Water Audit Report at the University of Illinois Urbana-Champaign

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Introduction

Water is a vital resource that humans depend on for survival, sanitation, hygiene and washing. Yet as the world population continues to grow, pressures on this limited resource continue to increase, making it an entity in need of sustainable use. Based on data from the U.S.G.S. in 2010, nearly 42 billion gallons of water were used per day nationwide for public supply withdrawals (Maupin et al., 2010). Therefore, maintaining the value of water in both a social and economic context is imperative to its sustainable use in the foreseeable future. With well over 100,000 people relying on water for basic daily needs in the Champaign-Urbana area alone, proper water management and distribution directly affect both student and residential quality of life (U.S. Census Bureau, 2016). As water scarcity becomes a greater reality, both campus and community action are helping to combat wasteful activities. Connecting with the community is often an effective method in changing the ways we use and save water. Texas A&M University is working with local water organizations to help homeowners perform their own water audits using checklists that help to make adjustments associated with sustainable water usage (Texas A&M University, n.d.). These checklists include changes to household fixtures, behaviors in the washroom and identifying problem areas that can all help to educate and elicit a response in the campus and local communities toward better water management.

In accordance with the Illinois Climate Action Plan (ICAP) goals aiming to reduce the usage of water campus-wide, water audits are useful in targeting which activities contribute most. The goal of this project is to evaluate water consumption on a per-building basis, but also to assess how the University of Illinois compares to other universities regarding more sustainable practices in resource consumption. As made evident in a study conducted in the North Marin Water District (NMWD) of California, water audits can provide insights about water usage through leak identification and repair, the need for installation of water-saving technologies and accurate data about flow rates (Nelson, 1992). Each component helped to pinpoint an aspect of the problem leading to a 5% decrease in water use in the sample group from this study. At the University of Illinois, much of the information from these audits can now be collected via water metering and building blueprints to assess how efficiently campus buildings use water on a monthly basis. The ones used on our campus give information on flow rate via gallons of water used and can also present historical data on how the current month's usage compares to the past.

For the purpose of this report, two campus buildings were audited in order to better assess how water is used and at what rate by the campus community. Below is an analysis and commentary aimed to provide insight on how facilities are used on campus and how that can be improved upon by students and faculty. It may also be utilized as an outline for further investigations into how our usage trends follow our goals in the ICAP. Finally, it provides some information on what other universities are doing to be more sustainable and how we can help to continue leading by example.

Methods

The first building chosen for the water audit is the Rehabilitation Education Center located at 1207 South Oak Street in Champaign, IL. It is a two-story building consisting of a basement and first floor. There are two bathrooms on the lower level and four bathrooms on the first floor. Of those on the first floor, two are located within the men's and women's locker rooms. The bathrooms on the first floor that are not connected to the locker rooms are wheelchair accessible as well as the two in the basement. The building is 42,546 sq. ft. The second building is the National Soybean Research Center located at 1101 West Peabody Drive in Urbana, IL. It is a three-story building that is 98,855 sq. ft. with two bathrooms on each floor. There are no locker rooms located within this building.

Beginning a few years ago, the University of Illinois began recording building utility data electronically via the eDNA Billing System (EBS). This software records usage totals for electricity, water, oil, gas and other building utilities. These can then be interpreted more easily on an interactive user platform by faculty and staff. For this audit, data for the two campus buildings described above were analyzed regarding water usage. Using the EBS interface provided by university facilities and services, water was chosen as the utility with the fiscal year range between 2013 to 2018. The chosen trend type was "consumption by month" with consumption given as "total" consumption. The data was then trended to show how water usage has changed over the five-year period with an additional predictive trend line for 2018. Each year was given a different colored trend line to distinguish its data from other years and was plotted on the same graph to determine similarities and differences. Months were plotted on the x-axis and consumption totals was plotted on the y-axis. The 2018 trend line estimates future usage in the coming months compared to what it has been historically. Additionally, each generated graph provided a table with more detailed breakdowns of water usage by month. Averaged billing days and degree days were provided for each fiscal year. There is also an "Overall" row listing totals for consumption (in KGL), billing days (average) and degree days per year located at the bottom of each table.

