Improving Water Sustainability Through Rainwater Catchment Systems

By Isabel Calleja, Daniela de Souza, Hayley Donnelly, Taite Drews-Jones, Elizabeth Farwell,
Ryan Moriarty, and Logan Spalding
Environmental Studies Capstone

Southwestern University

1. Introduction and Justification **3**
1.1 Introduction 3
1.2 Rainwater Catchment 3
1.3 Rainwater Catchment Case Studies 4
1.4 Why Rainwater Catchment is Right for Southwestern 5
1.4.1 Social Justifications 5
1.4.2 Environmental Justifications 6
Fig. 1.1 6
Fig. 1.2 7
1.4.3 Educational Justifications 7
Fig. 1.3 7
1.4.4 Economic Justifications 8
Fig. 1.4 8

2. Literature Review **9**
2.1 Components of a Rainwater Catchment System 9
2.2 Calculating Rainwater Utilization 10

3. Proposal for the Implementation of Rainwater Catchment Systems on Southwestern University's Campus **12**
3.1 Executive Summary 12
3.2 Project Proposal 12
Fig. 3.1 13
3.3 Why Rainwater is Right for Southwestern 13
3.3.1 Social Justifications 14
3.3.2 Environmental Justifications 15
Fig. 3.2 15
Fig. 3.3 16
3.3.3 Educational Justifications 16
Fig. 3.4 16
3.3.4 Economic Justifications 17
Fig. 3.5 17
3.4 Discovering the Place for a Catchment System 18
3.4.1 Supply Potential and Demand 18
3.4.2 Physical Considerations 18
3.5 Case Studies 18
3.5.1 Fondren Jones Science Building/Soule Promenade 18
3.5.2 Moody-Shearn Residential Hall 19
Fig. 3.6 19
Fig. 3.7 20
3.5.3 Mood-Bridwell 21
Fig. 3.8 21
3.5.3 Ruter Residential Hall 21

Fig. 3.9 22
3.6 Goals/Next Steps 22
3.6.1 Installation 22
3.6.2 Applying for Awards 22
3.6.3 Implementing Educational Aspects 22
3.6.4 Rainwater Catchment System as Part of the Admissions Tour 23
3.6.5 External Funding 23
3.7 The Future of Rainwater at Southwestern

4. Citations 24

1. Introduction and Justification

1.1 Introduction

Water scarcity has become a serious problem across the world due to increased demand from urbanization, more frequent droughts, and changes in climate patterns (Mendez et al., 2010). Improving water sustainability by means of conservation and efficient management strategies is now a necessity rather than a concern. Higher education institutions have the ability to implement water conservation efforts due to community-driven initiatives. By effectively implementing conservation initiatives across campus, institutions of higher education can demonstrate that water sustainability can be replicated on a scale similar to municipalities while educating students on the importance of water conservation. While sustainability has long been a focus at Southwestern University (SU), issues regarding water usage have yet to be adequately addressed.

Our Environmental Studies Capstone group has been working in coordination with Southwestern Physical Plant and Facilities Management to improve SU's water efficiency, conservation, and management to propose cost-effective solutions that maintain the aesthetics of campus without compromising the safety of faculty, students, and wildlife that inhabit our campus. Water sustainability is especially important as increased urbanization, more frequent and persistent drought, and changing weather patterns associated with global climate change will significantly impact water resources around the world, and Texas is no exception.

We believe that implementing a rainwater catchment irrigation system on campus with the six pre-existing rainwater catchment tanks would achieve water efficiency and conservation goals while allowing SU to become more sustainable in multiple forms. Rainwater irrigation would not only socially, environmentally, and economically benefit SU but could be used as an educational tool to strengthen water conservation awareness in the community. Furthermore, our campus' commitment to improving efforts to achieve greater water efficiency, conservation, and management can be utilized as a marketing tool, while cost-effectively maintaining the aesthetic appeal of our campus for generations to come. In this proposal, we illustrate how other educational campuses of various sizes successfully utilize rainwater irrigation to exemplify how SU can also install this system onto campus. We then discuss the justifications for our project to argue that rainwater irrigation would bring various benefits to the campus.

1.2 Rainwater Catchment

Rainwater catchment projects are merited through inter-related social, environmental, and economic effects that will improve community and sustainability. Capturing rainwater is ecologically beneficial because it reduces debris and sediment runoff into populated areas while conserving groundwater (Krishna, 2003). Additionally, rainwater is a free resource with only minimal costs associated with system installation and use (Krishna, 2003). Social benefits include the reduction of physical labor on employees during installation as compared to a traditional sprinkler system. A rainwater catchment system provides water conservation education for communities to learn the importance of water sustainability and awareness.

1.3 Rainwater Catchment Case Studies

We researched different campuses, both local and nonlocal, that installed rainwater catchment to obtain these previously listed benefits. Although these are not the only educational campuses that utilize rainwater, they are cases that demonstrate how rainwater is possible on multiple scales at multiple locations.

1.3.1 The University of Arizona

In 2016, UA installed a cistern tank above ground to harvest 28,000 gallons of rainwater (Falwell, Sanders, & Phillips, 2016). UA's Students for Sustainability Water Committee spearheaded the project with facilities management to improve water conservation and education on campus (Falwell et al, 2016). An important factor for the installing the cistern was due to the fact that Tucson, Arizona, where UA is located, receives more rainfall than the entire community consumes in one year (Falwell et al, 2016). The sustainability group partnered with facilities management and the Environmental Science Department to design the most ideal harvesting system for the campus. The team designed the cistern to harvest rainwater from the nearby parking garage, pumping the water into the UA irrigation system to pollinator-friendly plants in the campus garden (Falwell et al, 2016). The harvesting system, intentionally placed to be displayed to visitors of the garden, doubles as an educational tool to promote water sustainability on campus (Falwell et al, 2016). Such a project is designed to spark continuous water conservation efforts on campus and educate the campus on how water sustainability is necessary in a dry climate. While the exact figure of savings is unknown, UA experiences favorable financial benefit as it directs costs away from the municipal water line (Falwell et al, 2016).

1.3.2 Carpenter Hill Elementary School and Ralph Pfluger Elementary School

Winner of the Texas Water Development Board Raincatcher Award in 2011, the Hays Consolidated Independent School District took the initiative to install rainwater catchment systems at two of their campuses, Carpenter Hill and Ralph Pfluger elementary schools, in 2010 (Grizzard, 2017). Their system at each campus consists of two 53,000-gallon metal tanks that collect rainwater flowing off about 44,000 square feet of roof area. Approximately 3,500 gallons per 24 hours when the system is running at peak capacity is collected from the rooftop HVAC systems as a supplemental water supply to the tanks (Grizzard, 2017). The harvested rainwater and condensate water are pumped to the gardens at the school and used to irrigate the total campus, which includes grass and native vegetation. Excess rainwater is channeled to an onsite detention pond and allowed to infiltrate into the subsurface (Grizzard, 2017). On the educational side, the systems are being used to teach math, science, and ecology to kids in the schools (Grizzard, 2017).

These specific case studies demonstrate how water conservation practices on educational campuses is achievable and sustainable. The aforementioned campuses were able to save thousands of gallons of water and relieve financial stress through these conservation efforts.

