Analysis of UC Davis Cuarto Dorm's Water Usage and Water Reduction Methods

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Abstract

For our project, we are going to analyze water use in two UC Davis dorms in the Cuarto area: Webster Hall and Emerson Hall. We are interested in this project because the dorms hold a large and significant portion of the number of people on the UC Davis campus, and therefore they use a lot of water. However, at the same time Davis is a very eco-friendly campus, so we are curious to find out just how much water the students in the dorm are using, and if this number can be reduced. Our methods basically involve obtaining data from the Cuarto dorms on water devices such as sinks and toilets, and using this data along with average daily water uses to compile a chart of how much water the students really use in a year. We then want to run scenarios of water conservation and water efficiency to see if water can be saved, and if so, how much water can be saved. One of our major challenges was being able to collect data, as our original project idea involved comparing multiple UC campuses against each other, but sometimes our contacts can fall through or not acquire data in a timely fashion. Overall, we found that a combination of water conservation and water efficiency measures saved the most water for the Cuarto dorms.

Introduction

With the projected increase in global population, water demand will continue to rise, further stressing our freshwater supply (Coates 2011). At our current rate of consumption, there will not be enough water to meet these demands and the effects to the environment will be detrimental. This includes groundwater and surface water depletion, freshwater aquatic ecosystem deterioration and pollution. Thus, it is crucial to reduce water consumption to sustainable rates to sustain our growing population and to prevent further harm to the environment.

As an influential research institution with a high reputation for its commitment to sustainability, winning the title of "#1 Cool School" by Sierra Magazine for 2012-13, University of California, Davis is a global leader that uses its prestige and expertise to address environmental issues, including water sustainability (sustainability.ucdavis.edu, 2013). In the UC Davis campus, as well as in other college campuses, a significant portion of water consumption occurs in dormitories. These are ideal controlled settings to study the effectiveness of water strategies because of the uniformity in fixtures, building characteristics and the age group of residents. Our study will focus on water use in dormitories, specifically the Cuarto dorms (Emerson and Webster residence halls) in UC Davis, that will attempt to quantify and analyze water efficiency and conservation strategies (Coates, 2011). By examining the application of these two strategies, we will quantify the amount of water savings and project future water demand. Knowledge obtained from this study can be used by the scientific community to understand water use within the UC Davis campus and develop innovative ideas and technologies for water efficiency and conservation. This can also be applied to other settings, such as other college campuses or other buildings. The data can also be used to inform stakeholders and policymakers of policy changes that should be made to considerably reduce water use.

Objective

The main situation being assessed and compared is the indoor water usage per capita of two halls at UC Davis campus' Cuarto dorms (Emerson Hall and Webster Hall). In addition, this project is going to investigate possible solutions for both dorms to reduce their water utilization to with a variety of methods. Thus, the main objective of this project is two-fold:(1) to determine the water use per capita of students residing in Emerson Hall and Webster Hall in the Cuarto Area, and (2) to analyze possible reduction methods regarding indoor water use for both halls, using conservation and efficiency mechanisms. The overall goal is to determine the scenario that results in the highest water savings and its overall impacts.

In order to complete this objective, the following main tasks will have to occur which are outlined below:

1. Collection of actual water usage data for the Cuarto Area (Emerson Hall and Webster Hall). The water usage data is categorized based on appliance and hall.
2. Analysis of current water use data to calculate water use per capita for Emerson Hall and Webster Hall
    a. Base Scenario
3. Creation of three water reduction scenarios;
    a. Scenario 1 – water conservation practices
    b. Scenario 2 – water efficiency practices
    c. Scenario 3 – water conservation and efficiency practices
4. Analysis of the three water reduction scenarios individually
5. Comparisons conducted among each scenario and conducted between each scenario to the base scenario
    a. Implementation of each scenario in comparison to the base scenario
6. Determination of best water saving scenario
7. Large impact of implementing the best water saving scenario

Finally, the products of these analyses are below:

1. Tables determining total water use in Emerson Hall and Webster Hall. Information on these will include standard consumption, daily use, and both individual and total indoor water use
    a. Table for Base Scenario illustrating current water use
    b. Table for Scenario 1 illustrating the change in water use due to water conservation methods
    c. Table for Scenario 2 illustrating the change in water use due to water efficiency methods
    d. Table for Scenario 3 illustrating the change in water use due to water conservation and efficiency methods
2. Table and graph illustrating the population residing in Emerson and Webster Hall
3. Graphs comparing water use in Scenarios 1, 2, and 3 to the Baseline