Results

Based on data from the EBS, the two campus buildings for this water audit have significantly different trends in water usage. The Rehabilitation Education Center predictions for 2018 (yellow) vary considerably compared to consumption levels recorded in past years. The months of July, August and September are predicted to be two times higher than any other year while the months of October, November and December are predicted to be below what was consumed. Fiscal year 2013 is interesting to note because consumption quadrupled for a single month and then returned to more static levels (Figure 1). Fiscal year 2014 had a similar scenario occur in November where there was a spike in usage demonstrating a doubling in consumption. Of all years recorded, fiscal years 2013 (blue), 2014 (maroon) and 2017 (aqua) were the only years with substantial changes in consumption on a monthly basis. Fiscal years 2015 (green) and 2016 (pink) were relatively stable year-round. Overall consumption between fiscal year 2013 and 2017 averaged 244.900 KGL with billing days averaging about 29 days (Table 1). The consumption at this building was lower overall compared to the National Soybean Research Center hitting a maximum consumption level of 80.000 KGL in any given year.

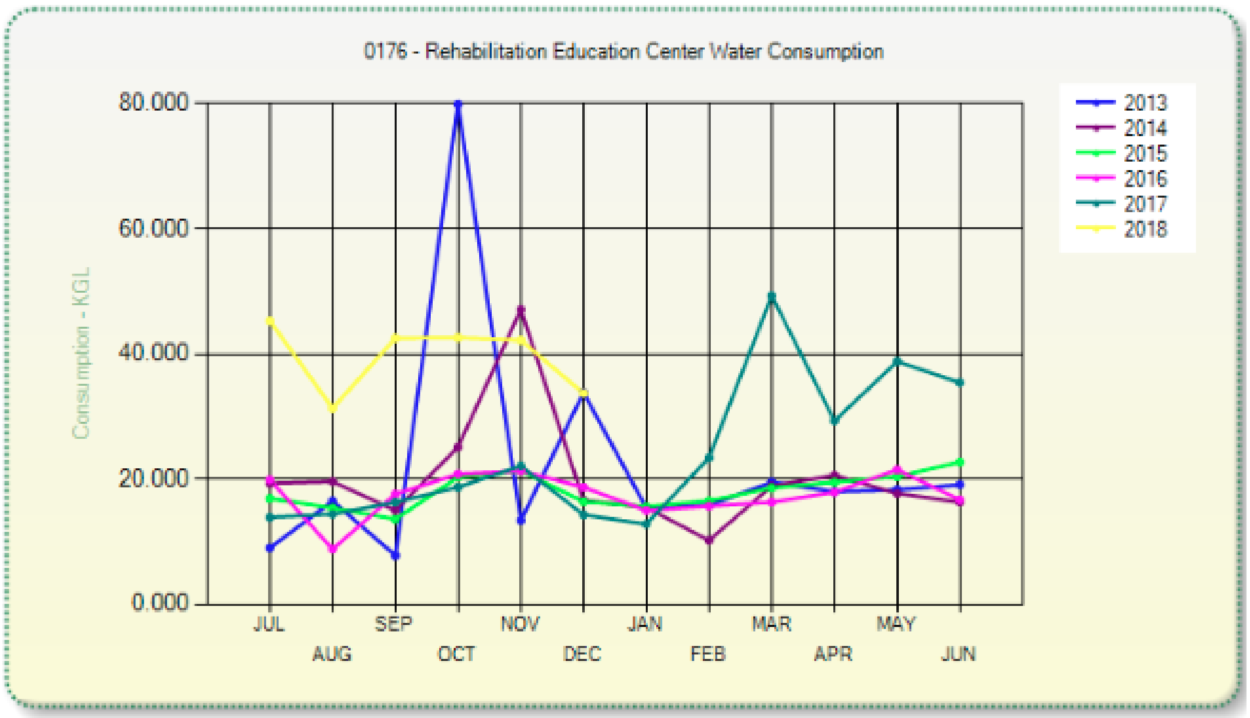

Figure 1. Monthly water consumption between fiscal years 2013 and 2018 with respective, colorized trend lines for the Rehabilitation Education Center in Champaign, IL.

Table 1. Exact monthly water consumption totals between fiscal year 2013 and 2018 shown with average billing days and degree days for the Rehabilitation Education Center. Column totals are given in the last row titled "Overall."

