the LSC's Biology and Earth Sciences undergraduate student teaching laboratory instructors (Palys, 2003: 129).

In order to ensure the validity of our results, a list was generated from the online academic calendar, and this sampling frame included all the laboratory instructors of Earth Science and Biology labs during the 2007 winter academic term. The survey was hand delivered to all individuals in the sampling frame, within a previously addressed departmental mail envelope. The departmental envelopes contained:

- one copy of the questionnaire
- an instruction sheet
- a second envelope in which the completed survey could be sealed in order to ensure confidentiality

Those individuals who chose to participate were instructed to return the survey to the Faculty of Science office within seven days (through departmental mail). The survey was then collected, the data was recorded, and all hard copies were destroyed to ensure confidentially of the research participants.

This descriptive method was deemed to be appropriate based upon the prescribed methods outlined in *Research Decisions: Quantative and Qualitative Perspectives* (Palys, 2003: 130). We believe that this approach ensures the validity of our findings, and the recommendations to follow because it will enable us to make those recommendations based upon a thorough preliminary investigation of the current requirements and perceptions of water use held by student teaching laboratory instructors.

The exploratory approach attempted to gain familiarity and understanding of the current water delivery system, and the various water use activities within the LSC (Palys, 2003:130). Our sampling also sought to seek out and identify, to the best of our ability, all “other” activities that consume water within the LSC. This was achieved through interviews with Facilities Maintenance personnel, water equipment personnel, physical sampling, and review of appropriate literature and reference materials.

To further our understanding of the identified major water use activities, and to approximate their consumption volumes, we embarked on a sampling scheme of the various components and activities that make up the water delivery system. This was achieved through further purposive sampling of each identified activity (Palys, 2003: 142). The particular nonprobabilistic sampling method used to approximately quantify the stationary and flowing volumes of water used by each activity was determined activity by activity, as appropriate techniques for each identified activity could be determined. However several of these techniques included, but were not limited to, observation, measuring equipment dimensions and flow rates, scheduled consumption patterns, and other relevant technical details. In circumstances where physical sampling was not feasible, estimations were made based on values cited in literature. In order to calculate and extrapolate annual consumption rates for each identified and sampled activity additional specific assumptions and limitations were required by each. Activity specific methods, assumptions and limitations are located in section 2.4, and complete calculations are located in Appendix A.

This exploratory method was deemed to be appropriate based upon the prescribed methods outlined in *Research Decisions: Quantative and Qualitative Perspectives* (Palys, 2003: 142). We believe that this approach will ensure the reliability and validity of our research, and the recommendations to follow because it enabled us to thoroughly investigate what equipment and processes make-up the LSC's water delivery system, and how water is being used by the identified major water use activities.

2.3 Research Tools

As an added qualitative component of our project, we distributed questionnaires to all Biology and Earth Sciences student lab instructors. Questions were designed to highlight water use patterns and requirements in teaching laboratories, and to gain insight into perceptions of laboratory water use by faculty who design and lead student laboratory activities. In the interest of time, research was limited to the biology and earth sciences undergraduate student teaching labs. Prior to administrating this survey, pilot tests were first conducted within similar populations so as to ensure quality assurance, and to ultimately provide the most representative answers.

Individuals were provided information related to the nature of our research and asked to voluntarily complete the survey within a period of seven days. This particular approach was chosen so as to provide the most accurate body of information related to attitudes and perceptions of water use within the Biology and Earth Sciences student teaching labs, as well as more particular information related to the amounts and locations of water used. As was previously mentioned, this method was deemed to be appropriate based upon the prescribed methods outlined in *Research Decisions: Quantative and Qualitative Perspectives* (Palys, 2003: 130).

2.4 Analysis Methods

As was previously stated, each major water use activity included in the project required a unique approach in order to estimate how much water it uses. Furthermore, the unique approach applied to each activity sampled helped to ensure reliability of the data, while the overall assumptions used to standardize the estimates helped to ensure the validity of the project itself.

2.4.1 Laboratories

Completed questionnaires were assembled and analyzed for water use trends, perceptions and attitudes amongst biology and earth science laboratory instructors. All information was recorded in spreadsheet, graphical and table formats. The frequency of individual answers was determined so as to provide a foundation for comparison amongst all those surveyed. The subsequent findings were in part based upon the attitudes and opinions expressed within these comparisons. Results of this questionnaire can be found in section 3.1.

2.4.2 Greenhouse

The greenhouse is located on the eighth floor of the LSC and is used to grow plants used in Biology student laboratories, for research purposes as well for raising plants for display purposes (Dalhousie University Biology Greenhouse, n.d.)

Figure 2 - Greenhouse located on the 8th floor of the LSC, Dalhousie University. Source: Jessica Hart, 2007

2.4.2.1 OVERVIEW

This area was identified to be included in the research project because the greenhouse utilizes water to fulfill its main purposes, raising plants. Methods used to gather data in this section included oral interviews with Carman Mills, physical data collection from water fixtures and identification of general water use patterns.

2.4.2.2 RESEARCH PROCEDURES

As a group identified water use activities in the LSC and identified the greenhouse as a water user. Started by using subject search on www.dal.ca to identify who was in charge of the greenhouse - identified Carman Mills as the Greenhouse Manager and Ornamental Horticulturist. I then used people search on www.dal.ca to determine his email address and the location of his office. He was contacted by an email discussing the project, what we would like to do, and asked if he would be willing to help us. Through email communication meeting times were arranged that were convenient for both parties.

Before the first meeting; the group met, identified and approved a standardized method (questions (qualitative data), and how we would calculate and estimate water use (quantitative data)) that the group agreed would be accurate to ensure reliability and validity.

Had the first meeting with Carman and toured the greenhouse and conducted an informal interview - collected qualitative data only and made list of limitations regarding the greenhouse and arranged for a second meeting to obtain quantitative data (i.e. flow rate, how often plants are watered, etc.). Prepared questions included:

- *What equipment does the greenhouse use?*
- *How often are the plants watered?*
- *How long are the plants watered for?*
- *How many rooms are there in the greenhouse?*

The full set of questions and answers can be located in Appendix D.

Estimates of water use were gathered using the tools:

- hose
- tub of known volume

At the second meeting, Carman used a tub of known volume and turned the hose on and timed how long it took to fill the tub of known value. The operational characteristics were confirmed (how often plants were watered, etc.). The calculations can be found in Appendix A.

2.4.2.3 ASSUMPTIONS

The assumption made for the greenhouse was that the estimated operational characteristics provided by the interview conducted (i.e. how long the plants are watered each day, and the length of summer and winter seasons) were accurate.

2.4.2.4 JUSTIFICATIONS

This assumption can be justified in that, to ensure reliability and validity, these estimations were gathered from an expert, Carman Mills. He is the greenhouse manager and would be the best person to estimate the greenhouse operation characteristics.

2.4.2.5 LIMITATIONS

Limitations for the greenhouse were specific and numerous, but pertained only to the greenhouse. There are many factors that caused limitations for the project that limited the extent to which we could make accurate claims. The main limitation revolved around the fact that we couldn't get a set schedule for the amount of time the plants were watered per day/week/month/season or year. Factors influencing the schedules of plant watering included the amount of sun (the more sun there is the more the plants need to be watered and therefore water use increases) and vice versa in that with increased cloud and rain the plants require less watering. The length of the summer and winter seasons (summer and winter seasons vary depending on the temperature of the months), the time spent in a single room varies depending on the number of plants in a room, some rooms are more humid than others and are therefore watered less frequently. Every plant requires different amounts of water depending on the plant type, plant size and size of the pot that the plant is in. These are all limitations specific only to the greenhouse and that affect the annual water use calculations in that the operational characteristics are only estimates based on the best available knowledge.

2.4.3 WASHROOMS

There are washrooms located on every floor in the LSC and in every wing, there are also two large "common" washrooms on the 2nd floor (Figure 3). There are both male and female washrooms in each location.

Figure 3. Washroom – LSC, Dalhousie University. Source: Jessica Hart, 2007

2.4.3.1 OVERVIEW

This area was identified to be included in the research project due to the fact that washrooms require water to perform their main functions (i.e. toilet, urinals, faucets). Methods used to collect data in this identified water use activity included collecting physical data from water fixtures, such as flow rates, and through literature based research into average litres per flush (Lpf) for non low-flow urinals as well as general patterns of washroom use for individuals.

We set out to identify and create a standardized method of how the quantitative data would be gathered and calculated to determine an estimate of water use in the washrooms in such a way that the numbers are accurate within the stated limitations and to ensure reliability and validity of the data.

2.4.3.2 RESEARCH PROCEDURES

Three wings were identified in the LSC that required sampling. It was also determined that the main floor (2^{nd} floor) would have to be done separately as the washrooms are not located in any of the three identified wings. The brand of toilet, faucet and urinal was identified, the number of each was noted, and , the litres per flush (Lpf) of the toilets and urinals was noted or determined in available literature. The number of sinks were noted (any leaky faucets were recorded), and flow rates were sampled and recorded for each. This was done by turning on the taps fully, and capturing the water flow per 3 second intervals. The flow rates were then converted to litres per minute. This method was used on all subsequent floors and in the Oceanography wing, the Psychology wing and the common washrooms located on the main floor.

Research was done in order to determine the average Lpf of the urinals in the LSC and for the estimated number of times people use the washroom per day. The urinals were determined to be using 6 Lpf, (Sloan, 2005) and the estimated number of times people used the washrooms was determined to be three times a day during an average 8 hour work day (Environment Agency, 2007). The data was gathered and the numbers were calculated to get an estimate of total water use annually for the washrooms (Look to Appendix A for calculations).

2.4.3.3 ASSUMPTIONS

An assumption made for the washrooms was that all of the washrooms located in the LSC were used equally (male/female, equipment type, and location).

2.4.3.4 JUSTIFICATIONS

This method was deemed appropriate since there was no information of this type available, and no way to definitively determine it ourselves due to strict time limitations. Therefore for ease in completing calculations this was determined to be the most accurate method in which to follow.

2.4.3.5 LIMITATIONS

A limitation for the washrooms was that there was no way to determine the actual number of individuals using the washrooms or accurately determine the number of times/day they used the washroom, or which bathrooms were used the most. Due to time constraints and that many people would find it uncomfortable to have someone sitting in the washroom taking notes, it would be unethical. Also, 1st floor washrooms were not included in our calculations. It was felt that there were not enough students that used the 1st floor washrooms to warrant us to include them into our measurements and calculations. Another limitation was the use of student numbers in each faculty as representative of the total number of individuals who use the LSC washrooms each day. Therefore, faculty, facilities management, researchers, visitors, etc were not specifically included in the calculations.

2.4.4 COLDROOMS

Throughout the LSC there are numerous coldrooms in use that are water-cooled (Fig. 4). During operation, water is more or less constantly cycling through the units in order to maintain a cool internal temperature; however, the system is not a closed one (Fig.5).

Figure 4. Outside view of a typical cold room. Source: Paula Francis, 2007.

Figure 5. Outflow pipe of a typical cold room. Source: Paula Francis, 2007.

2.4.4.1 OVERVIEW

These units were identified for inclusion to the research project because the units are utilized throughout the entire LSC and they require the use of water to maintain cool temperatures. Methods used to gather data in this section included unobtrusive observation, oral interviews with Steven Fry, the designated person in charge of the freezers in the Biology and Earth Sciences wing, and physical measurements and data collection of the cold rooms, including size and water flow rate.

