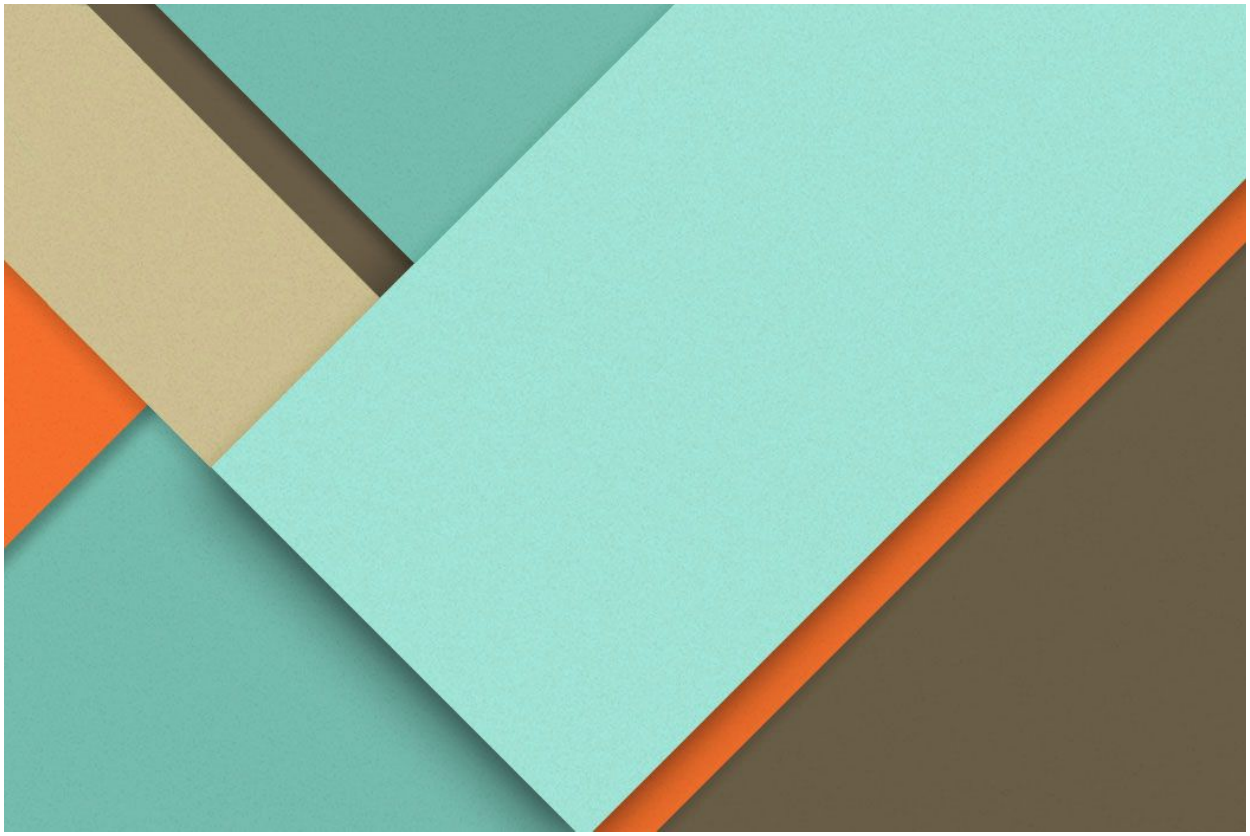

Enhancing Campus Resilience Through Sustainable Water Planning

06.06.2017

Stakeholder

Nurit Katz

Team Members

Manali McCarthy
Cayla Whiteside
Kathleen Knight
Ricardo Patlan
Lillian Wherry

Sustainability Action Research Program

Winter and Spring Quarter 2017
Institute of the Environment and Sustainability
University of California, Los Angeles

