Chapter 10: Water

10.1 Introduction

Throughout the last century, the rate of water consumption has more than doubled the rate of the world population growth (Zabarenko, 2011). Furthermore, merely one percent of the world's water is freshwater and accessible to humans (National Geographic, 2010). Stanton & Fitzgerald (2011) report that currently in California, there is scarcely enough water to satisfy people's demand from wet to dry months. Due to the limits of this natural resource and the increase in demand, individuals and institutions such as Chapman, have a responsibility to acknowledge and assess their impact and to adjust their habits towards being more sustainable. Chapman, in particular should be attentive to its water usage because of the required energy to extract, clean, and transport its water supply in such an arid region. According to the California Energy Commission, an estimated 19% of the total statewide energy usage is related to "the conveyance, treatment, storage, and distribution of its water supply" (The Metropolitan Water District of Southern California, 2013).

This water assessment will indicate where and in what ways the campus consumes water and will also suggest methods to improve/reduce water usage. Listed below are the objectives of this chapter:

- Provide an overview of accomplishments Chapman University has achieved in regards to reducing water consumption
- Determine the total cost and quantity of water consumed each year for the last three academic years
- Observe trends of water usage throughout different months of the year
- Assess which buildings on campus withdraw the greatest amount of water
- Gauge student's understanding and behavior regarding water usage
- Evaluate and recommend ways in which water can be more environmentally friendly and cost effectively consumed

10.2 History of Water at Chapman

10.2.1 Overview

Historically, Chapman has not been highly conscious of water usage, but over time has implemented several water-saving measures. The progress Chapman has achieved to reduce water usage is noteworthy and important to acknowledge. Some of these changes have occurred for convenience purposes, others were technical advancement upgrades, and several were efforts to reduce water and energy consumption. Below are descriptions of some of the University's accomplishments.

Figure 10.1. *Artificial athletic turf field, Wilson Field, main campus.*

Landscaping

In 2006, the campus replaced its primary grass athletic field with an artificial turf called FieldTurf©. This choice was made due to the high maintenance costs from the constant traffic of physical education classes, intramurals, club and University sport teams, and large

special events including graduation and concerts. Once implemented, the need for water, herbicides, and fertilizers were eliminated.

Chapman's restaurant services

In 2008, Sodexo, Chapman's restaurant services, made a companywide decision to replace all dishwashing systems with the Ecolab Apex™ dishwashing system within each foodservice unit. The new technology saves both water and energy. This was accomplished through technology which can detect the appropriate "rack-to-guest-ratio" (Sodexo 2008). Unfortunately, the cost and water savings have not been monitored at Chapman, but have been observed at other Sodexo catering locations. The Sodexo website vaguely states that they noticed "improved product performance[…] and/or a reduction in operational costs[…] All locations, however, received the benefits of using less water, energy and labor" (Sodexo 2008). Additionally, in 2007 Sodexo, implemented a trayless initiative which permanently eliminated trays from the Randall Dining Commons. Jennifer Harris, Sodexo's Marketing Director, reported that this initiative has minimized food waste and reduced the amount of water needed for tray cleaning. Unfortunately, Sodexo again did not track the quantity of water, food, or energy saved.

Storm water management

Chapman manages storm water through the use of porous pavement in one location on campus. The porous pavement is located across from the Randall Dinning Commons where students can lock their bikes along the Miller Parking Structure. Although most of the campus does not have porous surfaces, Mackenzie Crigger, Chapman's Sustainability Manager for the Facilities Department, stated that the campus's walkway surface is relatively porous and is the reason why power washing and sweeping are used on an as-needed basis (porous surfaces easily absorb substances).

Figure 10.2. *Porous pavement.*

Cleaning services

Before Aramark cleaning services began working with Chapman in 2011, a company named Diamond was responsible for maintaining the outdoor walkways through the use of pressure washers. Regan Winston, Director of Custodial Services for Aramark, stated that Aramark utilizes a street sweeper called the M20 which has almost completely replaced the need for the pressure washer, resulting in a large amount of water, time, and diesel gas savings. The pressure washer is only occasionally used and serves the purpose of removing major stains or reaching locations inaccessible to the sweeper. The M20 has improved productivity by integrating a cleaning system where sweeping and scrubbing functions are combined allowing the user to clean in a single pass using less water while doing so (Direct Industry, 2011).

Figure 10.3. *M20 street sweeper.*

Mr. Winston provided an estimate of how much water the M20 saves when cleaning the Attallah Piazza compared to the pressure washer. To wash the Attallah Piazza, which occurs on a daily basis, it takes about 30

minutes with the M20 and consumes about, 35-40 gallons of water in total which is 1.2-1.3 gallons per minute (gpm). Conversely, the pressure washer requires 105 gallons in that 30 minute period which is 3.5 gpm. The pressure washer however, would likely take longer than the 30 minutes the M20 requires, thus the M20 is at least three times as efficient as the pressure washer. Additionally, unlike the pressure washer which runs on diesel gas, the power washer utilizes propane which reduces greenhouse gases.

Facilities

In 2012, Mark Nolasco, the Project Coordinator of the facilities department, installed the Toilet Guardian on all toilets in the two residence halls, Henley and Pralle Sodaro Hall (approximately 262 toilets total), to eliminate water loss from leaks and running water. The device is designed to detect, alert facilities, and shut off the water flow from toilets when water has been running for longer than the normal period of time. This prevents both loss of water and potential damage to buildings from overflowing toilets. The Toilet Guardian is a battery operated mechanism designed for manual, not automatic toilets. Therefore, the toilet guardians only exist in the residence halls since almost all academic buildings have auto-flush toilets. The Facilities Department plans to continue installing these water-saving devices in every residence building.

Figure 3.4. *The Toilet Guardian.*

10.3 Current Status of Water at Chapman

10.3.1 Chapman's water source

Currently, Chapman receives water from the Orange County Water District (OCWD) located in Fountain Valley. OCWD is a leader of advancements in groundwater management, water reuse and purification, and seawater intrusion barriers (GWRS, 2010). The groundwater basin in Northern and Central Orange County supplies 2.3 million residents which is 70% of Orange County's population (GWRS, 2010). This groundwater basin is recharged with collected storm water runoff from the Santa Ana River, recycled water from sewage, and other natural sources (GWRS, 2010). The collected run-off and the recycled sewage prevents valuable freshwater from being directed to the ocean ultimately saving the county $16-$19 million a year (GWRS, 2010). In the city of Orange, 65% of the water supply comes from OCWD and the remaining 35% is supplied by the Metropolitan Water District of Sothern California (MWDSC) which purchases imported water from the Sacramento-San Joaquin River Delta (GWRS, 2010).

10.3.2 Wastewater disposal

Chapman's sewage is managed by the Orange County Sanitation District (OCSD) which operates in conjunction with the OCWD, the world's most advanced and largest reuse purification system for drinking water (Groundwater Replenishment System, 2004). The OCSD reuses a portion of the sewer water that would otherwise be cleaned and directed to the ocean. This method is estimated to save 50% of energy costs from water that would otherwise be imported from Northern California (GWRS, 2010). The Groundwater Replenishment System (GWRS) converts sewer water

into near-distilled water using a high-tech purification system consisting of three steps: microfiltration, reverse osmosis, and ultraviolet light with hydrogen peroxide (GWRS, 2010). After the three step cleaning process, roughly half, or 35 million gallons, of water from the GWRS is injected each day into the groundwater table through wells to be used as a seawater intrusion barrier to prevent sea water from entering the water table . The other 35 million gallons of water are mixed with the Santa Ana River which is then naturally filtered into the groundwater basin (GWRS, 2010). Eventually, the water is pumped from the ground by the OCWD and directed back to residences as tap water.