2.4.4.2 RESEARCH PROCEDURES

An informal interview was conducted with Steven Fry in order to garner further information regarding the number of functioning cold rooms in the Biology and Earth Sciences wing and how often they are in use.

In order to determine the average size of a cold room we used a four-meter tape measure to obtain length, width, and depth measurements for the cold rooms that we had access to. These measurements were then used to determine the average size of a cold room in cubic meters.

In order to measure the rate of water flowing out of the pipe we collected the water using two plastic bags and a large Rubbermaid container. One bag would be placed beneath the outflow pipe until it was almost full and then we would position another bag in its place so that no water was lost, and then we would empty the water from the first bag into the large Rubbermaid container. This was repeated constantly for a twenty-minute time period. At the end of the twenty-minute time period the total volume of water in the Rubbermaid container was determined by using a large one litre measuring cup. This was done by removing the water from the container, using the one litre measuring cup, and keeping track of the total number of litres emptied. Once we determined the total number of litres collected from this cold room during the twenty-minute time period we then used this number to calculate a litres per minute flow rate.

2.4.4.3 ASSUMPTIONS

Once we determined the total number of litres collected from this cold room during the twenty-minute time period we then used this number to calculate a litres per minute flow rate. Once this flow rate was determined for one cold room we based our calculations for total volume of water used per year per cold room on the assumption that each cold room is operating 24 hours a day for 365 days a year. This assumption is based on the fact that the freezers are in use for research purposes throughout the year and not only for the academic school year. Additionally, as a result of structural limitations we only had access to the outflow pipe of one cold room on the fifth floor. Despite variation in temperature settings (°C) and size (m^3) for each cold room we assumed that the variations would not significantly alter the total volume of water used. Therefore, our calculations for the total volume of water used per coldroom per year is based on the measurements obtained from the one cold room on the fifth floor that we had access to.

2.4.4.4 JUSTIFICATIONS

These specific methods, tools and assumptions were chosen based on observations carried out by our group members and interviews conducted with those more familiar with the operations of the cold rooms. Additionally, as a result of the age of the cold rooms, formal information in the form of operating manuals, were unavailable and methods to determine total volume of water used per cold room needed to be established. Finally, our methods, tools, and assumptions were chosen to ensure the reliability and validity of the measurements.

2.4.4.5 Limitations

The major limitations involved with this sample set included limited access to all cold rooms for both water flow measurements and size measurements; limited access to cold rooms housed outside of the Biology and Earth Sciences wing; and limited amounts of information pertaining to operating times.

2.4.5 Floor Scrubbers

The floor scrubbers, Karcher Automatic Scrubbers (Fig. 6), can be observed being used daily in the main hallways on the main floor, in the main section on the 3^{rd} floor, as well as in each additional wing. There are 4 floor scrubbers in use in the LSC; 1 large and 3 small. The large is for use in the main hallways and the Biology/Earth Sciences/Environmental Science wing, and the 3 small are for use in each of the wings respectively (Biology/Earth Sciences/Environmental, Psychology and Oceanography).

Figure 6. Floor Cleaner – LSC, Dalhousie University. Source: Jessica Harts, 2007

2.4.5.1 Overview

The floor scrubbers were included in the research project due to the fact that they use water to perform their main function of cleaning the floors. Methods used to collect data on the operational characteristics and volume of water held by the floor scrubbers was done by requesting the information from Gary Gaudet of Facilities Management.

2.4.5.2 Research Procedures

As a group identified water use activities in the LSC and identified floor cleaners as a user of water. We met with Gary Gaudet and asked him if he could provide the number of floor cleaners in use in the LSC, the volume of water held in each of the floor cleaners, and the daily use of the floor cleaners for both the summer and winter seasons. This information was then received by email, which can be found in Appendix C. The information was complete and thorough, and the estimated annual water use was then calculated from the given values and schedules. These calculations can be found in Appendix A.

2.4.5.3 ASSUMPTIONS

An assumption made for the floor scrubbers was that the schedule given was the schedule used for daily cleaning for each week and season and that the floor cleaners hold the volume stated in the email and are filled to capacity each time.

2.4.5.4 JUSTIFICATIONS

This is justified in that it is facilities management that makes the schedules and it can then be assumed that custodial personnel follow the schedule as given. Also that the volumes held by each scrubber are accurate in that the data in the email came from the manufacturers book that came with the machines.

2.4.5.5 LIMITATIONS

Not being able to spend an entire day observing the custodial personnel to see if the schedule given is followed as stated in the email is a limitation. It would be both time consuming and unethical.

2.4.6 FOOD SERVICES

Food services within the LSC are located within two main areas. The 3rd floor cafeteria which includes Easy Goes, Manchu Wok®, Pizza Pizza® and Grilleworks; and the 2nd floor snack stand, Tim Horton's® and associated bake shop.

2.4.6.1 OVERVIEW

These areas were identified for inclusion to the research project because food services are utilized by the greater LSC community; and because food service facilities require water use for preparation, serving, and clean-up as required by Nova Scotia's Food Safety Regulations (Province of Nova Scotia, 2006). However, it was determined through interviews that all food preparation is conducted in the Aramark main kitchen at

Howe Hall, therefore food service water consumption in the LSC includes only serving food, and subsequent clean-up.

Research tools used to gather data in this section included unobtrusive observation, oral interviews with food service staff and management, and physical measurements and data collection of water appliances and general water use patterns.

2.4.6.2 RESEARCH PROCEDURES

Both cafeteria and Tim Horton's shift managers were approached with a request for their time to answer questions and provide a tour of their facilities. Prepared questions included:

- *What equipment uses water*?
- *Where is food prepared*?
- *Where are dishes washed*?
- *How many hand washing sink's are in staff only areas*?
- *How many pots of coffee are prepared daily*? (Tim Horton's® specific)
- *How many people hours do your staff work on an average day*?

Estimates of water use were tailored to each piece of equipment, and tools used to gather the data included:

- 4m tape measure, to determine stationary volumes of water
- 1L measuring cup, to determine flowing volumes of water
- stop watch, to determine flowing volumes of water

Stationary volumes of water, found in the dish sink and steam table, were estimated by measuring and calculating height × width × depth of water. Flowing volumes of water, found in the hand sinks and grill, were estimated by capturing a volume of water per unit time. The total estimations of water used were then determined by extrapolating time related use patterns of each piece of equipment or through estimates provided in literature or through self reporting.

2.4.6.3 ASSUMPTIONS

Due to the nature of this data collection, from multiple varying sources, it was deemed necessary to make a number of equipment specific assumptions in order to ensure consistency in the estimates generated.

Grill: - The grill is active for 8hrs/day, 5 days/wk, 49 wks/yr (52 wks – (2 wk winter holiday + 1 wk reading break)

- One drip = $\frac{10\ 000L}{yr} = \frac{27.397L}{day} = \frac{1.142L}{hr}$ (USGS, 2006)

Hand Sinks: - The sinks are used 5 days/wk, 49 wks/yr
- Each employee washes their hands approximately twice an hour, based upon health and safety recommendations
- Hand wash time is based on posted Aramark guidelines, and was estimated, by trial, to be 80sec/wash = 1.333 min/wash

Steam Tray: - The steam tray is used 5 days/wk, 49 wks/yr

Dish Sink: - All LSC food service dishes are washed at this location
- Self reporting estimated one sink of dishes is washed per day
- The sink is used 5 days/wk, 49 wks/yr

Tim Horton's Coffee: - Approximately 100 pots of coffee are made each day, based on self reporting by Tim Horton's® staff
- Each pot contains 76 oz of coffee (measured by the automatic coffee maker), and 1.0 oz = 0.0296L
- The facility is used 5 days/wk, 49 wks/yr

2.4.6.4 JUSTIFICATIONS

These specific methods, tools and assumptions were chosen because food preparation areas and activities are closed to the general public. Also, the industrial equipment and protocol for food establishments and restaurants were unfamiliar to the group, and required 'insider' perspective. Furthermore they were chosen to ensure the reliability and validity of the measurements within the stated limitations.

2.4.6.5 LIMITATIONS

Limitations specific to this sample set include an inability to accurately determine the number of times each employee washes their hands each day. Also, the estimate for hand washing time is likely an overestimation as most individuals will not spend 1.33 minutes washing their hands. Also, no estimations were attempted for cleaning purposes such as washing and sanitizing of equipment, counters, and floors. As such, it was determined that there were too many variables involved in such estimations, and that any attempt made would not be valid or reliable.

2.4.7 OTHER

As was previously mentioned this accounting of "other" major water use activities was generated throughout the course of exploratory research. In particular, this list was achieved through interviews with Facilities Maintenance personnel, water equipment personnel, physical sampling, review of architectural plans, and review of appropriate literature and reference materials. These "other" major water use activities include, but are not limited to (Personal communication, February 26, 2007):

- Decontamination tanks (2)
- Industrial grade washing machine (1)
- Wet rooms (4)
- Autoclaves, water cooled (4)
- Slowpoke nuclear reactor, water cooled
- Freshwater fish tanks
- Cage washers (5)
- Distillation process, has a 5:1 ratio of domestic water to distilled water (2)
- deionization process, used in gene laboratories
- Growth chambers
- Industrial bottle washers (2)

2.5 COST ANALYSIS

In addition to generating estimates for volumes of water consumed in the LSC per year, part of our project included generating cost estimates for these estimated volumes. In order to generate these cost estimates we contacted Halifax Regional Water Commission to determine the price of water per meter cubed (CDN$/m^3) and to determine if Dalhousie's water charge was based on a pay structure different than that of other domestic water users. We determined that Dalhousie pays a similar rate to other domestic water users in Halifax Regional Municipality and that this rate is $1.46 per cubic meter, or 1000 litres.

This CDN$1.46 per cubic meter charge is broken down into a CDN$0.3770 charge for water itself, a CDN$0.7504 environmental protection charge, and a CDN$0.3286 waste water and storm management charge. In addition to the CDN $1.46 per cubic meter charge, Dalhousie is also charged CDN$319.75 per month for the one six-inch water meter that is installed on the LSC's domestic water line. Therefore, in total, it was determined that Dalhousie pays a base rate of approximately CDN$4000 per year plus CDN$1.46/m^3. It is important to note that included in the waste water and storm water management charge per month is a CDN$0.0042 commodity charge increase that was implemented on the 1st of April, and that a similar increase is scheduled for April 2008. These increases are a direct result of the Harbour Solutions Project; as this project progresses we can only assume that water costs will continue to rise.

2.6 LIMITATIONS

The overall limitations of this research project were that of size, time, and accessibility. The LSC is a large building complex with multiple wings and floors, with some areas of the building having restricted or limited access. Additionally, we were constrained by individual schedules that existed outside of the research project and the four-month period allotted to complete the research. Therefore, garnering information about every water use in the entire LSC was not feasible. This meant that we were unable to include all sections or wings of the LSC in our research project. Furthermore, we were limited by the availability of individuals who could provide expert opinion regarding water consumption trends in the LSC. Finally, a compelling limitation was the existence of only one water meter to monitor water usage for all water use activities in the entire LSC.

2.7 DELIMITATIONS

The greatest delimitation of this research project is the fact that it was designed to provide a solid framework, upon which further research can be sustained in the future, and not direct and immediate actionable outcomes. We believe that this is the correct approach because true sustainability is a process, and not an end point. Additionally, our initial picture of how water is currently used within the LSC was based upon the best possible estimates that could be generated within the limitations imposed. As such, a secondary delimitation of this research is that it can not recommend with certainty what actions *should* be taken in the future, but simply that some action *must* be taken in the future in order that we *are* able to understanding how water *is* used in the LSC.