Understanding Resilience

The term "resilience" in recent years has become a new environmental buzzword. Just what does it mean? Resilience at its heart serves to express the ability to successfully recover from difficulties, but it encapsulates so much more. Resilience means progress and sustainability. When applied to the environment, this meaning has the potential to create powerful impacts. With the effects of anthropogenic change apparent in our natural ecosystems and human societies, the ability for our societies to incorporate planning that has long term benefits and reduces our impact on the environment is a key step in ensuring that our actions will benefit future generations. While the Rockefeller Foundation has worked to establish resilience guidelines for cities and has initiated programs to increase the ability for cities to respond to natural disasters and climate change in a manner that is both practical and sustainable, resilience ideas have not been applied to university campuses. As universities tend to be the community forerunners in developing sustainable practices and advocating for the safety and benefits of its communities, our project aims to encourage UCLA to lead Los Angeles forward as a model of resilience.

Introduction & Background

The Team

The Sustainability Action Research (SAR) Program under the Institute of the Environment and Sustainability at UCLA brings together students from various disciplines to address sustainability issues on campus in a variety of fields. Our team was composed of five members, two who had been involved in the SAR program previously, and three who had not. The team members this year were:

Manali McCarthy - Manali is a second year SAR member and a third year Anthropology and Geography / Environmental Studies major. She was one of this year's resilience team leaders.

Cayla Whiteside - Cayla is a first year SAR member and a third year civil and environmental engineering major with an environmental systems and society minor. She was the other leader for this year's resilience team.

Kathleen Knight - Kat is a second year SAR member and was on the resilience team last year. She is a third year environmental science major.

Ricardo Patlan - Ricardo is a first year SAR member and a third year political science major.

Lilian Wherry - Lily is a first year SAR member and a third year environmental science major.

Last year, the 2015-2016 Resilience Team worked to develop tentative plans for a rainwater harvest system. Their work and designs inspired us to continue the water cistern project and use their idea of a sustainable water source that could serve as an emergency water supply in the case of a large scale disaster at UCLA, which we though perfectly emulated the idea of resilience: sustainability and contingency planning for the benefit of members of the community. While we modified their designs and site location, we stayed true to their mission of promoting local water sourcing and providing community opportunities for outreach and growth. Through our work, we are on target to fully fund and install a water cistern for completion during the 2017-2018 school year.

Goals

This year's resilience team focused on bringing the idea of a rainwater capture system to life on campus.

One Primary Goal: Implementation of a rainwater capture system

Sub-Goals:

1. Obtain location
2. Develop system design
3. Complete detailed budget
4. Apply for funding
5. Construct System

Progress

Building on the achievements of last year's team, much progress has been made throughout these past two quarters. Through the hard work and perseverance of the team, a location was selected, a preliminary design created, materials and budgeting information compiled, funding applied for (and received), and future plans drafted. The cistern system is now well on its way to being completed, however, the beginning of the year did not start off like that.

Figure 1: Team members surveying potential locations for advantages and disadvantages.

Location

At the beginning of January, there was still no set location for the system. This became the initial issue to address. The previous year's team had contemplated placing the system in a space in Boelter Courtyard. Nurit Katz also recommended locations by Franz Hall, the Botany Building, and Parking Structure 9. The team investigated each of these locations with the assistance of Tom Lukas. Photo evidence was taken and lists of the advantages and disadvantages to each space was discussed. Ultimately, Parking Structure 9 became the most desired location for a variety of reasons.

Parking Structure 9 had more available space for the cisterns than Boelter Courtyard and the Botany Building. It was located on level ground, unlike by Franz Hall. It was also out of sight of pedestrians which would limit interference with the project and ease approval from the campus architect. Additionally, Tom Lukas spoke with Transportation Services who was able to give verbal confirmation for our use of the space.

Figure 2: Photograph of the Parking Structure 9 site location from ground level.

