UNIVERSITY OF
ARKANSAS
Office for Sustainability

U of A Water Action Plan

A Preliminary Analysis
2019

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Executive Summary

This preliminary analysis quantifies and categorizes water usage on the University of Arkansas (U of A) campus, which sets the stage for the development of a comprehensive water reduction strategy. Nearly all water used on campus is potable water originating from Beaver Lake.

Despite a relatively consistent rate of use, the amount paid for water by the university has steadily increased over the past 14 years. To determine why, an initial usage breakdown was created, identifying the three largest areas of use; Housing, Heating/Cooling, and Irrigation. Direct Use covers all water used directly by campus occupants. This includes sinks, toilets, showers, washing machines, and water fountains. Heating/Cooling is a separate category from Direct Use because it is measured through the Combined Heat and Power Plant on campus. Irrigation includes every form of supplying water to green spaces on campus, including drip irrigation and above-ground sprinkler systems.

When categorizing water use by building type, Housing accounts for 40% of the total campus water use. Residential buildings (Housing) are utilized year round by students and other campus visitors. These buildings are unique to campus because occupants shower and wash their clothes, which are both large sources of water use. While campus occupancy varies throughout the year, somewhat affecting water usage, irrigation is highly dependent on time of year. The irrigation system is winterized during the cold and rainy season and active during the spring and summer. However, irrigation is still used during the winter to keep the athletic fields green for competitions. For example, during the off season, the football practice fields are still irrigated, using almost as much water as the other five fields combined.

When comparing the University of Arkansas's water consumption to other universities, the U of A is better than average with a lower use per user. The peer schools were selected based upon their Association for the Advancement of Sustainability in Higher Education, Sustainability Tracking Assessment & Rating System (AASHE STARS) rating, size, and geographical location relative to the U of A. The method of comparison is water use per Weighted Campus User (WCU), which is a weighted average of people populating the campus (Hoekstra, Chapagain, Aldaya, & Mekonnen, 2014). While the University of Arkansas uses less water per WCU on average, there is still room to improve. Currently the main source of campus water conservation is through updated low-flow fixtures in the buildings. These fixtures are adjusted to disperse a minimum flow of water while maintaining enough pressure to serve the user.

The University of Arkansas already has plans to become a carbon neutral and zero-waste campus by 2040. The next step is to create similar goals regarding water usage. Reviewing the water use data between 2008 and 2018, there has been an increase of use coinciding with the increase of enrollment during the same time frame (U of A *Fall 2018 Enrollment*, 2018). The largest contributors to the University of Arkansas' water footprint are Housing and the Heating/Cooling systems. Best practices applied to those areas could yield the largest reductions to campus water use.

Purpose

This preliminary analysis aims to quantify and categorize water usage at the University of Arkansas. This will allow for further investigation into which areas are using the most water and why. It will then be possible to determine the easiest areas to decrease water waste on campus. This analysis focuses on the University of Arkansas' blue water footprint, which is the amount of water that is removed from a surface or groundwater system that is not returned to its original system (Hoekstra et al., 2014).

If the University of Arkansas is to reduce waste, it is essential to prioritize the areas that consume the most water and define the most efficient strategies to reduce consumption. Figure 1 represents a framework for the implementation of a water reduction plan. To begin, it is necessary to inventory the University's water usage, measure, analyze, and identify opportunities for improvement. After completing a full inventory, it is essential to strategize and implement a reduction plan. This then becomes an iterative process where the University is constantly strategizing and implementing improvements to its water system.

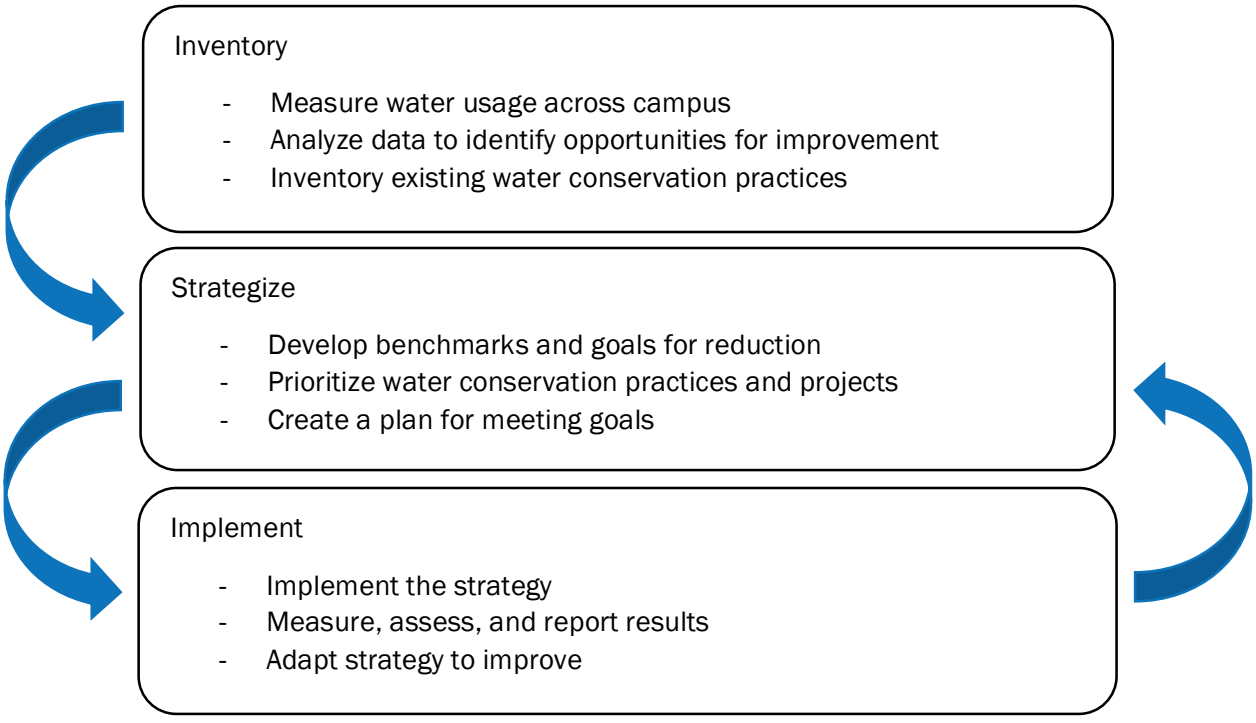


Figure 1. Framework for implementing water reduction.

Local Water Supply Characteristics

The University of Arkansas is a public university in the northwestern corner of Arkansas. The university receives potable water from the City of Fayetteville, which receives its water from Beaver Lake. This water supply is maintained and sold by Beaver Water District which serves approximately 330,000 customers, making Beaver Lake the primary water source for one in seven Arkansans. There are four main customers of Beaver Water District; the City of Bentonville, Rogers Water Utilities, Springdale Water Utilities, and the City of Fayetteville. Each of these customers acts as a secondary supplier to the other cities in their areas ("Beaver Water District," n.d.).

Beaver Lake is a man-made reservoir that was constructed in the 1960s by the U.S. Army Corps of Engineers. The reservoir was created by flooding a portion of the White River, using Beaver Dam to regulate the flow out of the area (Hales, 2017). Currently, the drainage area of Beaver Lake is about 3,000 km^2, and the surface area of the lake is roughly 114 km^2. At normal pool elevation, Beaver Lake contains approximately 538 billion gallons of water (2.04 km^3).

Despite the University of Arkansas's access to a stable water supply, it's imperative to proactively reduce the burden on that priceless water supply. In addition, the processing of potable drinking water embodies a significant energy footprint. Implementing best practices in water efficiency will decrease water usage without a burden to campus affiliates. With our climate changing and Northwest Arkansas's population growing it would be irrational to assume that we will always be within such a water rich region.

Based on previously collected 14-year cost/usage data, the price of water within the Beaver Water District is increasing. This increase is likely related to monetary inflation and the monopoly that the Beaver Water District has on water distribution. This allows the district to set and regulate their own pricing per thousand gallons sold to smaller distributers. The price of potable water within Beaver Water District is expected to continue increasing.

Inventory of Water Use on Campus

To develop water reduction goals for the university, it is important to look at the annual trends in usage. Figure 2 shows that water consumption rates have been relatively consistent for the university over the past fourteen years. The calculated average of the annual water use for the university is 226 million gallons. There have been a few years that vary from the average, but generally the usage levels are similar over time. There is a span of years from 2008 to 2011 that is relatively lower that the other years. This could be linked to the introduction of more efficient fixtures in campus buildings. This could also be linked to the year 2008 being the 7th wettest year in the history of Fayetteville with 57 inches of precipitation. Disregarding the peak in 2012, there is a modest but steady increase of water use from 2008 through 2018. This is likely connected to the increase of enrollment and increased fixture efficiency to help combat the population increase.

Five of the 14 years shown below are above the average water use. The years 2004 through 2006 are all in the top 50 driest years in Fayetteville, 2012 is ranked as the 4th driest year (National Oceanic and Atmospheric Administration, 2019). While this helps to explain why these years are above average for water use, it not the only reason behind the higher values. There are other factors that contribute to water use, such as, enrollment, fixture efficiency, and management strategies.