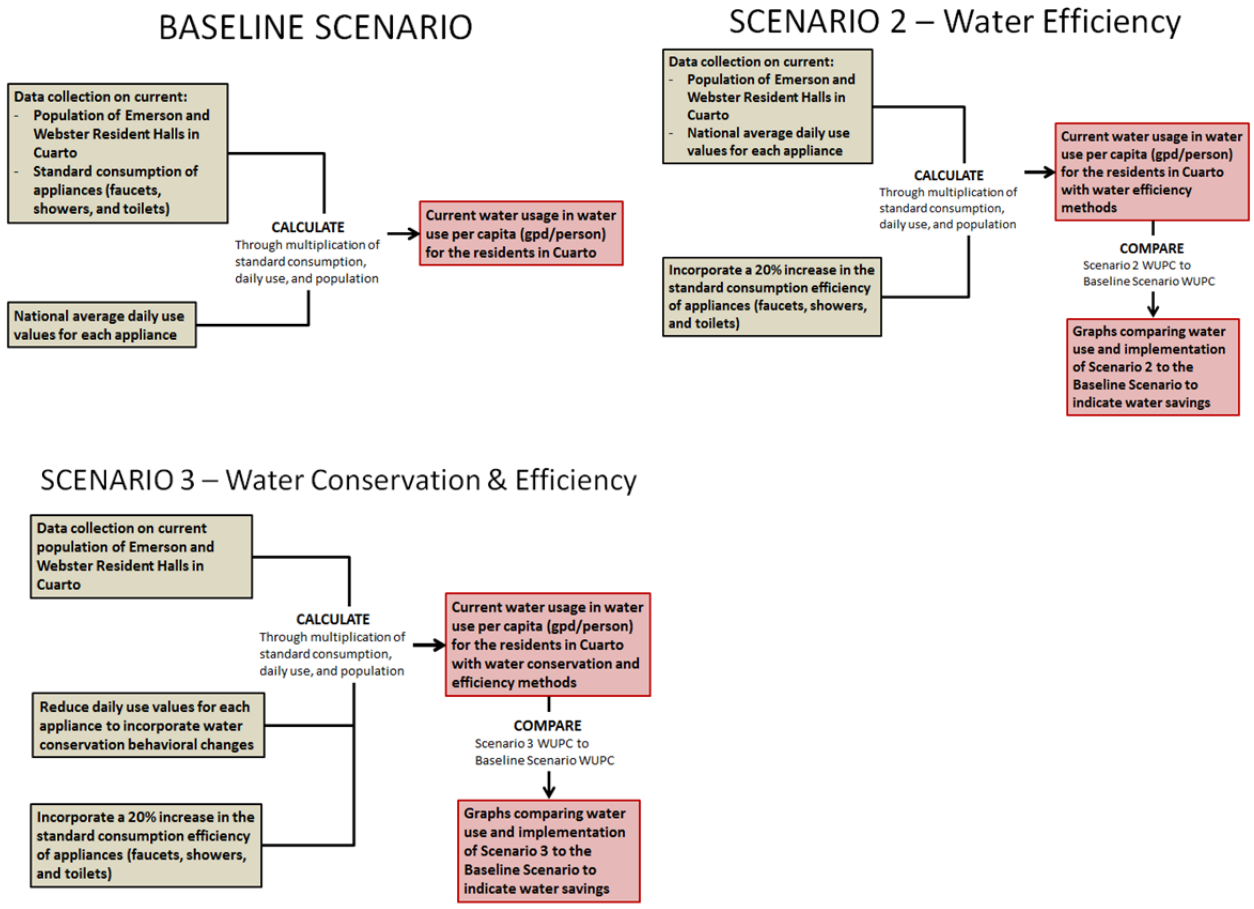
Data Sources

The data that was needed was the number of residents and the gpf and gpm for all appliances in both halls. That data was obtained from one person.

1. Jenni Porter, personal communication, November 13, 2013

Methods and Assumption

The following are flowcharts which illustrate the method used to complete the calculation aspects of the project. These charts are broken up into the Base Scenario, Scenario 1, Scenario 2, and Scenario 3.



Calculation/Results

Baseline

The Baseline Scenario is what is currently going on without any implementation of policies. This is the control situation in which the other scenarios are based on.

