UBC Social Ecological Economic Development Studies (SEEDS) Student Report

Water Conservation at Koerner's Pub Using Faucet Aerators

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Executive Summary

A Triple Bottom Line (TBL) assessment is conducted for faucet aerator implementation at Koerner's Pub. The pub is located in an old building, built with little concern for sustainability. The stakeholder, Tim Yu, would like to implement a water saving solution at the pub to become more sustainable and that would only require a small capital investment. There are two sinks in the kitchen on the main floor with faucets that do not have aerators and are the main focus of the analysis. One faucet has a double sink used for washing pots and cleaning dishes while the other faucet is a hand sink.

Aerators are attached to faucet outlets to decrease water consumption and improve the water stream while still maintaining pressure by partially obstructing the flow of water and introducing air into the stream. In order to attach an aerator to a faucet, the faucet must have threads so that the aerator can be screwed on. The two sinks analyzed at Koerner's Pub have threads and therefore it is possible to attach aerators.

In order to perform an accurate TBL assessment, data collection at the pub was required. The volumetric flow rates were obtained through the use of a bucket, a 500 mL graduated cylinder and a stopwatch. The maximum possible flow rates (valves fully opened) of the double sink and hand sink are 11.7 GPM and 8.49 GPM, respectively.

Since it is unlikely or very rare that restaurant employees use the faucets at their maximum flow rates the water savings and economic analysis for each sink is conducted based on an assumed flow rate of 4 GPM. The aerator chosen for the analysis based on pub requirements that it has a maximum output flow rate of 1 GPM and costs $6.00. This means that on average there will be a water savings of 3 GPM while the faucet is in use for activities that do not involve filling. Furthermore, it was calculated that it would take roughly 333 days to recover

the capital investment of one aerator. The installation of aerators in the hand sink and double sink is recommended, while monitoring how the reduced flow rate affects employees. The Tri-Max aerator stands out as a possible pick due to the cheap cost and the adjustable flow rate, which could be beneficial in the double sink where a higher flow rate may be required.

In addition to economic and environmental benefits, aerators also filter debris, prevent splashing, reduce faucet noise and prevent faucet leakage. Conserving water even in small amounts, such as through the use of aerators, aids in the protection of the precious resource and those who depend on it.

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Glossary

Aerator: An attachment for faucets that reduces the flow rate of water.

Capital Cost: The initial investment required.

Debris: Material in water stream.

Faucet: The part of the sink where the water exits.

Housing: The part of the aerator that has threads for easy attachment to the faucet.

Human Error: Errors caused by a person that can be reduced but not completely prevented.

Infrastructure: The physical structure of a building.

Mesh: The part of the aerator that introduces air into the water stream.

Silt: Fine material found in water streams.

Valves: Control the flow rate of water that exits the faucet.

1.0 Introduction

Water consumption is an important aspect of sustainability. Therefore, a sustainability analysis was conducted on the water usage in Koerner's Pub. Our stakeholder, Tim Yu, and the pub are aiming to reduce their water consumption to become more sustainable and economical.

During our visit to the pub, we obtained a brief overview of the bar and kitchens and determined the areas that required water conservation. The main difficulties presented were the limited budget and present infrastructure of Koerner's Pub. Tim did not want solutions implemented that would create a large capital investment or that would require a large infrastructure change. Therefore, we had to work with these constraints to come up with a simple yet effective solution. In addition to the constraints, it was recommended by Tim that our solution be easily implemented with the existing systems at the pub. Tim also suggested that procedural changes of the normal day-to-day operations of pub staff be investigated over infrastructure changes. However, after analyzing the options, we focused our attention to select water sinks, where the potential for poor water usage is high and hence a large potential for savings. More specifically, we investigated aerators that easily attach to the current sink faucets at the pub, which reduce water flow rate without reducing pressure. The analysis of aerators is conducted on a triple bottom line basis by investigating environmental, economic and social impacts. The environmental and economic benefits are determined by comparing current water flow rates of the two sinks in the main kitchen with researched aerator flow rates.