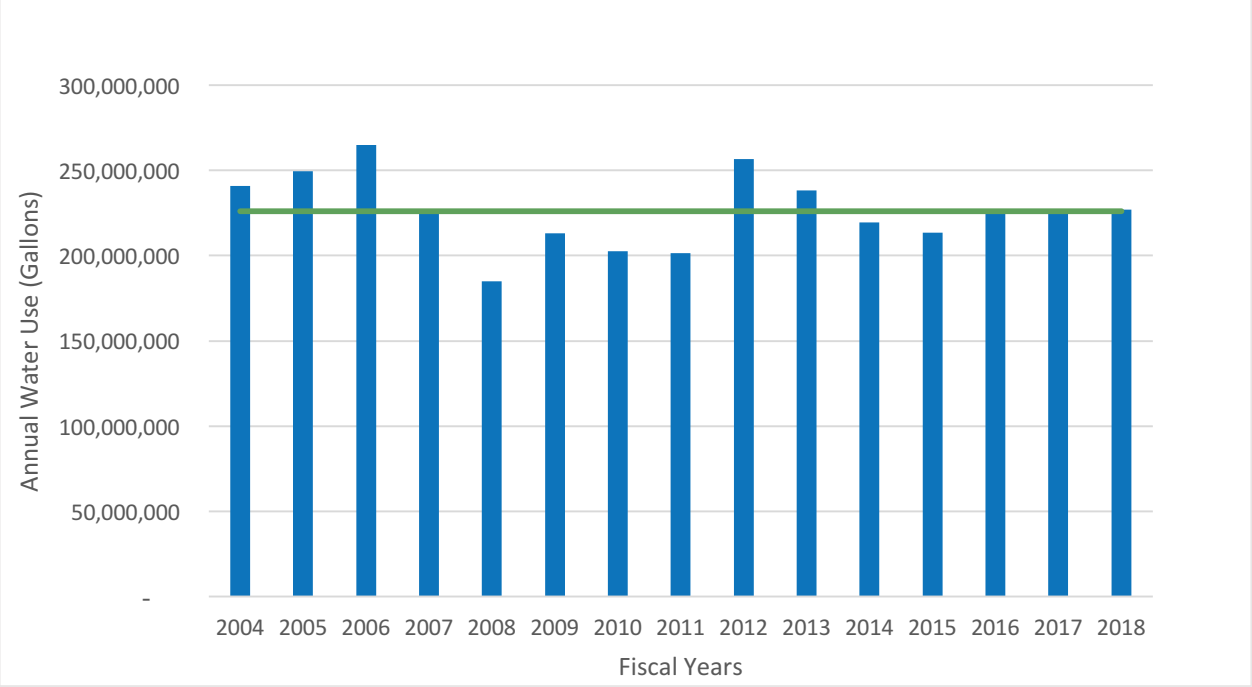


Figure 2. University of Arkansas annual water usage for fiscal years 2004 through 2018.

Fiscal years 2014 through 2018 (FY2014-2018) have shown similar annual use, however, it is interesting to note that despite having similar gallon use per year, Figure 3 demonstrates an overall increasing trend in cost per year. Assuming the increasing trend continues, in FY2020, the University of Arkansas will spend nearly 2 million dollars to cover expenses related to water use on campus.

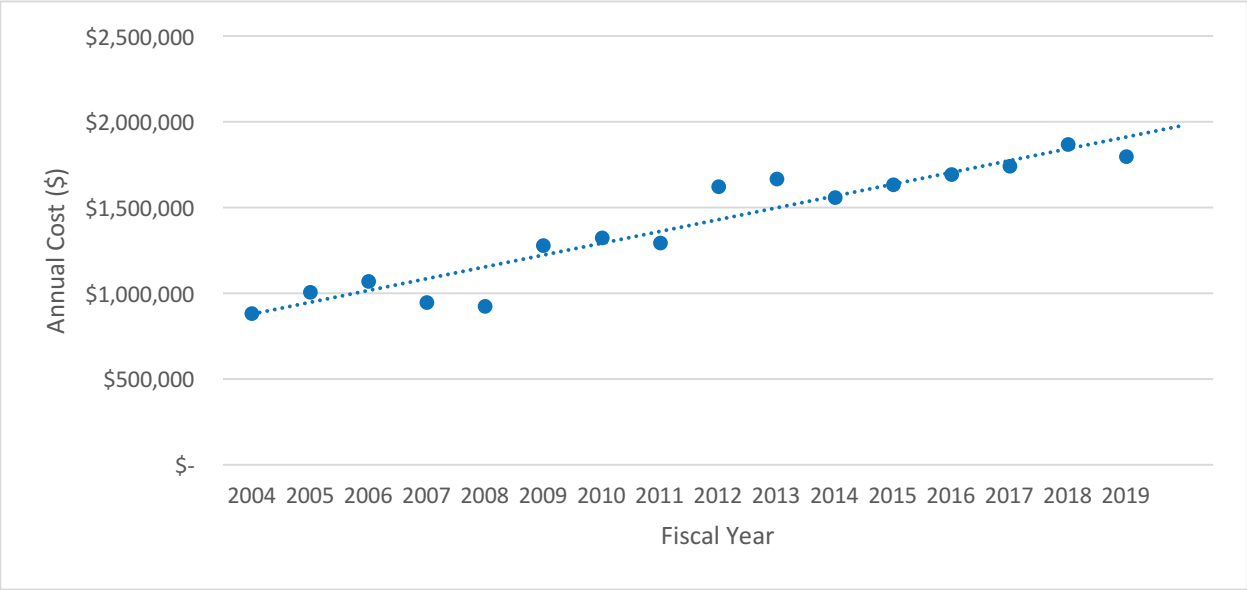


Figure 3. University of Arkansas annual cost of water for fiscal years 2004 through 2019, trendline demonstrates the increasing price leading up to year 2020.

2018 Water Use by Application

Utilizing FY2018 water data, it is possible to split the on-campus water usage into three main categories: Campus Irrigation, Heating/Cooling the buildings, and Direct Use. The Direct Use category is the most inclusive, as it covers all water used directly by people on campus, in bathrooms, laundry rooms, water fountains and food preparation. Campus Heating and Cooling makes up 30% of total campus use, which is approximately 68.7 million gallons over the fiscal year. These systems receive chilled water and steam from a district cooling and heating loop. Four separate chiller plants supply chilled water and one heating plant consisting of a series of boilers, a heat pump chiller, and a cogeneration steam turbine provides steam for campus use. Finally, Campus Irrigation encompasses all watering of vegetation on campus, including, lawns, gardens, and other green spaces. This makes up 12% of the total water use for FY2018 or about 27 million gallons.

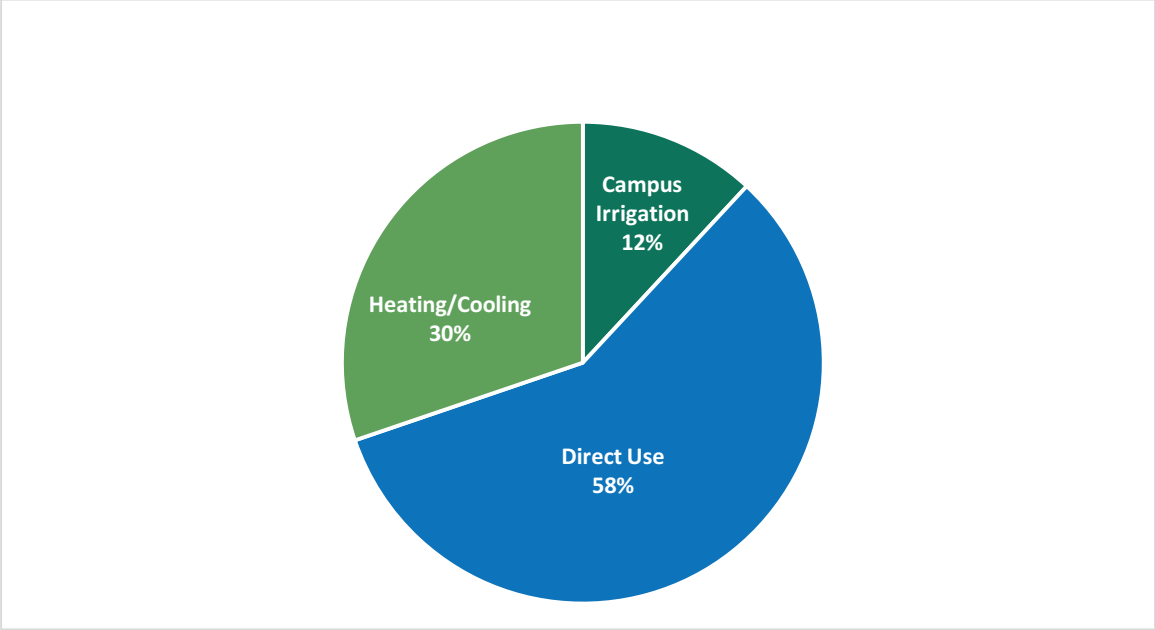


Figure 4. University of Arkansas water use by application on campus for FY18.

Another way to categorize water use for FY2018 is to separate the data into use by building type. These categories include residential buildings, educational buildings, athletic buildings, dining halls, administration buildings, and an "other" category. Figure 5 displays the percentage that each of these categories uses as a function of total campus use.

In FY2018 residential buildings used 40% of the total campus water for the 12-month period. This percentage includes the water used to heat and cool the residence halls, not only direct use. These buildings house students during the semester and other campus visitors during the summer.

An educational building's main purpose is hosting classes, research buildings have also been included in this category. This section used 19% of the campus water total for FY2018. These buildings have different usage than residence halls, despite having bathrooms and water

fountains, since they are only occupied for certain hours of the day instead of being a living space, which is in use all hours of the day.

Athletic buildings accounted for 24% of campus use in FY2018. Water is used in water fountains, swimming pools, toilets, and showers for athletes and other building occupants, however, many people prefer to go home to shower instead of using public showers. Water used to irrigate the athletic fields is also included in this section.

The dining halls category uses only 3% of the total water use for FY2018. The problem with this category is that some of the dining halls are connected to residence halls and not separately metered. This makes it difficult to separate the type of usage and properly categorize it, therefore, the data for these connected buildings are recorded in the residential section and not in the dining halls section.

The administration buildings category covers all buildings that function as office space for faculty and staff. There are faculty offices in some educational buildings, but most education buildings are majority classroom space. This category accounts for only 5% of the total water use in FY2018.