While we acknowledge that our proposal would irrigate a significantly smaller landscaping area than these campuses, size does not detract from beneficial conservation efforts. Specifically, SU has the ability to install a successful rainwater catchment irrigation system on multiple building locations such Fondres-Jones Science (FJS) Building, Mood-Bridwell, Moody-Shearn Residence Hall, and Ruter Residence Hall. Installation of SU's already owned six 2,500 rainwater catchment tanks for irrigation to one of these four locations would significantly increase SU's sustainability, education, and marketing efforts.

1.4 Why Rainwater Catchment is Right for Southwestern

Bringing rainwater catchment to SU is merited through inter-related social, environmental, economic and educational effects that will improve SU's community and overall sustainability. We believe that installing a rainwater catchment system would benefit both facilities management and the students, thus improving both the lives of the employees and students. Further, a rainwater catchment system would significantly improve the ecosystem surrounding campus and would increase water conservation efforts. For example, a rainwater catchment system would decrease pollution from runoff while simultaneously conserving groundwater. While economic savings are not as substantial as other projects, the educational benefits that would be introduced to Georgetown, the Southwestern community, and prospective students are extremely beneficial to the image of SU.

1.4.1 Social Justifications

A Rainwater catchment system would decrease facilities management manual labor during the initial installation of the irrigation system. A typical irrigation plan such as a sprinkler system, like that anticipated for the Soule Promenade project, would include multiple underground pipelines that are physically straining to install. Such a system would require a connection to the municipal water line and other various pipes attached to the sprinkler heads, involving precise construction that would be strenuous and time consuming. Our proposed rainwater irrigation system would be simpler to construct and install, thus decreasing labor costs and the risk of harm to the physical plant employees. Although underground piping installment is necessary for rainwater catchment, such a system would not require multiple pipelines connecting to the municipal water line and would not require coordinating with the city of Georgetown. Without these factors, installment of the rainwater catchment system would be less time consuming and less physically demanding than a sprinkler system. Although installation labor of the tanks is required, it is minimal compared to a municipal water irrigation system installation. The required maintenance includes transporting the empty tanks, visual inspection of the quality of the tank, and the set up of the water lines.

In addition, it is important to note that our rainwater catchment proposal would significantly decrease the possibility of flooding and ultimately reduce the need for facilities management to plan for flood damage on campus. Due to rainwater catchment ability to mitigate water and sediment runoff from roofs, facilities management's concern for flooding would decrease significantly due to rainwater being routed into the catchment tanks. Furthermore, flooding reduction can benefit facilities, staff, and students. Flooding occurs frequently on SU's campus, specifically in locations that are frequently visited, and becomes both a safety hazard and a nuisance. We propose that rainwater catchment installation would reduce flooding for the entire Southwestern community.

Ultimately, we argue that installing SU's pre-existing rainwater catchment tanks to irrigate a portion of SU's landscape is socially justified in that it decreases the amount of physical labor on facilities management employees and reduces the flood impact on campus.

1.4.2 Environmental Justifications

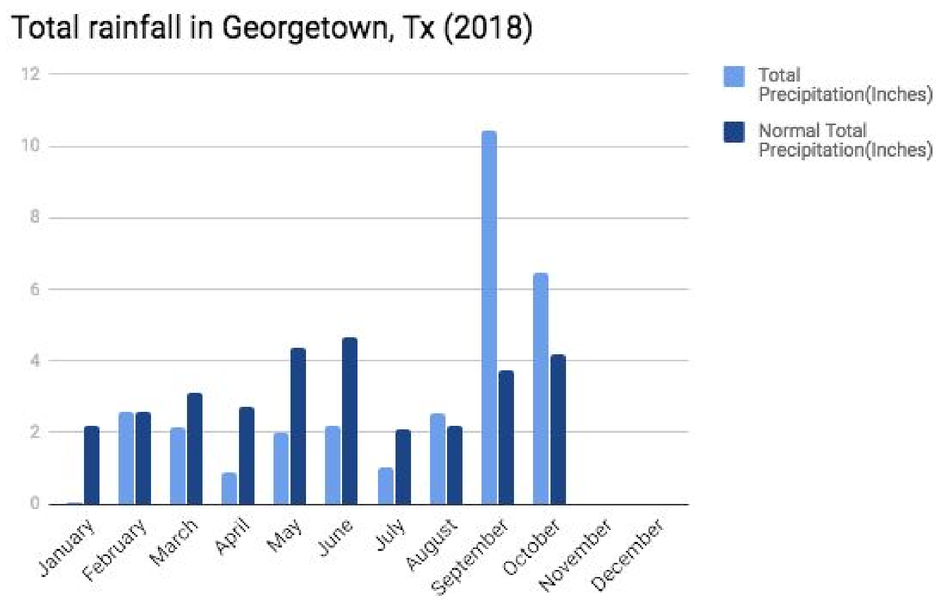

Fig. 1.1

Our proposal is environmentally justified in that rainwater irrigation would decrease pollution runoff and increase water conservation. Specifically in Georgetown, there has been an abundance of rain in 2018, as seen in figure 1.1, that has caused flooding and flood damage. A rainwater irrigation system provides storm mitigation by collecting rainwater directly, thus decreasing runoff that carries sediment and debris. Moreover, reducing runoff that carries pollutants and other debris onto campus during these floods would benefit SU's ecosystem and potentially aid in plant growth. This type of flooding can induce overwatering that is detrimental to some native plants that are suspected to be planted on SU's campus (Texas Mountain Laurel, Texas Sotol, Texas Sage, etc). Due to the increasing amounts of rainfall seen in recent years, we believe that using collected rainwater would help conserve groundwater. The City of Georgetown's municipal water supply is treated with multiple chemicals (i.e. calcium, fluoride, polyaluminum chloride) to adhere to potable water standards; however, these chemicals are not necessary for vegetation. Rainwater has organic bacteria and materials that are beneficial to plant life. Utilizing rainwater for these plants instead of Georgetown municipal water could help improve the overall lifespan of these plants.