2.0 About Aerators

Faucet aerators are fairly simple instruments used to reduce flow rate and improve the feel of taps and faucets. There are two main parts of an aerator; the first is the housing, which is threaded in order to secure the aerator to the faucet head. The housing simply screws on to the faucet using the threads. The second part, which is the functional part of the aerator, is the mesh. The mesh is normally made of metal; it is the component that introduces air into the stream.

The primary purpose of aerators is to reduce water usage. By partially obstructing the flow of the water, air is introduced into the faucet stream, and the overall flow rate is reduced. The flow rate reduction equates directly to water savings, assuming the faucet is not used for a longer duration in order to compensate for the reduced flow rate. This point is not always purely academic; in some scenarios, a large flow rate is actually preferred. For example, heavy-duty washing may require a higher flow rate than that allowed by a household aerator. For this reason, the choice of aerator must be considered.

A secondary effect of an aerator is the softening of the water stream. For the purpose of hand washing, the unusual flow of a non-aerator sink may be uncomfortable for users. With the aeration of the water and the reduced flow rate, the stream felt by the hands of the user tends to be less forceful and gentler. Similarly, the aerated stream will tend to splash less and produce less noise.

There is some marginal (non-capital) cost of using faucet aerators, however. Aerators can eventually block up over time, reducing faucet flow rate to unsatisfactory levels. Therefore, some maintenance is required to keep them running correctly. Further details on the specifics of

aerator debris will be provided below. Because of this issue, proper commissioning and basic training is required to ensure that users do not manually decommission the aerator.

2.1 Types of Aerators

The most basic type of aerator simply reduces flow rate and does nothing further. Most residential bathroom aerators use this type; they attempt to hide themselves. However, more complex versions exist. For example, some aerators feature multiple flow settings that the user may toggle between in order to tailor their flow rate to the specific situation. Even more functionality may be provided by options such as continuously variable flow (e.g. valved aerator), or different faucet stream options (e.g. shower vs. spray, etc.). There is, of course, a cost associated with the increased system complexity - more complicated faucet aerators have a higher up-front capital cost. Specific aerator types and their costs will be discussed further below.

3.0 Data

In order to provide an accurate environmental and economical analysis of water consumption at Koerner's Pub, we took volumetric flow rate measurements of the existing sink faucets. The simplest method of measuring flow rate is through the use of a graduated cylinder and stopwatch. However, with this method there are large human errors created from starting and stopping the timer at the same time that the water is turned on and off. To reduce the human error of starting and stopping the timer, a larger sample size is required. Therefore, the water sample was taken with a large bucket. Another potential error is splashing and spilling while filling the bucket. The large flow of the sink created splashing that caused water loss, but did not significantly impact the data collection results due to the large volume of the bucket.

3.1 Procedure

The procedure is rather tedious but provides effective results in a short amount of time. Only two team members are necessary to conduct the measurements. One team member was in charge of opening the valves and placing the bucket underneath the faucet while the other member was in charge of the timer. The procedure in a step-by-step format is presented below:

1. Turn the water on to its maximum flow.
2. Place a bucket under the faucet and simultaneously start the timer.
3. Fill the bucket.
4. Simultaneously turn off the water and stop the timer.
5. Measure the volume of water in the bucket with a 500 mL graduated cylinder.
6. Divide the volume of water measured by the time recorded.

The procedure was conducted on the two sinks shown in Figure 1, which are both located in the kitchen on the main floor of Koerner's Pub. The double sink in the left figure is mainly used for filling pots and rinsing dishes. The sink on the right is primarily used as a hand washing station for staff.