The "other" category covers 9% of the campus water use. This category includes multiuse buildings such as the Student Union, which has an exercise facility in the building along with classrooms, a ballroom, a dining area/food court, office spaces, study spaces, gaming rooms, postal services and even a hair salon. Other buildings in this category include areas like the Greek Theater, construction areas, warehouses, parking garages, Mullins Library, and the Union Station.

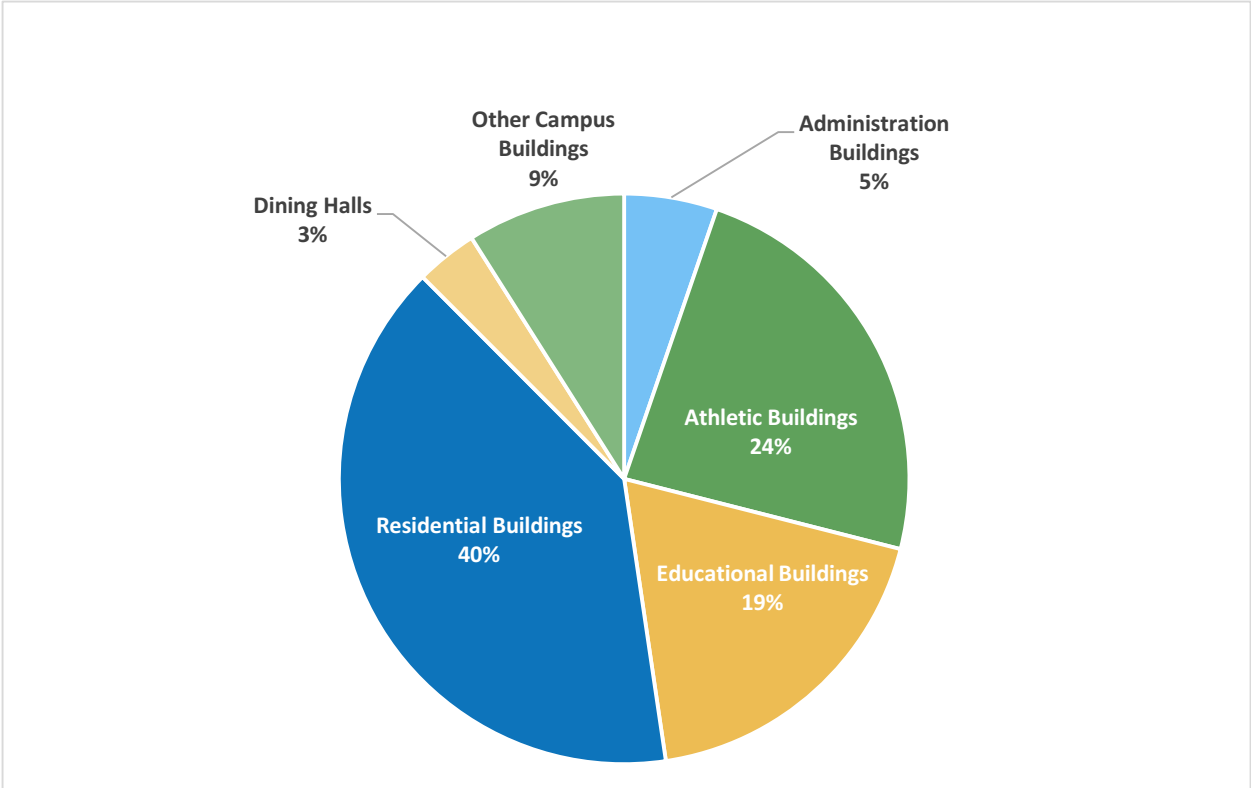


Figure 5. University of Arkansas water usage by building type for FY18.

Monthly Breakdown

Analyzing annual data gives an overview of the patterns of total campus use. Using a monthly breakdown of a chosen year allows for a more in depth look at peak months. Comparing data by month can help to determine how seasonality and occupancy affect water use. Figure 6 presents the monthly breakdown of total campus water use, excluding irrigation, for FY2018. This includes water usage related to the heating and cooling of buildings, residence hall usage, class building usage, and administration usage. It could be assumed that since most students are not on campus during summer months, the water usage would drop dramatically yet this does not seem to be the case.

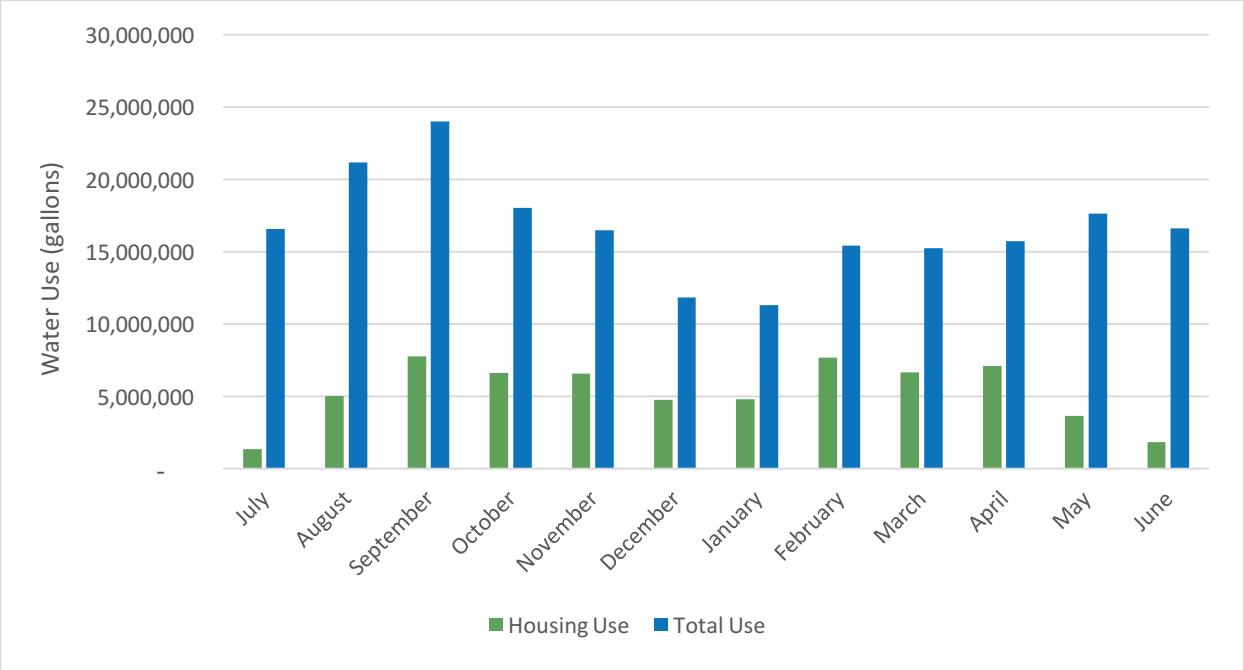


Figure 6. University of Arkansas total water use, excluding irrigation, compared to housing use, by month for FY2018.

Excluding irrigation allows us to look at water use based on campus occupancy factors. On average, housing utilizes 20-30% of the water on campus. The university hosts camps, training sessions, and the Walmart shareholders meeting for much of the summer, which is likely the reason why there is not a dramatic drop in usage. Offices are still operating through most of the summer, summer classes utilize the educational buildings along with research programs.

Each month has different circumstances affecting occupancy and therefore affecting water use. December and January have the lowest usage values likely because the entire university is closed for a week during the holiday season. Most of the student body is off campus for four weeks during this time; however, intercession classes are offered toward the end of winter break. September has the highest use of the year. This increase could be related to the high temperatures and humidity which increases the average person's frequency of showers and increases the use of air conditioning.

Housing

When incorporating the water used to heat and cool the buildings, residential buildings use approximately 40% of the total water use on campus each year, making Housing the largest contributor to water consumption on campus. Figure 7 plots 14 years of water data for housing as well as the amount paid by the university per fiscal year. The vertical bars represent the gallon use, which averages 32% of the total water use, not including the water used to heat and cool residential buildings. The horizontal lines represent the cost per year. Generating a trend line for annual water costs shows an increasing cost per year.

