Water Resource Management
Baseline Study and Conservation Initiatives

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Abstract

McGill is constantly working towards reducing its impact on the environment. This study investigates the water consumption of the downtown campus in order to determine a baseline consumption as well as categorize it. This was performed through building audits and walkthroughs. For the purpose of this study, water consumption has been broken down into five categories: Operational, Hygiene, Landscaping, Food Services, as well as Research & Academia. The results of this study show that the total downtown campus annual consumption is between 1.8 and 2.3 million m^3. Research & Academia is the most water consuming category, with 50.86% of the total of audited buildings, followed by the Operational category with 32.65%, and Hygiene with 16.35%. Food Services and Landscaping combined represent 0.14%. In order to validate the hypotheses and findings of this study, it is recommended to install water meters and compare readings to estimated values presented in this document. Water conservation initiatives have been proposed for the most water consuming categories. Some of the main conservation initiatives presented in this paper are: to replace once-through water cooled systems, to continue the University's policy to install low flow fixtures when performing washroom renovations, to consider the use of grey water and alternative water sources in new development, to pursue the installation of new cooling tower water treatment technologies, and to encourage researchers to bring forward conservation initiatives which are more adapted to the reality of laboratories.

Acknowledgements

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1. Introduction

Echoing the Ministry of Education's mandate to reduce on campus water consumption by 20% no later than 2017, McGill has recently committed to this objective. One of the major challenges facing McGill is the lack information about water consumption on campus, which makes it hard to estimate the impact of any potential water conservation initiative. The goals of this study are to establish a water consumption baseline for downtown campus and to develop a water conservation strategy for the University. Along with this baseline, a breakdown of water consumption per type of usage is necessary to draft a solid water conservation strategy and prioritize interventions and investment.

Buildings to be audited were prioritized and 32 were chosen. A full list of these buildings can be found in Appendix 1. The audit itself consisted of the study of floor plans to identify water installations, a walkthrough of the buildings, and inquiries to building directors and researchers. It should be noted that Ludmer, Duff Medical, Strathcona Music, New Music as well as all the self-funded units (University Centre, Brown Student Services, Currie Gym and Fieldhouse, and all the residences) were not audited due to lack of time.

While Utilities & Energy Management will work toward reducing the water consumption of mechanical equipment and other fixtures, we also need to raise awareness on water conservation. Several initiatives are currently under way on campus ("Water is Life" exhibit, water refill stations, policy on bottled water, etc.). Other initiatives can be put in place to tackle water usage in labs, for landscaping, to clean buildings, the Power House, etc. This strategy could also identify problematic areas more fit to grassroots initiatives (water conservation in labs for example) and areas of intervention where other entities on campus can take the lead.

2. Methodology

For the purpose of this study, water consumption was divided into five categories: Hygiene, Food Services, Operational, Landscaping, and Research & Academia. Hygiene comprises toilets, urinals, bathroom sinks, drinking fountains, kitchen sinks in office environments, and showers. Food Services consists of kitchen sinks in cafeterias, as well as coffee and tea consumption. Operational comprises cooling towers, chilled water loops, hot water loops, once-through water cooled equipment, boilers and maintenance sinks. Landscaping involves water used in washing the outdoor surfaces of campus and watering the various flowers, plants and trees. Research & Academia encompasses all water consumed for research and projects performed on campus. The general steps to determine the annual water consumption are 1) identifying the water consuming installations or equipment, 2) determining the unitary use, and 3) estimating how many times it is used per year. With this information it is possible to calculate annual consumption for the installations and equipment on campus.

2.1. Hygiene

Note: this section gives a brief overview of the methods and hypotheses used to estimate water consumption. For more details on how calculations were performed, please refer to Appendix 2 and to the '2012 Water Audit Calculations' Excel spreadsheet.

Identifying Installations and Equipment

Floor plans were used to identify the following installations: toilets, urinals, bathroom sinks, drinking fountains, kitchen sinks, and showers. Information was confirmed during walkthroughs of the buildings and the installations were grouped according to the following criteria: fixture (wall or floor), tap volumetric flow (normal or reduced), activation (manual, detector, or automatic), and the age (0 to 10 years, 10 to 25 years, and over 25 years).

Determining Unitary Water Use

Using *CAN-AQUA International: Services professionels en mécanique du bâtiment, Guide de sélection pour appareils sanitaires*[1] and the *U.S. Environmental Protection Agency (EPA) volumetric flow standards*[2], the flow of each type of installation was estimated. CAN-AQUA provided information on the flow rates of washroom fixtures currently on the market and the EPA standards provided information on flow according to age. Some of the fixtures located on campus have the flow printed on them, and these were noted during the walkthroughs.

Estimating the Number of Uses/Duration of Use per Year

The amount of times an installation is used is proportional to the amount of people in the building. To estimate this, the McGill Fact Book[3] was used to compile information on the total number of employees, graduate students and undergraduate students at McGill. Students and staff from the Macdonald campus were subtracted from the total. Next, the assumption was made that the population density is constant all across campus. Therefore, the number of people in a building is proportional to the gross area of the building. The number of people in a building was calculated by cross multiplication of the total number of people with the area of the building and the total area of the building. See Appendix 2 for an example. Whether an employee or student is full-time or part-time, vacation time, and varying enrollment by semester are variables taken into account in these calculations.

Leadership in Energy and Environmental Design (LEED) provides standard frequencies at which a person uses hygiene installations whether employee or student. The values differ for women and men. Using LEED fixture use rates[4], the number of people in a building and gender ratios supplied by McGill Fact Book for employees and by Statistics Canada[5] for university students, the number of uses for each of the hygiene installations per year was determined.