Figure 1: Main Floor Kitchen Double Sink (left) and Hand Sink (right)

3.2 Results

The procedure outlined above was repeated numerous times to improve the accuracy of the measurements. During the data collection it was observed that even though the valves were fully opened it seemed that the flow rate fluctuated without any added human error caused by the team members. The flow rates are calculated by dividing the volume measured in the bucket by the time and converting the units to gallons per minute (GPM) for simple comparison with the specified aerator flow rates. The average flow rates measured for the double sink and hand sink in the main kitchen are 11.7 GPM and 8.49 GPM, respectively. All flow rate measurements and unit conversions can be found in Appendix A. These flow rates are very large compared to the maximum allowed flow rates of aerators, which range from 0.5 GPM to 2.2 GPM (Conservation

Warehouse, 2014). From the comparison of the current flow rates at Koerner's Pub and the specified flow rates from the aerators, there is a large potential for environmental and economic benefits.

4.0 Environmental Impacts

Water is an abundant resource in Canada, which has supported the common belief that water conservation is not an issue in the present day. Canada is the world's second largest consumer of fresh water, next to the United States (Bakker, 2006). While Canada has a large store of water resources, using these resources can have a negative environmental impact on aquatic life. The practice of diverting water or damming rivers has a large impact on the ecosystems that interact with the water. Taking water from one place to meet the needs of a city, will leave an ecosystem and its indigenous people with less water, or in some cases, no water at all.

4.1 Impact of Water Conservation on Urban Environments

It is a very common conception in Canada that we have more freshwater than any other country on Earth. While twenty percent of the earth's freshwater is located in Canada, much of the water is sitting in inaccessible lakes far away from dense urban areas, and cannot be easily transported for use (Bakker, 2006). The real metric that should be used when measuring how much water Canada has access to is the amount of "renewable supply" that is available on a seasonal basis. Renewable supply consists of the rainwater that flows through rivers and would flow into the sea if not collected (Bakker, 2006). This supply cannot be depleted because the earth's natural processes renew it. In terms of renewable supply, Canada ranks sixth globally in the amount of renewable supply generated each year, surpassed by Brazil and Russia (Bakker, 2006). Any use beyond the renewable supply volume will not be replenished, and is therefore not sustainable.

Some Canadian municipalities face water shortages on a yearly basis. Between 1994 and 1999, twenty five percent of municipalities experienced water shortages because of draughts, increased consumption, or insufficient infrastructure (Bakker, 2006). While there are shortages in Canada, water use is still increasing faster than the rate of population growth (Law Center UVIC, 2009). In other words, Canadians are becoming increasingly wasteful of their water resources.

Perhaps Canada's massive reserve of fresh water is not as promising as it has been advertised. Water should be taken from renewable sources whenever possible, and should be treated as a precious resource. In order to reduce water shortages and our ecological footprint, water should be conserved wherever possible. If proper water management is not implemented, Canadian's will not have access to enough water to maintain their daily habits. The simple usage of faucet aerators is just one example of the very many ways to conserve water.

4.2 Impact of Water Conservation on Natural Ecosystems

The mass collection and distribution of fresh water disrupts ecosystems consisting of both animals and indigenous people. Diverting water from one source to another can leave an environment that was once plentiful with water resources, with an insignificant supply of water that is insufficient to support its ecosystem. Damming rivers blocks the running of salmon, and decreases the flow rate of rivers, further disrupting ecosystems. All of these actions are done for humans to easily access freshwater.

Dams are used to manage freshwater resources and to generate electricity. Dams and other water diversion projects impede the natural migration patterns of salmon, making it less likely for them to return to their natural spawning ground. There are approximately 80,000 dams in the United States, leading to the loss of millions of salmon (Service, 2011). Although salmon

ladders allow salmon to run despite dam blockages, they decrease the size of the salmon run by a factor of 100 (Service, 2011). If the salmon population decreases, then so does the population of animals that depend on salmon as food, damaging both aquatic and terrestrial ecosystems (Service, 2011).