3.0 RESULTS

The five major water use activities included in the project and that underwent sampling were able to account for 27,759,670 L/yr or 5.8% of the LSC's total annual water use (Table 1, Figure 7 & 8). The total annual water use of the LSC is ~ 480,843 m^3/yr based upon the average water use for the last two years of available data, which is equivalent to ~ CDN$702,030.78. This communication is located in Appendix C.

Table 1. List of identified water users in the LSC and their estimated water use in litres per year (L/year), and converted to meters cubed per year (m^3/year) for use in calculating the estimated total cost in Canadian dollars per year (CDN $/year). Source: Jess Hart, 2007.

Major Water Use Activity	L/year	m^3/year	CDN $/year
Greenhouse	571, 200	570	$830
Washrooms	16, 721, 890	16, 720	$24, 410
Food Services	1, 129, 500	1, 130	$1, 650
Cold Rooms	8, 094, 240	8, 090	$11, 820
Floor Cleaners	1, 242, 840	1, 240	$1, 820
Base Rate	-	-	$3, 840
Totals	27, 759, 670	27, 750	$44, 370

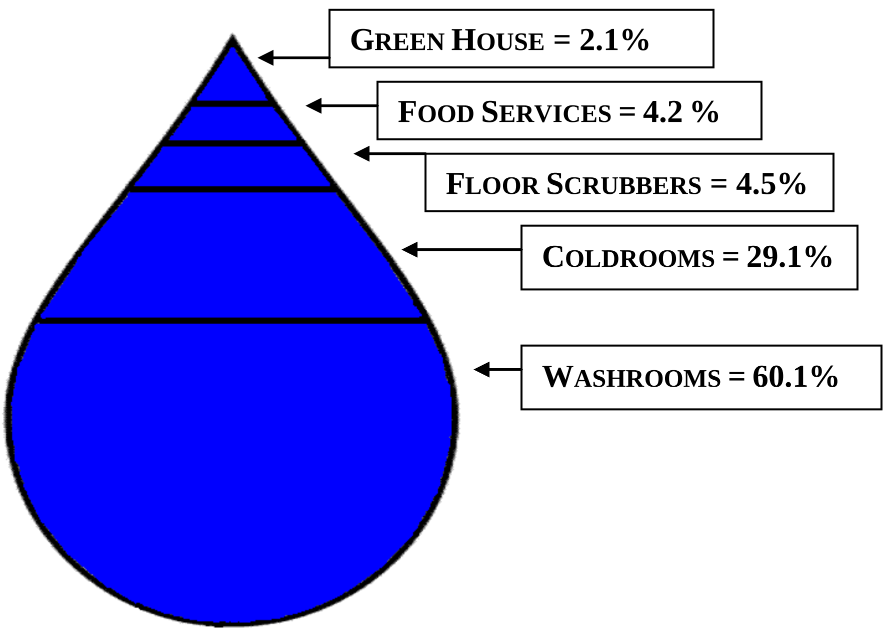

Figure 7: Percent composition, by water use activity, of total estimated major water use activities within the LSC. Source: Heather Reed, 2007

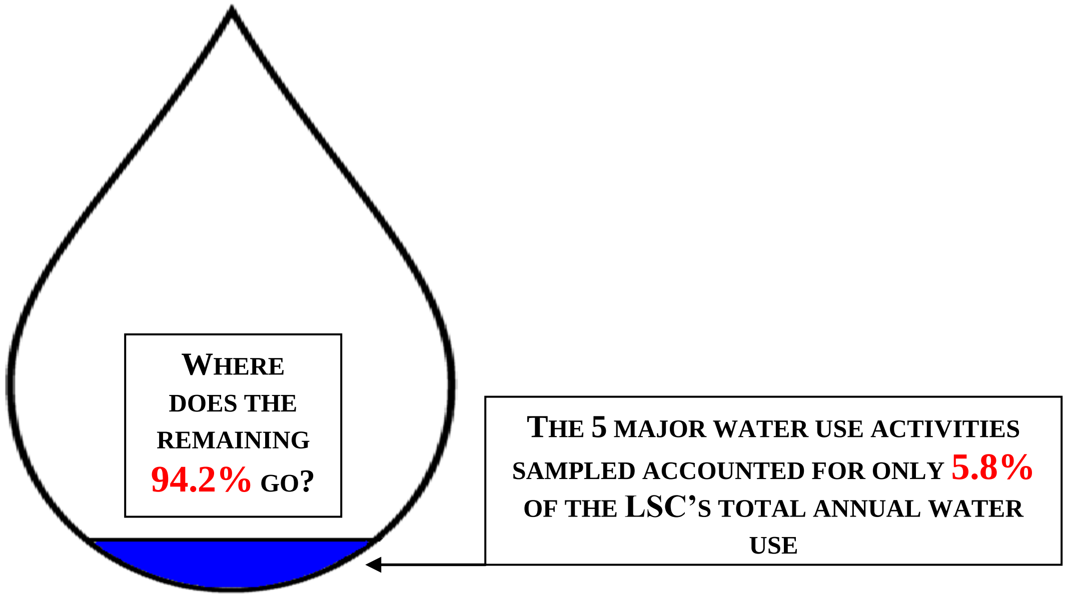

Figure 8: Percent composition, of the five sampled major water use activities, of the total annual LSC water use. Source: Heather Reed, 2007

3.1 Laboratory Survey Results

The following information applies to the sampled population of winter semester Dalhousie biology and earth science undergraduate student teaching lab instructors. Of the eighteen distributed surveys, twelve were returned. The following information therefore relates to the answers expressed within the survey as indicated by the twelve respondents. An analysis of the findings follows in the results section.

Table 2 – Attendance type in biology/ earth sciences laboratories

Laboratory Attendance Type	Number of Labs
Weekly	10
Bi-Weekly	2
Total	**12**

Table 3 – Frequency of water use in student teaching labs

Response	Frequency	%
0 (never)	1	8.3
1-25%	5	41.7
26-50%	3	25
51-75%	1	8.3
76-99%	-	-
100%	2	16.7
All Responses	**12**	**100**

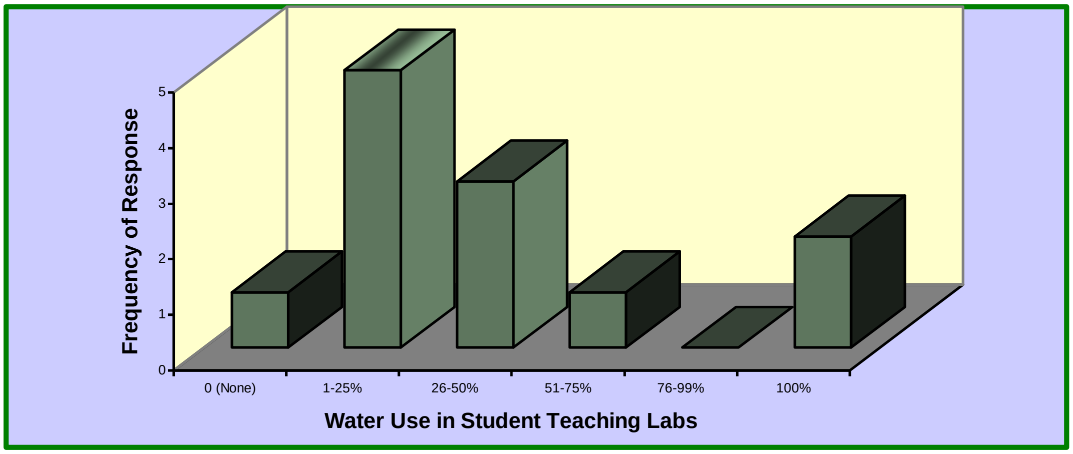

Figure 9- Frequency of water use in student teaching labs

Table 4– Water type used in student teaching labs

Response	Frequency	%
Domestic	11	55
Distilled	6	30
Dechlorinated	1	5
Salt	2	10
Other	-	-
All Responses	**20**	**100**

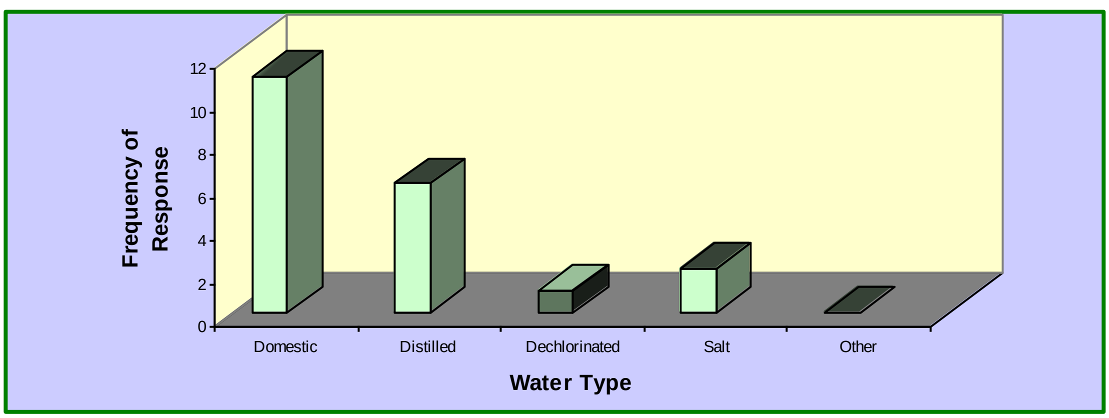

Figure 10- Water type used in student teaching labs

Table 5 – Laboratory water uses

Response	Experiment Preparation		Experiments		Cleaning of Equipment		Hygiene	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
Use water all of the time for this activity	2	18.2	1	10	6	54.5	5	45.4
Use water some of the time for this activity	6	54.5	5	50	3	27.3	4	36.4
Use water rarely for this activity	1	9.1	3	30	2	18.2	2	18.2
Never use water for this activity	2	18.2	1	10	-	-	-	-
All Responses	**11**	**100**	**10**	**100**	**11**	**100**	**11**	**100**

Table 6 – Response to query regarding instructor awareness of water use in student teaching labs

Response	Frequency	%
Completely aware	1	8.3
Mostly aware	3	25.0
Somewhat aware	4	33.3
Not aware at all	4	33.3
All Responses	**12**	**99.9**

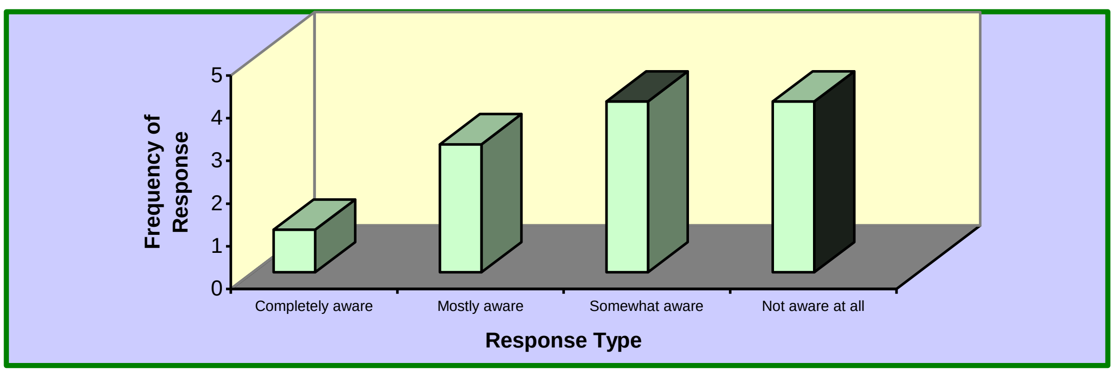

Figure 11- Response to query regarding instructor awareness of water use in student teaching labs