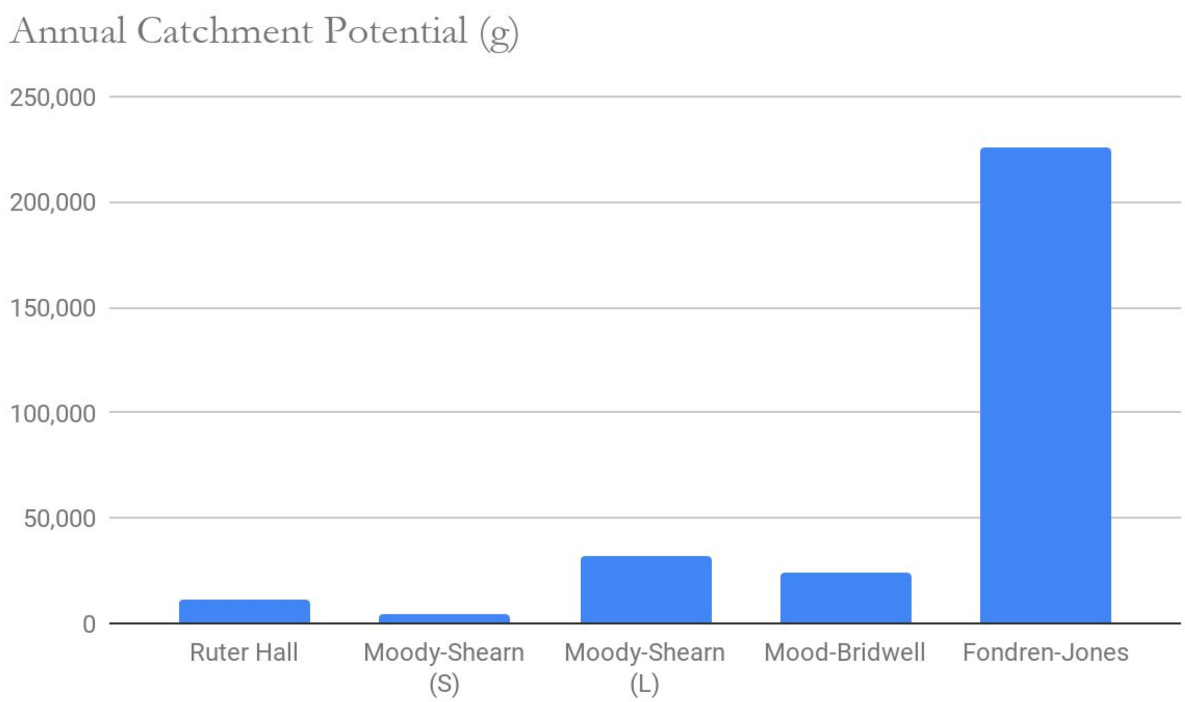

Fig. 1.2

Finally, SU would save thousands of gallons of water each year if it were to install the pre-existing rainwater catchment tanks. On each considered location for our proposal, we estimated the amount of gallons of water SU would save. Figure 1.2 illustrates these water savings, justifying the conservation reasoning for our proposal. These figures, along with the other environmental justifications, show just how large the environmental impact of our proposal can be and how crucial it is for SU to conserve water in an unpredictable area like Central Texas.

1.4.3 Educational Justifications

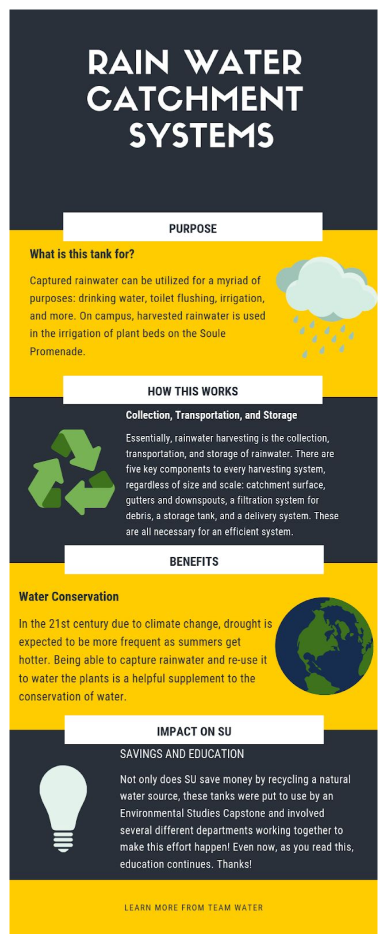

Fig. 1.3

We suspect that a rainwater irrigation system would not only benefit the SU community, but would also benefit prospective students and the Georgetown community. It is important to acknowledge that the pre-existing tanks would be placed on popular locations on campus. With an infographic stating the purpose of the rainwater catchment tanks on campus, as shown in figure 1.3, students and faculty would gain knowledge on how rainwater usage is sustainable.

Rainwater irrigation on SU's campus would be the first location in Georgetown where any type of rainwater system is used at any large institution. This type of publicity would inform the community that SU is contributing to water conservation, and would be a model to other institutions or individuals of how to make a commitment to sustainability. Most importantly, this project would be one way of showcasing Southwestern's commitment to sustainability to prospective students, potentially influencing their decision to enroll at SU. For instance, the Princeton Review's College Hopes and Worries Survey asked prospective students about their different interests regarding their future college campus. The 2018 College Hopes and Worries survey found that 63% of respondents would "strongly," "very much," or "somewhat" consider a college's commitment to environmental issues (The Princeton Review, 2018). Additionally, Sierra Club and the Association of the Advancement of Sustainability in Higher Education (AASHE) partner to compile a ranking of universities that are environmentally sustainable into a "Cool Schools" list, with water conservation being a core element of the ranking system (O'Reilly, 2018). This list is frequently viewed by prospective students and heavily influences their application decisions (O'Reilly, 2018). With these findings, it is certain that a majority of prospective students would be pleased to see that SU is using the pre-existing rainwater tanks to conserve water.

1.4.4 Economic Justifications

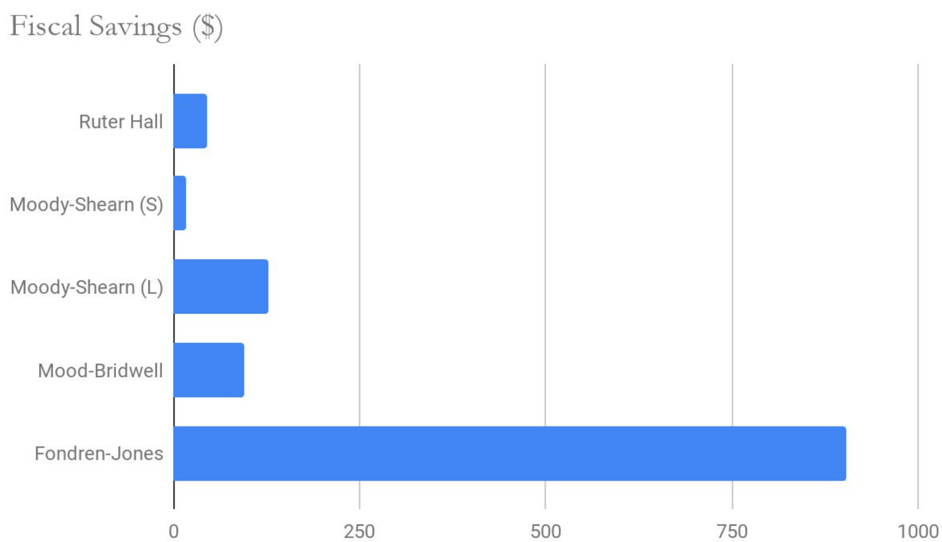

Fig. 1.4

We acknowledge that the economic justifications for our project are not as attractive, yet it is still important to note that there are some economic justifications for our proposal. Implementing rainwater catchment onto SU's campus would result in eliminating municipal water usage and thus would result in some fiscal savings. For example, irrigating the flowerbeds of the Soule Promenade would save roughly $231.84 annually. Due to the circumstances that we cannot obtain the Soule Promenade's exact landscaping size, we can only estimate that the figure would increase significantly if we were to irrigate all of the landscaping of the Promenade. Figure 1.4 shows the additional fiscal savings for the alternate locations on campus. Although these figures are small, research suggests that the impacts of climate change such as drought, flood, and rising sea levels will ultimately make water more expensive in the coming years. These findings justify our proposal that SU would benefit economically, if not now then later, by implementing rainwater irrigation on campus.