Calculating Annual Consumption

The number of uses per year is multiplied by the unitary consumption of each type of installations. The result equals the annual consumption. This method is used for toilets, urinals, bathroom sinks, and showers.

Kitchen sink usage calculations vary slightly. The number of uses of kitchen sinks is divided between Hygiene for the sinks located in offices and Food Services for the sinks located in cafeterias and snack bars.

The utilization of drinking fountains is also calculated differently. The average volume of water consumed per person per day[6,7] was found. To correct for the fact that not all a person's drinking water consumption occurs on campus, the total was multiplied by a factor which takes into account how much time the person spends on campus. This water consumption, assumed to be taken exclusively from drinking water fountains, was divided among the buildings in the same manner as the other installations (pro rata the number of occupants per building).

2.2. Food Services

Identifying Installations and Equipment

Food Services water usage comprises kitchen sinks, as well as coffee and tea machines. Floor plans were used to identify the locations of Food Services. During the walkthroughs, employees and managers of the cafeterias, coffee shops, and restaurants helped in the identification of the installations and equipment. The criteria to group them are the same as in hygiene: fixture, tap volumetric flow, activation, and age. Note that none of the main cafeterias on campus were located in the 32 buildings audited.

Determining Unitary Water Use

The CAN-AQUA guide and EPA flow standards were used to determine the usage from the kitchen sinks. For coffee and tea machines, the drinking of these beverages was determined using values provided by Statistics Canada[8] for annual consumption per person.

Estimating the Number of Uses/Duration of Use per Year

The use of kitchen sinks in cafeterias and drinking of coffee and tea is proportional to the number of people in the building. For the kitchen sinks, the LEED fixture use rates provided values for the number of uses per person. For the coffee and tea consumption, this does not apply.

Calculating Annual Consumption

The number of uses per kitchen sinks is divided between Hygiene (for the sinks located in offices) and Food Services (for the sinks located in cafeterias and snack bars). The resulting number of uses multiplied by the unitary consumption equals the annual consumption.

For coffee and tea, the hypothesis was that drinking of these beverages is constant throughout the entire duration of the day. Therefore, the quanity consumed on campus is proportional to the time people spend on campus. By multiplying the total consumption by the fraction of time spent on campus compared to time in a year gives us the estimate. These two beverages are assumed to be pure water when doing calculations.

2.3. Operational

Identifying Installations and Equipment

This category comprises cooling towers, chilled water loops, hot water loops, once-through water cooled equipment (AC units, air dryers, air compressors, cold rooms, sample systems, and thermal wheel cooling), boilers, and maintenance sinks. The program DREWTRAX monitors the cooling towers, hot water loops, and chilled water loops and provides details on their locations. For the once-through water cooled equipment, a study by Bouthillette Parizeau[9] provided information on the locations of 52 of these installations across campus, 27 of which were located in buildings which were part of our study. The boilers are located in the Powerhouse and supply the entire campus with steam; Utilities & Energy Management has data relative to make-up water used by the boilers. For the maintenance sinks, the same approach was used as for Hygiene and Food services. The floor plans helped identify the locations and walkthroughs confirmed this information.

Determining Unitary Water Use

For the once-through water cooled equipment, the Bouthillette Parizeau study contains information on cooling capacity and water consumption in units of volume per minute.

For the maintenance sinks, similarly to the previous two categories, the CAN-AQUA guide and the EPA standards were used to estimate unitary use.

For cooling towers, chilled water loops, hot water loops, and boilers, this section does not apply since the university has programs which track water consumption.

Estimating the Number of Uses/Duration of Use per Year

The once-through water cooled equipment runs all year. They do not function constantly at full capacity however, so calculations were made to correct consumption values. For a twelve-hour period which represents the day, they run at full capacity and for a twelve-hour period which represents the night, they run at 75% capacity.

For the maintenance sinks, a different approach was used to calculate consumption and is presented in the Calculating Annual Consumption section below.

For cooling towers, chilled water loops, hot water loops, and boilers, this section does not apply as the university has programs which track water consumption.

Calculating Annual Consumption

For the once-through water cooled equipment, the minutary usage is known and can be converted to annual consumption, taking into account the variation in capacity.

For the cooling towers, chilled water circuit, and hot water circuit, the program Drewtrax supplied data on the make-up water used. By graphing the data, the annual consumption can be found by subtracting the make-up meter reading at the end of the year from the one at the beginning of the year. In the case of cooling towers, hot water loops and chilled water loops which run only in the summer, the same calculation can be performed with the readings from the end subtracted from the readings from the beginning of the summer.

For the boilers, the program HISTO supplied information on the make-up water used every month. The sum of these is the annual consumption.

For the maintenance sinks, a meeting was scheduled with George Lazaris, Building Services Officer, University Services, to determine annual consumption. It was assumed that the water consumption of maintenance sinks revolved mostly around floor and surface cleaning activities. The method and frequency was discussed. In this way, it was possible to estimate the amount of water required to clean one square meter and then calculate how much is needed to clean each building. This quantity was distributed evenly between the maintenance sinks present in the buildings pro rata the surface of the buildings.

2.4. Landscaping

Identifying Installations and Equipment

A meeting was organized with Eric Champagne, Horticultural Supervisor, University services, and his co-workers. They provided information on their tasks and tools at their disposal. In the spring, the main tasks are to wash the stairs of the buildings, the garages and the various sidewalks across campus. In the summer, they water the flowers, plants and trees throughout campus.

Determining Unitary Water Use

To perform these tasks, a mobile water tank, automated sprinkler, and hoses on the outside of buildings are used. However, the sprinklers are not used regularly and the hose-usage is variable. Therefore, the water tank is the focus of this category's consumption. The volume of the tank is 2,500 litres.