10.3.3 Water bill

Water tiers

In March 2010, the City of Orange switched its water usage billing system to a three-tier rate structure, which is similar to the way in which electricity companies bill clients. See **Table 10.1** below for the quantity and rates of pricing for Orange City residence this year. The three-tier system charges the first portion of water consumed (20 hundred cubic feet (hcf) or 14,960 gallons) at a fixed rate, the second quantity of water (50hcf or37,400 gallons) at a higher rate, and the remaining water at the highest rate. The three-tiered system is intended to promote conservation of water and helps pay for the additional costs to pump and/or purchase additional water from outside sources (City of Orange, 2012). The increase in price between each tier was raised by 14% from 2010 to 2011 and 2011 to 2012 and 3% from 2012 to 2013. While cost increase can be considered fairly minimal, if it continues to increase at rates such as 14% each year, it will eventually become more critical for Chapman to consume less water in order to avoid higher priced tiers.

Table 10.1. *The City of Orange water bill tier rates from 2010-2013.*

Calendar Year	Tier 1 Rate	Tier 2 Rate	Tier 3 Rate	% Increase from prior year
	First 20hcf	Next 50hcf	Above 70hcf	
2010	$0.885	$1.480	$1.595	
2011	$1.009	$1.687	$1.818	14%
2012	$1.150	$1.923	$2.073	14%
2013	$1.185	$1.981	$2.135	3%

The City of Orange annual rate increase

The City of Orange has historically had some of the lowest water rates in Orange County (City of Orange, 2012). **Figure 10.6** shows the percent increases in the price of water each calendar year and **Figure 10.5** illustrates each tier rate increase for the last three years. If the cost of water continues to increase at rates such as 14% or 19%, water usage will become a growing concern. Later in this chapter, it will be documented that water price rates increase faster than water usage rates. In fact, in one year, Chapman consumed less water per person but paid more.

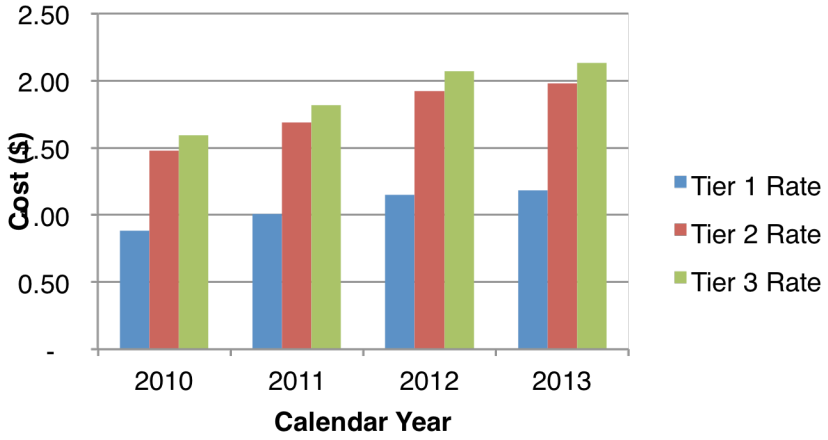

Figure 10.5. *Tier rate in dollars over time.*

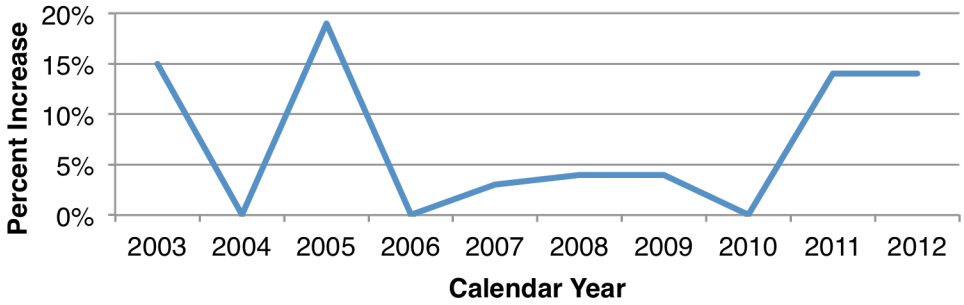

Figure 10.6. *Percent increase of water rates each calendar year.*

These annual increases are helpful when projecting what Chapman's water bill may look like in the future applying a "business as usual" model. If the annual percent rates are averaged for the past 10 years (**Figure 10.6**), there is an annual increase of 7%. Referencing the amount the University paid for water in 2011, $311,500, and assuming that water prices continue to grow at this 7% rate for the next 10 years, the University will at the end of that period be paying $612,800, or $301,300 more than a decade earlier. However, if the City of Orange starts charging higher rates in the future because of the predicted reoccurring drought years, the water bill could look quite different. Additional scenarios of price increases (3% and 14%) are shown in **Figure 10.7**.

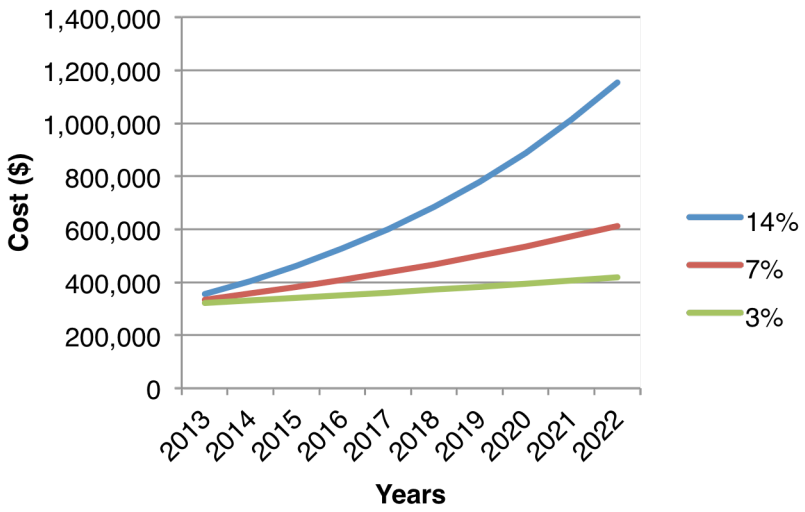

Figure 10.7. *Projected water costs.*

10.3.4 Chapman's water consumption

Background

When analyzing Chapman's water bills for this audit, only the top water-consuming buildings were included over a three year period. Of the estimated fifty buildings that are regularly billed, the top fifteen buildings and consolidated meters (multiple buildings attached to one meter) with the most water usage were surveyed. See appendices **Table 10.2** for the buildings analyzed. For the 2011 academic year, these fifteen buildings accounted for 80% of the total water cost and an even greater portion of the total cost for 2009 and 2010. For parts of this analysis, the buildings were split into two categories: academic buildings and student housing. These two categories were chosen because of the difference in the usage of the buildings and therefore they must be addressed with different analysis.

The bimonthly water bill incorporates not only water usage but also sanitation charges, which are part of the total cost and therefore included in this report. Sanitation charges include sewer

maintenance, stormwater compliance, street sweeping, city-street tree program, and collection/disposal of trash. The sewer maintenance, stormwater compliance, and street sweeping are based on the billing statement's water usage and a unique fixed rate (**Table 10.3**). The city-street tree program and the trash pickup are based on the number of times the maintenance was needed and has a set yearly price. The sanitation charges are included in the cost analysis of this report because the amount of water the University consumes influences sanitation costs.

Table 10.3. *The City of Orange water bill sanitation rates between 2010-2013.*

Sanitation Charges	Rate % 2010-2012 ($/hcf)
Sewer Maintenance	0.112
Stormwater/Env Comp	0.128
Street Sweeping	0.142
City-Wide Tree Program	3.200

One of the most significant challenges when gathering, sorting, and comprehending the water data was understanding why there were significant fluctuations in certain buildings from one year to the next. Some of these fluctuations are accounted for by adjustments in the connection of water lines between other building meters due to temporary construction or maintenance. Other reasons for the fluctuations could simply be from changes in water usage or possible new leaks. Furthermore, some buildings, such as Memorial Hall, consume more water than what would be expected. There could be unknown factors such as leaks or buildings sharing the same meters. Additionally, identifying the buildings that are attached to the three consolidated meters could not be determined. The facilities department has a vague idea of which consolidated meters connect to certain buildings and/or parts of campus, but are not certain. These unknown factors make observing and predicting the reason for certain patterns or phenomena challenging to explain.