2. Literature Review

We researched the multiple components needed to implement a successful rainwater catchment system. Major components include catchment surface, gutters and downspouts, a filtration system, a storage tank, and a delivery system. Additionally, we researched the formula to calculate the optimal amount of rain catchment potential from a building.

2.1 Components of a Rainwater Catchment System

Catchment Surface: A catchment surface is the surface for which rainwater runs off and is collected (TWDB, 2005). Most commonly, the collection surface is the roof of a building structure. The larger the surface, the more potential for rainwater to be captured and stored, increasing the cost-effectiveness of the system (TWDB, 2005).

Gutters and Downspouts: Gutters and downspouts channel water from the roof to the storage tank (TWDB, 2005). Gutters are installed on the eaves of the buildings and range in material from PVC to vinyl piping (TWDB, 2005). Gutters and downspouts determine the volume of water that can be efficiently captured, so considering elements such as sizing, proper installation, and aesthetics are important (Angima, 2014).

Filtration for Debris: Leaf screens, first flush diverters, and roof washers are essential components that remove debris and dust from the rainwater entering the tank to ensure efficient irrigation and higher quality of water (TWDB, 2005). Leaf screens are mesh screens placed in positions before the water enters the tank and just before it exits (TWDB, 2005). While leaf screens remove the larger debris, a first-flush diverter rids the system of smaller contaminants (TWDB, 2005, Angima, 2014). A first-flush diverter routes the first flow of water away from the storage tank to a new site, such as a planted area (TWDB, 2005). Roof washers are placed just ahead of the storage tank and filter small debris for non-potable and drip irrigation use (TWDB, 2005). This filtration consists of a tank with leaf strainers and a filter that must be cleaned to avoid restricting water flow and potential pathogens (TWDB, 2005).

Storage Tank: Cisterns, also known as storage tanks, are the most expensive component of the rainwater catchment system (TWDB, 2005). The size of the storage tank is determined based on rainwater supply (i.e. local precipitation), demand (i.e. area in need of irrigation), projected dry spells (i.e. length of time without rain), catchment surface area, aesthetics, and budget (TWDB, 2005). Cisterns must be opaque to mitigate algae growth inside the tank and covered with screened vents to prevent mosquito breeding (TWDB, 2005). Avoiding direct sunlight reduces damage and prolongs the lifespan of a cistern. Ideally, tanks should be located as close to demand points as possible to reduce the distance that water is transported, ultimately reducing the demand for pumps. Tank inlets must be lower than the lowest downspout from the catchment surface location and be placed as high as practicable to ease the load on a pump (TWDB, 2005). A leveled and stable pad, preferably concrete, should be in place under the tank and be checked for damaged during periods of heavy rain (TWDB, 2005). Various tank materials include fiberglass, polypropylene, wood, metal, concrete, ferrocement, or in-ground polypropylene (TWDB, 2005).

Delivery Systems: Delivery systems, consisting of gravity fed or motorized pumps, are necessary to transport water to the desired location of use (TWDB, 2005). The pumping systems within the delivery system gathers water from the catchment tank, pressurizing the water and then storing it in a pressure tank until needed (TWDB, 2005). Knowing the pressure required for the desired irrigation system will ultimately decide the size of the pump system for the delivering system.

Maintenance of a rainwater catchment system requires monitoring tank levels, cleaning gutters, installing first-flush devices, and repairing the system (Woodson, 2010). The environment, the catchment surface, and the storage tanks all have an effect on the quality of harvested rainwater. Ultimately, maintenance is essential for an efficient rainwater system.

Not every catchment system will be exactly the same, but there are a few materials needed for every system to be successful. The Rain Harvesting Downspout First Flush Diverter, costing about $30, causes pollutants, unwanted bacteria, and debris to flow into the water diverter chamber so they do not enter the tank water supply. The floating filter, priced at $85-$245, comes in different sizes. The filters are sized to collect particles ranged from 1.2mm to .3mm. The stainless steel insert is recommended to be cleaned 2-3 times a year (Rainwater Management, 2018). Because the water is being used for irrigation purposes, there is no need for additional measures such as chlorination or UV sterilization.

Ideally, gravity allows for water to flow directly through the filter and into the tank. This water can then be used for irrigation. But if this is not an option the use of a pump to allow easy flow of water through the closed irrigation system. This consists of a centrifugal pump and pvc piping. There are many varieties of centrifugal pumps which have different specs pertaining to horsepower (HP), gallons per minute (GPM), and pressure per square inch (PSI). These can range between $120-$450 per unit. A good example is the Pedrollo centrifugal pump which is priced at $250. The 1” pvc pipe can be bought at $1.51 per foot (US Plastic Corp, 2018).

2.2 Calculating Rainwater Utilization

Approximately 0.62 gallons/square foot of surface per one inch of rain can be potentially collected (TWDB, 2005). However, some rainwater can be lost to first flush diverters, evaporation, overflow from the gutters in hard rain events, and leaks (TWDB, 2005; Woodson, 2012). Despite these potential interferences, harvest potential calculates an efficiency of 75-90% (TWDB, 2005). The area of the collection surface and the area footprint of the roof calculates the maximum capacity of rainwater collection (TWDB, 2005). All types of roofs listed previously can be used to collect water for gardening or irrigation purposes (Angima, 2014). However, composite or asphalt shingles lose about 10% of water collected compared to metal roofs (Angima, 2014). Another factor to consider collection capacity is the monthly average rainfall in the area. The relationship between supply (catchment area and rainfall) and demand (end use consumption, area of irrigation) determines the required storage capacity for each individual case in the most efficient and cost-effective manner (TWDB, 2005). This can be calculated through a basic formula: rainfall (in inches) x roof area x 0.62 gal/sq.ft/in. rain x collection efficiency equals supply (TWDB, 2005). As stated previously, summer seasons use significantly more water than the other seasons because of the heat and aridity. Yet, watering infrequently and only when plants need water have been shown to promote a healthy landscape and reduce water demand (TWDB, 2005). In addition, it is recommended to plant native plants that do not consume much water to save both water and cost (TWDB, 2005).

Traditionally, Texas' rainfall occurs seasonally, requiring a large storage capacity to hold enough rainwater to to then be used through dry spells. Allowing for a connection to the public water supply system could serve to promote harvested rainwater as a supplemental water source to customers already connected to the public water supply infrastructure (Woodson, 2012; TWDB, 2005). However, this would require a backflow prevention device to keep rainwater from entering the public water supply (TWDB, 2005).

3. Proposal for the Implementation of Rainwater Catchment Systems on Southwestern University's Campus

3.1 Executive Summary

This proposal is based on the ongoing project of our Environmental Studies Senior Capstone group working with Southwestern Physical Plant and Facilities staff. The end goal is to improve Southwestern University's (SU) water efficiency, conservation, and management via cost-effective solutions that maintain the aesthetics of campus without compromising the safety and well being of the faculty, students, and wildlife that inhabit our campus.