Estimating the Number of Uses/Duration of Use per Year

Eric Champagne and his team were able to provide an estimate on how many times the water tank is filled daily. This value varies depending on the time of year and the type of activity being performed. The total number of times it is refilled annually was calculated.

Calculating Annual Consumption

The total consumption can be found by multiplying the size of the tanker by the total number of times it is refilled annually. Then, since this tank is mobile, the annual consumption was divided evenly among the buildings. We will assume for this report that the annual consumption of the water tanks covers only the buildings audited.

2.5. Research & Academia

Identifying Installations and Equipment

The first step in determining the water consumption of this category was to contact the building directors. They were asked to supply information regarding labs in the buildings which have research or projects which utilize water. The building directors forwarded the emails or supplied contact information of the researchers. Email conversations were initiated with the researchers and in many cases, visits were organized to discuss water consumption and to visit the labs. The following is a list of water consuming installations, equipment, and activities in this section: lab sinks, fish tanks, phytotron and greenhouses, animal cage and drinking water, rack washers, as well as equipment cooling.

Determining Unitary Water Use

For the lab sinks, the Can-AQUA guide and EPA standards were used to determine the lab sink minutary consumption.

For the fish tanks, researchers were asked how much water it takes to wash and refill the tanks during a given period. The same was done for the phytotron and the greenhouse in Stewart Biology. For the equipment cooled by city water (once-through mostly), the researchers provided information on estimated water use per minute.

A meeting was schedule with the manager of Facilities & Animal Care Operations, Comparative Medicine and Animal Resources Centre. Information was gathered regarding the animal cage and rack washers (model numbers and make) and animal drinking. The companies were contacted and information was gathered regarding the water use per cycle or per hour of use of the cage and rack washers.

Estimating the Number of Uses/Duration of Use per Year

For research related to Stewart Biology's fish tanks, phytotron, greenhouse, and water cooled equipment, the researchers estimated frequency and duration of their specific water use. The same was done for the consumption at the Comparative Medicine and Animal Resources Centre (CMARC).

The frequency and duration of the lab sink usage was impossible to calculate in this way. The method used will be explained in Calculating Annual Consumption.

Calculating Annual Consumption

Calculations based on the unitary use consumption and the frequency and duration of use gave the annual consumption for the fish research, the phytotron and Stewart Biology's greenhouse, animal cage and drinking water, rack washers, and equipment cooling. The only remaining variable is the lab sink usage.

The next step was to look at the McIntyre Medical, Life Sciences, Stewart Biology, and Chancellor Day Hall buildings. Two water entrances supply these four buildings and both are metered. Note that these are the only buildings on campus for which information is available from the City of Montreal. There is one other meter in the Northeast sector, but it cannot provide accurate information since it records many buildings and there are other, non-metered water entrances. The readings for the four buildings were added together. The difference between the estimated value of consumption and the metered one was then attributed to the laboratory sinks. The laboratory sinks usage found this way was utilized to estimate the water consumption of the laboratory sinks in the rest of the university. To account for the fact that labs can be more or less water intensive, buildings were rated as high, medium, or low lab sink water usage.

3. Findings

For the full list of water consuming installations and related material, please see the *McGillUniv.WaterConsumption* Excel spreadsheet and Appendix 2 for an overview of the Excel spreadsheet, calculation explanations, and assumptions.

Category (Unit)	Hygiene (m^3/year)	Food Services (m^3/year)	Operational (m^3/year)	Landscaping (m^3/year)	Research & Academia (m^3/year)	Total (m^3/year)
32 buildings audited	206,031	677	411,390	1,080	640,953	1,260,132
"Higher" extrapolation for Downtown Campus (w/ Res. & Acad.)	382,212	1,256	763,178	2,004	1,189,044	2,337,694
"Lower" extrapolation for Downtown Campus (w/o Res. & Acad.)	382,212	1,256	763,178	2,004	640,953	1,789,603