The ownership of water in Canada is under great dispute between the Government and First Nations. Ever since the settlement of Canada by the Europeans, First Nations have had their resources stolen and have suffered as a result. A good example of this scenario is the water crisis that the Nlaka'pamux First Nations faced. New settlers in Canada destroyed beaver dams that held the Nlaka'pamux First Nations water supply so that water would flow to their settlement (Bakker, 2006). When the beavers rebuilt their dams, the settlers proceeded to kill the beavers in the area (Bakker, 2006). Not only were the first nations left with little water, the ecosystem that interacted with the beavers suffered, all to provide water to a single settlement.

All Canadians should have access to fresh water, but not at the cost of harming others. In 2008, 100 First Nations Communities in Canada had boil advisories for their water supplies (Polaris Institute, 2008). Across Canada, First Nations Communities have suffered water issues from uranium contamination, abnormally high cancer rates, and disease causing bacteria (Polaris Institute, 2008). The use of freshwater is so immense that even the 330 million dollars allocated by the government to improve first nations water supplies in 2008 was insufficient (Polaris Institute, 2008). Clearly the use of water should be reduced to improve treatment and regulation.

As our freshwater supplies diminish, we will use up our non-renewable water reserves and destroy ecosystems in the process. The easiest and most environmentally beneficial option is to reduce water consumption before the effects of excessive water use become irreversible.

Governments should maintain their water management legislation to minimize the impact on the environment.

5.0 Economic Impacts

Prior to assessing the economic impact of the faucet aerators we consulted our stakeholder, Tim Yu, to understand the goal, budget limit and the extent of the change that can be made. As Koerner's Pub is a business, the economic aspect plays an important role in the decision making process. With all the constraints presented, a range of faucet aerators with different functions have been selected to meet the pub's requirements. These faucet aerators meet the criteria of not having to change the infrastructure, easy implementation and cost effectiveness. The goal of this section is to analyse the cost of an aerator and determine how long it will take to cover the initial investment. The potential faucet aerators selected for Koerner's Pub are as follows:

1. Ez-Flo 30292LF Dual Thread Low Flow Aerator
2. Tri-Max Aerator
3. Waxman 7610711 2 Function Water Saving Aerator
4. Bathroom faucet aerator with Flow Control Valve