0176 - Rehabilitation Education Center Water																		
	FY 2013			FY 2014			FY 2015			FY 2016			FY 2017			FY 2018		
	Consumption (KGL)	Billing Days (Average)	Degree Days	Consumption (KGL)	Billing Days (Average)	Degree Days	Consumption (KGL)	Billing Days (Average)	Degree Days	Consumption (KGL)	Billing Days (Average)	Degree Days	Consumption (KGL)	Billing Days (Average)	Degree Days	Consumption (KGL)	Billing Days (Average)	Degree Days
JUL	9.000	27	541	19.300	28	256	16.900	30	167	19.900	32	272	13.900	31	337	45.300	37	354
AUG	16.500	34	292	19.600	34	272	15.400	32	272	8.800	23	216	14.400	30	348	31.300	23	208
SEP	7.800	25	175	15.000	27	202	13.600	27	175	17.600	34	211	16.300	28	224	42.500	34	218
OCT	79.900	26	420	25.100	31	393	20.300	32	356	20.800	30	276	18.700	32	230	42.600	28	310
NOV	13.400	30	713	47.100	30	768	21.300	27	911	21.300	29	573	22.100	32	549	42.200	27	675
DEC	33.800	33	872	16.600	32	1190	16.400	29	993	18.700	34	764	14.300	27	1121	33.700	31	556
JAN	15.400	39	1133	15.500	37	1421	15.600	32	1253	15.000	33	1171	12.800	37	1018	--	--	--
FEB	15.800	20	986	10.200	19	1287	16.500	31	1295	15.700	27	900	23.400	25	677	--	--	--
MAR	19.500	28	946	18.900	27	936	18.600	26	849	16.300	23	531	49.300	28	681	--	--	--
APR	18.000	29	440	20.600	32	363	19.500	27	332	17.900	30	381	29.300	25	268	--	--	--
MAY	18.300	31	220	17.700	27	271	20.400	31	215	21.500	31	224	38.800	29	221	--	--	--
JUN	19.100	29	221	16.300	27	255	22.700	30	232	16.700	26	279	35.400	29	248	--	--	--
Overall	266.500	29	6,959	241.900	29	7,614	217.200	29	7,050	210.200	29	5,798	288.700	29	5,922	237.600	30	2,321

The National Soybean Research Center had a notably higher consumption base that never went below 500.000 KGL on a monthly basis over the five-year period. Predictions in 2018 for this building actually suggest lower consumption levels compared to historic data for five of the six months estimated thus far (Figure 2). Between July and December, only August is anticipated to have higher levels of water consumption though the increase is only by about 200.00 KGL. As for the other years with data fully recorded, fiscal years 2016 and 2017 had relatively higher consumption levels compared to years prior. Fiscal year 2013 had the lowest overall water consumption only surpassing 1,000.000 KGL a single during the month of January (Table 2). Fiscal year 2016 was the only year that experienced a spike, totaling 1,965.400 KGL in February. Overall consumption between fiscal year 2013 and 2017 averaged 11,830.474 KGL and billing days averaged about 29 days as well (Table 2). The consumption at this building was higher overall compared to the Rehabilitation Education Center hitting a minimum consumption level of around 500.000 KGL in any given year.