We acquired the data for the gpm and gpf from Jenni Porter, and multiplied that with the daily use averages to get the gallons per day of the different water devices, and added them together to g*et gpd/person=27.4*

	Standard Consuption		Daily Use		Indoor Wat. Use	
Indoor Water Use (gpd/person)	**Quantity**	**Unit**	**Quantity**	**Unit**	**Quantity**	**(%)**
Faucets	1	gpm*	6	minute	6.0	22%
Shower	1.5	gpm	10	minutes	15.0	55%
Toilet	1.6	gpf*	4	flushes	6.4	23%
				Total Indoor Water Use (gpd/person)	27.4	

We then multiplied the gpd/person by the number of residents in each hall to get the gpd of the hall. We then multiplied the gpd of the halls by 365 days to get the gallons per year of

both Emerson and Webster Hall.

GPD/Person	#Residents in Emerson Hall	GPD of Emerson Hall	GPY of Emerson Hall
27.4	508	13919.2	5080508

GPD/Person	#Residents in Webster Hall	GPD of Webster Hall	GPY of Webster Hall
27.4	263	7206.2	2630263

Scenario 1

Scenario 1 is about water conservation. Because water conservation is about changing the behavior in the end user, the amount of minutes and flushes were decreased. The amount of minutes using the faucet decreased from 6 minutes to *4 minutes*. The amount of minutes using the shower decreased from 10 minutes to *7 minutes*. Finally, the amount of flushes using the toilet decreased from 4 flushes to *3 flushes*.

To calculate the total indoor water use (gpd/person) for both Emerson and Webster Halls, the gpd/person for faucets, showers, and toilets were added together. This is shown in

Table 2
Scenario 1 : Water Conservation Emerson Hall

	Standard Consuption		Daily Use		Indoor Wat. Use	
Indoor Water Use (gpd/person)	**Quantity**	**Unit**	**Quantity**	**Unit**	**Quantity**	**(%)**
Faucets (1.0 gpm X 4 minutes = 4 gpd)	1.0	gpm**	4	minutes	4.0	21%
Shower (1.5 gpm X 7 minutes = 10.5 gpd)	1.5	gpm	7	minutes	10.5	54%
Toilet (1.6 gpf X 3 times/day = 4.8 gpd)	1.6	gpf***	3	flushes	4.8	25%
				Total Indoor Water Use (gpd/person)	19.3	

Table 2 and Table 3.

As seen in Table 2 and Table 3, the gpd/person for the faucet and shower were calculated by multiplying the gpm by the minutes; *4.0 gpd/person and 10.5 gpd/person respectively*. The gpd/person for the toilet was calculated by multiplying the gpf by the number of flushes; *4.8 gpd/person*. Because Emerson and Webster Hall had the same faucets, showerheads, and toilets, their Total Indoor Water Use was *19.3 gpd/person*.

Table 3
Scenario 1 : Water Conservation Webster Hall

	Standard Consuption		Daily Use		Indoor Wat. Use	
Indoor Water Use (gpd/person)	**Quantity**	**Unit**	**Quantity**	**Unit**	**Quantity**	**(%)**
Faucets (1.0 gpm X 4 minutes = 4 gpd)	1.0	gpm**	4	minutes	4.0	21%
Shower (1.5 gpm X 7 minutes = 10.5 gpd)	1.5	gpm	7	minutes	10.5	54%
Toilet (1.6 gpf X 3 times/day = 4.8 gpd)	1.6	gpf***	3	flushes	4.8	25%
				Total Indoor Water Use (gpd/person)	19.3	

To calculate the gallons per day for the entire Emerson and Webster Halls, the gpd/person was multiplied by the number of students in each hall. For Emerson, there were 508 residents so the gallons per day for all of Emerson Hall was *9,804.4 gpd* (Table 4). For Webster, there were 263 residents so the gallons per day for all of Webster Hall was *5,075.9 gpd* (Table 5). The gallons per day were then converted into gallons per year. This was done by multiplying the gpd by 365 days. Therefore, for Emerson Hall it came out to *3,578,606 gpy* (Table 4) and for Webster Hall it came out to *1,852,703.5 gpy* (Table 5).