5.1 Model Comparison

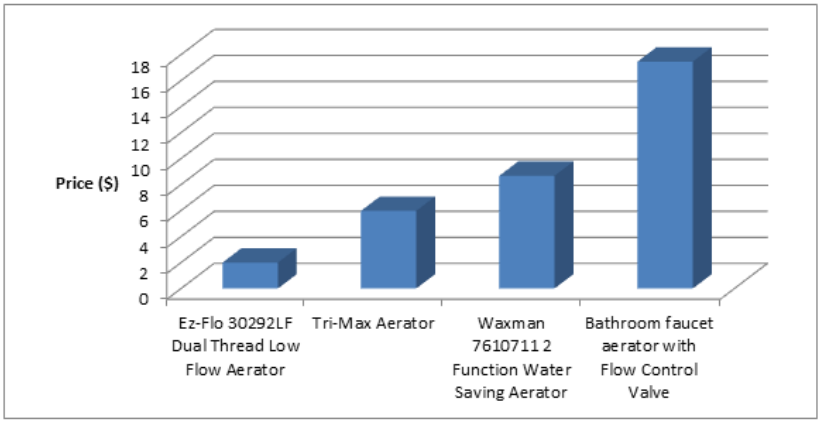

Figure 2: Cost of Selected Aerators

Figure 2 gives the price range of various faucet aerators available in the market. The aerator costs are determined from a popular online buying site, Amazon, and the local Walmart in Vancouver. The flow rate values are given in Table 1 below. The Ez-Flo aerator is a common aerator, which has a maximum flow rate of 0.5 GPM (Amazon, 2013). The tri-max aerator has adjustable flow rate options, which can be adjusted for different requirements (Walmart, 2012). Since the double sink in the kitchen is used to fill pots, having an option to increase the flow rate can be useful. The Waxman aerator has the option to select spray or stream water at a higher flow rate of 1.5 GPM (Amazon, 2013). The spray option can be used when washing hands and the stream option can be used to wash dishes or fill pots. Finally, the valve control aerator is the most user-friendly option that controls the flow rate to a maximum of 1.0 GPM (Amazon, 2012). Each aerator has different functions and costs but after inspecting the pub and learning about the use of the sinks, the Tri-Max Aerator is the most suitable. It is cost effective with a price of $6 and the flow rate can be adjusted.

Table 1: Flow Rates of Selected Aerators

Aerators	Flow (GPM)
Ez-Flo 30292LF Dual Thread Low Flow Aerator	0.5 GPM
Tri-Max Aerator	0.5 / 1.0 / 1.5 GPM
Waxman 7610711 2 Function Water Saving Aerator	1.5 GPM
Bathroom Faucet Aerator with Flow Control Valve	1.0 GPM

5.2 Life Cycle Cost Analysis

A typical aerator costs around $6 and this value is used in the cost analysis. The measured maximum flow rates of the double sink and hand sink in the main kitchen are 11.7 and 8.49 GPM, respectively. We estimated that the average flow rate of each sink to be about 4 GPM because the sinks are not typically used at their maximum flow rate.

The cost of water is $2.385 per cubic meter, which is equivalent to $0.00903 per gallon. The cost of water is taken from the city of Vancouver website. With the assumed flow rate for one sink, the price per minute of water is $0.036. Therefore, the amount of water that equals the cost of an aerator is calculated below:

$$\frac{6}{.036} \times 60 = 9969 \; gallons \; of \; water$$

By constricting the flow from 4 GPM to 1 GPM we save about 3 GPM of water. Taking this into account and assuming a sink is used for 10 minutes each day, at the nominal flow rate of 4 GPM; the total estimated amount of water saved every day is about 30 gallons. From this we have calculated that it will take 333 days or 11 months to recover the total cost of an aerator. The estimates that we have taken are low, as each sink will most likely be used more than 10 minutes in the 12.5 hours the pub is open each day. The NY Home Performance with ENERGY STAR has given an expected useful life of an aerator to be about 10 years.

5.3 Economic Analysis Conclusion

Economically a faucet aerator is an important item to have in Koerner's Pub. It reduces the water utility bill with a fast rate of return on the initial investment. There are no installation costs involved as it does not require any additional material to be fitted and anyone can install it.

Furthermore, the item is easily available at any home utility store. Buying them in bulk may also reduce the total average cost of the item. The economic analysis of the faucet aerator has demonstrated feasible values.

6.0 Social Impacts

It is important to understand the interactions engineering has with health, safety, and aspects of society. Based on our assessment, the three main categories that we looked into for social impacts are filtering debris, splash prevention, faucet noise reduction, and faucet leakage.

One issue many restaurant kitchens struggle with is keeping kitchen staff from removing aerators from faucets (Restaurant Water Efficiency, 2013). When it is a volume-based task, aerators will not save water. Therefore, kitchen staff remove the aerators because they reduce the water flow, thus increasing the time it takes for them to fill large jugs or pasta pots (Restaurant Water Efficiency, 2013.) One solution is to lock or tamper-proof aerators so that employees need a key to remove them.

6.1 Filtering Debris

The screen in the aerator is able to trap small debris that would otherwise exit the faucet. This means aerators not only save water but also ensures that consumers get silt or mineral free water. However, aerators may get clogged up with this debris.