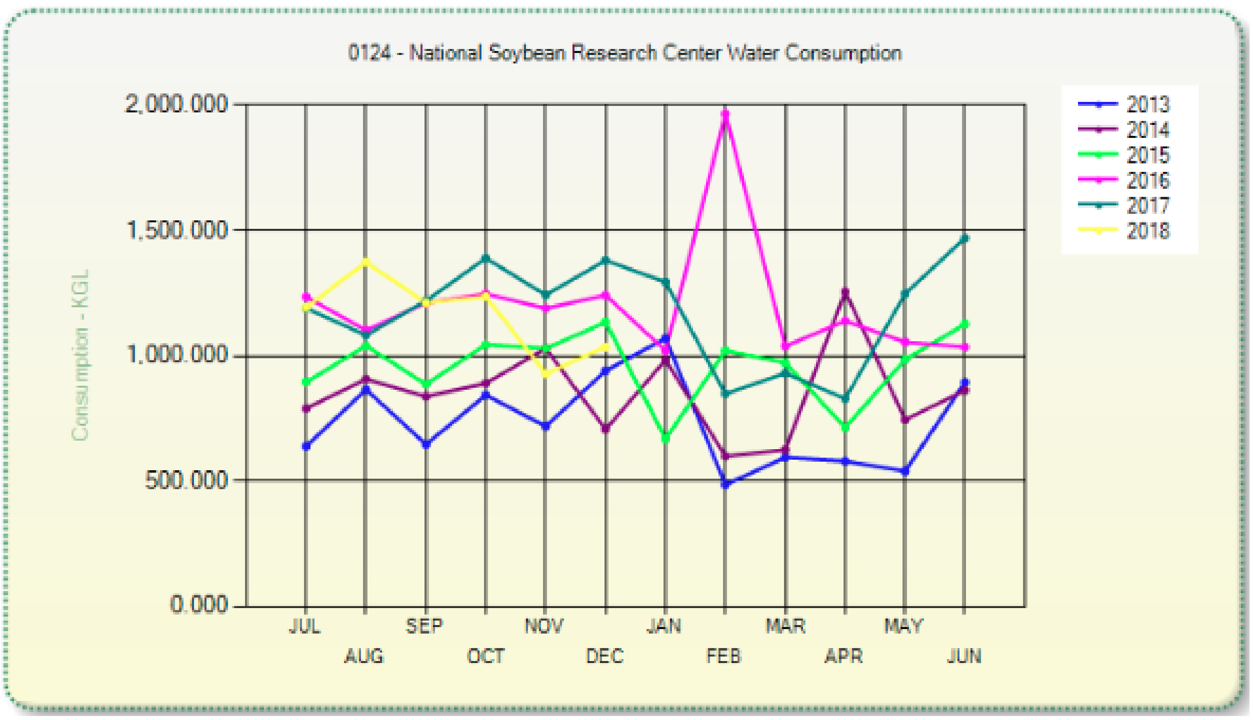

Figure 2. Monthly water consumption between fiscal years 2013 and 2018 with respective, colorized trend lines for the National Soybean Research Center in Urbana, IL.

Table 2. Exact monthly water consumption totals between fiscal year 2013 and 2018 shown with average billing days and degree days for the National Soybean Research Center. Column totals are given in the last row titled "Overall."

0124 - National Soybean Research Center Water																		
	FY 2013			FY 2014			FY 2015			FY 2016			FY 2017			FY 2018		
	Consumption (KGL)	Billing Days (Average)	Degree Days	Consumption (KGL)	Billing Days (Average)	Degree Days	Consumption (KGL)	Billing Days (Average)	Degree Days	Consumption (KGL)	Billing Days (Average)	Degree Days	Consumption (KGL)	Billing Days (Average)	Degree Days	Consumption (KGL)	Billing Days (Average)	Degree Days
JUL	638.780	26	541	789.720	28	256	895.350	27	167	1,234.760	32	272	1,189.400	32	337	1,192.590	26	354
AUG	864.760	34	292	906.640	31	272	1,039.380	31	272	1,101.530	28	216	1,082.210	28	348	1,373.230	32	208
SEP	646.450	26	175	837.180	28	202	886.820	27	175	1,211.240	30	211	1,218.640	30	224	1,211.430	29	218
OCT	843.030	30	420	890.200	29	393	1,044.240	30	356	1,246.830	30	276	1,389.320	32	230	1,236.490	32	310
NOV	718.490	26	713	1,029.160	34	768	1,029.200	30	911	1,189.400	29	573	1,242.380	28	549	928.630	27	675
DEC	940.220	33	872	706.490	25	1190	1,133.700	34	993	1,241.220	32	764	1,380.360	31	1121	1,034.400	30	556
JAN	1,069.550	37	1133	982.940	36	1421	668.170	21	1253	1,020.000	22	1171	1,293.940	35	1018	--	--	--
FEB	485.420	23	986	598.840	26	1287	1,019.810	35	1295	1,965.400	39	900	848.000	26	677	--	--	--
MAR	594.600	29	946	624.670	26	936	971.900	29	849	1,038.200	24	531	930.400	28	681	--	--	--
APR	579.030	29	440	1,255.930	32	363	712.960	28	332	1,139.040	30	381	828.460	23	268	--	--	--
MAY	539.770	25	220	744.740	28	271	984.660	27	215	1,054.560	29	224	1,247.520	32	221	--	--	--
JUN	894.320	35	221	861.740	30	255	1,126.350	32	232	1,034.620	27	279	1,469.730	35	248	--	--	--
Overall	8,814.420	29	6,959	10,228.250	29	7,614	11,512.540	29	7,050	14,476.800	29	5,798	14,120.360	30	5,922	6,976.770	29	2,321