Annual water cost

During the 2011-2012 academic year, Chapman spent about $311,500 on water, $258,800 of which could be attributed to the fifteen buildings observed. **Figure 10.8** compares the increase in water costs for the last three academic years for the same fifteen buildings that consume the most water. There was a 13% increase in the total cost between the academic years 2009 and 2010 whereas a 17% increase occurred between 2010 and 2011. This increase is partially from the City of Orange's change in pricing rates as well as from an increase in student population.

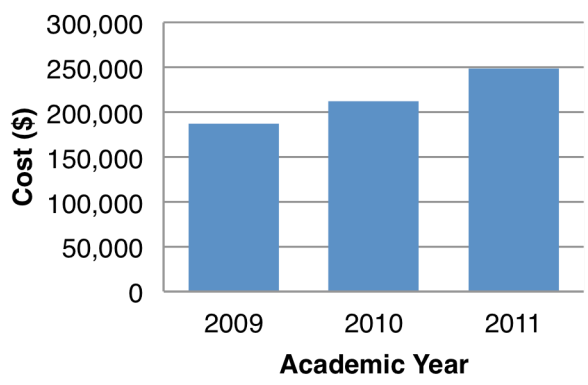

Figure 10.8. *Water costs for the entire University each academic year.*

Annual water usage

For the 2011-2012 academic year, the water usage for the fifteen buildings of focus was 98,837 hundred cubic feet (hcf). One hcf is equivalent to 748 gallons. This equates to almost 74 million gallons of water was/were consumed on Chapman's campus last year. This is close to 203,000 gallons a day. One year of Chapman's water consumption could fill over 112 Olympic-sized swimming pools. An important piece of data to consider is that the residence halls consume nearly

half of the University's water demand. In the 2011 academic year, the residence halls used 48,216 hcf of water whereas all of the academic buildings combined consumed 50,618 hcf.

The increase in water consumption is displayed in **Figure 10.9**. The increase in water usage from the 2009 to 2010 academic year was 2% and between 2010 and 2011 there was a 7% increase. These consumption increases are much less dramatic than the price changes shown in the previous section, which proves that although the amount of water the University consumes has only risen by a small percentage each year, the price has increased at a greater rate. **Figure 10.10** shows the average cost per hcf consumed by Chapman over the past three academic years. Between the 2009 and 2010 academic years, there was an 11% increase and from the 2010 to 2011 academic years, there was a 9% increase. If the University is not careful with lowering its water usage, the cost Chapman pays for water may escalate dramatically in years to come.

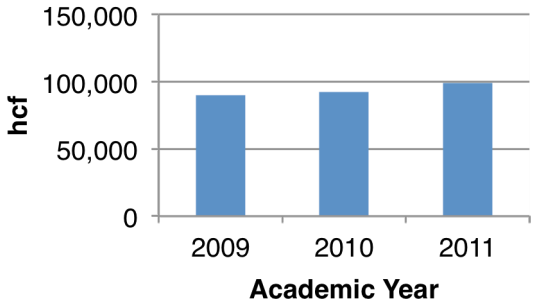

Figure 10.9. *Water usage for University each academic year.*

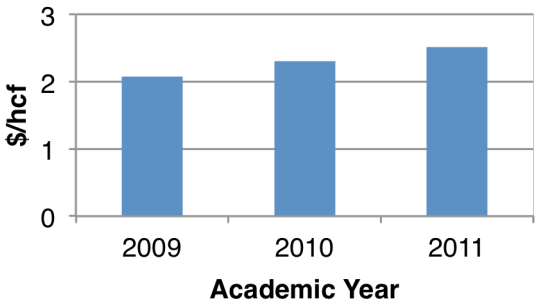

Figure 10.10. *Water cost per hcf for University each academic year.*

The buildings were separated into either academic buildings (**Figure 10.11** in the appendices) or residence halls (**Figure 10.12** in the appendices) to understand where water is being consumed during different months of the year. When doing so, it became quite apparent that the water usage in the academic buildings increases dramatically during the summer months whereas it drops significantly in the residence halls when students are on vacation (winter break and summer vacation). Due to the three consolidated meters being unidentified, it is difficult to suggest that the increase in water usage during the summer is from outdoor water demands during warmer months. The most probable reason for the increase in water usage during the summer months is from the greater usage of the HVAC systems which are responsible for cooling the buildings. There may be less students present and fewer classes in session during the summer months, but in order to keep the buildings at a comfortable temperature, more water is required during hotter months.

Annual water cost and usage per person

When analyzing water usage per person, it was logical to separate the residence halls from the academic buildings because of the different populations and usages associated with each. The total residential population was considered to calculate per person water usage in the student housing buildings whereas for the academic buildings all students, staff, and faculty working at or attending Chapman were included. Chapman summer school students were not a part of this total in order to avoid double counting those who attend school during the semesters. Details about Chapman's population are included in **Table 10.4** and **10.5**. The reason for the spike in the number of people living in the residence halls from the 2009 to 2010 academic year (**Table 10.5**), is that more students

were housed in each dorm room. Double rooms were converted to triples due to the greater influx of freshmen and the high demand for on campus housing from sophomores, juniors, and seniors.

Table 10.4. *Total Chapman University population.*

Year	Students	Faculty	Staff	Total (not including summer students)	Campus water Cost	Campus Water Usage (hcf)
2009	6,398	646	660	7,704	$94,423	46,372
2010	6,881	704	680	8,265	$109,486	46,763
2011	7,157	761	704	8,622	$127,067	50,618

Table 10.5. *Total dormitory population.*

Year	Fall	Spring	Average Population	Campus water Cost	Campus Water Usage (hcf)
2009	1,818	1,728	1,773	$92,944	43,752
2010	1,997	1,889	1,943	$102,359	45,321
2011	1,974	1,878	1,926	$121,728	48,219

Figure 10.13 includes the cost of water per person for academic buildings while **Figure 10.14** exhibits the same analysis but for the residence halls. The cost per person in the academic buildings increased by 8% from the 2009 to 2010 academic years while the difference between 2010 and 2011, was an 11% increase. For residence halls, there was no change from 2009 to 2010 whereas there was an astounding 20% increase of cost per person between the 2010 and 2011 academic year. Further investigation is needed to determine what caused such a drastic increase in the residence halls.

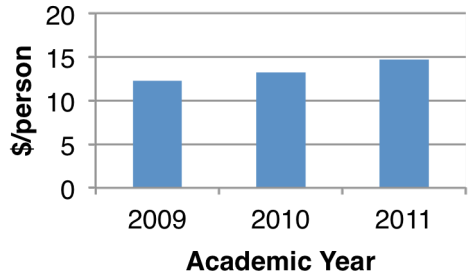

Figure 10.13. *Water costs per person for academic buildings for each academic year.*

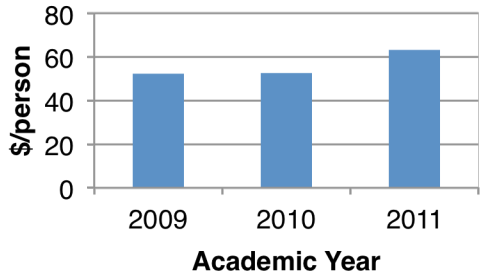

Figure 10.14. *Water costs per person for the residence halls each academic year.*

The water usage graphs per person display a very different pattern compared to the graphs above. From the 2009 to 2010 academic year, there was a 5-6% reduction in water usage per person for both the academic buildings and the residence halls as shown in **Figure 10.15 and 10.16**. The percent increase between the 2010 to 2011 academic years in the academic buildings was 4% which is still less than the cost per person in 2009. The increase in water usage per person in the dorms

from the 2010 to 2011 academic year was 7% and 1% more per person than the water consumption of 2009.