The most common source of build up in aerators is from the hot water heater (Drinking Water Quality FAQs, 2014). The hot water heater tube is made of a nontoxic plastic. This plastic can disintegrate and travel in hot water directly reaching the faucet and eventually collecting in the aerator (Drinking Water Quality FAQs, 2014). Moreover, dissolved calcium that is naturally found in our drinking water, can naturally change to calcium carbonate in hot water heaters (Drinking Water Quality FAQs, 2014). Over time, calcium carbonate may accumulate at the bottom of the hot water heater and eventually reach aerators and restrict the water flow (Drinking Water Quality FAQs, 2014).

Even though aerators can get clogged with debris, it is easy to remove and clean them. To clean the aerator, simply unscrew and remove the mesh. It may simply require rinsing and scrubbing with a small brush (Guide to Faucet Aerators, 2014). Mineral build up can be removed by soaking the aerator in a solution of water and vinegar for several hours, or by using a mild descaler (Guide to Faucet Aerators, 2014). The Faucet should be flushed before replacing the aerator to get rid of any unwanted sediment (Guide to Faucet Aerators, 2014).

Figure 3: Accumulated Silt Inside an Aerator

My Plumbing, Heating, and Drain Cleaning Experiences and Installation Tips. Low Water. (2012, September 22). *Pressure from Faucets*. Retrieved from http://plumbing-and-heating.blogspot.ca/2012/09/low-water-pressure-from-faucet html

6.2 Splash Prevention and Faucet Noise Reduction

Without an aerator, at maximum flow water exits the faucet in one big stream and splashes. By dividing the water into streams and slowing down the flow rate, an aerator is able to reduce splashing. This is particularly important in a restaurant or pub for safety of kitchen staff and servers, as a water spill on the ground creates a slippery and dangerous surface. Thus, mixing air into the flow of water produces a steadier, more stable flow of water.

Aerators also help reduce faucet noise. This is again particularly important in a restaurant. Customers in the pub sitting next to the kitchen do not want to be interrupted by a noisy faucet.

6.3 Faucet Leakage

Many restaurant workers do not think about the harmful effects just one leaky faucet can have on the environment, as well as the cost. At first it may not seem like much, but as time passes the cost will grow as the leak continues (Carney, 2011). If a faucet drips once every second day, it would only take four and a half hours to reach one gallon (Carney, 2011). That is 2,700 gallons of water each year. Which means installing an aerator on a leaky faucet at Koerner's Pub can save up to one thousand gallons of water every year.

7.0 Conclusion and Recommendations

Faucet aerators are a simple and cost-effective way to conserve water, and their installation should serve Koerner's pub well while requiring minimal maintenance and very low up-front capital cost. We recommend installing an aerator in the hand sink, and doing some short investigation before installing one in the double sink, in order to ensure the reduced flow does not impact any dishwashing or filling performances. In terms of make and model, the Tri-Max aerator stands out as the best choice. The adjustable flow rate means it may work with the kitchen/dishwashing sink, and its relatively cheap cost is a positive. Of course, many options are possible, and were described in detail in the Economic Impacts section.

Using very conservative estimates, we calculate approximate a one-year payback period on the purchase of the aerators. Coupled with the fact that they represent a relatively small capital investment, and also provide some social benefits along with the more evident environmental advantages, we recommend installation of faucet aerators.

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Appendix A

Table A 1: Flow Rate Measurements for Main Floor Kitchen Double Sink

Measurement	Time (s)	Volume (mL)	Flow Rate (mL/s)	Flow Rate (GPM)
1	4.26	3250	763	12.1
2	4.05	3265	806	12.8
3	4.31	3225	748	11.9
4	4.79	3270	683	10.8
5	4.90	3330	680	10.8
			Avg. Flow Rate=	**11.7**

Table A 2: Flow Rate Measurements for Main Floor Kitchen Hand Sink

Measurement	Time (s)	Volume (mL)	Flow Rate (mL/s)	Flow Rate (GPM)
1	6.79	3530	520	8.24
2	6.24	3414	547	8.67
3	6.15	3315	539	8.54
			Avg. Flow Rate =	**8.49**