There were a few disadvantages to the space that required some deeper brainstorming to overcome. First, was the quality of the water collected. Unlike water off the roof of a building, the water collected off the roof of the parking structure, where cars parked, would be full of dirt, oil, debris, and other toxic wastes. This meant our system would need to be approved by the Department of Environment, Health and Safety before used for irrigation. Another disadvantage was the lack of visibility of the system. A huge aspect of the project was the ability to educate visitors to campus on the project and about water conservation practices in general. The location of the system on Level 1 of the parking structure meant it was relatively out of view of pedestrians walking at street level. The team was able to come up with a variety of educational outreach ideas (which are discussed in further detail below); the main idea was to create signage near the system at street level to inform pedestrians. Additionally, adjustment or complete removal of the tarp covering this area would give greater visibility to the system.

Due to the reasons stated above, Parking Structure 9 became the set location for the cistern system which meant design could begin. A photo of the space can be seen in Figure 2. The space is currently used for old bike storage. The tarp covering the space can be seen in the upper left corner of the photo.

Design

Once the location had been selected, the design of the system began. Before the location had been selected, the team had reached out to the Capital Programs Department for the AutoCAD design plans of both Parking Structure 9 and Boelter Courtyard to measure the space available in each. The footprint of the space was easily measured using this program, however, the height of the space was not included in these plans. Tom Lukas connected us again with the Capital Programs and Facilities Management Departments. Hard copies of plans of the parking structure were obtained along with vertical profiles of the space. From these plans, the overall space was able to be dimensioned and a preliminary design constructed. Figure 3 shows the calculation process for the selection of the most relevant tank size and the number of tanks.

	Option1	Option2	Option3	Option4	Option5	Option6
Dimensions						
Storage (gal)	3000	4100	1900	1700	1200	1300
Diameter (in)	102	102	64	76	72	60
Height(in)	93	130	154	95	82	114
Weight - tank(lbs)	405	714	300	250	210	194
Weight-water (8.34 lb/ga	25020	34194	15846	14178	10008	10842
SG		1.2				1.2
Storage						
Total Storage - 6 tanks	18000	24600				
Total Storage - 7 tanks	21000	28700				
Total Storage - 8 tanks				13600		
Total Storage - 9 tanks				15300	10800	
Total Storage - 10 tanks			19000		12000	13000
Total Storage - 11 tanks			20900			14300
Weight						
Total Weight - 6 tanks	152550	209448				
Total Weight - 7 tanks	177975	244356				
Total Weight - 8 tanks				115424		
Total Weight - 9 tanks				129852	91962	
Total Weight - 10 tanks			161460		102180	110360
Total Weight - 11 tanks			177606			121396
Cost						
Cost per tank	$1,095.95	$2,289.95	$1,359.95	$764.95	$799.95	$849.94
Cost - 6 tanks	$6,575.70	$13,739.70				
Cost - 7 tanks	$7,671.65	$16,029.65				
Cost - 8 tanks				$6,119.60		
Cost - 9 tanks				$6,884.55	$7,199.55	
Cost - 10 tanks			$13,599.50		$7,999.50	$8,499.40
Cost - 11 tanks			$14,959.45			$9,349.34
Cost/gallon	$0.37	$0.56	$0.72	$0.45	$0.67	$0.65

Total Catchment Area (in^2)	12,492,099.29	* Level 6	
Total Catchment Area (ft^2)	86750.69		
1" precipitation (ft^3)	7229.224167		
Volume of runoff (ft^3)	6506.30175	**Assume runoff coef. =0.9,	
Volume of runoff (gal)	48667.13709		
Perimeter (ft)	1446		
Level 1 Elevation (ft)	355	** all lower half of parking lot	
Level 2 Elevation (ft)	366	* ground level	
Level 6 Elevation (ft)	410		
Height of outer wall (ft)	15.25	370.5 ft	
Height of cement overhang (ft)	21	376	
Ground level (ft)	355		
Horizontal distance apart (ft)	4.25		
Vertical distance apart (ft)	5.75		
Diagonal (ft)	7.150174823	**limiting value	
Length of area (in)	860		
Width of area (in)	162		
Stormdrain diameter (in)	18		

Figure 3: Calculations for determining the idea cistern size and number.