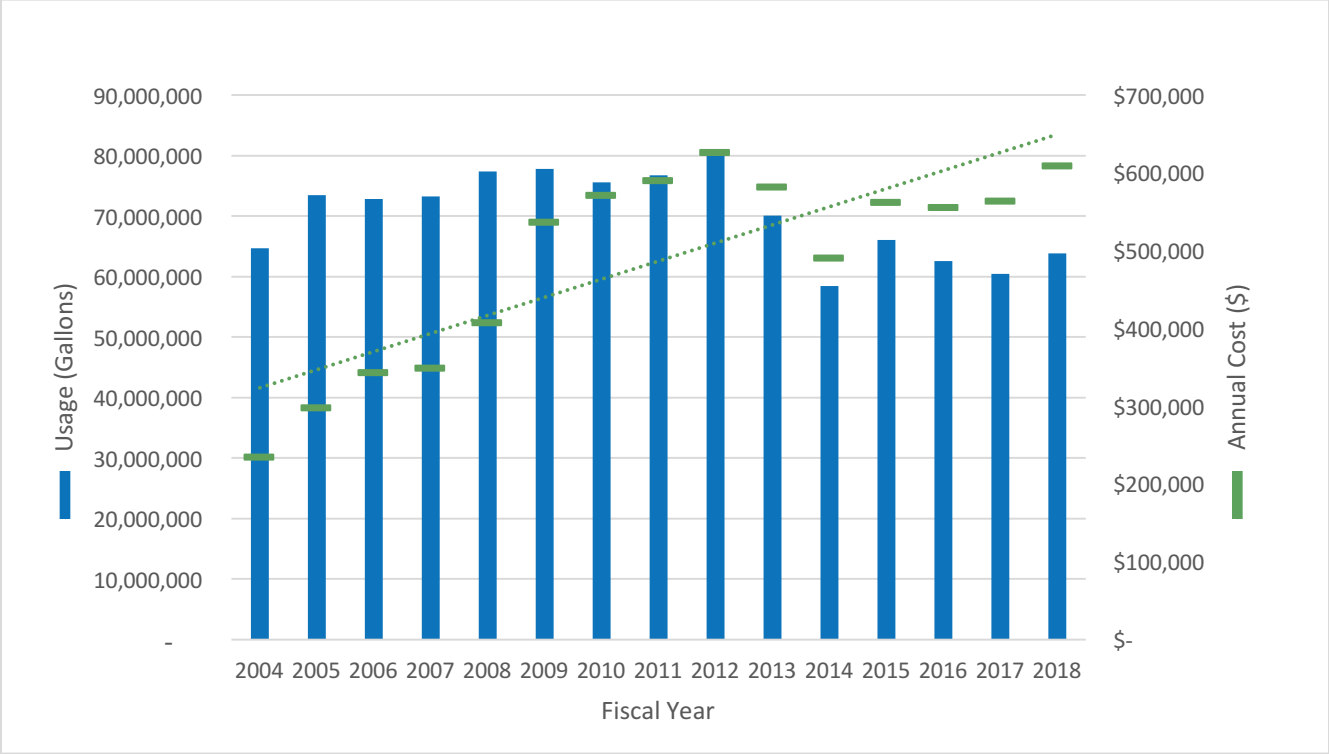


Figure 7. University of Arkansas housing percentage of total annual campus water use vs. annual cost per fiscal year.

It is useful to determine which categories are using the most water within the residential buildings. Figure 8 shows the water use comparison for FY2018. Water used to heat and cool residential buildings accounts for 30% of total residential usage. This was calculated by taking the square footage of residential buildings compared to the whole of campus and applying that ratio to the total gallon use of heating and cooling. Direct use makes up 68% of the total use, while irrigating the outside of residence halls only uses 2% of residential water.

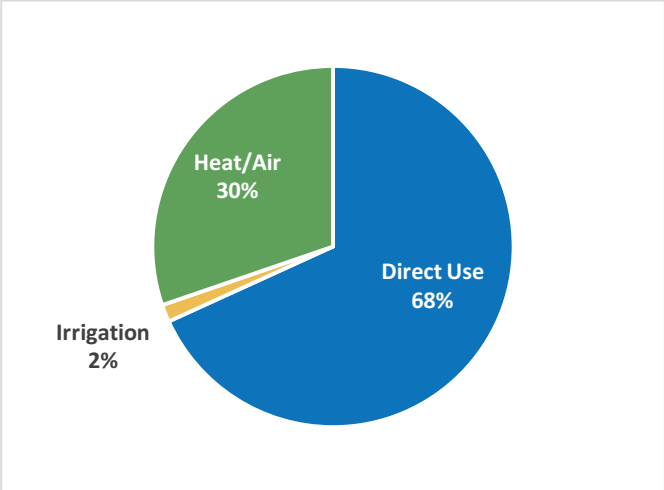


Figure 8. Use by application for residential buildings in FY18.

Because Housing contributes significantly to the total campus use, plotting the annual percentage used helps to anticipate what it may be in the future. Figure 9 plots the annual water use in Housing as a function of total campus use (not including heating and cooling). There is a spike in 2008 where Housing used 42% of total campus water, followed by a few relatively high percentage years, however, the values usually stay between 27% and 32%. The points do, however, show a relative decrease in percentage. This is likely related to renovations of bathrooms and the addition of water conserving fixtures starting in 2010.

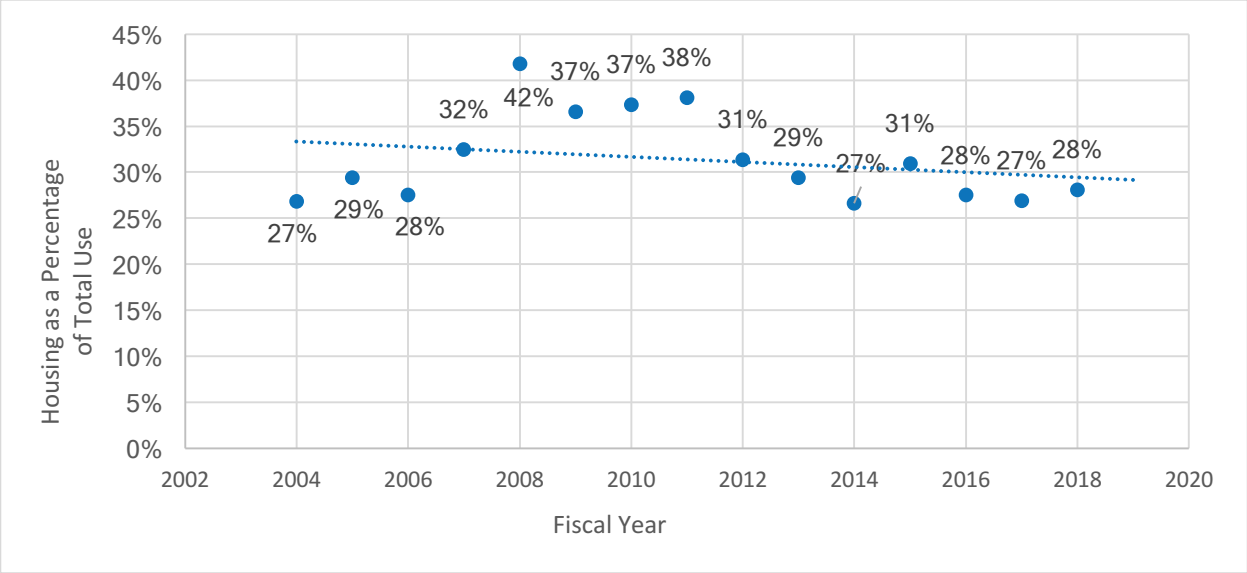


Figure 9. University of Arkansas water use in housing as a percent of total campus use by fiscal year.

Continuing with residential buildings, knowing the total water use per campus residence hall allows for identification of which buildings use the most and the least. Figure 10 graphs the actual water use for each residence hall compared to the average water use for all University of Arkansas residence halls (represented by the horizontal line). The average residence hall at the University of Arkansas uses around 2.6 million gallons of water each year.

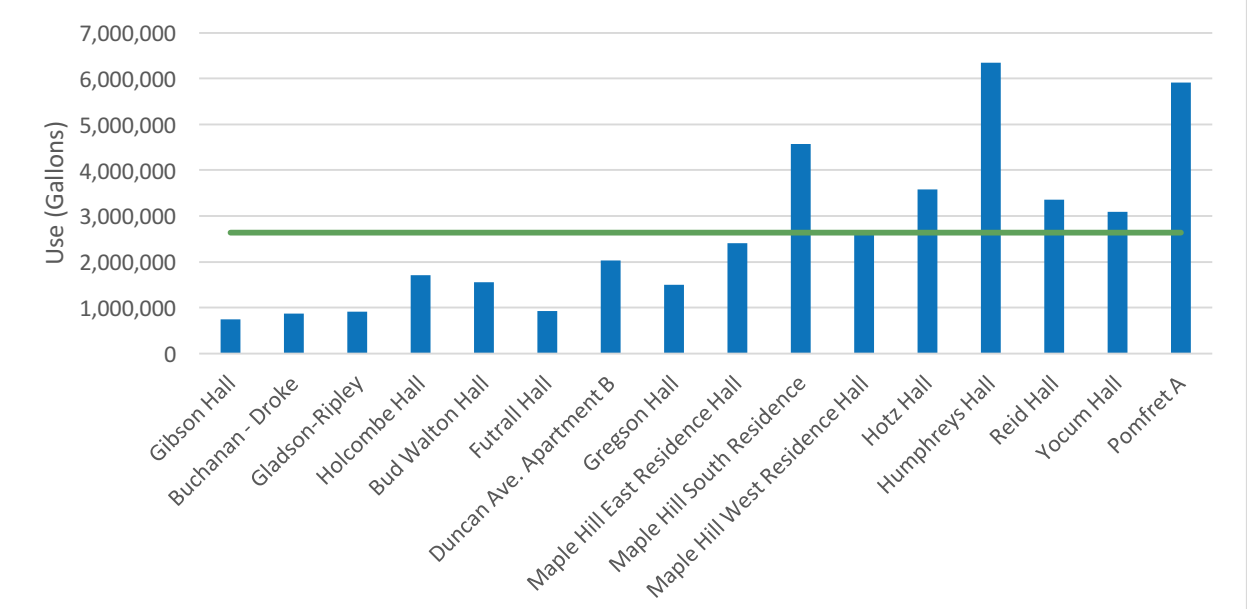


Figure 10. University of Arkansas average residence hall water use compared to specific residence building use for FY18.

The residence halls on campus vary widely in occupancy. Some halls house less than 100 students, while others house around 800. In order to more accurately compare the halls, the total gallon use is divided by the occupancy giving an average use per resident. Figure 11 plots these values compared to the campus average of approximately 9,000 gallons per resident. This water is used for showering, flushing toilets, using sinks, washing clothes, and drinking from water fountains. Further research is needed in order to figure out why some halls use more water per resident than others.