Table 7– Response to query regarding the likelihood of improving water efficiency in student teaching labs

Response	Frequency	%
Definitely yes	-	-
Likely	4	33.3
Unlikely	7	58.3
Definitely no	1	8.3
All Responses	**12**	**99.9**

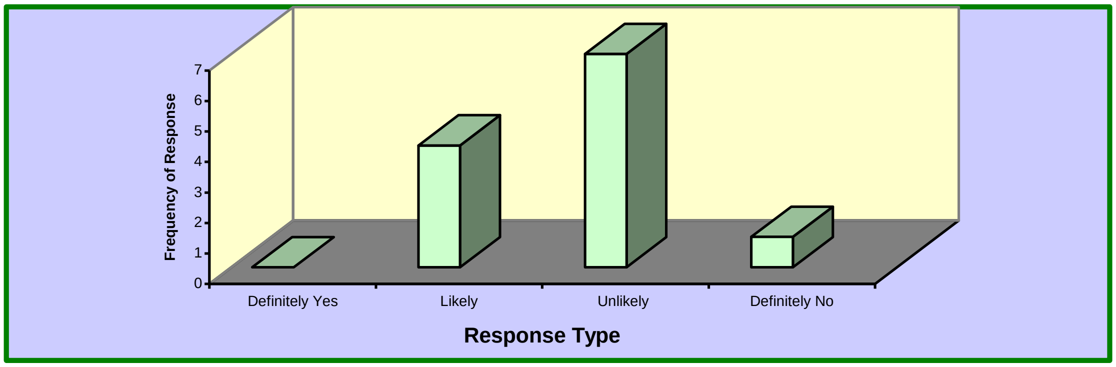

Figure 12 - Response to query regarding the likelihood of improving water efficiency in student teaching labs

Select Comments included with responses to query regarding the likelihood of improving water efficiency in student teaching labs:

1) "While we do not keep track of water usage, I don't think we overtly waste it either."
2) "In some instances water can be reused so that total volumes used can be lowered."
3) "Keep taps from running."
4) "Minimum water is used except for maintaining live algae where running water is needed. Tank is shut down at the end of term."
5) "Water is used primarily for cleaning equipment and washing hands, so I don't see how this can be reduced (i.e. there is a minimum amount of water required for hand washing)."
6) "I use very little."
7) "Students rinse their slides for too long a period of time."

Table 8 – Response to query regarding the amount of lab time requiring the use of refrigerated specimens and/or samples

Response	Frequency	%
0 (never)	7	58.3
1-25%	3	25.0
26-50%	1	8.3
51-75%	-	-
76-99%	1	8.3
100%	-	-
All Responses	**12**	**99.9**

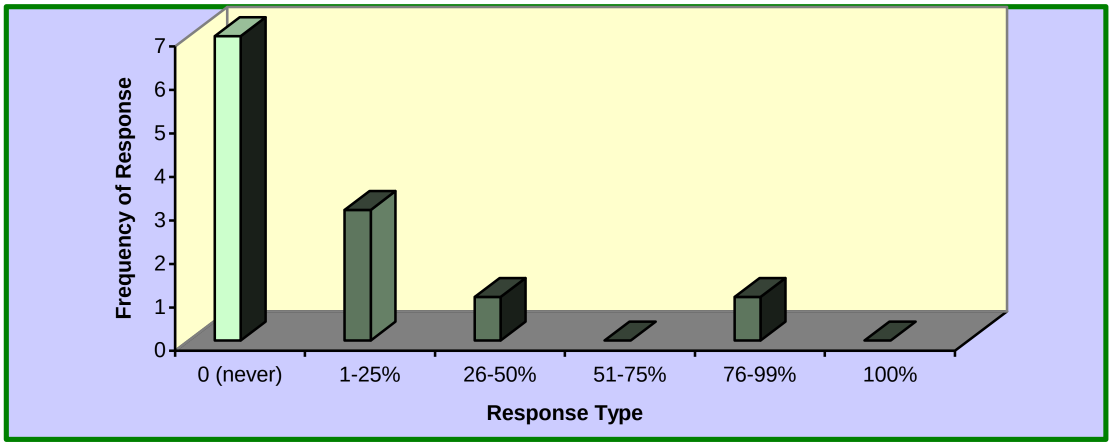

Figure 13 - Response to query regarding the amount of lab time requiring the use of refrigerated specimens and/or samples

Table 9 – Response to query regarding the likelihood of water being used more efficiently within the LSC

Response	Frequency	%
Definitely yes	4	33.3
Likely	7	58.3
Unlikely	1	8.3
Definitely no	0	0
All Responses	**12**	**99.9**

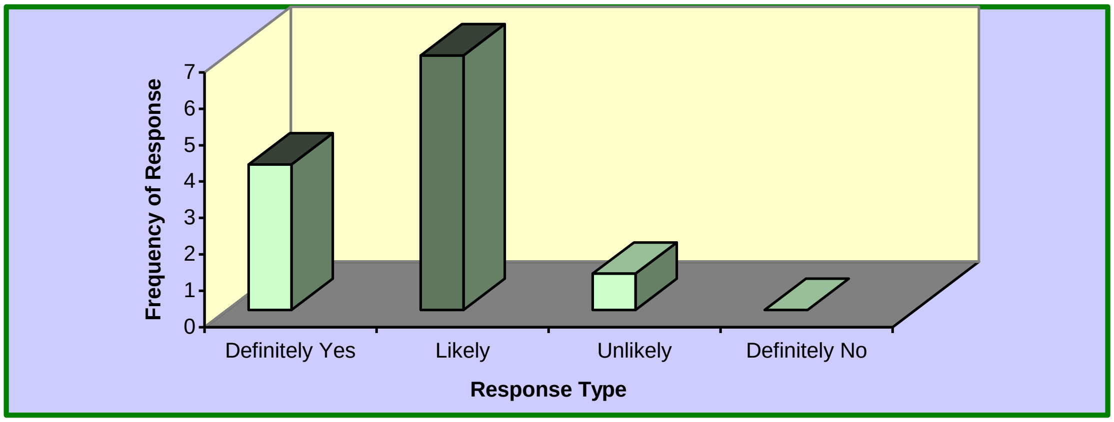

Figure 14 - Response to query regarding the likelihood of water being used more efficiently within the LSC

Select comments included with response to query regarding the likelihood of water being used more efficiently within the LSC :

1) "I feel that water could be used more efficiently, but outside my lab area I am not sure how efficiently water is used."
2) "Low flush toilets and taps that turn off automatically."
3) "Low water use faucets and toilets."
4) "Water is used for necessary cleaning, so I don't see how it could be reduced."
5) "Not sure, but usually some efficiencies can be found when looked for."
6) "Turn off taps quickly."
7) "In the toilets and washrooms (i.e. not necessary in the labs)."
8) "…probably always room for improvement (although unsure)."
9) "More efficient toilets."

Table 10 - Response to query asking if water efficiency is important to the individual

Response	Frequency	%
Strongly agree	3	25
Agree	8	66.7
Disagree	1	8.3
Strongly disagree	-	-
All Responses	**12**	**100**

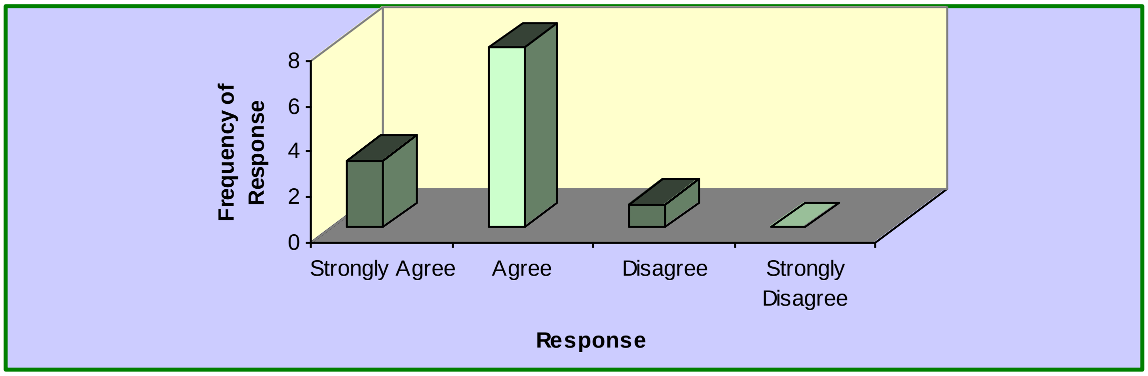

Figure 15 - Response to query asking if water efficiency is important to the individual

Table 11 – Response to query regarding support for water efficiency measures within student teaching labs

Response	Frequency	%
Strongly agree	3	25
Agree	7	58.3
Disagree	2	16.7
Strongly disagree	-	-
All Responses	**12**	**100**

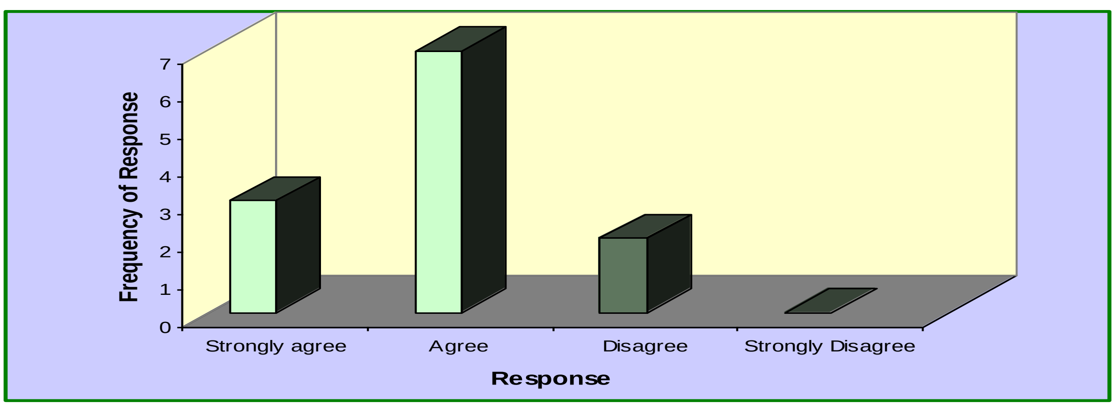

Figure 16- Response to query regarding support for water efficiency measures within student teaching labs

Comments included with response to query regarding support for water efficiency measures within student teaching labs:

1) "While there is no active program to be efficient in water use, there does not, however, appear to be an overuse issue that we are aware of."
2) "Part of the learning process – hopefully students will take these measures with them when the leave or graduate."
3) "I do not explain (water) efficiency to students."
4) "It sets a good example."
5) "I agree with the idea of using water efficiently, but am unsure as how to improve on this."
6) "Taps could be replaced to reduce water use."
7) "I try to tell my students in the labs but with 200 students in two lab rooms, I do not see how much water each student uses."