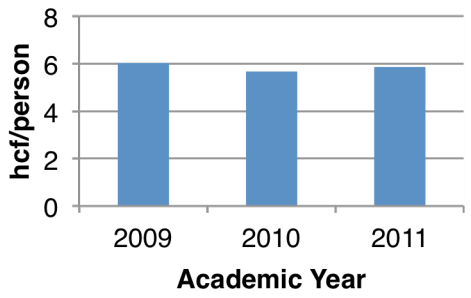

Figure 10.15. *Water usage per person on campus for each academic year.*

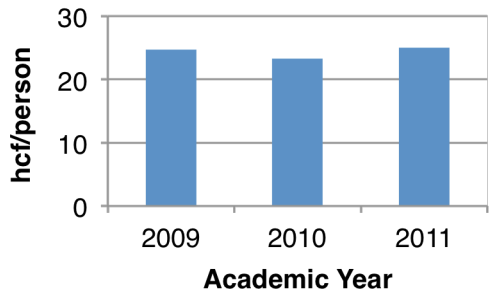

Figure 10.16. *Water usage per person in the residence halls for each academic year.*

Water usage of buildings

To better understand where water was being consumed on campus, the water usage of each building was studied. As depicted in **Figure 10.17**, there is no consistent pattern with an increase or decrease of water usage for the academic buildings each year. Excluding the consolidated meters, Beckman uses the most water, then close behind are Argyros Forum and the Kennedy Law School, and then last are Knott Studios and Memorial Hall.

- Beckman is a four-story building which includes two stories of offices, two floors of classrooms, and a small café.
- Argyros Forum has a large number of offices, student services, classrooms, food venues, a kitchen for catering, and is a popular area for students to convene.
- A large part of the Kennedy Law School is a library as well as a number of classrooms and office space.
- Knott Studios is the film school building which is heavily used at all hours of the day and during all times of the year. This building has significant student work space, classrooms, and offices.
- Finally, Memorial Hall is simply a three-story office building with the University's main auditorium.

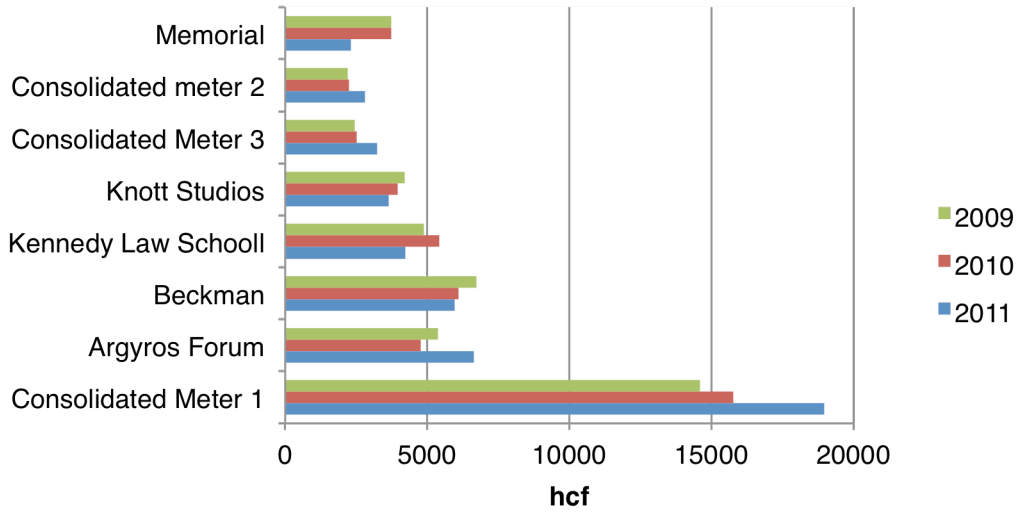

Figure 10.17. *Water usage of academic buildings each academic year sorted from least to greatest based on 2011 data.*

Figure 10.18 illustrates water consumed per square foot of each of the academic buildings which is one way to measure efficiency.

- The most water efficient building per square footage is the Kennedy Law School. This building, like Memorial Hall, has quite a bit of open space because of the two story library. However, there are a large number of classrooms and office spaces as well.
- Tied for second is a close trio between Knott Studios, Beckman, and Argyros Forum. All three of these buildings are heavily used. In particular, students use Knott Studios at all times of the day throughout the year. Argyros Forum has a high frequency of students and staff in addition to providing catering services, food venues, and events.
- Memorial Hall, the oldest building on campus, would be considered the least efficient. Oddly enough, this building likely has more open unused space compared to other buildings because of the large performing arts stage and the small number of offices. There may very well be a possible leak in this building if not other buildings connected to Memorial Hall's meter. Unfortunately, there was no supporting data found explaining why there was a dramatic drop in water usage per square foot in 2011, however, the construction of Doti Hall next door could be responsible for this fluctuation.

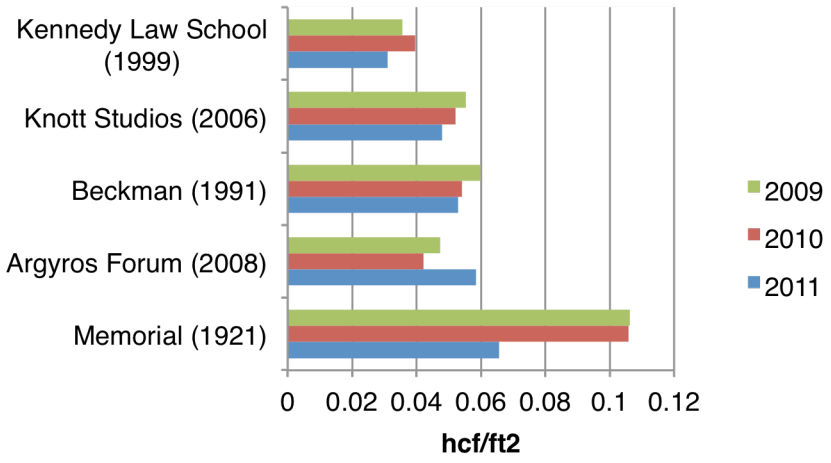

Figure 10.18. *Water usage per square foot of academic buildings each academic year sorted from least to greatest based on 2011 data.*

Figure 10.19 displays the water usage of each residence hall. The variation in the uses of each building can make determining the most and least water efficient buildings problematic.

- The Sandhu Residence and Conference Center consumes the greatest amount of water mostly likely because the Randall Dining Commons, the only cafeteria on campus, is situated inside. In addition, there is a conference room which accommodates several large events throughout the year.
- Pralle Sodaro and Henley Hall, the next greatest water consumers, are both freshman dormitories which do not include kitchens. Henley Hall had an increase of almost two fold between the 2010 to 2011 academic year. This substantial increase is also observed when accounting for the occupancy of the building (**Figure 10.20**). The reasoning for this is not clear; however it may be from a dramatic increase in the usage of the washing machines and public bathrooms in the basement.

- The fourth greatest water consumer, Glass Hall, consists of mostly regular student rooms. There is however, a section of the building that includes apartments which include kitchens.
- The Davis Apartments, which uses the next greatest amount of water, has kitchen units in all of the student units.
- The Davis Center and Morlan/Harris Hall consume the least amount of water of all the residence buildings. The Davis Center only has office space and a laundry facility while Harris is apartment style and Morlan Hall is all dormitory style. The quantity of water consumed by the Davis Community Center is almost equal to both Morlan Hall and the Harris apartments combined which likely indicates that the washing machines consume a large portion of water at the building the Davis Center.