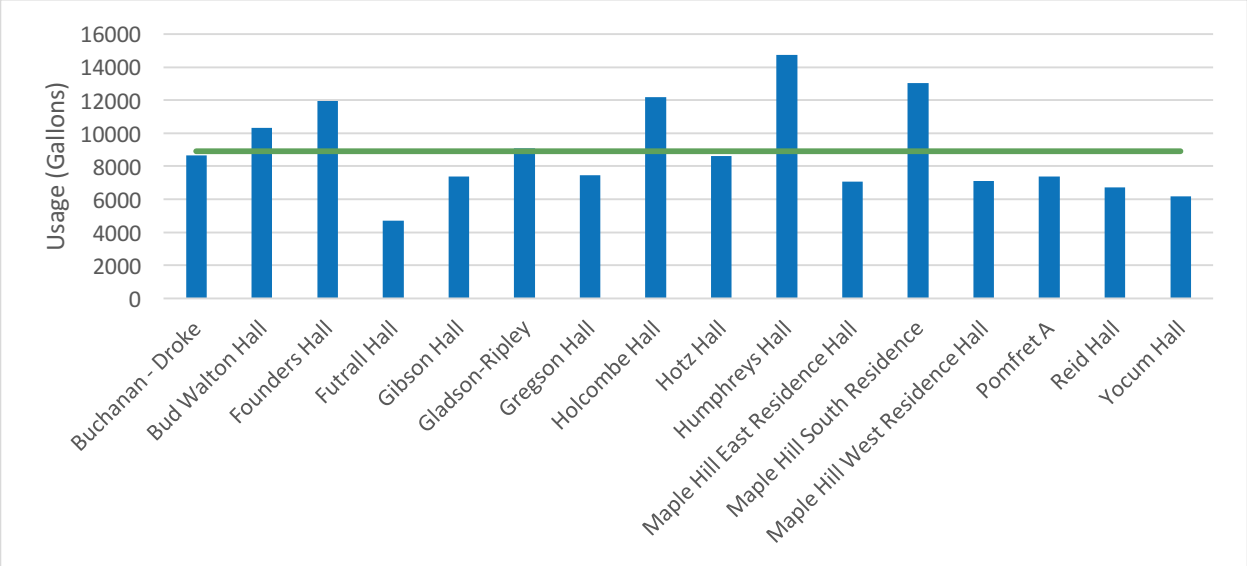


Figure 11. University of Arkansas water use per resident in on campus housing over FY2018.

Not all residence halls are included in the graphs presented above due to skew, error, or limited data. For example, Founders and the Northwest Quad buildings have been excluded because they have dining services attached that are not separately metered. This makes it impossible to correctly compute the per capita use or the total use as a standalone residence hall.

Table 1. University of Arkansas residence halls ordered by use per capita for FY2018

	Total (gallons)	Occupancy	Use per Capita (gallons)	Year of Renovation or Completion
Futrall Hall*	918,900	193	4,761	2009
Yocum Hall	3,095,500	530	5,841	2013
Maple Hill East Residence	2,400,300	346	6,937	2010
Maple Hill West Residence	2,634,700	376	7,007	2010
Reid Hall	3,356,400	459	7,312	2011
Pomfret A	5,905,512	803	7,354	2014
Gregson Hall	1,495,000	203	7,365	2011
Gibson Hall	738,300	98	7,534	2013
Buchanan - Droke	864,500	101	8,559	1954
Hotz Hall	3,575,000	416	8,594	2013
Gladson-Ripley	909,300	101	9,003	1954
Bud Walton Hall	1,550,400	152	10,200	1956
Holcombe Hall	1,704,800	143	11,922	2008
Founders Hall*	2,559,400	214	11,960	2013
Maple Hill South Residence*	4,563,900	357	12,784	2010
Humphreys Hall	6,345,300	432	14,688	2013

Heating/Cooling

Since 2004 the University of Arkansas has used over one billion gallons of water to heat and cool the buildings on campus. The university has approximately 8.55 million square feet (.79 $km^{2)}$ of building space on campus. In FY2018 the university used a little over 68 million gallons of water to heat and cool this building space. Dividing the gallon use by the square footage shows that in FY2018, each square foot required approximately 8 gallons of water for heating and cooling. This is essentially a foot of water covering each square foot of every building on campus. Figure 12 plots the gallons of water annually used to heat and cool all campus buildings. Horizontal lines show the amount paid by the university each year. The provided trend line demonstrates a pattern of increase in annual cost. The calculated average is approximately 66 million gallons per year used to heat and cool the buildings on campus. On average, heat and air annually uses 29% of the total campus water used.

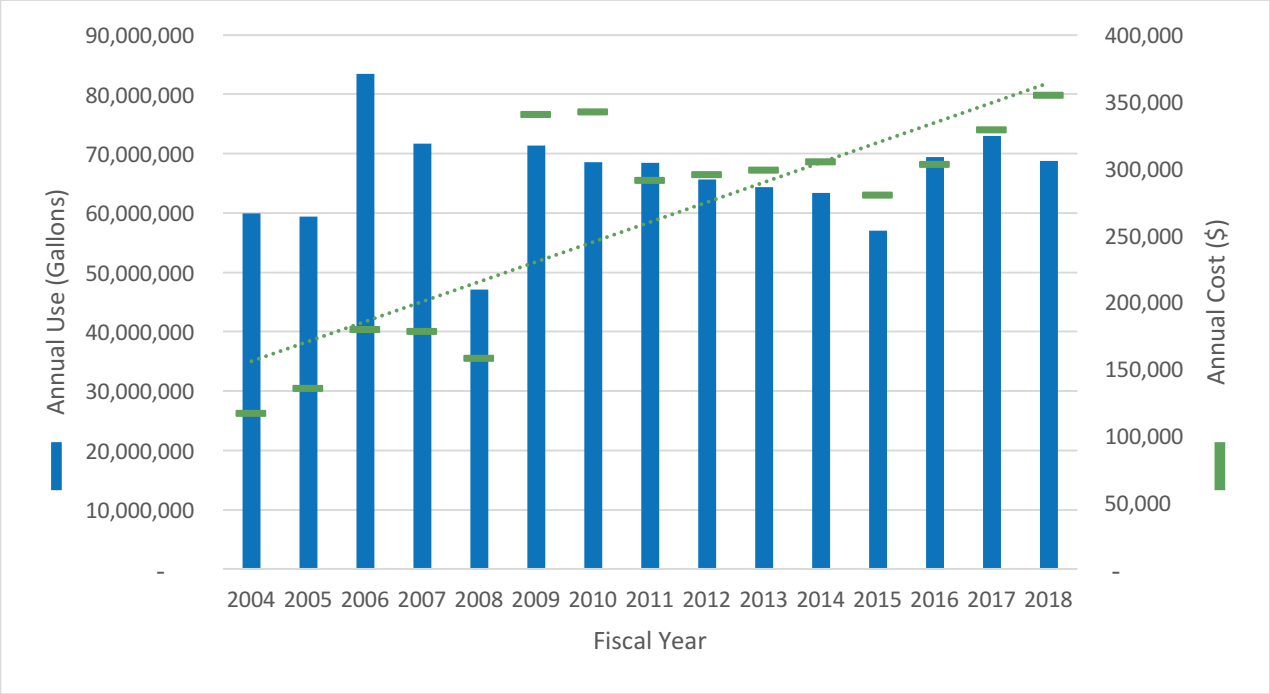


Figure 12. University of Arkansas use of heating and cooling compared to cost per fiscal year over the years 2004 to 2018.

The Combined Heat and Power Plant (CHP) serves the main campus regarding air systems. This system works in the Heating Plant along with a series of gas-fired boilers to provide steam which is used for heating and air conditioning while at the same time generating electricity which helps to reduce the amount of power purchased and to reduce the campus' carbon footprint.

Irrigation

The University of Arkansas has an automatic irrigation system that is complemented by daily inspections of vegetation health and weather forecasts. Figure 13 compares the annual irrigation used to the precipitation in inches that fell in Fayetteville for that fiscal year (U.S. Climate Data, n.d.). It should be expected that years with more precipitation show less irrigation use, however, this does not seem to be true. Yet, there does seem to be a pattern of increase shared by these two data sets.

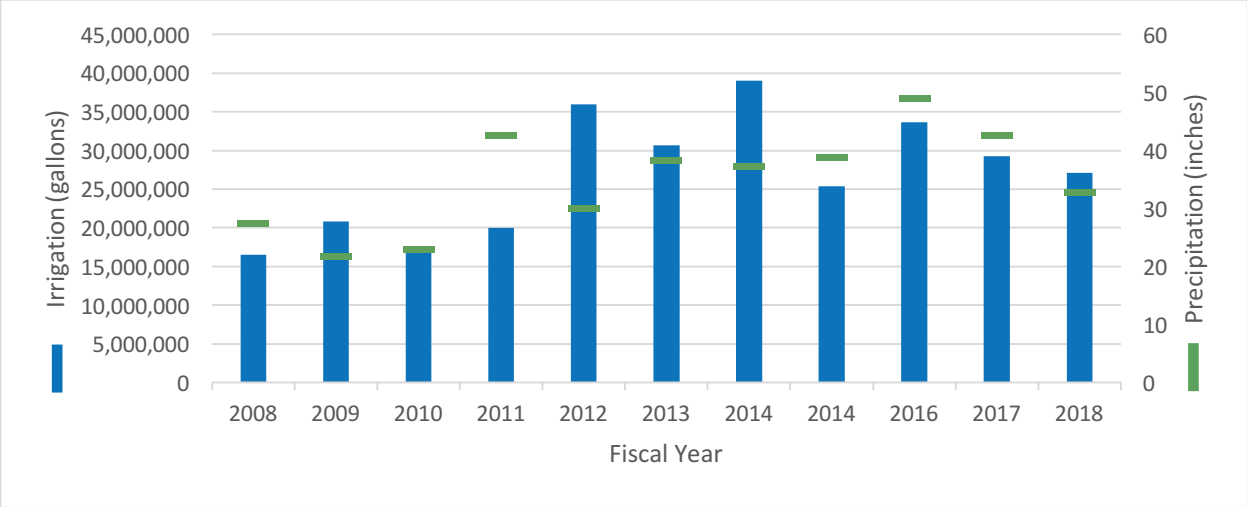
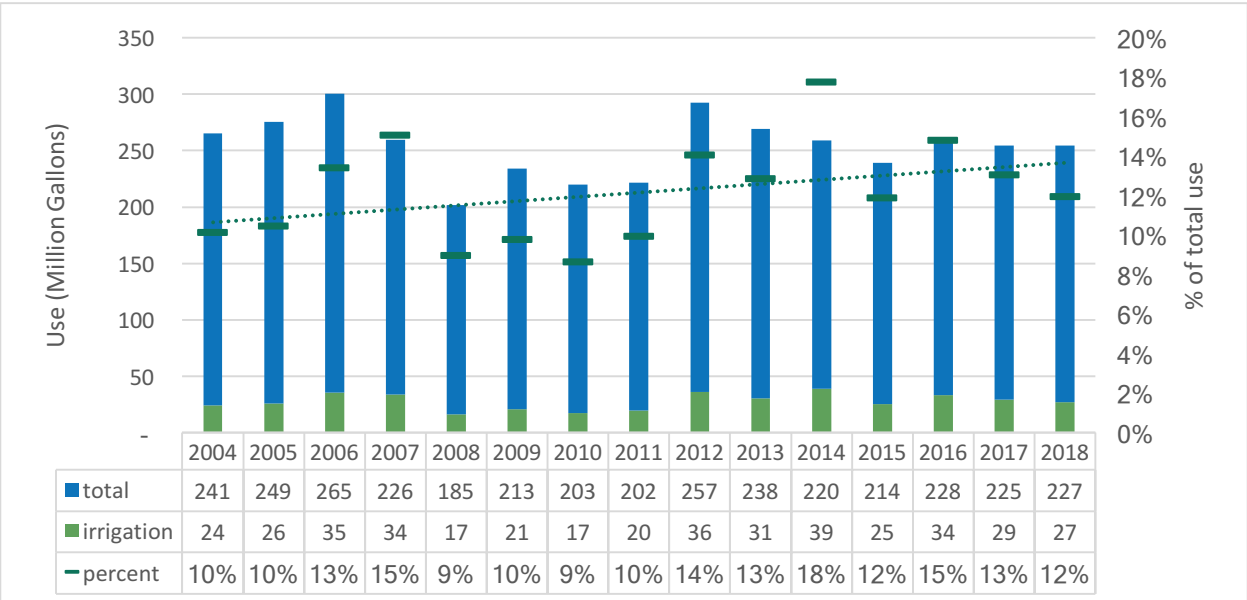