Discussion

For this water audit, consumption data for two campus buildings was compared based on monthly totals over a fiscal five-year period. The Rehabilitation Education Center is predicted to trend toward a higher level of consumption in 2018. As a smaller building, however, it is interesting that this will increase since the building does not receive as much foot traffic compared to other buildings on campus. One reason for the increase may be due to the presence of a men's and women's locker rooms which have showers, sinks and toilets. The Soybean Research Center only houses bathrooms with sinks and toilets. There are also more spikes in consumption compared to the National Soybean Research Center. They mostly occur in the fall months suggesting that fall sports may directly increase the amount of water used by disabled student athletes. With more data, we can better estimate how consumption during sport seasons affects the way we use water and how we can better prepare for a usage increase when the time comes. We could then relay this information to athletes and explain that although they will be taking more showers, they can limit how long they are even during the busiest times of the season. The data across all years is much more variable, making it difficult to pinpoint why certain months in certain years experienced a doubling and even quadrupling in use. There does not appear to be any patterns that might help to explain the surges, but now that we know they're there we can anticipate the trends and look for ways to alter behaviors that make usage more predictable in the long run.

The National Soybean Research Center followed trends that were much more predictable. In the year 2018, consumption is actually predicted to be lower in five of the six months compared to years past. Data between the months of July to January were all relatively stable across the years recorded. Since this building does not house any locker room facilities, the consumption on that end is likely lower, but the consumption baseline remains much higher due to increased amounts of foot traffic on a monthly basis. As a building with many more lecture halls and lab rooms than the Rehabilitation Education Center, more students cycle through it more often. With only two bathrooms on each floor, more students are using less fixtures which help contribute to the higher water use on a monthly and annual basis. A peculiar anomaly, however, is the spike during fiscal year 2016 when every other year at that month is considerably lower. It is difficult to explain how the data jumped so significantly, but does emphasize how predicting resource consumption can sometimes appear random. As always, further data can help to determine a trend that is easier to identify over a longer period.

Of the two buildings, it is evident that the water demand is much higher at the National Soybean Research Center. Therefore, efforts should be concentrated first on the campus buildings that see the most use and have the most foot traffic from students and faculty. The biggest problems should be addressed first in order to create a framework that makes smaller problems easier to solve. As one of the larger buildings on our campus that contributes to a larger utility footprint, attention should be focused on making it more sustainable.

Comparisons

With climate change as a major topic of focus, many universities around the nation have established their own climate action plans to emphasize their interest in sustainable programs. Beginning in 2009, Cornell University established one of the first climate actions plans aimed at creating a climate neutral campus by 2050. Tools and strategies provided in their plan have since been used by other universities across the country as a template to begin plans of their own. Since 2008, Cornell has reduced their greenhouse gas emissions by almost 33% (Cornell University, 2013).

In an ongoing program at the University of Arizona, the school developed a water audit program that combines both university and community efforts to strengthen mutual responsibility for efficient water use. The School Water Audit Program (SWAP) has led to projects that help to educate and implement water conservation strategies like installation of water-efficient technologies and data-driven recommendations with community and campus leaders to promote widespread support and action (University of Arizona, n.d.). Since its start a few years ago, nearly 50 million gallons have been saved on their campus and in the surrounding communities. Another program at California State University, Bakersfield conducted water audits on a few buildings around their campus. Their take on the water audit approach focused not only the building itself, but also how the sprinkler systems and vegetation surrounding campus buildings impacted the water table and availability. Though California continues to struggle with drought conditions, water conservation strategies are taken just as seriously as they are here to establish a standard for how university facilities use, manage, and treat water as a resource for the campus (Kaur and Rubi, 2015). Similar to our ICAP goals, CSU also plans to reduce water usage 20% before 2020.

Setting an international example, the University of Victoria in British Columbia, Canada conducted a water audit back in 2011. This included a fixture inventory and cost benefit analysis that considered what would be saved monetarily in the switch to more efficient products. Their analysis concluded that almost $20,000 could be saved from residential fixture upgrades and nearly

$110,000 could be saved by investment into water re-use opportunities (Reilly, 2011). This could be an interesting aspect to include in our own university audit since the 2015 climate action goals call for further exploration of re-use programs that could save the university both money and resources. Therefore, it is clear that our water audit findings must stack up to what's been accomplished by other leading universities regarding sustainable resource use on campuses.