Table 1 - Annual Consumption by Category for Different Scopes

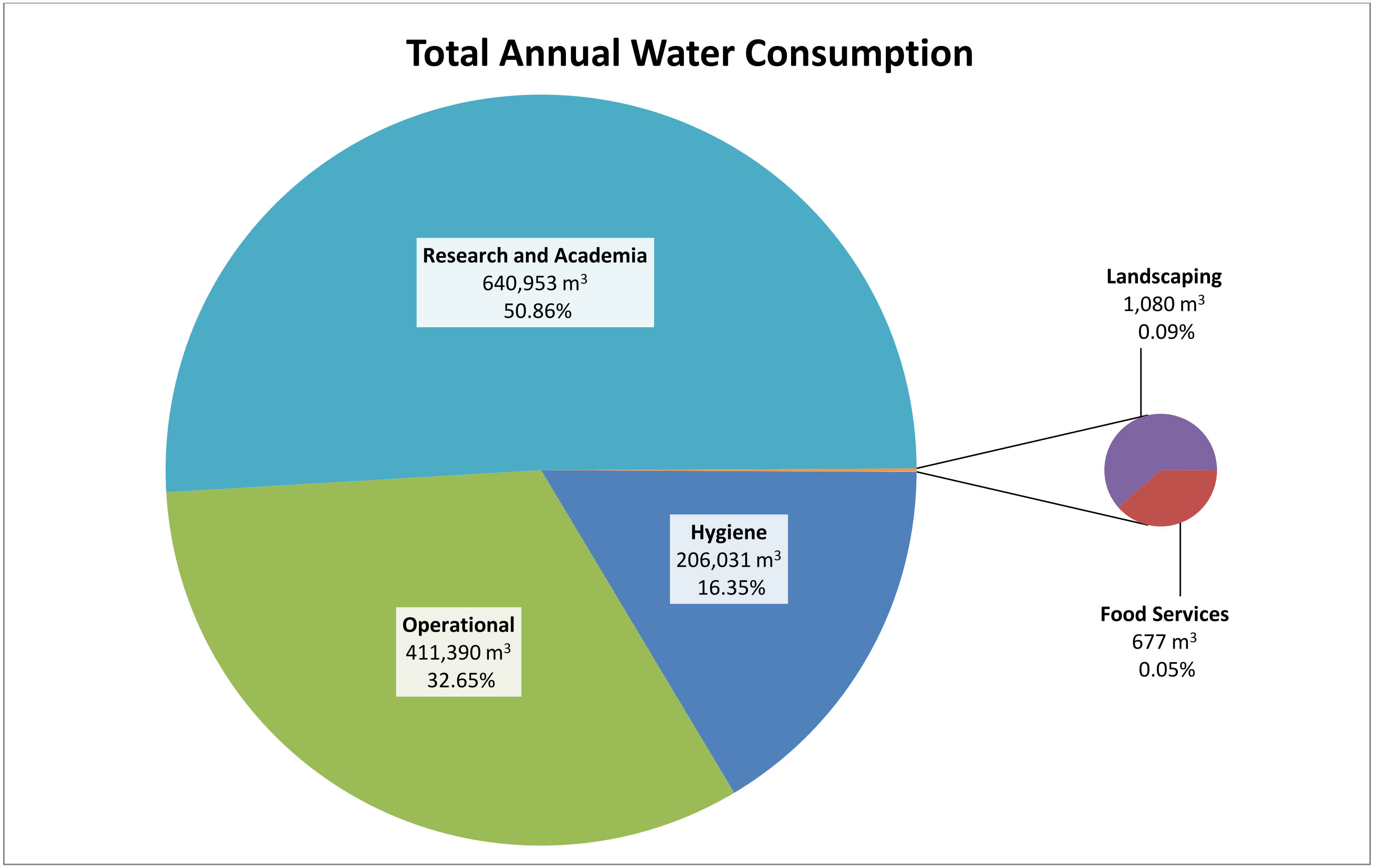

Figure 1 - Overall Water Consumption

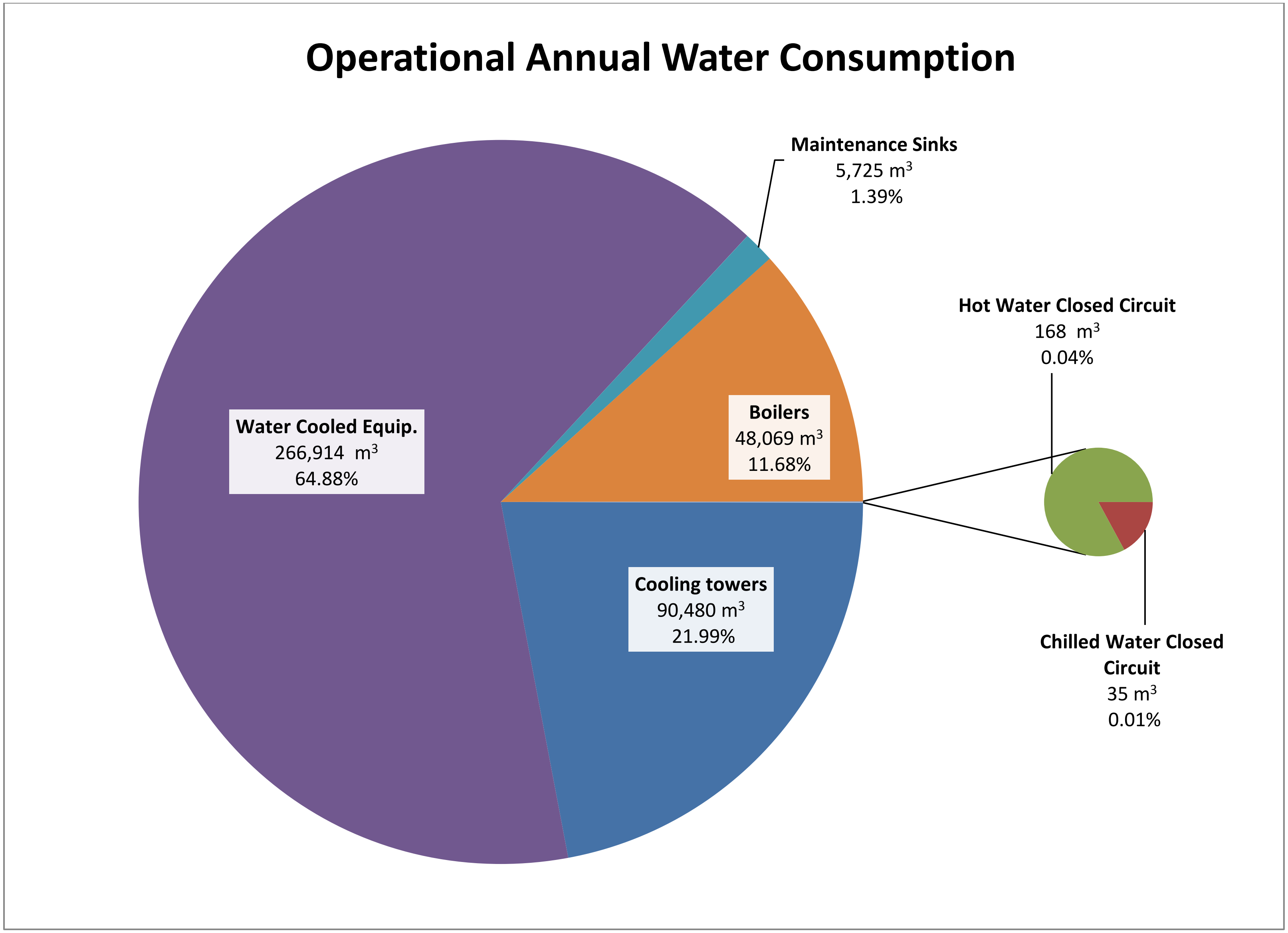

Figure 2 - Detailed Water Consumption, Operational

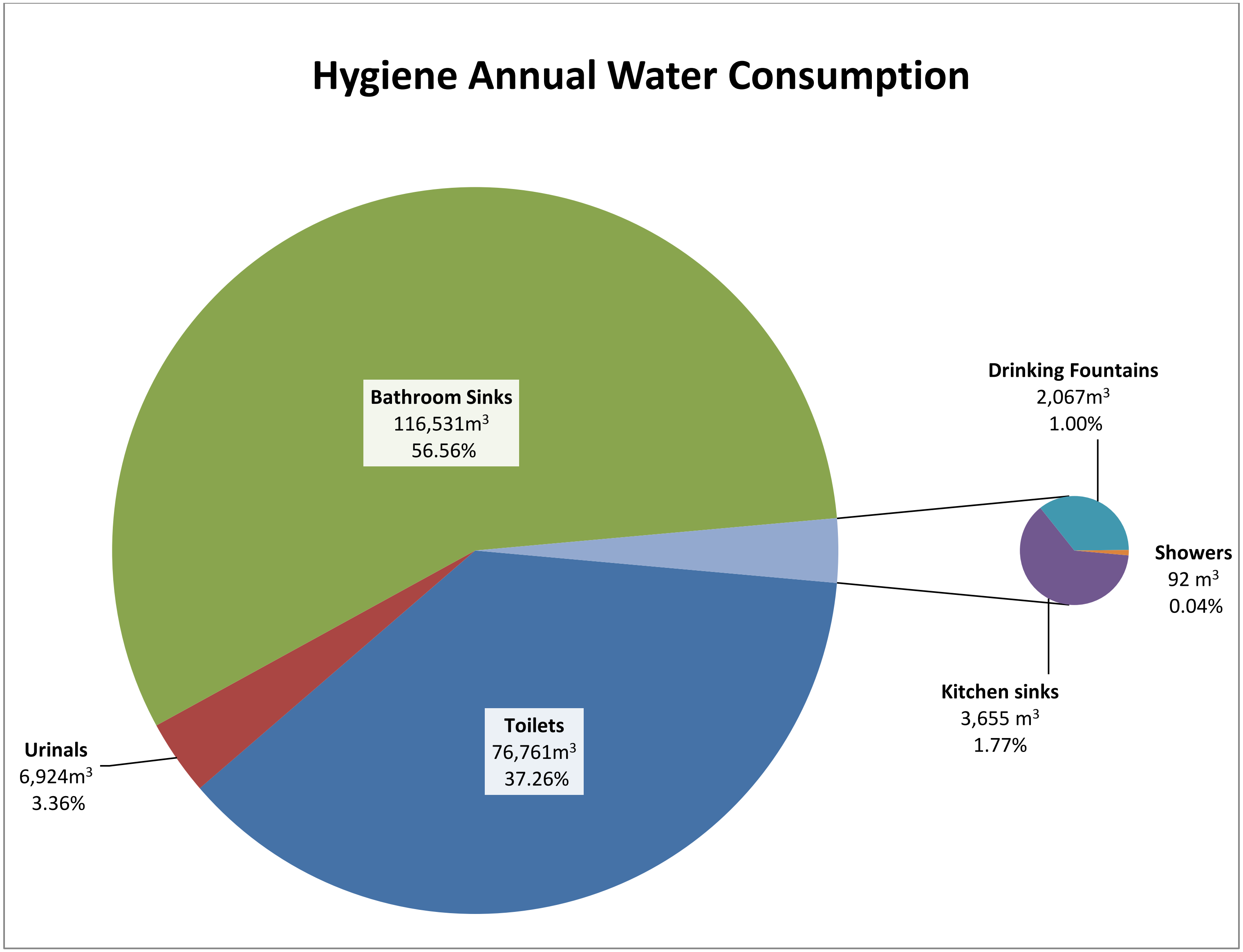

Figure 3 - Detailed Water Consumption, Hygiene

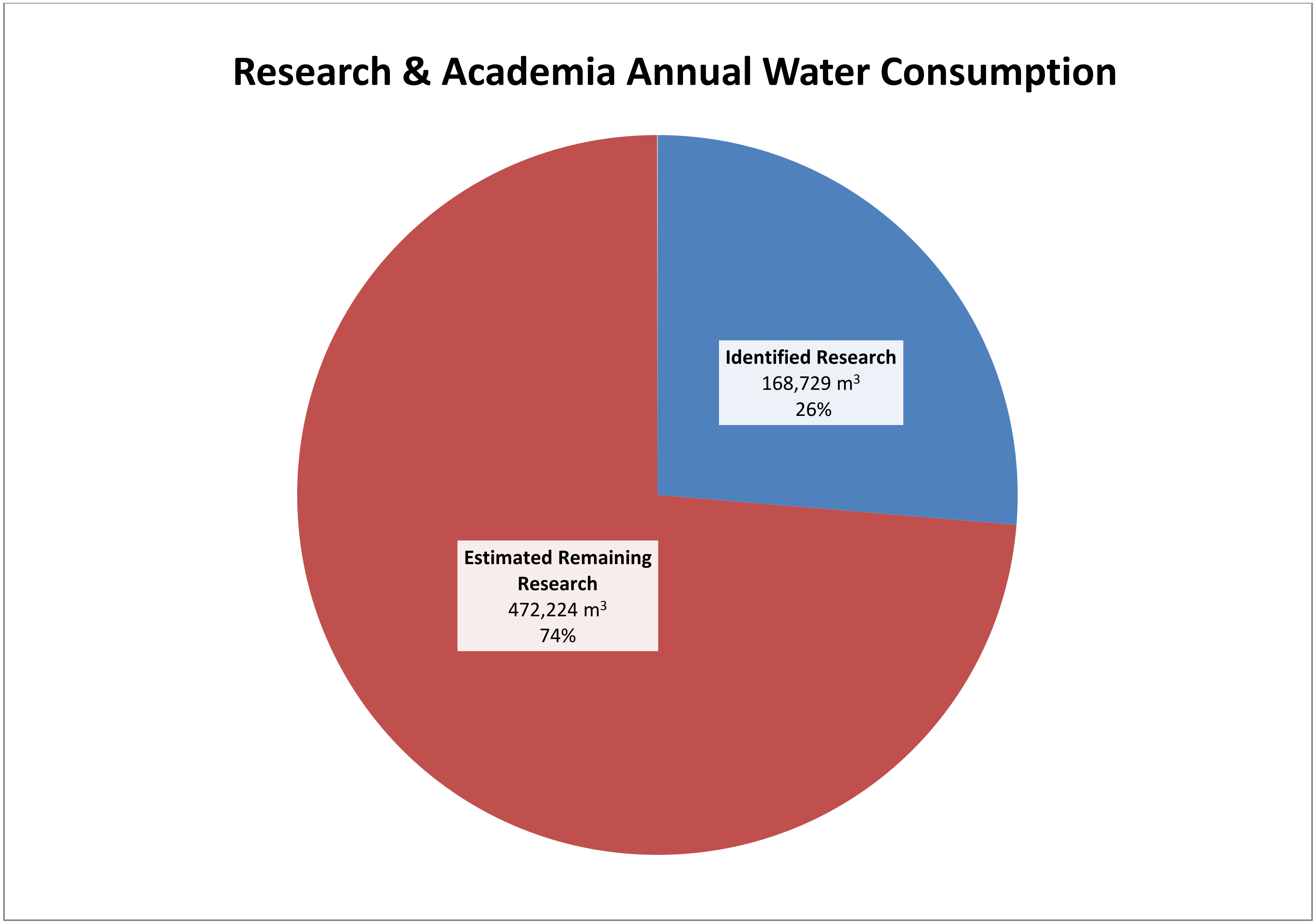

Figure 4 - Detailed Water Consumption, Research & Academia

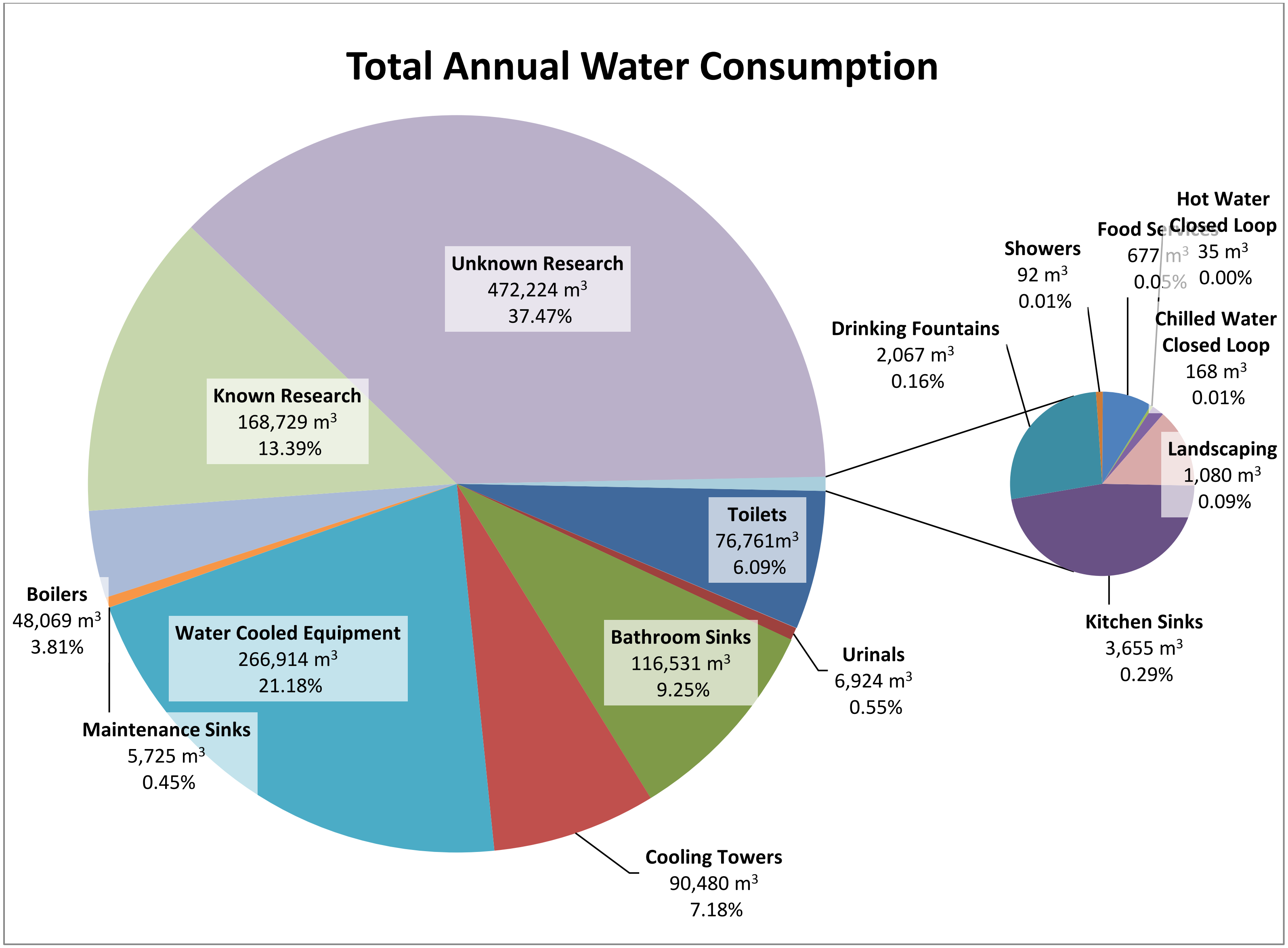

Figure 5 - Overall Water Consumption per Specific Use

4. Analysis

To extrapolate the total downtown campus consumption, two hypotheses were considered. The first is that there is no research usage in the unaudited buildings. Out of all the unaudited buildings, only the Ludmer and Duff Medical Buildings host research. For these buildings, the Research & Academia category is neglected in order to extrapolate to the whole campus. The consumption of the entire downtown campus can be found by performing a cross multiplication with the sum of all the categories but Research & Academia, the relative gross area of the 32 buildings audited, and the entire downtown campus. Research & Academia found for the 32 audited buildings is then added. This calculation leads to the lower extrapolated value found in Table 1. The second hypothesis is that the total consumption of the 32 buildings audited is proportional to the total downtown campus with regard to gross area and will lead to the higher extrapolated value found in the same table. With this hypothesis, we surmise that the consumption of buildings such as the residences, the athletic complex, and the remaining two research building (Ludmer and Duff Medical) is accounted for. We are confident that the true usage of downtown campus will be between these lower and higher extrapolations.