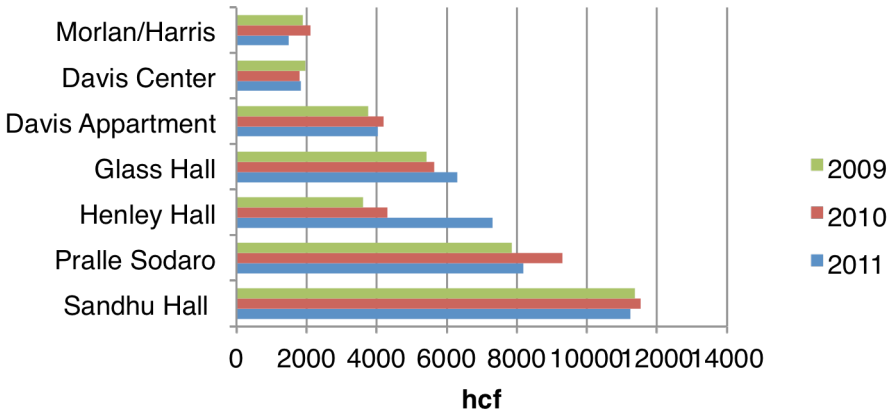

Figure 10.19. *Water usage of residence halls each academic year sorted from least to greatest based on 2011 data.*

A more informative way of looking at the water usage of the residence halls is to incorporate the number of people living in each building (**Figure 10.20**). Although almost all the buildings have some variation with how its water is consumed (e.g. kitchen vs. no kitchen), it is still possible to derive a very general idea of water efficiency.

- Sandhu Hall as the largest consumer of water per person most likely because those who do not live in the building but have meal plans for the dining commons are not accounted for.
- The Davis Apartments have the second-highest rate of water consumption per capita because it is the only building that includes kitchens in every room.
- Unreasonably, the third greatest consumer of water is Pralle Sodaro Hall which is a dormitory style building. It would be more logical for Henley Hall, which is the fifth most efficient residence hall, to consume more water because there is a food service venue, a fitness center, and the basement is a popular location for students to play games and hold meetings. This difference in ranking may have to do with the age of Pralle Sodaro Hall which was built in 1991 versus Henley Hall which has existed since 2001.
- It seems illogical that Morlan/Harris were not the third or fourth greatest consumers per person since both buildings consist of a mixture of apartments and dormitories and are the two oldest residence halls. Instead, Morlan/Harris are the most water efficient of all the residence buildings.

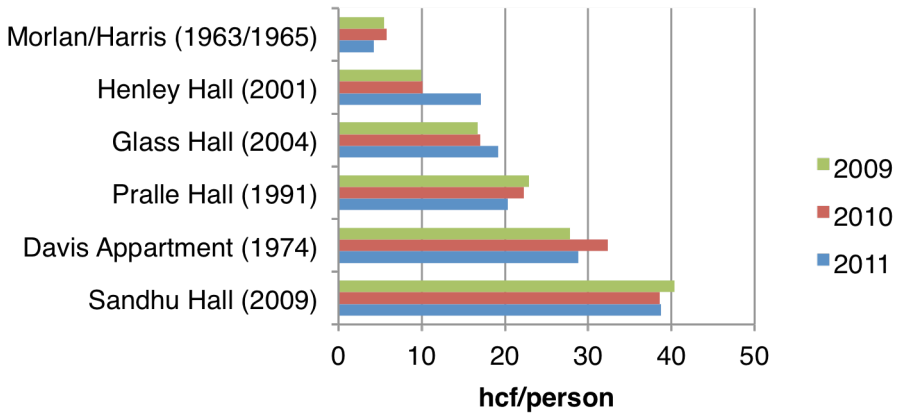

Figure 10.20. *Water usage per person in the residence hall each academic year sorted from least to greatest based on 2011 data.*

Assessing the water usage of Chapman's buildings is a challenging task. Further investigation to determine and explain why there are certain fluctuations and why some buildings are more efficient than others is required. One way of accomplishing this task, is to evaluate the various fixture flow rates and account for their total usage for each building. The next section of this paper uses Sandhu Hall as a case study model to do just that.

10.3.5 Fixture analysis

Background

Fixtures can be any type of equipment that is permanently part of a building or area of land. For this audit, a variation of fixtures that influence the consumption of water were evaluated including toilets, sinks, and showerheads. When completing a fixture analysis it is crucial to first understand the current state and federal standards, potential future standards, and what Chapman currently utilizes. The existing national legislation under the Energy Policy Act of 1992 took effect in 1994 and includes water usage standards for toilets, urinals, showerheads, and faucets. In 2007, California adopted its own legislation setting more stringent standards, which will take full effect in 2014. **Table 10.6** shows a list of the current restrictions, the new state legislation for both commercial and residential usage, the replacement options for low-flow toilets Chapman has stored in the facility stockroom, and the fixtures that are recommended in the payback analysis. The reason the residential standards were included in the table is because the residence halls abide by those standards. Many of the options that already exist in the stockroom are outdated. As the new legislation for fixture and appliances takes effect in the upcoming year, it is crucial that the facilities department considers more water-efficient replacement options for their stockroom. This is an optimal opportunity to plan ahead and exceed the future required water usage standards.

Life cycle analysis

For the fixture analysis, one of the residence halls, Sandhu, was analyzed in a case study. Sandhu was chosen because of the known occupancy in each room, the consistency of fixture brands and models throughout the building, and the accessibility to a number of rooms. When calculating for the life cycle analysis, the following assumptions were made:

- The average person goes to the bathroom 5.1 times a day (EPA WaterSense, 2007). Assume each person goes to the bathroom 3 times each day in their dorm room.

- The average person uses the faucet for about 1.75min a day (USEPA, 2005). Assume that the average person uses the faucet in the dorms for 1.4min (80% of total) a day.
- Assume the average number of showers each person takes is .5 showers per day (USEPA, 2005).
- Assume that the average resident at Chapman takes a 12 minute shower. This assumption was made from the data collected from the survey in **Section 10.3.6**.
- Assume that the average student lives in the dorm for 245 days of the year: excludes summers and school vacation periods
- Sandhu has an estimated 152 bathrooms in the dorm rooms and there are about 290 people living in the building (based on 2011-2012 academic school year statistics).
- Assume every toilet uses 1.6 gallons per flush (gpf), sink uses 2.2gpm, and showerhead uses 2.5gpm. There were 15 dorm bathrooms observed which is 10% of the total amount. All of the brands and flow rates were consistent.
- For the last 3 years Sandhu has continually been charged up to the third tier rate which for 2013 is $2.135 per hcf

***Table 10.6**. Fixture standards.*

Fixture or Appliance	Federal/California State required standards of 1994	California New required standards by 2014 (Commercial)	California New required standards by 2014 (Residential)	Chapman Stockroom Replacement Options	Recommended Fixture Flow Rate
Toilets	1.6 gpf	1.28 gpf	1.28 gpf	.25-4.5 gpf	0.8 gpf
Urinals	1 gpf	.5 gpf	NA	1-1.5 gpf	NA
Showerheads	2.5 gpm	2 gpm	2 gpm	2.5 gpm	1.5 gpm
Faucet Aerators	0.5 gpm	0.5 gpm	1.5 gpm	0.5-2.2 gpm	0.5 gpm

Reference: Appliance Standards Awareness Project, 2009; San Luis Obispo County Public Works Department, 2012

Details for the recommended fixtures are as follows:

- Flow Rate
  - Toilet: .8 gpf
  - Faucet aerator: 0.5 gpm
  - Showerhead: 1.5 gpm
- Brand
  - Toilet: Niagara Conservation © -Stealth © Toilet, model number N7717/N7714, which comes in both an elongated or round bowl shape (**Figure 10.21**)
  - Faucet aerator: Undetermined (**Figure 10.22**)
  - Showerhead: Niagara Conservation © - Earth © Showerhead, N2915CH (**Figure 10.23**)
- Cost
  - The toilet cost, of $172, is based on the amount UCI paid for the same toilet in 2011
  - The faucet aerator price of $1 is based on how much Adam Nolasco, UCI's Project Coordinator, estimated.
  - The showerheads were based on Amazon's sale price for a set of 50 showerheads for the total price of $255.99 ($5.12 apiece) including shipping.