Table 12 – Response to query regarding whether or not water efficiency measures would compromise the integrity of lab activities

Response	Frequency	%
Strongly agree	-	-
Agree	-	-
Disagree	10	83.3
Strongly disagree	2	16.7
All Responses	**12**	**100**

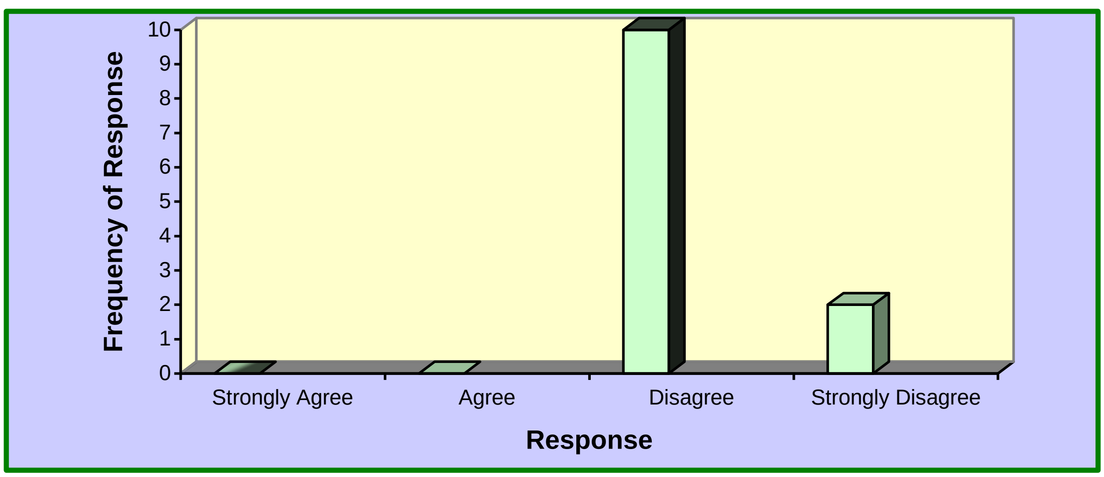

Figure 17 - Response to query regarding whether or not water efficiency measures would compromise the integrity of lab activities

Comments included with response to query regarding whether or not water efficiency measures would compromise the integrity of lab activities:

1) "I guess this would depend on the measures implemented, but I feel we could adapt to most measures, unless there was a dramatic reduction to access."
2) "Students would like it."
3) "Depends on the measure…could be a problem but not likely."
4) "The experiments themselves would not be compromised, but it would mean dirty hands and dirty equipment."

Suggestions for improving water efficiency in labs:

1) "I will try to remind students to turn off water taps when they do not need water."
2) "No – bathrooms are the main users."
3) "I don't know the seawater system well enough, but presumably tanks could be shut down of consolidated when not in use even between labs (some tanks run all the time and no one seems to be using them)."
4) "I can't think that the teaching labs are the problems – it's a more general problem – i.e. some research labs."
5) "Automatic on/off taps."
6) "Meters would be interesting to find out the actual volume used."
7) "Fix dripping taps."

3.2 GREENHOUSE RESULTS

Sampling revealed that eight hoses are operated in eight separate greenhouse rooms. In addition there are 4 overhead irrigation units, however they provide minimal contribution to plant watering and are used primarily to increase the humidity. Technical data was provided by Carman Mills during an interview, which is available in Appendix C.

Total estimates of greenhouse water use and cost were:
- 571, 200 L/year
- 571.2 m^3/yr
- CDN$833.95

3.3 WASHROOM RESULTS

Table 13 – Total number of toilets, urinals and faucets located in the Biology/ Earth Sciences/ Environmental Science, Oceanography and Psychology wings of the LSC. Source: Corey Webster, 2007.

LSC Washrooms	Toilets	Urinals	Faucets
Men	19	23	29
Women	34	-	32
Total	53	23	61

Total estimates of washroom water use and cost were:
- 16, 721, 885.26 L/yr
- 16, 721.88526 m³/yr
- CDN$24, 413.95

A more detailed table, with greater breakdown of data, is available in Appendix E.

3.4 Coldroom Results

Table 14 Location, quantity, temperature range and setting for cold rooms located in the Biology and Earth Sciences wing of the LSC. Source: Paula Francis, 2007

Location (floor)	Quantity (#)		Temperature Range (°C)	Current Temperature (°C)
	Operating	Not Operating		
1	1	-	4-14	14
2	1	-	7-10	5
3	3	-	5-10	8
			3-6	8
			N/A	N/A
4	1	2	5-room temp.	+/- 1
			0-25	-1
			N/A	17
5*	1		1-5	5
6	2	-	N/A	N/A
Total	9	2		

*The 5th floor coldroom measured 241cm in height to the top of the true ceiling (206 cm in height to the top of the false ceiling), 276cm long, and 276cm wide, resulting in an overall measurement of approximately $18.36m^3$

Table 15. Total estimate of water use in litres per year and meters cubed, and annual cost in Canadian dollars of coldrooms in the Biology and Earth Sciences wing of the LSC. Source: Paula Francis, 2007

Cold rooms in use	Litres/year (L/yr)	Cubic Meters/year (m^3/yr)	Canadian Dollars/year CDN$/year
1	735840	735.84	$1,074.33
All (11)	8,094,240	8,094.24	$11,817.59

3.5 Floor Scrubbers

Sampling revealed that 1 large (84.4L) and 3 small (42L) Karcher Automatic Scrubbers are used within the LSC. Technical data was provided by Gary Gaudet in a personal email, which is available in Appendix C.

Total estimates of floor scrubber water use and cost were:
- 1, 242, 841.6 L/yr
- 1, 242.8416 m^3/yr
- $1, 814.55/yr

3.6 FOOD SERVICES RESULTS

Sampling revealed that Aramark food serviced is not charged for its water use, and that no water meters are in place to record their water use within the LSC. Additionally, eight pieces of equipment were identified as requiring the use of water, and these were:

- 1 dish sink
- 3 hand sinks
- 2 automatic coffee machines
- 1 grill (with 2 drip drains)
- 1 steam tray

Total estimates of food service water use and cost were:
- 1,129,500 L/yr
- 1,130 m^3/yr
- CDN$1,650/yr

4.0 DISCUSSION

4.1 SUMMARY OF RESEARCH PURPOSE

We determined early in our project development that water consumption within the LSC is not fully understood, and that attempts at water management have been minimal. As such, there is a lack of transparency concerning current water consumption practices and activities. We took a unique dual approach experimental model that incorporates exploratory and descriptive research in an attempt to lay the groundwork for future projects. We feel that there exists a great deal of potential for more effective water management and conservation to occur. But in order to do so there must first be a framework laid down upon which other students can continue to build and develop projects that can go into more detail and ultimately create solid recommendations. Our project was an attempt to lay down this foundation, upon which others can build a complete understanding of how water is actually used in the LSC.

4.2 Overview of Descriptive Findings

According to those surveyed, water use within the biology and earth sciences student teaching labs was not believed to be particularly excessive or wasteful. While water was indeed used in nearly all surveyed labs to complete lab exercises (albeit in varying capacities), the relatively minimal amounts of water used went towards necessary functions – like personal hygiene and rinsing of equipment. However, this is not to dismiss possible efficiency recommendations, as the majority of those surveyed also indicated their awareness of water use within student teaching labs was minimal.

This awareness deficit consequently suggests potential room for improvement, as increased awareness is often followed by increased efficiency. Nevertheless, many cited the numbers of students in labs as being an obstacle to effectively monitoring laboratory water use. Additionally, when asked if water use could be made more efficient throughout student teaching labs, most respondents believed this was unlikely. Again, because water use was necessary for the functioning and maintenance of certain labs, reductions could be minimal at best. What suggestions were made, however, included low flow faucets and increased student awareness.

On the other hand, the overwhelming majority of those surveyed (92%) believed that water use could be made more efficient throughout the LSC, yet were unsure exactly how this could be done. Popular suggestions also included the installation of low flow toilets and faucets.

Of those surveyed, nearly all agreed that water efficiency measures were important to them, suggesting that while student teaching lab water use is not particularly high, there is, however, a belief that the water delivery system can be made more efficient throughout other areas of the LSC. While the sampled population was relatively small, the perceptions and attitudes expressed by the respondents are nevertheless valuable in their analyses of both laboratory water use, and overall water use throughout the LSC. These perceptions and attitudes also lend credence and support for improved transparency of the water delivery system within the LSC.

4.3 OVERVIEW OF EXPLORATORY FINDINGS

The descriptive approach of our project discovered that the LSC has one water meter monitoring the entire LSC water delivery system; thus limiting the possible knowledge available on water use and of water use activities. There was no way to determine with any accuracy where the water was being consumed, or how much water a certain activity was consuming. Our exploration was only able to create estimates of water use. In our research we were able to account for 5.8% of the LSC's total annual water use, the remaining 94.2% requires further research and investigation. The 5.8% is made up of 27, 759, 670 L/yr for a total of $44, 370 per year. We also discovered that the LSC's total annual water use (averaged over 2 years) is 480, 840, 000 L/yr, which is equivalent to CDN$705, 886 per year. The composition of the identified 5.8% was by majority made up of the washrooms which account for 60.1% of the total identified. The coldrooms were the second largest consumer of water of the identified water use, accounting for 29.1% of the total identified 5.8%.

During our investigation we learned of a commodity charge (increase in the cost of water) that would be added into the waste and storm water management section of the base rate water charge breakdown. This commodity charge was implemented as of April 1, 2007. In our calculations we took this increase into account and based all of our numbers on the rate of water that included this commodity charge. This charge is a result of the harbour solutions waste water treatment plant currently under construction. We also learned of a second commodity charge coming into effect within the next year, by April 2008, for the same reasons. We were able to determine that the increase that came into effect on April 1, added nearly an additional $2000 to the LSC's total annual cost for water. The second increase is only going to raise Dalhousie's annual water costs once more. This trend in the increase of the price of water is unlikely to change in the near future as water becomes an increasingly precious commodity.

4.4 IMPLICATIONS OF FINDINGS

Because our research employed an exploratory orientation, it is difficult to effectively compare findings vis-à-vis other existing action oriented projects and research. That is, much of the literature discussed within the opening pages referenced projects that have previously come to fruition with demonstrated cost and resource savings. Our project, on the other hand, was interested in gathering information so as to provide a body of work upon which subsequent action might possibly follow. Nevertheless, there is merit in comparing the implications of our findings in light of existing research.

Prior to our undertaking of this project, little to no research had been done regarding water consumption and water distribution within the LSC. From our sampling and investigations we were able to identify numerous water use activities and create an estimate of total water use. After a careful review of our findings, we have come to the conclusion that there exists a great deal of potential for more effective water management and conservation within the LSC. However, any subsequent improvements first require the necessary groundwork as provided within the body of our report. With a solid foundation, additional projects can tailor and refine their scope so as to create more specific and concrete recommendations or policy changes. Several examples help demonstrate the potential recommendations associated with our findings.

As previously mentioned, water conservation initiatives are familiar within university 'greening of the campus' initiatives. The University of Manitoba, for example, has successfully implemented conservation measures that have effectively cut campus water consumption in half. Through concerted efforts on the part of students and staff alike, the university has been able to save over 545 million gallons of water over a five year period. The measures taken to affect this sort of change were relatively simple, and included: the replacement of all fixtures with water conserving devices, the re-circulation of water in cooling devices, and the placement of water meters on all new buildings for improved water monitoring. (University of Manitoba, Office of Sustainability, 2005).