The most significant limitation in this study was the small number of water meters installed in the buildings on downtown campus. Only three meters are present; two of them installed on pipes serving the cluster of buildings comprising McIntyre Medical, Life Sciences, Stewart Biology, and Chancellor Day Hall. The third meter is installed on a pipe serving Strathcona Anatomy and Dentistry, Genome, and Trottier. However, there are numerous other pipes which supply water to these buildings so the third meter did not provide any useful information. As for the readings for McIntyre Medical, Life Sciences, Stewart Biology, and Chancellor Day Hall, there is no way of determining how much the buildings consume individually.

Note that the Estimated Remaining Research section (37.47% of total consumption) also contains the uncertainty of all five categories. The main uncertainty pertaining to Hygiene is the varying number of people in the buildings as people move around campus frequently as there is no way to estimate how many people are in each building. The main uncertainty in the Operational category is that the list of 52 once-through water cooled systems is incomplete, (some water cooled vacuum pumps were found in the Rutherford building's MicroFab and were not listed in the Bouthillette Parizeau study). The main uncertainty for the Food Services category is that some cafeterias and snack bars are closed during summer and little if any information was found. Also noteworthy is that since no residences were included in the audit, the Food Services utilization for the entire downtown campus may be higher than extrapolated since the residences have cafeterias that are much larger than many cafés on campus. For-the Landscaping category, the hoses on the outside of buildings are also used to water flowerbeds, plants, and trees but due to the difficulty of locating each hose and estimating usage time, only the 2,500-L mobile cistern was considered.