After using these assumptions and data on the current and recommended fixtures, the payoff time was calculated (**Table 10.7** and **Table 10.8** & **10.9** in the appendices). As **Table 10.7** shows, it would take 54 years for a new and more efficient toilet to pay for the initial cost of a new fixture. Since the cost of a toilet in the stock room ranges from $87.77-$419.41 it was difficult to assume whether the $172 toilet recommended would be more cost effective to replace when an old toilet breaks. If the cost of an aerator for a faucet is no more than a dollar, as Adam Nolasco said, the payback period would take less than four months. As for the showerhead, it would take 8 months to pay off its initial investment. Both cost and water savings for Sandhu Hall are shown in **Table 10.10** (appendices). From an ecological standpoint, if the entire building were to use both the recommended faucet aerator and the showerhead, the entire building would save over 595,000 gallons of water each year. This is equivalent to filling an Olympic-sized swimming pool 90%. As for cost savings, within the first year of use, the showerheads and faucet aerators together would save almost $800. Every year thereafter the savings would be $1,700. Also, it is important to note that there are some rooms that are occupied during the summer months or during holidays that were not accounted for in the calculation. This would only increase savings over time.

***Table 10.7**. Payoff time for recommended fixtures.*

Fixture	Recommend Fixture flow rate (gpf or gpm)	Flow Rate reduction (gpf or gpm)	Cost savings per year ($)	Recommended fixture cost ($)	Payback period (yrs)
Toilet	0.80	50%	3.20	172.00	53.72
Faucet/Aerator	0.50	77%	3.18	1.00	0.31
Showerhead	1.50	40%	8.01	5.12	0.64

10.3.6 Survey analysis

For this section of the audit, the 2013 Environmental Audit Survey was used to better understand Chapman student's knowledge of water consumption, habits, and willingness to incorporate more sustainable practices. Some questions were directed to those who reside on campus and others included commuter and resident students. There were a total of 977 students from the entire student body who participated, 288 of who live in the residence halls.

The first water-related question asked to all students was, "What percent of the world's water do you think is fresh water and accessible?" As shown in **Figure 10.24**, about one third of the respondents made the correct choice (1% or less). About 22% guessed 2-5% of water is fresh and accessible and the final 45% of the students thought that 6% or more of the water in the world is fresh and accessible. If students don't understand the limitedness of this resource, they may not be aware of the importance to conserve water. This is not necessarily a representative question for someone's understanding of water, but this is an indication that more emphasis on water

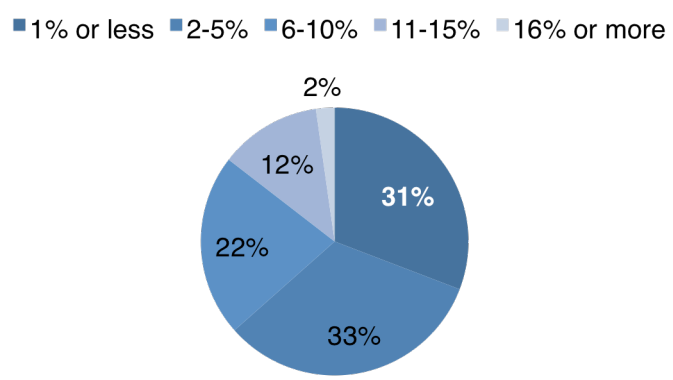

***Figure 10.24.** Percent of world's water thought to be fresh and accessible.*

education is necessary in order to reduce Chapman's water consumption.

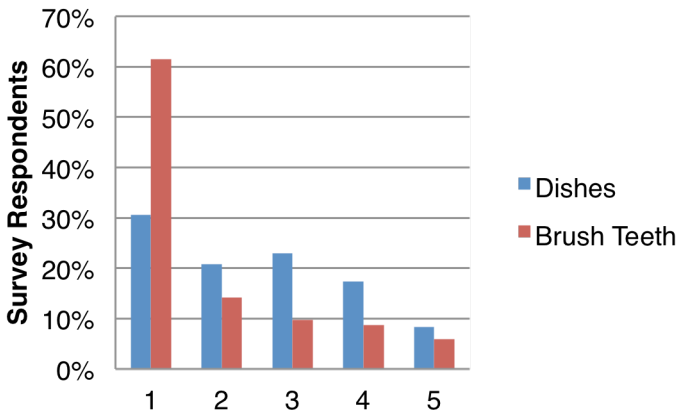

Figure 10.25. *Habits regarding keeping the faucet running while washing dishes and brushing one's teeth.*

The next few questions were directed to students who live on campus. The students were asked to rank the following activities on a scale of 1 to 5 (1=Rarely, 5=Very Often).

1. Keep the faucet running when you wash the dishes.
2. Keep the faucet running when you brush your teeth.

The results are shown in **Figure 10.25**. Most students accomplish these tasks rarely or almost rarely leaving the water running; brushing teeth (75%) and washing dishes (52%). About 15% said they often or very often keep the faucet on while brushing their teeth and 25% said the same while washing the dishes. The rest chose the middle option.

Resident students were also asked, "On average, how long are your showers?" (**Figure 10.26**). The most popular response, 45%, said they take 10 minutes or less to shower. About 30% take between 11-15 minutes to shower and the last 25% take 16 minutes or more. The EPA reports that the average American takes an estimated 8.2 minute shower (EPA, 2010) whereas the average Chapman student on campus takes an 11 to 15 minute shower.

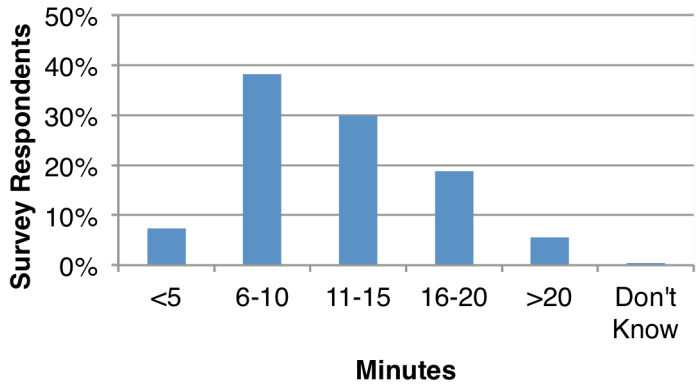

Figure 10.26. *Shower length.*

My final two water-related questions for all students were used to understand their overall water conservation behavior and consideration (**Figure 10.27**). The question stated, "On a scale of 1 to 5, how often do you do the following (1=Rarely, 5=Very Often):"

1. Consciously consider your level of water usage.
2. Make a conscious effort to reduce your water usage.

The most popular answer for both questions, 32%, was the middle ranking (3). When comparing these two questions, the results show that more people consciously consider their level of water usage (41% often considered (4 & 5) versus 27% rarely considered (1 & 2)) whereas less people said they often make an

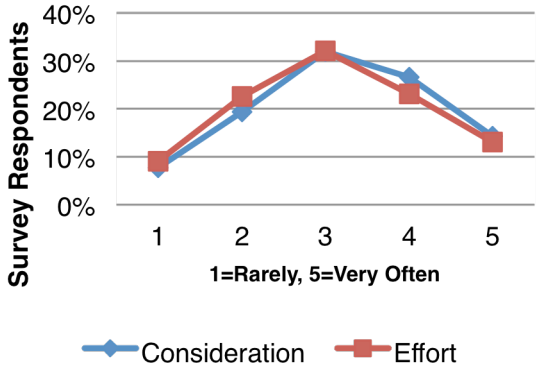

Figure 10.27. *Students' consideration of water usage and their effort to reduce water usage.*

effort to actually reduce their water usage (32% often made efforts (4 & 5) versus 36% rarely made efforts (1 & 2)). This means that more people generally notice that they are consuming water, but a smaller portion are willing to change their habits in order to conserve water. It is crucial that people are consciously thinking about their water intake because if they are then taught about the limitedness of this resource, the results of people's efforts to conserve water will also likely change.