The University of New Brunswick has also implemented energy improvement projects that mirror several of our recommendations with both reduced water consumption and cost. The replacement of previous water cooling equipment and fridges with more efficient water recycling systems has proved beneficial as evidenced by a substantial reduction of annual water consumption and equally substantial cost avoidance. (Natural Resources Canada, Office of Energy Efficiency, 2005).

Again, the Massachusetts Institute of Technology (MIT) has also had successful water conservation measures in place for the past decade. For example, between 1997 and 2005, the university was able to reduce campus water use by 60%. This enormous reduction was in part realized through simple but effective measures – measures that have become familiar to us and other campus sustainability projects. For example, the installation of low flush toilets and faucet aerators within all academic buildings has allowed MIT to incur savings of 11,802,922 gallons of water per year (Massachusetts Institute of Technology, Sustainability at MIT, 2007).

Opened in 1971, the LSC was built as a cutting edge scientific teaching, learning and research facility. However, as is the case with many buildings of a bygone era, dated infrastructure has put constraints upon various conservation efforts. However, this is not to dismiss the possibility of increased water efficiency within the LSC. The installation of energy efficient faucets, the installation of additional water meters or the installation of re-circulating cooling units, for example, have all contributed to water savings in other institutions, and have the potential to do the same within the LSC. Additionally, water efficiency technology has progressed greatly since the building opened, and there is currently more overall concern and awareness of both water quality and quantity issues.

Thus, our findings contribute to greater campus and community sustainability by highlighting various inefficiencies of water use, and possible avenues of improving upon these various inefficiencies. Moreover, our research provides the necessary foundation for further investigation and elaboration into water consumption and management within the LSC.

5.0 CONCLUSIONS

This research project was able to identify that there is only one water meter monitoring water use for the entire LSC water delivery system. Investigations into our five identified and sampled major water use activities was able to account for 5.8% of water use in the LSC, and the remaining 94.2% requires further investigation. Thus, we have determined there is a lack of transparency regarding water use in the LSC. It is important to note that the cost of domestic water increased April 2007, and will increase again within the next year (April 2008); therefore, Dalhousie's annual water costs will increase. It is also important to remain aware that water consumption also will continue to rise unless some action is taken to understand how water is used, and how water can be conserved.

Ultimately campus sustainability could increase with heightened awareness regarding water use within the LSC, one of Dalhousie University's largest consumers of domestic water.

5.1 Recommendations

The overall recommendations generated from our research project include the installation of multiple water meters, such as one water meter per floor, to monitor water use more effectively and to more specifically highlight the areas of the building that could benefit from increased water efficiency. Additionally, we recommend the implementation of scheduled water meter readings in order to better understand water consumption trends, and the installation of water efficient fixtures and equipment where feasible. Increasing the transparency regarding water use in the LSC community via educational campaigns, such as reminders in washrooms to not leave faucets running and to report leaky faucets to Facilities Management, has the potential to decrease water consumption in the building. Our research project has generated a foundation from which further exploratory research can be completed regarding the other major water use activities that we outlined in our report, and we recommend that this research be carried out.

5.1.1 Greenhouse Recommendations

Carman Mills suggestion of how to improve the water efficiency (decrease water use/consumption) in the greenhouse involves the installation of a supplementary humidifier to keep moisture in the air. Cycling water to keep the water in the decreases moisture plants will lose to the air through evaporation, and thus the plants will require less watering.

5.1.2 WASHROOM RECOMMENDATIONS

A recommendation for the washrooms would be to look into the feasibility of installing water efficient fixtures, such as automatic faucets and low flush toilets and urinals. Additionally, we recommend increasing awareness of individuals who use the washrooms on water use, not leaving faucets running, and reporting leaks and problems to Facilities Management immediately. An education campaign can have immediate and cost effective results.

5.1.3 COLDROOM RECOMMENDATIONS

Recommendations for the coldrooms include replacement of current water-to-air coldrooms with air-chilled coldrooms. This would greatly decrease the LSCs annual water cost as water-cooled cold rooms proved to be one of the top water use activities within the building. In lieu of replacing the current cold rooms, retrofits could be implemented, such as heat pumps and improved insulation, which would reduce the water currently used by the water-cooled cold rooms. Exploring alternative options, such as consolidating contents from cold rooms that require similar temperature conditions could minimize the quantity of cold rooms required, thus reducing total water consumption. The installation of additional water meters within the LSC could pinpoint those areas of the building that could benefit from improved water efficiency. Such action could highlight those water-cooled cold rooms that are utilizing large volumes of water, allowing for specific corrective action, such as retrofitting or replacement, to be taken.

5.1.4 FLOOR SCRUBBER RECOMMENDATIONS

A recommendation for the floor scrubbers would be the implementation of an “as required” cleaning regime, as opposed to a scheduled cleaning, as this may result in an unnecessary application of time and resources.

5.1.5 FOOD SERVICES RECOMMENDATIONS

Recommendations for food services include installation of water meters and monitoring of Aramark’s water use. Additionally, Dalhousie could begin to charge Aramark for its water use which could both cover the cost of meter instillation and encourage Aramark to educate its employees on issues of water consumption and efficiency. Alternately, Dalhousie can encourage water conservation within Aramark by allotting a set volume of water for use, with consumption beyond the set limit being charged at the standard rate of CDN$ 1.46/m^3.

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APPENDIX A: MAJOR WATER USE ACTIVITY CALCULATIONS

Calculations for sampled major water use activities were completed and presented below, they are each presented in the format we felt was easiest to understand.

GREENHOUSE CALCULATIONS

1. Hose Flow Rate → 30L/min
2. Plants are watered: 3-4 times a week in winter, daily in summer
3. Average winter months → Oct – Apr = 7 months
4. Average summer months → June – Oct = 5 months
5. 80 minutes spent watering on any given day (8 rooms at 10 minutes a room)

6. 30 L/min x 80 min/day = **2400 L/day**

   - 2400 L/day / 1000 L/m³ = **2.4 m³/day**

7. In winter; plants watered 3.5 times/week x 2400 L/day = 8400 L/week in the winter
   Since winter season is 7 months and 1 month has 4 weeks (7 x 4 = 28 weeks in winter)
   Therefore, 28 weeks in winter x 8400 L/week in the winter = **235, 200 L/winter**
   - 235, 200 L/winter / 1000 L/m³ = **235.2 m³/winter**

8. In summer; plants watered daily (7 times/week) x 2400 L/day = 16, 800 L/week in the summer
   Since summer season is 5 months and 1 month has 4 weeks (5 x 4 = 20 weeks in summer)
   Therefore, 20 weeks in summer x 16, 800 L/week in the summer =
   336, 000 L/summer

   - 336, 000 L/summer / 1000 L/m³ = **336 m³/summer**

9. Overall water used in 1 year = 336, 000 L/summer + 235, 200 L/winter =
   571, 200 L/year

   - 571, 200 L/year / 1000 L/m³ = **571.2 m³/year**

WASHROOM CALCULATIONS:

A. MEN'S CALCULATIONS: Includes the Biology/Earth Sciences, Oceanography and Psychology wings.

I. URINALS – they have a flow rate of 6 litres per flush (Lpf)

ASSUMPTIONS:

i. For these calculations we assume that half the men use the urinals a day and the other half use the toilets; therefore, all student totals will be halved for the purpose of these calculations.
ii. We assume everyone uses the washrooms 3 times a day
iii. We are using the enrolment numbers for each department for the 2006/2007 school year
iv. We are calculating the numbers as if everyone was in school all year except for the major holidays, 5 days/wk, 49 wks/yr
v. To calculate washroom use for the common areas we took 25% of the total number of men

ANNUAL USE $= 309 \text{ men} \times \frac{3 \text{ flushes}}{\text{day}} \times \frac{6\text{L}}{\text{flush}} \times \frac{5 \text{ days}}{\text{wk}} \times \frac{49 \text{ wks}}{\text{yr}}$

$= 1,362,690$ L/yr
$= 1,362.69 \text{ m}^3/\text{yr}$ $\quad = \frac{1,362.69\text{m}^3}{\text{yr}} \times \frac{\$1.46}{\text{m}^3} = \$1989.53$
= CDN \$1989.53/yr

II. TOILETTES – they have a flow rate of 13.2 Lpf

ASSUMPTIONS:

i. For these calculations we assume that half the men use the urinals a day and the other half use the toilets; therefore, all student totals will be halved for the purpose of these calculations.
ii. We assume everyone uses the washrooms 3 times a day
iii. We are using the enrolment numbers for each department for the 2006/2007 school year
iv. We are calculating the numbers as if everyone was in school all year except for the major holidays, 5 days/wk, 49 wks/yr
v. To calculate washroom use for the common areas we took 25% of the total number of men

ANNUAL USE $= 309 \text{ men} \times \frac{3 \text{ flushes}}{\text{day}} \times \frac{13.2 \text{ L}}{\text{flush}} \times \frac{5 \text{ days}}{\text{wk}} \times \frac{49 \text{ wks}}{\text{yr}}$

$= 2,997,818$ L/yr
$= 2,997.91\text{m}^3/\text{yr}$ $\quad = \frac{2,997.91\text{m}^3}{\text{yr}} \times \frac{\$1.46}{\text{m}^3} = \$4376.96$
= CDN \$4376.96/ yr

III. Faucets – the calculations used flow rates found by measuring the flow rate of faucets on each floor then finding the average for that wing.

ASSUMPTIONS:

- Each person who uses the bathroom washes their hands
- Enrolment per department is used to calculate the use per wing
- People use the bathroom 3 times a day

- People follow the procedures set out by Dalhousie for hand washing, so the faucet is running for 50 seconds or .833 minutes.
- People use the bathroom for 5 days/wk, 49 wks/yr
- For the common areas we took the total number of men and divided it in half and used that number to calculate faucet use

ANNUAL USE **:**

Biology/ Earth Sciences / Environmental Science

$$209 \text{ Men} \times \frac{3 \text{ washes}}{\text{day}} \times \frac{.833 \text{ min}}{\text{wash}} \times \frac{6.9 \text{ L}}{\text{min}} = \frac{3605.25 \text{ L}}{\text{day}} \times \frac{5 \text{ days}}{\text{week}} \times \frac{49 \text{ weeks}}{\text{yr}}$$

= 883, 286.25 L/yr
= 883.29 m^3/yr
= CDN$1,289.60/yr

$$= \frac{883.29 \text{ m}^3}{\text{yr}} \times \frac{\$1.46}{\text{m}^3} = \$1,289.60$$

Psychology

$$88 \text{ Men} \times \frac{3 \text{ washes}}{\text{day}} \times \frac{.833 \text{ min}}{\text{wash}} \times \frac{7.5 \text{ L}}{\text{min}} = \frac{1649.34\text{L}}{\text{day}} \times \frac{5 \text{ days}}{\text{week}} \times \frac{49 \text{ weeks}}{\text{yr}}$$

= 404, 088.3 L/yr
= 404.08 m^3/yr
= CDN$589.96/yr

$$= \frac{404.08 \text{ m}^3}{\text{yr}} \times \frac{\$1.46}{\text{m}^3} = \$589.96$$

Oceanography:

$$32 \text{ Men} \times \frac{3 \text{ washes}}{\text{day}} \times \frac{.833 \text{ min}}{\text{wash}} \times \frac{9 \text{ L}}{\text{min}} = \frac{719.71 \text{ L}}{\text{day}} \times \frac{5 \text{ days}}{\text{week}} \times \frac{49 \text{ weeks}}{\text{yr}}$$