In order to determine the feasibility of our design and iron out other details, the team reached out to RainHarvest Systems, an independent company that frequently designs and installs rainwater capture systems, the team was able to set up a meeting with them. The representatives from RainHarvest Systems were able

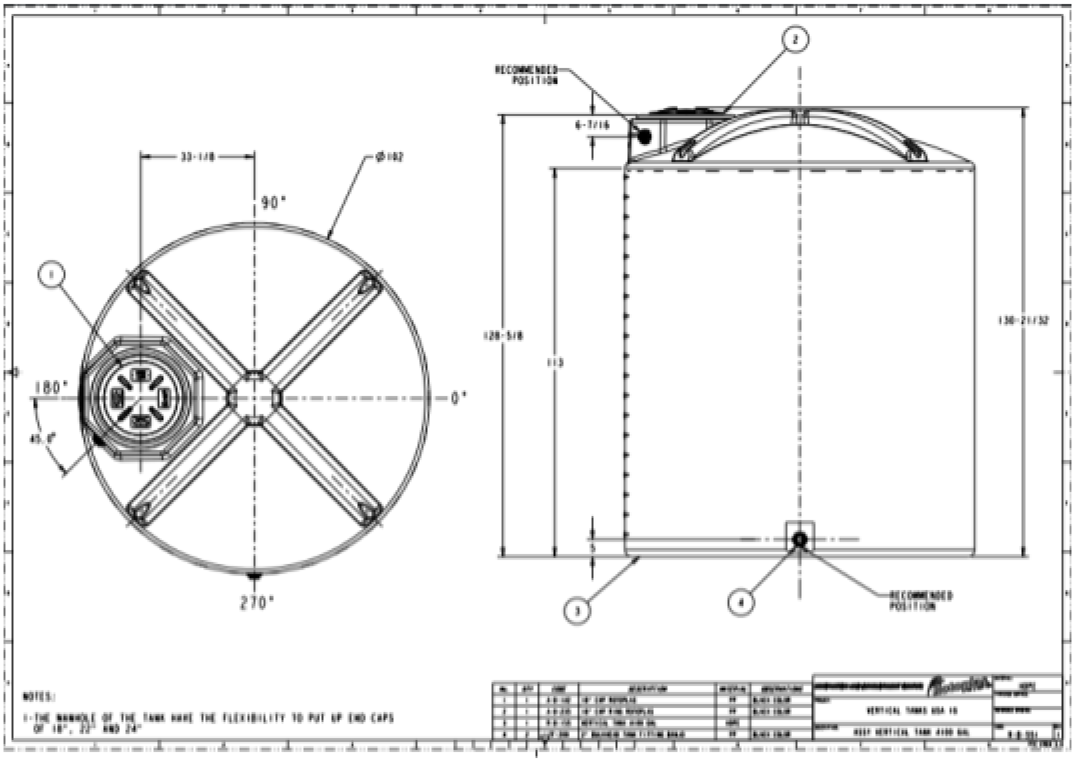

Figure 4: Diagram of Rotoplas Above Ground Cistern.

to provide advice on the type of filtration device needed, the type and number of systems, and other system elements to include in the design. RainHarvest Systems recommended the seven tank system composed of Rotoplas Above Ground Vertical tanks that had a 4,100 gallon capacity per tank. These seven tanks would have an overall capacity of 28,700 gallons. They also recommended the use of a hydrodynamic separator, an intensive filtration system that would clean the water before it entered the tank.