10.4 Concluding Assessment

10.4.1 Areas of progress

Chapman and those who are contracted through the University (Sodexo and Aramark) have made changes in how they operate and/or what they use to function in order to reduce their water consumption or maintenance costs. These gradual changes truly do go a long way in saving water over a long period of time. In the three years that were observed for this audit alone, there were noticeable improvements in water usage per person for certain years. The cause of these variations may not be clear, but it is valuable to note and worth tracking in order to find techniques to continue improving water efficiency.

10.4.2 Areas in which to improve

Mackenzie Crigger reports that water usage has never been a consideration on the Chapman agenda. The lack of urgency and/or desire to track and observe Chapman's water usage bills is due to the inexpensiveness when compared to the total cost of energy, which is over six times greater than water. Nevertheless, it is essential for Chapman to begin assessing its water usage to avoid the burden of likely inflated costs in the future. By reducing its consumption of water, the University can avoid higher tiers thus becoming more economically efficient. Data collection on water consumption is the first step to avoid this dilemma. Without tracking Chapman's history of water usage, it will be nearly impossible to understand where the University can most tangibly and effectively save in excessive costs and usage. The initiatives that have taken place (e.g. turf fields and the trayless initiative) do not have records on the amount of water and money saved. This could be due to the lack of concern or it may be that tracking this information is time consuming since the water bills exist only in hand copy or scanned formats (see appendices **Figure 10.28** for example). If the City of Orange offers a digital version of the water bills, it is highly recommended to gain access to these more desirable formats, in order to save unnecessary amounts of labor. A large portion of the research efforts for this chapter were spent simply collecting the statistics of all the bills for each building which could be prevented with digitalized copies. This would allow more time to be spent analyzing the data and investigating reasons for particular trends. Lastly, identifying exactly what each meter services is another ambiguity that needs to be resolved. Solving this mystery would ensure efficiency in determining which buildings would be most beneficial to address first. Some buildings, like Memorial Hall, appear to be withdrawing more water than what would be expected. This could be accurate, but more than likely it is from leaks or other sources being connected to the same meter.

10.4.3 Existing gaps in knowledge

One area where there is a gap in knowledge about water usage on campus is understanding which academic buildings or areas of campus are part of each consolidated meter. Buildings such as Hashinger Science Center and Lastinger Athletic Complex, which have relatively high occupancy, are not billed individually. Therefore determining which buildings are attached to each consolidated meter is not possible and makes assessing these buildings challenging.

10.5 Recommendations

10.5.1 Low cost/effort

- Facilities should continue tracking the records of the cost and amount of water being consumed by each building to monitor any pattern changes in the use of water. Tracking this data will likely explain why buildings such as Henley Hall and Memorial have significant spikes in their water usage from one year to the next. If there are no explainable differences in usage, this could suggest that there are leaks or problems with the meters. Also, to make this task easier, digitalized copies should be acquired.
- The residence halls, which account for nearly half of the total water consumed, could hold water competitions to reduce the amount of water consumed per student. Indiana University, successfully saved over 7,400,000 gallons of water (9,893 hcf) in the first three weeks of a water challenge they held (Indiana University, 2012). They also reported that after the challenge, many students continued to practice sustainable water habits. This could also be a chance to foster a more sustainable culture on campus.

10.5.2 Moderate cost/effort

- Retrofitting indoor faucets with new low-flow aerators and replacing all the showerheads with low-flow versions reduce Chapman's water footprint and save costs within a year payback period. The cost savings made from these efficient fixtures could be used towards purchasing more efficient toilets, which do not have as significant of an economic benefit. However, it is more than likely that when toilets do break, it is cost efficient to replace them with more water efficient options.

10.5.3 High cost/effort

- Over time, it is very useful to invest in meters that monitor buildings that are not already being tracked. There are some buildings that currently can't be observed because other buildings share the same metering gauge. Therefore, when there are upgrades to these buildings, it is challenging to determine the impact on the water bill. Also, alerts could signal to facilities if water appears to exceed average usage levels indicating leaks or other problems that need attention. Lastly, water meters would give facilities greater incentive to make more sustainable adjustments since their impact would be easily tracked.

10.5.4 Future areas of research

Additional ideas to address include: examining pipes for water leaks, looking into the feasibility of a grey water system on campus, and accounting for occupancy when determining a building's efficiency. Also, facilities should complete the same fixture analysis in this report for other dorm building fixtures. Furthermore, an in-depth analysis of other fixtures such as auto-flush toilets, auto-flush sinks, and washing machines should be considered. Lastly, it would be beneficial to research exactly what factors contribute to certain buildings consuming irrational amounts of water when compared to other buildings.

10.6 Contacts

Adam Feuerstein, Associate Construction Project Manager, UCI Facilities Management, (afeuerst@uci.edu, 949-824-8112)

Emily Brent, Housing Assignments Assistant, Office of Housing and Residence Life, (brent@chapman.edu, 714-997-6538)

Jennifer Harris, Marketing Director, Chapman University Dining Services, (Jennifer.harris2@sodexo.com, 760-277-7543)

Kathleen White, Facilities Management Depot Coordinator, Chapman University Facilities Management, (katwhite@chapman.edu, 714-997-6645)

Mackenzie Crigger, Sustainability Manager, Chapman University Facilities Management (crigger@chapman.edu, 714-997-7370)

Mark Nolasco, Project Coordinator, Chapman University Facilities Management, (nolasco@chapman.edu, 714-997-7851)

Regan Winston, Director of Custodial Services, Aramark (Winston-Regan@aramark.com, 714-470-3056)

Terence Velasquez, Utility Services, City of Orange, (tvelasquez@cityoforange.org, 714-744-5591)

10.7 References

Appliance Standards Awareness Project. (2009), Plumbing Products. Retrieved From: http://www.appliance-standards.org/product/plumbing-products

City of Orange. (2012). *City of Orange Proposed Increase of Water Rates and Charge*. Retrieved From: http://www.cityoforange.org/downloads/8948.pdf

Direct Industry. (2011). *Sweeper-scrubber-dryer*, Retrieved From: http://www.directindustry.com/prod/tennant/sweepers-scrubbers-dryers-7186-40502.html

EPA. (2010). WaterSense Specification for Showerheads supporting Statement. Retrieved From: http://www.epa.gov/WaterSense/docs/showerheads_finalsuppstat508.pdf

EPA WaterSense. (2007). *WaterSense Tank-Type High-Efficiency Toilet Specification Supporting Statement.* Retrieved From: http://www.epa.gov/WaterSense/docs/het_suppstat508.pdf

Groundwater Replenishment System. (2004). Purification Steps. Retrieved From: http://www.gwrsystem.com/the-process.html

GWRS. (2010). *Groundwater Replenishment System; Quenching a Thirst*. Retrieved From: http://www.gwrsystem.com/images/stories/AboutGWRS/GWRS%20Technical%20Brochure.pdf

Indiana University. (2012). *Million Gallon Challenge competition saves 7,346,565 gallons in first three weeks*. IU News Room. Retrieved From: http://newsinfo.iu.edu/news/page/normal/23187.html

National Geographic. (2010). *Freshwater Crisis*. Retrieved From: http://environment.nationalgeographic.com/environment/freshwater/freshwater-crisis

San Luis Obispo County Public Works Department. (2012). *Water Conservation Implementation Plan for the Los Osos Wastewater Project.* Retrieved From: http://www.slocounty.ca.gov/Assets/PW/LOWWP/document+library/Revised+Final+Draft+WCIP.pdf