= 176, 329 L/yr
= 176.33 m^3/yr
= CDN$257.44/yr

$$= \frac{176.33 \text{ m}^3}{\text{yr}} \times \frac{\$1.46}{\text{m}^3} = \$257.44$$

Common Areas:

$$206 \text{ Men} \times \frac{3 \text{ washes}}{\text{day}} \times \frac{.833 \text{ min}}{\text{wash}} \times \frac{8.46 \text{ L}}{\text{min}} = \frac{4,418.58 \text{ L}}{\text{day}} \times \frac{5 \text{ days}}{\text{week}} \times \frac{49 \text{ weeks}}{\text{yr}}$$

= 1,082,552.55 L/yr
= 1,082.55 m^3/yr
= CDN $1,580.53/yr

$$= \frac{1082.55 \text{ m}^3}{\text{yr}} \times \frac{\$1.46}{\text{m}^3} = \$1,580.53$$

B. Women's Calculations: Includes the Biology/Earth Sciences, Oceanography and Psychology wings

I. TOILETTES – they have a flow rate of 13.2 Lpf

ASSUMPTIONS:

- We assume everyone uses the washrooms 3 times a day
- We are using the enrolment numbers for each department for the 2006/2007 school year
- We are calculating the numbers as if everyone was in school all year except for the major holidays, 5 days/wk, 49 wks/yr
- To calculate washroom use for the common areas we took half of the total number of women

ANNUAL USE $= 1259 \text{ women} \times \frac{3 \text{ flushes}}{\text{day}} \times \frac{13.2\text{L}}{\text{flush}} \times \frac{5 \text{ days}}{\text{wk}} \times \frac{49 \text{ wks}}{\text{yr}}$

= 12, 214,818 L/yr

= 12,214.82 m^3/yr

= CDN $17,833.63/ yr

$= \frac{12{,}214.81\text{m}^3}{\text{yr}} \times \frac{\$1.46}{\text{m}^3} = \$17{,}833.63$

II. Faucets – the calculations used flow rates found by measuring the flow rate of faucets on each floor then finding the average for that wing.

ASSUMPTIONS:

- Each person who uses the bathroom washes their hands
- Enrolment per department is used to calculate the use per wing
- People use the bathroom 3 times a day
- People follow the procedures set out by Dalhousie for hand washing, so the faucet is running for 50 seconds or .833 minutes.
- People use the bathroom for 5 days/wk, 49 wks/yr
- For the common areas we took the total number of women and divided it in half
-

ANNUAL USE:

Biology/ Earth Sciences / Environmental Science

$446 \text{ Women} \times \frac{3 \text{ washes}}{\text{day}} \times \frac{.833 \text{ min}}{\text{wash}} \times \frac{7.98\text{L}}{\text{min}} = \frac{8{,}894.14\text{L}}{\text{day}} \times \frac{5 \text{ days}}{\text{week}} \times \frac{49 \text{ weeks}}{\text{yr}}$

= 2,179,064.52 L/yr

= 2,179.06 m^3/yr

= CDN $3,181.43/yr

$= \frac{2{,}179.06 \text{ m}^3}{\text{yr}} \times \frac{\$1.46}{\text{m}^3} = \$3{,}181.43$

Psychology

$$371 \text{ Women} \times \frac{3 \text{ washes}}{\text{day}} \times \frac{.833 \text{ min}}{\text{wash}} \times \frac{6.96\text{L}}{\text{min}} = \frac{6452.82\text{L}}{\text{day}} \times \frac{5 \text{ days}}{\text{week}} \times \frac{49 \text{ weeks}}{\text{yr}}$$

= 1,580,940.9 L/yr
= 1,580.94 m^3/yr
= CDN$2,308.17/yr

$$= \frac{1{,}5308.17\text{m}^3}{\text{yr}} \times \frac{\$1.46}{\text{m}^3} = \$2{,}308.17$$

Oceanography:

$$22 \text{ Women} \times \frac{3 \text{ washes}}{\text{day}} \times \frac{.833 \text{ min}}{\text{wash}} \times \frac{10.8 \text{ L}}{\text{min}} = \frac{593.76 \text{ L}}{\text{day}} \times \frac{5 \text{ days}}{\text{week}} \times \frac{49 \text{ weeks}}{\text{yr}}$$

= 145,471.79 L/yr
= 145.47 m^3/yr
= CDN$212.39/yr

$$= \frac{145.47 \text{ m}^3}{\text{yr}} \times \frac{\$1.46}{\text{m}^3} = \$212.38$$

Common Areas:

$$420 \text{ Women} \times \frac{3 \text{ washes}}{\text{day}} \times \frac{.833 \text{ min}}{\text{wash}} \times \frac{7.5 \text{ L}}{\text{min}} = \frac{7{,}871.85 \text{ L}}{\text{day}} \times \frac{5 \text{ days}}{\text{week}} \times \frac{49 \text{ weeks}}{\text{yr}}$$

= 1,928.603.25 L/yr
= 1,928.60 m^3/yr
= CDN$2,815.76/yr

$$= \frac{1{,}928.60 \text{ m}^3}{\text{yr}} \times \frac{\$1.46}{\text{m}^3} = \$2{,}815.26$$

COLDROOM CALCULATIONS:

Calculations for water usage and cost of one cold room – Measurements from 5th Floor cold room:

$$\frac{1.4\text{L}}{\text{min}} \text{ x } \frac{60\text{min}}{\text{hr}} \text{ x } \frac{24\text{hr}}{\text{day}} = 2016 \text{ L/day}$$

$$\frac{2016\text{L}}{\text{day}} \text{ x } \frac{365\text{days}}{\text{year}} = 735840 \text{ L/year} = 735.84 \text{ m3/year}$$

735.84 m^3/year x $1.46/$m^3$ = CDN$1,074.33/year

Calculations for water usage and cost if ALL 11 freezers were operating:

735840L x 11 freezers = 8,094,240 L/year = 8,094.24 m3/year

8,094.24 m^3/year x $1.46/$m^3$ = $11,817.59/year

FLOOR SCRUBBER CALCULATIONS

Karcher Automatic Scrubbers
- 3 small with a volume of 42 L
- 1 large with a volume of 84.4 L

Summer Use

Biology/Earth Sciences/Environmental wing
- small filled 3 times/week x 42 L/fill = 126 L/week
- 126 L/week x 4 weeks/month = **504 L/month in the summer**
- large filled 3 times/day x 84.4 L/fill = 253.2 L/day
- 253.2 L/day x 7 days/week = 1772.4 L/week
- 1772.4 L/week x 4 weeks/month = **7089.6 L/month in the summer**

Psychology wing
- filled 2 times/day x 42 L/fill = 84 L/day
- 84 L/day x 2 times/week = 168 L/week
- 168 L/week x 4 weeks/month = **672 L/month in the summer**

Oceanography wing
- filled 2 times/day x 42 L/fill = 84 L/day
- 84 L/day x 2 times/week = 168 L/week
- 168 L/week x 4 weeks/month = **672 L/month in the summer**

Total Summer Use
- 504 L/month + 7089.6 L/month + 672 L/month + 672 L/month = **8937.6 L/month in the summer**
- 8937.6 L/month in the summer x 4 months in the summer = **35, 750.4 L/summer**

Total Winter Use

Biology/Earth Sciences/Environmental wing
- small filled 3 times/day x 42 L/fill = 126 L/day
- 126 L/day x 7 days/week = 882 L/week
- 882 L/week x 4 weeks/month = **3528 L/month in the winter**
- large filled 4 times/day x 84.4 L/fill = 337.6 L/day
- 337.6 L/day x 7 days/week = 2363.2 L/week
- 2363.2 L/week x 4 weeks/month = **9452.8 L/month in the winter**

Psychology wing
- filled 2 times/day x 42 L/fill = 84 L/day
- 84 L/day x 2 times/day = 588 L/week
- 588 L/week x 4 weeks/month = **2352 L/month**

Oceanography wing
- filled 3 times/day x 42 L/fill = 126 L/day

- 126 L/day x 7 days/week = 882 L/week
- 882 L/week x 4 weeks/month = **3528 L/month in the winter**

Total Winter Use

- 3528 L/month + 9452.8 L/month + 2352 L/month + 3528 L/month = **150, 886.4 L/month in the winter**
- 150, 886.4 L/month in the winter x 8 months/winter = **1, 207, 091.2 L/winter**

Floor Scrubbers Total Annual Water Use

- 35, 750.4 L/summer + 1, 207, 091.2 L/winter = **1, 242, 841.6 L/yr**
- 1, 242, 841.6 L/yr / 1000 L/m³ = **1, 242.8416 m³/yr**
- 1, 242.8416 m³/yr x $1.46 = **$1, 814.55**

<u>FOOD SERVICES CALCULATIONS:</u>

A. <u>CAFETERIA:</u> Easy Goes, Manchu Wok®, Pizza Pizza® and Grilleworks; and the 2nd floor snack stand, Tim Horton's® and related bake shop

III. <u>GRILL</u> – the grill has 2 hot water 'drips', which clear grease from the drains, and are active as long as the stove is operating.

ASSUMPTIONS:

- The grill is active for 8hrs/day, 5 days/wk, 49 wks/yr
- One drip = $\frac{10\,000\text{L}}{\text{yr}} = \frac{27.397\text{L}}{\text{day}} = \frac{1.142\text{L}}{\text{hr}}$ (USGS, 2006)

ANNUAL USE = $\frac{2 \text{ drips}}{\text{stove}} \times \frac{1.142\text{L}}{\text{hr}} \times \frac{8\text{hrs}}{\text{day}} \times \frac{5 \text{ days}}{\text{wk}} \times \frac{49 \text{ wks}}{\text{yr}}$

= 4,476.64 L/yr

= 4.47 m^3/yr

= CDN$6.96

II. <u>HAND SINK</u> – there are two hand sinks exclusively for staff sanitary purposes behind the main counter

ASSUMPTIONS:

- The sinks are used 5 days/wk, 49 wks/yr
- Each employee washes their hands approximately twice an hour, based upon health and safety recommendations
- 52 ppl. hrs/ day, based on reported shifts worked at (4×8hrs + 2×7hrs + 1×6hrs) shifts
- Hand sink flow rate was sampled at 820 mL/ 5sec = 9.840 L/ min
- Hand wash time is based on posted Aramark guidelines, and was estimated, by trial, to be 80sec/wash = 1.333 min/wash

ANNUAL USE = $\frac{52 \text{ ppl/hrs}}{\text{day}} \times \frac{2 \text{ washes}}{\text{hr}} \times \frac{1.333 \text{ min}}{\text{wash}} \times \frac{9.840\text{L}}{\text{min}} \times \frac{5 \text{ days}}{\text{wk}} \times \frac{49 \text{ wks}}{\text{yr}}$
= 334,241.03 L/yr
= 334.21 m^3/yr
= CDN$487.95

III. <u>STEAM TRAY</u> – the steam tray is used to keep food at serving temperature throughout the day

ASSUMPTIONS:
- Steam tray size was measured to be (2.67m×0.52m×0.18m) 0.249 m^3
- The steam tray is used 5 days/wk, 49 wks/yr

ANNUAL USE = $\frac{0.249 \text{ m}^3}{\text{day}} \times \frac{5 \text{ days}}{\text{wk}} \times \frac{49 \text{ wks}}{\text{yr}}$
= 61,005 L/yr
= 61.01 m^3/yr
= CDN$89.07

B. <u>BAKE SHOP:</u> this location produces all the baking for both Tim Horton's on campus, and is the only dish washing sink available to food services in the LSC.