Figure 13. Annual irrigation totals compared to the precipitation total for Fayetteville, AR from 2008 to 2018.

The following graph represents the annual campus water use compared to irrigation. In past years, the average amount used for irrigation has been 12% of the total water usage. Irrigation for the first half of FY2019 is currently at 17%. The line segments appearing across the graph represent the percent of total water used for irrigation for that fiscal year. The dashed line shows the increasing trend of irrigation equaling a higher portion of total annual use.



	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
total	241	249	265	226	185	213	203	202	257	238	220	214	228	225	227
irrigation	24	26	35	34	17	21	17	20	36	31	39	25	34	29	27
percent	10%	10%	13%	15%	9%	10%	9%	10%	14%	13%	18%	12%	15%	13%	12%

Figure 14. Total use &. irrigation use per fiscal year over 2004 to 2018 including the percentage of the total water usage.

Comparing irrigation and precipitation by month helps to show the relationship between the two values. Figure 15 displays an inverse relationship between the two series. When there is a large amount of precipitation in months such as March and May, the amount of irrigation used is relatively low while in September and June, there was very little precipitation which resulted in higher amounts of irrigation.

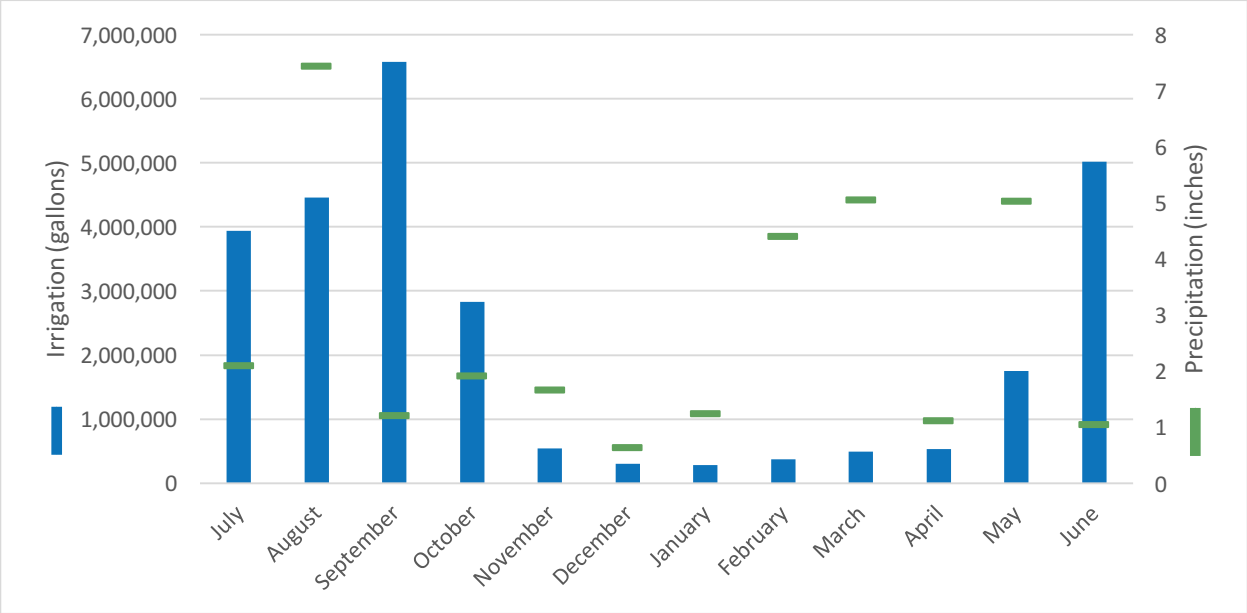


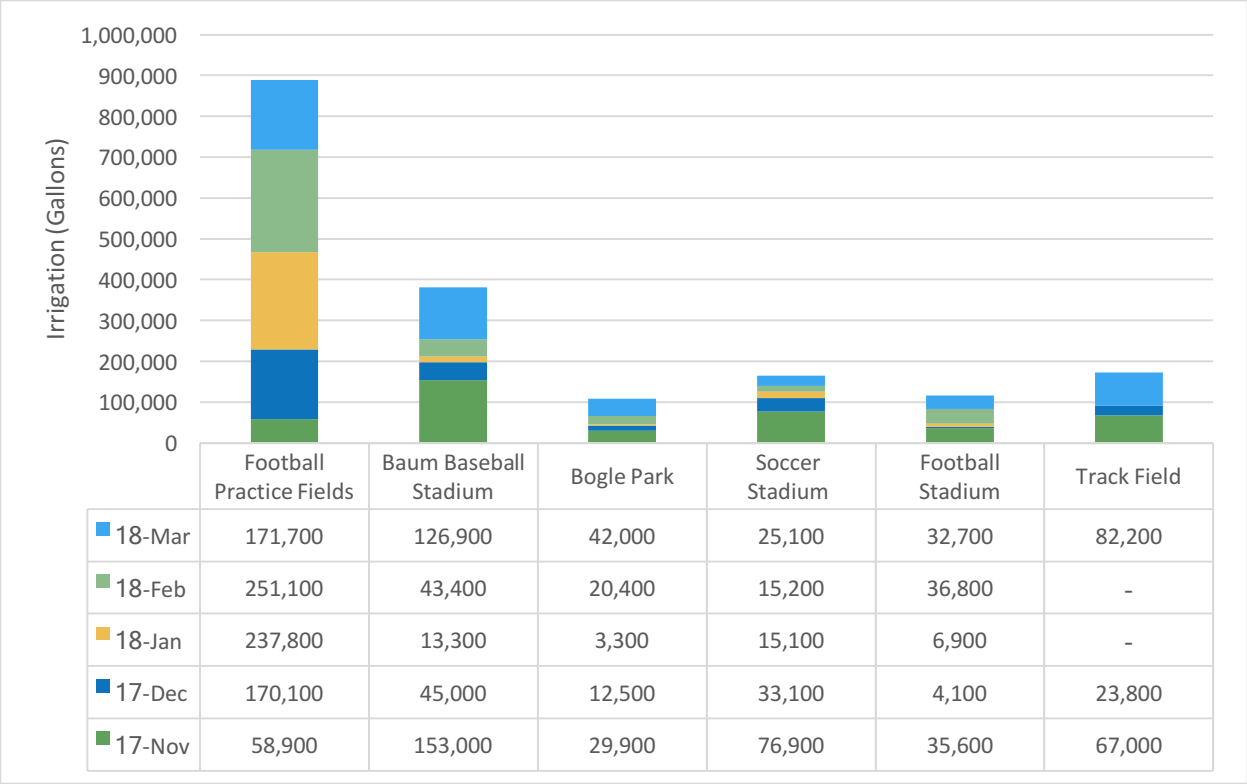
Figure 15. Irrigation by month of FY18 on the University of Arkansas campus and precipitation totals in the City of Fayetteville.

The University of Arkansas has an irrigation system that is based on seasonality. Starting in November, the system begins to winterize, decreasing the amount of irrigation. In the spring the system is reactivated and begins to irrigate the greenspaces around campus. It is interesting to note that while the cooler months of the year have low irrigation use, they still have some use, this is mostly due to the irrigation of athletic fields.

When walking through campus it is easy to spot drip irrigation in landscape beds. Drip irrigation is a good alternative to above ground sprinklers, but there is often an issue with exposed piping. Drip irrigation should be buried, but when it isn't buried deep enough it can become exposed and damaged which causes error in the system (Larson, 2016).

Gearhart Hall and the Jean Tyson Child Development Center both utilize buried stormwater cisterns. These cisterns collect rain/storm water and use it to irrigate the surrounding green spaces. Underground collection systems can be expensive to implement after the building has already be constructed but have been well received. It would be most efficient to put a system like this in place when constructing future buildings.