Another important limitation was related to the Research & Academia water consumption. Emails were sent to building directors to be distributed to researchers. While some researchers did respond with estimates as to how much water was consumed in their labs, others did not and yet others informed us it was too difficult to provide an accurate estimate of water use.

5. Recommendations

5.1. Suggestions to Fine-Tune Baseline

B1: Install Water Flow Meters

The audits performed allowed us to gather information used to make hypotheses about water consumption on downtown campus. To validate these hypotheses and accurately determine the water consumption baseline, water meters should be installed. Metering will allow McGill University to track water consumption and confirm whether or not its approach at reducing water usage is successful and to what extent.

B2: Audit Remaining Buildings

If flow meters cannot be installed, audit the athletic facilities, the residences and McGill Food and Dining Services' main cafeterias, University Centre, Brown Student Services, Strathcona Music, New Music, Ludmer, and Duff Medical to try and determine whether the extrapolation is accurate. As well, a water audit of Macdonald Campus is recommended to have a better portrait of McGill's overall water use.

B3: Further Investigate the Portion of Estimated Remaining Research

Identification of each lab can be done through Famis, and building walkthroughs can provide the contact information of the lab users as this is available on the laboratory doors.

Further investigating the uncertainties regarding each category mentioned in the Analysis section as well as determining whether leaks are a major factor in water consumption.

5.2. Water Conservation Recommendations