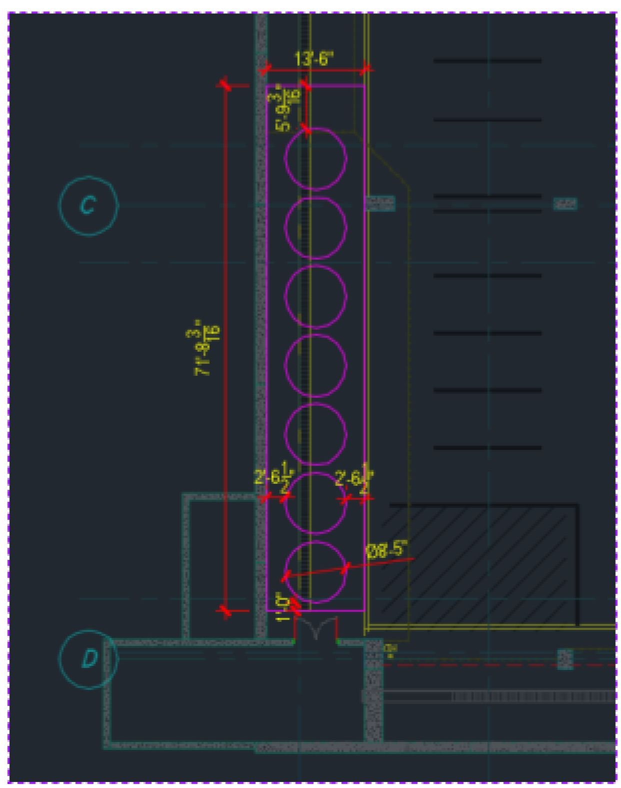

Figure 5: AutoCAD Drawing of preliminary system design.

Figure 4 shows a diagram of the selected tank from RainHarvest Systems. A rough design of this system in the space using AutoCAD is shown in Figure 5.

This preliminary design was presented to Tom Lukas who was able to develop a more sophisticated system design, complete with piping and valve design. This design is shown in Figure 6.

One advantage to this design is the expandability of this system - it can be constructed for any number of tanks, depending on the available. Then, if additional funding is received, more tanks can be easily added to the system as space allows, providing larger capacity for rainwater capture.

This final design was used as the basis for construction of the budget.

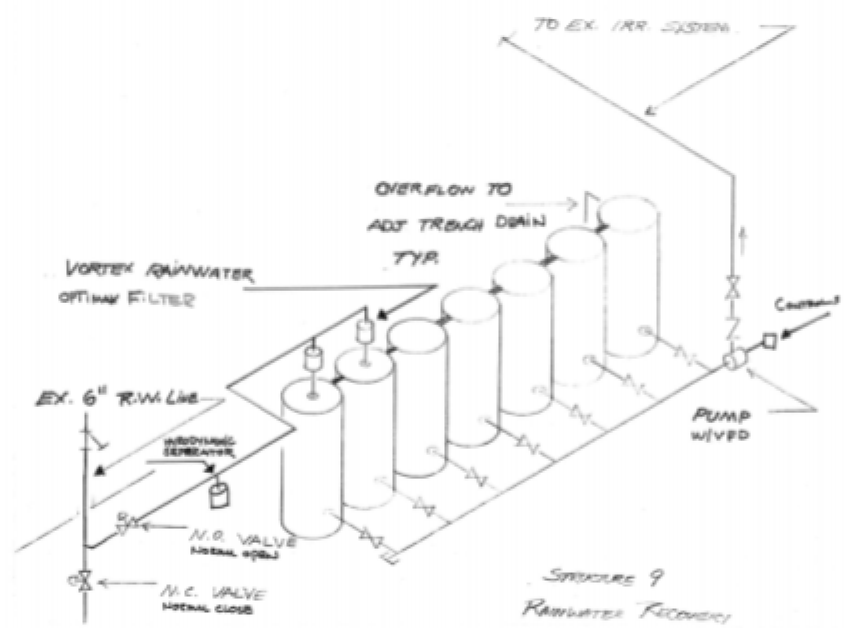

Figure 6: Draft of final design by Tom Lukas.

Funding Application

The future of our project depended on one major factor: would we receive enough funding to build the system?