Installation of rainwater catchment requires less labor than installation of an improved irrigation system. The potential for mitigation of stormwater damage subsequently decreases labor required by physical plant because the tanks mitigate flooding and water run off. In the role of flooding prevention, the students and faculty will greatly benefit from less rainwater collecting outside of dorms and frequented areas on campus, thus improving a quality of life for the SU public. Implementation of rainwater catchment directly correlates to the conservation of water as recycled water is used to nurture surrounding ecosystems. As a clean source, capture of natural rainwater proves beneficial to native plant species and can be used strategically to prevent debris and sediment pollution. While the return on investment is not necessarily a large figure, any reduction in use of municipal water will result in fiscal savings. The economics of this plan cast promise onto long-term savings, as correlated to frequence of drought in Texas, the cost of water rises when the supply diminishes. As the proposed locations for the tanks are in areas with heavy foot traffic, the SU community can witness Southwestern's commitment to sustainability and water conservation. We propose installing an infographic near the tanks for passersby to educate themselves about rainwater catchment. Southwestern may serve as a model for the Georgetown community as we will be the first institution in then area to recycle the natural resource of rainwater.

The following pages model how we arrived at choosing the ideal location for the rainwater catchment system, the Fondren Jones Science building. Also discussed are alternative sites on campus: Moody-Shearn Residence Hall, Mood-Bridwell, and Ruter Residence Hall. We propose these alternative sites because of their anticipated renovations and close proximity to frequently visited areas on campus.

3.2 Project Proposal

Our Environmental Studies Capstone group has been working in coordination with Southwestern Physical Plant and Facilities Management to improve SU's water efficiency, conservation, and management via cost-effective solutions that maintain the aesthetics of campus without compromising the safety of faculty, students, and wildlife that inhabit our campus. Water sustainability is especially important as increased urbanization, more frequent and persistent drought, and changing weather patterns associated with global climate change will significantly impact water resources around the world, particularly in Texas.

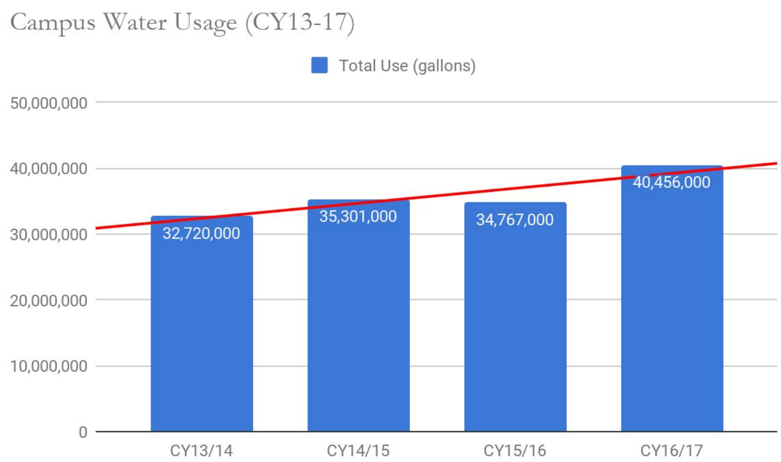

Fig. 3.1

As Southwestern's potable and nonpotable municipal water usage has followed an upward trend in the last few years, as seen in figure 3.1, it is imperative that we seek options to more effectively manage and reduce campus water use. A rainwater catchment system provides a logical starting point from which we can examine and improve water conservation, management, and efficiency. SU currently owns six rainwater catchment tanks which are not being adequately employed. Installing and incorporating a rainwater catchment system for irrigation presents financial, environmental, and educational benefits to the university and the Georgetown community.

By effectively implementing water conservation initiatives across campus, SU would serve as a leader in Georgetown in demonstrating how water sustainability can be replicated on a municipal scale. Southwestern has capitalized on the municipal use of wind energy as an effective marketing tool and the same can be done with the a rainwater catchment system on campus. The Phase II construction of Fondren Jones Science Center (FJS) and the new surrounding promenade provide an ideal scenario to implement a rainwater catchment system for irrigation. However, alternative options include buildings on campus that are anticipated to be renovated in the coming years, such as Mood Bridwell, Moody-Shearn, and Ruter Hall. In the following sections we will be discussing the implementation of a rainwater harvesting system on SU's campus on different locations, a cost-benefit analysis of this implementation, the limitations that arise from this scale, and the sustainable benefits of this project.

3.3 Why Rainwater is Right for Southwestern

Bringing rainwater catchment to SU is merited through inter-related social, environmental, economic and educational effects that will improve SU's community and overall sustainability. We believe that installing a rainwater catchment system would benefit both facilities management and the students, thus improving both the lives of the employees and students. Further, a rainwater catchment system would significantly improve the ecosystem surrounding campus and would increase water conservation efforts. For example, a rainwater catchment system would decrease pollution from runoff while simultaneously conserving groundwater. While economic savings are not as substantial as other projects, the educational benefits that would be introduced to Georgetown, the Southwestern community, and prospective students are extremely beneficial to the image of SU.

3.3.1 Social Justifications

A rainwater catchment system would decrease facilities management physical labor during the initial installation of the irrigation system. A typical irrigation plan such as a sprinkler system, like that anticipated for the Soule Promenade project, would include multiple underground pipelines that are physically straining to install. Such a system would require connection to the municipal water line and other various pipes attached to the sprinkler heads, involving precise construction that would be strenuous and time consuming. Our proposed rainwater irrigation system would be simpler to construct and install, thus decreasing labor costs and the risk of harm to the physical plant employees. Although underground piping installment is necessary for rainwater catchment, such a system would not require multiple pipelines connecting to the municipal water line and would not require coordinating with the city of Georgetown. Without these factors, installment of the rainwater catchment system would be less time consuming and less physically demanding than a sprinkler system. Although installation labor of the tanks is required, it is minimal compared to a municipal water irrigation system installation. The required maintenance includes transporting the empty tanks, visual inspection of the quality of the tank, and the set up of the water lines.

In addition, it is important to note that our rainwater catchment proposal would significantly decrease the possibility of flooding and ultimately reduce the need for facilities management to plan for flood damage on campus. Due to rainwater catchment ability to mitigate water and sediment runoff from roofs, facilities management's concern for flooding would decrease significantly due to rainwater being routed into the catchment tanks. Furthermore, flooding reduction can benefit facilities, staff, and students. Flooding occurs frequently on SU's campus, specifically in locations that are frequently visited, and becomes both a safety hazard and a nuisance. We propose that rainwater catchment installation would reduce flooding for the entire Southwestern community.

Ultimately, we argue that installing SU's pre-existing rainwater catchment tanks to irrigate a portion of SU's landscape is socially justified in that it decreases the amount of physical labor on facilities management employees and reduces the flood impact on campus.