Table 4	
Emerson Hall	
GPD	9804.4
GPY	3578606

Table 5	
Webster Hall	
GPD	5075.9
GPY	1852703.5

The gallons per year for both Emerson and Webster Halls were then compared with the gallons per year of the Baseline Scenario. The amount of water saved was calculated by subtracting the gpd/person of Scenario 1 from the gpd/person of the Baseline Scenario. This came out to *8.1 gpd/person of water saved* (Table 6)

Table 6
Summary Table Comparing Baseline and Scenario 1

	Baseline (gpd/person)	Scenario 1 (gpd/person)	Water Saved (gpd/person)
Indoor	27.4	19.3	8.1

Scenario 2

Scenario 2 incorporates water efficiency policies into the Cuarto Dorms (Emerson and Webster Hall) as a water saving mechanism. Water efficiency includes improving how efficiency an appliance functions, which is usually indicated by a reduced water flow rate. This analysis primarily focuses on indoor water use and furthermore on the installation more efficient faucets, shower heads, and toilets. In addition, the Scenario 2 analysis preserves the daily use quantities, which indicate human behaviors and preferences, and modifies the standard consumption values, which indicate the appliance efficiencies. Thus, the efficiency changes reflected in the following calculations is based on a 20% increase in efficiency (standard consumption) of the current flow rates of faucets, showers, and toilets in Emerson and Webster Hall illustrated in Table 7.

Table 7
Scenario 2 : Water Efficiency changes in Standar Consumption Rates

	Current Standard Consuption		Efficient Standard Consuption	
Indoor Water Use (gpd/person)	Quantity	Unit	Quantity	Unit
Faucets (0.8 gpm X 6 minutes = 4.8 gpd)	1	gpm	0.8	gpm
Shower (1.2 gpm X 10 minutes = 12 gpd)	1.5	gpm	1.2	gpm
Toilet (1.28 gpf X 4 times/day = 5.1 gpd)	1.6	gpf	1.28	gpf

To calculate the indoor water use (gallon per day per person) with the incorporation of water efficiency modifications for Emerson and Webster Halls, the water usage (gallons per day) per each resident was calculated. Then the water use per person for faucets, showers, and toilets were added together to determine total water use with water efficiency practices. These calculations are illustrated in Table 8 and Table 9.

Table 8
Scenario 2 : Water Efficiency Emerson Hall

	Standard Consuption		Daily Use		Indoor Wat. Use	
Indoor Water Use (gpd/person)	Quantity	Unit	Quantity	Unit	Quantity	(%)
Faucets (0.8 gpm X 6 minutes = 4.8 gpd)	0.8	gpm	6	minutes	4.8	22%
Shower (1.2 gpm X 10 minutes = 12 gpd)	1.2	gpm	10	minutes	12.0	55%
Toilet (1.28 gpf X 4 times/day = 5.1 gpd)	1.28	gpf	4	flushes	5.1	23%
			Total Indoor Water Use (gpd/person)		21.9	

Table 9
Scenario 2 : Water Efficiency Webster Hall

	Standard Consuption		Daily Use		Indoor Wat. Use	
Indoor Water Use (gpd/person)	Quantity	Unit	Quantity	Unit	Quantity	(%)
Faucets (0.8 gpm X 6 minutes = 4.8 gpd)	0.8	gpm	6	minutes	4.8	22%
Shower (1.2 gpm X 10 minutes = 12 gpd)	1.2	gpm	10	minutes	12.0	55%
Toilet (1.28 gpf X 4 times/day = 5.1 gpd)	1.28	gpf	4	flushes	5.1	23%
Total Indoor Water Use (gpd/person)					21.9	

As seen in Table 8 and Table 9, the daily use of water per capita for the faucet and shower were calculated by multiplying the standard consumption rate (gpm) by the daily use (minutes). This resulted in an indoor water use of 4.8 gpd/person and 12.0 gpd/person respectively. While the the daily use of water per capita for the toilet was calculated by multiplying the standard consumption rate (gpf) by the daily use (number of flushes) resulting in an indoor water use of 5.1 gpd/person. As both Emerson and Webster Hall utilize the same appliances including their faucets, showerheads, and toilets, the total indoor water use for both dorms was 21.9 gpd/person.

In order to find the total indoor water use for the entire Emerson and Webster Halls, the resident population was incorporated into the calculations. For Emerson Hall, there are 508 residents and when that is multiplied by the calculated water use (Table 8) the water use for the entire dorm is 11,135.36 gpd (Table 10). For Webster Hall, there are 263 residents and when that is multiplied by the calculated water use (Table 9) the water use for the entire dorm is 5,764.96 gpd (Table 11). In Table 10 and Table 11, the total water use in gallons per year in also calculated by multiplying 365 days to the gpd calculated earlier. This resulted in Emerson Hall using 4,064,406.4 gallons per year (Table 10) and Webster Hall using 2,104,210.4 gallons per year (Table 11).