After sitting down with Tom Lukas and requesting material quotes from RainHarvest Systems, we were able to compile a comprehensive budget allowing for a total of seven tanks. We then submitted this budget to The Green Initiative Fund (TGIF). Some selected big ticket items in the budget can be seen in the table below.

Item	Cost
Tanks (7)	$14,426.69
Hydrodynamic Separator	$12,256.25
Installation Costs	$65,000
Soft Costs	$20,300
Electrical Costs	$15,000
Signage	$1,500
Contingency	$13,500

The total price of these aspects, along with a multitude of other small necessities not listed, was **$174,200 for the seven-tank system**. As it was not realistic to anticipate TGIF to fulfill this entire amount, we attempted to cut down the budget to a more reasonable request. We were able to reduce the final budget on a few items such as electrical costs, soft costs, signage, and contingency. This was largely due to generous help from Facilities Management (the relationships that Tom, Nurit, and Bonny were able to provide). An example of the modification is lowering electrical costs from $15,000 to $10,000, and signage from $1,500 to $0. Completely cutting out signage costs will hopefully be attributable to Parking Management as part of their ‘Green Garage’ Program.

After modification, the budget of the seven-tank system totaled $133,589. Counting additional savings from RainHarvest Systems and even more utilization of Facilities Management connections, we reduced down our proposal request to TGIF to **$126,089.** This price reflects all components associated with the higher-cost, seven tank system. To provide an alternative and indicate the project’s flexibility, we also included a budget for a lower-cost, three-tank system. The biggest difference between the two was removing expenses involving the implementation of four cisterns, leaving only three. RainHarvest Systems was kind enough to send us an invoice of prices that accounted for three tanks instead of seven. Our total asking price for this **lower-cost system**, also reflecting Facilities Management connections, was **$74,795**.

Challenges

The process of implementing, as a student organization, what will potentially be the largest stormwater capture system on UCLA's campus was no easy task. Navigating our complicated schedules as students individually, and devoting the time necessary to see this project through was a challenge in and of itself. That being said, however, some challenges were more significant than others. The most significant of which were picking a location, designing the plans, acquiring funding, and managing correspondence and meetings.

When we first began our project, picking up where last year's Resilience Team had left off, we had four potential sites for the system. These included Bolter Hall, Franz Hall, the Botany building, and parking structure 9. Originally, we had written off parking structure 9, which is the site we ultimately chose. Each site brought something different to the table, which made it difficult to decide with site we should go with. The problem with parking structure 9 was that it lacked potential for an educational component and given that it was a parking structure, we new the water runoff would be dirtier than usual and would require intense filtration - making it more expensive. However, because of our relationship with Tom Lucas of Facilities management, the size of the space, and the capture potential , we felt confident that the parking structure was actually the best place for our project. It was our best chance of getting something done.

Designing the project layout was especially difficult because we were working with AutoCad, and engineering software, of which all but one of our team members had experience with. Her experience was limited at best, but she still managed to pull through. Aside from that, it was also difficult deciding the sizing and what type of cistern would be best for our site. We had to take into consideration cost, life expectancy of the cistern, and how easy or difficult it would be to install.

Luckily for us, UCLA as an institution is relatively supportive of sustainability projects and thus we had The Green Initiative Fund to tap into. However, the challenge was putting together a comprehensive, cost effective budget to make our project seem feasible. This was especially difficult considering that our initial estimations put our project at around 175,000 dollars. There was no chance we would get funded for this amount, and it put the feasibility of our project in question. Would TGIF invest in such a long term project? We could not take that chance. It was a team effort. The team, our stakeholder Nurit, and Tom each contributed to the downsizing efforts. It took time, but eventually we were able to cut costs significantly and put together an alternative budget for a 4 cistern system to show project flexibility.