3.3.2 Environmental Justifications

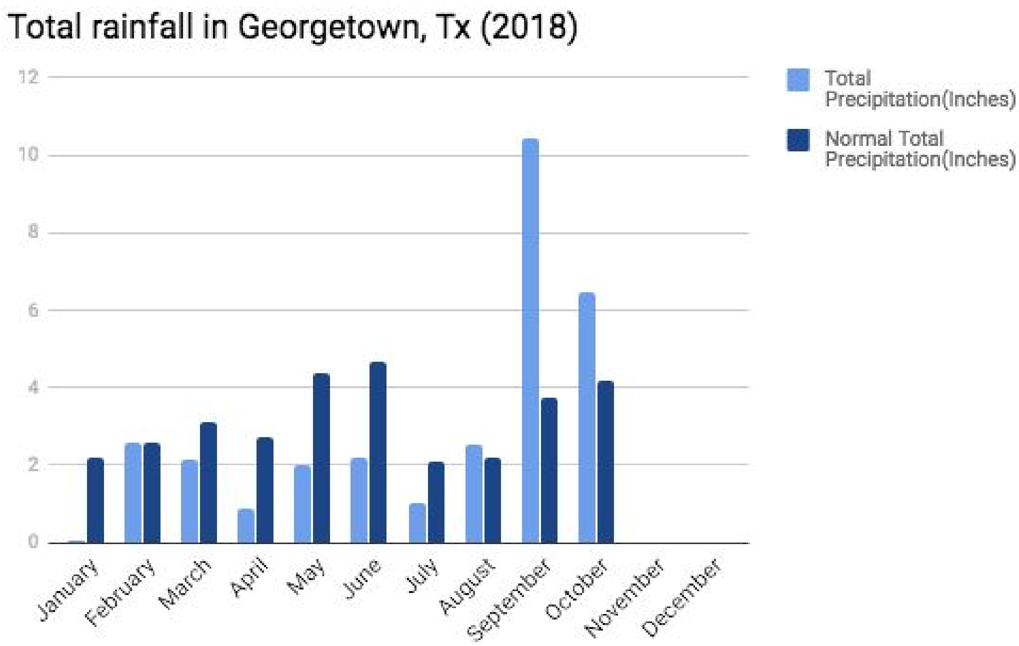

Fig. 3.2

Our proposal is environmentally justified in that rainwater irrigation would decrease pollution runoff and increase water conservation. Specifically at SU, there has been an abundance of rain in 2018, as seen in figure 3.2, that has caused flooding and flood damage. A rainwater irrigation system provides storm mitigation by collecting rainwater directly thus decreasing runoff that carries sediment and debris. Moreover, reducing runoff that carries pollutants and other debris onto campus during these floods would benefit SU's ecosystem and potentially aid in plant growth. This type of flooding can induce overwatering that is detrimental to some native plants that are suspected to be planted on SU's campus (Texas Mountain Laurel, Texas Sotol, Texas Sage, etc). Due to the increasing amounts of rainfall seen in recent years, we believe that using collected rainwater would help conserve groundwater. The City of Georgetown's municipal water supply is treated with multiple chemicals (i.e. calcium, fluoride, polyaluminum chloride) to adhere to potable water standards; however, these chemicals are not necessary for vegetation. Rainwater has organic bacteria and materials that are beneficial to plant life. Utilizing rainwater for irrigation of these plants instead of Georgetown municipal water could help improve the overall lifespan of these plants.

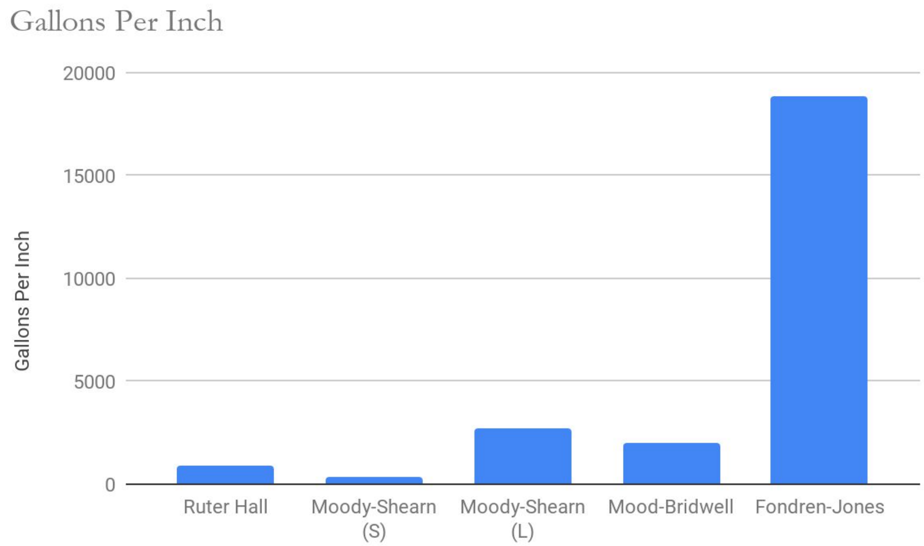

Fig. 3.3

Finally, SU would save thousands of gallons of water each year if it were to install the pre-existing rainwater catchment tanks. On each considered location for our proposal, we estimated the amount of gallons of water SU would save. Figure 3.3 illustrates these water savings, justifying the conservation reasoning for our proposal. These figures, along with the other environmental justifications, show just how large the environmental impact of our proposal can be and how crucial it is for SU to conserve water in an unpredictable area like Central Texas.

3.3.3 Educational Justifications

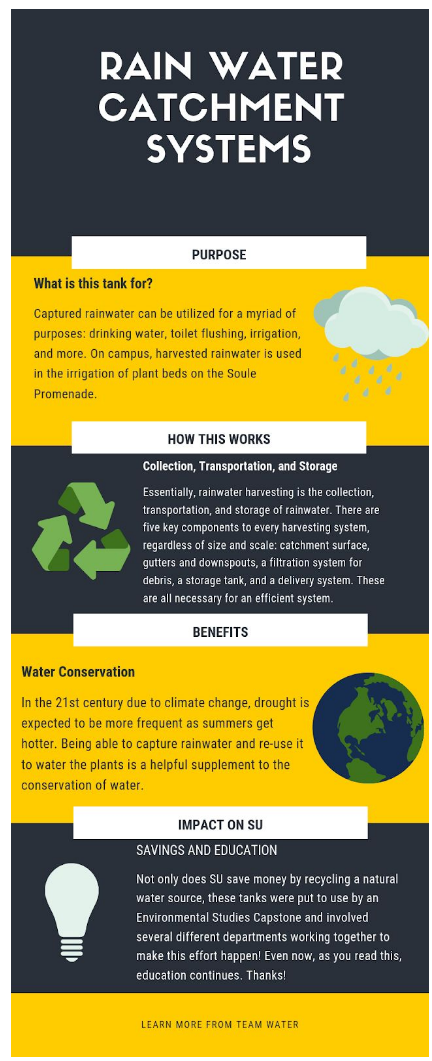

Fig. 3.4

We suspect that a rainwater irrigation system would not only benefit the SU community, but would be extended to prospective students and the Georgetown community. It is important to acknowledge that the pre-existing tanks would be placed on popular locations on campus. With an infographic, like figure 3.4, stating the purpose of the rainwater catchment tanks on campus, students and faculty would gain knowledge on how rainwater usage is sustainable.