The Higher Extrapolated Consumption value was used when calculating relative water savings and individual fixture consumption. By doing so, the values reported are conservative. This way, if meters are installed and the total consumption is found to be lower, then the relative savings will only be greater. This is preferable than the alternative, which is using the Lower Extrapolated Estimate. If the consumption is found to be higher, then the relative water savings would drop in percentage values.

WC1: New Water Treatment Technologies for Water Cooling Towers

Non-chemical water treatment is emerging as a viable option for water cooling towers. Pulsed power technology, ozone technology, and ultraviolet light[13] systems are some examples of this. General claims regarding this technology revolve around easier solid particle removal which allows the cooling tower to run at higher cycles of concentration and therefore lowering water consumption in the form of lower blowdown, reduced bacteria colony counts and monetary savings from eliminating the need for expensive chemicals. Of particular interest is the pulsed power technology. One of these products, an Evapco Pulse Pure is installed on a cooling tower in the McIntyre Medical building. Some research[13] supports the claims for the pulsed power technology, which consists of subjecting the circulating water to electrical pulses. Claims of lower water use due to higher cycles of concentration, lower bacteria counts, lower costs, and lower corrosion rates compared to chemical treatment seem to be supported. However, this type of water treatment has no residual effectiveness, meaning it stops functioning when the tower is turned off, unlike chemical treatment. Assuming that the amount of water used in cooling towers is proportional to gross area and a 20% blowdown, the water used in blowdown represents 1.4% of total consumption. The McIntyre Medical building cooling tower should be monitored and tested under different conditions in order to obtain data and verify these claims independently. This will help determine whether this technology is suitable to the needs of McGill University.