As previously mentioned, the University of Arkansas has an irrigation system that is winterized during the cooler, rainy months. Despite having a winterized system, campus still shows irrigation values during these months, this is due to irrigation of athletic fields. Figure 16 shows where irrigation is used during the "cool" months at the university (November through March). Some sports, such as baseball, are played mostly during the cooler season which means that the field must be irrigated to stay green. In this figure each of the bars exceeds 100 thousand gallons of use over the five-month period. The first bar shows the use by the football practice fields, which is almost larger than all the others combined.



	Football Practice Fields	Baum Baseball Stadium	Bogle Park	Soccer Stadium	Football Stadium	Track Field
18-Mar	171,700	126,900	42,000	25,100	32,700	82,200
18-Feb	251,100	43,400	20,400	15,200	36,800	-
18-Jan	237,800	13,300	3,300	15,100	6,900	-
17-Dec	170,100	45,000	12,500	33,100	4,100	23,800
17-Nov	58,900	153,000	29,900	76,900	35,600	67,000

Figure 16. University of Arkansas winter irrigation use over 100,000 gallons, from November through March of FY2018.

Speaking to a Senior Customer Service Representative from the City of Fayetteville, the method of irrigation described for these practice fields were water "cannons" used to disperse water across the fields. Above ground irrigation systems are generally less efficient than buried irrigation systems because as the water moves through the air, some of it evaporates. With water cannons, the length of time that the water is in the air is increased leading to an increased evaporation rate. The large nozzle size is good for this system because it allows for a larger surface area of the water drops which lowers the evaporation rate, however, there is still a large amount of evaporation. Other factors to consider are temperature, relative humidity and wind speeds (Zazueta, n.d.). Because there are so many factors in evaporation of water coming out of water cannons and other sprinklers, it would likely be more efficient to utilize drip irrigation beneath the field (*Water Efficiency: Agricultural Irrigation*, 2013).

Campus Comparisons

The weighted campus user is a weighted average of people present on campus during the year. Dividing the annual water use by the number of WCU's calculates the per capita water use for each university ("AASHE STARS Institutions," n.d.). Comparing campuses by their water use per WCU is a more accurate way to see the similarities and differences in water use while correcting for size/population differences. Comparing a large university to one that is much smaller based on total campus use would not give us an accurate comparison because, of course, the larger university will use much more water. Comparing by the average use per WCU provides a better picture of possible water waste.

The following table displays the formula used to calculate the number of WCUs on campus along with descriptions of each variable. Also seen in Table 2 are the corresponding numbers for the University of Arkansas. Using the information provided the use per WCU equals about 11,000 gallons for the most recently reported WCU values. The final values shown are the weighted number of people on campus for the reported fiscal year. To get the use by WCU, divide the total water use by the number of WCUs.

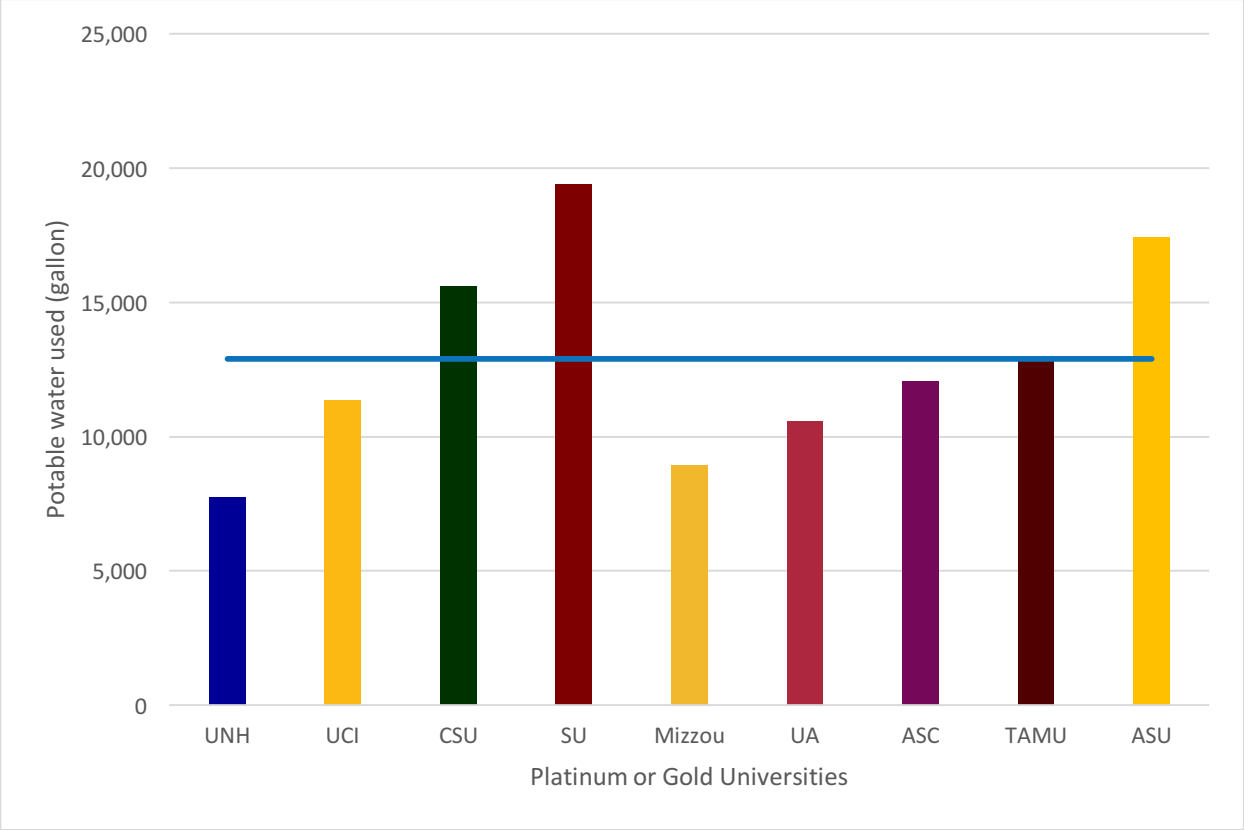
Table 2. University of Arkansas WCU information for baseline and performance years

$WCU = (A + B + C) + .75[(D - A) + (E - B) - F]$	Baseline (FY2009)	Performance year (FY2016)
A= Number of students residing on-site	4,545.0	6,012.0
B= Number of employees residing on-site	0.0	187.0
C= Number of other individuals residing on-site and/or staffed hospital beds	0.0	0.0
D= Total full-time equivalent student enrollment	14,814.0	23,585.0
E= Full-time equivalent of employees (staff + faculty)	3,747.0	4,553.0
F= Full-time equivalent of students enrolled exclusively in distance education	1,342.0	2,019.0
Weighted Campus Users	14,050.5	21,139.0

Note: Adapted from "AASHE STARS" Baseline and Performance year found in the University of Arkansas Water page WCU equation was found in the "STARS Technical Manual."(*STARS Technical Manual*, 2017)

Using AASHE STARS it is possible to see the reported water use for other universities all over the world. For the purpose of this research we only used universities located in the United States for comparison. These comparisons show that the University of Arkansas uses less than average for potable water use per WCU. It is not among the lowest in the country, however, leaving room for improvement.

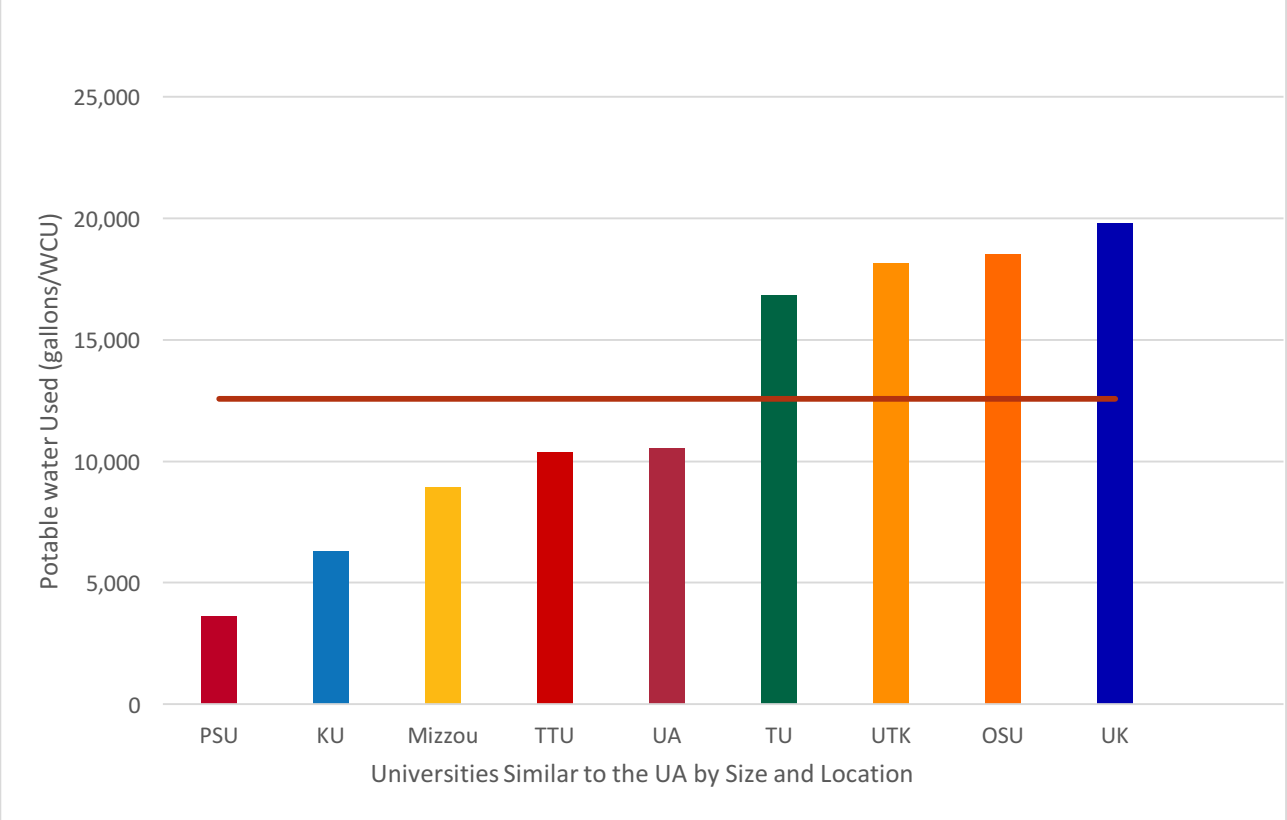
AASHE STARS give an overall ranking for the universities that report their impacts. Platinum is the highest ranking, then Gold, Silver, and Bronze. This ranking system is based on all aspects of sustainability on campus, not only water use. Figure 17 compares the University of Arkansas to other Platinum or Gold ranked universities in the United States. Colorado State University, Stanford University, University of California Irvine and University of New Hampshire are all ranked by AASHE STARS as Platinum universities. The University of Arkansas is ranked as a Gold university.