Sodexo. (2008). *Sodexo Announcement*. Retrieved From: http://www.sodexousa.com/usen/newsroom/press/ecolabapex040708.asp

Stanton & Fitzgerald. (2011). *California Water Supply and Demand: Technical Report.* Retrieved From: http://sei-us.org/Publications_PDF/SEI-WesternWater-CWSD-0211.pdf

The Metropolitan Water District of Southern California. (2013). *Energy of the Future*, Retrieved From: http://www.mwdh2o.com/BlueRibbon/pdfs/Energy-4-Future.pdf

USEPA. (2005). Appendix B: Benchmakrs Used in Conservation Planning. Retrieved From: http://www.epa.gov/WaterSense/docs/app_b508.pdf

Zabarenko, D. **(**2011). "The Daily Star: Water use rising at more than twice the rate of world population." *The Daily Star*. Retrieved From: http://www.dailystar.com.lb/News/International/2011/Oct-26/152211-water-use-rising-at-more-than-twice-the-rate-of-world-population.ashx#axzz1d546RLiE

10.8 Appendices

10.8.1 Data tables and figures

Table 10.2. *Buildings analyzed.*

Name	Year built
Campus buildings	
Memorial Hall	1921
Consolidated Meter 1	
Knott Studios	2006
Consolidated meter 2	
Argyros Forum	2008
Beckman	1999
Consolidated Meter 3	
Kennedy Law School	1999
Dorm Buildings	
Pralle Sodaro Hall	1991
Henley Hall	2001
Sandhu Hall	2009
Glass Hall	2004
Morlan/Harris	1963/1965
Davis Appartment	1974
Davis Center	1974

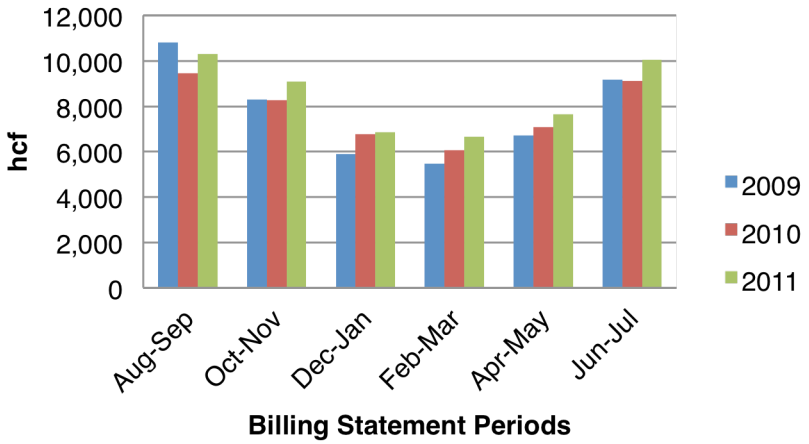

Figure 10.11. *Water usage of academic buildings for each water billing and academic year.*

Figure 10.12. *Water usage in the residence halls for each water billing and academic year.*

Table 10.8. *Total water usage of each fixture type per year.*

Fixture	Sandhu population 2011	Estimated number days spent in dorms	Number Fixtures in dorm rooms	Average dorm fixture flow rate (gpf or gpm)	Average length used (min)	Average number of times faucet used	Total hcf per person per year	Total gallons per year	Total hcf per year
Toilet	290	245	152	1.6	NA	3	1.57	341,040	456
Faucet				2.2	1.4	NA	1.01	218,834	293
Showerhead				2.5	12	0.5	4.91	1,065,750	1,425

Table 10.9. *Total cost of water per fixture per year.*

Fixture	Total hcf per person per year (hcf)	Tier 3 rate ($/hcf)	Number of people per fixtures	Total cost ($) of water per fixture per year
Toilet	1.57	2.135	1.91	6.40
Faucet/aerator	1.01			4.11
Showerhead	4.91			20.01

Table 10.10. *Total cost and water savings for Sandhu Hall.*

Fixture	Water saved after one year in hcf	Water saved after one year in gallons	First Year cost savings ($)	Cost savings after one year ($)
Faucet/aerator	226	169,099	331	483
Showerhead	570	426,300	439	1,217
TOTAL	796	595,399	769	1,699

Figure 10.21. *Recommended toilet brand.*

Figure 10.22. *Desired faucet aerator.*

Figure 10.23. *Recommended showerhead.*

Page 1 of

CITY OF ORANGE
300 E Chapman Avenue
Orange, CA 92866-1591
Ph 714-744-2233 Fax 714-744-2273
www.cityoforange.org

Account Summary

Name:	CHAPMAN UNIVERSITY
Account Number:	00063908-00
Service Address:	462 N GLASSELL ST
Bill Date:	09-21-2010
Delinquent After:	~~10-18-2010~~ * Due upon Receipt *
Amount Due:	$61 44

Billing Detail

PREVIOUS BALANCE			$61 44
PAYMENT 08-02-2010			-$61 44
BALANCE FORWARD			***$0.00***
Water Charges	**QTY**	**RATE**	**TOTAL**
SERVICE CAPACITY CHARGE	1	17 660	$17.66
WATER CONSUMPTION TIER 1	14	0.885	$12.39
Water Total			***$30.05***
Sanitation Charges	**QTY**	**RATE**	**TOTAL**
SEWER MAINTENANCE	14	0.112	$1.57
STORMWATER/ENV COMP	14	0.128	$1.79
STREET SWEEPING	14	0.142	$1.99
CITY-STREET TREE PROGRAM	1	3 200	$3.20
Sanitation Total			***$8.55***
Trash Collection Charges	**QTY**	**RATE**	**TOTAL**
COLLECTION/DISPOSAL	1	22.840	$22 84
Trash Total			***$22.84***

Water Usage (1 unit = 100 CF = 748 Gallons)

Billing Period	07-19-2010	to	09-20-2010
Meter No.	***Previous Read***		***Current Read***
0078534053	776		790

	Total Usage	**Average Per Day**
Current Usage	14	0 22
Prior Billing Period	14	0 23
Same Period Last Year	13	0.21

Message Center (Review the back of this document for more information)

TO LOWER COSTS, YOUR PAPER CHECKS/COUPONS NOW GO DIRECTLY TO OUR LOCAL BANK'S LOS ANGELES PROCESSING CENTER ALL ELECTRONIC PAYMENTS STILL COME DIRECTLY TO US WE HAVE REDUCED STAFF HOWEVER YOU CAN STILL COME IN OR CALL OUR OFFICE IN ORANGE FOR ALL SERVICES. THANK YOU.

RECEIVED
OCT 04 2010
FACILITIES MANAGEMENT

CO 018970
5540 520334
OK to pay
MCP 10/5/10

A 10% Late Penalty Fee will be assessed if payment is not received before the "Delinquent After" date.

PAYMENT COUPON (Return this portion with your payment)

CITY OF ORANGE
P.O. Box 30146
Los Angeles, CA 90030-0146

☐ **Check here to update personal information and provide it on the reverse.**

Account Number:	00063908-00
Route Number:	0724
Service Address:	462 N GLASSELL ST
Bill Date:	09-21-2010
Delinquent After:	10-18-2010
Amount Due:	$61.44
Call us to join the Paramedic Program	
Amount Enclosed:	61.44

RETURN SERVICE REQUESTED

To pay by credit card go online at www.cityoforange.org or fill out reverse and mail in, or use our free 24-HR payment line 866-342-4346.

Make checks payable to:

CITY OF ORANGE
PO BOX 30146
LOS ANGELES CA 90030-0146

AUTOSCH 5-DIGIT 92856 2 P55 64438RA21-A-1
363 1 AV 0-335

CHAPMAN UNIVERSITY
1 UNIVERSITY DR
ORANGE CA 92866-1005

000001000639080000000000061440000006144006

Figure 10.28. *Bill sample.*