Table 10

Emerson Hall	
GPD	11135.36
GPY	4064406.4

Table 11

Webster Hall	
GPD	5764.96
GPY	2104210.4

The water use in Emerson and Webster Halls were then compared with the current water use calculated in the Baseline Scenario. With the incorporation of water efficient practices and policies, the water saved was 5.5 gpd/person (Table 12) for both Emerson and Webster Halls. This was determined through subtracting the water use with the water efficiency modifications to the current water use.

Table 12

Summary Table Comparing Baseline and Scenario 2	Baseline (gpd/person)	Scenario 2 (gpd/person)	Water Saved (gpd/person)
Indoor	27.4	21.9	5.5

Scenario 3

Scenario 3 incorporates both water efficiency and water conservation policies, quantifying the water savings acquired when both strategies are implemented together. This was calculated by substituting the suggested conservation practices by water users and the 20 percent efficiency in fixtures as discussed in the previous scenarios.

Table 13

Scenario 3 : Water Efficiency and Conservation Emerson Hall						
	Standard Consuption		Daily Use		Indoor Wat. Use	
Indoor Water Use (gpd/person)	Quantity	Unit	Quantity	Unit	Quantity	(%)
Faucets (1.8 gpm X 4 minutes = 7.2 gpd)	0.8	gpm**	4	minutes	3.2	21%
Shower (2.0 gpm X 7 minutes = 14 gpd)	1.2	gpm	7	minutes	8.4	54%
Toilet (1.8 gpf X 3 times/day = 5.4 gpd)	1.3	gpf***	3	flushes	3.8	25%
			Total Indoor Water Use (gpd/person)		15.4	

Table 14

Scenario 3 : Water Efficiency and Conservation Webster Hall						
	Standard Consuption		Daily Use	Indoor Wat. Use		
Indoor Water Use (gpd/person)	Quantity	Unit	Quantity	Unit	Quantity	(%)
Faucets (1.8 gpm X 4 minutes = 7.2 gpd)	0.8	gpm**	4	minutes	3.2	21%
Shower (2.0 gpm X 7 minutes = 14 gpd)	1.2	gpm	7	minutes	8.4	54%
Toilet (1.8 gpf X 3 times/day = 5.4 gpd)	1.3	gpf***	3	flushes	3.8	25%
Total Indoor Water Use (gpd/person)					15.4	

Because of the uniformity in fixtures within Emerson and Webster Hall, the application of both strategies results to 15.4 gdp/person in both halls.

Table 15

Emerson Hall	
GPD	7843.52
GPY	2862884.8

Table 16

Webster Hall	
GPD	4060.72
GPY	1482162.8

Total indoor water usage was then calculated. With 508 residents, Emerson Hall's total indoor water usage resulted to 7,843.52 gallons per day and 2,862,884.8 gallons per year. With 283 residents, Webster Hall's total indoorwater usage resulted to 4,060.72 gallons per day and 1,482,162.8 gallons per year.

Comparing the water use between the Baseline Scenario and Scenario 3, the water savings that results is 12 gallons per day per person.

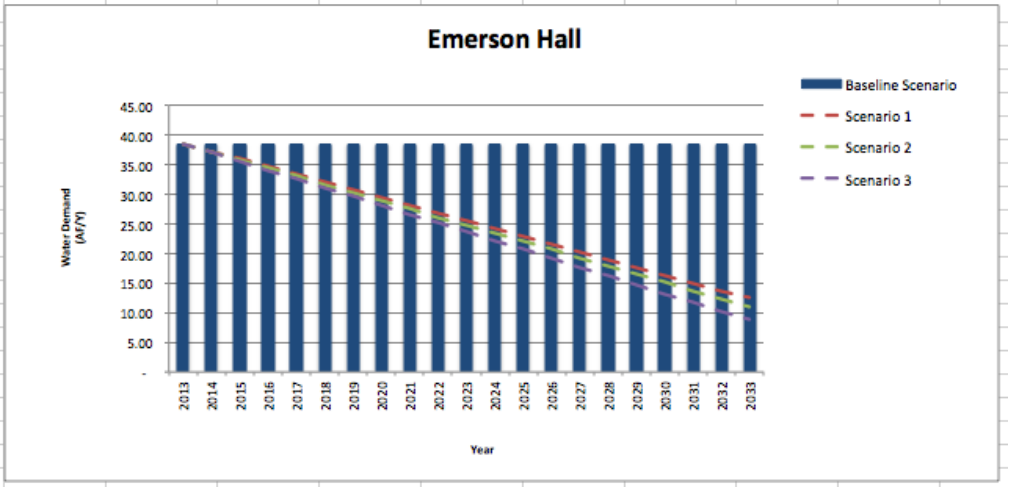
Table 17

Summary Table Comparing Baseline and Scenario 3	Baseline (gpd/person)	Scenario 3 (gpd/person)	Water Saved (gpd/person)
Indoor	27.4	15.4	12