Lastly, one should never underestimate the difficulties of accommodating for people's schedules. It was especially tough on our team leaders to coordinate with all the parties and collaborators we were working with for meeting times. These meetings were essential to the progress of our project, making it a stressful process to say the least. It didn't have to be meeting times though. Simply getting a hold of someone for information was a challenge at times. In some cases, the person you are trying to contact is the only person who can provide you with the information you need. Fortunately, this did not happen to us; however, there were some instances where we got no response from someone who could have helped, or contributed valuable insight at the least.

Although facing these challenges in the moment was tedious, we are all the better for it in the end. We gained practical skills and developed a better understanding of what it takes to pursue projects of this magnitude. More importantly, our project was a success – a testament to our ability as team to adapt and make the right adjustments.

Results

Impacts

There are significant impacts from the construction and implementation of our system. The quantifiable impacts are related to the amount of water saved per year and the amount of money saved over the lifetime of the system.

The surface area of the top level of Parking Structure 9 is approximately 86,750 ft^2. Therefore, for a one inch precipitation event, over 54,000 gallons of water will fall on the pavement of the roof level. Our rainwater capture system collects water from one-third of the roof of the parking structure. For a one inch precipitation event, assuming a runoff coefficient of 0.9, over 16,000 gallons of water will flow into a pipe leading to our system. On average, Los Angeles receives around 15 inches of rainfall annually. Assuming an average precipitation year, the originally seven tank system design has the potential to capture over 243,000 gallons of water per year. This seven tank system would capture 100% of the 16,000 gallons that would typically flow straight to the storm drain and out to the ocean from a one inch precipitation event. For a smaller three tank system, 75% of this amount

240,000+

Gallons saved per year → 7 tank system

would be captured. Over the course of an average year, the three tank system could capture up to 60,000 gallons of water. The yearly capture yield of the cistern system is dependent on the distribution and intensity of precipitation events throughout the year along with the frequency of use for irrigation. For wetter years, the cistern system has the potential to capture even more rainwater.

UCLA uses an average of 900 million gallons of water per year as detailed by the UCLA Water Action Plan. According to Richard O'Hara, the Senior Educational Facility Plans Supervisor, 68,000 gallons of water is used per acre of turf per watery cycle, with watering occurring 37-42 weeks every year on the 51 acres of turf on UCLA's campus. Additionally, 47,500 gallons of water is used on one acre of groundcover/landscape, with watering occurring 37-42 weeks for 57 acres of groundcover/landscape. This amounts to approximately 228-260 million gallons of water used for irrigation per year. This is a significant amount of water, so much that our system has a relatively small impact. However, over the life of the system, there are significant cost savings to our system. The water captured by our system will be used to water the vegetation surrounding Parking Structure 9 which will take the place of purchasing city water, which will lead to cost savings. For 240,000 gallons of savings, assuming a cost of $8.711 per one hundred cubic feet of water (from LADWP's commercial water prices for Tier 2, 2017), would amount to $2,800 savings per year. Over the 25 year lifespan, this would translate to $70,000 in overall savings.

$70,000

Savings over 25 year lifespan → 7 tank system

Funding

In total, our team received $86,856.95 from The Green Initiative Fund. This number incorporates the $18,000 granted to the Resilience Team last year, as well as the $68,865.95 the team received this year. This number will fund the three-tank, lower cost system with room to

$86,856.95

Total received from TGIF

implement a four-tank system. A huge advantage of our project design is in its flexibility. The ability to add additional cisterns easily makes expansion of the system an attainable goal for the future. We could not be more ecstatic about the future of this project and truly appreciate the opportunity TGIF has given the team to make the rainwater capture system a reality for the UCLA community.