WC2: Upgrade Once-Through Cooling

Follow the recommendations outlaid in the Bouthillette Parizeau study. Approximately half of the usage related to once-through cooling can be replaced by cooling tower water and the other half by an evaporator-condenser system. Assuming that both methods allow the water consumption to be reduced by 88% (cooling tower operating at 4.5 cycles), then water savings of 16.5 % of the total water used can be achieved.

WC3: Low Flow Bathroom Installations

Continue policy on installing low flow equipment during bathroom renovations. A simulation using the spreadsheet shows that by replacing all the remaining toilets, urinals and bathroom sinks by low flow models, water savings of 5.9% overall could be achieved.

WC4: Alternate Water Sources

Reuse reverse osmosis and cooling tower discharge water. Investigate if the reuse of discharged water from reverse osmosis systems and cooling towers is suitable as grey water to be used in toilets and urinals. Together, water discharged from reverse osmosis from the CMARC (Comparative Medicine and Animal Research Center) and cooling tower blowdown accounts for 1.5% of the total downtown campus consumption.

Install cisterns to collect rainwater for use in toilets and urinals. The Life Sciences complex has a 50,000-litre cistern which collects rainwater to be used for the toilets and sinks. From the LEED Certification document, this cistern provides 1,436 m^3 of water per year[14], which represents 46% of the water consumption of the toilets and the urinals when compared to the values provided in the LEED document but 64% when compared to the estimated values in this study. Supposing a cistern were installed on each building and that the amount of rainwater collected was of the same percent of the buildings toilet and urinal utilization, this would represent a 3.1% to 4.2% reduction in total water consumption.

However, the use of grey water in a building requires that grey water and city (clean) water be two separate networks. Besides, existing buildings were not designed to carry the extra load water cisterns would mean for the roof. Using grey water is therefore conceivable in the case of new developments only.

WC5: Promote Researchers Involvement

Include researchers and lab users in the water consumption reduction effort. Research & Academia is responsible for approximately half of the total water usage on the downtown campus. Facilities Operations and Development is limited in the actions it can take to reduce research water consumption. Involving the researchers themselves to find lab specific water conservation measures should be pursued. An email was sent out inquiring if any researchers had suggestions and a few responses were received:

Leaking lab sink faucets need repair.

Consolidate de-ionized water production from individual labs to a central system.

WC6: Cage Washer Water Reuse

Look into retrofitting cage and rack washers so that water from the final rinse of one cycle can be reused in the early rinse stages of the next cycle. Rack and cage washers account for 14.3% of the identified research consumption and 1.9 % of the total downtown campus utilization.

WC7: Residence Water Use Reduction Contest

Meter water use or audit residence buildings to estimate water consumption then organise a contest to see which residence can be the most water efficient. Monetary incentives may increase motivation. A few suggestions for water saving could be to only wash full loads of laundry and to turn off taps when not being used, such as while brushing teeth. The amount of water saved cannot be determined at this point since the residences were not audited as part of this study.

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14. *LEED CERTIFICATION – Life Sciences Complex*, McGill University, last modified June 2007, 288 pages.

Appendix 1

List of Buildings Studied

Building Name	Building Name
Bronfman	Pulp and Paper
Arts	Morrice Hall
McLennan Library	Education
Burnside	Macdonald Stewart Library
Stewart Biology	Adams
James Administration	Redpath Library
Macdonald Harrington	Redpath Museum
Otto-Maass	Redpath Hall
Chancellor Day Hall	Rutherford Physics
Dawson	Ferrier
Macdonald Engineering	Wong
McConnell Engineering	Gelber Law
Leacock	Genome
Strathcona Anatomy & Dentistry	Trottier
McIntyre Medical	Bellini (Life Science)
McIntyre Garage	Cancer (Life Science)

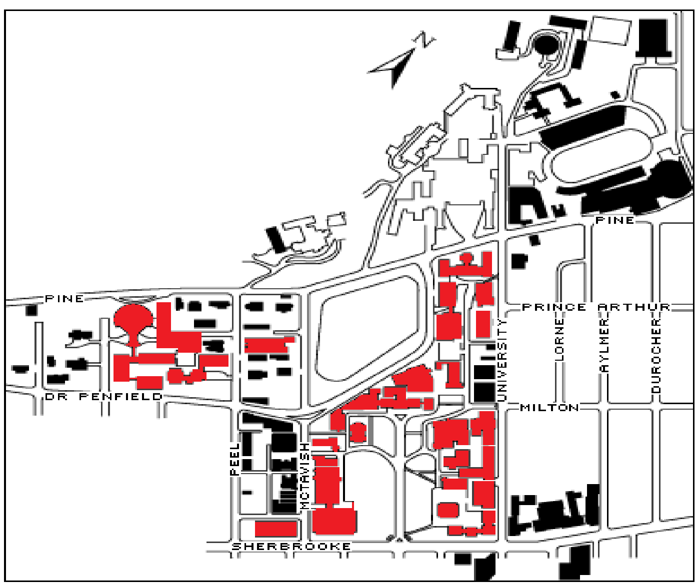

Figure 6: McGill Downtown Campus, buildings studied are designated by red.