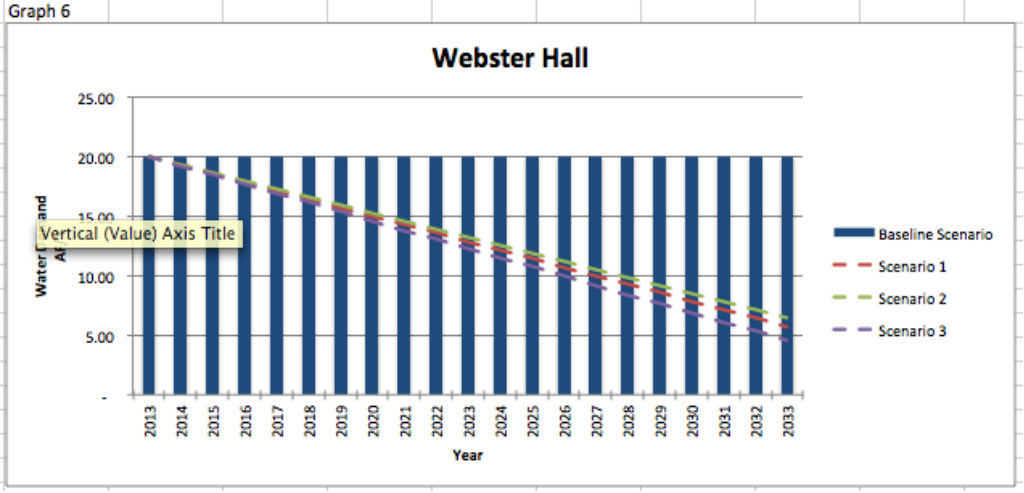
Estimating Future Water Demand

Future Water Demand is estimated for the implementation of the scenarios previously discussed in Emerson and Webster Halls. With the assumption that 5% of the population will modify their water usage from the Baseline Scenaro water use per capita to the respective scenario being examined yearly, water savings are calculated throughout the span of the scenario's implementation, while also incorporating time lags associated with the shift of water user habits to those in the scenario. The fixed residential capacity of these dormitories allows for these water savings to be solely based on the effects of the listed water saving strategies. Based on these calculations, Graph 5 and Graph 6 compare the Baseline Scenario water use with the implementation of the water use of each scenario.

Graph 5



Graph 6



Conclusions

It was found that the current gpd/person for both Emerson and Webster Halls was 27.4. While this number may seem low, it needs to be remembered that other household items such as a dishwasher were not taken into account; only appliances that are in the dorm rooms. It should also be noted that while 27.4 gpd/person is a small number, this is what accounts for most of the water consumption. Scenario 1 considered a water conservation approach. Through this approach, there was a water savings of 8.1 gpd/person. Scenario 2 considered a water efficiency approach in which there was a water savings of 5.5 gpd/person. Finally, Scenario 3 considered using both a water conservation and water efficiency approach. With this there was a water savings of 15.4 gpd/person.

It makes sense that Scenario 3 would have the greatest water savings. That is because two different policies are added together and each have their own amount of water savings. It is important to note that improving the water efficiency of appliances can only save so much water. For instance, from our data we obtained that with the water conservation approach 8.1 gpd/person was saved and with water efficiency only 5.5 gpd/person was saved. By simply decreasing the amount water usage, even by a small amount, a lot more water was saved than increasing the efficiency of the appliances. This shows that we can rely on the improvements of

water efficiency only by so much. People are eventually going to have to do work on their part to use less water.

Recommendation/Limitations

One of our main limitations was the data acquisition. We originally wanted to compare two separate UC campuses, but the data did not come flowing in. Another limitation is that the number of students in Webster Hall and Emerson Hall is set at a standard number, so we cannot view the changes with population increases. On the other hand, we used the set population to our advantage because we know that we have exact numbers and the population is not a projection, so the predictions should be more accurate, and hopefully more useful. Recommendations for future projects would be to search for data even earlier than a quarters length (so maybe like six months) to ensure that you can collect as much as you need. Another recommendation would be to cut down on your water use and save water!

References

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