	STARS ranking	Potable Water Use per WCU (gallons)
University of New Hampshire (UNH)	Platinum	7,743
University of California, Irvine (UCI)	Platinum	11,357
Colorado State University (CSU)	Platinum	15,612
Stanford University (SU)	Platinum	19,403
University of Missouri (Mizzou)	Gold	8,925
University of Arkansas (UA)	Gold	10,568
Agnes Scott College (ASC)	Gold	12,074
Texas A&M (TAMU)	Gold	12,966
Arizona State University (ASU)	Gold	17,442

Figure 17. University of Arkansas compared to other platinum or gold ranked universities. Note: Adapted from "AASHE STARS institutions." Note: Adapted from ("AASHE STARS Institutions," n.d.).

Another way to compare universities is by region. This allows for a more accurate comparison because the universities are subject to the same or similar climates. Figure 18 compares the University of Arkansas to other universities that are in the same geographical region. Student population size was also taken into consideration but is less relevant due to the use of weighted campus users.



	State	Potable Water Use per WCU (gallons)
Pittsburg State University (PSU)	Kansas	3,636
University of Kansas (KU)	Kansas	6,293
University of Missouri (Mizzou)	Missouri	8,925
Texas Tech University (TTU)	Texas	10,373
University of Arkansas (UA)	Arkansas	10,568
Tulane University (TU)	Louisiana	16,837
University of Tennessee at Knoxville (UTK)	Tennessee	18,150
Oklahoma State University (OSU)	Oklahoma	18,549
University of Kentucky (UK)	Kentucky	19,802

Figure 18. University of Arkansas compared to other universities that are similar in size and location. Note: Adapted from ("AASHE STARS Institutions," n.d.).

Current Water Conservation Methods

At the University of Arkansas, the main sources of water conservation are through fixtures. Most residence halls have been remodeled to include water saving fixtures, such as low flow toilets, showers, and aerated faucets. Showers are all fit with fixtures allowing for a flow rate of two gallons per minute. Toilets across campus all comply with the Energy Policy Act requirement of 1.6 gallons per flush. There are also buildings fitted with dual flush toilets. Dual flush technology allows for two different flush rates depending on the type of material being flushed, for solids the user can choose the 1.6 gallon per flush feature, and for liquids there is a 1.1 gallon per flush option (Elliot, 2008). Another conservation feature used on campus is the pint urinal. The Walton College of Business is the primary location for this technology. This urinal uses a pint of water per flush as opposed to a gallon which is a reduction of 87.5%.

The faucets across campus are aerated to allow a flow rate of 0.5 gallons per minute. There are also a wide variety of motion detecting sinks across campus, which protects against users leaving the tap open by accident or the faucet being left on when unnecessary. There are, however, some issues related to accuracy of the motion sensors. Motion sensing faucets can also be expensive to fix when they break. A lower tech alternative to motion activated faucets is push taps. Push taps work on a timed basis, the user pushes on the tap head which starts the faucet, the water then runs for a certain amount of time before shutting itself off. This kind of technology is relatively inexpensive and easy to use, as well as a good method of conserving water.

Table 3. Cost comparisons for suggested water reduction technology

What	Cost	Efficiency
Pint urinal	Low	High
Dual flush	Low	Med
Low flow	Low	Med
Aerated faucets	Low	Med
Low flow showers	Low	Med
Drip irrigation	Med	High
Push tap	Low	High
Water cisterns	High	High
Motion sense	Med	Med

Conclusions

The University of Arkansas is committed to reducing energy and water usage in university buildings and campus landscapes (*Facilities Management Statement of Sustainable Practices November 2006, 2006*). The university has already retrofit all toilets on campus in accordance with the 1992 Energy Policy Act. Faucets and showers have also been fit to allow reduced flow without compromising the required pressure to meet efficiency standards. Two buildings on campus use underground collection cisterns to irrigate their building greenspaces effectively lowering the irrigation used by those buildings.

Data outlining all water used by the University of Arkansas for the past 14 years was provided by Facilities Management for this analysis. When looking at the water totals for that span of 14 years, there is a slight downward trend, but if you only look at the past ten years starting in 2008, there is actually an increasing trend of total water use on campus that coincides with the increase of enrollment over that period of time. In FY 2008, the student enrollment was 19,000. This gradually increased to over 27,000 for FY 2018 (*Fall 2018 Enrollment*, 2018).

When assessing the water footprint regarding application, the largest contributors are housing and the campus heating/cooling system. Residential buildings and the heating and cooling system use 40% and 30% of the total water used on campus, respectively. These are most likely the best opportunities to decrease campus usage in the future, however, further analysis is required to be certain.

To get a sense of how the University of Arkansas is doing in terms of water use, other universities were used for comparison. These universities were selected based on AASHE STARS ranking as well as size of the university and geographic location similar to the University of Arkansas. To be able to accurately compare these schools, the water use was calculated per WCU. Taking an average of water use per WCU for these schools, the University of Arkansas does use less than average, however, it is also not among the lowest regarding water use. Moreover, there are many opportunities on campus to reduce water waste.

Next Steps

Further Investigation

This document is focused on quantifying the campus water use to create an accurate look at the total water footprint of the university, but future research and program implementation is on the horizon. It is important to dive deeper into the categories of use to determine what behavior is causing water waste. This is important if we are to make accurate future reduction goals.

Setting Goals

Making lasting changes requires a strong set of goals. Goals create something to work toward and allow for benchmarks to be set to analyze progress. The University of Arkansas already has reduction goals in place for carbon emissions and waste, a similar reduction goal should be established for potable water usage. In the process of building this report, water action plans from other universities were consulted. These reports were also used to assist in assessing possible goals for the future.

- University of California, Irvine discusses already having reduced use by 88 million gallons in their 2017 update to their Water Action Plan (*University of California, Irvine Water Action Plan*, 2017).
- University of California, Los Angeles plans to reduce water use 20% by 2020 as of 2013 (*University of California, Los Angeles Action Plan*, 2013).
- University of California, San Diego has a reduction plan of 36% by 2025 (2017 – 2025) (*University of California, San Diego Water Action Plan*, 2017).
- University of California, Santa Cruz has a reduction plan of 20% by 2020 36% by 2025 (*University of California, Santa Cruz Water Action Plan*, 2017).
- Colorado University's goal is to reduce 5% per year for 5 years (*Campus Water Use*, 2006).

Based on reduction goals set by other universities the University of Arkansas should be able to achieve a short-term reduction goal of 20% over a period of 5 years. This would mean reducing the annual potable water use by 45 million gallons, theoretically saving $300,000 each year after reaching the 20% mark. In the long term, goals should be in relation to 2040 to match the carbon neutrality and waste reduction goals.

Table 4. Possible reduction goal of 20% over a period of 5 years.

Year	Use (gallons)	Cost ($)
2020	217,169,403	1,339,423
2021	208,120,678	1,283,614
2022	199,071,953	1,227,805
2023	190,023,228	1,171,995
2024	180,974,503	1,116,186

Potential Water Conservation Measures

To achieve a reduction in water consumption, various water conservation measures would need to be deployed. Some examples of applicable water conservation measures include:

Educational Strategies – low cost

- Implement signage in residence halls
    - "Reducing your shower length by 5 minutes saves over 3 thousand gallons a year. With over 5000 students living on campus, the savings could total over 15 million gallons a year!"
    - "Take shorter showers"
    - "Only do a load of laundry when you have a full load, or use the size settings on the washer, as a bonus, washing in cold water saves energy."
    - "Turn off the faucet when not in use"
    - "Turn off when you're brushing your teeth, on to rinse"
    - "Use showers to relax? Here are more sustainable ways to relax…"

Direct Use Reduction – medium cost

- Update fixtures across campus
    - Dual flush toilets – 1.6 gallons per flush for solids, 1.1gpf for liquids
    - Lower flush rates – decrease all flush rates with more efficient toilets
    - Pint urinals – Replace all urinals with pint urinals.
        - Theoretically, would reduce water use by 0.875 gallons each time a urinal is flushed.
    - Waterless urinals
    - Energy efficient washing machines in residence halls
    - Greywater catchment system in which recycled water could be used in toilets

Irrigation Reduction – medium to high cost

- Water catchment system for irrigation, stormwater used for irrigation instead of potable water
    - Cisterns, above and below ground systems
    - Below ground good for new construction
    - Above for existing buildings – these are not atheistically pleasing but could hide them to improve aesthetics.

Heating/Cooling Reduction – high cost

- Satellite water treatment plant
    - Allows for reuse of grey water in air systems
    - Could also be used for irrigation

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