Rainwater irrigation on SU's campus would be the first location in Georgetown where any type of rainwater system is used at any institution. This type of publicity would inform the community that SU is contributing to water conservation, and would be a model to other institutions or individuals of how to make a commitment to sustainability. Most importantly, this project would be one way of showcasing Southwestern's commitment to sustainability to prospective students, potentially influencing their decision to enroll at SU. For instance, the Princeton Review's College Hopes and Worries Survey asked prospective students about their different interests regarding their future college campus. The 2018 College Hopes and Worries survey found that 63% of respondents would "strongly," "very much," or "somewhat" consider a college's commitment to environmental issues (The Princeton Review, 2018). Additionally, Sierra Club and the Association of the Advancement of Sustainability in Higher Education (AASHE) partner to compile a ranking of universities that are environmentally sustainable into a "Cool Schools" list, with water conservation being a core element of the ranking system (O'Reilly, Club, 2018). This list is frequently viewed by prospective students and heavily influences their application decisions (O'Reilly, 2018). With these findings, it is certain that a majority of prospective students would be pleased to see that SU is using the pre-existing rainwater tanks to conserve water.

3.3.4 Economic Justifications

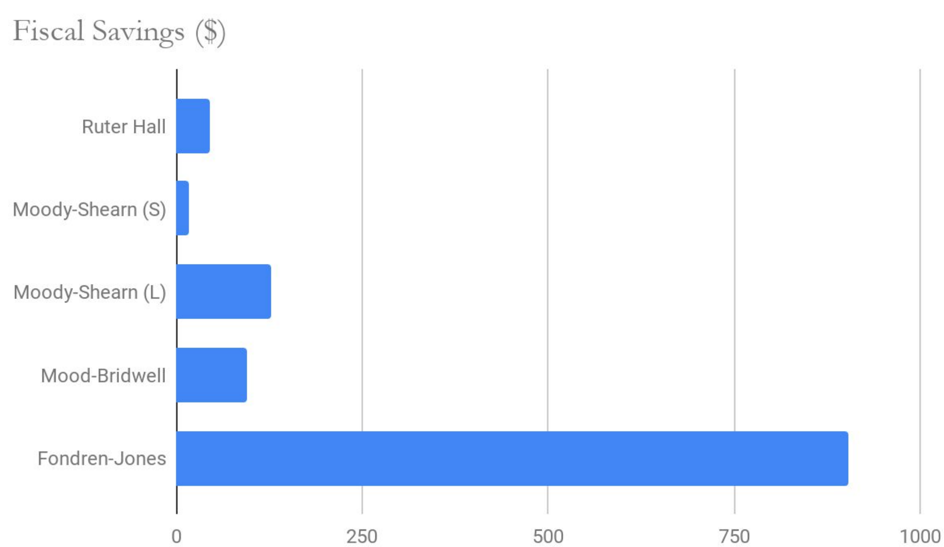

Fig. 3.5

We acknowledge that the economic justifications for our project are not as attractive, yet it is still important to note that there are some economic justifications for our proposal. Implementing rainwater catchment onto SU's campus would result in eliminating municipal water usage and thus would result in some fiscal savings. For example, irrigating the flowerbeds of the Soule Promenade would save roughly $231.84 annually. Due to the circumstances that we cannot obtain the Soule Promenade's exact landscaping size, we can only estimate that the figure would increase significantly if we were to irrigate all of the landscaping of the Promenade. Figure 3.5 shows the additional fiscal savings for the alternate locations on campus. Although these figures are small, research suggests that the impacts of climate change such as drought, flood, and rising sea levels will ultimately make water more expensive in the coming years. These findings justify our proposal that SU would benefit economically, if not now then later, by implementing rainwater irrigation on campus.

3.4 Discovering the Place for a Catchment System

Deciding our need of the catchment system was to help the irrigation systems on campus, the following factors led us to the case-studies of where a system would best work.

3.4.1 Supply Potential and Demand

The following formula mathematically explains how we calculated how much rain each building would catch, and how effective this would be in terms of irrigating the surrounding land:

Potential= (Projected rainfall (in inches) x roof area x 0.62 gal/sq.ft/in x collection efficiency= supply)

Demand= (evapotranspiration x plant coefficient x .62 x square feet of irrigated area)

3.4.2 Physical Considerations

The architecture of each building also played a role in the feasibility. For example, a sloped roof with downspouts would maximize collection. In investigating the best building, we examined the spouts and gutter system, then divided the surface area square footage by the number of downspouts in the area that could fit the catchment tank. The material of the the roof was also considered. For example, metal shingles collect 10% more water than composite or asphalt shingles, since asphalt will weather and erode into the water supply. To reiterate: the larger the surface area of the building, the larger the capacity for rainwater collection. Other external factors to be considered include: in-place plumbing pipes, electric lines, irrigation, etc., which may make it difficult to install rainwater catchment in the space in mind.

The installation process has multiple factors to be considered. As mentioned, there needs to be a logical, as well as aesthetically-pleasing, location to put the tanks. Planting honeysuckle or creating an encasement of metal or brick structure can conceal these storage units. Since these tanks will hold thousands of gallons of water, they must be placed in a risk-free location (ideally in the shade) to ensure a long and healthy life. To further be considered is the pump for the tank and any needed piping to get the water into the tank.

3.5 Case Studies

This section includes multiple locations on campus that could benefit from rainwater catchment installation. These locations include Fondren Jones Science Building (FJS)/Soule Promenade, Moody-Shearn Residence Hall, Mood-Bridwell, and Ruter Residence Hall. We recognize that these are not the only locations on campus that can efficiently house rainwater catchment, but we study these locations due to their anticipated renovations.

3.5.1 Fondren Jones Science Building/Soule Promenade

We began by examining the feasibility of a rainwater catchment system on FJS. Water collected on this building would be used as the primary irrigation source for the newly proposed Soule Promenade. As such, we propose to use the tanks to act as the primary irrigation source for three flower beds on the new Soule Promenade. Additionally, this location provides a large rainwater downspout that would directly carry a large portion of the rainwater from the roof to the tanks. The following estimates are based in data for the current irrigation cycles that use:

- 161 gallons for each bed a day during the 90 days of summer,
- 30 irrigation cycles using the same amount of water during the remaining three months that receive irrigation
- No irrigation cycles in the winter season
- For a total of approximately 43,470 gallons used per year.

Since each catchment tank SU owns can hold 2,500 gallons at full capacity, each tank would be able to irrigate each bed for one full cycle of each bed. At a rate of $0.004/gallon (the current cost of municipal water per gallon), this equates to $10 saved for every 2,500 gallons of water caught and substituted into the irrigation system and $904.03 saved over the course of a year if full catchment potential is utilized.

As mentioned previously, this project would allow a highly visible educational opportunity that showcases SU's water conservation efforts in an area of high pedestrian traffic. While the tanks will be visually integrated with the exterior of the building, the placement of an rainwater infographic enhances the educational opportunity given by the installation.

Installing an infographic can educate the community and prospective students regardless of the location. Moreover, the project could be included in promotional information released by the campus to prospective students. As stated previously, a large percentage of prospective students are concerned with environmental issues. With the tanks in such visible locations or marketed by admissions, we can ensure that students would be pleased with SU's ability to become more sustainable. Tour groups can walk by the area and use it to show the active commitment this university is showing to improving water sustainability. Furthermore, SU could included the rainwater catchment project in applications for environmental certification programs such as the STARS program.