In efforts to remain competitively ambitious, the University of Illinois recently released an updated version of its own climate action plan (ICAP) in 2015. Of the eight objectives set in the 2010 version of the plan, six were successfully achieved. This included a reduction in potable water usage by 20% in just five years despite an increase in population. Although this reduction is impressive, the university hopes to lower it even further by an additional 10% by 2025. The 2015 plan also aims to inventory and benchmark existing landscape performance to better evaluate whether these structures contribute to greater runoff or absorption with emphasis on reducing storm water discharge that can be collected and used (University of Illinois, 2015). This could help to get back some of the water we could be using from sources other than groundwater. The plan mentions that holistic and inclusive water audits will need to be conducted to establish conservation targets and determine upper limits for water demand. With this report, it could act as one such precursor that may help to shift focus toward practical and feasible goals for water use on our campus.

Conclusions

As a follow-up to this report, there are some improvements I'd like to suggest regarding future and more professional water audit analyses for the University of Illinois campus. To better understand the components of a water audit, it is essential to understand the different categories of water and their associated footprints: blue, green and grey. A blue water footprint is an indicator of fresh surface or groundwater used for consumption. This considers water from freshwater lakes, rivers and aquifers. Green water footprints involve precipitation on land that does not run off or recharge groundwater supplies, but is stored in the soil or temporarily stays on top of the soil or vegetation. Grey water footprints are associated with the water used in washing machines, sinks, showers and tubs. This water is not counted in the flushing of toilets or anything that may come into contact with waste material (Aldaya et al., 2011). Each of these categories can be utilized to identify what types of water usage are contributing the most to overuse and wastefulness as well as provide more detailed information when conducting water audits.

On that note, I believe it is necessary to categorize data presented on the EBS platform in a manner that separates usage based on these three footprints. Though this may come across as something initially cost-prohibitive or simply not possible at this time with current technologies, this is one area that could help to pinpoint certain problems. Hypothetically speaking, if usage data could be compiled and separated into blue, green and grey water footprints, it would be much easier to identify which water source is being depleted and what use is contributing the most to wasteful practices. It could also help alter some behavioral aspects of the problem since this data could later be published in newsletters or emails, leading to the possibility of direct change students and faculty behavior.

Similarly, another benefit to the water audit analysis could be greater participation by both university employees and the surrounding community to create awareness and promote education. This could include facilities personnel working alongside students to regularly check campus buildings for leaks, unauthorized connections, proper meter measurements and any other sources that may be contributing to greater water use and loss. With any technology, there is room for miscalculation that requires some human intervention. Furthermore, students who are interested in resource management would be provided with an experiential learning opportunity outside of independent studies to get involved. As for greater community involvement outside the university, a similar study could be conducted like the one done in California by the NMWD. Informing the public about technologies available in combination with some involvement could help not only the university reach the ICAP goals by 2020 but also could assist the greater Champaign-Urbana area in becoming more sustainable.

As a school with a larger student body, it is crucial that we identify the problems and solutions associated with sustainable water consumption. The water audits to be conducted later in this project will help to spearhead efforts across the campus and residential community about ways we can each contribute to the bigger picture. As a limited resource, it is necessary to assess all options, especially when water scarcity is becoming a bigger problem globally moving forward. Overall, it is clear that these audits will provide the university and its constituents with the necessary means to achieve the goals set out in the ICAP program. I hope this project helps to establish a benchmark that can be used to effectively manage our water resources here on campus while also making our university an example of what it means to be a sustainable educational institution.

Literature Cited

Aldaya, M.M., Chapagain, K.A., Hoekstra, Y.A., and Mekonnen, M.M. (2011). "The Water Footprint Assessment Manual. Setting the Global Standard." *Social and Environmental Accountability Journal*, 23-30.

Cornell University. (2013). 2013 Climate Action Plan Update & Roadmap 2014–2015.

Kaur, G., and Rubi, L. (2015)., Water Audit at California State University, Bakersfield.

Maupin, M.A., Kenny, J.F., Hutson, S.S., Lovelace, J.K., Barber, N.L., and Linsey, K.S. (2014). Estimated use of water in the United States in 2010: U.S. Geological Survey Circular 1405, 56.

Nelson, J. O. (1992). Water Audit Encourages Residents to Reduce Consumption. *American Water Works Association, 84*(10), 59-64.

Reilly, K. (2011, October 3). *Water Use Audit University of Victoria* (Rep.).

Texas A&M University. (n.d.). Home Water Audits. Texas Water.

University of Arizona. (n.d.). School Water Audit Program.

University of Illinois. (2015, October 15). The 2015 Illinois Climate Action Plan.

U.S. Census Bureau. (2016). State and Country Quick Facts: Champaign city, Illinois.