I. <u>HAND SINK</u> – there is one hand sink exclusively for staff sanitary purposes

ASSUMPTIONS:
- Each employee washes their hands approximately twice an hour, based upon health and safety recommendations
- 19 ppl. hrs/ day, based on reported shifts worked at (1×11hrs + 1×8hrs) shifts
- Hand sink flow rate was sampled at 600 mL/ 2sec = 18 L/ min
- Hand wash time was based on [company] regulations, and was estimated, by trial, to be 80sec/wash = 1.333 min/wash
- The sinks are used 5 days/wk, 49 wks/yr

ANNUAL USE = $\frac{19 \text{ ppl/hrs}}{\text{day}} \times \frac{2 \text{ washes}}{\text{hr}} \times \frac{1.333 \text{ min}}{\text{wash}} \times \frac{18 \text{ L}}{\text{min}} \times \frac{5 \text{ days}}{\text{wk}} \times \frac{49 \text{ wks}}{\text{yr}}$
= 223,384.14 L/yr
= 2223.38 m^3/yr
= CDN$3,246.13

II. <u>DISH SINK</u> – there is one dish sink for all the food services located in the LSC

ASSUMPTIONS:
- All LSC food service dishes are washed at this location
- Self reporting estimated one sink of dishes is washed per day
- The sink is used 5 days/wk, 49 wks/yr

- Sink size was measured to be (1.28m×0.26m×0.56m) = 0.183 m^3

ANNUAL USE = $\frac{0.183\ m^3}{day} \times \frac{5\ days}{wk} \times \frac{49\ wks}{yr}$
= 45,660 L/yr
= 45.66 m^3/yr
= CDN$66.66

C. TIM HORTON'S:

I. HAND SINK – there is one sink located behind the counter used for staff sanitary purposes as well as for rinsing coffee pots

ASSUMPTIONS:

- Each employee washes their hands approximately twice an hour, based upon health and safety recommendations
- 34.5 ppl. hrs/ day, based on reported shifts worked at (2×8hrs + 1×9hrs+ 1×9.5hrs) shifts
- Hand sink flow rate was sampled at 600 mL/ 2sec = 18 L/ min
- Hand wash time was based on [company] regulations, and was estimated, by trial, to be 80sec/wash = 1.333 min/wash
- Approximately 100 pots of coffee are made each day, based on self reporting by Tim Horton's staff
- The sinks are used 5 days/wk, 49 wks/yr

ANNUAL USE = $\frac{34.5\ ppl/hrs}{day} \times \frac{2\ washes}{hr} \times \frac{1.333\ min}{wash} \times \frac{18L}{min} \times \frac{5\ days}{wk} \times \frac{49\ wks}{yr}$
= 405,618.57 L/yr
= 405.62 m^3/yr
= CDN$592.21

COFFEE – as coffee is the primary product sold by Tim Horton's it has been included in the estimate of water consumption/use in the LSC

ASSUMPTIONS:

- Approximately 100 pots of coffee are made each day, based on self reporting by Tim Horton's staff
- Each pot contains 76 oz of coffee (measured by the automatic coffee maker), and is the equivalent of (100pots × 76 oz pot × 0.0296 oz/L) = 224.960 L coffee/day
- The facility is used 5 days/wk, 49 wks/yr

ANNUAL USE = $\frac{224.960\ Lcoffee}{day} \times \frac{5\ days}{wk} \times \frac{49\ wks}{yr}$
= 55,115.20 L/yr
= 55.12 m^3/yr
= CDN$80.48

APPENDIX B: CONTACT LIST – In order to facilitate further projects and research into the LSC's water use, we have included the contact information of several individuals who were of great assistance.

CONTACT NAME	ASSOCIATION	PHONE #	EMAIL
Peter Coolen	Facilities Management – provided guidance and contacts	494 - 6765	peter.coolen@dal.ca
Kevin Powless	Facilities Management – provided LSC facility tour	N/A	k.powless@dal.ca
Gary Gaudet	Facilities Management – floor scrubbers information	494 - 3519	Gary.Gaudet@dal.ca
Carman Mills	Greenhouse Manager – facility tour, consumption & operational characteristics	494 - 6537	Carman.Mills@dal.ca
Stephen Fry	Chief Technologist/Technical Support Staff – Biology Department – provided much of the overall water use information	494 - 3530	steve.fry@dal.ca
John Batt	Aquatron Laboratory Manager	494 - 3874	John.Batt@dal.ca
Jim Ramsay	Financial Analyst – Dalhousie University	494 - 2323	jkramsay@dal.ca

APPENDIX C: SUPPLEMENTARY COMMUNICATIONS

Greenhouse Interview Questions- Answered by Carman Mills and containing technical details used to complete greenhouse calculations:

Question: What equipment in the greenhouse uses water (i.e. hoses, sprinklers, etc)?

Answer: They use both hoses and overhead irrigation systems. The overhead irrigation system is to maintain moisture in the air; watering by hose must still be done

……………………………………………………………………………………………

Question: Operation characteristics (i.e. how often are the plants watered, are they on a schedule, how many rooms are there, and are they on their own different schedules)?

Answer: There are 8 rooms. They use hot water, cold water, de-ionized water, de-chlorinated water, ocean (salt) water, and distilled water. 4 of the rooms have overhead irrigation systems and all 8 have hoses. In the winter the plants are watered, on average, 3 to 4 times a week manually. The overhead irrigation system can be put on a timer and schedule

……………………………………………………………………………………………

Question: Is it possible to go in and determine the theoretical amount of water used?

Answer: Yes, we are more than welcome to go and attain estimates, but they would be completely theoretical and not valid due to the number of variables and limitations.

Floor Scrubber Communication (email) - from Gary Gaudet containing technical details used to complete floor scrubber calculations:

Hi Jessica,

Here is some information that you asked me for. This is from the manufacture itself, so it is accurate.(see below)
These are Karcher Automatic scrubbers, I have 3 smaller ones, 1 in Psychology, 1 in Oceanography, 1 here in Biology / Earth Sciences and 1 large unit here in Biology / Earth Sciences as well. Depending on the time of year, these machines are used more frequently.

Biology Winter; both units are used daily. The smaller one is used by 3 staff here in Biology, this would mean 3 fill ups per day. The larger unit is 4 fill ups per day, this unit is used in the upper and lower Link hallways.
Psychology unit about 2 fill ups a day
Oceanography unit about 3 fill ups a day

Summer months the larger unit is used daily, the smaller unit once a week.

Biology Summer; The smaller one is used by 3 staff here in Biology, this would mean 3 fill ups per week. The Larger unit is filled 3 times per day. This Link area is done everyday, Summer & Winter. Winter more water used due to salt residue.
Psychology unit about 2 fill ups a day, twice per. week
Oceanography unit about 2 fill ups a day, twice a week

I hope this information helps.
Regards… - Gary -

Water use Communication (email)- from Jim Ramsy containing information used to determine the Life Sciences Centre's total annual water consumption .

Hi Drummond:

Regarding your request for water usage information for the LSC, we only have the past few years of usage information readily available. 2006/07 consumption, in cubic meters, as of December 31 was 369,387. For comparison, last years consumption over the same time period was 414,160. 2005/06 consumption was 540,278 and 2004/05 consumption was 421,381.

Dalhousie pays the established price from the Halifax Regional Water Commission for a 6" water meter. April 07 will see a commodity charge of $0.0042 per cubic meter. There is also a per unit environmental protection charge of $0.7004 and a wastewater management charge of $0.3286.

If you have any other questions, feel free to inquire.

Jim Ramsay
Financial Analyst
Dalhousie University
902.494.2323
jkramsay@dal.ca

APPENDIX D – DESCRIPTIVE RESEARCH QUESTIONNAIRE

Survey: Water Consumption in Laboratories of the Life Sciences Centre
Dalhousie University

The following questionnaire collects information regarding water consumption habits within laboratories of the Life Sciences Centre. Please sign below and return to the drop-off box located in room 827 of the Life Sciences Centre.

I, ____ (name, lab type, lab room), hereby consent to the use of the following information for research purposes only. All efforts have been made to ensure the confidentiality of the responses located herein, and that the researcher-participant privilege is upheld. The following information will be viewed exclusively by those conducting the questionnaire. Only aggregate data will be reported in the final report.

1. How many hours per week do you require the use of this laboratory for scheduled student labs?
a) 1-3
b) 4-7
c) 8-11
d) 12-15
e) 16 or more

2. On average, how many students do you guide in your lab?
a) 1-7
b) 8-14
c) 15-21
d) 22-28
e) 29 or more

3. How often do your laboratories for scheduled student labs require the use of water? (Circle one)

never rarely sometimes often always

4. Check the types of water commonly used in this lab (check all that apply):
___domestic
___distilled
___dechlorinated

5. The majority of water use in your laboratory is for the following purposes:
a) experiment preparation
b) experiments
c) cleaning or rinsing of equipment
d) hygiene
e) other ______________________

6. Are you aware of the volume of water used for laboratory activities during a given lab period? (Circle one)

not at all somewhat aware mostly aware completely aware

7. Are there instances where you feel water is being wasted in your labs? (Circle one)

definitely yes likely unlikely definitely no

Please explain your answer: ____
____

8. Are there instances where you feel water is being wasted in the LSC? (Circle one)

definitely yes likely unlikely definitely no

Please explain your answer: ____
____

9. To what extent do you agree or disagree with the following statement: Water conservation is important to me. (Circle one)

strongly disagree disagree agree strongly agree

10. To what extent do you agree or disagree with the following statement: I support water conservation measures in my laboratory (Circle one)

strongly disagree disagree agree strongly agree

11. To what extend do you agree or disagree with the following statement: Water conservation initiatives would compromise the integrity of my laboratory activities. (Circle one)

strongly disagree disagree agree strongly agree

Please explain your answer: ____
____

12. Do you have any suggestions for improving water conservation in your laboratory, or laboratories in general?
____
____
____
____

13. Additional Comments?
____
____
____

Thank you for taking the time to fill out this survey

Appendix E

Table X – Detailed breakdown of the total number of toilets, urinals and faucets located in the Biology/ Earth Sciences/ Environmental Science, Oceanography and Psychology wings of the LSC. Source: Corey Webster, 2007.

Floor	**Urinals**				**Leaky**	**Toilets**								**Faucets**								**Faucet Flow Rate (l/3sec)**							
	B/E	Psych	Ocean	Common	Faucets	B/E		Psyc		Ocean		Common		B/E		Psyc		Ocean		Common		B/E		Psych		Ocean		Common	
						M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
2nd	1	2	1	3	5	2	3	1	2	1	1	3	7	2	2	2	2	1	1	5	6	.375	.350	.400	.450	.400	.800	.450	.450
3rd	1	2	1			1	2	1	2	1	1			1	2	2	2	1	1			.350	.400	.400	.350	.500	.300		
4th	1	2	1		1	1	2	1	2	1	1			1	2	2	2	1	1			.400	.400	.250	.300	.450	.700		
5th	1	2	1		2	1	2	1	2	1	1			1	2	3	2	1	1			.100	.100	.450	.300	.450	.350		
6th	1				2	1	2							1	2							.250	.550						
7th	1				2	1	2							1	2							.350	.350						
8th	1					1	2							2	2							.700	.350						
Totals	7	8	5	3	12	8	15	4	8	4	4	3	7	9	14	9	8	4	4	7	6								
																					Average Flow Rate	.360	.357	.362	.350	.450	.538	.450	.450