Educational Outreach

In addition to the water and cost savings, this project also has a range of educational opportunities. First, we hope to incorporate the cistern system into future campus tours, such as within the engineering or sustainability department. This would educate future and current students about sustainability projects, resilience, and the Sustainability Action Research Program. Through signage, site visitors would learn about the goal of the project. We also hope to establish rain barrel workshops. These would be attended by UCLA students, staff, and faculty and would serve to demonstrate how to conserve water at home. We also plan on working with DESMA, IOES, and other UCLA departments to get as many groups as involved as possible. DESMA could potentially design the exterior of the cisterns, and IOES could

Future Plans

Now that the initial design has been completed and funding acquired, the construction of the system can begin. In May, the team met once again with Nurit Katz, Bonny Bentzin, and Tom Lukas to discuss the procedure going forward. Tom Lukas will be taking over the project management position. He is going to get approval from the campus architect and fire chief for the project and then final design and construction can begin. The future plans of our project are detailed below.

Construction Timeline

Now that funding has been acquired, the project timeline can begin. Using estimates from Tom Lukas, the following timeline has been constructed. If all goes according to plan, the system will be finished by the end of 2017.

Milestone	Estimated Completion Date
Acquisition of Funds	May 20, 2017
Project Approval	June 30, 2017
Architecture/Engineering Phase	July 31, 2017
Contracting Phase	October 31, 2017
Construction Phase	November 21, 2017
Commission Phase	December 7, 2017
Project Completion	December 14, 2017
Final Project Report to TGIF	December 31, 2017

Outreach Opportunities

Apart from the above-mentioned educational outreach plans, we also hope to hold a ribbon cutting ceremony upon completion of the project. Through this ceremony, we will be able to discuss the history and purpose of the project and the benefits of the cistern system. We would also like to invite campus art students to the opening for an interdisciplinary approach and to make the space more aesthetic and inviting.

Future Projects

Arguably, the best part about our project is that it sets a precedent on campus for others within the institution or within the community at large to follow. Our stormwater capture system will provide valuable data for research, and could potentially serve as a blueprint for other similar projects. In order to make this a reality it is important that we create a template or file, containing all of the necessary documentation detailing each step we took, that's easy to access and easy to understand. This is definitely something we plan to work on in the near future.

Summary and Conclusion

This project will have a definite impact on UCLA students in that it not only leads the way in establishing a sustainable and resilient opportunity for water conservation, but also opens the door for other students to take initiative in designing and implementing their own projects to benefit our campus. As future scientists, engineers, and professionals, it is important to encourage students to work together to positively impact their surrounding environments, and give them the tools and experience to succeed in their efforts toward securing a sustainable world. It will also provide data which can be used in future student projects, and educational and outreach opportunities. Upon completion, this project will benefit UCLA as a whole by contributing to reductions required for UCLA to achieve its requirement of 20% and 36% reduction in water use by the years 2020 and 2025, respectively. Our project represents a significant first step towards attaining these highly ambitious goals.

Furthermore, relying on imported water is an unsustainable practice–one that puts the UCLA community at risk in the event of a severe earthquake or other natural disaster. Many of LADWP's pipes are approaching 100 years in age, and have undergone significant corrosion. Moreover, the agencies who are responsible for the pipes' upkeep have limited funding to proactively maintain and replace pipes. Corrosion is often only discovered after ruptures, which leads to intermittent water supply. Even pipes in great condition will burst during an earthquake. All of this points to one thing: the farther the water has to travel to reach its consumers, the less secure it is. The water main burst that flooded the UCLA campus three years ago occurred under normal conditions. Relying on these old pipes to withstand a severe earthquake is not recommended; we need to fortify UCLA's local water supply. To be a resilient and sustainable campus, UCLA needs new water supply solutions. Those solutions start here, with rainwater capture.

Acknowledgements

We would like to thank everyone who helped us make this project a success over the past six months. We would like to express special appreciation to the following groups/individuals:

Nurit Katz

Thomas Lukas

Bonny Bentzin

Jeff Fuller and the RainHarvest Systems Team

Facilities Management

Parking and Transportation Services

Capital Programs

Environmental Health and Safety

The IOES Department

Austin Park

Mochi Li

Cully Nordby

Carl Maida