3.5.2 Moody-Shearn Residential Hall

Fig. 3.6

Two scenarios have been proposed and discussed for this location. Because of the many different sections of roofs, a small scale option collecting water from two existing downspouts location was proposed. These would each collect rainwater from 598 square feet and water could be incorporated into upcoming landscape renovations in the immediate area. These two locations were chosen because they would minimize aesthetic and environmental impact since the area is already a dirt bed and could be easily enclosed. While we acknowledge that the area is small and the cost savings would be minimal, it would be a start to a rainwater collection system that we examine in the second scenario.

Fig. 3.7

The second scenario involves collecting water from all downspouts that do not dump into the interior courtyard of the building. The roof measurement estimates to 4,329 square feet, thus requiring all six tanks for this scenario. These tanks could be installed around the building's adjacent downspout locations or underground piping installed allowing multiple tanks to be enclosed together in one location while collecting from multiple downspouts. Both scenarios we have proposed would increase project cost due to updating the downspout material. However, the catchment potential provided by such a project would be around the amount required to satisfy the upcoming landscape renovations in the area, allowing this section of irrigation to lead campus in rainwater utilization.

3.5.3 Mood-Bridwell

Fig. 3.8

A prevalent location, this building is slated for renovation and currently has many downspouts which allows for many options of where to place the tanks. In addition, the PVC downspouts installed on this site make the installation of a rainwater catchment system simpler. The upcoming landscape renovation in the area could provide a potential use for rainwater. In addition, there is no current irrigation system surrounding this building that would allow current the irrigation system to be fitted to the rainwater catchment system. The multitude of PVC downspouts and choices in the placement of the tanks makes Mood a possible candidate for a beneficial rainwater catchment system.

3.5.4 Ruter Residential Hall

While Ruter Hall does have nearly six thousand feet of roof space, the space around Ruter provides large limitations for our project. The dense surrounding physical infrastructure, lack of available tank space, and interior renovations all cause setbacks for installing the rainwater catchment tanks for irrigation. As a result, this can be looked at as more beneficial for stormwater management than collecting water to mitigate irrigation use. The front of Ruter Hall has severe flooding issues that could be mitigated by collecting water from the two copper gutters which currently dump water into the area. These tanks would collect water falling on around 5,916 square feet of roof space and able to collect 3,667 gallons per inch of rain. This water could be collected during a heavy rain event and dumped later, offsetting the impact of heavy rain events on the area in front of the building. While there would be no current clear use for the water, it could be used in nearby irrigation renovations.

Fig. 3.9

3.6 Goals/Next Steps

We believe that our proposal can reach substantial goals that would help Southwestern not only improve sustainability on campus, but be recognized for their efforts in doing so. We have estimated potential outcomes that could occur if SU was to implement a rainwater catchment irrigation system on campus.

3.6.1 Installation

If the rainwater catchment tanks were to be installed onto FJS, we would propose that installation should aline with the project plans. Ideally, the tanks would be implemented onto FJS by the time of reveal of the new building in Fall of 2019. We propose that the tanks would be installed on any of the alternative locations in Fall of 2020.

3.6.2 Applying for Awards

If a rainwater catchment system can be officially installed on Southwestern University's Campus, there are multiple awards that the school can be nominated for in regards to sustainability on campus. For example, SU could apply for the Texas Water Development Board Raincatcher Award that Carpenter Hill Elementary and Ralph Pfluger Elementary School had received.

3.6.3 Implementing Educational Aspects

As stated previously, the rainwater catchment tanks would be a phenomenal educational opportunity for the SU and Georgetown community. We propose that implementing an infographic in front of the tanks would allow for individuals to learn the benefits about conservation. Additionally, the tanks could influence other individuals to implement water conservation strategies of their own to overall improve Georgetown sustainability.

3.6.4 Rainwater Catchment system as Part of the Admissions Tour

The final goal is to have the rainwater catchment system and tanks be implemented as part of the admissions tour on campus. If achieved prospective students and visitors of the school can learn about rainwater catchment, and can see just how important sustainability is on Southwestern University's campus.

3.6.5 External Funding

We have applied for Green S.A.F.E. funding for our project in hopes to receive full or a portional funding for our project. However, there are other opportunities to receive external funding, such as the Texas SWIFT (State Water Implementation Fund for Texas) and Coca-Cola Foundation.

3.7 The Future of Rainwater at Southwestern

We believe that SU sustainability could be improved with rainwater catchment irrigation. The social, environmental, education, and economic justifications provide convincing reasons as to why SU would benefit from rainwater. From our application of our studies and research, we propose that SU would most benefit from implementing rainwater on FJS. FJS provides the most water catchment potential and fiscal savings while simultaneously having the most optimal location for installation out of each case study. However, rainwater catchment could benefit SU at any location, making this type of irrigation an accessible way to achieve water conservation. Water conservation is important for the campus community, Georgetown community, and the environment. We believe that SU implementing rainwater catchment would only make the campus a stronger player in sustainability and could improve the livelihoods of many to come.

4. Citations

U.S. Plastic Corp. (2018). 1/8" x 48" x 48" Gray PVC Sheet. Retrieved From www.usplastic.com/search/?it=item&keyword=1%22%2Bpvc%2Bpipe.

Angima, S. (2014). Harvesting rainwater for use in the garden. Retrieved from https://catalog.extension.oregonstate.edu/sites/catalog/files/project/pdf/em9101.pdf

Texas A&M Agrilife Extension. (N.D.). Rainwater harvesting: Distribution. Retrieved From rainwaterharvesting.tamu.edu/distribution/.

Falwell, A., Sanders, A., & Phillips, C. (2016). Highland garage cistern: Saving water, cutting water bills, and spreading the word on rainwater harvesting. 1-8.

Grizzard, J. (2017). *Rainwater harvesting: Overland partner architects* [PowerPoint slides].

Krishna, H., (2003), "An overview of rainwater harvesting systems and guidelines in the United States," *Proceedings of the First American Rainwater Harvesting Conference*, Austin, TX, August 2003, pp. 335-343

Mendez, C. B., Afshar, B. R., Kinney, K., Barrett, M. E., & Kirisits, M. J. (2010). *Effect of roof material on water quality for rainwater harvesting systems: Additional physical, chemical, and microbiological data*. Austin, TX: Texas Water Development Board.

O'Reilly, K. (2018, August 27). *The top 20 coolest schools 2018: Here's why the greenest colleges of 2018 rank at the top of their class.* Retrieved from https://www.sierraclub.org/sierra/cool-schools-2018/top-20-coolest-schools-2018

Texas Water Development Board. (2005) *Texas manual on rainwater harvesting.* Retrieved from http://www.twdb.state.tx.us

The Princeton Review. (2018). *Guide to 399 green colleges: 2018 Edition press release.* Retrieved from https://www.princetonreview.com/press/green-guide/press-release

Woodson, D. (2012). "Rainwater Harvesting for Irrigation," https://agrilifecdn.tamu.edu/urbantarranthorticulture/files/2012/03/RainWater-Harvesting-DW.pdf